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## Contextual Framework of Communications Functions Supporting Complex System Governance

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CONTEXTUAL FRAMEWORK OF COMMUNICATIONS FUNCTIONS  
SUPPORTING COMPLEX SYSTEM GOVERNANCE

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## ABSTRACT

CONTEXTUAL FRAMEWORK OF COMMUNICATIONS FUNCTIONS SUPPORTING  
COMPLEX SYSTEM GOVERNANCE

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The purpose of this research was to develop a systems theory-based contextual framework of communication functions supporting complex system governance using an inductive research design. Communication, as one aspect of Management Cybernetics (communication and control for effective system organization) constructed of channels of communication, provides for the movement of information internally and externally for a system. This flow reflecting new information, decisions, questions, and intelligence is critical for viability of a system. This research looked for communication mechanisms as developed in system theory, communication theory, management theory, and organizational theory. The literature indicates the importance of communications, but a systemic perspective of communication mechanisms and an effect on the viability of a system are not described. This gap in knowledge was addressed by this research. Specifically, the research looked at the description and system functions serviced by the development of content that flows through the channels of communication. The extensive use of grounded theory method enabled a rigorous inductive analysis of literature dealing with channels of communication. The research produced a construct of communication mechanisms that consists of an integrated grouping of the concepts; Direction, Mode, Product, and Technology (Conveyance). A communication design when developed and/or maintained suggests the communication mechanisms are subject to underlying influences; Identity (motive/intent), Variety Attenuation, Variety Amplification, and Transduction that must be recognized with respect to how Channels of Communication support the viability of the system of interest. While system emergence was not directly related to the Communication Mechanism, the role of Channels of Communication in system emergence is evident as the conduit for the emergence process. Identification of the communication functions means that communication mechanisms, beyond the identification provided by Beer (1979) and Shannon (1948) can be described based in systems theory, communication theory, management theory, knowledge management, and organizational theory. From this construct, a face validation in the form of a survey was conducted. The content of the questionnaire was aligned to the communication mechanisms with the intent to support triangulation. There was peer validation of the questions to the subject of communication, for ease of use and exclusion of private personal information. This was followed by a test run of the survey. The actual accomplishment of the survey was through a web service.

This research provides a theoretical construct of communication mechanisms when viewing a system of interest to determining the state of the system channels of communication.

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## DEDICATION

This work is dedicated to my parents Charles and Barbara, from them life, liberty, the reward for hard work of more hard work to do and so many dreams. To Dr. G Dallas (Doc) and Margret Hanna and Captain Charles P. Woodson, USN, Ret. who expanded my foundations with the sea. To the Bubba's for whom only yesterday was an easy day, a privilege and honor on my part.

“When all that holds you is the horizon, that is called freedom.”

*Unknown*

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## I. INTRODUCTION

### PURPOSE

The purpose of this chapter is to establish the foundation for research to address a significant deficiency in the body of knowledge concerning the Communication construct of Complex System Governance. Complex System Governance (CSG) as described by Keating, Katina, and Bradley (2014) in their paper *Complex system governance: concept, challenges, and emerging research* is built on System Theory and Management Cybernetics and incorporates as one of their cornerstones the metasystem as described in Beer's (1979) Viable System Model (VSM). Communication as one portion of Management Cybernetics (communication and control for effective system organization) provides for "The flow and processing of information within and external to the system, that provides for consistency in decisions, actions, and interpretations made with respect to the system" (Keating, 2015, p. 265). Nyström points out that the VSM "has been used for diagnosing different kinds of organizations at different levels where its use highlights existing or missing communication patterns and information flows in different communication channels and relates findings to a viable system" (Nyström, 2006, p. 523). However, the specific mechanisms associated with communications have not been described.

Through identification, analysis, and evaluation of the mechanisms of Communication an explicit construct can be constructed. The construct is built systematically or formulated as a synthesis of complex or simple ideas with an orderly result. Differently, a framework of the mechanisms of Communication provides the structure or plan containing the mechanisms of communications. The development of an explicit framework can provide: (1) the basis for accurately identifying the existence, absences or work around of channels of communication, (2) the nature and make up of amplification, attenuation and transduction mechanisms, (3) identification of variance in the channels of communication for evolving systems, or (4) identification of variation in the content that flows through the channels of communications. Finally, the establishment of indicators associated with Communications enables objective representative state level to be defined that with time can be used to evaluate respectable degrees of change to the complex system.

## BACKGROUND OF THE PROBLEM

Systems and Complex Systems definitions have evolved and have reached a degree of maturity. Through this evolutionary process, communications have been included in the definition of a system. Jackson, in providing supportive information to managers, stated, “Simply defined, a system is a complex whole the functioning of which depends on its parts and the interactions between those parts” (Jackson, 2003, p. 1). Skyttner when discussing general system theory stated, “Another pragmatic definition, used especially in the realm of management, is that a system is the organized collection of men, machines and material required to accomplish a specific purpose and tied together by communication links” (Skyttner, 1996, p. 17). Likewise, the works of von Bertalanffy (1950, 1968) include in their works the terms of communication, interaction, and information.

Jackson (2003) describes significant contributors to system understanding and theory by identifying Norbert Wiener as making a very significant contribution where “In 1948 Wiener published a book on what he called, borrowing from the Greek, cybernetics - the science of control and communication in the animal and the machine” (Jackson, 2003, p. 7). The concept of control having a dependency on communication is further described as the “systems regulate themselves and are controlled, in the face of environmental disturbances, through the effective communication of information” (Jackson, 2003, p. 8). Accordingly, as System Theory has evolved, communication is perceived as having a central role.

At the same time, as “systems engineering grew out of engineering in the 1940s and 1950s” (Jackson, 2003, p. 48), work was being accomplished in communications. C. E. Shannon in his journal article “A Mathematical Theory of Communication” points out that the “fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point” (Shannon, 1948, p. 623). Shannon described a communication as a system containing five parts: (*Information source* – produces a message or sequence of messages to be communicated to the receiving terminal, *transmitter* – which operates on the message in some way to produce a signal suitable for transmission over the channel, *channel* – the medium used to transmit the signal from the transmitter to receiver, *receiver* – performs the inverse operation of that done by the transmitter reconstructing the message from the signal, and *destination* - is the person or thing for whom the message is

intended). Shannon (1948) also described noise – the perturbation of the transmission at one or the other of the terminals meaning that the received signal is not necessarily the same as sent out by the transmitter. Shannon (1948) did not describe how to identify the information source, neither the destination nor the channel. This is quite possibly due to the nature of his work dealing with mechanical and electrical transmission systems and the issue of rate of communication.

Subsequent work on communications has seen it expanded into Communications Theory and Information Theory. Losee states that “When communication is defined in terms of informative processes, one can study both the information that is conveyed and the processes that carry it. Definitions of “communication often involve terms such as knowledge, belief, meaning, or intention” (Losee, 1999, p. 2). Losee’s work following the works of: Katz (1957) *The Two-Step Flow of Communications: An Up-to-Date report an Hypothesis*; Ackoff (1958) *Towards a Behavioral Theory of Communication*; Hage, Aiken, and Marrett (1971) *Organization Structure and Communications*; Baskin and Bruno (1977) *A Transactional Systems Model of Communications: Implications for Transactional Analysis*’ and Dervin (1993) *Verbing Communication: Mandate for Disciplinary Invention* and makes the case for a process model that is comprehensive, in that it deals with both the process of communicating, the content of the communication and what can occur when the communication is received. Craig in his work on *Communication Theory*, summarizes that with respect to cybernetics “in contrast to other traditions of communication theory, cultivates a practical attitude that appreciates the complexity of communication problems and questions many of our usual assumptions about differences between human and nonhuman information-processing systems” (Craig, 1999, p. 142). From the perspective of Communication or Information Theory, one can “define a communication as information that enters a process and eventually leaves its inverse process” (Losee, 1992, p. 1).

The development of Complex System Governance (CSG) as described by Keating, works on addressing “three primary shortcomings in addressing modern complex system problems” (Keating, 2015, p. 226). Firstly, there are complex systems with “constituent problems, require inquiry and solutions that lie beyond the limited grasp of technology-centric approaches” (Keating, 2015, p. 226). This is especially true for complex systems with problems for which “solutions must cross the entire spectrum of organizational, managerial, human, social, policy, and political dimensions” (Keating, 2015, p. 226). Secondly, current system based solution sets

“have not yet managed to bridge the divide between the hard, technical, objective based aspects of complex systems and the soft, non-technical, subjective aspects” (Keating, 2015, p. 226). Finally, the “landscape for modern systems has changed appreciably into a much more ‘complex problem space’” (Keating, 2015, p. 226). As many readers can appreciate, the landscape includes “difficulties encountered across the holistic range of technical, organizational, managerial, human, social, information, political, and policy issues” (Keating *et. al*, 2015, p. 2944). With respect to this area that CSG is dealing with, there are several consistent characteristics:

***Uncertainty*** - incomplete knowledge casting doubt for decision/action consequences

***Ambiguity*** - lack of clarity in interpretation

***Emergence*** - unpredictable events and system behaviors

***Complexity*** - systems so intricate that complete understanding is not possible

***Interdependence*** - mutual influence among related elements

(Keating *et. al*, 2015, p. 2944)

CSG, which is grounded in systems theory and management cybernetics, works on the area described above through an “evolution of the [nine] metasystem functions necessary to provide control, communication, coordination, and integration of a complex system” (Keating, *et al.*, 2014). As the described metasystem functions,

account for system performance by purposeful development of control (constraints necessary to ensure consistent performance and future system trajectory), communications (flow and processing of information necessary to support consistent decision, action, and interpretation throughout the system), coordination (providing for effective interaction to prevent unnecessary oscillations within and external to the system), and integration (maintaining system unity through common goals, designed accountability, and balancing system and constituent interests (Keating, 2015, p. 265).

The Complex System Governance (CSG) Reference Model also known as the Metasystem Governance Reference Model has nine metasystem functions included in the metasystem and they are listed in Table 1 below.

**Table 1: CSG Metasystem Functions**

<b>Function</b>	<b>Description</b>
<b><i>Policy and Identity</i></b> – Metasystem Five (M5)	focused on overall steering and trajectory for the system. Maintains identity and defines the balance between current and future focus.
<b><i>System Context</i></b> – Metasystem Five Star (M5*)	focused on the specific context within which the metasystem is embedded. Context is the set of circumstances, factors, conditions, patterns, or trends that enable or constrain execution of the system.
<b><i>Strategic System Monitoring</i></b> – Metasystem Five Prime (M5')	focused on oversight of the system performance indicators at a strategic level, identifying performance that exceeds or fails to meet established expectations.
<b><i>System Development</i></b> – Metasystem Four (M4)	maintains the models of the current and future system, concentrating on the long range development of the system to ensure future viability.
<b><i>Learning and Transformation</i></b> –Metasystem Four Star (M4*)	focused on facilitation of learning based on correction of design errors in the metasystem functions and planning for transformation of the metasystem.
<b><i>Environmental Scanning</i></b> – Metasystem Four Prime (M4')	designs, deploys, and monitors sensing of the environment for trends, patterns, or events with implications for both present and future system viability.
<b><i>System Operations</i></b> – Metasystem Three (M3)	focused on the day to day execution of the metasystem to ensure that the overall system maintains established performance levels
<b><i>Operational Performance</i></b> – Metasystem Three Star (M3*)	monitors system performance to identify and assess aberrant conditions, exceeded thresholds, or anomalies.
<b><i>Information and Communications</i></b> – Metasystem Two (M2)	designs, establishes, and maintains the flow of information and consistent interpretation of exchanges (through communication channels) necessary to execute metasystem functions.
(Keating <i>et. Al.</i> , 2015, p. 6-7.)	

The Information & Communications (M2) Function, Primary Responsibilities and Product descriptions are listed in Table 2 below.



**Table 2: Information & Communications (M2)**

Function	Designs, establishes, and maintains the flow of information and consistent interpretation of exchanges (through communication channels) necessary to execute metasystem functions.
PRIMARY RESPONSIBILITIES	<p>Designs and maintains the architecture of information flows and communications within the metasystem, between the metasystem and environment, and between the metasystem and the governed system</p> <p>Ensures efficiency by coordinating information accessibility within the system</p> <p>Identifies standard processes and procedures necessary to facilitate transduction and provide effective integration and coordination of the system</p> <p>Identifies and provides forums to identify and resolve emergent conflict and coordination issues within the system</p>
PRODUCTS	<p>Standard processes and procedures for internal coordination of the system</p> <p>Communications architecture for the metasystem</p> <p>Defined external coordination vehicles necessary for support for the system (<i>e.g.</i> public relations, press releases).</p>
Drawn from: Metasystem Governance Reference Model, National Centers for System of Systems Engineering, Old Dominion University, C. Keating, 11/19/2014	

A comparison of the Information & Communication descriptions found in Table 1 above to the discussion on the evolution of systems and communication, finds that there is a match. While there may be differences of opinion on how these functions are accomplished, the Function, Primary Responsibilities and Products reflect the key and essential concept of cybernetics focused on “control and communication in the animal and the machine” (Jackson, 2003, p. 7) and that “systems regulate themselves and are controlled, in the face of environmental disturbances, through the effective communication of information” (Jackson, 2003, p. 8).

Whitney *et al* in *Systems theory as a foundation for governance of complex systems* updated a set of previously published propositions where each “proposition is backed by empirical research from an array of disciplines that provides insight about the characteristics, tendencies and considerations of real-world systems” (Whitney *et al.*, 2015, p. 19). This revised set of thirty propositions was acted upon with an “inductive inference methodology which provided insight of the common themes integrated among systems theory principles in order to produce a set of axioms that describe systems” (Whitney *et al.*, 2015, p. 17). The resulting set of

seven axioms include: centrality axiom, contextual axiom, goal axiom, operational axiom, viability axiom, design axiom, and information axiom. Table 3 below contains a listing of Axioms and their Descriptions. A match up of the Communication Propositions from Whitney *et al.*, (2015) was made and this alignment is shown in Table 3 below in the column labeled Communication Support Proposition.

**Table 3: Axioms for systems theory**

<b>Axiom</b>	<b>Axiom Description</b>	<b>Communication Supporting Proposition</b>
<i>centrality axiom</i>	<i>Central to all systems are two pairs of propositions; emergence and hierarchy and communication and control.</i> The centrality axiom's propositions describe the system by focusing on (1) a system's hierarchy and its demarcation of levels based on emergence arising from sub-levels; and (2) systems control which requires feedback of operational properties through communication of information.	Communication (Shannon, 1948a, 1948b)
<i>contextual axiom</i>	<i>System meaning is informed by the circumstances and factors that surround the system.</i> The contextual axiom's propositions are those which bound the system by providing guidance that enable an investigator to understand the set of external circumstances or factors that enable or constrain a particular system.	Boundary (von Bertalanffy, 1968; Skyttner, 2005)
<i>design axiom</i>	<i>System design is a purposeful imbalance of resources and relationships.</i> Resources and relationships are never in balance because there are never sufficient resources to satisfy all of the relationships in a system's design. The design axiom provides guidance on how a system is planned, instantiated and evolved in a purposive manner.	null
<i>goal axiom</i>	<i>Systems achieve specific goals through purposeful behavior using pathways and means.</i> The goal axiom's propositions address the pathways and means for implementing systems that are capable of achieving a specific purpose.	Purposive behavior (Rosenblueth <i>et al.</i> , 1943)

<b>Axiom</b>	<b>Axiom Description</b>	<b>Communication Supporting Proposition</b>
<i>information axiom</i>	<i>Systems create, possess, transfer and modify information.</i> The information axiom provides understanding of how information affects systems.	Information redundancy (Shannon and Weaver, 1949) Redundancy of potential command (McCulloch, 1965)
<i>operational axiom</i>	<i>Systems must be addressed in situ, where the system is exhibiting purposeful behavior.</i> The operational axiom's propositions provide guidance to those that must address the system in situ, where the system is functioning to produce behavior and performance.	null
<i>viability axiom</i>	<i>Key parameters in a system must be controlled to ensure continued existence.</i> The viability axiom addresses how to design a system so that changes in the operational environment may be detected and affected to ensure continued existence.	Feedback (Wiener, 1948)
Whitney <i>et al.</i> , (2015)		

The review found that for the design axiom and the operational axiom, there does not appear to be a communication supporting proposition. However, the products of the Metasystem function of Information & Communications (M2) would indicate that the Primary Responsibility of *Designs and maintains the architecture of information flows and communications within the metasystem, between the metasystem and environment, and between the metasystem and the governed system* would have to be associated with the design axiom. Likewise, the Primary Responsibility of *Ensures efficiency by coordinating information accessibility within the system and Identifies standard processes and procedures necessary to facilitate transduction and provide effective integration and coordination of the system* would appropriately be associated with the operational axiom.

This review highlights that while the proposition listing to develop the axioms was restricted to thirty, for the communication responsibilities identified in the CSG Reference Model, identification of appropriate corresponding propositions would eliminate any confusion.

Secondly, the axiom work undertaken by Whitney *et al.*, (2015) clearly indicates that there is no single proposition that completely satisfies all the requirements of a function (i.e. Information and Communications).

The development of Information Theory by Shannon when dealing with physical systems has progressed and works very well as new technologies have been introduced into communication systems. However, even as Information Theory and Communication Theory were being advanced, there were criticisms that the theory did not encompass the social science part of the extensive communication system. Specifically, Weaver indicated the problematic nature,

Relative to the broad subject of communication, there seem to be problems at three levels. Thus, it seems reasonable to ask, serially:

**LEVEL A.** How accurately can the symbols of communication be transmitted? (The technical problem.)

**LEVEL B.** How precisely do the transmitted symbols convey the desired meaning? (The semantic problem.)

**LEVEL C.** How effectively does the received meaning affect conduct in the desired way? (The effectiveness problem.) (Weaver, 1953 p. 2).

Weaver continues and states,

It was suggested that the mathematical theory of communication, as developed by Shannon, Wiener, and others, and particularly the more definitely engineering theory treated by Shannon, although ostensibly applicable only to Level A problems, actually is helpful and suggestive for the level B and C problems (Weaver, 1953, p. 11).

Unfortunately, over the years the problems of Level B and C have not been resolved with the Communication Theory developed by Shannon and the expansion made to the theory.

As discussed earlier, Communication Theory and System Theory were developed by different individuals during the same period and the evolution continues. The movement of communications to Communications Theory and Information Theory reflects that a reductionist paradigm is insufficient to advance knowledge on communications. Listing all the reasons for past limited success is beyond the scope of this work; however, in dealing with the inherent

complexity and variety endemic to social systems, that until Systems Theory advanced, there could be only limited success pertaining to advances in knowledge related to communications.

The work on Complex System Governance has been described as the “design, execution, and evolution of the metasytem functions necessary to provide control, communication, coordination, and integration of a complex system” (Keating *et al.*, 2014, p. 264). This is a holistic approach focused on the metasytem. As described in Complex System Governance where,

the metasytem construct only defines ‘*what*’ must be performed to maintain system viability (existence). It does not specify ‘*how*’ a particular system is configured, or what devices (mechanisms) the system implements to achieve the metasytem functions (Keating, 2015, p. 228).

The development of the communications “how” by holistic methods that incorporate all the functionalities of communications, allowing for emergence as well as variety engineering, as proposed by Beer (1979) in his Viable System Model in a complex environment will be significant and applicable to advance understanding of the social systems aspects related to communications that exist beyond the original formulations.

## RESEARCH PROBLEM

The purpose of this research is to develop a Communications construct of Complex System Governance using an inductive research design. As will be articulated below and in Chapter III, the inductive approach will be using grounded theory.

The development of Complex System Governance (CSG) as described by Keating, works on addressing “three primary shortcomings in addressing modern complex system problems” (Keating, 2015, p. 226). CSG, built on System Theory and Management Cybernetics, looks towards the “analysis and development of nine essential (metasytem) governing functions” (Keating *et al.*, 2014, p. 2944). This research will concentrate on the communications (flow and processing of information necessary to support consistent decision, action, and interpretation throughout the system) aspects of the CSG metasytem.

As stated previously, Channels of Communications identified in Beer’s Viable System Model (VSM) are described as a critical feature of Management Cybernetics. Beer described in

The Zaheer Lecture (5th December 1974) that “the main proportion of the effort we made in Chile was to install a regulatory system for the social economy”. Called Project Sybersyn, Beer stated that the two identified problems were “What exactly is going on? And how quickly shall we know today’s results” (Beer, 1974, p. 6). The solution for knowing what was occurring was the construction of a “new sort of model, to express this content uniquely for each enterprise, each industry” (Beer, 1974, p. 6) and secondly, establishment of “a primary set of critical variables in each system under study” (Beer, 1974, p. 6) by the participants both in the field and in Santiago, Chile. The resolution of the problem of how quickly and at what frequency of getting the variables was resolved evident by “Within four months of the start of our work our telecommunications team had established Cybernet. This was a network of Telex communication extending by some means or other, to every enterprise” (Beer, 1974, p. 7). Beer goes on to explain how data was processed and reports made using this network to direct system level decisions and subsequent action.

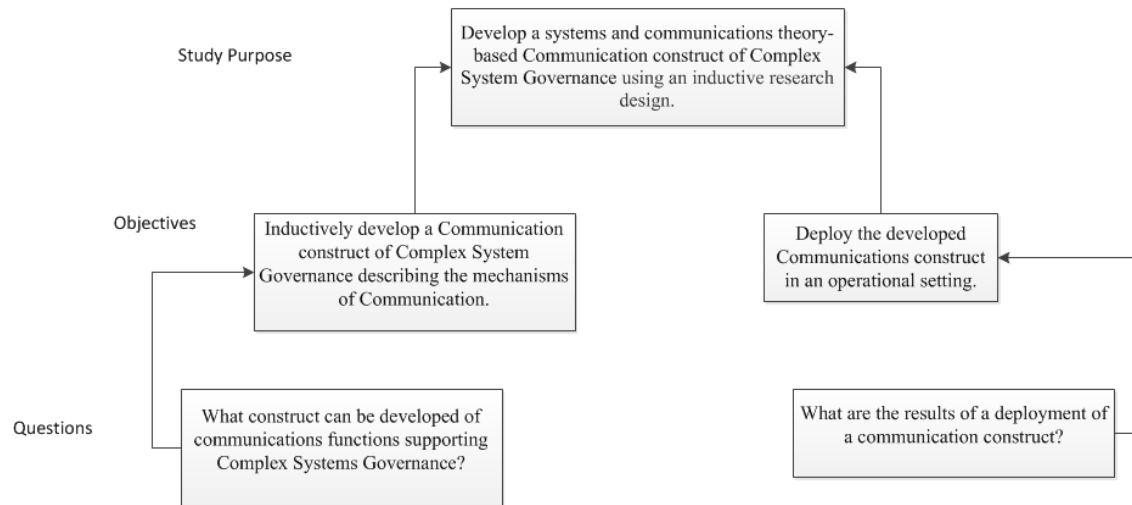
The Chilean work accomplished by Beer was bringing cybernetics and the VSM concepts to an economy that was being operated by individuals who knew “nothing about modern theories of cost and prices” (Beer, 1974, p. 3). However, when there is an existing complex system management technique, and nothing about that is assumed to be viable, what are the channels of communications in use? This research will answer the following questions:

- **What construct can be developed of communications functions supporting Complex System Governance?**
- **What are the results of a deployment of a communication construct?**

This research seeks to expose communication mechanisms beyond the identification provided by Beer and Shannon based in systems theory, communication theory, management theory, knowledge management and organizational theory. This developed construct of communications, suited to CSG, would enable the analysis and development of the channels of communications associated with the nine essential (metasystem) governing functions. The use of the grounded theory would provide the method to obtain a theory or a Communication construct. The second research question, while limited in scope, affords the researcher the opportunity to conduct a “face value” validation of the construct, developed through the

grounded theory method, through application to a field setting in an operational context. This application of the theory to the operational area supports research significance related to the implications for advancing practice.

Figure 1 below graphically depicts research questions, objectives, and the purpose of this research.



**Figure 1: Research Questions, Objectives, and Purpose**

## SIGNIFICANCE OF THE STUDY

The intent of the research is to build a Communication construct of Complex System Governance (CSG) using an inductive research design. The articulation of the Communication construct is expected to be a significant original contribution to several areas of knowledge.

Firstly, the research will be adding to the existing body of knowledge in systems theory and methodologies. The development of a Communication construct based upon systems theory will contribute to the advancement and maturity of Complex System Governance. Secondly, with the development of a Communications construct, analysis of complex systems will be aided with rigorous examination of communications, especially in the initial problem formulation stages as well as subsequent analysis.

The specific analysis tools that a Communications construct would lead to be developed are unknown at this time. However, with their development, they are expected to facilitate complex system communications initial analysis as well as monitoring. Finally, as the use of

Grounded Theory has not extensively been used as a research methodology associated with systems engineering and engineering management. Use in this research will continue to expand grounded theory from its original domains of application. Additionally, most researchers use questionnaires, interviews, and/or detail observations as the source of rich data. This research intends to use peer reviewed journal articles as the data source for inductive theoretical development of the construct.

## **LIMITATIONS AND DELIMITATIONS**

This section presents the limitations and delimitations that can be associated with this research. There are two primary limitations (validity and generalizability) identified relative to this research. These limitations will be acknowledged here and further examined in the research perspective presented in Chapter III. Chapter III includes a detailed discussion of how these limitations will be addressed and how the implications are expected to be mitigated in the design and conduct of the research.

### **Limitations**

Limitations are influences that are beyond the control of the researcher. The use of inductive methods of theory building, specifically grounded theory has the related issues of validity and generalizability. While overall challenges to the use of the grounded theory method have receded, the use of the method is not extensive to systems engineering and engineering management and thus the use of grounded theory in this research must ensure that the design and execution of the research are conducted with the highest level of openness and transparency that provide confidence in: (1) logic and traceability for decisions made in the inductive building of the construct and (2) accountability for execution of the research design such that a level of auditability and credibility are supported such that scholarly challenges can be effectively answered. Secondly, the use of a developed theory to facilitate complex system initial analysis, as well as monitoring, suggests that practitioners must judge the results to be useful in an applicable setting.

There is great desire that the results of the research will be generalizable to the maximum extent possible. Internal validity of the theory is accomplished as part of accomplishing grounded theory and is imbedded in the research design. However, extension of research generalizability beyond the theoretical formulation will be limited to the single application case



targeted, providing a limited ‘face’ validation of the research. Again, the use of inductive research historically can be perceived to impose limitations on generalizability or transferability. While the objections to generalizability can be associated with limited sample size, the use of grounded theory, where a significant breadth of data is used, and where detail description, memoing and theoretical analysis is accomplished, supports the full richness of details that are exposed for development of well supported theory.

### **Delimitations**

The research pursues the development of a Communication construct that will contribute to the advancement and maturity of Complex System Governance. While the research is anticipated to inform future development of analytical tools for assessment of communications for CSG, it is beyond the scope of this research to produce such a set of validated tools (instruments) to facilitate complex system initial analysis as well as monitoring with respect to communications. The Communication construct, or the communication mechanisms identified by Beer and Shannon, will be grounded in systems theory, communication theory, management theory, knowledge management and organizational theory as further described in Chapter III. This set of literature provides the scope of literature which will be used as the data to support inductively developing the construct.

The establishment of limitations and delimitations establishes a frame of reference which signals the scope of the research grasp (delimitations) as well as the projection of the results (limitations). With the articulation of the limitations and delimitations, the reader will better understand what is included and what is excluded in the proposed research design. An inductive research design using Grounded Theory is proposed to be used to develop a construct of communications functions supporting Complex System Governance. There are issues relative to using this inductive method and they will be discussed in depth in Chapter III. To accomplish an initial “face” validation of the developed construct, the proposed method will likewise be discussed in Chapter III. This research is intended to conform to a rigorous Grounded Theory approach from the works of: Corbin & Strauss (1990) *Basics of qualitative research: Grounded theory procedures and techniques*, Strauss & Corbin (1998) *Basics of qualitative research techniques*, and Charmaz (2006) *Constructing grounded theory: A practical guide through qualitative research*. It can be

expected that there will be a construct of communications functions that support Complex System Governance that will emerge. With a wider spectrum of literature to use as data, it is anticipated that a broad construct can emerge that can be applied to many social systems that can be viewed from the perspective of the range of literature used as source material for construction of the construct.

## **INTRODUCTION SUMMARY**

This chapter has provided a description of the purpose of the study as well as a description of system theory and communication theory development and relationships. Though Complex System Governance is maturing as the problem statement indicates, the proposed research in the area of a Communication construct has significance beyond a contribution to systems theory. The follow-on chapter will provide a review of the body of knowledge on systems and communications to establish the gap to be filled by a Communications construct.

## II. SYNTHESIS OF REVELANT LITERATURE

### INTRODUCTION

The previous chapter described the purpose of the study as well as the relationship to system theory and communication theory. This chapter is organized to provide a review of the body of knowledge on system theory and communication theory that lead to developing a synthesis of the literature. This will then be followed by a critique of the literature that leads to problem formulation.

The significance of research needs to be placed within the context of several areas, one of which are gaps in the existing body of knowledge that may be reflected in current literature as described by (Fink (2005), Hart (1998), Jesson (2011), Ridley (2012), and Van de Ven (2007)). They suggest that a literature review surveys books, scholarly articles, and any other sources relevant to a particular issue, area of research, or theory, and by so doing, provides a description, summary, and critical evaluation of those works in relation to the research problem being investigated. Literature reviews are designed to provide an overview of sources one has explored while researching a particular topic and to demonstrate to one's readers how the research fits within a larger field of study.

Associated with the choice of Grounded Theory is the question of what amount of literature ought to be reviewed prior to the conduct of research, as unlike other qualitative research designs, "The literature review is, however, not a key part of a grounded theory approach" (Birtsch, 2005, p. 79). As pointed out by Bryant and Charmaz referring to Barry Gibson's advice on literature review,

Anyone starting research will most certainly have preconceived ideas relevant to the research area. A researcher can account for these ideas in some way, but certainly should not simply ignore them. Secondly, the advice about postponing exploration of the literature usually emanates from experienced researchers, who themselves have developed an extensive knowledge of a vast mass of literature together with a general familiarity with key topics and an array of concepts at their fingertips (Bryant & Charmaz, 2007, p. 20).

Therefore, the author chose to review literature to determine if there existed gaps in the literature with respect to Communications. It was found that there is an abundance of literature on the topics of System Theory, Complex System, Management Cybernetics as well as

Communications Theory. This chapter is not a synthesis of all literature related to these fields, but instead is organized to provide an essential depiction of the related fields with a focus on development and appreciation of foundational knowledge related to the research questions. In effect, the literature review is engaged to provide an essential grounding that establishes relationship of the current research to the prevailing knowledge, and gaps, for which the research will contribute to knowledge gaps.

The world is composed of systems, complex systems and systems of systems where the operation of the included systems can function independently from the system of systems. Systems have been studied and described in the various fields of science and the humanities. While some systems appear to continue to exist seemingly forever, others persist; but seem to change while others that existed and are now extinct. *The ISO/IEC/IEEE Standard for Systems and Software Engineering — Vocabulary (2010)* defines a system as a "combination of interacting elements organized to achieve one or more stated purposes" (p.363). Another definition is that a system is "an assemblage or combination of functionally related elements or parts forming a unitary whole . . ." (Blanchard and Fabrycky, 2011, p. 3).

Jackson in his book, *Systems Thinking: Creative Holism for Managers* provides a historical development of Systems Theory starting off with first defining a system as a "complex whole the functioning of which depends on its parts and the interactions between those parts" (Jackson, 2003, p. 3). He continues to point out that "traditional, scientific method for studying such systems is known as reductionism" (Jackson, 2003, p. 3) and where "reductionism sees the parts as paramount and seeks to identify the parts, understand the parts and work up from an understanding of the parts to an understanding of the whole" (Jackson, 2003, p. 3). Jackson goes on to describe an alternative view that of Holism where,

Holism considers systems to be more than the sum of their parts. It is of course interested in the parts and particularly the networks of relationships between the parts, but primarily in terms of how they give rise to and sustain in existence the new entity that is the whole (Jackson, 2003 p. 4).

Jackson continues the historical narrative pointing out that in 1948, Norbert Wiener "published a book on what he called, borrowing from the Greek, cybernetics - the science of control and communication in the animal and the machine" (Jackson, 2003, p. 7). Wiener's

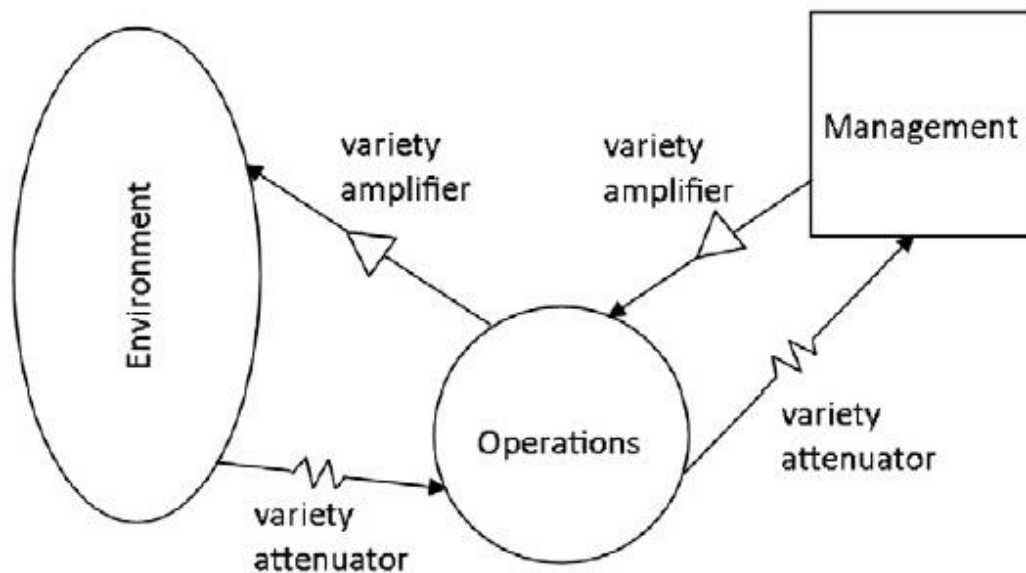
contribution at this time frame is equal in importance to that of the contribution of Ludwig von Bertalanffy in 1950,

published an article in which he made the well-known distinction between closed systems and open systems. A closed system engages in no exchanges with its environment. An open system, such as an organism, has to interact with its environment to maintain itself in existence. Open systems take inputs from their environments, transform them and then return them as some sort of product back to the environment. They depend on the environment for their existence and adapt in reaction to changes in the environment (Jackson, 2003, p. 6).

Jackson (2003), next introduces the concept of *variety* as a depiction which indicates the number of states that a system can exhibit and “According to Ashby’s law of requisite variety, systems can only be controlled if the would-be controller can command the same degree of variety as the system” (Jackson, 2003, p. 9). This work of Ashby forms part of the foundational work to be accomplished by Stafford Beer.

