Fall 2016

Systems Theory Based Architecture Framework for Complex System Governance

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SYSTEMS THEORY BASED ARCHITECTURE FRAMEWORK FOR COMPLEX SYSTEM GOVERNANCE

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

DOCTOR OF PHILOSOPHY

ENGINEERING MANAGEMENT AND SYSTEMS ENGINEERING

OLD DOMINION UNIVERSITY
December 2016

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ABSTRACT

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The purpose of this research was to develop a systems theory based framework for complex system governance using grounded theory approach. Motivation for this research includes: 1) the lack of research that identifies modeling characteristics for complex system governance, 2) the lack of a framework rooted in systems theory to support performance of complex system governance functions for maintaining system viability.

This research focused on answering: What systems theoretic framework can be developed to inform complex system governance and enable articulation of governance function performance? The grounded theory research approach utilized three phases. First, the literature in systems theory, management cybernetics, governance and enterprise architecture was synthesized and open-coded to generalize main themes using broad analysis in NVivo software, researcher note taking in EndNote, and cataloging in Excel spreadsheets. Second, the literature underwent axial-coding to identify interconnections and relevance to systems theory and complex system governance, primarily using Excel spreadsheets. Finally, selective coding and interrelationships were identified and the complex system governance architecture framework was shaped, reviewed, and validated by qualified experts.

This research examined a grounded theory approach not traditionally used in systems theory research. It produced a useful systems theory based framework for practical application, bridging the gap between theory and practice in the emerging field of complex system

governance.

Theoretical implications of this research include identifying the state of knowledge in each literature domain and the production of a unique framework for performing metasystem governance functions that is analytically generalizable. Management cybernetics, governance, and systems theory are expanded through a testable tool for meta-level organizational and system governance theories. Enterprise architecture is advanced with a multi-disciplinary framework that coherently presents and facilitates new use for architecture at the metasystem level.

Methodological implications of this research include using grounded theory approach for systems theory research, where it is atypical. Although a non-traditional method, it provides an example for conducting fruitful research that can contribute knowledge.

Practical implications of this research include a useable framework for complex system governance which has never before existed and a living structure adaptable to evolutionary change coming from any related domain or future practical application feedback.

This dissertation is dedicated to Esmeralda and Alexandra.
-Together Forever-

ACKNOWLEDGMENTS

I am most grateful to Dr. Charles B. Keating, my Advisor, for opening the aperture of my worldview in systems thinking and inspiring me to be part of a Learning Community on the leading edges of complex system governance. Thank you Dr. Mamadou D. Seck, Dr. Teddy Cotter, and Dr. James C. Pyne for your academic partnership and oversight as research committee members. Thank you Dr. Kim Sibson for your time and effort conducting editing review. Thank you Learning Community members for your professional partnership and critical peer reviews of this research and related briefings, journal articles, and book chapter material. I look forward to continuing the journey with you.

Many cast doubt on the potential for return on investment in time and resources required to pursue this endeavor of independent scholarly research, but never once was there a shred of doubt expressed by my devoted wife or loving daughter despite the many competing challenges we faced together along the way. Esmeralda and Alexandra, thank you.

NOMENCLATURE

ADP	Architecture Development Process
AF-EAF	Air Force Enterprise Architecture Framework
AFIoT	IEEE P2413 – Architecture Framework for the Internet of Things
AGA	Australian Government Architecture Reference Models
AGATE	Atelier de Gestion de l'ArchiTecturE des Systèmes d'Information et de Communication
AM	Avancier Methods
ARCHI	ArchiMate
AUSDAF	Australian Defence Architecture Framework
AAF	Automotive Architecture Framework
ATO	Australian Taxation Office
BCA	Business Capability Architecture
BDAF	Big Data Architecture Framework
BEAM	Business Enterprise Architecture Modeling
BPEAM	Best Practice Enterprise Architecture Management
CAFCR	Customer Objectives, Application, Functional, Conceptual, and Realisation Model
CAFEA	Common Approach to Federal Enterprise Architecture
CBDI-SAE	CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA
CEA	CEA Framework: A Service Oriented Enterprise Architecture Framework
CEAF	Commission Enterprise IT Architecture Framework
CIAF	Capgemini Integrated Architecture Framework

CSG	Complex System Governance
CSGAF	Complex System Governance Architecture Framework
DoDAF	Department of Defense Architecture Framework
DND/CF	Canadian Department of National Defense and the Canadian Forces
DNDAF	DN/CF Architecture Framework
DRA1	Dragon 1
DYA	Dynamic Architecture
EA	Enterprise Architecture
EAB	Enterprise Architecture Blueprinting
E2AF	Extended Enterprise Architecture Framework
EAM-PC	EAM Pattern Catalog
EAP	Enterprise Architecture Design Principles
EEAF	US OMB Enterprise Architecture Assessment Framework
EES	Extended Enterprise Systems
EPCAF	EPC Global Architecture Framework
ESAAF	European Space Agency Architecture Framework
ESG	Enterprise Systems Governance
ESSAF	Essential Architecture Framework
eTOM	Business Process Framework
EXAF	Extreme Architecture Framework
FEAF	Federal Enterprise Architecture Framework
FESS	Framework of Enterprise Systems and Structures

FFLV+GODS	Functions-Flows-Layers-Views + Governance-Operations-Development-Support
FMLS-ADF	FMLS Architecture Description Framework 3.0
FSAM	Federal Segment Architecture Methodology
GA	Garland and Anthony
GEAF	Gartner's Enterprise Architecture Framework
GERA	ISO 15704 Generic Enterprise Reference Architecture
HEAF	Health Enterprise Architecture Framework
HV	Human View (NATO)
IADS	IBM Architecture Description Standard
IAF	Index Architecture Framework
ICODE	iCode Security Architecture Framework
IFW	IBM Information Framework
3D EAF	3-Dimensional Enterprise Architecture Framework
4+1	Kruchten's 4+1 View Model
LEAD	Leading Enterprise Architecture Development Practice
LST	Living Systems Theory
MACCIS	An Architecture Description Framework for Technical Infostructures and their Enterprise Environment
MCS	Minimal Critical Specifications
MBSA	Model Based System Architecture
MEGAF	Mega-modeling Architecture Framework
MODAF	Ministry of Defense Architecture Framework

MP	Metasystem Pathology
MV	Metasystem Viewpoint
NAF	NATO Architecture Framework
NIST-EAM	NIST Enterprise Architecture Model
OIO	OIO Enterprise Architecture Method
PEAF	Pragmatic Enterprise Architecture
PPOOA	Processes Pipeline in Object Oriented Architectures
PRINCE2	Projects In Controlled Environments
PRISM	Partnership for Research in Information Systems Management
QGEA	Queensland Government Enterprise Architecture
RASDS	Reference Architecture for Space Data Systems
RM-ODP	ISO Reference Model for Open Distributed Processing
RWSSA	Rozanski and Woods
S4V	Siemens 4 Views
SABSA	Sherwood Applied Business Security Architecture
SASSY	Self-Architecting Software Systems
SDLC	System Development Life Cycle
SGCAF	Smart Grid Conceptual Architecture Framework
SoS	System of Systems
ST	Systems Theory
TEAF	(US) Treasury Enterprise Architecture Framework
TOGAF	The Open Group Architecture Framework
TRAK	The Rail Architecture Framework

UADF	Universal Architecture Description Framework
VCD	Value Chain Diagram
VSM	Viable System Model
WFM	Work Flow Model
xAF	Extensible Architecture Framework
ZAF	Zachman Framework

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CHAPTER I

INTRODUCTION

The purpose of this chapter is to lay the foundation for building knowledge where critical gaps exist in the complex system governance domain.

Problem Statement and Background

Keating, Katina and Bradley (2014) coalesce systems theory, governance and management cybernetics in their introduction of the emerging field of complex system governance and offer a provisional definition of complex system governance as the:

> *Design, execution, and evolution of the metasystem functions necessary to provide control, communication, coordination, and integration of a complex system. (p. 274)*

A pending contribution to the emerging field of complex system governance is architecture framework for performing governance functions because complex system governance is not associated with an existing architecture framework. (Carter, 2015; Walters, Moorthy, & Carter, 2014). Architecture framework is defined as:

> *Conventions, principles and practices for the description of architectures established within a specific domain of application and/or community of stakeholders. (ISO/IEC/IEEE, 2011, p. 2)*

A recent survey of architecture frameworks identifies no less than 68 different architecture frameworks (ISO/IEC/IEEE, 2016). The growth in the number of architecture frameworks may explain why there is a lack of standardization regarding the form/fit/function of architecture frameworks, but this could also be explained as a need to tailor architecture frameworks to suite the unique needs of a system. At a minimum, architecture frameworks should describe a system's processes and information flow, physical and logical architecture, related interaction with the environment, operational and lifecycle requirements, and system outputs. Complex system governance may benefit from unique governance architecture framework that facilitates completion of metasystem governance functions.

Governance architecture framework is described as a framework for development of architecture views necessary to perform complex system governance functions, which are defined in the Governance Reference Model (Keating & Bradley, 2015) and will be discussed further in Chapter II but are briefly outlined here.

Metasystem Five (M5) – Policy and Identity: Focused on overall steering and trajectory for the system. Maintains identity and balance between current and future focus.

Metasystem Five Star (M5)* – System Context: Focused on oversight of the system performance indicators at a strategic level, identifying performance that exceeds or fails to meet established expectations.

Metasystem Five Prime (M5') – Strategic System Monitoring: Focused on the specific context within which the metasystem is embedded. Context is the set of circumstances, factors, conditions, or patterns that enable or constrain execution of the system.

Metasystem Four (M4) – System Development: Maintains the models of the current and future system, concentrating on the long-range development of the system to ensure future viability.

Metasystem Four Star (M4)* – Learning and Transformation: Focused on facilitation of learning based on correction of design errors in the metasystem functions and planning for transformation of the metasystem.

Metasystem Four Prime (M4') – Environmental Scanning: designs, deploys, and monitors sensing of the environment for trends, patterns, or events with implications for both present and future system viability.

Metasystem Three (M3) – System Operations: Focused on the day-to-day execution of the metasystem to ensure that the overall system maintains established performance levels.

Metasystem Three Star (M3)* – Operational Performance Monitoring: Monitors system performance to identify and assess aberrant conditions, exceeded thresholds, or anomalies.

Metasystem Two (M2) – Information and Communications: Designs, establishes, and maintains the flow of information and consistent interpretation of exchanges (communication channels) necessary to execute metasystem functions.

These functions are rooted in Stafford Beer's [1926-2002] work in Management Cybernetics and the Viable System Model (VSM) (Beer, 1959, 1966, 1968, 1970, 1972, 1975, 1979, 1981, 1985, 1994). Fundamentally, models statically represent something at one point in time for the purpose of conveying information about what is being represented. A simple example of this is a two-dimensional drawing of an event or thing using one's finger or a stick drug through dirt to create the representation, perhaps done thousands of years ago by people of that time. Carrying this example forward to today's realm of sophisticated tools and technology, models are used to represent system interactions and change over time. A simple example of this is manipulating a system model such that it reveals interactions not apparent between two static representations of the system (two drawings in the dirt). Enterprises and organizations are forms of complex systems. Enterprise architecture is a form of system model relevant to complex system governance. Enterprise architecture (EA) is defined by Rao, Reedy, and Bellman (2011) as:

> *…a rigorous description of the structure of an enterprise. EA describes the terminology, the composition of enterprise components, and their relationships with the external environment and the principles for the requirement, design, and evolution of an enterprise. (712-713)*

Table 1 describes primary VSM metasystem governance functions, Table 2 describes a randomly chosen existing enterprise architecture framework's views (DoDAF) (*The DoDAF Architecture Framework Version 2.02*, 2010) to initially explore a set of views, and Table 3 provides assessment of potential application of the chosen framework's views for supporting governance functions.

Table 1. VSM Metasystem Governance Functions
(Adapted from Carter, Moorthy & Walters (2016))

Metasystem Primary Functions
V1. Oversee system and retain accountability to and for the system
V2. Facilitate system evolution
V3. Implement system policy
V4. Allocate system resources
V5. Monitor strategic and operational system performance
V6. Identify system performance trends and variations
V7. Identify system transformation initiatives
V8. Identify system weaknesses, opportunities and threats from within the system and its operating environment
V9. Implement architecture for information flow and communication within the system and its operating environment

Table 2. DoDAF View Categories and What They Provide
(Adapted from Carter et al. (2016))

DoDAF Views	
Name	Contribution
D1. All View (AV)	Potential for deriving system context using all viewpoints
D2. Capability View (CV)	System capabilities
D3. Data and Information View (DIV)	Data relationships and alignment
D4. Operational View (OV)	Intended system operations
D5. Project View (PV)	Operational and capability requirement and dependency alignment
D6. Services View (SvcV)	Design for exchange between performers (system elements), activities and services
D7. Standards View (StdV)	Systems engineering process policies, standards, guidance, and constraints
D8. Systems View (SV)	Design for solutions supporting operational and capability functions

Table 3. Assessment of Existing Architecture Framework Views Potential for Supporting Governance Reference Model and VSM Metasystem Functions

DoDAF	Governance Reference Model and VSM
D1	M5*, M5'
D2	M4, M4*, V7
D3	M2
D4	M3, M3*, V5
D5	M4, V5, V7
D6	V9
D7	
D8	

This initial assessment indicated some potential utility referencing DoDAF views to develop complex system governance architecture (Table 3 reveals limited application of DoDAF views in D1-6 and none in D7-8). At this point, further investigation was warranted for determining appropriateness for reusing or repurposing existing enterprise architecture views or viewpoints to develop complex system governance architecture.

Governance is not simply system operations or system management, the focus of many enterprise architecture frameworks. Governance refers to metasystem governance, which functions at a higher logical level and time horizon than existing enterprise architecture. The focus of metasystem governance is clearly rooted in Beer's VSM but still includes technical system considerations. At this point in the research formulation stage, classifying existing architecture frameworks broadly became necessary. Table 4 is the initial classification of 68 then-known existing architecture frameworks into their stated or perceived area(s) of focus or intent. Classifications fell within three general categories of technical, governance and management. Specific to this classification and research effort, the following initial characterizations were adopted for each category.

Technical:

- The technical category includes activities and interests centered in a system's information technology and/or electronic communications.

Governance:

- The governance category includes activities and interests centered in maintaining a system's viability over time.

Management:

- The management category includes activities and interests centered in a system's daily operations.

These characterizations were used to gain insight into the landscape of existing architecture frameworks for further study. This research does not suggest the characterizations should be adopted for other research.

Table 4. Generalized Construct for Classifying Architecture Frameworks (Adapted from ISO/IEC/IEEE (2016))

Classification of Architecture Framework Characteristics			
Name / Identifier	Technical	Governance	Management
CSGAF	X	X	X
AF-EAF	X	X	
AFIoT	X		
AGA	X		X
AGATE	X		
AM	X	X	
ARCHI	X		
AUSDAF	X		
AAF	X		
BCA	X		X
BDAF	X		
BEAM	X		
BPEAM	X		X
CAFEA	X		X
CBDI-SAE	X	X	
CEA	X		X
CEAF	X		
CIAF	X	X	
DoDAF	X		
DNDAF	X		
DRA1	X		
DYA	X		X
EAB	X		
E2AF			X
EAM-PC			X
EEAF			X
EPCAF	X		
ESAAF	X		
ESSAF	X		
eTOM			X
EXAF	X		X
FEAF	X		X
FESS			
FFLV+GODS	X		X
FMLS-ADF	X		
FSAM	X		
GA	X		
GEAF	X		
GERA	X		X
HEAF	X		
IADS	X		
IAF			X
ICODE	X		
IFW	X		
4+1	X		
LEAD			X
MACCIS	X		
MEGAF	X		

Table 4 (continued)

MODAF	X		X
NAF	X		
NIST-EAM			
OIO			
PEAF		X	
PPOOA	X		
PRISM	X		
QGEA		X	X
RASDS	X		
RM-ODP	X		
RWSSA	X		
S4V	X		
SABSA	X		
SASSY	X		
SGCAF	X		X
TEAF			
TOGAF	X		
TRAK	X		
UADF			
xAF	X		
ZF	X		X

Table 4 indicated existing architecture frameworks trended toward technical system architecture support, where their use appeared to benefit system designers and developers. Where multiple classifications exist indicates a balance or indistinguishable prominence of one focus over another. This survey seemed to indicate the value of employing enterprise architectures was on system technical characterizations and utilizations, which is not the dominant need in a complex system governance architecture framework. The most significant gaps in existing enterprise architectures and systems theory literature at this stage was observed as 1) high variety in existing frameworks and architectures and 2) lack of defined minimal critical specifications for a complex system governance architecture framework.

Architecture models and modeling approaches are highly tailored to suit the specific needs of a system. Identifying applicability of existing architecture models to a complex system governance architecture framework became part of the focus of this study because it was hypothesized subsequent architecture modeling efforts would then prove more efficient than attempting to fit complex system governance into an architecture model designed for other purposes.

Enterprise architecture frameworks primarily provide tailoring of system technical architecture models. A complex system governance architecture framework is expected to provide foundation for developing tailored complex system governance architecture models and potentially offer other contributions (Keating et al., 2014).

Research Question

The previous section identified a complex system governance architecture framework rooted in systems theory would be beneficial but does not exist. The utilization of existing enterprise architecture and knowledge from the domains of enterprise architecture, governance, management cybernetics and systems theory may contribute to complex system governance architecture framework development. The following question shapes the purpose of this research.

What systems theoretic framework can be developed to inform complex system governance and enable articulation of governance function performance?

Research Purpose

Based on the research question established in the previous section, the purpose of this research is to develop a systems theoretic complex system governance architecture framework that supports the performance of complex system governance functions. This framework, to be rooted primarily in systems theory but also in the domains of governance, management cybernetics and enterprise architecture, must consist of concepts and definitions relevant to or referenced in scholarly literature for systems theory to be considered systems theoretic. The performance of this research will demonstrate understanding of systems theory and concepts and of the broader areas of knowledge being considered.

Architecture frameworks are *conventions, principles and practices for the description of architectures* established within a specific domain of application and/or community of stakeholders (ISO/IEC/IEEE, 2011, p. 2). A complex system governance architecture framework therefore describes the conventions, principles and practices for establishing complex system governance architectures (this initial definition is further clarified in later chapters).

Grounded theory research approach will be used to capture the framework's requirements and shape its development. Using grounded theory approach enables the researcher to derive "a general, abstract theory of a process, action, or interaction grounded in the views of participants" (Creswell, 2009, p. 13) and has two primary characteristics, "constant comparison of data with emerging categories and theoretical sampling of different groups to maximize the similarities and the differences of information" (Creswell, 2009, p. 13). Analyzing data using a grounded theory approach includes coding (open, axial and selective) the data (text, pictures, other) and developing a theory, which is reported by describing the research question, literature review, methodology, analysis and implications (Creswell, 1998; Leedy & Ormrod, 2010).

Research Delimitations

This research is not intended to develop complex system governance architecture. Architecture is the fundamental *organization of a system* embodied in its components, their relationships to each other and to the environment, and in the principles guiding its design and evolution (ISO/IEC/IEEE, 2011, p. 2). Therefore, it is anticipated complex system governance architecture will be producible using the architecture framework derived through this research.

This research is not intended to study modeling types, practices, tools or uses beyond architecture framework models revealed in enterprise architecture literature. A detailed study of modeling techniques and tools may become relevant for future research using the governance architecture framework developed in this research as a basis for modeling requirements.

This research is not a case study. Case studies "are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time" (Creswell, 2009, p. 13). The nature and context of complex system governance detailed in subsequent chapters includes extended time horizons commensurate with organizational strategic planning that are not suitable for developing an architecture, collecting and analyzing data over time, and reporting on the results. A case study analysis would be more appropriately accomplished in future research over an extended period.

Research Significance

This research provides theoretical, methodological and practical advancements in the governance domain. While enterprise architecture has been dominant in system technical characterizations, it has not been advanced through systems theory or applied to metasystem governance functions. Enterprise architecture, systems theory, governance and management cybernetics have not been used to develop a complex system governance architecture framework. This research advances ideas for an integrated common operational picture, environmental landscape, or virtual reality space for complex system governance. Table 5 indicates the contributions of this research spanning theoretical, methodological, and practice dimensions.

Table 5. Research Contributions

Theoretical	Methodological	Practical
Provide classification schema for characteristics and attributes of a systems theory based Governance Architecture Framework	Use of Grounded Theory in a field of study to produce a useful systems theory based framework for practical application	Bridge gap between governance theory and practice through a framework for performing governance functions

Research Limitations

The limitations of this research are 1) it is qualitative and 2) it does not seek to establish the utility of the proposed complex system governance architectural framework through case study application or other empirical data collection techniques. These are limitations that may be unacceptable in certain professional or academic minds without otherwise testing or validating the claims. These limitations are overcome as much as possible using detailed descriptions of the research process and peer review of the results. The rigorous execution of Grounded Theory Method (Glaser & Strauss, 1967) provides for internal validity of the theoretical construct produced from the method (Creswell, 2009, pp. 162-169, 190-193). Maximizing acceptability also demands validation of the results, meaning the research must show how utilization of a complex system governance architecture framework helps accomplish the functions of metasystem governance. The following issues and specific responsive strategies were considered as the researcher designed the research to advance knowledge in the complex system governance domain.

Design:

- The scope of reaching saturation in any of the literature domains may be too large in the context of developing architectural views/models that can be validated and credible.

    - The proposed research design focuses on developing the framework through which governance architecture views/models are constructed.
    - Regarding the qualification of credible peers, they are identified as doctoral students, candidates, or those PhDs who have conducted and published peer-reviewed research in complex system governance.
    - Regarding the utilization of credible peers for feedback, all interactions and outcomes are documented to provide transparency in the research process.

Execution:

- Unintended scope creep may be a risk during literature review, literature data analysis, or framework development.
    - Avoiding scope creep includes maintaining understanding of the purpose of literature review and literature data for research. Development concepts and ideas are formulated through iterative discussions and literature review. Literature review cites conclusions of previous studies that are synthesized to establish design criteria for the framework. Maintaining this understanding will reduce risk of scope creep in a research endeavor (Creswell, 2009).

Potential Utilization of Research:

- The enterprise architecture community may misinterpret the findings and attempt to apply governance architecture in an IS/IT management context. This could lead to negative evaluation of the findings and exacerbate misunderstanding between management and governance.

  - Strategy to mitigate includes disclaimers and clear articulation of the meaning of the findings. Future use and follow-on research implications will clearly state the narrow focus of complex system governance architecture framework.
  - Presentations and publications can also serve to mitigate any misunderstanding.
- Readers may attempt to utilize the complex system governance architecture framework to develop tailored governance architecture in an operational environment with unrealistic expectations.
  - Strategy to mitigate includes disclaimers and clear articulation of the meaning of the findings. Future use and follow-on research implications will clearly state the narrow focus of complex system governance architecture framework.
  - Presentations and publications can also serve to mitigate any misunderstanding.

Every study can and should be scrutinized and provided with critical assessment. Recognizing the limitations of a qualitative research study enables the researcher to develop a structure that is transparent, detailed, and able to meet acceptable standards for original scholarly contribution to a body of knowledge. Such a structure ensures research reliability and validity, which has also been conceptualized as trustworthiness, rigor and quality in the qualitative research paradigm (Golafshani, 2003).

Dissertation Structure

The remainder of this document is organized where Chapter II builds on literature identified in Chapter I to include synthesis of literature domains in systems theory, governance, management cybernetics, and enterprise architecture as it applies to complex system governance and a supporting architecture framework. Chapter III describes the researcher's perspective and paradigms on research, concerns about grounded theory and inductive research, and potential research performance issues with strategies to mitigate. Chapter IV details the research methodology, including research design, phases and analysis. Chapter V reveals research results with detailed explanation of the complex system governance architecture framework. Chapter VI summarizes findings by drawing conclusions and identifying future research.

Chapter Summary

This chapter provided research foundation to fill an existing gap in the body of knowledge for complex system governance. It provided detailed explanation of the problem statement and background, purpose and significance of the study, and relevance of the research question. The chapter also identified the research limitations and potential research performance issues with strategies to mitigate. The chapter closed by describing the remainder of the dissertation document.

CHAPTER II

LITERATURE REVIEW

This chapter discusses literature associated with the research. Literature is organized into domains of Systems Theory, Management Cybernetics, Governance and Enterprise Architecture. The objectives of this literature review are to identify, evaluate, and integrate the relevant findings in each literature domain.

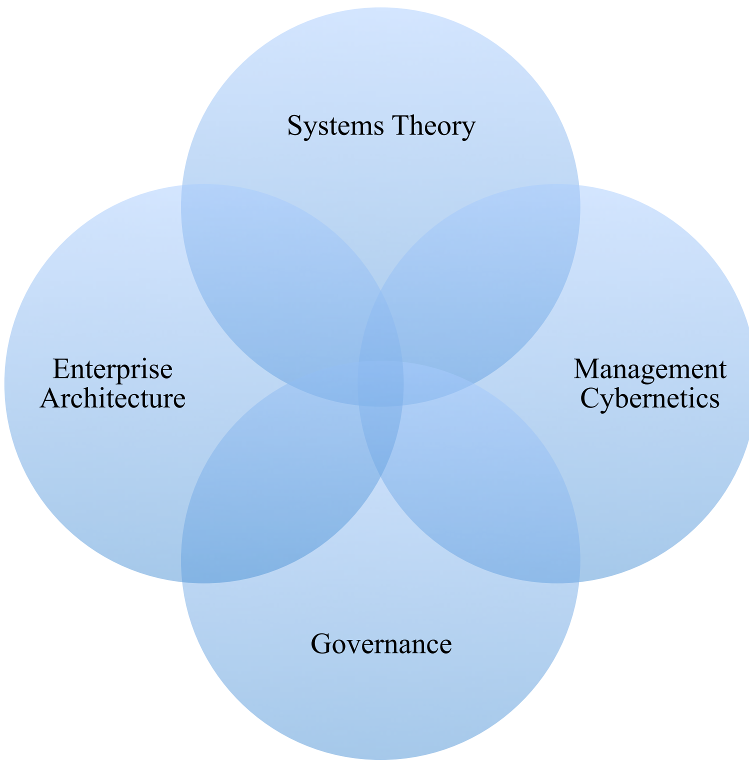

Figure 1. Literature Domains Under Study

Initial presentation of literature in these domains articulated in Chapter I established basis for research design, question, objectives, and contributions. Further study of literature in these domains was required to answer the research question through grounded theory-based development of an applicable systems theoretic complex system governance architecture framework.

Literature was qualified for inclusion to manage research scope and ensure quality of domain knowledge referenced in formulating the research question's answer. Qualification requirements for each domain's literature to be included in this study are described in Table 6 with an over-arching requirement that literature entails some aspect of systems theory.

Table 6. Literature Qualifying Requirements

	Requirement / Characteristic / Bona-fides
Include	Peer-reviewed publication, proceedings
Include	Cited in peer-reviewed publication, proceedings
Exclude	Unpublished works
Exclude	Non-peer-reviewed publications

This approach bounds the literature review into a focused study and assists in identifying interrelations in the literature and in performing coding in support of executing a grounded theory approach to answering the research question.

Literature Domain Reviews and Critique

This section focuses on identifying prominent aspects of the literature that relate directly to developmental considerations for a complex system governance architecture framework. Initial literature targets were focused on linkages in the literature. The following linkages were explored during literature search, listed in order of investigation.

Table 7. Literature Search Combinations

Subject / Phrase	And, Or	Subject / Phrase
Systems theory	And	Management cybernetics
Systems theory	And	Governance
Systems theory	And	Enterprise architecture (framework)
Management cybernetics	And	Enterprise architecture (framework)
Governance	And	Management cybernetics
Governance	And	Enterprise architecture (framework)
Architecture framework	And	Systems theory
Architecture framework	And	Management cybernetics
Architecture framework	And	Governance
Complex system governance	And	Systems theory
Complex system governance	And	Management cybernetics
Complex system governance	And	Enterprise architecture (framework)
Complex system governance	And	Architecture framework
Complex system	And	Systems theory
Complex system	And	Management cybernetics
Complex system	And	Governance
Complex system	And	Architecture framework
Complex system	And	Enterprise architecture (framework)
Modeling	Or	Modelling
[above]	And	Systems theory
[above]	And	Management cybernetics
[above]	And	Governance
[above]	And	Enterprise architecture (framework)
[above]	And	Architecture framework

The following table represents a portion of over 130 journals and databases consulted.

