Summer 2015

Systems Theory-Based Construct for Identifying Metasystem Pathologies for Complex System Governance

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SYSTEMS THEORY-BASED CONSTRUCT FOR IDENTIFYING METASYSTEM PATHOLOGIES FOR COMPLEX SYSTEM GOVERNANCE

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A Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

ENGINEERING MANAGEMENT

OLD DOMINION UNIVERSITY
August 2015

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ABSTRACT

SYSTEMS THEORY-BASED CONSTRUCT FOR IDENTIFYING METASYSTEM PATHOLOGIES FOR COMPLEX SYSTEM GOVERNANCE

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The purpose of this research was to develop a systems theory-based construct for metasystem pathologies identification in support of the problem formulation phase of systems-based methodologies using an inductive research design. Problem formulation has been identified as one of the most critical stages in complex system development since it influences later stages in complex system understanding. In modern society where the operating landscape is characteristically ambiguous, mired by complexity, emergence, interdependence, and uncertainty, the concept of problem formulation is used to ensure right issues affecting complex systems surface and addressed to meet expected system performance and viability. In this research, this role of problem formulation is examined in systems-based methodologies in connection with systems theory. While the literature indicates the importance of problem formulation phase in systems-based methodologies, the conceptual foundations of systems theory that form the basis for 'systemic' thinking in these methodologies is not clearly inculcated into the problem formulation phase. This research addresses this gap by providing the necessary detailed discussion linking systems theory to problem formulation. The research focused on the lack of explicit use of systems theory in problem formulation and metasystemic issues of a higher logical order beyond single system of interest. A rigorous approach employing grounded theory method was used to analyze systems theory (laws, principles, and

theorems) in terms of problem formulation to develop a construct – *Metasystem Pathologies Identification* and derived systems theory-based pathologies (circumstances, conditions, factors, or patterns) that act to limit system performance. A case study was then undertaken to face validate the applicability of emerging systems-theory pathologies in an operational setting were possible utility were developed.

Fundamentally, this research presents a new approach to problem formulation where systemic thinking is at the foundation of identifying systemic issues affecting system performance. A significant promise for those interested in problem formulation is the inclusion of systems theory-based pathologies during problem formulation phase of systems-based approaches.

For Elizabeth
And the proposition that a great civilization is not conquered from without until it has destroyed itself from within - *Ariel Durant*

ACKNOWLEDGMENTS

I express my deepest appreciation to my dissertation advisor, Dr. Charles B. Keating, who has provided a rigorous and innovative environment enabling challenging and unsurpassed rewarding doctoral experience. Dr. Adrian V. Gheorghe, Dr. Patrick T. Hester, and Dr. James Pyne patiently provided time and expertise as members of the dissertation committee.

My appreciation is extended to fellow colleagues including Walt Akers, Dale Baugh, Dr. Joe Bradley, Dr. Behnido Calida, Jennifer Shauger, Joe Sisti, Drew Smith, Mike Smith, and David Walters.

Finally, my siblings, you deserve special recognition for your patience and insightful reminders, surely whoever thinks is standing securely should watch out so he/she doesn't fall.

PREFACE

This research was conducted to contribute to ongoing research efforts dedicated to understanding and developing solutions to contemporary issues in complex systems. Many disciplines in engineering management and systems engineering are moving towards systems theoretic approach in dealing with issues affecting systems prevalent in 21st century systems. As it is increasingly becoming apparent that complex systems do not operate in isolation, there is a need to understand such systems as interdependent and complex - being affected by a multitude of issues that can hinder expected performance and viability. This requires that we think systemically about these systems and the ways we use to address such systems. In conjunction with this thinking, there were two primary motivations for the current research: First, the researcher grew up in different countries and become keenly interested in how humans deal with problematic issues affecting livelihood. These issues include but not limited to energy and food, healthcare, transportation, manufacturing, terrorism, and natural disasters. These issues appear to be accelerating, without end insight, and challenging the very existence of human being. Convenient examples include the 1995 Kobe earthquake, the 1998 ice storm in Canada, the 9/11 terrorist attacks, the 2002/2003 severe acute respiratory syndrome outbreaks, the 2004 tsunami in South Asia, the 2005 devastation of New Orleans during Hurricane Katrina, the 2010 Deepwater Horizon oil spill, and the 2008 global financial crisis,. It most certainly appears that dealing with such issues, be it before, during, or afterwards, requires a holistic approach that might involve technical, human/social, organizational/managerial, policy/political elements as well as their interrelationships. As I have come to learn, *cause and effect* in these instances is not easy to articulate. Often, there is a need to think holistically about these situations. Second, as I undertook my graduate studies in the Department of Engineering Management and Systems Engineering of the Frank Batten of Engineering and Technology, it become apparent that (1) the academic world has devoted time to develop numerous approaches, often referred to as systems-based methodologies, to confront complex issues affecting human well-being. However, (2) the availability of such approaches has not translated into systemic understanding complex systems as evidenced in frequency of occurrence and consequences of issues affecting society. I wanted to do research that has the potential to contribute to this area of research by focusing on utility of systemic thinking as espoused by systems theory.

Systems theory is taken as an alternative to reductionism which is closely aligned with the scientific method (holding that a complex organism is nothing but the sum of its parts, and therefore they can be reduced to constituent elements). A specific philosophical paradigm for systems theory, the need to holistically deal with entities as organizations and taking account of their interrelations rather than isolated parts, was a major influence. This is exemplified in the idea that concepts and insights of one discipline can be used to contribute other disciplines. This appears to be supported by development and application of principles and laws irrespective of their particular kind (Adams et al., 2014; Strijbos, 2010; von Bertalanffy, 1968). Specifically, it was importance for me to see how different concepts of systems theory could be used to address different aspects of complex systems. Ultimately, this research focused on the area of *problem formulation*. Consequently, the inductive nature of this research prompted a design as well as selection of grounded theory as a method for the execution of this research. In Chapter III, the research paradigm from which this research was conducted is further elaborated upon along the dimensions of methodology, epistemology, ontology, and human nature. The figure below captures the different elements of the inductive-subjective approach, compatible with the holistic thinking of systems theory, which was undertaken for this research.

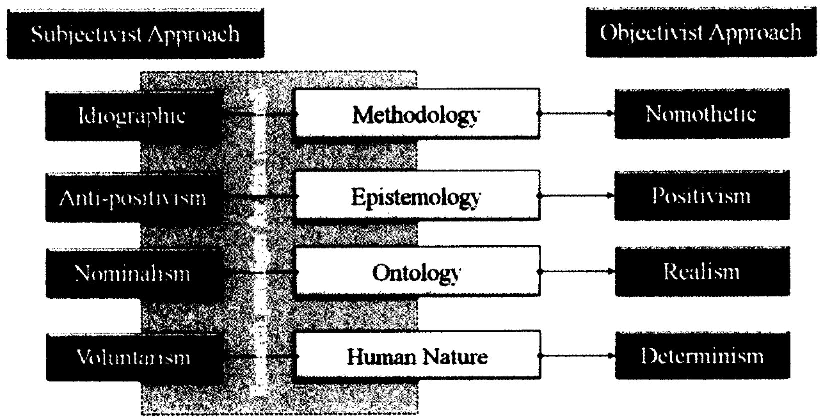

Figure 1: A Research Paradigm for this Research, Adapted from Burrell & Morgan, 1979

When an inductive-subjective paradigm is undertaken in connection with methodology (means for investigating to obtain knowledge about world), there becomes a need to get first-hand knowledge about the world. This can be done through an attempt to understand how individuals create, modify, and interpret the world. Epistemologically (understanding and communicating knowledge), this research was undertaken from the perspective that knowledge is soft and subjective and therefore based on insights of a personal nature. This is necessary as people could hold different views on the same issue. Ontologically (the nature of reality), this research was undertaken from the perspective of nominalism where 'reality' becomes a construct dependent on the interpretation of the observer. In this thinking, reality includes accounting for individual consciousness where concepts provide major utility in structuring reality. Finally, the nature of human beings as voluntaristic was undertaken to suggest that humans are free-willed beings capable of creating their environment. This becomes apparent in how humans address issues affecting them, including different activities associated with *problem formulation*.

This view of the world has several implications that are addressed in this research in connection with the concept of *systems theory-based pathology* and the Metasystem Pathologies Identification construct for problem formulation in the systems-based methodologies that we use to intervene complex systems. Specifically, conclusions from the research indicate current utility of the research and a wide range of future research. In practice, this research provides practitioners with the means to integrate systems theory and its aspect of holistic thinking in problem formulation and hopefully a better grasp of reality for dealing with complexity.

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CHAPTER I: INTRODUCTION

The purpose of this chapter is to establish the foundation for research to address a significant deficiency in the body of knowledge concerning initial phases of systems-based methodologies intended to provide understanding of the problem domain. Descriptors such as 'formulating the mess' (Ackoff, 1974; 1981a; Majone & Quade, 1980; Mason & Mitroff, 1981; Mitroff & Emshoff, 1979), 'problem articulation' (Wellington, 1887), 'problem bounding' (Checkland, 1993), 'problem context' (Crownover, 2005; Jackson, 1991; 2003), 'problem definition' (Dery, 1984; Blanchard & Fabrycky, 2006; Gibson, Scherer, & Gibson, 2007; Warfield, 1976), 'problem framing' (Fairhurst & Sarr, 1996; Keating, Peterson, & Rabadi, 2003a; Adams & Meyers, 2011), 'problem identification' (Majone & Quade, 1980), 'problem setting' (Majone & Quade, 1980; Miser & Quade, 1988a), and 'problem situation' (Miser & Quade, 1988b) represent different ways to which this critical phase of inquiry is described. However, there is a paucity of rigorous research related to the identification of systemic issues in the initial phase, 'problem formulation', of systems-based approaches to address complex systems and their derivative problems. This research is directed towards development of a system theoretic construct for identification of systemic pathologies, endemic to complex systems. The organization of Chapter I is depicted in Figure 2 below.

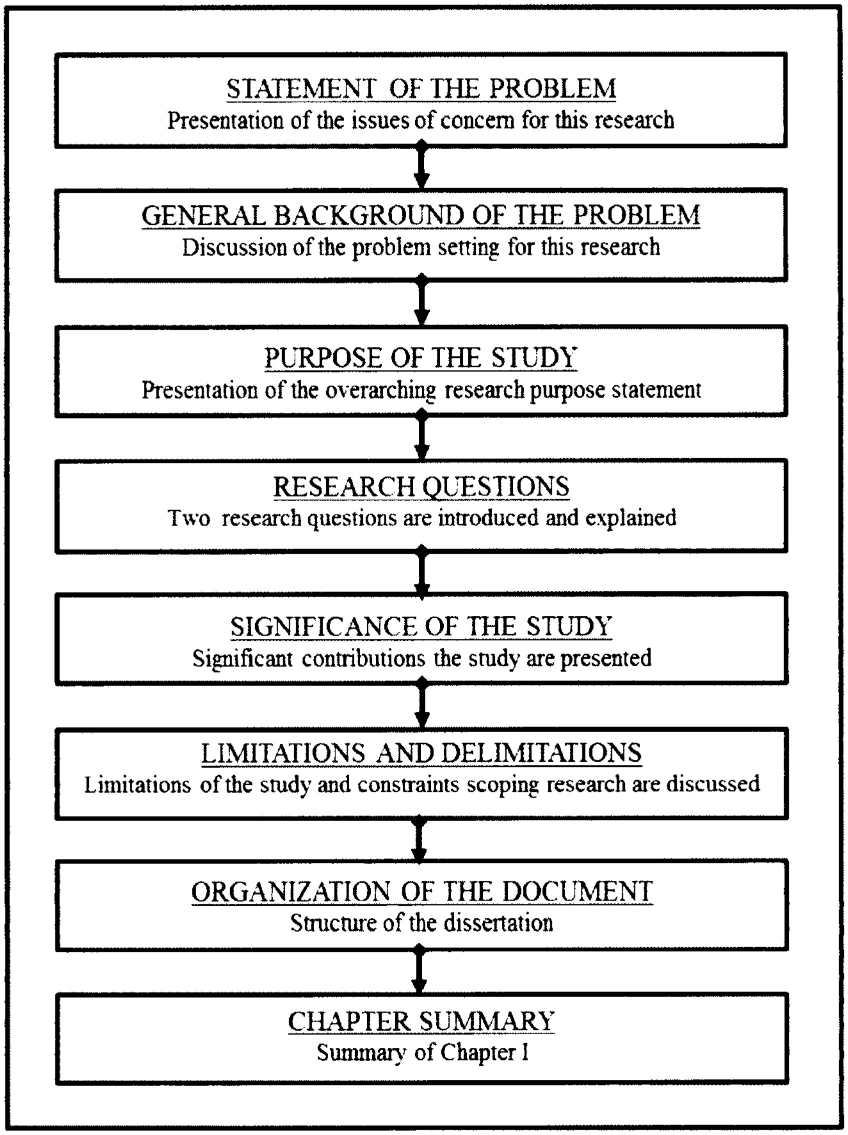


Figure 2: Organization Diagram for Chapter I

1.1 STATEMENT OF THE PROBLEM

21st century complex systems, such as healthcare systems, energy systems, transportation systems, security systems, operate under conditions of ambiguity, complexity, emergence, interdependence, and uncertainty (Flood & Carson, 1993; Katina, Pinto, Bradley, & Hester, 2014b; Skyttner, 2005). In the face of these conditions, systems-based methodologies (e.g., critical systems heuristics, interactive planning, sociotechnical systems, soft systems methodology, systems of systems engineering methodology, systems analysis, systems engineering, and the Viable Systems Model) have emerged as preferred approaches to understanding complex systems and bringing about change (Jackson, 2003). *Problem formulation* is a key theme among these systems-based approaches. It provides an initial entry into the problem space and is a fundamental aspect of the analysis critical to eventual formulation of complex situation solutions (Dery, 1984; Fairhurst & Sarr, 1996; Flood & Carson, 1993; Jackson, 2003; Keating, Sousa-Poza, & Mun, 2004; Kimball, 1957; Mingers & Rosenhead, 2004; Mintzberg, Raisinghani & Théorêt, 1976; Mitroff & Featheringham, 1974; Mosteller, 1948). However, while problem formulation is discussed in the literature, there are two principal criticisms: (1) there is a lack of explicit use of systems theory grounding problem formulation phases, and (2) an absence of focus on problem formulation at the metasystem level. For present purposes, metasystem is synthesized from the literature (Beer, 1979, 1981, 1985; Djavanshir, Khorramshahgol, & Novitzki, 2009; Djavanshir, Alavizadeh, & Tarokh, 2012; Krippendorff, 1986; Keating & Katina, 2012; Ríos, 2012) as a *governing structure that provides coordination and integration of subsystems in complex systems and systems of systems to achieve overarching goals, functions, and missions beyond those capable of individual constituent subsystems*. The resulting state of knowledge leaves a significant deficiency in addressing problem formulation at the metasystem level in system-based approaches for complex systems.

The following sections of this chapter introduce research background information on the issue of problem formulation at the metasystem level, purpose of the study, research questions, significance of the research, limitations and delimitations, and organization of the document. The chapter concludes with organization of the dissertation and a chapter summary.

1.2 GENERAL BACKGROUND OF THE PROBLEM

Understanding and bringing about change in complex systems and systems of systems requires that we properly formulate the problem. According to Mintzberg et al. (1976) problem formulation "is probably the single most important routine, since it determines in large part...the subsequent course of action" (Mintzberg et al., 1976, p. 276). It is also referred to as "the most critical stage" in policy problem analysis (Dery, 1984, p. 3). Similarly, Keating et al. (2004) refer to problem formulation as "the most critical phase...since errors in this phase will be amplified at later phases and throughout the cycling of the SoSE [systems of systems engineering] effort" (Keating et al., 2004, p. 10).

Moreover, the conditions under which complex systems operate might make it difficult for the analyst to "understand the object of such pursuits" (Dery, 1984, p. 14) and thus one runs the risk of developing what Dery (1984, p. 29) referred to as "pseudo-solutions" to "pseudo-problems" without a proper frame of reference. The importance of problem formulation in complex systems cannot be overstated. There is need to pay attention to diagnosis rather than "focus[ing] on the selection routines" (Mintzberg et al., 1976, p. 274), understanding "why problem situations occur" (Jackson, 2003, p. 204), and avoiding solving the wrong problem, otherwise known as Type III error (Adams & Hester, 2012; Kimball, 1957; Mitroff & Featheringham, 1974; Mosteller, 1948). The foundation of this research provides a rigorous exploration of the systemic underpinnings supporting these thoughts and ideas regarding the importance of problem formulation in efforts involving complex system understanding, design, (re)design, and transformation.

1.3 PURPOSE OF THE STUDY

The purpose of this research is to develop a systems-theory based construct for metasystem pathologies identification for problem formulation in systems-based approaches using an inductive approach of grounded theory. Glaser and Strauss (1967) first articulated the grounded theory method as an approach for developing theoretical constructs for a broad range of data. Details on the applicability and utility of the grounded theory method for this research are provided in Chapter III.

Typically, a complex system is composed of interconnected parts that, as a whole, exhibit one or more properties not obvious from the well understood properties of the individual parts (Joslyn & Rocha, 2000). As such, complex systems exhibit one or more of the following attributes: "1) significant interaction; 2) high number (of parts, degrees of freedom or interactions); 3) nonlinearity; 4) broken symmetry; and 5) nonholonomic constraints" (Yates, 1978, R201).

The concepts of system-based approach, problem formulation, and metasystem pathology are described in detail in Chapter II; however, in order to provide an essential foundation in relationship to the purpose of this research, it is necessary to elaborate on the use of these terms with respect to the present research. For the purpose of this study, a system-based approach is taken as a systematic methodological approach, grounded in theoretical underpinnings based in systems, enabling exploration of complex systems and their constituent problems. A methodology, according to Jackson (1991), is a set of "procedures for gaining knowledge about a systems and structured processes involved in intervening in and changing systems" (p. 134). Problem formulation is the initial phase or activity in gaining knowledge and understanding and transformation of problematic situation into a more clearly defined problem (Dery, 1984; Keating et al., 2004; Mintzberg et al., 1976). "This process usually takes not only extensive communication between the analysts and those responsible for deciding what to do about the situation but also a great deal of disciplined effort by both parties; it also requires inquiry into, and agreement on, the goals, constraints, and limitations on what is to be investigated" (Miser & Quade, 1988b, p. 22-23). While a metasystem is a logical higher order governing structure that provides coordination and integration of subsystems to achieve overarching capabilities beyond those of individual subsystems (Beer, 1979, 1981, 1985; Djavanshir et al., 2009; 2012; Krippendorff, 1986; Keating & Katina, 2012; Ríos, 2012), a pathology is defined as "a circumstance, condition, factor, or pattern that acts to limit system performance, or lessen system viability, such that the likelihood of a system achieving performance expectations is reduced (Keating & Katina, 2012, p. 253). Hence, a metasystem pathology is a pathology that acts to limit performance or lessen viability of a system at the metasystem level.

This research addresses the gap in systems body of knowledge concerning: (1) the limited explicit use of systems theory during problem formulation and (2) the lack of focus on pathologies at the metasystem level during problem formulation phases in systems-based approaches for complex systems. The approach is driven by developing a system theoretic construct for establishing and articulating metasystem pathologies in support of problem formulation phases for system-based methodologies. As used in the purpose statement, a construct is a set of related concepts forming a building block enabling understanding of situations (Bunge, 1974; Krippendorff, 1986; Linsky, 2012). This construct is referred to as the Metasystem Pathologies Identification (MPI) to support the problem formulation phase of system-based methodologies.

To meet purpose of this research, there is a need to further articulate how the research will be conducted and what the research will achieve. The following section elaborates two central questions that serve to focus the research effort.

1.4 RESEARCH QUESTIONS

The foundation of this research rests on systems theory and concepts related to the problem formulation phase in systems-based approaches related to studying complex systems. This research is specifically focused on two research questions:

1. ***How can systems theory be used to generate a metasystem pathologies identification construct to support problem formulation phase of systems-based methodologies?***
2. ***What results from the deployment of the metasystem pathologies identification construct in an operational setting?***

As used above, the term systems theory refers to a "unified group of specific propositions which are brought together to aid in understanding systems, thereby invoking improved explanatory power and interpretation with major implications for systems practitioners" (Adams, Hester, Bradley, Meyers, & Keating, 2014, p. 113). These propositions have basis in different fields of science and have been used to explain and understand system phenomena (Adams et al. 2014; Angier, 2007). This research seeks to extend the use of systems propositions to the problem formulation phase of systems-based methodologies. The first question is focused on establishing a relationship between propositions of systems theory and problem formulation for complex systems with emphasis on metasystem pathologies identification. The thrust of this question is to develop a construct for metasystem pathologies identification, based in systems theory, with applicability to the problem formulation phases of systems-based methodologies for complex systems and their constituent problems. Grounded theory method is used discover such potential relationships, interconnections, and interdependencies that systems theory provides for metasystem pathologies. For Research Question 1, the output is a theory (i.e., construct) of Metasystem Pathologies Identification (MPI) and its supportive systems theory-based pathologies.

In the second research question, the developed construct is applied to an operational system. The thrust of this research question is to establish a 'face' validation for the construct through application to an operational system. A single operational system serves as the focus for investigation using a case study method (Yin, 2009). Figure 3 depicts research questions, objectives, and the purpose of this research.

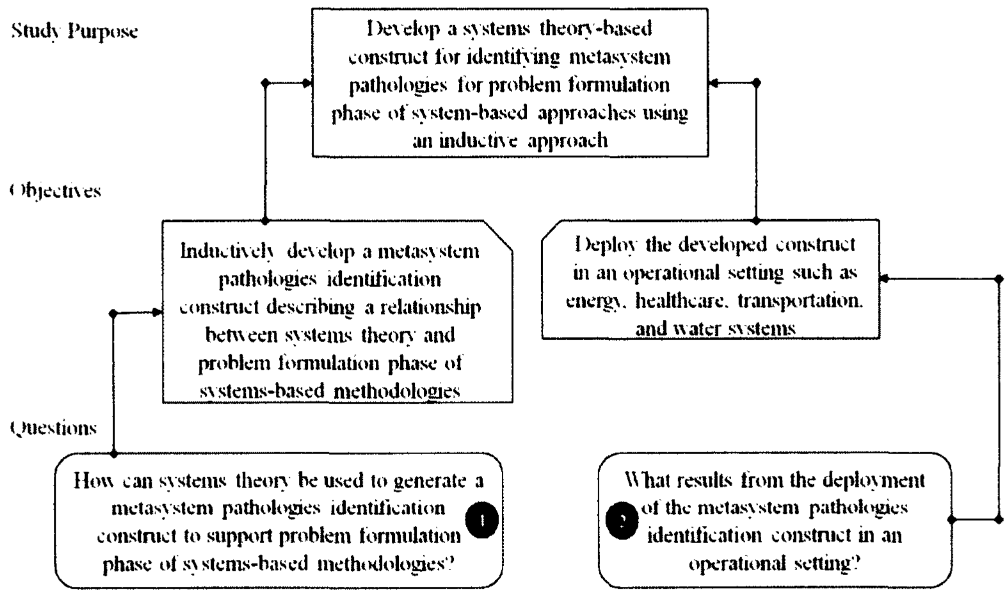


Figure 3: Research Purpose, Objectives, and Questions

As a result of addressing these two questions, this research makes substantial contributions to the systems body of knowledge. First, it extends the use of propositions of systems theory to problem formulation phases of systems-based methodologies. Second, this research is concerned with the use of systems propositions in problem formulation phases of systems-based methodologies, focused at the metasystem level. Thus, this research is concerned with metasystem pathologies as an essential element of problem formulation in complex systems.

1.5 SIGNIFICANCE OF THE STUDY

The importance of systems-based methodologies in understanding and bringing about change in complex systems is established in literature and elaborated further in Chapter II. Central to systems-based methodologies is the concept of the problem formulation phase and its critical role in the analysis of complex systems. Therefore, the basis of this research in bringing a rigorously developed construct for metasystem pathologies identification in complex systems makes significant contributions to systems body of knowledge by:

- Contributing to research methodologies in the systems engineering and related fields of engineering management using grounded theory. Grounded theory method "is the most widely used qualitative interpretative framework in the social sciences today" (Denzin, 1994, p. 508) including sociology, psychology, information science, education, and healthcare (Bryant, 2002; Locke, 2001). Thus, applying grounded theory in systems domain provides opportunities for an enhanced capacity to conduct inductive research into the systemic issues endemic to the domains related to systems, including such domains as engineering management, systems engineering, and systems of systems engineering.
- Adding to the existing body of knowledge in systems theory, system-based methodologies, and problem formulation by developing a construct drawing upon the propositions of systems theory and projecting them to the complex system problem formulation phase in system-based methodologies.
- Providing a basis for including metasystem pathologies in the analysis of complex systems, thereby enhancing the problem formulation phase of systems-based methodologies.
- Making a significant contribution to the practice related to problem formulation phases that must be undertaken as an initial activity in virtually any complex systems-based inquiry. Foundations for development of a new set of technologies, methods, tools, and techniques to support Metasystem Pathologies Identification will be informed from the research.

This section has discussed significance of this research to methodology, theory, and practice. Limitations and delimitations of this research are the basis for the following section.

1.6 LIMITATIONS AND DELIMITATIONS

This section presents the limitations (restrictions on the generalizability and projection of research results) and delimitations (established boundary conditions) guiding this research. Together, these two aspects provide the scope of this research with respect to how the findings and implications resulting from the execution of the research design can be interpreted.

1.6.1 Limitations

There are three limitations of this research. Detailed discussion on research limitations, steps taken for mitigations, and implications with regards to grounded theory and the case study method are discussed in detail in Chapter III. However, to frame the research, it is necessary to explore limitations related to, credibility, confirmability, and generalizability.

Concerning credibility (the degree to which the research is 'believable' and trustworthy from the perspective of the participants), this research takes into account several steps including use of well-established research methods and triangulation in the local case application (Glaser & Strauss, 1967; Lincoln & Guba, 1985). However, this provides a limitation for extensibility of the research beyond the case application. This research uses a grounded theory method to enhance problem formulation phase through pathology articulation based on systems theory. Steps taken to explain the relationship between systems theory and problem formulation and their implications are elaborated upon in Chapter II. A single real world complex system was investigated using case study method (Yin, 2009) to examine the degree to which the theoretical construct can transfer to an operational setting. The judgment of the ability to transfer to the operational setting must be established from the perspective of the participants with respect to the trustworthiness of the results of application.

Confirmability of the research establishes a limitation of the research concerning availability of data and the procedures upon which the research findings are based. In qualitative research, "confirmability builds on audit trails...and involves the use of field notes, memos, a field diary, and process and personal notes, and a reflexive journal" (Denzin, 1994, p. 513). The use of readily available research methods (i.e., grounded theory and case study) combined with accessible data (i.e., databases, books, and journal articles) and QSR International's NVivo 10 software package for coding provide the basis for confirmability of the research. Steps undertaken to ensure confirmability of the case study are elaborated upon in Chapters III and IV.

Generalizability (the ability to project the results of the research beyond the research application), there is an inclination for concepts of metasystem pathologies to be generalizable beyond the research. However, the nature of qualitative research design and the use of grounded theory and case study methods provide a list of challenges for generalizing beyond the scope of the study. Douglas (2003) insists:

> *The explanatory power of grounded theory is to develop predictive ability – to explain what may happen ...the wider the theoretical sampling frame develops the more embedded the theory becomes; and general theory generation becomes achievable...transferability to other research areas depends on the degree of similarity between the original situation and the situation to which it is transferred. (p. 51)*

Hence, while the construct linking systems theory to problem formulation at the metasystem level might be generalized, the results of application of the construct will vary based on the context of different complex situations (Patton, 2002; Yin, 2009). The generalizability of the theoretical construct is held with the validity provided by the grounded theory method. However, the generalizability of the application is limited by the application to the specific nature of the context surrounding the case study. Therefore, a limitation for application, based on the case study method, must be considered.

1.6.2 Delimitations

This section discusses four delimitations of this research. These delimitations provide the boundary of this research: problem formulation, construct for metasystem pathologies, systems theory, metasystem pathologies.

Problem formulation – the area of focus for this research is limited to support for the problem formulation phase as it relates to systems-based approaches to complex system understanding. As such, the research is not about an end-to-end analysis of complex systems as expected in application of a system-based methodology employed to understand, devise change, transformation and evaluation of complex systems. However, as indicated in Chapter II, metasystem pathologies can be considered an essential part of the problem formulation phase for any systems-based endeavor.

Construct for metasystem pathologies – the major part of this research is the development of a construct linking systems theory to metasystem pathologies within the context of the problem formulation phase of systems-based methodologies. This construct is best described as conceptual model for problem formulation in metasystems and therefore it does not represent a model of any real world problem formulation.

However, it can be applied in any real world situation related to problem formulation at the metasystem level from a systems theory perspective. The results of applying the construct are unique to the case study and, as an application significance, are bounded to the specifics of the case study situation.

Systems theory – this research focuses on propositions of systems theory and how such propositions can be used to inform development of problem formulation phase of systems-based methodologies and articulation of pathologies. This research is not about developing new propositions; rather it only uses existing systems propositions to develop ideas about metasystem pathologies identification and pathologies using grounded theory approach.

Metasystem pathologies - this research focused on pathologies at the metasystem level of complex systems and thus concepts of governance, integration, and coordination beyond functions, goals, and missions of individual systems (Beer, 1979, 1981, 1985; Djavanshir et al., 2009; 2012; Krippendorff, 1986; Keating & Katina, 2012; Ríos, 2012) take precedence. As such, the concept of pathologies is limited to understanding circumstances, conditions, factors, or patterns that may act to limit expected performance within the scope of problem formulation phase for systems-based methodologies. The metasystem view presented in this research is directly drawn from management cybernetic (Beer, 1979).

1.7 ORGANIZATION OF THE DOCUMENT

This section introduces the organization of the rest of this document. In Chapter II, critique of literature pertinent to problem formulation is established along with a research setting for need and the development of the Metasystem Pathologies

Identification (MPI) construct. Chapter III describes research perspective including theoretical underpinnings of grounded theory and case study methods as an inductive research approaches necessary for development of the construct. This discussion includes applicability and key concerns regarding the use of grounded theory and case study methods. Chapter IV describes the research methodology and lays out the research design, research phases, data collection, and the analysis process with respect to grounded theory and case study methods. Chapter V provides an in-depth discussion of the research results including detailed relationships between systems theory and problem formulation, the emerging theory of metasystem pathologies identification, the application and the results of the developed construct in real system. The research concludes with Chapter VI, which provides conclusions, recommendations for application of the results, and future research. Figure 4 depicts the flow of chapters and the remainder of this dissertation.

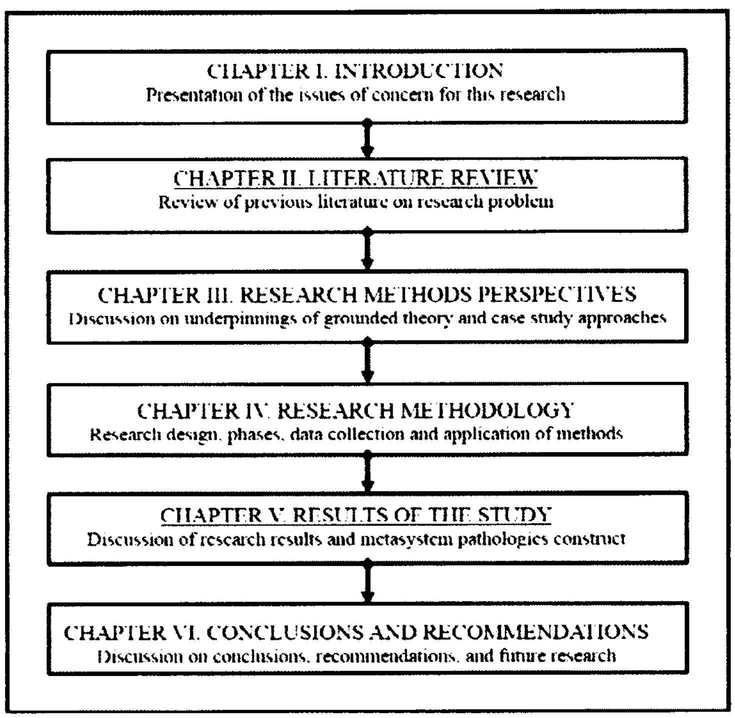


Figure 4: Organization of Dissertation Chapters

1.8 CHAPTER SUMMARY

This chapter provides the foundation of the research developed to address a significant deficiency in systems body of knowledge. It provides a statement of research pertinent to problem formulation in 21^{st} century complex systems, background information on the importance of problem formulation, and the purpose of study as related to use of systems theory in the problem formulation phase of systems-based methodologies. Furthermore, this chapter articulates two research questions, offers significance of the study in relation to contributions, and lays-out the study's limitations and delimitations along with the organization of the rest of the document.

The following chapter, Chapter II, is a literature review on systems body of knowledge aimed at illustrating the gap of using systems theory in problem formulation phases of systems-based approaches.

CHAPTER II: LITERATURE REVIEW

Chapter I demonstrated the role of problem formulation in systems-based approaches when dealing with 21st century systems operating under the conditions of ambiguity, complexity, emergence, interdependence, and uncertainty. This chapter reviews the literature relevant to problem formulation. A synthesis of the literature is developed across systems-based perspectives to obtain threads and concepts pertinent to the research idea of problem formulation at the metasystem level. This chapter also articulates shortcomings pertaining to use of systems theory in identification of metasystem issues. This is followed by a research setting which frames this current research and how the proposed research addresses gaps in the systems body of knowledge. Figure 5 is provided to represent the organization of this chapter.

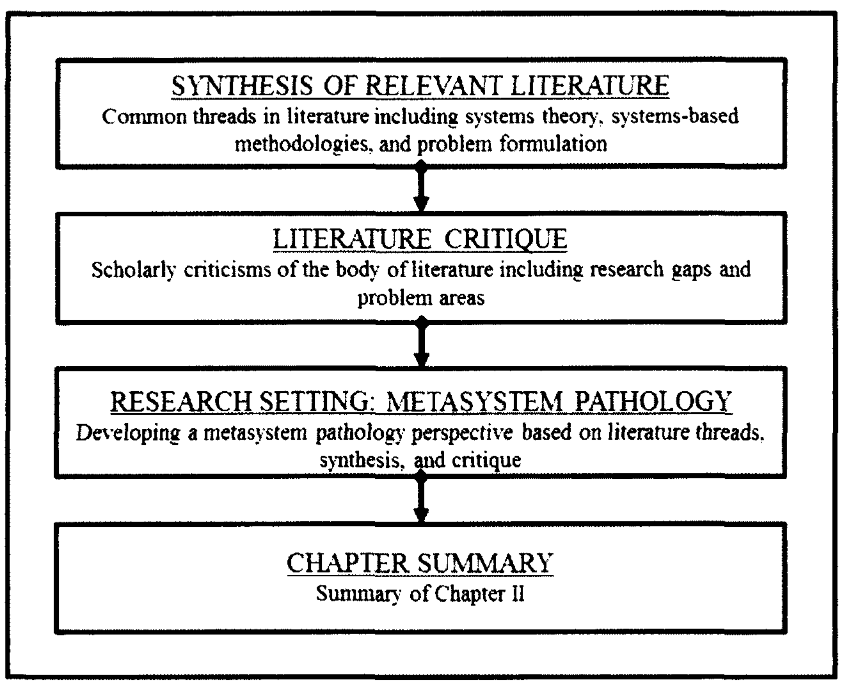


Figure 5: Organization Diagram for Chapter II

2.1 SYNTHESIS OF RELEVANT LITERATURE

The literature review includes the three major areas of systems theory, systems-based methodologies, and problem formulation, as depicted in Figure 6. The literature on systems theory forms the body of literature relevant to topics of systems, complex systems, systems of systems, and systems-based methodological approaches. Literature on system-based methodologies discusses different approaches used to intervene in 21st century system problems. The area of problem formulation discusses the role and importance of proper problem formulation in the eventual success of a system. In order to sufficiently establish the concept of metasystem pathologies within the systems theory body of knowledge, it was necessary to include topics on laws, principles, and theorems that can be used to understand and explain system behavior and thus enhance an analyst's ability to intervene in systems. Moreover, the topic of metasystem is included in this research since the research is concerned with understanding problem formulation at the *metasystem* level.

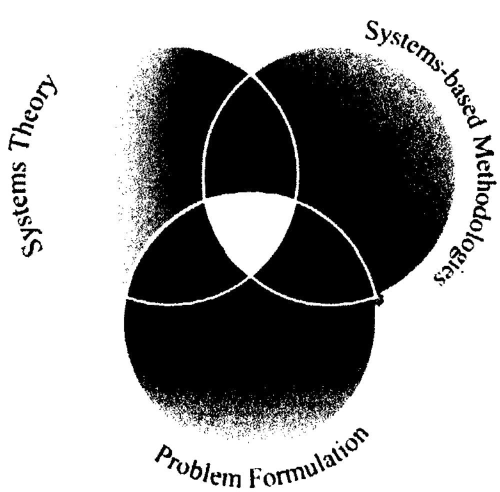


Figure 6: Three Major Streams of Research

The streams of research that emerged from the literature review serve as the basis for Figure 7, which are inclusive of issues related to complex systems, complex problem formulation, system pathologies, systems of systems, metasystem, systems theory, and systems-based approaches.

This research contributes to complex problem formulation at the metasystem level as indicated by the red-dotted line connecting the concepts of 'problem formulation' and 'metasystem' in Figure 7. This contribution is directly rooted to laws, principles of systems theory (Adams et al., 2014) which is the basis from understanding complex systems (Hammond, 2002; von Bertalanffy, 1968; Warfield, 1976).

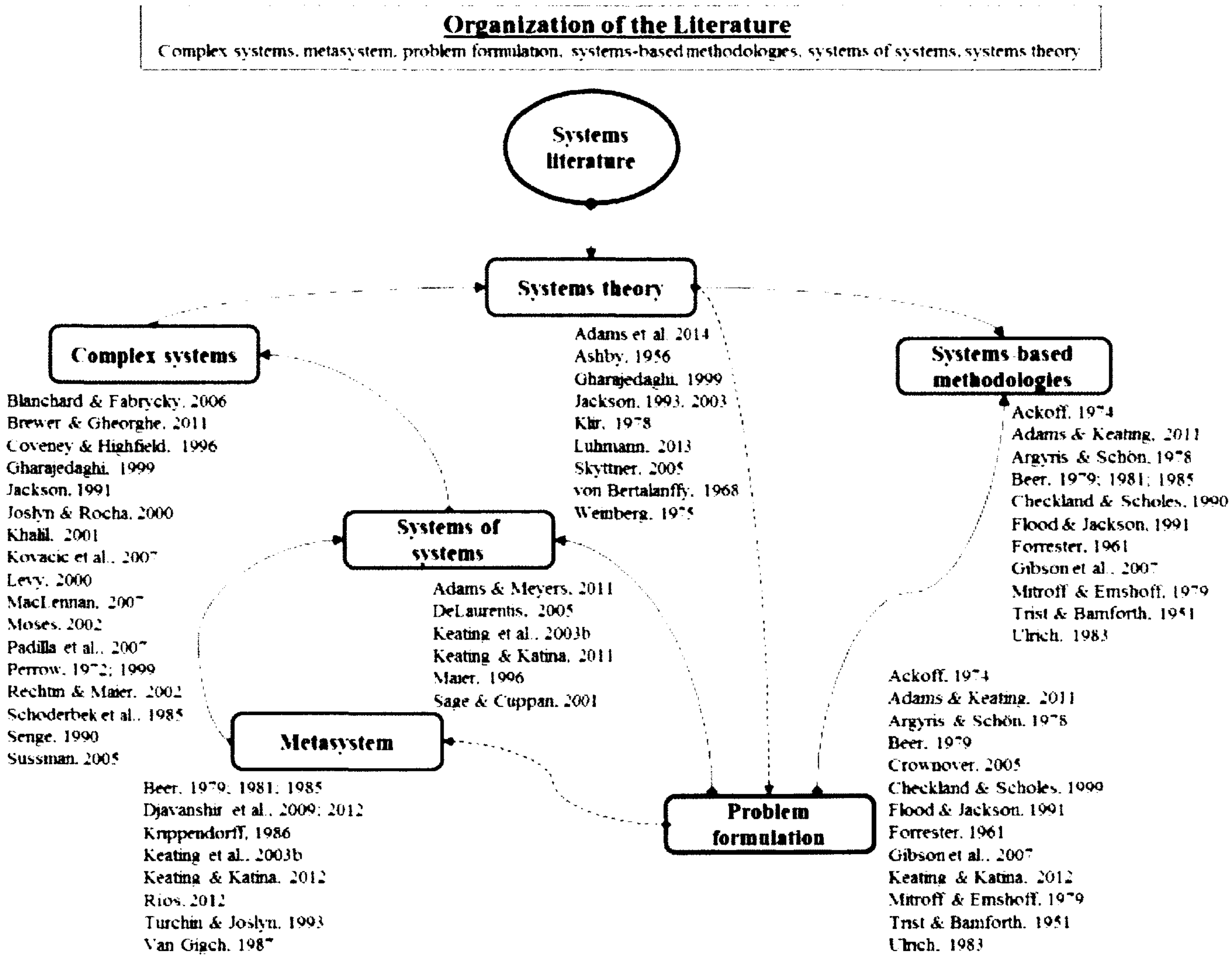


Figure 7: Literature Review Threads

2.1.1 Systems Theory

Systems theory does not have a single common or accepted definition. The term is commonly attributed to Anatol Rapoport, Norbert Weiner, Karl Ludwig von Bertalanffy and Ross Ashby (Klir, 1972; Laszlo & Krippner, 1998) and emerged in the 1940s as an attempt to provide an alternative to reductionism. Reductionism is closely aligned with the scientific method, which holds that a complex organism is nothing but the sum of its parts, and therefore they can be reduced to constituent elements (Hammond, 2002; von Bertalanffy, 1968). As doubts regarding the classical scientific approach of isolating constituent elements became clear in different fields, researchers became more interested in notions of 'organization' of wholes rather than parts (von Bertalanffy, 1972). They kept re-discovering the Aristotelian dictum of the whole being greater than the sum of its parts in biology, psychology, sociology, and physics (von Bertalanffy, 1968; Laszlo, 1996).

The argument for systems theory started in 1920's when von Bertalanffy (1972) stated:

> *Since the fundamental character of the living thing is its organization, the customary investigation of the single parts and processes cannot provide a complete explanation of the vital phenomena. This investigation gives us no information about the coordination or parts and processes. (p. 410)*

The proposed solution to this issue in biology was to "discover the laws of biological systems (at all levels of organization)" (von Bertalanffy, 1972, p. 410) to gain knowledge about the complete picture that includes coordination of parts and processes. In terms of systems and understanding, the purpose of systems theory emerged as a platform for uniting different disciplines through inductive discovery of models, principles and laws that help explain 'system' phenomena (Heylighen & Joslyn, 1992; Laszlo & Krippner, 1998; Laszlo, 1996; von Bertalanffy, 1950).

According to Laszlo (1996), systems theory is related to ideas of 'wholes,' 'having irreducible properties,' 'environment,' 'centralization,' 'self-organization,' and 'holarchy of nature.' Fundamentally, these propositions are meant to grasp the ideas of organization, relationships, and interrelations among all systems (von Bertalanffy, 1972). Additionally, these propositions not only attempted to link different and diverse systems; they also suggest that there is commonality among different disciplines, which could be found in systems theory and this could be leveraged to enhance our understanding of the world. This is illustrated in Kenneth Boulding's letter to von Bertalanffy (1968):

> *I seem to have come to much the same conclusion as you have reached, though approaching it from the direction of economics and the social sciences rather than from biology - that there is a body of what I have been calling 'general empirical theory,' or 'general system theory' in your excellent terminology, which is of wide applicability in many different disciplines. I am sure there are many people all over the world who have come to essentially the same position that we have, but we are widely scattered and do not know each other, so difficult is it to cross the boundaries of the disciplines. (p. 14)*

The founders of systems theory foresaw this as a necessary and sufficient platform for transcending the boundaries of the classical sciences (e.g., physics, biology, psychology, social science) (von Bertalanffy, 1968; 1972). Thus, the notion of systems theory was not limited to living organisms. It transcended machines, physicochemicals, organizations, and social systems (Stichweh, 2011).

The foundation of the *Society for General Systems Research* (since renamed, *International Society for the Systems Sciences*) in 1954 provides further clarification on the need of systems theory. The original bylaws stated that the aims of general systems theory:

1. To investigate the isomorphy of concepts, laws, and models from various fields, and to help in useful transfers from one field to another
2. To encourage development of adequate theoretical models in the fields which lack them
3. To minimize the duplication of theoretical efforts in different fields
4. To promote the unity of science of through improving communications among specialists. (Adams et al., 2014; Hammond, 2002; von Bertalanffy, 1972)

In postulating general systems theory, von Bertalanffy's objective was to bridge the gap that exists in different disciplines via the discovery of principles and laws common across disciplines (von Bertalanffy, 1968):

> *...there exist models, principles, and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relationships or 'forces' between them. It seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles applying to systems in general.*
>
> *The meaning of this discipline can be circumscribed as follows. Physics is concerned with systems of different levels of generality. It extends from rather special systems, such as those applied by the engineer in the construction of a bridge or of a machine; to special laws of physical disciplines, such as mechanics or optics; to laws of great generality, such as the principles of thermodynamics that apply to systems of intrinsically different nature, mechanic, caloric, chemical, or whatever. Nothing prescribes that we have to end with systems traditionally treated in physics. Rather, we can ask for principles applying to systems in general, irrespective of whether they are of physical, biological, or sociological nature. If we pose this question and conveniently define the concept of system, we find that models, principles, and laws exist which apply to generalized systems irrespective of their particular kind, elements, and the 'forces' involved.*
>
> *A consequence of the existence of general system properties is the appearance of structural similarities or isomorphisms in different fields. There are correspondences in the principles that govern the behavior of entities that are, intrinsically, widely different. (pp. 32-33)*

The problem, according to Laszlo (1996), was that classical science was promoting bubbles of knowledge without a sense on holistic understanding. In order to promote holistic thinking, proponents of system theory suggested that there is a need for a discipline that can bridge the gap created by compartmentalization of reductionist thinking. In the case of understanding and knowledge generation, Laszlo (1996) suggested that compartmentalization emerged out of the belief that the "human mind has a limited capacity for storing and processing information [hence]...individual people can work in teams, and what one of them knows can be complemented by the knowledge of the others. Hence knowledge can proceed in depth without thereby losing breadth" (p. 2). Later, Laszlo (1996) notes that compartmentalization created "closed bubbles in their own right. [Where] specialists in one field can communicate with one another if they share a specialty, but experience difficulty when their interests do not coincide" (Laszlo, 1996, p. 2). The outcome is "the unfortunate consequence of such specialty barriers is that knowledge, instead of being pursued in depth and integrated in breadth, is pursued in depth in isolation" (Laszlo, 1996, p. 2). This applies that a specialist may be able to "tell how one cell or organ reacts to one particular kind of stimulant, or how one body reacts to one particular kind or force" (Laszlo, 1996, p. 3). However, Laszlo (1996) argues that the specialist cannot tell us "how a number of different things act together when exposed to a number of different influences at the same time" (p. 3). Expressed differently by von Bertalanffy (1972):

> *This method [scientific method] worked admirably well insofar as observed events were apt to be split into isolable causal chains, that is, relations between two or a few variables. It was at the root of the enormous success of physics and the consequent technology. But questions of many-variable problems always remained. (p. 409)*

The traditional scientific method and its reductionist mindset, notes Hammond (2002) is:

> *...rooted in the mechanistic worldview we inherited from the scientific revolution of the seventeenth century...we needed a more ecological or systemic world, based on an understanding of our fundamental interconnectedness and interdependence, with each other and with all of life. (p. 430)*

Rather than relying on Newtonian science which "looked upon the physical universe as an exquisitely designed giant mechanism, obeying elegant deterministic laws of motion" (Laszlo, 1996, p. 7), systems theorists seek to "concentrate on structure on all levels of magnitude and complexity, and fit detail into its general framework. They discern relationships and situations, not atomic facts and events" (Lazlo, 1996, p. 9).

Consequently, it was shown that there was a significant difference between systems and reductionist approaches. Laszlo (1996) notes that to speak of systems is not a means to reduce entities into a general term referred to as 'systems.' The systems approach is not a simplification since (Laszlo, 1996):

> *...traditional reductionism sought to find the commonality underlying diversity in reference to a shared* ***substance****, such as material atoms, contemporary systems theory, seeks to find common features in terms of shared aspects of* ***organization****. (p. 17)*

Similarly, Capra (1997) states:

> *They [systems] arise from the 'organizing relations' of the parts - that is, from a configuration of ordered relationships that is characteristic of that particular class of organisms, or systems. Systemic properties are destroyed when a system is dissected into isolated elements. (p. 36)*

It thus appears that the premise of systems theory is related to the idea that problems we are confronting in the 21st century cannot be understood or solved in isolation. Nonetheless, the 'general systems' idea received great criticism and was labeled as a field of truisms and analogies. von Bertalanffy (1968) notes:

> *The proposal of system theory was received incredulously as fantastic or presumptuous. Either – it was argued - it was trivial because the co-called isomorphisms were merely examples of the truism that mathematics can be applied to all sorts of things, and it therefore carried no more weight than the 'discovery' that 2 + 2 = 4 holds true for apples, dollars, and galaxies alike; or it was false and misleading because superficial analogies - as in the famous simile of society as an 'organism' – camouflage actual differences and so lead to wrong and even morally objectionable conclusions. Or, again, it was philosophically and methodologically unsound because the alleged 'irreducibility' of higher levels to lower ones tended to impede analytical research whose success was obvious in various fields such as in the reduction of chemistry to physical principles, or of life phenomena to molecular biology. (p. 14)*

To suggest that systems theory was trivial and potentially harmful to already created knowledge, von Bertalanffy (1968) argued that it would be a gross misunderstanding of what systems theory stood for: "...attempting scientific interpretation and theory where previously there was none, and higher generality than that in the special sciences. General system theory responded to a secret trend in various disciplines" (von Bertalanffy, 1968, p. 14). Moreover, the examination of three different but related aspects of systems theory: systems science, systems technology, and systems philosophy, helps to further distinguish the field of general systems theory (Strijbos, 2010; von Bertalanffy, 1972).

Systems science – this is the "scientific exploration and theory of 'systems' in various sciences (e.g., physics, biology, psychology, social sciences), and general systems theory as the doctrine of principles applying to all (or defined subclasses of) systems" (von Bertalanffy, 1972, p. 414). This is the aspect of systems theory deals with knowledge of the connected 'wholes' - complexity as opposed detailed and isolated systems. Laszlo (1996) expounds on this by suggesting:

> *If this is the case, to have an adequate grasp of reality we must look at things as systems, with properties and structures of their own. Systems of various kinds can then be compared, their relationships within still larger systems defined, and a general context established. If we are to understand what we are, and what we are faced with in the social and the natural world, evolving a general theory of systems is imperative. (p. 10)*

Although this aspect of general systems theory was developed in mathematical terms emphasizing isomorphic relationships (von Bertalanffy, 1968), Hammond (2002) established that "much of his [von Bertalanffy's] writing reflects a deeper concern with the mechanistic and reductionist orientation of then current models in biology and psychology" (Hammond, 2002, p. 436). This is supported by the work of von Bertalanffy

(1972) who later stated that "classical science in its various disciplines, such as chemistry, biology, psychology, or the social sciences, tried to isolate the elements of the observed universes…We have learned, however, that for an understanding not only the elements but their interactions as well are required – say, the interplay of enzymes in a cell, the interactions of many conscious and unconscious processes in the personality, the structure and the dynamics of social systems, and so forth" (pp. 414-415).

A general systems theory has yet to emerge (Adams, 2012; Adams et al., 2014; Gaines, 1977; Monod, 1974). However, the aspects of systems theory describing isomorphic concepts, laws, principles, and theorems applicable to different systems are becoming increasingly evident (Adams et al., 2014; Clemson, 1984; Flood & Carson, 1993; Stichweh, 2011; Strijbos, 2010; von Bertalanffy, 1968; Weinberg, 1975). Since there is no one field of systems, systems theory can only provide a set of concepts, laws, principles, and theorems from different discipline to describe different system structures and their behaviors. Hence, there is bound to be different articulations of systems theory as espoused by Adams et al. (2014). Nonetheless, Stichweh (2011) suggests that systems theory:

> *…is a science which has the comparative study of systems as its object…[Furthermore]…Such comparative research program for heterogeneous types of systems presupposes a highly general concept of systems, for which numerous features have been proposed: the interdependency of the parts of a system; the reference of any structure and process in a system to the environments of the system; equilibrium and adaptedness and continuous re-adaptations to environmental demands as core elements of the understanding of a system; self-organization of a system as the principal way it responds to external intervention; complexity as trigger mechanism for system-formation and as the form which describes the internal network structures of connectedness among system elements. (p. 2579)*

Additionally, Strijbos (2010) suggests that systems theory is concerned with how "some of the concepts and insights of one discipline contribute to the problems and theories of another" (p. 453). In this instance, Strijbos' work supports the notion that systems theory is about how different theoretical perspectives can be transported from one field to another to address a wide range of issues in distinctive disciplines. This was the case in control engineering which had roots in cybernetics (Jackson, 2003; Strijbos, 2010; von Bertalanffy, 1968). It is from this perspective that this research adopts the following formal definition of systems theory (Adams et al., 2014):

> *...a unified group of specific propositions which are brought together to aid in understanding systems, thereby invoking improved explanatory power and interpretation with major implications for systems practitioners. (p. 113)*

Drawing on six major sectors and 42 individual fields of science, Adams et al., (2014,), using axiomatic methods, proposed 30 constituent propositions - inclusive of laws, principles, and theorems - as a collective of systems theory clustered around seven (7) axioms of centrality, context, design, goal, information, operational, and viability. Table 1 is drawn to indicate Adams et al.'s (2014) axioms and propositions of systems theory. Therefore, the systems science aspect of systems theory challenges researchers to use systems theory (i.e., laws, principles, and theorems) for holistically investigating and understanding systems. In this research, an expanded view of systems theory is provided in Chapter IV.

Table 1: A Cotemporary View of Systems Theory, Adapted from Adams et al., 2014

Axiom	**Associated principles and proponents**	**Description of principles**
Centrality	**Communication** (Shannon, 1948a; 1948b)	In communication, the amount of information is defined, in the simplest cases, to be measured by the logarithm of the number of available choices. Because most choices are binary, the unit of information is the *bit*, or binary digit
	Control (Checkland, 1993)	The process by means of which a whole entity retains its identity and/or performance under changing circumstances
	Emergence (Aristotle, 2002; Checkland, 1993)	Whole entities exhibit properties which are meaningful only when attributed to the whole, not its parts – e.g. the smell of ammonia. Every model of systems exhibits properties as a whole entity which derive from it component activities and their structure, but cannot be reduced to them
	Hierarchy (Pattee, 1973; Checkland, 1993)	Entities meaningfully treated a wholes are built up of smaller entities which are themselves wholes . . . and so on. In a hierarchy, emergent properties denote the levels
Context	**Complementarity** (Bohr, 1928; Mehra, 1987)	Any two different perspectives or models about a system will reveal truths about that systems are neither entirely independent nor entirely compatible
	Darkness (Ashby, 1956; Cilliers, 1998)	Each element in the system is ignorant of the behavior of the system as a whole, it responds only to information that is available to it locally. This point is vitally important. If each element 'knew' what was happening to the system as a whole, all of the complexity would have to be present in that element
	Holism (Smuts, 1926)	The whole is not something additional to the part: it is the parts in a definitive structural arrangement and with mutual activities that constitute the whole. The structure and the activities differ in character according to the stage of development of the whole; but the whole is just this specific structure of parts with their appropriate activities and functions

Table 1 (cont.)

Design	**Minimum critical specification** (Cherns, 1976; 1987)	This principle has two aspects, negative and positive. The negative aspect of the principles states that no more should be specified than is absolutely essential for design; the positive aspect of the principle requires that we identify what is essential for design
	Pareto (Pareto, 1897)	In any large complex system, eighty percent of the outputs or objectives will be produced by only twenty percent of the system means
	Requisite Parsimony (Miller, 1956; Simon, 1974; Warfield, 1995)	Human short-term brain activity (memory) is incapable of dealing or recalling more than seven plus or minus two items
	Requisite Saliency (Boulding, 1966)	The factors that will be considered in a system design are seldom of equal importance. Instead, there is an underlying logic awaiting discovery in each system design that will reveal the saliency of these factors
Goal	**Equifinality** (von Bertalanffy, 1950)	If a steady state is reached in an open system, it is independent of the initial conditions, and determined only by the system parameters (i.e. rates of reaction and transport). Hence, taking different paths, the same final state may be reached from different initial conditions
	Multifinality (Buckley, 1967)	Radically different end states are possible from the same initial conditions
	Purposive Behavior (Rosenblueth, Wiener, & Bigelow, 1943)	Purposeful behavior is meant to denote that the act or behavior may be interpreted as directed to the attainment of a goal to a final condition in which the behaving object reaches a definite correlation in time or in space with respect to another object or event
	Satisficing (Simon, 1955; 1956)	The decision-making process whereby one chooses an option that is, while perhaps not the best, good enough
	Viability (Beer, 1979)	A function of balance must be maintained along two dimensions: (1) autonomy of subsystem versus integration and (2) stability versus adaptation

Table 1 (cont.)

Information	**Redundancy of Potential Command** (McCulloch, 1965)	Effective action is achieved by an adequate concatenation of information. In other words, power resides where information resides
	Information Redundancy (Shannon & Weaver, 1949)	Errors in information transmission can be protected against, to any level of confidence required, by increasing the redundancy in the messages
Operational	**Dynamic Equilibrium** (D'Alembert, 1743)	For a system to be in a state of equilibrium, all subsystems must be in a floating (not steady or stable) state characterized by invisible movements and preparedness for change equilibrium. All subsystems being in a state of equilibrium, the system must be in equilibrium
	Homeorhesis (Waddington, 1957; 1968)	The concept encompassing dynamical systems which return to a trajectory, Even if disturbed in development. In homeorhesis, systems return to a particular path of a trajectory while in homeostasis systems which return to a particular state
	Homeostasis (Cannon, 1929)	The property of an open system to regulate its internal environment so as to maintain a stable condition, by means of multiple dynamic equilibrium adjustments controlled by interrelated regulation feedback mechanisms
	Redundancy (Pahl, Beitz, Feldhusen, & Grote, 2011)	These are the means of increasing both the safety and reliability of systems by providing superfluous or excess resources usually in form of backup or fail-safe
	Relaxation Time (Iberall, 1972; Holling, 1996)	Systems stability is possible only if the system's relation time is shorter than the mean time between disturbances
	Self-organization (Ashby, 1947)	Complex systems organize themselves; they exhibit emergence global structure and behavior out of interactions of local parts
	Sub-optimization (Hitch, 1953)	If each subsystem, regarded separately, is made to operate with maximum efficiency, the system as a whole will not operate with utmost efficiency

Table 1 (cont.)

Viability	**Circular Causality** (Foerster, Mead, & Teuber, 1953)	Any effect becomes a causative factor for future effects, influencing them in a manner particularly subtle, variable, flexible, and of an endless number of possibilities
	Feedback (Wiener, 1948)	All purposeful behavior may be considered to require negative feedback. If a goal is to be attained, some signals from the goal are necessary at some time to direct the behavior
	Recursion (Beer, 1979)	If a viable system contains a viable system, then the organizational structure must be recursive; in a recursive organizational structure, any viable system contains, and is contained in, a viable system
	Requisite Hierarchy (Aulin-Ahmavaara, 1979)	The weaker in average the regulatory abilities are and the larger the uncertainties of available regulators, the more hierarchy is needed in the organization of regulation and control to attain the same result, if at all possible
	Requisite Variety (Ashby, 1956; Flood & Carson, 1993)	The control achieved by a given regulatory sub-system over a given system is limited by : 1) the variety of the regulator and 2) the channel capacity between the regulator and the system

These propositions not only provide means to bridge the isolation problem between disciplines, they provide ability to think and intervene in different systems (Adams et al., 2014; Jackson, 2003), which is in accord with the bylaws of the *International Society for the Systems Sciences*. Furthermore, Adams et al. (2014) suggest that the seven axioms of systems theory form a basic construct for defining any system. A construct in this case is a set of related concepts forming a building block enabling understanding of situations (Bunge, 1974; Krippendorff, 1986; Linsky, 2012). Since a system can be defined as "a set of interrelated components working together toward some common objective or purpose" (Blanchard & Fabrycky, 2006, p. 2), the proposed set of axioms and their constituent laws, principles, and theorems might be used to describe and understand systems.

Systems Technology – this is the aspect of systems theory that deals with "problems arising in modern technology and society, including both 'hardware' (control technology, automation, computerization, etc.) and 'software' (application of systems concepts and theory in social, ecological, economical, etc., problems)" (von Bertalanffy, 1972, p. 420). As the need for the science of 'systems' became increasingly apparent, there was also a need to address emerging world issues related to pollution, economies, health, politics, and international conflicts (Strijbos, 2010; von Bertalanffy, 1972; Warfield, 1976). The argument is that the current state of affairs characterized by increasing levels of ambiguity, complexity, emergence, interdependence, and uncertainty require a holistic (systems) and interdisciplinary approach that complements reductionism of classical sciences (Hammond, 2002; von Bertalanffy, 1972). Systems analysis (Atthill, 1975; Digby, 1989; Gibson et al. 2007), systems engineering (Blanchard

& Fabrycky, 2006; INCOSE, 2011), operational research (Churchman, Ackoff & Arnoff, 1957), systems dynamics (Forrester, 1961; Sterman, 2000), organizational cybernetics (Beer, 1979; 1981; 1985), strategic assumption surfacing and testing (Mason & Mitroff, 1981; Mitroff & Emshoff, 1979), interactive planning (Ackoff, 1974; 1981a; 1981b; 1999), soft systems methodology (Checkland, 1990; Wilson, 1984), systems of systems engineering methodology (Adams & Keating 2009, 2011; Keating et al., 2004), critical systems heuristics (Ulrich, 1983; 1987), organizational learning (Argyris & Schön, 1978; 1996), sociotechnical systems (Trist & Bamforth, 1951; Cherns, 1976), and total systems intervention (Flood, 1995; Flood & Jackson, 1991; Jackson, 1991) are examples of the holistic approaches necessary to address current vexing issues from a systems theory perspective. Usually selected on the basis of context of problematic situation and purpose of analysis (Crownover, 2005; Jackson, 2003), these methodological approaches were first used to gain knowledge and intervene in behaviors of complex systems at the beginning of the 20^{th} century.

Consequently, the systems technology element of systems theory is concerned with developing and applying unique sets of systemic approaches to enable understanding, problem solving, and bring about positive change in society (Hieronymi, 2013). These approaches are uniquely distinct in comparison to the scientific approach in that rather than being piecemeal, they are holistic since they embrace the tenets of systems thinking. Figure 8 is drawn to depict the mutual influence of four developmental cycles associated with systems approaches.

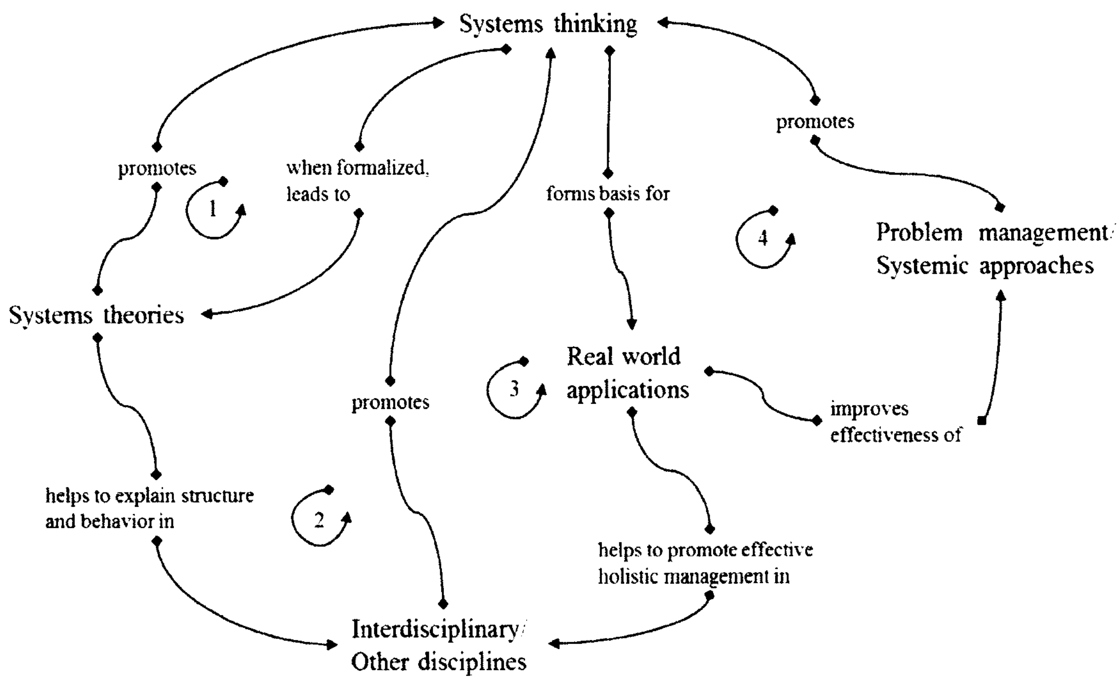


Figure 8: Developmental cycles of systems science, adapted from Flood & Carson, 1993, p. 4

Systems philosophy – a third element of systems theory is systems philosophy and deals with philosophical issues related to paradigm change within which systems theory supposedly operates. Three elements epitomize this aspect of systems theory. First is *systems ontology*, which deals with how an observer views reality. Two opposing extremes of realism and nominalism exist along ontological aspect of reality (Flood & Carson, 1993; Burrell & Morgan, 1979; Katina et al., 2014a). The realism view of the world suggest that reality is "external to the individual imposing itself on individual consciousness; it is a given 'out there,' and is of an objective nature" while reality, [under nominalism], "is a product of individual consciousness, a product of one's own mind or of individual cognition" (Flood & Carson, 1993, p. 247). While there is certainly a spectrum along the continuum between nominalism and realism, the polarizing nature of this distinction provides for different views of reality and the corresponding acceptability of different worldviews for systems.

The second element of systems philosophy is *systems epistemology*. It deals with how we obtain and communicate of knowledge (Burrell & Morgan, 1979; Flood & Carson, 1993; Katina et al., 2014a). Two opposing extremes of the spectrum of epistemological thought are positivism (i.e., knowledge is hard, real, and capable of being transmitted in a tangible form) and anti-positivism (i.e., knowledge is soft, more subjective, spiritual, or even transcendental – based on experience, insight, and essentially of a persona nature) (Flood & Carson, 1993). Again, there is certainly a spectrum between these diametrically opposed philosophical perspectives concerning epistemology. However, differences in epistemological orientation help to define the 'appropriate' underlying perspective of philosophical orientation for systems theory.