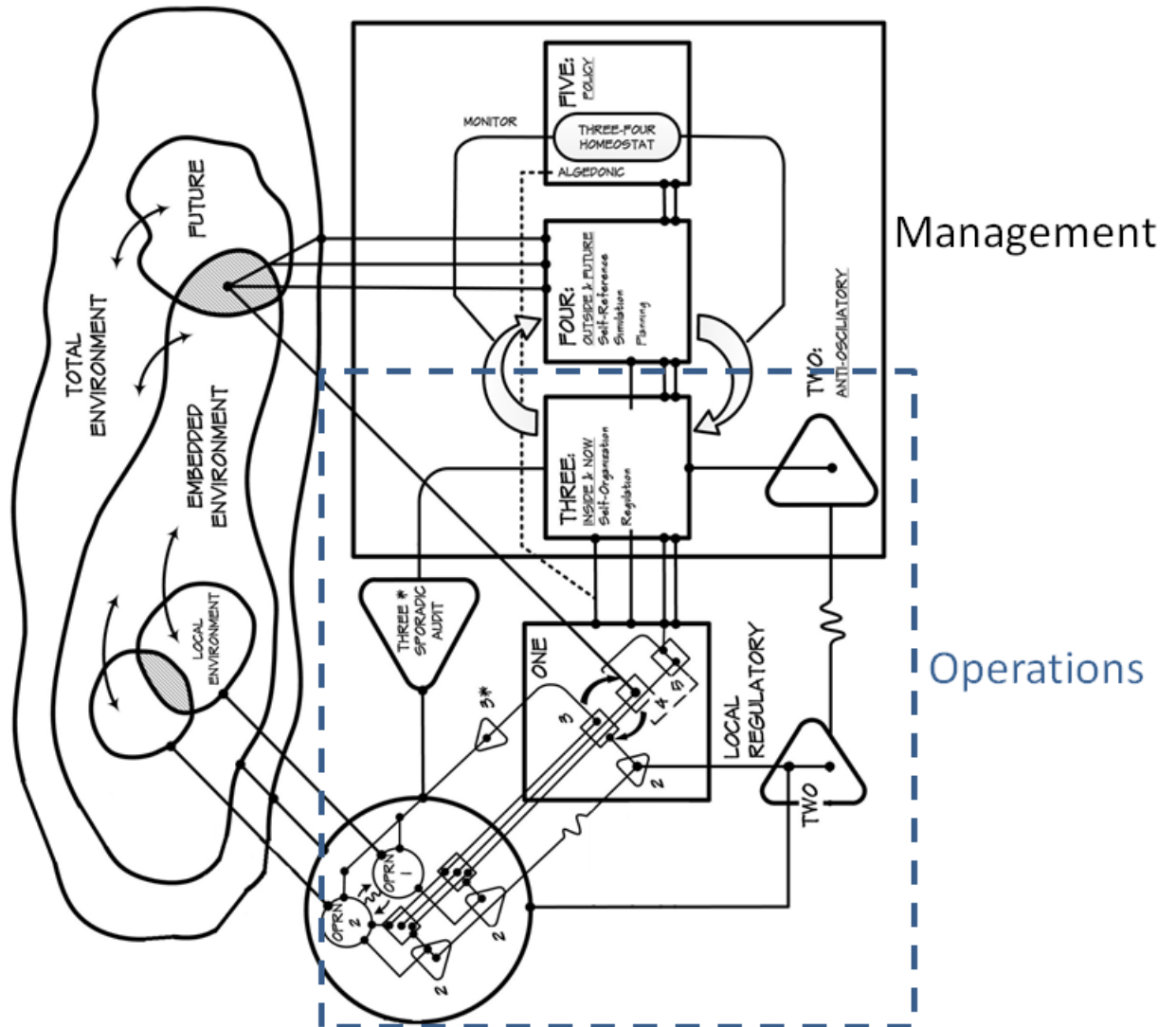
The work of Stafford Beer moved Cybernetics from the control and communications of Wiener to organizational cybernetics or variety engineering. Beer presents the Viable System Model (VSM) with the book *Brain of the Firm* (1972) followed by *The Heart of Enterprise* (1979) and finally *Decision and Control* (1966). The VSM reflects Beer’s neuro-cybernetic model that, with its five subsystems, imitates the human brain and body and their functional requirements. Similar to the body, “Viable systems maintain equilibria behavior only by multiple contact with whatever lies outside themselves” (Beer, 1966, p. 257). This ability to contact is a principal function of a channel of communication. But not only is there contact, and while it is complex, “It is characteristic of a viable system that all its parts may interact; not indeed to the extent that all possible permutations of all possible parts with all other possible parts must manifest themselves, but to the extent that subtle kinds of interaction drawn from all these permutations can and do take place” (Beer, 1966, p. 257) and this does not overwhelm the system because there is control as Variety Engineering provides. With continuous interaction between the five subsystems, Beer draws upon biology and the process of homeostasis, through which control and equilibrium is achieved. With respect to variety, Beer indicates that “ONLY variety absorbs variety” (Beer, 1979, p. 89) and that this law of requisite variety is accomplished because it is required by nature. Accordingly, it also means that when systems are designed, there needs to be mechanisms of amplification (projection) and attenuation (filtering) of variety included.

Figure 2 below shows graphically Beer's First Principal of Organization (Beer, 1979, p. 96), displaying the relationship between the management unit, the operational unit that is regulated by the management unit and the environment for the operational unit. As there will be transmission of variety between all three elements, with the proper design of amplifiers and attenuators there will be diffusion and equivalency of variety over time. Unlike natural systems, "it is management's job to DESIGN the necessary amplifiers and attenuators" (Beer, 1979, p. 97) as the engineering of variety in a complex system.



**Figure 2: Relationship of Units and Channels of Communication**  
(Adapted from (Beer, 1979, p. 96))

Represented below in Figure 3 is a graphical representation of Beer's Viable System Model that is an expansion of the three units (Environment, Operations and Management) and the incorporation of the metasystem functions and showing lines representing channels of communication.



**Figure 3: Representation of Beer's Viable System Model**  
 (Used with permission and adapted from Akers, Walt (2015). Viable Systems Model. An Approach for the Development of Complex Systems Archetypes (Page 32), Old Dominion University, Norfolk, VA.)

The metasystem functions as described by Beer are contained in Table 4 below.

**Table 4: VSM Metasystem Functions**

<b>VSM Function</b>	<b>Description</b>
<b>S1</b>	Elements concerned with performing the key transformations of the organization; produces the products. (Beer, 1981)  The autonomous unit that produces the product or service. (Beer, 1981)
<b>S2</b>	Anti-oscillatory regulatory, input filter to S3. (Beer, 1981)  Divisional/Corporate regulatory. (Beer, 1981, p. 157)  Metasystem subsuming all S1's. (Beer, 1981, p. 172)
<b>3</b>	Provides interface with S4 and S5 structures and controls that establish rules, resources, rights, and responsibilities of S1. (Beer, 1982)  Highest level of autonomic management. (Beer, 1981, pp. 175-176)  Lowest level of corporate management. (Beer, 1981)  Govern the stability of the internal environments of the project. (Beer, 1981)  Transmitter of policy/special instructions to the divisions. (Beer, 1981)  Tracer of information of internal environment: metasystem controller downward, senior filter of information upward. Handles S2 information circuits. (Beer, 1981)
<b>S3*</b>	Audit. (Beer, 1981)
<b>S4</b>	Development directorate of the organization. (Beer, 1981, p. 181).  Elements which look outward to the environment to understand how the organization needs to adapt to remain viable. (Beer, 1981)
<b>S5</b>	Responsible for policy and decisions. (Beer, 1981)  "Collegiate authority". (Beer, 1981, p. 154).  Provides the identity of the organization. (Beer, 1981).  Creates policy decisions within the organization as a whole to balance demands from different organizations and provide direction to the organizational as a whole. (Beer, 1982)

The reader can easily see the variety attenuator and variety amplifiers in Figure 2 above. The same occurrence of variety attenuator and variety amplifiers are not shown on Figure 3, as this would over complicate the graphical representation. In addition, *transducers* are the “mechanism at the boundary capable of coding or decoding these messages as they pass. This decoding mechanism is called a transducer, because it ‘leads across’” (Beer, 1979, p. 101). The transducers are shown as enlarged dots where the lines representation channels of communication intersects/connects to a sub system.



The representation of Beer's First Principal of Organization (Figure 2) and the Viable System Mode (Figure 3) graphically show many of the parts or components that are fully described by Beer. Likewise, the orientation of the parts or components relative to the Channels of Communication and the VSM Functions importantly reflect how they could form a construct of the metasystem communication. These parts or components will be discussed relative to comparable parts or components found in Communication Theory.

C. E. Shannon in his journal article "A Mathematical Theory of Communication" points out that the "fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point" (Shannon, 1948, p. 623). Shannon described a communication system containing five parts (*information source* – produces a message or sequence of messages to be communicated to the receiving terminal, *transmitter* – which operates on the message in some way to produce a signal suitable for transmission over the channel, *channel* – the medium used to transmit the signal from the transmitter to receiver, *receiver* – performs the inverse operation of that done by the transmitter reconstructing the message from the signal, and *destination* - is the person or thing for whom the message is intended). Shannon (1948) also describes the impact of noise – the perturbation of the transmission at one or the other of the terminals meaning that the received signal is not necessarily the same as sent out by the transmitter. The issue of a discrete noiseless channel and the occurrence of noise along the transmission, at the transmitter or receiver, were addressed. Shannon did not describe how to identify the information source, the destination nor the channel, quite possibly as his work was dealing with mechanical and electrical transmission systems.

The linear and mathematical model developed by Shannon was modified by Wilbur Schramm. In his *The Process and Effects of Communication*, 1954, Schramm described how the decoding and encoding as activities were accomplished simultaneously by sender and receiver and that there is in effect a two-way interchange between the sender and receiver. As communication is reciprocal, however the two-way or feedback may not always be instantaneous, as there is a wide time spectrum relative to the response that can be classified as direct (instantaneous) to indirect (sometime in the future). While Schramm's model of communications did address bilateral communication between the sender and receiver, complex and multiple levels of communication between several sources was not addressed. Relative to

Beer's VSM, Schramm and those that followed do not differ from Shannon's description of a communication system.

Table 5 below is an initial alignment of system parts described by Shannon and function used by Beer. For purpose of simplicity in constructing Table 5, the feedback communication path was not considered and there is no output from the destination entity. Depending upon how the parts and functions are arranged with respect to a system and its environment, it was possible to create more than one arrangement of functions to parts as shown in Table 5. However, with the current state of this literature, while there may be one or more possible constructs, only through further research will the mechanisms of communication be accurately identified. The depiction in Table 5 provides an organization of central contrast of Beer's VSM (as the foundation of the CSG Metasystem) and Shannon's communications work (serving as the foundation of communications theory).

Arrangement A: reflects that there are three systems. The Information Source System, Communication Channel System and Destination System. As the transduction is part of the Information Source and Destination System, the implication is that the Communication Channel System is universal for any Information Source or Destination System and can be used either in transmission or feedback.

Arrangement B: reflects that there are three systems. The Information Source System, Communication Channel System and Destination System. As transduction is part of the Communication Channel System, the implication is that the Information Source and Destination System have been uniquely constructed for the Communication Channel System and only transmission from Information Source System to Destination System is possible.

Arrangement C: reflects that there is only one system. Input is received by the Information Source entity, adjusted with respect to variety and passed to the Destination entity.

**Table 5: Comparison of Communication and VSM terms**

Shannon		Beer (Arrangement A)	Beer (Arrangement B)	Beer (Arrangement C)
INFORMATION SOURCE		Message through TRANSDUCER		Message through VARIETY ATTENUATOR or VARIETY AMPLIFIER
	Message	Modified Message	Message	Message
TRANSMITTER		TRANSMITTER	TRANSDUCER and TRANSMITTER	TRANSMITTER
	Signal	Signal	Signal	Signal
CHANNEL OF COMMUNICATION				
	Received Signal	Received Signal	Received Signal	Received Signal
RECEIVER		RECEIVER	RECEIVER and TRANSDUCER	RECEIVER
	Message	Message	Message	Message
DESTINATION		TRANSDUCER	VARIETY ATTENUATOR or VARIETY AMPLIFIER	
		VARIETY ATTENUATOR or VARIETY AMPLIFIER		
		Received Message	Received Message	Received Message

Since Beer published his works (1975; 1979; 1981; 1985) several authors have used different descriptions of the sub systems as well as different management terms to describe the grouping of the sub systems other than Environment, Operations and Management. For example, the grouping of the sub systems into Normative Management, Strategic Management and Operational Management by Schwaniger (2000) was to reflect management perspectives. Keating and Morin (2001) provided to nursing leaders an effective method for system self-analysis of current operations to be “optimized for the environment” (Keating & Morin, 2001, p. 363). Their work expanded the sub systems to include:

System 4\* - Primary focus is on detection and correction of immediate errors, not long-range or system design errors. Limited purposeful mechanisms for system redesign. (Keating & Morin, 2001, p. 362)

Likewise, the channels of communications have been described as something other than the vertical loop and algedonic. Keating and Morin (2001) to support the expansion of sub systems added three new channels of communication:

The *dialog channel* has the primary purpose of providing examination and interpretation of organizational decisions, actions, and events. This aligns perspectives and creates a shared understanding of organizational decisions and actions in light of system purpose and identity.

The *system learning channel* supports the System 4\* function. This channel provides detection and correction of system errors, testing of assumptions, and identification of system design deficiencies.

The *informing channel* is designed to provide routine transmission of information throughout the system. Thus, information that is not appropriate for other channels is made accessible across the entire system through this channel. (Keating & Morin, 2001, pp. 358-359)

O’Grady (2009) proposes that for the VSM “there are four types of communication channels each involved in a different form of communication “These are the special communication channel, the routine channel, the management channel, and the channel between the operational elements” (O’Gradey, 2009, p. 5).

While this renaming or regrouping of sub systems or proposing that there are more than two channels of communication may cause some confusion, it reflects various researcher's methods of using the VSM as a tool to compare methods of management, to create design models and to support analysis of information and communicating the applicable results to their peers.

The use of the VSM continues to grow and be applied to many fields. A proposed method to use the VSM as an analytical model was described by Flood and Jackson (1991). What is called the viable system diagnosis (VSD) starts with determining what is the system (the identity), what entities are considered interior and exterior and associated with Operation and Management and the activities undertaken. Similarly, Achterbergh and Vriens (2002) used the VSM to propose sets of organizational knowledge needed to support the viability of a system. Their work concentrated on the VSM Functions and did not extend to the channels of communication. These sets of knowledge are organized by the associated sub system. Work by Preece, Shaw, and Hayashi (2013) combined these previous works to analyze the complexity of information processing but only looked at VSM Functions. Pernet and Cano (2014) discuss the current state of Maturity Models used to guide management in organizational improvements with the principles of statistical quality control and continuous improvement (Plan, Do, Check, Act). They point out that the statistical method's limitations can be offset by the use of a systemic maturity model based upon the VSM. Sheehan, Nittbaur, and Mulhaney (2015) advanced the use of the VSM as a tool to evaluate for organizational weaknesses and then use the ISO 9001:2000 guidelines as the method for organizational structural issues to be modified.

The development of Complex System Governance (CSG) is "an emerging field that is still in the earliest stages of development" (Keating, 2015, p. 226). The CSG work, while being accomplished in parallel to the above VSM associated works, is a blending of management cybernetics and systems theory. Keating (2015) continues to articulate that management cybernetics contributes the strong foundations of communication, control and "the science of effective [system] organization" (Keating, 2015, p. 227). Importantly, the contribution of system theory as described by Adams, *et al.* (2104) adds the foundational layer of axioms and propositions that directly affect a complex system's structure, how it performs and its behavior. Development of the constructs of the communications functions supporting CSG will fill a

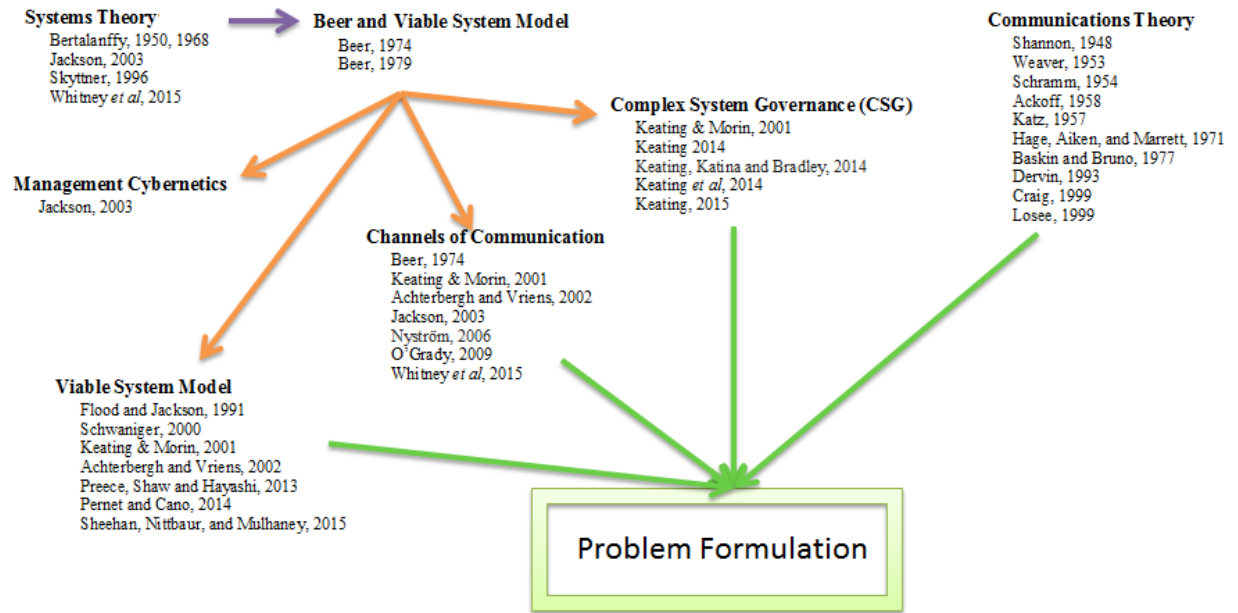
current void, as the current state of literature is sparse with respect to rigorous formulation of communications specifically in relationship to CSG.

The architectural construct of the metasytem functions and channels of communication as pointed out above could be of two or more constructs. Besides the location issue of the mechanism of channels of communications there is the issue of the number of channels. O'Grady (2009) suggests four channels and an interpretation of Achterbergh and Vriens (2002) is that each type of knowledge, because it goes from one subsystem to another, requires a unique means of conveyance. Accordingly, acquiring knowledge of the metasytem function and the channels of communication ought to proceed together, but has not received developmental consideration in the literature.

The work of Achterbergh and Vriens (2002) and Metasytem Governance Reference Model (MGRM) for Complex System (C. Keating, 1/14/2014, National Centers for System of Systems Engineering) has provided a set of functional descriptions for subsystems of the metasytem. The integrated use of these descriptions certainly suggests specific research design implications based on the current state of literature. A knowledge gap in existing formulations of communication suggests a lack of identification of individuals and or machines that perform the specific metasytem subsystem functions. Similarly, the literature is absent on the set of subsystems that need be altered for a specific complex system or that the architecture of the channels of communication may differ from what has been described. Only through additional research, targeted to further development of the Communication construct, will the identified knowledge gap be addressed.

## **LITERATURE CRITIQUE**

The initial reading of literature concentrated on articles associated with the area of interest; VSM, Channels of Communication, Stafford Beer and Management Cybernetics to provide a partial understanding of the topics and the potential linkage to the research questions. Figure 4 below is a graphical representation of the streams of the topics from the literature that lead to the formulation of the problem.



**Figure 4: Streams of the Topics from the literature**

The results, as mentioned above, finds that the architecture of information flows and communications within the metasystem, with the external environment, and between the metasystem and the one or more governed systems are only mentioned in passing as part of an introduction to VSM. Likewise, the conclusions, recommendations, or areas of future research did not include channels of communication either as a contributing factor to the results or an area of more research for anticipated contribution.

The literature search to date has not answered the question on what are the mechanisms associated with Channels of Communications or the methods that can be used to identify, analyze and model these channels. While there is a Theory of Communications (Shannon, 1948), it does not provide an explanation on how a communication channel provides for consistency in decisions, actions, and interpretations made by the metasystem nor how requisite variety is accommodated.

Based upon this lack of inclusion, which is significantly contradictory to descriptions provided by Beer (1974) for his Chilean work, leads the researcher to conclude that the major themes to be included in the literature review include System Theory, Communication Theory, Cybernetic Theory, and the developing area of Complex System Governance.

## LITERATURE REVIEW SUMMARY

This chapter provided the results of the literature review supporting this research. The literature review was accomplished in keeping with the Grounded Theory research method to provide an essential grounding that establishes the relationship of the current research to the prevailing knowledge, and gaps, for which the research will contribute to closing one or more of those knowledge gaps. The results of the review were placed within a historical chronology that started with definitions of systems, system thinking, Viable System Model (VSM) and Complex System Governance (CSG). Additionally, the evolution of the included concepts: reductionism, holism, simple systems, complex systems, cybernetics and variety, was presented.

Stafford Beer's VSM as a foundational part of Complex System Governance (CSG) was presented including the identity of the various communication channels, components of communication channels and several applications of the VSM that have been used by practitioners. Shannon's Communication Model does not appear to have been directly incorporated by Beer in the VSM communication channels. Three possible alignments of these components were presented in Table 5 above.

The literature review found that left unanswered are the questions: (1) what are the mechanisms associated with Channels of Communications?, and (2) the methods that can be used to identify, analyze and model these channels? This gap concerning Communication constructs or the channels of communication as described by Beer indicated that the proposed research questions unanswered in the current state of the body of knowledge. The follow-on Chapter will discuss the use of Grounded Theory to develop a Communication construct.



### III. RESEARCH METHODOLOGY

#### INTRODUCTION

The purpose of this chapter is to present the paradigm which informed this research. Inductive research was chosen to develop a theory or construct specific to channels of communication as described by Stanford Beer (1974, 1979; 1981; 1985). The chapter will present the rationale on selection of the philosophical underpinnings associated with conducting this research. Lastly, as mentioned earlier, use of Grounded Theory in systems engineering has been limited. As there are associated concerns with Grounded Theory, the mitigation of these concerns will be discussed.

#### THE RESEARCH PERSPECTIVE

There is considerable literature dealing with what is knowledge and the ongoing philosophical debates. As defined, knowledge is “the body of truths or facts accumulated in the course of time” (knowledge, retrieved from Retrieved March 07, 2016 from Dictionary.com website <http://dictionary.reference.com/browse/knowledge>).

Creswell along with many others offer that “... research approaches have multiplied to a point at which investigators or inquirers have many choices” (Creswell, 2013, p. 3) and proposes that a “general framework be adopted to provide guidance about all facets of the study, from assessing the general philosophical ideas behind the inquiry to the detailed data collection and analysis procedures” (Creswell, 2013, p. 3). The work of Guba and Lincoln (1994) stresses that the “Questions of method are secondary questions of paradigm which we define as the basic belief system or worldview that guides the investigator, not only in choices of method but in ontologically and epistemological fundamental ways” (Guba & Lincoln, 1994, p. 105). In this sense, a paradigm,

... represents a worldview that defines, for its holder, the nature of the “world,” the individual’s place in it, and the range of possible relationships to that world and its parts, as for example, cosmologies and theologies do. The beliefs are basic in the sense that they must be accepted simply on faith (however well argued); there is no way to establish their ultimate truthfulness (Guba & Lincoln, 1994, p. 107).

Creswell building upon the work of Crotty (1998) proposes for consideration “... three framework elements: philosophical assumptions about what constitutes *knowledge claims*; general procedures of research called *strategies of inquiry* and detailed procedures of data collection, analysis, and writing called *methods*” (Creswell, 2013, p. 3, highlight and italics in the original). The review of the knowledge claims write ups and strategies of inquiry provided by Creswell (2013) as well as Guba and Lincoln (1994) led the author to a research paradigm of Constructivism.

As the “researcher's intent, then, is to make sense of (or interpret) the meanings others have about the world. Rather than starting with a theory (as in postpositivism), inquirers generate or inductively develop a theory or pattern of meaning” (Creswell, 2013, p. 9). Accordingly, the strategy of inquiry best suited to the subject of Communication as part of the construct of Complex System Governance would be a Qualitative Study. Creswell (2013) lists several strategies (Ethnographies, Grounded Theory, Case studies, Phenomenological research, and Narrative research) along with their characteristics (Creswell 2013, pp. 14 – 15) to conduct a qualitative study. Richards and Morse (2012) similarly list strategies (Ethnography, Grounded Theory, Phenomenology, Discourse Analysis and Case Study Method) and provided for each an exploration of the strategies (Richards & Morse, 2012, pp. 54 – 79). Knowing that “there is a relationship between the research question, method and desired results” (Richards & Morse, 2012, p. 23) the choice of strategy directly affects the success of the research. Hence, Grounded Theory with “... the constant comparison of data with emerging categories and theoretical sampling of different groups to maximize the similarities and the differences of information” (Creswell 2013, p. 14) appears to be the research strategy most appropriate for this research.

Inductive Research was identified as the basis for the development of the research design to guide the investigation for the research. This selection was the result of reviewing philosophical, selected strategies of inquiry and research methods as recommended by Creswell where he states,

researchers need to think through the philosophical worldview assumptions that they bring to the study, the strategy of inquiry that is related to this worldview, and the specific methods or procedures of research that translate the approach to practice (Creswell, 2009, p. 5).

Establishing the philosophical worldview of the researcher can be facilitated by answering a series of questions to establish a research paradigm. As compiled by Dash (2005), a sample set of questions could be;

- What is the nature or essence of the social phenomena being investigated?
- Is social phenomenon objective in nature or created by the human mind?
- What are the bases of knowledge corresponding to the social reality, and how knowledge can be acquired and disseminated?
- What is the relationship of an individual with her environment? Is she conditioned by the environment or is the environment created by her?

The philosophical world view contains three assumptions of epistemological, ontological, and axiological as follows:

epistemology describes ‘how’ researcher knows about the reality and assumptions about how knowledge should be acquired and accepted. The ontology explains ‘what’ knowledge is and assumptions about reality. Axiology reveals the assumptions about the value system (Pathirage *et al.*, 2008, p. 5).

Crotty (1989) points out that there are a wide range of epistemologies but concentrates on the following:

- Objectivist - “holds that meaning, and therefore meaningful reality, exists as such apart from the operation of any consciousness” (Crotty, 1998, p. 8).
- Constructionism - “There is not objective truth waiting for us to discover it. Truth, or meaning comes into existence in and out of our engagement with the realities in our world” (Crotty, 1998, p. 8).
- Subjectivism - “meaning does not come out of an interplay between subject and object but is imposed on the object by the subject. Here the object as such makes no contribution to the generation of meaning” (Crotty, 1998, p. 9).

A researcher with a positivist orientation “encapsulates the spirit of the Enlightenment, the self-proclaimed Age of Reason ... and offers assurance of unambiguous and accurate knowledge of the world” (Crotty, 1998, p. 18). Positivist researchers do not place themselves as a variable in the context of the research and have the view that they must remain detached from the research evolution. The philosophical basis is that the world exists and is knowable and researchers can use quantitative methodology to discover it (Cohen, Manion & Morrison, 2000). Through this orientation, knowledge is a given and must be studied using objective means.

Typically, research findings are represented in numbers (quantitative) which speak for themselves or may be qualitative method which would use descriptive words (Cohen, Manion & Morrison, 2000). Crotty injects that “It is possible for quantitative piece of work to be offered in non-positivist form. On the other hand, there is plenty of scope for qualitative research to be understood positivistically or situated in an overall positivist setting” (Crotty, 1998, p. 41). Accordingly, “what turns their study into a positivist piece of work is not the use of quantitative methods but the attribution of objectivity, validity and generalizability to quantitative findings” (Crotty, 1998, p.41).

The positivist research paradigm usually underpins quantitative methodology and requires a research methodology that is objective or detached, where the emphasis is on measuring variables and testing hypotheses that are linked to general causal explanations (Marczyk, DeMatteo & Festinger, 2005). The research method measures effects and the data collection techniques focus on gathering hard data in the form of numbers to enable evidence to be presented in quantitative form (Neuman, 2003).

The interpretivist sees the world as constructed, interpreted, and experienced by people in their interactions with each other and with wider social systems (Bogdan & Biklen, 1992; Lincoln & Guba, 1985). Through this paradigm the nature of inquiry is interpretive where the purpose of the inquiry is to understand a phenomenon. Researchers within the interpretivist paradigm are naturalistic since they apply to real-world situations as they unfold naturally, more specifically; they tend to be non-manipulative, unobtrusive, and non-controlling. According to Creswell, the ethnography method relies on personal contact between the researcher and the group under study over some period. This builds a deeper insight into the context under research hopefully leading to richness and depth in the data collected. Thus, qualitative methodologies are inductive, that is, oriented toward discovery and process, have high validity, are less concerned with generalizability, and are more concerned with deeper understanding of the research problem in its unique context (Creswell, 2009).

Creswell calls the philosophic the worldview “as meaning a basic set of beliefs that guide action (Guba, E. (1990)), *The paradigm dialog*. In J. Creswell, *Research design, qualitative, quantitative, and mixed methods approaches*, (edition 3, p. 6), Los Angeles: SAGE. (Original work published 2009). Below, the contents of Table 6 was taken from Creswell (2009) where he has ordered what he considers the major elements.

**Table 6: Worldviews**

<b>Postpositivism</b>	<b>Constructivism</b>
<ul style="list-style-type: none"> <li>• Determination</li> <li>• Reduction</li> <li>• Empirical observation and measurement</li> <li>• Theory validation</li> </ul>	<ul style="list-style-type: none"> <li>• Understanding</li> <li>• Multiple participant meanings</li> <li>• Social and historical construction</li> <li>• Theory generation</li> </ul>
<b>Advocacy/Participatory</b>	<b>Pragmatism</b>
<ul style="list-style-type: none"> <li>• Political</li> <li>• Empowered Issue-oriented</li> <li>• Collaborative</li> <li>• Change-oriented</li> </ul>	<ul style="list-style-type: none"> <li>• Consequences of actions</li> <li>• Problem-centered</li> <li>• Pluralistic</li> <li>• Real-world practice</li> </ul>
Based on Creswell, (2013), p. 6.	

Ontology according to Crotty “is the study of being. It is concerned with ‘what is’, with the nature of existence, with the structure of reality as such” (Crotty, 1998, p.10). He further discusses,

Were we to introduce it into our framework, it would sit alongside epistemology informing the theoretical perspective, for each theoretical perspective embodies a certain understanding *what is* (ontology) as well as a certain way of understanding *what it means to know* (epistemology) (Crotty, 1998, p. 10).

Pathirage writes that,

Based on whether the external world is having a pre-determined nature and structure or not, two ontological assumptions known as realist (Johnson & Duberly, 2000) and idealist (Gummesson, 1991) are defined. Realists start with a stance of a commonly experienced external reality with predetermined nature and structure (Sexton, 2004) whereas, idealists assumes that different observers may have different viewpoints and that, “what counts for the truth can vary from place to place and from time to time” (Collins, 1983) (Johnson & Duberly (2000), Gummesson (1991), Sexton (2004), Collins (1983). In Pathirage, C. P., Amaratunga, R. D. G., & Haigh, R. P. (2008). The role of philosophical context in the development of research methodology and theory (*The Built and Human Environment Review*, 1(1), p. 7).

Researchers using qualitative methodology immerse themselves in a culture or group by observing its people and their interactions, often participating in activities, interviewing key people, taking life histories, constructing case studies, and analyzing existing documents or other cultural artifacts (Crotty, 1998). The word qualitative implies an emphasis on the qualities of

entities and on processes and meanings that are not experimentally examined or measured (if measured at all) in terms of quantity, amount, intensity, or frequency. Qualitative researchers stress the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and the situational constraints that shape inquiry. Such researchers emphasize the value-laden nature of inquiry. They seek answers to questions that stress how social experience is created and given meaning. In contrast, quantitative studies emphasize the measurement and analysis of causal relationships between variables, not processes. Qualitative forms of inquiry are considered by many social and behavioral scientists to be as much a perspective on how to approach investigating a research problem as it is a method Creswell (2013).

Identification and classification of the different forms of Inductive Research available to scholarly researchers is captured in Table 7 below.

**Table 7: Forms Available**

<b>Research Strategy</b>	<b>Classification</b>
Ethnography	Qualitative
Grounded Theory	Qualitative
Case Study	Qualitative
Phenomenological Research	Qualitative
Narrative	Qualitative
Discourse Analysis	Qualitative
Drawn from: Creswell, 2013, p. 13. Richards & Morse, 2012, pp. 30-33.	

The research strategies shown in Table 7 above, though classified as Qualitative, are not all directly appropriate to meet the researcher's interest in building a theoretical construct. Review of work by Creswell (2013), limited literature review of System Theory and Communication Theory literature and review of recent CSG research lead the researcher to conclude that the Grounded Theory method would support the development of a Communications construct of Complex System Governance. As will be articulated below, while the use of Grounded Theory has been fully accepted in some areas of scientific research there are issues related to its use. These issues, and research strategies to address them, will be developed in the following section.

## QUALITY EVALUATION OF RESEARCH

Associated with research in general are criteria that would support categorizing quality that need be associated with the results of research. The criterion of Significance or Truth, Applicability, Consistency, and Neutrality have been added to in the below Table 8 below associates with the qualitative and quantitative approach strategies and each criterion a set of strategies to establish trustworthiness.

**Table 8: Criterion to Categorize Quality**

Criterion	Qualitative Approach	Qualitative Approach Strategies with Which to Establish Trustworthiness	Quantitative Approach	Quantitative Approach Strategies with Which to Establish Trustworthiness
Truth Value: How credible are the findings? By what criteria are they judged?	Credibility	<ul style="list-style-type: none"> <li>• Prolonged and varied field experience</li> <li>• Time sampling</li> <li>• Reflexivity (field journal)</li> <li>• Triangulation</li> <li>• Member checking</li> <li>• Peer examination</li> <li>• Interview technique</li> <li>• Establishing authority of research</li> <li>• Structural coherence</li> <li>• Referential adequacy</li> </ul>	Internal Validity	<ul style="list-style-type: none"> <li>• Control</li> <li>• Randomization</li> <li>• Instrument</li> <li>• Deductive (Theory Testing)</li> </ul>
Applicability: How transferable and applicable are the findings to other settings or contexts?	Transferability	<ul style="list-style-type: none"> <li>• Nominated sample</li> <li>• Comparison of sample to demographic data</li> <li>• Time sample</li> <li>• Dense description</li> </ul>	External Validity	<ul style="list-style-type: none"> <li>• Randomized Sampling</li> <li>• Statistical Inference</li> </ul>
Consistency: What assurance do we have that the findings could be replicated?	Dependability	<ul style="list-style-type: none"> <li>• Dependability Audit</li> <li>• Dense description of research methods</li> <li>• Stepwise replication</li> <li>• Triangulation</li> <li>• Peer examination</li> <li>• Code-recode procedure</li> </ul>	Reliability	<ul style="list-style-type: none"> <li>• Replication (repeatability)</li> <li>• Control</li> </ul>

<b>Criterion</b>	<b>Qualitative Approach</b>	<b>Qualitative Approach Strategies with Which to Establish Trustworthiness</b>	<b>Quantitative Approach</b>	<b>Quantitative Approach Strategies with Which to Establish Trustworthiness</b>
Neutrality How can we be sure that findings result from inquiry and not from the researcher or design prejudice & bias)?	Confirmability	<ul style="list-style-type: none"> <li>• Confirmability audit</li> <li>• Triangulation</li> <li>• Reflexivity</li> </ul>	Objectivity	<ul style="list-style-type: none"> <li>• Researcher separation</li> <li>• Control</li> </ul>
Drawn from: Freshwater, Cahill, Walsh & Murphy (2010), Houghton, Casey & Shaw (2013), Krefting (1991), Ryan-Nicholls & Will (2009) and Tuli (2011)				

Subsequent writings about quality in qualitative and interpretive research by Lincoln voice cautions with respect to the criteria. Firstly, “specific criteria might apply to specific kinds or classes of research” (Lincoln, 1995, p. 286). Additionally, “To put it another way, any given criterion might have been extracted from a specific set of studies in which the proposer was engaged, and thus another inquirer might find limited utility or applicability for the specific criterion” (Lincoln, 1995, p. 286). Secondly, “some of the criteria may be applicable at a certain stage of the inquiry but less applicable at another” (Lincoln, 1995, p. 286). Finally, “all, or virtually all, of these criteria are relational. Reason and Rowan (1991b) emphasized this idea when they pointed out that ‘any notion of validity must concern itself both with the knower and with what is to be known’” (Lincoln, 1995, p. 286).