Table 8. Journals and Databases Consulted

Journals	Databases
Cybernetica	Digital Dissertations
Decision Science	EBSCOhost
Engineering Management Journal	Emerald Management
Engineering Management Review	Google Scholar
IEEE Systems Journal	IEEE Xplore
International Journal of SoS Engineering	JSTOR
Management Science	ScienceDirect
Systems Engineering	Springer LINK
The Academy of Management Journal	Wiley Online

Literature reviews revealed several significant events in each domain relevant to answering the research question. The next sections discuss literature domains individually, followed by a synopsis of findings in the chapter summary.

Governance

Governance spans a vast array of disciplines and literature is extensive. Advancement of governance related concepts began decades ago and has been regularly intertwined with other domains like complexity (Duit & Galaz, 2008) and management cybernetics (Beer, 1959, 1966, 1968, 1970, 1972, 1975, 1979, 1981, 1985, 1994), including such concepts as the law of requisite variety (Ashby, 1956; Conant & Ashby, 1970) and minimal critical specifications (Cherns, 1976, 1987; Morgan, 1993, 1997; Oborski, 2003). The relationship between governance literature and other fields also includes association with complex system governance and systems theory (Keating et al., 2014), development of a system governance framework (Calida, 2013), system of systems governance implications (Keating, 2014) and introduction of a complex system governance reference model (Keating & Bradley, 2015) which spans multiple domains.

Definitions of governance vary in meaning or intent, including ‘control’, ‘manage’, ‘constrain’, ‘operate’ and ‘coordinate’. A common governance theme is interaction and collaboration between people, units, organizations, stakeholders, networks and other system elements (Kaivo-Oja & Stenvall, 2013). Discussing complexity and governance, Francois (2008) advised social scientists and systems theorists:

> *In order to manage problems, it is high time for both groups to join in their study of complex social systems. In this way, we may finally get rid of our generally authoritarian and high-handed view of governance and replace it by informed and pragmatic concepts of manageability (p. 357).*

Mansouri and Mostashari (2010) offered just such a pragmatic interdisciplinary approach in their proposal of the field of Enterprise Systems Governance (ESG) and study of the fundamentals of effective governance in Extended Enterprise Systems (EES), suggesting that ESG combine complexity, social science, systems, and network theories to explore how complex problems in EES are governed. Portions of the combinations suggested by Mansouri and Mostashari (2010) are addressed by Gutierrez, Ciarletta and Chevrier (2013) in their consideration of techno-social systems under what they call 'multi-agent simulation based governance of complex systems', where they adopt from Ferber (1999) that agents are autonomous entities capable of achieving goals and moreover they are social entities that interact with other agents and the environment. They present four (4) algorithms used in a generic architecture to control an example complex system, represented as a peer-to-peer network, and suggest the ability to address key governance issues of: 1) multiple levels of description (local and global), 2) sensibility to initial conditions (large number and high dynamics of system participants) and 3) autonomy of entities (avoiding system control actions that modify inner behavior of participants). They conclude their perspective needs "validation, calibration and translation of the models" (p. 97).

Keating et al. (2014) outline the existence of differing governance perspectives in the literature, differences between management and governance, and from Calida (2013) suggest governance includes the continuous performance of direction, oversight, and accountability. In addition to offering a description of governance, Calida (2013) provides a system governance framework that makes analysis and planning of governance activities more explicit for determining outcomes. Although ESG introduced by Mansouri and Mostashari (2010) is comprised of architectural design, metrics, awareness and learning processes, Keating and Bradley's (2015) introduction of the Complex System Governance Reference Model appears to offer a broader synergy with systems theory and solidifies the intent of direction, oversight, and accountability identified in Calida's work. Keating and Bradley (2015) not only describe metasystem governance functions (M5, M5*, M5', M4, M4*, M4', M3, M3*, and M2) introduced in Chapter I, but also relate systems theory axioms with Complex System Governance Reference Model implications and extend the description of governance functions to include responsibilities and products or outcomes. Keating and Bradley also chart a course for further development of the reference model, including the need for a development framework to support application of complex system governance in a variety of fields.

Governance literature indicates a complex system governance architecture framework may support the application of complex system governance in a variety of fields, provided the main themes in governance literature are integrated in the framework. The main themes in governance literature relevant to systems theory and developmental considerations for a complex system governance architecture framework are 1) complex system governance architecture framework must be able to span a variety of fields (François, 2008; Keating & Bradley, 2015; Mansouri & Mostashari, 2010), 2) the framework must address complex system governance functions, responsibilities and outcomes (Keating & Bradley, 2015), and 3) the framework must be explicit (Calida, 2013; Gutierrez et al., 2013).

Management Cybernetics

Norbert Wiener originated the term cybernetics (Wiener, 1948, 1961). Ross Ashby described cybernetics as "the art of *steermanship*" and suggested its link with physics and the scientific method was a needed way of dealing with system complexity through design for requisite variety/complexity, which is an equalizing of internal system variety with external/environmental variety (Ashby, 1956; 1958). Nearly a decade after Wiener's origination

Stafford Beer associated management with cybernetics, originating the term management cybernetics, and illuminating cybernetics' holistic approach in contrast with traditional scientific reductionism (Beer, 1959). Beer later described management as "the profession of control" and cybernetics as "the science of control" (Beer, 1966). Beer organized management cybernetics in the Viable System Model as the "science of effective organization" (Beer, 1979, 1981, 1985). Beer references the human body's nervous system in describing the Viable System Model's five metasystems, each having several control functions. The underlying principle of the Viable System Model is that as long as the five metasystems are functioning through their communication channels to filter and amplify variety where required and to transduce (transfer or convert) meaning across system boundaries, a system will remain viable (Keating & Bradley, 2015; Steinhaeusser, Elezi, Tommelein, & Lindemann, 2015). These metasystem functions and communications channels are described in Table 9.

Table 9. VSM Metasystem Functions and Communication Channels
(Adapted from Keating and Bradley (2015, p. 39) and Steinhaeusser et al. (2015, pp. 7-8))

Identifier / Function		Description / Role
Five (M5)	Policy / 3-4 Balancer	Prevents System 3 or 4 domination through regulation, policy, or control; Maintains system identity through strategic decision & direction
Four (M4)	Managing – Outside & Future	Manages/regulates based on impact introduced by the system's environment; Scans/captures/assesses information from environment for strategic impact; Models future system evolution
Three* (M3*)	Auditing / Monitoring	Means for investigating and validating information flow between Systems One, Two, and Three; Monitors for aberrations, determines source
Three (M3)	Managing – Inside & Now	Maintains day-to-day operations; Monitors autonomic functions, implement plans/policy, reports; Helps coalesce body of System Ones' individual contributions; Distributes resources; Maintains System Ones' performance levels
Two (M2)	Coordinating	Links System Ones to System Three; Harmonizes/Prevents unnecessary oscillations/turbulence within the set of System Ones; Increases system efficiency & effectiveness
One (S1)	Operational Control (not metasystem)	Controls an operational unit which is a viable system itself; Can be multiple System Ones

Table 9 (continued)

Command Channel	Provides direction to operational units and disseminates non-negotiable direction to the system
Resource bargain / accountability Channel	Provides/determines the resources (manpower, material, money, information, support) for operational units; Defines performance levels to which operational units will be held responsible; Determines how operational units will interface for performance reporting and accountability
Operations Channel	Provides for the routine interface between operational system entities and from the metasystem to operational units
Coordination Channel	Provides for system balance and stability by ensuring that information concerning decisions and actions necessary to prevent disturbances are shared among operational units
Audit Channel	Provides routine and sporadic feedback on the performance of system operations; Investigates and reports on problematic areas of concern internal to the system
Algedonic Channel	Provides instant alert to crises or potentially catastrophic situations occurring in the system; Bypasses routine communications channels and structure to identify system threats
Environmental Scanning Channel	Monitors predetermined aspects of the environment to provide intelligence for the system; Senses emerging activities, events, trends, or patterns in the environment that might hold significance for the system
Dialog Channel	Provides examination and interpretation of organizational decisions, actions, and events; Seeks alignment of perspectives and shared understanding of organizational decisions and actions in light of system purpose and identity
System Learning Channel	Provides detection and correction of system errors, testing of assumptions, and identification of system design deficiencies; Ensures the system continually questions the adequacy of its design
Informing Channel	Provide routine transmission of information throughout the system; Routes information that is not appropriate for other channels for accessibility throughout the system

Keating and Bradley extend the Viable System Model through solid foundation in Management Cybernetics, Systems Theory, and Governance concepts in an initial construct for a Complex System Governance Reference Model (Keating & Bradley, 2015). Keating and Bradley bounded their introduction of the reference model to clarify intent and assuage concerns about departure from Beer's VSM.

> *Our departure from the strict confines of Beer's VSM metasystem formulation (proposed nearly four decades ago) may be unsettling to purists. However, we have elaborated,*

modified, and extended the metasystem of the VSM to fit our purposes for CSG. This does not cast doubt or challenge the basis or formulation of the VSM. On the contrary, it simply evolves and extends the VSM to better fit our intended use for representation of CSG. (p. 42)

The Complex System Governance Reference Model's nine (9) metasystem functions were previously discussed. This summary table identifies key characteristics, groundings, associations, and new initiatives within the reference model that are relevant to further discussion in later Chapters in this research study.

Table 10. Complex System Governance (CSG) Reference Model's Significant Characteristics (Adapted from Keating and Bradley (2015))

Significant Characteristic	Item	Meaning / Description
Definition specific to CSG	Communication	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
Definition specific to CSG	Control	Invoking the minimal constraints necessary to ensure desirable levels of performance and maintenance of system trajectory, in the midst of internally or externally generated system perturbations
Definition specific to CSG	Coordination	Providing for interactions (relationships) between constituent entities within the system, and between the system and external entities, such that unnecessary oscillations are avoided
Definition specific to CSG	Integration	Continuous maintenance of system unity as a dynamic balance between autonomy of constituent entities and the interdependence of entities necessary to invoke a coherent whole. This interdependence produces the system identity (uniqueness) that exists beyond the identities and capabilities of the individual constituent entities
Definition specific to CSG	Design	Purposeful and deliberate arrangement of the governance system consistent with the achievement of desirable performance outputs and outcomes
Definition specific to CSG	Execution	Performance of the system design within the unique system context, subject to the emergent perturbations stemming from both dynamic interactions with the environment as well as internal elaborations within the system
Definition specific to CSG	Evolution	The change of the governance system in response to internal and external shifts. These shifts may be in response to new knowledge, environmental perturbations, internal system perturbations, or emergent circumstances

Table 10 (continued)

Definition specific to CSG	Metasystem	The set of interrelated higher level functions that provide for governance of a complex system to maintain viability (existence)
CSG Field Triad of Development	Research Agenda	Provides for the organization of the focus for research to move the CSG field forward
CSG Field Triad of Development	Reference Model & Development Framework	Provides a research based CSG representation and corresponding approach for application
CSG Field Triad of Development	Challenges	Identifies issues in complex system to focus research directions for improvement in practice
Systems Theory Axiom Linkage	Centrality	Central to all systems are emergence and hierarchy and communication and control; CSG Reference Model must: - Deal with emergent conditions and perturbations - Define relationships for accountability and responsibility - Provide information for consistent decision, action, and interpretation - Monitor and maintain performance while preserving maximum autonomy
Systems Theory Axiom Linkage	Contextual	Meaning in systems is derived from the circumstances and factors that surround them; CSG Reference Model must: - Remain compatible with the context and environment within which the system exists - Remain flexible based on shifting context - Articulate, monitor, interpret, and respond to context and contextual shifts
Systems Theory Axiom Linkage	Goal	Systems achieve specific goals through purposeful behavior using pathways and means; CSG Reference Model must: - Establish, monitor, and maintain strategic direction and identity - Maintain consistency in system purpose, goals, and objectives - Maintain coherence in identity - Maintain integrity of system focus
Systems Theory Axiom Linkage	Operational	Systems must be addressed in situ, where the system is exhibiting purposeful behavior; CSG Reference Model must: - Guide system strategic execution - Maintain consistency in system behavior and performance - Produce outputs and outcomes consistent with expectations
Systems Theory Axiom Linkage	Viability	Key parameters in a system must be controlled to ensure continued existence; CSG Reference Model must: - Measure system performance - Monitor and process internal and external fluctuations - Regulate key parameters essential to continued system existence

Table 10 (continued)

Systems Theory Axiom Linkage	Design	Purposeful imbalance of resources and relationships; CSG Reference Model must: - Maintain and evaluate system model against execution - Model the present and future system - Establish exchange in system (matter, energy, information)
Systems Theory Axiom Linkage	Information	Systems create, process, transfer, and modify information; CSG Reference Model must: - Identify information needs for decision, action, and interpretation support - Facilitate efficiency in exchanges - Provide for dynamic information access, availability, or utility
Systems Theory Contribution	Grounding	The model is grounded in a strong philosophical, theoretical, and conceptual basis
Systems Theory Contribution	Grounding	The model relies on philosophical/theoretical foundation that has withstood the test of time
Systems Theory Contribution	Grounding	Multidisciplinary foundation supports the model's deployment across a spectrum of fields and applications.
Management Cybernetics Contribution	Control	CSG Reference Model facilitates control necessary to ensure a system continues to exist in response to environmental perturbations
Management Cybernetics Contribution	Control	CSG Reference Model should only provide for a minimal set of constraints [regulation] on the system necessary and sufficient to maintain performance and behavior of the system
Management Cybernetics Contribution	Control	CSG Reference Model should provide for preserving autonomy [freedom and independence of decision, action, and interpretation (Keating et al., 2014; Keating et al., 2003) of constituent entities in a system]
Management Cybernetics Contribution	Control	CSG Reference Model's control feature is something that can, and should be, purposefully designed (variety engineering) for a complex system
Conceptual Foundation	Metasystem	Since the metasystem operates at a higher logical level beyond (meta) the elements (entities) that it must integrate, we can focus on the integration, coordination, communication, and control at a level beyond the entities that are governed
Conceptual Foundation	Metasystem	Since the metasystem has been conceptually grounded in the foundations of systems theory and management cybernetics, the conceptual lineage has been established and provides a more robust foundation
Conceptual Foundation	Metasystem	The 'function' view of metasystem permits a focus on defining *what* must be achieved to fulfill the function, as opposed to *how* it must be fulfilled
Conceptual Foundation	Metasystem	The metasystem functions are interrelated and do not operate in isolation from one another, in effect operating as a system in and of itself

Table 10 (continued)

Conceptual Foundation	Metasystem	The performance of metasystem functions are necessary to produce continued viability, not necessarily high performance, as a system can exist at various levels of performance and still remain viable
Conceptual Foundation	Metasystem	By understanding the nature and role of the metasystem functions, these functions can be purposefully designed, executed, and maintained – in effect 'variety engineering' for a system
Common grounding reference point	CSG Reference Model – to – Emerging CSG Field	A common model for identification of 'what' a governing metasystem must accomplish if the system is to remain viable. Arguably, any complex system that exists is performing the functions of the CSG reference model, albeit they may be performed at a minimal level. The model is generalizable, with applicability to all manmade systems
Set of common functions and requirements	CSG Reference Model – to – Emerging CSG Field	Provides a detailed explication of the functions that must be performed for governance of any complex system. This level of detail for governance, drawing back to the foundations of systems theory and management cybernetics, does not currently exist
Multiple utility	CSG Reference Model – to – Emerging CSG Field	Provides a basis for analysis, design, maintenance, and evaluation for CSG. As such, it provides both researchers and practitioners a valuable artifact for dealing with complex systems
Foundation for field related development	CSG Reference Model – to – Emerging CSG Field	Can provide a foundation for other developments and contributions to the CSG field, not strictly limited to development methodologies, methods development, tools/software development, and research
VSM correlation	CSG M5	Corresponds to VSM System 5
VSM correlation	CSG M5*	Elaborates a responsibility of VSM System 5
VSM correlation	CSG M5'	Elaborates a responsibility of VSM System 5
VSM correlation	CSG M4	Corresponds to VSM System 4
VSM correlation	CSG M4*	Elaborates a responsibility of VSM System 4
VSM correlation	CSG M4'	Elaborates a responsibility of VSM System 4
VSM correlation	CSG M3	Corresponds to VSM System 3
VSM correlation	CSG M3*	Corresponds to VSM System 3*
VSM correlation	CSG M2	Elaborates Coordination Function of VSM System 2; Extends focus to include the design for flow of information and consistent interpretation of exchanges (communication channels)

Keating and Bradley also present a detailed mapping of the metasystem functions to nine (9) associated roles, sixty-five (65) responsibilities and thirty-four (34) products (2015). These 108 characteristics as part of the complex system governance reference model are presented as a contribution to the emerging field of complex system governance and reveal deep roots in systems theory and management cybernetics based on being 1) an extension of Beer's (1979, 1981, 1985) VSM, 2) grounded in the philosophical, theoretical and conceptual basis of systems theory, 3) and generic applicability supporting performance improvement across a variety of fields (Keating & Bradley, 2015).

Katina's (2015) research on metasystem pathologies is likewise rooted in systems theory and management cybernetics and further enhances the emerging field of complex system governance. Katina describes the pathology/management cybernetics relationship and research purpose relating to systems theory.

> *In management cybernetics, pathology describes deviations or shortcomings in subsystem functions of the Viable System Model (VSM) based on the seminal work of Stafford Beer. Pathologies act to limit organizational viability. (p. 76)*

Further,

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

Katina's research derived eight (8) metasystem pathologies with 83 associated systems theory-based pathologies that affect a complex system's performance. System performance management is part of the utility of a system's architecture and will be discussed in the next section, which discusses enterprise architecture.

The field of management cybernetics brought forth the concept of cybernetics, Law of Requisite Variety, Viable System Model, Complex System Governance Reference Model that extends the Viable System Model, and Metasystem Pathologies. The main themes in management cybernetics literature relevant to systems theory and complex system governance architecture framework are 1) the complex system governance reference model is deeply rooted in system theory, management cybernetics, and governance (Ashby, 1956, 1958; Beer, 1959, 1966, 1979, 1981, 1985; Keating & Bradley, 2015; Wiener, 1948, 1961), 2) a complex system governance architecture framework should address all characteristics of the CSG reference model to ensure the model's intent and system's theoretic principles are fulfilled through the framework (Keating & Bradley, 2015; Steinhaeusser et al., 2015), 3) a complex system governance architecture framework must integrate metasystem pathologies, systems theory-based pathologies and metasystem governance functions in order to effectively approach problem formulation in addressing systemic issues (Katina, 2015; Keating & Bradley, 2015).

Enterprise Architecture

John A. Zachman (1978) is oft mentioned in the literature as founding contributor to enterprise architecture and continues advancing the discipline (Zachman, 2015). Enterprise Architecture was originally directed at information systems but Zachman recently identified "…Enterprise Architecture is not well understood in the ranks of General Management who see Enterprise Architecture as just an I/S or IT issue…" and he declares "…Enterprise Architecture may well be the "Issue of the Century."" (Zachman, 2012, p. 7). Since the introduction of Zachman's (1987) Framework, enterprise architecture frameworks have expanded along with technology growth (DiMario, Cloutier, & Verma, 2008; *The DoDAF Architecture Framework Version 2.02*, 2010; Medini & Bourey, 2012; Piaszczyk, 2011; Šaša & Krisper, 2011; Walters et al., 2014). The following definitions were adopted for this research.

- Architecture Frameworks are *conventions, principles and practices for the description of architectures* established within a specific domain of application and/or community of stakeholders (ISO/IEC/IEEE, 2011).
- An Architecture is the fundamental *organization of a system* embodied in its components, their relationships to each other, and to the environment, and in the principles guiding its design and evolution (ISO/IEC/IEEE, 2011).
- An Architecture Viewpoint is a work product *establishing the conventions* for the construction, interpretation and use of architecture views to frame specific system concerns (ISO/IEC/IEEE, 2011).
- An Architecture View is a work product *expressing the architecture* of a system from the perspective of specific system concerns (ISO/IEC/IEEE, 2011).

Literature indicates architecture frameworks support unique communities of stakeholders. Most literature identifies a few prominent architecture frameworks, usually including Zachman, DoDAF, FEAF, and TOGAF. One example discusses multi-attribute information systems analysis (Narman, Johnson, & Nordstrom, 2007) and another is supply chain process driven (Medini & Bourey, 2012). Urbaczewski and Mrdalji (2006) offer yet another example but they include two key elements all enterprise architectures should have:

- *A definition of the deliverables that the architecting activity should produce;*
- *A description of the method by which this is done. (p. 19)*

Khayami (2011) suggests in addition to these two basic elements, enterprise architectures must include the properties:

- Alignment: of management strategies with organizational functions
- Convergence: of architecture design elements to support goals
- Maintainability: to allow for change
- Integrity: in frameworks, in data, and applications integrity
- Reliability: measured in average time between faults
- Efficiency: in time behaving and resource behaving
- Security: from unauthorized access, disruption, destruction, etc.
- Usability and
  Implementability: when considering compatibility with positions and organizational possibilities

Clearly Khayami, like most literature on architecture frameworks has revealed, is discussing aspects more in line with technology implementation rather than metasystem level concerns associated with system viability. Nonetheless, these properties are good qualities for any type of architecture framework when contextualized for application. An example of contextualizing an architecture framework in process and project management reveals the following architecture framework characteristics specific to PRINCE2 methodology for project management (Ilin & Lyovina, 2014):

- Decomposition of main project management processes
- Clear definition of project management processor roles and responsibilities
- Document flow system and document templates

Contextualization may also need to extend down into an architecture views and viewpoints to solidify understanding for consumers of the architecture. An example of contextualizing an architecture framework at this lower level is the NATO Human View's eight architecture products (Handley & Smillie, 2008, 2009).

- HV-A: Concept (high level view of human component in architecture)
- HV-B: Constraints (based on capabilities / limitations of humans)
- HV-C: Tasks (human specific activities)
- HV-D: Roles (human interacting with other system elements)
- HV-E: Human Network (human-human communication patterns)
- HV-F: Training (how all aspects impact humans)
- HV-H: Human Dynamics (human-system component dynamics)

These views provide opportunity to bound, constrain, manage, and protect the scope and expectations for architecture when used under a specific architecture framework following a defined Architecture Development Process (ADP). An example is the 3-D Enterprise Architecture Framework (3D EAF) for Systems Engineering and Management and 36-step, 3-Dimensional Architecture Development Process (3D ADP) that is intended to be iterated under a Multi-Stroke System Architecting Decomposition and Integration Process (Morganwalp & Sage, 2003). Morganwalp and Sage's three dimension interrogatives relate contextual awareness, stakeholders and system of systems levels. Their ADP and multi-stroke process facilitates capturing many layers of detail as far into a system under study as is desired. Using a complex system governance architecture framework for developing architecture is not expected to need this level of iteration due to its 'meta-level' focus but the iteration does provide insight into how a framework can and probably should include architecture development process instructions.

The utility of architectures (models) is not lost in complex systems despite inherent nature of unpredictable emergence.

> *Enterprise architectural views, simply put, help represent the complex system in a non-reductionist light (systemically). This enables not only an increase in the governor's knowledge about the system but also an increase in the knowledge of system stakeholders… …This increase in knowledge comes from the organization of known system components and modeling them to characterize functions and behaviors. (Walters et al., 2014, p. 259)*

A proposed sub-discipline of enterprise architecture called 'EA Cybernetics' takes aim at addressing the challenges of modeling complex systems using a 'Co-evolution Path Model and cybernetic principles to investigate management of complexity in changing environments (Kandjani, Bernus, & Neilsen, 2012). This model suggests that using Generic Enterprise Reference Architecture (GERA) concepts and viewpoints leaves no gaps in environmental change observation and enables the system manager to model and steer effectively through four groups of system states described in Table 11.

Table 11. 'EA Cybernetics' Co-Evolution Path Model State Groups
(Adapted from Kandjani et al. (2012))

Groups	Description	State	Complexity Assessment
Co-evolving / viable system	Able to maintain Complexity of system (CS) = Complexity of environment (CE) as variety changes	1	CS = CE
		2	CS < CE (something happens in environment causing it to have more complexity than system, e.g. new regulation)
		3	CS = CE (system able to respond)
Inefficient system	CS > CE due to unexpected desired complexity such as non-purposeful system design places demand on amplifying desired and removing undesired complexity in the system. System eventually able to equalize/balance complexity	4	CS > CE (something happens causing system to have more complexity than environment, e.g. new product is developed)
		5	CS > CE (system responds by adapting logistics to support product but there is still excess complexity)

Table 11 (continued)

		6	CS > CE (system removes undesired excess complexity but retains desired complexity)
		7	CS = CE (system amplifies excess desired complexity to environment)
		8	CS < CE (environment produces undesired complexity, e.g. competitors take market share)
Vulnerable system	Complexity imbalance persists despite system response	9	CS > CE (system responds but in doing so obtains excess complexity)
		10	CS > CE (system removes undesired complexity but still has excess complexity)
		11	CS > or < CE (complexity imbalance remains)
Non-viable system	System unable to respond to large complexity imbalance – doomed to fail	12	CS <<< CE (environment produces significantly higher complexity than system, which cannot respond)
		13	CS <<< CE (no feedback keeps complexity imbalance large)
		14	CS <<< CE (system doomed)

The authors of ‘EA Cybernetics’ and Co-evolution Path Model recognized their effort to show how systems co-evolve with their environments was limited and considered an initial integration of cybernetics and enterprise architecture to address challenges in modeling complex systems.

> *We expect that a synthesis would yield a new, unified cybernetic model of EA, more powerful theories, reference models, and methodologies than we have today, both in the problem domain and meta level (discipline development). (Kandjani et al., 2012, p. 9)*

A step in the direction of yielding a unified cybernetic model of EA was taken by Zadeh, Lewis, and Millar (2014) where they outline design principles based on Beer’s VSM and previous studies of governance of corporate IT. The resulting design principles are intended to address IT and organizational resources beyond IT to be regarded as organizational viability requirements and guidelines for EA Principles (EAP). Despite their Australian Taxation Office (ATO) example being centered on Technical/IT in the form of Cloud Computing, the Zadeh et al.

construct addresses VSM elements and identifies the need to tailor EAP language for end users (Zadeh et al., 2014), much like tailoring an enterprise architecture into organizational language. Table 12 outlines the design principles and their intent.

Table 12. Enterprise Architecture Design Principles (EAP) and their Intent
(Adapted from Zadeh et al. (2014))

EA Design Principle (EAP)	Description / Intent
Requisite Variety – "Ashby's Law of Requisite Variety is a very potent principle in cybernetics and especially in deriving the VSM. The other principles in this paper flow from this fundamental law, and therefore, this law is regarded as the preeminent design principle here:" (Zadeh et al., 2014, p. 1022)	Control can be obtained only if the variety of the controller is at least as great as the variety of the situation to be controlled.
Viability	Viability (survival) is the ultimate goal of the enterprise.
Recursion	All embedded organizational units of the enterprise must comply with these principles.
Black Box	Rather than how the function is performed, more important for those using the services of any organizational unit are its interfaces (input and output) and the relation between them.
Value Creation	All resources in the organization are directed and controlled to achieve viability through the creation of value that is meaningful to key stakeholders.
Value Preservation	Ongoing survival of the organization is preserved by managing risks that impact its value proposition.
Autonomy	Operational systems (Business units) are granted the maximum degree of autonomy consistent with the constraint of maintaining organizational cohesion.
Cohesion	Synergies across the various business units are exploited to ensure that the enterprise as a whole delivers more than the sum of its parts.
IT/Business Alignment	The primary purpose of the IT function is to enable the enterprise to achieve its business objectives through the delivery of proper services.
Core IT	Where IT is part of the organization's value chain then it is an operational unit and must comply with all the EA principles.
Coordination	Organizational synergies are promoted through the coordination of the activities of the enterprise and business-unit groups.
Resource Management	Corporate executives in such a way as to maximize business value allocate scarce resources.
Performance	The performance of the subsidiary units is monitored properly against their agreed objectives.