The third aspect of systems philosophy has to do with the *nature of man* (Burrell & Morgan, 1979; Flood & Carson, 1993; Katina et al., 2014a). von Bertalanffy noted that "If reality is a hierarchy of organized wholes, the image of man will be different from what is in a world of physical particles…Rather, the world of values…is something very 'real'" (von Bertalanffy, 1972, p. 423). The two opposing extremes of *determinism* and *voluntarism* exist along continuum of systems philosophy with respect to the viewpoint for the nature of man in systems theory. Determinism describes the view that humans are mechanistic, determined by situations in the external world; human beings and their experiences are products of their environment; they are conditioned by external circumstance (Flood & Carson, 1993). On the other hand, voluntarism suggests that humans have a creative role and have free will; human beings create their environment (Flood & Carson, 1993).

Flood and Carson (1993) have argued that since the scientific approach embraces elements of reductionism, setting hypotheses, designs in artificial situations, a limited number of variables, experimentation, and with knowledge accruement, the approach is ontology-realist, epistemology-positivist and is largely influenced by a high degree of determinism regarding nature of humans. Conversely, systems theory at the philosophical level promotes ontology-nominalist, epistemology-anti-positivist and is concerned with 'systems' as they are influenced by human values (Burrell & Morgan, 1979; Flood & Carson, 1993; von Bertalanffy, 1972).

Therefore, while it appears that systems theory is mostly interested in developing systems laws, principles, and theorems that govern complex systems, there is also emphasis on holistic thinking supported by ontology, epistemology, and consideration of nature of man and his values. Arguably, it is from this need to understand the totality of systems that the ideas of complex systems and systems of systems have emerged.

2.1.2 Complex Systems

Firstly, it is important to note that complexity, as noted by Gharajedaghi (1999) and Kovacic, Sousa-Poza, & Keating (2007), is a feature related to human perception and understanding. This is especially the case when an analyst might desire to move a complex system from one state to another with the goal of meeting needs of members of the system in question. In this regard, the perception, understanding, and actions of the analyst are influenced by complexity (Gharajedaghi, 1999). Previously, Blanchard and Fabrycky (2006) suggested that a system is a set of interacting components having well-defined purpose. However, Moses (2002) suggests that the purpose of the system might be poorly understood based on the behavior of the system. This begins to point to complexity in systems such that the composed interconnected parts as a whole exhibit one or more behaviors not obvious from the well-understood properties of the individual parts (Joslyn & Rocha, 2000). Table 2 is drawn from discovery of the multitude of perspectives that permeates complex systems. While this listing is not presented as complete, it demonstrated the diversity in perspectives concerning the nature, role, and utility for complexity.

Table 2: Varying Perspectives on Complexity

Authors	**Complexity perspective**	**Implications for understanding**
Sussman, 2005	A system is complex when it is composed of a group of *related units* (subsystems), for which the degree and nature of the relationships is *imperfectly known*	It is difficult to predict overall emergent behavior even if the behaviors of subsystems are predictable. Thus, small changes may produce large changes in behavior
Rechtin & Maier, 2002	A *complex system* has a set of different elements so connected or related as to perform a *unique function* not performable by the elements alone	To address problems in such systems, a different logic of problem-solving technique is requires at different level of abstraction
Coveney & Highfield, 1996	*Scientific complexity* is related to the behavior of macroscopic collections of units given the *capability* to potentially *evolve* over time	An inherent behavior of complex units as opposed to a – for example - complexity of a mathematical operations (i.e., number of mathematical operations needed to solve a problem)
Levy, 2000	*Complexity theory* along with chaos theory attempt to accommodate the unpredictability nature of non-linear dynamic systems with a sense of underlying order and structure	There is a good chance for short-term predictability. However, long-term planning is impossible due to occurrence of unexpected changes occur. Must be innovative and adaptive
Brewer & Gheorghe, 2011	*Forensic complexity* is "a multidisciplinary approach to the study of comprehension in *complex situations* in order to enable justifiable action" (Brewer & Gheorghe, 2011, p. 351)	Comprehensibility and understanding are key to reducing complexity. Reality and its representations cannot be separated to the entity seeking understanding or knowledge

Gharajedaghi's (1999) organized simplicity, chaotic simplicity, organized complexity, and chaotic complexity is complemented by MacLennan's (2007) complex adaptive systems and Khalil's (2001) nonlinear systems. Consequently, Guckenheimer and Ottino's (2008) four distinctive properties of complex systems (Table 3) provide further clarification of complex system landscape suggesting that the analyst should be interested in 'wholes' rather than parts. It is these characterises that form the basis for 'systems' approaches in dealing with the issues facing modern society.

Table 3: Characteristics of Complex Systems

Characteristic of complex systems	**Description of characteristic**
Many interacting parts	Internal structure of complex systems consists of many interacting components forming a network of subsystems over time and space. Subsystems could be complex in their own right
Emergent behavior	Complex systems exhibit emergent system behavior that arise from the interaction of subsystems (these could themselves be complex) but is not evident from analysis of individual subsystems
Adaptation and change	Complex systems can change their behavior based on environmental changes to continue providing for their functionality
Systems uncertainty	Complex systems exhibit the state of being unfixed, unknown, and undetermined such that they are best described as non-ergodic (not returning to a previous state) and non-monotonic (varying trajectory) conditions

2.1.3 Systems of Systems

An emerging subset of complex systems and therefore an area of interest for systems theory is systems of systems (SoS) and its problem landscape (Barot et al., 2012; DeLaurentis & Callaway, 2004; Eusgeld, Nan, and Dietz, 2011; Keating, et al. 2003b; Keating & Katina, 2011; 2012; USAF SAB, 2005). In addition to exhibiting the general characteristics of complex systems, SoS exhibit special characteristics of operational independence, managerial independence, evolutionary development, emergent behavior, and geographical distribution (Keating et al., 2003b; Maier, 1996). Table 4 is drawn to depict characteristics of systems of systems.

Table 4: Characteristics of Systems of Systems

SoS characteristic	Description of characteristic
Operational independence of systems	Disaggregating systems of systems into constituent systems does not render the constituent system inoperable. Rather, each constituent system has the ability to operate independently since constituent systems are also complex within their own rights (Maier, 1996)
Managerial independence of systems	The constituent systems comprising a systems of systems can be separately acquired and are independently managed (Maier, 1996)
Evolutionary development	Systems of systems evolve over time. Consequently, component systems capabilities may be added, removed, or modified as needs change and experience is gained (Maier, 1996)
Emergent behaviour	Systems of systems have emergent capabilities and properties that do not reside in the component systems (Maier, 1996). Consequently, managing such systems requires holistic thinking
Geographical distribution of systems	Systems of systems are comprised of constituent complex systems geographically distributed with the ability to readily exchange information (Maier, 1996). Consequently, managing such systems requires understanding the whole

The nature of systems of systems (Keating & Katina, 2011; 2012; Keating et al. 2003b) provides for articulation of the following attributes persistent in the domain (Keating & Katina, 2011):

1. proliferation of information intensive systems and technologies that have not necessarily been developed for the integrated SoS missions they are being conscripted to perform
2. multiple stakeholders with potentially incompatible worldviews and divergent objectives, often politically driven
3. scarce and dynamically shifting resources that create a source of uncertainty and potential instabilities in mission support
4. constantly shifting conditions and emergent understanding of problems and context that make stable requirements life cycle driven approaches unrealistic
5. technology advancements that outpace the capabilities, and potential compatibility, of infrastructures necessary to support their development, integration, maintenance, and evolution
6. urgency in demands for responsive action and solution development to alleviate mission shortfalls
7. the abdication of long term thinking in response to immediate perceived operational needs – rendering traditional forms of long range planning virtually innocuous

8. increasing complexities and uncertainties that bring to question the ability of traditional systematic approaches, based in assumptions of stability, to effectively deal with SoS problems. (pp. 235-236)

Clearly, the systems of systems problem landscape must emphasize holistic approaches. This is further amplified by Sousa-Poza, Kovacic, and Keating (2008) research on seven (7) characteristics of SoS problem domain. Table 5 is drawn to depict the characteristics of SoS problem landscape.

Table 5: SoS Problem Landscape

SoS problem domain space	**Domain characteristic description**
Holistic problem space	The nature of the systems of systems problem space requires consideration of the technical, human/social, managerial, organizational, policy, and political dimensions (Sousa-Poza et al., 2008)
Ambiguity	The difficulty in clearly demarking problem boundaries, as well as their interpretation, is an inherent characteristic of the systems of systems problem domain (Sousa-Poza et al., 2008)
Uncertainty	Systems of systems problems are not tightly bound, flexing as additional knowledge of the situation is developed (Sousa-Poza et al., 2008)
Highly contextual	Consideration of circumstances, conditions, factors, and patterns that give meaning and purposes to systems of systems (Sousa-Poza et al., 2008)
Emergence	Systems of systems behavioural and structural patterns, their interpretations, knowledge, understanding and conditions are in constant flux (Sousa-Poza et al., 2008)
Non-ergodicity	Systems of systems exhibit phenomenological conditions of having no defined states or discernible transitions between states (Sousa-Poza et al., 2008)
Non-monotonicity	Systems of systems exhibit the condition in which increases in knowledge are not reciprocated by increases in understanding. Under this condition, decisions are defeasible or tentative (Sousa-Poza et al., 2008)

Ideally, the integration of complex autonomous systems, their resources, and capabilities should enable new functionality, performance, and missions that exceed functions, performance, or mission of the constituent systems (Adams & Meyers, 2011, USAF SAB, 2005). This idea is consistent with 'systems' approaches where the concern is at the system level rather than the parts – constituent systems.

The concepts of complex systems and systems of systems are purposefully selected to illustrate three key issues for this research:

First, the study of the properties of complex systems and systems of systems suggest that the need to understand the multitude of factors that influence decision-making in terms of systems. The decisions of actors in such systems are influenced by "political, cultural, ethical and similar factors…[that make] it difficult for the problem solver to fully understand the 'rationale' behind decisions made by actors in the systems" (Jackson & Keys, 1984, p. 476).

Second, to intervene and bring about change in real-world systems, it is necessary to understand nature of systems in which systems theory is intended for application. This provides a starting point for understanding – a fundamental element of complex systems relevant to systems theory (Kovacic et al., 2007):

> *a situation in which, for any number of reasons, the level of understanding that an observer(s) has of the situation is extremely low at any point in time, and knowledge claims are bound to have a high probability of being erroneous. (p. 58)*

In such a case, it becomes necessary to include the observer, the system being observed system, and their interactions within analysis efforts. This is especially necessary since "the activity of observing [done by an analyst]…has some influence on the observed system [system under study]" (Clemson, 1984, p. 21). In support of this concept, Flood and Carson (1993) posit: "The nature of perceived reality is inevitably conditioned by our nature as observing systems" (p. 35). Therefore, understanding complexity using a 'systems' approach significantly differs from a deductive problem solving approach in terms of irreducibility, transiency, and perception (Padilla, Sousa-Posa, Tejada, & Kovacic, 2007). Table 6 is drawn from discovery of the multitude of distinguishing between complex and linear systems (Jackson, 1991; Perrow, 1972; 1999; Schoderbek, Schoderbek, & Kefalas, 1985).

Table 6: Differentiating Linear and Complex Systems

Linear (non-complex) Systems	**Complex Systems**
Equipment spread out	Tight spacing of equipment
Segregated production steps	Proximate productive steps
Common-mode connections limited to power supply and the environment	Many common-mode connections of the components not in production sequence
Failed components are easily isolated	Limited isolation of failed components
Specializations increases understanding of elements	Specialization of personnel limits awareness of systems interdependencies
Extensive substitution of supplies and materials	Limited substitutions of supplies and materials
Few unfamiliar or unintended feedback loops	Unfamiliar or unintended feedback loops
Control parameters are few, direct, and segregated	Many control parameters with potential interactions
Direct, online information sources	Indirect or inferential information sources
Extensive understanding of all processes (i.e., step-by-step processes)	Limited understanding of processes (i.e., transformational in nature)

Unlike the traditional view of the world, complex and systems of systems must be addressed at a different logical level. We must account for irreducibility of systems, transient nature of knowledge about such systems, and inclusion of people's perception of reality.

Third, systems theory provides a conceptual foundation for dealing with, intervening and bringing about change in real-world complex systems and systems of systems at the holistic perspective (Adams et al. 2014; Flood & Carson, 1993; Jackson, 1991; 2003; Warfield, 1976). It provides the underlying theoretical foundation for dealing with entities as 'systems,' and therefore must be used to support systems ideas including understanding of structures, behaviors, and relationships. Moreover, systems theory can be used as a means to intervene with the objective of bringing about desirable output (i.e., enhanced capability) beyond those of individual systems. Interestingly, there is no shortage of systems-based methodological approaches supporting complex system understanding, intervention, and bringing about change in 21st century systems. Systems-based methodologies are the subject of the following section.

2.1.4 Systems-Based Approaches

The problem space associated with complex systems and systems of systems evokes ideas postulated in systems theory were the emphasis is placed on understanding the whole in terms of structure and behavior of the system rather than parts (Laszlo, 1996; Hammond, 2002; Flood & Carson, 1993; Jackson, 1991; 2003; von Bertalanffy, 1968). Consequently, system practitioners and theorists have developed methodologies that can be used to understand complex systems structure and behaviors.

It is generally agreed that there is a need for robust methodologies capable of holistically and systemically analyzing behaviors of systems under the current conditions within which they must function. These conditions are marked by high levels of ambiguity, complexity, emergence, interdependence, and uncertainty (Conrad & Gheorghe, 2011; Jackson, 1991, 2003; Keating, 2014; Keating et al., 2014). In such cases, a methodology includes theoretical underpinnings and is used to "refer to methods for exploring and gaining knowledge about systems" (Jackson, 1991, p. 3). Consistent with Checkland's (1993) perspective on a methodology, Jackson (1991) suggests that a methodology is:

> *...procedures for gaining knowledge about systems and structured processes involved in intervening in and changing systems. (p. 134)*

Hence, methodologies might be used to investigate and obtain knowledge about our 21st century world systems. Furthermore, it is important to establish that methodological approaches might be categorized into two opposing extremes of idiographic and nomothetic based on Burrell and Morgan (1979) and amplifications as suggested by Flood and Carson (1993). An idiographic view of a methodology supports subjectivity in research of complex systems as suggested by Flood and Carson (1993):

> *...the principal concern is to understand the way an individual creates, modifies, and interprets the world. The experiences are seen as unique and particular to the individual rather than general and universal. An external reality is questioned. An emphasis is placed on the relativistic nature of the world to such an extent that it may be perceived as not amenable to study using the ground rules of the natural sciences. Understanding can be obtained only by acquiring firsthand knowledge of the subject under investigation. (p. 248)*

The opposing view of methodology – nomothetic - supports the traditional scientific method and its reductionist approach to addressing problematic issues (Churchman, 1968; 1971). This suggests that a nomothetic view of methodology (Flood & Carson, 1993) subscribes to:

> *...analyze relationships and regularities between the elements of which the world is composed...identification of the elements and the way relationships can be expressed. The methodological issues are concepts themselves, their measurement, and identification of underlying themes. In essence, there is search for universal laws that govern the reality that is being observed. Methodologies are based on systematic process and technique. (pp. 247-248)*

It would thus appear that systems-based methodologies are idiographic in nature since they adhere to the notions put forward by Flood and Carson (1993). This is supported by systems theory ideas of complementarity (Bohr, 1928; Mehra, 1987) and complexity (Gharajedaghi, 1999; Sousa-Poza et al., 2008) in understanding and bringing about change in complex systems and systems of systems. Furthermore, review of systems literature indicates that there is no shortage of systems-based methodologies that might be used to gain knowledge and intervene in behaviors of systems. Table 7 is drawn from systems literature suggesting two major categories of systems-based methodologies. A hard systems approach, according to Jackson (1991):

> *...assume that problems are set in mechanical-unitary contexts. Hard methodologies take it as a given that it is relatively easy to establish clear objectives for the system in which the problem resides – so context must be unitary. They then try to represent that system in a quantitative model that simulates its performance under different operational conditions – something only possible if the system is simple and the context mechanical. (p. 30)*

Exemplars of hard systems approaches include systems analysis, systems engineering and operations research (Checkland, 1978; Jackson, 1991; 2000). These methodologies share "the assumption that the problem task they tackle is to select an efficient means of achieving a known and defined end" (Checkland, 1978, p. 73).

However, since "it is often difficult to define precise objectives on which all stakeholders can agree" especially in complex systems (Jackson, 2003, p. 20), soft systems thinking approaches emerged to accommodate multiple and sometimes conflicting values, beliefs, and worldviews that are prevalent in complex systems. To support a needed change, "the solution was to make subjectivity central, working with a variety of world views during the methodological process" (Jackson, 2003, p. 22). This is the logic that underlies the second category of systems-based approaches. While the aim of a 'hard' systems approach is to optimize the system based on a known goal, the 'soft' systems approaches recognize that (Jackson, 2003):

> *...the vast numbers of relevant variables and the myriads of interactions make this [optimization] an impossible requirement. The solution...[is] to identify those key mechanisms or structures that govern the behavior of the elements or subsystems...aspects that lie behind system viability and performance. (p. 21)*

In the exemplars of 'soft' systems approaches, we can add systems of systems engineering methodology insofar as it embraces systems ideas (Adams & Keating, 2011) and yet rejects the idea of optimization (Hester, 2012).

Table 7: System-based Methodologies and Classification

Classification	**Systems-based Methodology**	**Primary Proponents**
Hard Systems Thinking	Systems Analysis	Atthill (1975); Digby (1989); Gibson et al. (2007)
	Systems Engineering	INCOSE (2011); Blanchard & Fabrycky (2006)
	Operational Research	Churchman, Ackoff & Arnoff (1957)
Soft Systems Thinking	Systems Dynamics	Forrester (1961); Sterman (2000)
	Organizational Cybernetics	Beer (1979; 1981; 1985)
	Strategic Assumption Surfacing and Testing	Mitroff & Emshoff (1979); Mason & Mitroff (1981)
	Interactive Planning	Ackoff (1974; 1981a; 1981b; 1999)
	Soft Systems Methodology	Checkland (2000); Wilson (1984)
	Systems of Systems Engineering Methodology	Adams & Keating (2009; 2011); Keating et al., (2004)
	Critical Systems Heuristics	Ulrich (1983; 1987)
	Organizational Learning	Argyris & Schön (1978; 1996)
	Sociotechnical Systems	Trist & Bamforth (1951); Cherns (1976)
	Total systems Intervention	Flood & Jackson (1991); Flood (1995); Jackson (1991)

According to Jackson (2003) a methodology is source of "guidance given to practitioners about how to translate [systems] philosophy and [systems] theory of an approach into practical application" (p. 51). With this in mind, it would thus appear that systems theory might be used confront "problems confronting humanity at this stage in our history (poverty, violence, crime, environmental degradation and nuclear weapons…terrorism) [since these problems] are systemic and cannot be understood or resolved in isolation" (Hammond, 2002, p. 430). Moreover, since such problems do not occur in isolation, systems-based methodologies could be used since they embrace ideas such as participatory decision-making processes, self-organization, free will, creativity, and holism - concepts synonymous with systems theory - to address the interdisciplinary and multidisciplinary nature of world issues (Strijbos, 2010; von Bertalanffy, 1972; Warfield, 1976).

Ultimately, learning and bringing about positive change are the hallmarks of any methodological approach. Clearly, the nature of human beings, as well as the nature of systems and their environment make it difficult to select an efficient means to achieve a known objective and a defined end (Jackson 2000; 2003). In fact, Warfield (1976) notes that for centuries, man has faced highly intensified and interlocked shortages in basic necessities (e.g., energy, food, knowledge) and yet experiences excesses in pollution, crime, and war. In the words of Warfield:

> *It is only within the last two hundred years and in a sense almost within this generation that man has become widely conscious of his own societies and of the larger sociosphere of which they are a part. (as cited in François, 2002, p. 89)*

It becomes obvious that a methodology must be multifaceted and should enable exploration, promotion of diversity, ensure fairness, and contribute to understanding, and increase performance and viability of systems in a holistic manner (Jackson, 2003; Laszlo

& Krippner, 1998; Ryan, 2008). In this case, a systems-based methodology must support "grappling with complexity [and] has to be a methodology for human learning" (Warfield, 1976, p. 2). Table 8 is drawn from various literatures of systems-based methodologies suggesting areas of applicability and specific phases of the methodologies. A key unifying theme among these approaches is problem formulation – an area of interest for this research. The role of problem formulation and its implications in systems-based methodologies in complex system governance are the basis of the following section.

Table 8: Overview Description of Systems-based Methodologies

Systems-based methodology	**Description and Phases of the Methodology**
Systems Analysis	Attributed to Research ANd Development Corporation (RAND) and used extensively in the US military, this methodology emerged out of Operations Research after the Second World War (Jackson, 2003). Intrinsically related to systems engineering and mechanistic in nature, this methodology is largely dependent on feedback loops and black boxes of cybernetic management to optimize socio-technical systems based on fixed parameters such as cost and benefits (Atthill, 1975; Checkland, 1993; Digby, 1989; Ryan, 2008). Miser & Quade (1988a) suggest that this methodology has three (3) stages. Gibson et al. (2006) expands these stages into six (6) phases: • Determine goals of the system • Establish criteria for ranking alternative candidates • Develop alternative solutions • Rank alternative candidates • Iteration • Taking action to improve the system
Systems Engineering	Traced to Bell Telephone Laboratories in the 1940s, Systems Engineering is interdisciplinary field of engineering and a methodology for enabling realization of successful systems out of many interacting systems (INCOSE, 2011; Schlager, 1956). It focusses on defining technical and business customer needs with the goal of producing quality products that meet user needs (INCOSE, 2011). A generic life-cycle model associated with this approach includes five (5) high level stages (Blanchard & Fabrycky, 2006): • Need identification (conceptual design) • Preliminary design • Detail design and system development • Production/construction of system components • Operational use and system support

Table 8 (cont.)

Operations Research	Initially developed in the United Kingdom prior to and during World War II, operational research is defined as "the application of the methods of science to complex problems arising in the direction and management of large systems of men, machines, materials and money in industry, business, government and defense. The distinctive approach is to develop a scientific model of the system, incorporating measurements of factors such as chance and risk, with which to predict and compare the outcomes of alternative decisions, strategies or controls. The purpose is to help management determine its policy and actions scientifically" (Jackson, 2000, p. 128) by the British Operational Research Society. Commonly associated with determining a maximum or minimum variable (e.g., profit, performance, yield, loss, risk) inventory, allocating, waiting-time, replacement, competitive, and combined processes, operations research was developed to deal with complex organizations that are under control of management (Churchman et al., 1957; Jackson, 2000). A generic model associated with this approach includes six (6) high level phases (Churchman et al., 1957; Jackson, 2000): • Formulating the problem • Construction of a mathematical model representing a system under study • Deriving a solution from the developed model • Testing the model and the derived solution • Establishing controls over the solution • Implementation of the solution to real system problem
Systems Dynamics	Developed by Jay Wright Forrester at Massachusetts Institute of Technology, this methodology is concerned with limits of growth and understanding of the system structure using feedback loops as the main determinants of system behavior (Forrester, 1961; Senge, 1990; Sterman, 2000). Four major variables associated with this methodology include (1) system boundary, (2) network of feedback loops, (3) variables of 'rates' or 'flows' and 'levels' or 'stocks' and (4) leverage points. Mathematical in nature, this methodology is comprised of five (5) phases (Maani & Cavana, 2000): • Problem structuring • Causal loop modeling • System dynamic modeling • Scenario planning and modeling • Implementation and organizational learning

Table 8 (cont.)

Organizational Cybernetics	Developed by Stafford Beer, this cybernetic methodology embodies the idea that organizations are black boxes characterized by complexity, self-regulation and probabilistic behaviors (Jackson, 2003). Using the human body as the most complex known viable system, Beer set out to create a model that can be used to explore complex system behavior without breaking it into parts (Espejo & Reyes, 2011). The output was the Viable System Model (VSM) which is based on neurocybernetic model consisting of five (5) essential subsystems that are aligned with major viable organizational functions: • System 1 - elements concerned with performing the key transformations of the organization • System 2 - information channels that enable System 1 elements to communicate between each other and allow System 3 to monitor and co-ordinate System 1 activities • System 3 - consists of structures and control mechanisms that establish rules, resources, rights, and responsibilities for System 1 and provides an interface with Systems 4 and 5 • System 4 - elements which look outward to the environment for issues that might affect the viability of the organization • System 5 - creates policy decisions within the organization as a whole to balance demands from different organizations and provides direction for the organization as a whole (Beer, 1979; 1981; 1985). It is important to note that the VSM is more "a model rather than a methodology and can be used for purposes other than those prescribed by Beer" (Jackson, 2003, p. 88). Being a model, it does not have a clear set of prescribed phases for deployment. Nonetheless, Jackson (2003) suggests two (2) general stages: • System identification – arriving at an identity for the system and working out appropriate levels of recursion • System diagnosis – reflecting on the cybernetic principles that should be obeyed at each level of recursion (Jackson, 1991)

Table 8 (cont.)

Strategic Assumption Surfacing and Testing	Attributed to Ian Mitroff and Richard Mason, this methodology is concerned with policy and planning aimed at organized complexity of 'wicked problems' which are characterized by interconnectedness, complicatedness, uncertainty, ambiguity, conflict, and societal constraints (Mason & Mitroff, 1981). The methodology is based on the premise that formulation of right solutions to the right problem requires uncovering critical assumptions underlying policy, plan, and strategy. This enables management to compare and contrast and gain new insights on their assumptions and 'wicked' problems (Mitroff & Emshoff, 1979). There are five (5) phases associated with this methodology (Mason & Mitroff, 1981; Mitroff & Emshoff, 1979): • Group formation • Assumption surfacing and rating (regarding the problem) • Dialectic phase • Assumption integration phase • Composite strategy creation
Interactive Planning	Developed by Russell L. Ackoff, this methodology focuses on creating a desired future by designing desirable present conditions. It is made up two parts: *idealization* and *realization*. These parts are divisible into six interrelated phases (Ackoff, 1974; 1981a; 1981b; 1999): • Formulating the mess • Ends planning • Means planning • Resource planning • Design of implementation • Design of controls

Table 8 (cont.)

Soft Systems Methodology	Attributed to Peter Checkland and his colleges at Lancaster University, this methodology emerged as a response to need for methods that can be used to intervene in 'ill-structured' problem situations where it is important to learn about systems while still focusing on 'goal-seeking' endeavors that answer 'what' should be done and 'how' it should be done (Jackson, 2003). Checkland's (1990) work suggested that understanding issues such as context, largely ignored in systems engineering provided a more rigorous attempt to tackle problematic situations coherently. This methodology is comprised of seven (7) stages (Checkland, 1990; Checkland & Poulter, 2006; Wilson, 1984): • Situation considered problematical • Problem situation expressed • Root definitions of relevant purposeful activity systems • Conceptual models of relevant systems named in the root definitions • Comparison of models and the real world situation • Define changes that are desirable and feasible • Take actions to improve the problem situation

Table 8 (cont.)

Systems of Systems Engineering Methodology	Attributed to researchers at the National Centers for Systems of Systems Engineering (see Adams & Keating, 2009; 2011; Keating et al., 2004), this methodology is intended to provide a high-level analytical structure to explore complex system problems (Adams & Keating, 2011). In order to enhance our understanding of complex systems, SoSEM is taken as a "rigorous engineering analysis that invests heavily in the understanding and framing of the problem under study" (Adams & Keating, 2011, p. 113). In DeLaurentis, Sindiy, and Stein (2006) research, a three-phase approach (i.e., defining SoS problem, abstracting the system, modeling and analyzing the system for behavioral patterns) is suggested. In Adams and Keating (2009; 2011) and Keating et al. (2005), a seven (7) stage process which consists of twenty three (23) constituent elements is suggested: • Framing the system under study • Designing the unique methodology • Designing the SoSE team • SoSE exploration and analysis • Transforming the analysis into action • Reporting the results of SoSE study • Assessing the impact of the SoSE study
Critical System Heuristics	Developed by Werner Ulrich, this methodology is concerned with 'unfairness in society' (Jackson, 2003). It promotes emancipatory systems thinking for planners and citizens alike. Synonymous with this methodology are three phases (Ulrich, 1983; 1987): • Identify system of interest in terms of time, space, and human intentionality (i.e., system purposefulness) • Reveal human understanding of the whole using 'system', 'moral' and 'guarantor' concepts • Make system transparent to system designers and stakeholders using twelve (12) boundary questions. The methodology uses a four level of categorization of stakeholders - clients, decision-makers, designers, and witnesses

Table 8 (cont.)

Organizational Learning	Developed by Chris Argyris and Donald Schön, this methodology is concerned with single-loop and double-loop learning where management of organization is able to contrast 'expected outcomes' with the 'obtained outcomes.' Contrasting these outcomes involves learning based on errors discovered during single-loop learning and provides the basis for modifying organizational norms, policies, and objectives (Fiol & Lyles, 1985). A key premise of this methodology is that learning and adapting new knowledge must be generated at the individual as well as at organizational level (Argyris & Schön, 1978; 1996; Argyris, 1985). This is done through (Argyris & Schön, 1996): • Shared ideas regarding problem system • Shared understanding of possible actions • Developing a common meaning of problem system including solutions
Sociotechnical Systems	Attributed to Eric Trist, Ken Bamforth and Fred Emery and their work at the Tavistock Institute in London, this methodology is concerned with a joint optimization of both social/soft including human and technical aspects of organizations (Pasmore, 1988). This methodology involves seven (7) phases, or nine (9) major steps as postulated by Pasmore (1988) for redesigning of sociotechnical systems (Taylor & Felten, 1993): • Discovery (recognizing a need for change) • Open system scan • Technical system analysis • Social system analysis • Joint optimization designing • Provisional design • Implementation

Table 8 (cont.)

Total Systems Intervention	Developed in the early 1990s by Robert Flood and Michael Jackson, this meta-methodology emerged out of the recognition of strengths of capabilities of individual systems approaches, the need for pluralism in systems thinning, and calls for emancipatory ideas in systems thinking – in reference to critical systems thinking (Jackson, 2003). This methodology is based on the premise that contemporary systems-base methodologies are not complementary. Laszlo and Krippner (1998) thus suggested that a successful complex organizational intervention might require a 'combination' of any set of systems-based approaches. This methodology is underpinned by principles of complex situations and consists of three (3) phases (Flood & Jackson, 1991; Flood, 1995; Jackson (1991): • Creativity - highlighting dominant concerns, issues, and problems in a problem context • Choice - selection of suitable systemic strategy • Implementation - employing the selected systems methodology to impose change on reality

2.1.5 Problem Formulation

A key fundamental activity of systems-based methodological approaches is formulation of problems in the system of interest. This phase provides a portal into complex system understanding and is instrumental to the eventual development of solutions that might bring about positive change (Dery, 1984; Lynn, 1980; Warfield, 1976).

There are differing terminologies associated with the phase of problem formulation. Descriptors such as *formulating the mess* (Ackoff, 1974; 1978; Majone & Quade, 1980; Mason & Mitroff, 1981; Mitroff & Emshoff, 1979), *problem articulation* (Wellington, 1887), *problem bounding* (Checkland, 1993), *problem context* (Crownover, 2005; Jackson, 1991; 2003), *problem definition* (Dery, 1984; Blanchard & Fabrycky, 2006; Gibson et al., 2007; Warfield, 1976), *problem framing* (Adams & Meyers, 2011; Fairhurst & Sarr, 1996; Keating et al., 2003a), *problem identification* (Majone & Quade, 1980), *problem setting* (Majone & Quade, 1980; Miser & Quade, 1988a), and *problem situation* (Miser & Quade, 1988b) reflect different ways to which problem formulation has been described.

Regardless of different descriptors, there is wide acknowledgement of the importance of problem formulation - ranging from ideas of defining problems to developing effective solutions. First, this phase is intrinsically linked to how human beings view the world. Quade's (1980) work suggests that a major element of problem formulation relates to being "dissatisfied with current or projected state of affairs" (Quade, 1980, p. 23). To enable successful succeeding steps, the analyst must attempt to bring as much clarity as possible to the situation under study (Warfield, 1976). Such efforts, according to Quade (1980) involve "identify[ing] the problem to be studied and define its scope in such a way that he has some hope of finding an acceptable and implementable solution within the economic, political, technological, and other constraints that exist, including the limitations imposed by the policy maker's span of control and the time available for decision" (p. 23). Consequently, how the analyst views the situation has a major impact on problem formulation.

Additionally, problem formulation is not simply "a descriptive definition [of situations], for it does not merely describe but also chooses certain aspects of reality as being relevant for action in order achieve certain goals" (Dery, 1984, p. 35). As supported by Vennix's (1996) work that suggests "people [may] hold different views on (a) whether there is a problem, and if they agree there is, (b) what the problem is" (Vennix, 1996, p. 13) and the fact that problems "arise from a problem area or nexus of problems rather than a well-define problem" (Quade & Miser, 1985, p. 17) coupled with Dery's (1984) supposition that "problems are not objective entities in their own right" (Dery, 1984, p. 65), problem formulation must address a plurality of objectives held by involved stakeholders (Rittel & Webber, 1973). It would thus appear that problem formulation includes identification of issues, aids in directing solutions, and accounts for the human element.

Moreover, problem formulation is recognized as being related to overall systems success. Wellington (1887) suggests that "the correct solution of any problem depends primarily on a true understanding of what the problem really is, and wherein its difficulty, we may profitably pause upon the threshold of our subject to consider first, in a more general way, its real nature – the causes which impede sound practice; conditions on which success or failure depends; directions in which error is most feared. Thus we shall more fully attain that great prerequisite for success in any work - a clear mental perspective, saving us from confusing the obvious with the important and the obscure and remote with the unimportant" (p. 1). Table 9 is drawn to indicate the breath of concepts associated with problem formulation from systems literature. Consequently, the problem formulation phase, irrespective as to what it is named, "has subsequently been considered the most critical stage in policy analysis" (Dery, 1984, p. 2) and is "probably the single most important routine, since it determines in large part...the subsequent course of action" (Mintzberg et al., 1976, p. 274).

Table 9: Breadths of Concepts Related to Problem Formulation

		Concepts related to problem articulation for complex systems									
Authors	**Domain**	**Multiple views of the problem**	**Define/Formulate/Frame the problem**	**Problem as objective entity**	**Problem as constructive or interpretive entity**	**Generalize**	**Context/Contextual Integrity**	**Context of Problem/Situation/Study**	**Problem setting**	**Frame the context**	**Problems as Pathological conditions**
Beer (1984); Ríos (2012)	Management Cybernetics	x	x								x
Bergvall-Karebon (2002)	Systems Analysis	x			x		x				
Bowen (1998)	Systems Analysis		x								
Checkland (1985)	Systems Analysis	x			x		x	x			
Crownover (2005)	Engineering Management	x	x	x	x	x	x	x	x	x	
Dery (1984)	Policy Analysis		x	x							x
Farr and Buede (2003)	Systems Engineering		x								
Gibson et al. (2007)	Systems Analysis					x	x				
Hitchins, 2003	Systems Engineering		x						x		
Keating et al. (2001b, 2003a); Keating & Sousa-Poza (2003)	Systems Engineering/SoSE		x				x	x			
Quade & Miser (1985)	Systems Analysis				x		x	x			
Schön, 1983	Systems Analysis				x		x		x	x	
Vennix (1996)	Systems Analysis	x									
Katina (2015)	Complex System Governance	x	x	x	x	x	x	x	x	x	x

Moreover, it could be argued that the problem formulation phase serves to reduce the probability of solving the wrong problem precisely. Known as Error of the Third Kind (Kimball, 1957; Mitroff & Featheringham, 1974; Mitroff, 1998; Mosteller, 1948), solving the wrong problem originated in statistics where Mosteller (1948) suggested:

> *In other words it is possible for the null hypothesis to be false. It is also possible to reject the null hypothesis because some sample O_i has too many observations which are greater than all observations in the other samples. But the population from which some other sample say O_j is drawn is in fact the right-most population. In this case we have committed an error of the third kind.* (p. 61)

Guarding against this error appears relevant in current operating conditions of ambiguity, complexity, emergence, interdependence, and uncertainty. This view is reinforced by the nature of problem complex systems as indicated by Quade and Miser (1985):

> *[they have] problems in which many elements interact as part of what, by definition, is conceived to be the system associated with the problem [calling for] numerous interrelated but disparate elements…The complexities of each of these problems and the large numbers of people concerned with how they are solved, make it clear that many decision-makers are involved, many people's interests are affected, and many constituencies may have competing objectives…moreover, …attended by many uncertainties. (pp. 12-13)*

In such instances failing to properly scope the problem might create the conditions for solving the wrong problem and can result in developing ineffective solutions (Mitroff, 1998). This might result in cost spiraling out of control (Katina et al., 2014a) and harm an analysts "measure of credibility" (Majone & Quade, 1980, p. 97). Hence, efforts dedicated to problem formulation must be pluralistic and consider multiple "disciplines involved, methods used, the forms of communication adapted, [as well as] context" (Quade & Miser, 1985, p. 18). Adams and Hester (2012) suggest that systems analysts must ensure that a "problem system …[is] adequately bounded, [and] include[s] empirical data of both the quantitative and qualitative types, and include[s] an understanding of both the environment and relevant stakeholders" (p. 236).

Each methodological approach includes an activity or phase dedicated to problem formulation. In the 'hard' systems approaches, this phase is necessary in the optimization process relevant to "efficient means of achieving a known and defined end" (Checkland, 1978, p. 73). This is supported by the set of assumptions underlying 'hard' systems approach (Jackson, 2003):

1. There is a desired state of a system S_1, which is known
2. There is a present state of the system S_0;
3. There are alternative ways of getting from S_0 to S_1;
4. It is the role of the systems person to find the most efficient means of getting from S_0 to S_1 (p. 54)

In this regard, the problem formulation phase is instrumental in identifying the system-of-interest, user needs, and goal/objective tree, which are gained through requirements analysis (Atthill, 1975; Blanchard & Fabrycky, 2006; Gibson et al. 2007; INCOSE, 2011).

Highly dependent on user requirements (Forsberg & Mooz, 1999), problem formulation in 'hard' systems approaches also employs several tools and techniques such as 'needs analysis' (Smith, 2011) to elicit "a complete, unambiguous, consistent, understandable, traceable, and modifiable set of requirements" from various stakeholders including system owners, system engineers, and related third party contractors (Katina et al. 2014a, p. 54).

Similarly, the problem formulation phase in 'soft' systems approaches uses different tools and techniques to produce descriptions, system purpose, system context, relevant stakeholders, and system state which might include dominant and dependent concerns and issues from stakeholder worldviews. Moreover, there is a greater emphasis on the subjectivity in the soft systems-based approaches. At the core of problem articulation is the assumption that dealing with real world systems requires evaluation of human participants including their interests, values, and assumptions (Adams & Keating, 2011; Jackson, 2003; Mason & Mitroff, 1981; Mitroff, 1998; Ulrich, 1987). Therefore, the need to be holistic in systems approaches transcends methodological approaches and includes the problem formulation phase, especially in 'soft' systems approaches as indicated by the increased nature of subjectivity. Table 10 is drawn to indicate role of problem formulation in corresponding systems-based methodologies.

Table 10: The Role of Problem Formulation in Systems-based Methodologies

System-based Methodology	Methodology Themes	Problem Formulation Method	Purpose of Problem Formulation Method
Systems Analysis (Atthill, 1975; Gibson et al., 2007)	A logical, objective procedure for applying in an efficient, timely manner new and/or expanded performance requirements to the design, procurement, installation, and operation of an operational configuration	'Problem definition' phase	• Produces objectives and goals tree that enable clarification of requirements and traceability. This is primarily based on 'needs analyses' and requirements engineering processes
Systems Engineering (INCOSE, 2011; Blanchard & Fabrycky, 2006)	An interdisciplinary approach to enable realization of successful systems that meets stakeholder needs. This is done through customer needs definition, development of system functionality, requirements documentation, design synthesis, and verification and validation. Major emphasis is placed on technical operations, cost and schedule, performance, training and support, test, manufacturing, and systems disposal - system life cycle	'Exploratory research' stage	• Initial pass on user needs and requirements documentation • Addresses early cost and schedule projection • Identification of system-of-interest, its elements, sub-systems, and an early integration, verification, validation planning

Table 10 (cont.)

Operational Research (Churchman et al., 1957; Morse & Kimball, 1951)	An interdisciplinary field that deals with the application of advanced analytical methods to help develop better decision-making schema. Characterized by the need to develop optimal solutions for problem situations, this approach uses mathematical models to represent systems under study, deriving solutions, and testing the model and establishing controls for solution	'Problem formulation' phase	• Recognizing situation that provides the context for problem through need analysis and produces: – Statements of objectives – Constraints on solutions – Appropriate assumptions – Descriptions of processes – Data requirements – Alternatives for action and – Metrics for measuring progress
Systems Dynamics (Forrester, 1961; Senge, 1990; Sterman, 2000)	Mathematical modeling approach to framing, understanding, and discussing complex situations in a dynamic environment. Characterized by feedback loops, accumulation of flows into stocks, and time delays. It is instrumental in understanding relationships and underlying behaviors of complex systems	'Problem structuring' phase	• A description of the real world problem domain including; – The purpose of the system – The boundary of the system – The network of feedback loops – The 'rates' and 'level' variables – The 'leverage' system points
Organizational Cybernetics (Beer, 1979, 1981, 1985)	Diagnosis of structure system functions, relationships, and communications channels necessary and sufficient for any system to maintain viable in turbulent environment	'System purpose,' or 'System in focus' phase	• Identifies system purpose; • Establishing system boundary • Processes for 'design' and/or 'diagnosis' of system problem • System context

Table 10 (cont.)

Strategic Assumption Surfacing and Testing (Mason & Mitroff, 1981; Mitroff & Emshoff, 1979)	Focuses on the resolution of ill-structured problems by identifying multiple stakeholders and examining their underlying assumptions in a collaborative problem solving strategic design plan. It involves dialectical debates that enable solving the 'right problem.'	'Problem formulation' phase	• Retrieval of relevant stakeholders and their strategies about 'wicked problem' at hand • Listing of assumptions as to why the stakeholders strategy are relevant • Listing of ranked assumptions based on presumed importance of the assumptions and truthiness of the listed assumptions
Interactive Planning (Ackoff, 1974, 1981a; 1981b, 1999)	Derived from the concept of 'interactivism.' This is a participative method for dealing with complex interrelated problems where it is believed that unless something is done, a desirable future is less likely to occur (i.e., taking inappropriate actions increases the likelihood of meeting undesirable future). This method has six unique phases divided into two parts - idealization and realization	'Formulating the mess' phase	• Formulation of the current state of an organization and its environment (what the organization does, rules and customs, internal and external conflicts, and trends that can affect system performance) • Identification of a system's Achilles' Heels • Provides an area of focus to enable planning followed by identifying what must be avoided at all costs

Table 10 (cont.)

Soft Systems Methodology (Checkland & Scholes, 1999; Checkland, 2000; Wilson, 1984)	Process of inquiry focused on formulation of ill-structured problems with appreciation for multiple perspectives	'Entering the problem situation' phase	• Produces rich pictures (i.e., symbols, sketches and/or 'doodles' pictorially representing information about the situation
Systems of Systems Engineering Methodology (Adams & Keating, 2009, 2011; Keating et al., 2004)	Design, deployment, operation, and transformation of metasystems that must function as an integrated whole to produce desirable outcomes. It promotes an emerging approach of dealing with grand challenges where the interactions of technology, policy, and economics are the primary drivers in systems characterized as operational and managerial independence, evolutionary and having emergent behaviors. Often such systems are geographical distributed having inter-disciplinary, heterogeneity and networked elements	'Perspective 1' phase	• Produces 9 primary elements for consideration in framing complex situations (i.e., situation-wide context, characterization of system, nature of system, justification for system complexity, framing, problem statement and objectives, stakeholder analysis, contextual analysis, and implication of study) • Each primary element is associated with set of goals, input, outputs, methods, techniques, and tools that enable holistic understanding of a complex satiation

Table 10 (cont.)

Critical System Heuristics (Ulrich, 1983, 1987)	Emancipatory methodological approach to complex problems that allows its users to challenge prevailing behaviors and worldviews. It calls for enhancing reflective competence, reflective practice based on theoretical underpinning, 'heuristics,' and systems thinking. Hence, it is used to examine the legitimacy of prevailing designs by contrasting 'what is' as opposed to 'what ought to be.'	'Boundary critique' phase	• Identification of relevant stakeholders - clients, decision-makers, designers, etc. including 'environment.' • Categorization of stakeholders - 'involved stakeholders' and 'affected but not involved' stakeholders • A synthesis of worldviews related to sources of motivation, control, expertise, legitimation (i.e., values), and basis of control
Organizational Learning (Argyris, 1985; Argyris & Schön, 1978, 1996)	Testing studies, models, and theories on the way organizations learn and adapt in rapid changing environment; efficient use of feedback in single and double loop learning	'Diagnosing the organization' phase	• Identify possible areas for improvement based on learning
Sociotechnical Systems (Pasmore, 1988; Taylor & Felten, 1993; Trist & Bamforth, 1951)	Concerned with joint optimization between people and technology at the workplace. The approach recognizes the importance of interaction between people and technology in workplace. Considers social and technical factors that create conditions for successful or unsuccessful system performance. Optimizes one aspect (socio or technical) while accounting for impact on overall system performance	'Process scanning' phase	• Establishment of problem boundaries, conceptual team understanding, alignment of goals, and plan of analysis

Table 10 (cont.)

Total Systems Intervention (Flood & Jackson, 1991; Flood, 1995; Jackson, 1991)	A system problem solving approach based on creative thinking, appropriate method selection, and implementation of method based on change proposals to solve complex issues	'Creativity' phase	• Identification of dominant and dependent concerns including current issues and problems in the system

Cleary, problem formulation is an essential element of overall systems development as illustrated by the degree of agreement of the necessity across the systems-based approaches. Moreover, the purview of problem formulation includes identification of factors that may act to limit expected performance of the system under study. However, Brewer's (1975) remarks: "the simple question, 'what's the problem? Is often never asked at all by the analysis; it is assumed" (p. 5) is a concern. Rein and White (1977) echo this concern, suggesting that while problem formulation is "perhaps the most crucial part …it has traditionally been the least well codified aspect of research in the canons of methodology" (p. 131). It would thus appear that there is still opportunity to clarity how to do complex problem formulation (Crownover, 2005).

Therefore, Dery's (1984) statement: "As teachers, consultants, and researchers, we often warn against the hazards of poor problem formulation. We praise 'systems thinking,' ridicule the tendency to do the same, and leave the rest to creative minds" (p. 3) supports the conclusion that there is a need to (re)think problem formulation. One possible approach is to draw attention to identification of systemic pathologies that may act to limit expected performance of a system under study that must operate in the milieu of ambiguity, complexity, emergence, interdependence, and uncertainty as the hallmarks of modern systems and their constituent problems.

2.1.6 System Pathologies

This section provides a perspective on pathologies in a broader sense and then in systems related to the problem formulation phase of systems-based methodologies. First, it is essential to recognize the etymology of the term 'pathology.' Webster's New Explorer Encyclopedic Dictionary suggests that the term *pathology* is derived from two ancient Greek terms: *pathos* (i.e., suffering, experiencing, and emotions) and *logia* (i.e., study of) (Merriam-Webster, 2006). The usage of the term emerged in early 17th century and was commonly associated with examination of dead bodies in hope of uncovering the cause of death (Long, 1965). Since earlier attempts to uncover causes of death where often related to understanding structural and functional changes, paying close attention to physical changes played a critical role in understanding morphological changes (van den Tweel & Taylor, 2010).

In the middle ages, it was widely believed that life was sustained by humors. Medical philosophy of humoral theory held that the human body was filled with four basic well-balanced substances of black bile, yellow bile, phlegm, and blood (Bynum & Porter, 1997). It was then held that these basic substances were intricately linked to four elements of earth, fire, water, and air that sustained life and that imbalance (i.e., excess or deficit) in the humors was the cause of diseases and death (Bynum & Porter, 1997; van den Tweel & Taylor, 2010). However, it was not until the 19th century that this philosophy was replaced by a more scientific cellular theory of Rudolf Virchow and bacteriological theory of Louis Pasteur where disease is understood via microscopic analysis of infected cells (Bynum & Porter, 1997). The discoveries of disease-causing microbes (e.g., bacteria, virus, and fungi) suggested that symptoms could be observed and treated to prevent structural and functional changes in the human body (Long, 1965). However, since a symptom is only indicative of an underlying problem, it became obvious that there was a need to examine underlying causes of symptoms so that proper treatment can be prescribed (e.g., see van den Tweel & Taylor, 2010).

Thus etymologically, the term 'pathology' relates to attempts to understand observed symptoms and determining the cause of disease and death through dissection. Moreover, pathology is also intrinsically related understanding structural and functional morphological changes and encompasses disease etiology, disease pathogenesis, cell morphologic changes and consequences of changes (Kumar et al., 2010). Interestingly, the term 'pathology,' is not restricted to understanding symptoms and cause of diseases in human and animal systems. In fact, pathology has also been used in relation to understanding issues that might act to lessen system performance and growth in inanimate systems and is found in management theory, policy analysis, management cybernetics, and intelligent systems.

In management theory and organizational studies, pathology is used to describe organizational issues that can affect performance of formal organizations. Barnard's (1946) work on formal organizations describes functional and scalar pathological conditions that affect organizational growth. The functional status of a system describes the individual conditions such as privileges, rights, immunities, duties, and obligations that can affect performance of an organization while the scalar status of a system is determined by relationships of superiority in organizational hierarchy and jurisdiction (Barnard, 1946). Since Barnard's (1946) view of pathology suggests that pathologies limit organizational growth, understanding 'system status' is pertinent to improving and maintaining system performance. Table 11 provides an overview of Barnard's (1946) six pathological conditions affecting organizations. In this instance pathologies are related to organizational management structures that can act to limit growth of an organization.

Table 11: System Status Pathologies

System Status Pathologies	**Pathology Description**
Time-relevant pathology	A pathology that emerges in an organizational setting because of human tendency to become complacent overtime in relation to functional status (i.e., duties) and scalar status in an organization (i.e., relationships and boundaries)
Elite circulation pathology	A pathological condition associated with failure to recognize effects of aging, deterioration of physical, moral, and human intellect on organizational growth
Justice distributive pathology	A pathological condition associated with an organizational setting that is biased towards one end of an organization and failure to protect essential but not powerful members or elements of an organization (e.g., lower ranked members in the organization)
Communication-relevant pathology	These pathologies emerge from having ineffective communication mechanisms where important organizational standards (i.e., visible policies) are largely ignored while the heuristics of the organization (i.e., invisible policies) are easily acknowledged and adopted in the organization setting
Position-relevant pathology	A pathological condition associated with symbolism, rank, office, class, or trade especially when the people in a position become to symbolize status such as 'clergymen' or a 'doctor.'
Adaptability pathology	These pathological conditions can emerge out of external environment that the organization must adapt to in order to remain stable while providing for coherence, coordination and *esprit de corps*

In policy analysis, an area of research that deals with "determining which of various alternative policies will most achieve a given set of goals in light of the relations between the policies and the goals" (Nagel, 2001, p. 71), problem identification is one of the key aspects of analysis. In this phase, determination of goals, setting the boundary, understanding context, target social system, and drawing an initial approach, takes place (Quade, 1980). Interestingly, Dery (1984) equates pathologies to "discrepancies [in social systems] between cherished goals and reality - whose existence and undesirability can be taken for granted" (p. 38). Moreover, the complexities involved in understanding social issues, suggests that the concept of social pathologies varies based on people's worldviews where "a problem is not the same to all interested parties" (Becker, 1966, p. 7) and yet a given problem may not "necessarily [be] the same to all disinterested parties, or even to the same researcher" (Dery, 1984, p. 25).

In management cybernetics, pathology describes deviations or shortcomings in subsystem functions of the Viable System Model (VSM) based on the seminal work of Stafford Beer. Pathologies act to limit organizational viability. Using principles of communication and control to govern complex systems, Stafford Beer's work supplemented by research of Espejo and Harnden (1989), and Keating and Morin (2001), envisioned the necessary and sufficient subsystems of productive (S1), coordination (S2), operations (S3), monitoring (S3 Star [*]), system development (S4), learning and transformation (S4*), and system policy and identity (S5) as well as their functions for organizational viability (continued existence) despite turbulent environmental conditions (Beer, 1979; 1981; 1985). Moreover, Beer also postulated that "viable systems of all kind are subject to breakdown. Such breakdowns may be diagnosed, simply in the fact that some inadequacy in the system can be traced to malfunction in one of the five subsystems, where in turn one of the cybernetic features ...will be found not to be functioning" (Beer, 1984, p. 17). With this view in mind, Beer (1984) postulated that management ought to give attention to configuration of systems to avoid the following pathological conditions that might affect organization viability: (1) recursive pathology - system lacks viability because it is not contained in a viable system, (2) identity pathology - where S5 does not represent the totality of the system, (3) subsystems 2-4 mismatch pathology – lacking of synergy and interactivity among S2, S3, S3*, S4, and

S4*, and (4) metasystem pathology – lacking of S2, S3, S3*, S4, S4* and S5 in the system.

Similar to Beer's (1984) postulation that "the etiology of the disorder may be traced, a prognosis may be prepared, and antidotes (even surgery) may be prescribed" (p. 17) based on cybernetic enquiries with respect to viable organizations. Ríos (2010; 2012) noted that pathologies are related to inadequacies (or lack of adhering to) cybernetic principles in designing complex organizations. Three broad categories of organizational pathologies are structural, functional, and informational. Structural pathologies are "related to an inadequate treatment of total complexity faced by an organization" (Ríos, 2012, p. 142). Functional pathologies are deficiencies associated with "each of the organisations that compose the total organization…The aim is to see whether the essential functions (systems) necessary for the organisation's viability exists and work adequately" (Ríos, 2012, p. 142). The communication and information pathologies pertain lack of (or inadequacies in) mechanisms that must enable transfer of information between subsystems and the environment (Beer, 1984; Ríos, 2012). Table 12 provides a broad categorization of pathologies from a cybernetics perspective.

Since, "the degree to which the system effectively performs Beer's five VSM subsystem functions, coupled with the flow of information in support of those functions, determines the efficacy of the system and ultimately the level of system performance achieved" (Keating & Katina, 2012, p. 249), it is reasonable to conclude that the concept of pathologies associated with organizational (system) viability is related to inadequacies in functions, communications systems, and mechanisms associated with such elements of an organization.

Table 12: Expanded VSM Pathologies

Organizational Pathology	VSM associated pathologies
Structural	Non-existence/inappropriate of vertical unfolding: the inexistence of vertical division necessary to reduce complexity (variety) into appropriate scope of activity
	Lack of recursion levels (level 1): this recursion occurs only at the second level. Recall that S1 address issues in their environment. However, there might be instances where there is no corresponding to recursion level 0 where issues transcending S1s must be addressed
	Lack of recursion levels (middle level): there exists level 0 and level 2. However, the intermediate organizational level structure linking organization (level 0) to level 2 is missing
	Entangled vertical unfolding: various interrelationships contribute to viability of an organization. However, such relationships must be maintained. Lack of maintaining such relationships can create conflicting system identities especially if the system does not have appropriate communication channels
Functional	Subsystem 5 pathologies: the pathologies include ill-defined system identity, institutional Schizophrenia, collapsing S5 into S3, and inadequate representation of system
	System 4 pathologies: these pathologies are associated with concepts of a headless chicken (i.e., it might run around for a while but soon dies) and an ostrich with its head in the sand (i.e., it is afraid to partake in environmental scanning activity for outside and future issues that might enable or constrain its operations) and dissociation between S4 and S3
	System 3 pathologies: these pathologies are associated with having an inadequate management style (e.g., excessive direct intervention by S3), S3 that is Schizophrenic, weak connections between S3 and S1s and hypertrophy of S3
	System 3* pathologies: these pathologies include a lack of or insufficient development of S3 such that it is overwhelmed by information generated from S1s, S2, and S3
	System 2 pathologies: these pathologies relate to disjoint behavior of S1s (i.e., each on his own) and authoritarian S2 (i.e., authoritarian operational management styles)
	System 1 pathologies: these pathologies include having an S1 that becomes an autopoietic system and an S1 that becomes dominant over the metasystem

Table 12 (cont.)

Information and communication	Lack of information systems that may be used to linking different systems and increase awareness
	Fragmentation of information systems such that information may not be easily captured, stored, processed, and interchanged among different systems - interoperability
	Lack of key communication channels (infrastructure) capable of handling required information exchanges
	Lack of or insufficient algedonic channels capable of transmitting vital information from S1s to S5 regarding viability of the organization
	Presence of incomplete or inadequate channel capacity such that there is delay in information transmission or channels fail to transmit information properly
VSM Independent pathologies	Lack of metasystem pathology: this pathology relates to absence or weakness of the Metasystem (i.e., S2, S3, S3*, S4, S4*, and S5). This occurs when exclusive attention is placed on developing S1 elements while ignoring metasystem elements and their functions
	Organizational autopoitic beasts pathology: this occurs when S1 "become obsessed with achieving their own goals relating to growth and power, regardless of whether or not they contribute to facilitating the task of System 1" (Ríos, 2012, p. 163)

In intelligent systems, pathology is used in connection with adopted organizational structures that might contribute to eroding system effectiveness (Sheptycki, 2004). In such a system, knowledge is created from acquired data which eventually leads to taking specific actions. At a general level, there is a *direction activity* in which the 'customer's intelligence needs' are identified and established. A *collection activity* in which information pertinent to customer need is gathered, and a *processing activity* in which analysis takes place to convert information into consumable 'intelligence packages.' A *dissemination activity* involves giving 'intelligent packages' to customers and then a *final activity* which involves a joint assessment of what was done and what should take place (Sheptycki, 2004). To accomplish these activities especially in a crime policing environment, there is need for collaborative effort involving different organizations at different levels of intelligence.

Two issues pertinent to current dialogue come into play: First, the principles of information flow for "intelligence [systems] is supposed to flow upwards in the data pyramids" (Sheptycki, 2004, p. 313). However, Sheptycki (2004) notes that since different agencies operate on different pyramids of intelligence, there is no standard operating procedure across all intelligence systems. Second, given that the structure of intelligent systems is multi-agency, there is a need for "movement of information between or across these information hierarchies" (Sheptycki, 2004, p. 313). Moreover, the multi-agency hierarchies of intelligence systems ensure that different agencies operate at different levels on the intelligence landscape. These two issues coupled with the desire to transform intelligent systems into more effective intelligent systems, according to Sheptycki (2004), create the right conditions for the 11 organizational process pathological conditions. These conditions include digital divide, linkage blindness, noise pathology, intelligence overload, non-reporting and non-recording, intelligence gaps, duplication pathology, institutional friction, intelligence hoarding and information silos, defensive data concentration, and occupational subcultures. These pathological conditions may act to lessen effectiveness in intelligence systems. Sheptycki's (2004) work not only suggests that adapted organization structures, policies, or strategies might be sources of deficiencies in organizational operations, but also illustrates that pathology can be described in terms of technology and day-to-day organizational processes.

This selected literature serves two primary purposes. First, it provides a means to diverge from the traditional medical formulation of 'pathology' (Dietel & Schäfer, 2008; van den Tweel & Taylor, 2010) commonly associated with disease etiology, disease pathogenesis, cell morphological changes, and health change consequences (Kumar et al., 2010) to a more contemporary formulation that considers health of inanimate systems including computer systems (Bobba, et al. 2007), complex organizations (Barnard, 1946; Beer, 1984; Ríos, 2012), and social systems (Beer, 1984; Yolles, 2007). Second, this extended view of pathology provides a platform for viewing pathology in terms of factors and issues that act to limit expected system performance triggered by violation of (or inadequacy in) underlying expected system functions. Figure 9 is drawn to depict an emerging concept of systems-based function pathology. Certainly, identifying factors acting to limit system performance is a natural fit for problem formulation, as demonstrated from the literature. This process might involve articulation of internal (e.g., organizational policy) or external (e.g., environmental changes) factors that may limit growth, sustainability, and viability systems operating in contemporary turbulent environmental conditions.

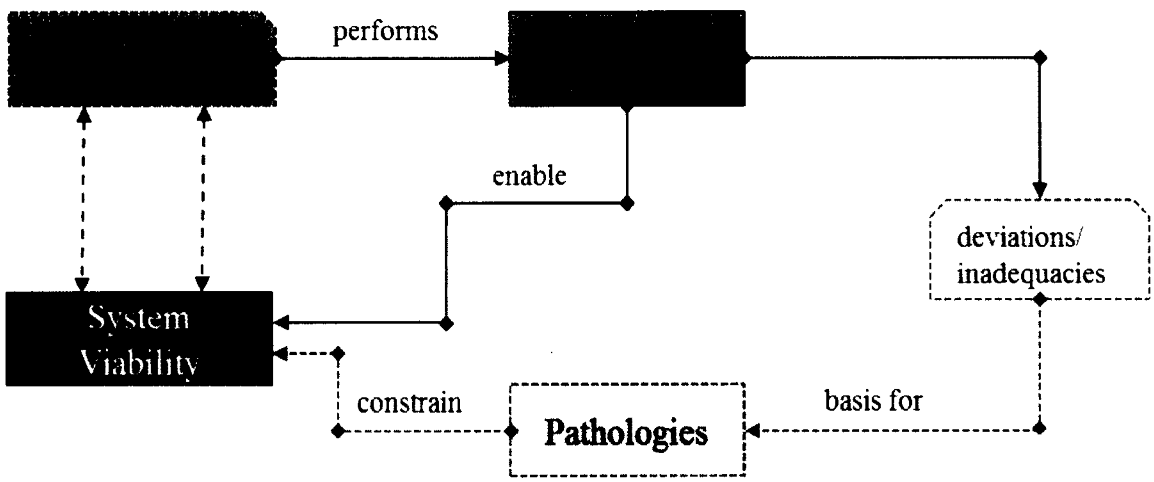


Figure 9: A Logic of System Function-based Pathologies

This section indicates that when we view organizations as systems (Beer, 1984; Ríos, 2010; 2012; Skyttner, 2005), pathologies revolve around the ideas of deficiencies associated with adopted 'organizational policies and processes,' and 'environmental conditions' that enable or disable system functions. Certainty, Keating and Katina's (2012) definition of pathology fits within the scope of this research:

> *A circumstance, condition, factor, or pattern that acts to limit system performance, or lessen system viability [and growth], such that the likelihood of [the] system achieving performance expectation is reduced. (p. 253)*

Additionally, since complex systems do not operate in isolation (Hammond, 2002; Katina et al. 2014b; Skyttner, 2005), it stands to reason that problem formulation and the identification of pathologies must be include the concept of metasystem - a higher logical order beyond a single system of interest (Djavanshir et al., 2009; Krippendorff, 1986).

The concept of metasystem pathology is the basis for the following section.

2.1.7 Metasystem Pathologies

It was previously established that complex systems and systems of systems operate under conditions of ambiguity, complexity, emergence, interdependence, and uncertainty. Under such conditions, it is expected that systems and their related problems cannot exist in isolation (Hammond, 2012). Consequently, researchers have argued that society's most vexing problems cannot be addressed in isolation (Capra, 1997; Hammond, 2002; Laszlo, 1996). To bring about positive change in today's systems based society, researchers often suggest the application of systems theory as a potential source of response to addressing today's most pressing issues in a holistic manner (Adams et al. 2014; Hammond, 2002; von Bertalanffy, 1972). By extending these ideas to problem formulation, it appears that identifying system pathologies can be extended to the metasystem level as well.

The idea of using systems theory to enhance the problem formulation phase is certainly within the bounds of application of systemic thinking where the concern is placed on whole systems rather than parts of the system (Simon, 1969). This might provide a convenient place to address system pathologies beyond single isolated systems and place focus on the pathologies at the higher logical order beyond any given system (metasystem). A metasystem is said to lie beyond individual system objectives and overrides such systems in favor of overall system functions, missions, or objectives (Djavanshir et al., 2009; 2012; Krippendorff, 1986). In this regard, *a metasystem is a governing structure that integrates autonomous complex systems (i.e., governed complex systems) to achieve functionality beyond constituent systems*. Figure 10 is drawn to provide a basic structure metasystem in relation to a governed system.

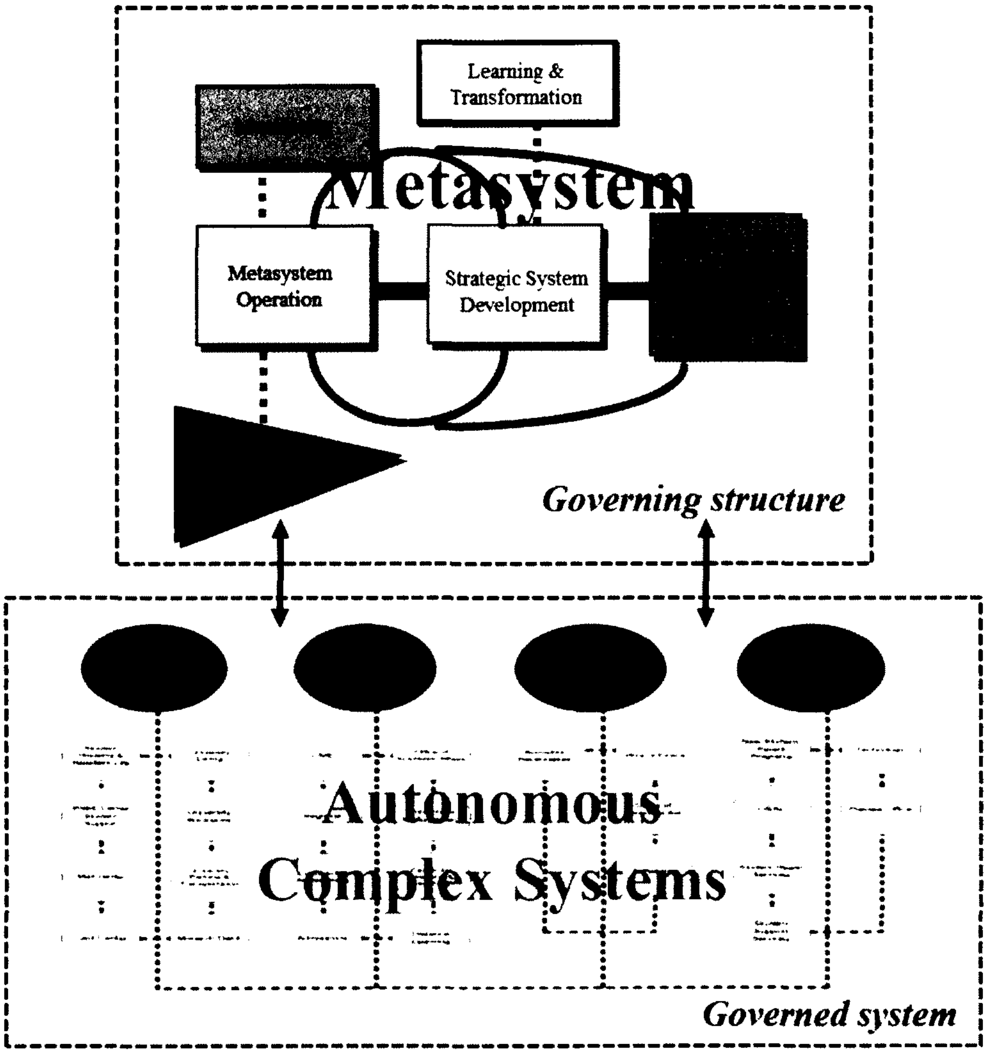


Figure 10: The Logic of Metasystem in Relation to a Governed System

There is a long history of governance in Greek and Latin languages. In Greek, it refers to *kybernetikos* which translates to the art of steering (Mason & Mitroff, 1981). The equivalent term in Latin is *gubernetes* and relates to gubernator or to govern. Schneider and Kenis (1996) have extended governance to include societal control and self-regulation. Moreover, Schneider and Bauer (2007) espouse that "if a 'problem' is defined as the difference between a preferred state and an undesired status quo, the function of governance is 'problem-solving' in the sense of moving to desired states" (p. 11). Hence, governance is related to regulation such that realization of desired long and short-term goals is enabled. In addition, a governing structure provides principles, norms, rules, and procedures that guide and restrain formal and informal processes in organizations (Nye & Donahue, 2000). Furthermore, governance ensures that members under the governing structure adhere to specific regulations. For complex systems and systems of systems, these definitions would suggest that a metasystem provides the essential sets of mechanisms, principles, and regulations to enable the governed system to move toward a desired overall state (Yolles, 2006). Consequently, a metasystem structure can be used to enhance problem formulation, especially in identifying pathologies at a higher logical order beyond single systems that constrain system performance.