The use of Inductive Research design is dependent upon the research question and the basic philosophical assumptions that the researcher has formed. Describing the specific types of research issues/questions and scholarly disciplines for which Inductive Research designs offer an appropriate approach or an inappropriate approach would be a huge endeavor. That is why developing an understanding of the breadth of philosophical underpinnings of research is important. Secondly, the development of the research question as well as acquiring an appreciation of the various strategies of inquiry and data collection will determine if an Inductive or Deductive Research design is appropriate.



As discussed by Creswell (2013) and found in the University of Southern California, Organizing Your Social Sciences Research Paper: Qualitative Methods (2016) a condensed listing of noted strengths associated with Qualitative Methods when applied to the study of social research:

Obtain a more realistic view of the lived world that cannot be understood or experienced in numerical data and statistical analysis;

Provide the researcher with the perspective of the participants of the study through immersion in a culture or situation and as a result of direct interaction with them;

Allow the researcher to describe existing phenomena and current situations;

Develop flexible ways to perform data collection, subsequent analysis, and interpretation of collected information;

Yield results that can be helpful in pioneering new ways of understanding;

Respond to changes that occur while conducting the study e.g., extended fieldwork or observation] and offer the flexibility to shift the focus of the research as a result;

Provide a holistic view of the phenomena under investigation;

Respond to local situations, conditions, and needs of participants;

Interact with the research subjects in their own language and on their own terms; and,

Create a descriptive capability based on primary and unstructured data.

Strengths of Using Qualitative Methods (2016). In University of Southern California, Research Guides, Organizing Your Social Research Paper, Qualitative Methods. Retrieved from <http://libguides.usc.edu/writingguide/qualitative>, (paragraph 4).

Additionally, both Creswell (2013) and as found in the University of Southern California Organizing Your Social Sciences Research Paper: Qualitative Methods (2016) there were noted limitations and criticisms with respect to the use of Qualitative Methods, specifically:

Drifting away from the original objectives of the study in response to the changing nature of the context under which the research is conducted;

Arriving at different conclusions based on the same information depending on the personal characteristics of the researcher;

Replication of a study is very difficult;

Research using human subjects increases the chance of ethical dilemmas that undermine the overall validity of the study;

An inability to investigate causality between different research phenomena;

Difficulty in explaining differences in the quality and quantity of information obtained from different respondents and arriving at different, non-consistent conclusions;

Data gathering and analysis is often time consuming and/or expensive;

Requires a high level of experience from the researcher to obtain the targeted information from the respondent;

May lack consistency and reliability because the researcher can employ different probing techniques and the respondent can choose to tell some particular stories and ignore others; and,

Generation of a significant amount of data that cannot be randomized into manageable parts for analysis.

Strengths of Using Qualitative Methods (2016). In University of Southern California, Research Guides, Organizing Your Social Research Paper, Qualitative Methods. Retrieved from <http://libguides.usc.edu/writingguide/qualitative>, (paragraph 5).

In the book *Constructing Grounding Theory*, Kathy Charmaz states,

I have argued throughout the book that grounded theory methods contain untapped versatility and potential. We need to consider our audience, be they teachers or colleagues. They will judge the usefulness of our methods by the quality of our final product. (Charmaz, 2006, p. 182).

Charmaz continues, to provide under the criteria categories of; Credibility, Originality, Resonance, and Usefulness (Charmaz, 2006, pp. 182-183) questions for the researcher to consider with respect to the use of Grounded Theory.

The evaluation of quality can be based upon a set of criteria as discussed above. Quality though is not an attribute that is added at the end of research, rather its tenants of trustworthiness through transparency and practices are applied throughout the research effort and as such are one of the critical elements of the research design.

## **INDUCTIVE RESEARCH, CITICISM AND MITIGATION**

Scholarly criticisms of Inductive Research approaches have continued for some time. Some major criticisms regarding qualitative methods are that,

they diverge from scientific explanation models in terms of the need for hypothesis testing ... qualitative researchers continue to be questioned about the relationship between observational and theoretical statements, the role of theory in qualitative research ... and what function does empirical data play in the theorizing process (Bendassolli, 2013, p. 1).

The counter to this criticism is,

qualitative researchers contend that their work as being inductive does not consist of proposing and testing hypotheses. Their primary interest is to achieve understanding (*Verstehen*) of a particular situation, or individuals, or groups of individual, or (sub) cultures, etc. (Bendassolli, 2013, p. 1).

The core of the issue is validity, and justification for it, where, “induction negotiates the relationship between empirical reality and its theorization, in addition to the production and validation of knowledge” (Bendassolli, 2013, p. 1). Daymon and Holloway (2010) in their book *Qualitative research methods in public relations and marketing communications* added to work of Bryman, A., Becker, S., & Sempik, J. (2008) by articulating with respect to common criticism of inductive research, a set of implications and considerations that a researcher may use to mitigate criticisms list in Table 9 below.

**Table 9: Common Criticism**

Common Criticism	Description	Implications/Considerations
<i>Too subjective</i>	Those holding to a quantitative research orientation sometimes accuse qualitative studies of being too impressionistic and subjective.	Subjectivity should be viewed as a resource for the qualitative researcher. Subjectivity is also about critical self-awareness when seen through the perspective of individuals that participate in studies. By making the work be participatory the informed audience will not claim subjectivity.
<i>Difficult to replicate</i>	Because qualitative investigators are the main research instrument, it is practically impossible to replicate a study	But qualitative researchers are not associated with an interest in replication; their interest lies in specific settings, and they do not always wish for generalizability. Their commitment is much more to the integrity of their findings.
<i>Problems of generalization</i>	Qualitative research studies are not supposed to be representative of a larger population, yet a common challenge is that they are too restricted in their conclusions.	By providing rich descriptions of what goes on in a particular context, they help to illuminate important issues in a specific case or regarding a particular group of people.
<i>Lack of transparency</i>	Qualitative researchers have been remiss in failing to articulate clearly the procedures they followed to select samples, collect the data and analyse them; in other words, the audit trail has to be described so that readers can follow it.	How data were analysed and interpreted and how a study's conclusions were arrived at are details that are missing from the majority of published texts in managed communication.
(Daymon and Holloway, 2010, p. 10-11)		

There are strategies that might be employed to mitigate potential threats, or amplify utility of research approaches to enhance their scholarly ‘defensibility’. Table 10 below contains the strategies applicable to qualitative research provided by Guba & Lincoln (1989) elaborating

on six techniques to ensure credibility: (a) prolonged engagement, (b) persistent observation, (c) peer debriefing, (d) negative case analysis, (e) progressive subjectivity, and (f) member checks.

**Table 10: Techniques of Mitigation**

Technique	Description
<i>Prolonged Engagement.</i>	Substantial involvement at the site of the inquiry, in order to overcome the effects of misinformation, distortion, or presented “fronts” to establish the rapport and build the trust necessary to uncover constructions, and to facilitate immersing oneself in and understanding the context’s culture (Lincoln & Guba, 1986a, pp 303-304).
<i>Persistent Observation.</i>	Sufficient observation to enable the evaluation to “identify those characteristics and elements in the situation that are most relevant to the problem or issue being pursued and [to focus] on them in detail” (Lincoln & Guba, 1986a, p. 304). The object of persistent observation is to add depth to the scope which prolonged engagement affords.
<i>Peer Debriefing.</i>	The process of engaging, with a disinterested peer, in extended and extensive discussions of one’s findings, conclusions, tentative analyses, and occasionally, field stresses, the purpose of which is both “testing out” the findings with someone who has no contractual interest in the situation and also helping to make propositional that tacit and implicit information that the evaluator might possess. The disinterested peer poses searching questions in order to help the evaluator understand his or her own posture and values and their role in the inquiry; to facilitate testing working hypotheses outside the context; to provide an opportunity to search out and try next methodological steps in an emergent design; ad as a means of reducing the psychological stress that normally comes from fieldwork – a means of catharsis within a confidential, professional relationship.
<i>Negative Case Analysis.</i>	The process of revising working hypotheses in the light of hindsight, with an eye toward developing and refining a given hypothesis (or set of them) until it accounts for all known cases. Negative case analysis may be thought of as parallel or analogous to statistical tests for quantitative data (Kidder, 1981) and should be treated in the same way. That is, just as no one achieves statistical significance at the .000 level, so probably the qualitative data analyst ought not to expect that <i>all</i> cases would fit into appropriate categories. But when some reasonable number do, then negative case analysis provides confidence that the evaluator has tried and rejected all rival hypotheses save the appropriate one.

Technique	Description
<i>Progressive Subjectivity.</i>	The process of monitoring the evaluator's (or any inquirer's) own developing construction. It is obvious that no inquirer engages in an inquiry with a blank mind, a <i>tabula rasa</i> . It is precisely because the inquirer's mind is not blank that we find him or her engaged in the particular investigation. But it is equally obvious that any construction that emerges from an inquiry must, to be true to constructivist principles, be a <i>joint</i> one. The inquirer's construction cannot be given privilege over that of anyone else (except insofar as he or she may be able to introduce a wider range of information and a higher level of sophistication than may any other single respondent). The technique of progressive subjectivism is designed to provide a check on the degree of privilege. And it is simple to execute. Prior to engaging in <i>any</i> activity at the site or in the context in which the investigation is to proceed, the inquirer records his or her <i>priori</i> construction – what he or she expects to find once the study is underway – and archives that record. A most useful archivist is the debriefer, whom we have already discussed. At regular intervals throughout the study the inquirer <i>again</i> records his or her developing construction. If the inquirer affords too much privilege to the original construction (or to earlier constructions as time progresses), it is safe to assume that he or she is not paying as much attention to the construction offered by the other participants as they deserve. The debriefer is in a sensitive position to note such a tendency and to challenge the inquirer about it. If the inquirer “finds” only what he or she expected to find, initially, or seems to become “stuck” or “frozen” on some intermediate construction, credibility suffers.
<i>Member Checks.</i>	The process of testing hypotheses, data, preliminary categories, and interpretations with members or the stakeholding groups from whom the original constructions were collected. This is the single most crucial technique for establishing credibility. If the evaluator wants to establish that the multiple realities he or she presents are those that the stakeholders have provided, the most certain test is verifying those multiple constructions with those who provided them. This process occurs continuously, both during the data collection and analysis stage, and, again, when (and if) a narrative case study is prepared. Member checks can be formal and informal, and individuals (for instance, after interviews, in order to verify that what was written down is what was intended to be communicated) or with groups (for instance, as portions of the case study are written, members of the stakeholding groups are asked to react to what has been presented as representing their construction).
(Guba & Lincoln, 1989, pp. 236-239).	

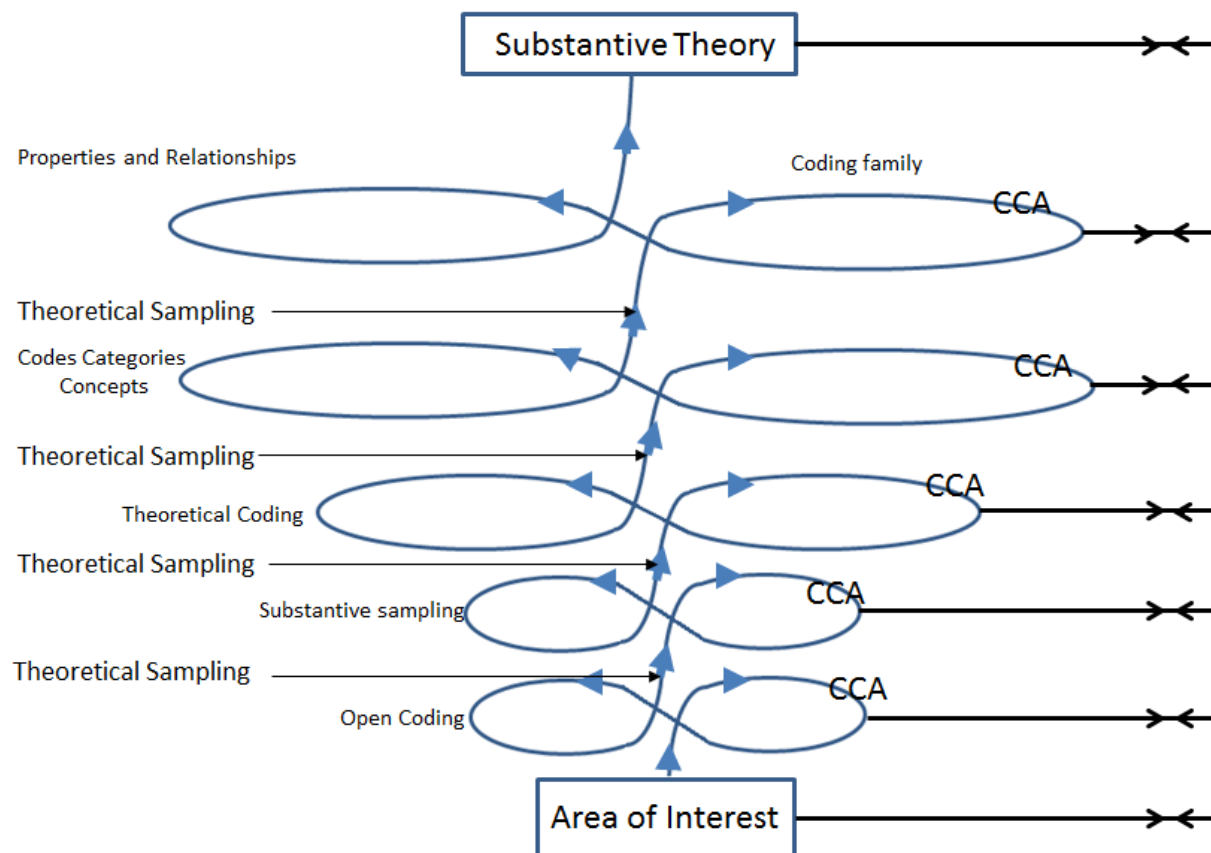
Inductive Research approaches will be subject to criticisms for a variety of reasons, with the principal issues being validity and justification. The discussion above presents the criticisms of Inductive Research as well as effective research strategies in response to those criticisms. In some cases, researchers being open with methods of research and transparent with respect to execution of the research design offer response with respect to the specific criticisms. For other types of issues there are specific strategies that can be employed to mitigate potential threats, or amplify utility of research approaches to enhance their scholarly ‘defensibility’.

## **GROUNDING THEORY, CRITICISM AND MITIGATION**

The research question with respect to communications is not a validation of a set of hypotheses of an established theory rather the research question is attempting to build a theory. Grounded Theory as informed by Creswell, Guba, Lincoln and many others is considered an appropriate research strategy. As described by Locke (2001), Charmaz (2006), Bryant & Charmaz (2007) this method has been widely used when researchers are interested in building a theoretical construct.

Grounded Theory was first developed in the 1960's by two sociologists Barney Glaser and Anselm Strauss Locke (2001), Charmaz (2006), Bryant & Charmaz (2007). Grounded Theory, Charmaz claims, is where the researcher “study our early data and begin to separate, sort, and synthesize these data through qualitative coding” (Charmaz, 2006, p.3). The researcher then allows the data to drive the research until a theory (construct) emerges (Glaser (1992); Strauss & Corbin (1990)). With respect to applicability to other than strictly social studies, Strauss and Corbin stated 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” (Strauss & Corbin, 1990, p. 26).

The process of generating a grounded theory is summarized in Figure 5 below where the starting point is the area of interest or concern. On the left-hand side are indicated, in a sequential presentation, the several actions/phases/steps/events/works that the researcher accomplishes in pursuing the development of substantive theory. Depicted on the right-hand side of Figure 5 is Constant Comparative Analysis (CCA). As described by Strauss & Corbin (1990), Glaser (1992), and Charmaz (2006) Constant Comparative Analysis is associated with the operations on each level of operations and comparing data that evolves to what was found previously as well as comparing data across different paths that the investigator has taken. The CCA allows for identification of variables as well as affords the opportunity to clarify or expand upon the data that has emerged. This listing and presentation is not shown to suggest that the development of theory is proscriptive but only to identify the actions that the researcher accomplishes to take data and increase the level of abstraction. This continues through the use of additional data to develop more abstractions such that the range and scope are increased for the developed theory.



**Figure 5: Grounded Theory Abstraction**  
(adopted from Andersen *et al.*, 2012)

The researcher will approach the area of interest or concern with some knowledge or hunches that “can come from sources other than data” (Glaser & Strauss, 1967, p. 6). For this research, the area of interest is Communications and for this substantive area ‘slices of data’ (Glaser & Strauss, 1967) will be used. As the first element of a grounded theory, these conceptual categories are first described by their properties.

The sources of data will come from literature. It is anticipated that the literature used will be that associated with System Theory, Communication Theory, Decision Theory, Cybernetic Theory and the developing area of Complex System Governance. The criteria for choice of literature as a data source is listed in Table 11 below.

**Table 11: Criteria for Inclusion of Literature Data**

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

The sources of data need be reduced to data that is relative to the Communication construct. The Research Schema of Inclusion is reflected in Table 12 below, where the source of data (Area of Interest) is the initial criteria to reduce the sources of data to be used in the grounded theory method. Unique to the area of System Theory will be an initial reduction of literature to that used by Katina (2015) in his development of Metasystem Pathologies thus providing the first source of data. The use of the Primary Sort/Search Terms will be applied to the other Areas of Interest providing another set of sources of data to be combined with the first. It is to this combined source of data that the Secondary Sort/Search Terms will be applied.

**Table 12: Research Schema of Inclusion**

<b>Area of Interest</b>	<b>Primary Sort/Search Terms</b>	<b>Secondary Sort/Search Terms</b>
Systems Theory		INFORMATION SOURCE
Communication Theory	Beer	TRANSMITTER
Management Theory	Shannon	CHANNEL OF COMMUNICATION
Knowledge Management	Communication	RECEIVER
Organizational Theory	Complex System Governance	DESTINATION
Organizational Design	Viable Systems Model	TRANSMITTER
		VARIETY ATTENUATOR
		VARIETY AMPLIFIER
		TRANSDUCER
		FEEDBACK



Coding is at the heart of Grounded Theory. “Grounded theory coding consists of at least two main phases: 1) an initial phase involving naming each word, line or segment of data followed by 2) a focused, selective phase that uses the most significant initial codes to sort, synthesize, integrate and organize large amounts of data.” (Charmaz, 2006, p. 46).

Criteria of codes initially will follow the advice of Charmaz, where “qualitative codes take segments of data apart, name them in concise terms, and propose an analytic handle to develop abstract ideas for interpreting each segment of data. As we code, we ask: which theoretical categories might the segments indicate” (Charmaz, 2006, p. 45). It is recognized that *in vivo codes* may also be used. Recognizing that the subject of communications can be classed as having both technical and social aspects, the use of *in vivo codes* that “preserve participants’ meaning of their views and actions” (Charmaz, 2006, p. 55) may be used in initial coding.

Focused coding, as the second major phase is where codes are more directed, they become more selective and they are to become more conceptual than qualitative codes. This pushes more towards an analytic direction reflecting synthezation (Glaser, 1978). Either as part of initial coding or as part of focused coding, there may well need be the accomplishment of theoretical sampling. This is where the data drives the researcher into acquiring more data in an area not initially planned. This is a good effect, as it will increase the scope of applicability of the theory.

Reflected in Figure 5 above on the right-hand side is constant comparative analysis that Charmaz describes as core to the grounded theory method (Charmaz, 2006). Constant comparison is the comparing coded data to prior coded data of the same code to “find similarities and differences” (Charmaz, 2006, p. 54). This review, called combing in data base management, of the whole body of coded data importantly enables outliers or questionable data to be identified. Likewise, as a rigorous element in looking at data more than during the initial coding helps drive towards abstraction. The coding continues until saturation, no new conception categories or relations emerge (Glaser, 1978, Charmaz, 2006).

While Grounded Theory has “been widely adopted in scientific research in recent decades, this qualitative methodology has been the subject of various interpretations and criticisms from a variety of perspectives” (Age, 2011, p. 1599). Age indicates some of the criticisms include:

- some authors have classified grounded theory methodology as a positivist methodology (Charmaz, 2006).
- others have considered it to be an interpretive methodology (Brown, 1995; Goulding, 1998).
- the methodology occupied a pragmatic position that went beyond other philosophical schools of thought (Glaser, 1998) (Charmaz (2006), Brown (1995), Goulding (1998), Glaser (1998). In Åge, L. J. (2011). Grounded theory methodology: positivism, hermeneutics, and pragmatism (*The Qualitative Report*, 16(6), p. 1599).

Besides the Techniques of Mitigation contained in Table 10 above, techniques that are specific to Grounded Theory to mitigate criticism are the use of theoretical sensitivity and theoretical sampling;

- Theoretical sensitivity is the process by which the researcher guards against potential biases that can threaten the rigor of the study. Theoretical sensitivity is the ‘ability of the researcher to think inductively and move from the particular (data) to the general or abstract (Schreiber, R. & Stern, P. (2001) The “how to” of grounded theory: Avoiding the pitfalls. In Andersen, P., Inoue, K., & Walsh, K. An animated model for facilitating understanding of Grounded Theory and the processes used to generate substantive theory. *Journal of Research in Nursing*, 18(8), p. 736).
- In GT, theoretical sampling is a deductive process undertaken to focus the collection and analysis of data and verify the properties of categories. It is directed by the emerging codes and categories. ‘It is the “where next” in collecting data, the “for what” according to codes, and the “why” from the analysis of memos (Glaser B. (1978) Theoretical Sensitivity: Advances in the Methodology of Grounded Theory (p. 157), Mill Valley, CA: Sociology Press. In Andersen, P., Inoue, K., & Walsh, K. An animated model for facilitating understanding of Grounded Theory and the processes used to generate substantive theory. *Journal of Research in Nursing*, 18(8), p. 737).

Additionally, because of the criticism of Grounded Theory it is appropriate starting with the development of the research design all the way to conclusion establishing a mechanism that will easily capture assumptions, decisions, etc. to present full transparency of all activities.

## **METHODOLOGY SUMMARY**

This Chapter presented the results of the process to determine the philosophical paradigm to be used as the foundation for the conduct of the research. Beginning with issues of what is knowledge and establishing a philosophical worldview of the researcher it was found that a Qualitative research strategy would support the development of a theoretical construct. The use of Grounded Theory as opposed to other qualitative research strategies was felt to be an appropriate fit. Associated with all research are criteria to categorize the quality of the research results. These were discussed and the importance of trustworthiness through transparency and practices that are applied throughout the research effort were established as one of the critical elements of the research design.

Inductive research has been subject to criticism, where the core issue is validity and justification. Common criticisms and the implications and considerations for mitigation of the issues were developed. Grounded Theory as a part of Inductive Research has accumulated its own set of criticisms that were detailed. The researcher presented specifics on how several actions, working in phases, criteria for inclusion of data, research schema of inclusion, specific steps of work (coding) can be incorporated in the research design to overcome and mitigate these historical criticisms. The work discussed in this Chapter laid the foundation for the research design and intentions to accomplish the research using grounded theory and a survey method to provide a face validation.

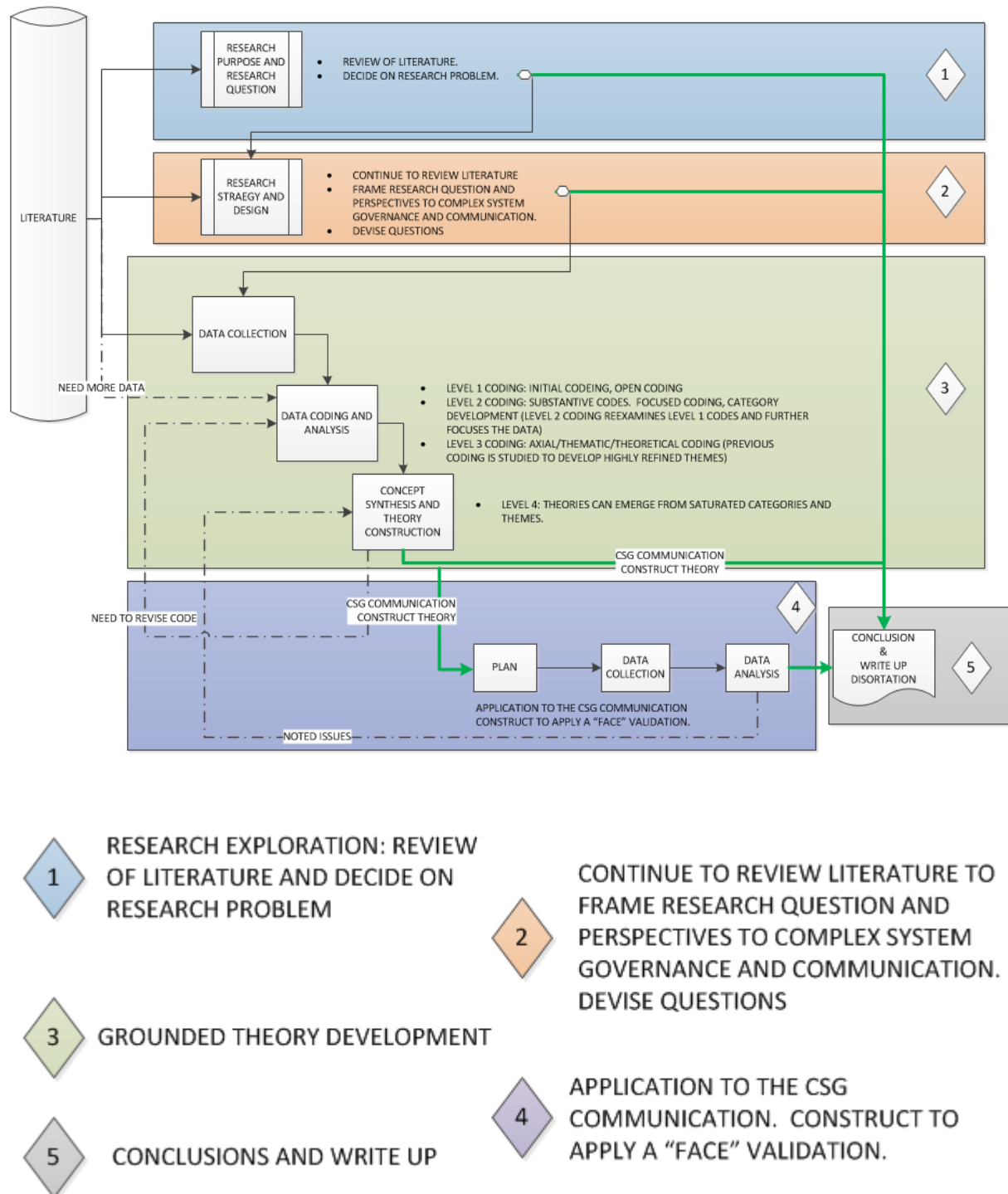
## **IV. RESEARCH DESIGN**

### **INTRODUCTION**

This chapter will discuss the research design, details on how the research was accomplished using grounded theory methods and the details of a face validation of the framework using a survey instrument. The purpose of this research was to develop a Communication construct of Complex System Governance using an inductive research design. Previously described in Chapter I was the result of the literature review with respect to Complex System Governance as well as the proposition of Communication. The developed models for communication and the constituent components described by Shannon (1948) and Beer (1974, 1979; 1981; 1985) were the initiation point of this research. Chapter III described the design of the research methodology and this chapter will discuss the details on how the first research question research was accomplished using grounded theory methods. For the second research question the details on the deployment of the construct is elaborated. Thus, this chapter provides the linkage between the previous chapters and the actual accomplishment of research that will be discussed in Chapter V. The research design is to enable research on a construct that can be developed for the communications functions supporting Complex System Governance and the accomplishment of a deployment based on that construct. The theory development section provides the activities associated with the use of Grounded Theory including a peer review. The deployment section will articulate how the developed theory was used for the identification, analysis and evaluation of the mechanisms of communication.

### **THE RESEARCH DESIGN**

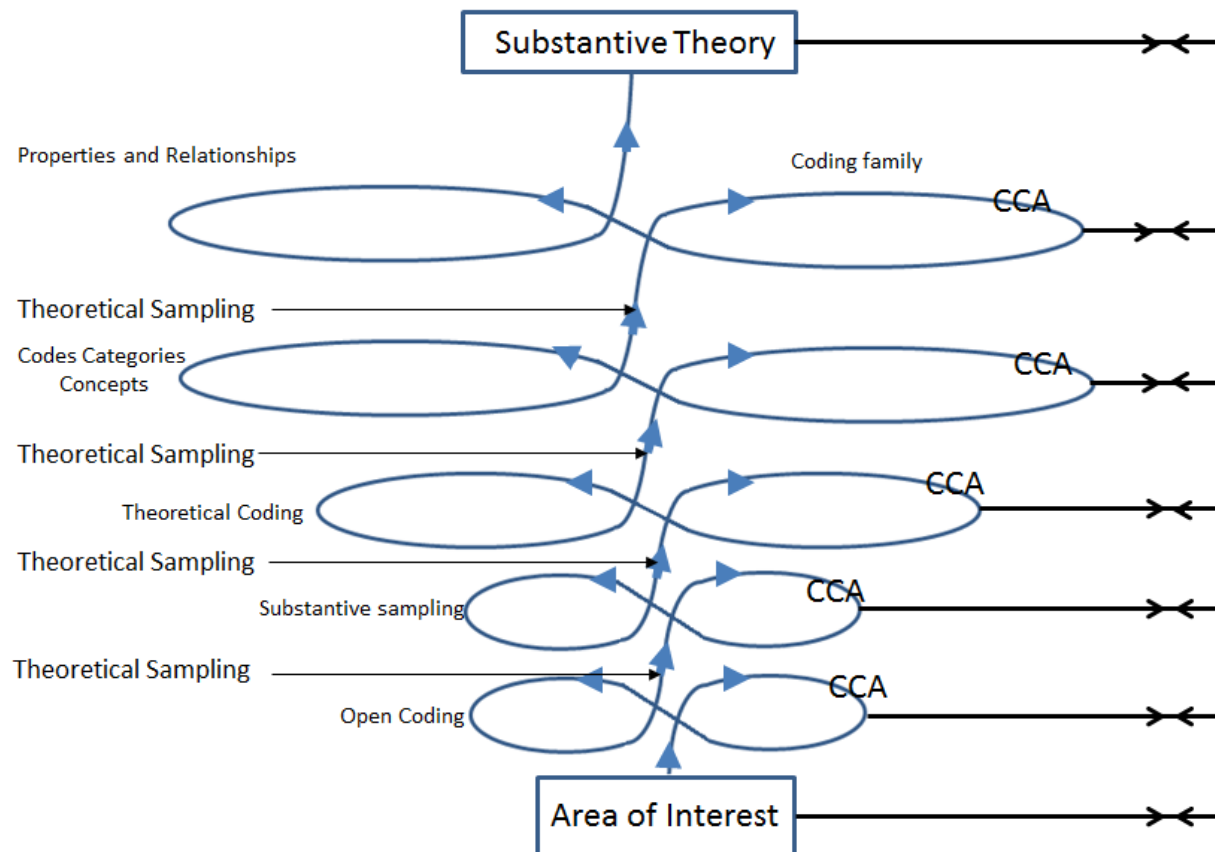
The overall research plan is presented in Figure 6 below where there are five phases starting with Research Exploration, Limited Literature Review, Grounded Theory Development, Application of Face Validation and Conclusions.



**Figure 6: Research Design**

The core of the plan is the use of Grounded Theory which as a cyclical process as shown in Figure 7 below supporting several emergent opportunities that a more restrictive process

would have limited. The Grounded Theory cyclical process that occurs between data collection and data analysis represents the iterative nature of this part of the research and following the constant comparative method concept of grounded theory. As the data was analyzed assigned codes and the subsequent emergence of categories and concepts, the research continually used the data.



**Figure 7: Grounded Theory Abstraction**  
(adopted from Andersen *et al.*, 2012)

The existing body of knowledge on complex systems and specifically with the communication paths or communication channels within a metasystem is limited. The Grounded Theory Method supported pursuing coding source articles in Management Theory, Knowledge Management, Organizational Theory, and Organization Design to locate and provide sources of data. Secondly, the increase in amount of data to process, enabled reevaluation or engagement for clarification on direction or source of communication mechanisms. This second use of data also ensured that the developing theoretical constructs were grounded.

The research plan was influenced by scholarly and professional literature specifically related to Communication Systems and the Viable System Model. Class work and subsequent literature review formed the initial interest in the works of Shannon and Beer which were very important in the development of an emerging understanding of what a communication channels accomplishes. An interest in communication channels lead to the development of the research questions that are addressed in this research. Various authors writing on the use of Grounding Theory have cautioned the researcher when using Grounded Theory of potential undue influence that existing literature may bring to the early portions of the research effort. As discussed in Chapter III, the literature review that the researcher engaged in importantly provided familiarity with system literature as a necessary step to adequately frame the research. Additionally, as will be demonstrated in the discussions on the conduct of the research there was no captivating influence by the literature review. Finally, a peer review was conducted of the Grounded Theory methodology design.

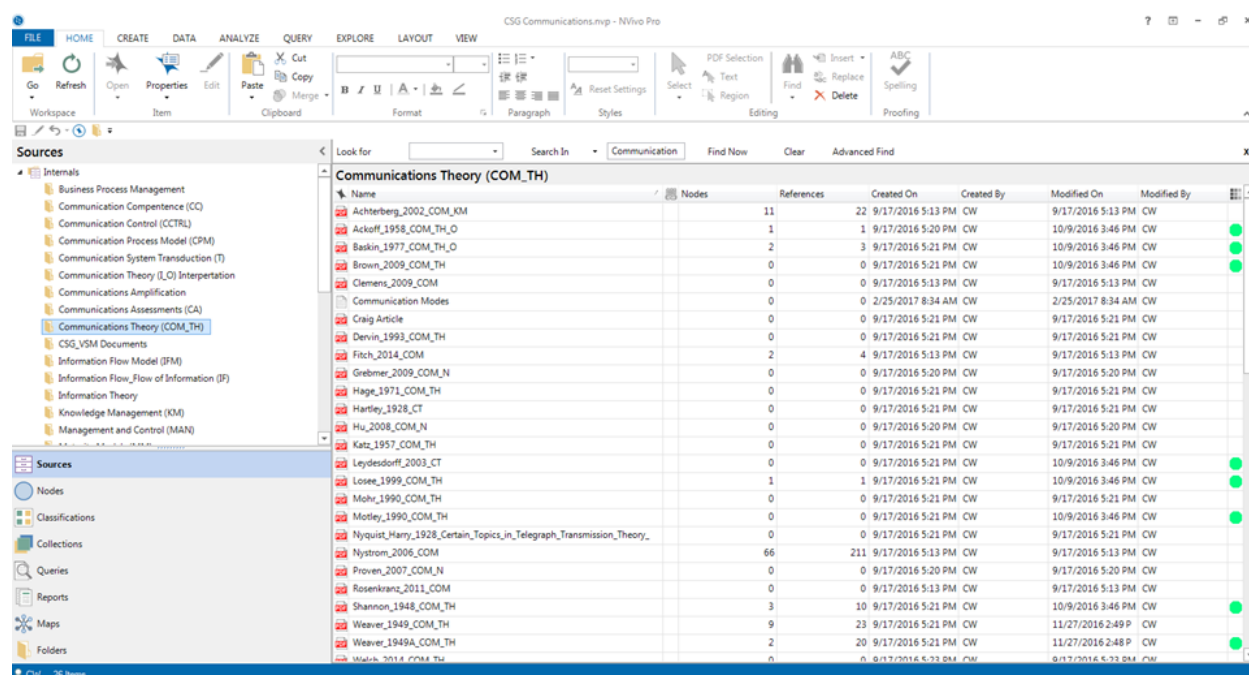
## **DESCRIPTION OF DATA COLLECTION AND OPEN CODING PROCESS**

The QSR International Nvivo 11 Software application was used to support the research. Nvivo 11 is specifically designed to support qualitative and mixed methods research. It is designed to support the organization of content such as: interviews, articles, social media and memos. Through the Grounded Theory process, it supports the development of coding, memo writing, category development, coding content to more than one node as well as combining data as well as expanded, split and rearranged to reflect the relationships that were emerging.