Table 12 (continued)

Audit	The enterprise is able to independently monitor (audit) the performance of its subsidiary units.
Adaptation	The enterprise is enabled to adapt to its changing environments.
Identity	The enterprise demonstrates to internal and external stakeholders a consistent identity, which represents its purpose and ethos.
Governance	The governing body, as the ultimate decision-making body within the enterprise, assumes responsibility for the governance of the enterprise.
Compliance	The enterprise, as a whole, complies with legislative, regulatory, and societal obligations, and established policies.

Zadeh et al. (2014) identify VSM limitations in supporting ‘meta-principles’ when addressing “the role of people and politics in organizations” and call for further study of other “cybernetic principles to compensate for this limitation” (p. 1026).

The discipline of Enterprise Architecture experienced steady growth in architecture frameworks created to suite unique system needs, most referring to the Zachman Framework. As the discipline expanded, mostly in military context but also in industry, standardization waned. An initial attempt at joining enterprise architecture with cybernetics was made introducing the Co-evolution Path Model and EA-Cybernetics (Kandjani et al., 2012). Enterprise Architecture Design Principles (EAPs), rooted in the Viable System Model (VSM), intended as EA design requirements for viable systems were then introduced to alleviate limitations in EA for supporting system viability (Zadeh et al., 2014). More recently explored was an expanded integration beyond the VSM and EA to include domains of Governance, Management Cybernetics, Systems Theory and Enterprise Architecture in the context of Complex System Governance (CSG) (Carter, 2015; Carter et al., 2016; Walters et al., 2014). While ‘EA Cybernetics’ and Co-evolution Path Model and EA Principles were evolving, much occurred in systems theory based on management cybernetics and the need to codify system of systems engineering (Adams, Hester, Bradley, Meyers, & Keating, 2014; Bradley, 2014; Calida, 2013; Katina, 2015; Keating, 2014; Keating & Bradley, 2015; Keating et al., 2014; Whitney, Bradley, Baugh, & Chesterman, 2015), but more evolution must occur to address concerns in these areas and in the emerging field of complex system governance (Carter, 2015; Carter et al., 2016; Nielsen, Larsen, Fitzgerald, Woodcock, & Peleska, 2015; Walters et al., 2014).

The main themes in enterprise architecture literature relevant to systems theory and development of a systems theoretic complex system governance architecture framework are 1) frameworks tend to be established and most useful for a specific, unique stakeholder group (Handley & Smillie, 2008, 2009; Ilin & Lyovina, 2014; Khayami, 2011; Medini & Bourey, 2012; Narman et al., 2007; Urbaczewski & Mrdalj, 2006; Zachman, 2012) and 2) frameworks need to require specific architecture outcomes and describe how to produce them (Carter, 2015; Carter et al., 2016; Kandjani et al., 2012; Morganwalp & Sage, 2003; Nielsen et al., 2015; Walters et al., 2014; Zadeh et al., 2014).

Systems Theory

Systems Theory finds its origins in Open Systems (von Bertalanffy, 1950b) and General Systems Theory (GST) (Boulding, 1956; von Bertalanffy, 1950a, 1968, 1972) and is described as a scientific doctrine about principles of systems in general (von Bertalanffy, 1950b) with a purpose of organizing subject matters and disciplines of science (Boulding, 1956) to view individual events or phenomena as being interrelated (Klir, 1972) and complex (van Gigch, 1974). Beer (1972) addressed system complexity issues and the various states of a system in the Viable Systems Model (VSM), using Ashby's Law of Requisite Variety (Ashby, 1958) to drive shaping the VSM as a mechanism for matching variety generated by the environment outside a system's boundaries. Beer's model describes five systems, the environment and alerts that may be recognized and used in system governance efforts to maintain a system's viability.

Table 13. Interpretation of Key Elements of Stafford Beer's Viable Systems Model (Adapted from Carter (2015))

VSM System / Element	Purpose
System 1	The system being governed (fundamental operations / organizational output)
System 2	Coordination (plans, schedules, non-executive managing)
System 3	Control (executive management of Systems 1 & 2)
System 3*	Audit/evaluation (monitoring, inspections)
System 4	Transformation (future changes assessed based on environment of system)
System 5	Policy (defines system identity; balances management of current and future state
Environment	Generates variety which must be matched by a system's governor/governance
Algedonic Alerts	Provide instantaneous alerting to emergency/catastrophic failures or situations

The aforementioned linkages in the literature evolved from and/or complemented earlier knowledge foundations in: holism (view the system as a whole instead of the sum of its parts) (Smuts, 1926); complementarity (different perspectives of a system yield truths that are not entirely independent or compatible) (Bohr, 1928); homeostasis (open system property regulating internal environment through dynamic equilibrium adjustments controlled by interrelated regulators to maintain stability) (Cannon, 1929); purposive behavior (behavior directed to accomplish a specific goal) (Rosenblueth, Wiener, & Bigelow, 1943); self-organization (order emerging out of independent actions/elements) (Ashby, 1947); feedback (negative feedback from the specific goal about all purposeful behavior is required to steer behavior to accomplish the goal) (Wiener, 1948); and communication (information exchange between a source and receiver that generates and reproduces symbols, transmitted as a particular state among alternatives) (Shannon, 1948a, 1948b; Shannon & Weaver, 1949).

While Beer (1979, 1981, 1985) evolved the VSM, Miller (1978) introduced general living systems theory as a subset of GST, focused on concepts of space, time, matter, energy and information. Miller (1978), investigating systems from a more focused Living Systems Theory (LST) viewpoint than Beer's metasystem level view of the VSM, identified twenty (20) critical subsystems in three (3) combinations of processing categories, operating on each of eight (8) levels of organization that he suggests living systems develop: 1) cells, 2) organs, 3) organisms, 4) groups, 5) organizations, 6) communities, 7) societies and 8) supranational systems (Miller, 1978; Nechansky, 2009).

Table 14. Interpretation of Key Elements of Miller's Living Systems Theory (LST) (Adapted from Miller (1978) and Nechansky (2009))

LST Subsystem / Element	Processing Category	Subsystem Function
1. Reproducer	Matter-energy and Information	Activates matter, energy and information to produce similar systems
2. Boundary	Matter-energy and Information	Surrounds system, contains and protects components from environment, filters matter, energy and information
3. Ingestor	Matter-energy	Brings matter-energy into system from environment through boundary
4. Distributor	Matter-energy	Transports matter-energy within system from input to output
5. Converter	Matter-energy	Changes inputs as needed for system processing/use
6. Producer	Matter-energy	Produces matter and/or energy from system inputs and/or converter outputs
7. Matter-energy storage	Matter-energy	Stores matter-energy
8. Extruder	Matter-energy	Moves matter-energy from system to environment through boundary
9. Motor	Matter-energy	Moves entire system, system parts, environment or components of environment
10. Supporter	Matter-energy	Provides structure to maintain all subsystem functions
11. Input Transducer	Information	Brings information markers into system, changes them to matter-energy forms suitable for internal transmission
12. Internal Transducer	Information	Receives system-internal information markers, changes them to other matter-energy forms for transmission
13. Channel and net	Information	Transmits information markers to all parts of system over a single or multiple routes

Table 14 (continued)

14. Timer	Information	Times related states; transmits to Decider
15. Decoder	Information	Alters information code from transducers into code used internally by system
16. Associator	Information	Completes initial stage of learning and forms enduring associations among information items in system
17. Memory	Information	Completes second stage of learning; stores and retrieves information
18. Decider	Information	Controls entire system; causes subsystems to interact
19. Encoder	Information	Alters information code used internally by system into 'public' code readable by other systems in environment
20. Output Transducer	Information	Disseminates information markers from system; changes internal information markers into matter-energy that can be transmitted over channels in system's environment

Nechansky (2009) translates Beer's (1979) VSM and Miller's (1978) LST into a framework for comparison and finds both indicate the need for repetition of lower level functions and structures. Nechansky then suggests Beer focuses on the contents of data processing and Miller focuses on functions and structure of data processing while concluding:

> *Miller's (1978) living systems theory has a wider scope, and covers viability more completely than Beer's (1979) viable systems theory. But it is suggested that both do not cover it. (p. 111)*

What reveals itself in Nechansky's analysis is there exists a lack of explicit framework for accomplishing system governance for complex systems or living systems. In that vein, key systems theory literature of late that is deeply rooted in the aforementioned literature and related to developmental considerations for a complex system governance architecture framework includes organization of systems theory propositions and axioms, development of a framework for competency models, and generation of metasystem pathologies.

Adams, Hester, Bradley, Meyers, and Keating (2014) propose systems theory as a unified group of propositions assembled to understand systems. They show how systems theory intersects with 42 fields of science on philosophical, theoretical, methodological, and technique levels. They define theory as:

> *A unified system of propositions made with the aim of achieving some form of understanding that provides an explanatory power and predictive ability. (p. 115)*

Using this definition, Adams et al. (2014) bring together 30 propositions under seven axioms to act as a lens in focusing study of an array of multidisciplinary systems and their problems.

Bradley (2014) developed a competency model framework based on systems theory. This conceptual model can be used to apply systems theory propositions and axioms in competency modeling and management. Its utility in relation to a complex system governance architecture framework includes 1) managing expectations in systems theory understanding, application, and framework outcomes produced by users and 2) facilitating an assessment of individual and organizational competency in systems theory principles, before and after related training initiatives, operational activities, or architecture development efforts.

Katina (2015) brings together aforementioned works in a coding structure that integrates systems theory seminal works with newly developed metasystem pathologies to establish reasoning for pathologies in complex system governance. These pathologies are essential to complex system governance architecture framework because they improve understanding of organizational (system) issues that must be addressed to effectively accomplish metasystem governance functions. It is appropriate to note the seminal authors of systems theory elements are captured and linked to metasystem pathologies by Bradley (2014) and Adams et al. (2014) through Katina (2015). This is presented (with Katina's permission) in the research's resulting complex system governance architecture framework so future changes or additions to metasystem pathologies will be accurately reflected in updates to the framework. Additionally,

Table 15 presents a mapping of Systems Theory Axioms to Propositions to Metasystem Pathologies to System Pathologies. This relationship assessment identifies where pathologies may be revealed in a complex system governance architecture framework's viewpoints and views when systems theory is used as a foundation construction.

Table 15. Relational Mapping of Systems Theory Axioms and Propositions with Metasystem Pathologies and System Pathologies
(Adapted from Katina (2015); Keating & Bradley (2015) and Whitney et al. (2015))

Systems Theory Axioms	Systems Theory Propositions (Seminal Authors)	Metasystem Pathologies	System Pathologies
Centrality	Communication (Shannon, 1948a, 1948b; Skyttner, 2005)	Systemic Information Pathology	Pathology of communication
	Control (Checkland, 1993)	Systemic Regulatory Pathology	Pathology of control
	Emergence (Aristotle, 2002; Checkland, 1993)	Systemic Dynamic Pathology	Pathology of emergence
	Hierarchy (Checkland, 1993; Pattee, 1973)	Systemic Structure Pathology	Pathology of hierarchy
Contextual	Complementarity (Bohr, 1928)	Systemic Understanding Pathology	Pathology of complementarity
	Incompressibility (Cilliers, 1998; Richardson, 2004)	Systemic Understanding Pathology	Pathology of darkness
	Holism (Smuts, 1926)	Systemic Understanding Pathology	Pathology of holism
	Boundary (Skyttner, 2005; von Bertalanffy, 1968)	Systemic Structure Pathology	Pathology of system boundary

Table 15 (continued)

Goal	Equifinality (von Bertalanffy, 1950a)	Systemic Goal Pathology	Pathology of equifinality
	Multifinality (Buckley, 1967)	Systemic Goal Pathology	Pathology of multifinality
	Purposive behavior (Rosenblueth et al., 1943)	Systemic Goal Pathology	Pathology of purpose behaviorism
	Satisficing (Simon, 1955, 1956)	Systemic Goal Pathology	Pathology of satisficing
Operational	Dynamic equilibrium (Miller, 1978; von Bertalanffy, 1968, 1972)	Systemic Dynamic Pathology	Pathology of dynamic equilibrium
	Homeorhesis (Waddington, 1957, 1968)	Systemic Regulatory Pathology	Pathology of homeorhesis
	Homeostasis (Cannon, 1929)	Systemic Regulatory Pathology	Pathology of homeostasis
	Redundancy (Pahl, Beitz, Feldhusen, & Grote, 2011)	Systemic Resources Pathology	Pathology of redundancy of resources
	Relaxation time (Clemson, 1984; Holling, 1996)	Systemic Dynamic Pathology	Pathology of relaxation time
	Self-organization (Ashby, 1947)	Systemic Dynamic Pathology	Pathology of self-organization
	Sub-optimization (Hitch, 1953)	Systemic Process Pathology	Pathology of sub-optimization
Viability	(Viability)	(Systemic Goal Pathology)	(Pathology of viability)
	Circular causality (Korzybski, 1994)	Systemic Understanding Pathology	Pathology of circular causality
	Feedback (Wiener, 1948)	Systemic Regulatory Pathology	Pathology of feedback
	Recursion (Beer, 1979)	Systemic Structure Pathology	Pathology of recursiveness
	Requisite hierarchy (Aulin-Ahmavaara, 1979)	Systemic Regulatory Pathology	Pathology of requisite hierarchy
	Requisite variety (Ashby, 1956)	Systemic Regulatory Pathology	Pathology of requisite variety

Table 15 (continued)

Design	Minimal critical specification (Cherns, 1976, 1987)	Systemic Regulatory Pathology	Pathology of minimal critical specification
	Power law (Newman, 2006)	Systemic Regulatory Pathology	Pathology of Pareto
	Requisite parsimony (Miller, 1956; Simon, 1974)	Systemic Understanding Pathology	Pathology of requisite parsimony
	Requisite saliency (Boulding, 1966)	Systemic Understanding Pathology	Pathology of requisite saliency
Information	Information redundancy (Shannon & Weaver, 1949)	Systemic Information Pathology	Pathology of information redundancy
	Redundancy of potential command (McCulloch, 1965)	Systemic Regulatory Pathology	Pathology of redundancy of potential command

The main themes revealed in systems theory literature relevant to complex system governance architecture framework are 1) a systems theoretic complex system governance architecture framework must be rooted in systems theory to be valid for use in facilitating metasystem governance functions (Adams et al., 2014; Keating & Bradley, 2015; Whitney et al., 2015), 2) systems theory facilitates understanding of systems in a holistic context and in contrast with traditional scientific or reductionist perspectives (Beer, 1979, 1981, 1985; Bohr, 1928; Klir, 1972; Smuts, 1926), 3) developing a holistic context includes addressing metasystem pathologies (Katina, 2015; Keating et al., 2014), 4) assessing individual and organizational systems theory competencies will manage expectations in the application of a complex system governance architecture framework (Bradley, 2014), and 5) that a framework for complex system governance must be explicit to avoid confusion or leaving the framework open to misinterpretation (Nechansky, 2009).

Chapter Summary

This chapter described literature in each domain specifically related to developmental considerations for a complex system governance architecture framework. Systems Theory seems to have experienced the most growth and been far-reaching into the other fields. Two main threads or groupings stand out in Systems Theory literature, General Systems Theory and Complex System Governance. Understanding and acknowledging their intertwined relationship is essential to crediting their individual value-contributions. General Systems Theory has been widely discussed since the 1950s and but more recently, Systems Theory Propositions and Axioms were proposed (Adams et al., 2014; Keating, 2014). That helped shaped a Competency Model Framework for systems thinking (Bradley, 2014). Systems Theory Propositions were then refined (Whitney et al., 2015) and nearly simultaneously there occurred development of the Complex System Governance Reference Model (Keating & Bradley, 2015) and Metasystem Pathologies (Katina, 2015). Struggling a bit more for consensus on meaning is System of Systems Engineering (Keating et al., 2003; Walker, 2014). An attempt to solidify its meaning has been presented in discussions on System of Systems versus Systems Engineering (Keating, Padilla, & Adams, 2008), System of Systems Governance Implications (Keating, 2014), and recently the state of System of Systems Practice (Nielsen et al., 2015; Walters et al., 2014), including implications for Enterprise Architecture (Walters et al., 2014).

It has been shown in the literature review that each domain's literature of interest to this study is woven together through referencing across domains and in discussion topic similarities, although less so for enterprise architecture than the others. The literature review confirmed there exists no systems theoretic architecture framework to address the needs associated with fulfilling metasystem governance functions. However, deep roots in systems theory, management cybernetics and governance are evident in recent contributions that shape characteristics for a complex system governance architecture framework (previously discussed systems theory axioms and principles, competency model framework, governance analytical framework, CSG reference model, metasystem pathologies).

Figure 2 provides visual representation of the literature relations and linkages. It is recognized this comprehensive map is dense, rich and difficult to read presented in this report's dictated format. The purpose of this map's presentation is to provide an indication of the linkages in the literature domains from a high level view. This map is by no means all-inclusive of the literature reviewed for this study. It captures some of the main events and linkages in the literature previously discussed. Subsequent Figures (3-6) spotlight individual literature domains and combinations of domains to provide opportunity for further inspection of the comprehensive map in Figure 2. These mappings are an initial effort and expected to change over time as new literature is produced or additional literature linkages are confirmed.