Perhaps a well-articulated description of a metasystem is that of Beer's (1979) work related to viability of complex systems. Consistent with Espejo and Reyes (2011), Keating and Katina (2012), and Ríos (2012), Beer's (1979) articulation of the viable system model (VSM) suggest that a metasystem is comprised of five subsystems of coordination (S2), operations (S3), monitoring (S3*), system development (S4), learning and transformation (S4*), and system policy and identity (S5) and their associated functions. The purpose of the metasystem is to provide for the integration of the autonomous productive subsystems (S1) that produce the value of system as an integrated unity. Table 13 identifies VSM functions and their corresponding objectives.

Table 13: Summary of VSM Functions

VSM Function	Primary Objectives
Productive (S1)	1. Produce system products and services to agreed-upon standards and performance levels within allocated resources (from S3)
	2. Provide direct interface to the local (e.g., customer) system environment
	3. Operate autonomously to execute system work with agreed-upon integration parameters
	4. Interface with S2 for coordination with the larger system
Coordination (S2)	1. Maintain coordination among S1s (productive units)
	2. Promote system efficiency by identifying unnecessary or redundant resources in use across S1s
	3. Identify system integration issues for system level resolution
	4. Identify and manage emergent conflict between S1s
Operations (S3)	1. Operational planning and control for on-going system performance
	2. Operational response to inputs from other Subsystems
	3. Interprets and implements policies and direction from S5
	4. Interface with S4 to re-design operations in response and anticipation of identified environmental shifts
	5. Negotiate resource, performance accountability, and reporting expectations for S1s
Monitoring (S3*)	1. Monitor subsystem and system level performance
	2. Identify and analyze deviant performance, unexpected events (crises), and operational conditions and trends
Development (S4)	1. Foster strategic system learning, development, and transformation
	2. Maintain environmental scanning, analysis, and interpretation
	3. Maintain models of the environment, entire system, and future
	4. Interface with Subsystems concerning system implications stemming from environmental scanning results
	5. Disseminate essential environmental intelligence information throughout the system for potential action
Learning and Transformation (S4*)	1. Identify, assess impact, and derive learning implications for trends, events, and patterns occurring in the system environment
	2. Guide system transformation strategy development and implementation

Table 13 (cont.)

Identity and Policy (S5)	1. Maintain and propagate system identity
	2. Define and clarifies the system vision, purpose, mission, values and their consistent interpretation
	3. Balance focus between present (S3) and future (S4) needs and priorities
	4. Establish system policy and strategic direction
	5. Represent and communicate the system to external entities
	6. Process input from other Subsystems for system implications

Following Keating and Katina's (2012) definition of pathology, it would thus appear that a metasystem pathology is:

> *a circumstance, condition, factor, or pattern that acts to limit system performance, or lessen system viability and growth at the metasystem level, such that the likelihood of achieving desired performance is reduced.*

The concept of metasystem pathology has been briefly discussed in literature. Beer's (1979; 1981; 1985) work on VSM identifies four pathological conditions that hinder system viability. One of these instances is described as a lack of metasystem subsystems (i.e., S2, S3, S3*, S4, S4* and S5). This metasystem pathology emerges from inadequacies in the design of the system such that subsystem functions are non-existent (Beer, 1984). Extending Beer's work on pathologies, Ríos (2012) has suggested that a metasystem pathology might also be observed as a weakly performing, or executed, metasystem. This is the case when an organization pays more attention to developing governed autonomous productive subsystems (S1) while ignoring the governing structure of metasystem (S2, S3, S3*, S4, S4* and S5) and their functions (Ríos, 2012).

Furthermore, Keating and Katina's (2012) research extended the concept of metasystem pathologies to the domain of systems of systems (Keating et al., 2003b; Keating & Katina, 2011). Using 41 primary objectives of the six (6) VSM based metasystem subsystem functions (Beer, 1979; 1981; 1985), Keating and Katina (2012) developed 41 metasystem pathologies "indicative of inadequacies in the design, execution, or interpretation of the performance of the system[s] of systems" (Keating & Katina, 2012, p. 253). Table 14 is drawn to indicate potential systems of systems (metasystem) pathologies based on the cybernetic VSM metasystem functions (Keating & Katina, 2012).

Table 14: Systems of Systems VSM-derived Pathologies

Metasystem Function	**Nature of Potential Systems of Systems Pathologies**
Coordination (S2)	S2.1. Unresolved coordination issues within the system
	S2.2. Excess redundancies in system resulting in inconsistency and inefficient utilization of resources (including information)
	S2.3. System integration issues stemming from excessive entity isolation or fragmentation
	S2.4. System conflict stemming from unilateral decision and action
	S2.5. Excessive level of emergent crises within the system
	S2.6. Weak or ineffective communications between system entities
	S2.7. Insufficient standardized methods (procedures, processes) for routine system level activities
	S2.8. Overly ad hoc system coordination versus purposeful design
	S2.9. Difficulty in accomplishing cross system activities requiring integration or standardization
	S2.10. Introduction of uncoordinated system change resulting in excessive oscillation

Table 14 (cont.)

Operations (S3)	S3.1.	Imbalance between autonomy of productive elements and integration of whole system
	S3.2.	Resource stability inconsistencies
	S3.3.	Mismatch between resources and productivity expectations
	S3.4.	Lack of clarity for responsibility, expectations, and accountability for performance
	S3.5.	Operational planning frequently pre-empted by emergent crises
	S3.6.	Inappropriate balance between short term operational versus long term strategic focus
	S3.7.	Lack of clarity of operational direction for S1s
	S3.8.	Difficulty in managing integration of system S1s
	S3.9.	Slow to anticipate, identify, and respond to environmental shifts
Monitoring (S3*)	S3*.1.	Limited accessibility to data necessary to monitor performance
	S3*.2.	System level performance indicators absent, limited, or ineffective
	S3*.3.	Absence of monitoring for subsystem and system level performance
	S3*.4.	Lack of analysis for performance variability or emergent deviations from expected performance levels
	S3*.5.	Performance auditing is non-existent, limited in nature, or restricted mainly to troubleshooting emergent issues
	S3*.6.	Periodic examination of system performance largely unorganized and informal in nature
	S3*.7.	Limited system learning based on performance assessments
Development (S4)	S4.1.	Lack of forums to foster system development and transformation
	S4.2.	Environmental scanning, interpretation, and processing are non-existent, sporadic, or limited in nature
	S4.3.	Absence of system representations or models to guide analysis
	S4.4.	Processing and dissemination of environmental scanning results inconsistent or ineffective
	S4.5.	Long range strategic development is sacrificed for management of day to day operations - limited time devoted to strategic analysis
	S4.6.	Strategic planning/thinking focuses on operational level planning and improvement

Table 14 (cont.)

Learning and Transformation (S4*)	S4*.1.	Limited learning achieved related to environmental shifts
	S4*.2.	Integrated strategic transformation not conducted, limited, or ineffective
	S4*.3.	Design for system learning informal, non-existent, or ineffective
Identity and policy (S5)	S5.1.	Identity of system is ambiguous and does not effectively generate consistency system decision, action, and interpretation
	S5.2.	System vision, purpose, mission, or values remain unarticulated, or articulated but not embedded in the execution of the system
	S5.3.	Balance between short term operational focus and long term strategic focus is unexplored or lacks ability to guide decisions related to resource allocation
	S5.4.	Strategic focus lacks sufficient clarity to direct consistent system development
	S5.5.	System identity is not routinely assessed, maintained, or questioned for continuing ability to guide consistency in system decision and action
	S5.6.	External system projection is not effectively performed

Furthermore, it appears that the concept of metasystem and metasystem pathologies might be relevant in dealing with supra-institutional issues that cross traditional organizational boundaries. Cornock (1977) suggests that working in isolation provides the right condition for the problem of "one man's 'solution' [to become] another man's 'problem'" (p. 738). Supra-institutional issues require an analyst to have a wider view which might be provided at a metasystemic level. Certainly, Churchman's (1971) comments

> *...it seems at least plausible to argue that 'verification' of a research project of a dialectical inquirer is not the establishment of a solution, but the creation of more knowledgeable political process in which the opposing parties are more fully aware of each other's Weltanschuungen [worldview] and the role of data in the battle for power. (p. 185)*

seems to support a need for a higher logical view beyond any one system of interest. To this end, the problem formulation phase also is a logical candidate for a consideration for pathologies at the metasystem level.

This section has illustrated two critical points from the literature. First, metasystem plays a critical role in governance of complex systems. The concept of metasystem supports the systems idea of treating systems as interdependent systems (wholes) rather than completely independent systems capable of operating in isolation. Thus, a metasystem provides a governing structure that integrates autonomous complex systems (i.e., governed complex systems) to achieve functions, goals and missions beyond those of constituent systems. Second, the literature highlights a gap related to the extension of the concept of system pathologies to metasystem pathologies using systems theory. Metasystem pathologies are related to deficiencies and/or lack of adhering to metasystemic functions which find their basis in systems theory, as suggested from the examination of the literature. By extending the previously articulated logic of system function-based pathology to systems theory, a systems pathology might be defined as an inadequate use of systems theory (i.e., not recognizing unity of laws, principles, and theorems of systems theory) or violation of systems theory (i.e., ignoring laws, principles, and theorems of systems theory). Figure 11 is drawn as an integration of the literature to provide an emerging logic of systems theory-based metasystem pathology. This concept of might be used to identify metasystemic issues acting to limit expected growth, performance, sustainability, and viability of complex systems as part of problem formulation endeavors for systems-based methodologies.

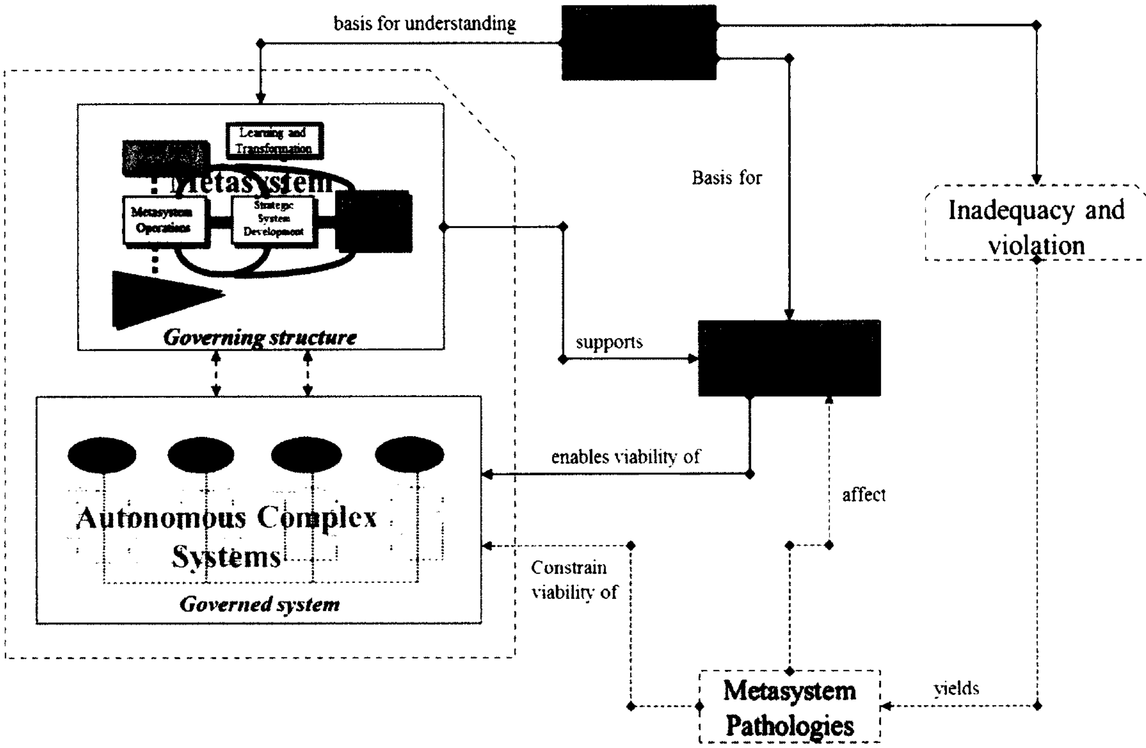


Figure 11: An Emerging Construct for Systems Theory Metasystem Function-based Pathologies

2.2 LITERATURE CRITIQUE

This section discusses various segments presented in the synthesis of literature and provides shortcomings in the systems body of knowledge related to metasystem pathologies – and in the process establishes the particular gap which forms the focus for this research effort. First, the overarching message from synthesis of literature in this chapter is the utility that systems theory offers in dealing with complex system problems that plague society. There is overwhelming evidence that modern society systems operate under the conditions of ambiguity, complexity, emergence, interdependence, and uncertainty (Flood & Carson, 1993; Keating et al., 2014; Skyttner, 2005). Second, "In order to meet these challenges, approaches must be available for addressing and resolving these problems" (Crownover, 2005, p. 43). Third, a possible approach to addressing current challenges may be found in the body of knowledge of 'system(s).' This entails using systems theoretic laws, principles, and theorems that appear to govern all systems (Adams et al., 2014; Ashby, 1956; Hammond, 2002; von Bertalanffy, 1968).

A review of systems literature for systems-based methodologies indicates that there is no shortage of structured approaches that embraces ideas of systems. Such methodologies are systemic and recognize the complexity associated with 21st century problem systems which cannot be solved in isolation from the larger context and problem domain within which they are inextricably embedded. The tenets of 'systems' form the foundation for the systems-based methodological approaches and the holistic underpinnings upon which deployment of such methods depends (Flood & Carson, 1993; Jackson, 2003; Klir, 1977; Mason & Mitroff, 1981; von Bertalanffy, 1968).

A key feature of systems-based approaches is the need to formulate the problem. While the importance of problem formulation in understanding and the eventual development of problem resolutions are described in the systems literature, it appears that there is "lack of clarity as to what problem ...[formulation] is or how to do it" (Crownover, 2005, p. 30). Moreover, the complexity associated with the 21st century problem landscape appears to influence establishment of clarity in the phase of problem formulation. Dery (1984) indicates:

> *...whether we seize, set, define, discover, or formulate a problem, we are not certain of precisely what we are doing; nor is it obvious that we understand the object of such pursuits. (p. 14)*

Nonetheless, failure to properly formulate problems has implications on overall success of system endeavors and failure in this critical phase might create the right conditions for solving the wrong problem. However, this does not justify the lack of rigorous means that can be used to formulate problems for systems-based analysis.

Therefore, two critiques can be made regarding use of systems theory in problem formulation and identification of pathologies at the metasystem level. ***First, problem formulation for systems-based approaches lacks rigorous and explicit linkage to the underlying systems theory upon which the approaches are assumed to be based***. The reviewed literature illustrates the importance of systems theory in development of systems-based approaches. The role of problem formulation and the underlying assumptions in systems-based approaches is also well-established in systems literature. However, literature on systems-based methodologies does not explicitly indicate how systems theory is used to enhance problem formulation, beyond some base level acknowledgement. It appears that the conceptual foundations of systems theory that form the basis for 'systemic' thinking in systems-based methodologies is not clearly inculcated in the problem formulation phase.

Second, there is lack of focus on metasystemic pathologies during problem formulation. The reviewed literature indicates that the concept of systems pathology offers an essential and yet untapped potential element for problem formulation. However, contemporary problem formulation activities do not appear to focus on identification of metasystem pathologies or the underlying systems theory from which they might be implicitly derived. Specifically, there is no discussion on how systems theory is used to inform problem formulation at the metasystem level. Dent's (2013) work, although written from a different perspective, appears to support these criticisms. Dent (2013) proclaims that users of systems theory appear to subscribe to a limited 'philosophical assumptions' of systems theory and thus there remains a gap of realizing the full potential of systems theory. Table 15 is drawn to indicate research gaps associated with use of systems theory in problem formulation. These gaps indicate a need to more rigorously extend systems theory to the problem formulation phase of systems-based methodologies and to articulate metasystemic pathologies. This is the area of this research.

Table 15: Research Gaps Related to Metasystem Pathologies

			Relevant concepts related to systems theory-based problem formulation		
Authors	**Systems-based methodology**	**Method for articulation of problems**	**Articulation of nature of framing**	**Explicitly linkage to Systems Theory**	**Identifies metasystem pathologies**
(Ulrich, 1983, 1987)	*Critical Systems Heuristics*	*Boundary Critique*	x		
(Ackoff, 1974, 1981a; 1981b, 1999)	*Interactive Planning*	*Formulating the mess*	x		
(Argyris & Schön, 1978, 1996; Argyris, 1985)	*Organizational Learning*	*Diagnosing the organization*	x		
Mason & Mitroff, 1981; Mitroff & Emshoff, 1979)	*Strategic Assumption Surfacing and Testing*	*Problem formulation*	x		
(Pasmore, 1988; Taylor & Felten, 1993; Trist & Bamforth, 1951)	*Sociotechnical Systems*	*Process scanning*			
(Checkland & Scholes, 1999; Checkland, 2000; Wilson, 1984)	*Soft Systems Methodology*	*Entering problem situation*	x		
(Adams & Keating, 2009, 2011; Keating et al., 2004)	*Systems of Systems Engineering Methodology*	*Perspective I*	x		
(Atthill, 1975; Gibson et al., 2007)	*Systems Analysis*	*Problem definition*	x		
(INCOSE, 2011; Blanchard & Fabrycky, 2006)	*Systems Engineering*	*Exploratory research*			
(Forrester, 1961; Senge, 1990; Sterman, 2000)	*Systems Dynamics*	*Problem structuring*	x		
(Flood & Jackson, 1991; Flood, 1995; Jackson, 1991)	*Total Systems Intervention*	*Creativity*	x		
(Beer, 1979, 1981, 1985)	*Viable System Model*	*System purpose/ system in focus*	x		x
(Katina, 2015)			**x**	**x**	**x**

2.3 RESEARCH SETTING FOR METASYSTEM PATHOLOGIES CONSTRUCT

This section of Chapter II frames a research perspective for a construct development related to metasystem pathologies identification in support of the problem formulation phase of systems-based methodologies. The genesis for this Metasystem Pathologies Identification construct started in the broader examination of the role and importance of problem formulation in 'systems' ideas. In von Bertalanffy's (1968) work, it is suggested that when we view the world in terms of systems, there appear general laws, principles, and theorems that govern systems regardless of their particular differences. Fundamental to this view is that systems theory might be used to holistically address 21st century systems, and their derivative problems, despite the increasing ambiguity, complexity, interdependence, and uncertainty that define the present landscape.

The emphasis on the whole is a key element of systems theory. This emphasis is evident in von Bertalanffy's (1972) work where the examination of parts or systems in isolation is said to be incapable of yielding a complete picture of a phenomenon. In fact, Simon (1969) notes that current systems are so intricately woven that "the whole is more than the sum of parts,...given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole" (p. 86). This is in a sharp contrast to the reductionist-based approach where grasping reality is based on isolating systems (Hammond, 2002; Laszlo, 1996).

Apart from embracing the ideas of systems, systems-based methodologies have been developed to intervene and bring about positive change in real world situations. A fundamental aspect of such methodological approaches is problem formulation, which provides an initial entry into the problem space. Problem formulation has been referred as the "*most critical stage*" (Dery, 1984, p. 3), "*most crucial part*" (Rein and White, 1977, p. 131), and "*most important routine*" (Mintzberg et al., 1976, p. 276) and is routinely identified as critical to understanding and eventual system success. The purview of problem formulation spans an array of concepts including system pathologies. Borrowing from the medical field, the concept of pathology involves systemically understanding deep underlying circumstances, conditions, factors, patterns, or issues acting to limit system performance, or lessen system viability and growth, such that the likelihood of system achieving performance expectation is reduced (Beer, 1984; Keating & Katina, 2012; Ríos, 2012). Moreover, a key prevalent issue in systems ideas is holistic understanding. Therefore, this suggests that problem formulation phase might need to be undertaken in a holistic fashion. This might be pursued by ensuring focus on metasystem pathologies that exist beyond any single system of interest. This is also consistent with a fundamental idea of systems theory - understanding the whole rather than parts. Therefore, the literature has suggested: (1) the importance of problem formulation in dealing with complex systems and their associated problems, (2) the unique role of systems theory in providing a grounded theoretical basis for further development of problem formulation, and (3) the relatively unexplored utility of pathologies, related to systems theory, for explaining performance at the metasystem level.

This research suggests that relationship between systems theory and metasystem pathology is one that must be addressed in (re)thinking problem formulation phase of systems-based methodologies. ***The perspective taken in this research was systems theory (i.e., laws, principle, and theorems) and perspectives on metasystem functions***

based on management cybernetics (i.e., the science of effective organization) can be used to develop a construct for metasystem pathologies. Exploring this relationship might provide an explicit linkage between systems theory and problem formulation while considering pathologies at the metasystem level.

Finally, aspects of different discussions on topics of systems theory, complex systems, systems of systems, systems-based methodologies, problem formulation phase, and metasystem pathologies were essential in establishing a need for a metasystem pathologies identification (MPI) construct. The literature has been coalesced to provide and support the construct as an organizing structure for drawing relationships across a seeming disparate body of knowledge. Moreover, before moving into development of the construct, it was necessary to establish a research perspective on metasystem pathologies. This perspective is drawn from and consistent with the supporting literature for the research and offered as a critical point of departure for grounding further exploration:

- A metasystem pathology is a circumstance, condition, factor, pattern, or issue that acts to limit system performance, or lessen system viability and growth at the metasystem level.
- A metasystem pathology emerges out of inadequacy associated with the use of systems theory which might be expressed as lack of use of laws, principles, and theorems of systems theory or a direct violation of laws, principles, and theorems of systems theory.
- Moreover, a metasystem pathology does not have one correct interpretation. Even if there is agreement on the 'existence' of a pathology, the interpretations concerning the source and meaning will not necessarily be

congruent among observers. Thus, the idea of system pathology embraces systems theoretic principle of complementarity.

- Metasystem pathologies are also dependent on systems and observer perspective. Thus, a pathology cannot exist in absence of attribution from an observer. Therefore, there is no pathology independent of system observers.
- Metasystem pathologies include internal factors and external factors acting to limit system performance, or lessen system viability and growth at the metasystem level.
- Metasystem pathologies also include organizational structures, policies, activities, or decisions that may hinder systems development, viability, or growth.
- A metasystem pathology is directly drawn from ***violation of essential metasystem functions***. To enable system viability, systems theory is the basis for developing system functions at the metasystem level. Consequently, violations of systems theory affect metasystem functions.
- Moreover, in order to perform metasystem functions, there is a need to have effective and efficient mechanisms. ***Deficiencies in such mechanisms*** also create pathological conditions inhibiting system performance and viability.

2.4 CHAPTER SUMMARY

This chapter developed the literature review to support this dissertation research. Synthetized literature discussed the importance of systems theory in relation to the reductionist approach of the traditional 'scientific method.' The role of 'systems' approach in promoting holistic thinking in systems-based methodologies is also discussed in relation to intervening in 21st century problematic conditions.

A critical analysis of the literature was then given pointing out the importance of problem formulation in systems-based methodologies. This analysis suggested a lack of explicit use of systems theory in problem formulation as well as a lack of focus on identifying metasystem pathologies. Lastly, a research setting was developed to show how systems theory and management cybernetics was being used in this research to enhance problem formulation phase. The chapter concludes with developing a grounding perspective for the research on metasystem pathologies. Chapter III expands on these ideas by providing underpinnings for a method that might be used to develop a construct for identifying metasystem pathologies; namely, the Grounded Theory Method and a method that might be used for initial 'face' validation of the developed construct of metasystem pathologies; namely, the Case Study Method.

CHAPTER III: PERSPECTIVE OF THE RESEARCH

The purpose of this chapter is to establish a clear and common basic research paradigm and its impact on the research efforts. The chapter presents two major paradigms of research and establishes the philosophical underpinnings that form the basis for conducting this research. Methods that can be used to gain knowledge within the selected paradigm are then discussed across philosophical underpinnings of methodological, epistemological, ontological, and human nature dimensions of research. The chapter also discusses rationale for selection of grounded theory and mixed case research design as well as their associated concerns and means for mitigating those concerns. Figure 12 is drawn to depict the organization of this chapter.

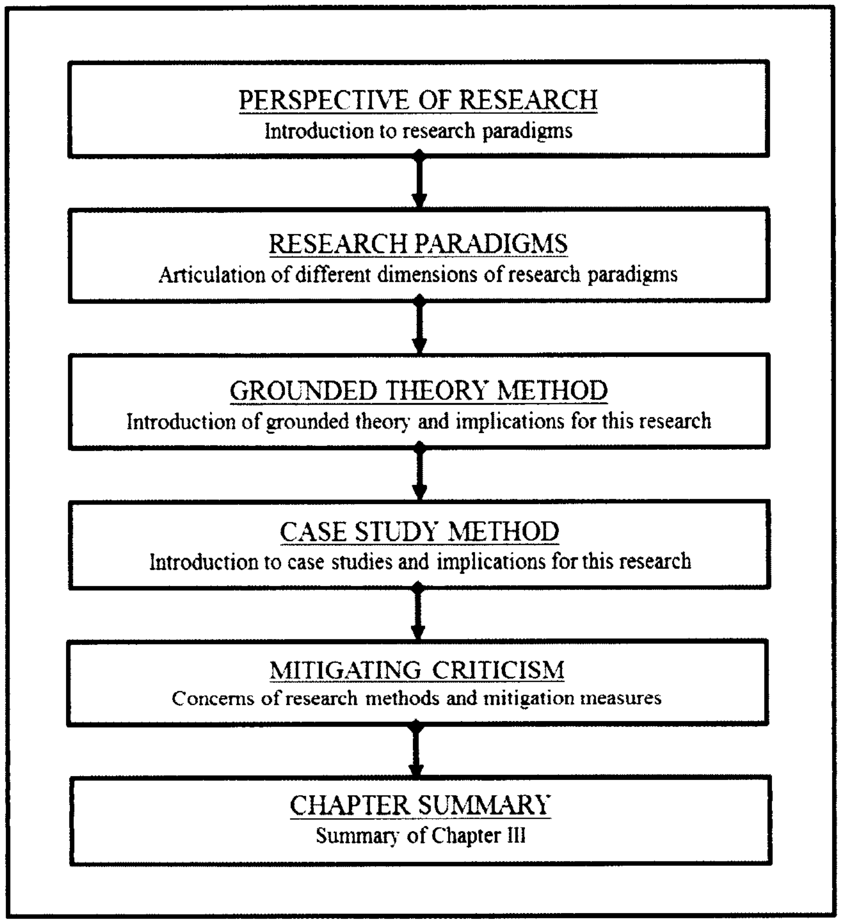


Figure 12: Organization Diagram for Chapter III

3.1 RESEARCH PARADIGMS

The importance of establishing a research paradigm is prevalent in the literature (Bateson, 1972; Burrell & Morgan, 1979; Churchman, 1968; Flood & Carson, 1993; Denzin & Lincoln, 1994). This section of the research elaborates on the research paradigm that underlies the design, execution, and interpretation of the research. In essence, a research paradigm is taken as a particular worldview that informs the conduct of research. Central tenets of research paradigm have been captured as:

- a world view, a general perspective, a way of breaking down the complexity of the real world (Patton, 1990)
- an interpretative framework, guided by a particular set of beliefs and feelings concerning how the world should be studied and understood (Guba, 1990).

Therefore, at the most fundamental level, the heart of any rigorous research is the need to establish a paradigm for contrasting knowledge claims. Typically, knowledge claims are established along two contrasting ends of a spectrum. At one end of this spectrum, we have the traditional scientifically-based research paradigm for advancing knowledge in natural sciences (Denzin & Lincoln, 1994; Flood & Carson, 1993). On the other end, we have a renewed call for social inquiry from a social science perspective (Churchman, 1971; Flood & Carson, 1993). In a traditional model of scientific research, the researcher "initially requires reduction; singling out a portion of reality ...set[s] a hypothesis about this portion of reality...design[s] an artificial situation where this small number of variables can be investigated while the remainder are held constant. Experimental design is important, with the experiment purposely devised to test the hypothesis with the aim of refutation. Knowledge accrues from this method" (Flood & Carson, 1993, p. 249). In effect, this perspective represents the positivist perspective of knowledge as being absolute, objective, and confirmable.

Conversely, a researcher may focus on the social science perspective, the interpretive or naturalistic paradigm, where deeper understanding of reality and meaning of phenomena are subjective rather than being based on hypothesis, cause and effects (Creswell, 2009; Lincoln & Guba, 1985; Patton, 2002). Consequently, the basic difference between these paradigms can be described in terms of deduction - theory testing (Abraham, 1936; Leedy & Ormrod, 2010) and induction - theory building (Feibleman, 1954; Lipton, 2002; Robinson, 1951). Figure 13 is drawn to illustrate the basic underlying differences in two research paradigms.

These contrasting ideas form the basis for a long standing debate on reality and knowledge (Guba, 1990; Johnson and Onwuegbuzie, 2004; Patton, 2002). This debate continues as unsettled and is beyond the purpose of this research. However, the following remarks can be used to provide the essence of this long standing debate (Patton, 2002):

> *In its simplest and most strident formation, this debate has centered on the relative value of two different and competing inquiry paradigms: (1) using quantitative and experimental methods to generate and test hypothetical-deductive generalizations versus (2) using qualitative and naturalistic approaches to inductively and holistically understand human experience and constructed meanings in context-specific settings. (p. 69)*

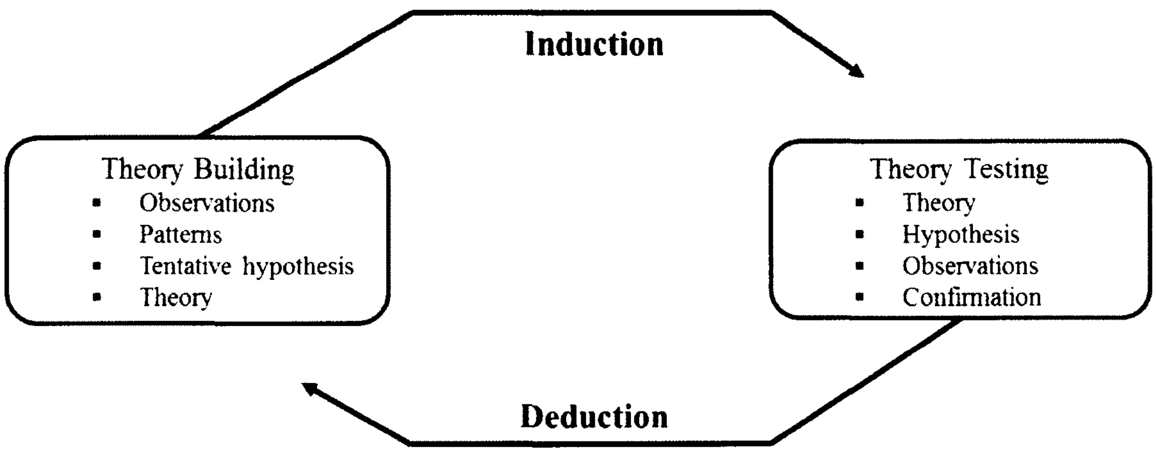


Figure 13: Two Major Paradigms of Research

To this end, it was necessary to establish the paradigm for this research. The paradigm for this research draws on the preceding chapters, especially the research questions in Chapter I and the developed perspective on nature of metasystem pathologies as articulated in Chapter II. It also helped establish "a set of ideas, a framework (theory, ontology) that specifies a set of questions (epistemology), which are then examined (methodology, analysis) in specific ways" (Denzin & Lincoln, 2000, p. 11). Moreover, Bateson (1972) argues that as one conducts research, one is "bound within a net of epistemological and ontological premises which – regardless of the ultimate truth or falsify – become partially self-validating..." (p. 314).

Therefore, the researcher had to develop an informing perspective for this research. Four philosophical underpinnings of methodology, epistemology, ontology, and nature of human beings as described by Burrell and Morgan (1979) and extensions of Flood and Carson (1993) are the basis for the research perspective developed to inform a paradigm for this research. Each of the philosophical dimensions exists along two extremes of subjectivity (induction) and objectivity (deduction). These dimensions are often used to shape the direction, interpretation, and the outcome of the research (Bradley, 2014; Calida, 2013; Crownover, 2005). The following section discusses the four dimensions of research paradigm and their implications for this research.

3.1.1 Methodological Perspective

A methodological aspect of research describes the means by which the researcher attempt to understand, investigate, and gain knowledge in the world. Flood and Carson (1993) establish that methodology deals with the way a researcher "attempts to investigate and obtain knowledge about the world in which we find ourselves" (p. 247). Extrapolating from Burrell and Morgan's (1979) work, Flood and Carson (1993) also suggest that there are two opposite extremes of methodology: nomothetic and idiographic. A ***nomothetic*** perspective of methodology is undertaken when a researcher is interested in "analyz[ing] relationships and regularities between the elements of which the world is composed; the concern is the identification of the elements and the way relationships can be expressed. The methodological issues are concepts themselves, their measurement, and identification of underlying themes. In essence, there is search for universal laws that govern the reality that is being observed. Methodologies are based on systematic process and technique" (pp. 247-248). This approach supports a quantitative, or positivist worldview where the researcher tests a theory (Creswell, 2009; Leedy & Ormrod, 2010).

However, as expressed in Chapters I and II of this research, the researcher was interested in building a theory (construct). Therefore, the dimension of methodology directed toward building theory was needed. This is supported under the ***idiographic*** dimension, which assumes that "one can only understand the social world by obtaining first-hand knowledge of the subject under investigation. It thus places considerable stress upon getting close to one's subject and exploring its detailed background and life history" (Burrell & Morgan, 1979, p. 6). Under this dimension, Flood and Carson (1993) suggest that the researcher's "principal concern is to understand the way an individual creates, modifies, and interprets the world" (p. 248). Thus, in this respect the researcher must be willing to develop "situation-specific meanings" (Schwandt, 1994, p. 118) in the research drawn from an immersive and interpretative engagement with the research data.

Following the research questions in Chapter I and discussions on systems theory, complex systems, systems of systems, systems-based methodologies, and systems pathology in Chapter II, an ideographic approach to methodology was considered necessary to support the aims of the research. This is consistent with a systemic view of social aspects of reality, including 21st century problems that can neither exist in isolation nor be understood in isolation (Capra, 1997; Hammond, 2002; Laszlo, 1996; von Bertalanffy, 1972) from the context within which they are embedded. Additionally, the complexity associated with the phenomenon under study and participants in the case study aspects of the research suggest, "objectives are unclear, some important variables are unquantifiable, and the analysis will necessarily have to include examining the value systems underlying the various possible objectives" (Checkland, 1985, p. 155). Furthermore, values may be "implicit and most probably incomplete and conflicting" (Gibson et al., 2007, p. 63), requiring a 'systemic,' subjective, and interpretive approach as most appropriate to respond to the research questions.

A rigorous interpretative approach is consistent with qualitative research where subjectivity is a key element (Glaser & Strauss, 1967; Strauss & Corbin, 1990). In this present research, subjectivity is demonstrated in participant's views of pathological conditions as suggested by Dery (1984). Therefore, "a problem [or pathology] is not the same for all interested parties" (Becker, 1966, p. 7) and might even not be the same to all "disinterested parties, or even to the same researcher" (Dery, 1984, p. 25). A nomothetic-objective stance is not appropriate for this research, since knowledge of pathologies is subjective and dependent on the different perspectives of those experiencing a particular pathology.

It is noteworthy to establish that a qualitative research design supports the inductive paradigm and "begins not with a preestablished truth or assumption but instead with an observation...people use specific instances or occurrences to draw conclusions about the entire classes of objects or events. In other words, they observe a sample and then draw conclusions about the population from which the sample has been taken"

(Leedy & Ormrod, 2010, p. 33). Similar to Gioia & Pitre's (1990) view of methodology, this research is concerned with "coherent description, or explanation of observed or experienced phenomena…the process or cycle by which such representations are generated, tested, and refined" (Gioia & Pitre, 1990, p. 587). Consequently, this research considers concepts underlying metasystem pathologies as new, unique, and particular to each situation. As such, attempts to investigate and obtain knowledge in such cases have to include notions of subjectivity. Table 16 is drawn to list different qualitative methodologies and their appropriateness in support of this research. The research methodology section (Chapter IV) - including the case study application and the results section of this research (Chapter V) attest to this aspect of research.

Table 16: Qualitative Research Methods and Fit Selection

Methodology	***Descriptions***	***Fit Selection***
Ethnography	"…a strategy of inquiry in which the researcher studies an intact cultural group in a natural setting over a prolonged period of time by collecting, primarily, observational and interview data. The research process is flexible and typically evolves contextually in response to the lived realities encountered in the field setting" (Creswell, 2009, p. 13)	Not suitable for development of a systems-based construct for metasystem pathologies. The data being applied in developing construct are literature. This appears to contradict James Spradley's 12 step method applicable in ethnographic studies (Spradley, 1979)
Grounded Theory	"…a strategy of inquiry in which the researcher derives a general, abstract theory of a process, action, or interaction grounded in the views of participants. This process involves using multiple stages of data collection and the refinement and interrelationship of categories of information. Two primary characteristics of this design are the constant comparison of data with emerging categories and theoretical sampling of different groups to maximize the similarities and the differences of information" (Creswell, 2009, p. 13)	Does support inductive development of theory and construct from data. Thus suitable for first part of this research (constant comparison of data allowing for related concepts and categories related to metasystem pathologies to emerge)
Case Studies	…a strategy of inquiry in which the researcher explores in depth a program, event, activity, process, or one or more individuals. Cases are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time (Creswell, 2009, p. 13)	Suitable for the second part of this research where the interest is to provide a face validation of the proposed metasystem pathologies in real world settings

Table 16 (cont.)

Phenomenological Research	"…a strategy of inquiry in which the researcher identifies the essence of human experiences about a phenomenon as described by participants. Understanding the lived experiences marks phenomenology as a philosophy as well as a method, and the procedure involves studying a small number of subjects through extensive and prolonged engagement to develop patterns and relationships of meaning. In this process, the researcher brackets or sets aside his or her own experiences in order to understand those of the participants in the study" (Creswell, 2009, p. 13)	Not suitable since the researchers' perspective --- especially in development of the construct and extended understanding of systems theory and problem formulation --- are included in the research
Narrative Research	"…a strategy of inquiry in which the researcher studies the lives of individuals and asks one or more individuals to provide stories about their lives. This information is then often retold or restoried by the researcher into a narrative chronology. In the end, the narrative combines views from the participant's life with those of the researcher's life in a collaborative narrative" (Creswell, 2009, p. 13)	Not suitable for this research. The researcher was not concerned with neither 'tales from the field,' 'tales of the field,' no subscribe to ideas of chronology or 'participant's life' as suggested in Patton (2002)
Ethology	Ethology is the biological study of behavior (Merriam-Webster, 2006). This approach emphasizes observing subjects (typically animals) under more-or-less natural conditions, with the objective of understanding the evolution, adaptation (function), causation, and development of the species-specific behavioral repertoire. A typical approach to this method includes (1) identifying the behavior to be studied, (2) identifying the study population, (3) select participants, (4) collecting data by observing subjects in their natural environment, and (5) analyzing data (Gay & Airasian, 2002)	Not suitable for this research. The approach does not support inductive development of constructs

Table 16 (cont.)

Participatory Action Research	Participatory Action Research differs from other forms of qualitative research in that the research is conducted by the participants and the results are used directly to address the problems of the participants (Wadsworth, 1998; Whyte, 1943; 1991)	Not suitable for this research. The approach does not support inductive development of constructs. It could support the second of the research similar to case studies

3.1.2 Epistemological Perspective

An epistemological aspect of research deals with how a researcher (i.e., a system observer) begins to understand problematic situations and communicate knowledge to fellow researchers or observers. This dimension provides the form of knowledge, how knowledge is acquired, and what is considered to be 'true' or 'false' (Burrell & Morgan, 1979). There are two opposite extremes of epistemology: positivism and anti-positivism. A ***positivistic*** approach to research indicates that "knowledge is hard, real, and capable of being transmitted in a tangible form" (Flood & Carson, 1993, p. 247). This stance of epistemology supports the idea that it is possible to "explain and predict what happens in the social world by searching for regularities and causal relationships between its constituent elements…[and] that the growth of knowledge is essentially a cumulative process in which new insights are added to existing stock of knowledge and false hypotheses eliminated" (Burrell & Morgan, 1979, p. 5).

In contrast to positivism, the ***anti-positivism*** approach to research opposes positivism's view of knowledge as a hard, concrete, and tangible. This approach does not search for "laws or underlying regularities in the social affairs…[but supports] that one can only 'understand' by occupying the frame of reference of the participant in action" (Burrell & Morgan, 1979, p. 5). In anti-positivism, "knowledge is soft, more subjective, spiritual, or even transcendental – based on experience, insight, and essentially of a personal nature" (Flood & Carson, 1993, p. 247).

The researcher, well-aware of scarcity of literature supporting explicit use of systems theory in problem formulation and concepts of metasystem pathology, sided with the anti-positivistic view of knowledge. This research supports the notion that knowledge on the topic of metasystem pathologies is subjective and based on individual experiences – as articulated in literature of participants. Certainly, this is the case when "...people hold different views on (a) whether there is a problem [or metasystem pathology], and if they agree there is, (b) what the problem [metasystem pathology] is" (Vennix, 1996, p. 13). *Certainly, a successful development of a construct for metasystem pathology identification and testing of the construct's ability to articulate metasystem pathologies requires an anti-positivistic perception of pathological knowledge – knowledge about metasystem pathology is socially constructed.*

3.1.3 Ontological Perspective

An ontological aspect of research deals with existence of entities and how such entities can be grouped based on similarities and differences. Moreover, ontology can also describe how "an observer views the nature of reality or how concretely the external world might be understood" (Katina et al. 2014a, p. 49). Two opposite extremes of ontology are realism and nominalism. Based on Burrell and Morgan (1979) and extrapolations from Flood and Carson (1993), ***realism*** is captured as "external to the individual imposing itself on individual consciousness; it is a given 'out there'" (p. 247). Realism suggests that reality is objective in nature. On the other hand, ***nominalism*** describes reality as a product of individual consciousness. More significantly, nominalism ascribes to the assumption of individual cognition. Under nominalism, Burrell and Morgan (1979) note that "the social world external to individual cognition is made up of nothing more than names, concepts and labels which are used to structure reality" (p. 4). The utility of 'concepts,' 'labels,' and 'names,' is based on the convenience they offer as tools that can be used to make sense and describe reality (Flood & Carson, 1993).

In this research, a nominalistic view of the nature of reality informs the nature, development, and interpretation of metasystem pathologies. This is necessary since the idea of metasystem pathology identification construct are emerging and the constituent systems theory-based pathologies are partially dependent on cognition of observers – especially the ideas of 'existence' and 'consequences' of pathologies as later articulated in the case application of the developed construct.

3.1.4 The Nature of Human Beings

A final dimension of research paradigm is the nature of human beings. This aspect is essential since it provides a stance on man and his activities in society. It has been suggested that two opposite extremes of *determinism* and *voluntarism* can describe the nature of human beings (Burrell & Morgan, 1979; Flood & Carson, 1993). A *deterministic* view of human beings suggests that a researcher views human beings as "mechanistic, determined by situations in the external world; human beings and their experiences are products of their environment; they are conditioned by external circumstances" (Flood & Carson, 1993, p. 247). On the other hand, *voluntarism* suggests that human beings are "completely autonomous and free-willed" (Burrell & Morgan, 1979, p. 6) and therefore they have a "creative role [in their environment] and [can] create their environment" (Flood & Carson, 1993, p. 247). Burrell and Morgan's (1979) research also indicates that to the extent that social theories are concerned with human activities, a theory must be disposed to either implicitly or explicitly to one these viewpoints or an intermediate that can used to address human activities.

Given the nature of the research objectives and the descriptions of the nature of human and his activities, *the researcher felt that it was necessary to view human beings as voluntaristic. This suggests, for example, the need to account for different views when identifying the degree of existence of systems theory-based pathologies.* Making this point explicit allows for the influence of voluntaristic nature of humans to shape research design, the activities involved, and interpretation of research results, particularly the case application.

In Chapter I, the purpose of the research was presented. Fulfillment of this purpose will produce a construct for metasystem pathologies within the selected research paradigm. The research paradigm does not suggest that, regardless of design and execution rigor, the emergent construct will define absolute truth concerning metasystem pathologies. This is consistent with selection of Grounded Theory Method. In fact, Goulding (1999) states that "grounded theory will not appeal to the researcher in search of absolute certainties, neatly defined categories and objectively measured explanations" (p. 19). Figure 14 is drawn to illustrate the line of demarcation for this research along the dimensions of methodology, epistemology, ontology, and nature of human beings. This distinction is important, as it establishes the frame of reference, within which the research design and execution is planned, executed, and appropriately interpreted.

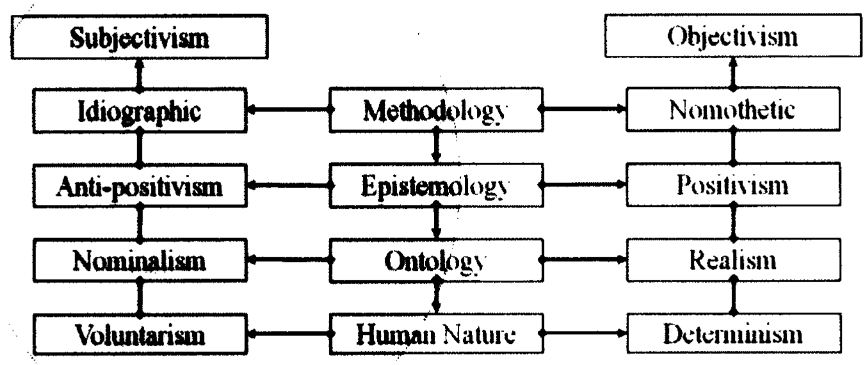


Figure 14: Research Perspectives and their Dimensions

3.2 GROUNDED THEORY METHOD

In this section, the Grounded Theory Method, selected for conducting this research, is introduced. As will be established, the Grounded Theory Method aligns with a more subjective, interpretivist, and qualitative paradigm of social sciences. This research stance is consistent with the developed perspective on metasystem pathologies and congruent with the tenets of the research paradigm articulated for this research. Grounded theory is one of the qualitative research methodologies supportive of the idiographic dimension of methodological perspective in the research paradigm. This method has been widely used when researchers are interested in building theoretical constructs (Glaser & Strauss, 1967; Strauss & Corbin, 1990).

The ultimate output of this method is a grounded theory. A grounded theory is discovered, developed, and verified within a dataset from which it emerges. Thus, Strauss and Corbin (1990) could declare that a grounded theory is a theory "that is inductively derived from the study of the phenomenon it represents" (p. 23). First developed in the

1960's by two sociologists (Barney Glaser and Anselm Strauss), the Grounded Theory Method operates in a reverse mode to the traditional scientific mode of research where a hypothesis is first proposed for a phenomenon (Allan, 2003; Glaser & Strauss, 1967; Strauss & Corbin, 1990). In grounded theory, a researcher does not begin with a theory and then attempt to 'prove' or 'disprove' it. Rather, research begins with data collection in a relevant area of study. The researcher then allows the data to drive the research until a theory (construct) emerges (Glaser, 1992; Moghaddam, 2006; Strauss & Corbin, 1990). This method is suited for researchers who "believe that the development of theoretically informed interpretations is the most powerful way to bring reality to light…and believe that theories represent the most systematic way of building, synthesizing, and integrating scientific knowledge" (Strauss & Corbin, 1990, p. 22).

As a methodology, grounded theory emerged as a response to what Glaser and Strauss (1967) called a "trend toward emphasizing verification" (p. 10) where it was widely accepted that "our 'great men' forefathers (Weber, Durkheim, Simmel, Marx, Veblen, Cooley, Mead, Park, etc.) had generated a sufficient number of outstanding theories on enough areas of social life to last for a long while" (Glaser & Strauss, 1967, p. 10). The next job was therefore, the applications and modifications of the already generated theories. However, with the passing of time, some researchers began to realize that the 'great men' had "not provided enough theories to cover all areas of social life" (Glaser & Strauss, 1967, p. 11). Even more troubling was the lack of methods for generating theories from data. Glaser and Strauss (1967) contended that "some theories of our predecessors, because of their lack of grounding in data, do not fit, or do not work, or are not sufficiently understandable to be used and are therefore useless in research, theoretical advance and practical application" (Glaser & Strauss, 1967, p. 11). Therefore, Glaser and Strauss set out to develop methodology that "enables discovery of theory from data" (Glaser & Strauss, 1967, p. 1) using processes of comparative analysis to generate conceptual categories that can be used to predict, explain, interpret, and apply in different settings (Goulding, 1999).

In Chapter II, it was indicated that there is a lack of explicit use of systems theory and identification of systematic pathologies during the problem formulation phase of systems-based methodologies. Given the essence of the Grounded Theory Method, there is a match to the purpose of this research. Consequently, the idea of attempting to establish possible relationships between *systems theory* and *problem formulation* to articulate *metasystem pathologies* fits within the scope of the Grounded Theory Method. Additionally, Egan (2002) established that the Grounded Theory Method is appropriate when little to nothing is known about the phenomena of interest. As indicated in Chapter II, there is scarcity of literature describing how systems theory is related to problem formulation especially at the metasystem level. Therefore, the researcher selected the Grounded Theory Method because of (1) its ability to help develop grounded theoretic constructs that makes the relationship between systems theory and problem formulation more explicit and (2) a grounded construct can help in inductive development and articulation of systems theory-based as well as metasystem pathologies.

The term theory in 'grounded' theory has a specific, and yet, broad meaning. Strauss and Corbin (1990) suggest that the term 'theory' is best described when contrasted to yet another term - *description*. They suggest that while the term 'theory' can be described in terms of a *set of related concepts that propose a reasonable explanation* *to explain a phenomena under study*, a 'description' might only provide themes and summaries of data with "little, if any, interpretation of data" (Strauss & Corbin, 1990, p. 29). Morse's (1994) definition enhances this view of theory when she writes that theory provides "the best comprehensive, coherent and simplest model for linking diverse and unrelated facts in a useful and pragmatic way" (p. 25). In this instance, a theory enables making the implicit relationships or links explicit using a variety of mechanisms including questions (Goulding, 1999). Therefore, the idea of developing a construct, metasystem pathologies identification, that helps explain how systems theory can be used to enhance problem formulation including at the metasystem level, is within the scope of the Grounded Theory Method.

Rather than a theory, this research uses the term 'construct' to project the idea that the discovered relationship, between systems theory and problem formulation - in terms of systems theory-based and metasystem pathologies, may have to go through several revisions before reaching a maturity level expected for a well-established theory. Needless to say, the developed construct is "a set of well-developed categories (e.g., themes, concepts) that are systematically interrelated through statements of relationship to form a theoretical framework that explains… [systems theory-based pathologies in complex systems]" (Strauss & Corbin, 1998, p. 22).

The Grounded Theory Method is not restricted for use in a particular research domain. In fact, one of the original developers of the method notes that "Grounded theory is a general method. It can be used in any data or combination of data" (Glaser, 1999, p. 842). Moreover, Strauss and Corbin (1990) proclaim that "One need not be a sociologist or subscribe to the interactionist perspective to use it. What counts are the procedures and they are not discipline bound" (p. 26). Since its introduction in the 1960s, grounded theory "has gradually spread beyond its initial concentration, and …is making inroads into other practical fields and other disciplines" (Dey, 1999, p. 13).

In this research, the researcher selected the Grounded Theory Method as a viable approach for developing a construct for metasystem pathology identification. *This selection is largely based on the researcher's initial methodological, epistemological, and ontological perspectives on the topic of research.* Literature is replete with different applications and utility of the Grounded Theory Method. However, the Grounded Theory Method is not without criticism.

3.2.1 Criticisms of the Grounded Theory Method

Just like any other approach, the Grounded Theory Method is with by no means faultless and without criticisms. Thus, the purpose of this section is to articulate criticisms associated with grounded theory research method and their impact on the research. A subsequent section, Section 3.4 of this chapter, identifies specific strategies for mitigating such criticisms. Since its inception, the Grounded Theory Method has encountered noteworthy criticisms. In a large part, these criticisms emerged due to the founders' attack on well-established 'logico-deductive' approaches (Crownover, 2005) as well as confusion brought by the method founder's use of 'positivistic' language (Keddy, Sims, & Stern, 1996). In fact, Keddy et al. (1996) posits that the founders of Grounded Theory Method "used the language of positivism: variables, hypothesis, properties, theoretical sampling, theoretical ordering, and so on. It is often this discourse that causes the frustration for the qualitative researcher" (p. 450). Their major criticisms appear to be at the forefront of challenges for grounded theory as a viable approach to conducting rigorous research.

One of the recent criticisms of the Grounded Theory Method is *the question of 'theory' being a product of application of the method.* Thomas and James (2006) write, "The 'theoretical' notion in grounded theory, in other words, conflates and confuses two processes in inquiry. It conjoins the spark to inspiration...with the predictive function of theory in the natural sciences and in functionalism. For describing what happens in qualitative research, the use of the term 'theory' only confuses what is going on. The former type – involving tacit patterning, interpretation and inspiration – really a vernacular employment of the term...and is part of everyday reasoning...The latter is about generalization following systematic and extensive data collection, and the testing of the generalization following systemic and extensive data collection, and the testing of the generalization for the purposes of verification or falsification" (p. 772). The first part of this criticism suggests that what Glaser and Strauss (1967) call 'theory' is simply everyday common knowledge. Glaser and Strauss would clearly object to this idea since their grounded theory has to be discovered "from data systematically obtained from social research" (p. 2).

In this research, the researcher was interested in generating a construct for metasystem pathologies based on the analysis of an extensive dataset as indicated in Chapter IV. The developed construct (theory) and the derived systems theory-based pathologies as well as clusters of metasystem pathologies are grounded in a variety of the dataset describing various laws, principles and theorems of systems theory.

Thomas and James's (2006) second criticisms has to do with the *utility of the developed grounded theory*. They argue that there is need to test and verify the developed theories. This criticism appears to be supported by earlier research. Specifically, Keddy et al. (1996) suggested that the language used in original text on grounded theory seems to suggest that the method is positivistic and therefore subject to traditional quantitative canons of verification. However, when the Grounded Theory Method was first introduced as a research method, the purpose was "to build theory that is faithful to and illuminates the area under study" (Strauss & Corbin, 1990, p. 25). There was a lack of theories and means to develop grounded theories. Moreover, Glaser and Straus's (1967) work clearly states: "While verifying is the researcher's principal goal and vital task for existing theories, we suggest that his main goal in developing new theories is their purposeful systematic generation from the data of social research. . . . Thus, generation of theory through comparative analysis both subsumes and assumes verification, and accurate descriptions, but *only* to the extent that the latter are in the service of generation" (p. 28). Additionally, the very selection and the application of the Grounded Theory Method "forces the analyst to verify and saturate categories" (Glaser, 1978, p. 58) because "While coding we are constantly moving between inductive and deductive thinking. . . There is a constant interplay between proposing and checking. This back and forth movement is what makes our theory grounded!" (Strauss & Corbin, 1990, p. 111). Furthermore, researchers employing this method "do not follow the traditional quantitative canons of verification. They do, however, check the development of ideas with further specific observations, make systematic comparison and often take the research beyond the initial confines of one topic or setting" (Goulding, 1998, p. 55).

Therefore, in this research, verification is maintained within the dataset used for the development of metasystem pathology identification construct and the derived systems theory-based pathologies using procedures of open, axial, and selective coding. Moreover, the researcher took measures to provide a 'face' validation of the articulated systems theory-based pathologies through a case application as indicated in Chapter IV.

A second shortcoming of grounded theory is the *failure for researchers to go beyond what appears to be simple surface data analysis*. Benoliel (1996) claims that a grounded theory should "explain how social circumstances could account for behaviors and interaction of people being studied" (p. 413). This criticism has been brought against the Grounded Theory Method because it appears that many researchers fail to "analyze data fully and especially to develop more abstract 'conceptual and theoretical codes'...[that form] the building block of theory" (Dey, 1999, p. 14). To be clear, Glaser and Strauss (1967) suggested that the Grounded Theory Method is defined as "the discovery of theory from data" (p. 2). The researcher is responsible for data collection and sense-making through the process of coding. A researcher is encouraged to use "constant comparative method of joint coding and analysis ...to generate theory more systemically than allowed by ...explicit coding and analytic procedures" (Glaser, 1965, p. 437). Four stages of this grounded theory (i.e., comparing incidents applicable to each category, integrating categories and their properties, delimiting the theory, and writing the theory) enable a researcher to go through a "continuous growth process – each stage after a time transforms itself into the next – previous stages remain in operation throughout the analysis and provide continuous development to the following stage until the analysis is terminated" (Glaser, 1965, p. 439). Failure to follow these foundational process might result in "fail[ure] to transcend an initial 'in vivo' coding and …fail[ure] to move beyond the face value of their data" (Dey, 1999, p. 14).

In this research, conceptual and theoretical codes for systems theory-based pathologies as well as the subsequent metasystem pathologies identification construct were developed based on the systems theory the dataset. The researcher developed and used several tools to ensure that theory (construct) was consistent with the dataset as well as intent of the research.

A related issue that forms another criticism of grounded theory is use of pre-conceived notions. The use of the Grounded Theory Method suggests that the researcher lets a theory emerge from the data. Thus, the researcher relies on his/her theoretical sensitivity to recognize important concepts pertinent to the research and his/her ability to give meaning to data (Glaser, 1978; Strauss & Corbin, 1990). The researcher is assumed to limit the use of pre-conceived notions. In other words, a researcher is urged to have "as few predetermined views as possible, especially logically deduced, prior hypotheses" (Urquhart, 2002, p. 49). It turns out that there is a divide between Glaser and Strauss on the issue of theoretical sensitivity.

The seminal work of Glaser and Strauss (1967) suggested that theoretical sensitivity is accomplished when a researcher identifies an 'emerging' theory from data without use of pre-conceived theories or hypotheses. In a later work, Glaser (1978) refers to 'theoretical coding' as means to "conceptualize how the substantive codes [codes developed ad-hoc during 'open coding' – the first stage of the coding process and relates to the empirical substance of the research area] may relate to each other as hypotheses to be integrated into a theory" (Glaser, 1978, p. 72). Theoretical codes emerge from "cues in the data" and can work to "weave the fractured story back together again" (Glaser, 1978, p. 72). However, Strauss and Corbin's (1990) work on 'theoretical sensitivity' suggests that coding should be based on a pre-selected theoretical perspective (Kelle, 2005) or a "coding paradigm" (Strauss, 1987, p. 28). A coding paradigm, which consists of four items (i.e., 'conditions,' 'interactions among the actors,' 'strategies and tactics,' and 'consequences'), is the essential piece that enables the researcher to structure data and clarify codes and their relationships (Kelle, 2005; Strauss & Corbin, 1990; Strauss, 1987). Thus, on one hand, the Glaserian approach encourages having as little preconceived concepts as possible on the area of study (Glaser, 1992, p. 22) while the Straussian approach advocates for use of guides that may enhance understanding (Walker & Myrick, 2006). The Straussian approach is appealing. A researcher is able to develop a grounded theory "without taking the risk of drowning in the data" (Kelle, 2005, p. 7) because of use *a priori* guiding frame of reference. However, the researcher must acknowledge possible limitations associated with use of a priori knowledge especially if the research is exploratory (inductive) rather than deductive (Glaser, 1992; Kelle, 2005). On the other hand, Glaser's (1992) criticism of Strauss and Corbin's 'coding paradigm' suggest that a researcher might 'force' categories into data rather than letting categories to 'emerge' from the data appears to have merit. Glaser (1992) goes as far as suggesting "not to review any of the literature in the substantive area under study" (Glaser, 1992, p. 22). However, this does not mean a researcher has to develop a grounded theory from a clean slate. In fact, Urquhart (2002) reminds researchers that "The 'tabula rasa' idea remains a popular misconception about GTM [Grounded Theory Method]...there is nothing in the

GTM literature that specifically precludes looking at relevant literature before entering the field" (p. 50).

Regardless of this criticism, both perspectives recognize the importance developing a theory from data. Moreover, a researcher is encouraged to "mix the two approaches with caution, aware that they may violate philosophical underpinnings of both; boundaries between the two should be maintained rather than a synthesis attempted" (Heath & Cowley, 2004, p. 147). Furthermore, it appears that the Glaserian approach "presents a wider range of perspectives on data than [Straus and Corbin's approach of] the coding paradigm" (Dey, 1999, p. 107). Cleary, the use of initial literature review to provide a guide for theoretical sensitivity for this research fits within the frames of the Grounded Theory Method. Moreover, a ***variety of mechanisms – including personal and professional experience, and the analytical process itself*** (Strauss & Corbin, 1990) could be used to enhance the theoretical sensitivity of the research.

This provides a convenient place to remind the reader that the researcher took a constructivist-subjective approach to grounded theory. The subjective perspective of grounded theory "assumes emergent, multiple realities, indeterminacy; facts and values as linked; truth as provisional; and social life as processual" (Charmaz, 2006, pp. 126-127) and as such, the researcher "sees both data and analysis as created from shared experiences and relationships with participants and other sources of data" (p. 130). By taking this perspective, the researcher assumes to develop a general metasystem pathology identification construct that respects specific situations and context from which different pathological conditions might emerge. However, the above criticisms appear to suggest that the Grounded Theory Method is not suitable as a research approach. In fact, Bryant (2002) writes, "Given the foregoing discussion, why not simply jettison GTM [Grounded Theory Method] in its entirety? The weaknesses of GTM [Grounded Theory Method] are evident" (p. 34). The response is simple: "the strengths of the methodology far outweigh its shortcomings" (Crownover, 2005, p. 80). Section 3.4 indicates how adhering to the procedures of Grounded Theory Method and canons of qualitative research helped to mitigate these criticisms.

3.3 CASE STUDY METHOD

The proceeding discussion provides a critique of the Grounded Theory Method and its appropriateness in developing a metasystem pathology identification construct. One of the key products of this research is the articulation of systems theory-based pathologies. During the course of this research, there emerged an opportunity to 'face' validate the utility of ideas of pathologies emerging from the research. In connection with this opportunity, a research method, a mixed case study method, selected for 'face' validating pathologies is introduced. Literature on the case study method (e.g., see Rouse & Boff, 2003; Stake, 1995; Thomas, 2011; and Yin, 2009) suggest that this method is suitable for situations when one is interested in a focused analysis for a given unit of analysis. This is in line with the objective of the second research question.

The second research question states: "***What results from the deployment of the metasystem pathologies identification construct in an operating setting?***" The purpose of this question is to provide a 'face' validation of the developed construct in a specific setting. The obvious methodological choice is a case study approach. A case study method can be used to provide a story about something pertinent to the study (Stake, 1995). Specifically, Yin (2009) suggests, "...you would use the case study method because you wanted to understand a real-life phenomenon in depth, but such understanding encompassed important contextual conditions – because they were highly pertinent to your phenomenon of study" (p. 18). By using a case study, the researcher is then capability of drawing preliminary conclusions regarding a developing theory (i.e., metasystem pathologies identification), insights into the phenomenon under study (i.e., linking systems theory to problem formulation) as well as constituent elements of systems theory-based pathologies and proposed future research.

Taken as a research method, a case study offers a rigorous approach for data collection, analyzing, and interpretation of observations and data (Frankfort-Nachmias & Nachmias, 1992). In this capacity, a case study becomes a research design or a blueprint for addressing study questions, identifying data to collect, and how to analyze data (Philliber, Schwab, & Samsloss, 1980). Thus, a case study is expected to "describe what happened when, to whom, and with what consequences in each case" (Neale, Thapa, & Boyce, 2006, p. 3). These ideas where appealing to the researcher since, there is a chance to provide immediate feedback on the utility of the construct. Specifically, the researcher is interested in the construct's utility in articulating the systems theory-pathologies, conditions affecting system performance, in different settings as well as identifying changes, if any, that need to be make the construct (theory) of metasystem pathologies identification to better contribute to problem formulation. In this research, Yin's (2009) well-established approach to the case study method is used as the baseline for face validating the developed systems theory-based pathologies identified in the theory development phase. A detailed discussion on the activities undertaken during mixed case study is provided in Chapter IV.

Several factors influence the selection of case study as an appropriate research method. These are stipulated by Yin (2009) as: (1) the type of research question, (2) the extent to which the researcher has control over actual behavioral events, and (3) the degree of focus on contemporary as opposed to historical events. Table 17 represents Yin's (2009) criteria for selection of a research method. Given the nature of the second research question, the methods addressing the 'what' type of questions are of interest to the researcher. Interestingly, Yin (2009) suggests that the 'what' type of questions is related to exploration or enumeration of phenomena under study. The exploratory-type of 'what' might yield relevant propositions that could further be explored to understand a situation under study. In such a situation, "any of the five research methods can be used" (p. 9) by a researcher. However, the enumeration-type of 'what' is mainly concerned with, for example, 'a number of ways' to improve a given situation. In such a situation, a survey or archival method would be a preferred approach (Yin, 2009).

Table 17: Criteria for Selection of Research Method, Adapted from Yin, 2009, p. 8

Method	**(1) Form of research question**	**(2) Requires control of behavioral events?**	**(3) Focuses on contemporary events?**
Experiment	how, why?	yes	yes
Survey	who, what, where, how many, how much?	no	yes
Archival Analysis	who, what, where, how many, how much?	no	yes/no
History	how, why?	no	no
Case Study	how, why?	no	yes

A survey design is appropriate for this research. It can be used to enumerate pathologies in a given unit of analysis. However, the researcher is also interested in variability in participants' view on pathologies (e.g., existence of pathologies, potential consequence, organizational resilience against pathologies, organizational susceptibility [state of being easily affected] against pathologies). This calls for specifically designed case that goes beyond enumeration of pathologies. Moreover, it is possible to have varying perspectives on the same pathology in the same unit of analysis or different units of analysis. ***Therefore, the researcher used a mixed approach to explore the results the deployment of the developed construct. The detailed design of this mixed approach is presented in Chapter IV.***

Furthermore, the choice of a case study mixed research design reflects a long standing philosophical paradigm consistent with the dimensions of methodology, epistemology, ontology, and nature of human being identified as grounding for this research. Methodologically, the researcher is interested in understanding different perspectives underlying different individuals or settings related to pathologies. Thus, this research supports the **idiographic** dimension of methodology, which assumes that "one can only understand the …world by obtaining first-hand knowledge of the subject under investigation" (Burrell & Morgan, 1979, p. 6). Epistemologically, this research suggests that knowledge about existence of pathologies of an organization "is soft, more subjective, spiritual, or even transcendental – based on experience, insight, and essentially of a personal nature" (Flood & Carson, 1993, p. 247). Thus, this anti-positivism perspective of the results of deployment of the construct suggests that we can expect different degrees of existence and variability in measures for pathologies.