The pattern of data collection and analysis alternating in a cyclic sequence as essential part of Grounded Theory started the data collection on the articles used by Katina (2015) in his development of Metasystem Pathologies, specifically the articles related to communication. These initial articles were loaded into Nvivo where the software would be used to support the various phases of Grounded Theory.

Figure 8 below, is a screenshot from the CSG Communications Project established using Nvivo Software. On the left, there is a section labeled “Sources” where there is a section called “Internals” that is open with a display of folders. The folder labeled “Communication Theory (COM\_TH)” is slightly highlighted and to the right is a Panel likewise labeled “Communication

Theory (COM\_TH". It shows a listing of 26 items either .PDF of articles or memos. The .PDF is organized by Author/Year of Publication/First Key Word of Article.



**Figure 8: CSG Communications Project - Sources**

When the original set of articles were exhausted, the body of literature was expanded based upon the results of Open Coding to over 590 articles that meet the Criteria for Inclusion of Literature found in Table 11 above. The expanded body of literature included articles from System Theory, Communication Theory, Management Theory, Knowledge Management, Organizational Theory and Organizational Design with a secondary search on Beer, Shannon, Communication, Complex System Governance, and Viable Systems Model.

Listed in Table 13 below are the components related to Shannon and Beer, two authors whose works had been determined to be critical to the function or capability of a communication channel including the term channel of communication.

**Table 13: Component (Terms/Categories)**



<b>Component (Terms/Categories)</b>	<b>Shannon</b>	<b>Beer</b>
CHANNEL OF COMMUNICATION	X	X
INFORMATION SOURCE	X	
MESSAGE	X	
RECEIVED MESSAGE	X	
RECEIVED SIGNAL	X	
RECEIVER	X	
SIGNAL	X	
TRANSDUCER		X
TRANSMITTER	X	
VARIETY AMPLIFIER		X
VARIETY ATTENUATOR		X

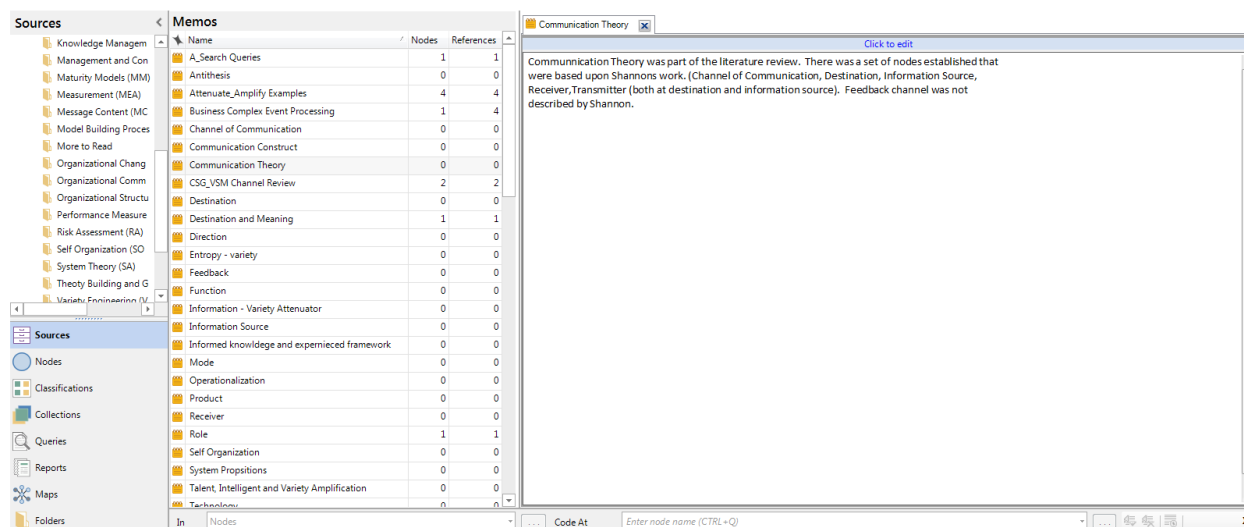
These components, terms or categories formed the initial constructed codes used in Open Coding. Of note, it was found that while some of the categories yielded identified data (that could be coded), employing the technique of the antithesis as well as synonyms for the categories identified additional data for inclusion.

Figure 9 below, is a screenshot from the CSG Communications Project established using Nvivo Software. On the left, there is a section labeled “Nodes” which are “codes”. The right Panel contains expanding folders of Nodes (codes) and the “VSM and Channel of Communication” has been expanded to show sub-nodes. Associated with the sub-node “Variety” is a symbol indicating that the sub-node can be further expanded. The column labeled “Sources” contains many sources (articles) relative to the node and the term “References” relates to the number of times the code was applied to portions of the source.

Name	Sources	References	Created On	Created By	Modified On	Modified By
System Theory		4	15 10/1/2016 4:35 PM	CW	1/15/2017 1:12 PM	CW
Theory Building		4	41 2/4/2017 6:58 AM	CW	2/4/2017 12:45 PM	CW
VSM and Channel of Communication		14	33 9/17/2016 4:28 PM	CW	3/5/2017 12:04 PM	CW
Channel of Communication		22	52 9/17/2016 4:27 PM	CW	3/23/2017 9:25 PM	CW
Environment		1	2 1/21/2017 6:05 PM	CW	3/4/2017 11:45 AM	CW
Feedback		1	1 2/5/2017 10:14 AM	CW	2/5/2017 10:14 AM	CW
Heuristics		1	1 1/11/2017 4:41 PM	CW	1/11/2017 4:41 PM	CW
Homeostasis		8	17 11/27/2016 11:14 AM	CW	2/4/2017 4:32 PM	CW
Latency Index		1	1 1/15/2017 3:53 PM	CW	1/15/2017 3:53 PM	CW
Management		2	2 1/21/2017 6:03 PM	CW	3/4/2017 11:44 AM	CW
Operations		1	1 1/21/2017 6:03 PM	CW	3/4/2017 11:45 AM	CW
Recursion		2	2 1/11/2017 9:14 PM	CW	3/4/2017 11:40 AM	CW
Regulator		1	1 2/4/2017 4:11 PM	CW	2/4/2017 4:11 PM	CW
Second Order Change		1	1 1/7/2017 5:32 PM	CW	1/7/2017 5:32 PM	CW
Self Organization		5	12 1/14/2017 3:54 PM	CW	2/26/2017 5:50 PM	CW
Transducer		2	2 2/18/2017 10:31 AM	CW	4/1/2017 10:25 AM	CW
Transduction		18	47 9/17/2016 4:29 PM	CW	3/4/2017 11:39 AM	CW
Variety		17	90 12/11/2016 12:21 PM	CW	3/4/2017 4:27 PM	CW
Variety Amplifier		25	69 9/17/2016 4:29 PM	CW	3/20/2017 4:58 PM	CW
Variety Attenuator		34	175 9/17/2016 4:28 PM	CW	3/20/2017 4:58 PM	CW
VSM Analysis		1	14 1/10/2017 8:40 PM	CW	1/10/2017 8:43 PM	CW
VSM Channels of Communication		2	5 1/21/2017 4:05 PM	CW	4/8/2017 4:30 PM	CW
VSM Generic Channels of Communication		3	7 2/5/2017 4:46 PM	CW	4/8/2017 4:30 PM	CW

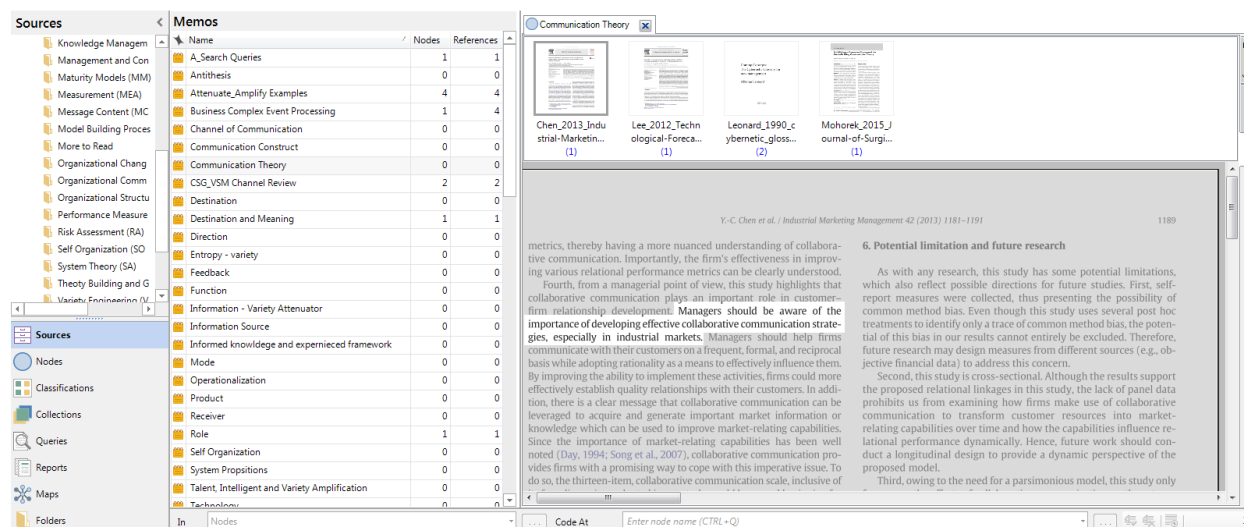
**Figure 9: CSG Communication – Nodes**

While reading through the source articles for a specific category, the section of text (sometimes an entire paragraph or a diagram/figure) surrounding the category was identified and assigned a constructed code. Sometimes for one specific category, when reading the coded section, it was found that the meaning or concepts being described in the section was relative to multiple categories and accordingly additional constructed codes were applied. The researcher found at times that the concept of the section could be adequately coded, but the concepts had stimulated questions or ideas of potential relationships that needed to be reviewed later. These occurrences were documented in a Memo, which Nvivo software supported, and the memo review was incorporated into the code reviews. Figure 10 below, is a screenshot from the CSG Communications Project established using Nvivo Software. On the left, there is a section labeled “Memos” and a selected memo for the category of Communication Theory is displayed in the left-hand panel of the screenshot.



**Figure 10: CSG Communication – Memo Text**

The following Figure 11 below is a screenshot from the CSG Communications Project established using Nvivo Software. The presentation is for the same Communication Theory memo, but on the right-hand side is displayed linked references and the specific text that was linked to the memo.



**Figure 11: CSG Communication – Memo References**

When source articles for a specific category were completed, the coding was reviewed. The intent of the code review was to determine if there were codes that were similar and if they could be grouped into categories based on their common properties. This review was accomplished by grouping codes in a Collection Set where the coded text and the applicable codes were presented for review. There were consolidations and the codes were changed. Finally, the grouping of the sections of coded text afforded the opportunity to verify that the coding was specific to fullness of the concepts.

The review of all source articles for all the specific categories coincided with a point in the research when no new codes were being generated. Open Coding had found over 1010 text sections aligned to over 330 unique Codes. As described by Glaser and Strauss, this was the theoretical saturation as no new data was emerging from data collection and the analysis of the data. At this point initiation of Axial Coding was started.

## **AXIAL CODING**

The intent of the axial coding was to consolidate the data into a new perspective (Glaser & Strauss, 1967), which would then lead to a framework of communications. The results of the Open Coding had offered potentially more than one perspective that could be developed. There was the channel of communication perspective of Shannon where a package of information was created by the originator and received by the receiver. This does not necessarily coincide with the VSM perspective of Beer where the channel of communication as one portion of Management Cybernetics (communication and control for effective system organization) and as discussed in Chapter II the channel of communication must deal with variety and transduction. With the purpose of this research to develop a Communication construct of Complex System Governance, the direction of the Axial Coding was to make connections between the codes consistent with a VSM perspective.

Using the Nvivo Software, codes were initially associated within a Concept Grouping. The Concept Groupings were created by a combination of actions. Firstly, during the coding reviews as part of Open Coding, when there was a consolidation of codes, this review not only modified codes, it also resulted in grouping of codes for a Concept. Secondly, the constructed codes with their origin relative to Shannon and Beer's works impart a condition of similarity to sets of related codes. Taking a perspective to view the codes based upon actions, and the

consequences of the action or lack of consequences, resulted in grouped codes for these perspectives. This achieved a reduction of initial codes to 154 Concept Groups relative to Channels of Communication in support of CSG. As these Concept Groups were dealing with the composition of channels of communication, it was found possible to abstract the Concept Groups into four categories (Direction, Mode, Product and Technology (Conveyance)).

## **SELECTIVE CODING AND CONSTRUCTING THE INITIAL FRAMEWORK**

Corbin and Straus point out that “it is not until the major categories are finally integrated to form a larger theoretical scheme that the research findings take the form of theory. Selective coding is the process of integrating and refining categories” (Corban & Straus, 2008, p. 143).

Böhm points out that Selective Coding is the

starting point for establishing the main phenomenon of the analysis it is advisable to look at coding lists, summarizing memos and representations of networks. The main phenomenon is described as the core category and is possibly already present in the formulation of the research question of the particular investigation. Admittedly it must sometimes occur in the research process that a different phenomenon than originally assumed will take on central importance for the issue in question (Böhm, 2004, p. 274)

Following the intents of Corbin and Straus as well as Böhm the researcher settled on the term Communication Channel Mechanisms. The selection of these terms, firstly, fully encompasses the core direction of the research. Secondly, all the Concept Groups back to the original constructed codes align with Communication Channel Mechanisms. While not all the literature reviewed had as key words: Communication, Channel, and especially Mechanisms, the literature that did yield sections of text were dealing with communication. While for some the term of Components would appear to be exchangeable with Mechanism, what will be described in Chapter V shall provide a better understanding of the interrelationships between Communications, Channels, and Mechanisms for which a mere listing of the components or constituents of a system is not sufficient. The sections of text were also describing effect of communication on or to a system, including the environment associated with a system. The listing of Grounded Theory source literature used for the research are presented in Appendix A.

## METHOD OF PEER REVIEW OF RESEARCH DESIGN

As described in Chapter III, the use of Grounded Theory methodology was not without challenge. Integral to the maturity of research application using the method has been several events used by the researcher to bolster research credibility through peer review. This exposure of the research, or transparency, has not only benefited both the community (engineering based disciplines) with exposure to new research method, but has also allowed the rich background of the peers to be brought to bear on the research. Toward that end, the involvement of peers was invoked by this researcher to ensure that the research would benefit by exposure to a wider array of scholars for review.

The primary objective of the peer review of the research on the contextual Framework of Communication Functions Supporting Complex System Governance was to increase the internal validity or credibility of the research. The peer review of this research examined the credibility of the researcher to properly use the Grounded Theory Method and dependability was achieved by auditing the research. Using a peer review of the current research was pursued to examine: (1) agreement on current efforts with respect to design and execution, and (2) provide for comments or recommendations that could be applied to improve on the research effort. The peer review that was conducted examined the efforts used in data creation, coding, analysis, and conception construction. There was no intent to achieve an agreement on the research findings; rather value was sought in review of the methodology. It was anticipated that the review will improve the researcher's efforts.

The Peer Review Qualifications and process is contained in Table 14 below.

**Table 14: Peer Review Qualifications and Process**

Peer Reviewer Qualifications	Enrolled in Old Dominion University Engineering Management and Systems Engineering as a Ph.D. Candidate
	Graduate with a Ph. D.
	Authored articles associated with the topic of Complex System Governance.
Number of Peer Reviewers	Minimum of 3 and maximum of 5.
Conduct of the Peer Review	The Peer Reviewers were provided an extract from Chapter IV that was presented as a presentation as well as a Peer Review Data Sheet for the recording of comments or questions for the researcher.

	The Presentation was made live and recorded for Reviewers unable to attend the presentation.
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The Research Topic and Questions used for assessment) are contained in Table 15 below.

**Table 15: Peer Review Topic and Questions**

<b>Topic</b>	<b>Question</b>	<b>Comments</b>
Data Collection	Was there a schema to select documentation?	
	Was the selected documentation schema aligned to the topic of research?	
	Was Theoretical Sampling used?	
Open Coding	Was the initial identified Component (Terms/Categories) aligned to the topic of research?	
	Was the initial set of Component (Terms/Categories) added to and why?	
	Was Constant Comparative Analysis incorporated in Open Coding?	
Axial Coding	What were drivers for consolidation of data during Axial Coding?	
	Was Constant Comparative Analysis incorporated in Axial Coding?	
Selective Coding	What were the drivers for Concept Groups?	
	Was there a relationship between the Concept Groups and the Component (Terms/Categories)?	
Theory Development	Was theory fully supported by the data and analysis?	
Framework Development	Will the framework adequately fulfill the research objective?	

### **Validation Analysis of Peer Review**

Five participants were identified and four participated in the review. All the individuals meet the criteria as outlined in Table 14 above and all provided responses to each of the Topics and Questions. The peer review responses were consolidated and are contained in Appendix B. The results were favorable and the following Table 16 will provide a short synopsis of the results of the peer review for each of the topics.

**Table 16: Peer Review Synopsis**

<b>Topic</b>	<b>Comments</b>
Data Collection	The schema to select documentation enables the researcher to focus on credible work. The schema did conform to the original starting point based upon the literature review.
Open Coding	The terms align well research topic with the categorization of components are clear and relevant to communication. The initial set was expanded based on the expanded literature/data search. Constant Comparative Analysis was incorporated in Open Coding,
Axial Coding	Drivers for consolidation of data during Axial Coding were the topic of communication and how it takes place in complex systems. Constant Comparative Analysis was incorporated in Axial Coding. The data sources expanded as consolidation occurred.
Selective Coding	The drivers for Concept Groups were the refinement of categories, association of categories to channels of communication – in support of theory and framework development.
Theory Development	The framework is anticipated to adequately fulfill the research objective. However, case applications might be necessary to realize implications on real world systems.

The Peer Review or Peer Debriefing was discussed in Chapter III and was included in the design of the research as a strategy to mitigate potential threats, or amplify utility of research approaches to enhance the scholarly ‘defensibility’ of the research process (Grounded Theory). Engaging with peer’s through the presentation on how the Grounded Theory was used for each of the phases of the research, while it did not specifically change the results of the research, it did positively confirm the Researchers understanding of the Grounded Theory method and the expectation of each phase. Secondly, it provided an opportunity to discuss some of the intricacies associated with using the method with scholars cognizant of research design. The accomplishment of a face validation of the framework using a survey instrument follows.



## **METHOD FOR DEPLOYMENT OF THE CONSTRUCT OF COMMUNICATION CHANNEL MECHANISMS**

The deployment of the Communication Channel Mechanisms construct was to help establish the soundness of this qualitative research. As discussed by Lincoln & Guba (1985), Krefting (1991), Ryan-Nicholls & Will (2009), Freshwater, Cahill, Walsh & Murphy (2010), Tuli (2011) and Houghton, Casey & Shaw (2013), there are four alternative criteria for judging qualitative research (credibility transferability, dependability, confirmability) in contrast to traditional criteria. In particular, how can one be sure that the findings result from inquiry and not from the researcher or design prejudice and/or bias? (Lincoln & Guba (1985)). As described in Chapter III, there are several mitigation techniques that can be employed to offset the concerns related to qualitative research. The researcher chose to use confirmability as a mitigation technique. Confirmability refers to the degree to which the results could be confirmed or corroborated by others (Creswell, 1998; Patton, 1999). There are many strategies associated with confirmability (Confirmability Audit, Audit Trail, Triangulation and Reflexivity) (Cohen, 2006). According to Carter (2014), triangulation can be used to test validity through the convergence of information. Specifically, “Data source triangulation involves the collection of data from different types of people, including individuals, groups, families, and communities, to gain multiple perspectives and validation of data” (Carter, 2014, p. 545).

The accomplishment of data collection was using a survey instrument. While there was a choice of instruments; questionnaire and interview, the ease of asking questions where the survey respondent would provide descriptive answers, maintain confidentiality of the respondent, reaching a larger population and taking less time, favored using a questionnaire. There are numerous guides to the design of a questionnaire and one provided by Burgess (2001) was used. The first step which is to “define your research aims” (Burgess, 2001, p. 3) was critical. As the questionnaire was relative to an academic subject vice market research, the aim was to acquire data associated with Communication Channel Mechanisms to support triangulation. Secondly, the participants or population and the sample selected to take the questionnaire need be identified. Communication is relevant to all humans, as such the population could be rather large and as not all the population can be a respondent to the questionnaire, Burges recommends, “A sample is a sub-set of the population that is usually chosen because to access all members of the population is prohibitive in time, money and other resources” (Burgess, 2001, p. 4). The size of

the sample is also important and fortunately, as the purpose of the questionnaire was confirmability by triangulation, a sample of 100 individuals associated with an organization would be adequately representative and hopefully reach saturation across the Communication Channel Mechanisms.

The steps of “decide how to collect replies” (Burgess, 2001, p. 5) and “design your questionnaire” (Burgess, 2001, p. 6) are intertwined. Old Dominion University maintains a software account with Qualtrics.Com. The developed software (Qualtrics) supports the design, collection and analysis associated with questionnaires. The Qualtrics Service allows the Researcher to establish accounts where they own and control all information they input into the Qualtrics software (“Data”) and any information generated from that Data. Qualtrics does not provide a service to classify or represent the Data but is only used to provide a hosting service of in support of the survey instruments. The Qualtrics software provides templates for construction, testing and review of questions.

Importantly, the Qualtrics service and the design of the survey instrument can be used to ensure confidentiality of the respondent in support of Human Subjects Research (HSR) protections. Confidentiality is ensured by the design of the instrument not to ask private personal information (name, age, sex, etc.) and the taking of the questionnaire was designed to be voluntary. Separating the questionnaire respondent for the Researcher was achieved by not using know associates of the researcher. Secondly, organizations not associated with the Researcher, were requested to solicit volunteers to take the survey by the organization. This was achieved by forwarding to their members a document containing a description of the survey as well as a web link to the survey if they elected to participate in the survey.

The survey instrument was designed so that Respondents would provide descriptive answers. The question areas as the basis for the survey instrument design are provided in the Table 17 below. The survey instrument was designed to be completed in a maximum of 30 minutes. To facilitate ease in taking the survey instrument and to support use of the resultant data, the survey instrument was organized in four sections, an initial set of questions general in nature to describe the organization, then to a section that best suits the Respondents function in their organization, specifically; Member of a Group/Project(s) and not a Supervisor, Supervisor and a Member of Project(s) and Supervisor and not directly involved in Project(s).

**Table 17: Face Validation Questions Areas**

Question Areas	Description
Identity	The CSG Function did it appear that the survey respondent worked in.
Purpose	What the respondent ascribed to their work to accomplish.
Interface	Was communication interior (and with whom) and if exterior (was it to the environment or what CSG Function if in another organization)
Product	<p>Communication is the process by which meaning is assigned and conveyed to create shared understanding. The Source creates a Message that is the result of developing meaning. Shannon's work could be interpreted that the Message is the result of only the Source. Expansion of the Transmission Model or Standard View of Communication that incorporates feedback up to the Transaction Model where a basic premise is that individuals (Source/Receiver) are simultaneously engaging in the sending and receiving of messages means that the "message" may not be the sole creation of the Source and that there are other influences. Taking the Advertising Industry as a potential model of message creation that follows a life cycle design pattern, the term Product moves the concept of the "message" to a higher level.</p> <p>Therefor the Product may be actions proposed, actions to be taken, constraint (attenuation) on actions as well as liberation (amplification) of actions.</p>
Technology (Conveyance)	<p>Communication is the process by which meaning is assigned and conveyed to create shared understanding. The conveyance of the Product may be limited by the composition of the channel of communication or it may be the construct of the channel of communication that may enhance the spectrum of Products that are conveyed.</p> <p>Therefor the Technology is the conveyance used to support the channel of communication.</p>
Direction	<p>As described by Shannon and Beer and many others, there are at least a minimum of two participants associated with a channel of communication. There is the Source and the Recipient. The Source is always active by creating a packet of information. The Recipient may be active or passive where active is where a packet of information is received or consumed. Recipient passivity has two senses inferences, the first where the packet of information is received and no action is taken. The alternative Recipient passiveness is where the Source writes a message on a deserted beach.</p> <p>Having established that there is a Source and a Recipient, the direction of communication by convention is always from the Source to the Recipient.</p> <p>Within the construct of the metasystem, the channel of communications originates with a function and is connected to one or more functions (direction is <u>from- to</u>).</p>

Question Areas	Description							
Mode	<p>Communication is the process by which meaning is assigned and conveyed to create shared understanding.</p> <p>The Mode that the meaning is conveyed can be visual, auditory, tactile (such as in Braille) and haptic, olfactory, Kinesics, electromagnetic, or biochemical. Human communication is unique for its extensive use of abstract language.</p>							
	Non-Verbal	<b>NV</b>	Verbal	<b>V</b>	Verbal & Non-Verbal	<b>VNV</b>	Tactile	<b>TA</b>
	<p>While there is a significant difference between Non-Verbal and Visual, for coding NV will be used for both Non-Verbal and Visual.</p>							

The content of the questionnaire not only had to be organized to acquire data associated with Communication Channel Mechanisms, but also to support triangulation. The questions need a validation. As described by Collingridge, the subjection of the questions to face validity has two steps;

First is to have experts or people who understand your topic read through your questionnaire. They should evaluate whether the questions effectively capture the topic under investigation. You might have them pretend to fill out the survey while scribbling notes. (Collingridge, 2014, p. 1)

The second step was to test run the survey. Based upon the results of both steps, the survey was updated. The survey instrument used is contained in Appendix C. The Qualtrics software supports these two steps through a testing environment prior to distribution for data collection.

### Permission to Conduct Survey

Permission to conduct the survey was requested in accordance with the ODU Procedure for Review of Human Subjects Research. The request was approved on 2 November 2017, see Appendix D.

## RESEARCH DESIGN SUMMARY

In this chapter, the research design and its detailed procedures for the Grounded Theory Method for the research associated with the first research question were discussed. To add to the

transparency of grounded theory the description and scope of the research was made part of a Peer Review process. The four responding members of the Peer Review provided comments for a favorable confidence in the researcher's use of Grounded Theory. To address the second research question a Confirmability method was presented. By the nature of the subject, the grounded theory research effort was iterative and went in directions not originally considered. The open coding found that the initial search terms needed to be expanded and that subsequently sufficient data could be identified. Axial coding began the process of consolidating data into more expansive codes leading to a construct that will be fully described in Chapter V.

## **V. RESEARCH RESULTS**

### **INTRODUCTION**

The purpose of this chapter is to report on the results of the research. The purpose of this research was to develop a Communication construct of Complex System Governance using an inductive research design. The perspective of the research was discussed in Chapter II and in Chapter IV the integrated steps used relative to the data was discussed. This Chapter will present the results of the research where the core categories or concepts emerged providing an understanding of the interrelationships between Communications, Channels and Mechanisms. Next the Concept Groups (Direction, Mode, Product and Technology (Conveyance)) making up the functional mechanisms of Channels of Communication will be discussed. This will be followed by addressing the underlying influence of Intent composed of Identity (motive/intent) as part of Complex System Governance as well as Variety Attenuation and Variety Amplification will be discussed. The final section deals with underlying influences on the Channel of Communication Design Concepts.

### **RESEARCH FINDINGS**

The purpose of this research was to develop a Communications construct of Complex System Governance using an inductive research design. The use of Grounded Theory supported the research to concentrate on the communications (flow and processing of information necessary to support consistent decision, action, and interpretation throughout the system) aspects of the CSG metasytem. Identification of the communication functions means that communication mechanisms, beyond the identification provided by Beer and Shannon can be described based in systems theory, communication theory, management theory, knowledge management, and organizational theory.

Starting with the literature review and through the actual research, numerous articles and books were read, they included: Weaver (1953) Recent contributions to the mathematical theory of communication; Ackoff (1958) Towards a behavioral theory of communication; Baskin & Bruno (1977) A transactional systems model of communication: Implications for Transactional Analysis; Herbert (1977) Toward an administrative model of the communication process; Beer

(1979) The Heart of Enterprise; Targowski & Bowman (1988) The layer-based, pragmatic model of the communication process; Calabrese (2004) The evaluation of quality of organizational communications: a quantitative model; Björk (2005) A lifecycle model of the scientific communication process; Miles (2007) A cybernetic communication model for advertising; Thackeray & Neiger (2009) A multidirectional communication model: Implications for social marketing practice; Chang (2012) Ambivalent attitudes in a communication process: An integrated model and Karimova (2015) A Dialogic Communication Model for Advertising. In addition to the identification of the channels of communication mechanisms, the researcher developed a synthesis of what the communication process accomplishes. Simply stated, communication is taken as the process by which meaning is assigned and conveyed to create a shared understanding.

Communications and the channels of communication whether it is between two individuals or the members of an organization or a society in general, have a single functionality. The number of individuals that are senders or receivers does not change that singular functionality. Likewise, the content or the package that was developed by the sender and intended for the receiver still is in support of the singular functionality. There were 151 individual channels of communication identified and the complete listing of the Channels of Communication can be found in Appendix E.

For all Channels of Communication that were identified, the Researcher could determine from the channel text or the surrounding text, the Authors intended Source and Recipient. The Researcher could relate the Authors intended Source and Recipient (one or more) to one of the nine CSG Metasystem Functions described in Table 1.

There were no cases of Authors having a Recipient in more than a single CSG Function. Not all individual Channels of Communication yielded data for Technology, Product, and or Mode. In these cases, the researcher was not able to determine the data from either the channel text or the surrounding text. An individual Channel of Communication yielded in many cases more than a single data element (node) for Technology, Product, and or Mode. Through the Grounded Theory Method some of these data elements (nodes) were coalesced during Open Coding or Axial Coding.

The Concepts of Direction, Mode, Product, and Technology (Conveyance) as drawn from the research data and Variety Attenuation and Variety Amplification are not independent of the

use of the mechanisms of communication. The interrelationship began to be identified/described as part of Open Coding in the Grounded Theory method and then fully emerged. The Concepts individually or independently do not answer; who, what, when and how questions of communication. Also, if one were to start with one of the Concepts the reviewer would need to go to the others to achieve the degree of understanding that they collectively bring to communications. While this interrelationship would appear to be a ‘continuous do loop’ and never achieve a result as it is possible to create in a software application, Variety Engineering as described in Beer’s *The Heart of the Enterprise* lays out the four principles of organization, recursion, and relaxation time that give relevance to the above concepts. This offers support for establishment of the construct of the communications functions supporting Complex System Governance. There will follow sections that are devoted to the four Concept Groups, the integration of Communication, Channels and Mechanisms, and how this emerged from the research and were constructed.

### **Direction**

Communications is framed as a minimum of two participants and associated with the participants is a channel of communication or some type of conveyance. The works of: Shannon (1948) A Mathematical Theory of Communication; Beer (1979) *The Heart of the Enterprise*; and Keating (2014) Metasystem Governance Reference Model (MGRM) for Complex Systems and many others articulate this communications framework. Within this framework the participants are identified with the roles Source and Recipient. When the process of feedback was added between the same set of participants, the roles of the participants are exchanged. The Source will always be associated with the origination/creation/designing/establishment/mandating a packet of information. The Recipient as designated will be the intended receiver of the packet of information. In this framework, the packet of information, to be fully described in the section on Product, will always be originated/created/designed/established/mandated for the particular Recipient. While it is possible that the packet of information may be received by others, the design by the Source is always for the Receiver. The Receiver having acquired the packet of information takes action intended because of the design by the Source. Accordingly, a direction convention that the packet of information always is created by the source and then conveyed to the recipient (direction is from - to).



The idea of Direction was an accepted concept when starting the research, but the identification of who or what organizational or metasystem function would be associated with either the Source or Recipient was not known. Secondly, direction for a particular set of Source or Recipients and how the channel of communication would contribute to Complex System Governance was unknown.

The term Direction was not part of the set of components, terms or categories forming the initial constructed codes used in Open Coding. Reading through the source articles the constructed code of Channel of Communication was expanded to include Communication Channels as well as the following additional codes (type of channels) (Algedonic, Coordination, Anti-Oscillation or Coordination, Command, Audit, Resource Bargaining, Accountability, Homeostat, Policy Intervention, Resource and Provision) found in the literature on Beers VSM. For each section of text (sometimes an entire paragraph or a diagram/figure) the constructed codes (nodes) were linked first to the text with respect to the “type” of channel and where it was possible to identify a Source and a Receiver, then constructed coding was made with a “term/title” to associate with the Source and a Receiver. Code reviews were conducted where the coded text and a specific constructed code were presented for review. This achieved consolidations and the trend was to apply terms consistent with CSG as well as for Beer’s First Principle of Organization.

This review resulted in the identification of 18 codes for CSG and 6 codes for Beer’s First Principle of Organization that are associated with a specific Direction (from Source to Recipient) for a Channel of Communication. As will be discussed in following sections, development of Direction for the Source and Receiver has a specific structure and all models of communication including Shannon’s have a Direction. While it is true that two individuals may meet and start an interaction or conversation, they do so because one or the other initiates an interaction. The motive behind the initiation is always associated with the Source.

## **Mode**

The technology associated with Communication has significantly progressed from what could be recognized as the original communication capabilities to the current spectrum of communication capabilities. While Shannon was dealing with telecommunications (telegraph,

telephone, television, telephony, teletype, and telegraphy) which was concerned with electromagnetic signals, there are many communication capabilities associated with a Channel of Communication that are not electromagnetic. Such terms as auditory (hearing), balance, biochemical, electromagnetic, haptic, kinesthetic, olfactory (smell), pain, tactile (touch), taste, temperature, or visual (sight) reflect the senses that humans have.

The idea of Mode was not considered prior to Open Coding. Likewise, it was not part of the set of components, terms or categories forming the initial constructed codes used during the first iteration of Open Coding. What started to emerge were questions; how does the recipient receive the packet of information, can the same packet of information be constructed as different packages such as a written report or could it be a verbal report or both? Additionally, does the Direction of the packet of information effect how it was received? Lastly, within the context of Variety Engineering, would the design associated with Variety Engineering have an impact on the optimum construct for a packet of information? These questions were captured as memos in accordance with the Grounded Theory protocol.