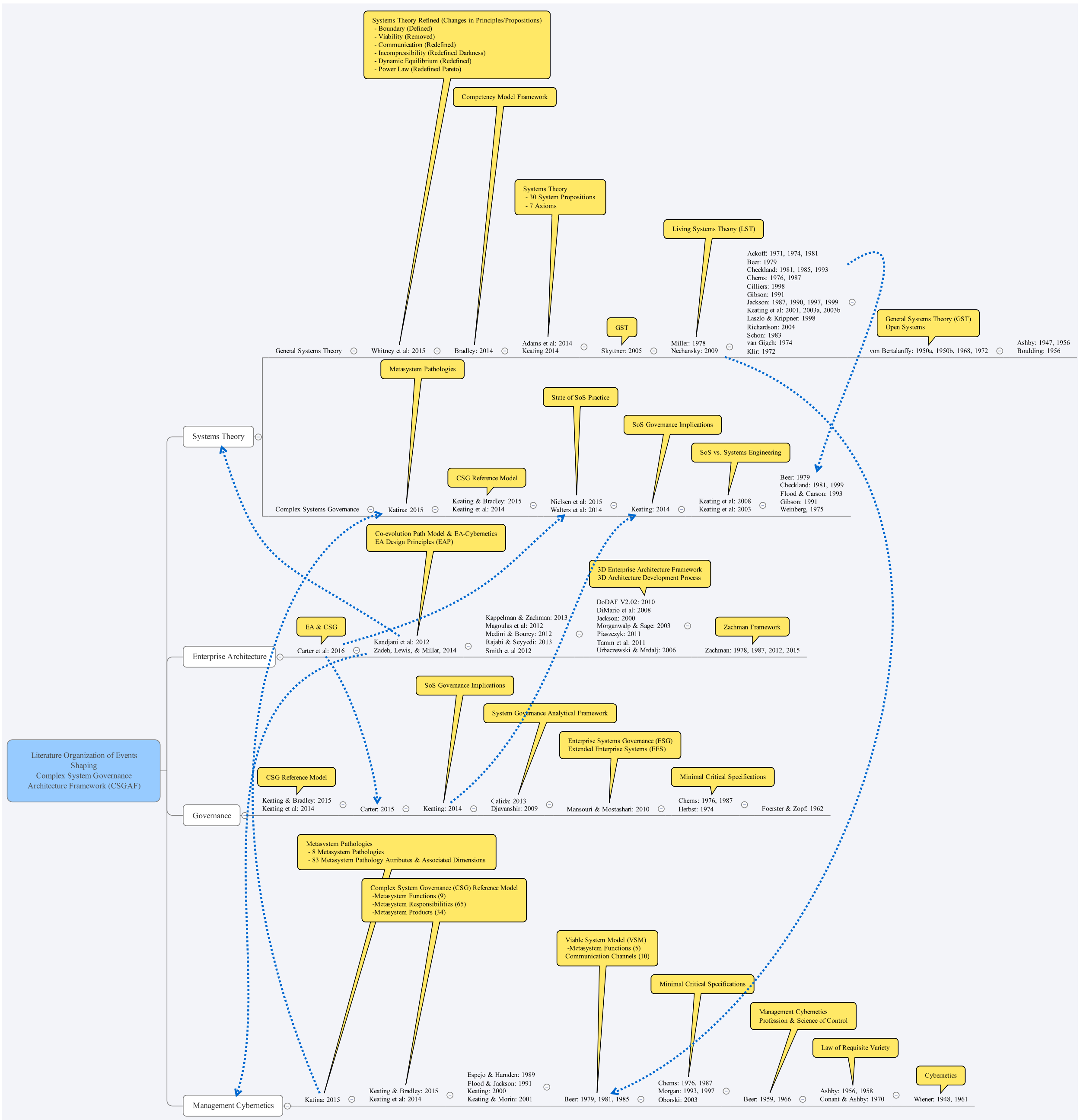

Figure 2. Integrated Literature Map - Dense, Rich, and Difficult to Read

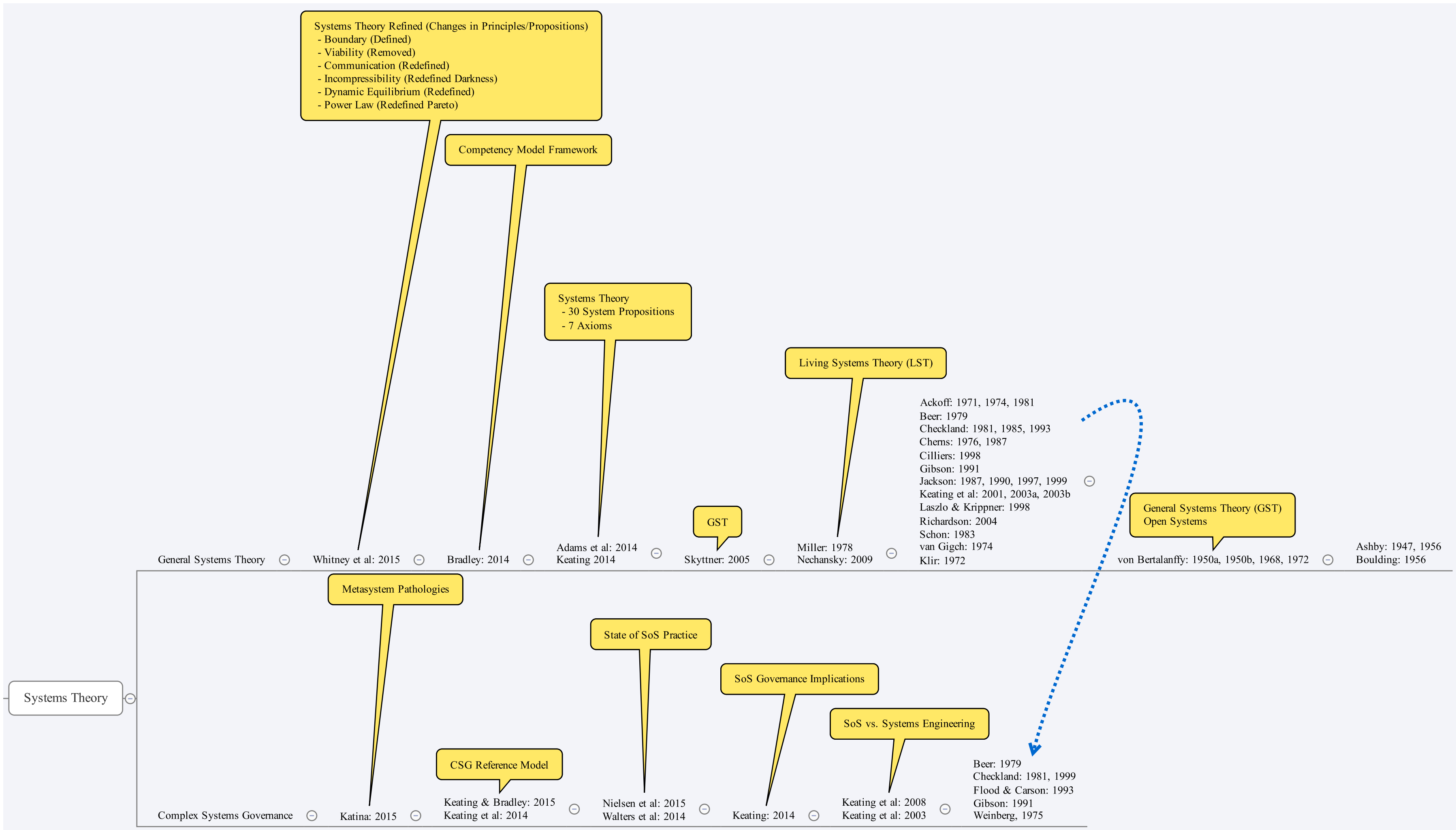

Figure 3. Literature Map of Systems Theory Domain

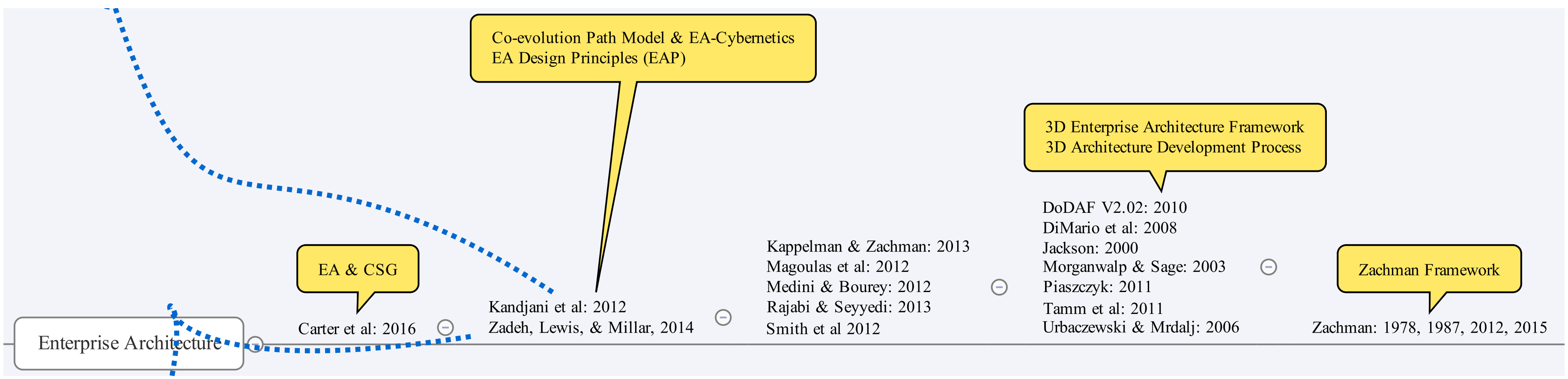

Figure 4. Literature Map of Enterprise Architecture Domain

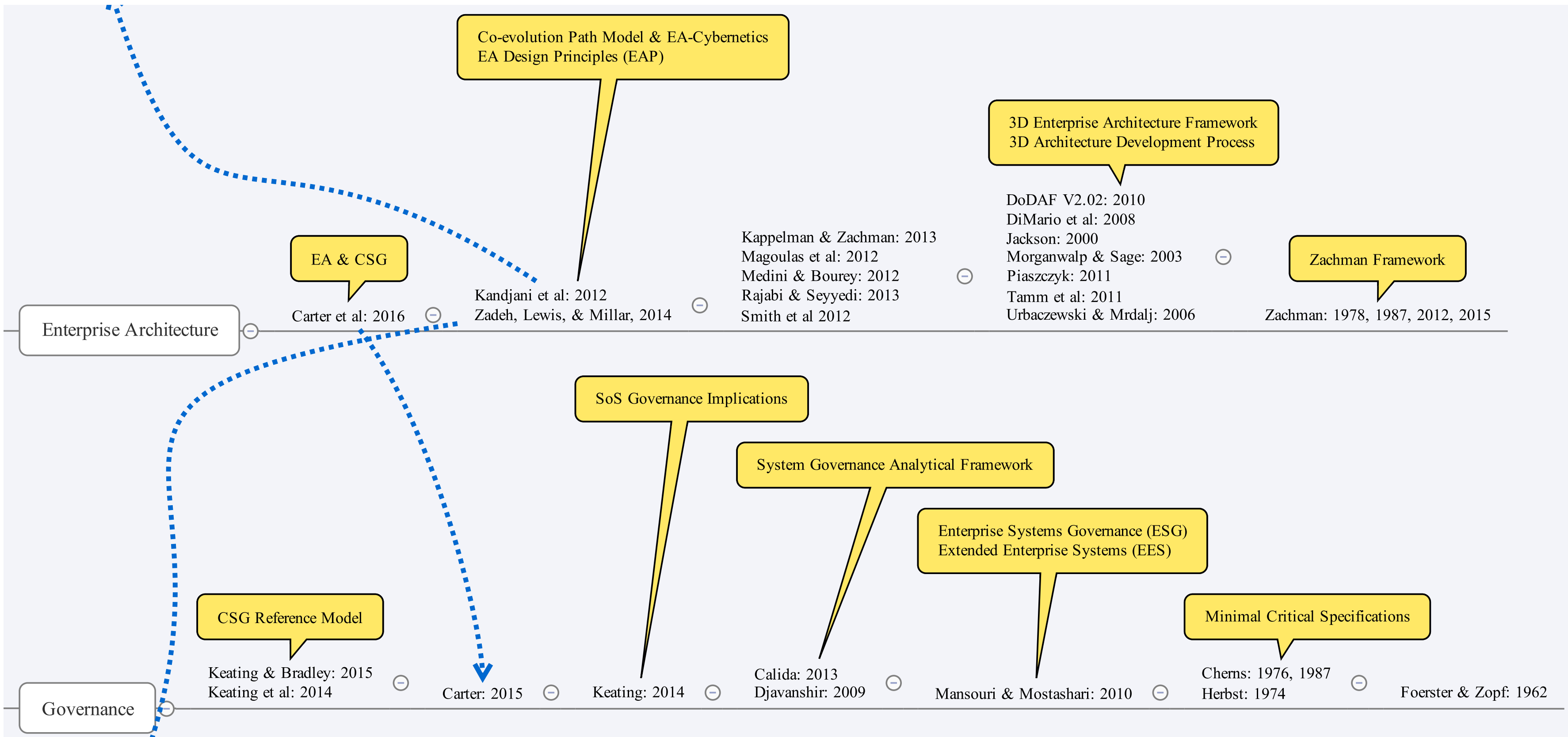

Figure 5. Literature Map of EA and Governance Domains

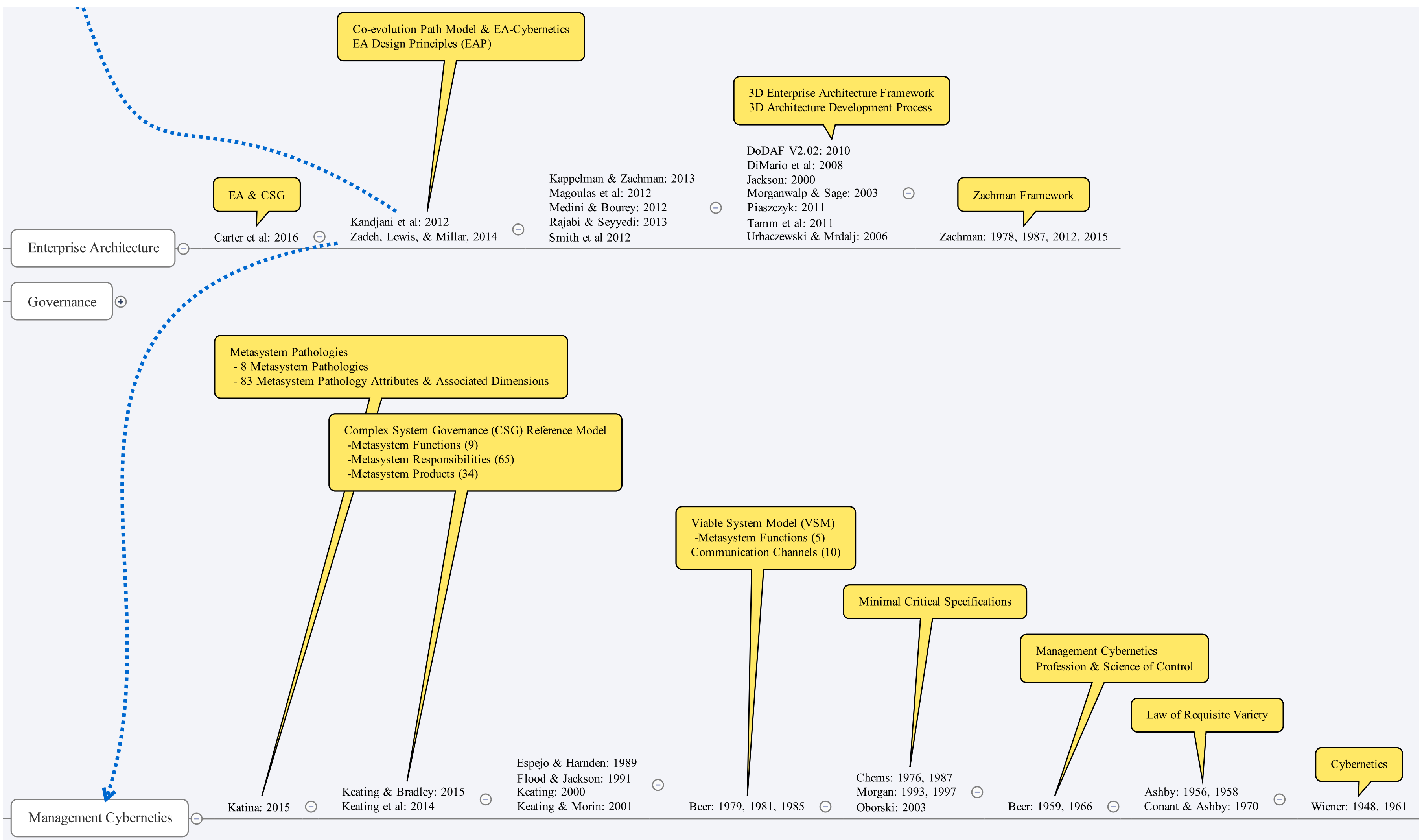

Figure 6. Literature Map of EA and Management Cybernetics Domains

In closing, each domain was explored to draw out relevance to a framework in the form of desirable characteristics of a systems theoretic complex system governance architecture framework. Table 16 summarizes the characteristics gleaned from the literature and provides a pre-look at this study's grounded theory open and axial coding results discussed in the chapters following the discussion on research perspective in Chapter III.

Table 16. Characteristics for Systems Theoretic Complex System Governance Architecture Framework (CSGAF) Indicated in the Literature

Literature Domain / Stream	Indicated Characteristics for CSGAF
Governance	Must be able to span variety of fields Must address CSG functions, responsibilities, and outcomes Must be explicit
Management Cybernetics	Must address aspects of systems theory, management cybernetics and governance related to CSG Must address all characteristics of the CSG reference model to ensure its intent is fulfilled Must integrate metasystem pathologies, systems theory-based pathologies and metasystem governance functions
Enterprise Architecture	Must address stakeholder group through unique/tailored framework Needs to require specific outcomes and describe how to produce them Must be rooted in systems theory to be valid for use in facilitating metasystem governance functions
Systems Theory	Must be rooted in systems theory Must provide a holistic context versus reductionist perspective on the system under study Must facilitate addressing metasystem pathologies Must be used in conjunction with an individual and organizational assessment of systems theory competencies to manage expectations for its application Must be explicit to avoid misinterpretation

CHAPTER III

RESEARCH PERSPECTIVE

The purpose of this chapter is to frame the researcher's perspective on research for this study and discuss the research design considerations. First, a discussion on research acceptability and transparency is provided followed briefly by research design considerations that address transparency. Then, a scholarly critique of inductive research based approaches, including grounded theory is provided, identifying and classifying different forms of inductive research. Next, a discussion on philosophical (ontological, epistemological, methodological) perspectives, issues, and canons of science for inductive vs. deductive research is presented, including scholarly criticism and support for inductive research approaches and an assessment of implications for research design. Strategies are then presented to mitigate potential threats and amplify utility of inductive research to enhance scholarly 'defensibility'. Types of research issues/questions and scholarly disciplines for which inductive research designs offer an appropriate (and inappropriate) approach are subsequently included, along with a discussion of validity and reliability for inductive research design. The chapter closes with an assessment of the appropriateness of inductive research, specifically grounded theory research, for the research purpose and question studied.

Research Paradigms

Given its importance to the continued viability of systems as they grow in complexity, purposeful design of the governance mechanisms for those systems should be achieved. When undertaking research concerning design of system governance mechanisms, it is necessary to build a general foundation upon philosophical considerations for research with discussion of philosophical perspective or worldview, so that justification exists for the belief in truth of a proposition, and that justification can stand up to scrutiny of the relevant facts over an appropriate time period. It is equally important to address ontology (the study of reality), epistemology (how meaning is constructed), methodology (a system of methods used in an area of activity or study), philosophical considerations and canons of science by which the research may be judged. Acceptability of research by the community of interest is a necessary element in rigorous research. There are two facets to acceptability – the first is related to philosophical foundations of research and the second is related to the community's reception of the research. The foundation of the research pertains to the philosophical underpinnings that influence the research methods chosen and how they align with perspectives and canonical views. Foundational perspective reveals acceptable research, produces knowledge, is philosophically and methodologically consistent, has a well-defined problem statement, good design quality, sampling, measurement, analysis, validity and reporting, and is consistent with the research method. Acceptability of research also requires community of interest reception of the research. Research in complex system governance architecture is likely to be of interest to systems engineering, management cybernetics, enterprise architecture, and governance communities. Communities have generally accepted practices which, when not followed, require solid reasoning and support for that reasoning. This is where the canons by which the research might be judged are critical. Knowing the audience, their worldview, and their preferred research methods will enhance the acceptability of the research by communities of interest.

Research design is a plan that guides decisions on when and how often data is collected, what data to gather, from where and whom data is gathered, how to analyze the data, and how to examine data linkages, causation and relationships. Transparency in research increases its potential for acceptability of the research reliability and validity. Representing research design reasoning through modeling of the decision making process is an effective way to transparently document and communicate design thinking. Since complex system governance architecture research can span many disciplines, it creates potential risk of research design vulnerabilities due to the broadened stakeholder base. Complex system governance being an emerging field adds to skepticism and increases scrutiny of related research. Accounting for the intricacies associated with research in general and the added challenges of research in an emerging field increases the probability of a researcher conducting and producing rigorous research.

Inductive Research

George McNair (1914) identified three general forms of inductive research and classified them as follows.

Enumeration: Having observed a few instances, a generalization is made.

Analogy: Having noted two or more characteristics resembling each other in certain respects and they belong to the same type, then any fact known about one can be asserted on the other.

Analysis: Having separated a whole into its parts, a generalization is derived relative to the nature and causal connections of the parts.

McNair (1914) finds fault with enumeration and analogy while identifying "Induction by analysis is superior to the other forms because it secures a higher degree of probability and is a positive time saver" (pp. 373-374).

Glaser and Strauss (1967) introduced grounded theory, a form of inductive analysis, which indicates theory is produced based on data categorizations made by the researcher, how clearly the categorizations describe interpretations being made, and how relevant the categories are to the research question. In grounded theory, the theory that is being constructed helps determine which data are collected and data analysis takes place concurrently with data collection. The expectation in this iteration is that theoretical understanding may change/update. This means grounded theory is appropriate when producing knowledge about a researcher's interpretation of reality. There are issues associated with grounded theory.

Inductive vs. Deductive Research

Worldview should be considered in research decision. Everyone has a philosophical point of view – a way of seeing the world around them and interpreting events (Creswell, 2009; Hudson & Ozanne, 1988). This point of view has been characterized as a worldview or paradigm. Guba (1990) characterized a paradigm as "a basic set of beliefs that guide action" (p. 17). Creswell adopted this characterization as his definition of worldview which he viewed as "a general orientation about the world and the nature of research that a researcher holds" (Creswell, 2009, p. 6). A person's worldview influences their beliefs about the nature of reality as well as what constitutes knowledge (Krauss, 2005). The researcher's worldview is the lens through which they view the nature of the problem under study and influences the strategy adopted to study the problem under consideration. Regarding the nature of reality, Nicholls (2009) suggested two perspectives – "1) a single objective reality or 2) multiple realities" (2009, p. 527). The concept of a single objective reality relates to the belief that objects (or reality) exists regardless of our knowledge of them or our ability to perceive them, objects are what they are and reality is what it is. The 'multiple realities' point-of-view relates to the belief that reality is perceived by individuals with different perspectives. So, one person's reality perspective may not be the same as another's, hence multiple realities. Depending upon a person's worldview they may believe that reality is either mind-dependent, a mental construct (idealism) which aligns with the concept of multiple realities, or that reality is mind-independent, exists independent of our awareness of it or our attempts to know it (realism) (Smith, 1983; Van De Ven, 2007) and which aligns with the concept of single objective reality. These distinct perspectives are critical to understand since they influence a person's understanding of the nature of reality (ontological perspective), which impacts the choice of research subject, how research is conducted (Creswell, 2009; Holden & Lynch, 2004) and what outcomes are viewed as acceptable, for either a deductive or inductive research approach.

Deductive research moves from a general theory toward hypothesis development, which aids in establishing observation criteria that can produce conclusive results. Inductive research pulls from specific observations to produce a theory. Along the inductive research path patterns emerge and a tentative hypothesis is developed and used to work toward the resultant theory. Generally, these methods are described as:

Deduction: moving from general to specific; primarily uses rules / laws for arguments

Induction: moving from specific to general; primarily uses observation for arguments

Their basis for reasoning is described as:

Deduction: being based on formal logic, objectivity, and causation

Induction: being based on critical thinking, subjectivity, and meaning

Philosophically, they are categorized as:

Deduction: ontological (what exists in the world: formal language of reasoning)

Induction: epistemological (what an intelligent being believes about facts)

Ontology

Ontology is the study of reality – what exists and the ways it can be represented (Christ, 2013; Holden & Lynch, 2004) or as Potter (1996) suggests, "whether the world exists, and if so, in what form" (p. 36). The main focus is how individuals perceive reality and the world around them (Allison & Pomeroy, 2000). Potter (1996) makes the case that since we experience the world through our senses and not directly, we cannot know the world as it really is; therefore, one worldview is no better or worse than another worldview. From an ontological perspective, one might believe a fixed reality exists externally, or alternatively that reality is in one's mind and nothing exists if the mind does not know it. The first perspective, an external reality exists, has been referred to as realism (Holden & Lynch, 2004), materialism (Potter, 1996) or an objectivist ontological perspective (Holden & Lynch, 2004). The second perspective, that reality is in the mind and only exists if one knows it, has been referred to as idealism (Potter, 1996) or a subjectivist ontological perspective (Holden & Lynch, 2004). The importance of an ontological perspective to research is that the way in which a researcher perceives reality and accepts what qualifies as knowledge, influences their choice of research method.

Epistemology

Epistemology is the "study or a theory of the nature and grounds of knowledge especially with reference to its limits and validity" (Merriam-Webster, 2014), it seeks to know about knowledge (Lockie, 2014) including how knowledge is constructed. How humans construct meaning is the concern of epistemology. If a person has a mind-dependent worldview, they can be expected to believe in multiple realities, which are contingent on the context used in the interpretation and are constructed in the mind. This epistemological perspective has been called constructivism (Potter, 1996). Alternatively, if a person has a mind-independent worldview, they can be expected to believe a single reality exists independent of the person and be knowable. Potter (1996) called this epistemological perspective realism. The importance of epistemological perspective to research is the way in which a researcher believes meaning can be constructed influences their choice of research methodology.

Methodological Perspectives and Issues

A methodology is a system of methods used in an area of activity or study. Checkland (1993) suggests that a methodology provides a framework, which is more specific than philosophy, but more general than a detailed method or tool. Therefore, a research methodology should provide a framework that can be elaborated to guide action. For example, a researcher might choose a qualitative, quantitative or what has been referred to as a mixed method to study the problem of interest. Once the method is chosen, the researcher can then determine which tools associated with the chosen method best support the objective. The methodology chosen and the form in which it is elaborated (methods chosen) are influenced by the worldview of the researcher and the problem chosen for study (Holden & Lynch, 2004).

Methodological view is based on the researcher's experience with different forms of research and the research question's subject matter area. Based on limited experience in different forms of research, this researcher has mapped his research thinking tendencies as shown in Figure 7. Although the researcher's more prominent research tendencies (green block) are toward rationalism, this research needed to include the development of a systems theoretic governance architecture based partially on observation of existing architecture applications. Observation as a justification for developing knowledge is a canon of empiricism. In developing architecture, models need to be created based in part on evaluation of variables representing characteristics of each observation within the data set of existing architecture, indicating the research method needed to include empiricism.

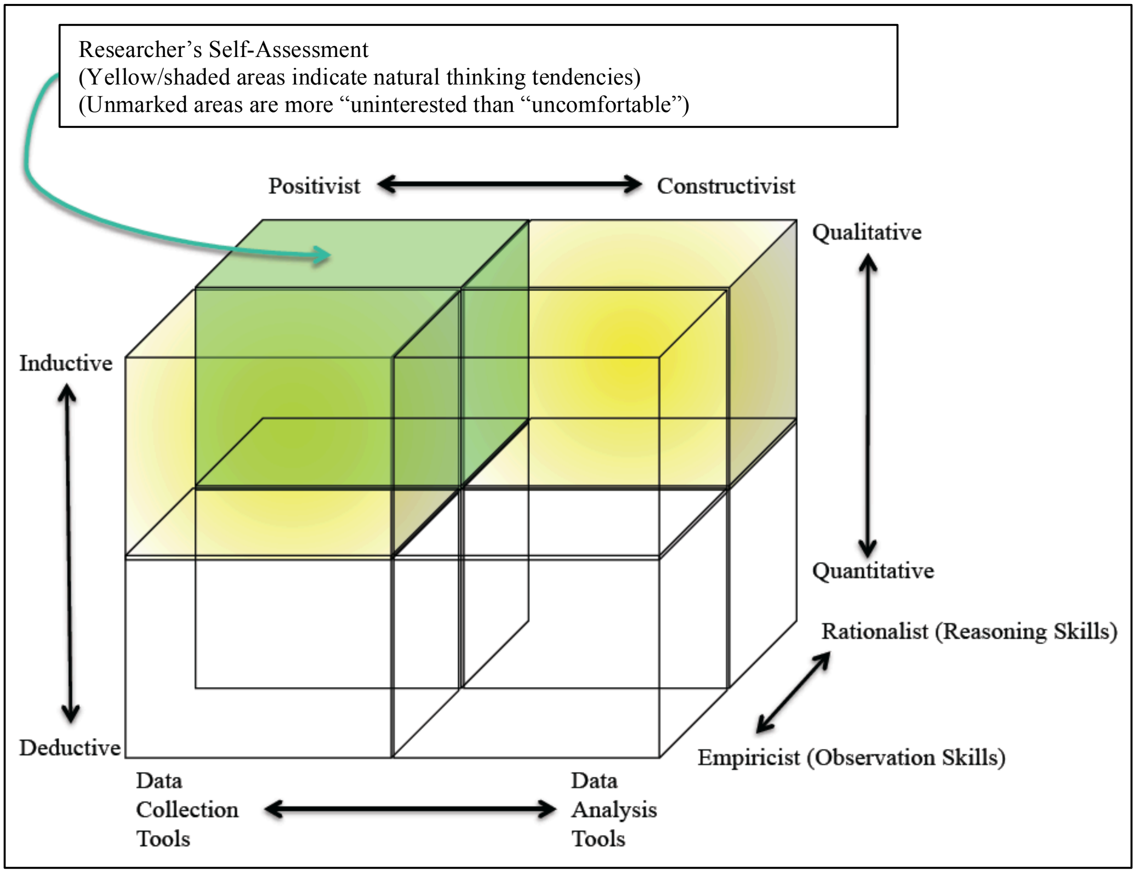

Figure 7. Researcher's Natural Thinking Tendencies for Research
(Adapted from Siangchokyoo & Sousa-Poza, 2012)

Canons of Science Basis for Inductive vs. Deductive Research

Research credibility demands some standard by which knowledge is identified and how it can be gained. Fundamental research principles and rules provide a framework by which the research can be measured and thus judged. These principles and rules are the canons of research. The Oxford English Dictionary, online edition, defines a canon as "a general law, rule, principle, or criterion by which something is judged" (OED, 2014). Guba (1981) introduced criteria for assessing the trustworthiness of research that, when met, helps increase confidence in the research conclusions. Trustworthiness is a measure of research quality (Morrow, 2005), and has also been called rigor, credibility, or validity. The criteria he suggested included truth-value, applicability, consistency, and neutrality as four major concerns of research trustworthiness. These are examples of canons of science that may be used to evaluate research. Different measures are used to assess these criteria depending upon the research design. Table 17 illustrates this.

Table 17. Research Trustworthiness Criteria
(Adapted from Guba (1981))

Criteria	Deductive Research (Typically Quantitative)	Inductive Research (Typically Qualitative)
Truth Value	Internal validity	Credibility
Applicability	External validity Generalizability	Transferability
Consistency	Reliability	Dependability
Neutrality	Objectivity	Confirmability

The basic philosophical differences between qualitative and quantitative methods are not trivial as they have far reaching implications throughout academia (Smith, 1983). Until " … these two approaches are felt to constitute distinct, yet equally appropriate perspectives, then different standards are needed, and it is unfair to judge qualitative efforts from a quantitative perspective and vice versa (Smith, 1983, p. 13)."

Inductive Research Implications

Acceptability is "the quality or state of meeting one's needs adequately <the acceptability of a broken key or two on a secondhand piano might depend on which keys are broken>" (Merriam-Webster, 2014). There is a preciseness of language in choosing the term acceptable over accepted. Where in one case the term refers to adequacy and the other with implications of receiving, or having a favorable opinion of (Merriam-Webster, 2014). What is acceptable research? There are two facets to the research acceptability question. The first is defined by the research foundation. The second is how it is perceived. The foundation of research lies in the philosophical realm and begins with the definition of knowledge, which in turn defines how the methods chosen align with philosophical and canonical views. The reception of research is based on how a particular community views the research. From the perspective of acceptability, canons are the key element of evaluation of research for philosophical and methodological consistency as they provide the means for "… defining credible research within the discipline" (Brewer & Sousa-Poza, 2009, p. 1). The canons are dependent upon the research design. While the complex interrelationship of a researcher's philosophy, worldview, and methodology (research methods and cannons) indicate the uniqueness of each research problem, there are consistent constructs that may be used to assess the research for acceptability. From a foundational perspective, research that produces knowledge is acceptable when it is philosophically and methodologically consistent, ensures the problem is well defined, and when the design, sampling, measurement, analysis, validity, and reporting are of good quality and consistent with the research method. However, research being accepted may be a different story.

Appropriate Applications of Inductive Research

Inductive research questions are less constrained than deductive. Where a deductive question may be based on a construct similar to a programming language (if this, then that) for hypothesis development, an inductive question provides "room" for exploration and the development of theory from data analysis. In other words, appropriate inductive research questions replace what deductive research uses in the form of a hypothesis, in order to guide data collection with the understanding of potential for new questions to come from the data analysis. The result, or basis for the research argument put forth at the close of the research, will be deeply rooted in the data by showing parallels, cross-connections and other intersections. This is often performed using software tools like NVivo qualitative data analysis software: QSR International Pty Ltd.

A governance architecture research philosophical view and methodology should remain focused on the intended audience (Creswell, 2009, p. 19). Just as individuals have a worldview, a community at large shares a collective worldview of their discipline. However, the community view of research philosophies and methods may be so disparate as to prevent a particular method from being acceptable. As indicated by Brewer and Sousa-Poza (2009), there is not at this time an accepted generalized approach to assessing knowledge claims due to the irreconcilable nature of differing philosophical perspectives. Knowing the audience, their worldview, and their preferred research methods will enhance the community's reception of the research, much like zeroing in on the bull's-eye of a target.

Target shooting is graded on the precision and accuracy of the bullet's final location on a target. A shooter is precise and accurate if all shots are co-located on or very near the target's bull's-eye, or center of the target. Hitting a bull's-eye can be related in research to arriving at truth. A researcher's work is evaluated on the reliability (precision) and validity (accuracy) of the research findings. The difference for a researcher is that the goal is not to hit a bull's-eye, but rather to show the actions taken justify a conclusion that the research resulted in truth. Thus, in order for a researcher ("shooter") to be justified in feeling confident in the research findings and to be able to effectively defend those findings, the researcher must execute a research process and be able to defend it. That process is threefold centered on showing peers and evaluators that the research is not: 1) imprecise and inaccurate; 2) accurate but imprecise; and 3) precise but inaccurate.

Research Reliability and Validity

Fundamentally, this process of showing "what the research is not" is rooted in an understanding of what is necessary in order to show the research is reliable and valid. Reliability in research suggests that significant results must be repeatable. In order to establish this a researcher must either show that results have been repeated and/or provide the process by which results may be repeated (Vaz, Falkmer, Passmore, Parsons, & Andreou, 2013). Validity in research suggests that data must reflect what is identified as having actually occurred. In order to prove this a researcher must describe data from a primary source and without confounding variables (Kamangar, 2012). There are some cautions to consider when striving for characterizing research as reliable and valid.

One is circular reasoning. Circular reasoning suggests a researcher is justified in conclusion statements about a premise that is based on data collected during research (Lammenranta, 2006). The result is the research is both unreliable and invalid, or in the context of a shooter it is both imprecise and inaccurate. A researcher must refer to the original premise developed as part of the research proposal and draw conclusions about the data and analysis as it relates to the original premise. In doing so, the researcher will show peers and evaluators that circular reasoning did not make the research vulnerable. Grounded theory should not be excluded based on this reasoning, as it is important to understand that in grounded theory, the “original premise” and associated “conclusion” is iterative.

Another caution is extended justification. Extended justification suggests that if it is necessary to justify an aspect of the research and then necessary to justify the justification, then the research may well be valid, but it is definitely unreliable. This is analogous to a shooter's target indicating accuracy but imprecision (bullet holes are scattered on the target). The opposite of this, when research is evaluated reliable but invalid, comes when the researcher presumes there are perfect and indisputable notions and concepts that will force peers to accept what amounts to "truth". In the realm of the shooter, the shooting is evaluated as precise but inaccurate (tight groupings that are not on the bull's-eye). To avoid either of these situations, a researcher must develop sound reasoning for collecting specific data, sound method(s) for data collection, and sound processes for analyzing those data to show the research truth wasn't arrived at simply by shifting the target around until the bull's-eye came closest to the most bullet holes.

The aforementioned techniques will help a researcher avoid ignoring the implications of the Münchhausen Trilemma (Eemeren & Grootendorst, 2004), which are:

(1) ending up in an infinite regress of new justifications;

(2) going round in a circle of mutually supporting arguments; and

(3) breaking off the justificatory process at an arbitrary point.

Thus, any research undertaking must avoid being vulnerable to suspicions of invalid (inaccurate) and unreliable (imprecise) research methods and results. This is possible only through strong defense in proving the negative situations do not exist. Just as shooters must perform necessary actions to hit the bull's-eye, researchers must perform necessary actions to achieve reliable and valid results. Establishing and maintaining transparent and planned research actions will provide the researcher necessary justification to be confident in their research conclusions and be able to effectively defend their findings.

Andrew Van De Ven (2007, p. 141) proposes two ways in which to gain confidence in the plausibility of a theory using inductive research.

(1) Credibility of a theory is a function of its probability of rejection. The greater the number and variety of tests that do not reject a hypothesis, the more credible it is.

(2) Rule out plausible alternative hypotheses. A new theory should provide a better explanation for a phenomenon that the status quo explanation.

This means for the conduct of research in governance architecture to be reliable and valid, it requires transparency in the ongoing analysis and detailed documentation of analytical findings. There is also a need to justify what data to collect and to obtain professional peer and research leadership reviews.

Complex system governance is an emerging field and literature is sparse at best and non-existent in complex system governance architecture. There exists no systems theoretic framework that informs complex system governance such that it enables the performance of governance functions. A grounded theory, inductive, research approach is appropriate because data will be analyzed in order to develop the framework. Meaning, existing data in the domains of enterprise architecture, systems theory, management cybernetics and governance will not be tested against a static hypothesis but analyzed and continuously compared with the developing systems theoretic framework until the researcher reaches saturation in each domain. Saturation will suggest the latest version of a theory, or in this research case the systems theoretic framework, is stable and no longer sensitive to new data (Ambert, Adler, Adler, & Detzner, 1995; Bradley, 2014; Dunican, 2005; Fossey, Harvey, McDermott, & Davidson, 2002; Glaser & Strauss, 1967; Luckerhoff & Guillemette, 2011).