Ontologically speaking, then the concept of metasystem pathology would have to be "a product of individual consciousness" (Flood & Carson, 1993, p. 247). This is indicated by the variance in case study results captured in Chapter V. Finally, the nature of human beings is taken to be voluntaristic since different people in the same organization may have a varying perspective on the same pathology. By taking a more inductive-subjective approach to the case study, a researcher is then able "to retain the holistic and meaningful characteristics of real-life events – such as individual life cycles, small group behavior, organizational and managerial processes, neighborhood changes, school performance, international relations, and the maturation of industries" (Yin, 2009, p. 4). The literature is replete with different applications and utility for the case study approach. However, just like the Grounded Theory Method, the case study method is not without criticism.

3.3.1 Criticisms of the Case Study Method

The purpose of this section is to articulate criticisms associated with case study approach and their implications for the research. Subsequent sections (3.4) identify research design responses for mitigating such criticisms. Four dominant criticisms of the case study method for research are addressed in this section. A first general criticism of case study method is that it lacks rigor (Neale et al., 2006; Yin, 2009). Surely, this criticism stems for the fact that the case study method is associated with qualitative research. Neale et al. (2006, p. 4) suggests that the case study method is "still considered unscientific by some and in many cases...[additionally] case study researchers have not been systematic in their data collection or have allowed bias in their findings" (Neale et al. 2006, p. 4). Moreover, researchers claiming to use case study method have been "sloppy, [have] not followed systematic procedures, or [have] allowed equivocal evidence or biased views to influence the direction of the findings and conclusions" (Yin, 2009, p. 14). This may as well be the case since the case study method is not widely used and therefore may have lacked specific guidelines that a researcher must follow (Yin, 2009).

A second common criticism of case study method is that case study results are not generalizable. The question here is, "How can you generalize from a single case?" (Yin 2009, p. 15). It turns out that critics fail to realize that scientific facts are rarely based on single experiments (Yin, 2009). Conversely, a researcher doing a case study must realize that multiple replications are needed before making concrete statements about generalizability of results to other settings. Nevertheless, Yin makes a point to distinguish between 'statistical' and 'analytical' generalization. Rather than focusing on statistical generalization (stemming from enumerate frequencies), the researcher doing a case study should focus on analytical generalization (expand and generalize a theory) in different conditions (Yin, 2009). ***In this research, the case study is only used to face validate pathologies articulated during development of metasystem pathologies identification construction. The purpose of the research served by the case study is to provide initial insights regarding construct's utility in formulating factors and issues affecting system performance.***

A tendency to have long narratives of the cases forms the basis for a third criticism against case studies. A researcher is advised to have a rich description of the case study using "detailed information [and] using a variety of data collection procedures" (Creswell, 2009, p. 13). Consequently, the narrative may be too long and therefore "massive [and] unreadable" (Yin, 2009, p. 15). However, a researcher can avoid creating a massive and painstakingly unreadable document by using current readily available computer-based tools. Moreover, a researcher can adapt better writing and displaying tactics (e.g., Data Accounting Log, Conceptually Clustered Matrix, Effects Matrix, etc.) as described in Miles, Huberman, and Saldaña (2014). ***In this researcher, the researcher utilized QSR International's NVivo 10 software package (Edhlund & Mcdougall, 2013) to aid in organization of coding and construct development in addition to implementing matrixes and displays to manage and analyze datasets.***

A noteworthy final criticism of case studies is that they are not 'true experiments.' The role of true experimentations is to indicate "*casual* relationships – that is, whether a particular 'treatment' has been efficacious in producing a particular 'effect'" (Yin, 2009, p. 16). Case studies are often not taken seriously because they are not designed to show causal relationships. However, Yin (2009) suggests that this criticism is superficial because true experiments do not address the question of 'how' or 'why' a specific treatment worked. ***In this research, the researcher is interested in utility of the developed construct especially in aiding to articulation of pathologies. The case is not used to draw conclusions of causal relationship to pathologies, why there are divergence in participant perspectives or whether a particular treatment is effective – treatment does not take place in this research.*** Moreover and in accordance with the purpose of this research, deployment of the developed construct in an operational setting is meant as an initial application to attempt to address issues affecting systems from a systems theory perspective. Therefore, the results of the case application might be of valuable complement to future experimental research and treatment of systems pathologies rather than an alternative.

3.4 MITIGATING CRITICISMS

Throughout this research, the importance of active accountability for research design decisions was purposefully maintained in selection of research methods. The purpose of this section is a two-fold. First, achieving trustworthiness in qualitative research based on rigorous canons of science is described. Second, specific measures undertaken to mitigate criticisms to grounded theory and case study methods are described.

At a general level, all research, qualitative or quantitative, is judged based on the degree to which four elements (canons of science) are met: significance, generalizability, consistence, and neutrality (Creswell, 2009, Guba, 1981; Leedy & Ormrod, 2010; Miles et al. 2014; Strauss & Corbin, 1998; Yin, 2009). Significance deals with truth-value and ensuring that the findings are credible based of a set criteria. Generalizability is the extent to with research findings are transportable to other situations beyond those of the original study. Consistence deals with the repeatability of research findings. Neutrality deals with ensuring that the findings are not biased by the researcher or the selected research design. Moreover, the divide between inductive-based qualitative and deductive-based quantitative research approaches forms the basis for differing criteria for judging the efficacy of each research approach.

In an inductive type of inquiry, the research is judged along the lines of credibility, transferability, dependability, and confirmability (Lavrakas, 2008; Patton, 2002). Conversely, deductive type of inquiry is judged along the lines of internal validity, external validity, reliability, and objectivity (Creswell, 2009; Yin, 2009). Figure 15 is drawn to identify the differing perspectives for judging research along the dimensions of qualitative – induction and quantitative – deductive distinctions.

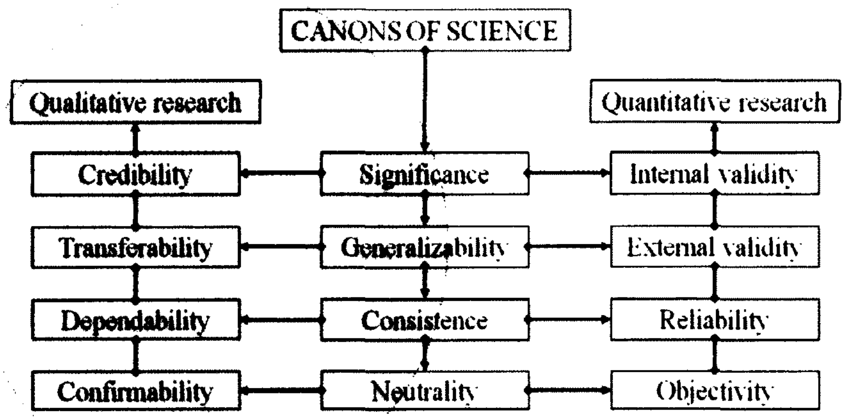


Figure 15: Dimensions of Canons of Science

Additionally, Table 18 presents further distinctions between canons of science for inductive and deductive research. Each column provides indicators that can be taken to enhance each element of the selected element of the canons of science. This suggests that criticisms to research have to be acknowledged in relationship to the specific type of research being pursued.

Table 18: Two Dimensions of Canons of Science and Their Indicators

Elements of Canons of Science	***Inductive Research***	***Traditional - deductive research***
Significance	**Credibility** - concerned with the level of congruency of findings and the reality (Merriam, 1998). Credibility can be established in qualitative research through (Shenton, 2004): ▪ Selection and use of well-established research method ▪ Familiarity with participants in the organization serving as a unit of analysis ▪ Use of random sampling ▪ Use of different methods to arrive at similar results (triangulation) ▪ Use of iterative questioning and transparency ▪ Use of negative case analysis ▪ Holding debriefing sessions with research a director ▪ Peer scrutiny and participant checking of the research project ▪ Theory building ▪ Background, qualifications, and experience of the researcher	**Internal validity** – this is concerned with ensuring that we measure what we think we are measuring (Brewer & Sousa-Poza, 2009; Sharpe, 1940). A researcher thus takes precaution to eliminate other possible explanation for the observed results. Internal validity in quantitative research can be increase through (Leedy & Ormord, 2010): ▪ Conducting research in a well-controlled setting so that environmental conditions are regulate ▪ Conducting research in a double-blind setting that attempts to eliminate any subjective, unrecognized biases carried by an experiment's subjects and conductors ▪ Conducting experiments in an unobtrusive manner such that participants or subject do not know that they are being observed ▪ Triangulation approach where multiple sources of data are collected with the hope that they will all converge to support hypothesis

Table 18 (cont.)

Generalizability (Applicability)	**Transferability** – This is equivalent of generalizability. However, since the purpose of inductive research is not to generalize findings to sites or systems beyond those of the original research, the value of qualitative research is in the descriptions and themes developed in context of specific cases (Creswell, 2009; Yin, 2009). Transferability is established in qualitative research through (Shenton, 2004): ▪ A researcher ensures that he/she is not concerned with statistical generalization ▪ Provision of background data to establish context of study ▪ Provision of detailed description of phenomenon under study to allow comparisons similar parameters, populations or characteristics	**External validity** – entails generalizability. This is concerned with the extent to which results of a quantitative study apply to situations beyond the study itself (Creswell, 2009). Generalizability in quantitative research can be enhanced through (Leedy & Ormord, 2010): ▪ Designing an experiment that incorporates as many real-life settings as possible ▪ Using a 'representative sample' of the population under study ▪ Undertaking the same study in different contexts and ensuring that the results are the same

Table 18 (cont.)

Consistence	**Dependability** – this is equivalent of consistence and refers to research's ability to account for changes in the phenomena of study and the design (Creswell, 2009; Guba, 1981). Dependability is established in qualitative research through (Shenton, 2004): ▪ Documentation of procedures as well as steps in the research design ▪ Provision of operational detail and data collection ▪ Avoid transcription mistakes ▪ Avoid drift in meaning of 'coding terms' ▪ Cross-checking of codes in a project that involves more than one member or restricted by space (evaluation of project)	**Reliability** – this is equivalent to consistence and it refers to the extent to which results are consistent over time using the same procedures, methods, tools and techniques (Golafshani, 2003). The research instruments are considered reliable if they can produce repeatable measurements, tests, and experimental findings (Brewer & Sousa-Poza, 2009; Creswell, 2009). Reliability in quantitative research is established through (Leedy & Ormord, 2010): ▪ The instrument should always be administered in a consistent manner with all participants or systems ▪ Establishment of a standard criteria for judging research results ▪ Any person using the tool should be well-trained and understand the underlying assumptions

Table 18 (cont.)

Neutrality	**Confirmability/Auditability** – this is qualitative research comparable concern to objectivity. It is concerned with ensuring that the findings are the result of experiences and ideas of participants (Guba, 1981). A researcher must make explicit any predispositions (Creswell, 2009; Guba, 1981). Confirmability is established in qualitative research through (Shenton, 2004): ▪ Use of triangulation to reduce effects of researcher's bias ▪ Explicit articulation of researcher's assumptions ▪ Recognition of research shortcomings in the applicable methods and their potential effects ▪ Provision of in-depths methodological description to allow scrutiny of research results ▪ Provision of diagrams to illustrate auditability that allows observer to trace course of research step-by-step through decisions make and procedures	**Objectivity** – this is quantitative researcher comparable concern to objectivity. This is concerned with ensuring that researcher's influences and biases are minimized to an acceptable level (Brewer & Sousa-Poza, 2009). Objectivity quantitative research can be enhanced through (Leedy & Ormord, 2010): ▪ Define the behavior being studied in precise and concrete manner so it is easily recognizable when it occurs ▪ Divide observation period into small increments to allow consistent measuring of observation behavior ▪ Standardization of a rating scale for evaluation of behaviors ▪ Use of independent measurers who can rate behavior without knowledge of each ones rating ▪ Training of raters in a standard evaluation technique to ensure consistence

In addition to adhering to the 'appropriate' the canons of science, a researcher may consider doing an evaluation of the research question to help decide an appropriate research approach to research – qualitative or quantitative. Table 19 is adapted from the work of Leedy and Ormrod (2010, p. 96) to distinguish between qualitative and quantitative research.

Table 19: Distinction between Qualitative and Quantitative Research, Adapted from Leedy and Ormrod, 2010, p. 96

Question	**Qualitative - inductive**	**Quantitative - deductive**
What is the purpose of research?	▪ To describe and explain ▪ To explore and interpret ▪ To build theory	▪ To explain and predict ▪ To confirm and validate ▪ To test theory
What is the nature of the research process?	▪ Holistic ▪ Unknown variables ▪ Flexible guidelines ▪ Emergent methods ▪ Context-bound ▪ Personal view	▪ Focused ▪ Known variables ▪ Established guidelines ▪ Predetermined methods ▪ Somewhat context-free ▪ Detached view
What are the data like, and how are they collected?	▪ Textual and/ image-based data ▪ Informative, small sample ▪ Loosely structured or non-standardized observations and interviews	▪ Numeric data ▪ Representative, large sample ▪ Standardized instruments
How are data analyzed to determine their meaning?	▪ Searches for themes and categories ▪ Acknowledgment that analysis is subjective and potentially biased ▪ Inductive reasoning	▪ Statistical analysis ▪ Stress on objectivity ▪ Deductive reasoning
How are the findings communicated?	▪ Words ▪ Narratives, individual quotes ▪ Personal voice, literacy styles	▪ Numbers ▪ Statistics, aggregated data ▪ Formal voice, scientific style

Once a research effort is classified as qualitative or otherwise, the researcher can then use such insights to focus on different elements of the selected research type to ensure that the appropriate instantiation of the canons of science are employed. Table 20 is also drawn from Leedy and Ormord (2010, p. 107) to elaborate on key features that guide a research in a selection of an appropriate research approach. A researcher can use these suggestions to aid in development of a defensible research design.

Table 20: Research Design Consideration Issues, Adapted from Leedy and Ormrod, 2010, p. 107

Use this approach if:	**Qualitative**	**Quantitative**	**For current research**
You believe that:	▪ There are multiple possible realities constructed by different individuals	▪ There is an objective reality that can be measured	▪ In systems research, different individuals construct realities and these realities are complimentary in nature. This is the taken for pathologies
Your audience is:	▪ Familiar with/supportive of qualitative studies	▪ Familiar/supportive of quantitative studies	▪ The researcher is familiar with qualitative research
Your research question is;	▪ Exploratory, interpretive	▪ Confirmatory, predictive	▪ The type of research under consideration is exploratory in nature
The available literature is:	▪ Limited	▪ Relatively large	▪ There is limited literature describing pathologies from systems theory
The focus of your research is:	▪ Involves in-depth study	▪ Covers a lot of breadth	▪ This research is focused in an in-depth study of relationship between systems theory and problem formulation
Your time available is:	▪ Relatively long	▪ Relatively short	▪ There was relatively long period of time to study the phenomenon
Your ability/desire to work with people is:	▪ High	▪ Medium to low	▪ The source of data is literature and there is high desire understand people`s ideas as presented in literate as well as their perspectives in settings
Your desire for structure is:	▪ Low	▪ High	▪ The research is mostly driven by data and not a preselected structured approach
You have skills in the area(s) of:	▪ Inductive reasoning and attention to detail	▪ Deductive reasoning and statistics	▪ Researcher extensively relies inductive reasoning to develop a construct for metasystem pathologies
Your writing skills are strong in the area of:	▪ Literary, narrative writing	▪ Technical, scientific writing	▪ There is an extensive use of memos narrating ideas related to pathologies

3.4.1 Measures to reduce criticisms

Section 3.4 provides a general distinction between qualitative and quantitative research as well as measures that can be undertaken to ensure that research fits within a selected research paradigm. The purpose of this section is to elaborate on specific measures undertaken to increase credibility, transferability, dependability as well as confirmability (i.e., trustworthiness) in this research concerning grounded theory and case study methods.

The Grounded Theory Method was exclusively used in development of systems theory-based pathologies as well as the metasystem pathologies identification construct. The face validation of the pathologies was undertaken in a mixed case-survey study that focused on identification of pathologies a unit of analysis. Table 21 is drawn to identify research methods, purpose of the methods, area of focus, elements of data collection, and means for data analysis.

Table 21: Basic Information Pertinent to this Research Design, Adapted from Leedy and Ormord, 2010, p. 146

Research Design	**Purpose**	**Focus**	**Methods of Data Collection**	**Methods of Data Analysis**
Grounded Theory	To derive a theory (construct) of metasystem pathology identification in systems theory literature	Relating to how systems theory can be used to enhance problem formulation phase of systems-based methodologies at the metasystem level	▪ Develop a codebook to further expand meaning systems theory dataset (e.g., Saldaña, 2013) ▪ Use Adams et al. (2014) paper to provide an initial starting point for data collection ▪ Elicit input from 'system experts' to ensure rigor undertaken in data collect and consistence in grounded theory application	▪ Develop a prescribed and systematic method of coding dataset into categories and identifying interrelationships ▪ Construct a theory from the developed categories and interrelationships – using seminal texts on Grounded Theory Method (e.g., Birks & Mills, 2011; Glaser & Strauss, 1967; Strauss & Corbin, 1990)
Case Study	To face validate theory (construct) and its derivative systems theory pathologies in an operating environment	Focus on an organization in it natural setting as a unit of analysis	▪ Use written documents ▪ Develop a standard survey tool to aid in data collection ▪ Use the developed survey to measure aspects of pathologies	▪ Agreement on existence the development pathologies and their enumeration ▪ Variability in individual perspectives pathologies ▪ Applicability and utility of the developed construct to aid in problem formulation

Overall, the trustworthiness of this research was improved by making of different mechanisms. The advice drawn from Creswell (2009), Eisenhardt (1989), Guba (1981), Leedy and Ormrod (2010), Shenton (2004), and Yin (2009) are used to address trustworthiness of the different areas of this research. More specifically, Eisenhardt (1989) research on reason for improving research is adapted to this research. Table 22 provides a summary of activities undertaken to improve quality of this research. Additionally, it's worth noting that some of mechanisms (e.g., QSR International's NVivo 10 software package for coding) are obvious from the beginning. However, other measures had to be developed as the research unfolded given the emergent nature of this research.

Table 22: Measures Undertaken to Improve Research Trustworthiness

Phase of Research	***Undertaken Activities***	***Reason for Activity***
Research initiation	▪ Developed a purpose consistent with qualitative research ▪ Ensure 'theoretical sensitivity'	▪ Alerts researcher of the appropriate research design ▪ Alerts researcher of possible preconceived concepts and biases
Literature selection	▪ Set a criteria for selection of literature	▪ A researcher retains theoretical flexibility
Enfolding literature	▪ Comparison of ideas with other - possible conflicting ideas ▪ Ongoing idea and concept comparison	▪ A researcher builds credibility, raises theoretical level, and sharpens theory (construct) definitions ▪ A researcher sharpens transferability, raises theoretical level, and improves theory (construct) definition
Crafting instruments and protocols	▪ Documentation of procedures and steps ▪ Elicit feedback from experts ▪ Apply external review ▪ Use triangulation (more than one survey responses)	▪ A researcher strengthens dependability ▪ A researcher strengthens confirmability of researcher ▪ A researcher provides means to assess biases and missing data from the research
Shaping theory	▪ Iterative tabulation of codes, concepts, and construct development	▪ A researcher confirms, extends, sharpens theory ▪ A researcher builds credibility
Reaching closure	▪ Theoretical saturation (ensure no more relevant codes, concepts emerge from data)	▪ A researcher ends process of coding when marginal improvement on the theory (construct) is small
Testing theory	▪ Application of the developed construct (case application in an operational setting) ▪ Avoid statistical generalization	▪ A researcher face validates the developed construct ▪ A researcher improves transferability
Theory implications	▪ Documentation of insights from application, suggesting changes, if any, and suggested venues of research	▪ A researcher ends research with implications for the developed theory (construct) ▪ A researcher draws conclusions of construct applicability, weaknesses, and future research

3.5 CHAPTER SUMMARY

This chapter introduced a philosophical paradigm in support of this research. Specifically, two contrasting approaches to formulation of a rigorous research paradigm were presented in regards to knowledge claims. This chapter indicated that dimensions of methodology, epistemology, ontology, and nature of human beings form the basis of any research. Using information presented in the preceding chapters, this research was identified as following an idiographic view of methodology were knowledge is subjective. Knowledge on pathologies is also soft and based on experiences and insights of the individuals making the attribution. Thus, elements of cognition and environment are essential elements of understanding systems theory-based pathologies for problem formulation.

In preparation of the second research question, this chapter demonstrated the level of appropriateness of the Case Study Method in face validating the emerging metasystem pathologies identification construct. A review of the method, its weaknesses, and the means to address criticisms were provided. This chapter forms the foundation for Chapter IV, which discusses details of the specific research design undertaken to execute grounded theory and deploy a mixed case-survey research design.

CHAPTER IV: RESEARCH DESIGN

This chapter discusses the research design for theory (construct) development and case application to respond to the research questions. Information pertinent to different activities in each of the research designs is discussed. The chapter builds upon research questions articulated in Chapter I, supported by pathology perspectives in Chapter II, and complimented by philosophical underpinnings presented in Chapter III. The research design enables development of the theory and supported through a case study to provide face validation. The theory development section discusses the Grounded Theory Method and the different activities that were undertaken during data collection and the coding that permitted construction of the systems theory-based pathologies. The outcome is the grounded theory-based phase of the research design is a theory (construct) for ***metasystem pathologies identification*** along with articulated pathologies that can be used to inform problem formulation in systems-based approaches. The case application phase discusses details of the mixed-survey case study application design that provided 'face' validation for the articulated systems theory-based pathologies. This face validation serves to demonstrate the capability of the theoretical construct for metasystem pathologies to be deployed in an operational setting. The findings from execution of this research design are presented in Chapter V. Chapter VI, which concludes this research, discusses implications and insights gleaned through the execution of this research as well as future proposed research directions based on findings. Figure 16 provides the organization of this chapter.

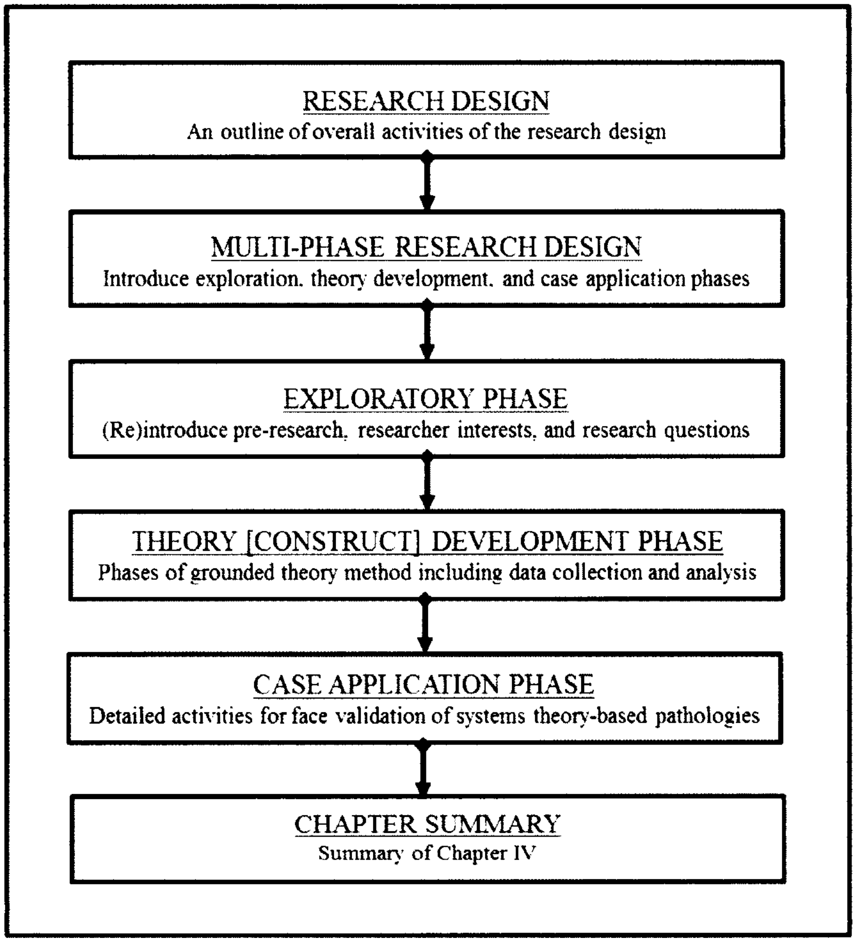
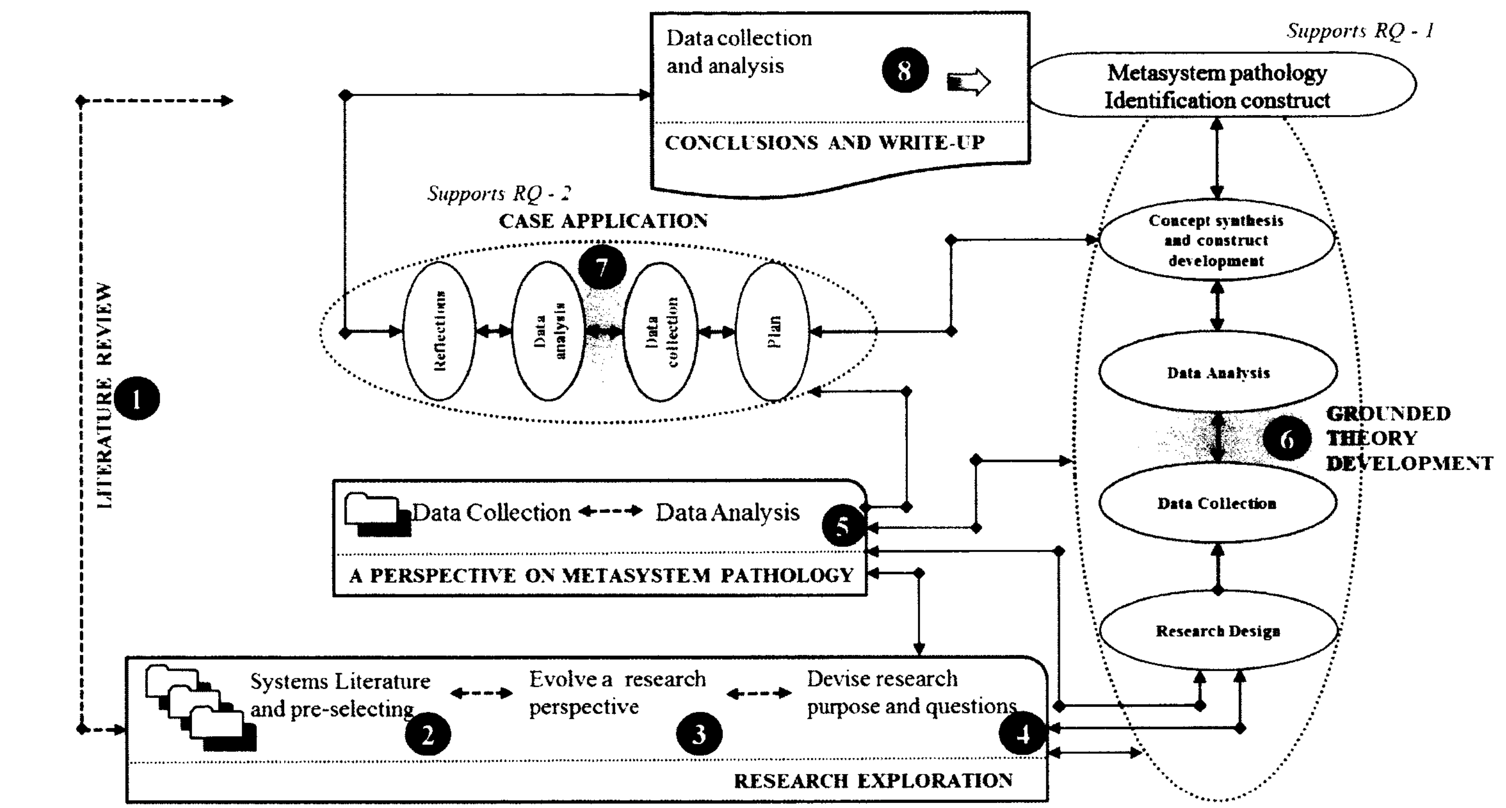


Figure 16: Organization Diagram for Chapter IV

4.1 MULTI-PHASE RESEARCH DESIGN

This section provides the overall plan and stages of the research design. Figure 17 depicts the high-level organization of the research design. A key aspect of this research is the role of literature and familiarity with key concepts of research. To keep research aligned with tenets of the Grounded Theory Method's call for avoiding preconceived notions, the researcher made it a point of emphasis to consciously avoid influence from previous research. However, it should be noted that the literature review section provided the basis for the research questions undertaken in the research. The scarcity of theoretical concepts explicitly linking systems theory to the problem formulation phase of systems-based methodologies supported the objective of avoiding preconceived concepts of systems theory-based pathologies and the subsequent theory (construct) of metasystem pathologies identification. The early exploration research and familiarization with emerging and evolving key concepts in literature aided in developing a 'working' definition of systems-based pathology as well as an 'emerging' perspective on metasystem pathology. This is does not violate the tenets of the Grounded Theory Method. In fact, Urquhart (2002) reminds us that we do not have to start with a "tabula rasa…[since] there is nothing in the GTM [Grounded Theory Method] literature that specifically precludes looking at relevant literature before entering the field" (p. 50). Glaser's (1992) warning to researchers: "there is a need not to review any literature in the substantive area of study" (p. 31) is meant to ensure that codes, categories and eventually theory (construct) emerge from data, not preconceived prior to the analysis.

The exploration phase of the research design represents a wider-range of literature including systems literature that formed the basis for devising research purpose, objectives and research questions. In this phase, the research was largely unstructured and involved insights from various venues including classes undertaken in the master's program, interests of the researcher, spinets of discussions with the dissertation advisor, and inputs provided on the dissertation proposal. In addition, the week-long process of candidacy examination and input from the dissertation committee provided a much-needed input to shape concepts in this research. During this phase, a working 'definition' of *systems-based pathology* took shape and as well as development of a *perspective on metasystem pathologies*. This phase concluded with the formulation of research purpose, objectives, and research questions. Section 4.2.1 provides a detailed account of activities in this phase of research. In addition, these preparations provided the 'theoretical sensitivity' identified by Glaser (1978) as a critical component of the Grounded Theory Method.



1 2 3 4 5 **RESEAERCH EXPLORATION:** Review of literature and clustering concepts that helped draw out ideas, research questions and perspectives pertinent to Systems Theory as the basis for Problem Formulation

6 **GROUNDED THEORY DEVELOPMENT:** Synthesis of literature 'data' using phases of Grounded Theory Method to inductively develop a construct of Metasystem Pathologies Identification based on concepts of Systems Theory

7 **CASE APPLICATION:** Application of the developed construct in a an operating setting to provide a 'face' validation of the articulated Systems Theory-Based Pathologies

8 **CONCLUSIONS AND WRITE UP:** A summary of how the state of knowledge was advanced through selected research design including critique of the developed theory (construct) and proposed future research

Figure 17: Overall Research Phases

The theory development phase was designed to respond to Research Question 1. This phase describes how systems theory can be used to generate systems theory-based pathologies and eventual development of a metasystem pathology identification construct that supports problem formulation in systems-based methodologies using the Grounded Theory Method. This is represented by the vertical ellipse in Figure 17. This ellipse, describing high-level stages of the Grounded Theory Method, is dashed to indicate that ideas and data from multiple streams were used to shape development of the theory (construct). As the research progressed through the different activities of the Grounded Theory Method, a constant comparison of ideas was made to purposely continue improvement of ideas being developed. This was especially important as data collection was a continuous process. It is important to stress that the "constant comparative method is designed to aid the analyst who possesses these [skills and sensitivities to the phenomena under study] abilities in generating a theory that is integrated, consistent, plausible, close to the data – and at the same time is in a form clear enough to be readily, if not partially, operationalized for testing in quantitative research. Still...the constant comparative method is *not designed...to guarantee that two analysts working independently with the same data will achieve the same results*; it is designed to allow, with discipline, for some of the vagueness and flexibility that aid the creative generation of theory" (Glaser & Strauss, 1967, p. 103 *emphasis is mine*). At the same time, notice that the double-headedness of lines linking different activities of grounded theory and case application, are meant to illustrate the iterative nature of the constant comparative method. The output of the theory development phase is a grounded theoretic construct of Metasystem Pathologies Identification and a listing of Systems Theory-Based

Pathologies pertinent to problem formulation phase in systems-based approaches. Section 4.2.2 provides a detailed discussion of steps undertaken during theory (construct) development.

The case application phase was designed to respond to Research Question 2. Originally, the research was designed to conclude with the discovery of an inductive theory of Metasystem Pathologies Identification. However, an opportunity emerged to explore construct utility in operational setting. In the case application phase, the researcher describes how the developed metasystem pathologies identification construct was 'face' validated in an operational setting using a mixed-case study approach. Yin's (2009) well-established case study method and its activities processes as well as a survey tool were used for a design that 'face' validated systems theory-based pathologies that were developed during theory (construct) development. It is important to note that the 'face' validation demonstrated the ability of the metasystem pathology construct to be deployed in an operational setting. Section 4.2.3 provides a detailed discussion on the design for case application including tools that were used. In each of these three major stages of research design, an emphasis on rigorous design and accountable execution were pursued to enhance the credibility of the results obtained to respond to the research questions.

4.2 DETAILED PHASES OF RESEARCH

The three phases of this research are research exploration, theory development, and case application. In each phase of research, specific mechanisms were used to execute the analysis strategy. Table 23 illustrates methods/techniques and primary references used in connection with data collection and analysis.

Table 23: The Three Major Phases of Research

Research phase	Data collection methods	Data Collection References	Data Analysis Methods	Data Analysis References	Expected output(s)
Exploratory	Data Accounting Log; Document Review	Patton, 2002; Miles et al., 2014; Strauss & Corbin, 1990	Grounded Theory Method	Patton, 2002; Miles et al., 2014; Strauss & Corbin, 1990	– A working definition of 'metasystem pathology' – An emerging 'perspective on metasystem pathology'
Theory [construct] development	Grounded Theory Method; Document Review	Birks and Mills, 2011; Glaser & Strauss, 1967; Strauss & Corbin, 1990	Grounded Theory Method; Document Review	Birks & Mills, 2011; Glaser & Strauss, 1967; Strauss & Corbin, 1990	– A listing of systems theory-based pathologies – Metasystem Pathologies Identification (MPI) construct
Case application	Case Study Method; Construct Table	Yin, 2009; Miles et al., 2014	Case Study Method; Construct Table	Yin, 2009; Miles et al., 2014	– Enumeration of pathologies – Degree of existence of pathology – Degree of consequence of pathologies – An overall pathological profile of the unit of analysis – Utility of the developed construct

4.2.1 Exploratory Phase

The exploratory phase is best described as a combination of pre-research and conception of research questions. As previously indicated, the researcher's interest in qualitative research was developed over an extended time and immersion in research literature. At the background, the researcher has always had interests in thinking in terms of *systems* and literature discussing holistic thinking. However, key concepts such as how a concepts of system theory might be used to enhance different phases of systems-based methodologies including problem 'framing', did not emerge until efforts for the preparation for doctoral research proposal were undertaken. In preparation for the proposal and especially during the candidacy exam, the researcher encountered interesting literature discussing 'system pathologies.'

Once the researcher sought to focus on problem formulation in terms of pathologies, literature discussing 'system pathology' was documented in a 'Data Accounting Log' to collect ideas concerning pathology in reference to 'health' of inanimate systems such as complex organizations (Barnard, 1946; Beer, 1984; Ríos, 2012), computer systems (Bobba, et al. 2007), and social systems (Beer, 1984; Yolles, 2007). During this process, the researcher examined Beer's (1984) work, *The viable system model: Its provenance, development, methodology and pathology*. In this work, Beer suggested that systems theoretic concepts of 'communication' and 'control' could be used to ensure complex system viability (Beer, 1984). Previously, Beer's (1979; 1981) research, as supplemented by Keating and Morin (2001) had suggested that viability of complex systems depended on execution of the necessary and sufficient subsystem functions of productive (S1), coordination (S2), operations (S3) and monitoring (S3*), system development (S4) and learning and transformation (S4*), and system policy and identity (S5). A key feature of Beer's (1984) paper is that "viable systems of all kind are subject to breakdown. [and] Such breakdowns may be diagnosed, simply in the fact that some inadequacy in the system can be traced to malfunction in one of the five subsystems, where in turn one of the cybernetic features …will be found not to be functioning" (p. 17). By linking concepts of systems theory (i.e., communication and control) to functions and viability of complex systems, it appeared that systems theory could serve as a basis for defining various aspects of complex systems. It is from here that the researcher sought to begin exploring how concepts of systems theory might enhance other aspects of complex systems in our natural world. Figure 18 shows the format for the initial Data Accounting Log, adapted from Miles et al. (2014) for 'systems pathology' in literature.

Sources	Definition of 'system pathology'	Ideas related to 'systems theory'
Beer, 1984	• Pathologies limit viability (i.e., capable of independent existence) of animate and inanimate systems • In addition, "viable systems of all kind are subject to breakdown. Such breakdowns may be diagnosed, simply in the fact that some inadequacy in the system can be traced to malfunction in one of the five subsystems, where in turn one of the cybernetic features …will be found not to be functioning" (Beer, 1984, p. 17)	• Management cybernetic is basis for viability functions • Viability functions are part of 'holistic thinking' • Pathologies are described in terms of: - Structure pathologies - Functional pathologies - Information and communication pathologies - 2-3-4-5 'metasystem' pathology
Barnard, 1946	• Pathology is used to describe organizational issues that affect performance of formal organizations	• Pathologies are described in terms of: - Functional pathologies - Scalar pathologies

Figure 18: A Partial Data Accounting Log for 'System Pathology'

Naturally, the initial ideas of 'systems pathology' led the researcher to expand into other areas of systems literature including 'systems theory,' 'complex systems,' 'systems of systems,' and 'systems-based methodologies.' Following further immersion in the literature, the researcher pursued the idea of using systems theory to enhance 'problem formulation' phase in 'systems-based methodologies' while focusing on a 'metasystem.' At this point in time, three assumptions were used as a guide to further formulation: (1) The concept of how 'systems theory' can be used to enhance problem formulation at the metasystem level was not explicitly articulated in systems literature, (2) The concept of 'metasystem pathology' had not translated into any rigorous research, with a minor exceptions of an emerging and related idea of 'system pathology' (e.g., Barnard, 1946; Beer, 1984, Keating & Katina, 2012), and (3) The concept of 'metasystem pathology' could be useful in helping to understand complex interdependent systems.

The combination of document reviews, insights on 'problem formulation' and 'system pathology' provided the basis for the emergent research purpose, objectives, and questions. Consequently, a working definition of 'metasystem pathology' was developed: *a circumstance, condition, factor, or pattern that acts to limit system performance, or lessen system viability and growth at the metasystem level, such that the likelihood of achieving desired performance is reduced.* Emerging out of a possible relationship among concepts of systems theory, metasystem pathology, and problem formulation in complex systems was an emerging perspective of metasystem pathologies as described in Chapter II. This emerging research perspective formed the basis for a 'research paradigm' underlying this research design as discussed in Chapter III.

Based in the emerging perspective of the research, coupled with the state of knowledge, the selection of appropriate research methods was performed. The selection of the method was based on reviews of different methods and their applicability to research questions. Table 24 (re)introduces research questions that were used in selection of research methods.

Table 24: Notes on Research Questions

Research purpose	**Research objectives**	**Research questions**	**Notes on research methods**
…to develop a systems theory based construct for identifying metasystem pathologies in the initial phases of complex system problem formulation for systems-based methodologies using the Grounded Theory Method	– Inductively develop a metasystem pathologies identification construct describing a relationship between systems theory and problem formulation phase of systems-based methodologies	– How can systems theory be used to generate a metasystem pathologies identification construct to support problem formulation phase of systems-based methodologies?	– Review well established methods to see their 'fit' to research questions
	– Deploy the developed construct to face validate its utility in an operational setting	– What results from the deployment of the developed metasystem pathologies identification construct in an operational setting?	

Finally, the researcher developed a filtering mechanism to protect the research from inclusion of *any* data. More specifically, a criterion for inclusion of systems literature as data was developed. A primarily criteria for inclusion of data in the research was that the literature must be describing systems theory. Systems theory was taken as "a unified group of specific propositions [laws, principles, and theorems] which are brought together to aid in understanding systems" (Adams et al., 2014, p. 113) in this research.

Table 25 provides further clarification on the criteria for inclusion/exclusion of different literature as data. The literature that passed these criteria were used during the first two phased of this research and by extension, the same data were essential in information of the statements and design for the mixed-survey case study application.

Table 25: Criteria for Inclusion of Literature Data

	Criteria for Literature Data
Include	Peer-reviewed literature
	Published a journal
	Published in conference proceedings
	Published in a textbook
	Cited in other published work
Exclude	Non-peer reviewed literature (e.g., magazine articles)
	Unpublished literature

4.2.2 Theory [Construct] Development Phase

The purpose of this section is to provide details on different stages and activities of the grounded theory research method application. This includes data, data collection, and data analysis as well as measures undertaken to support canons of qualitative research. The well-established phases of the Grounded Theory Method helped the researcher to surface impressions (pathological conditions) from evidence (data), conceptualization the data and analyzing it for emerging relationships between concepts (Egan, 2002; Birks & Mills, 2011; Glaser & Strauss, 1967; Saldaña, 2013; Strauss & Corbin, 1990; 1998). Figure 19 elaborates stages/activities of the Grounded Theory Method. It is noteworthy to point out that while the activities and processes in this phase of research appear linear, they are not. The researcher continually collected data and contrasted ideas until the point of saturation was achieved. Similar to Egan's (2002) suppositions on saturation, the saturation point for this research was achieved once ongoing data collection and analysis failed to yield new concepts contributing to or elaborating on systems theory-based pathologies or the central phenomena of metasystem pathology identification construct. The scope of theory development phase conforms to delimitations of this research as set in Chapter I.

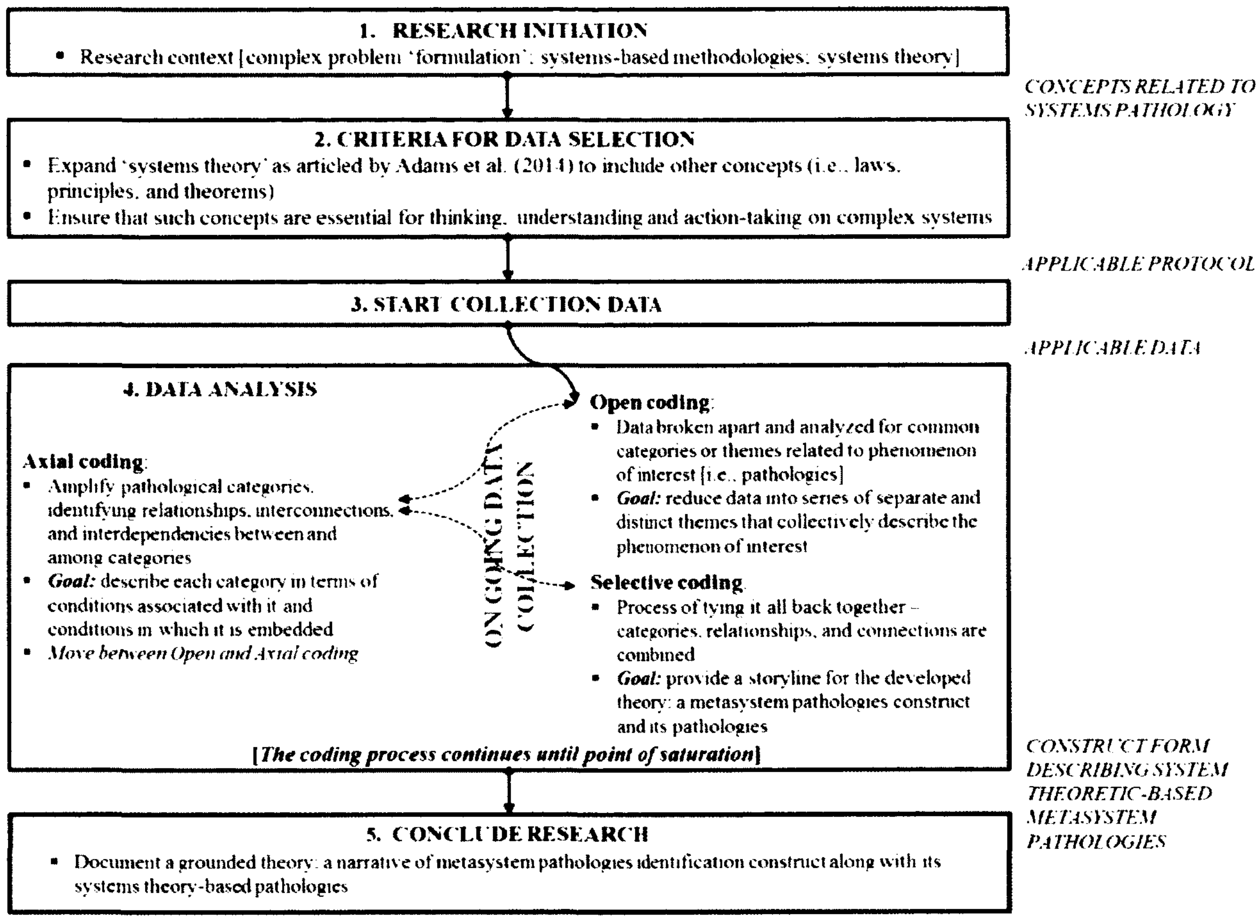


Figure 19: Activities of Grounded Theory Method, Adapted from Egan, 2002 and Strauss and Corbin, 1990

4.2.2.1 Research Initiation

The initiation phase of this research provides the area and context of the research. Egan (2002) notes that initiation of research is "an area of inquiry by the researcher can be described in a variety of ways or levels, including as a specific phenomenon, a place or location, or context" (p. 282). As previously articulated, the researcher wished to explore possible ways 'systems theory' can be used to inform different aspects of complex systems. Considerable time went into divulging research to sharpen the research focus before eventually settling on a finding possible ways 'systems theory' can be used to inform the 'problem formulation' phase of 'systems-based methodologies.' The definition of 'systems theory' from Adams et al. (2014) proved useful:

> *a unified group of specific propositions [laws, principles, and theorems] which are brought together to aid in understanding systems, thereby invoking improved explanatory power and interpretation with major implications for systems practitioners. It is precisely this group of propositions that enables thinking and action with respect to systems. (p. 113)*

Moreover, the perspectives projected in the Adams et al. (2014) appear to align with bylaws of *International Society for the Systems Sciences* – especially the investigation and transfer of concepts, laws, and models from various fields to help in understanding other fields (Adams et al., 2014; Hammond, 2002; von Bertalanffy, 1972). In this case, systems theory was used to inform problem formulation with a concentration on issues affecting system performance (i.e., pathologies).

Consequently, and in accordance with Beer's (1984) formulation of pathology (especially the idea of adhering to cybernetic principles) and supplements of Keating and Katina (2012), one might describe pathology as ***inadequate use of systems theory. Expressed as either the lack of application of laws, principles, and theorems of systems theory (i.e., not recognizing utility of systems theory) or a direct systems theory (i.e.,***

disregard for systems theory laws, principles, and theorems). Thereafter, initial investigation suggested that the contemporary view of systems theory, as postulated by Adams et al. (2014), might be extended to further our understanding of issues affecting complex system growth, performance and viability, in particular, from a pathological perspective as part of problem formulation that informs design, execution, and evolution of newly designed or operating systems.

4.2.2.2 Data Collection

Naturally, the systems theory literature data collection began with the journal article of Adams et al. (2014). In this paper, the authors draw from six major fields of science and 42 individual fields of science, using axiomatic methods, to propose 30 constituent propositions - inclusive of laws, principles, and theorems - as a collective of systems theory clustered around seven axioms. The axioms included centrality, context, design, goal, information, operational, and viability. A collective of the supporting literature for these 30 propositions formed an initial 'dataset' for building 'codes' and 'categories' for systems theory-based pathologies using the Grounded Theory Method.

In the Adams et al. (2014) alone, the authors present over 30 references to different laws, principles, and theorems of systems theory. However, since the purpose of the Adams et al. (2014) article was to articulate a formal definition of systems theory, the authors only provided a sufficient set proposition to satisfy their objective. The authors did not make the claim that the 30 constituent propositions reflect an exhaustive listing of systems theory laws, principles, and theorems. This formed the need for researcher to expand the search for additional concepts of systems theory. In the search for systems theory laws, principles, and theorem, Table 25 and Table 26 below were used to develop a comprehensive list of laws, principles, and theorems for systems theory.

Table 26: Criteria for Inclusion/Exclusion of Systems Theory Concepts

The laws, principles, and theorems "must have at least two specific areas of application" (Weinberg, 1975, p. 42)
A systems theory law is a well-established "generalization, based upon empirical evidence, which is well established, widely accepted, and which has considerable history behind it" (Clemson, 1984, p. 199)
A systems theory principle is a well-established "generalization, based upon empirical evidence, but which does not yet enjoy the status of a law" (Clemson, 1984, p. 199)
A systems theory theorem is a "a generalization which has been proven in a formal mathematical or logical sense" (Clemson, 1984, p. 199)

Unfortunately, there is scarcity of literature discussing 'systems theory' as a set of a "*unified group of specific propositions*" (Adams et al. 2014, p. 113). However, three documents: (1) Skyttner's (2005) *General Systems Theory: Problems, Perspectives*, (2) Clemson's (1984) *Cybernetics: A New Management Tool*, and (3) Krippendorff's (1986) *A Dictionary of Cybernetics*) provided an enhanced view of systems theory and the associated principles, laws, and theorems.

At the point in the research, sources for data of system theory concepts (systems principles, laws, theorems) were identified, the researcher then developed and applied a codebook. The construction and utility of this codebook followed Miles et al. (2014) along with supplements from Saldaña (2013) to assist in articulation of the meaning of the concepts associated with systems theory. This association was developed with an emphasis on pathological aspects of the concepts of systems theory. As a starting point, this manual process began with the 30 systems propositions as articulated in Adams et al. (2014). During this process, it became increasing evident that the concepts of systems theory for collection and analysis could be significantly expanded from the starting set provided by Adams et al. (2014). This expanded set provided for a deeper and rich set of system theoretic concepts pertinent to our understanding of complex systems, especially for ideas related to problem formulation. Perhaps not surprisingly, there emerged a theme suggesting that different concepts of systems theory are relevant to complex system growth, performance, and viability. Figure 20 shows an example of entries into the codebook developed for discerning the meaning of different concepts of systems theory. Appendix A contains a comprehensive set of these concepts.

Principle of emergence	
Short description	'emergence'
Detailed description	Complex systems exhibit properties which are meaningful only when attributed to the whole, not its parts. "Every model of systems exhibits properties as a whole entity which derive from it component activities and their structure, but cannot be reduced to them" (Adams et al. 2014, p. 11").
Seminal author(s)	Aristotle, 2002
Inclusion criteria	This principle suggests that there is need to understand wholes and parts alike. Knowing parts or processes of subsystems does not equate to understanding behavior that occurs as a result of their interactions
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	Weather, life
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	This principle suggests that understanding complex systems exhibit properties and behaviors that cannot be understood by studying parts or elements of the complex system
Aspect(s) of pathology	A lack of consideration of this principle could result in a an attempt to make a direct correlation between local issues (behavior) and system-wide issues (emergent issues)

Additional notes:

"Whole entities exhibit properties which are meaningful only when attributed to the whole, not its parts.....Every model of human activity system exhibits properties as a whole entity which derive from its component activities and not their structure, but cannot be reduced to them." (Checkland, 1993, p. 314)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.
Aristotle. (2002). *Metaphysics: Book H - Form and being at work*. (J. Sachs, Trans.) (2nd ed.). Santa Fe, CA: Green Lion Press.
Checkland, P. B. (1999). *Systems thinking, systems practice*. New York, NY: John Wiley & Sons.

Figure 20: An Example Codebook Page for Principle of Emergence

The set of parameters of inclusion/exclusion of literature as articulated this section only provides minimum requirements to initiate comparative data collection. It would be notes that in grounded theory, the ongoing sampling of literature as 'data' is expected and recommended.

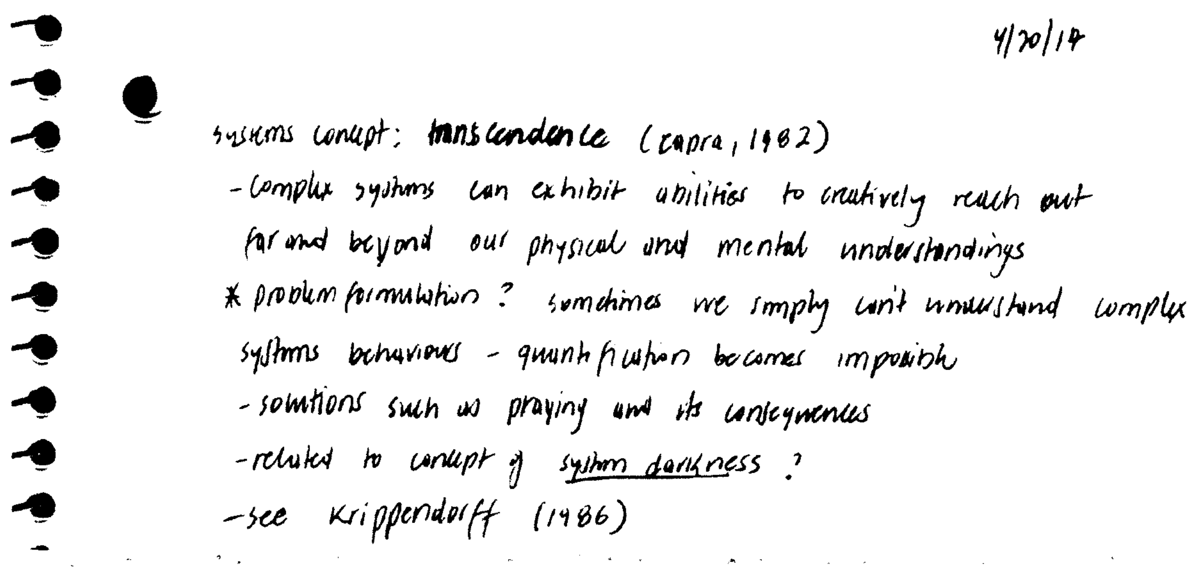
4.2.2.3 Data Collection Initiation

Any research method depends heavily on data collection and the Grounded Theory Method is no different. However, a key aspect of the Grounded Theory Method is that data can be collected from a variety of sources – including interview transcripts, participant observation field notes, journals, documents, drawings, artifacts, photographs, video, internet sites, e-mail correspondence and many other forms of literature such as textbooks (Birks & Mills, 2011; Leedy & Ormrod, 2010; Glaser & Strauss, 1967; Strauss & Corbin, 1990). As previously noted, the researcher began with three primary sources of literature pertinent to systems theory: *General Systems Theory: Problems, Perspectives (Skyttner, 2005), Cybernetics: A New Management Tool (Clemson, 1984), and A Dictionary of Cybernetics (Krippendorff, 1986)]*. Other literature data sources were acquired over time in accordance with the criteria established for inclusion in the set of data for analysis based on the Grounded Theory Method. This process was an on-going process that can be described as 'finding' concepts of systems theory. Generally, the concepts of systems theory were limited to well-known laws, principles, and theorems as indicated by Clemson (1984). Whenever possible, these laws, principles, and theorems are represented as quotations from the original works of the scholars to whom they are attributed. These concepts were coded for meaning around 'system pathology' within the context of *problem formulation*.

An initial saturation was reached when no new concrete concepts, laws, principles, or theorems describing complex systems emerged. In a similar manner, an initial saturation for pathological issues was reached when no new pathologies emerged from the collected concepts of systems theory. To aid in this process, the researcher created hand memos to capture insights from the collected literature datasets. At all times, the guiding question for the development of pathologies was:

- ***What does it mean to deviate from this concept?***

The researcher found that having this constant perspective as a reference point, helped assure continued focus on the relevant area of research (i.e., problem formulation) and drawing insights relevant to ideas of pathologies. Figure 21 presents an example of a hand memo developed for a systems theory concept of 'transcendence.' The researcher first found this concept in Capra's (1982) textbook *[The turning point: Science, society, and the rising culture].* Subsequently, Krippendorff's (1986) research was used in the development of 'codes' and 'concepts' of pathology related to transcendence.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systems concept: transcendence (Capra, 1982)
- complex systems can exhibit abilities to creatively reach out far and beyond our physical and mental understandings

* problem formulation? sometimes we simply can't understand complex systems behaviors - quantification becomes impossible
- solutions such as praying and its consequences
- related to concept of system darkness ?
- see Krippendorff (1986)

Figure 21: An Example of a Memo Taken to Capture Insights Related to the Concept of Transcendence

To supplement literature data collection, a six expert reviewers were asked to provide feedback on the initial list of concepts of systems theory as articulated by Adams et al. (2014). Table 27 provides a set of qualification for expert reviewers.

Table 27: Criteria for Outside Expert Qualifications

Qualification	**Criteria**
Education	Earned doctorate in complex systems, engineering management, systems engineering, systems of systems engineering, or engaged in a doctoral level program in one of these areas
Experience	Experienced in the field of systems, well-read researcher, author, or speaker with commercial or government systems engineering and systems-based methodologies

The selected experts provided validation of concepts of systems theory as well as expanded a listing of concepts of systems theory to be included in the analysis. Figure 22 provides the additions of concepts resulting from expert input concerning concepts associated systems theory.

#	Concept Type	Name of concept	Relevant source(s)
1	Principle	Basins of stability	Weinberg, 2001
2	Principle	Cybernetic stability	Macy, 1991
3	Principle	Frame of reference	Krippendorff, 1986
4	Principle	Least effort	Ferrero, 1894; Krippendorff, 1986; Zipf, 1949
5	Principle	Omnivory	Skyttner, 2005
6	Principle	Polystability	Ashby, 1960; Krippendorff, 1986
7	Principle	Safe environment	Skyttner, 2005
8	Principle	System Context	Keating, Calida, Sousa-Poza, and Kovacic, 2010; Keating, Peterson, and Rabadi, 2003
9	Theorem	Conant-Ashby	Conant and Ashby, 1970; Skyttner, 2005
10	Theorem	Pareto optimality	Barr, 2012; Yan and Haimes, 2011
11	Theorem	Shannon-Hartley (i.e., Channel capacity)	Price and Woodruff, 2012; Shannon and Weaver, 1949
12	Theory	Sociotechnical	Clegg, 2000; Cherns, 1976; Keating, Jacobs, Sousa-Poza, and Pyne, 2001

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Zipf, G. K. (1949). *Human behavior and the principle of least effort* (Vol. xi). Oxford, England: Addison-Wesley Press.

Figure 22: Results from Systems Experts

The concepts of systems theory that emerged out of the 'initial search' and validation by systems experts was further narrowed down in data collection and the subsequent analysis following (1) applicability of the concepts consistent with the area of research and (2) redundancy of the concepts. Specifically, the Second Law of Thermodynamics (Feynman, Leighton, & Sands, 1963; Landau & Lifshitz, 1955; McCulloch, 1965), despite being well-recognized in systems literature (Clemson, 1984; Skyttner, 2005), lacked clear applicability in the research. This law states, "in any closed system the amount of order can never increase, only decrease over time" (Skyttner, 2005, p. 99). However, the very nature of complex systems suggests that they operate as open systems in as much as the must exchange information with their environment (Warfield, 1976). In fact, Clemson (1984) posits: "Any organizational unit closed to its environment can never increase in order and must eventually decrease in order. Openness to the environment is the first requirement for survival, growth, learning, or change" (p. 209). While there might exist pathological conditions associated with thinking that an organization is a closed systems, and there are certainly implications for thinking so, this research is interested in complex systems that interact with their environment. In this research, such systems are not considered as 'closed' systems as in second law of thermodynamics. This said, however, it is possible to consider a complex system 'closed,' so long as a system is "taken together with its environment" as suggested in Skyttner (2005, p. 63). Conversely, other concepts of systems theory were omitted because they were already subsumed in other related concepts. For instance, the principle of variety-adaptability (Skyttner, 2005; Watt & Craig, 1988) is considered redundant. Skyttner (2005) notes that "systemic variety enhances stability by increasing adaptability" (Skyttner, 2005, p. 102). This concept is clearly subsumed in systems concepts of system environment (Skyttner, 2005), adaptation (Hitchins, 1992), viability (Beer, 1979; Clemson, 1984) and redundancy (Clemson, 1984; Pahl et al. 2011).

Therefore, pathological conditions associated with such a principle are reasonably addressed by considering pathological implications for the associated laws, principles, and theorems. Table 28 provides a list of concepts that met the criteria for omission and therefore not included in this research.

Table 28: A List of Common Concepts Systems Theory Not Used in Analysis

Concepts of systems theory	**Sources**
Law of indeterminability	Weinberg, 1975
Principle of negative feedback causality	Skyttner, 2005
Principle of positive feedback causality	Skyttner, 2005
Principle of variety-adaptability	Skyttner, 2005
Second law of thermodynamics	Clemson, 1984; Skyttner, 2005
Theorem of feedback dominance	Skyttner, 2005

Having done this iterative process, the researcher was left with eighty-three (83) concepts of systems theory for analysis in this research. Whenever possible, the researcher took every opportunity to collect and use original literature sources data describing concepts of systems theory. However, this was not always possible. In such instances, the researcher sought secondary literature for inclusion in the 'dataset' describing those relevant concepts of systems theory. Following the initial data collection and the subsequent continuous data collection, concepts of pathologies were developed in the data analysis.

4.2.2.4 Data Analysis

This section provides a detailed accounting for the activities that were undertaken for the data analysis. These analyses eventually led to the metasystem pathology construct (theory) and its corresponding systems theory-based pathologies. Four primary activities associated with the Grounded Theory Method - open coding, axial coding, selective coding, and theory development were used (Leedy & Ormrod, 2010; Strauss & Corbin, 1990). Table 29 provides an overview of these primary activities.

Table 29: Activities of Grounded Theory Method, Adapted from Leedy and Ormrod, 2010, p. 143

Activity	**Descriptions**
Open Coding	"The [text] data are divided into segments and then scrutinized for commonalities that reflect categories or themes. After the data are categorized, they are further examined for *properties* – specific attributes or subcategories – that characterize each category. In general, open coding is a process of reducing data to a small set of themes that appear to describe the phenomenon under investigation" (Leedy & Ormrod, 2010, p. 143). During open coding, specific 'codes' and 'categories' which are "researcher-generated construct that symbolizes and thus attributes interpreted meaning to each individual datum [concept of systems theory] for later purposes of pattern detection, categorization, theory building…" were developed (Saldaña, 2013, p. 4)
Axial Coding	"Interconnections are made among [emerging] categories and subcategories [of systems theory pathologies]. Here the focus is on determining more about each category in terms of: ▪ Conditions that give rise to it ▪ The context in which its embedded ▪ The strategies that people use to manage it or carry it out ▪ The consequences of those strategies The researcher moves back and forth among data collection, open coding, and axial coding, continually refining the categories and their interconnections as additional data are collected" (Leedy & Ormrod, 2010, p. 143). During axial coding, further refinement of system pathology categories was undertaken – including development of relationships to develop a more synthesized categorization of a coherent whole of system theory-based pathologies. These pathologies are organized and grouped together since "they share some characteristic" (Saldaña, 2013, p. 9) that make them "look alike" and "feel alike" (Lincoln & Guba, 1985, p. 347)

Table 29 (cont.)

Selective Coding	"The categories and the interrelationships are combined to form a *story line* that describes 'what happens' in the phenomenon being studied" (Leedy & Ormrod, 2010, p. 143). During selective coding, a storyline for metasystem pathologies identification was developed. During this phase of the Grounded Theory Method, all pathology 'codes' and 'categories' were integrated to develop a central/core idea emerging from data and "appears to have the greatest explanatory relevance" in the research (Corbin & Strauss, 2008, p. 104)
Theory Development	"A theory, in the form of a verbal statement, visual model, or series of hypothesis, is offered to explain the phenomenon in question. The theory depicts the evolving nature of the phenomenon and describes how certain conditions lead to certain actions or interactions, how those actions or interactions lead to *other* actions, and so on, with the typical sequence of events being laid out. No matter what the form of the theory takes, *it is based entirely on the data collected*" (Leedy & Ormrod, 2010, p. 143). A verbal narrative of the developed theory (construct) of metasystem pathologies identification (MPI) is provided in Chapter V – including its relationship to *problem formulation* in systems-based methodologies for complex system understanding

For this research, it can be said that the process of data analysis began with the Codebook for Systems Theory as depicted in Appendix A. In this codebook, each of the 30 concepts of systems theory (Adams et al., 2014) were recorded as 'codes' in a Microsoft Office's Word 2013 document and synthetized for pathological meaning. Table 30 provides properties of the codebook as modified from Saldaña's (2013) to support the present research purposes. This table was the basis for an expanded view of systems theory as well as initial development of systems theory-based pathologies.

Table 30: Properties of Initial Codebook for System Theory

Short description	**A code name for the selected concept of system theory**
Detailed description	A 2-3 sentence description of the coded datum's qualities or properties
Seminal author(s)	Citation(s) of author(s) who strongly influenced developments of the selected concept of systems theory
Inclusion criterion	Conditions of the concept or phenomenon that merit the code inclusion in this research
Exclusion criterion	These are exceptions or particulars of the datum that do not merit the code's inclusion in this research
Typical exemplars	1-2 examples of data that best represents the code
Atypical exemplars	An extreme example (if necessary) of data that still represent the code
'close' but 'no'	An example (if necessary) of data that could be mistakenly be assigned this code
Relevant note	Initial insights into how the code is relevant to phenomenon of complex problem formulation
Aspect of pathology	Initial insights into pathological issues based on the 'code'

Later, each systems theory concept was (re)analyzed using QSR International's NVivo 10 software package. In this analysis, each concept of systems theory was imported and coded as a distinctive 'text unit' and analyzed for meaning related to complex system problem formulation in NVivo 10. Figure 23 provides an illustration of the NVivo 10 interface used in this research. The left side of this figure illustrates the 'text units' from different authors that were coded for various concepts of systems theory. In this instance, 'law of complementarity' is selected to demonstrate the 'text data' used in developing codes for pathology related to law of complementarity. Some 'text units' were imported into NVivo 10 as 'memos', since it is not possible to import more extensive data sources such as textbooks into the software. Memo entries included 'analytic memos' which are defined as "not just as a significant word or phrase you applied to a datum, but as a prompt or trigger for written reflection on the deeper and complex meanings it evokes" (Saldaña, 2013, p. 42). More specifically, Mason (2002) notes that analytic memos enable "thinking critically about what you [the researcher] are doing and why, confronting and often challenging your own assumptions, and recognizing the extent to which your thoughts, actions and decisions shape how you research and what you see" (Mason, 2002, p. 5).