During Open Coding, the questions that had been captured were addressed by a review of each section of text (sometimes an entire paragraph or a diagram/figure) that had been identified with constructed codes (nodes). This iterative review was to resolve how the packet of information was packaged for the recipient. In most cases the text offered up that the packet of information such as a document was provided to the intended recipient (receiver) or that the document was part of an agenda for a face to face meeting. In this case the text was coded for written (Non-Verbal) and written and presented (Non-Verbal & Verbal). There were coded texts where it was not easy to identify how the recipient was to receive the packet of information. For these instances, they were not coded. During the Axial Coding, the codes were reviewed against the text for each particular code and the consolidation resulted in four Axial Codes of Non-Verbal, Verbal, Verbal & Non-Verbal, and Tactile.

The choice of Mode by the Source appears to address the concerns voiced by Weaver with respect to Shannon's Model of Communication,

**“LEVEL B.** How precisely do the transmitted symbols convey the desired meaning? (The semantic problem.)

**LEVEL C.** How effectively does the received meaning affect conduct in the desired way? (The effectiveness problem.)” (Weaver, 1953, p. 2).

where the Mode chosen enables the Recipient to receive the desired meaning of the packet of information and will take the appropriate action. While it is recognized that there can be a breakdown in the Channel of Communication, to be addressed in the Technology (Conveyance) section, Mode helps reveal part of the purposeful design associated with Channels of Communication supporting CSG. The choice with which Mode to use depends on the motive and intent of the Source and on when to initiate communication. Secondly, with respect to increased technological advances instead of a single option for Technology (Conveyance) the research indicates that for a given section of text that more than one Mode was used. Additionally, where there was a 'blind' person as the expected Recipient, the Source chose not to use a Visual Mode but rather both Tactile and Verbal Modes. Again, there is an interrelationship between the Concepts.

## **Product**

Communication is the process by which meaning is assigned and conveyed to create a shared understanding. Previously, the term Message or package of information was presented as the result of developing meaning by the Source. As has been discussed in Chapter I, it was Shannon that associated the package of information with the Source. Shannon's Model of Communications did not include feedback but Communication Theory has progressed since then to the Transmission Model or Standard View of Communication and then the Transaction Model. The last model has a basic premise of individuals (Source/Receiver) simultaneously engaging in the sending and receiving of messages so that the 'message' may not be the sole creation of the Source but can change depending on other contributors/individuals or other influences. An example of many influences or contributions other than the final Source is with the Advertising Industry where the model of message creation has similar phases as a life cycle design of a physical product (e.g. car). Rather than thinking solely in terms of a package of information the term Product moves the concept of 'meaning' (formally called package of information) to a higher contextual level.

The term Product was not used in the initial set of components, terms, or categories of initial constructed codes used in Open Coding. Unlike Direction or Mode, Products have a specific structure in their development. As just stated, the meaning that is assigned and

conveyed can have a life cycle in its development. This perception was not immediate but began to emerge when one considers dealing with variety. The following quote from Beer's, *Designing Freedom*, provides an example of communication interrelated with variety but that the communication is also a process.

But not for nothing is that store called departmental. There is a shoe salesman, and a cake salesman; that is what organizational structure is for to carve up the total system variety into subsystems of more reasonably sized variety. ... But if the store is careful, it will have an information bureau—which exists precisely to absorb this excess variety. (Beer, 1973, p. 8)

The above example lays out the effect of a business purposely organizing itself and communicating to the environment (public) and the business organization structure (internal) by departments. This conveyance to the public and its shared understanding of where to find goods and services (business departments) also demonstrates that communication is not necessarily an instantaneous event and this is especially true with respect to variety attenuation and variety amplification.

Most Products found in the research could be related with one or more Modes. As an example, a written document can be read (not vocal) and it can also be delivered vocally (Source) to a group (Recipients), same Product with but two different Mode associations. For this example, the Direction in both cases was from a Source to the Recipients, but the Product could have been developed by Staff (Source) and given to the Program Manager (Recipient) and then the Program Manager (Source) delivers at a professional gathering of peers (Recipients). The creation of the Product has associated with it motives and intent like Mode. The data did not reflect that the motive or intent for the Product was different than the Mode. As the Source was responsible for both the choice of Product and the Mode, it can be assumed that motive and intent is solely with the Source and the Product and Mode reflect the development. As always, the Product is required to create a shared understanding by the Recipient.

The creation of a shared understanding has the implication that the language or culture is likewise shared between the Source and the Recipient. The coded data did not contain associations with language or culture with either the Source or the Recipient. This is most likely due to the choice of data as there is significant research dealing with speech communities but that

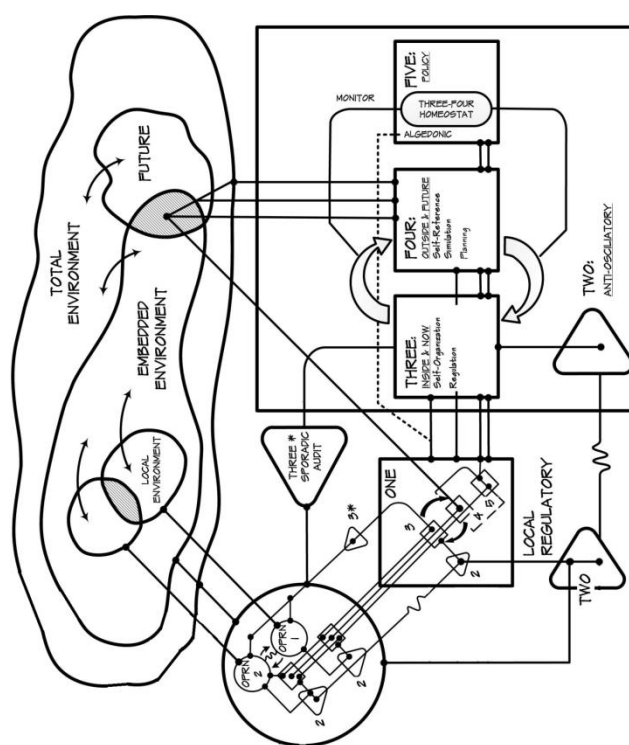
literature did not fall within this research. The subject of Ethnography of Communication is an interesting area and more will be discussed on the topic in Chapter VI.

The idea of intent or motive by the Source in formulating the Product has been mentioned and is directly supported by the data. The text material associated with a specific channel, finds the Source establishing the pretext for communication and the context of what was being accomplished. Additionally, as Variety Attenuation, Variety Amplification and Transduction were part of the initial constructed codes used in Open Coding, this drew attention to text surrounding the respective constructed codes which focused on intent. Finally, creation of a shared understanding was to achieve a goal. This, coupled with many instances of data, showed the formulation of the Product was accomplished through bargaining, which leads one to report that most Product formulations incorporated a dialectic process to achieve a completed entity. This is consistent with speech communities that continually discover and exchange new speech where Sennett says that as a dialectic process “with the explicit meaning of statements, and tends to lead to closure and resolution” (Sennett, 2012, video: see 18:30 – 30:00) the speech community achieves closure and a new formulized speech.

There are writings that indicate that the Recipient may be active or passive, where active is when a packet of information is received and consumed. Recipient passivity could imply that the packet of information is received and no action is taken or that there is no Recipient such as the Source writes a message on a deserted beach. Weaver wrote on two problems, “How precisely do the transmitted symbols convey the desired meaning” and “How effectively does the received meaning affect conduct in the desired way” (Weaver, 1953 p. 2). With respect to both problems, the data and subsequent coding that formed the Product, does not indicate that this is a problem, rather the data shows that the actions of the Source are heavily invested in forming a Product that the Recipient expects and knows what to accomplish. The term “Coordination Channel” and/or “Resource Bargaining Channel” are found numerous times in VSB literature where there is clear intent to reduce variation in the response to the Product to preclude an intervention. With respect to the example of the message on the beach, this is a Technology (Conveyance) issue and will be discussed in the next section.

## Technology (Conveyance)

The commencement of research had been preceded by several questions such as for example; what is the makeup of the Channels of Communication, what is the number of channels required, or would a particular channel by its characteristic determine what could be conveyed. While not a complete listing of unknowns, the researcher was helped by considering them, as the gathering of articles was the source of data to accomplish an inductive research design using the Grounded Theory Method. A quick refresher on a simplified representation of the channels of communication and the functions associated with the VSM, see Figure 12 below, finds it full of many channels labeled as Algedonic, Coordination, Anti-Oscillation or Coordination, Command, Audit, Resource Bargaining, Accountability, Policy Intervention, Resource, and Provision.



**Figure 12: Representation of Beer's Viable System Model**  
(Used with permission and adapted from Akers, Walt (2015). Viable Systems Model. An Approach for the Development of Complex Systems Archetypes (Page 32), Old Dominion University, Norfolk, VA.)

Open Coding for all specific categories offered sections of text (sometimes an entire paragraph or a diagram/figure) where coding could be made that in Axial Coding lead to

channels best described by Technology (Conveyance). One might assume that all the codes reflected an electronic conveyance. This was not true as there were Codes reflecting a wide spectrum of conveyance such as Face to Face Meetings, Library of Documents and Personnel Changing Location. When accomplishing the coding, there were times when it was not possible to accurately determine what the author had intended, even with searching paragraphs before and after the data point. This was when the author of the article simply used the term “channel”. The data sources provided 151 individual channels of communication.

The data shows that a better mapping of the VSM would be a single line connecting the functions with arrows reflecting that there are products being conveyed in both directions. The CSG Nine interrelated functions that form the metasystem, Figure 13 below reflects a better representation of channels of communication than VSM. Secondly, the relationships between the meta functions in the VSM, within the context of current technology, are not a one to one (excluding the Algedonic concept), but can be thought of as a network of one to many depending upon the technology used. A good example is a web service and e:mail where an e:mail is generated by one function and sent too one or more different functions at the same time. This example complies with the communication Direction of ‘from-to’ and by design in support of the Product, the e:mail is to select Function/s. A slightly different example is broadcast, which conforms to Direction, is one to many but there is the desire for less control on the Recipients. The process of advertising though would indicate that there is considerable work in Product generation so that the Recipients are targeted, a form of selection of Recipients.

Besides the use of single line diagrams, the terms associated with all the Channels (Algedonic, Coordination, Anti-Oscillation or Coordination, Command, Audit, Resource Bargaining, Accountability, Policy Intervention, Resource, and Provision) has more to do with the Source’s intent, to be discussed later, and underlies the design involved with creating the Product more so than the specific mechanism of how a channel accomplishes the conveyance. An excellent example is the Algedonic Channel, “To quickly convey information in the event of emergency or failure in the (S2-S3- S3\*-S4) management system (an organizational ‘override’ channel)” (O’Gradey, 2016, p. 5). The necessity of override is easily met with current electronic technology and could enable the S1 (productive function) to communicate to the S5 (policy and identity function); however, as a practice this need shows a failure in Mode design or pathologies associated with Direction, Mode, Product, Technology (Conveyance). Failure of Mode design

would be to use non-electronic technology such as Face to Face Meetings, Library of Documents, and Personnel Changing Location as their failure suggests no accommodation of an “emergency”. This lack of accommodation has everything to do with poor design rather than the abilities of a special Algedonic Channel by itself to achieve the shared understanding.

The building and what may be specific methodologies with respect to building channels of communication was not found in the data and the coding. The documentation that provided the data, treated communications from the “as built” state as opposed to a future and changing, or how to design and build the channels of communication. With respect to the Product and the issue of Variety Amplification and Variety Attenuation, the coding was specific on the building of a future condition and this will be discussed in the subsection on Variety. What the data and coding did find, with respect to a life cycle view of channels of communication, is that the advances in technology have increased the options of conveyance and decreased concerns and issues relative to the Recipient not adequately developing an understanding of the product. Secondly, in advertisement, the model of communication has moved to participatory communications where the product is interactively developed. Another example of this participatory communications can be seen in software development using the Agile Methodology (*Manifesto for Agile Software Development, 2001*) where an application is developed in short bursts, released prior to final testing (beta format) for the user to use and comment on. These comments on the beta product are absorbed with internal directions for the next iteration.

The conveyance of the Product may be limited by the composition of the channel of communication or it may be the construct of the channel of communication that may enhance the spectrum of Products that are conveyed. Channel Capacity was at the heart of Shannon’s work and as Reissberg points out, “It is important to note that the provision of Channel Capacity depends to a high degree on technology” (Reissberg, 2010, p. 42). From the data, a measurement schema to determine channel’s capacity was not exposed. This lack of measurement schema may be due to the author’s concentration on what channels of communication achieve vice operational experience with communication channels. With a perspective that the channel of communications can be disrupted or can have saturation in Product, the consideration of channel capacity in a complex system makes the issue part of the design sequence or a sub-element of the design methodology.



Channel composition or construct was found to have a direct relationship to the Mode, Direction and Product. The research data identified, and coding reflects, an intelligent design by the Source integrating Direction, Mode and Product dependent upon the intended meaning and equally the intended Recipient. The resultant design builds a total integrated construct. When the desired result is not achieved, the Source makes modification to the communication mechanisms used, or if there is change in the environment associated with the complex system; likewise, the Source makes modifications. As an extreme example, Personnel Changing Location, either to affect Variety Attenuation or bring new leadership or management was found in the data. There was no indication that the conditions of communication channels were static, but always evolving dependent upon the requirements of the complex system.

### **Variety Attenuation, Variety Amplification and Transduction**

Beer's First Principle of Organization, highlights the need for regulation. Both the intent of the VSM and Complex System Governance is to provide to the observer of a complex system of interest the lenses to understand this regulation and the mechanisms of Variety Attenuation and Variety Amplification. The intent is that the transmission of variety between all meta functions, as well as the interface with the environment that with proper design of amplifiers and attenuators there will be diffusion and equivalency of variety over time. Unlike natural systems, "it is management's job to DESIGN the necessary amplifiers and attenuators" (Beer, 1979, p. 97) as the engineering of variety in a complex system.

The terms Variety Attenuation, Variety Amplification and Transduction from preparatory work were considered part of the initial set of components, terms or categories forming the constructed codes used during the first iteration of Open Coding. What started to emerge were significant sources containing Variety Attenuation and Variety Amplification and limited occurrences related to Transduction. Transduction will be discussed following that of Variety Attenuation and Variety Amplification.

During Open Coding, searching on Variety, Attenuation and Amplification identified sections of text (sometimes an entire paragraph or a diagram/figure) where the specific wording, relative to channel of communication, the intent of Attenuation or Amplification was coded. Additionally, a specific review of the coding relative to Mode, Direction, Product, and

Technology (Conveyance) was also accomplished to determine if the related data conveyed the intent to accomplish Attenuation or Amplification.

Associated with each channel of communication there were specific mechanisms of Variety Attenuation and Variety Amplification. Appendix F displays the count of Communication Mechanism relative to the Direction of a Channel of Communication. The Communication Mechanisms that are associated with Variety Attenuation and Variety Amplification are Mode, Product, and Technology (Conveyance). Found in the source material were instances where the Author specified the use of a mechanism/s to achieve Variety Attenuation and Variety Amplification. What was found was that there was a significant preponderance of Variety Attenuation mechanism occurrences versus Variety Amplification. Secondly, Variety Amplification was not restricted to a limited a specific Direction between VSM Functions.

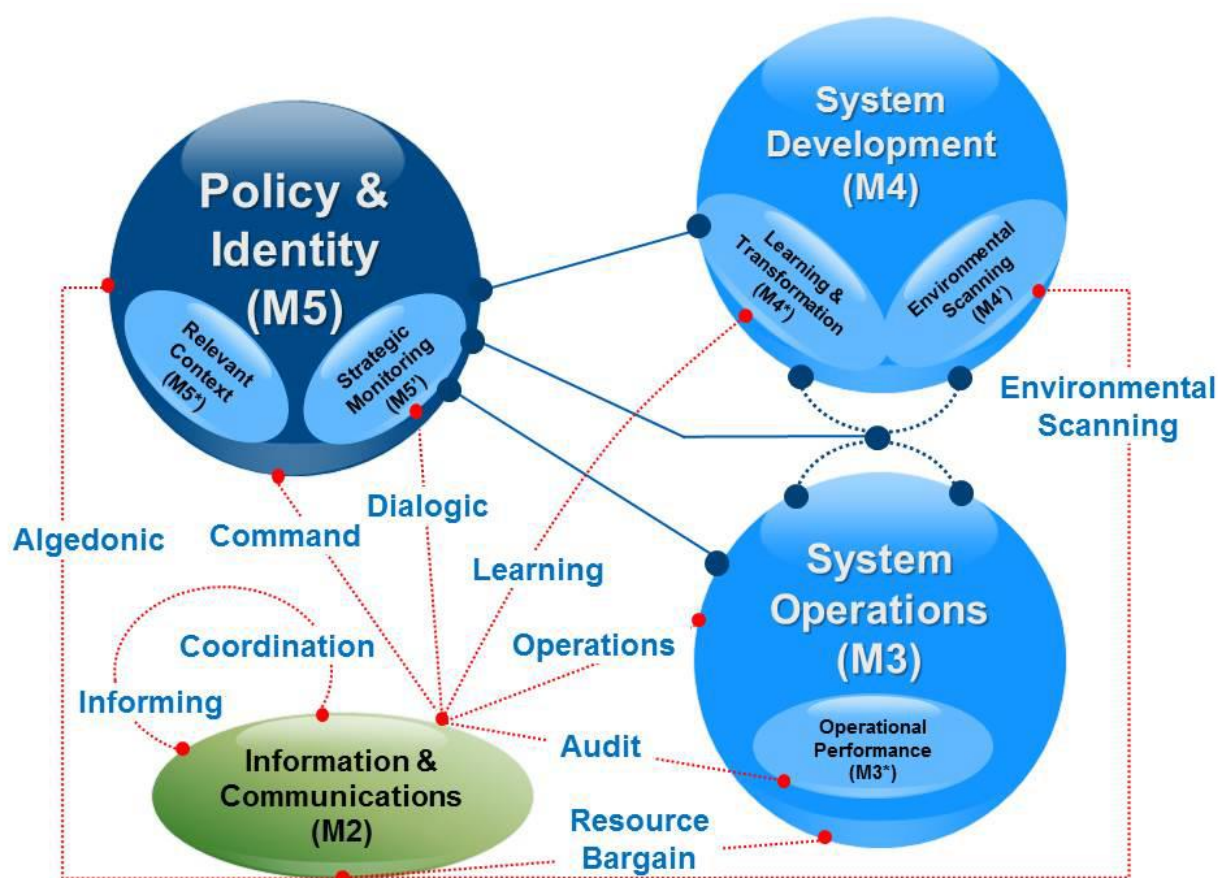
The specific mechanisms of Variety Attenuation and Variety Amplification were present in all channels of communication. Table 18 presented below shows the relationship between the Concept Groups and the respective Sub groups and the count of mechanisms that were coded as Variety Attenuation or Variety Amplification. As this breakdown comes from the same coding information, it again shows the same preponderance of Variety Attenuation to Variety Amplification. However, it also demonstrates that there are mechanisms of Variety Attenuation that can be robustly used in any of the Concept Groups. This gives to the Source great flexibility when going about communication design. While there are less mechanisms of Variety Amplification found in the data, it appears there was still a sufficient amount to support communication design.

**Table 18: Count of Variety Attenuation and Variety Amplification Mechanisms relative to Concept Groups**

Concept Group	Sub Group	Variety Attenuation	Variety Amplification
Mode	Non-Verbal	35	2
Mode	Verbal	5	0
Mode	Verbal & Non-Verbal	68	34
<b>Mode Total</b>		<b>108</b>	<b>36</b>

Concept Group	Sub Group	Variety Attenuation	Variety Amplification
Product	Advertisement	5	2
Product	Business Practices	48	28
Product	Directive	8	4
Product	Report	68	11
<b>Product Total</b>		<b>129</b>	<b>45</b>
Technology	Channel	23	8
Technology	Computer	44	2
Technology	Computer and/or Internet	26	20
Technology	Document Depository	0	1
Technology	Establish network	6	1
Technology	Internet	4	0
Technology	Mailing List	3	0
Technology	Management Channel	1	0
Technology	Meeting Face to Face	37	16
Technology	Personnel Change Location	1	3
Technology	Physical Organization	1	0
Technology	Video Feed	1	1
<b>Technology Total</b>		<b>147</b>	<b>52</b>

When discussing channel capacity, the technology used has a direct effect. Previously it was stated that with current technologies a better mapping/representation of the VSM would be a single line representing a channel of communications connecting the functions and use of arrows at both ends would reflect that Products are being conveyed in both directions. The latest representation of Complex System Governance based upon recent research Figure 13 below shows single line connections between the metasystem Functions (M2-M5).



**Figure 13: Nine interrelated functions that form the metasystem**  
(Used by permission of C. Keating)

If there were several different channels connecting functions and not knowing which channel had a higher capacity or rate, then a general communication design would favor greater amounts of Variety Attenuation, which the data shows. The data shown is for a single channel and not several channels of communication for a particular function. Additionally, Table 18 presented above shows that within the Concept Groups that Technology (Conveyance) that there were more mechanisms coded as Variety Attenuation or Variety Amplification than Mode or Product. This is consistent with an overall effect of technology which from the articles reviewed is expected to have the least effect on Mode and highest on Technology (Conveyance).

## Transduction

Transduction is the translation of information across the boundaries of systems where Beer (1979) described this important function “Transduction” of bringing stimulus into a system. Beer captured this in his Third Principle of Organization indicating the capacity of transduction with respect to variety, “Wherever the information carried on a channel capable of distinguishing a given Variety crosses a boundary, it undergoes Transduction; the Variety of the transducer must be at least equivalent to the Variety of the channel” (Beer, 1979, p.101). When considering control “Autonomic control must correct imbalances to the internal environment; the first necessity is to detect the change; receptors then alter their state, transducing the change into efferent impulses which then go to the control center” (Beer, 1981, p. 103). The VSM describes two system type interfaces associated with the S1 (Productive) and S2 (Coordination) functions with respect to the environment (Table 19).

**Table 19: S1 and S2 Functions with Environment**

<b>S1 Function with respect to Environment</b>	<b>S2 Function with respect to Environment</b>
Provide direct interface to the local system environment. (Keating, <i>et al.</i> , 2012).	Environment areas to account for include: commercial, social, demographic, technological, political, legal, economic, ecological, and educational. (Ríos, 2012)
	Maintain environmental scanning, analysis, and interpretation. (Keating, <i>et al.</i> , 2012)
	Maintain models of the systems for other subsystems and the environment; guides system transformation; identify system trends and patterns. (Keating, <i>et al.</i> , 2012)

Beer noted that “System Four is the innovation generator that uses existing channels and transducers through which to stimulate and interrogate the problematic environment” (Beer, 1979, p. 238). Beer does not indicate that transduction is any less important for the S1 than the S4, nor is there an indication that the makeup of the mechanism would be different.

The term Transduction (Transducer, Gateway and Transduction) from preparatory work was considered as part of the set of components, terms or categories forming the initial constructed codes used during the first iteration of Open Coding. The search through over 560

source articles found only 19 articles where Transduction was discussed. These discussions were centered on the need for Transduction and what it achieves. A good example of the description of Transduction is provided by Espejo,

That communications between agents and actors need transducers. Transducers are media that transforms signals from one expression into another expression that is more appropriate to the receiver. They are necessary every time that signals cross a boundary; they change an ontology into another making signals more meaningful to receivers. A decoder alters the input code into internally meaningful code and an encoder alters the output code into externally meaningful code (Beer, 1985). (Espejo, 2015, p. 1023)

The coding of these articles did not create descriptions of the consistency of the mechanisms of Transduction. This was in stark contrast to the coding that emerged for Variety Attenuation and Variety Amplification. When Beer was discussing Variety Amplifiers and Variety Attenuation, “when they are not designed, they simply occur because Ashby’s law asserts itself” (Beer, 1979, p. 92). The work of Holten and Rosenkranz (2011) point out several cases where “Facing failed design, requisite variety asserts itself in other ways so that Ashby’s law always holds and varieties are balanced” (Holten, 2011, p. 565). Unlike Variety Attenuation and Variety Amplification, none of the articles implied that Transduction creation would be part of emergence or the balancing of variety. From a cybernetic perspective, the absence or non-operation of Transduction is a pathology that is part of a failure in design of the channel of communication.

Understanding the requirement for Transduction, one might question if a mechanism of Transduction is relevant with respect to channel of communication design. Particularly, with respect to current technology, or the possibility that the design of channels of communication having reached stability and maturity with respect to Variety. Thus, the suggestion that Transduction can always be considered as an integral part of the communication design process. The integrated aspect of the Concepts of Direction, Mode, Product, and Technology (Conveyance) could imply that Transduction need not be considered. The researcher does not agree with this premise, rather considers Transduction part of the underlying influence of Intent composed of Identity (motive/intent) as part of Complex System Governance and Variety Attenuation and Variety Amplification that will be discussed next.

## Identity

The research has shown that for a communication design there are four Concepts that are interlinked forming the necessary part of communication design. The previous sections have described the mechanisms of Variety Attenuation and Variety Amplification working in concert with the Concepts. Transduction, while there were no specific mechanisms that emerged from the data, is still considered of such significance that inclusion in the emerging framework of Channels of Communication Design is essential. This section will address the influences of Identity on the framework.

Collected in Table 20 below are a set of statements from VSM and CSG literature with respect to Identity. What the reader will notice is that Identity does not have a single definition,

**Table 20: Identity**

Identity is the collection of primary activities of a viable system (Espejo <i>et al.</i> , 1996, p. 110)
Sustaining a coherent identity supports consistent decision, action, interpretation, and strategic priorities. (Keating <i>et al.</i> , 2014, p. 269)
Identity is the persistent structure of the organization (measure of identity) (Herring, 2002, p. 60)
Identity of the organization can be expressed terms of the purposes it is to pursue. (Jackson, 2003, p. 89)
Identity must express and represent the purposes, but, obviously, should not be the sole repository of identity. (Jackson, 2003, p. 89)
The identity derived from purposes need to be derived taking into account the state of the organization's environment and the opportunities and threats that exist. (Jackson, 2003, p. 89)
Professional identity accommodates attributes, beliefs, values, motives, and experiences in terms of which people define themselves in a professional role (Schein, 1978). (from Khuong, 2014, p. 229)
Organizationally professional identity is seen to evolve interactively with role change (Ashforth & Saks, 1995). (from Khuong, 2014, p. 229)
The collective message conveys an organization identity through every form, manner and medium of communication to the respective stakeholders. (Mohamad, 2004, p. 117)
A business has relationships with stakeholders in its environment. These relationships are necessary for the business to maintain its identity as distinct from other businesses. Maintaining a separate identity defines a business' success and survival. (Regev, 2004, pp. 696-697)
The number of norms that a business maintains is very large. Examples of such norms are the stability of a business' name, its reputation, its revenues, its profits, its number of employees, etc. The norms maintained by the business define its identity. A norm is stable but not necessarily static. It may change over time as the business adapts to its environment, for example, when the revenues grow as the business adapts to a growing market. (Regev, 2004, p. 697)

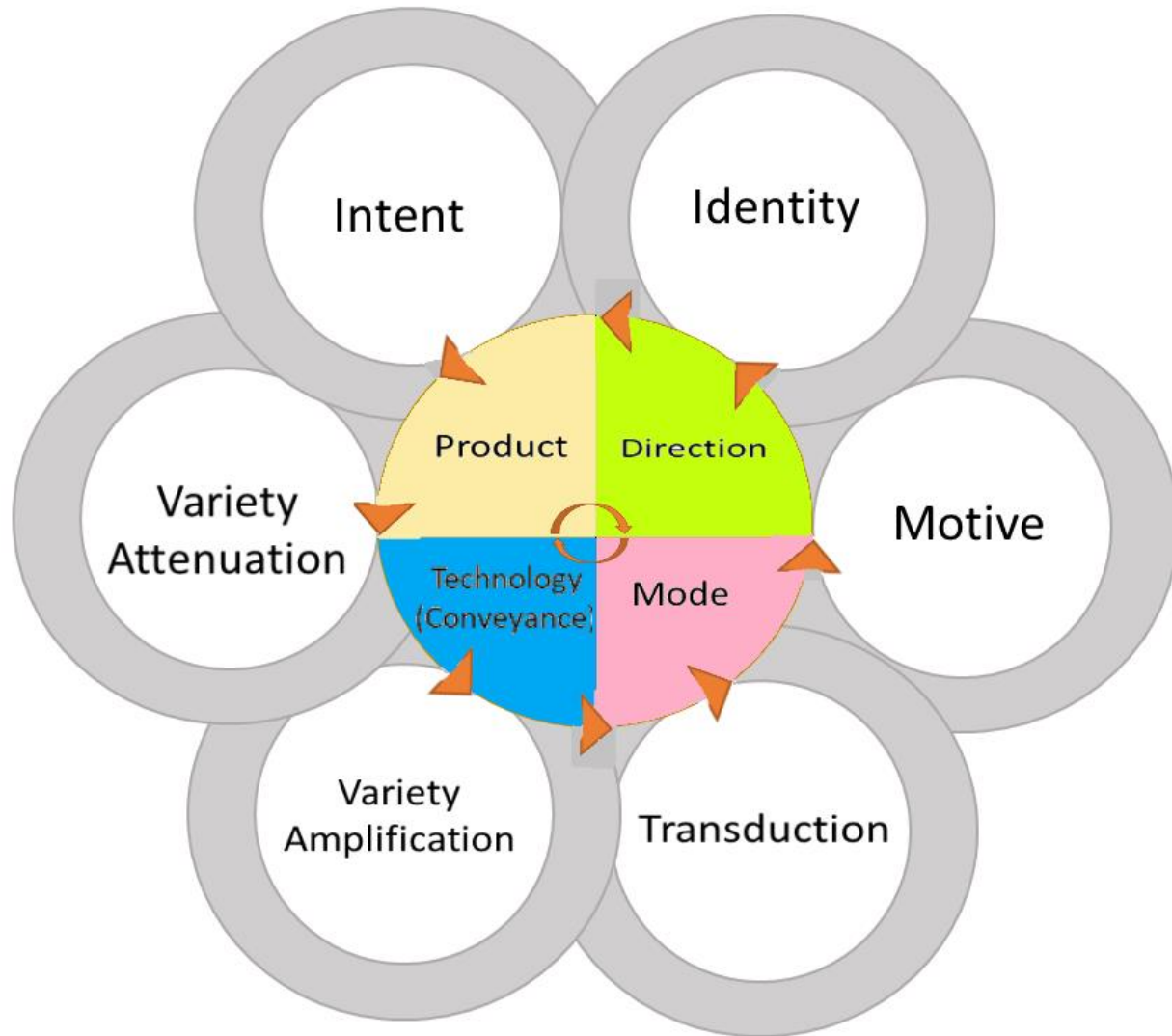
Once the boundaries of the organization, along with its identity and purpose, have been clarified, the next step is to identify the relevant environment where our organization carries on its activities. (Rios, 2010, p. 1535)

rather there are a set of terms such as; primary activities, persistent structure, purposes of a system, relative to system boundaries and environment, accommodates attributes (beliefs, values, motives and experience), and is communicated internally for operation and externally additionally for messaging. The nature of Identity is dynamic and evolves interactively due to external and internal changes. The reading of the source material with respect to Identity finds that Identity and Communications are the core attributes of Control.

With respect to channels of communication, the Identity of the Complex System needs the channels of communication to support the primary activities for which the entities in the system respond to the system inputs as well as convey the output. The achieved or designed structure of the channels of communication provides a persistent structure that actively supports the selective purposes of a system. The channels of communication have the interface with the system boundaries and the external environment. The system is dependent upon information of the environment as it is 'in the now' and information that can impact and shape the environment 'in the tomorrow'. These influences of information, while they will evolutionarily modify the Identity, exist on a time scale that is subject to the nature of the system, with the internal changes occurring at a different rate due to beliefs, values, motives and experience of the individuals associated with the metasystem functions. Finally, the information generated internally as well as from external sources is conveyed externally to reflect a messaging of the systems Identity.

This background on Identity brings forth a similar conundrum as Transduction. While there were 1,240 occurrences of the term Identity, there were no relationships with sections of text (sometimes an entire paragraph or a diagram/figure) where the specific wording was relative to channel of communication. The relationship of Identity was with the metasystem function of M5: Policy. The researcher considers Identity (Intent/Motive) similarly to Transduction as part of the underlying influences on the Channel of Communication Design Concepts. Figure 14 below shows these influences graphically surrounding and iteratively affecting the mechanisms of communication.





**Figure 14: Influences on Channel of Communication Design Concepts**

## FACE VALIDATION

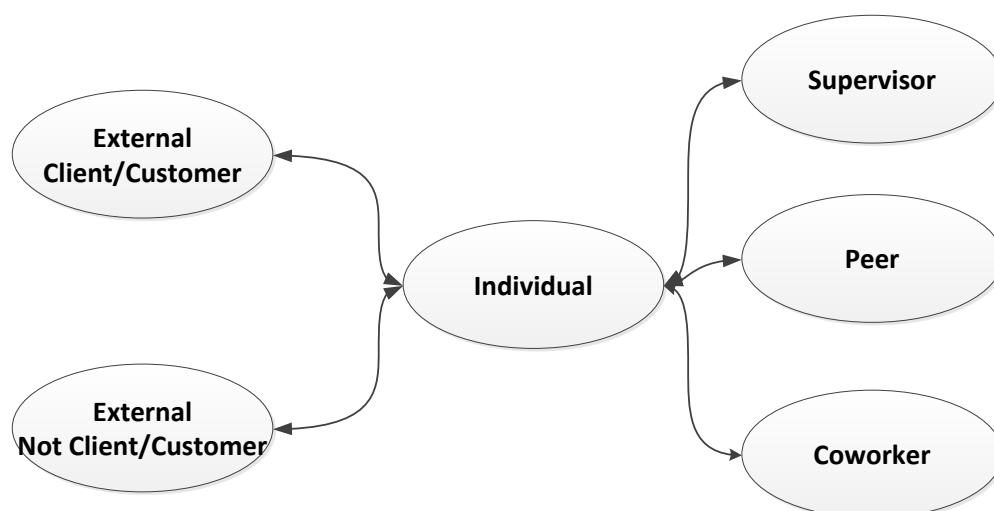
Face validation was accomplished for the purpose of mitigating concerns relative to qualitative research and to apply the developed theoretical communication mechanisms in a practical application on a Complex System. The researcher chose to use confirmability as a mitigation technique where confirmability refers to the degree to which the results could be confirmed or corroborated by others (Creswell, 1998; Patton, 1999). A particular strategy that was used was Triangulation where according to Carter (2014), triangulation can be used to test validity through the convergence of information. Specifically, “Data source triangulation involves the collection of data from different types of people, including individuals, groups,

families, and communities, to gain multiple perspectives and validation of data” (Carter, 2014, p. 545).

The deployment of a survey instrument drawn from the construct provided by this research enabled the generation of a clear picture of the operations of the communications mechanisms. The development of the survey instrument now enables practitioners an ability to understand the communication mechanisms with respect to a channel of communications. This understanding will provide the basis for more informed design and assessment as well as the means to be able to center the system of interest in a framework such that changes are identifiable.

The Survey Instrument design and development was described in Chapter IV. The use of the Qualtrics service significantly contributed to the ease in survey development as well as ensuring the confidentiality of the respondent as well as not asking personnel questions. This requirement limited establishment of Organizational Identity within the context of Complex System Governance as well as limiting the identification of the functional role of the Survey Participant. Two different organizations, an Engineering Firm and an Insurance Agency were approached with the request of having their employees participate in taking the survey instrument; over 40 individuals completed the instrument. The consolidation of Survey Participants responses are presented in Appendix G.