Chapter Summary

Research in complex system governance architecture is important to the continued viability of systems as they grow in complexity. This research, like any rigorous research, is developed with consideration of a host of critical issues and concerns (philosophical perspectives, worldviews, justification standing up to scrutiny, ontology, epistemology, methodology, philosophical considerations and canons of science) by which the research may be judged acceptable by the community of interest. This researcher conducting inductive research ensured the problem was well defined and that the design, sampling, measurement, analysis, validity, and reporting were of good quality and consistent with the research method.

Acceptability of research requires the community of interest to accept the research. Research in complex system governance architecture is likely to be of interest to systems engineering, management cybernetics, enterprise architecture, and governance communities. Knowing these audiences, their worldview, and their preferred research methods has enhanced acceptability of this research by communities of interest and was achieved through professional interactions, publication, and peer review.

Transparency in research increases its potential for acceptability. Representing research design reasoning through modeling of the decision making process is an effective way to transparently document and communicate design thinking. Since complex system governance architecture research can span many disciplines, it potentially creates risk of vulnerabilities in the research design due to the broadened stakeholder base. Complex system governance being an emerging field adds to skepticism and increases scrutiny of related research. Accounting for the intricacies associated with research in general and the added challenges of research in an emerging field has ensured this inductive research endeavor is rigorous.

Inductive research has a significant history in application and approaches to guide the conduct of rigorous scholarly research. This chapter provided a scholarly critique of inductive research based approaches, including grounded theory. It identified and classified different forms of inductive research, discussed the philosophical (ontological, epistemological, methodological) perspectives, issues, and canons of science for inductive vs. deductive research, provided scholarly criticism and support for inductive research approaches and an assessment of implications for research design. In so doing, strategies were presented to mitigate potential threats and amplify utility of inductive research to enhance scholarly 'defensibility'. Types of research issues/questions and scholarly disciplines for which inductive research designs offer an appropriate (and inappropriate) approach were included, along with a discussion of validity and reliability for inductive research design. The chapter closed with an assessment of the appropriateness of inductive research, specifically grounded theory research, for the research purpose and question studied.

CHAPTER IV

RESEARCH DESIGN

This chapter discusses the research design for complex system governance architecture framework development in response to the research question identified in Chapter I. Activities are detailed for each phase of the research, including the grounded theory-based coding activities, using perspectives offered in Chapter II and philosophical foundations presented in Chapter III. The research design facilitates development of a systems theoretic framework and validation of it through peer review. The findings from executing this research design are delivered in Chapter V and their associated implications and related future research opportunities are discussed in Chapter VI.

Research Methodology

The best research design depends on its purpose, the evaluation audience, available time, and the interests, abilities and biases of the researcher (Patton, 2002). Designs should also account for ethical issues in research, applied methods, analysis, conclusions, and the researcher's preconceived notions and bias. Data sources should be identified as primary or secondary to apply proper context and ensure transparency. Research design is the framework that specifies the actions taken to arrive at acceptable conclusions. Precision and accuracy in research execution and presentation of results demands good research design that includes the minimum characteristics identified in Table 18.

Table 18. Design Evaluation Criteria
(Adapted from Patton (2002) and Simpson et al. (2013))

Research Design Evaluation Criteria	Yes	No
Is the design consistent with the intent of the study?		
Does the design include procedure for capturing related issues?		
Does the design justify breadth over depth or vice-versa?		
Does the design show what type of data will be collected?		
Does the design describe the analytical approach in sufficient detail?		
Does the design address time issues and provide phasing and/or sequencing of events?		
Does the design describe how validity and confidence (or lack of) in the findings will be addressed?		
If needed, does the design address logistical issues and how they will be met?		
Does the design address ethical issues related to the data, research activities and arrival at findings/conclusions?		
Does the design identify the necessary and available resources?		

Ultimately, the research design serves to answer the research question through organization of the study so it can be defended against disadvantages, while promoting the advantages and garnering trust in the findings.

When a qualitative research method and grounded theory approach is used to answer the research question the criteria for evaluating the research should serve to confirm methodological rigor and trustworthiness of interpretations being made, such as the heuristic provided in Table 19 (Fossey et al., 2002).

Table 19. Methodology Evaluation Criteria
(Adapted from Fossey et al. (2002) and Reid & Gough (2000))

Research Methodology Evaluation Criteria	Yes	No
Does the methodology fit the research issue?		
Do the methods fit the methodology?		
Was the study conducted in a manner congruent with the methodology?		
Was the data collection strategy suitable to identify sources to inform the research question being addressed?		
Were suitable data gathering methods used to inform the research question?		
Was the data gathering process described?		
Was the analytical process described to include how data were converted and condensed into theoretical constructs?		
Was the extent to which the iterative data collection and analysis process described (# of iterations, evolution of subsequent efforts, significant changes)?		
Were sufficient sources of information sampled to develop a full description of the issue being studied?		
Were corroborating, illuminating, and rival opinions gathered and analyzed to explore multiple aspects of the research issue?		
Is the description of the methods detailed enough to enable the reader to understand the context of what is being studied and how (enough that the research can be repeated)?		

Although it is necessary to document research methodology in detail, Thomas (2006) reminds us “the primary purpose of the inductive approach is to allow research findings to emerge from the frequent, dominant, or significant themes inherent in raw data, without the restraints imposed by structured methodologies” (p. 218), suggesting a checklist approach or strict adherence to evaluation criteria should be avoided. Rather, the methodology and its evaluation should be used as a guide versus compulsory tool set.

This research is qualitative and inductive using a Systematic Design (Strauss & Corbin, 1998) to Grounded Theory Method (Glaser & Strauss, 1967). Systematic design in grounded theory includes three phases of coding: open, axial, and selective (Creswell, 1998; Leedy & Ormrod, 2010). In open coding, the data are divided into segments and studied for commonalities to categorize by primary emphasis or theme. This distills the data into a concentrated (discreet) set of characteristics that describe the study focal points. In axial coding, the discrete codes are grouped based on specific points of intersection. At this point of the research effort, coding (axial) is based on interpretations and abstractions of the researcher. In selective coding the coded clusters are examined for relations to each other so the researcher can develop relational statements to explain the context of what is observed. This Grounded Theory Research systematic design highlights: 1) connections between the derived categories and literature data, 2) explanation of the actual problem under study and the supporting research process, 3) how changes were managed as conditions changed or the researcher collected additional information, 4) the intent of the resulting theoretical model or framework, 5) the central issues of the model or framework, and 6) that the model or framework emerged through phases of coding and was not a pre-conceived notion held by the researcher.

Figure 8 presents a conceptual framing of the research as it relates to the current state of knowledge and answering the proposed research question. The methodological approach used to achieve desired outcomes of the research follows.

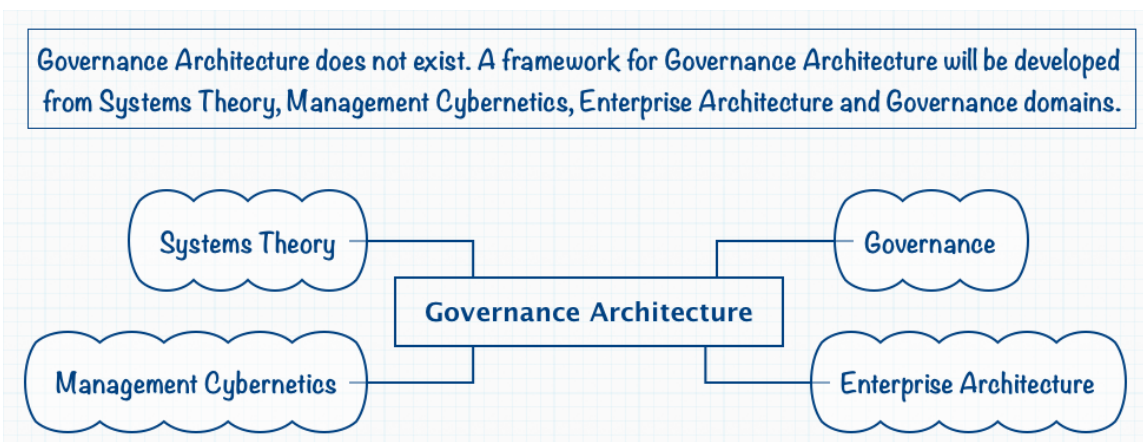

Figure 8. Research Conceptual Picture

This research includes analysis of four domains of literature including systems theory, management cybernetics, enterprise architecture, and governance. Discovery was holistic using an interpretive theoretical perspective to establish significance, applicability, consistency and neutrality of conclusions. Through this approach, the research solidifies its credibility, transferability, transparency (dependability), and accountability (auditability).

Data collection consisted of acquiring literature electronically in each of the four domains. Keyword and key phrase searches in literature databases are an effective way of identifying and qualifying relevant literature. Initial keywords and key phrases included: management cybernetics, governance, enterprise architecture, architecture framework, architectural views, systems thinking, systems theory, complex system governance, and system of systems. Where research searches and threads (pathways) led to literature not available electronically, hard copy acquisition was pursued. Because grounded theory analysis was used in this research, the initial set of qualifying keywords and key phrases was expected to change or grow as discoveries were made. NVivo for Mac qualitative data analysis software (QSR International Pty Ltd. Version 11.1.1, 2015) was used to support the grounded theory based coding (Richards, 1999, 2005).

Analysis of the literature data started by identifying and documenting the elements of knowledge through decomposition of facts and detailing the concepts, both in the literature and as revealed to the researcher through synthesis. Concepts and facts were further analyzed to establish governance architecture requirements, the first major milestone. NVivo was used for axial coding. Verification of the analysis was performed as part of the governance architecture development process by aligning the characteristics of each governance architectural view with governance functions and products, which are defined in the complex system governance reference model (Keating & Bradley, 2015). NVivo was used for selective coding. Figures 9 and 10 provide overviews of the research phasing, which are discussed in detail in the next section.

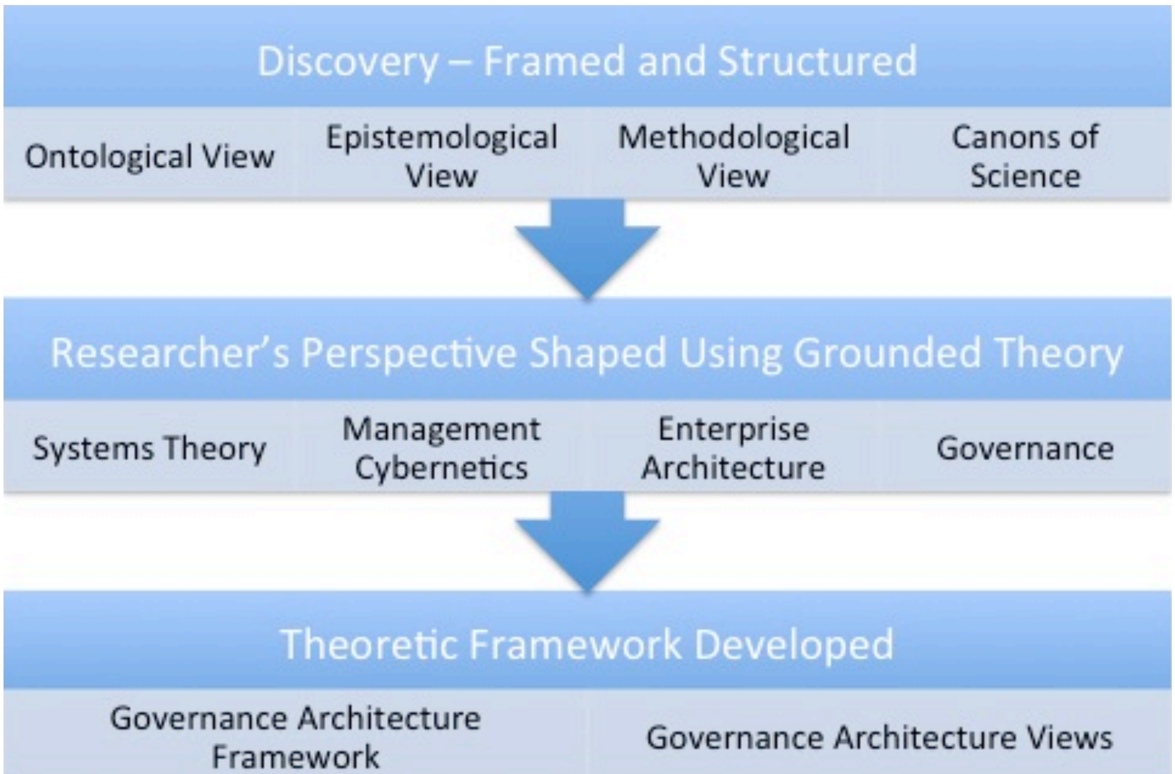

Figure 9. Research Design Lineage

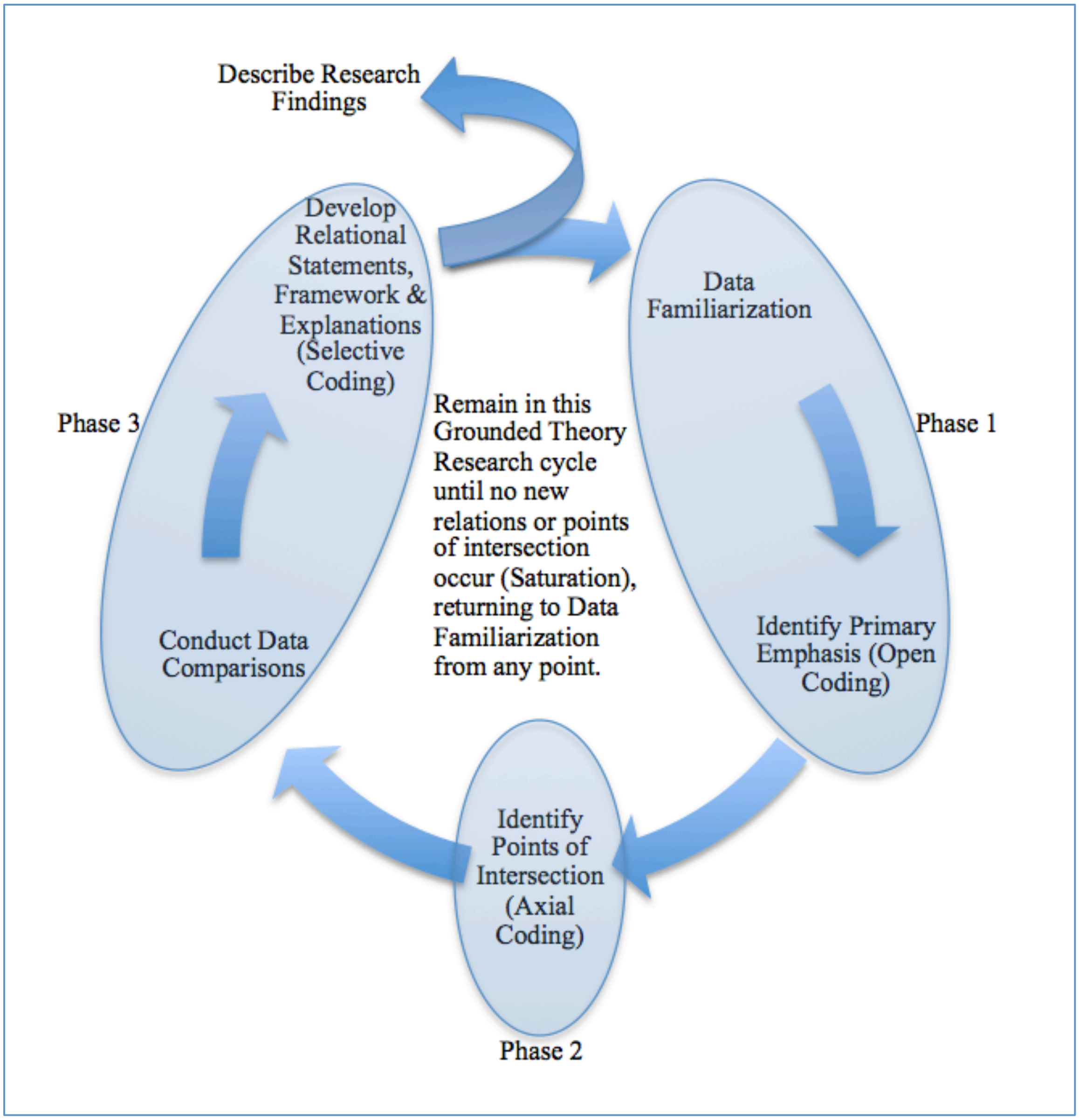

Figure 10. Research Method

Research Phases

The three broad research phases were requirements definition, domain synthesis, and peer reviewed framework development. Table 20 depicts elements associated with each phase.

Table 20. Broad Research Phases and their Elements

Research Phase	Grounded Theory Activities	Outcome(s) (Known or Anticipated)
Requirements Definition	Literature Review Data Collection Analysis (Open Coding)	Main Themes in Literature, Framework Requirements
Domain Synthesis	Literature Review Data Collection Analysis (Axial Coding)	Emergent Framework Requirements, Clustering Relevance to Systems Theory & CSG
Framework Development	Construction (Selective Coding) Peer Evaluation	Requirements/Source Data Linkages Framework Description/Intent Framework Toolset

Phase 1 of the research was to develop generalizations of governance architecture framework requirements from synthesis of the literature in the domains of systems theory, management cybernetics, enterprise architecture, and governance. This identified the origins of each domain's pertinent qualities, solidified the current state of relationships with systems theory and complex system governance, and identified initial requirements for the governance architecture framework. Phase 1 included open coding groupings utilizing NVivo, notes on the literature assembled within EndNote X7 and cataloging analysis in custom Excel spreadsheets. In Phase 1, literature from each domain was assessed and coded by main themes to confirm associations in the literature during deeper exploration. The literature was characterized and cataloged in Excel as indicated in the sample data set in Table 21.

Table 21. Sample of Research Phase 1 Data Collection and Coding

Literature Source	Main Theme, Discussion Thread, or Segment in Literature
Morganwalp and Sage (2003)	Enterprise Architecture Framework; Architecture Development; System of Systems
Urbaczewski and Mrdalj (2006)	Enterprise Architecture Frameworks
Ashby (1947, 1956)	Management Cybernetics; System Viability; Requisite Variety; Self-organization
Wiener (1948, 1961)	Management Cybernetics; System Viability; Feedback
Cherns (1976, 1987)	Minimal critical Specification; Information Flow; Multifunctional Principle
Beer (1959, 1966, 1968, 1970, 1972, 1975, 1979, 1985, 1994)	Management Cybernetics, System Viability; Viable System Model
Mansouri and Mostashari (2010)	Governance; Enterprises

Phase 1's assessment led the researcher to explore deeper into literature threads based on prominent themes and potential strength of relevance to systems theory and complex system governance. One example of an unexpected, emerging thread discovered during this effort was system pathologies and the development of a codebook of systems theory principles and laws (Katina, 2015). The researcher did not initially consider system pathologies as being relevant to the development of a governance architecture framework, but because the documentation met the literature review's inclusion criteria and fell within the main theme of systems theory it was explored in more detail during Phase 2. Katina's codebook was subsequently filtered through remaining research phases and eventually became a contributing reference tool within the research's resulting framework, an element that would not have been considered by the researcher for inclusion in an architecture framework without executing this research methodology.

Phase 2 was a comprehensive synthesis of the literature, analyzing to investigate the boundaries between the literature domains to identify interconnections, relevance to systems theory, and relevance to complex system governance. Where they existed, commonalities were identified based on the context in which they existed and potential for application in development of a complex system governance architecture framework. Where no commonalities existed, requirements were identified for developing complex system governance architecture framework artifacts. Table 22 indicates a sample of the axial coding during Phase 2. Axial coding marked a transition for the researcher away from NVivo to focus analysis efforts primarily in Excel spreadsheets and to a lesser extent in EndNote, due to researcher familiarity and efficiency.

Table 22. Sample of Research Phase 2 Data Collection and Coding

Literature Source	Main Theme, Discussion Thread, or Segment in Literature	Relevance to Systems Theory	Relevance to Complex System Governance
Morganwalp and Sage (2003)	Enterprise Architecture Framework; Architecture Development; System of Systems	Contextualizing systems	Development of AFs in SoS context
Urbaczewski and Mrdalj (2006)	Enterprise Architecture Frameworks	Introduction to AFs for system descriptions	Considerations for architecture development (AD)
Ashby (1947, 1956)	Management Cybernetics; System Viability; Requisite Variety; Self-organization	Foundational; Introduction; Seminal	Establishes fundamental governance criteria
Wiener (1948, 1961)	Management Cybernetics; System Viability; Feedback	Foundational; Introduction; Seminal	Establishes fundamental governance criteria
Cherns (1976, 1987)	Minimal critical Specification; Information Flow; Multifunctional Principle	Foundational; Introduction; Seminal	Establishes fundamental governance criteria
Beer (1959, 1966, 1968, 1970, 1972, 1975, 1979, 1985, 1994)	Management Cybernetics, System Viability; Viable System Model	Foundational; Introduction; Seminal	Establishes fundamental governance criteria
Mansouri and Mostahari (2010)	Governance; Enterprises	Governance processes	Links governance & enterprises

Phase 3 is where selective coding and interrelationships were identified and where the complex system governance architecture framework was shaped. At this point in the research phasing, the value of grounded theory methodology was solidified for the researcher because it facilitated the researcher's need to move freely and repeatedly between open, axial, and selective coding to gain confidence in identifying when a thorough synthesis of the literature and analysis in the coding had occurred. The researcher iterated through all three phases until an exit from Phase 3 revealed itself, which coincided with the initial completion of a framework. The coding portion of Phase 3 continued as an extension of Phase 2, using primarily Excel spreadsheets and to a lesser extent Endnote. Once the complex system governance architecture framework was developed, 15 members of a doctoral and post-doctoral learning community knowledgeable in one or more domains related to this research were solicited for feedback. Their minimum qualifications for participation and specific feedback are detailed in Chapter V. Also detailed in Chapter V are the feedback responses and actions taken by the researcher as part of Phase 3's selective coding and evolution of the framework. This afforded the opportunity to iterate and absorb variety in perspectives and in additional literature emerging at any point in research process, as did occur in Phase 3. For example, one expert reviewer of the initial framework identified Zadeh et al. (2014) in Phase 3 which helped confirm previous coding related to enterprise architecture, the viable system model and the resulting complex system governance architecture framework. Table 23 indicates a sample of the selective coding of Phase 3.

Table 23. Sample of Research Phase 3 Data Collection and Coding

Literature / Input Source	Main Theme, Discussion Thread, or Segment in Literature	Relevance to Systems Theory	Relevance to Complex System Governance	Complex System Governance Architecture Framework Characteristics
Morganwalp and Sage (2003)	Enterprise Architecture Framework; Architecture Development; System of Systems	Contextualizing systems	Development of AFs in SoS context	Must address systems theory principles, metasystem governance functions and EA process
Urbaczewski and Mrdalj (2006)	Enterprise Architecture Frameworks	Introduction to AFs for system descriptions	Considerations for architecture development (AD)	Must address EA process
Ashby (1947, 1956)	Management Cybernetics; System Viability; Requisite Variety; Self-organization	Foundational; Introduction; Seminal	Establishes fundamental governance criteria	Must address metasystem governance functions
Wiener (1948, 1961)	Management Cybernetics; System Viability; Feedback	Foundational; Introduction; Seminal	Establishes fundamental governance criteria	Must address metasystem governance functions
Cherns (1976, 1987)	Minimal critical Specification; Information Flow; Multifunctional Principle	Foundational; Introduction; Seminal	Establishes fundamental governance criteria	Must address metasystem governance functions
Beer (1959, 1966, 1968, 1970, 1972, 1975, 1979, 1985, 1994)	Management Cybernetics, System Viability; Viable System Model	Foundational; Introduction; Seminal	Establishes fundamental governance criteria	Must address metasystem governance functions
Mansouri and Mostashari (2010) and Zadeh et al., (2014)	Governance; Enterprises	Governance processes	Links governance & enterprises	Must address metasystem governance functions and EA process

Chapter Summary

This chapter presented the research design and process in detail. The research design characteristics include:

- An explanation of the procedure for capturing related issues within source material
- A justification of breadth over depth in literature synthesis to absorb the widest variety in framework developmental considerations
- An explanation on the type of data collected and how data gathering methods were employed
- A description of the analytical approach and the extent of the iterative data collection and analysis process
- An address of time issues by providing phasing/sequencing of events
- A description of how validity in the findings were addressed and in so doing confirms an ethical approach and that corroborating, illuminating, and rival opinions were gathered and analyzed to explore multiple aspects
- An identification of the resources necessary to conduct the research
- An explanation of how the methodology fit the research issue and methods fit the methodology, and
- Sufficient detail of the approach to enable the reader to understand the context of what was being studied and how the result was derived

The research was conducted as planned and described in this Chapter and the detailed results are provided in Chapter V. The process described in this Chapter is repeatable to the point of the framework's production requirements or characteristics. Meaning, there is no assurance that frameworks or even data assembly and analysis formats produced by other researchers following this process will be the same due to variety of preferences in how to assemble and analyze data or present a framework, but the characteristics of a resulting framework are expected to be the same.

CHAPTER V

RESEARCH RESULTS

Complex System Governance Architecture Framework

Grounded theory approach was used to study aspects of a systems theoretic complex system governance architecture framework to complete this research study. The research reveals necessary elements of systems theory, governance, management cybernetics, and enterprise architecture for development of a systems theoretic complex system governance architecture framework. Keating and Bradley's (2015) complex system governance reference model embodies management cybernetics, governance, and systems theory including the propositions of Adams et al. (2014) and identifies metasystem governance function responsibilities and outcomes, which are the fundamental goals of a complex system governance architecture framework.

The resulting complex system governance architecture framework describes the conventions, principles, and practices for establishing complex system governance architectures in support of accomplishing the nine governance functions, 65 related responsibilities, and 34 related outcomes. The framework also integrates 30 systems theory propositions and eight metasystem pathologies encapsulating 83 systems theory-based pathologies (Katina, 2015).

Complex systems have unique characteristics, evolve uniquely, and experience different emergent properties than other complex systems. Complex system governance architecture framework stakeholders include those responsible for metasystem governance functions and continued system viability. Traditional stakeholder participation includes anyone affected by or who affects a system or organization, and is often extended to include those interested in or trying to affect a system or organization. Complex systems are beyond traditional regarding governance related stakeholders, in part because they experience emergent behavior. Governance functions of complex systems exist at higher logical levels than traditional management and oversight functions for organizations, in part to increase the response time and effectiveness for emergent behavior. Limiting the stakeholder population at the governance level reduces stakeholder variety and by extension facilitates achieving requisite variety necessary for governance. Stakeholders for governance include complex system owner(s), metasystem governor(s), and/or metasystem governance function owner(s). Because complex systems experience many levels of uniqueness and emergent behaviors, it is understood that allocations of responsibility may exist in any combination of owner, governor, or function owner to suit the unique needs of a complex system. The following definitions were adopted for development of the framework.

Complex System Owner is a person or organizational body responsible for maintaining system viability through decision making not delegated to a Metasystem Governor or Metasystem Governance Function Owner.

Metasystem Governor is a person or organizational body responsible for maintaining system viability through accomplishment of all metasystem governance functions.

Metasystem Governance Function Owner is a person or organizational body responsible for accomplishment of one or more metasystem governance function(s).

Governance stakeholder groups are not exclusive to these newly defined participants. Typical enterprise architecture stakeholders may also need to be governance stakeholders depending on system structure. Table 24 provides a comparison of complex system governance architecture framework stakeholders versus traditional enterprise architecture framework stakeholders.