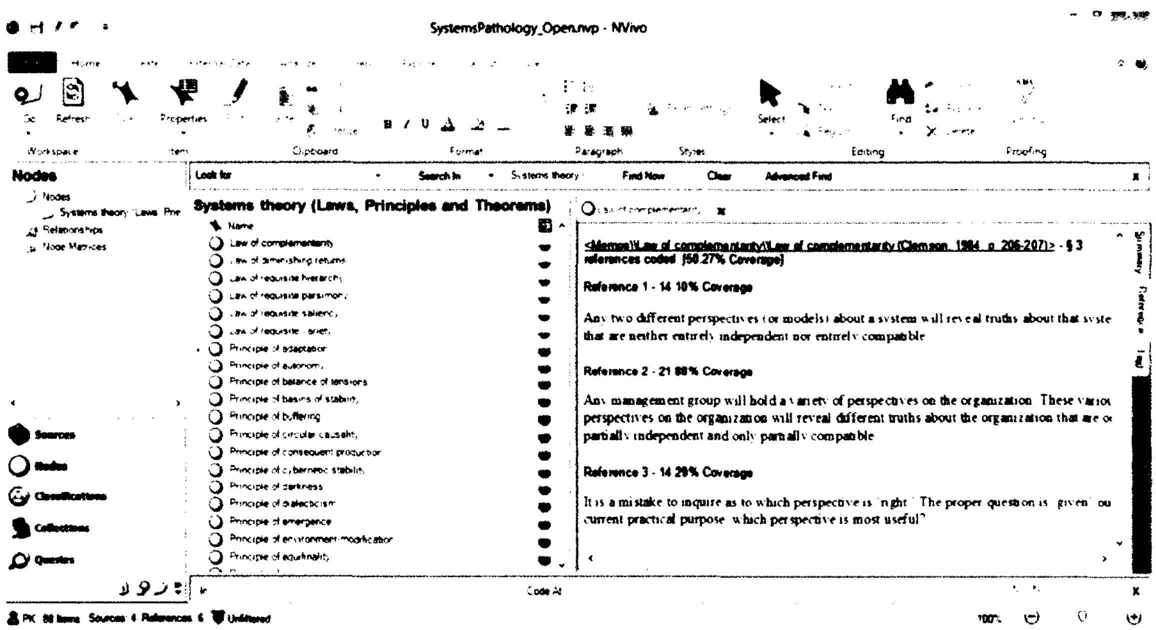

Figure 23: A Screenshot of QSR International's NVivo 10 Used in this Research

To initiate a grounded theory development of themes pertinent to problem formulation --- the data used for articulating concepts of systems were coded for pathology meaning. This was undertaken against the pathology perspective articulated for the research. This perspective included systems theory-based circumstances, conditions, factors, or patterns that act to limit system performance or lessen system viability and growth such that the likelihood of achieving performance is reduced (Barnard, 1946; Beer, 1984; Keating & Katina, 2012). The 'text data' in literature that were identified during data collection were coded for possible issues affecting system performance. Beer's (1984) notion of inadequate use of concepts of systems theory and Katina's (2015a; 2015b) suggestion of direct violation and not knowing the utility of laws, principles, and theorems of systems theory in design, execution, and evolution of newly designed or operating systems, proved useful. The listing of pathologies elaborated and changed over time based on discovery of new concepts of systems theory in the literature. The pathologies were developed by reflecting on the meaning of concepts of systems theory in relation to problem formulation.

The inductive approach undertaken in this research is consistent with the literature guiding researchers pursuing qualitative research (Auerbach & Silverstein, 2003; Boyatzis, 1998; Butler-Kisber, 2010; deSantis and Ugarriza, 2000; Saldaña, 2013). In inductive research, a researcher extracts "significant statements" (Butler-Kisber, 2010, p. 50) from data, "formulating meanings" (Butler-Kisber, 2010, p. 61) about them through the researcher's interpretation, and clustering meanings into coherent 'codes' and 'categories' with written descriptions supported by the text data. At the point of saturation, which was reached when no new unique ideas could be developed from data, a total of 362 codes describing possible issues affecting system performance had emerged. The themes associated with the 362 codes were then grouped to form an initial set of systems theory categories of circumstances, conditions, factors, or patterns that act to limit system performance emerged had emerged. A total number of 83 categories emerged from breakdown of concepts of systems theory. In grounded theory, an initial grouping of codes is done to discover "how various themes are similar, how they are different, and what kind of relationships may exist between them" (Saldaña, 2013, p.

178). This activity is referred to as **open coding** and the results of this activity are provided in Chapter V. The researcher then moved into axial coding activity.

In grounded theory, **axial coding** is used for "linking seemingly unrelated facts logically [and] fitting categories one with another" (Morse, 1994, p. 25). In this research, axial coding helped establish relationships among the developing system theory categories to enable further refinement of the developing pathologies. Following advice from Birks and Mills (2011) and Saldaña (2013), the researcher focused on different patterns such as conditions (i.e., similarities, differences, and sequencing), context, correspondences, and consequences that could be used to characterize different pathology categories. Saldaña (2013) notes that "before [relevant] categories are assembled, your data may have to be recoded because more accurate words or phrases were discovered for the original codes; some codes will be merged together because they are conceptually similar; infrequent codes that seemed like good ideas during First Cycle coding [open coding] may be dropped altogether because they are latter deemed 'marginal' or 'redundant' after the data corpus has been fully reviewed" (Saldaña, 2013, p. 207).

This axial coding approach proved essential in uncovering new relationships between the developed categories. QSR International's NVivo 10 software package proved useful in this aspect of research. The Query section of the software was used to uncover subtle data trends concerning word frequencies and overlaps in the categories. The software package gives the researcher the ability to view coded data units from a top down perspective to uncover potentially different interconnections. These were used refine groupings of pathology conditions.

To maintain principles of the Grounded Theory Method, the researcher went back and forth between open coding and axial coding to ensure that there existed a sufficient set of pathology categories for problem formulation rooted in concepts of systems theory. At saturation, a total of 15 initial major groupings of systems theory-based pathologies emerged from a set of 83 system theory categories. These 15 major groupings emerged through a critical examination of potential interrelationships among the seeming different 83 categories. The process of reducing 83 categories into 15 major grouping is consistent with Saldaña (2013) who suggest that "your First Cycle codes (and their associated coded data) are reorganized and reconfigured to eventually develop a smaller and more select list of broader categories, themes, concepts, and/or assertions" (Saldaña, 2013, p. 207). Yet the goal is "not to necessarily develop a perfectly hierarchical bullet-pointed outline or list of permanently fixed coding levels during and after this cycle of analysis" (Saldaña, 2013, p. 208). Once the 15 major groupings appeared integrated and there emerged no new categories without going into further abstraction, the researcher took this as an indication to transition into the next phase of grounded theory coding, selecting coding.

However, it was important to note that categories in this phase of grounded theory might be artificial. This view is supported by Wertz et al. (2011) research which suggests that "human life [and affairs] is of a piece, multilayered, contradictory, and multivalent, to be sure, but the strands are always interconnected" (p. 232). This is why, Saldaña (2013) suggests that "some interpretive leeway is necessary [and that] imagination and creativity are essential to archive new and hopefully striking perspective about the data" (p. 208).

The 15 categories appeared to be "the most salient categories" (Charmaz, 2006, p. 46) that could be grounded in the systems theory data to support "metasynthesis" (Saldaña, 2013, p. 207) of systems theory concepts as related to pathologies for problem formulation. In essence, the researcher took "to determine which [categories] in the research are the dominant ones and which are the less important ones…[and to] reorganize the data set: synonyms are crossed out, redundant codes are removed and the best representative codes [of pathologies] are selected" (Boeije, 2010, p. 109). The results of execution of the axial coding activity and the resulting major groupings are provided in Chapter V. Following completion of axial coding, the next phase of grounded theory coding, selective coding, further refined major groupings into metasystem pathologies.

Selective coding enables to achieve integration among categories developed in open and axial coding (Birks and Mills, 2011; Leedy & Ormrod, 2010; Glaser & Strauss, 1967; Strauss & Corbin, 1990). In fact, Saldaña (2013) refers to this activity as "an umbrella that covers and accounts for all other codes and categories formulated thus far in grounded theory analysis" (p. 223). It forms an integration phase where the search for the primary theme of the research is initiated (Birks & Mills, 2011; Glaser & Strauss, 1967; Leedy & Ormrod, 2010; Saldaña, 2013; Strauss & Corbin, 1990).

Initially, this process proved to be a difficult one as the different categories could not be integrated into one 'core category'. A core category has to be "abstract enough to encompass all [systems theory-based pathology categories related to problem formulation] that has been described in the [research] story" (Strauss & Corbin, 1990, p. 120). Eventually, the researcher settled on terms *metasystem pathology*. This was primarily influenced by two factors: First, this research was about a 'wide' range of listing of pathological conditions that might act to limit performance and lessen viability of complex systems. Second, the use of a grounded theory coding scheme – especially the activities of open and axial coding, could enable the researcher to group categories beyond any one grouping of the pathology categories. Consequently, the researcher adapted the term 'meta' from the systems language to suggest 'beyond and above' in describing a wide variety of issues that might be explored during problem formulation phase – to be identified as pathologies (Beer, 1979; Bunge, 1974; Krippendorff, 1986). This section of research was also enhanced by contrasting categories (i.e., systems theory-based pathologies) to an initial perspective on metasystem pathologies as developed in Chapter II along with notions of categorizing concepts of systems theory as postulated by Young (1964), Troncale (1977), and Adams et al. (2014).

In all, eight metasystem pathologies were developed. They constitute of several systems-theory based pathologies. While these eight metasystem pathologies represent integrated themes in systems theory-based pathologies, they are in themselves "not the theory itself, but an abstraction that models the integration" (Glaser, 2005, p. 17). The results of execution of the selective coding activity are provided in Chapter V. At this stage in research, the Open, Axial and Selective coding presented codes and categories that "have relevance for, and [can] be applicable to, all cases [systems theory concepts] in the study. It is the details included under each category…through the specifications of properties and dimensions, that bring out the case differences and variations within a category" (Glaser, 1978, p. 148).

Grounded theory research often concludes with a central idea. A central idea is a theory and might take a form of a "verbal statement, visual model, or series of hypothesis, is offered to explain the phenomenon in question" (Leedy & Ormrod, 2010, p. 143). Saldaña (2013) echoes similar sentiments when suggesting that "The central/core idea may lie in the name of one of the codes or categories developed thus far, but it may also emerge as a completely new word or phrase that subsumes all of the other above [previously articulated codes and categories]" (p. 225). This is also consistent with Corbin and Strauss' (2008) notion of developing a 'core category' "that appears to have the greatest explanatory relevance" (p. 104) for the phenomenon under study.

In accordance with Saldaña (2013), the researcher formed theory (i.e., the *Metasystem Pathologies Identification*) construct by reflecting on codes and categories as developed from the data of systems theory. In this research, the 'central/core' idea is presented as a statement accompanied by a conceptualization describing the phenomenon of metasystem pathology. The accompanying narrative describes how the codes and categories of systems theory-based pathologies relate to the central/core idea. This also includes descriptions of supporting context, conditions, and interrelationships within the frame of problem formulation for systems-based methodologies in complex systems. This aspect of research also "identif[ies] any variations within the developing theory" (Saldaña, 2013, p. 227). The issue of variations is essential in this research since, "...By focusing on a single variable [central/core idea], the research agenda may become one-dimensional rather than multi-dimensional" (Dey, 1999, p. 43). Metasystem Pathologies Identification (MPI) construct is presented in Chapter V.

The three activities described in this section - Open, Axial, and Selective Coding as well as the resulting construct are interrelated and did influencing another. Figure 24 is provided to illustrate this relationship as well as expected output of each phase.

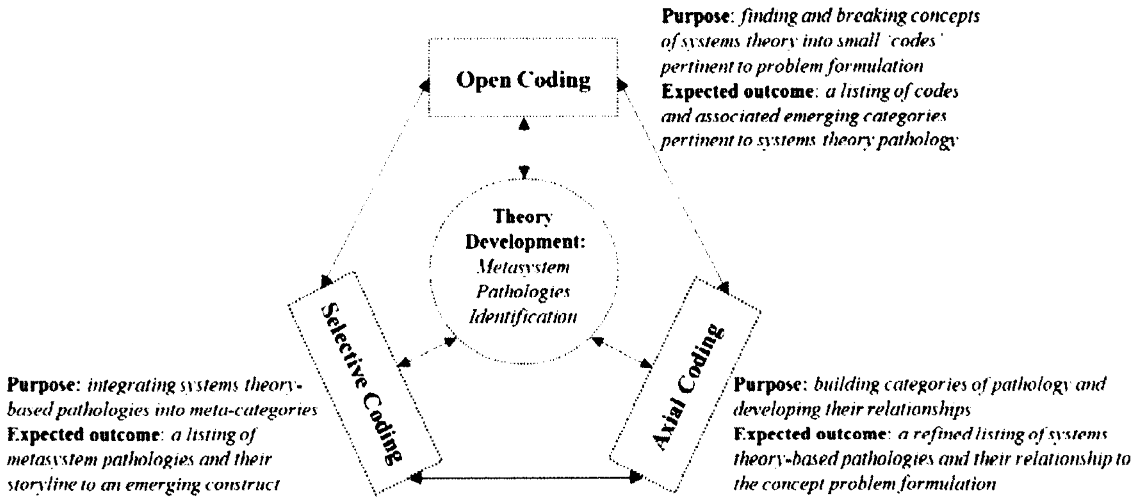

Figure 24: The Interrelated Activities of GTM Undertaken in this Research

Once systems theory-based pathologies were developed, a team comprising of eight members with advanced knowledge of the research were asked to provide feedback. These members had to meet a set of minimum qualifications as articulated in Table 31 below. A summary of their feedback is discussed in Chapter V.

Table 31: Criteria for Reviewing Systems Theory-based Pathologies

Qualification	**Criteria**
Education	Earned doctorate in complex systems, engineering management, systems engineering, systems of systems engineering, or engaged in a doctoral level program in one of these areas
Experience	Experienced in the field of systems, well-read researcher, author, or speaker with commercial or government systems engineering and systems-based methodologies

As the research was ongoing, there emerged an opportunity to 'face' validate the newly established metasystem pathologies identification and its systems theory-based pathologies. 'Face' validation provided a substantive value to ideas developed in the theory development phase. It is important to note that the 'face' validation was targeted to the ability to show utility of the theoretical for practice. The establishment of validation of the theoretical development of the grounded theory based theoretical construct is contained within the performance of the method itself. The design and activities of a mixed case-survey study for 'face' validation of the systems theory-based pathologies of this research are the subject of the following section.

4.2.3 Case Application Phase

The purpose of this section is to provide details on a mixed case study design used to face validate the developed construct for metasystem pathology identification. The case study phase of research responds to Research Question Two: ***What results from the deployment of the developed metasystem pathologies identification construct in an operational setting?*** In this section, a link between theory development and the case application phase is established. Also included is detailed information on the activities undertaken in the mixed case-survey design including data collection, data analysis, and reflections consistent with Yin's (2009) formulation of case study research design. Figure 25 is provided to illustrate an overview of activities for the case application for this research.

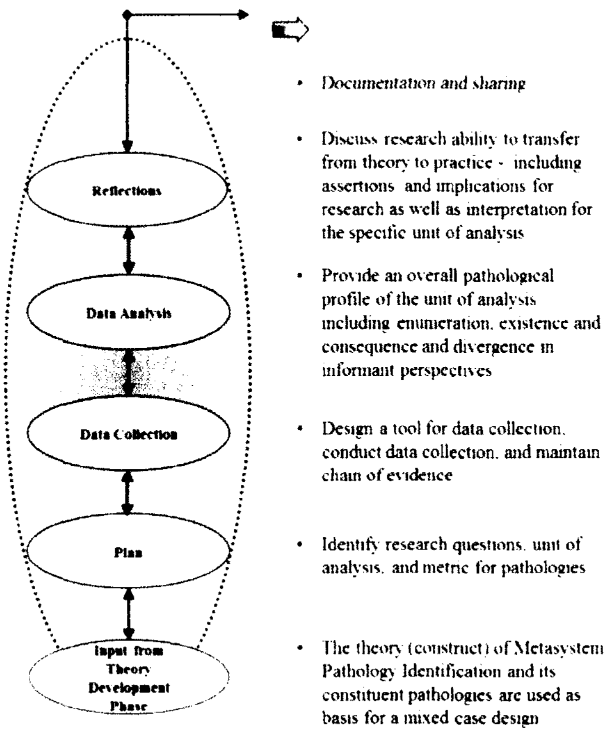

Figure 25: Activities of Case Design Approach, Designed from Shaughnessy et al. 2011 and Yin, 2009

4.2.3.1 Case Study Planning

Face validation of metasystem pathologies identification construct and the constituent pathologies in an operational setting required a detailed implementation design and planning. The purpose of this planning activity was to ensure that the results of the case could provide a relevant input pertaining to pathological conditions in an operational setting. To pursue this purpose, a mixed case-survey design approach was selected. This approach is especially recommended when a researcher is interested in a specific unit of analysis, a case (Yin, 2009). The survey part of the research was needed in connection with data collection (Shaughnessy et al. 2011). Consequently, to achieve the desired rigor related to case study research design, the following factors were considered relevant:

4.2.3.1.1 THE NEED FOR A UNIT OF ANALYSIS

A unit of analysis is defined as a "case" (Yin, 2009, p. 29) under study. The concept of a unit of analysis encompasses an "event or entity other than a single individual. Case studies have been done about decisions, programs, the implementation process, and organizational change" (Yin, 2009, p. 29). In this research, the targeted unit of analysis is identified as an organization (system). An organization is a complex multiminded sociocultural system with a specific purpose that may not be understood by analysis of component parts (Ríos, 2012). In this case, an organization is not limited to a governmental, non-profit or private, or an academic organization. The unit of analysis is used as a focus of the case study for purposes of 'face' validation of the applicability of the systems theory-based pathologies to an operational practice setting. Specifically, a unit of analysis is used for establishing the capacity for application of pathological concepts identified in the theory development phased to an operational setting.

Two indicators were developed as part of preparation work to assess pathologies. First was the degree of existence of pathology (P_E) in the unit of analysis. P_E was measured in terms of participant agreement on how a statement about a pathology accurately depicts the condition of the unit of analysis. These survey questions are presented in Chapter V. Participants were asked to provide their responses based on a seven point scale as indicated in Table 32. A seven-point scale was preferred over, say a five-point scale; since literature indicates that a seven-point scale is more reliable and offers stable results (Bandalos & Enders, 1996; Comrey, 1988; Nunnally, 1978; Preston & Colman, 1999).

Table 32: A Seven-Point Scale for Assessing P_E

Measured on a seven point Likert scale						
strongly disagree	*disagree*	*disagree somewhat*	*undecided*	*agree somewhat*	*agree*	*strongly agree*

The second indicator for assessing pathology was the "range of possible effects" (ASCE, 2009, p. 16) associated with the existence of the pathology (P_C) in the unit of analysis. P_C was measured in terms of participant agreement on the degree to which statement of pathology impacts the unit of analysis. Table 33 illustrates a seven-point scale used in connection with P_C. The intersection of P_E and P_C provided an X-Y plot of pathologies the unit of analysis.

Table 33: A Seven-Point Scale for Assessing P_C

Measured on a seven point Likert scale						
negligible	*very low*	*low*	*moderate*	*high*	*very high*	*extreme*

4.2.3.1.2 A WILLINGNESS FOR MEMBERS OF THE UNIT OF ANALYSIS TO WORK WITH THE RESEARCHER

To collect data pertinent degree of pathology existence and degree of consequences, the researcher needed to 'interact' with members of the unit of analysis. The process of data collection cannot take place without the cooperation of members of the organization (system). This agreement is essential on two fronts: (1) members of the unit of analysis (i.e., participants) are experts in the unit of analysis under study and (2) true to the holistic nature of this research, the different perspectives of participants reveal different 'truths' about phenomena of interest. Participants' perspective on their organization (i.e., unit of analysis) is the basis for P_E and P_C. Thus, development of these perspectives within the unit of analysis serves to provide a 'face' validation of the developed metasystem pathologies construct and its related systems theory-based pathologies.

4.2.3.1.3 A PROVISION OF ANONYMITY FOR THE UNIT OF ANALYSIS AND ITS MEMBERS

Some units of analysis require the provision of anonymity (Shaughnessy et al. 2011). The unity of analysis in this study was no different. The researcher ensured that the unit of analysis and the rights of participants in the unit of analysis were protected through anonymity and confidentiality. The software used in data collection, Qualtrics © software, was used to conceal the identities of individuals whose perspectives shaped this research. The researcher provided the participants with information regarding opting out at any time and well as the ability to change responses before submission of the survey. Finally, since the attributes of individual participants were masked, only participant numbers were used as well aggregated results of the analysis.

4.2.3.1.4 DEFINITION OF PROCEDURES AND TOOLS FOR MEASURING PATHOLOGIES

In addition to the above specifications, the researcher established qualification of an acceptable organization to be considered as a unit of analysis. Table 34 lists these qualifications. These qualifications ensured that an appropriate organization could be selected. Following agreement for participation, the researcher then introduced the research and guided the administration of the anonymous on-line survey instrument, Qualtrics © software, in the operational setting.

Table 34: Qualifications for an Acceptable Unit of Analysis

Criteria for qualification	**Relevant observations**
The unit of analysis had to be in existence	The statements of pathologies were crafted in relation to an existing system
The unit of analysis had to be meet the requirement for a complex system	There would be no need to engage in identification of pathologies in a simple system
Participants had to have sufficient knowledge of the state of governance for the unit of analysis	Pathologies exist at a deeper level of the system. With all likelihood, certain members of the system might not know the inner workings of the system. In the current research, the system owners provided a list of participants who had sufficient knowledge to assess the state of governance for unit of analysis (i.e., organization)
At least nine participants of the organization had to agree to participate in the study corresponding to George Miller's (1957) seven minus or plus two	The literature indicates that there is no required number of participants for a qualitative research study (Guest, Bunce, & Johnson, 2006). In fact, Barker and Edwards (2012) suggests that 'it depends' on many factors including context of the study

4.2.3.2 Data Collection

To enable data collection, the researcher set up a web-based survey in Qualtrics© software that participants could use to evaluate their unit of analysis. The questions, more accurately, statements that participants responded to, were developed from the systems theory-based pathologies. These statements were extracted from systems theory-based pathologies to enable simplification of the concepts to the unit of analysis. In all 88 survey statements were created from the 83 system theory-based pathologies that emerged in the theory (construct) development phase. The survey was designed to enable participants to anonymously provide their evaluation of pathologies in the unit of analysis.

The participants were asked to provide their assessment of the unit of analysis along P_E (i.e., the degree of existence pathology) and P_C (i.e., the degree of consequence of existing pathology). Figure 26 represents an example that was provided to the participants in the survey.

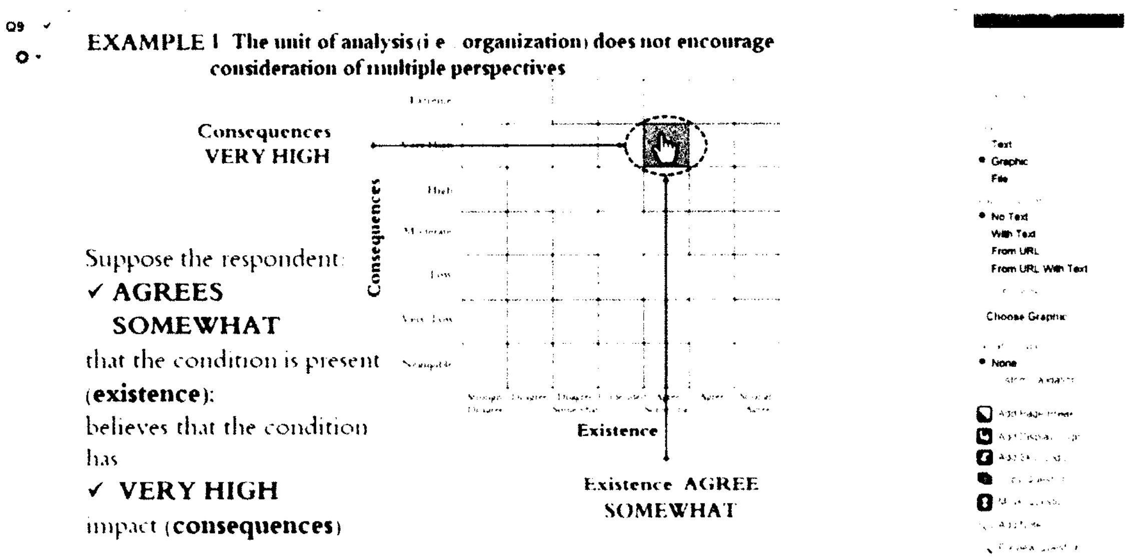

Figure 26: An Illustration of Intersection of P_E and P_C for this Research

The premise of this part of data collection was to establish applicability of inductively developed systems theory-based pathologies in an operational setting. Table 35 shows the meaning each scale as associated with P_E. Likewise, Table 36 elaborates on the meaning of each scale associated with P_C.

Table 35: A Range of Possible Reponses to the P_E Assessment

If participant selects:	**This means:**
strongly agree	Participant believes that this pathological condition exists (i.e., very detectable)
agree	Participant believes that this pathological condition exists (i.e., a lot detection)
agree somewhat	Participant believes that this pathological condition exists (i.e., little detection)
undecided	Participant is not sure as to the level of which pathology exist
disagree somewhat	Participant believes that this pathological condition does not exist (i.e., rarely detected)
disagree	Participant believes that pathological condition does not exist (i.e., none detected)
strongly disagree	Participant believes that this pathological condition does not exist

Table 36: A Range of Possible Responses to the P_C Assessment

If participant selects options:	**This means:**
extreme	Pathology condition has extreme impact on the unit of analysis
very high	Pathology has a very high degree of consequences on our operations
high	Pathology condition has high impact on the unit of analysis
moderate	Pathology condition has moderate impact on the unit of analysis
low	Pathology condition has low impact on the unit of analysis
very low	Pathology condition has very low impact on the unit of analysis
negligible	Pathology condition has no impact on the unit of analysis

Additionally, the survey included two open-ended questions at the end where participants could provide comments on pathologies as well as the utility of the survey itself.

4.2.3.3 Data Analysis

After data collection, the researcher examined the data to provide insights on pathologies with respect to the unit of analysis. The survey results are plotted on an X-Y axis where the X axis represents P_E while the P_C is represented by the Y axis. Three general statements could be inferred from the X-Y plot (i.e., graph). First, there are three general regions for the graph. The first region ranges from *agree somewhat-Negligible* on the X-axis and diagonally extends to *Strongly Disagree-High* on the Y-axis. The second region covers between *Agree–Negligible* and diagonally extends to *Strongly Disagree-Very High* and *Disagree-Extreme*. The third region is presented by the reminder of the space. These regions are presented as means for analyzing a unit of analysis Figure 27 represents these regions.

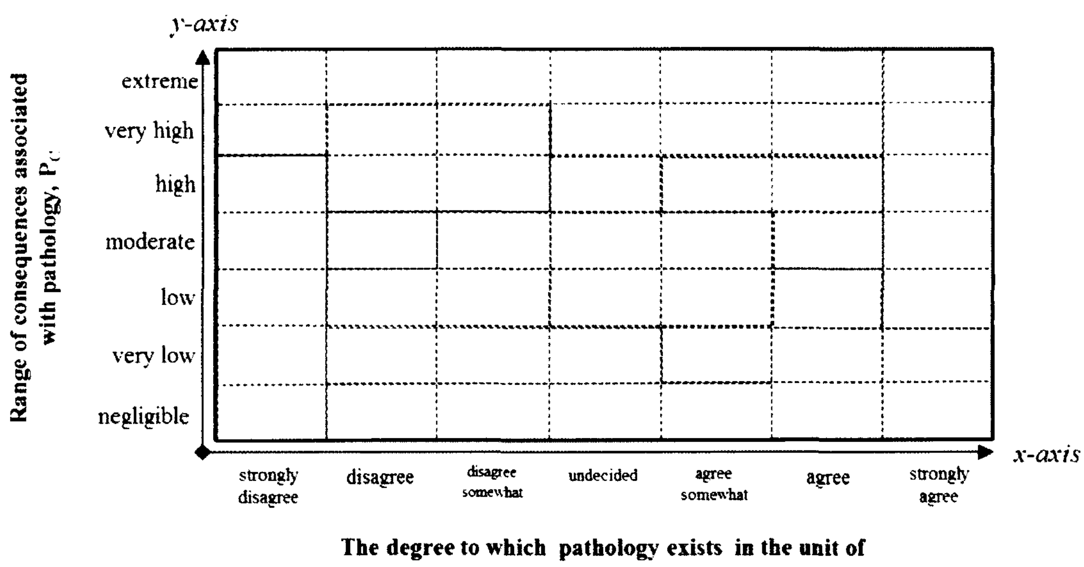

Figure 27: Major Regions for Pathological Conditions in this Research

These regions begin to establish relative importance of pathologies that could serve to distinguish pathologies. This is especially the case where a pathology is located in, for example, *strongly disagree-negligible* as opposed to *strongly agree- extreme.*

Second, the intersections of P_E and P_C assessments for all 88 statements could be plotted in the different regions and differentiated. Figure 28 represents an example of pathological assessment of one participant's view of P_E and P_C on six pathologies.

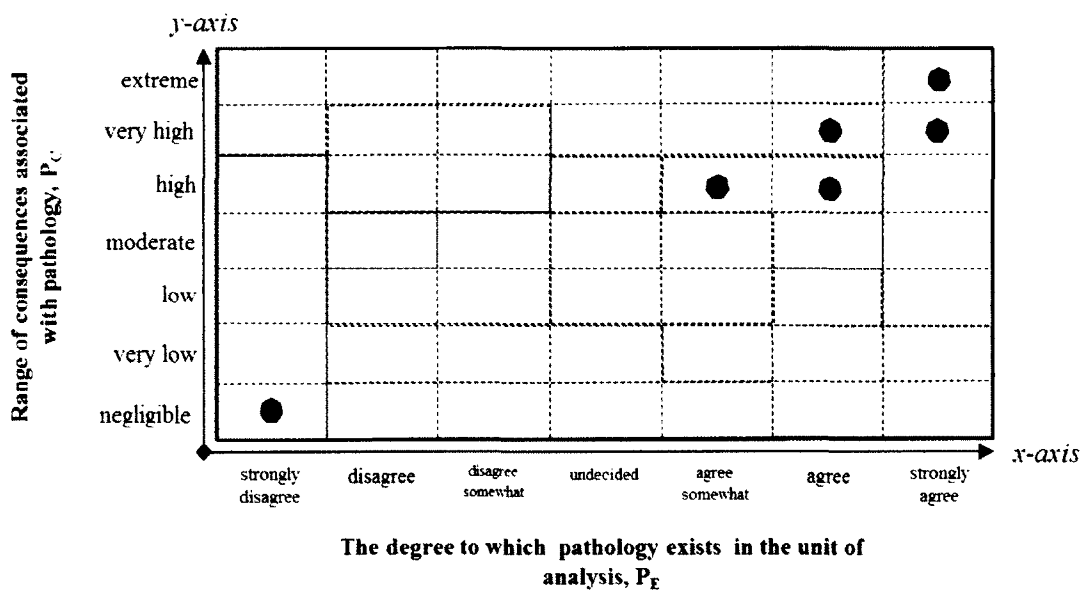

Figure 28: A Participant Perspective Assessing *six Different* Pathologies

Third, assessments of different participants could be plotted to indicate varying perspective on the same pathological statements. Figure 29 represents an example of six participants' view of the *same* pathology.

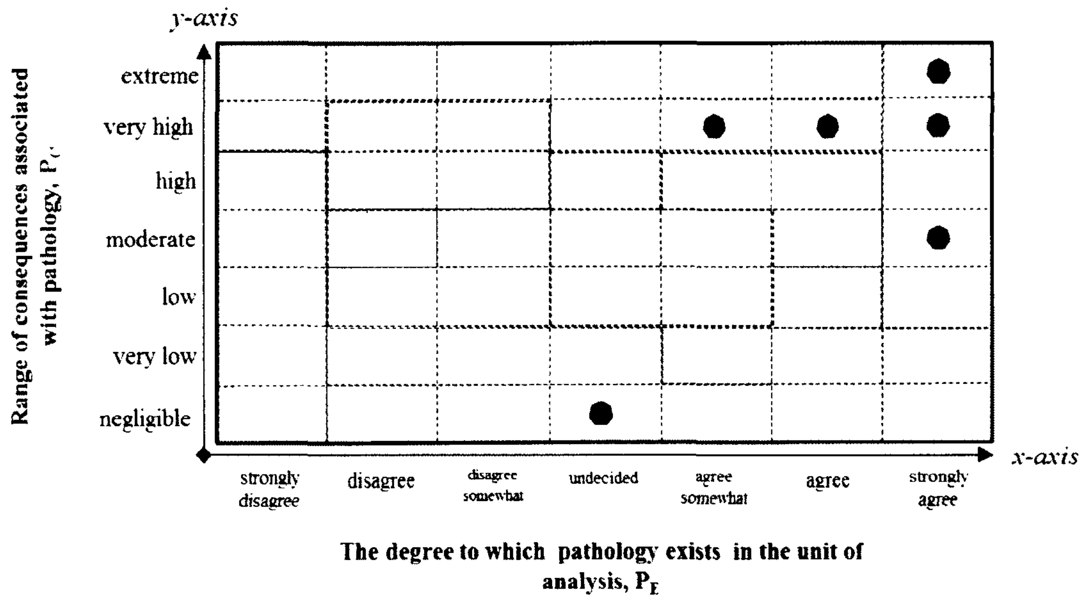

Figure 29: An Example of Six Participant Perspectives on the *Same* Pathology

These representations provide a unique visual profile for a unit of analysis along the concepts of pathologies affecting system performance. A pathological profile could then be used to inform enhanced problem formulation for complex systems. This design application shows a clear role of systems theory in providing a grounded theoretical basis identifying issues that can be feed to further analysis of complex systems to enables complex system development. More specifically, this design could be used to surface potential systemic issues affecting viability of complex systems based on the metasystem pathologies construct as supported by systems theory-based pathologies developed during theory (construct) development phase. The results of execution of this design are presented in Chapter V.

4.2.3.4 Case Reflections

The reflections section provided the opportunity for a deliberate critical analysis of the case application. A reflection in this sense provided a certain measure of judging the research especially the ability to transfer to the theoretical research into an operational setting. This section includes discussions on: (1) *evidence that disconfirmed the ability to discover the existence of pathologies in the unit of analysis*. More specifically, discovery by listing the degree of existence of pathologies in the unit of analysis is provided. The researcher sought to 'see' pathologies that are marked in the range of 'strongly disagree' to 'undecided.' These were considered to be non-existent in the unit of analysis, (2) *assertions regarding pathologies in the unit of analysis were developed.* As indicated, perspectives of participants will vary along their assessments of P_E and P_C on the same pathologies. These differences are highlighted along with possible 'clusters' of agreements among different participant perspectives. Figure 30 shows two possible clusters, (3) *reflecting on any changes that could be made undertaken to improve the developed construct and its related pathologies.* The Grounded Theory Method for theory development, suggests that researchers have an open mind regarding developing theories and to be flexible enough to capture any emerging issues that could enhance the theory (Merton, 1948), and (4) *developing implications and suggestions for the theoretical construct transfer to the operational setting.* This section discusses elements of the case application design that could be improved to enhance the execution of pathologies identification for problem formulation. A detailed discussion of these reflections is presented in Chapter V.

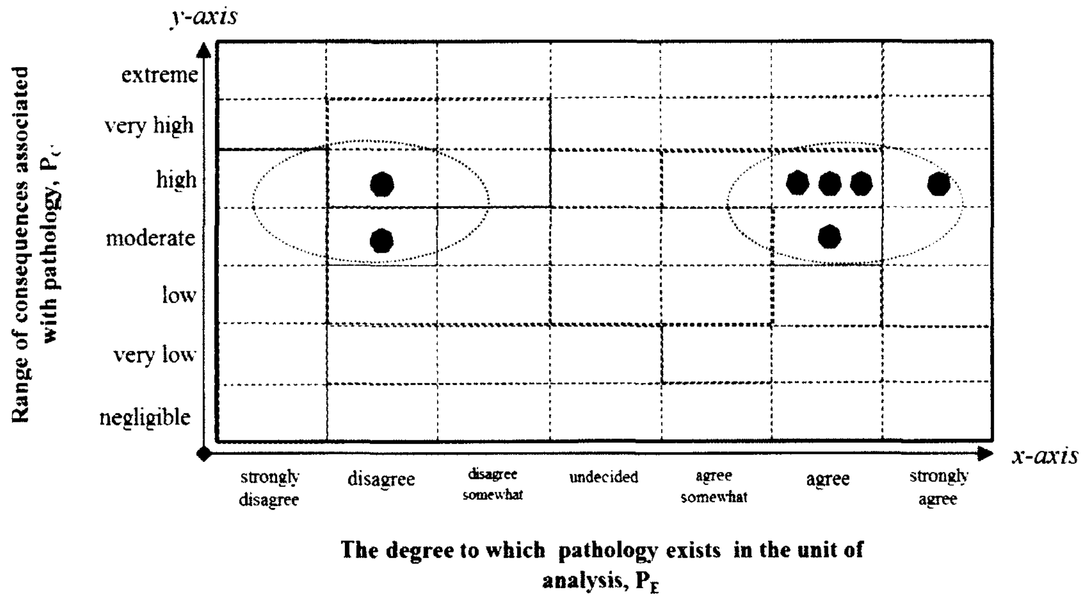

Figure 30: An Example of What Appears as Diverging Perspectives on the Same Pathology

Naturally, the 'conclusion and write up' phase represents high-level remarks pertinent to the case study application, focused on the second research question. This section of research is intertwined with theory (construct) development as well as the case application phase. Specifically, the results of the case application are catalogued and serve as findings for the second research question. Chapter VI serves to provide elaborated interpretation of the results and implications emanating from the case study application.

4.3 CHAPTER SUMMARY

This chapter introduced research designs for: (1) a grounded theory (construct) development --- the *Metasystem Pathologies Identification* and its related systems theory-based pathologies and (2) 'face' validating systems theory-based pathologies in an operational setting. First, an overall view of the research methodology was presented to offer a logical order that was followed for execution of the research. Detailed accounts of three phases (i.e., *Exploration, Theory Development, and Case Application*) and their associated activities were provided. The exploration phase lays the groundwork for the area of interest, research questions, and development of the appropriate detailed research design. The theory development outlined the specific procedure and implementing techniques for the Grounded Theory Method of inductive discovery of systems theory-based pathologies and the development of a central/core idea. Finally, a detailed account of the case study design for examination of the pathologies in an operational setting was provided. This design provided a 'face' validation for the capability and utility of the theoretical construct for system pathologies to be applied in an operational setting. This chapter also included specific strategies for data collection and analysis for the case study application in the targeted unit of analysis. Therefore, this chapter serves as a guide that enabled the rigorous scholarly execution and interpretation of this research in response to the research questions. The following chapter, Chapter V, outlines the results of execution of these designs.

CHAPTER V: RESEARCH RESULTS

Chapter I identified that the purpose of this research was to inductively develop a systems theory-based construct for metasystem pathologies. This development was done to address two primary issues. First is the lack of explicit use of systems theory in problem formulation. Second is to increase focus on metasystemic issues of a higher logical order beyond a single system of interest. Specifically, this research focused on addressing the following research questions:

1. *How can systems theory be used to generate a metasystem pathologies identification construct to support the problem formulation phase of systems-based methodologies?*
2. *What results from the deployment of the developed metasystem pathologies identification construct in an operational setting?*

To accomplish the purpose of this research, a multi-phase design approach was undertaken. Chapter II was structured to provide the basis for the research questions as developed from literature review as well as a setting for development of metasystem pathologies. In Chapter III, research perspectives informing the inductive research design were established as a foundation for the pursuit of systems theory-based pathologies, the development of a metasystem pathologies identification construct, and the 'face' validation of the pathologies application. Chapter IV then presented a multi-phase research design for execution of the research effort. This design includes use of the Grounded Theory Method (GTM) to inductively develop a metasystem pathologies identification construct and its related systems theory-based pathologies. The design also includes a mixed Case-Survey Study Design (CSSD) method that was used to 'face' validate the operational applicability of the inductively developed systems theory-based pathologies in an operational setting.

In this chapter, the results of the multi-phase research design are presented. First, the results from the GTM application is discussed, starting with the results from Open Coding that was performed on concepts of systems theory. Key codes (i.e., concepts) extracted from systems theory and developed into themes (i.e., categories) related to problem formulation for complex systems are presented. This is followed with presentation of a schema elaborating the interconnections among the categories (i.e., pathologies), developed from Axial Coding. This section also elaborates on how the pathologies where refined and synthesized to form coherent clusters based on shared characteristics. The Selective Coding section discussion of results further refines related pathologies to develop a set of interrelated metasystem pathologies edging closer to a central idea of metasystem pathologies identification. Finally, a fully emerging theory (i.e., construct), Metasystem Pathologies Identification (MPI), is presented.

In the second part of the presentation of findings, the results of the mixed CSSD are presented. This section presents pathology enumeration, variances in participant perspectives, and reflections on the unit of analysis. Figure 31 presents the organization of this chapter.

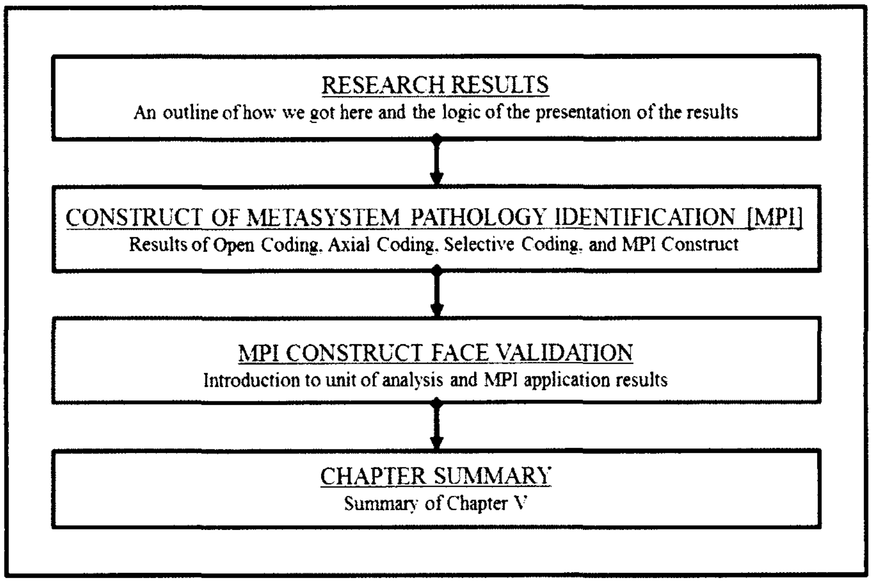

Figure 31: Organization Diagram for Chapter V

5.1 CONSTRUCT OF METASYSTEM PATHOLOGY IDENTIFICATION [MPI]

This section of the research report sets out to provide a response to the first research question: *How can systems theory be used to generate a metasystem pathologies identification construct to support problem formulation phase of systems-based methodologies?* The results produced a grounded theoretic construct developed through a rigorous examination of systems theory (laws, principles, and theorems) through the Grounded Theory Method. The developed construct (i.e., theory) is consistent with the criteria of a good theory as suggested by Geels (2007), including the following characteristics: 1) generality/scope – where the construct is balanced as not seeking to encompass all universal knowledge and yet not based on personal accounts, 2) simplicity/parsimony – where the construct reduces a large body of knowledge to clear and grounded concepts, and 3) accuracy/specificity – where the construct can be traced to source documents as described by grounded theory method. In support of Glaser and Strauss's (1967) argument that the 'great men' of social sciences had "not provided enough theories to cover all areas of social life" (p. 11), the developed construct in this research merely covers an area of 'problem formulation' from a systems theory perspective.

The establishments of the findings from the GTM application are elaborated in the following sections. First, Section 5.1.1 examines the discovery and articulation of key building codes (i.e., ideas) from systems theory (i.e., laws, principles, and theorems) and formation of categories (i.e., pathologies) related to problem formulation as part of the Open Coding activity of GTM. Second, Section 5.1.2 establishes the relationships among categories to develop related major categories – corresponding to the Axial Coding phase of GTM. Third, Section 5.1.3 provides a listing of eight metasystem pathologies that appear to encompass the examined areas of systems theory-based pathologies acting to limit system performance based on shared characteristics – corresponding to Selective Coding. Finally, an emerging construct in the form of a verbal statement combined with a visual model for metasystem pathology identification is provided as a finding of the research.

5.1.1 Open Coding: Codes and Categories

In Open Coding of the GTM, each concept of systems theory (i.e., law, principle, or theorem) was broken down and coded as a distinctive text unit in form of a significant word or phrase or as an analytic memo consistent with Saldaña (2013). Figure 32 presents an example of codes and categories for the concept of law of complementarity.

Law of complementarity

Systems theory concept	**Law of complementarity**
Basic description	Any two different perspectives or models about a system will reveal truths about that systems are neither entirely independent nor entirely compatible
Concept proponents	Bohr, 1928, Clemson, 1984, Krippendorff, 1986, Mehra, 1987, Murdoch and Murdoch, 1989, Skyttner, 2005

A GUIDING QUESTION *What does it mean to deviate from this concept?*

References and Text Data	CODES	CATEGORY: Pathology of complementarity
Clemson (1984, p. 206-207): Any two different perspectives (or models) about a system will reveal truths about that system that are neither entirely independent nor entirely compatible	'need for more than one perspective'	System fails to be viable through having one perspective. This pathology is related to: • Different truths not being revealed • Options not being explored (i.e., not having the whole picture)
Any management group will hold a variety of perspectives on the organization. These various perspectives on the organization will reveal different truths about the organization that are only partially independent and only partially compatible	'revealing truths' 'anticipating utility of perspectives'	• Operating under 'here and now' while ignoring 'there and then' (i.e., the future) • Assuming the environment is static • Assuming well-defining and understanding of a system
It is a mistake to inquire as to which perspective is 'right.' The proper question is 'given' our current practical purpose, which perspective is most useful?	'causes massive confusion'	• Working under 'ideal' conditions • Lack of system context operations
A variety of perspectives is a powerful resource in dealing with a dynamic environment because it is not possible to anticipate which perspective will be needed for some new set of conditions		Failure to be viable through having too many perspectives. This is related to: • There appears to be compatibility 100% of the times
A variety of perspectives can lead to mass confusion if the perspectives are not reasonably explicit and understood by all concerned. An effective management team should be able to self-consciously adopt a particular perspective as the need arises		• Many perspectives lead to mass confusion • Perspectives not being made explicit or understood

Figure 32: Partial Data Text, Codes, and Category for a Systems Theory Concept of Complementarity

Mason (2002) recommended thinking about research in terms of why it's being conducted and challenging researcher's own assumptions. Following this recommendation and guided by the view that concepts of systems theory explains system behavior and performance, the researcher examined what it meant to *not* adhere to each of the concepts of systems theory. Specific text extracted from concepts of systems theory, which is indicated as 'codes' in Figure 32 above, were used to generate ideas of what could happen if one does not adhere to a selected concept of systems theory. The individual codes where then examined for combination into a higher level 'category' which describes a pathological condition, factor, or pattern that might act to limit system performance. As previously indicated, such pathologies increase the likelihood that a system will not achieve expected performance (Barnard, 1946; Beer, 1984; Bobba et al., 2007; Katina, 2015a; 2015b; Keating & Katina, 2012; Ríos, 2010, 2012; Sheptycki, 2004; Yolles, 2007).

In the case of the systems theory concept of complementarity, nine codes (i.e., anticipating utility of perspectives; causes massive confusion; circular definitions of each other; classical concepts have a limited applicability; need for more than one perspective; perspective might not be compatible; requiring both parties; revealing truths; there must be well-defined elements) were extracted from literature data to form a category of PATHOLOGY OF COMPLEMENTARITY. As a category, it describes a ***situation in which an organization ignores other perspectives/modes of thinking that are not entirely compatible with the established-predominate perspectives***. This view emerges out of contrasting what it means to not adhere to or violating the concept of complementarity in terms of an issue (i.e., problem) that could be of interest during problem formulation. The pathology is supported by literature on systems theory (Clemson, 1984; Krippendorff, 1986; Murdoch & Murdoch, 1989; Skyttner, 2005). Specifically, Clemson (1984) notes, "**Any management group will hold a variety of perspectives on the organization. These various perspectives…will reveal different truths about the organization that are only partially independent and only partially compatible**." Clemson adds: "**It is a mistake to inquire as to which perspective is 'right.' The proper question is 'given' our current practical purpose, which perspective is most useful?**" (p. 206). One can then reasonably conclude that having multiple perspectives on missions, goals, or objectives of a system is actually good. In contrast, a system (i.e., an organization) that mistakenly assumes that there is only one 'right' perspective, will shun inclusion of different and yet relevant perspectives that can make important contributions in problem formulation for complex systems. Thus, the different perspectives that could be useful are lost, affecting more holistic and informed problem formulation.

In an organizational setting, this pathology could be explained as direct violation of the concept of systems theory (e.g., complementarity) where management dismisses and ignores other perspectives/models, despite knowing the value of having a variety of perspectives. On the other hand, this pathology might be experienced in an organization where management is unaware of principles of systems theory (e.g., the need to have a variety of perspectives). None of these situations is desirable since the organization could be placed in a situation where the likelihood of achieving performance expectations is reduced due to lack of variety in perspectives. Within problem formulation, the identification of such an issue is vital for system development, growth, and performance. This is especially the case since one cannot predetermine which perspective will be necessary for a complex system in a dynamic environment (Clemson, 1984; Murdoch & Murdoch, 1989). In other words, the lack of appreciation for this particular principle from systems theory creates conditions with implications for systems problem formulation.

In a similar manner the pathologies, as generated from the Grounded Theory Method, were developed for the deviations from the range of laws, principles, and theorems of systems theory to generate 'codes' and 'categories' that could emerge from the data analysis. Open coding concluded when no new ideas emerged from the text data in connection to problem formulation. Notice that this section is purposefully condensed to provide the synthesis of the findings, to avoid making the narrative too long and risk being labeled as 'massive and unreadable' (Yin, 2009). An extensive database of all the text data and memos, from which 'codes' were extracted was saved in NVivo® 10 software. Obviously, the scope of this voluminous data is too large to include in this document. In the presentation of findings, the base datasets are not included, only the direct higher level results of the findings in response to the research questions are included. Where appropriate, examples of the form and structure of data analysis are included.

5.1.2 Axial Coding: Systems Theory-Based Pathologies

In Axial Coding, more 'categories' of pathologies were developed following the GTM. Then the researcher grouped categories to form major categories. This is in accordance with Leedy and Ormrod (2010) who suggest that such major categories can be based on conditions that give rise to the phenomena under study (pathologies), the context within which they are embedded, the strategies associated with how people manage the category, or the consequences of those strategies.

Extending the ideas developed in Open Coding and applying the same logic to concepts of systems theory, the researcher extracted 362 codes from systems theory dataset. There was significant overlap among 'codes' in different 'categories'. However, the meaning of those 'codes' had to be conceptualized in relation to specific 'categories.' These 'codes' are directly related to 83 different concepts of systems theory and are the basis for systems theory-based pathologies. A systems theory-based pathology is a situation in which one inadequately applies systems theory concepts (Beer, 1984). The constant comparison of codes suggested that a pathology can be expressed as either not knowing the utility of concepts of systems theory or having a disregard for concepts of systems theory in in managing complex systems. In both of these situations, a system is affected (Katina, 2015a). This view is also supported by Keating and Katina (2012) who suggest that these situations reduce the "likelihood of a system [organization] achieving performance expectations" (p. 253). A continuous and rigorous examination of the concepts of systems theory, as articulated in Chapter IV, yielded 83 systems theory-based pathologies. These pathologies evolved in response to the guiding question: *What does it mean to deviate from this concept?* Figure 33 provides the next evolution of codes, categories as well as a statement of systems-theory pathologies.

Category	Codes	Supporting sources	Statement of a systems theory-based pathology
Pathology of complementarity	- need for more than one perspective - revealing truths - anticipating utility of perspectives - causes massive confusion	Clemson, 1984	***The pathology of complementarity*** is a situation in which an organization ignores other perspectives models that are not entirely compatible with the established-predominate perspectives including missions, goals and objectives. An organization in this case mistakenly assumes that there is only one 'right' perspective. Thus, different truths contained in different perspectives are shunned. Murdoch and Murdoch (1989) suggest that this pathology is more likely related to a management style that assumes that the organization operates under 'ideal' conditions. Moreover, too many perspectives, especially the ones not being made explicit and understood, could cause "mass confusion" (Clemson, 1984, p. 207) in an organization. This pathology is expected in an operation landscape characterized as ambiguous, complex, interdependent, and uncertain
	- requiring both parties - circular definitions of each other	Krippendorff, 1986	
	- classical concepts have a limited applicability - there must be well-defined elements	Murdoch and Murdoch, 1989	
	- perspective might not be compatible	Skyttner, 2005	
Pathology of diminishing returns	- diminishing marginal productivity - fixed variables - yielding becomes progressively smaller - improving methods and tools - corresponding change in other variables (e.g., advance in technology) - raising subsystem well-being	Encyclopedia Britannica, 2013	***The pathology of diminishing returns*** is a condition in which management mistakenly assumes that increasing number of workforce increases the productivity of the organization as a whole without expanding the landscape of operations. In farming example, if a farmer with a specific acreage and a specific number of workers decides to increase the number of workers; overall productivity might not increase (Krippendorff, 1986). In fact, the Encyclopedia Britannica, suggests that the output of each worker is reduced and thus affecting the whole organization. There must be a corresponding change in other variables such as advanced technology and investing in better skilled-workers
	- additional units - fixed amounts of the other inputs - smaller increments	Krippendorff, 1986	
Pathology of requisite hierarchy	- increasing hierarchy of a system	Adams et al., 2014	***The pathology of requisite hierarchy*** is a situation in which the regulatory body of an organization is not well-designed to

Figure 33: A Partial Evolution of Codes, Categories, and Statement of Systems Theory-Based Pathologies

In each category (i.e., systems theory-pathology) the name of concept of a systems theory from which it emerged was kept intact. Appendix B provides a complete listing of these categories. Having established these pathologies, the researcher continued refining the pathological categories as encouraged in this phase of GTM (Boeije, 2010; Charmaz, 2006; Morse, 1994; Saldaña, 2013). The researcher looked for themes and patterns within the categories. Initially, the researcher relied on a perspective concerning *metasystem pathologies* and their relationships to problem formulation as developed in Chapter II. This perspective is presented in Table 37 along with its related themes.

Table 37: An Initial Research Perspective on Metasystem Pathologies

Pathological Theme	**Theme Description**
Affecting system performance	A metasystem pathology is circumstance, condition, factor, pattern, or issue that acts to limit system performance, or lessen system viability and growth at the metasystem level
They emerge out of **inadequacy** use of systems theory	A metasystem pathology emerges out of inadequacy associated with the use of systems theory which might be expressed as lack of use of laws, principles, and theorems of systems theory or a direct violation of laws, principles, and theorems of systems theory
There is no one 'correct' **interpretation** of source or meaning	Moreover, a metasystem pathology does not have one correct interpretation. Even if there is agreement on 'existence' of a pathology, the interpretations concerning the source and meaning will not necessarily be congruent among observers. Thus, the idea of metasystem pathology embraces systems theoretic principle of complementarity.
They are influenced by individual **perspectives**	Metasystem pathologies are also dependent on systems and observer perspective. Thus, a pathology cannot exist in absence of attribution from an observer. Therefore, there is no pathology independent of system observers.
Inclusive of **internal** and **external** system factors	Metasystem pathologies include internal factors and external factors acting to limit system performance, or lessen system viability and growth at the metasystem level.
Inclusive of **system structure**, **processes**, and **actions**	Metasystem pathologies also include system structures, policies, activities, or decisions that may hinder systems development, viability, or growth.
Can be drawn from violation of metasystem **functions**	A metasystem pathology is directly drawn from violation of the principles providing for essential metasystem functions. To enable system viability, systems theory is the basis for developing system functions at the metasystem level. Consequently, violations of systems theoretic principles affect metasystem functions.
Having effective and efficient **mechanisms**	Moreover, in order to perform metasystem functions, there is need to have effective and efficient implementing mechanisms. Deficiencies in such mechanisms also create pathological conditions inhibiting system performance and viability.

A rigorous examination of these themes and constant comparison of the codes and categories (i.e., systems theory-based pathologies) suggests systems theory-based pathologies might be characterized in terms of:

- inadequate use of principles governing complex systems
- violation of essential system functions
- having ineffective and inefficient mechanisms implementing the system principle
- areas in which pathology effects the system of interest
- perspective of individuals in interpreting pathology and effects
- management style, policy, activities and decisions of people engaged with the system
- identifying a pathology as existing internal to or external to the system of interest

These themes were then used to develop an initial set of fifteen major groupings of systems theory-based pathologies. Table 38, below, was developed by examining the 83 systems theory-based pathologies in this research. These major groupings present a set of related systemic issues along different conditions that give rise to pathologies for the context within which that are embedded. Consistent with Boeije (2010) and Saldaña (2013), these groupings are referred to as metagroupings since they encompass more than one pathology.

Table 38: Major Themes for Categorizing Systems Theory-Based Pathologies

	Category Dimension	**Category attributes related to pathological conditions (of/concerning):**
1	*Adaptation*	failing to adapt to changes
2	*Communication*	failure in communication and transference of messages and information
3	*Environment*	basis in an external environment
4	*Interactions*	failing to understand complex system interactions among systems and their environments
5	*Learning*	failing to learn complex system and providing needed changes
6	*Management*	having inefficient management styles in managing complex systems
7	*Mechanisms*	having ineffective mechanisms in place that enable system performance
8	*Output/outcomes*	affecting actual system expectations – outputs and outcomes
9	*Perspectives*	human worldview affecting how to approach complex systems
10	*Regulating*	controlling and regulating systems
11	*Resources*	allocation of resources
12	*Stability*	failing to create stability in a system
13	*Structure*	nature of structure affecting a system
14	*Understanding*	associated with capacity to discern complexities in systems
15	*Viability*	balancing tensions among different system dimensions

This schema was then applied to 83 categories of systems theory-based pathologies. Figure 34 presents a graphical representation of these groupings along with the associated pathologies. Since no new dimensions could be generated, the researcher moved into selective coding to develop metasystem pathologies along with their storylines for problem formulation.

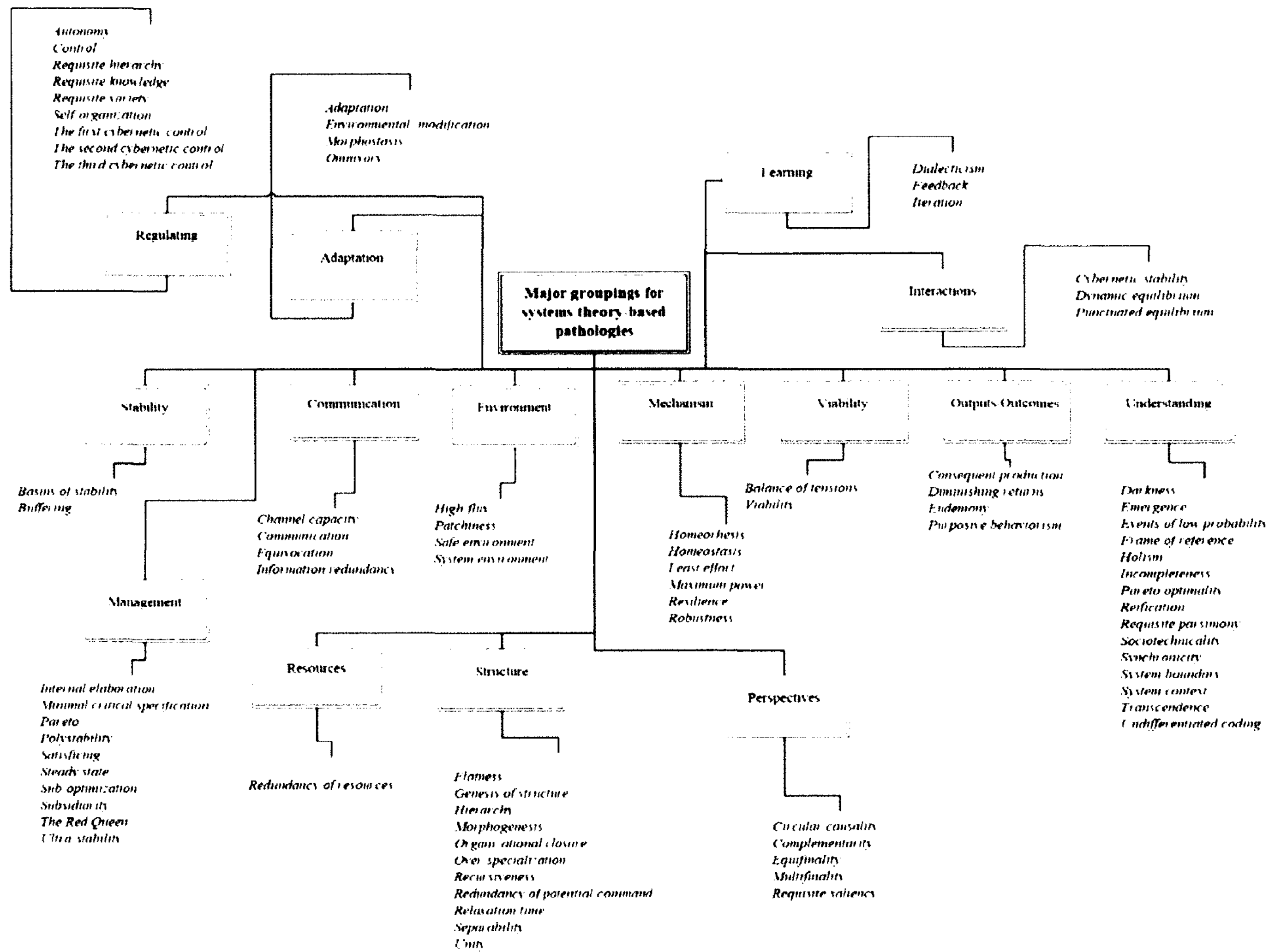

Figure 34: Fifteen Groupings for Systems Theory-based Pathologies

5.1.3 Selective Coding: Codes and Categories

After carefully developing the fifteen major categories using the research perspectives developed in Chapter II, the researcher revisited systems theory in search of any groupings, if any, that might suggest further refinements. This was done to reduce being biased by previous research. This was not an issue for this research since there exists no known groupings of systems theory-based pathologies. There exists no literature on pathologies grouping. However, three groupings for concepts of systems theory, found in literature, appeared to be relevant to this research. First, is Young's (1964) four major categorization of systems theory along the themes of 'systemic and descriptive factors,' 'regulation and maintenance,' 'dynamics and change,' and system 'decline and breakdown.' Table 39 presents these categories along with their descriptions.

Table 39: Young's (1964) Categories of Concepts of Systems Theory

Categories	**Descriptions**
Systemic and descriptive factors	Systems theory concepts that make important system distinctions, classifying large quantities of data, and outlining the basic structure and processes; concepts dealing with system types, structure of systems, internal system organization, and their surroundings
Regulation and maintenance	Systems theory concepts dealing with the regulation, control, and stabilization of systems
Dynamics and change	Systems theory factors dealing with problems of non-disruptive change, responses to altered environmental conditions, and internally generated processes of change
Decline and breakdown	Systems theory concepts emphasizing problems of disruption, dissolution and breakdown in systems

A second grouping is Raphael Troncale's categorization for concepts of systems theory. Troncale's (1977) categorization is made up of eleven categories, consisting of: (1) concepts and definitions of systems, (2) systemic interactions and interrelationships,

(3) systemic feedback process, (4) systemic equilibrium processes and states, (5) cyclical systems processes, (6) systemic energy flows, (7) hierarchical structure, (8) systemic evolution, (9) systemic processes of growth and development, (10) systemic decay processes, and (11) systemic information flow. These eleven categories of systems theory concepts merely present "a convenient hierarchical listing of …systems concepts" (Troncale, 1977, p. 34) in support of a linkage proposition construct that was developed by Troncale.

Most recently, researchers at the National Centers for System of Systems Engineering (NCSOSE) at Old Dominion University developed a set of seven 'axioms' into which thirty concepts of systems theory, inclusive of laws, principles and theorems, can be categorized (Adams, 2012; Adams et al., 2014). Table 40 represents the seven axioms of concepts of systems theory.

Table 40: Seven Axioms of Concepts of Systems Theory

Categories (axioms)	**Descriptions**
Centrality axiom	A pair of systems theory concepts describes central to all systems
Contextual axiom	Systems theory concepts an analysis uses to understand systems in terms of external circumstances and factors surrounding systems
Design axiom	Systems theory concepts describing imbalance in system resources, their relationships, and how systems should be planned, instantiated, and evolved in a purposive manner
Goal axiom	Systems theory concepts describing how systemic means and pathways can be used to achieve purposeful behavior
Information axiom	Systems theory concepts describing how systems create, poses, transfer information as well as how information affects systems
Operational axiom	Systems theory concepts for guiding system operations *in situ*
Viability axiom	Systems theory concepts describing key parameters that must be controlled to ensure continued existence in environment

The researcher used these categorizations to compare and contrast current major groupings of pathologies into the most salient categories, 'metapathologies' (Boeije, 2010; Charmaz, 2006; Morse, 1994; Saldaña, 2013). Certainly, there is no accepted guide or one 'correct' way to group pathologies. In fact, Troncale's (1977) research recognizes that his hierarchical tree of concepts stemming from systems theory was only meant as one of "many [possible] alternative hierarchies [or categories] among P.S.C.'s [Principal Systems Concepts that] could be logically supported and empirically demonstrated for real systems" (p. 36). Similar to Troncale's (1977) view that "many alternative trees [groupings can be] derived from [a] complex, diagraph network [of systems theory concepts]" (p. 36), the researcher was not bound by previous research and sought to develop a new and higher level grouping of the systems theory-based pathologies, insomuch as the groupings emerge from data.

The fifteen major groupings were compared and collapsed into eight emergent categories that appear to provide an umbrella covering the entire set of systems theory-based pathologies. This set of *metasystem pathologies* is clustered along the themes of (1) systemic dynamics, (2) system goals, (3) systemic information flow, (4) systemic process and activities, (5) systemic regulation, (6) systemic resources, (7) systemic structures, and (8) understanding of systems. ***Similar to a systems-theory pathology, a metasystem pathology acts to limit system performance. However, rather than treating pathology as isolated issues, metasystem pathologies involve a set of related pathologies, forming a cluster of high-level issues, affecting complex systems such that the likelihood of achieving desired systems-wide performance is reduced.*** A metasystem pathology revolves around inadequate use of two or more concepts of systems theory (i.e., laws, principles, or theorems). Similar to the systems theory-based pathologies developed in Axial Coding, metasystem pathologies involve not recognizing utility of systems theory or a direct violation of a systems theory based principle. The different systems theory pathologies were clustered together since they appear to "share some characteristic" (Saldaña, 2013, p. 9) that make them "look alike" and "feel alike" (Lincoln & Guba, 1985, p. 347). Figure 35 represents the eight higher-level metasystem pathologies.