The survey instrument was designed so that Respondents would provide descriptive answers vice sets of multiple choice options. None of the terms used in the Communications Mechanism Construct were used in the survey. The language used in the survey implied that there was an orientation of the Participant (Individual) relative to other identified individual/s or groups as shown in Figure 15 below.



**Figure 15: Survey Instrument Participant relationship with Individual/s or Groups**

The Participant was asked a series of questions that hopefully would lead to a description of Identity and Purpose for themselves, their group and their organization. The next set of questions dealt with the applicable five channels of communication relative to Product, Technology (Conveyance), Direction, and Mode without the use of these terms. The question ‘What are the Communication Methods that you use with your Peers?’ is an example of where Communication Methods is used vice Communication Channel. The term ‘use with’ vice Direction implies that either the Individual or the identified individual/s or groups may be the Source or the Receiver. Finally, CSG Metasystem Functions with an interface with the Environment are found in the M1 and M4’ function as described in Table 1. To better describe the Participants identity, all participants were provided questions on external individuals.

The survey question flow was structured so that the Survey Participant would answer several general questions and continue with one of three paths (Member of a Group/Project(s) and not a Supervisor, Supervisor and not directly involved in Project(s) and Supervisor and a Member of Project(s)). The consolidation of the responses for each of these three paths is presented in Appendix H.

The responses by Survey Participants that selected ‘Where Member of a Group/Project(s) and not a Supervisor’ indicated that they predominantly used Non-Verbal communication (electronic mail/email/E-mail, text) to accomplish their communications. The two exceptions were communicating to Supervisor or to Co-Workers (not Peers) where their response was

Verbal and Non-Verbal (face to face/face to face communication/face to face discussions/face to face meetings/person to person/verbal/direct conversation/ meeting). The other exception was the communications to external individuals (not Customer or Client) was Verbal (Phone/Telephone/calling/ teleconferences).

The path of ‘Supervisor and not directly involved in Project(s)’ was the smallest group of Survey Participants. Overall, the responses indicated the use of Non-Verbal communication (electronic mail/email/E-mail, text and Drawing/written report/letter). The Survey Participants that identified with ‘Supervisor and a Member of Project(s)’ overwhelmingly selected Non-Verbal (electronic mail/email/E-mail, text) to accomplish their communications. The exception was for communications with Co-Workers (not Peers) where the preference was Verbal and Non-Verbal (face to face/face to face communication/face to face discussions/face to face meetings/person to person/verbal/direct conversation/ meeting).

The Survey Participants overall response to their communication to Peer, Supervisor, Customer, Co-Worker, Client and Groups Supervised found an overwhelming response to be Non-Verbal (212 responses), followed by Verbal and Non-Verbal (145 responses) and finally Verbal (129 responses). The breakdown dealing with communications to Peer, Supervisor, Customer, Co-Worker, Client and Groups Supervised is displayed in Table 21 below.

**Table 21: Breakdown of Communication to Individuals**

	<b>Peer to Peer</b>	<b>To Supervisor</b>	<b>To Customer or Client</b>	<b>To external individuals not Customer or Client</b>	<b>To Co-Workers</b>	<b>To Groups you supervise</b>	<b>Total Responses</b>
Non-Verbal	45	37	47	29	25	19	202
Verbal Non-Verbal	34	29	23	10	28	13	137
Verbal	32	22	21	22	17	10	124

The Survey Participants responded to communication with external individuals, customers or clients with primarily the communication method response of Non-Verbal (e:mail,

e:mail with attachments and followed distantly by drawing/written report/letter). The initiator of the communications response as well as the intended receiver of the communications included such terms as: individuals, customers, clients, group member, staff, engineer, manager, and supervisor.

The survey instrument regardless of flow, contained several general questions to help identify CSG functions (see Table 1, CSG Metasystem Functions for full description of the functions) that best aligned to the Survey Participant based upon the responses. Additionally, several questions were phrased to determine initiation of communication, receiver of communication as well as and substituent the role of supervisor and member of a group. The consolidation of these responses for only two CSG Functions (M3 and M3\*) is presented in Appendix I as demonstration of the capture of responses from the survey.

The responses by individuals that most associated with the *System Operations* – Metasystem Three (M3) (focused on the day to day execution of the metasystem to ensure that the overall system maintains established performance levels) were similar in that the responses were predominantly Non-Verbal communication (electronic mail/email/E-mail) followed by Verbal and Non-Verbal communication (face to face/face to face communication/face to face discussions/face to face meetings/person to person/verbal/direct conversation/ meeting) closely followed by Verbal (Phone/Telephone/calling/ teleconferences). A similar set of responses was also found for the responses by individuals associated with *Operational Performance* – Metasystem Three Star (M3\*) (monitors system performance to identify and assess aberrant conditions, exceeded thresholds, or anomalies). While some Survey Participants could be associated other CSG Functions (M4, M5', M1 and M5) calling out these responses has limited contribution to the overall effort for the face validation.

The survey instrument and the Survey Participant responses did not divulge the identity of the participants. The responses reflected Survey Participants full engagement in answering the questions, the responses were devoid of 'none' related comments and were directly applicable to the survey questions. The responses support the perspective that communication between individuals or functions does not require separate channels of communications, but the technology may require a unique technology channel. The grouping of responses, if only organized by Mode, found the overwhelming Mode to be Verbal. This is consistent with the development of Communication Technology, where the trend is to mimic the ability of two

individuals to engage in communication that includes audio and visual. The mode and technology at the time of Shannon and Beer did not mimic an actual two-person communication. With the advances in technology there is simultaneous transmission of video and audio signals. While Skype as a Technology (Conveyance) was not the most mentioned response, the response of Meeting/Face to Face and Phone/Telephone still indicate that there is a strong desire for personal over the impersonal nature of e:mail.

The Survey Participants responses beyond the above-mentioned consolidations provided a set of findings in relationship to Complex System Governance communications. The below Table 22 provides the summary breakdown of these issues and finding comments.

**Table 22: CSG Issues**

CSG Issue	Finding Comment
Governance	Survey Respondents level of understanding of Governance of Complex system can be termed as nascent.
Purpose	Survey Respondents could describe their work, but did not relate their work to a channel of communication.
Identity	Survey Participants did not indicate or elaborate on their Identity beyond a concise Job Title. Note. This lack of the self-identification to a specific Function in the Governance of Complex system may be due to the not specifically having a listing of some of the CSG Functions presented for the Survey Participant to identify with, chose or compare with.
Function	Survey Participants did not link their function to their responses. For example, when responding to the question “What are the Communication Methods that you use with your Supervisor?” the respondents simply answered with a set of methods. The responses did not answer the question for example with; my supervisor desires the following methods to be used or for this supervisor we do it this way.
Variety Attenuation/Amplification	Technology (Conveyance) was identified but how the Variety was Amplified or Attenuated through what was in place not identified.
Interface	Well described.
Product	Other than the use of terms of Drawing/written report/letter the why or intention of the Product not articulated.
Technology (Conveyance)	Technology (Conveyance) was well described but the why, design, current improvements were not related. When asked what new technology could be responses were limited to improvement is use of current communication method such as; Help us come prepared. If there will be a round-table discussion, provide a heads up so we can ponder it beforehand. Not everyone thinks best when put on the spot. Add the ability to share documents. And Have clients answer the phone.
Direction	Well described.
Mode	Well described and matched items found in Grounded Theory work.
Transduction	The need of having transduction between the internal of the organization and the external client/customer or external individuals was not indicated.

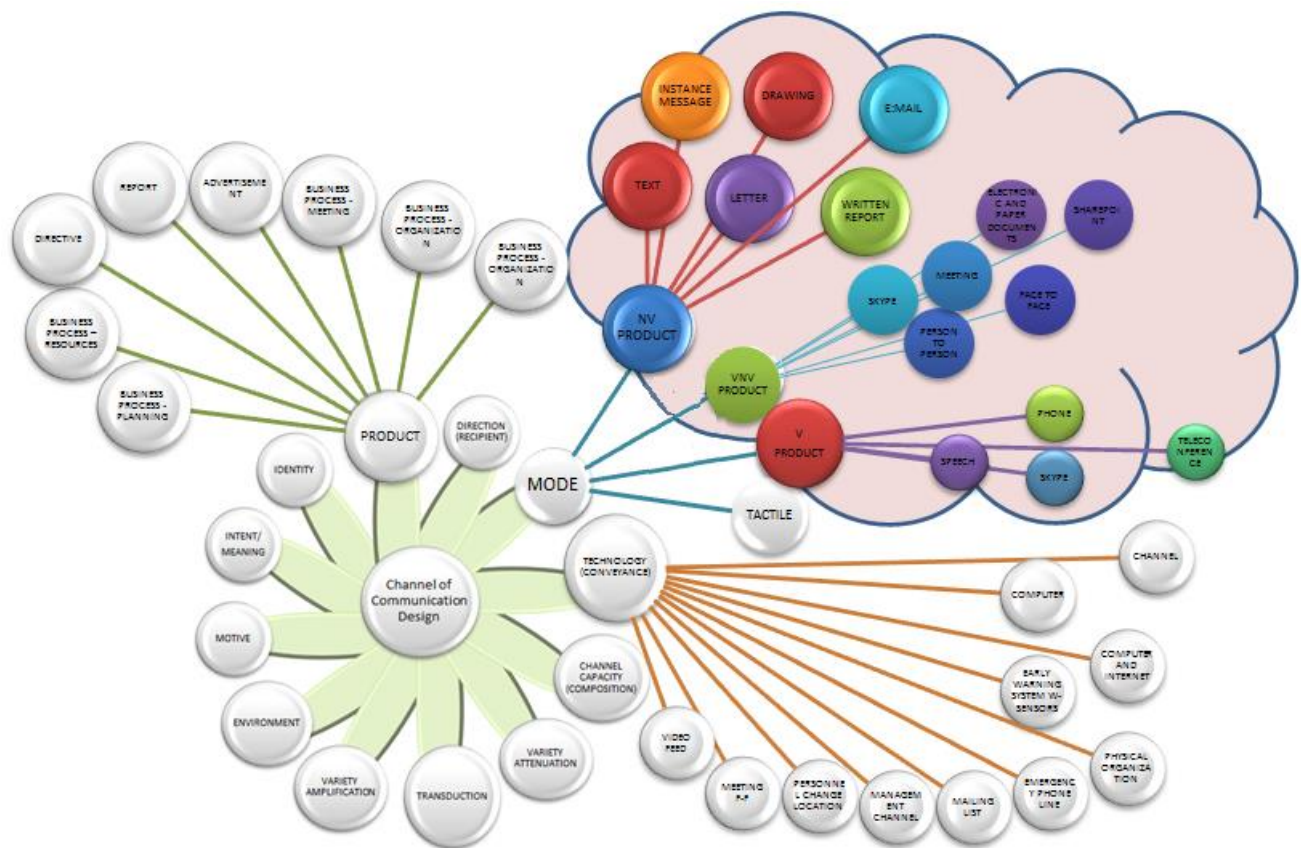
The results of using the survey instrument supported the face validation conclusion that the communications framework can in fact provide utility and insights stemming from deployment in an operational setting. As articulated above, the participants' responses were very similar to the terms found in systems literature that lead to the development of the concepts of Direction, Mode, Product, and Technology (Conveyance). While the systems literature was more direct on Product and Mode as well as the interdependencies of all the concepts with Identity (motive/intent), Variety Attenuation, Variety Amplification and Transduction, potential modifications to the Survey Instrument were suggested from the application. The primary focus of these modifications would be directed to better expose responses to areas of interest concerning communications. Secondly, rather than be administered anonymously, the modifications would enable an initialization study of communications in an organization/system using the full breadth and depth of participation in Complex System Governance functions.

## **RESULTS SUMMARY**

This chapter presented the results of the inductive qualitative analysis using the grounded theory method. The results of coding and synthesis lead to the development of the Concepts of Direction, Mode, Product, and Technology (Conveyance). These concepts were discussed and their integrated support of a communication design. Additionally, taking the concepts and core categories, a face validation was accomplished to determine how good the fit of the concepts was and the utility based on deployment in an operational setting. The Survey Instrument found excellent correspondence with the developed concepts helping to established that there was soundness in the qualitative research. Additionally, the survey results show the potential utility in the survey instrument as a basis for possible elaboration.

Figure 14 provided a presentation of an integrated merger of the influences on the design of Channels of Communication other than the Concepts of Direction, Mode, Product and Technology (Conveyance). As the design process for Channels of Communication goes beyond a proscriptive selection of the mechanisms (Direction, Mode, Product, and Technology (Conveyance), including lifecycle factors as well as the dependencies between Mode, Product, and Technology (Conveyance) this is better reflected in the single representation shown in Figure 16 below.

The Influences on Channel of Communication Design (Figure 16) are fanned around the circle labeled 'Channel of Communication Design'. There are at least 12 specific influences that this research has identified and addressed above. Relative to three of this influences; Product, Mode, and Technology (Conveyance) are extensions containing a short description. The various technologies used in the channels of communication are associated with Technology (Conveyance). Product lines that were identified passing through the channels of communication are radially presented with Product. Mode has the four coded forms; Non Verbal, Tactile, Verbal, and Non Verbal & Verbal, displayed in a pink cloud representing the dependency between Product and Mode. Associated with each of the coded forms are the specific products.



**Figure 16: Influences on Channel of Communication Design**

While only four of the twelve Influences on Channel of Communication Design were presented this is an indication of the current state of identification of Communication Mechanisms. The



follow-on chapter, Chapter VI will provide conclusions, interpretations and new directions as the result of the research.

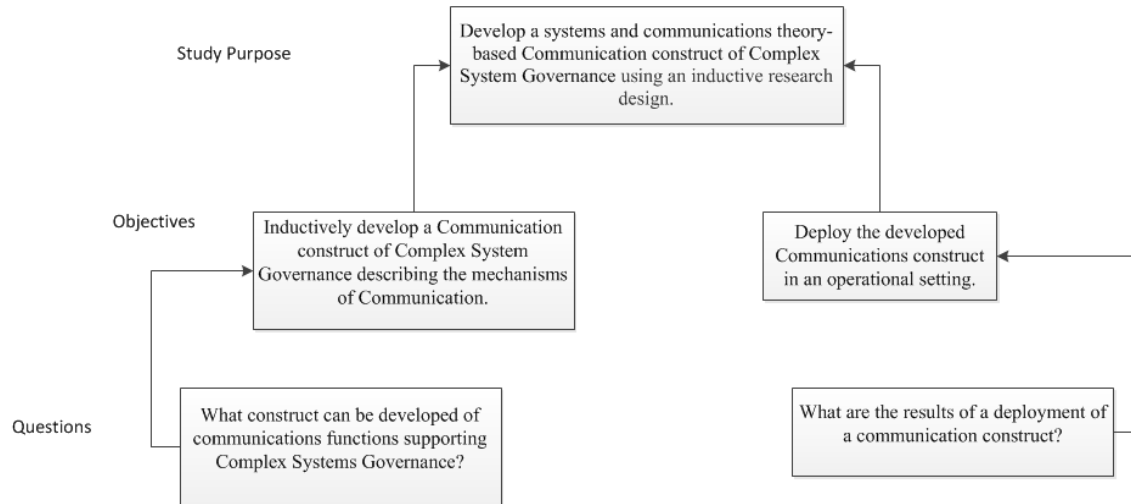
## **VI. CONCLUSIONS**

### **CONCLUSIONS AND INTERPRETATIONS**

The previous chapter presented the mechanisms of communications as well as the face validation. This chapter provides the conclusion and implications that resulted from this research effort. Interpretations of the significance and implications of the work for theory (fields), methodology, and practice are presented and explored. Examination of implications for the Body of Knowledge in communications and the emerging field of Complex System Governance are discussed, including identification of fruitful areas for future research directions. Results from the application of the inductively developed communication construct are also examined for implications of research practice in the engineering management and systems engineering fields. The examination of implications for practice, practitioners, and future research areas in the professions is also presented.

### **RESEARCH CONCLUSIONS**

This section discusses the overarching conclusions arrived at from the research. As found from the literature review as described in Chapter II, there is a gap in understanding how communications are constructed and what, if identifiable, are the various mechanisms that work in an integrated fashion to ensure that the meaning developed by the Receiver will match the meaning of the Sender. Figure 16 below graphically depicts the research questions and objectives. The purpose of this research was accomplished, as a construct for communications in Complex System Governance was developed.



**Figure 17: Research Questions, Objectives, and Purpose**

The research was undertaken to fill the shortcoming in the body of knowledge and the two objectives of the research were met. Chapter V, the previous chapter contains the fully articulated Communication Mechanisms that were developed through Grounded Theory, inductively built from the literature from the following fields: Systems Theory Management Theory, Knowledge Management, Organizational Theory and Organization Design. The use of a limited Face Validation was developed using the Communications Mechanisms as a framework for survey development. The instrument showed that there was a good fit of the concepts in an operational setting.

## CONTRIBUTION TO THE THEORY

This research effort has contributed to the body of knowledge in the fields of Management Cybernetics, Complex System Governance, and Communications Theory. While the literature concerning the VSM as well as Communication Theory identified that conceptually there are Communication Mechanisms, they are not specifically identified and not aligned to the necessity to ensure that the meaning derived by the Receiver is the same as that intended by the Sender. Additionally, while VSM as a mechanism of Variety Engineering is understood, the actual mechanisms that enable the increase or decrease of Variety are not articulated. Additionally, how these mechanisms related to Variety are integrated with Communication

Mechanisms to achieve the desired Variety Engineering is provided by this research. This articulation of Communications dependency on the Influences on Channel of Communication Design (Figure 16) lays out a theoretical foundation for future research in Knowledge Management, Management Communications, and Culture Communications. The 12 specific influences that this research has identified and addressed satisfactorily (only four) does not close out the need for future research, rather the framework provides focus areas.

The more sophisticated consideration of systems communication channels and the exercise of communications in complex systems, beyond the depth provided in the existing body of knowledge provide a substantial step forward in filling this theoretical gap. More specifically, the communications construct: (1) extends the existing communications paradigm in Communications Theory as well as Management Cybernetics (evolving and extending the paradigm to be more robust and congruent with the advances in technology having occurred since the original development of the basis for the theoretical dispositions in the both Communications Theory as well as Management Cybernetics fields), (2) challenges the depth of development and articulation concerning the nature, role, and function of communications channels in Management Cybernetics and Complex System Governance, and (3) provides a rigorously developed construct of communications that both challenges and extends the existing body of knowledge related to communications in complex systems. This elaboration of communications through the development of the Construct for Communications in complex systems, stemming from this research, provides a research-based extension to the existing body of knowledge.

Knowledge contribution from this research serves to address significant gaps in the body of knowledge for Communications Theory, Management Cybernetics, and Complex System Governance. Communications Theory has been challenged to deepen more limited traditional models by the inclusion of extensions to include distinctions related to Direction, Mode, Product, and Technology (Conveyance). The construct developed from this research does not negate prior seminal works in communications (e.g. Shannon and Weaver), but rather offers an extension to existing paradigmatic and theoretical formulations of communications in complex systems. The inclusion of elements as Mode, Product, Direction, and Technology (Conveyance) provides a significant elaboration of early theoretical works and the more limited perspectives that do not include these additional explanatory theoretical inclusions. Management Cybernetics

has been extended by a deeper accounting of the communication channels nature, role, and function in relationship to variety amplification, attenuation, and transduction. The extension and examination of the transduction function as well as system identity are significant advancements provided for the Management Cybernetics field. Additionally, Management Cybernetics has been advanced by the depth of examination of both the theoretical formulation of communications (e.g. variety engineering) as well as the explication in greater depth of the communications channels in viable systems. Prior to this research, although communication channels in the Viable System Model (Management Cybernetics) were acknowledged, the more rigorous examination of the execution of those channels was relatively unexamined. Thus, Management Cybernetics has been challenged to advance the understanding and theoretical explanation of communication channels. Complex System Governance has been extended by the incorporation of a more focused development and accounting of the nature of communications with respect to a central tenet of ‘variety engineering’ as well as a more rigorous accounting of communications in such areas as system identity. As Complex System Governance is in the embryonic stages of field development, the rigorous examination and theoretical accounting of communications provides substantial grounding and conceptual advancement of the field.

## **CONTRIBUTION TO THE PRACTICE**

The field of Complex System Governance is new and developing. Within this emerging field, and the continuing drive to advance practice, communications continues to be at the center of the further development of the field. More specifically, the communication channels used by the metasystem provide for understanding the exchange of all information and subsequent interpretation to support subsequent decision and action. However, while recognized, the specific practical mechanisms to understand communications and how this is achieved in support of system governance remain elusive. However, stemming from this research effort, several practical contributions stemming from the examination of communications for Complex System Governance have been suggested. The prospects for utility of using the communications construct to better identify, analyze, and provide developmental directions for advancing communications were confirmed in the research. While this was not the major thrust of the research, the ‘face validation’ application demonstrated the unfolding potential for further practical application development. The further development and inclusion of practice-based

methods, tools, and applications related to communications for Complex System Governance might hold significant insights for practitioners as they deal with design, analysis, and development of modern complex systems. An entirely different array of decisions, actions, and interpretations might accrue from the insights offered by derivative practical applications stemming from the research. This practical set of implications might be beneficial across the spectrum of the essential activities engaged for Complex System Governance, including design, execution, development/maintenance, and evolution of communications.

The results of this research provide to the practitioner, especially when viewing a system of interest, the ability to understand the communication mechanisms with respect to a channel of communications. The deeper understanding of communications in complex systems provides a basis for more informed design, assessment, and development of communications. Although at present there are not a host of deployable support tools drawn from the construct provided by this research, the practice foundations have been established. Notwithstanding that current lack of research derived tools to support communications development, the framework itself, and corresponding ‘face validation’, offer practitioners a more advance way of thinking and identification of developmental issues across the communication channels.

In sum, three primary practice implications are suggested. First, the construct of the mechanisms enables the observation, review, assessment and articulation of the state of the channel of communications. What has been called ‘barriers to communication’ can now be linked to specific mechanisms such that an organization may better understand the issues relative to their channels of communication. This offers practitioners a more informed perspective relative to better examination, understanding, and response to communication issues. Second, practitioners can place communications within a larger context of complex systems. Instead of considering communications as a ‘separate category’ of system function, placed within the larger Complex System Governance framework gives practitioners a broader perspective of communications, the relationship of communications to other critical system functions, and potentially more robust development alternatives based on a more ‘holistic’ view of the nature of communications with respect to the larger system. Finally, the face validation effort now provides, especially the Communication Survey Tool, a foundation from which further field of practice development can be engaged. While this was a first generation approach to examining communications, nevertheless it provides practitioners with a research informed approach to

examine communications. Further development will permit all interested practitioners of a system under study a method to view channels of communication in operation.

## **CONTRIBUTION TO THE METHOD**

With respect to methodological contributions, this research demonstrated how the use of grounded theory as a research method could be effectively deployed in a field (engineering) that is not generally a candidate for the method. Grounded Theory is normally associated with social sciences (sociology, psychology, public health, especially nursing). However, grounded theory provided to the researcher the methodology to deal with the subjective parts of Communications Theory and Cybernetics.

It is instructive that the richness of the research discoveries was made possible by the pursuit of a rigorous grounded theory research approach and supplemented by a 'face validation' application. It is somewhat doubtful that these discoveries would have been possible in more restrictive (theory testing) research designs. As such, the need for more robust research methodological alternatives for the engineering management and systems engineering disciplines are suggested from the present research. This does not demean other research approaches. On the contrary, it serves to elucidate the potential that other research approaches might bring to both engineering management as well as the systems engineering disciplines. On the methodological front, this suggests that development of management methodologies might be re-examined to include a more systems-based perspective related to communications. This might preclude exclusion of critical systems aspects identified in this research that were beyond the grasp of more traditional research methodologies (e.g. experimental). This research suggests that further methodological development and pluralism in the engineering management and systems engineering disciplines would be well served by a more robust accounting of the nature of systems theory as a more holistically based paradigm to inform research design. This also suggests that Grounded Theory, focused on communications in complex systems might prove advantageous in development of more advanced 'holistic' systems-based methodologies for engineering related disciplines. These methodologies might extend this research to other similar contexts and venues. This might suggest methodological pluralism in defining appropriate fitting of 'systems-based' methodologies to particular circumstances. However, as this research has shown, the more pronounced systems basis for consideration of communications in complex

systems might prove instructive in consideration, assessment, and selection of appropriate research methodologies, methods, and tools. The demonstration of the capabilities of Grounded Theory as a methodological approach might certainly be projected to development and deployment of methodologies in other similar research questions and contexts. Additionally, methods based on this research effort could be expanded to examination of communications from which future generalizations might be possible with rigorous analysis. In essence, the inductive method of research that led to the development of the Communication Mechanism construct furthers the applicability of the grounded theory to other inductive research areas.

## **FUTURE RESEARCH**

As discussed in Chapter IV, the researcher found at times that there were stimulated questions or ideas of potential relationships that needed to be reviewed. The review either incorporated them in the research or the review found some of the issues outside the scope of the research. This section will discuss several areas of potential future research.

Transduction and Identity were discussed in Chapter V and are considered by the researcher as part of the four underlying influences: Transduction, Identity, Variety Attenuation, and Variety Amplification, on Communication Mechanisms all contribute to Complex System Governance. The research found how Variety Attenuation and Variety Amplification influenced or facilitated channels of communication. The underlying construct of Transduction was not fully described. Whether the lack of literature on the subject is due to the current technology or has the design of channels of communication reached stability and maturity was not sufficiently described. There is a wealth of literature on the need for interface control between electrical and electronic systems, but the topic of conversion is limited to specific electronic measurement instruments. Research specifically on transduction may better develop how transduction influences the Communication Mechanism.

Identity is an area in relationship to communications that is ripe for further research. While associated with the metasystem function of M5: Policy, identity from systems and cybernetic literature does not have a single definition but instead offers a somewhat disjointed set of terms. The nature of identity for a system of interest would appear to be dynamic and evolving interactively due to external and internal changes. Appreciating that the core attributes of control include Identity and Communications, coupled with the notion that functions are



accomplished by humans as well as machines, the contextual relationship and construct (between Identity and Communications) would be an area of future research to better develop the construct.

The term Culture of Communications was often mentioned in literature discussing Organizational Communications and Knowledge Management for Organizations. The term implies that there is some grouping or community and with shared interests, collaboration and cooperation on shared goals that there is a developed culture with a specific communication vocabulary that sets this community apart from others. Using the same research method and looking for the occurrence of channels of communication and determining if there are similar Communication Mechanisms that equally apply would be an expansion of this research to another area of interest.

The literature dealing with Organizational Management and Business Cultures often stated that a continuous significant effort needed to be accomplished by management to reduce or eliminate ‘barriers of communication’. These barriers have associated with them a variety of solutions, were the authors are establishing a cause and effect relationship. It must be noted that in most cases a systemic pathological construct is not proposed, that in the methods and tools to be applied by this literature that the term *Satisficing* was not included nor did it appear that the recommended efforts, methods or tools would match the concept of Satisficing. The role of Satisficing in Communications either as an underlying part of Identity or, assuming that the ‘barriers of communication’ could be reduced to pathological constructs, what Satisficing methods and tools could be developed that would enable organizations to better understand the issues relative to their channels of communication and the measures that could be taken to alleviate the ‘barriers of communication’.

The survey instrument developed for the face validation allowed for a method of data collection from different groups of individuals, with the primary objective being the establishment of soundness in the qualitative research and demonstration of utility implications. The survey instrument can provide a snap shot in time of how participants view their means and methods of communication as well as provide an insight into the communications network. This initialization study of an organization/system will help establish the ‘as is’ for a full implementation of Complex System Governance. The tool was not designed to capture data to support an analysis of the maturity of the channels of communication of an organization/system.

However, the successful use of the Survey Instrument in Face Validation identified the specific items that need to be modified to evolve the Survey Instrument to be able to establish the ‘as is’ state of communications. Following this, support would be provided to monitor the operation of the channels of communication, lending itself to maturity analysis as well as understand impacts stemming from any modifications made to the channels of communication.

The design of a Communication System that supports a Complex System would be expected to experience significant changes as the result of external and/or internal sources. This research did not address this fact nor the rate of change that may be relative to the sources. It was not the intention of the researcher to imply that the all Communication Systems exist in a stable environment. As indicated previously in this section on future research, the underlying construct of Transduction was not fully described. Additionally, the underlying effect of emergence with respect to Transduction or the design of a Communication System was not fully explored.

Finally, this research suggests the potential development of several areas lacking in the current state of Complex System Governance research and development. Among these are: (1) further examination of the incorporation of the theoretical construct for communications into the larger field, reference model, and methodology for Complex System Governance, (2) definition and further development of the communications paradigm for Complex System Governance in relationship to existing paradigms (worldviews) of communications in communications theory and management cybernetics, (3) closer coupling of the systems propositions of systems theory to the construct for communications to potentially elaborate the construct underpinnings and inform applications for deployment, (4) definition of developmental needs for the methods, tools, and technologies to support deployment and utilization of the communications construct in practice applications, and (5) continue development and deployment of the communications construct and survey instrumentation to improve the practice of communications and support continued validation of theoretical concepts related to the theoretical formulation of communications in Complex System Governance. This research has provided an essential first step in more rigorous accounting of the nature, role, and utility of communications in Complex System Governance.

## CONCLUSIONS SUMMARY

The purpose of this research effort was to develop an understanding of how communications are constructed and develop a construct for communications in Complex System Governance. The objective was accomplished with an inductive research design and the second question was accomplished using a limited deployment of a survey instrument. Table 21 below summarizes the significant contributions for this research effort as described in detail in this chapter:

**Table 23: Significant Contributions of this Research**

<b>Significant Contributions of this Research</b>	
<b>Theoretical</b>	Contributed to the field of System Engineering, Management Cybernetics, Communications, and Complex System Governance.
	Provided a theoretical construct for communications for Complex System Governance.
	Articulated Communication dependency on Communication Mechanisms that are influenced by Variety Amplification, variety Attenuation, Transduction and System Identity.
	Articulated how System Identity and Communications are the core attributes of Control.
<b>Methodological</b>	Expanded the use of Grounded Theory to deal with the subjective areas of Communication Theory and Cybernetics.
<b>Practical</b>	Facilitated the observation, review, assessment of channels of communication.
	The ability to understand “barriers to communication” as specific to communication mechanisms.
	The capability to articulate the state of channel of communications using a survey tool.
	Provided a foundation of development of methods, tools, and techniques to support assessment, design, and development of communications for complex systems

The area of future research is stimulated from many issues that were identified during the research, but not within the scope of the research. Table 24 below will summarize the several areas identified for future research.

**Table 24: Areas for Future Research**

<b>Areas for Future Research</b>	
<b>Theoretical</b>	Further examination of the theoretical construct for communications and the

	underlying construct of Transduction.
	Develop a better understanding of the nature of identity for a system of interest and what is the relationship to external and internal changes.
	Determine the contextual relationship and construct between Identity and Communications.
	Investigate organizational Culture of Communications relative to Communication Mechanisms.
	Develop an understanding of what are the pathological constructs relative to Communication mechanisms.
	Determine if Satisficing can be relative to Communication Mechanisms and “barriers of communication”.
	Explore to effect of Emergence and Transduction on design and construct of a Communication System.
	Further development of the distinction of the communications paradigm for Complex System Governance distinct from existing communication paradigms
	Examination of system propositions from systems theory in relationship to communications in Complex System Governance
<b>Methodological</b>	Add to the Communications Survey Instrument a capability to capture maturity of Channels of Communication.
	Add to the Communications Survey Instrument a capability to monitor Channels of Communication in real time.
<b>Practical</b>	Modify the Communications Survey Instrument with the capability to receive inputs to monitor the operation of the channels of communication
	Modify the communications Survey Instrument with the capability to support development of current capabilities.
	Definition of methods, tools, and technologies to support further deployment of communications for Complex System Governance

The researcher welcomed the opportunity to conduct research on the Contextual Framework of Communications Functions supporting Complex System Governance. This was recognized as significant as the field of Complex System Governance continues to emerge and had significant needs to be developed related to communications. The development of the Communication Mechanisms based upon System Theory and Communications Theory, using a Grounded Theory approach, facilitated the identification of the subjective character of Communications as practiced by humans. The importance of Variety Attenuation and Variety

Amplification with respect to how Channels of Communication support the viability of the system of interest was fully developed. While system emergence was not directly related to the Communication Mechanism, the role of Channels of Communication to systems emergence was suggested from the investigation. While the Communications Mechanisms were developed, this research identified multiple future research areas that offer fruitful derivatives stemming from the present findings.

## BIBLIOGRAPHY

- Achterbergh, J., Vriens, D., 2002. Managing viable knowledge. *Systems Research and Behavioral Science* 19 (3), 223–241.
- Ackoff, R. L. (1958). Towards a behavioral theory of communication. *Management Science*, 4(3), 218-234.
- Adams, K. M., Hester, P.T., Bradley, J.M., Meyers, T.J., & Keating, C.B. (2104). Systems Theory as the Foundation for Understanding Systems. *Systems Engineering* 17(1), doi:10.1002/sys.21255.
- Åge, L. J. (2011). Grounded theory methodology: positivism, hermeneutics, and pragmatism. *The Qualitative Report*, 16(6), 1599.
- Andersen, P., Inoue, K., & Walsh, K. (2013). An animated model for facilitating understanding of Grounded Theory and the processes used to generate substantive theory. *Journal of Research in Nursing*, 18(8), 734-743.
- Baskin, O., & Bruno, S. J. (1977). A transactional systems model of communication: Implications for Transactional Analysis. *Journal of Business Communication*, 15(1), 65-73.
- Beer, S. (1966). *Decision & Control, The Meaning of Operational Research & Management Cybernetics*, John Wiley and Sons.
- Beer, S. (1974). *Designing Freedom*. John Wiley & Sons Ltd., London.
- Beer, S. (1979). *The Heart of Enterprise*. John Wiley & Sons Ltd., Chichester.
- Beer, S. (1981). *Brain of the firm: the managerial cybernetics of organization*. J. Wiley, New York.
- Beer, S. (1985). *Diagnosing the System*. John Wiley & Sons Ltd., Chichester.
- Bendassolli, P. F. (2013, January). Theory building in qualitative research: reconsidering the problem of induction. In *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research* (Vol. 14, No. 1).
- Björk, B. C. (2005). A lifecycle model of the scientific communication process. *Learned publishing*, 18(3), 165-176.
- Blanchard, B. S., & Fabrycky, W. J. (2011). *Systems Engineering and Analysis* (5th ed.). Upper Saddle River, NJ: Prentice-Hall.
- Bogdan, R., & Biklen, S. (2007). *Qualitative research for education: An introduction to theory and practice*.
- Bryman, A., Becker, S., & Sempik, J. (2008). Quality criteria for quantitative, qualitative and mixed methods research: A view from social policy. *International Journal of Social Research Methodology*, 11(4), 261-276.
- Bryant, A., & Charmaz, K. (Eds.). (2007). *The Sage handbook of grounded theory*. Sage.
- Burgess, T. F. (2001). Guide to the Design of Questionnaires. *A general introduction to the design of questionnaires for survey research*, 1-27.