Table 24. Comparison of Typical Stakeholders

Typical CSGAF Stakeholders	Typical Enterprise Architecture Stakeholders		
Complex System Owner(s)	Client(s), Customer(s), End User(s)	Potential Client(s)/Partner(s)	Contractor(s)/Sub-Contractor(s)
Metasystem Governor(s)	System Planner(s)	System Designer(s)/Architect(s)	Vendor(s)/Service Provider(s)
Metasystem Governance Function Owners(s)	Resource Sponsor(s)	System Developer(s)	System Maintainer(s)

The complex system governance architecture framework is considered a dynamic toolset for complex system owners, metasystem governors, and metasystem governance function owners to discover, develop, and maintain information necessary for development of complex system governance architecture products (model-centric outcomes/representations) that facilitate greater understanding of a complex system under study and performance of complex system governance functions.

Complex system governance architecture framework conventions are identified in Table 25 and associated principles and practices in Table 26. These conventions, principles, and practices are integrated in the framework presented in Appendix (A).

Table 25. Complex System Governance Architecture Framework Conventions

Metasystem Viewpoint or Key Element	Nomenclature Construct	Example
Metasystem Viewpoint	MV-(Metasystem Function #)	MV-5
Metasystem Viewpoint Information Need	MV-(#) I-(1-4).(#)	MV-5 I1.1
Metasystem Viewpoint Outcome	MV-(#) O-(#)	MV-5 O1
Metasystem Pathology	MP(1-8)	MP1
Systems Theory	ST(1-30)	ST1

Table 26. Complex System Governance Architecture Framework Conventions, Principles, and Practices

Metasystem Viewpoint		Principles and Practices
MV-5	Policy & Identity	Provides for understanding of governance function
MV-5 I1.x	Information Need	Human Requirements
MV-5 I2.x	Information Need	Technical System Requirements
MV-5 I3.x	Information Need	Integrated Human-System Requirements
MV-5 I4.x	Information Need	Environmental Requirements
MV-5 O1	Forums & Mechanisms	Guides development of architecture to define, maintain, and evolve system identity & focus
MV-5 O2	Strategic System Plan	Guides development of architecture to define, disseminate, maintain, and evolve strategic system plan
MV-5 O3	Public Relations Plan	Guides development of architecture to define, execute, evaluate, and evolve public relations plan
MV-5 O4	Marketing Plan	Guides development of architecture to define, execute, evaluate, and evolve marketing plan
MV-5 O5	Integrated System Mapping	Guides development of architecture to map, display, and evolve integrated system mapping
MV-5 O6	Satisficing System Policies	Guides development of architecture to: -attributes of system policy alternatives -identify and assess policy alternatives impact -develop and evolve satisficing system policies
MV-5 O7	Governance Architecture	Guides development of architecture to define, model, evaluate, and evolve the CSGAF metasystem model
MV-5*	System Context	Provides for understanding of governance function
MV-5* I1.x	Information Need	Human Requirements
MV-5* I2.x	Information Need	Technical System Requirements
MV-5* I3.x	Information Need	Integrated Human-System Requirements
MV-5* I4.x	Information Need	Environmental Requirements
MV-5* O1	Stakeholder Analysis	Guides development of architecture to identify, define interests and concerns, and evaluate and monitor SWOT of stakeholders
MV-5* O2	Contextual Mapping	Guides development of architecture to map, display, and evolve contextual system mapping
MV-5* O3	Contextual Monitoring & Development Strategy	Guides development of architecture to define, maintain, and evolve system context
MV-5’	Strategic System Monitoring	Provides for understanding of governance function
MV-5’ I1.x	Information Need	Human Requirements
MV-5’ I2.x	Information Need	Technical System Requirements
MV-5’ I3.x	Information Need	Integrated Human-System Requirements
MV-5’ I4.x	Information Need	Environmental Requirements
MV-5’ O1	Dashboard Measures for Strategic System Performance	Guides development of architecture to: -define performance measures of interest and baseline -capture performance indicators -display performance measures
MV-5’ O2	Results of Performance Issues	Guides development of architecture to identify, analyze, and respond to performance issues

Table 26 (continued)

MV-5’ O3	Performance Measure Analysis	Guides development of architecture to: -evaluate usefulness of performance measures in monitoring system viability -evaluate performance measure for conflict with system context and focus -recommend continuance, modification, or deletion of performance measures
MV-4	System Development	Provides for understanding of governance function
MV-4 I1.x	Information Need	Human Requirements
MV-4 I2.x	Information Need	Technical System Requirements
MV-4 I3.x	Information Need	Integrated Human-System Requirements
MV-4 I4.x	Information Need	Environmental Requirements
MV-4 O1	Response to Environmental Scanning	Guides development of architecture to: -identify potential environmental scanning results -develop and prioritize response plans to results -evaluate environmental scanning results
MV-4 O2	System Models	Guides development of architecture to develop models: -of present system -of future system -of environment
MV-4 O3	Strategic System Development Plan and Map	Guides development of architecture to: -define and execute strategic system development plan -map and display system development -evaluate and evolve strategic system development plan, mapping, and display
MV-4*	Learning & Transformation	Provides for understanding of governance function
MV-4* I1.x	Information Need	Human Requirements
MV-4* I2.x	Information Need	Technical System Requirements
MV-4* I3.x	Information Need	Integrated Human-System Requirements
MV-4* I4.x	Information Need	Environmental Requirements
MV-4* O1	Second Order System Learning	Guides development of architecture to identify and analyze metasystem design errors and develop alternatives for transformation
MV-4* O2	System Transformation Strategy	Guides development of architecture to: -identify potential design modifications and prioritization -determine transformation strategy activities -develop system transformation strategy
MV-4* O3	Learning Results, Implications, Opportunities	Guides development of architecture to: -verify transformation strategy identifies learning results, implications, and opportunities -disseminate transformation strategy -confirm transformation strategy informs development of strategic plan
MV-4’	Environmental Scanning	Provides for understanding of governance function
MV-4’ I1.x	Information Need	Human Requirements
MV-4’ I2.x	Information Need	Technical System Requirements
MV-4’ I3.x	Information Need	Integrated Human-System Requirements
MV-4’ I4.x	Information Need	Environmental Requirements

Table 26 (continued)

MV-4' O1	Design for Environmental Scanning	Guides development of architecture to: -define environmental scanning objectives and organization -develop and execute environmental scanning activities -evaluate environmental scanning performance
MV-4' O2	Publication of Environmental Scanning Activities	Guides development of architecture to: -develop environmental scanning activity publication methods -publish environmental scanning activities -evaluate performance of publication -evolve publication methods
MV-4' O3	Disseminate Scanning Results	Guides development of architecture to: -capture and analyze environmental scanning data -develop and disseminate environmental scanning results and implications
MV-3	System Operations	Provides for understanding of governance function
MV-3 I1.x	Information Need	Human Requirements
MV-3 I2.x	Information Need	Technical System Requirements
MV-3 I3.x	Information Need	Integrated Human-System Requirements
MV-3 I4.x	Information Need	Environmental Requirements
MV-3 O1	Operational Plan	Guides development of architecture to: -define value criteria for system production operations -develop, evaluate, and evolve operational plan for system production
MV-3 O2	Execution Forums for Operational Maintenance	Guides development of architecture to: -define operational maintenance goals and performance measures -identify opportunities and methods for execution forums -execute and evaluate execution forums
MV-3 O3	Resource Planning	Guides development of architecture to: -identify, characterize, and prioritize resource requirements -develop resource acquisition and allocation plan -execute and evaluate resource planning
MV-3 O4	Operational Goals	Guides development of architecture to: -identify strategic performance objectives -define, evaluate, and evolve operational goals
MV-3 O5	Priority and Resource Allocation	Guides development of architecture to: -identify operational support activity and investment priorities -allocate resources -evaluate resource allocation return on investment
MV-3 O6	Performance Measure Targets	Guides development of architecture to: -define performance measure targets -identify performance measure indicators -develop performance measure collection and analysis plan
MV-3*	Operational Performance	Provides for understanding of governance function
MV-3* I1.x	Information Need	Human Requirements
MV-3* I2.x	Information Need	Technical System Requirements
MV-3* I3.x	Information Need	Integrated Human-System Requirements
MV-3* I4.x	Information Need	Environmental Requirements

Table 26 (continued)

MV-3* O1	Dashboard Measures for Operations	Guides development of architecture to: -define dashboard measures of interest -identify or define sources of dashboard measures -integrate sources into dashboard displays and/or tools
MV-3* O2	Results of Performance Issues	Guides development of architecture to: -facilitate acquisition of performance data -analyze performance data -assemble and disseminate implications of issues
MV-3* O3	Performance Measure Analysis	Guides development of architecture to: -identify usefulness of performance measures -identify alternative performance measures -recommend changes to performance measures
MV-2	Information & Communications	Provides for understanding of governance function
MV-2 I1.x	Information Need	Human Requirements
MV-2 I2.x	Information Need	Technical System Requirements
MV-2 I3.x	Information Need	Integrated Human-System Requirements
MV-2 I4.x	Information Need	Environmental Requirements
MV-2 O1	Internal Coordination Processes and Procedures	Guides development of architecture to: -identify or define internal coordination requirements -develop, evaluate, and evolve standardized processes and procedures to meet requirements
MV-2 O2	Metasystem Communications Architecture	Guides development of architecture to: -define metasystem communication requirements -identify and model metasystem communication links & nodes
MV-2 O3	External Coordination Vehicles	Guides development of architecture to: -define external coordination requirements -identify existing or develop new coordination vehicles -facilitate use of external coordination vehicles
ST(1-30)	Systems Theory Propositions	Inform development of architecture at higher logical level necessary for governance
MP(1-8)	Metasystem Pathologies	Inform development of architecture at higher logical level necessary for governance

Not yet discussed in this chapter is enterprise architecture domain’s influence on development of the complex system governance architecture framework. Enterprise architecture domain is vast and research reveals it is largely centered on system acquisition and integration related to software development, information technology management in support of business and military operations, functioning at a lower logical level or lower level of holism than used in performing metasystem governance functions. It is important to understand that the complex system governance architecture framework is not meant to replace traditional enterprise architecture frameworks but rather complement the body of existing enterprise architectures by filling the voids they leave at metasystem governance logical and functional levels. There are linkages between the complex system governance architecture framework's viewpoints and enterprise architectures that can serve as starting points in development of complex system governance architectures. These linkages may also be backward compatible in supporting the maintenance and use of enterprise architecture's lower logical level functions that remain necessary within an organization or other complex system's boundary-formation. Results of this research include identification and assessment of non-systems theory based architecture frameworks and architecture views warranting further inspection during development of complex system governance architectures. Analysis using NVivo, Endnote, and Excel of 166 known architecture frameworks, methods, or models identified 33 having potential for supporting development of complex system governance architectures based on the following inclusion and exclusion criteria.

1. Inclusion – architecture framework is active / in-use.
2. Inclusion – architecture framework description is related to one or more governance functions.
3. Exclusion – architecture framework is inactive or superseded.
4. Exclusion – architecture framework's main focus is technical, IT, or software development AND unrelated to one or more governance functions.

A sample of framework analysis is highlighted in Table 27. The comprehensive list with embedded analysis is provided in Appendix B.

Table 27. Sample Analysis of Non-Systems Theory Based Architecture Frameworks

Classification of Architecture Framework MAIN Focus (Open Coding)				Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
CSGAF		X			
BCA	X			None - business enterprise foundation to enhance accountabilities and improve decision-making	
DoDAF			X	Multiple views are related to CSG.	Potential, system dependent
DNDAF			X	Rooted in DoDAF	Potential, system dependent; also see DoDAF

The number of viewpoints and views within the initial set of 68 and subsequent research-based expansion of 166 known architecture frameworks is quite large and analysis of their utility in the development of complex system governance architectures was beyond the scope of this research study for two reasons 1) this study establishes a framework that shows how, when, and why existing non-systems theory based architecture frameworks should be considered for further investigation into providing opportunities for reuse/repurpose of their views during development of complex system governance architectures and 2) architecture views for complex system governance are not entirely prescriptive due to each complex system's unique context, so it remains essential that development efforts be unconstrained by existing architecture frameworks and their views. It is anticipated, as evidenced by the body of existing frameworks, complex system governance architecture views will evolve, as they are field developed and tested, with a possible outcome of formally establishing more prescriptive development templates.

Despite the reasons for not expanding the scope of this research study, a sample subset of documented architecture views including Department of Defense Architecture Framework (DoDAF), the Zachman Framework™, the Federal Enterprise Architecture Framework (FEAF), The Open Group Architecture Framework (TOGAF®), the United Kingdom (UK) Ministry of Defence Architecture Framework (MoDAF), and the North Atlantic Treaty Organization (NATO) Architecture Framework (NAF), was analyzed to map their views with metasystem governance functions and outcomes. Analysis of this sample consisted of 248 architecture views or equivalent logical level diagrams, matrices, lists, charts, objects, events, catalogs, and mappings to reveal the most relevant and highest potential for reuse/repurpose. The sample is shown in Table 28. The comprehensive list with embedded analysis is provided in Appendix C.

Table 28. Sample Mapping of Existing Views to Metasystem Governance Functions

Originating EA Framework(s)	ID	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
FEAF ZAF	AA	Application(s) Architecture	Human and Machine Boundaries / Interfaces, Controls, Mechanisms, Inputs, Outputs of Functions / Processes	MV-5 O7 MV-2 O1	Needs field study
TOGAF	ACD	Application Communication Diagram	Mapping of Communications Between Applications Components, Interfaces, Data Entities, and Business Services	MV-5 O7 MV-2 O1	Needs field study
MoDAF	AcV	Acquisition View	Dependencies and timelines for achieving solutions	MV-5 O7 MV-2 O3 MV-3 MV-4* O2 MV-4	Needs field study

This chapter has thus far explained the research-based foundational elements of the complex system governance architecture framework. At this point it is necessary to explore the framework using the following instructions.

Navigating the Complex System Governance Architecture Framework in Appendix A

1. Navigation is provided through links on each page. Starting with the Reference Model (RM) page, hover over an item of interest to see if there is a link (each item on the RM page is linked, not all items on subsequent pages need links).
2. The right side of each remaining page in the Framework links back to the Reference Model and each of the nine Metasystem Functions.
3. The nine Metasystem Functions are presented in "Metasystem Viewpoint" format that includes established/published definitions of the primary Function and associated Responsibilities and Outcomes.
4. Metasystem Viewpoints (MV-#).
    a. Each of the nine Metasystem Functions has associated Responsibilities, identified on the left side of a Metasystem Viewpoint, that are the foundation of a Metasystem Function's Outcomes, identified on the right side of a Metasystem Viewpoint. Responsibilities do not require additional explanation and are therefore not expanded further within the Framework.
    b. There can be no generic architecture that applies to all complex systems, only an architecture framework. Therefore, architecture development for a complex system under study using this Framework will require understanding of the complex system's unique Architecture Information Needs. On each of the nine Metasystem Function pages, hover/link off of each of the four Information Needs to see the intended

development and application via a Metasystem Viewpoint for Architecture Information Need (MV-# I-#.#).

c. The Framework is rooted in the Reference Model. Systems Theory Propositions (ST) and Metasystem Pathologies (MP) will heavily influence resulting complex system governance architectures. The Framework does not assume a Complex System Owner, Governor, or Governance Function Owner has comprehensive knowledge and understanding of Systems Theory Propositions, Metasystem Pathologies, or underlying Systems Theory Pathologies, therefore all are referenced in each Metasystem Viewpoint - hover/link off of each on any of the nine Metasystem Function pages (Metasystem Viewpoint) to see their utility.

5. Metasystem Viewpoint Outcomes (MV-# O-#) and Existing Non-Systems Theory Based Architectures.

   a. Each Metasystem Viewpoint Outcome in the Framework includes the complex system architecture development intention - that the result is a model-centric outcome/product/representation. Outcomes identified on each of the nine Metasystem Function pages have been further developed and coded - hover/link off of those Outcomes and cycle through to see their intended development pathway.

   b. Achievement of desired outcome does not depend on legacy/existing non-system theory based architecture frameworks. However, existing non-systems theory based architecture frameworks may aid in development of complex system governance architectures, as noted in the discussion associated with Table 4 in Chapter I that shaped the development of this research effort and in Chapter V's research results. Analysis of the initial survey of 68 and research-discovered total of 166 non-systems theory based architectures resulted in comprehensive assessment of those that passed inclusion criteria for framework consideration and which assessment is provided as Appendices (B and C). Hovering/linking off non-systems theory based architecture (N#) included on the Metasystem Viewpoint Outcome pages reveals the extended research analysis (Appendix C). It is anticipated that this initial assessment of potential application of existing architectures will continue to evolve as the emerging field of complex system governance continues to evolve and related architectures are developed and field tested.

Research Validation

This research resulted in development of a complex system governance architecture framework by adhering to grounded theory methodology and is therefore validly established as a systems theoretic framework in response to the research question. There is no doubt the framework will evolve over time as this initial theoretical construct is explored beyond the research's validating peer review and operationally tested (Glaser & Strauss, 1967; Leedy & Ormrod, 2010), which is beyond the scope of this research.

The need for research validation is outlined in Chapter III so discussion here is centered on this research's validation efforts and results. The value of a complex system governance architecture framework, and by extension the research used to develop the architecture, is established in part by critical peer review of experienced researchers and experts in complex system governance. Because complex system governance is an emerging field, there are inherent difficulties identifying experts and obtaining their professional and scholarly critique. Nonetheless, a qualifying questionnaire and validation critique was produced and networked within the known group of peers knowledgeable in complex system governance. The only information provided to reviewers beyond the framework itself was the following introduction and the previously described navigation steps.

Framework Introduction Provided to Scholarly Peer Reviewers

The document you are about to review presents a Complex System Governance Architecture Framework (CSGAF) in response to the research question:

> "What systems theoretic framework can be developed to inform complex system governance and enable articulation of governance function performance?"

The following definitions were adopted from (ISO/IEC/IEEE, 2011) to establish boundaries for the research and resulting Complex System Governance Architecture Framework.

Architecture Frameworks are *conventions, principles and practices for the description of architectures* established within a specific domain of application and/or community of stakeholders.

An Architecture is the fundamental *organization of a system* embodied in its components, their relationships to each other, and to the environment, and in the principles guiding its design and evolution.

An Architecture Viewpoint is a work product *establishing the conventions* for the construction, interpretation and use of architecture views to frame specific system concerns.

An Architecture View is a work product *expressing the architecture* of a system from the perspective of specific system concerns.

The Framework is considered a dynamic toolset for complex system governors to actively utilize in the discovery and/or development of information that goes into a complex system's architecture products (model-centric outcomes/representations) in an effort to achieve greater understanding of the complex system and facilitate the performance of governance functions.

The Framework is in the final stages of development and provided in this format for peer review. A peer review qualifying questionnaire and framework assessment questionnaire is provided separately. You are requested to assess this framework and provide feedback through the questionnaire.

Table 29 describes what peers were asked in order to obtain education and/or professional experience qualifying data to validate their individual peer review of the complex system governance architecture framework.

Table 29. Qualifying Questionnaire

Qualifying Questionnaire for CSGAF Validation	Respondent Answer		
1. Have you earned a doctorate or are you engaged in a doctoral program of study in systems engineering, system of systems engineering, management cybernetics, engineering management, complex systems or enterprise architecture with focus on complex system governance?	Yes		No
2. How many years have you been a practitioner, researcher, author or speaker of systems engineering, system of systems engineering, management cybernetics, engineering management, complex systems or enterprise architecture with focus on complex system governance?	<1 yr	1-5 yrs	>5 yrs

Table 30 describes what peers were asked in order to assess the complex system governance architecture framework to enhance the validation of the research design results and the scope of utility in the framework.

Table 30. Validation Questionnaire

Peer Review for CSGAF Validation	Respondent Answer		
1. Does the CSGAF address all nine metasystem functions in a way that facilitates developing a complex system governance architecture that is tailored to a specific system under study and useful in accomplishing governance of that complex system?	Yes (why/how?)	No (why not?)	Partially (what is missing?)
2. Does the CSGAF address the elements of enterprise architecture(s) applicable to complex system governance?	Yes (why/how?)	No (why not?)	Partially (what is missing?)
3. Does the CSGAF address the elements of systems theory applicable to complex system governance?	Yes (why/how?)	No (why not?)	Partially (what is missing?)
4. Does the CSGAF address the elements of management cybernetics applicable to complex system governance?	Yes (why/how?)	No (why not?)	Partially (what is missing?)
5. What utility or value does CSGAF offer the field of research in complex system governance?			
6. What utility or value does CSGAF offer the practice or practical application of complex system governance?			

Validation Analysis of Scholarly Peer Review

Fifteen participants were identified for the review based on their past or present work in developing the emerging field of complex system governance. Nine participated and their responses are identified in Table 31. Within the table, the researcher provided clarifying comments and/or noted the actions taken in response to the feedback.

Table 31. Validation Analysis

Qualifying Questionnaire (QQ) or Peer Review (PR) Question	Percentage / Response	Respondent Comments and Researcher Clarification/Actions
QQ1.	(8) 89% / Yes (1) 11% / No	**QQ1 Researcher Clarification/Actions:** One respondent believed she was not participating "in a doctoral program of study in systems engineering, system of systems engineering, management cybernetics, engineering management, complex systems or enterprise architecture with focus on complex system governance" because her dissertation was not focused on complex system governance. Further clarification revealed the participant's research focus is directly related to complex system governance in that it is a study on human dynamics and developing an instrument to generate a general measure of perceived productivity. This type of research spans several elements of complex system governance. The participant's responses were particularly insightful and indeed caused this researcher to make improvements to the Framework.
QQ2.	(0) 00% / <1yr (2) 22% / 1-5yrs (7) 78% / >5yrs	**QQ2 Researcher Clarification/Actions:** All respondents indicated they have more than one year, and in a majority of cases more than 5 years, of experience as a practitioner, researcher, author or speaker of systems engineering, system of systems engineering, management cybernetics, engineering management, complex systems or enterprise architecture with focus on complex system governance.
PR1.	(5) 56% / Yes (0) 00% / No (4) 44% / Partially	**PR1 "Yes" Responses Included:** *"Any complex system can utilize the framework."* *"Comment: Each of the nine metasystems functions are covered in depth by the CSGAF. The CSGAF is consistent with the published materials on CSG."* *"Yes, the elements of the proposed architecture touches on all functions of CSG"* *"All 9 metasystem functions covered. Using the framework allows for answering what needs to be considered, what is needed to address what needs to be considered, theoretical underpinning, what can be expected if theoretical underpinnings are violated or ignored, and what architectural outputs may result. Question: are the products that result outputs or outcomes?"* *"having the framework refer to each of the design attributes of th[e] GOCS model capture all 9 functions adequately. Tailoring to system of interest should easily flow down from the 9 functions and associated AF model. Maybe the better question is why would it be relevant to any system of interest,*

Table 31 (continued)	*is it general enough, is it better for some kinds of systems than others??"* **PR1 "Partially" Responses Included:** *"It is possible to navigate to incomplete portions of the framework – see page 86 for links that are not live"* *"Some boundary clarification, criteria or a checklist of i) what the actual 'complex system' is, its goals, etc.; and, ii) the identity/qualifications of a potential 'complex system governors'. I think this should be clearly introduced. In its current form, one can assume but it is not clearly articulated or expressed. There should be a 'placeholder' somewhere in the front-end of the articulation process that captures this. Perhaps, it may be worth considering a notional 'complex system' case which could be used to populate a demonstration of the proposed framework."* *"As Communication is the area that I am most interested in, I reviewed the same listing that you did. Please find attached a listing of the pathologies and those that I feel are related I have a "X" in the second column."* *"I think it's always going to be "partially". In a specific system the meta system functions will be expressed to fit the specific environment and context of the system. The mapping of the elements of the CGAF to the actual meta system functions will never be a perfect fit. It's a model. We get into trouble when we begin to think that our models closely represent reality."* **PR1 Researcher Clarification/Actions:** Regarding *"Question: are the products that result outputs or outcomes?"* They are Outcomes, in accordance with the Governance Reference Model. Regarding *"It is possible…incomplete portions…"* The Framework was updated subsequent to receiving this feedback and included in the research with all links and information supported by the research results. Regarding *"Some boundary clarification…."* For *"i)"* Identifying the actual complex system, its goals, etc. becomes apparent when identified by the user of the Framework as part of the resulting architecture that is developed for the complex system. For *"ii)"* Identity/qualifications of a potential 'complex system governor' is clarified and introduced in the research and presented in Chapter V, RESEARCH RESULTS. For "…considering a notional 'complex system' case…" The presentation/testing of an actual case is recommended as a future research activity. Regarding *"As Communications is…Please find attached a listing of the pathologies and those that I feel are related…"* The research explains the Framework is meant to facilitate a

Table 31 (continued)

		broad range of circumstances associated with the development of a tailored architecture for a complex system under study. **PR2 "Yes" Responses Included:** *"It appears to, however enterprise architecture is not my area of expertise, nor have I dug into the literature. It looks like you have analyzed many architectures (p. 85-118, slide 11). Does your dissertation document discuss how you compiled this list—qualifying criteria?"* *"By clicking and/or searching, one is able to cover many different elements where architecture is called out in different views"* *"Comment: The CSGAF covers expected elements of enterprise architecture and provides an excellent structuring of architecture consistent with the CSG reference model. Additionally, it does go beyond some of the more traditional aspects of EA by identification of the applicable pathologies and systems theoretic formulation of the architecture elements."* *"Yes, this is the case since all elements of CSG are addressed. However, there are might be elements of an enterprise architecture that are missing in CSG – they might have been 'not relevant to' CSG framework"* *"Appears to provide necessary elements for holistic integration."* *"By clicking and/or searching, one is able to cover many different elements where architecture is called out in different views"* *"yes this is the connection you are trying to make and appears you have made it and made it understandable"* **PR2 "Partially" Responses Included:** *"What do we mean by 'enterprise' (e.g. definition)? Is it part of the complex system? Is it limited to only the 'governance'-related parts of the complex system? Existing enterprise architectures have very specific notions of what an enterprise is in their context. It is important to resolve the definitional and operational nuances, if any."* *"I think it's always going to be "partially". In a specific system the meta system functions will be expressed to fit the specific environment and context of the system. The mapping of the elements of the CGAF to the actual meta system functions will never be a perfect fit. It's a model. We get into trouble when we begin to think that our models closely represent reality."* **PR2 Researcher Clarification/Actions:**
PR2.	(7) 78% / Yes (0) 00% / No (2) 22% / Partially	

Table 31 (continued)

		Regarding *"Does your dissertation document discuss how you compiled this list-qualifying criteria?"* The research explains in detail the inclusion and exclusion criteria for recommending existing enterprise architectures for consideration during architecture development for complex system governance. Regarding *"…However, there are might be elements….that are missing…"* The researcher acknowledges this may indeed be the case and addresses this in the research by identifying the research design used a Grounded Theory, Inductive approach. This approach accommodates the possibility of need for future changes/updates to the Framework, as it is field tested and studied further. Regarding *"What do we mean by 'enterprise'…..It is important to resolve the definitional and operational nuances, if any."* The research provides a description/definition of enterprise and addresses the individual characteristics of existing enterprise architectures within the inclusion/exclusion analytical process to derive which enterprise architectures are brought forth as recommended for close inspection during development of a complex system governance architecture.
PR3.	100% / Yes	**PR3 "Yes" Responses Included:** *"Is this the set from Adams et al. (2014)? Boundary proposition is missing—added in Whitney et al. (2015). Unless you have to use this same original set to be able to build off other works?"* *"Systems Theory is embedded throughout the framework – one can search on any of the propositions or axioms and find a plethora of links"* *"Comment: It is evident by the formulation of the CSGAF that it is based in Systems Theory and traces well to the lineage provided by Systems Theory."* *"Yes, this is the case since the proposed architecture is grounded in the most recent research on Systems Theory"* *"Although terms are explained (in layman's terminology), in may be interesting to see how some folks with no systems background interpret the propositions."* *"Yes. One is able to search throughout the framework. The description to a "none system" individual may be a bit overwhelming. A simple example of how to use the framework would greatly improve the learning experience."* *"From what I see the answer is yes since it is grounded in systems theory. Of course the real question is how well does systems theory relate to actual complex systems."* *"this is the best part for all of us since we have done the most*