Certainly, other clusters of pathologies could be developed since one's understanding of systems theory and derived pathologies is "likely incomplete" (Adams, 2012, p. 218). This issue is more pronounced by Troncale's (1977) supposition that "man's inborn limited span of attention and depth of awareness…often inhibits mankind's awareness of 'networks' of or holistic interactions" (Troncale, 1977, p. 36).

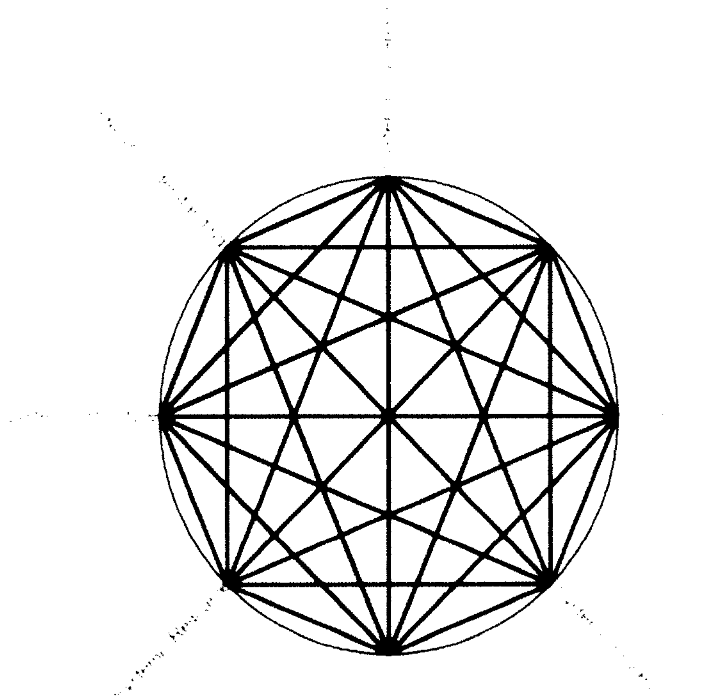

Figure 35: A Graphical Representation of Emerging Metasystem Pathologies

Before discussing a synthesis for the eight metasystem pathologies, it is important to recall two critical issues in this research. First, it's important to recognize that this research contributes to the area of problem formulation in systems-based approaches. The breadth of concepts associated with this area of research include such categorizations as *formulating the mess, problem articulation, problem bounding, problem context, problem definition, problem framing, problem identification, problem setting, and problem situation.* The utility of problem formulation as an activity for systems-based methodologies ranges from definition for problems affecting systems to subsequent development effective measure and solutions to such problems. Moreover, this area of research involves the subjective of knowledge and reality as presented by people.

Subjectivity is essential in problem formulation since people can choose "certain aspects of reality as being relevant for action in order achieve certain goals" (Dery, 1984, p. 35). This is not surprising since "people [may] hold different views on (a) whether there is a problem, and if they agree there is, (b) what the problem is" (Vennix, 1996, p. 13).

Second, the purview of problem formulation includes identification of factors that may act to limit expected system performance. The need to identify such factors has never been more pronounced than in the 21st century where the operating landscape is characterized by ambiguity, complexity, emergence, interdependence, and uncertainty (Keating et al., 2014; Keating & Katina, 2012; Keating, 2014). Consequently, there is no shortage of methodologies that promote systemic thinking and holistic identification of factors affecting complex systems. As discussed in Chapter II, a key phase of such systems-based methodologies is problem formulation. Although, systems theory is the foundation for holistic system understanding, there is no research that explicitly links systems theory to problem formulation --- how systems theory can be used to enhance problem formulation, especially articulation of pathologies affecting system performance.

Using activities of the Grounded Theory Method, 'codes' where extracted from systems theory data text to form 'categories' of pathologies supporting the concepts of failure to take notice and/or ignoring the utility of systems theory. Moving back and forth among systems theory data collection and continually refining the categories and their interconnections as additional data were collected yielded 83 systems theory-based pathologies (i.e., conditions and issues that might affect system performance) that were then merged into fifteen major groups. Extending systems theory to the area of problem formulation to articulate systemic issues affecting system performance is not an overreach since it aligns well with aims of systems theory and the bylaws of the *International Society for the Systems Sciences* (Hammond, 2002; von Bertalanffy, 1968).

Up to this point in research, the findings identified a high-level description of systems theory-based pathologies and their relationships. A detailed discussion of the eight metasystem pathologies that emerged from a metasynthesis of categorizations of systems theory and contrasting them to the major groupings of pathologies is presented in the following sections.

5.1.3.1 Systemic dynamic pathology

This cluster describes a set of systemic pathological issues affecting system performance from the view of the dynamic nature of complex systems. Complex systems continuously interact with other systems to produce performance. This theme emerges from fifteen different concepts of systems theory. In terms of pathology, the theme of systemic dynamic pathology involves not taking notice and ignoring the systems theory concepts that influence the dynamic interactive nature of complex systems, their subsystems, and the interplay with their environment. Table 41 shows the attributes of systemic *dynamic* pathology and its associated element pathologies.

Table 41: Attributes and Dimensions for Systemic Dynamic Metasystem Pathology

Systemic Dynamic Pathology	
Metasystem pathology attributes	Metasystem pathology dimensions
Pathology of adaptation	System is unable to change its structure in response to external disturbances or it is unable to influence environment and its changes
Pathology of dynamic equilibrium	There is imbalance in interaction in exchange of resources between system and that which is external (systems and environment)
Pathology of emergence	Assumptions that behaviors of the system as a whole can be directly inferred through the examination of properties of subsystems, independent of their interaction

Table 41 (cont.)

Pathology of environmental-modification	System fails to undertake efforts to influence its environment to reduce the extent of fluctuations
Pathology of high-flux	The rate of arrival of resources to systems is less than that necessary to address failures. Resources need to arrive as soon as failure occurs
Pathology of morphostasis	System stability is reduced through resistance to change (preferring the *status quo*)
Pathology of over-specialization	System becomes too specialized to initiate changes or accommodate other system demands
Pathology of polystability	Managing a system as though system level equilibrium is similar to that of its subsystems
Pathology of punctuated equilibrium	The long periods of stasis (i.e., relative calmness) creates a false sense of safeness for a system until a catastrophic event is experienced
Pathology of relaxation time	A system experiences too many changes at the same time; becomes incapable of assimilating change; becomes chaotic
Pathology of safe environment	System fails to create a permanently stable environment
Pathology of self-organization	Failure to work with the self-organizing tendencies of complex systems; global patterns of organization dominate instead of fostering local interactions
Pathology of steady state	Focus is placed on steady state (i.e., capability) of a system whole while ignoring capabilities of subsystems
Pathology of system environment	Failure to understand lines of demarcation such that there is confusion as to what is part of the environment and what is not
Pathology of the Red Queen	System fails to survive because of inability to compete with other systems in the same environment. Beyond adapting, a system must expend all its energy to stay in the same place

5.1.3.2 Systemic goal pathology

This cluster describes a set of systemic pathological conditions affecting system performance in terms of goals. This theme emerged from systems theory concepts that suggest that complex systems have goals and those goals can be achieved through effective use of six concepts of systems theory. In terms of pathology, the theme of systemic goal pathology involves not taking notice and/or ignoring six concepts of systems theory that appear to affect the goal-seeking behaviors of complex systems. Table 42 shows attributes of systemic *goal* pathology and its associated element pathologies.

Table 42: Attributes and Dimensions for Systemic Goal Metasystem Pathology

Systemic Goal Pathology	
Metasystem pathology attributes	Metasystem pathology dimensions
Pathology of equifinality	Managing a system with the belief that there exists only one approach/method to achieve a final desired state - including goals, missions, and objectives
Pathology of multifinality	Tendency to draw premature conclusions based on previous experiences; a particular conclusion is reached since initial operation conditions of a system of interest appear to be similar to another situation
Pathology of purposive behaviorism	System purpose is unguided (i.e., not goal-oriented) and primarily based on *intended* results as opposed to what the system is actually producing, including outcomes that are indirectly related that are experienced as unintended consequences
Pathology of satisficing	The management team actively searches for the best possible solution (i.e., optimization) instead of searching for appropriate solution(s) in a given situation with the information at hand; a good-enough solution
Pathology of unity	Lacking a clear purpose that serves to internally unify and externally distinguish the system
Pathology of viability	Key system parameters are not controlled and maintained within their physiological limits
	Productive subsystems lack capability to survive as independent systems

5.1.3.3 Systemic information pathology

This cluster describes a set of systemic conditions affecting a system in terms of information and communication. Systems theory suggests that performance of a complex system is related to ability to create, transmit, receive, and extract meaning from information (i.e., messages). This theme emerges from four specific concepts of systems theory suggesting information and information flow is essential in dealing with complex systems. Again, in terms of pathology, the theme of systemic information pathology involves not taking notice and/or ignoring the concepts of systems theory that relate to communication and information transference. Table 43 shows attributes of systemic *information* pathology and its associated element pathologies.

Table 43: Attributes and Dimensions for Systemic Information Metasystem Pathology

Systemic Information Pathology	
Metasystem pathology attributes	Metasystem pathology dimensions
Pathology of channel capacity	Ineffectiveness in transmitting different messages; channel needs to be modified to transmit; does not account for noise (i.e., disturbance) in transmission; information not received in a timely manner
Pathology of communication	Receiver of information is unable to receive information as intended by the sender; it involves issues emanating from communication mechanisms that enable processing, storing, and retrieval of information
Pathology of equivocation	Inefficiency in delivering intended concealed messages from one point to another so that only the intended receiver can decipher and understand its meaning; even though the message is a secret, anyone getting hold of the massage is able to decipher and understand the secret
Pathology of information redundancy	Information transmission (i.e., communication) is not enhanced though redundant information transmission; redundant information transmission is viewed as a waste of resources since it is repetitive and requires extra channel capacity; inability to combat noise which works to reduce efficiency (i.e., bits of information per second that can be sent and received) and accuracy (i.e., clear reception of message)

5.1.3.4 Systemic process pathology

This cluster describes a set of systemic conditions affecting processes of complex systems. This theme emerges out of six concepts of systems theory describing several processes --- internal and external to the system that must take place to ensure system development, stability, and continued viability. Again, in terms of pathology, the systemic process pathology emerged out of not taking into account and/or ignoring systems theory associated with activities/processes and outputs of such activities. Table 44 shows attributes of systemic *process* pathology and its associated element pathologies.

Table 44: Attributes and Dimensions for Systemic Process Metasystem Pathology

Systemic Process Pathology	
Metasystem pathology attributes	Metasystem pathology dimensions
Pathology of consequent production	Failure to focus on the underlying processes/relationships in the system responsible for producing the results (desirable/undesirable); focus is increasingly placed on the outcome/outputs themselves as opposed to the producing system
Pathology of diminishing returns	Mistakenly assuming that productivity can be increased simply by increasing the number of workforce; investing in better technology or improving the skills of the existing workforce are ignored
Pathology of events of low probability	Expecting a system to process and accommodate all scenarios without differentiation; attempting to account for all possible scenarios is too complex to be workable and jeopardizes those fundamental processes and scenarios critical to system survival
Pathology of maximum power	System is able to take in and transform information but lacking in the ability to increase the transformation capacity to accommodate increases; the system is slow to keep up with the information being generated
Pathology of sociotechnicality	Preference is placed on either the social (i.e., soft/human) or the technical (i.e., technology) aspects of the system as opposed to a joint optimization of both social and technical; one aspect is promoted as more important than the other
Pathology of sub-optimization	Making independent improvements to processes in subsystems to improve performance the system whole; optimizing subsystems rather than trying to design and create a process that supports system level performance

5.1.3.5 Systemic regulatory pathology

This cluster describes a set of systemic conditions affecting a system in terms of control and regulation. This theme emerges from concepts of systems theory suggesting that a certain level of control is required to guide complex system development and enabling growth, stability, and continued viability. Consistent with previous pathologies, the theme of systemic regulatory pathology involves not taking notice and/or ignoring twenty-one concepts of systems theory such that the ability to achieve and maintain system control is reduced. Table 45 shows attributes of systemic *regulatory* pathology and its associated element pathologies.

Table 45: Attributes and Dimensions for Systemic Regulatory Metasystem Pathology

Systemic Regulatory Pathology	
Metasystem pathology attributes	Metasystem pathology dimensions
Pathology of autonomy	Subsystems are not afforded the ability to act as independently with respect to taking actions and making decisions; they are over-constrained by a higher system
Pathology of balance of tensions	Lacking a governing structure that must relieve tension among different subsystems; finding the right balance between independence of subsystems and integration of the whole, self-organization and structured design, and maintaining a balance between system stability and change
Pathology of control	Lacking effective control mechanisms to preserve system identity; inability to remove inappropriate or incompatible goals; inability to consistently achieve intended goals; inability to efficiently utilize resources; inability to effectively contribute to the higher-level system purpose
Pathology of cybernetic stability	Lacking a sufficient number of external connections to the external environment; a system lacks a broad sense of self and responsibility; does not exchange information or develop effective controls to provide self-governance
Pathology of dialecticism	Lacking the ability to reflect on errors and deploy efforts to correct detected errors; recommendations can be made, but the system lacks ability to implement the recommendations
Pathology of feedback	Lacking the ability to improve system behaviors using scanning mechanisms; scanning mechanisms are incapable to feeding back information to reduce fluctuations; small effects are ignored and in time produce devastating effects on the system
Pathology of frame of reference	Lacking an explicit and consistent standard by which system performance can be judged; presuppositions and assumptions are not made explicit
Pathology of homeorhesis	Lacking mechanisms to guide and enable a system to return it its pre-set path of trajectory following an environmental disturbance
Pathology of homeostasis	Lacking monitoring mechanisms that are used to alert of any external changes affecting system such that essential internal variables are not maintained
Pathology of iteration	Lacking means to enable continuous comparison of first iteration to the normal and subsequent measures for error detection; the iteration process is overly long, overly elaborate, and performing only one iteration
Pathology of least effort	Electing to progress by selecting a path of high resistance; using methods and tools that are convenient and not necessarily effective; least efforts are not compatible with desired results
Pathology of minimal critical specification	Activities that must be undertaken are overly prescribed as to how they must be done; there is no room for creativity or flexibility
Pathology of Pareto	Undertaking significant efforts inconsistent with the '80/20 production' curve; assuming the existence of a direct 'causal-interrelationship' in system performance
Pathology of redundancy of potential command	Subsystems and their elements are lacking the 'freedom' to decide and act on behalf of the system as a whole; the speed at which the system responds to novel events, information, trends, threats, and opportunities is reduced
Pathology of requisite hierarchy	Lacking an effective multi-regulatory system body designed to handle variety at each level of the system
Pathology of requisite knowledge	Lacking a system regulator that is well-informed of relevant knowledge essential for viability; regulator lacks ability to select the right actions from a knowledge base to address perturbations; taking actions on the basis of *trial and error* in hopes of eventually solving system issues

Table 45 (cont.)

Pathology of requisite variety	The variety of the regulator is not equal to the variety of the situation to be controlled; lacks sufficient capacity to match variety of situations being controlled
Pathology of subsidiarity	Preferring to defer to a higher authority on local issues; elevating subsystem issues (i.e., local) issues to a higher system level; subsystems should only seek system level solutions when they have exceeded their capacity to deal with issues
Pathology of the first cybernetic control	Lacking ability to compare system behavior against a set standard; if the comparison is done, the system might lack mechanisms to continuously undertake commensurate corrective measures and actions
Pathology of the second cybernetic control	Control is a function of communication; a system might go out of control if its communications are incapable of proving sufficient regulatory capacity to address variety
Pathology of the third cybernetic control	Attempting to bring a system into control that hasn't gone out of control; if a system is performing, 'tinkering' may make performance worse

5.1.3.6 Systemic resources pathology

This cluster describes a set of systemic conditions affecting a system in terms of resources and resources utilization. This theme emerges from four concepts of systems theory that suggest a need for resources in enabling system development. In addition, the manner in which resources are utilized can have an adverse effect on system productivity. In terms of pathology, systemic resources pathology involves not taking notice and/or ignoring four concepts of systems theory that aid in effective utilization of resources. Table 46 shows attributes of systemic *resources* pathology and its associated element pathologies.

Table 46: Attributes and Dimensions for Systemic Resources Metasystem Pathology

Systemic Resources Pathology	
Metasystem pathology attributes	Metasystem pathology dimensions
Pathology of buffering	Lacking a surplus of resources; operating a system without sufficient slack; unaware that unused resources become waste and take up space
Pathology of Pareto optimality	Undertaking a measure (e.g., allocation of resources) to improve one part of a system without knowing the adverse effects to other parts of the system; it's not possible to make one part of the system better without making another part worse-off; the resources being used have to come from somewhere
Pathology of patchiness	Lacking ability to consume a variety of resources available from the environment; counter to the pathology of omnivory where internal structure can only consume one type of resource; failure to *acquire* test to determine use of different resources; despite presence of many resources, a system only consumes one type of resource
Pathology of redundancy of resources	Subsystems lacking 'freedom' to decide and act on behalf on the system; a well-designed system will provide subsystems the independence necessary to seize opportunities; decision making is not conferred to the system level that first receives information and can most expeditiously respond, instead deferring to the chain of command

5.1.3.7 Systemic structure pathology

This cluster describes a set of systemic pathological conditions pertaining to the structure of a system. Systems theory suggests that all systems can be characteristically organized in certain patterns and relationships to enable achieving maximum performance. In terms of pathology, the theme of systemic structure pathology involves not taking into account and/or ignoring systems theory concepts that describe fundamental structures of systems. Table 47 shows attributes of systemic *structure* pathology and its associated element pathologies.

Table 47: Attributes and Dimensions for Systemic Structure Metasystem Pathology

Systemic Structure Pathology	
Metasystem pathology attributes	Metasystem pathology dimensions
Pathology of flatness	The governance structure is an inverted pyramid; a system has a larger number of administrators relative to that of producers; everyone can't be an administrator
Pathology of hierarchy	Lacking a basic structure of a hierarchy; organization and people are not organized into an integrated system with appropriate levels of hierarchy that permit regulation necessary to provide appropriate control; using the same regulations at all levels of a hierarchy
Pathology of internal elaboration	Overemphasizing policy development and procedural elaboration to manage in the system; limited efforts are directed towards purposeful system development
Pathology of morphogenesis	Failing to create new and potentially radically different structures that supports existing structures; frequently allowing new changes without allowing old changes to take hold
Pathology of omnivory	Having internal structures (i.e., pathways) that cannot easily be modified to increase their capacity to take in a variety of resources
Pathology of organizational closure	Lacking a unified structure that provides an unambiguous identity for the system; system goals and those of subsystems are not complementary; having subsystems that are too autonomous to support a unified system acting as a whole; extrinsic purpose/goal might exist but system lacks a set of relationships that unify subsystem to system and to the environment
Pathology of recursiveness	Incapable of defining self as containing viable systems and being embedded in a larger viable system
Pathology of resilience	Inability to withstand disturbances; temporally failing and then unable to return to previous configuration; only resilient to a narrow range external fluctuations
Pathology of robustness	Lacking ability to use simple or complex mechanisms to withstand environmental changes without modifying system structure; system not being accustomed to coping with large and sudden changes
Pathology of separability	Being too tightly coupled together such that a small disturbance is reflected throughout the system; a single breakdown can have a major effect on the system as a whole
Pathology of genesis of structure	Lacking initiative that maintains information flow between a forming structure and the system; not allowing sufficient time for a new structure to take shape
Pathology of system boundary	Having a fuzzy defined line of demarcation that delineates a system and its environment; lacking minimum description distinguishing the system
Pathology of system context	Attempting to address a system independent of the context within which it is embedded; not accounting for conditions, or patterns that enable and/or constrain system solution development, system solution deployment, or interpretation

5.1.3.8 Systemic understanding pathology

This cluster describes a set of systemic pathological conditions related to the theme of human understanding of complex systems. This theme is developed from fourteen concepts of systems theory that suggest that the human capacity for understanding plays a major role in how one deals with complex systems. In terms of pathology, the theme of systemic understanding involves not taking into account and/or dismissing systems theory concepts that influence human understanding and divergence of human perspectives concerning complex systems. Table 48 shows attributes of systemic *understanding* pathology and its associated element pathologies.

Table 48: Attributes and Dimensions for Systemic Understanding Metasystem Pathology

Systemic Understanding Pathology	
Metasystem pathology attributes	Metasystem pathology dimensions
Pathology of basins of stability	Reduction in system stability as attributed to inability to recognize different system configurations or their transition periods; assuming that each configuration uses the same resources and produces different consequences; difficulty in initiating a required move from one basin to the next; inability to direct the system – letting it to gravitate towards a least energy state
Pathology of circular causality	Using a traditional (linear) causality model of thinking without recognizing the intricate interrelationships in a complex system; assuming it is not possible to have a wide range of conditions leading to the same result; focusing on cause rather that processes and patterns; assuming simple cause-effect relationships rather that mutual or multiple causality
Pathology of complementarity	Ignoring alternative perspectives/models that are not entirely compatible with the established-predominate perspectives including missions, goals and objectives; assuming there is only one 'right' perspective; shunning different perspectives and the insights they contain; not making different perspectives explicit
Pathology of darkness	Operating under the assumption that all relevant aspects, including behaviors, are known; striving to know all aspects of a system including elements as well as their interactions; focusing on crucial aspects of a system while avoiding irrelevant details
Pathology of eudemony	Placing precedence on financial profitability above all other measures; lacking the right balance in material, technical, physical, social, nutritional, cognitive, spiritual, and environment aspect
Pathology of holism	Operating under assumption that behaviors of an integrated system are possessed in parts of the system; assuming that understanding of a system can be maintained even past a particular point of reduction; system level behaviors can be deduced from behaviors of the parts
Pathology of incompleteness	Operating under the assumption that the traditional terms of discourse/frame of reference of organization is both consistent and complete; assuming that the framework of reference considers all possible events including unforeseen ones; assuming all problems are solvable in current frame of reference

Table 48 (cont.)

Pathology of reification	Distorting reality by confusing abstract ideas with concrete physical entities; confusing parameters of subjectivity and objectivity accorded to systems, their operation, or their representations
Pathology of requisite parsimony	Assigning more responsibilities beyond what the human element of the system can reasonably handle; going beyond seven plus/minus two elements for human processing and still expecting sound reasoning
Pathology of requite saliency	Failing to differentiate between different missions/objectives of the system; emphasizing the wrong elements, out of proportion to what they deserve; system members are creating more issues rather than solving them; not operating using a common knowledge base; creating unfocused dialog, unjustified decisions, and arbitrary design outcomes that are not understood or even actionable by a diverse workforce
Pathology of synchronicity	Ignoring meaningfully related events because they are impossible to explain in terms of cause-effect language; assuming that current methods and tools can discern all relationships in a complex system
Pathology of transcendence	Operating under the assumption that stability and viability of a system is only achievable within the confines of reality as defined by the objective realm of scientific/physical laws; the universe simply organizes itself in dimensions of physical space-time frame; human logic is powerful enough to understand all complexity; faith is neglected
Pathology of ultra-stability	Designing a system to fend off anticipated disturbances but not designed to fend against unknown disturbances; designing for both requires modifying one's view of stability and system structure
Pathology of undifferentiated coding	Attributing reality and knowledge only to directly observable results; involving traditional human sensors of sight, hearing, taste, smell and touch; inferring reality and developing knowledge from indirect communication is rejected

This section provided a detailed breakdown of the eight metapathologies supporting the metasystem pathology identification construct. A comprehensive description of each metapathology including individual attributes (i.e., related systems theory-based pathologies), detailed accounts of dimensions of pathologies, and relation to systems theory in terms of problem formulation was provided. The research results as presented in this section articulate systems conditions affecting system performance (i.e., pathologies), these conditions are described in terms of not adhering/violating systems theory concepts, and are rigorously grounded in concepts of systems theory. In the next section, a final key output, construct for metasystem pathology identification is developed to conclude theory development phase.

5.1.4 Theory: Metasystem Pathologies Identification (MPI) Construct

This section discusses the resulting construct from all the previous coding and categorizations. This is done to provide a response to Research Question One. The following development depicts the evolving nature of the construct grounded in the systems theory data to support systemic problem formulation.

The first concept that emerged from the Grounded Theory Method was that problems affecting systems exist independent of *'not knowing systems theory.'* A driving force behind the eight metasystem pathologies, supported by major categories, and certainly exhibited in the codes, is the notion that it is possible to know the concepts of systems theory. When one does not know a concept of systems theory, he or she may or may not adhere to it - totally independent of knowledge of the principle. However, not knowing a concept and its utility does not preclude a system from failing to achieve expected performance due to violation of the applicable system principle(s). Consequently, this *not knowing* places a complex system in a situation in which concepts of systems theory may not be fully utilized to enhance elements of systems that are critical to its development, growth, sustainability, and continued viability.

The second concept that emerged from grounded theory method is that *problems affecting systems involve 'violation of systems theory.'* It is critical to acknowledge that one could know a concept of systems theory and its utility, yet still chooses to ignore it or misapply it. After all, it is possible for one to select 'reality' according to one's view (Dery, 1984) or embrace a particular perspective (Clemson, 1984). Additionally, there is need to have the right balance in application of concepts of systems theory. Selecting an extreme application of a concept can have a significant effect on the system. Figure 36 represents these relationships in construction of pathologies.

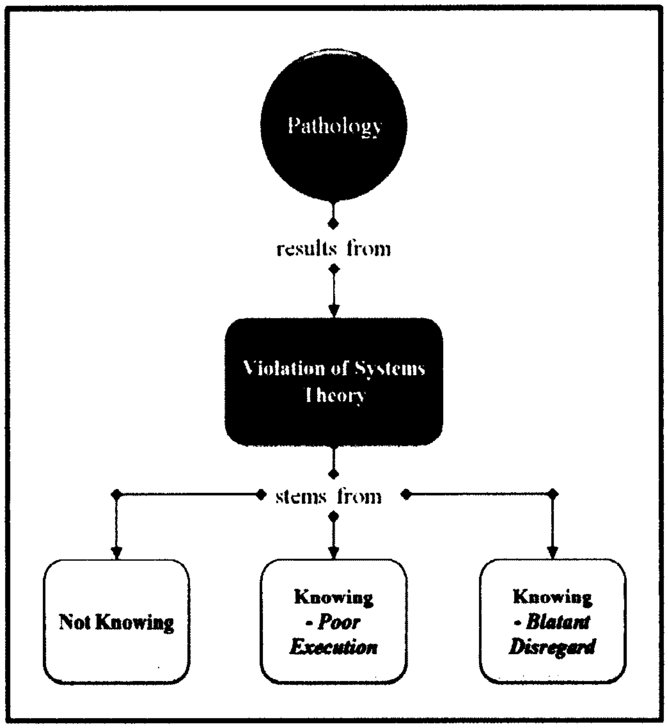

Figure 36: A Model for Supporting Deviation from Systems Theory

This basic idea of either not knowing or violating systems theory is directly related to systems-based pathologies (discussed earlier in detail) and therefore related to metasystem pathologies (discussed earlier in detail as well). Thus, we have the ideas of: (1) not knowing and therefore not accounting for concepts of systems theory, (2) knowing, but engaging in poor execution of concepts of systems theory, or (3) blatantly ignoring concepts of systems theory. In the case of poor execution, it appears that one could choose certain aspects of systems theory while ignoring others (Dent, 2013). This dimension, while not obvious from systems theory data, suggests that it is possible to partially apply concepts of systems theory with varying degrees of execution effectiveness. Collectively, the violation of systems theory (principles), regardless of the reason for the violation, places the system in a position whereby the resulting pathology is a prelude to diminished system performance. In bringing the research together under the guide of GTM, the result is a unique verbal qualitative model (theory) describing pathologies that result for violation of systems principles:

Metasystem pathologies derive from the violation of systems theoretic principles. This violation might stem from not knowing, poor execution, or blatant disregard, but irrespective of source, violations diminish the capacity for a system to meet performance expectations.

This metasystem pathologies identification construct is consistent with codes (Figure 32), categories (Figure 33 and Appendix B), category major groupings (Figure 34), and metapathologies (Figure 35). These figures encapsulate the outcome of grounded theory that creates an explicit link between systems theory and problem formulation and provide a granular list of systems theory-based pathologies affecting system performance. Figure 37 provides a graphical representation of this linkage.

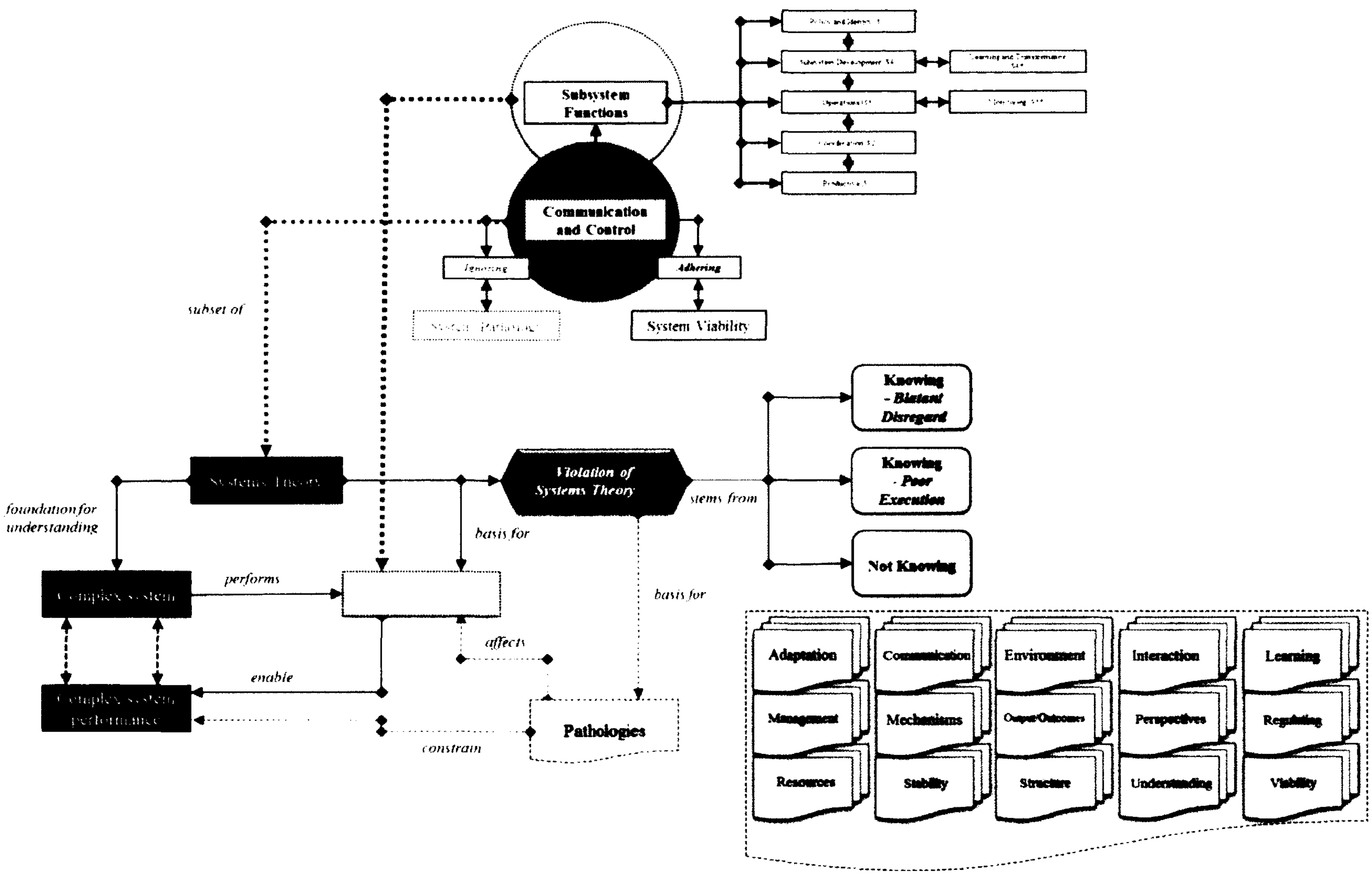

Figure 37: A Graphical Representation of the Construct for Metasystem Pathologies Identification

Having inductively developed a construct explicitly linking systems theory to problem formulation, the researcher moved into the phase in which the outcome of the construct can be 'face' validated, demonstrating the ability to deploy the construct in an operational setting. The following section elaborates the case application of this construct.

5.2 MPI CONSTRUCT FACE VALIDATION

The grounded theory of metasystem pathologies identification is valid having been developed from adherence to the GTM. However, this does not mean that this theory cannot be improved. In fact, when appropriate, theories developed in grounded theory are often improved when they are empirically tested (Denzin & Lincoln, 1994; Glaser & Strauss, 1967; Leedy & Ormrod, 2010). In this research, the proposed grounded theory was advanced to a position where it could serve as a launching point for further development and the beginnings of 'theory testing' from deductive examinations. However, that testing is beyond the scope of the present investigation.

Nevertheless, research engaged in an examination of the application of the construct in an operational setting as depicted in Chapter IV. In pursuit of this aspect of research, this portion of the research sets out to provide a response to the second research question: *What results from the deployment of the developed metasystem pathologies identification construct in an operational setting?*

5.2.1 Input and Planning

In order to operationalize the theory put forth in the theory development phase; there was a need to simplify systems theory-based pathologies. Specifically, the pathologies, as listed in Appendix B, were synthetized to create a set of statements that could be deployed in an operational setting. This process was enhanced by input from eternal experts as indicated in Chapter IV. Too large to be included in this research, systems experts provided questions that captured the essence of pathologies and yet 'simple' enough to be understood by practitioners without expertise in systems theory. Appendix C illustrates a correspondent that was used to elicit input from experts. In all, 88 statements were developed from 83 systems theory-based pathologies. The number of statements for evaluation is higher than the number of pathologies since more than one statement was necessary in several cases, including the pathologies of *Dialecticism*, *Feedback*, *Recursiveness*, *Sub-optimization*, and *Viability*.

The operational setting for the application was focused on a common system of interest. Anonymity was preserved for all participants and the web-based survey was reviewed by the Institutional Review Board for administrative review. As indicated in Chapter IV, the participants were to evaluate the statements developed from pathologies along two dimensions: 1) the degree to which they agree/disagree that the statement as described exists in their organization (i.e., unit of analysis) and the degree of consequence associated with the specified pathology. The deployment took place at an organization that meets criteria described in Table 34 in Chapter IV. The unit of analysis that was evaluated for pathologies can be categorized as a government entity and is part of a large number of organizations that are under the Department of Defense.

5.2.2 Data Collection and Analysis

As indicated in Chapter IV, an on-line survey was designed tool was designed and anonymous administered through Qualtrics© software. In this section, a breakdown of the survey results are presented. Table 49 presents an overall picture of numbers associated with the survey.

Table 49: Overall Numbers of the Survey Results

Categories of participants	**Total numbers**	**Relevant notes**
Number of people who responded	111	Initially, at least 9 participants were needed to get substantive results from the survey as indicated in Table 34. 111 participants is more than what the researcher anticipated, given the purpose of this section of the research, this indicates that the tool was well developed for the research
Results omitted	0	For some reason or another, the survey was not completed

The raw data from the survey are presented in a 49 by 88 grid table in Appendix E. There are 49 grids corresponding to intersection of 'existence' and 'consequence' related to pathology statements as indicated in Figure 26 in Chapter IV. The table contains 88 columns corresponding to the 88 different survey statements for pathologies as indicated in Appendix D. A summary of the results from all 111 participants are presented in Appendix E. In the following sections, several representations are presented in reference to the data collected.

5.2.2.1 Regions of pathologies in the unit of analysis

For the current unit of analysis, Figure 38 presents a composite of percentage by the different regions. In accordance with the aim of this research, it appears possible to represent pathologies in terms of regions. It is also possible to focus on individual grids. In fact, we are able to determine that over 15% participants were 'Undecided' regarding the existence the systems theory-based pathologies and recognize that those pathologies can have 'Moderate' consequences on the operations of their organization (Figure 39).

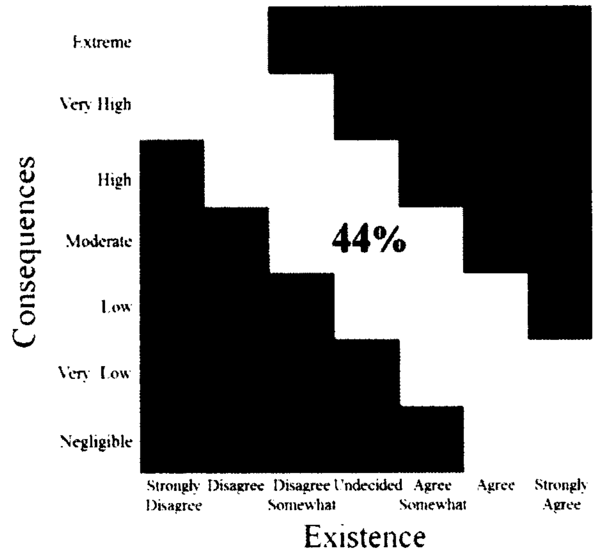

Figure 38: Three Regions and Percentages of Composite Pathology Profile for the Unit of Analysis

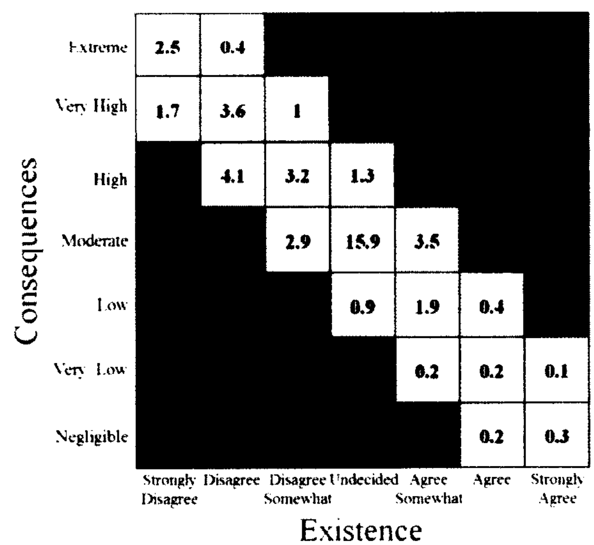

Figure 39: Percentages of Composite by Grid for the Unit of Analysis

These composite views indicate all the pathologies as numbered 1 to 88. An individual view of each pathology provides an even clearer picture of pathologies. Specifically, Figure 40 is selected to indicate the number of participant and their perspective on the same pathology. In this case Statement: *(SYSTEM OF INTEREST)* *does not encourage consideration of multiple perspectives* which what developed for the Pathology of Complementarity.

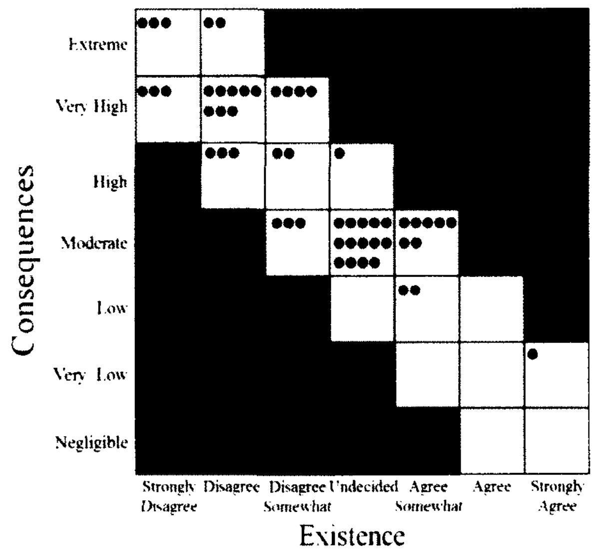

Figure 40: Different Perspective on the Pathology of Complementarity

5.2.2.2 Reflections for the case application

This section is developed to provide some insights related to ability to more theoretical inductive research on systems theory-based pathologies to an operational setting. Specifically, we focus on four elements as described in Section 4.2.3.4 as presented in Table 50, below.

Table 50: Reflections for the Case Application

Ability to discover pathologies	The overall picture suggests that it is possible to use the developed pathologies to address discover issues that could be affecting system performance and thus impacting system viability. The approach that was undertaken indicates that 20% appear in a region that should be not of much concern. However, this doesn't mean that those pathologies DO NOT exist. Moreover, the SD-N grid might only represent what was found for the specified unit of analysis. It does not mean that those pathologies do not exists in other 'exist' and have 'consequences' in other settings
Assertions regarding pathologies for the unit of analysis	For this particular unit of analysis the following general statements are drawn: 1. It's important to find out the cause of divergent of perspectives on pathologies (e.g., see Figure 40) 2. There appears to be a cluster around 'Undecided-Moderate,' what pathologies underline this cluster and what should be done
Changes that could be made to improve construct	The feedback received from the participant was positive in regards to the use of the tool. They especially liked the use of regions and color as the researcher suggested areas that might need to be discussed as part of *problem formulation* activities. The researcher remained open to changes that could be made to improve representations
Implications and suggestions for improving execution	The statements that are used in evaluations must be structured to enable participant to easily provide their responses. It also appears that there is a need to have a pre-tool deployment where participant discus the survey and perhaps have pilot test and a post-tool deployment phase to clear up any issues that may have arisen while participant took the survey. This enables the analysis to develop a better pathology profile for the unit of analysis

These reflections greatly enhance the concluding chapter. However, it can be said that there is no evidence supporting that the theoretical research could not be transferred into an operational setting.

5.3 CHAPTER SUMMARY

This chapter presented the results of qualitative research that was conducted based on the research designs described in Chapter IV. There are two major sections in this chapter. First, is the development of a problem formulation construct, *Metasystem Pathologies Identification*, which stems from the violation of systems theory. This construct was developed by adhering to tenets of grounded theory method and involved the development of 'codes' and 'categories' of pathologies from concepts of systems theory. A schema elaborating the interconnections among these categories was then developed, refined, and synthesized for coherent clusters based on shared characteristics in order to edge closer to a central idea of metasystem pathologies identification. A construct is then presented along with how it emerges from the violation of systems theory. Second, the emerging grounded theory (construct) is advanced to a position where it can serve as a launching point for further development. Specifically, a first generation case application of construct's pathologies is undertaken in an operational setting for 'face' validation and utility. The presented case application results indicate that the construct provides a viable means for enhancing problem formulation phase in systems-based methodologies through its ability to identify and consequently articulate systemic issues affecting complex systems. The following concluding chapter, Chapter VI, provides conclusions, interpretations, and implications from this research.

CHAPTER VI: CONCLUSIONS AND RECOMMENDATIONS

Chapter V presented the results of the detailed research analysis that were performed using a multi-phase research design of grounded theory method and case study. This analysis produced a grounded metasystem pathologies identification construct and its derived pathologies as factors and issues affecting system performance. The preliminary case-study results that 'face' validated the constructs utility in an operational setting were also presented. This chapter discusses contributions of the research to systems body of knowledge and practice in the areas of systems theory and problem formulation. Following this discussion, the research implications for systems theory, systems related domains, practice, as well as theory are developed. Finally, future research directions are presented along the dimensions of philosophy, methodology, method, theory, axiomatic, axiological, and applications. Figure 41 illustrates a layout and flow of this concluding chapter.

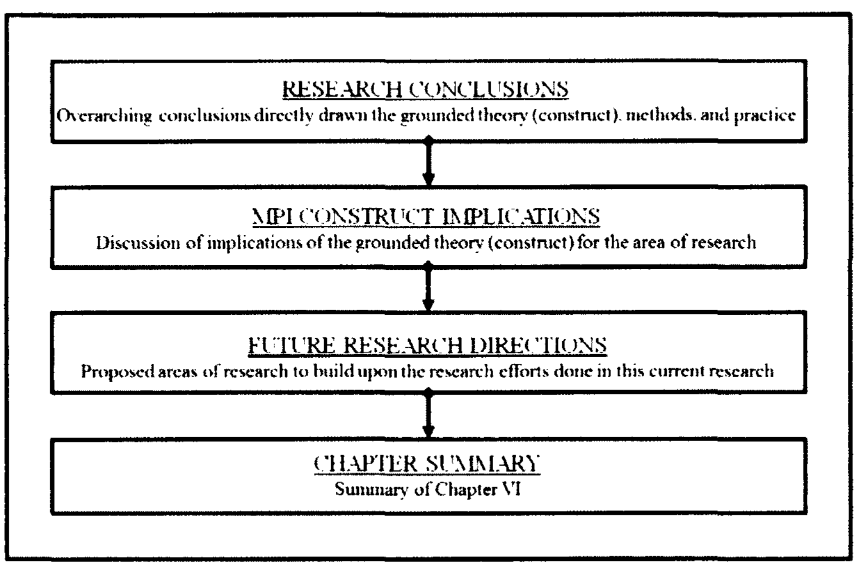

Figure 41: Chapter VI Layout Diagram

6.1 RESEARCH CONCLUSIONS

In Chapter II of this research the importance of promoting holistic understanding of our world was expressed. It was suggested that systems thinking was essential to this call for holistic understanding since our world and its systems do not exist in isolation; they exist as interdependent complex systems and systems of systems. This chapter also noted that there is no shortage of robust systems-based methodologies that can be used to holistically and systemically understand behaviors of such systems and address the problems they spawn. The premise of such methodologies is to holistically understand complex systems and their behavior as articulated in systems theory. A key and common activity of such methodologies was identified as *problem formulation.* A gap in the systems body of knowledge associated with the problem formulation phase utilization of systems theory and lack of focus on metasystemic pathologies during problem formulation, was identified. This research was initiated to fill these gaps.

Recall that the purpose of this research was to use a Grounded Theory Method to develop a systems theory-based construct for metasystem pathologies identification in support of problem formulation phase of systems-based methodologies. The research was especially designed to provide responses to two research questions:

1. ***How can systems theory be used to generate a metasystem pathologies identification construct to support problem formulation phase of systems-based methodologies?***
2. ***What results from the deployment of the developed metasystem pathologies identification construct in an operational setting?***

In concluding this research, it is necessary to consider whether the purpose of this research was met along with whether the research questions were answered. Simply stated, yes, the research fulfilled its purpose and provided responses to the questions as articulated in Chapter V. Specificity, concerning research purpose and questions, the following outcomes were archived:

- Development of a concept of systems theory-based pathology
- Identification of systems theory-based pathologies for problem formulation
- Delineation of dimensions of metasystem pathologies and their attributes
- Discovery of a metasystem pathologies identification construct
- Application and results of construct application

In addition, this research supported a research perspective on metasystem pathologies (see Table 50) that was introduced in Chapter II. The results as presented in Chapter V supported the basic concepts of metasystem pathologies.

Table 51: Research Perspective for Metasystem Pathologies Identification Construct

Includes circumstances, conditions, factors, patterns, or issues that acts to limit system performance, or lessen system development, growth, and viability
Emerges out of inadequate use of systems theory (i.e., laws, principles, theorems) which involved not accounting for systems theory and/ blatant systems theory
Does not have one correct interpretation. Even when there is agreement on pathology existence, the interpretations concerning the source, meaning, etc. will not necessarily be congruent among observers. Therefore, the idea of pathology embraces systems theoretic principle of complementarity
Dependent on systems and observer perspective. Pathology cannot exist in absence of attribution from an observer
Includes factors internal and external, to the system, acting to limit system performance, or lessen system development, growth, and viability
Include organizational structures, policies, activities, or decisions that may hinder systems development, viability, or growth
Involves essential system functions. Essential system functions are necessary for system viability. Developing such functions and maintaining them involves holistic thinking which is based on systems theory. Consequently, violating systems theory affects essential functions of a system and metasystem
Involves system mechanisms that enable the system to perform the essential system functions. A system might lack mechanisms or might have mechanisms that are not effective in execution of the system/metasystem functions, creating a condition in which the expected level of performance is not met

Even though the research perspective on pathologies was developed from the literature prior to the execution of the research; the results appear to be consistent with the research paradigm and underpinnings that constitute systems holistic thinking. However, and in a truly emerging fashion, the systems theory-based pathologies, their groupings, and metapathologies as well their attributes/dimensions, emerged as research evolved. The following discussion elaborates the outcomes of this research.

6.1.1 Significant Research Conclusions

This section elaborates the key overarching conclusions as presented above. It includes the key outcomes drawn from research with respect to research purpose, research questions, and the research perspective on pathologies.

First, the pathology concept from Beer's (1984) Viable System Model of management cybernetics provided a spotlight into intersection of systems theory and problem formulation to articulate systems theory-based pathologies. It was determined that violating concepts of systems theory can have adverse effects on complex system performance. Using Grounded Theory Method, literature was collected and coded for definition of pathologies in complex systems as violations or shortcomings in meeting the tenets of systems theory. A significant number of codes emerged from systems theory data supporting creation of pathology categories, and provided a reformed definition of systems theory-based pathology, ***the inadequate use of systems theory in problem formulation, expressed as either the lack of application, misapplication, or disregard of laws, principles, and theorems of systems theory.***

Second, continuing data collection and following procedures of grounded theory, the researcher applied, extracted, contrasted, and compared the emerging concept of systems theory-based pathologies to other concepts of systems theory. Systems significant statements, memos, and text were used to formulate meanings for pathologies resulting in emerging of 362 codes that were grouped to form an initial set of systems theory categories of circumstances, conditions, factors, or patterns that act to limit system performance. Further analysis using the Grounded Theory Method produced a total number of 83 categories from the initial codes. These categories comprise the systems theory-based pathologies that represent deep systemic issues, grounded in systems theory, which can affect system performance and can be examined during problem formulation.

Third, in this research, it was acknowledged that complex systems do not exist in isolation. Likewise, pathologies affecting such systems do not exist in isolation.

Following procedures of grounded theory, it was necessary to consider relationships among systems theory-based pathologies. The 83 systems theory-based pathologies were grouped into fifteen major groupings which then collapsed into eight metagroupings that appear to provide an umbrella covering the systems theory-based pathologies that emerged from the analysis. These pathologies included: 1) systemic dynamics, (2) system goals, (3) systemic information flow, (4) systemic process and activities, (5) systemic regulation, (6) systemic resources, (7) systemic structures, and (8) understanding of systems. A rigorous use of grounded theory activity of selective coding and software (QSR International NVivo 10) proved insightful in articulating these metasystem pathologies. ***Similar to a systems-theory pathology, a metasystem pathology acts to limit system performance. However, rather than treating pathologies as isolated, metasystem pathologies involve a set of related pathologies, forming a cluster of higher-level pathologies. These pathologies affect the likelihood of complex system such that achieving desired systems-wide performance is reduced.*** Each metasystem pathology contains a number of systems theory-based pathologies clustered around a common theme which is further clarified in the dimensions of each systems theory-based pathology. These dimensions identify the direct relationship between the pathology and the corresponding concepts of systems theory and problem formulation.

Fourth, a key feature of this research was to develop a general construct of metasystem pathologies that could be used in conjunction with problem formulation phases of any systems-based methodology. The construct as stated is simple and yet grounded in systems theory data. In addition, literature on systems theory support an assumption that in all likelihood human understanding of what constitutes systems theory is limited. The general nature of the construct as presented in this research renders it malleable to our continued and evolving understanding of concepts of systems theory in connection to problem formulation. New or revised concepts of systems theory can be used to generate pathologies that could be then be used to enhance problem formulation activities in support of systems-based methodologies.

A final observation of this research has to do with the application of the construct in an operational setting. A lot of work went into operationalizing the concepts underlying systems theory-based pathologies so as to be deployable in an operational setting. The one case study presented in Chapter V not only illustrates the ability to derive operational application of the theoretically formulated construct of the research, as such it provided a level of 'face' validation for the operational deployment of the theoretical construct of the pathologies. The organization in which assessment of pathologies took place is not presented as a special case. Granted that every system (i.e., organization) is unique in its own way, the perspectives of pathologies identified in this organization suggest that it's possible to apply the theory in other settings and through other application (tools) developments for the purposes of problem formulation.

In conclusion, this research forms the foundation for a richer inclusion of systems theory in problem formulation activities of systems-based methodologies such as systems engineering. The construct also adds to the systems body of knowledge by projecting another use of concepts of systems theory, outlining factors and issues that affect system performance, and proving a springboard for developing new technologies, methods, and tools that can support problem formulation. In line with these conclusions, the following section outlines the far reaching implications based in this research.

6.2 RESEARH IMPLICATIONS

The metasystem pathologies construct generated in this research and the results presented in Chapter V have several far reaching implications for theory, method, and practice. First, the research activities were undertaken to purposely and proactively engage in the creation of the systems theory-based knowledge that serve as a frame of reference for identifying systemic issues affecting complex system performance. Consideration of the systems theory-based pathologies might act to enhance understanding and create the possibility for alternative remedial design modifications for systems prior to operational fielding. For operating systems, examination might be aided for systems that might be experiencing the performance deficiencies stemming from the existence of one or more of systems theory-based pathologies. Whether dealing with a newly designed or operating system, a rigorous problem formulation that includes articulation of pathologies can be used to inform design, execution, and evolution of functions necessary for successful system governance.

For systems theory in general, the research provides clarity on a significant use of a systems theory, comprehensively, in connection to a key activity associated with complex systems. This key activity is *problem formulation* as established in systems-based methodologies. Through grounded theory, this research puts forth a construct that can be used to identify systemic issues affecting system performance. Thus, attempting to increase the probability that an analyst will address true systemic issues affecting system performance. In effect, this supports avoidance of committing a Type III error of solving the wrong problem precisely (Kimball, 1957; Mitroff & Featheringham, 1974; Mitroff, 1998; Mosteller, 1948). Since the construct is grounded in systems theory, it can surface truly systemic issues that affect systems from the systems theory perspective. In addition, since problem formulation is an important phase of most systems-based approaches, it can be used in connection with any systems-related approaches where problem formulation is a necessary activity.

In many systems-related approaches such as systems analysis, systems engineering, operational research, systems dynamics, organizational cybernetics, strategic assumption surfacing and testing, interactive planning, soft systems methodology, systems of systems engineering methodology, critical systems heuristics, organizational learning, sociotechnical systems, and total systems intervention, *Metasystem Pathologies Identification (MPI)* has significant implications. MPI is structured to help the problem formulation phase of these methodologies by creating input stemming from systems theory-based pathologies that can be used to better place the emphasis of subsequent analysis in context. Ultimately, this supports more efficient and effective development of solutions to systemic issues. The proposed approach to better inform problem formulation supplements contemporary problem formulation methods and tools (e.g., needs analysis, Fishbone diagraming, SWOT analysis; requirements analysis, rich picture, etc.). This research stands to provide a different level of utility for problem formulation that will vary based on the domain system of interest and context of application.

In connection with contribution to systems-related domains, this research also has significant implications for practice. While not presented as a repeatable method for identifying pathologies, MPI and supporting systems theory-based pathologies provide working practitioners with basic knowledge that can enhance approaches to problem formulation. This can complement tools already in practice. A practitioner concerned with problem formation can now include assessment of pathologies during problem formulation. Appendix E provides an example of how the MPI could be used in conjunction with problem formulation in SOSE Methodology. In addition, further research will move to deliver a repeatable method for identifying pathologies, provide substantive tools for ranking and prioritizing pathologies and, specific tools (metrics) to validate pathologies.

Associated with the case application is the development of a first rendition of a 'pathological profile' for the unit of analysis. This profile is based on two initial measures of degree of existence and consequences. As research evolves, other measures are expected to refine the profile to provide a more robust accounting of system pathologies. In relation to the pathologies profile, the researcher is not under illusion that the results of the case application or those that will follow, including the profiles, are generalizable (i.e., transportable) to other settings or systems. It is the expectation of the researcher that each system will have a different profile even though they share the same input measures. However, this does not negate the utility of having a general pathology profile that can be used for diagnostic accounting of pathological conditions existing in a system which can be discovered during problem formulation.

A final implication of the research has to do with the use of grounded theory in an area of research not typically associated with grounded theory as a research method. While grounded theory as a research method is widely used in qualitative social sciences, it is rarely used beyond this domain and has certainly not gained popularity in systems related fields as articulated in this research. Nonetheless, the method's interpretive nature coincided well with the subjective nature of the research undertaken and contributed immensely to the development of the MPI construct and its systems theory-based pathologies. Thus, applying grounded theory in systems domain provided an opportunity for an enhanced capacity to conduct inductive research and could provide further insights into other research agendas for systems related domains. In line with these research implications, the following section discusses proposed future research.

6.3 FUTURE RESEARCH DIRECTIONS

Research into pathologies should not be confined to a privileged intellectual school of thought. However, the paradigm from which this research was undertaken is clearly articulated as 'subjective-inductive' in accordance with ontology, epistemology, methodology, and nature of humans. This begs the question, is the knowledge presented in this research of any value to the 'objective' based paradigms of knowledge and reality? Clearly, there is a need to further extend this research. In a truly systemic thinking fashion, both of these paradigms have historically established utility and each provide insights into complex phenomena. Neither paradigm is 'correct' and therefore should be considered not as mutually exclusive of one another, but rather complementary in forming a more holistic perspective of phenomena. Drawing on this understanding, the following research questions are also proposed to increase the maturity of the derived construct and the development of systems theory-based pathologies.

6.3.1 Research Pertaining to Philosophical Issues

At the most fundamental level, any rigorous research needs to establish a paradigm for contrasting knowledge claims. At one end of this spectrum, one can use the traditional scientifically-based research paradigm in which the researcher "initially requires reduction; singling out a portion of reality ...set[s] a hypothesis about this portion of reality...design[s] an artificial situation where this small number of variables can be investigated while the remainder are held constant. Experimental design is important, with the experiment purposely devised to test the hypothesis with the aim of refutation. Knowledge accrues from this method" (Flood & Carson, 1993, p. 249). Conversely, a researcher might focus on the social science perspective, the interpretive or naturalistic paradigm, where deeper understanding of reality and meaning of phenomena are subjective rather than being based on hypothesis, cause and effects. In line with this thinking, the following future research questions are proposed as a potential guide to follow the present state of research from this effort:

- Is a single paradigm of philosophy sufficient to address all aspects of systems theory-based pathology? Or should a specific aspect of philosophy be adapted to address pathologies for problem formulation?
- Can the idea of systems theory-pathologies be empirically established? In addition, what are the dimensions and theory testing protocols that necessitates empirical examination?

6.3.2 Research Pertaining to Methodological Issues

In connection with philosophical paradigm (the subjective-inductive approach undertaken in this research), methodology deals with the means by which a researcher attempts to understand, investigate, and gain knowledge in the world. In this research, the focus was placed on developing a grounded theoretic construct for pathologies. However, there is a need to develop theoretically informed methodologies (i.e., frameworks) that can be used to provide high level guidance for deployment, analysis, and evolution of the construct in operational settings. In line with this thinking, the following questions are suggested:

- Given the MPI construct and its systems theory-based pathologies, what methodology can be developed to implement the construct to systemically analyze and evolve complex systems?
- How can such a methodology be tested and validated with regards to how they enable investigation and transformation of a complex system?

6.3.3 Research Pertaining to Epistemological Issues

Epistemology deals with how a researcher (i.e., a system observer) begins to understand problematic situations and communicate knowledge to fellow researchers or observers. In this research, supported by the scarcity of literature on concepts of pathology, an anti-positivistic view of knowledge that suggests understanding pathologies is based subjectivity of individual experiences was undertaken. By applying lessons learned from this research, a foundation for further general knowledge development has been established. In line with this thinking, the following questions are posed for consideration of further development:

- Given the developed systems theory-based pathologies, are there pathologies that appear to be unique to certain industries or system types?
- In practice, what pathologies appear to be closely related such that they can be clustered together?

6.3.4 Research Pertaining to Ontological Issues

Ontology deals with existence of entities and how such entities can be concretely understood by the external world. Regardless of whether reality is taken as external to the individual imposing itself on individual consciousness (i.e., realism) or as a product of individual consciousness (nominalism), the impact has to be real to the world. With respect to systems theory-based pathologies, the effects, be they conceptual or tangible, must be made explicit. In line with this thinking, the following research questions are suggested:

- How are the effects of systems theory-based pathologies manifested?
- What are the dominant dimensions of the effects of systems theory-based pathologies?

6.3.5 Research Pertaining to Theoretical Issues

Much of the current research was devoted towards development of a construct (theory) for metasystem pathology identification for the problem formulation phase of systems-based pathologies. Imposed on this research are ideas that emerged from 'codes' and 'categories' of systems theory that, at first, appear to have nothing to do with the identification of issues affecting performance and viability of complex systems. A theoretical discussion linking pathologies to performance was presented. However, there is a need to develop metrics that link systems theory-based pathologies to the effects on performance of complex systems. In line with this thinking, the following research questions are proposed:

- What measures can be developed to explicitly link a systems theory-based pathology to performance of a complex system?

- How can the effects of a systems theory-based pathology be mitigated? Is it a matter of resources allocation, change in policy, education, etc.?

3.3.6 Research Pertaining to Axiomatic Issues

The development of self-evident truth is necessary for systems theory-based pathologies to be fully appreciated. A large responsibility is placed on the research community to evolve these ideas into self-evident truths. This might involve articulating a set of pathologies that appear to be common to all industries, concepts of systems theory that appear to be frequently violated, as well as seeking to refine our understanding of systems theory as applied in this research. In line with this thinking, the following research questions are proposed:

- What are the self-evident truths regarding systems theory-based pathologies that appear common in many settings?
- How can our view of systems theory be expanded to include concepts (i.e., laws, principles, and theorems) that can be used to evolve systems theory-pathologies and its construct in relation to modern system problems?

6.3.7 Research Pertaining to Axiological Issues

Axiology deals with the nature of value and value judgments. As indicated in this research, people can have differing perspectives of the same phenomena. It could be argued that identifying and assessing pathologies implicitly brings value to the system owner. However, beyond this implicit value, it is evident that there is a need to explicitly articulate values associated with inclusion of pathologies in system development. Values and value judgments should become an important aspect of MPI. The issue of value could be addressed by looking into why people might have different perspectives on the same pathology. In line with this thinking, the following research questions are proposed:

- Why might people have varying perspectives on pathologies in the same system?
- What does having differing/same perspectives on pathologies mean for a problem formulation activity?

6.3.8 Research Pertaining to Method

A method is a particular form of procedure for accomplishing or approaching something, systematically. This research provides a high level construct for pathologies based on systems theory. However, it does not offer a prescribed step-by-step method that can be used to identify pathologies in complex systems. This is not to criticize this research, or to cast doubt on construct utility in assisting to surface systemic issues affecting systems. On the contrary, this critique offers an opportunity to develop a repeatable method that can be used to systematically identify pathologies. In line with this thinking, the following research questions are proposed:

- What method(s) can be developed to systematically identify, assess, and respond to pathologies in complex systems?
- What tools, techniques, and processes can be developed and employed in connection with these methods to facilitate identification, assessment, and response to pathologies?

6.3.9 Research Pertaining to Applications

The emerging paradigm presented in this research involves explicit usage of systems theory in *problem formulation* to articulate factors and issues affecting complex systems. There is not currently a vast array of applications that can be used as an exemplary case demonstrating application of these ideas. Applications of these theoretical ideas should be deployed in areas marked with ambiguity, complexity, interdependency, and uncertainty as is that case in numerous venues such as critical infrastructures (Gheorghe, 2006; Kröger & Zio, 2011; Rinaldi, Peerenboom, & Kelly, 2001; Thissen & Herder, 2003; Tolone et al., 2009). These venues are essential for maintaining and sustaining public wellbeing, security, and prosperity. Beyond the single case application presented in this research, multiple applications in different areas might provide a means to widen the boundary associated systems theory-based pathologies. In line with this thinking, the following research questions are proposed:

- What are the domains which are suitable for assessment of pathologies and with what results that might be expected to accrue?
- How has the pathology perspective of complex systems enhanced, for example, complex system governance (Keating, 2014; Keating et al., 2014)?

Additionally, it should be noted that while this research places emphasis on the level of existence of pathologies and their associated perceived consequences in case application, there is potential for expanded future research involving other measures. Traditional measures such as exposure, feasibility, fragility, resilience, risk, susceptibility, vulnerability, etc. could adapted for pathologies and aid in ranking and prioritizing pathologies or strategies to address pathologies for systemic development.

Finally, there is a good relationship between current research and Reason's (1990; 2000) research into human error and the focus on the nature of human cognition and mistakes. Specifically, Reason (1990) notes that human fallibility is inherently related to *failures of expertise* – where humans might inappropriately apply solution and *lack of expertise* - they might lack an appropriate 'off-the-shelf' routine or solution (p. 12). Given current concepts of '***not knowing***, ***knowing – poor execution***, and ***knowing – blatant disregard***' for systems theory, there is need to ensure that people become component in systems theory and that they appropriately exposed to its different solutions to current vexing issues.

These possible areas of research can only serve to increase knowledge of the theoretic construct and its systems theory-based pathologies developed in this research.

6.4 CHAPTER SUMMARY

This chapter discussed research conclusions and recommendations. A summary of the main research findings is articulated with respect research purpose, objectives, and research questions. These significant research conclusions include the role of management cybernetics and the Grounded Theory Method in the inductive development of metasystem pathologies identification and its systems theory-based pathologies that can be used in conjunction with problem formulation phase of systems-based methodologies. Also, the ability to apply the emerging theoretically formulated construct in an operational setting was discussed. Next, the implications of the research were presented with regard to theory, systems body of knowledge, and practice of problem formulation. These included developing possible alternative remedial designs for complex systems, increasing the probability of solving the right problems, supplementing contemporary problem formulation methods and tools, and a platform to further the research beyond single case application. Also, implications were drawn with respect to the Grounded Theory Method since it has not gained popularity in systems-related domains. Finally, recommended future research was presented on philosophical, methodological, epistemology, ontology, theory, axiomatic, axiology, method, and application dimensions. Specific research questions were identified.

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APPENDIX A: CODEBOOK FOR SYSTEMS THEORY

As indicated in Chapter IV, this research uses *systems theory* as dataset in connection with *problem formulation*. This appendix provides the 30 constituent propositions of systems theory - inclusive of laws, principles, and theorems – based on Adams et al. (2014). These 30 propositions formed an initial 'dataset' for building 'codes' and 'categories' for systems theory-based pathologies. Following Miles et al. (2014) along with supplements from Saldaña (2013), the researcher codes the meaning associated with the concepts of systems theory in relation to problem formulation.

The developed codebook consists of 30 codebook pages with each page providing a concept of systems theory that is under consideration. A code name for the concept is then provided. This is followed by a detailed description of the concept under consideration. In some cases, the researcher maintained the verbatim text as used in Adams et al. (2014). However, in several cases, the definition of the concept was expanded. A citation of author(s) who strongly influenced the concept is provided. The researcher also offers conditions that merit inclusion/exclusion of the concept in this research. An example of 'data text' that could best represent the concept is provided. In some cases, extreme examples of the code are offered as well as those that do not represent the concept. *Initial* insights into how the code relates to problem formulation are offered. Finally, the aspects of pathology as violation of the concept are provided. Full citations to reference material are provided at the each of each code.