- Calabrese, A. (2004). The evaluation of quality of organizational communications: a quantitative model. *Knowledge and Process Management*, 11(1), 47-67.
- Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J., & Neville, A. J. (2014, September). The use of triangulation in qualitative research. In *Oncology nursing forum* (Vol. 41, No. 5).
- Charmaz, K. (2006). Constructing grounded theory: A practical guide through qualitative research. *Sage Publications Ltd, London*.
- Cohen D, & Crabtree B. "Qualitative Research Guidelines Project." July 2006. Retrieved from <http://www.qualres.org/index.html>
- Cohen, L., Manion, L., & Morrison, K. (2013). *Research methods in education*. Routledge.
- Collingridge, Dave (2014), Validating a Questionnaire, Retrieved from: <http://www.methodspace.com/validating-a-questionnaire/>
- Corbin, J., & Strauss, A. (1990). Basics of qualitative research: Grounded theory procedures and techniques. *Basics of qualitative research: Grounded Theory procedures and techniques*, 41.
- Craig, R. T. (1999). Communication theory as a field. *Communication theory*, 9(2), 119-161.
- Creswell, J.W. (1998). *Qualitative Inquiry and Research Design Choosing Among Five Traditions*. Thousand Oaks, CA: Sage Publications.
- Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process*. Sage.
- Dash, N. (2005). Retrieved from [http://www.celt.mmu.ac.uk/researchmethods/Modules/Selection\\_of\\_methodology/](http://www.celt.mmu.ac.uk/researchmethods/Modules/Selection_of_methodology/)
- Daymon, C., & Holloway, I. (2010). *Qualitative research methods in public relations and marketing communications*. Routledge.
- Dervin, B. (1993). Verbing communication: Mandate for disciplinary invention. *Journal of Communication*, 43(3), 45-54.
- Espejo, R., Schuhmann, W., Schwaninger, M., & Bilello, U. (1996). *Organizational transformation and learning: A cybernetic approach to management* (p. 350). Wiley.
- Espejo, R. (2015) "The cybernetics of self-organization", *Kybernetes*, Vol. 44 Issue: 6/7,
- Fink, Arlene. *Conducting Research Literature Reviews: From the Internet to Paper*. 2nd ed. Thousand Oaks, CA: Sage, 2005;
- Flood, R., Jackson, M., 1991. *Creative Problem Solving*. John Wiley & Sons Ltd., Chichester.

- Freshwater, D., Cahill, J., Walsh, E., & Muncey, T. (2010). Qualitative research as evidence: Criteria for rigour and relevance. *Journal of Research in Nursing*, 15(6), 497-508.
- Garson, D. & Lillvik, C. (2016). *The literature review: A research journey*. Retrieved from (<http://guides.library.harvard.edu/literaturereview>).
- Glaser, B.G. & Strauss, A.L. (1967) *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Aldine Publishing Company, Chicago, IL, USA.
- Glaser, B.G. (1978) *Theoretical Sensitivity: Advances in the Methodology of Grounded Theory*. The Sociology Press, Mill Valley, CA, USA.
- Glaser, B. G. (1992). Emergence vs forcing: Basics of grounded theory analysis. Sociology Press.
- Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation*. Sage.
- Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research*, 2(163-194), 105.
- Hage, J., Aiken, M., & Marrett, C. B. (1971). Organization structure and communications. *American Sociological Review*, 860-871.
- Hart, Chris. *Doing a Literature Review: Releasing the Social Science Research Imagination*. Thousand Oaks, CA: Sage Publications, 1998.
- Herbert, T. T. (1977). Toward an administrative model of the communication process. *The Journal of Business Communication* (1973), 14(4), 25-35.
- Herring, C. E. (2002). Viable software: The Intelligent control paradigm for adaptable and adaptive architecture.
- Holten, R., & Rosenkranz, C. (2011). Designing viable social systems: The role of linguistic communication for self-organization. *Kybernetes*, 40(3/4), 559-580.
- Houghton C, Casey D, Shaw D, Murphy K (2013) Rigour in qualitative case-study research. *Nurse Researcher*. 20, 4, 12-17.
- ISO/IEC/IEEE. (2010). Systems and software engineering - Vocabulary. New York and Geneva: Institute of Electrical and Electronics Engineers and the International Organization for Standardization and the International Electrotechnical Commission.
- Jackson, M. C. (2003). Systems thinking: Creative holism for managers (p. 378). Chichester: Wiley.
- Jesson, Jill. *Doing Your Literature Review: Traditional and Systematic Techniques*. Los Angeles, CA: SAGE, 2011.
- Karimova, G. (2015). A Dialogic Communication Model for Advertising. *International Journal of Marketing & Business Communication*, 4(1).
- Katina, P. F. (2015). Systems theory-based construct for identifying metasytem pathologies for complex system governance. Old Dominion University.
- Katz, E. (1957). The two-step flow of communication: An up-to-date report on an hypothesis. *Public opinion quarterly*, 21(1), 61-78.



- Keating, C. B., & Morin, M. (2001). An approach for systems analysis of patient care operations. *Journal of Nursing Administration*, 31(7/8), 355-363.
- Keating, C.B. (2014), Metasystem Governance Reference Model (MGRM) for Complex Systems , National Centers for System of Systems Engineering.
- Keating, C. B., Katina, P. F., & Bradley, J. M. (2014). Complex system governance: concept, challenges, and emerging research. *International Journal of System of Systems Engineering*, 5(3), 263-288.
- Keating, C. B., Katina, P. F., & Bradley, J. M. (2015, January). Challenges for developing complex system governance. In *IIE Annual Conference. Proceedings* (p. 2943). Institute of Industrial and Systems Engineers (IISE).
- Keating, C. B. (2015, May). Complex system governance: Theory to practice challenges for system of systems engineering. In *System of Systems Engineering Conference (SoSE), 2015 10th* (pp. 226-231). IEEE
- Keating, C.B., (2015), *Complex System Governance: Confronting 'System Drift'*, p. 17
- Khuong, L. N., Harindranath, G., & Dyerson, R. (2014). Understanding knowledge management software-organisation misalignments from an institutional perspective: A case study of a global IT-management consultancy firm. *International Journal of Information Management*, 34(2), 226-247.
- Krefting, L. (1991). Rigor in qualitative research: The assessment of trustworthiness. *American journal of occupational therapy*, 45(3), 214-222.
- Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry* (Vol. 75). Sage.
- Lincoln, Y. S. (1995). Emerging criteria for quality in qualitative and interpretive research. *Qualitative inquiry*, 1(3), 275-289.
- Locke, K. (2001). Grounded theory in management research. Sage.
- Losee, R. (1999). Communication Defined as Complementary Informative Processes, *Journal of Information, Communication and Library Science*, 5 (3) 1999, pp 1–15.
- knowledge. (n.d.). *The American Heritage® Dictionary of Idioms by Christine Ammer*. Retrieved March 07, 2016 from Dictionary.com website <http://dictionary.reference.com/browse/knowledge>
- Marczyk, G., DeMatteo, D., & Festinger, D. (2005). *Essentials of research design and methodology*. John Wiley & Sons Inc.
- Metasystem Governance Reference Model, National Centers for System of Systems Engineering, Old Dominion University, C. Keating, 11/19/2014
- Miles, C. (2007). A cybernetic communication model for advertising. *Marketing Theory*, 7(4), 307-334.
- Mohamad, B., Bakar, H. A., Halim, H., & Ismail, A. R. (2014). Corporate Communication Management (CCM) and Organisational Performance: A Review of the Current Literature, Conceptual Model and Research Propositions. *Procedia-Social and Behavioral Sciences*, 155, 115-122.

- Neuman, W., L. (2003). *Social Research Methods: Qualitative and Quantitative Approaches* (5<sup>th</sup> ed.). Boston: Allyn and Bacon.
- Nyström, C. A. (2006). Design rules for intranets according to the viable system model. *Systemic Practice and Action Research*, 19(6), 523-535.
- O'Grady, W. (2009, November). An alternate management control framework: The viable system model (VSM). In *submitted to Auckland Regional Accounting Conference*.
- Organizing our social sciences research paper: qualitative methods (2016). Retrieved from <http://libguides.usc.edu/writingguide/qualitative>
- Pathirage, C. P., Amaratunga, R. D. G., & Haigh, R. P. (2008). The role of philosophical context in the development of research methodology and theory. *The Built and Human Environment Review*, 1(1), 1-10.
- Patton, MQ. (1999). "Enhancing the quality and credibility of qualitative analysis." HSR: Health Services Research. 34 (5) Part II. pp. 1189-1208.
- Pérez Ríos, J. (2010). Models of organizational cybernetics for diagnosis and design. *Kybernetes*, 39(9/10), 1529-1550.
- Pernet, E. H., & Cano, J. J. A Systemic Maturity Model. World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic, *Business and Industrial Engineering*, 8(12), 3767-3775.
- Preece, G., Shaw, D., & Hayashi, H. (2013). Using the Viable System Model (VSM) to structure information processing complexity in disaster response. *European Journal of Operational Research*, 224(1), 209-218.
- Regev, G., Alexander, I. F., & Wegmann, A. (2005). Modelling the regulative role of business processes with use and misuse cases. *Business Process Management Journal*, 11(6), 695-708.
- Reissberg, A. (2010, July). A cybernetic approach to hurricane hazard management on O'ahu, Hawai'i. In *Proceedings of the 54th Annual Meeting of the ISSS-2010, Waterloo, Canada* (Vol. 54, No. 1).
- Richards, L., & Morse, J. M. (2012). *Readme first for a user's guide to qualitative methods*. Sage.
- Ridley, Diana. *The Literature Review: A Step-by-Step Guide for Students*. 2nd ed. Los Angeles, CA: SAGE, 2012.
- Ryan-Nicholls, K. D., & Will, C. I. (2009). Rigour in qualitative research: mechanisms for control. *Nurse Researcher (through 2013)*, 16(3), 70.
- Schramm, W. (1954). How communication works. The process and effects of mass communication, 3-26.
- Schwaninger, M. (2000). Managing complexity—the path toward intelligent organizations. *Systemic Practice and Action Research*, 13(2), 207-241.
- Sennett, R. (28 February 2010). The Architecture of Cooperation (video: see 18:30 – 30:00). Harvard Graduate School of Design. Retrieved 7 December 2016.

- Shannon, C. E. (1948). A Mathematical Theory of Communication, Part 2. *Bell System Technical Journal*, 27(4), 623-656.
- Skyttner, L., (1996) "General systems theory: origin and hallmarks", *Kybernetes*, Vol. 25 Iss: 6, pp.16 – 22.
- Sheehan, J., Nittbaur, G., & Mulhaney, A. LEARNING TO MANAGE KNOWLEDGE FOR LONG TERM VIABILITY.
- Strauss, A., & Corbin, J. (1998). Basics of qualitative research techniques. Sage publications.
- Targowski, A. S., & Bowman, J. P. (1988). The layer-based, pragmatic model of the communication process. *The Journal of Business Communication* (1973), 25(1), 5-24.
- Taylor, D. (2016). The literature review: A few tips on conducting it, Health Sciences Writing Centre, University of Toronto. Retrieved from <http://www.writing.utoronto.ca/advice/specific-types-of-writing/literature-review>
- Thackeray, R., & Neiger, B. L. (2009). A multidirectional communication model: Implications for social marketing practice. *Health promotion practice*, 10(2), 171-175.
- Tuli, F. (2011). The basis of distinction between qualitative and quantitative research in social science: reflection on ontological, epistemological and methodological perspectives. *Ethiopian Journal of Education and Sciences*, 6(1).
- Van de Ven, A. H. (2007). *Engaged scholarship: a guide for organizational and social research: a guide for organizational and social research*. OUP Oxford.
- von Bertalanffy, L. (1950). 'An outline of general systems theory', *The British Journal for the Philosophy of Science*, Vol. 1, No. 2, pp.134–165.
- von Bertalanffy, L. (1968). *General System Theory: Foundations, Development, Applications*, rev. ed., George Braziller, New York.
- Weaver, W. (1953). Recent contributions to the mathematical theory of communication. *ETC: A Review of General Semantics*, 261-281.
- Whitney, K., Bradley, J. M., Baugh, D. E., & Chesterman, C.W. (2015). Systems theory as a foundation for governance of complex systems. *International Journal of System of Systems Engineering*, 6(1-2), 15-32.

APPENDIX

## A. GROUNDED THEORY SOURCE LITERATURE

- Achterbergh, J., & Vriens, D. (2002). Managing viable knowledge. *Systems Research and Behavioral Science*, 19(3), 223-241.
- Azadeh, A., Darivandi, K., & Fathi, E. (2012). Diagnosing, simulating and improving business process using cybernetic laws and the viable system model: the case of a purchasing process. *Systems Research and Behavioral Science*, 29(1), 66-86.
- Beckford, J. (2003). *Quality: A critical introduction*. Routledge.
- Beer, S. (1974). *Designing Freedom*. John Wiley & Sons Ltd., London.
- Beer, S. (1975). Fanfare for effective freedom. *Platform for Change*, 423-452.
- Beer, S. (1994). Cybernetics of national development evolved from work in chile. *How Many Grapes Went into the Wine—Stafford Beer on the Art and Science of Holistic Management*. John Wiley and Sons, Chichester.
- Bolin, H., & Hultén, L. (2002). *Information Exchange and Controllability in Logistics*. TFK-Institutet för transportforskning.
- Bustard, D. W., Sterritt, R., Taleb-Bendiab, A., & Laws, A. (2006). Autonomic system design based on the integrated use of SSM and VSM. *Artificial Intelligence Review*, 25(4), 313-327.
- César Puche Regaliza, J. (2014). Extending the viable system model scope on ICT-sector software projects in Castilla y León. *Kybernetes*, 43(2), 192-209.
- Dokas, I. M., Feehan, J., & Imran, S. (2013). EWaSAP: An early warning sign identification approach based on a systemic hazard analysis. *Safety science*, 58, 11-26.
- Espejo, R. (2015). Performance for viability: complexity and variety management. *Kybernetes*, 44(6/7), 1020-1029.
- Gregory, A. (2006). Systemic reflections on our past, present and future. *Systems Research and Behavioral Science*, 23(5), 685-694.
- Herring, C. E. (2002). Viable software: The Intelligent control paradigm for adaptable and adaptive architecture.
- Hildbrand, S., & Bodhanya, S. (2013). The potential value of the Viable System Model as a managerial tool. *Management Dynamics: Journal of the Southern African Institute for Management Scientists*, 22(2), 2-15.
- Hildbrand, S., & Bodhanya, S. (2015). Guidance on applying the viable system model. *Kybernetes*, 44(2), 186-201.
- Hilder, T. (1995). The viable system model. Retrieved June, 28, 2005.
- Hogard, E., & Ellis, R. (2006). Evaluation and communication using a communication audit to evaluate organizational Communication. *Evaluation review*, 30(2), 171-187.

- Holten, R., & Rosenkranz, C. (2011). Designing viable social systems: The role of linguistic communication for self-organization. *Kybernetes: The International Journal of Systems & Cybernetics*, 40(3-4), 559-580.
- Jackson, M. C. (2003). *Systems thinking: Creative holism for managers* (p. 378). Chichester: Wiley.
- Jafarov, N., & Lewis, E. (2014). Mapping the Cybernetic Principles of Viable System Model to Enterprise Service Bus. *INFORMATION TECHNOLOGY IN INDUSTRY*, 2(3), 68-78.
- Jones, P. H. (2014). Systemic design principles for complex social systems. In *Social systems and design* (pp. 91-128). Springer Japan.
- Karayaz, G., Keating, C. B., & Henrie, M. (2011, January). Designing project management systems. In *System Sciences (HICSS), 2011 44th Hawaii International Conference on* (pp. 1-10). IEEE.
- Keating, C. B., & Katina, P. F. (2012). Prevalence of pathologies in systems of systems. *International Journal of System of Systems Engineering*, 3(3-4), 243-267.
- Leonard, A. (1990). Coming concepts: The cybernetic glossary for new management. *Unpublished Work, Toronto*.
- Leonard, A., & Beer, S. (1994). The systems perspective: Methods and models for the future. *AC/UNU Project*.
- Leonard, A. (2009). The viable system model and its application to complex organizations. *Systemic practice and action research*, 22(4), 223-233.
- Losscher, H. (2011). Being seen as” and “seeing as. *Kybernetes*, 40(3/4), 494-506.
- Morlidge, S. P. "Money, time and variety engineering: the application of cybernetics to the diagnosis and design of financial performance management systems." *Systemic Practice and Action Research* 22.4 (2009): 235-247.
- Neely, A. (2002). *Business performance measurement: theory and practice*. Cambridge University Press.
- Nyström, C. A. (2006). Design rules for intranets according to the viable system model. *Systemic Practice and Action Research*, 19(6), 523-535.
- O’Grady, W., Morlidge, S., & Rouse, P. (2016). Evaluating the completeness and effectiveness of management control systems with cybernetic tools. *Management Accounting Research*, 33, 1-15.
- Preece, G., Shaw, D., & Hayashi, H. (2013). Using the Viable System Model (VSM) to structure information processing complexity in disaster response. *European Journal of Operational Research*, 224(1), 209-218.
- Rai, V. K., & Subramanian, K. Project Management Leadership Conference 2007.
- Reissberg, A. (2010, July). A cybernetic approach to hurricane hazard management on O’ahu, Hawai ‘i. In *Proceedings of the 54th Annual Meeting of the ISSS-2010, Waterloo, Canada* (Vol. 54, No. 1).

- Reissberg, A. (2012, November). THE ACCELERATION OF THE SPEED OF CHANGE–THE ULTIMATE THREAT FOR SOCIETY. In *Proceedings of the 56th Annual Meeting of the ISSS-2012, San Jose, CA, USA*.
- Richter, J., & Basten, D. (2014, January). Applications of the Viable Systems Model in IS Research--A Comprehensive Overview and Analysis. In *System Sciences (HICSS), 2014 47th Hawaii International Conference on* (pp. 4589-4598). IEEE.
- Robinson, G. J., & Theall, D. F. (1975). *Studies in Canadian Communications*.
- Rosenkranz, C., & Holten, R. (2011). The variety engineering method: analyzing and designing information flows in organizations. *Information Systems and E-Business Management*, 9(1), 11-49.
- Schwaninger, M. (2015). Organizing for sustainability: a cybernetic concept for sustainable renewal. *Kybernetes*, 44(6/7), 935.
- Sergeyev, A., & Moscardini, A. (2006). Governance of economic transitions: a case study of Ukraine. *Kybernetes*, 35(1/2), 90-107.
- Siau, K, (2002), *Advanced topics in database research-vol. 1*, Idea Group Publishing, Hersey, PA.
- Vidgen, R. (1998). Cybernetics and business processes: using the viable system model to develop an enterprise process architecture. *Knowledge and Process Management*, 5(2), 118-131.

**B. PEER REVIEW TOPIC, QUESTIONS AND COMMENTS**

Topic	Question	Comments
Data Collection	Was there a schema to select documentation?	I like the presented schema as it enables on to focus on credible work.
		Yes
		YES.
		Yes
Data Collection	Was the selected documentation schema aligned to the topic of research?	Yes.
		Yes
		YES
		Yes
Data Collection	Was Theoretical Sampling used?	It was used. It would increase researcher's credibility to elaborate on <i>why</i> the initial work was selected.
		Yes
		YES. 590 collected and sampled. Not able to tell from the presentation
		Yes
Open Coding	Was the initial identified Component (Terms/Categories) aligned to the topic of research?	Yes. The terms align well research topic.
		Yes - categorization of components are clear and relevant to communication
		Yes. How were synonyms/discinymys accounted for? Description of Nvivo was incomplete. Implied not all data was in Nvivo.
		Yes
Open Coding	Was the initial set of Component (Terms/Categories) added to and why?	The initial set was expanded based on the expanded literature/data search.
		Yes
		YES. A synonym/antonym list was also developed
		Assumed Yes (No Audio)

Topic	Question	Comments
Open Coding	Was Constant Comparative Analysis incorporated in Open Coding?	The issue of <i>how</i> Constant Comparative Analysis was accomplished is not evident in the presentation.
		Yes
		YES. This was described. Some codes were combined (seems like axial coding)
		Assumed Yes (No Audio)
Axial Coding	What were drivers for consolidation of data during Axial Coding?	Focusing on the topic of communication and how it takes place in complex systems.
		Data consolidation, code aggregation, grouping of communication channels, the observation that two main perspectives exist (Beer & Shannon)
		Choice of Shannon/Beer perspective- data versus C&C perspective. There is also the concept of meaning (Gerbner/Lasswell refer)(Gerbner, 1956) (Lasswell, 1948)
		Specific, aggregated, multi-channel
Axial Coding	Was Constant Comparative Analysis incorporated in Axial Coding?	This is not evident in the presentation.
		Yes
		Not discussed
		Assumed Yes (No Audio)
Selective Coding	What were the drivers for Concept Groups?	Similarity among the different concepts.
		Refinement of categories, association of categories to channels of communication – in support of theory and framework development
		Channel to element of VSM, two part – intent or identity drive mechanism of communication. Transduction has limited literature – is this a future research area?
		Association with any communication channel
Selective Coding	Was there a relationship between the Concept Groups and the Component (Terms/Categories)?	This is not evident from the presentation material. However, the researcher was able to speak to the issue.
		Yes



Topic	Question	Comments
		Not explained in presentation. Three step coding implies early edition of Corbin and Strauss, rather than current edition. Was this purposeful?
		Assumed Yes (No Audio)
Theory Development	Was theory fully supported by the data and analysis?	The theory, while supported by the data...the name of the theory was not identified.
		Yes
		Asserted in presentation, would be interesting to see this.
		Yes
Framework Development	Will the framework adequately fulfill the research objective?	The theory will fulfill the objective as suggested by the researcher. However, case applications might be necessary to realize implications on real world systems.
		Yes
		Not covered in presentation
		Yes

## C. CSG COMMUNICATION SUVEY INSTRUMENT

### GCS Communication\_Lite

#### Default Question Block



**Q1 Welcome.** Thank you for taking the time to take this survey. The subject of the survey is on Communication Functions. The taking of this survey is voluntary. You were provided the link to this survey by your organization. The use of the web site insures that your identity is unknown to the Researcher as well as your organization. Private personal information (name, age, sex, etc.) is not being collected and there is no feedback provided to your organization. There are no expected foreseeable risks or discomforts to you the User. If you desire not to continue, click on the decline button below and you will forwarded to the final page of this survey.

The anticipated time required for the survey is approximately 30 minutes. If you have concerns then please address them with Dr. Stacie Ringleb, Chair of the Batten College of Engineering and Technology Human Subjects Committee, [sringleb@odu.edu](mailto:sringleb@odu.edu) or 757.683.5934. Again participation is voluntary.

- ☐ Yes, I want to participate in the survey. (1)
- ☐ Decline (2)

*Skip To: Q2 If Q1 = Yes, I want to participate in the survey. (1)*

*Skip To: Q44 If Q1 = Decline (2)*

**Q2 What does your company do?** *(Write a brief description of the work that your company accomplishes and what is the sector (for example: Service, Manufacturing, Energy, Health Care, Financial, Information Technology, Telecommunication, Utilities or Real Estate).)*

---

**Q3 What part of your company's organization do you work in?** *(Write a brief description of the part of the organization that you are part of)*

---

**Q4 How long have you worked in this current position?** *(Type a numeric value of years)*

---

**Q5 Have you held other positions in your current company?**

☐ No (1)

☐ Yes (2)

---

**Q6 Do you have co-workers with your current position?**

☐ No (1)

☐ 5 or less Co-Workers (2)

☐ 7 to 5 Co-Workers (3)

☐ 8 to 10 Co-Workers (4)

---

**Q7 What Work do you do/engage in?** *(Provide a brief description of your work.)*

---



**Q8 This Survey will now be split into sets of questions associated with the description that best suits your function in your company. Select one of the below choices that best represents your functions.**

- ☐ Member of a Group/Project(s) and not a Supervisor (1)
- ☐ Supervisor and a Member of Project(s) (2)
- ☐ Supervisor and not directly involved in Project(s) (3)

*Skip To: Q9 If Q8 = Member of a Group/Project(s) and not a Supervisor (1)*

*Skip To: Q20 If Q8 = Supervisor and a Member of Project(s) (2)*

*Skip To: Q26 If Q8 = Supervisor and not directly involved in Project(s) (3)*

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Page Break

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**Q9 What are the Communication Methods that you use with your Peers?**

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**Q10 What are the Communication Methods that you use with your Supervisor?**

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**Q11 For your Work, what are inputs to your work and where do they come from?** *(Provide brief description of the inputs to your work, provide a brief description of the Communication Method where your work comes from and identify whom (Supervisor/Co-Worker, etc.) does your work come from)*

	Comment (1)
Description of Work (1)	
Description of Communication Method (2)	
Identity of source of Work (3)	



**Q12 Does any of your Work involve Clients or Customers?**

- ☐ Clients (1)
- ☐ Customers (2)
- ☐ No Clients or Customers (3)

Skip To: Q14 If Q12 = No Clients or Customers (3)

**Q13 What is the preferred Communicate Methods do you use to communicate with your Clients or Customers?** *(Provide a brief description of the Communication Method you use with your Clients or Customers)*

---

Page Break

---

**Q14 Does your Work involve individuals (not Clients or Customers) outside of your Company?**

☐ Yes (1)

☐ No (2)

*Skip To: Q16 If Q14 = No (2)*

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Page Break

---

**Q15 For the Work that involve individuals outside of your Company what Communication Methods do you use?**

---

Page Break

---

**Q16 What improvements would you make to the current Communication****Methods?** *(Describe the Current Communication Method and then the Improvements)*

	Communication Method Improvement (1)
Existing Communication Method (1)	
Existing Communication Method (2)	

**Q17 What Communication Method do you not have available at work but if you change the environment you would add?** *(Describe Communication Methods not existing that you would bring to your organization)*

---



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**Q18 What Communication Method do you most prefer to communicate with your coworkers?** *(Provide a brief description of the Communication Method you use with your coworkers)*

---

**Q19 Were there any additional comments?**

*Skip To: Q44 If*

*Skip To: Q44 If*

**Q20 What are the Communication Methods that you use with your Peers/Co-Workers?**

**Q21 What are the Communication Methods that you use with your Supervisor?**

**Q22 Does any of your Work involve Customers?**

- ☐ Customers (2)
- ☐ Not Customers (3)

*Skip To: Q24 If Q22 = Not Customers (3)*

Page Break

**Q23 What is the preferred Communicate Methods do you use to communicate with your Customers?** *(Provide a brief description of the Communication Method you use with your Customers)*



**Q24 For the Work that involve individuals (Not Customers) outside of your Company what Communication Methods do you use?** *(Provide a brief description of the Communication Method you use with individuals outside of your Company)*

---

**Q25 What Communication Method do you most prefer to communicate with your coworkers?** *(Provide a brief description of the Communication Method you use with your coworkers)*

---

**Q26 How many Groups do you Supervise?**

- ☐ 2 or less Groups (1)
- ☐ 4 or less Groups (more than 2) (2)
- ☐ 6 or less (more than 4) (4)
- 

**Q27 What are the Primary Communication Methods you use with the Groups that you supervise?**

---

**Q28 What are the Secondary Communication Methods you use with the Groups that you supervise?**

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---

**Q29 What are the Communication Methods you use for exchanging Documents with Groups that you supervise?**

---

**Q30 What type of Document is exchanged and who is Initiator/Receiver and with the Groups that you supervise?**

	Description (1)
Type of Document (1)	
Initiator of Document (2)	
Receiver of Document (3)	

---

**Q31 What Documentation helps you in coordination of the folks in each group?**

---

**Q32 What documentation or data do you provide/receive from individuals outside of your Company?**

---

**Q33 What improvements would you make to the current Communication****Methods?** *(Describe the Current Communication Method and then the Improvements)*

	Communication Method Improvement (1)
Existing Communication Method (1)	
Existing Communication Method (2)	

**Q34 What Communication Method do you not have available at work but if you change the environment you would add?** *(Describe Communication Methods not existing that you would bring to your organization)*

New Communication Method (1)
New Communication Method (2)

**Q35 Does any of your Project work involve Clients?**

- ☐ Clients (1)
- ☐ Not Clients or Customers (3)

Skip To: Q37 If Q35 = Not Clients or Customers (3)

Page Break

**Q36 What Communicate Methods do you to communicate with your Clients?**

**Q37 Besides the current Communication Methods what additional methods would you like to be able to use?(Provide a description of the additional methods)**

	What New Communication Method? (1)
New Communication Method A (1)	
New Communication Method B (2)	
New Communication Method C (3)	

**Q38 Outside of work, what other Communication Methods do you use?** *(Provide a brief description of other Communication Methods)*

	What other Communication Method outside of work? (1)
Other Communication Methods A (1)	
Other Communication Methods B (2)	
Other Communication Methods C (3)	

---

**Q39 What Communication Method does your supervisor desire you to use?** *(Provide a brief description of the Communication Methods, Ranking and Frequency of use (times a week))*

---

**Q40 What Communication Method do you use to communicate with your coworkers?** *(Provide a brief description of the Communication Method you use with your coworkers and ranking of preference to use)*

---

**Q41 For your Groups does the work change?**

☐ No (1)

☐ Yes (2)

---

**Q42 For your Groups how does the work change?** *(Provide a brief description of how work changes)*

---

**Q43 For your Groups what is the Communication Method for notifying you of upcoming work changes?** *(Provide a brief description of the Communication Method notifying you of future work changes)*

---

**Q44 Thank you for participating in this survey.**

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End of Block

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**D. CSG COMMUNICATION SUVEY INSTRUMENT APPROVAL NOTIFICATION**

Date: 11/02/2017 01:37 AM

To: "Charles Chesterman" <cches008@odu.edu>

From: "Stacie Ringleb" <no-reply@irbnet.org>

Reply To: "Stacie Ringleb" <sringleb@odu.edu>

Subject: IRBNet Board Document Published

Please note that Old Dominion University Engineering Human Subjects Review Committee has published the following Board Document on IRBNet:

Project Title: [1119938-2] CSG Communications

Principal Investigator: Charles Keating, Ph.D.

Submission Type: New Project

Date Submitted: October 11, 2017

Document Type: Exempt Letter

Document Description: Exempt Letter

Publish Date: November 2, 2017

Should you have any questions you may contact Stacie Ringleb at [sringleb@odu.edu](mailto:sringleb@odu.edu).

Thank you,

The IRBNet Support Team

[www.irbnet.org](http://www.irbnet.org)

## E. INDIVIDUAL CHANNELS OF COMMUNICATION

### Notes on Channels of Communication Data:

Notes	Description
1	All Channels of Communication that were identified, the Researcher could determine from the channel text or the surrounding text, the Authors intended Source and Recipient.
2	The Researcher could relate the Authors intended Source and Recipient (one or more) to a CSG Function (E, 1-5). There were no cases of Authors have a Recipient in more than a single CSG Function.
3	Not all individual Channels of Communication yielded data for Technology, Product and or Mode and are the void is indicated with the symbol “- “. The researcher was not able to determine the data from either the channel text or the surrounding text.
4	An individual Channel of Communication yielded in many cases more than a single data element (node) for Technology, Product and or Mode. Through the Grounded Theory Method some of these data elements (node) were coalesced during Open Coding or Axial Coding.