Table 31 (continued)

		work here and have clear references, the 9 GOCS functions are derived from ST so that the theory linkage is strong throughout" **PR3 Researcher Clarification/Actions:** Regarding *"Is this the set from Adams et al. (2014)?....."* Researcher: Yes, the research credits the incorporation of Systems Theory Propositions to Adams et al (2014) through its extensions related to system pathologies by Katina (2015). Regarding *"…The description to…A simple example of how to use the framework would greatly improve the learning experience."* The presentation/testing of an actual case is recommended as a future research activity.
PR4.	100% / Yes	**PR4 "Yes" Responses Included:** *"The framework articulates all metasystem functions very well."* *"Management Cybernetics is embedded throughout the framework – one can search on any of the appropriate terms and find a plethora of links"* *"Comment: The structure and configuration of the CSGAF are consistent with the elements of Management Cybernetics as articulated in the Viable System Model (VSM). The CSGAF has a direct correspondence to the VSM elements as well as their underlying formulation stemming from Cybernetics."* *"Yes, the elements of management cybernetics related to control and communications are articulated. However, the researcher could acknowledge 'flexibility' in the architecture for any new elements of management cybernetics that might emerge out of research."* *"Seems to me it does if the model does. We may have missed something, but we've plowed that ground extensively. CSGAF appears to cover these elements."* *"Yes, as the embedded links allow the user to link to the terms that they would like to learn more."* *"I have to assume that it does to the extent that it can. Management Cybernetics is broadly interpreted so CSGAF can address the elements of Management Cybernetics only as well as the interpretation fits the system of interest."* *"again since almost all of our work is grounded in Beers VSM, this connection is strong. It is also a point of weakness that the VSM is the only model we have examined in detail—what if it is wrong and his viability theories are not correct?"* **PR4 Researcher Clarification/Actions:** Regarding *"…However, the researcher could acknowledge 'flexibility' in the architecture…."* Flexibility in resulting

Table 31 (continued)

		architectures is implied as the research presents an Architecture Framework through which architectures will be developed. Additionally, the research design used a Grounded Theory, Inductive approach to develop the CSGAF. This approach accommodates the possibility of need for future changes/updates to the Framework, as it is field tested and studied further. Finally, the Framework is rooted in the Governance Reference Model, which is rooted in Management Cybernetics. By extension, the CSGAF has multiple input triggers to pull in (flex) any new elements of management cybernetics that emerge out of research.
PR5.	100%	**PR5 "Yes" Responses Included:** *"The CSGAF demonstrates applicability and relevance of CSG. Utilization of the framework in research could allow for further analysis into metasystem functioning."* *"This is a fantastic portrayal of the CSG field in an easily learned and easily navigated tool."* *"Comment: In the field of research for CSG, there are a couple of highlighted utilities offered. First, the CSGAF provides a definitive way to model performance of CSG in an enterprise. This allows making explicit the CSG reference model functions. Therefore, research concerned with building methods and tools to facilitate CSG can be supported. Additionally, new emergent research 'lines' concerned with phenomena and application questions arising from utilization of the CSGAF can be captured to advance the research agenda."* *"It provides a key instrument to deploy CSG theory into application-specific domains."* *"For those involved and interested in governance of complex systems research, CSGAF appears to be is a position to offer an approach that could be used to explicitly link different functions and offer an approach to evaluate mechanisms in governance"* *"From my perspective, the value of the CSGAF is it provides a means to achieve greater understanding of the governance functions of a complex system and in my particular situation, a means to help identify functions, roles and responsibilities of leadership in enabling and ensuring those governance functions are in fact performed."* *"It is a good graphic that if modified with a simple example of how to use the framework would greatly improve the learning experience. With respect to research, I am not sure if it shows where there is Governance knowledge and where it is missing. While that may not be the use of the tool, potentially having areas that are not fully developed, indicated as such, might help fill in the missing knowledge."* *"It provides a benchmark. A launching point for investigation*

Table 31 (continued)		
		and articulation of alternate framework modifications that may better suit specific meta systems of interest." *"It provides the ST grounded framework for analysis that can help both assess and improve a given system of interest, and possible lead to new way of looking at complex systems that will contribute to future endeavors."* **PR5 Researcher Clarification/Actions:** Regarding *"….would greatly improve the learning experience."* The Framework was developed based on the research-based requirements for facilitating architecture development. A process example has both benefits and risks as it may lead readers to constrain their perception of how it can be used to tailor their complex system governance architecture. Regarding *"…having areas that are not fully developed…"* The Framework was updated subsequent to receiving this feedback and included in the research with all links and information supported by the research results.
PR6.	100%	**PR6 "Yes" Responses Included:** *"The CSGAF enables the architecture view that provides the necessary visual to produce a system model, and map and address system concerns."* *"While incomplete, there are an enormous number of resources, relationally collected and associated, so that one can follow a stream of thought and develop an understanding of the topic of interest."* *"First, the CSGAF brings CSG to an audience that has responsibility for design, execution, and evolution of governance for an enterprise – in effect it make CSG pragmatically accessible to those who have governance responsibilities. Second, it brings CSG from a theoretical/conceptual level to an operational level. In this way practitioners can more firmly grasp the notions of CSG and better engage in bringing concepts to practice. Finally, through application of the CSGAF, an enterprise can establish: (1) a baseline for the current CSG structure and performance, (2) an articulated framework against which current and future planned initiatives can be mapped for consistency with greatest need, (3) the future strategic development, aligned with gaps articulated through exploration of CSG performance, can be established, and (4) architecture can finally be 'owned' by those responsible for governance functions of an enterprise."* *"It helps to specify and assess the 'governance' aspects of a complex system from its identity, its interrelationships and its performance. It provides for an easier basis to transition towards model-based approaches. I agree with proposals to incorporate web-based solutions to capture and document responses to each ST and MP considerations, and eventually*

Table 31 (continued)	*to quantify these responses with some form of multi-criteria decision theoretical framework."* *"It can serve to integrate present and in-use frameworks by articulating relationships at the governance level"* *"The CSGAF will facilitate a practitioner's effort to understand the complex system they are dealing with and help ensure performance of requisite governance functions. Underlying reasons for the failure of the governance system may be more apparent also."* *"It is a good graphic that if modified with a simple example of how to use the framework would greatly improve the learning experience.* *It ought to be able to be used as a comparison tool to what is the current architecture. I thought that you were going in that direction, but could not make it work where I could put in the architecture of a system and see how it compared. Also if exhibits are to be developed, how will they be incorporated into a .pdf?"* *"It provides stability in the practice. Practitioners will be developing custom frameworks to suit the systems they are involved with. CSGAF will provide a starting point and is hopefully robust enough that only modest modifications will be required for specific applications."* *"Again I think it provides a way to "look at" a system of interest in all its complexity to assess the systems ability to viably function from the AF perspective , that is grounded in appropriate ST, as are the other research projects in the LC. Thus we can look at complexity from a common theory perspective for sake of analysis leading to improvement. AF is one of those "looks"."* **PR6 Researcher Clarification/Actions:** Regarding *"While incomplete, there are an enormous number of resources…"* The Framework was updated subsequent to receiving this feedback and included in the research with all links and information supported by the research results. Regarding *"…but could not make it work where I could put in the architecture…"* The CSGAF is not meant to be used as a comparison tool against existing Enterprise Architectures, rather it is meant to facilitate the potential for adaptation of certain elements of existing architecture frameworks that have been assessed through this research as related to the accomplishment of metasystem governance functions.

Chapter Summary

This chapter described the research result, a systems theoretic complex system governance architecture framework developed to inform complex system governance and enable articulation of governance function performance. The chapter identifies metasystem governance stakeholders and details the resultant conventions, principles, and practices associated with the framework. Definitions were introduced for Complex System Owner, Metasystem Governor, and Metasystem Governance Function Owner. The construct of the framework was provided, including how and where existing architecture frameworks are integrated and the analysis leading to their integration. The scope of the research on existing architecture frameworks was explained, recognizing the integration limitations and opportunity for evolving the complex system governance architecture framework over time through integration field study. A brief step beyond this research scope was described as an analysis of 248 existing architecture views and potential for applying them when developing complex system governance architectures using the newly established complex system governance architecture framework. Navigation of the framework in Appendix A was detailed along with a description of how it was introduced to a peer review team for validation. Nine of 15 scholars known for their experience and leading edge studies in complex system governance were able to respond to the call for peer validation. The results were favorable but included some indicators for the researcher to perform follow up activities to improve validation. All observations made by peer reviewers were addressed by the researcher and documented within the results provided at the close of the chapter.

CHAPTER VI

RESEARCH CONCLUSIONS

This chapter reviews the research question posed in Chapter I and summarizes how it was answered by the research. The significance of the research is discussed including its contribution to the emerging field of complex system governance. The chapter concludes with a summary of research recommended to extend the body of knowledge for complex system governance and related fields of study.

The research was guided by the question: *What systems theoretic framework can be developed to inform complex system governance and enable articulation of governance function performance?* Considering the intersecting domains of management cybernetics, systems theory, governance, and enterprise architecture, the research question led to utilization of grounded theory approach to explore these domains. Consistent with grounded theory approach, the research exploration developed groupings of characteristics for a framework that were iteratively refined into specific minimal critical specifications, including specifications on the framework's integration of existing enterprise architecture framework ideas and resources. Along the grounded theory research path it became evident metasystem pathologies and the complex system governance reference model were deeply rooted in systems theory, management cybernetics, and governance domains. Metasystem pathologies and the complex system governance reference model were thus incorporated into the resulting framework to answer the research question.

The framework was constructed in a way that provides the reader insight into metasystem governance functions and utility in applying the framework in development of tailored complex system governance architecture and supporting sets of architecture views. Additionally, the framework provides a starting point for research and development of dashboard or other type models that can enhance complex system governance performance.

Research Limitations

The research's iterative analytical process brought forth the minimal critical specifications to shape the resultant complex system governance architecture framework in a way that facilitates leveraging existing enterprise architecture frameworks and their subordinate viewpoints and views. Notwithstanding absence of testing the resultant framework, research validation was achieved through peer review by systems theory and complex system governance -experienced participants against the minimal critical specifications. Regardless, there are three main limitations in the research, grounded theory application in an area where not traditionally applied, confirmation of results may elude differing researchers attempting to replicate the research, and extending the research application beyond its initial intent.

The research used a grounded theory approach. This inductive approach is not typically used in the knowledge areas involved and therefore may be challenging for non-inductive research traditionalists to accept its credibility, validity, reproducibility, or confirmability. The challenge is not unique to this research and is addressed as other inductive research efforts are by providing a full accounting in Chapter IV of the inductive process used. The research process is well defined and in no way is a departure from long standing grounded theory research practices.

Results of different researchers following the described research methodology will likely differ based on a researcher's preferred product delivery style, potentially leading to questions regarding acceptability of the research. However, the main elements and characteristics of a systems theoretic complex system governance architecture framework resulting from following the same methodology outlined in Chapter IV will be similar enough to validate the approach and confirm acceptability. Chapter V provides evidence wherein the peer reviewers' scrutiny concluded a high rate of acceptability of the elements and characteristics of the resultant governance architecture framework.

Extending application of the research into other research areas may be problematic beyond the context of the research. This is known as generalization. It is typically used as an evaluation measure in quantitative research. Generalization types include statistical, transferable, and analytical (Polit & Beck, 2010). Statistical and transferable generalizations are not considered to be in evidence in this research, but there is evidence of analytical generalization. Attempting to apply the resulting theoretical construct of the complex system governance architecture framework to research areas not specifically addressing complex system governance may present issues due to differences in governance logical levels or present disconnects between the framework and desired architectural views not intended to be developed from the framework. This is a transferable generalization limitation in the research. Polit and Beck (2010) drawing from Ayres, Kavanaugh, and Knafl (2003) explain analytic generalization.

> *In an idealized model of analytic generalization, qualitative researchers develop conceptualizations of processes and human experiences through in-depth scrutiny and higher-order abstraction. In the course of their analysis, qualitative researchers distinguish between information that is relevant to all (or many) study participants, in contrast to aspects of the experience that are unique to particular participants. (p. 1453)*

Because of the similarities in this research study's methodology with the description of analytic generalization, it could be argued this research fulfills a sufficient portion of generalization evaluation measures. Nonetheless, application limitations are acknowledged.

Research Implications

This research has three (3) significant implications. It provides a classification schema for characteristics and attributes of systems theory based on complex system governance architecture framework (theoretical implication). It examines a grounded theory approach not traditionally used in systems theory research (methodological implication). It produced a useful systems theory-based framework for practical application, bridging the gap between theory and practice of the emerging field of complex system governance (practical implication).

The research theoretical implications cross multiple domains. The research articulated the state of knowledge for complex system governance based on the state of knowledge in the emerging field of Complex System Governance as well as established fields of Systems Theory, Governance, Management Cybernetics, and Enterprise Architecture. The research developed a unique and original framework for performing metasystem governance functions. The framework is analytically generalizable, having no constraints on practical application disciplines or industry. The framework is deeply rooted in Systems Theory and through the research it links the entire body of literature and bonds them through the key elements of complex system governance. The structure of the framework lends itself to adaptability in all aspects of its construction and in providing further knowledge contributions in any of the related domains through feedback on its performance. Specifically regarding complex system governance, classification schema are provided for use in preliminary assessment of architecture frameworks and views for further study of their application potential. Knowledge in management cybernetics, governance, and systems theory is expanded in the delivery of a testable tool for meta-level organizational and system governance theories. Enterprise architecture is also advanced in the delivery of a multi-disciplinary framework that coherently presents and facilitates a new use for architecture functioning at the metasystem logical level and not previously explored.

The research methodological implications center on using a grounded theory approach for a systems theory research endeavor when it is typically used in softer science research. Using an inductive approach to explore multiple domains related to systems theory facilitated open, unassuming spotlighting of developments, attributes, characteristics, and associations in and between the domains that may not have been discovered through quantitative research methods or other approaches. The framework is theoretically grounded in multiple domains with deepest grounding in Systems Theory. The research approach provides a template for metasystem governance function and metasystem pathologies identification and assessment using theory and practice as forcing functions for evaluation. Although the research method is non-traditional in the research area and multi-disciplinary by design, it provides examples of how to conduct fruitful research that is unique in its contribution to the body of knowledge.

The research practical implications are far reaching. Born out of the research is a tool in the form of a framework that can be applied in the performance of complex system governance and which has never before existed. The framework's genome is comprised of hundreds of combined years of dedicated research in General Systems Theory, Living Systems Theory, Governance, Management Cybernetics, Enterprise Architecture, and Complex System Governance. The framework's birthright is to be exercised with the widest possible variations in context amongst complex system governance application opportunities. This implies the framework is transportable across industries, governmental organizations, and any other real or perceived complex system. Although the framework recognizes and facilitates leveraging elements of enterprise architecture frameworks, it is not an enterprise architecture framework.

Therefore it is not constrained by traditional enterprise architecture constructs and able to function at the metasystem level of governance. Finally, the framework is a living structure, adaptable to evolutionary change coming from any one or all of its ancestral knowledge domains or practical application.

Future Research

This research provides directional indicators to new opportunities for extending the complex system governance body of knowledge through related research. Subsequent research should emphasize advancing theoretical and practical knowledge in complex system governance. Theoretical advancements could be provided seeking answers to: How can the performance of metasystem governance functions be improved through the evolving field of complex system governance? What theoretical underpinnings in complex system governance present challenges in practical applications? Are there theoretical elements that remain elusive in attempts to measure and attribute their existence to specific emergent properties in complex systems? Practical advancements could be provided seeking answers to: What architectures and views can be developed using the complex system governance architecture framework to provide utility in performing metasystem governance functions? What modeling software or system can be derived from the complex system governance architecture framework to provide a rich picture for metasystem governance?

This research's resultant framework establishes initial requirements for modeling technologies to be developed and tailored to support governance architecture development efforts and metasystem governance performance monitoring and tracking. This research also indicates opportunities for exploring complex system governance application in operational environment, human dynamics, human-system interfaces, human-only complex system structures, and tacit knowledge transfer initiatives. Specific future research may include:

- Organizational Psychology: Studying human social relationships within an institution using governance architecture developed on the framework this research provides may develop broader understanding of variables affecting a system's viability when implementing organizational change. It may also provide further insight into social change management strategies directly related to metasystem governance functions. People being part of a system, studying how people interact and impact the system through governance change or maintenance efforts may broaden understanding of how governance functions are performed and improved. Recall the metasystem governance functions.
  - *Metasystem Five (M5)* – Policy and Identity: Focused on overall steering and trajectory for the system. Maintains identity and balance between current and future focus.
  - *Metasystem Five Star (M5*)* – System Context: Focused on oversight of the system performance indicators at a strategic level, identifying performance that exceeds or fails to meet established expectations.
  - *Metasystem Five Prime (M5')* – Strategic System Monitoring: Focused on the specific context within which the metasystem is embedded. Context is the set of circumstances, factors, conditions, or patterns that enable or constrain execution of the system.
  - *Metasystem Four (M4)* – System Development: Maintains the models of the current and future system, concentrating on the long-range development of the system to ensure future viability.

- *Metasystem Four Star (M4*)* – Learning and Transformation: Focused on facilitation of learning based on correction of design errors in the metasystem functions and planning for transformation of the metasystem.
- *Metasystem Four Prime (M4')* – Environmental Scanning: Designs, deploys, and monitors sensing of the environment for trends, patterns, or events with implications for both present and future system viability.
- *Metasystem Three (M3)* – System Operations: Focused on the day-to-day execution of the metasystem to ensure that the overall system maintains established performance levels.
- *Metasystem Three Star (M3*)* – Operational Performance Monitoring: Monitors system performance to identify and assess aberrant conditions, exceeded thresholds, or anomalies.
- *Metasystem Two (M2)* – Information and Communications: Designs, establishes, and maintains the flow of information and consistent interpretation of exchanges (communication channels) necessary to execute metasystem functions.

Each function provides an opportunity for significant future research contribution in complex system governance. Answering a compelling question on one or more of these functions will contribute to the body of knowledge and specific to this research, will provide indicators for change based on the new discoveries.

- Metasystem Governance Architecture Implementation: Case studying the development and implementation of a metasystem governance architecture using the framework developed in this research may provide further insight into application of metasystem governance functions, systems theory, enterprise architecture, governance and management cybernetics. Because the architecture framework developed through this research is deeply rooted in the aforementioned domains it facilitates application efforts and associated data collection and analysis of domain theory and knowledge usefulness in real world environments. These types of case studies can provide external validation (generalizability) of the research's resulting framework. Case study will also provide validation of the research framework's intended governance architecture for performing metasystem governance functions or indicators for change to any number of elements within the architecture or the overarching complex system governance architecture framework produced in this research.

Chapter Summary

This chapter described the research and development of complex system governance architecture framework, recognized the framework’s shortcomings, established context for how the framework can be used, identified how the framework adds value to metasystem governance performance, and charted directions toward related and tangential research opportunities.

This research provided theoretical, methodological, and practical advancements in the complex system governance domain. While enterprise architecture has been dominant in system technical characterizations, it has not been advanced through systems theory or applied to metasystem governance functions. This research advanced ideas for an integrated common operational picture, environmental landscape and/or virtual reality space for complex system governance by using the domains of enterprise architecture, systems theory, governance, and management cybernetics to develop a complex system governance architecture framework. Exploring these domains using grounded theory to develop a framework specific to metasystem governance functions is unique and provides methodological contribution to research areas that do not traditionally engage in inductive based approaches.

Development of the complex system governance architecture framework advances the emerging field of complex system governance, which increases the body of knowledge and serves as a catalyst for transition from theoretical underpinnings to real world application of complex system governance and performance of metasystem governance functions. The framework is validated as being rooted in systems theory, management cybernetics, governance, and enterprise architecture. The framework is reliant upon the complex system governance reference model and integrates metasystem pathologies throughout, two characteristics that emerged from the research as prominent and essential. These characteristics ensure the framework will remain properly synchronized with evolution of complex system governance body of knowledge.

Performing metasystem governance is the primary responsibility for complex system owners, metasystem governors, and metasystem governance function owners but comes at a price and carries risk of over-specifying or over-simplifying response planning for emergent behaviors in complex systems. Understanding that complexity in systems increases emergent behavior and essential to the ability to decrease response time to emergence (i.e. ability to govern efficiently and effectively) is the need to understand the nature, characteristics, performance and context of a complex system. Response to emergence includes integrating the desirable properties and extricating, filtering, or mitigating the undesirable properties where the result is continued system viability between the realms of perfect harmony and chaos (Walters et al., 2014). Complex system governance architecture framework establishes a heading toward understanding where a system is and where it needs to go in evolution, in response to emergence and in harmony with its environment.

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APPENDIX A

COMPLEX SYSTEM GOVERNANCE ARCHITECTURE FRAMEWORK (CSGAF)

This document presents a Complex System Governance Architecture Framework in response to the research question:

"What system theoretic framework can be developed to inform complex system governance and enable articulation of governance function performance?"

The following definitions were adopted to bound the research and resulting Complex System Governance Architecture Framework (CSGAF).

Architecture Frameworks are _conventions, principles and practices for the description of architectures_ established within a specific domain of application and/or community of stakeholders. (ISO/IEC/IEEE, 2011, p.2)

An Architecture is the fundamental _organization of a system_ embodied in its components, their relationships to each other, and to the environment, and in the principles guiding its design and evolution. (ISO/IEC/IEEE, 2011, p.2)

An Architecture Viewpoint is a work product _establishing the conventions_ for the construction, interpretation and use of architecture views to frame specific system concerns. (ISO/IEC/IEEE, 2011, p.2)

An Architecture View is a work product _expressing the architecture_ of a system from the perspective of specific system concerns. (ISO/IEC/IEEE, 2011, p.2)

A System Owner is a person or organizational body responsible for maintaining system viability through decision making not delegated to a Metasystem Governor or Metasystem Governance Function Owner.

A Metasystem Governor is a person or organizational body responsible for maintaining system viability through accomplishment of all metasystem governance functions.

A Metasystem Governance Function Owner is a person or organizational body responsible for accomplishment of one or more metasystem governance function(s).

The CSGAF construct is considered a dynamic toolset for complex system owners, metasystem governors, and metasystem governance function owners to actively utilize in the discovery, development, and maintenance of information necessary for development of a complex system's governance architecture products (model-centric outcomes/representations), used to achieve greater understanding of the complex system under study and to facilitate the performance of complex system governance functions.

Further Explanation of the Framework Construct and Insights to Navigating the CSGAF.

1. Navigation is provided through links on each page. Starting with the Reference Model (RM) page, hover over an item of interest to see if there is a link (each item on the RM page is linked, not all items on subsequent pages need links).

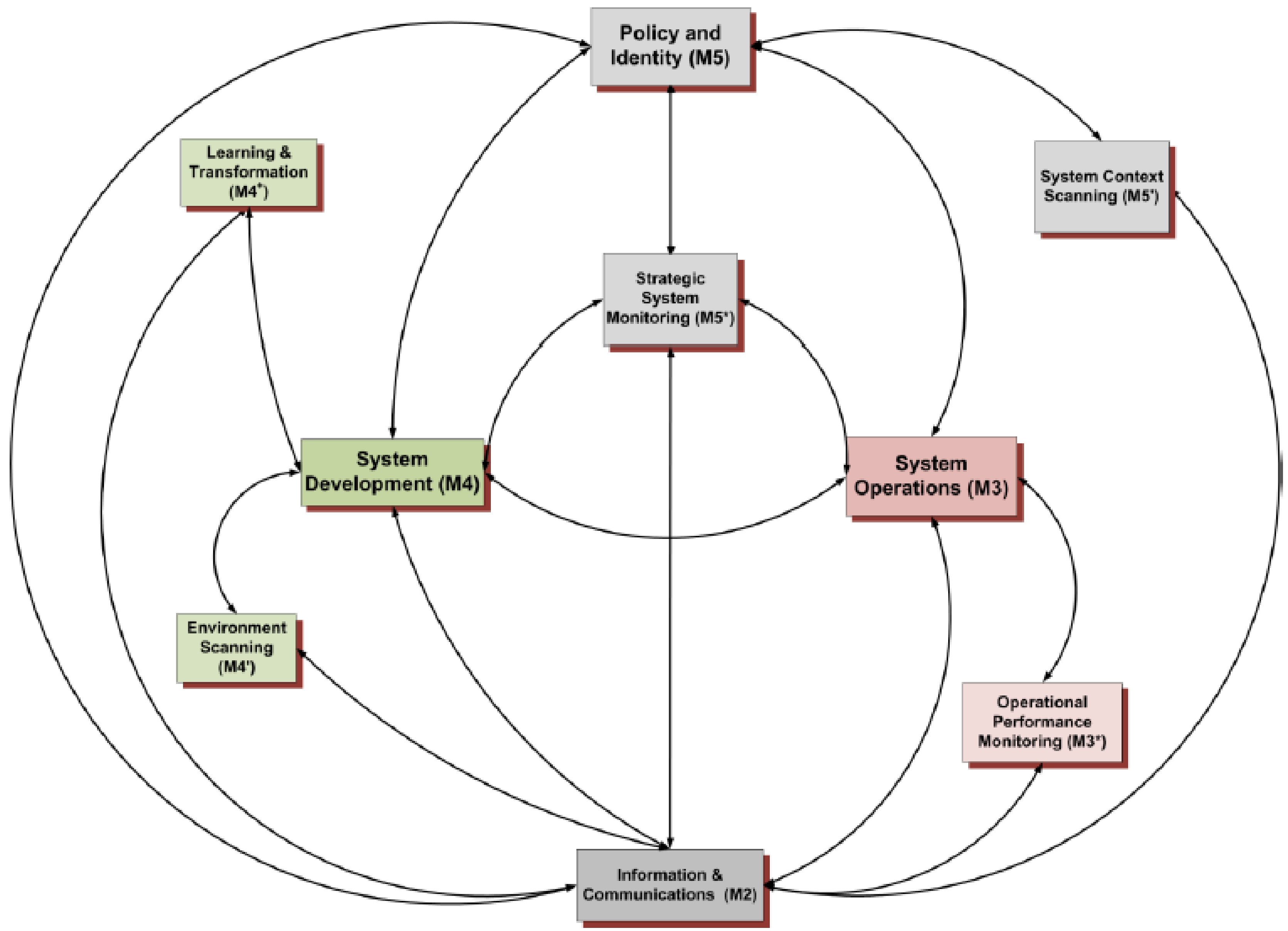
2. The right side of each remaining page in the Framework links back to the Reference Model and each of the 9 Metasystem Functions.

3. The 9 Metasystem Functions are presented in "Metasystem Viewpoint" format that includes established/published definitions of the primary Function and associated Responsibilities and Outcomes.

4. Metasystem Viewpoints (MV-#).
   a. Each of the 9 Metasystem Functions has associated Responsibilities, identified on the left side of a Metasystem Viewpoint, that are the foundation of a Metasystem Function's Outcomes, identified on the right side of a Metasystem Viewpoint. Responsibilities do not require additional explanation and are therefore not expanded further within the Framework.
   b. There can be no generic architecture that applies to all complex systems, only an architecture framework. Therefore, architecture development for a complex system under study using this Framework will require understanding of the complex system's unique Architecture Information Needs. On each of the 9 Metasystem Function pages, hover/link off of each of the 4 Information Needs to see their intended development and application via a Metasystem Viewpoint for Architecture Information Need (MV-# I-#.#).
   c. The Framework is rooted in the Reference Model. Systems Theory Propositions (ST) and Metasystem Pathologies (MP) will heavily influence resulting complex system governance architectures. The Framework does not assume a complex System Owner, Governor, or Governance Function Owner has comprehensive knowledge and understanding of Systems Theory Propositions, Metasystem Pathologies, or underlying Systems Theory Pathologies, therefore all are referenced in each Metasystem Viewpoint - hover/link off of each on any of the 9 Metasystem Function pages (Metasystem Viewpoint) to see their utility.

5. Metasystem Viewpoint Outcomes (MV-# O-#) and Existing Non-Systems Theory Based Architectures.
   a. Each Metasystem Viewpoint Outcome in the Framework includes the complex system architecture development intention - that the result is a model- centric outcome/product/representation. Outcomes identified on each of the 9 Metasystem Function pages have been further developed and coded - hover/link off of those Outcomes and cycle through to see their intended development pathway.
   b. Achievement of the desired outcome does not depend on legacy/existing non-system theory based architectures. However, existing non-systems theory based architectures may aid in development of complex system governance architectures. The analysis of a survey of 68 (ISO/IEC/IEEE, 2016) and research-discovered total of 166 non-systems theory based architectures resulted in comprehensive assessment of those that passed inclusion criteria for CSGAF consideration and which assessment is provided as Appendices (B and C) of the dissertation. Hovering/linking off non-systems theory based architectures (N#) included on the Metasystem Viewpoint Outcome pages reveals the dissertation's extended research analysis (Appendix C). It is anticipated that this initial assessment of potential application of existing architectures will continue to evolve as the emerging field of complex system governance continues to evolve and related architectures are developed and field tested.