Principle of circular causality	
Short description	'circular causality'
Detailed description	In linear thinking, the interest is cause and effect such that A causes B, B causes C, etc. However, circular causality suggests that the relationship between A and B is not linear. "An effect becomes a causative factor for future effects, influencing them in a manner particularly subtle, variable, flexible and of an endless number of possibilities" (Adams et al. 2014, p. 117). A or B is influenced by multiple factors which might include B and B
Seminal author(s)	Korzybski, 1994
Inclusion criteria	This principle suggests a need to go beyond cause and effect to include systems beyond those that direct influence system of interest such as interdependent systems and their relationships
Exclusion criterion	This principle would not be included if it is not used to describe a system and is not part of 'systems theory'
Typical exemplars	This concept is applicable to living organisms as well as machines. Most common application involves understanding effect (not the relationship between cause and effect). In circular causality if A makes B happen, B can also make A happen
Atypical exemplars	Not needed
'close' but 'no'	'feedback' (Clemson, 1984)
Relevant note	This principle suggests that there is an endless number of possible issues that might affect system behavior whose relationship to the system is not easily understood
Aspect(s) of pathology	Lack of consideration of this principle, especially in complex systems, might result in a limited level of analysis and synthesis of issues influencing performance of complex systems including behaviors

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Korzybski, A. (1994). *Science and sanity: An introduction to non-Aristotelian systems and general semantics*. New York: NY: Wiley.

Theory of communication	
Short description	'communication'
Detailed description	"...*transference of representative substitutions for that which should be communicated*" (Skyttner, 2005, p. 207). This transference can include objects, energy, or information. "In communication, the amount of information is defined, in the simplest cases, to be measured by the logarithm of the number of available choices. Because most choices are binary, the unit of information is the *bit*, or binary digit" (Adams et al. 2014, p. 117)
Seminal author(s)	Shannon, 1948a; 1948b; Weaver, 1948
Inclusion criteria	This theory suggest that there is a need to have a number of different communication systems that can enable transfer of information
Exclusion criterion	This theory would not be included if it is not used to understand systems. Something is not information if sender, means for sending, or receiver is missing (Skyttner, 2005)
Typical exemplars	This theory has applications in living organisms and machines. Most common application of the theory of communication involves transference of acoustic and visual information. In machines, the theory evokes concepts of information processing, storing, and retrieval.
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	This theory deals with information and "In this matter it is mainly concerned with the process by which messages can be coded, transmitted, and decoded" (Skyttner, 2005, p. 204)
Aspect(s) of pathology	A lack of consideration of theory of communication or an ineffective communication system might result lack of transference of information (messages) and/or partial delivery of information. Thus, information processing, storing, retrial, and use becomes impossible; affecting organizational operations and performance (Katina and Keating, 2012; Ríos, 2012)

References:

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Principle of complementarity	
Short description	'complementarity'
Detailed description	Any two different perspectives or models about a system will reveal truths about that systems are neither entirely independent nor entirely compatible (Adams et al. 2014)
Seminal author(s)	Bohr, 1928
Inclusion criteria	This principle suggests that there is a need to consider a variety of perspectives when dealing with any complex systems. Moreover, there is no 'right' or 'wrong' perspective; only utility offered by the specific perspectives
Exclusion criterion	This principle would not be included if it were not used to describe systems. In simple systems, it is likely that there are very varying perspectives
Typical exemplars	Light is a wave and particle at the same time (Bohr, 1928). Both concepts describe light. However, an effective team selects specific perspectives as need arises
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	In complex organizations, there is a higher probability of having a variety of perspectives on different issues (e.g., operations, practices, etc.). These perspectives "reveal truths about the organization that are only partially independent and only partially compatible" (Clemson, 1984, p. 206)
Aspect(s) of pathology	A lack of consideration of principle of complementary might limit surfacing of relevant perspectives that might be pertinent to current and future complex system development

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Control theory	
Short description	'control'
Detailed description	Complex systems have the ability to select their input so as to influence the output (desired). In other words, this is "the process by means of which a whole entity retains its identity and/or performance under changing circumstances" (Adams et al. 2014, p. 117)
Seminal author(s)	Checkland, 1993; Krippendorff, 1986
Inclusion criteria	This principle defines a critical characteristic of complex system ability for survival
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	Open loop and closed loop control systems
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	Cybernetic control is defined as "purposive influence toward a predefined goal involving continuous comparison of current states to future goals" (Skyttner, 2005, p. 77). This suggest a need for mechanisms that enable processing of environmental information to archive desired results
Aspect(s) of pathology	A lack of control system to process and distribute information might result in the system that does not have means to control environmental information. The system becomes overwhelmed and collapses

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Darkness principle	
Short description	'darkness'
Detailed description	No system can be known completely (Skyttner, 2005). This is because "Each element in the system is ignorant of the behavior of the system as a whole, it responds only to information that is available to it locally…If each element 'knew' what was happening to the system as a whole, all of the complexity would have to be present in that element" (Adams et al. 2014, p. 117)
Seminal author(s)	Cilliers, 1998
Inclusion criteria	This principle is relevant to the concept of effective management. Effective managers recognize "survival worthy systems make no attempt to know all about those systems…[and] avoid knowing about…irrelevant details" (Clemson, 1984, p 204)
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	Top management do not try to understand every detail at local levels
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	Since a "manager cannot possibly be aware of all possible of all the states of his subordinate…it is not necessary to enter the black box to understand the nature of the functions it performs" (Beer, 1979, p. 40)
Aspect(s) of pathology	This principle suggest that a need to treat certain elements of complex systems as black boxes. Failure to utilize this principle might result in micro-management

Additional notes:
No system or the details of its components and interactions can ever be completely known (Skyttner, 1996)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Dynamic equilibrium	
Short description	'dynamic equilibrium'
Detailed description	For a system to be in a state of equilibrium, all subsystems must be in a floating (not steady or stable) state characterized by invisible movements and preparedness for change equilibrium (Adams et al. 2014)
Seminal author(s)	D'Alembert, 1743
Inclusion criteria	This principle helps establish necessary and sufficient conditions for whole system dynamics
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	Reactants are converted into products and products are converted to reactants at an equal and constant rate. Equilibrium deals with state of equal opposite rates and not equal concentrations
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	An organization in the state of dynamic equilibrium, remains in this state unless all its subsystems (units) change their states – which must have been in the state of dynamic equilibrium
Aspect(s) of pathology	A lack of consideration of this principle could result in not working towards a stable state of dynamic equilibrium or moving away from a steady state of dynamic equilibrium

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Principle of emergence	
Short description	'emergence'
Detailed description	Complex systems exhibit properties which are meaningful only when attributed to the whole, not its parts. "Every model of systems exhibits properties as a whole entity which derive from it component activities and their structure, but cannot be reduced to them" (Adams et al. 2014, p. 117).
Seminal author(s)	Aristotle, 2002
Inclusion criteria	This principle suggests that there is need to understand wholes and parts alike. Knowing parts or processes of subsystems does not equate to understanding behavior that occurs as a result of their interactions
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	Weather, life
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	This principle suggests that understanding complex systems exhibit properties and behaviors that cannot be understood by studying parts or elements of the complex system
Aspect(s) of pathology	A lack of consideration of this principle could result in a an attempt to make a direct correlation between local issues (behavior) and system-wide issues (emergent issues)

Additional notes:

"Whole entities exhibit properties which are meaningful only when attributed to the whole, not its parts.....Every model of human activity system exhibits properties as a whole entity which derive from its component activities and not their structure, but cannot be reduced to them." (Checkland, 1993, p. 314)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Checkland, P. B. (1993). *Systems thinking, systems practice.* New York, NY: John Wiley & Sons.

Principle of equifinality	
Short description	'equifinality'
Detailed description	If a steady state is reached in an open system, it is independent of the initial conditions, and determined only by the system parameters (Adams et al., 2014). "Hence, the same final state may be reached from different initial conditions and in different ways" (von Bertalanffy, 1968, p. 40)
Seminal author(s)	von Bertalanffy, 1950
Inclusion criteria	The principle suggests that complex systems, more specific open systems, exhibit equifinality principle and influenced by "soul-like vitalistic factor which governs processes in foresight goal…" (von Bertalanffy, 1968, p. 40)
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"…development of a normal organism from a whole, a divided, or a fused ova, or from any pieces as in hydroids or planarians…" (von Bertalanffy, 1968, 142)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	The principle deals helps to place focus on different initial conditions that may all lead to the same state of a complex system (positive or otherwise)
Aspect(s) of pathology	A lack of consideration of this principle may lead an analyst to assume a one-to-one mapping between cause and effect. It's important to recognize that the final state of the system can be caused by a multitude of factors

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Principle of feedback	
Short description	'feedback'
Detailed description	"The result of behaviour is always scanned and its success or failure modifies future behaviour" (Skyttner, 2005, p. 102). "All purposeful behavior may be considered to require negative feed-back. If a goal is to be attained, some signals from the goal are necessary at some time to direct the behavior" (Adams et al. 2014, p. 117)
Seminal author(s)	Wiener, 1948
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"one form of steering engine of a ship carries the reading of a wheel to an offset from the tiller, which so regulates the valves of the steering engine as to more the tiller in such a way as to turn these valves off…" (Wiener, 1948, p. 6)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	When we set up appropriate feedback loops we can be confident that the system will achieve results (Clemson, 1984)
Aspect(s) of pathology	A lack of consideration of this principle suggests that an analysis cannot regulate behavior of a complex system

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Wiener, N. (1948). *Cybernetics: Or control and communication in the animal and the machine*. Cambridge: MA: MIT Press.

Principle of hierarchy	
Short description	'hierarchy'
Detailed description	"Entities meaningfully treated a wholes are built up of smaller entities which are themselves wholes . . . and so on. In a hierarchy, emergent properties denote the levels" (Adams et al. 2014, p. 117)
Seminal author(s)	Pattee, 1973
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"Nature has a strong tendency to evolve sets of semi-autonomous systems nested within larger systems which are in turn nested within larger systems" (Clemson, 1984, p. 207)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	Complex organizations can be organized into hierarchies with each level being made u of integrated systems
Aspect(s) of pathology	A lack of consideration of this principle implies failure to recognize a nature structure of complex wholes and the relationships to subsystems. The subsystems could be complex in their own right

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Pattee, H. H. (1973). *Hierarchy theory: The challenge of complex systems*. New York: NY: Braziller.

Principle of holism	
Short description	'holism'
Detailed description	"The whole is not something additional to the part: it is the parts in a definitive structural arrangement and with mutual activities that constitute the whole. The structure and the activities differ in character according to the stage of development of the whole; but the whole is just this specific structure of parts with their appropriate activities and functions" (Adams et al. 2014, p. 117)
Seminal author(s)	Smuts, 1926
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"A formal [complex] organization has holistic properties possessed by none of its parts. Each of the units of the organization has properties not possessed by the organization as a whole" (Clemson, 1984, p. 203)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	This principle suggest that good decision-making in complex systems requires recognition of system holistic properties as well as properties of parts in the complex system
Aspect(s) of pathology	A lack of consideration of holistic properties – focusing of properties of the parts – leads to degradation of properties of the whole. This results in sub-optimized system

Additional notes:

"It is very important to recognize that the whole is not something additional to the parts: it is the parts in a definite structural arrangement and with mutual activities that constitute the whole. The structure and the activities differ in character according to the stage of development of the whole; but the whole is just this specific structure of parts with their appropriate activities and functions." (Smuts, 1926, p. 104). Therefore, cannot understand a complex system by reduction to the component or entity level (Skyttner, 1996)

References:

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Principle of homeorhesis	
Short description	'Homeorhesis'
Detailed description	The concept encompassing dynamical systems which return to a trajectory, even if disturbed in development. In homeorhesis, systems return to a particular path of a trajectory while in homeostasis systems which return to a particular state (Adams et al. 2014)
Seminal author(s)	Waddington, 1957; 1968
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	Composition of Earth's atmosphere, hydrosphere, and lithosphere are regulated around 'set points' as in homeostasis, but those set points change with time (Margulis, 1999)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	This principle suggests a need to consider a path of trajectory that a complex system takes in order to arrive at a preferred destination.
Aspect(s) of pathology	Lack of consideration of this principle creates the right conditions for ignoring issues that can halt the path of trajectory of a complex system. Need to design and maintain mechanisms that ensure system remains of the right trajectory

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Principle of homeostasis	
Short description	'homeostasis'
Detailed description	"The property of an open system to regulate its internal environment so as to maintain a stable condition, by means of multiple dynamic equilibrium adjustments controlled by interrelated regulation feedback mechanisms" (Adams et al. 2014, p. 117)
Seminal author(s)	Cannon, 1929
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	A thermostat. It detects changes in the condition being regulated. These essential "variables should be continuously monitored so that serious departures …can be detected and corrected immediately" (Clemson, 1984, p. 215)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	A complex system survives so long as its essential variables are maintained (Skyttner, 2005)
Aspect(s) of pathology	A lack of consideration of this principle could result in not knowing the essential elements of a complex system and developing mechanisms for detecting serious departures or corrections necessary for system survival

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering*, *17*(1), 112–123.

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Theorem of information redundancy	
Short description	'information redundancy'
Detailed description	"The number of bits used to transmit a message minus the number of bits of actual information in the message" (Adams et al. 2014, p. 117)
Seminal author(s)	Shannon and Weaver, 1949
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	Errors in information transmission can be protected against (to any level of confidence required) by increasing the redundancy in the messages (Shannon & Weaver, 1949
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	This principle suggests a need to have redundancy of messages to avoid errors in communication
Aspect(s) of pathology	A lack of consideration of this principle could result in errors in transmission of information such that information is not received; waste of capacity required to transmission of redundant information; lack of balance between "tolerable levels of error and tolerable amount of redundancy required" (Clemson, 1984, p. 211)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Shannon, C. E., & Weaver, W. (1949). *The mathematical theory of communication.* Champaign: IL: University of Illinois Press.

Principle of minimal critical specification	
Short description	'minimal critical specification'
Detailed description	This principle has two aspects, negative and positive. The negative aspect of the principles states that no more should be specified than is absolutely essential for design; the positive aspect of the principle requires that we identify what is essential for design (Adams et al. 2014)
Seminal author(s)	Cherns, 1976; 1987
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"It is of wide application and implies the minimal critical specification of tasks, the minimal critical allocation of tasks to jobs or of jobs to roles, and the specification of objectives with minimal critical specification of methods for obtaining them" (Cherns, 1976 p. 786)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	"...it is a mistake to specify more than is needed because by doing so options are closed that could be kept open" (Cherns, 1976, p. 786)
Aspect(s) of pathology	A lack of consideration of this principle could result in generation of single or narrow view of alternatives. The alternatives can be logged and challenged in the future.

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering*, *17*(1), 112–123.

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Principle of multifinality	
Short description	'multifinality'
Detailed description	"Radically different end states are possible from the same initial conditions" (Adams et al. 2014, p. 118)
Seminal author(s)	Buckley, 1967
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"from a given initial state, [it is possible to] obtain different, and mutually exclusive, objectives (divergence)" (Skyttner, 1996, p. 34)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	This principle suggests that complex organizations with similar histories can have outcomes that vary widely. Thus, we can't draw premature conclusions regarding organizations that appear to be operating under similar conditions
Aspect(s) of pathology	A lack of consideration of this principle could result in drawing incorrect assumptions, conclusions, and taking ill-advised actions based on past or current experiences in regards to complex systems

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Principle of Pareto	
Short description	'Pareto'
Detailed description	In any large complex system, eighty percent of the outputs or objectives will be achieved (produced) by only twenty percent of the system means (Adams et al. 2014)
Seminal author(s)	Pareto, 1897
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"In round terms, this so-called law usually works – which is why people noticed it...Eighty percent of the shares are held by twenty percent of the shareholders...Eighty percent of production goes to twenty percent of the orders" (Beer, 1979, p. 15)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	This principle suggest that "strategies to shift the point of inflection in the curve [80-20 percent curve] to be overall more profitable, must not interfere with the organization's ability to flexibly respond to its environment or they will make the situation worse" (Clemson, 1984, p. 206)
Aspect(s) of pathology	A lack of consideration of this principle could result in 'squeezing' the system too much and lead to its eventual system demise

Additional notes:

Eighty percent of the objectives are achieved with twenty percent of the means (Pareto, 1897)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Theorem of purposive behaviorism	
Short description	'purposive behaviorism'
Detailed description	"Purposeful behavior is meant to denote that the act or behavior may be interpreted as directed to the attainment of a goal – i.e., to a final condition in which the behaving object reaches a definite correlation in time or in space with respect to another object or event" (Adams et al. 2014, p. 118)
Seminal author(s)	Rosenblueth, Wiener, & Bigelow, 1943
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"Let me begin by presenting diagrams for a couple of typical mazes, an alley maze and an elevated maze. In the typical experiment a hungry rat is put at the entrance of the maze (alley or elevated), and wanders about through the various true path segments and blind alleys until he finally comes to the food box and eats. This is repeated (again in the typical experiment) one trial every 24 hours and the animal tends to make fewer and fewer errors (that is, blind-alley entrances) and to take less and less time between start and goal-box until finally he is entering no blinds at all and running in a very few seconds from start to goal. The results are usually presented in the form of average curves of blind-entrances, or of seconds from start to finish, for groups of rats" (Tolman, 1948, p. 189)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	There are complex cognitive mechanisms and purposes that guide behavior of complex systems
Aspect(s) of pathology	A lack of consideration of this theorem could result in misuse of scarce resources, lack of emphasis on mechanisms and unexplored purposes that are guiding complex system behaviors

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering*, *17*(1), 112–123.

Rosenblueth, A., Wiener, N., & Bigelow, J. (1943). Behavior, purpose and teleology. *Philosophy of Science*, *10*(1), 18–24.

Tolman, E. C. (1948). Cognitive maps in rats and men. *Psychological Review*, *55*(4), 189–208.

Theorem of recursive system	
Short description	'recursion'
Detailed description	if a viable system contains a viable system, then the organizational structure must be recursive; in a recursive organizational structure, any viable system contains, and is contained in, a viable system (Adams et al. 2014)
Seminal author(s)	Beer, 1979
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"Every system of whatever size must maintain its own structure and must deal with a dynamic environment, i.e., the system must strike a proper balance between stability and change" (Clemson, 1984, p. 222)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	"Higher level managers who have been drawn into the details of their sub-units' operations will have no time for planning, exploring the environment or generally palling for the future" (Clemson, 1984, p. 223)
Aspect(s) of pathology	A lack of consideration of this principle could result in "a top management that experiences a loss of cohesion and integration and feels that the organization is too decentralized" [and] unit managers that experience a loss of independence and autonomy and feel the organization is too centralized" (Clemson, 1984, p. 222)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Theory of redundancy	
Short description	'redundancy'
Detailed description	"Means of increasing …safety and reliability [and stability] of systems by providing superfluous or excess [critical] resources" (Adams et al. 2014, p. 118)
Seminal author(s)	Pahl et al., 2011
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	The unpredictability in complex system elements of safety, reliability, and stability require provision of excess critical resource in form of backup or fail-safe
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	"Stability relative to overall objectives may require considerable change in short term objectives, in ways of operating, and in technology utilized. These changes all require extra resources" (Clemson, 1984, p. 212)
Aspect(s) of pathology	Complex systems operating environmental conditions might offer different opportunities. However, a lack of consideration of this theory could result in having no extra capabilities (in terms of resources) needed to explore and seize new opportunities

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Principle of redundancy of potential command	
Short description	'redundancy of potential command'
Detailed description	"Effective action is achieved by an adequate concatenation of information. In other words, power resides where information resides" (Adams et al. 2014, p. 118)
Seminal author(s)	McCulloch, 1965
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"A management that encourages utilization of redundancy of potential command will increase its speed of response; ability to detect novel events, information, trends, threats, and opportunities; creativity of decision-making; and comprehensiveness of decision-making" (Clemson, 1984, p. 212-213)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	"Information confers power" (Clemson, 1984, p. 212)
Aspect(s) of pathology	Failure to consideration of this principle "robs the organization of creative solution; ability to recognize crucial facts, trends, and events; and , in general, a large fraction of its overall decision making capability" (Clemson, 1984, p. 212)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Principle of relaxation time	
Short description	'relaxation time'
Detailed description	"Stability near an equilibrium state, where resistance to disturbances and speed of return to the equilibrium are used to measure the property. The system's equilibrium state is shorter than the mean time between disturbances" (Adams et al. 2014, p. 118)
Seminal author(s)	Holling, 1996; Iberal, 1972
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"It is a characteristic of our society that its institutions…have a longer relaxation time [recovery time] on average than the mean time interval between massive external perturbations" (Beer, 1978, p. 404)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	"If too many pebbles are thrown *very* rapidly, the pond surface will appear chaotic and will have no discernible pattern of expanding circular ripples – the systems (*sic*) ability to respond is destroyed by a too rapid series of disturbances" (Clemson, 1984, p. 213)
Aspect(s) of pathology	A lack of consideration of this principle could result in taking on too many changes at one time. "Too many changes at the same time can and often do destroy organizations" (Clemson, 1984, p. 213)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Law of requisite hierarchy	
Short description	'requisite hierarchy'
Detailed description	"The weaker in average are the regulatory abilities and the larger the uncertainties of available regulators, the more hierarchy is needed in the organization of regulation and control to attain the same result, if possible at all" (Adams et al. 2014, p. 118)
Seminal author(s)	Aulin-Ahmavaara, 1979
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	In other words, "the lack of regulatory ability can be compensated to a certain extent by greater hierarchy in organization" (Aulin, 1982, p. 115)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	This law suggests that if a regulatory system lacks ability to control uncertainties (internal or external), then the higher hierarchy must be in control of those uncertainties
Aspect(s) of pathology	A lack of consideration of this principle could result in dealing with uncertainties that are clearly beyond the level of the current level of control

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Aulin-Ahmavaara, A. Y. (1979). The law of requisite hierarchy. *Kybernetes, 8*(4), 259–266.

Law of requisite parsimony	
Short description	'requisite parsimony'
Detailed description	"Human short-term memory [brain activity] is incapable of recalling more than seven plus or minus two items" (Adams et al. 2014, p. 118)
Seminal author(s)	Miller, 1956; Simon, 1974
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"There is a clear and definite limit to the accuracy with which we can identify absolutely the magnitude of a unidimensional stimulus…and I maintain that for unidimensional judgments this span is usually somewhere in the neighborhood of seven" (Miller, 1956, p. 90)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	In dealing with complex systems, the human mind can only deal with seven items – a number that is reached with three items and there points of intersection – plus or minus two
Aspect(s) of pathology	A lack of consideration of this principle could result in taking on too much items or actions in the organization. "Attempts to go beyond this scope of reasoning are met with physiological and psychological Limits that prelude sound reasoning" (Warfield, 1999, p. 25). Moreover, "If the law of requisite parsimony is being unknowingly violated, one would expect that the impact would be revealed in the failure of large systems design. This is precisely what is being observed all around the world" (Warfield, 1995, p. 126)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering*, *17*(1), 112–123.

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Law of requisite saliency	
Short description	'requisite saliency'
Detailed description	"The factors that will be considered in a system design are seldom of equal importance. Instead, there is an underlying logic awaiting discovery in each system design that will reveal the saliency of these factors" (Adams et al. 2014, p. 118)
Seminal author(s)	Boulding, 1966
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"The situational factors that require consideration in developing a design Target and introducing it in a Design Situation are seldom of equal saliency. Instead there is an underlying logic awaiting discovery in each Design Situation that will reveal the relative saliency of these factors" (Warfield, 1999, p. 34)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	"Characteristically individuals who become involved in the design process exhibit great diversity in their assessment of relative saliency...This diversity, if uninfluenced by thorough exploration of the Design Situation, will support unfocused dialog, unjustified decisions, and arbitrary design outcomes not likely to be understood or even actionable" (Warfield, 1999, p. 34)
Aspect(s) of pathology	A lack of consideration of this law could contribute to poor intellectual productivity which is attributed to "spurious saliency - emphasizing the wrong things, out of proportion to what they deserve, unproductive emulation - behaving like those who help create rather than resolve problems, and cultural lag - not using established knowledge with dispatch" (Warfield, 1999, p. 34)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Warfield, J. N. (1999). Twenty laws of complexity: Science applicable in organizations. *Systems Research and Behavioral Science, 16*(1), 3–40.

Law of requisite variety	
Short description	'requisite variety'
Detailed description	"Control can be obtained only if the variety of the controller is at least as great at the variety of the situation to be controlled" (Adams et al. 2014, p. 118)
Seminal author(s)	Ashby, 1956
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"*To put it more picturesquely: only variety in R* [system] *can force down the variety due to D* [another system]; **only variety can destroy variety**" (Ashby, 1956, p. 207)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	"The control achieved by a given regulatory sub-system over a given system is limited by 1) the variety of the regulator, and 2) the channel capacity between the regulator and the system" (Clemson, 1984, p. 216)
Aspect(s) of pathology	Failure to consideration of this law could result in insufficient development dedicated to system for regulating variety and thus system might have no capability to adapt or grow (Clemson, 1984)

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Principle of satisficing	
Short description	'satisficing'
Detailed description	"The decision-making process whereby one chooses an option that is, while perhaps not the best, good enough" (Adams et al. 2014, p. 118)
Seminal author(s)	Simon, 1955; 1956
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"…attaining a certain minimum quality level for the decision, enough to solve the problem but not necessarily more…because the first acceptable solution is considered to be as good as all the others. To satisfy is to use the principle of least effort" (Skyttner, 2005, p. 395)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	"The main reason why decision-making in most cases appears to be satisficing is the following limiting circumstances…*Limited time*…*Limited information*…*Limited information-processing capability*…" (Skyttner, 2005, p. 396)
Aspect(s) of pathology	A lack of consideration of this principle in complex systems operating under uncertainty conditions could result in misuse of scarce resources

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering*, *17*(1), 112–123.

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Principle of self-organization	
Short description	'self-organization'
Detailed description	"The spontaneous emergence of order out of the local interactions between initially independent components [systems, elements or parts]" (Adams et al. 2014, p. 118)
Seminal author(s)	Ashby, 1947
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"Complex systems organize themselves and their characteristic structural and behavioural patterns are mainly a result of interaction between subsystems" (Skyttner, 2005, p. 101)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	"Most of the structural and behavioral patterns in an organization are a result of interactions among the parts of the organization; they are primarily the result of the management's deliberate decisions" (Clemson, 1984, p. 2019)
Aspect(s) of pathology	A lack of consideration of this principle could result in forcing a new culture and identity of the system which is most likely to face strong opposition

References:

Adams, K. M., Hester, P. T., Bradley, J. M., Meyers, T. J., & Keating, C. B. (2014). Systems theory as the foundation for understanding systems. *Systems Engineering, 17*(1), 112–123.

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Principle of sub-optimization	
Short description	'sub-optimization'
Detailed description	"If each subsystem, regarded separately, is made to operate with maximum efficiency, the system as a whole will not operate with utmost efficiency" (Adams et al. 2014, p. 118)
Seminal author(s)	Hitch, 1953
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"It is silly to look for an optimal solution to a mess. It is just as silly to look for an optimal plan. Rather we should be trying to design and create a process that will enable the system involved to make as rapid progress as possible towards its ideals, and to do so in a way which brings immediate satisfaction and which inspires the system to continuous pursuit of its ideals" (Ackoff, 1977, p. 5)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	This principle suggests that optimizing each subsystem independently will not in general lead to a system optimum, or more strongly, improvement of a particular subsystem may actually worsen the overall system (Heylighen, 1992)
Aspect(s) of pathology	A lack of consideration of this principle could lead to pursuit of solutions that will no merit on system and would act to limit overall system performance

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Heylighen, F. (1992). Evolution, selfishness and cooperation. *Journal of Ideas*, *2*(4), 70–76.

Hitch, C. (1953). Sub-optimization in operations problems. *Operations Research*, *1*(3), 87–99.

Principle of viability	
Short description	'viability'
Detailed description	"A function of balance must be maintained along two dimensions: (1) autonomy of subsystem versus integration and (2) stability versus adaptation" (Adams et al. 2014, p. 118)
Seminal author(s)	Beer, 1979
Inclusion criteria	This principle can be used in understanding and development of complex systems
Exclusion criterion	This principle would not be included if it were not used to describe complex systems
Typical exemplars	"…conditions that are necessary and sufficient [for complex system survival]" (Beer, 1979, p. 115)
Atypical exemplars	Not needed
'close' but 'no'	Not needed
Relevant note	"Organizational effectiveness is a function of the balance maintained along two dimensions…autonomy of organizational units verses integration of the business as a whole [and] stability of operations versus adaptation to changing conditions" (Clemson, 1984, p. 221)
Aspect(s) of pathology	A lack of consideration of this principle could result in too much of autonomy; too much integration; too much stability; too rapid pace of adaptability – none of which support existence of a complex system

References:

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APPENDIX B: CATEGORIES FOR SYSTEMS THEORY-BASED PATHOLOGIES

This appendix provides further elaboration on the categories of systems theory-based pathologies. A theme that emerged out of open coding activity of GTM was that conditions, factors, or patterns that might act to limit system performance might be attributed to the failure to adhere to concepts of systems theory (Beer, 1984; Clemson, 1984: Katina, 2015a; Ríos, 2012). Consequently, when one fails to adhere to concepts of systems theory, there is an increased likelihood that the system in question will not achieve its expected performance (Beer, 1984; Keating & Katina, 2012). These ideas were first illustrated in Appendix A, where the researcher developed initial insights into pathologies. Once the Grounded Theory Method was selected as a viable approach for this research, each systems theory concept was (re)analyzed using QSR International's NVivo 10 software package --- initially, each of the 30 concepts of systems theory from Adams et al. (2014) were recorded as 'codes' in a Microsoft Office's Word 2013 document and synthetized for pathological meaning. The dataset (i.e., text units) related to the concept of systems theory were imported into NVivo 10 as either 'memos,' "significant word or phrase you applied to a datum" (Saldaña, 2013, p. 42). Then, the researcher, thinking critically about the meaning of each concept and reflecting on the purpose of the research as well as challenging own assumptions (Mason, 2002).

developed pathological meanings for the various concepts of systems theory. Consequently, a database of 362 'codes' and 83 'categories' of systems theory-based pathologies was developed from the 30 propositions and 53 other concepts of systems theory. These pathologies are presented in this appendix.

Table 52: A Comprehensive Listing of Codes and Categories Supporting Systems Theory-Based Pathologies

Category	Codes	Supporting sources	Statement of a systems theory-based pathology
Pathology of complementarity	- need for more than one perspective - revealing truths - anticipating utility of perspectives - causes massive confusion	Clemson, 1984	**Pathology of complementarity** - a situation in which an organization ignores other perspectives/models that are not entirely compatible with the established-predominate perspectives including missions, goals and objectives. An organization in this case mistakenly assumes that there is only one 'right' perspective (Bohr, 1928; Mehra, 1987). Thus, different truths contained in different perspectives are shunned. Murdoch and Murdoch (1989) suggest that this pathology is more likely related to a management style that assumes that the organization operates under 'ideal' conditions. Moreover, too many perspectives, especially the ones not being made explicit and understood, could cause "mass confusion" (Clemson, 1984, p. 207) in an organization. This pathology is expected in an operation landscape characterized as ambiguous, complex, interdependent, and uncertain
	- requiring both parties - circular definitions of each other	Krippendorff, 1986	
	- classical concepts have a limited applicability - there must be well-defined elements	Murdoch and Murdoch, 1989	
	- perspective might not be compatible	Skyttner, 2005	

Table 52 (cont.)

Pathology of diminishing returns	- diminishing marginal productivity - fixed variables - yielding becomes progressively smaller - improving methods and tools - corresponding change in other variables (e.g., advance in technology) - raising subsystem well-being	Encyclopedia Britannica, 2013	**Pathology of diminishing returns** - a condition in which management mistakenly assumes that increasing number of workforce increases the productivity of the organization as a whole without expanding the landscape of operations. In a farming example, if a farmer with a specific acreage and a specific number of workers decides to increase the number of workers; overall productivity might not increase (Krippendorff, 1986; Samuelson & Nordhaus, 2001; Smith, 1904). In fact, the Encyclopedia Britannica, suggests that the output of each worker is reduced and thus affecting the whole organization. There must be a corresponding change in other variables such as advanced technology and investing in better skilled-workers
	- additional units - fixed amounts of the other inputs - smaller increments	Krippendorff, 1986	

Table 52 (cont.)

Pathology of requisite hierarchy	- increasing hierarchy of a system	Adams et al., 2014	**Pathology of requisite hierarchy** - a situation in which the regulatory body of an organization is not well-designed to match the variety of the organization. This pathology is evident in situations in which the variety of the system is higher than what the regulatory body can handle (Aulin, 1982; Aulin-Ahmavaara, 1979). The structure of the organization might change (i.e., horizontal or vertically) without consideration of a matching multilevel regulatory body (Ríos, 2012). In this situation, the current regulatory body might reach its limit, if it exists at all. A well-designed regulatory body is "necessary for effective regulation and survival of the society" (Klir, 1991, p. 211)
	- increasing regulatory ability	Aulin, 1982	
	- matching the variety of the system being regulated - necessary for survival of the system - upper limit to the of each hierarchy	Klir, 1991	
	- need for more hierarchy	Skyttner, 2005	

Table 52 (cont.)

Pathology of requisite knowledge	- good regulars represent the good models of the system' - needs for regular to learn for the survival of the system'	Conant and Ashby, 1970	**Pathology of requisite knowledge** - a situation in which an organization simply has a bad regulator. A bad regular for an organization is simply a regulator that is not well-informed of the relevant facts that enable viability. To Schwaninger (2009), a regulator can only regulate (i.e., control) a system better if a regular understands the system well. This is something that is provided by a model that has requisite knowledge. Control and regulation can only take place if the model of the organization has a well-articulated knowledge base and the ability to select the right actions against perturbations. In line with Heylighen's (1992), an organization in requisite knowledge pathology might blindly take actions using, for example, trial and error approaches in hopes of *eventually* solving organizational issues. An organization under this pathology will eventually "dissipate" (Schwaninger, 2009, p. 20) since it is not operating under the guidance of the relevant facts
	- regulator must know actions to take - selects the right responds to perturbations - might involve a one-to-one mapping - knowledge is embedded in connections - bad regulators try blindly and eventually solve the problem	Heylighen, 1992	

Table 52 (cont.)

Pathology of requisite parsimony	- assuming unreasonable number activities	Adams et al., 2014	**Pathology of requisite parsimony** - a condition in which a system fails because the human element of the organization has assumed more activities than what can reasonably be handled. The number is limited to seven plus or minus two (Miller, 1956). This number can be as low as having three activities (i.e., functions, missions, and objectives) and four interacting combinations of those activities (Skyttner, 2005). Any attempts to go beyond this scope "prelude sound reasoning" (Warfield, 1999, p. 25) and might diminish accuracy and is a source of bad judgment (Miller, 1956)
	- diminishing accuracy and might result in bad judgment	Miller, 1956	
	- as low as three elements and four interacting combinations	Skyttner, 2005	
	- limited sound reasoning - system design failures	Warfield, 1995	

Table 52 (cont.)

Pathology of requisite saliency	- all factors of system designs are not of equal importance	Adams et al., 2014	**Pathology of requisite saliency** - a condition in which organization productivity is reduced due having undifferentiated importance of organizational missions and objectives (Boulding, 1966). According to Warfield (1999), this pathology is related to having spurious saliency (i.e., the organization is emphasizing the wrong elements, out of proportion to what they deserve), unproductive emulation (i.e., members of the organization might be behaving as those who help create rather than resolve problems), and having a cultural lag (i.e., not operating using a common established knowledge base). With all likelihood, the workforce of a complex organization is diversified. Left unchecked, the workforce can develop unfocused dialog, incorrect decisions, and arbitrary design not likely to be understood by leadership or individuals and actions that cannot achieve the desired results (Warfield, 1999). These circumstances create the right conditions for failure to articulate the relative importance of different elements of the organization, leading to "poor intellectual productivity" (Warfield, 1999, p. 34)
	- having major implications on intellectual productivity - spurious saliency - unproductive emulation - cultural lag - team diversity negatively influencing the design and understanding	Warfield, 1999	

Table 52 (cont.)

Pathology of requisite variety	- only variety destroy can variety	Ashby, 1956	**Pathology of requisite variety** - a situation in which the regulatory entity of an organization has insufficient capacity to address the variety of the system. In this situation, the regulatory entity of the organization, according to Clemson (1984), might not be designed to handle organization's variety or the channel linking the regulator and system might be limited. The regulatory entity including its management team and the procedures are never 100% accurate, competent, knowledgeable, and capable. However, the organization should have the ability to (re)design the regulatory entity (Clemson, 1984). Organizations in this situation, might still manage to deal with variety at high costs using duplicative and guesstimating measures. In either situation, the organization is being operated without sufficient control since "Control can be obtained only if the variety of the controller [regulator] is at least as great as the variety of the situation to be controlled" (Skyttner, 2005, p. 100)
	- the regulating subsystem is limited by the capacity of its regular and channel capacity linking the regulator and system - this includes management and its procedures - reducing variety of subsystems is directly related to variety of the system - the regulator is never 100% efficient - some systems can be operated regulatory subsystems lacking variety; guesstimating and costs are involved	Clemson, 1984	

Table 52 (cont.)

Pathology of adaptation	- maintaining essential variables - responding to external disturbances using internal mechanisms - some systems do not have this ability and operate efficiently - they stay to close to the fire or too far from the fire	Ashby, 1960	**Pathology of adaptation** - a situation in which neither the internal structures of a system are able to change in response to external disturbances, nor system being able to lessen environmental changes affecting it. As noted by Ashby (1960), a system's ability to survive is highly dependent on being able to change in response to change and/or changing the environment (Krippendorff, 1986). More specifically, Hitchins (1992) notes that a system's rate of adaptation must equal or exceed the mean rate of change of its environment. An organization in this situation might find that its essential variables are overrun by the environment disturbances. Failure to act "homeostatically" (Ashby, 1960, p. 62) in the presence of environmental disturbances is indicative of this pathology
	- system rate of change of adaptation must match that of the environment	Hitchins, 1992	
	- the system remains stable in the face of change - the system changes its internal structure - the system changes the external environment	Krippendorff, 1986	

Table 52 (cont.)

Pathology of autonomy	- being able to act independently without constraint of higher a system - it can be disputed as to whether autonomy is good or bad	Bateson, 1980	**Pathology of autonomy** – a situation in which a subsystem does not have the ability to act as an independent agent without the constraints of a higher system. Autonomy in this case might include being able to make decisions and taking actions (Bateson, 1980; Chirkov, Ryan, & Sheldon, 2011). Autonomy is beneficial for the subsystem(s) and the system itself. For instance, experts suggest that a worker who is free to make choices in the workplace and accountable for his or her decisions tends to be happier and more productive (Chirkov et al., 2011). In essence, a subsystem operating an autonomous pathological condition might seek guidance in all its actions and decisions. The question is not whether autonomy is good or bad for the subsystem and the system (Bateson, 1980); rather, the issue at play is recognizing situations in which a subsystem can act as an independent agent within the confines of a larger-networked system (Varela, 1979). An entity without autonomy, constrains the organization
	- autonomous system is organizationally closed as a network - even systems in a network depend on each other	Varela, 1979	

Table 52 (cont.)

Pathology of balance of tensions	- the needs for metasystem structure - the metasystem relieves tensions - the metasystem helps in preparing for emerging issues - a poor performing metasystem can worsen the tensions	Keating, 2009	**Pathology of balance of tensions** - a situation in which the system lacks a governing structure that can relive tension among different subsystems/elements. Specifically, Keating (2009) suggests that a metasystem structure can be used to balance tensions along the dimensions of (1) independence of subsystems and missions of the whole, (2) structured design and self-organization, and (3) maintaining stability and allowing for change commensurate with unpredictability in the system/environment. This balance is necessary for the viability of the system (Keating et al., 2010; Keating, 2010). In fact, these tensions might "result in decreases performance, and although the system may maintain viability (continued existence), it may not be at the levels of performance desired" (Keating, 2010, p. 6). An organization operating under this pathological condition might lack a governing structure or have a governing structure that is inadequate. Under these conditions, the system becomes incapable of anticipating and preparing for emerging trends and patterns affecting the system (Keating, 2009)
	- tensions in systems will always exists and they must be dealt with - tensions reduce system performance - the metasystem structure can be used maintain a desired level of performance	Keating, 2010	
	- balancing tensions	Keating et al., 2010	

Table 52 (cont.)

Pathology of basins of stability	- different configurations have different consequences for a system	Bateson, 1972	**Pathology of basins of stability** - a condition in which system's stability is reduced because of the inability to recognize different system configurations and their periods of transitions. Hester and Adams (2014) suggest that complex systems have three configurations: order, chaos, and the transition phase. Each configuration requires different resources and produces different consequences (Bateson, 1972). Regardless of the configuration, it takes effort to move a system from one state to another and once a system settles in a specific basin, significant efforts might be required to move it to a more preferred basin (Clemson, 1984). An organization suffering from this pathology might not recognize the need to move from one basin to another or the scope of efforts required to move it from one basin to another (Nicolis & Prigogine, 1975). While the organization is in the transition period, it might lack the ability to brake and thus keep gravitating towards the least energy state (Clemson, 1984). Since it is difficult to initiate a move, the current organization basin might be viewed as if it were in a permanent state. An example of basins of stability pathological condition is "investment in one type of building (or in one technology or in one location) puts an organization in one basin of stability as compared to other possible plants, technologies, or locations" (Clemson, 1984, p. 221). These actions reduce systems stability or the ability to respond to changes
	- a system seeks to use lowest energy - changing from one configuration requires sufficient resources - once the system starts to move, it continues until affected - systems can be placed in a number of basins	Clemson, 1984	
	- the basins are not a permanent state - it can be difficult to distinguish transition phases	Hester and Adams, 2014	
	- the periods of transition are tumultuous	Nicolis and Prigogine, 1975	

Table 52 (cont.)

Pathology of buffering	- enhancing stability through surplus of resources	Skyttner, 2005	**Pathology of buffering** – a condition in which a system lacks surplus resources. In essence, the system is being operated without slack (Skyttner, 2005). In this case, slack is reverse and might be defined as "capacity in excess of immediate needs" (Wildavsky, 1988, p. 116). A certain amount of reserves enhances system stability since it is only used in case of unexpected increase in demand (Wildavsky, 1988). Unlike the pathology of redundancy of resources (i.e., not having the same kind resource in case of failure), this pathology simply addresses a need for 'slack' in case of unexpected increase in demand while being aware that unused surplus could actually harm efficiency of the system. An organization in this condition might have zero reserves or too many reserves – neither of which is desirable for the system
	- it provides the system some slack - the reserves are used in case of unexpected increased demand - reserves can decrease efficiency and lead to failure	Wildavsky, 1988	

Table 52 (cont.)

Pathology of circular causality	- the effects become causes with an endless number of possibilities	Adams et al., 2014	**Pathology of circular causality** – a situation in which a traditional (linear) causality model of thinking is applied without recognizing the nature of intricate interactions in subsystems of a complex system. In the traditional model of thinking, an event A is directly related to B (i.e., causes) and in turn B causes C. However, C might not be considered as a contributor to the formation of A along with a multitude of other factors (Adams et al., 2014; Keesing, 1981). Clemson (1984) notes that it is in fact possible to have a wide range of conditions leading to the same results as in *positive feedback*. As pathology, this situation is evidenced when an organization fails to focus on processes and the emerging patterns of events in systems. Emphasis might be placed on finding single causes. However, since social events are rarely uni-directional, as suggested by Krippendorff (1986, p. 9), there is a need to focus on multi-casual of factors for complex systems. This is supported by Korzybski (1994) who suggested that its best view oneself as a member of a society who could be affected by many factors in a spiral process of causality. Thus, it is a fundamental error to operate a complex systems using a linear causality model of thinking since this focus could limit exploration of other relevant factors affecting system performance
	- shifting from causality - focusing of processes and emergent structures and patterns of events	Bale, 1995	
	- spiral process of causality - fundamental to human thinking - related to how we defines ourselves as members of the society - this is a non-linear process with implications of negative feedback	Korzybski, 1994	
	- the process of linking more than one event - A causes B and B cause C without recognizing that C could as well contribute to the formation of A - social events are never uni-causal; they are more multi-causal	Krippendorff, 1986	

Table 52 (cont.)

Pathology of consequent production	- balancing tensions through design modification	Keating, 2010	**Pathology of consequent production** - a condition in which there is failure to focus on the underlying structure of the system; rather focus is placed on the outcome/outputs themselves. Keating et al. (2010) notes that when a system produces undesirable outputs, the focus should not be on the output. The focus should be on attempting to (re)calibrate the structures of the system in order to produce an improved product (Keating, 2010). A system, according to Keating et al. (2003a) can only provide what it can produce. It is an error to assume improvement without improving the system itself. The pathology of consequent production might be exhibited in systems that continue to produce 'wrong' products despite making changes
	- looking at the system generating undesired behavior	Keating et al., 2010	
	- a system can only produce what it produces - adjusting the structure and not the outcomes	Keating et al., 2003a	

Table 52 (cont.)

Pathology of cybernetic stability	- configuration becomes more intricately organized - increased numbers of variables make the system more sensitive - they also make the system more effective in adapting - the system increases its ability to remain viable - enhanced control for system governance	Bale, 1995	**Pathology of cybernetic stability** - a condition in which a system lacks a sufficient number of external connections. This is a like a freestanding structure. It has been suggested that an increased the number of connections makes a system more stable and easily adaptive (Bale, 1995). A system operating without a without a sufficient number of connections is unable broaden its sense of self and responsibility and might become unconscious of needs of other systems (Macy, 1991). Bale's (1995) work also suggests that the exchange of information among interacting systems is relevant to effective control, refrain, and governance of the system of interest. Still, too much exposure to other systems can make the system too "intricately organized and more intimately interrelated" which might make the system "more sensitive and responsive to change, and thereby less stable" (Bale, 1995, p. 194). An organization in this situation might act as though it was a self-sustaining system
	- becomes more conscious of interactions and needs of others - broadening of sense of self and responsibility including respect - the very survival of society and ecosystems requires a shift in identification	Macy, 1991	

Table 52 (cont.)

Pathology of darkness	- not aware of all states of subsystems	Beer, 1979	**Pathology of darkness** - a situation in which a system is operated upon under the assumption that all its relevant aspects including behaviors are known. At the very best, one might be able to understand behaviors of local systems as noted by Cilliers (1998). However, and as supported by systems literature, no system or the details of its components and interactions can ever be completely known (Beer, 1979; Clemson, 1984: Skyttner, 1996). Thus, when the principle of darkness is violated, one might strive to know all aspects of a complex system, its elements as well as their interactions, which can only lead to wasting scarce resources. Effective management is still possible so long as there is focus only on the "crucial aspects of the system and to actually avoid knowing about (hopefully) irrelevant details" (Clemson, 1984, p. 204). An organization in this pathological condition might attempt to make all system elements and their interactions as transparent as possible
	- a subsystem is only aware of the local events	Cilliers, 1998	
	- can still be managed effectively - essential to holistically the system we are responsible for - the more we more from the local system, the more opaque systems become	Clemson, 1984	

Table 52 (cont.)

Pathology of dialecticism	- correcting errors through single and double loop learning	Argyris and Schön, 1978; 1996	**Pathology of dialecticism** - a condition in which a system lacks the ability to detect errors and learn. More specifically, this condition involves the lack of means to correct errors through single loop where reflection is made on what is good/bad about operations. It also includes double loop learning in which reflections, for example, on goals, are made with regards to how they are achieved, modifying the approach, and or rejecting a goal. An organization in this pathological condition might have the ability to reflect on what was learned including recommendations but still lacks the means to follow-up and implement the recommendations
	- reviewing as in telling stories - self-reflecting	Boje, 2008	

Table 52 (cont.)

Pathology of emergence	- properties attributed to the whole	Checkland, 1993	**Pathology of emergence** – a condition in which management assumes behaviors of the system whole can be directly inferred by the properties of subsystems, independent of subsystem interaction. In this case, management fails to recognize that complex systems exhibit behaviors beyond those of the individual subsystems (Aristotle, 2002; Guckenheimer & Ottino, 2008; Heylighen, 1989). This principle, when explained in terms of meaning, suggests that system wholes "entities exhibit properties which are meaningful only when attributed to the whole, not its parts" (Checkland, 1993, p. 314). Thus, this pathology might be exhibited when a system whole is divided into parts in hope of understanding it better. As indicated, it would be an error to assume that better understanding of the whole can be developed from a clear understanding of isolated parts
	- emerges from interactions	Guckenheimer and Ottino, 2008	

Table 52 (cont.)

Pathology of environmental-modification	- to maintain survival	Watt and Craig, 1988	**Pathology of environmental-modification** - a condition in which a system fails to negotiate its environment. As indicated by the pathology of adaptation, systems can either change themselves or change the environment. The pathology of environmental-modification places more emphasis on the efforts undertaken to influence the environment of the system (Douglas & Wildavsky, 1982; Watt & Craig, 1988; Wildavsky, 1988). More specifically, this pathology is exhibited by systems that lack the ability of "negotiating the environment [for example] (by collusion on practices or by diving market shares) so as to reduce the extent of fluctuations to which the unit in question has to respond" (Wildavsky, 1988, p. 116). The line of demarcation separating the system from its environment plays a key role. It could be too narrow, broad, or missing (Douglas & Wildavsky, 1982). While environmental-modification capability is recommended, there is a caveat especially in monopolistic situations in which monopolies "strengthen stockholders but not necessarily the economic system on which these monopolies ultimately depend" (Wildavsky, 1988, p. 116). Clearly, these conditions are neither good for the system nor other systems in the large environment
	- negotiating the environment - reduces fluctuations - much depends on the line of demarcation - can strengthen system of interest by weaken other systems	Wildavsky, 1988	

Table 52 (cont.)

Pathology of equifinality	- achieving similar results but starting with different initial conditions	Cummings and Worley, 2005	**Pathology of equifinality** - a situation in which a system is operated with a belief that there exists only one approach/method to achieve a final desired state - -- including goals and missions. There might indeed be one approach, however, the issue at hand is whether other alternative approaches can be examined and taken into consideration (Katina et al., 2014a). Researchers have indicated that it is possible to arrive at a similar goal and mission while starting out with different approaches (Cummings & Worley, 2005; Paritsis, 2000; von Bertalanffy, 1968). More specifically, von Bertalanffy (1968, p. 40) notes that "the same final state may be reached from different initial conditions and in different ways." Thus, an organization that fails to explore and recognize other viable alternatives and measures that would still result in achievement of the same desired mission and objectives is suffering from pathology of equifinality. Such an organization becomes closed and deterministic and lacks proper governing structure to maximize system survivability chances
	- applying different methods to achieve similar ends - it maximizes basic changes for survival	Paritsis, 2000	
	- if the system is closed, then initial conditions yield same results - implications for governance	von Bertalanffy, 1968	

Table 52 (cont.)

Pathology of equivocation	- knowing meaning at a particular time	Damer, 2000	**Pathology of equivocation** - a situation in which communication channels of a system are inefficient in delivering intended signal (i.e., messages) from one point to the next. In delivering messages (i.e., information), the sender may wish to conceal the meaning (Shannon, 1949) so that only the intended receiver can decipher and understand its meaning. In a secret system, the receiver is able to understand the meaning (Damer, 2000). Thus, communication is still possible despite the noise - any factor in the process that works against the predictability of the outcome of the communication process. However, when the principle of equivocation is violated, the communication system might lack the ability to conceal the information. In fact, a poorly designed communication channel could increase the noise such that the receiver is unable to understand the meaning (Krippendorff, 1986; Shannon, 1949). An organization experiencing this pathology might require further clarification, simplification, generalization or condensation of the signals or messages sent
	- reduction of variety and noise/increasing clarity - equivocation leads to poor understanding	Krippendorff, 1986	
	- the true meaning might be hidden - ensuring that despite noise, communication is still possible - the level of equivocation decreases over time	Shannon, 1949	

Table 52 (cont.)

Pathology of eudemony	- money is highly valued but it only helps in achieving well-being - money actually constraints happiness	Beer, 1978	**Pathology of eudemony** - a situation in which precedence is placed on the financial profitability of a system above any other measures. This situation involves ignoring import measures that are desirable in describing overall well-being since that not easily quantifiable. Specifically, the literature suggests that the overall well-being of a system, including people and the society at large, is related to having a right balance in material, technical, physical, social, nutritional, cognitive, spiritual, and environment (Beer, 1978; Kant, 1991; Li, 2013). Financial profitability (i.e., money) should only be taken as an enabler for eudemony (Beer, 1978; Li, 2013). When the principle of eudemony is violated, Li (2013) suggests that it's indicative of one's lack a sense of self, being unbalanced with social surroundings, and therefore not in tune with the universe. In this regard, money should be seen as a "constraint" to happiness (Beer, 1978, p. 159). Therefore, an organization suffering from this pathology is expected to place more emphasis on money. However, placing emphasis on money and attaining it will not necessarily improve the quality of life
	- if its unconsidered the result could include a quiet death	Kant, 1991	
	- it involves peoples well-being and being in tune with the universe - it involves having the right balance between several factors beyond financial profitability - unfortunately, western culture does not place emphasis on it - it involves social worthiness and money does not provide the right measure	Li, 2013	

Table 52 (cont.)

Pathology of events of low probability	- attempting to be all things to all the people all the time - including events of low probability - such a system is too complex to be workable - can be sympathetic but focus on maximizing expected value	Machol and Miles, 1973	**Pathology of events of low probability** - a situation in which a complex system is expected to accommodate all scenarios including those of low probability. More specifically this pathological condition indicates that it's an error to attempt to be all things to all people at all times (Machol & Miles, 1973). The attempt to account for all possible scenarios in a complex system is too complex to be workable, could be costly, and could be the basis for jeopardizing the fundamental objectives of the system (Machol & Miles, 1973; Machol et al., 1965). Therefore, an organization under the pathology of events of low probability, might attempt to serve all subsystems and entities (including people) without any differentiation (i.e., prioritization)
	- does not jeopardize fundamental objectives to accommodate events of extremely low probability	Machol, Tanner, and Alexander, 1965	

Table 52 (cont.)

Pathology of feedback	- being able to scan and use failures to improve future behavior	Skyttner, 2005	**Pathology of feedback** - a situation in which a system lacks the means to improve its behaviors because of insufficient scanning processes. Scanning processes provide the basis for bringing the system close to a desired state (Skyttner, 2005; Wiener, 1948). The pathological feedback situation has two sides: first, a system might lack scanning mechanisms to enable negative feedback in which system output is fed back into the system to reduce fluctuations caused by the system or other systems. Second, a system might lack scanning mechanisms to enable positive feedback in which small effects on the system are ignored and in time produce more and devastative effects on the system. Luhmann's (2013) work also suggests that such a system might be operated under the thinking that there exists a limited set of events affecting system behavior. Hence, there becomes failure to consider multiplicity of causes and effects on system behavior
	- helps in bringing the system close to a desired state	Wiener, 1948	
	- includes accounting for negative feedback which becomes basis for acting - there is a need to consider the multiplicity of causes and effects	Luhmann, 2013	

Table 52 (cont.)

Pathology of flatness	- a wider base increases stability	Watt and Craig, 1988	**Pathology of flatness** - a situation in which the structure of governance is an inverted pyramid. This is a situation in which there is a "larger the number of administrators relative to that of producers" (Wildavsky, 1988, p. 114). This type of governing structure reduces system stability and is comparative to a dictatorial regime in which "the death of only a handful of people might well cause [regime] collapse" (Wildavsky, 1988, p. 114). Watt and Craig (1988) elaborate on this issue by suggesting that a larger number of independent actors under the guidance of sufficient set of administrators will increase system stability. Thus, an organization in this pathological condition might either have a large number of administrators in proportion to systems being administered to or have a single administrator attempting to administer a large number of complex systems
	- a large number of administrators reduces stability - politically, widespread legitimacy is better than dictatorial	Wildavsky, 1988	

Table 52 (cont.)

Pathology of frame of reference	- providing a reliable means in which a system can be judged	Krippendorff, 1986	**Pathology of frame of reference** - a situation in which a system lacks standards by which it can be judged. In this case, a standard is not a sufficient measure for the truth of the judgment but it is a reliable indication of how the system and its elements are (Keating, 2010; Krippendorff, 1986). This pathological condition might be indicated by lack of an explicit articulated underlying presuppositions and assumptions and operating system context (Krippendorff, 1986). In this case, a common vantage point for judging the system is lacking

Table 52 (cont.)

Pathology of hierarchy	- each hierarchy is more complex than the one below	Checkland, 1999	**Pathology of hierarchy** - a situation in which a system lacks a basic structure of a hierarchy. A hierarchy provides a regulatory structure that enables 'organization' of the system to generate desired system performance/behavior (Pattee, 1973). At each level of a hierarchy, several systems are integrated into a more complex than the one below (Checkland, 1999). In terms of viability, Simon (1973) notes that hierarchies "provide the most viable form for any system of even moderate complexity" (p. 27). An organization in this pathological condition might be organized as a flat system perhaps with independent systems whose missions are non-uniform due to lack of hierarchy. Insufficient or ineffective hierarchy might fail to provide the required level of regulatory controls to reduce uncertainty in the face of turbulent and emergent system conditions
	- each hierarchy consists of several integrated systems - at each level of a hierarchy, subsystems are more autonomous than the one above	Clemson, 1984	
	- viable system within a viable systems	Simon, 1973	

Table 52 (cont.)

Pathology of high-flux	- reducing the time taken for a resources to arrive at the needed destination	Watt and Craig, 1988	**Pathology of high-flux** - a situation in which the rate of arrival of resources to systems in less than failures. Related to recovery time, the pathology of high-flux suggests the need to have resources arrive as soon as a failure occurs. The lag in arrival of resource has implications on system stability (Watt & Craig, 1988; Wildavsky, 1988). Researchers have indicated that "increasing the rate of resource input per unit of life form steadily increased stability" in a variety of ecosystems (Wildavsky, 1988, p. 113). This pathology is most concerned with the rate of arrival of resources and not necessarily the efficient use of resources that arrive. In addition, this pathology calls for the arrival of the right resources and how bureaucracy can increase the arrival of resources (Wildavsky, 1988). An organization might become unstable simply due to delay in arrival of resources caused by, for instance, politics
	- the recovery time may be longer if the resources take longer to arrive - the delay in the arrival of could be due bureaucracy	Wildavsky, 1988	

Table 52 (cont.)

Pathology of holism	- properties not possessed by parts and properties not possessed by the whole	Ackoff, 1971	**Pathology of holism** - a situation in which the management assumes a mode of operation suggesting that behaviors of an integrated system are possessed in its subsystem parts. This pathology is different from the pathology of emergence in that it suggests that understanding of a system cannot be maintained past a particular point of reduction. Under the pathological condition of holism, there are system properties (i.e., behaviors) that cannot be deduced from parts and there are subsystem behaviors that cannot be deduced from the system (Ackoff, 1971; Clemson, 1984; Skyttner, 1996). Nonetheless, both are needed (Clemson, 1984) and they vary in arrangement, activities and functions (Smuts, 1926). A system operating under this pathology might attempt to optimize subsystems in hope of improving the system whole. Clemson's (1984) work also suggests that an organization under this condition might lack "clear roles definitions or divisions of responsibilities" and in turn lack "clear communication about the nature of the organization", both of which are "source of enormous trouble" (p. 203). The concern in this pathology is a diminished understanding through either examination the whole without parts or parts without the whole
	- both types of properties are needed - the properties of the whole are not predicted by understanding parts - sub-optimization parts of the system and not the system - corporate understanding requires a clear role definition and communication	Clemson, 1984	
	- the whole is not in addition to parts and more of an arrangement and activities and functions	Smuts, 1926	

Table 52 (cont.)

Pathology of homeorhesis	- maintaining internal stability	Hester and Adams, 2014	**Pathology of homeorhesis** - a situation in which a system lacks mechanisms to guide and enable it to return it to a pre-set path or trajectory following an environmental disturbance. As noted by Hester and Adams (2014), the ability to return to a trajectory is essential for stability and survival of the system. Disturbances are inevitable in complex system landscape. However, a well-designed system must include 'set points' on a timescale that ensure that the system can return to its trajectory (Margulis, 1999; Waddington, 1957). Without such effective mechanisms, a system may be delayed in returning to intended trajectory, if it can return at all
	- regulated a system based on a set of external points	Margulis, 1999	
	- being able to return to a set path forward	Waddington, 1957	

Table 52 (cont.)

Pathology of homeostasis	- tendency towards stability using negative feedback in the midst of change	Becvar and Becvar, 1999	**Pathology of homeostasis** - a situation in which a system lacks monitoring mechanisms that can be used to alert of any external changes affecting system's essential internal variables. Systems can use negative feedback to reduce fluctuations in the output caused by the environment (Cannon, 1929; Cannon, 1932; Clemson, 1984; von Bertalanffy, 1968). Such mechanisms help in monitoring internal essential variables and keeping them within a safe operating condition (Hester & Adams, 2014). These mechanisms are essential because of mophogenesis --- emerging structures and morphocatalysts --- change conditioned by system contact or co-presence of another system (Krippendorff, 1986). This pathology also emphasizes situations in which the monitoring mechanism cannot distinguish between states of different subsystems within a system, as in *double bind* of Krippendorff (1986). Thus, an organization under this pathological condition might have inefficient monitoring mechanisms that cannot warn the system of external changes, if they exist at all. Moreover, such mechanisms might also be unable distinguish demands of all subsystems; placing the system "in a catastrophic difficulty before any warnings of trouble were recognized" (Clemson, 1984, p. 215)
	- monitoring and maintaining internal essential variables	Clemson, 1984	
	- might become problematic for systems that do not like current state of affairs	Krippendorff, 1986	

Table 52 (cont.)

Pathology of internal elaboration	- moving towards greater complexity	Kast and Rosenzweig, 1972	**Pathology of internal elaboration** - a condition in which the management style creates silos due to overemphasis on development of policies and procedures of subsystems and people management. Higher levels of organization are not necessarily bad (Lutz & Hedaa, 2006). In fact, Kast and Rosenzweig (1972) suggest that open complex systems will "move in the direction of greater differentiation, elaboration, and a higher level of organization" (p. 450). The problem, however, is activities could institutionalizing over time creating unnecessary rules (Lutz & Hedaa, 2006). Duffy (2004) suggests that even activities that were "once a simple…becomes a bureaucratic exercise in getting multiple 'permission' signatures" (p. 24). Moreover, the higher increasing differentiation might be used as a basis for forging types of relationships that over time limit fruitful relationships with other systems (Lutz & Hedaa, 2006). It thus appears that internal elaboration is expected for complex systems. However, when left unchecked, it can result in an explosion of policies and procedures for subsystems to the point that little attention to directed towards system development; limiting system productivity
	- activities could institutionalizing over time - preferences might be developed that hinder effectiveness of relationships	Lutz and Hedaa, 2006	

Table 52 (cont.)

Pathology of iteration	- a continuous process of comparing actual and desired state - comparing the results of the first iteration to the normal to discover error - it promotes efficiency through quick survey - it promotes efficient problem understanding - it eliminates the fear of failing - promotes efficient use of scarce resources	Gibson et al., 2007	**Pathology of iteration** – a situation in which a system lacks means to account for continuous comparison of first iteration to the norm to discover errors. Similar to a continuous process that keeps comparing actual state and the desired state of the system, the iteration process provides the means to measure errors in a timely manner (Gibson et al., 2007). Doing iteration promotes efficiency in three ways: first, it is a quick process that precludes careful examination of all issues, second, it eliminates the fear of making initial errors, and third, it minimizes wasting resources spent unnecessarily on subtasks (Gibson et al., 2007). Iteration also provides the basis for an evolving system since knowledge of the system is always evolving (Keating et al., 2010). In fact, without iteration, Keating et al. (2010) suggests that one can create the right conditions for "solving the wrong problems or producing inadequate system solutions" (p. 20). In this case, solving the wrong problem might involve too detailed an exploration that is resource intensive or too shallow of an exploration which provides no substance understanding of system context
	- promotes evolving of a system with increased knowledge	Keating et al., 2010	

Table 52 (cont.)

Pathology of least effort	- choosing a path of least resistance	Ferrero, 1894	**Pathology of least effort** - a situation in which a system attempts to move forward by selection of a path of high resistance. Started differently, this is a situation in which a system pursues its goals using methods and tools that are deemed inefficient. Researchers have suggested that systems will always select a path of least resistance (i.e., requiring least energy) to achieve its goals and missions (Ferrero, 1894; Zipf, 1949). Choosing between changing internally or changing the environment is an example that involves looking at the alternatives requiring least expenditure of resources (Krippendorff, 1986). In this case, the expending least energy is desirable to the extent that it enables production of desired levels of system performance. Therefore, it's essential to ensure that a system does not simply follow path of least resistance without considering maintaining desired system performance levels
	- selecting a path that is easier	Krippendorff, 1986	
	- minimize total energy spend in solving problems - still with the preference of largest outcomes	Zipf, 1949	

Table 52 (cont.)

Pathology of maximum power	- systems that maximize their flow of energy survive - the structure of a system is designed to maximize the rate of energy transformation - systems with lower rate of transformation are eliminated	Gilliland, 1978	**Pathology of maximum power** - a situation in which a system lacks ability to maximize its production through increased capacity for intake and transformation rate. These functions "reinforce production and efficiency" (Odum, 1995, p. 311). In a competitive landscape, it's not simply enough to transform energy (Gilliland, 1978); systems must have a higher rate of intake and transformation (Gilliland, 1978; Hall, 1995; 2004; Moe, 2013). A system in this pathological condition might not be able to keep up will demand. The increased demands force the system to be replaced becoming absolute and "eventually eliminated" (Gilliland, 1978, p. 101)
	- prevailing system are the ones that have higher energy intake and transformation	Odum, 1995	

Table 52 (cont.)

Pathology of minimal critical specification	- providing minimal specifications need'	Cherns, 1976	**Pathology of minimal critical specification** - a situation in which a system is managed by prescribing detailed account of what must be done and how it must be done. In managing complex systems, it is recommended to minimal specifications (Cherns, 1976; 1987). This might include what (i.e., task) that must be done and not necessarily, how the task is to be done. Cherns's (1987) work suggests that how a task is done should be left up to the autonomous subsystem since it is more likely to know the local context in which the task can be fulfilled. A system operating under this pathology will likely provide detailed instructions on tasks and roles as well as methods and tools for accomplishing those tasks. In such situations, creativity and flexibility --- essential elements necessary to deal with complexity (Stacey, 1996), is lost
	- what should be done and not how it is done - flexibility to enable subsystems to decide	Cherns, 1987	

Table 52 (cont.)

Pathology of multifinality	- similar conditions; different end-states	Buckley, 1967	**Pathology of multifinality** - involves the notion of experience. Humans have a tendency to draw premature conclusions regarding complex situations that they have previously experienced (Eraut, 2009). In such a situation, an analyst might draw conclusions since the initial operation conditions in the system of interest appear to be similar (Skyttner, 2005). The familiar conditions might cloud important 'distinctions' and compel the analyst to assume knowing how to move forward, perhaps with more positive results, using a particular approach. However, Clemson (1984) notes that "radically different end states are possible from the same initial conditions" (p. 214). Consequently, it is an error for one to anticipate the *same* results using the same approach even though outcomes might vary widely based on subtle situational differences
	- divergent results; same initial state	Skyttner, 1996	

Table 52 (cont.)