### Description of Table Headers:

Header Title	Description
<b>Channel</b>	A unique Channel of Communication found in a source. Number solely for purposes of identification.
<b>Source</b>	Author and date of publication of the source document. Citation found in Appendix A.
<b>DIRECTION</b>	<p>As described by Shannon and Beer and many others, there are at least a minimum of two participants associated with a channel of communication. There is the Source and the Recipient. The Source is always active by creating a packet of information. The Recipient may be active or passive where active is where a packet of information is received or consumed. Recipient passivity has two senses inferences, the first where the packet of information is received and no action is taken. The alternative Recipient passiveness is where the Source writes a message on a deserted beach.</p> <p>Having established that there is a Source and a Recipient, the direction of communication by convention is always from the Source to the Recipient.</p> <p>Within the construct of the metasytem, the channel of communications originates with a function and is connected to one or more functions (direction is <u>from</u> - <u>to</u>).</p>
<b>TECHNOLOGY</b> (Conveyance)	Communication is the process by which meaning is assigned and conveyed to create shared understanding. The conveyance of the Product may be limited by the composition of the channel of communication or it may be the construct of the channel of



	communication that may enhance the spectrum of Products that are conveyed.																				
	Therefor the Technology is the conveyance used to support the channel of communication.																				
PRODUCT	<p>The Source creates a Message that is the result of developing meaning. Shannon’s work could be interpreted that the Message is the result of only the Source. Expansion of the Transmission Model or Standard View of Communication that incorporates feedback up to the Transaction Model where a basic premise is that individuals (Source/Receiver) are simultaneously engaging in the sending and receiving of messages means that the “message” may not be the sole creation of the Source and that there are other influences. Taking the Advertising Industry as a potential model of message creation that follows a life cycle design pattern, the term Product moves the concept of the “message” to a higher level.</p> <p>Therefor the Product may be actions proposed, actions to be taken, constraint (attenuation) on actions as well as liberation (amplification) of actions.</p>																				
MODE	<p>The Mode that the meaning is conveyed can be visual, auditory, tactile (such as in Braille) and haptic, olfactory, Kinesics, electromagnetic, or biochemical. Human communication is unique for its extensive use of abstract language.</p> <table><tr><td>Non-Verbal</td><td>NV</td><td></td><td>Verbal</td><td>V</td><td></td><td>Verbal &amp; Non-Verbal</td><td>VNV</td><td></td><td>Tactile</td><td>TA</td></tr></table> <p>While there is a significant difference between Non-Verbal and Visual, for coding NV will be used for both Non-Verbal and Visual.</p>										Non-Verbal	NV		Verbal	V		Verbal & Non-Verbal	VNV		Tactile	TA
Non-Verbal	NV		Verbal	V		Verbal & Non-Verbal	VNV		Tactile	TA											

### Individual Channels of Communication

Channel	Source	DIRECTION	TECHNOLOGY	PRODUCT	MODE
1	O'Grady_2014	1-1	Computer	Profit and KPI Performance Report	Non-Verbal
2	Preece_2013	1-2	-	-	Verbal
3	Herring_2002	1-2	Channel	Production Report	Non-Verbal
4	Raj_2007	1-2	Channel	Project Templates	Non-Verbal
5	Nystrom_2006	1-2	Computer	Divergent Report	Non-Verbal
6	Cesar_2014	1-2	Computer and or Internet	Agreements Report	Non-Verbal
7	Cesar_2014	1-2	Computer and or Internet	Process Definition and Adherence	Non-Verbal
8	Cesar_2014	1-2	Computer and or Internet	Planning Instrument	Non-Verbal
9	Cesar_2014	1-2	Computer and or Internet, Meeting_F to F	Status Report	Verbal & Non-Verbal
10	Cesar_2014	1-2	Computer and or Internet, Meeting_F to F	Meeting	Verbal & Non-Verbal
11	Cesar_2014	1-2	Computer and or Internet, Meeting_F to F	Report	Verbal & Non-Verbal
12	Cesar_2014	1-2	Meeting_F to F	Planning Instrument	Verbal & Non-Verbal
13	Preece_2013	1-2	Video Feed	Visual Feed	Non-Verbal
14	Sergeyev_2006	1-3	Channel	Available Resources	Verbal & Non-Verbal
15	Sergeyev_2006	1-3	Channel		Verbal & Non-Verbal
16	Nystrom_2006	1-3	Computer	Messages	
17	Nystrom_2006	1-3	Computer	Continuous Information	
18	Nystrom_2006	1-3	Computer	Work Environment Condition Report	
19	Nystrom_2006	1-3	Computer	Tax Payments	
20	O'Grady_2014	1-3	Computer	Profit and Loss Reports	Non-Verbal
21	O'Grady_2014	1-3	Computer	New Plan	Non-Verbal
22	Herring_2002	1-3	Computer and or Internet, Meeting_F to F	Weekly Report	Verbal & Non-Verbal
23	Nystrom_2006	1-3	Emergency Phone Lines	Message	Verbal & Non-Verbal
24	Nystrom_2006	1-3	Emergency Phone Lines	-	Verbal
25	Preece_2013	1-3	Video Feed	Location geo	Non-Verbal
26	Jafarov_2014	1-5	Channel	Signal	Verbal & Non-Verbal

Channel	Source	DIRECTION	TECHNOLOGY	PRODUCT	MODE
27	Losscher_2011	1-5	Channel	Meeting	Verbal & Non-Verbal
28	Siau_1984	1-E	Channel	Adding Resources	Verbal & Non-Verbal
29	Vidgen_1998	1-E	Channel	Advertisement	Verbal & Non-Verbal
30	Hildbrand_2013	1-E	Channel	Group-Specific Products	Verbal & Non-Verbal
31	Herring_2002	1-E	Computer	Time Table	Non-Verbal
32	Herring_2002	1-E	Computer	Advertisement	Verbal & Non-Verbal
33	Cesar_2014	1-E	Computer and or Internet	Training Courses, Training and Learning-Knowledge and skill Management	Verbal & Non-Verbal
34	Cesar_2014	1-E	Computer and or Internet	Customer support	Verbal & Non-Verbal
35	Reissberg_2010	1-E	Computer and or Internet	Audit Report, Information Survey and Analysis	Verbal & Non-Verbal
36	Cesar_2014	1-E	Computer and or Internet, Meeting_F to F	Demo	Verbal & Non-Verbal
37	Cesar_2014	1-E	Computer and or Internet, Meeting_F to F	Training and Learning-Knowledge and skill Management	Verbal & Non-Verbal
38	Reissberg_2010	1-E	Computer and or Internet, Meeting_F to F,	Communication an Interoperability, Incentive Program, Information	Verbal & Non-Verbal
39	Cesar_2014	1-E	Computer and or Internet, Meeting_F to F	Offer_products	Verbal & Non-Verbal
40	Reissberg_2010	1-E	Computer and or Internet, Meeting_F to F	Directive	Verbal & Non-Verbal
41	Cesar_2014	1-E	Computer and or Internet, Meeting_F to F	Meeting	Verbal & Non-Verbal
42	Cesar_2014	1-E	Meeting_F to F	Social Relationship	Verbal & Non-Verbal
43	Cesar_2014	1-E	Meeting_F to F	Information Bureau	Verbal & Non-Verbal
44	Cesar_2014	1-E	Meeting_F to F	Meeting	Verbal & Non-Verbal
45	Reissberg_2010	1-E	Meeting_F to F	Resource Negotiation Tools	Verbal & Non-Verbal
46	Reissberg_2010	1-E	Meeting_F to F	Rules	Verbal & Non-Verbal
47	Achterberg_2002	2-1	Channel	New Plan	Verbal & Non-Verbal
48	Achterberg_2002	2-1	Channel	New Plan	Verbal & Non-Verbal
49	Beckkford_1995	2-1	Channel	Time Table	Non-Verbal
50	Raj_2007	2-1	Channel	Project Plan	Non-Verbal
51	Raj_2007	2-1	Channel	Program Management Standards	Non-Verbal

Channel	Source	DIRECTION	TECHNOLOGY	PRODUCT	MODE
52	Raj_2007	2-1	Channel	Resource Leveling	
53	Hilder_1995	2-1	Channel	Newsletter	Non-Verbal
54	Raj_2007	2-1	Channel	Program Management Methodology	Non-Verbal
55	Beckkford_1995	2-1	Channel, Computer and or Internet, Meeting_F to F	Allocation of Service bays, Available Resources	Non-Verbal, Verbal & Non-Verbal
56	Raj_2007	2-1	Computer	Business Process Redesign	Verbal & Non-Verbal
57	Herring_2002	2-1	Computer	Time Table	Non-Verbal
58	Vidgen_1998	2-1	Computer	Workflow	Non-Verbal
59	Vidgen_1998	2-1	Computer	Procedures	Non-Verbal
60	Raj_2007	2-1	Computer	Process Definition and Adherence	Verbal & Non-Verbal
61	Raj_2007	2-1	Computer	Training and Learning-Knowledge and skill Management	Verbal & Non-Verbal
62	Raj_2007	2-1	Computer	Workflow	Verbal & Non-Verbal
63	Raj_2007	2-1	Computer	Project Management Tools	Verbal & Non-Verbal
64	Preece_2013	2-1	Computer and or Internet	Control Rules	Verbal & Non-Verbal
65	Beckkford_1995	2-1	Computer and or Internet, Mailing List, Channel	Procedures, Teller Window in Bank	Non-Verbal
66	Cesar_2014	2-1	Computer and or Internet, Document repositories, Meeting_F to F	Documents, Procedures	Verbal & Non-Verbal, Non-Verbal
67	Cesar_2014	2-1	Computer and or Internet, Meeting_F to F, Personnel change location	Resource Leveling	Verbal & Non-Verbal
68	Cesar_2014	2-1	Computer and or Internet, Personnel change location	Provide Aid, Resource Leveling	Verbal & Non-Verbal
69	Cesar_2014	2-1	Computer and or Internet, Meeting_F to F	Directive	Verbal & Non-Verbal
70	Cesar_2014	2-1	Computer and or Internet, Meeting_F to F	Documents	Verbal & Non-Verbal
71	Cesar_2014	2-1	Computer and or Internet, Meeting_F to F	Meeting	Verbal & Non-Verbal
72	Beckkford_1995	2-1	Computer and or Internet, Internet, Mailing List, Meeting_F to F	-	Verbal & Non-Verbal
73	Jafarov_2014	2-1	Meeting_F to F	Agreement	Verbal & Non-Verbal
74	Nystrom_2006	2-1	Meeting_F to F	Regular Meetings	Verbal & Non-Verbal

Channel	Source	DIRECTION	TECHNOLOGY	PRODUCT	MODE
75	Raj_2007	2-1	Meeting_F to F, Personnel change location	Implicit and Explicit Inter and Intra team Exchanges	Verbal & Non-Verbal
76	Reissberg_2010	3-1	-	Location geo, Meeting, Procedures	Verbal & Non-Verbal
77	Reissberg_2010	3-1	-	Planning Instrument	Verbal & Non-Verbal
78	Nystrom_2006	3-1	Computer	Directive	
79	Nystrom_2006	3-1	Computer	Budget Report, Resource Report	Non-Verbal
80	Nystrom_2006	3-1	Computer	Agreements Report, Results of Negotiations Report	Verbal & Non-Verbal
81	Raj_2007	3-1	Computer	Continuous Information	Non-Verbal
82	Raj_2007	3-1	Computer	Status Report	Verbal & Non-Verbal
83	Nystrom_2006	3-1	Computer	Instructions and Conditions on Budget	Verbal & Non-Verbal
84	Nystrom_2006	3-1	Computer	Rules	Non-Verbal
85	Reissberg_2010	3-1	Computer and or Internet	Communication an Interoperability	Verbal & Non-Verbal
86	Reissberg_2010	3-1	Computer and or Internet		Verbal & Non-Verbal
87	Reissberg_2010	3-1	Computer and or Internet	Collect, analyze and respond	Verbal & Non-Verbal
88	Raj_2007	3-1	Computer, Meeting_F to F	Audit Report	Verbal & Non-Verbal
89	Raj_2007	3-1	Computer, Early Warning System w_ Sensors, Emergency Phone Line	Continuous Information	Verbal & Non-Verbal
90	Raj_2007	3-1	Computer, Meeting_F to F	Accountability Report	Verbal & Non-Verbal
91	Reissberg_2010	3-1	Establish Network	Adding Resources	Verbal & Non-Verbal
92	Nystrom_2006	3-1	Meeting_F to F	Meeting	Verbal & Non-Verbal
93	Reissberg_2010	3-1	Meeting_F to F	Training and Learning-Knowledge and skill Management	
94	Raj_2007	3-1	Meeting_F to F	Resource Negotiation Tools	Verbal & Non-Verbal
95	Raj_2007	3-1	Meeting_F to F	Spot Check	Verbal & Non-Verbal
96	Nystrom_2006	3-1	Meeting_F to F	Meeting	Verbal & Non-Verbal
97	Nystrom_2006	3-4	Computer	Short Term Status, Status Report	Verbal & Non-Verbal
98	Nystrom_2006	3-5	-	Suggestion	Verbal
99	Nystrom_2006	3-5	Meeting_F to F	Committee, Teaching Staff with information, Working Committee with Information	Verbal & Non-Verbal
100	Achterberg_2002	3S-1	Channel	Audit Report	Non-Verbal
101	Azadeh_2012	3S-1	Channel	-	Non-Verbal

Channel	Source	DIRECTION	TECHNOLOGY	PRODUCT	MODE
102	Azadeh_2012	3S-1	Channel	Purchase Documents Report	Non-Verbal
103	Beckkford_1995	3S-1	Channel	Audit Report	Verbal & Non-Verbal
104	Hogard_2006	3S-1	Channel	Survey and Analysis	Non-Verbal
105	Hogard_2006	3S-1	Channel, Computer and or Internet	Communication Experience	
106	Vidgen_1998	3S-1	Computer	Monitor	Non-Verbal
107	Bustard_2007	3S-1	Computer and or Internet	Virus Checker	Non-Verbal
108	Hogard_2006	3S-1	Computer and or Internet	Network Analysis	Non-Verbal
109	Beckkford_1995	3S-1	Computer and or Internet, Meeting_F to F	Sporadic Audit	
110	Herring_2002	3S-1	Computer and or Internet, Meeting_F to F	Independent Audit	Verbal & Non-Verbal
111	Hogard_2006	3S-1	Meeting_F to F	Interviews	
112	Herring_2002	4-3	Channel	Control Rules, Rules	Verbal & Non-Verbal
113	Sergeyev_2006	4-3	Channel	High Variety Model	Verbal & Non-Verbal
114	Herring_2002	4-3	Channel	Structural Changes	Verbal & Non-Verbal
115	Preece_2013	4-3	Channel	Detail Report on Emergency	Verbal
116	Nystrom_2006	4-3	Computer	Statistics	Verbal & Non-Verbal
117	Nystrom_2006	4-3	Computer	Continuous Information	Verbal & Non-Verbal
118	Nystrom_2006	4-3	Computer	Future Trends Report, Market Demands Report	Verbal & Non-Verbal
119	Nystrom_2006	4-3	Computer	Planning Instrument	Verbal & Non-Verbal
120	Nystrom_2006	4-5	Computer	Corporate Planning Information, Future Trends Report, Policies	Verbal & Non-Verbal
121	Nystrom_2006	4-5	Computer and or Internet	R D Report	
122	Nystrom_2006	4-5	Computer, Meeting_F to F	Corporate Planning Information, Market Opinion Analysis	Verbal & Non-Verbal
123	Nystrom_2006	4-5	Computer, Computer and or Internet	Corporate Planning Information	Verbal & Non-Verbal
124	Nystrom_2006	4-5	Internet, Meeting_F to F	Structure Standard Report	Verbal & Non-Verbal
125	Nystrom_2006	4-5	Internet, Meeting_F to F	Regular Meetings	Verbal & Non-Verbal
126	Hildbrand_2013	4-E	Channel	Market Opinion Analysis, Research	Verbal & Non-Verbal
127	Nystrom_2006	5-3	Computer	Policies	Verbal & Non-Verbal
128	Nystrom_2006	5-3	Computer	Rules	Verbal & Non-Verbal
129	Nystrom_2006	5-3	Management Channel	Policies	Verbal & Non-Verbal

Channel	Source	DIRECTION	TECHNOLOGY	PRODUCT	MODE
130	Nystrom_2006	5-4	Computer, Meeting_F to F	Directive	Verbal & Non-Verbal
131	Nystrom_2006	5-4	Establish Network	Tasks	Verbal & Non-Verbal
132	Nystrom_2006	5-4	Mailing List	Partner Identification	Verbal & Non-Verbal
133	Jackson_2003	5-4	Meeting_F to F	Experts or Consultants	Verbal & Non-Verbal
134	Siau_1984	E-1	Channel	Policies	Verbal & Non-Verbal
135	Nystrom_2006	E-1	Computer	Forms_Orders	Non-Verbal
136	Cesar_2014	E-1	Computer and or Internet Meeting_F to F	Documents	
137	Nystrom_2006	E-1	Computer and or Internet	Diary Journal	Non-Verbal
138	Cesar_2014	E-1	Computer and or Internet, Meeting_F to F	Forms_Orders	Verbal & Non-Verbal
139	Cesar_2014	E-1	Computer and or Internet, Meeting_F to F	Change Forms, Customer Comments	Verbal & Non-Verbal
140	Cesar_2014	E-1	Computer and or Internet, Meeting_F to F	Customer Comments, Meeting	Verbal & Non-Verbal
141	Cesar_2014	E-1	Computer and or Internet, Meeting_F to F	Meeting	Verbal & Non-Verbal
142	Reissberg_2010	E-1	Computer and or Internet, Establish Network, Meeting_F to F	Public education	Verbal & Non-Verbal
143	Cesar_2014	E-1	Computer and or Internet, Meeting_F to F	Information	Verbal & Non-Verbal
144	Beer_1973	E-1	Computer, Meeting_F to F	Information Bureau	Verbal & Non-Verbal
145	Nystrom_2006	E-1	Computer, Internet	Chat, FAQ	Verbal & Non-Verbal
146	Preece_2013	E-1	Personnel change location	Resource Leveling	Verbal & Non-Verbal
147	Beer_1973	E-1	Physical Organization	Organization Structure	Verbal & Non-Verbal
148	Nystrom_2006	E-4	Computer	Survey and Analysis	Verbal & Non-Verbal
149	Preece_2013	E-4	Computer	Message	Verbal & Non-Verbal
150	Nystrom_2006	E-4	Computer	Sensors	Non-Verbal
151	Nystrom_2006	E-4	Meeting_F to F	Market Demands Report	Verbal & Non-Verbal

## F. VARIETY ATTENUATION OR VARIETY AMPLIFICATION FOR A PARTICULAR CHANNEL DIRECTION

### Notes on Variety Attenuation and Variety Amplification:

Notes	Description
1	Not all the 151 individual Channels of Communication yielded Communication Mechanisms that could be determined to be used to Attenuate/Amplify Variety. The void count is indicated with the symbol “-“.
2	The Authors of the source material in some case indicated specifically that the intent of the Communication Mechanism/s had the specific intent of Attenuate/Amplify Variety.

### Description of Table Headers:

Header Title	Description
Direction (From – To)	<p>As described by Shannon and Beer and many others, there are at least a minimum of two participants associated with a channel of communication. There is the Source and the Recipient. For this research, the Source and the Recipient one of the VSM Metasystem Functions and not an individual. The Source is always active by creating a packet of information. The Recipient may be active or passive where active is where a packet of information is received or consumed. Recipient passivity has two senses inferences, the first where the packet of information is received and no action is taken. The alternative Recipient passiveness is where the Source writes a message on a deserted beach.</p> <p>Having established that there is a Source and a Recipient, the direction of communication by convention is always from the Source to the Recipient.</p> <p>Within the construct of the metasystem, the channel of communications originates with a VSB Function is connected to one or more VSB Functions (direction is <u>from</u> - <u>to</u>).</p>
Variety	“According to Ashby’s law of requisite variety, systems can only be controlled if the would-be controller can command the same degree of variety as the system” (Jackson, 2003, p. 9).
Variety Attenuation	The count of Communication Mechanisms identified for a Channel of Communication direction that are used to decrease Variety
Variety Amplification	The count of Communication Mechanisms identified for a Channel of Communication direction that are used to increase Variety

### Counts of Communication mechanisms that cause Variety Attenuation or Variety Amplification for a Channel Direction



<b>Direction (From – To)</b>	<b>Variety Attenuation</b>	<b>Variety Amplification</b>
1-1	3	-
2-1	73	37
1-2	42	3
3-1	51	15
1-3	31	-
3*-1	35	-
1-3*	-	-
5-1	-	-
1-5	5	3
1-E	12	58
E-1	44	3
4-3	20	6
3-4	4	-
5-3	9	-
3-5	7	-
5-4	16	-
4-5	20	4
E-4	12	-
4-E	-	4
<b>Total</b>	<b>382</b>	<b>133</b>

### G. CSG COMMUNICATION SURVEY INSTRUMENT PARTICIPANT CONSOLIDATED RESPONSES

Question Number	Question	Multi-Answer	Question Intent	Consolidated Participant Responses
Q2	What does your company do?		Identity	Consulting engineering and architecture, CPA Firm, Engineering, Engineering Consulting, Engineering Design Consulting, Engineering Services, Financial, Financial Planning, Financial Planning/Insurance, Financial Services, Insurance and Financial Advising, Investments and Insurance.
Q3	What part of your company's organization do you work in?		Identity, Function	Accounting, Administration, Chemical and Mechanical Engineering, Chemical engineer, Chemical Engineering, Chemical Engineering Department, Civil Engineering, Civil/Structural department, Coordination of New Business, Department Manager and Project Manager, Director, Electrical Engineering, Electrical Engineering, Engineering and Design, Engineering Management, Engineering Manager. Human Resources, Management, Marketing, Mechanical Engineering, New Business Manager, Operations and Supervision, Project Controls, Project Management, Staff, Upper management.
Q4	How long have you worked in this current position?		Identity	2 Months to 41 Years
Q5	Have you held other positions in your current company?	Y/N	Identity	Yes and No
Q6	Do you have co-workers with your current position?	No (1) 5 or less Co-Workers (2) 7 to 5 Co-Workers (3) 8 to 10 Co-Workers (4)	Identity, Function	No - 6 5 or less Co-Workers - 14 7 to 5 Co-Workers - 2 8 to 10 Co-Workers - 17
Q7	What Work do you do/engage in?		Identity, Function	

Question Number	Question	Multi-Answer	Question Intent	Consolidated Participant Responses
Q8	This Survey will now be split into sets of questions associated with the description that best suits your function in your company. Select one of the below choices that best represents your functions.	Member of a Group/Project(s) and not a Supervisor (1) Supervisor and a Member of Project(s) (2) Supervisor and not directly involved in Project(s) (3)	Identity	N/A
Q9	What are the Communication Methods that you use with your Peers?		Technology, Direction, Mode	Email, meetings, phone calls, electronic, speech, Instant message, face to face discussions, face to face meetings, Skype meetings, text messages, electronic and paper documents and drawings
Q10	What are the Communication Methods that you use with your Supervisor?		Technology, Direction, Mode	Face to face meetings, email, phone, text, Skype
Q11	For your Work, what are inputs to your work and where do they come from?	Description of Work (1)	Identity, Product	Client or Manager, Client Service, Design Calculations, Engineering work, Design documents, Design Reports, Design, increasing sales opportunities, keep track and help the contractual and underwriting process of new life insurance business, Structural Design, plans to design, plans to draw, Project engineering, Projects & reports, Statements of work, scope of work from the client
		Description of Communication Method (2)	Technology, Product	Email, Face to face, face to face meeting, hand to hand, in-person, mail, meetings, Personal, phone calls, Skype
		Identity of source of Work (3)	Direction	Client and inputs are usually other project documents, Client through the Program manager, Co-workers and peers, Engineer, generally process Systems, Manager, Supervisor
Q12	Does any of your Work involve Clients or Customers?	Clients (1) Customers (2) No Clients or Customers (3)	Purpose, Environment	Yes and No

Question Number	Question	Multi-Answer	Question Intent	Consolidated Participant Responses
Q13	What is the preferred Communicate Methods do you use to communicate with your Clients or Customers?		Purpose, Environment, Technology, Direction, Mode	Email, face to face, face to face meetings, meeting, Phone, skype, voice, written reports or other deliverables
Q14	Does your Work involve individuals (not Clients or Customers) outside of your Company?	Yes (1) No (2)	Purpose, Environment, Technology, Direction, Mode	Yes and No
Q15	For the Work that involve individuals outside of your Company, what Communication Methods do you use?		Purpose, Environment, Technology, Direction, Mode	Email, email and phone, Face to face, letters, meeting, Phone, teleconferences
Q16	What improvements would you make to the current Communication Methods?	Existing Communication Method (1)	Purpose, Environment, Direction, Technology, Mode	Email - Include everyone who needs to be in the know. Provide the why and how, not just the what. Follow up with in person discussion/review so questions may be answered. Less "reply to all". Determine if the other person is online or not. Telephone follow-up. Meeting per month - Weekly meetings. Phone - Have clients answer the phone. Voicemail - Eliminate the computer conversion of voicemail to text.
		Existing Communication Method (2)	Direction, Technology, Mode	Meetings - Help us come prepared. If there will be a round-table discussion, provide a heads up so we can ponder it beforehand. Not everyone thinks best when put on the spot. Email - Have clients respond with greater frequency. Skype - Add the ability to share documents.

Question Number	Question	Multi-Answer	Question Intent	Consolidated Participant Responses
Q17	What Communication Method do you not have available at work but if you change the environment you would add?		Environment, Technology, Mode	A way for the project team to do their work in a system that is more visible to others on the team. This would be a block diagram (dash board like display) that gets input from team members computers as what they are working on. It would be a digital way of seeing what your team members are working on at the moment. Company online communication board (not Facebook). Facetime. Skype. Video Conference.
Q18	What Communication Method do you most prefer to communicate with your coworkers?		Purpose	Direct conversation, Email, Email and face to face, Face to face, Face to Face or Phone, Person to person, Phone conversation.
Q19	Were there any additional comments?		N/A	
Q20	What are the Communication Methods that you use with your Peers/Co-Workers?		Product, Mode, Technology, Direction	design drawings, email, email and telephone, Email and verbal, emails and instant messages, Face to Face Meetings, face to face, Face-to-face discussions, instant messaging, meetings, periodic and call-off meetings, personal meetings, phone, reports and specifications, Skype for Business, tele-conferences, telephone, text message, Verbal face to face or phone, weekly one on one and group meetings.
Q21	What are the Communication Methods that you use with your Supervisor?		Product, Mode, Technology, Direction	design drawings, Emails, Face to Face Meetings, Face to face, Face-to-face discussions, instant messaging, meetings, personal meetings, phone, reports and specifications, Skype for Business, snail mail, tele-conferences, telephone, texts, weekly group meetings.
Q22	Does any of your Work involve Customers?	Customers (2) Not Customers (3)		Yes and No
Q23	What is the preferred Communicate Methods do you use to communicate with your Customers?		Product, Mode, Technology, Direction, Environment	Email, face to face meetings, Face to Face, Face-to-face discussions, instant messages, meetings, Phone, reports, Skype for Business, snail mail, studies, tele-conferences, Telephone, texts, Verbal.

Question Number	Question	Multi-Answer	Question Intent	Consolidated Participant Responses
Q24	For the Work that involve individuals (Not Customers) outside of your Company, what Communication Methods do you use?		Environment, Product, Mode, Technology, Direction	design drawings, Email, Face-to-face discussions, personal meetings, phone, Skype for Business, specifications, talking in person, tele-conferences, telephone, texts, Verbal and written.
Q25	What Communication Method do you most prefer to communicate with your coworkers?		Product, Mode, Technology, Direction	Email, face to face, tele-conference, Verbal.
Q26	How many Groups do you Supervise?	2 or less Groups (1) 4 or less Groups (more than 2) (2) 6 or less (more than 4) (4)	Identity	
Q27	What are the Primary Communication Methods <u>you</u> use with the Groups that you supervise?		Product, Mode, Technology, Direction	Email, face to face discussions, face to face meetings, Meetings, phone, skype, Talking in person, tele-conference, telephone, text, Verbal face to face
Q28	What are the Secondary Communication Methods <u>you</u> use with the Groups that you supervise?		Product, Mode, Technology, Direction	conference calls, email, face to face, Letters, phone, phone, SharePoint, Skype, Talking in person, telephone, text.
Q29	What are the Communication Methods <u>you</u> use for exchanging Documents with Groups that you supervise?		Product, Mode, Technology, Direction	Common access to file server and email, document routing procedures, Email, email attachments, hard copy, hard copy printouts, hyperlinks to network sites, Server folders scans, SharePoint.
Q30	What type of Document is exchanged and who is Initiator/Receiver and with the Groups that you supervise?	Type of Document (1)	Product, Mode, Technology, Direction	Calculations, Doc., Drawings, Drawings and Specifications, electronic files, engineering drawing, Excel., multiple types, power points, Reports, Specifications, technical documents, technical drawings technical reports, training material.

Question Number	Question	Multi-Answer	Question Intent	Consolidated Participant Responses
		Initiator of Document (2)		All people in group, drafter, Engineer, project manager, Supervisor or client / outside advisors, Supervisor.
		Receiver of Document (3)		agents, Any group member, Client, design team members, drafter, engineer, executive management team, sales managers, staff, workers.
Q31	What Documentation helps <u>you</u> in coordination of the folks in each group?		Product, Mode, Technology, Direction	action item lists, Box and save all of our documents, daily calendar, Design Basis, Email, Excel, meeting minutes, metrics on time use and financial activity, Microsoft Outlook, Project, Execution Plan, reports, Schedule, Scope of Work, skype to pull up and discuss, Status reports.
Q32	What documentation or data do you provide/receive from individuals outside of your Company?		Environment, Product, Mode, Technology, Direction, Identity	Calculations, data sheets, design basis, Drawings, Email, equipment drawings, Equipment specification, evaluations, hard copy, provide request for quotation specifications, Quotations, quotes, receive vendor data sheets of equipment specs, Reports, Requests for information, Requests for proposal, Scopes of Work, Specifications and standards, Specifications, studies, summary reports, Tax forms, technical data, technical drawings, technical information, Vendor Technical Data.
Q33	What improvements would you make to the current Communication Methods?	Existing Communication Method (1)	Product, Mode, Technology, Direction	All - training for consistency Email - archiving by job number Email - face to face or telephone for clarification of email face to face, email, phone - none mostly face to face and email - more detail and whom should be included Security - Security Skype for Business - send attachments between organizations some individual change subject of email discussion without changing subject line of email so hard to find or continue the previous discussion Verbal - More verbal interpersonal discussions.

Question Number	Question	Multi-Answer	Question Intent	Consolidated Participant Responses
		Existing Communication Method (2)		Meetings - Better Participation not consistent - be consistent Telephone - email for documentation of conversation Work phone (land line) - ability to send and receive text messages.
Q34	What Communication Method do you not have available at work but if you change the environment you would add?		Environment, Product, Mode, Technology,	All methods are available. Just a better job of including everyone that should be. Real time updated drawing and vendor data files on network. Web server
Q35	Does any of your Project work involve Clients?	Clients (1) Not Clients or Customers (3)	Environment	Yes and No
Q36	What Communicate Methods do you to communicate with your Clients?		Purpose, Environment, Product, Mode, Technology, Direction	design drawings, Email, Face-to-face discussions, instant messages, meetings, phone, reports and specifications, Skype for Business, studies, talking in person, tele-conference, telephone, text messages, Verbal face to face.
Q37	Besides the current Communication Methods what additional methods would you like to be able to use?		Mode, Technology, Direction	Skype for Business with ALL my clients, Shared desktop, sharing service for large electronic files, skype, video conference.
Q38	Outside of work, what other Communication Methods do you use?		Mode, Technology, Direction	Email, face to face, Shared worktop, Skype / Face Time, telephone, text messages.
Q39	What Communication Method does your supervisor desire you to use?		Product, Mode, Technology, Direction	email, face to face, meetings, phone calls, reports, studies, tele-conference, text, Verbal.
Q40	What Communication Method do you use to communicate with your coworkers?		Product, Mode, Technology, Direction	design drawings, email, Face-to-Face, instant message, meetings, phone, reports and specifications, reports, Skype for Business, studies, Talking in person, tele-conference, text, Verbal face to face.
Q41	For your Groups does the work change?	No (1)	Purpose	Yes and No



Question Number	Question	Multi-Answer	Question Intent	Consolidated Participant Responses
		Yes (2)		
Q42	For your Groups how does the work change?		Purpose, Product, Mode, Technology, Direction	All projects are unique and different. Different client financial information. Different projects require different work activities. Each client and each project is different. Most often its scope creep initiated by a client or something that was missed at the planning stage. New clients with new projects with different requirements. Scope of work changes; design development changes.
Q43	For your Groups what is the Communication Method for notifying you of upcoming work changes?		Purpose, Product, Mode, Technology, Direction	When it happens, it is most often a meeting followed up with a corresponding email. Email. Verbal, meetings, and email. Talking in person, phone, email, Skype for Business, texts (the best form of communication depends on the situation, but email is generally preferable). Face to face, email, telephone. Change request. Staff Meetings. Design basis documents, project kick off meetings.
Q44	Thank you for participating in this survey.		N/A	

## H. CSG COMMUNICATION SURVEY INSTRUMENT BY ROLE CONSOLIDATED RESPONSES

### Member of a Group/Project(s) and not a Supervisor

	Response Count by Question						
<b>Responses (Grouped by Product, Mode, Technology, Direction)</b>	<b>Peer to Peer</b>	<b>To Supervisor</b>	<b>Inputs to Work how provided</b>	<b>To Customer or Client</b>	<b>To external individuals not Customer or Client</b>	<b>To Co- Workers</b>	<b>Product, Mode, Technology, Direction</b>
Drawing/written report/letter				1	1		Product, Mode (NV)
electronic and paper documents/SharePoint	1		1				Product, Mode (VNV)
electronic mail/email/E- mail, text	18	13	10	13	12	7	Technology, Product, Mode (NV)
face to face/face to face communication/ face to face discussions/face to face meetings/person to person/verbal/direct conversation/ meeting	16	15	6	6	3	9	Product, Mode (VNV)
Instant message	5	1					Technology, Mode (NV)
Phone/Telephone/calling/ teleconferences	16	6	5	5	10	2	Technology, Mode (V)
Skype	4	1	1	1			Technology, Mode (VNV)
Personal/contact/Speech	1						Technology, Mode (V)
Verbal and electronic	2	3				1	?

Note: Shaded box is highest response



### Supervisor and a Member of Project(s)

	Response Count by Question					
<b>Responses (Grouped by Product, Mode, Technology, Direction)</b>	<b>To Peers/Co- Workers</b>	<b>To Supervisor</b>	<b>To Customer</b>	<b>To external individuals not Customer or Client</b>	<b>To coworkers</b>	<b>Product, Mode, Technology, Direction</b>
Drawing/written report/letter	2	3	3	5		Product, Mode (NV)
electronic and paper documents/SharePoint						Product, Mode (VNV)
electronic mail/email/E-mail, text	17	17	11	11	3	Technology, Product, Mode (NV)
face to face/face to face communication/ face to face discussions/face to face meetings/person to person/verbal/direct conversation/ meeting	12	12	7	6	7	Product, Mode (VNV)
Instant message	2	2	1			Technology, Mode (NV)
Phone/Telephone/calling/teleconferences	9	10	5	10	1	Technology, Mode (V)
Skype	1	1	1	1		Technology, Mode (VNV)
Personal/contact/Speech						Technology, Mode (V)
Verbal and electronic	4	3	2	2	3	?

Note: Shaded box is highest response

**Supervisor and a Member of Project(s) (Cont.)**

	Response Count by Question						
<b>Responses (Grouped by Product, Mode, Technology, Direction)</b>	<b>Primary to Groups you supervise</b>	<b>Secondary to Groups you supervise</b>	<b>Communication to Exchanging Documents with Groups you supervise</b>	<b>To Clients</b>	<b>To Coworkers</b>	<b>Communication Method for work changes</b>	<b>Product, Mode, Technology, Direction</b>
Drawing/written report/letter		1	1	4	1	2	Product, Mode (NV)
electronic and paper documents/SharePoint		1	6				Product, Mode (VNV)
electronic mail/email/E- mail, text	9	8	10	12	13	6	Technology, Product, Mode (NV)
face to face/face to face communication/ face to face discussions/face to face meetings/person to person/verbal/direct conversation/ meeting	7	2		7	11	5	Product, Mode (VNV)
Instant message				1	1		Technology, Mode (NV)
Phone/Telephone/calling/ teleconferences	2	5		7	8	2	Technology, Mode (V)
Skype	2			1	1	1	Technology, Mode (VNV)
Personal/contact/Speech							Technology, Mode (V)
Verbal and electronic	3			2	2	1	?

Note: Shaded box is highest response

# I. CSG COMMUNICATION SURVEY INSTRUMENT BY FUNCTION CONSOLIDATED RESPONSES

## Response by Members of Function M3

	Response Count by Question				
<b>Responses (Grouped by Product, Mode, Technology, Direction)</b>	<b>With Peers/Co- Workers</b>	<b>With Supervisor</b>	<b>Communicate with Clients or Customers (E)</b>	<b>To external individuals not Customer or Client (E)</b>	<b>Product, Mode, Technology, Direction</b>
Drawing/written report/letter			1	1	Product, Mode (NV)
electronic and paper documents/SharePoint	1				Product, Mode (VNV)
electronic mail/email/E-mail, text	22	15	13	12	Technology, Product, Mode (NV)
face to face/face to face communication/ face to face discussions/face to face meetings/person to person/verbal/direct conversation/ meeting	18	18	6		Product, Mode (VNV)
Instant message	2				Technology, Mode (NV)
Phone/Telephone/calling/teleconferences	16	6	4	10	Technology, Mode (V)
Skype	4	1	1		Technology, Mode (VNV)
Personal/contact/Speech					Technology, Mode (V)
Verbal and electronic	2	3	1		?

Note: Shaded box is highest response

**Response by Members of Function M3\***

	Response Count by Question							
<b>Responses (Grouped by Product, Mode, Technology, Direction)</b>	<b>With Peers/Co- Workers</b>	<b>With Supervisor</b>	<b>Communicate with Clients or Customers</b>	<b>To Co- Workers</b>	<b>To external individuals not Customer or Client</b>	<b>Primary to Groups you supervise</b>	<b>Secondary to Groups you supervise</b>	<b>Product, Mode, Technology, Direction</b>
Drawing/written report/letter	1	2	3		2		1	Product, Mode (NV)
electronic and paper documents/SharePoint							1	Product, Mode (VNV)
electronic mail/email/E-mail, text	15	15	11	1	10	7	8	Technology, Product, Mode (NV)
face to face/face to face communication/ face to face discussions/face to face meetings/person to person/verbal/direct conversation/ meeting	11	12	9	7	5	7	2	Product, Mode (VNV)
Instant message	2	2	1					Technology, Mode (NV)
Phone/Telephone/calling/teleconferences	7	8	5	1	8	3	3	Technology, Mode (V)
Skype	1	1	1		1	2	2	Technology, Mode (VNV)
Personal/contact/Speech								Technology, Mode (V)
Verbal and electronic	4	3	2	3	1	3		?

Note: Shaded box is highest response

**VITA**  
for  
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Dr. Chesterman served in a variety of positions as a Surface Warfare Officer and an Engineering Duty Officer

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"Systems theory as a foundation for governance of complex systems", Int. J. System of Systems Engineering, Vol. 6, Nos. 1/2, 2015.

"Metasystem communication in governance of complex systems", Int. J. System of Systems Engineering, Vol. 6, Nos. 1/2, 2015.

U.S. Patent Application Number 13/030,158, Date- 02/18/2011.

Fleet-originated Maintenance Figure of Merit (MFOM), American Society of Naval Engineers, September 2010.

Fleet-Originated Distance Support, Maintenance Figure of Merit (MFOM), American Society of Naval Engineers, February 2009.

"Standardizing Material Condition Assessments", U.S. Naval Institute, Proceedings, January 2001.