Pathology of omnivory	- taking in different resources	Watt and Craig, 1988	**Pathology of omnivory** - a situation in which system's internal structures (i.e., pathways) cannot be modified to increase their ability to intake a diverse number of resources. It has been shown that systems that are able to take in a diverse number of resources are more stable since a decline on one of the resources will not affect the system (Watt & Craig, 1988; Wildavsky, 1988). In order for a system to take in different resources, it must have a modifiable internal structure (Watt & Craig, 1988). A system operating under the pathological condition of omnivory might lack sufficient internal structural diversification to enable intake and processing of different resources
	- the ability to diversify - systems that are take in different types of food are more stable	Wildavsky, 1988	

Table 52 (cont.)

Pathology of organizational closure	- systems definition goes beyond goal, purpose, and functions - it must include the concepts of autonomy and unity - system relationships enable it to be self-referential - there is need to consider components and processes	Bednarz, 1988	**Pathology of organizational closure** - a situation in which a system lacks a critical part in the structure that provides closure. It appears that this essential part is identity (Bednarz, 1988; Beer, 1979). Identity of a system goes beyond goal, purpose, and functions and it enables a system to "maintain their unitary continuity of pattern despite the ceaseless turnover of their components" (Bednarz, 1988, p. 57). A system that violates the principle of organizational closure might have too autonomous subsystems such that there is no unit of the system (Bednarz, 1988). The relationship between the system and subsystems might not be complementary such that the processes undertaken are not closed. Beer (1979) suggests that a system lacking closure might not be viable at different recursion levels. An organization with this pathology might have extrinsic purpose and goal; but lack set of relationships or process that unify subsystem to the system and to the wider environment
	- provides the basis for viability of the system at different levels	Beer, 1979	

Table 52 (cont.)

Pathology of over-specialization	- becoming too specialized to the point of lacking capacity to change - high-level systems can be compromised by legitimate demands of individuals	Gould, 1982	**Pathology of over-specialization** - a situation in which a system specialized too much to the point that it cannot afford to change. Gould's (1982) research suggests that following Darwinian advantage, a system might evolve to the point it restricts itself from any necessary adaptation especially in the face of a drastic changes. In the face of change, too much of a good thing at the system level might actually harm the system since needs of subsystems might be ignored (Watt and Craig, 1988; Wildavsky, 1988). In fact, Gould (1982) suggests that higher-level systems infringe on lower-level systems. An organization suffering from this pathological condition could be too specialized consider any demands made by its subsystems or other 'lesser' systems
	- in the face of change, too much of a good harms a system	Watt and Craig, 1988	

Table 52 (cont.)

Pathology of Pareto	- 80% of the benefits are generated by 20% of the efforts - such systems operate on a non-linear relationship - attempts to make the system more profitable can actually make it less productive	Clemson, 1984	**Pathology of Pareto** - a condition in which significant efforts are undertaken to alter the 80/20 production curve. This pathology steams from assuming the existence of a 'causal-interrelationships' evident in simple system (Clemson, 1984). Research suggests that complex systems richly interconnected form the basis for the 80/20 law in various systems including the fact that "eighty percent of the shares are held by twenty percent of the shareholders" (Beer, 1979, p. 15). More importantly is the fact that this behavior is poorly understood (Adams et al., 2014; Beer, 1979; Clemson, 1984). Any "attempts to increase productivity (i.e., more of some desired output) are frequently counter productive" (Clemson, 1984, p. 206). Failure to adhere to this principle might be exhibited as attempts to increase system productivity using a variant of the 80/20 curve. However, such efforts might only increase cost and might even reduce system productivity
	- majority of the land is own by 20% of the population	Pareto, 1897	

Table 52 (cont.)

Pathology of patchiness	- ability to use a variety of resources	Watt and Craig, 1988	**Pathology of patchiness** - a situation in which a system lacks ability to increase diversity in terms of consumption of resources from the environment. This pathology does not apply situations where the environment has only one resource. This pathology is counter to the pathology of omnivory which is primarily concerned with diversification of internal structures. Under the patchiness pathological condition, a complex system fails to 'acquire' a taste for different resources such that "if one set of resources declines, there will not be any other to take their place" (Wildavsky, 1988, p. 117). Additionally, this pathology is the basis for consideration of interdependencies of resources in the environment (Watt & Craig, 1988; Wildavsky, 1988). Specifically, research indicates that in an environment where resources are weakly interrelated, a failure in one of resources should not affect other resources; providing a system with another sources of nutrients (Wildavsky, 1988). However, in an environment with coupled resources, a seemingly inane event affecting resources in one area could be a source of instability since resources might be interconnected. A system is likely to be affected by this pathology if it only consumes one kind of a resource despite the availability of multiple resources
	- external counter-part to principle of omnivory - declining resources are replaced with others - too much interconnectivity reduces stability	Wildavsky, 1988	

Table 52 (cont.)

Pathology of polystability	- a system has interconnected systems, each with its own state of equilibrium - the system takes longer to reach state of equilibrium' - the system becomes immune to localized injuries	Ashby, 1960	**Pathology of polystability** - a circumstance in which a system is managed as if system level equilibrium is similar to those of its subsystems. Ashby (1960) suggests that subsystems have theory own equilibriums which are different from that of the system whole. In fact, a system with many interconnected parts, according to Ashby (1960) will take longer to reach system level equilibrium. This is good inasmuch as local injuries (i.e., local issues) will tend to stay local and do not instantaneously propagate throughout the system (François, 2004). Thus, managing such system requires understanding the "equilibrium of the whole is not merely selective of and may not even coincide with the equilibria of its parts" (Krippendorff, 1986, p. 58). Clearly, managing such a system might require mechanisms dedicated to system and subsystem level equilibriums
	- events in different parts of the system do not instantaneously propagate	François, 2004	
	- system equilibriums might not coincide with local equilibrium - the system might have many different temporal rests	Krippendorff, 1986	

Table 52 (cont.)

Pathology of redundancy of potential command	- ability to resolve issues by subset managers - creativity is reduced - reduced speed of response	Clemson, 1984	**Pathology of redundancy of potential command** - a condition where subsystems entities lack the 'freedom' to decide and act on behalf on the system. Clemson (1984) suggests that a system that is well-designed will provide subsystem with the ability to seize opportunities. When management empowers subsystems it "increase[s] its speed of response; ability to detect novel events, information, trends, threats, and opportunities; creativity of decision-making; and comprehensiveness of decision-making" (Clemson, 1984, p. 213). In complex system decision making, the potential to act effectively is conferred to whoever receives information first (McCulloch, 1965). A system suffering from this pathology might adhere to the chain of command (i.e., acting based on what is explicitly prescribed) and thus ignoring the essential services that can be provided by subsystem auxiliary channels
	- information is power	McCulloch, 1965	

Table 52 (cont.)

Pathology of redundancy of resources	- requiring redundancy of critical resources - complex systems do not operate in ideal conditions - can be used to seize opportunities; but involves cost	Clemson, 1984	**Pathology of redundancy of resources** - a condition in which a system is designed and operated under the assumption of optimum efficiency. Under this condition, the resources that are allocated might be exactly what is needed – no more no less. In other words, critical redundant resources are not provided (Clemson, 1984; von Bertalanffy, 1968; Watt & Craig, 1988). However, complex systems rarely operate under 'ideal conditions' (Clemson, 1984, p. 212). Redundancy, while it adds little, if any, is important in complex systems since it helps combat noise in a communicating system (Shannon & Weaver, 1949). In fact, Clemson (1984) suggests that "new opportunities can be seized only if there exists some extra managerial" (p. 212) resources. Moreover, Pahl et al. (2011) suggests that if reliability in a system is desired, then duplication of critical resources/functions is necessary. An organization subject to this pathology might operate without consideration of extra critical resources; but it does so at the risk of reliability and redundancy necessary to buttress performance in the wake of unforeseen circumstances
	- intent is to increase reliability of the system	Pahl et al., 2011	

Table 52 (cont.)

Pathology of relaxation time	- the system is constantly bombarded by changes - there is need to reduce relaxation time - reduction of system internal stability	Clemson, 1984	**Pathology of relaxation time** - a situation in which a system experiences too many changes at the same time. When a system is continuously bombarded with many changes, it becomes incapable of processing or assimilating any of the changes and becomes chaotic (Clemson, 1984; Hester & Adams, 2014). Iberal (1972) recommended having a longer relaxation time (i.e., recovery time) on average than the mean time interval between massive external perturbations. Having a longer recovery time increases system internal stability (Clemson, 1984). Otherwise, the system will operate in a crisis mode trying to understand impacts and consequences of interaction of multiple changes without any degree of confidence
	- essential in analysis of cause of decreased relation time	Hester and Adams, 2014	
	- having shorter time periods than mean between failures	Iberal, 1972	

Table 52 (cont.)

Pathology of resilience	- ability to remain or return to a stable domain - more resiliency systems respond to wider array of fluctuations	Holling, 1973	**Pathology of resilience** - a situation in which a system, when it experiences a disturbance, has no ability to quickly return to its previous configuration. When a disturbance happens, a system can either withstand the disturbance, temporally fail and then return to previous configuration (i.e., performance levels) or fail to return to its previous configuration (Gheorghe & Katina, 2014; Holling, 1973; Katina & Hester, 2013; Martin-Breen & Anderies, 2011). A system exhibiting this pathology might be described as inflexible, brittle, and hard. This pathology is also evident in a system that is only resilient to a narrow range of external fluctuations (Gheorghe & Katina, 2014; Holling, 1973)
	- ability to withstand a crises	Martin-Breen and Anderies, 2011	

Table 52 (cont.)

Pathology of robustness	- using simple or complex mechanisms for protection	Watt and Craig, 1988	**Pathology of robustness** - entails lacking the ability to use simple and/or complex mechanisms to withstand environmental changes without system modifications. A truly robust system is like "an animal accustomed to coping with large and sudden changes in temperature" (Wildavsky, 1988, p. 117). Such a system does not need to rely on modifying anything to increase its ability to withstand environment changes (Wildavsky, 1988). Such a system is always robust under a wide range of issues, for instance extreme heat or extreme cold. However, a non-robust system is only designed to be viable under narrow set of variables. This pathology also encompasses costs of robustness as in "those stalled in tanks or overburdened by heavy armor can testify if only they survive" (Wildavsky, 1988, p. 117). Regardless of the nature of the mechanisms for protection, simple or complex, the trick is to ensure that the mechanisms do not require modification of the system
	- withstanding environmental changes without modifications - accustomed to coping in extreme changes - robustness is not cheap	Wildavsky, 1988	

Table 52 (cont.)

Pathology of safe environment	- 'creating permanently stable environment'	Watt and Craig, 1988	**Pathology of safe environment** - a situation in which a system fails to create a permanently stable environment. Watt and Craig (1988) notes that systems that wish not to adapt to the environment, they need to create a permanently stable environment so that they are protected from any change from the environment. Wildavsky (1988) questions, and rightfully so, as to whether the environment can ever stay stable forever. However, research indicates that creating a more permanently stable environment shields the system since the environment is stable to produce any disturbance (Watt & Craig, 1988; Wildavsky, 1988). Hence, this pathology addresses inability of a system to attempt creating a stable environment in order to reduce disturbances from the environment
	- 'the system becomes immune to change'	Wildavsky, 1988	

Table 52 (cont.)

Pathology of satisficing	- making the best possible solution with current-incomplete information	Hester and Adams, 2014	**Pathology of satisficing** - a condition in which the management team of a system searches for the best possible solution (i.e., optimization) instead of searching for good-enough solution (i.e., satisficing). By following the principle of satisficing, the management team makes the best possible solution with given the current nature of the information at hand (Hester & Adams, 2014; Simon, 1956). Researchers also note that the satisficing solution is necessary in complex situations since time and information are always limited as well as limited information-processing capability (Skyttner, 2005). However, it importance to note that satisficing "it does not mean ignoring the optimum by not striving for the most satisfactory in decisions that support a system's purpose, goal or objectives" (Hester & Adams, 2014, p. 62). Moreover, failure to adhere to the principle could results in unnecessary pursuit of locating the best solutions for complex system
	- systems do not necessarily maximize; rather they satisfice	Simon, 1956	
	- first acceptable solution is considered to be as good as all others - it is necessary because of limited time, limited information, and limited information-processing capability	Skyttner, 2005	

Table 52 (cont.)

Pathology of self-organization	- complex system organize themselves through interaction	Ashby, 1962	**Pathology of self-organization** - a condition in which management fails to work with the self-organizing tendencies of complex systems. This condition might happen when an organizing structure limits autonomy of its subsystems by using global patterns to influence local interactions (Camazine et al., 2008). This is in direct contrast to letting behavioral patterns to emerge out of the interaction of subsystems (Ashby, 1962; Clemson, 1984; Skyttner, 2005). As suggested by Clemson (1984), "some of the aspects [for example, culture] that are not intentionally designed" (p. 219) by managers and that it's best to work with the organization rather than against those aspects that cannot be designed. However, there is a fine balance between surrendering all autonomy and dependence on a system. Thompson and Cuff (2012) argue that unrestricted autonomy might results in unconstrained run-away independence while a dependent subsystem could be limited in its freedom of decision, action, and interpretation. Therefore, pathological condition of self-organization provision for self- organization but not run-away freedom
	- rules specifying interactions among subsystems are executed using only local information	Camazine et al., 2003	
	- behavioral patterns are due to interactions and not necessarily managerial deliberate actions - some aspects of a system are not intentionally designed - good managers work with the system and not against the system	Clemson, 1984	

Table 52 (cont.)

Pathology of separability	- if they are too coupled, a breakup in one will reverberate - small disturbances increase in the magnitude	Wildavsky, 1988	**Pathology of separatibility** - a situation in which subsystems are tightly coupled together such that a small disturbance is reflected throughout the entire system. In other words, the tight coupling in a large number of subsystems along with positive feedback creates the right conditions for a single breakdown in one of the subsystems to have a major effect on other subsystems and the system as a whole (Watt & Craig, 1988; Wildavsky, 1988). In such a situation, a small disturbance is able to increase in the magnitude and could result in "spiral[ing] out of control" system (Wildavsky, 1988, p. 115). Research shows stability is compatible with an increase in variety of subsystems or connections among subsystems; but not both (Wildavsky, 1988). An organization that does both, creates enabling conditions for a single failure to affect the entire organization

Table 52 (cont.)

Pathology of steady state	- each subsystem has power to veto	Ashby, 1960	**Pathology of steady state** - a condition in which one focuses on the steady state of a system whole while ignoring steady states of subsystems. This is an error since a system cannot be in a steady state if any of its subsystems are not in steady states. In creating a steady system, Ashby (1960) notes that it is necessary to account for each subsystem since they all have the "power to veto" (p. 79). Moreover, one must account for all subsystems, since they affect each other's behavior (Clemson, 1984). A steady state in this pathology involves issues such as system and subsystem capabilities and not necessarily growth or decline. This is why Clemson (1984) warns against a false sense of safety created by past success. Since system steady state cannot be archived with subsystems that are not in their steady states, it becomes necessary to ensure all subsystems are in steady states
	- a system can only a steady state if subsystems are in steady state - behavior of each subsystem affects other subsystems - a false sense of safety is created due to past success	Clemson, 1984	

Table 52 (cont.)

Pathology of sub-optimization	- looking for an optimal solution to a mess	Ackoff, 1977	**Pathology of sub-optimization** - elaborates on several other pathologies including emergence, holism, and satisficing. It suggests that independent improvement of subsystems does not always improve the performance of the integrated system whole (Ackoff, 1977; Hester & Adams, 2014; Heylighen, 1992; Hitch, 1953). In fact, seeking to independently optimize subsystems can worsen the performance the integrated system whole (Heylighen, 1992). Rather than looking for an optimal solution, "we should be trying to design and create a process that will enable the system involved to make as rapid progress as possible towards its ideals" (Ackoff, 1977, p. 5). In operations research, this is done through a series of compromises between the analyst and his client (Hitch, 1957). This pathological condition might be evidenced when sacrifices for global system level unity are done in the interest of individual local member subsystems
	- independently dealing with subsystems worsens overall system	Heylighen, 1992	

Table 52 (cont.)

Pathology of subsidiarity	- ensuring that local issues are solved by local authority	Koornstra et al., 2002	**Pathology of subsidiarity** - a situation in which local issues need to always be solved by a higher authority. A local issue is a subsystem issue and a local authority must solve it (Koornstra et al., 2002; Wheeler, 1970). In the European Union, for instance, the local members always handle local transport safety issues (Koornstra et al., 2002). When the principle of subsidiarity is ignored, a local issue might be elevated to the system level platform which shifts and divides the attention and resources from truly system-level issues. Thus, this pathology is the situation in which subsystem issues/conflicts are always resolved at a "higher authority" despite the fact that there is more value to solving such issues at a local level so long as the solution is in harmony with the objectives of the system. In other words, subsystems can only refer a tool-bag of system level solutions, so long as their tool-bag does not contain the solution
	- problem solving without involving higher authorities	Wheeler, 1970	

Table 52 (cont.)

Pathology of system context	- understanding the system of interest and establishing meaning - it is not defined by a line of demarcation - systems do not operate independent of context	Crownover, 2005	**Pathology of system context** - simply attempts to address the issue of viewing a system independent of the context in which it is embedded. Researchers have suggested that it is impossible to understand and draw the meaning of system independent of its context (Crownover, 2005; Keating et al., 2010; Keating et al., 2003a; Krippendorff, 1986). Context, according to Keating et al. (2010) includes "circumstances, factors, conditions, or patterns that enable and/or constrain the system, system solution development, system solution deployment, or interpretation" (p. 19). Unlike environment, system context is not represented by a line of demarcation (Crownover, 2005). In fact, Keating et al. (2003a) notes that system structure and the behavioral patterns are a result of interaction with the context; hence, one cannot be understood without the other. Attempting to understand the system without its context is restricting and could be a source of development of an ineffective solution space
	- system structure and behavior are interrelated to context	Keating et al., 2003a	
	- elaborates in the meaning of a system	Krippendorff, 1986	

Table 52 (cont.)

Pathology of the first cybernetic control	- system control involved automatic comparisons followed by continuous feedback	Skyttner, 2005	**Pathology of the first cybernetic control** - a situation in which system lacks ability to compare system behavior against a set standard. When the comparison is done, the system might lack mechanism to enable corrective measures and actions to be undertaken (Skyttner, 2005). Cybernetic control is only possible if behavioral characteristics of a system are continuously monitored and adjusted. An organization with this pathology might lack means to compare behaviors and/or means to adjust behavior
Pathology of the Red Queen	- a system change environment or keep adapting	Quentall and Marshall, 2013	**Pathology of the Red Queen** - the condition in which a system fails to survive because of its inability to compete with other systems in the same environment. This goes beyond ideas of adapting, evolving and proliferation inasmuch as they relate to gaining a competitive advantage. It relates to the idea of simply surviving inasmuch as surviving means an organization takes all the running it can do, to stay in the same place (van Valen, 1973). Each system must continuously improve in order to survive since related systems are always continuously improving as well (Quentall & Marshall, 2013; van Valen, 1973). An organization operating under this pathology might not be doing enough development (i.e. running) to keep up with other organizations. The objective of running is not to gain advantage; it is to ensure the system is keeping with other systems
	- a system must continuous develop to remain its fitness - a situation in which a predator and prey must run faster - on average, there are only relative improvements	van Valen, 1973	

Table 52 (cont.)

Pathology of the second cybernetic control	- control is related to commination - communication provide regulations which can be used address disturbances	Ashby, 1956	**Pathology of the second cybernetic control** – is similar to the first cybernetic control pathology and addresses control in terms of communication. It states that a system might go out of control if its communication elements are incapable of providing sufficient regulations to address variety. In this case, communications provides regulations that enable the system to address any disturbances that might impede the system (Ashby, 1956; Skyttner, 2005). More specifically, Skyttner (2005) suggests that cybernetic "control is synonymous with communication" (p. 101). This means achieving desired performance is actually directly related to efficient communications. Thus, a pathology of second cybernetic control involves having communications that are incapable of providing regulations to combat system variety
Pathology of the third cybernetic control	- going out of control	Skyttner, 2005	**Pathology of the third cybernetic control** - provides a grave warning regarding tinkering with unbroken systems. It states that a system can only be brought into control (i.e., a more preferred state) if it has gone out of control (Skyttner, 2005). In other words, a system that has not gone out of control can never be brought into control. A system is more likely to suffer from this pathology, if efforts are undertaken to improve system performance that is not out of control: *if it ain't broke don't fix it*

Table 52 (cont.)

Pathology of transcendence	- beyond physical and mental boundaries - God is seen as the source of understanding	Capra, 1982	**Pathology of transcendence** – addresses assumption of stability and viability in complex systems as only be achievable within the confines of reality as defined and understood within the objective realm of scientific/physical laws. According the White and Krippner (1977), this is an error since the universe sometimes organizes itself in dimensions beyond just the physical space-time frame. Krippendorff (1986) further elaborates that sometimes the human logic is simply not powerful enough to understand the complexities of universe realities. In such situations, God is seen as the source of all understanding (Capra, 1982). A system suffering from this pathology might discourage belief in God and dismiss accompanying activities (e.g., praying) since science and human understanding takes precedence. This pathology suggest belief that understanding might lie beyond rational, scientific, or determinate explanation in which explanation exists at the metaphysical level and must be taken on 'faith'
	- some experiences are beyond human logic	Krippendorff, 1986	
	- information beyond physical laws of science	White and Krippner, 1977	

Table 52 (cont.)

Pathology of ultra-stability	- a system capable of operating in the face of unknown events	Beer, 1979	**Pathology of ultra-stability** - a condition in which a system can fend off anticipated disturbances but it is not sufficiently designed to fend off unknown disturbances without changing its internal structures. This pathology addresses system stability at a logically higher level (Krippendorff, 1986; Young, 1968) than, for instance, pathology of adaptation, environment-modification, and patchiness, inasmuch as they require modification of system structures. Moreover, the pathology of ultra-stability calls for stability against unknown disturbances (Beer, 1979). Thus, an ultra-stable system is designed to operate under anticipated disturbances and well as those that are not anticipated and without changing the structure of the system
	- a logic higher level of stability in which the system deals with perturbations without changing internal structure	Krippendorff, 1986	

Table 52 (cont.)

Pathology of undifferentiated coding	- being able to infer reality and knowledge from indirect communication - being able to tell varying degrees of pressure without seeing - when we can use of sensors, progress can still be done: suppressing belief that the sensors - making inferences about the world based on one's own sensations	Segal, 2001	**Pathology of undifferentiated coding** - deals with the issue of objectivity and subjectivity in understanding issues affecting systems. More specifically, this pathology is a situation in which reality and knowledge are directly attributed to observable results such that anything that does not involve human sensors such as eyes, ears, and touch is not valued (Segal, 2001). Researchers indicate that it is possible to infer reality and develop knowledge from indirect communication including being able to tell the difference between varying degrees of pressure (Segal, 2001; von Foerster, 1973). This supports the notion that human sensors can be used to project the real world such that rather seeing and then feeling the world, it becomes possible to feel and then see the world (von Foerster, 1973). This pathology suggests a need to include subjectivity in problem formulation. Failure to include subjectivity limits the deductive power of individuality (i.e., feelings and interpretations) in dealing with complex systems, which could be a reflection of the real world
	- reality can be deductive in nature	von Foerster, 1973	

Table 52 (cont.)

Pathology of unity	- ensuring consistency among the performance of metasystem and subsystems	Beer, 1985	**Pathology of unity** - a situation in which a system lacks an integrated system purpose or having an identity that is not easily distinguishable from other systems. In cybernetics research, unity of s system is directly related purpose (Angelo, Gudwin, & Queiroz, 2006; Beer, 1985; Keating et al., 2010). The metasystem structure is what is tasked with achieving an integrated system purpose (Keating et al., 2010). Moreover, an integrated system purpose forms the basis for systems existence and distinguishes it from other systems (Maturana & Varela, 1980). Since it is not easy to design, maintain, and evolve system identity over time, it is easy to not pay attention to it. Over time, the system might lose that which makes it unique
	- work is required to maintain a purpose	Keating et al., 2010	
	- provides the basis that enables a system to exists	Maturana and Varela, 1980	

Table 52 (cont.)

Pathology of viability	- keeping key parameters in control	Adams et al., 2014	**Pathology of viability** – is concerned with failure to balance two related elements: subsystem autonomy and integration of the whole and system stability and system adaptation. First, researchers have indicated that in order for system to be and remain viable, key system parameters must be controlled and maintained within their physiological limits (Adams et al., 2014; Ashby, 1960). Secondly, viability, according to Beer (1979) involves ensuring that productive subsystems have capability to survive as independent systems. Clearly, this can only happen if the key variables are also present in subsystems. The manager plays a significant role in ensuring system viability and stability. Beer's (1979; 1981) work suggests that the manager establishes criteria for stability, detects instability, and modifies criteria based on assessment. Such assessments are the basis for balancing the two major dimensions of autonomy-integration and stability- adaptation. Without the right balance, the system is more likely to cease existing because of being too autonomous subsystems, too integrated, too stable, or experiencing too many rapid changes (Clemson, 1984). Failure to balance dimensions of autonomy-integration and stability- adaptation is the basis for viability pathology
	- ensuring subsystems can exist as a separate systems - balancing autonomy of sub-systems and integration of system whole - balancing stability and allowing adaptation - the manager must establish criteria for stability, detect instability, and modify criteria - adaptation involves progressive modification	Beer, 1979; 1981	
	- too much autonomy, integration, stability or rapid adaptation can harm the system	Clemson, 1984	

Table 52 (cont.)

Pathology of channel capacity	- the difference in messages should not affect the transmission	Agarwal and Tiwari, 2005	**Shannon-Hartley's channel capacity pathology -** has to do with the ability of a communication channel to transmit different messages without channel modification. A well-designed communication channel accounts for noise (i.e., any factor in the process that works against the predictability of the outcome of the communication process) in transmission (Price & Woodruff, 2012). It also enables transmission of information, measured in bits, regardless of its kind (Agarwal & Tiwari, 2005). In order for this to take place, a communication channel must have a maximum possible rate of transmission, which involves transmission time, propagation time, throughput, and system noise (Agarwal & Tiwari, 2005; Shannon & Weaver, 1949; Shannon, 1948a; 1948b). Failure to account for the maximum rate of information transmission might create the right conditions to partially receive information, information arriving late, or not arriving at all. These situations are not desirable and could contribute to "misinterpretation of …information" (Shannon & Weaver, 1949, p. 40). An organization under these conditions can have communication systems that are not effective with providing relevant information in a timely manner
	- message the transmission affected by noise	Price and Woodruff, 2012	
	- the transmission accounts for channel capacity	Shannon and Weaver, 1949	

Table 52 (cont.)

Pathology of incompleteness	- language of a framework is always incomplete - there is always a change to encounter unforeseen events - a system can always encounter issues that have not been expressible in the traditional discourse - subsystem language frameworks are developed with certain assumptions when compared to the system level - humans provide closure otherwise we run into an infinite progression of meta-meta-meta systems - the framework itself could be a problem	Clemson, 1984	**Gödel's incompleteness pathology** - a condition in which a system is operated upon as if its traditional terms of discourse/frame of reference is both consistent and complete. Any given frame of reference/framework is always incomplete (Clemson, 1984; Kleene, 2002; Gödel, 1962; Skyttner, 2005). This is because the design of a framework cannot possible consider all events including unforeseen ones (Clemson, 1984; Kleene, 2002). There is always a chance that a framework will encounter an issue that hasn't been articulated Clemson (1984). Theoretically, even a generated theory cannot be both consistent and complete since it is often developed within certain assumptions (Kleene, 2002). Similarly, in a hierarchy, the same framework is not expected to be applicable in all levels. Human intervention is needed to provide closure. Otherwise, there might be an infinite progression of meta-meta-meta etc. systems and corresponding frameworks (Clemson, 1984). Under this condition, management may assume all performance issues are understood and therefore solvable using the same frame of reference. However, this thinking limits system development as there is always a likelihood that issues will arise beyond the current frame of reference. This pathology is evident in healthcare, terrorism, and intractable conflicts that appear to defy resolution within the different frames of reference in which they exist
	- a generated theory cannot be both consistent and complete	Kleene, 2002	

Table 52 (cont.)

Pathology of information redundancy	- making messages redundant to reduce error in communication - redundancy is expensive - redundancy requires extra channel capacity	Clemson, 1984	**Pathology of information redundancy** - describes a situation in which little insufficient efforts are dedicated to reducing error in information transmission. More specifically, researchers suggest that information transmission (i.e., communication) can be enhanced by making messages that are being transmitted redundant (Clemson, 1984; Hester & Adams, 2014; Shannon & Weaver, 1949). However, this redundancy can be viewed as waste of resources (Hester & Adams, 2014) since it is reparative (Shannon & Weaver, 1949) and requires extra channel capacity and might cause fatigue (Clemson, 1984). Nonetheless, redundancy reduces the probability of error in the system (Hester & Adams, 2014; Shannon & Weaver, 1949). Thus, the pathology of information redundancy might be experienced as a failure to balance between tolerable error levels and redundancy required. This pathology is reinforced by the notion of reluctance to enact redundancy mechanisms that might be viewed as waste. In such a situation, the probability that organization will receive the right information is greatly reduced
	- redundancy can be viewed positively or negatively	Hester and Adams, 2014	
	- redundancy might be viewed as unnecessary since its repetitive - an error in transmission can be reduced through redundancy	Shannon and Weaver, 1949	

Table 52 (cont.)

Pathology of morphogenesis	- the process of creating new organizational structures - can be radical such as a realization of new ideas - can take place in a gradual setting	Krippendorff, 1986	**Pathology of morphogenesis** - a situation in which a system fails to remain stable after creating a new and radically different structure elaborating on the existing structures as conditioned by morphocatalyst influencing the system. Regardless of how the new structure is created, gradually or overnight, the purpose of the new structure is to support the existing system. In this case, a morpohogenic system in the new system that is developed to address a new need (Becvar & Becvar, 1999; Krippendorff, 1986; von Bertalanffy, 1968). Such efforts can be classified as a failure if the morpohogenic system does not address the original intended purpose. Another aspect of this pathology is having a morphocalalyst (e.g., a consultant) who is frequently allowed to provide new information to the system without allowing sufficient time for information assimilation (von Bertalanffy, 1968). Pathologically, creating a new useless structure and/or allowing changes such as innovations and other developments from other systems, to influence you might contribute to your demise
	- structure development elaborates on a system structure - a morphogenic system is capable of continuity by changing its essential aspects	von Bertalanffy, 1968	

Table 52 (cont.)

Pathology of morphostasis	- changing appropriately to remain stable - stability is required to change and maintain self - balancing morphogenesis (change) along with morphostatis (stability) - either extreme of morphogenesis and morphostatis is not desirable - a well-functioning system will involves subsystems as well as their relationships	Becvar and Becvar, 1999	**Pathology of morphostasis** - a condition in which stability of an organization is reduced by resisting change (i.e., preferring the *status quo*). Systems must be able to appropriately change to maintain their stability (Becvar & Becvar, 1999). This involves allowing changes that do not threaten the existing level of stability and keeping the current stability structure (Krippendorff, 1986). This pathology is relevant since some systems go to great lengths to keep themselves working as they have always done in the past (Day, 2014). Clearly, extreme change (i.e., morphogenesis) and extreme stability (i.e., morphostatis) is not desirable (Becvar & Becvar, 1999). However, failure to allow relevant changes to take effect, creates the right condition for denying good innovations and developments to positively impact stability of a system
	- the process of retaining structure of stability - permitting changes that do not threaten existing stability	Krippendorff, 1986	

Table 52 (cont.)

Pathology of Pareto optimality	- part of fundamental of welfare economics - not possible to make one part better without making another worse - society-wise, efficient resource allocation may be possible but not desirable	Stiglitz, 1991	**Pathology of Pareto optimality** - a situation in which a measure (e.g., allocation of resources) is undertaken to improve one part of a system; this is believed to have no adverse effects on other systems. In welfare economics, it has been shown that it is not possible to make one part of the system better without making another part worse-off (Stiglitz, 1991; Tan, 2008; Wright, 2003). When the theorem of Pareto optimality is violated, one might operate a system in a manner that suggests that one can take certain measures to improve a system/subsystem without making other subsystems worse-off. Wright (2003) notes that this is a flawed thinking since measures undertaken to improve one part of the system have to be allocated from "somewhere" (p. 78). In this case, the terms of 'worse-off' and 'better-off' are relative to 'desirability' of each entity involved. This pathology is likely have adverse effects especially in situations where one lacks perfect information on entities such that a full picture is missing
	- developing a solution in which at least one receives a penalty	Tan, 2008	

Table 52 (cont.)

Pathology of purposive behaviorism	- a system has a purpose and it does include outputs and outcomes	Beer, 1979	**Pathology of purposive behaviorism** - a situation in which the purpose of the system is unguided and primarily based on intended results as opposed to what the system produces. Tolman (1948) noted that system behavior is related to both purpose and objectives. This was instrumental in demonstrating system actions are always purposeful and goal-oriented. Along the same thought process, Beer (1979) noted that regardless of the intent of the user, the system will produce what it does. The implications for this include the need to guide system purpose while accounting for directly measurable 'outputs' that includes patterns, products, and service and the 'outcomes' that are indirectly measured such as consequences (Beer, 1979; Keating et al., 2010). This pathology might be evidenced in organizations that focus on what they are supposed to produce (e.g., treating consequence) rather than improving the underlying structure producing the results
	- the purpose is ascertained via examination what is being produced and not was is intended - the purpose includes tangibles and intangibles	Keating et al., 2010	
	- combining objective and purpose - actions must be purposeful and deliberate goal-orientated	Tolman, 1948	

Table 52 (cont.)

Pathology of recursion	- availability of fundamental laws at different recursions	Beer, 1978	**Pathology of recursiveness** - is a violation of the theorem of system recursion that can be defined as a condition in which the system in question is incapable of defining itself as a viable system containing viable systems and being contained in a viable system. Researchers have suggested that viable systems are recursive in nature; containing other viable systems and contained in a higher viable structure (Beer, 1978; Krippendorff, 1986; Smith, 1994). In a recursive structure, each system becomes self-referential as in a "program that knows its own name and hence, [it] can access its own code, and then it is to figure out how to apply the recursion theorem" (Smith, 1994, p. 39). In this structure, any attempt to exist as an independent system, without appreciation of the system within which the system is embedded, as well as the systems that are embedded within the system, presents potential difficulties. These potential difficulties including system collapse are possible since the governing laws, processes, functions, and structure might create insurmountable dysfunctions within the system at different recursion levels
	- recursion makes the structure of the system grow	Krippendorff, 1986	
	- defining the system in terms of itself - the system becomes self –referential	Smith, 1994	

Table 52 (cont.)

Pathology of reification	- confusing abstract ideas with material things	Krippendorff, 1986	**Pathology of reification** - a situation in which reality is distorted because of confusing abstract ideas to concrete entities. Young's (1964) words make it more apparent: this pathology occurs when "an analytic or abstract relationship [is treated] as though it were a concrete entity" (p. 109). Evidently, this is not a new problem in many fields. Krippendorff (1986), for instance, notes that the term 'system' is often confused with physical entities despite being a construct helping to explain situations in the real world. This pathology could also be extended to operating worldviews such as in objectivism and subjectivism (Flood & Carson, 1993) and capitalism and communism (Menke, 1999). For instance, subjectivity is well suited for complex system requirements elicitation as opposed to an objective approach (Katina et al., 2014a). Clearly confusing entities for others especially abstract and real ones has implications for how one approaches world issues

Table 52 (cont.)

Pathology of structure genesis	- the theorem of structure genesis is supported by many systemic viewpoints - they relate to efficient use of space changing structure to enable order	François, 2004	**Pathology of genesis of structure** - addresses the need to initiate and maintain communications among forming structures in a system. As noted by Maturana and Varela (1980), a structure cannot be formed unless there is a relationship between involved parts. In fact, it has been suggested that development of the forming structure is dependent on communication among elements (Krippendorff, 1986). Keating (2009) suggests that time is also needed - letting enough time to pass by for a structure to take shape. The theorem of genesis of structure is supported in other viewpoints including D.K. Hutchin's configuration entropy concept of maintaining overall system structure but changing some elements (François, 2004). The emerging structure contributes to viability of the system. However, a system might fail to keep consistent flow of information to its subsystems including a new forming structure: this is the basis for pathology of genesis of structure. The new forming structure cannot mature into a viable system. The merging structure simple becomes a waste of time and other resources with implications of the viability of the system as a whole
	- letting enough time to pass by for a structure to take shape	Keating, 2009	
	- development of structure is dependent on communication among elements and time	Krippendorff, 1986	

Table 52 (cont.)

Pathology of synchronicity	- meaning is created by observer	Jung, 1960	**Pathology of synchronicity** - a situation in which phenomena about a system appears to be meaningfully related but is ignored since it is impossible to be explained in terms of causality-language. Traditionally, there is a tendency to explain events in terms of cause and effect. However, the theorem of synchronicity suggests it is possible to observe acausal events (Jung, 1960; 1973). This is a situation in which occurrence of two or more events appear to be meaningfully related and yet not causally related (Tarnas, 2007). The observer creates the meaning (Jung, 1960). In fact, upon further inspection, a causal relationship might appear inconceivable (Jung, 1973). In terms of pathology, if a system is managed from a traditional approach, then a phenomena in a system is expected to be understood in terms cause-effect relationship. The acausal events might be ignored. In fact, Jung's (1973) research indicates that it is an error to ignore acausal relationships since present resources might not be equipped to handle an acausal relationship. A lack of causality does not in itself prove that there is no relationship. Dismissing acausal relationships as unsound is a characteristic of the pathology of synchronicity
	- a closer inspection might even reveal that there is no causality	Jung, 1973	
	- events might appear to be related	Tarnas, 2007	

Table 52 (cont.)

Pathology of communication	- communication is necessary for system survival	Checkland, 1999	**Pathology of communication** - the receiver of information is unable to receive information as intended by the sender. Communication is broadly defined as "all of the procedures by which one mind may affect another" (Shannon & Weaver, 1949, p. 3). This involves an information source (message source, a transmitter, a signal), a receiver (of the message), and a destination. The message must be translated into a code in terms of bits (Shannon & Weaver, 1949). Communication involves representing information as intended by the sender (Skyttner, 2005) and includes mechanisms that enable processing, storing, and retrieval of information (Shannon, 1948a; 1948b). It is not limited to information processing and can be extended to other objects including energy (Skyttner, 2005). Communication is instrumental in system survivability and viability (Checkland, 1999; Hester & Adams, 2014). Communication takes place when the receiver understands the information and is influenced by it (Weaver, 1948). Failures to transmit, receive, and/or decode messages for meaning so that the receiver can't provide responses are aspects of this pathology. Thus, such a system will lack *efficiency* (bits of information per second that can be sent and received) and *accuracy* (extent that signals of information can be understood). A system that can't efficiently and accurately transmit information is not expected to viable
	- communicating goes hand in hand with control and essential viability	Hester and Adams, 2014	
	- need for different communication mechanisms to enable processing, storing, and retrieval	Shannon, 1948a; 1948b	
	- involves representation of information as sender intents - communication is not limited to information processing	Skyttner, 2005	
	- communication includes influencing mind and meaning of message	Weaver, 1948	

Table 52 (cont.)

Pathology of control	- control is necessary for system survival	Checkland and Scholes, 1990	**Pathology of control** - a condition that emerges out of having ineffective control mechanisms. Control, is what "permits the system to adapt and remain viable" (Hester & Adams, 2014, p. 58). In terms of mechanisms, inadequate control involves a lack regulatory capacity needed to preserve system identity which includes the concepts of unity, uniqueness, and continuity (Aizermann, 1975). The required regulations must be communicated, hence the importance of communication in system control (Hester & Adams, 2014). A system with a control problem might use significant efforts in order to provide control and therefore will tend not adhere to the use of minimal efforts as suggested by Skyttner (2005). This pathology might be evidenced along three dimensions: 1) *ineffectiveness* --- the extent to which organization is unable to consistently achieve its intended mission/goals, 2) *inefficiency* --- the extent to which organization is unable to utilize resources efficiently, and 3) *inefficacy* --- the extent to which an organization is unable to effectively contribute to the higher-level system purpose to produce desired effects (Skyttner, 2005). A system in this condition is incapable of maintaining its goals or realigning them, or removing bad goals
	- control is not possible without communication	Hester and Adams, 2014	
	- control should be done with minimal efforts - control involves minimal constraints necessary to ensure desirable performance	Skyttner, 2005	

Table 52 (cont.)

Pathology of dynamic equilibrium	- for a system to be in equilibrium, all its subsystems must be in in equilibrium	D'Alembert, 1743	**Pathology of dynamic equilibrium** - a situation in which system expected performance is reduced due to imbalance in interactions with external systems. To maintain stability, a complex system is designed to continuously interact and exchange resources with its environment and other systems (D'Alembert, 1743; Hester & Adams, 2014; von Bertalanffy, 1968). The pathology of dynamic equilibrium occurs when the rate of exchange, say information, between system/subsystems and its environment/other systems, is altered such that it is increased or decreased. In fact, a system will remain in a state of dynamic equilibrium, as a preferred state, unless an altercation happens (Hester & Adams, 2014). Altercation might make the system lose its dynamic stability which then affects performance of the system. In terms of pathology, this would seem to indicated the need to effectively balance interactions with other systems/environment

Table 52 (cont.)

Pathology of punctuated equilibrium	- long periods of relative stability while building stress	Calida and Katina, 2012	**Pathology of punctuated equilibrium** - a situation in which the long periods of stasis (i.e., relative calmness) become the basis for a potentially catastrophic event. Evidently, some systems exhibit little change over the course of a life time (Gould & Eldredge, 1977). Such systems might remain relatively stable even if stress is built-up over time (Eldredge & Gould, 1972; Gould & Eldredge, 1977). However, these periods of relative calmness can create a false sense of safeness up to and leading to point of a 'burst' (Calida & Katina, 2012; Eldredge & Gould, 1972; Gould & Eldredge, 1986). These bursts might be explained in terms of black swan event that are often labeled as *low probability, high consequences* and/or x-event event that are often rare and unthinkable. These events are often dismissed and labeled as fictitious and improbable (Casti, 2012; Taleb, 2010). This pathology is unique in that its consequences cannot simply be understood *a priori*. Moreover, the relative calmness, rarity and the low probability of a catastrophic event should not be used as a basis for ignoring events that could have major implications for a system
	- longer periods of stasis followed by a burst	Eldredge and Gould, 1972	
	- exhibiting little changes, but when change happens, it is drastic	Gould and Eldredge, 1977	

Table 52 (cont.)

Pathology of sociotechnical system	- improving design and performance by including both social and technical	Cherns, 1976	**Pathology of sociotechnicality** - a condition in which preference is offered to either the social (i.e., soft/human aspect) or the technical (i.e., technology in the workplace) aspect of an organization. The sociotechnical perspective explicitly embraces the idea that social and technical aspects of a system are interconnected, that none should take logical precedence over the other (Cherns, 1976; 1987; Clegg, 2000; Jordan, 1963; Keating et al., 2001a; Klein, 1994). This notion is well established with numerous principles that can be used to enhance system design (Clegg, 2000). These ideas are reinforced by Keating et al. (2001a) which suggests that the strength of the sociotechnical systems perspective lies in the systemic consideration of the technical subsystem, the social subsystem, and the joint influence of subsystems on one another. Failure to adhere to a joint optimization of the social and technical aspects of complex systems could be expressed as promoting one aspect over the other. Such efforts can only constrain system potential
	- numerous principles sociotechnical systems	Clegg, 2000	
	- joint optimization of social and technical with being subordinate to the other	Keating et al., 2001a	

Table 52 (cont.)

Pathology of system boundary	- providing a line of demarcation to distinguish system from environment	Bowler, 1981	**Pathology of system boundary** - a situation in which a boundary (i.e., line of demarcation) of a system is fuzzily defined. A line of demarcation provides minimum description distinguishing a system from its environment (Bowler, 1981; Forrester, 1994; Mitroff, 1998; Warfield, 1976). However, a lack of a line of demarcation, as suggested by Troncale (1977), might make it difficult to attain system goals. In this case, system goals and objectives are directly established in terms of boundary. Consequently, a lack of this boundary creates the right conditions for pursuing too narrow or too wide a scope of goals/objectives. These contribute to a false impression of system of interest promoting pursuit of wrong problems and wrong solutions (Mitroff, 1998). Specifically, Taylor and Felten (1993) suggested that having a wrong boundary ensures that a system cannot be divided into any meaningful portions to enable rigorous examinations of a system involving goals, interactions, and input/outputs. The inability to define, recognize, and purposefully (re)define a system boundary are characteristic of this pathology
	- a boundary is essential to properly define system goals	Troncale, 1977	

Table 52 (cont.)

Pathology of system environment	- surrounding things influencing the system	Krippendorff, 1986	**Pathology of system environment** – is concerned with understanding the relationship between system and its environment. A complement to pathology of boundary, this involves a failure to understand a line of demarcation distinguishing *environment* from system. Laszlo's (1996) research suggests that environment includes things that are outside the control of the system. In many cases, such things can influence the system but are not influenced by the system (Krippendorff, 1986; Weinberg, 1975). This concept is supported by Skyttner (2005) who notes that the "environment can exert a degree of control over the system but cannot be controlled by the system" (p. 63). Umpleby et al. (1990) elaborates on this concept by suggesting that the environment includes those things beyond influence of the decision-maker and is commonly known as the 'world.' In terms of pathology, treating an issue under control of a system as if it were outside the control of the system is a concern for system environment. In this case, a system could be overwhelmed issues that it must attempt to influence
	- typically these are things that are outside the control of the system	Laszlo, 1996	
	- things beyond the influence of the decision-maker - sometimes referred to as the world	Umpleby, Heylighen, and Hu, 1990	

APPENDIX C: GUIDELINES FOR THE OUTSIDE EXPERT

Background. The researcher is conducting an inductive research study intended to develop systems theory-based pathologies informing problem formulation phase using concepts of systems theory. In contemporary systems research, systems theory-based pathology is defined as *the inadequate use of systems theory in problem formulation, expressed as either the lack of application, misapplication, or disregard of laws, principles, and theorems of systems theory* (Katina, 2015a; 2015b). This notion of pathology is supported by Keating and Katina (2012) who suggested that pathology includes "circumstance, condition, factor, or pattern that acts to limit system performance, or lessen system viability, such that the likelihood of a system achieving performance expectations is reduced" (p. 253).

An integral part of this inductive research is to develop survey questions that will be used to 'face' validate the inductively developed pathologies. Specifically, the survey will be used to assess 1) the *degree of existence of pathology* and (2) the *degree of consequence of pathology*. Degree of existence of pathology is defined as the degree to which a particular pathology exists in an organization. A seven-point standard convention scale of *strongly disagree*, *disagree*, *disagree somewhat*, *undecided*, *agree somewhat*, *agree*, and *strongly agree* will be used to indicate both; the degree of existence of pathologies and the degree of consequence of pathologies.

You have been identified as meeting the criteria to act as a qualified outside expert reviewer for participation in the research. Table 52 indicates the qualifications of an outside expert.

Table 53: Outside Expert Qualifications

Qualification	**Criteria**
Education	Earned doctorate in complex systems, engineering management, systems engineering, systems of systems engineering, or engaged in a doctoral level program in one of these areas.
Experience	Experienced in the field of systems, well-read researcher, author, or speaker with commercial or government systems engineering and systems-based methodologies.

Requested Action. In order to enhance both content validity of the research design as well as the scope and depth of the survey design, the researcher requests your review of systems theory-based pathologies, listed in the following table, considering the focus area of the study, provide your input on the nature questions that could be developed for use in an operational setting. Specifically, pathologies as listed in the following table are in *systems theory* language. This language might not be suitable in a practitioner setting. The researcher needs to develop corresponding sets of statement(s) for practitioners before running a survey. Should you not be familiar with these concepts, please send the researcher an email to obtain an electronic copy.

Method of Response. Please make your comments and/or additions directly into the table below and email your completed response to the researcher.

Table 54: A Partial Table Used in Capturing Expert Feedback

#	Descriptions of pathology	Expert Reviewer's Comment
1.	Pathology of complementarity - a situation in which an organization ignores other perspectives/models that are not entirely compatible with the established-predominate perspectives including missions, goals and objectives. An organization in this case mistakenly assumes that there is only one 'right' perspective (Bohr, 1928; Mehra, 1987). Thus, different truths contained in different perspectives are shunned. Murdoch and Murdoch (1989) suggest that this pathology is more likely related to a management style that assumes that the organization operates under 'ideal' conditions. Moreover, too many perspectives, especially the ones not being made explicit and understood, could cause "mass confusion" (Clemson, 1984, p. 207) in an organization. This pathology is expected in an operation landscape characterized as ambiguous, complex, interdependent, and uncertain	

References

Katina, P. F. (2015a). Emerging systems theory-based pathologies for governance of complex systems. *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 144–159.

Katina, P. F. (2015b). Systems theory as a foundation for discovery of pathologies for complex system problem formulation. In A. J. Masys (Ed.), *From problem framing to problem solving: Applications of systems thinking and soft operations research in managing complexity* (*in press*). Geneva, Switzerland: Geneva, Switzerland: Springer International Publishing.

Keating, C. B., & Katina, P. F. (2012). Prevalence of pathologies in systems of systems. *International Journal of System of Systems Engineering*, Vol. 3, Nos. 3/4, pp. 243–267.

APPENDIX D: PATHOLOGIES STATEMENTS FOR ASSESSMENT

The theory (construct) development phase of this research used grounded theory to develop a construct of metasystem pathologies identification for problem formulation by considering systems theory. The design that was undertaken is provided and the results are provided in Chapter V. These results include 83 systems theory-based pathologies that act to limit performance of complex systems. With respect to problem formulation as addressed in Chapter II, identification of these pathologies lies within the purview of problem formulation.

The validity of the theory is maintained within the different phases of Grounded Theory Method. However, utility of the theory could be illustrated in terms of ability to move from the theoretical lens to the operational setting. Specifically, the researcher thought to show utility of results of theory development in an operational setting. The initial outlook was that one could simply ask if such pathologies are present in a given organization. However, it was discovered that the language used in connection with pathologies is not common and might not easily be understood by a practitioner. In light of this issue, 88 simplified statements were developed from the 83 pathologies for use in survey assessment tool while still maintaining the original meaning of pathologies. These pathologies statements are listed in this appendix and were targeted towards capturing participant perspective on agreement/disagreement to existence/consequences of pathologies.

Table 55: Pathology Survey Statements

#	The Pathology of	Survey Statement
1	***Complementarity***	(SYSTEM OF INTEREST) does not encourage consideration of multiple perspectives
2	***Diminishing returns***	In efforts to increase productivity, (SYSTEM OF INTEREST) frequently expends resources in excess of the gains realized
3	***Requisite hierarchy***	There are not adequate procedures at appropriate levels to maintain (SYSTEM OF INTEREST) performance
4	***Requisite knowledge***	(SYSTEM OF INTEREST) does not have sufficient knowledge of (SYSTEM OF INTEREST) to effectively respond to externally driven changes
5	***Requisite parsimony***	(SYSTEM OF INTEREST) assigned work responsibilities are beyond what we can be reasonably expected to manage
6	***Requisite saliency***	(SYSTEM OF INTEREST) priorities are not well defined or frequently shift
7	***Requisite variety***	(SYSTEM OF INTEREST) lacks sufficient capacity to absorb environmental flux without degrading our performance
8	***Adaptation***	We have difficulty adapting to circumstances generated external to (SYSTEM OF INTEREST)
9	***Autonomy***	(SYSTEM OF INTEREST) lacks sufficient independence for making decisions and taking action
	Balance of tensions	Combined under #65 , Viability
10	***Basins of stability***	For (SYSTEM OF INTEREST), results from new initiatives frequently fall short of intentions
11	***Buffering***	In (SYSTEM OF INTEREST) there are not enough reserve resources to accommodate unexpected shifts in work demands
12	***Circular causality***	(SYSTEM OF INTEREST) tends to oversimplify complex interrelationships
13	***Consequent production***	Our intended purpose for (SYSTEM OF INTEREST) does not match what we actually achieve in execution
14	***Cybernetic stability***	(SYSTEM OF INTEREST) external relations do not provide adequate stability in the midst of turbulence
15	***Darkness in a situation***	(SYSTEM OF INTEREST) behaves as if we have complete understanding of our operations when in fact we don't
16	***Dialecticism*** 1	We are not effective in detecting errors in (SYSTEM OF INTEREST)
17	***Dialecticism*** 2	We are not effective in correcting detected errors in (SYSTEM OF INTEREST)

Table 55 (cont.)

18	***Emergence***	(SYSTEM OF INTEREST) does not act effectively when situations emerge in ways we can't predict
19	***Environmental-modification***	(SYSTEM OF INTEREST) reacts to changes in the external environment rather than proactively attempt to change the environment
20	***Equifinality***	(SYSTEM OF INTEREST) subscribes to the idea that there is usually one best way to proceed
21	***Equivocation***	Communications within (SYSTEM OF INTEREST) are frequently misinterpreted
22	***Eudemony***	(SYSTEM OF INTEREST) overemphasizes financial considerations often creating an imbalance with other important considerations
23	***Events of low probability***	(SYSTEM OF INTEREST) has difficulty in differentiating among competing priorities
24	***Feedback*** 1	For (SYSTEM OF INTEREST), feedback from the external environment is not effectively incorporated to maintain stability
25	***Feedback*** 2	In (SYSTEM OF INTEREST) small deviations frequently escalate into more serious issues
26	***Flatness***	In (SYSTEM OF INTEREST) excess administrative emphasis negatively impacts productivity
27	***Frame of reference***	(SYSTEM OF INTEREST) lacks sufficient overlap in perspectives to provide consistent interpretations
28	***Hierarchy***	The levels of hierarchy are not appropriate for (SYSTEM OF INTEREST) to function effectively
29	***High-flux***	Adequate resources are not provided in a timely manner to address (SYSTEM OF INTEREST) failures
30	***Holism***	(SYSTEM OF INTEREST) tends to focus more on the details of parts rather than the bigger picture of the whole.
31	***Homeorhesis***	(SYSTEM OF INTEREST) has difficulty maintaining course after experiencing a disturbance
32	***Homeostasis***	We do not actively monitor essential variables of (SYSTEM OF INTEREST) to ensure performance remains constant
33	***Internal elaboration***	The level of formalization is excessive in (SYSTEM OF INTEREST)
34	***Iteration***	(SYSTEM OF INTEREST) is ineffective in iterating decisions and actions to produce better results
35	***Least effort***	(SYSTEM OF INTEREST) frequently expends more energy or resources than necessary to address issues

Table 55 (cont.)

36	***Maximum power***	(SYSTEM OF INTEREST) does not adjust well to demands for increased capacity
37	***Minimal critical specification***	(SYSTEM OF INTEREST) is overly prescriptive in defining how things must be done
38	***Multifinality***	(SYSTEM OF INTEREST) suffers by assuming that successful past approaches will be equally successful for new issues
39	***Omnivory***	(SYSTEM OF INTEREST) lacks flexibility to accommodate utilization of different resource types
40	***Organizational closure***	(SYSTEM OF INTEREST)'s identity lacks sufficient clarity to provide continuity in the midst of change.
41	***Over-specialization***	Specialization within (SYSTEM OF INTEREST) limits the ability to respond to opportunities that cut across multiple specialties
42	***Pareto***	We do not adequately distinguish between different factors contributing to (SYSTEM OF INTEREST) performance
43	***Patchiness***	Limited diversity in sources of (SYSTEM OF INTEREST) resources creates vulnerability to shifts in resource availability
44	***Polystability***	(SYSTEM OF INTEREST) has difficulty maintaining stability when its subunits are in continual flux
45	***Redundancy of potential command***	(SYSTEM OF INTEREST) decision and action is overly constrained by higher level entities
46	***Redundancy of resources***	(SYSTEM OF INTEREST) lacks sufficiently redundant resources to effectively respond to unforeseen opportunities/threats
47	***Relaxation time***	Frequency of changes does not permit (SYSTEM OF INTEREST) to operate in stability
48	***Resilience***	(SYSTEM OF INTEREST) has difficulty returning to previous levels of execution following disturbances
49	***Robustness***	(SYSTEM OF INTEREST) can only absorb a limited range of external disturbances without the need for modification
50	***Safe environment***	(SYSTEM OF INTEREST) is not proactive in attempting to stabilize environmental flux
51	***Satisficing***	(SYSTEM OF INTEREST) seeks to identify the best possible solution to an issue rather than one that is satisfactory
52	***Self-organization***	(SYSTEM OF INTEREST) lacks sufficient flexibility concerning how to accomplish work

Table 55 (cont.)

53	***Separatibility***	Very small disturbances or changes by one (SYSTEM OF INTEREST) individual or entity can quickly escalate into major issues
54	***Steady state***	(SYSTEM OF INTEREST) does not sufficiently focus on the member entities
55	***Sub-optimization 1***	Even though individual entities in (SYSTEM OF INTEREST) are performing well, (SYSTEM OF INTEREST) performance as a whole is lacking.
56	***Sub-optimization 2***	Even though (SYSTEM OF INTEREST) as a whole is performing well, performance of individual entities is lacking
57	***Subsidiarity***	Local level (SYSTEM OF INTEREST) issues frequently escalate to a higher level for resolution
58	***System context***	(SYSTEM OF INTEREST) issues are frequently simplified by avoiding the wider context in which they are embedded
59	***First cybernetic control***	(SYSTEM OF INTEREST) lacks an adequate baseline against which performance can be assessed
60	***Red Queen***	(SYSTEM OF INTEREST)'s rate of development is not sufficient to keep up with other related organizations.
61	***Second cybernetic control***	Communications within (SYSTEM OF INTEREST) are not sufficient to enable desired levels of performance
62	***Third cybernetic control***	Changes are introduced in (SYSTEM OF INTEREST) even though performance expectations are being met
63	***Transcendence***	In (SYSTEM OF INTEREST) we do not accept the premise that there are issues that lie beyond our capacity to understand
64	***Ultra-stability***	New or novel (SYSTEM OF INTEREST) disturbances that are unfamiliar present a particularly difficult challenge to our existing structure
65	***Undifferentiated coding***	(SYSTEM OF INTEREST) prefers to view issues from an objective versus subjective perspective
66	***Unity***	(SYSTEM OF INTEREST) lacks a clear purpose that serves to internally unify and externally distinguish the organization
67	***Viability 1***	(SYSTEM OF INTEREST) does not balance change and stability well
68	***Viability 2***	(SYSTEM OF INTEREST) does not have a good balance between the interests of the whole organization and those of individual entities
69	***Viability 3***	(SYSTEM OF INTEREST) does not have an appropriate balance between 'ad hoc' design and purposeful design

Table 55 (cont.)

70	***Gödel's incompleteness***	The current (SYSTEM OF INTEREST) frame of reference is not adequate to address the problems that must be confronted
71	***Information redundancy***	(SYSTEM OF INTEREST) information exchange does not effectively assure that the right information is transmitted
72	***Morphogenesis***	Frequent structural changes in (SYSTEM OF INTEREST) result in instabilities
73	***Morphostasis***	(SYSTEM OF INTEREST) resists change in favor of maintaining the status quo
74	***Pareto optimality***	(SYSTEM OF INTEREST) undertakes initiatives without adequate consideration for their potential impact on other initiatives or entities
75	***Purposive behaviorism***	With respect to fulfilling the (SYSTEM OF INTEREST) purpose, achievement falls short of intentions
76	***Recursiveness*** 1	(SYSTEM OF INTEREST) lacks a clear understanding of the larger organization in which it is embedded
77	***Recursiveness*** 2	(SYSTEM OF INTEREST) lacks a clear understanding of the entities that comprise (SYSTEM OF INTEREST)
78	***Reification***	(SYSTEM OF INTEREST) has difficulty moving abstract ideas into concrete plans and actions
79	***Channel capacity***	(SYSTEM OF INTEREST) communications lack effectiveness in providing relevant information in a timely manner
80	***Genesis of structure***	For (SYSTEM OF INTEREST), information flows are not effectively adjusted to compensate for organizational changes
81	***Synchronicity***	(SYSTEM OF INTEREST) has a hard time dealing with problems that cannot be objectively analyzed for cause and effect
82	***Communication***	(SYSTEM OF INTEREST) communications frequently result in misinterpretation of the intended meaning
83	***Control***	(SYSTEM OF INTEREST) lacks effective constraints necessary to ensure performance expectations are met
84	***Dynamic equilibrium***	(SYSTEM OF INTEREST) does not effectively balance its interactions with the external environment to maintain performance
85	***Punctuated equilibrium***	(SYSTEM OF INTEREST) work moves from periods of relative calm to periods of crisis without knowing when the shift will occur

Table 55 (cont.)

86	***Sociotechnicality***	(SYSTEM OF INTEREST) tends to focus more on the technical aspects of problems to the exclusion of the social aspects
87	***System boundary***	(SYSTEM OF INTEREST) has difficulty establishing boundaries that clearly delineate (SYSTEM OF INTEREST), its work, and its problems from those that are external
88	***System environment***	The critical aspects of the external environment that influence (SYSTEM OF INTEREST) are not well understood

APPENDIX E: THE RAW RESULTS OF ASSEMENT IN THE UNIT OF ANALYSIS

In Appendix D, the survey statements that are used in the survey tool are presented. In this Appendix, the raw data associated with the results of the survey tool for assessing the level of participant's agreement with 'existence' of the pathologies statement and their 'consequence' are presented. In all, 111 participants responded to the survey instrument. The first raw of the table represents the 49 different grids corresponding to the X (i.e., existence) and Y (i.e., consequence) plot. For example, [SD, E] is one grid. It represents the intersection of {Strongly Disagree} for 'existence' and {Extreme} for 'consequence' of pathologies as described in Chapters IV and V. The columns are labeled 1 through 88 and there numbers directly correspond to the 88 different *survey statements* for pathologies as indicated in Appendix D. The numbers in different grids represent the number of participants who selected a specific grid. For example, eight participants noted that they 'Disagree' with the statement for pathology statement, which is labeled as 1 and corresponds to: *SYSTEM OF INTEREST) does not encourage consideration of multiple perspectives*. The same eight participants note that consequences associated the pathology under evaluation could be 'Very High.'

[redacted]

3	2	1	0	2	2	3	3	[redacted]	4	2	1	7	3	7	3	2	1	5	5	1	2	3	3	14	7	2	0	1	3	3	0	2	0	0	0	2	0	0	0	0	1	2	0	0	2	0	0	0
3	0	1	1	1	2	8	3	4	0	1	3	7	3	4	4	1	4	8	8	1	2	5	3	16	3	2	0	0	2	4	0	3	0	0	1	1	1	0	0	0	0	0	0	0	2	0	0	1
1	2	1	0	1	4	12	3	7	3	1	4	8	5	1	5	2	0	14	5	1	0	2	1	9	6	2	0	0	4	4	0	0	1	0	0	2	0	0	0	0	0	0	0	0	1	0	0	1
3	0	3	1	0	3	10	5	7	1	1	6	7	1	1	2	3	3	12	5	0	2	2	3	15	3	1	0	0	1	1	0	1	0	0	0	3	0	1	0	0	0	2	0	0	1	0	1	0
2	2	0	0	0	0	5	6	8	6	1	3	4	0	3	4	2	1	8	5	0	0	6	2	17	4	0	0	1	10	5	0	0	0	0	2	2	0	0	0	0	0	2	0	0	1	0	0	0
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2	0	1	0	0	2	7	3	4	1	1	1	12	2	3	2	5	1	7	7	1	0	5	5	13	5	3	0	0	3	5	1	1	0	0	1	3	0	1	0	0	0	0	0	0	1	1	0	1
4	1	0	0	1	5	8	1	5	0	0	1	10	4	0	3	6	0	8	12	3	0	0	5	13	7	0	0	0	3	3	0	2	1	0	1	1	0	1	0	2	0	1	0	1	1	0	1	0
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APPENDIX F: AN EXAMPLE OF APPLICATION OF SYSTEMS THEORY-BASED PATHOLOGIES

This research makes several significant contributions and implications to the systems body of knowledge in support of problem formulation phase of systems-based methodologies. The construct, *Metasystem Pathologies Identification* and the *systems theory-based pathologies* also provide a substantive help for those involved in analysis of complex systems. This utility comes in the form of the means in which the developed construct can be used in endeavors related to any problem formulation activity.

For example, those interested in Systems of Systems Engineering (SOSE) as a methodology to intervene in systems of systems problem landscape could be involved in application of National Centers for System of Systems Engineering approach (Adams & Keating, 2009; 2011; Keating et al., 2004). This approach provides a high-level analytical structure for "rigorous engineering analysis that invests heavily in the understanding and framing of the problem under study" (Adams & Keating, 2011, p. 113) through which understanding of complex systems is possible. Typically, seven stages are involved in this methodology (1) framing the system under study, (2) designing the unique methodology, (3) designing the SoSE team, (4) SoSE exploration and analysis, (5) transforming the analysis into action, (6) reporting the results of SoSE study, and (7) assessing the impact of the SoSE study (Adams & Keating, 2009; 2011; Keating et al., 2004). Obviously, this methodology recognizes the importance of problem formulation.

During the problem formulation phase of this methodology, a total of nine primary elements (i.e., situation-wide context, characterization of system, nature of system, justification for system complexity, framing, problem statement and objectives, stakeholder analysis, contextual analysis, and implication of study) with 23 executable elements are involved to "expose problems under study and produce actionable results" (Adams & Meyers, 2011, p. 164). Each of the nine elements are associated with a set of goals, input, outputs, methods, techniques, and tools that enable holistic understanding of a complex satiation. However, this process can be supplemented by current research on systems theory-based pathologies. MPI provides a set of systems theory-based pathologies that could be evaluated in terms of existence and consequence on the system of interest.

Given that system theory-based pathologies act to limit expected performance, and could therefore hinder viability, it is critical that they are identified during 'Perspective I' phase of SOSE methodology. With the MPI in hand, the SoSE team could develop a simple template to evaluate each of the 83 pathologies based on a set of agreed upon measures for evaluation (e.g., impact of the systems theory-based pathologies, susceptibility of the organization to the systems theory-based pathologies). This type of assessment provides a different view of issues that could affect a complex system. These issues could then supplement, for requirements, identified using during a traditional approach of 'needs analysis' (Smith, 2011). Moreover, since there is a greater emphasis on the subjectivity in SOSE methodology, the SoSE team, during pathologies assessment is afforded the opportunity to capture divergence perspectives in the SoSE team. At the core of problem formulation in this research is the assumption that dealing with systems requires evaluation of human participants, in this case the SoSE team, including their interests, values, and assumptions (Adams & Keating, 2011; Jackson, 2003; Mason & Mitroff, 1981; Ulrich, 1987). As each member of the team provides his or her input in the assessment, divergence in the perspectives of the SoSE team is revealed and then discussed as part of attempt to understand pathologies. Pathologies can then be ranked and prioritized as the SoSE team sees fit.

This is only one example of how this large number of systems theory-based pathologies could be used in a problem formulation activity. Since these pathologies are not restricted to a particular industry, anyone facing interested in assessing their system (i.e., organization) is provided with invaluable means to systemically evaluate issues affecting performance from a systems theory perspective.

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