References:
ISO/IEC/IEEE. (2011). IEEE and ISO/IEC Standard 42010: Systems and Software Engineering - Architecture Description. New York and Geneva: Institute of Electrical and Electronics Engineers and International Organization for Standardization and International Electrotechnical Commission.
ISO/IEC/IEEE. (2016, Jan 27). Survey of Architecture Frameworks. Retrieved 03/15/2016, from http://www.iso-architecture.org/ieee-1471/afs/frameworks-table.html



Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

CSGAF Metasystem Viewpoint - 5 (MV-5): Policy & Identity

M5 Primary Function: Provide direction, oversight, accountability, and evolution of the system. Focus includes policy, mission, vision, strategic direction, performance, and accountability for the system such that:

1 the system maintains viability
2 identity is preserved and maintained
3 the system is effectively projected both internally and externally.

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

MV-5 Responsibilities

- **R1** *Establish & Maintain System Identity*
- **R2** *Establish & Maintain System Vision, Strategic Direction, Purpose, Mission & Interpretation*
- **R3** *Active Determination & Balance for System Focus Between Present & Future*
- **R4** *Disseminate & Oversee Execution of Strategic Plan*
- **R5** *Provide for Capital Resources Necessary to Support System*
- **R6** *Set Problem Space to Focus Product, Process, Service, & Content Development & Deployment*
- **R7** *Set Strategic Dialog Forums*
- **R8** *Preserve Autonomy - Integration Balance in the System*
- **R9** *Market System Products, Services, Content, and Value*
- **R10** *Plan and Execute Public Relations*
- **R11** *External Mentorship Development (Board of Directors)*
- **R12** *Establish System Policy Direction and Maintain System Identity - Executed Through Strategic Direction*
- **R13** *Represent System Interests to External Constituents*
- **R14** *Define & Integrate the Expanded Network for the System (Strategic Partnerships)*
- **R15** *Evolve Scenarios for System Transformation & Implement Strategic Transformation Direction*

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

Architecture Information Needs

- **I1** *Human Requirements*
- **I2** *Technical System Requirements*
- **I3** *Integrated Human-System Requirements*
- **I4** *Environmental Requirements*

Systems Theory Considerations for Architecture

ST1 Circular Causality	ST11 Holism	ST21 Redundancy of Potential Command
ST2 Communication	ST12 Homeorhesis	ST22 Relaxation Time
ST3 Complementarity	ST13 Homeostasis	ST23 Requisite Hierarchy
ST4 Control	ST14 Information Redundancy	ST24 Requisite Parsimony
ST5 Darkness	ST15 Minimum Critical Specification	ST25 Requisite Saliency
ST6 Dynamic Equilibrium	ST16 Multifinality	ST26 Requisite Variety
ST7 Emergence	ST17 Pareto	ST27 Satisficing
ST8 Equifinality	ST18 Purposive Behaviorism	ST28 Self-Organization
ST9 Feedback	ST19 Recursion	ST29 Sub-Optimization
ST10 Hierarchy	ST20 Redundancy	ST30 Viability

Metasystem Pathology Considerations for Architecture

- MP1 Systemic Dynamics
- MP2 System Goals
- MP3 Systemic Information Flow
- MP4 Systemic Process & Activities
- MP5 Systemic Regulation
- MP6 Systemic Resources
- MP7 Systemic Structures
- MP8 Understanding of Systems

MV-5 Outcomes that Influence, Shape or Assign Development of a Metasystem Architecture or its Supporting Architectural Views

- **MV-5 O1** Forums & Mechanisms to Define, Maintain, & Evolve System Identity & Focus
- **MV-5 O2** Strategic System Plan
- **MV-5 O3** Public Relations Plan Execution & Performance Monitoring
- **MV-5 O4** Marketing Plan Execution & Performance Monitoring
- **MV-5 O5** Integrated System Mapping
- **MV-5 O6** Satisficing System Policies
- **MV-5 O7** Governance Architecture for the Metasystem

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

CSGAF Metasystem Viewpoint - 5* (MV-5*): System Context

M5* Primary Function: Monitor the system context (the circumstances, factors, conditions, or patterns that enable and constrain the system). Maintains system context.

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

MV-5* Responsibilities

- **R1** *Identify System Context & Provide for Assessment of Contextual Impacts on System Performance*
- **R2** *Actively Manage Context*
- **R3** *Conduct Boundary Spanning to Determine Boundary Conditions, Values, & Judgements for the System*
- **R4** *Conduct Inquiry into Contextual Barriers to System Execution or Development*
- **R5** *Monitor and Assess the Influence of Contextual Aspects for the System*
- **R6** *Inform Development of the Strategic Plan*
- **R7** *Identify, Classify, & Manage System Stakeholders*

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

Architecture Information Needs

- **I1** *Human Requirements*
- **I2** *Technical System Requirements*
- **I3** *Integrated Human-System Requirements*
- **I4** *Environmental Requirements*

Systems Theory Considerations for Architecture

ST1 Circular Causality	ST11 Holism	ST21 Redundancy of Potential Command
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ST3 Complementarity	ST13 Homeostasis	ST23 Requisite Hierarchy
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ST8 Equifinality	ST18 Purposive Behaviorism	ST28 Self-Organization
ST9 Feedback	ST19 Recursion	ST29 Sub-Optimization
ST10 Hierarchy	ST20 Redundancy	ST30 Viability

Metasystem Pathology Considerations for Architecture

- MP1 Systemic Dynamics
- MP2 System Goals
- MP3 Systemic Information Flow
- MP4 Systemic Process & Activities
- MP5 Systemic Regulation
- MP6 Systemic Resources
- MP7 Systemic Structures
- MP8 Understanding of Systems

MV-5* Outcomes that Influence, Shape or Assign Development of a Metasystem Architecture or its Supporting Architectural Views

- **MV-5* O1** Stakeholder Analysis
- **MV-5* O2** Contextual Mapping
- **MV-5* O3** Contextual Monitoring & Development Stategy

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

RM
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MV-5*
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MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 5’ (MV-5’): Strategic System Monitoring

M5’ Primary Function: Monitor measures for strategic system performance and identify variance requiring metasystem level response. Particular emphasis is on variability that may impact future system viability.

Reference: Keating, C.B. and Bradley, J.M. (2015), ‘Complex system governance reference model’, *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

MV-5’ Responsibilities

- **R1** *Track Ongoing Strategic System Performance Based on Dashboard Measures of Performance (MOP)*
- **R2** *Disseminate System Performance*
- **R3** *Conduct Inquiry Into Strategic Performance Aberrations*
- **R4** *Monitor & Assess the Continuing Adequacy of Operational Performance Measures in Light of Strategic Performance*
- **R5** *Inform Development of the Strategic Plan*

Reference: Keating, C.B. and Bradley, J.M. (2015), ‘Complex system governance reference model’, *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

Architecture Information Needs

- **I1** *Human Requirements*
- **I2** *Technical System Requirements*
- **I3** *Integrated Human-System Requirements*
- **I4** *Environmental Requirements*

Systems Theory Considerations for Architecture

ST1 Circular Causality	ST11 Holism	ST21 Redundancy of Potential Command
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ST3 Complementarity	ST13 Homeostasis	ST23 Requisite Hierarchy
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ST8 Equifinality	ST18 Purposive Behaviorism	ST28 Self-Organization
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Metasystem Pathology Considerations for Architecture

- MP1 Systemic Dynamics
- MP2 System Goals
- MP3 Systemic Information Flow
- MP4 Systemic Process & Activities
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- MP6 Systemic Resources
- MP7 Systemic Structures
- MP8 Understanding of Systems

MV-5’ Outcomes that Influence, Shape or Assign Development of a Metasystem Architecture or its Supporting Architectural Views

- **MV-5’ O1** Dashboard Measures for Strategic System Performance
- **MV-5’ O2** Results of Inquiry & Analysis of Performance Issues
- **MV-5’ O3** Recommendations for Continuance, Modification, or Deletion of Performance Measures

Reference: Keating, C.B. and Bradley, J.M. (2015), ‘Complex system governance reference model’, *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

CSGAF Metasystem Viewpoint - 4 (MV-4): System Development

M4 Primary Function: Provide for the analysis and interpretation of the implications and potential impacts of trends, patterns, and precipitating events in the environment. Develops future scenarios, design alternatives, and future focused planning to position the system for future viability.

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

MV-4 Responsibilities

- **R1** *Analyze & Interpret Environmental Scanning for Shifts, Implications, & Potential Impact on System Evolution*
- **R2** *Guide Development of System Strategic Plan & System Development Map*
- **R3** *Inform Development of the Strategic Plan*
- **R4** *Guide Future Product, Process, Service, & Content Development*
- **R5** *Identify Future Relationships Critical to System Development*
- **R6** *Identify Development Opportunities & Targets that can be pursued in support of System Mission & Vision*

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

Architecture Information Needs

- **I1** *Human Requirements*
- **I2** *Technical System Requirements*
- **I3** *Integrated Human-System Requirements*
- **I4** *Environmental Requirements*

Systems Theory Considerations for Architecture

ST1 Circular Causality	ST11 Holism	ST21 Redundancy of Potential Command
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Metasystem Pathology Considerations for Architecture

- MP1 Systemic Dynamics
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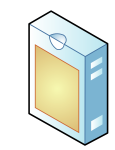
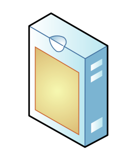
- MP6 Systemic Resources
- MP7 Systemic Structures
- MP8 Understanding of Systems

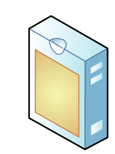
MV-4 Outcomes that Influence, Shape or Assign Development of a Metasystem Architecture or its Supporting Architectural Views



MV-4 O1 Planning for Response to Environmental Scanning



MV-4 O2 Models of the Present, Future, & Environment for the System



MV-4 O3 Strategic System Development Plan & System Development Map

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

CSGAF Metasystem Viewpoint - 4* (MV-4*): Learning & Transformation

M4* Primary Function: Provide for identification and analysis of metasystem design errors (second order learning) and suggest design modifications and transformation planning for the system.

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

MV-4* Responsibilities

- **R1** *Detect & Process Variance Inputs for System Wide Implications*
- **R2** *Identify Mechanisms for Double Loop Learning*
- **R3** *Design Objectives, Measures, and Accountability for Second Order Learning in the System*
- **R4** *Lead Future Transformation Analysis*
- **R5** *Provide Future Focused Input to Strategy Development*
- **R6** *Inform Development of the Strategic Plan*

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

Architecture Information Needs

- **I1** *Human Requirements*
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Systems Theory Considerations for Architecture

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ST9 Feedback	ST19 Recursion	ST29 Sub-Optimization
ST10 Hierarchy	ST20 Redundancy	ST30 Viability

Metasystem Pathology Considerations for Architecture

- MP1 Systemic Dynamics
- MP2 System Goals
- MP3 Systemic Information Flow
- MP4 Systemic Process & Activities
- MP5 Systemic Regulation
- MP6 Systemic Resources
- MP7 Systemic Structures
- MP8 Understanding of Systems

MV-4* Outcomes that Influence, Shape or Assign Development of a Metasystem Architecture or its Supporting Architectural Views

MV-4* O1 Design for Second Order System Learning

MV-4* O2 System Transformation Strategy

MV-4* O3 Dissemination of Learning Results, Implications, & Opportunities

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

CSGAF Metasystem Viewpoint - 4' (MV-4'): Environmental Scanning

M4' Primary Function: Provide the design and execution of scanning for the system environment. Focus is on identification of circumstances, patterns, trends, threats, events, and opportunities for the system.

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

MV-4' Responsibilities

- **R1** *Design for Environmental Scanning for Entire System (Trends, Changes, Patterns, etc.)*
- **R2** *Execute Environmental Scanning Designs*
- **R3** *Maintain Model of the Metasystem Environment*
- **R4** *Capture Emergent Environmental Conditions, Events*
- **R5** *Consolidate Results from Environmental Scanning & Provide Synthesis*
- **R6** *Inform Development of the Strategic Plan*
- **R7** *Disseminate Essential Environmental Information & Shifts Throughout the System*

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

Architecture Information Needs

- **I1** *Human Requirements*
- **I2** *Technical System Requirements*
- **I3** *Integrated Human-System Requirements*
- **I4** *Environmental Requirements*

Systems Theory Considerations for Architecture

ST1 Circular Causality	ST11 Holism	ST21 Redundancy of Potential Command
ST2 Communication	ST12 Homeorhesis	ST22 Relaxation Time
ST3 Complementarity	ST13 Homeostasis	ST23 Requisite Hierarchy
ST4 Control	ST14 Information Redundancy	ST24 Requisite Parsimony
ST5 Darkness	ST15 Minimum Critical Specification	ST25 Requisite Saliency
ST6 Dynamic Equilibrium	ST16 Multifinality	ST26 Requisite Variety
ST7 Emergence	ST17 Pareto	ST27 Satisficing
ST8 Equifinality	ST18 Purposive Behaviorism	ST28 Self-Organization
ST9 Feedback	ST19 Recursion	ST29 Sub-Optimization
ST10 Hierarchy	ST20 Redundancy	ST30 Viability

Metasystem Pathology Considerations for Architecture

- MP1 Systemic Dynamics
- MP2 System Goals
- MP3 Systemic Information Flow
- MP4 Systemic Process & Activities
- MP5 Systemic Regulation
- MP6 Systemic Resources
- MP7 Systemic Structures
- MP8 Understanding of Systems

MV-4' Outcomes that Influence, Shape or Assign Development of a Metasystem Architecture or its Supporting Architectural Views

MV-4' O1 Design for Environmental Scanning Including Objectives, Organization, Execution, & Performance Monitoring

MV-4' O2 Publication of Environmental Scanning Activities Enabling Coordination of Targets, Execution, Data Capture & Analysis

MV-4' O3 Dissemination of Scanning Results & Implications of Patterns, Trends, Threats, Events, & Opportunities for the System

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

CSGAF Metasystem Viewpoint - 3 (MV-3): System Operations

M3 Primary Function: Maintain operational performance control through the implementation of policy, resource allocation, and design for accountability.

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

MV-3 Responsibilities

- **R1** *Oversee Products, Processes, Services, Value, & Content Delivery*
- **R2** *Execute System Planning & Control for Day-to-Day Operational Effectiveness*
- **R3** *Develop Near Term System Design Response to Evolving Issues & Monitor Performance Measures*
- **R4** *Operationally Interpret & Ensure Implementation of System Policies & Direction*
- **R5** *Interpret & Translate Implications of Environmental Shifts for Operations*
- **R6** *Inform Development of the Strategic Plan*
- **R7** *Determine Resources, Expectations, and Operational Performance Measurements*
- **R8** *Design for Accountability & Performance Reporting for Operations*

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

Architecture Information Needs

- **I1** *Human Requirements*
- **I2** *Technical System Requirements*
- **I3** *Integrated Human-System Requirements*
- **I4** *Environmental Requirements*

Systems Theory Considerations for Architecture

ST1 Circular Causality	ST11 Holism	ST21 Redundancy of Potential Command
ST2 Communication	ST12 Homeorhesis	ST22 Relaxation Time
ST3 Complementarity	ST13 Homeostasis	ST23 Requisite Hierarchy
ST4 Control	ST14 Information Redundancy	ST24 Requisite Parsimony
ST5 Darkness	ST15 Minimum Critical Specification	ST25 Requisite Saliency
ST6 Dynamic Equilibrium	ST16 Multifinality	ST26 Requisite Variety
ST7 Emergence	ST17 Pareto	ST27 Satisficing
ST8 Equifinality	ST18 Purposive Behaviorism	ST28 Self-Organization
ST9 Feedback	ST19 Recursion	ST29 Sub-Optimization
ST10 Hierarchy	ST20 Redundancy	ST30 Viability

Metasystem Pathology Considerations for Architecture

- MP1 Systemic Dynamics
- MP2 System Goals
- MP3 Systemic Information Flow
- MP4 Systemic Process & Activities
- MP5 Systemic Regulation
- MP6 Systemic Resources
- MP7 Systemic Structures
- MP8 Understanding of Systems

MV-3 Outcomes that Influence, Shape or Assign Development of a Metasystem Architecture or its Supporting Architectural Views

- **MV-3 O1** Operational Plan for System Production that Generates Value
- **MV-3 O2** Execution Forums for Ongoing Operational Maintenance
- **MV-3 O3** Resource Planning for Operational Requirements
- **MV-3 O4** Operational Goals in Relationship to Strategic Performance Objectives
- **MV-3 O5** Priority & Resource Allocation for Operational Support Activities & Investments
- **MV-3 O6** Performance Measure Targets

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

CSGAF Metasystem Viewpoint - 3* (MV-3*): Operational Performance

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

M3* Primary Function: Monitor measures for operational performance and identify variance in system performance requiring system level response. Particular emphasis is on variability and performance trends that may impact system viability.

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

MV-3* Responsibilities

- **R1** *Track System Performance on Dashboard*
- **R2** *Disseminate System Performance Throughout System*
- **R3** *Conduct Inquiry into Performance Aberrations*
- **R4** *Inform Development of the Strategic Plan*
- **R5** *Monitor & Assess the Continuing Adequacy of Operational Performance Measures*

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

Architecture Information Needs

- **I1** *Human Requirements*
- **I2** *Technical System Requirements*
- **I3** *Integrated Human-System Requirements*
- **I4** *Environmental Requirements*

Systems Theory Considerations for Architecture

ST1 Circular Causality	ST11 Holism	ST21 Redundancy of Potential Command
ST2 Communication	ST12 Homeorhesis	ST22 Relaxation Time
ST3 Complementarity	ST13 Homeostasis	ST23 Requisite Hierarchy
ST4 Control	ST14 Information Redundancy	ST24 Requisite Parsimony
ST5 Darkness	ST15 Minimum Critical Specification	ST25 Requisite Saliency
ST6 Dynamic Equilibrium	ST16 Multifinality	ST26 Requisite Variety
ST7 Emergence	ST17 Pareto	ST27 Satisficing
ST8 Equifinality	ST18 Purposive Behaviorism	ST28 Self-Organization
ST9 Feedback	ST19 Recursion	ST29 Sub-Optimization
ST10 Hierarchy	ST20 Redundancy	ST30 Viability

Metasystem Pathology Considerations for Architecture

- MP1 Systemic Dynamics
- MP2 System Goals
- MP3 Systemic Information Flow
- MP4 Systemic Process & Activities
- MP5 Systemic Regulation
- MP6 Systemic Resources
- MP7 Systemic Structures
- MP8 Understanding of Systems

MV-3* Outcomes that Influence, Shape or Assign Development of a Metasystem Architecture or its Supporting Architectural Views

MV-3* O1 Dashboard Measures for Operations

MV-3* O2 Results of Inquiry & Analysis of Performance Issues

MV-3* O3 Recommendations for Continuance, Modification, or Deletion of Performance Measures

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

CSGAF Metasystem Viewpoint - 2 (MV-2): Information & Communications

M2 Primary Function: Enables system stability by designing and implementing the architecture for information flow, coordination, transduction and communications within the metasystem and between the metasystem, the environment and the governed system.

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

MV-2 Responsibilities

- **R1** *Design & Maintain Architecture of Information Flows & Communications*
- **R2** *Ensure Efficiency by Coordinating Information Accessibility Within the System*
- **R3** *Identify Standard Processes & Procedures Necessary to Facilitate Transduction*
- **R4** *Provide Effective Integration & Coordination of the System*
- **R5** *Inform Development of the Strategic Plan*
- **R6** *Identify & Provide Forums to Identify & Resolve Emergent Conflict & Coordination Issues*

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

Architecture Information Needs

- **I1** *Human Requirements*
- **I2** *Technical System Requirements*
- **I3** *Integrated Human-System Requirements*
- **I4** *Environmental Requirements*

Systems Theory Considerations for Architecture

ST1 Circular Causality	ST11 Holism	ST21 Redundancy of Potential Command
ST2 Communication	ST12 Homeorhesis	ST22 Relaxation Time
ST3 Complementarity	ST13 Homeostasis	ST23 Requisite Hierarchy
ST4 Control	ST14 Information Redundancy	ST24 Requisite Parsimony
ST5 Darkness	ST15 Minimum Critical Specification	ST25 Requisite Saliency
ST6 Dynamic Equilibrium	ST16 Multifinality	ST26 Requisite Variety
ST7 Emergence	ST17 Pareto	ST27 Satisficing
ST8 Equifinality	ST18 Purposive Behaviorism	ST28 Self-Organization
ST9 Feedback	ST19 Recursion	ST29 Sub-Optimization
ST10 Hierarchy	ST20 Redundancy	ST30 Viability

Metasystem Pathology Considerations for Architecture

- MP1 Systemic Dynamics
- MP2 System Goals
- MP3 Systemic Information Flow
- MP4 Systemic Process & Activities
- MP5 Systemic Regulation
- MP6 Systemic Resources
- MP7 Systemic Structures
- MP8 Understanding of Systems

MV-2 Outcomes that Influence, Shape or Assign Development of a Metasystem Architecture or its Supporting Architectural Views

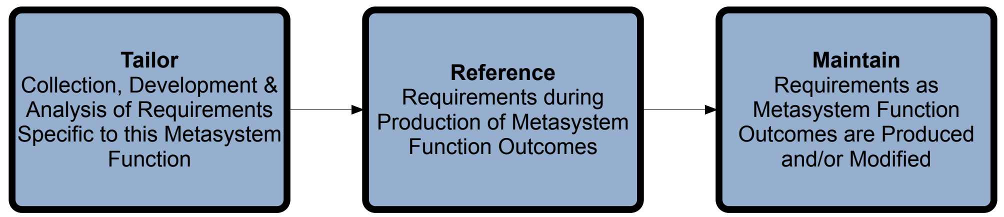
MV-2 O1 Standard Processes & Procedures for Internal Coordination of the System

MV-2 O2 Communications Architecture for the Metasystem

MV-2 O3 Defined External Coordination Vehicles Necessary for Support for the System

Reference: Keating, C.B. and Bradley, J.M. (2015), 'Complex system governance reference model', *International Journal of System of Systems Engineering*, Vol. 6, Nos. 1/2, pp. 33-52.

CSGAF Metasystem Viewpoint - 5 Architecture Information Need 1 (MV-5 I1): Human Requirements for Policy & Identity



Human Requirement 1 (MV-5 I1.1): Placeholder.

Human Requirement 2 (MV-5 I1.2): Placeholder.

RM
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MV-5'
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MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 5* Architecture Information Need 1 (MV-5* I1): Human Requirements for System Context

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

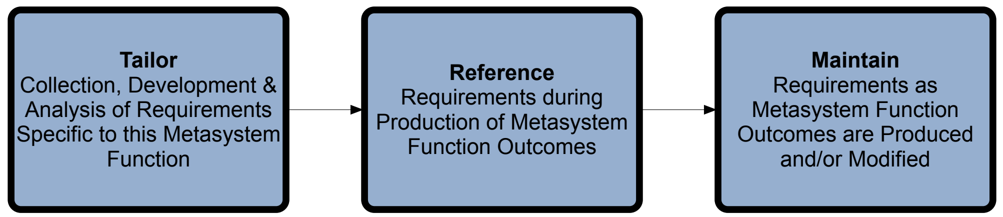
→ **Reference**
Requirements during Production of Metasystem Function Outcomes

→ **Maintain**
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Human Requirement 1 (MV-5* I1.1): Placeholder.

Human Requirement 2 (MV-5* I1.2): Placeholder.

CSGAF Metasystem Viewpoint - 5’ Architecture Information Need 1 (MV-5’ I1): Human Requirements for Strategic System Monitoring



Human Requirement 1 (MV-5’ I1.1): Placeholder.

Human Requirement 2 (MV-5’ I1.2): Placeholder.

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MV-4’
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 4 Architecture Information Need 1 (MV-4 I1): Human Requirements for System Development

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→

Reference
Requirements during Production of Metasystem Function Outcomes

→

Maintain
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Human Requirement 1 (MV-4 I1.1): Placeholder.

Human Requirement 2 (MV-4 I1.2): Placeholder.

CSGAF Metasystem Viewpoint - 4* Architecture Information Need 1 (MV-4* I1): Human Requirements for Learning & Transformation

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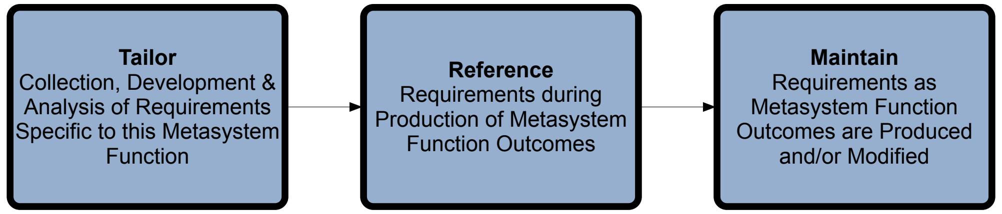
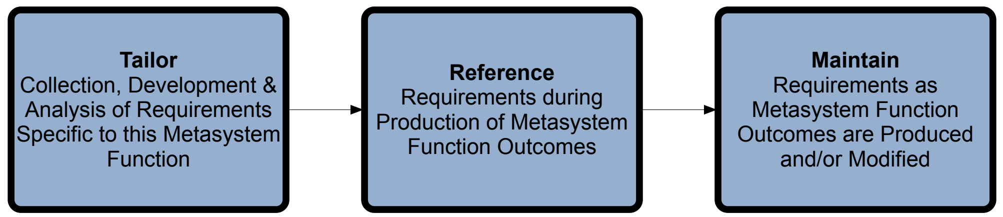
MV-2



Human Requirement 1 (MV-4* I1.1): Placeholder.

Human Requirement 2 (MV-4* I1.2): Placeholder.

CSGAF Metasystem Viewpoint - 4’ Architecture Information Need 1 (MV-4’ I1): Human Requirements for Environmental Scanning



Human Requirement 1 (MV-4’ I1.1): Placeholder.

Human Requirement 2 (MV-4’ I1.2): Placeholder.

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MV-5*
MV-5’
MV-4
MV-4*
MV-4’
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 3 Architecture Information Need 1 (MV-3 I1): Human Requirements for System Operations

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→

Reference
Requirements during Production of Metasystem Function Outcomes

→

Maintain
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Human Requirement 1 (MV-3 I1.1): Placeholder.

Human Requirement 2 (MV-3 I1.2): Placeholder.

CSGAF Metasystem Viewpoint - 3* Architecture Information Need 1 (MV-3* I1): Human Requirements for Operational Performance

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→ **Reference**
Requirements during Production of Metasystem Function Outcomes

→ **Maintain**
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Human Requirement 1 (MV-3* I1.1): Placeholder.

Human Requirement 2 (MV-3* I1.2): Placeholder.

CSGAF Metasystem Viewpoint - 2 Architecture Information Need 1 (MV-2 I1): Human Requirements for Information & Communications

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→

Reference
Requirements during Production of Metasystem Function Outcomes

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Maintain
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Human Requirement 1 (MV-2 I1.1): Placeholder.

Human Requirement 2 (MV-2 I1.2): Placeholder.

RM
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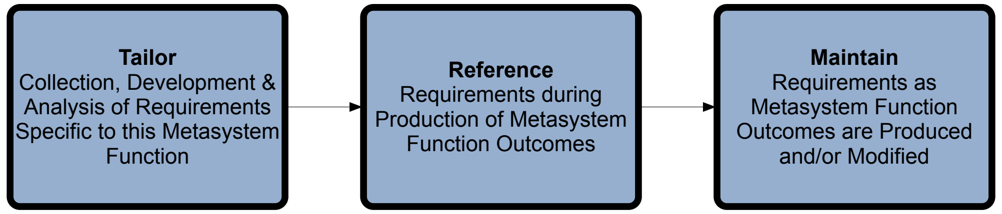
MV-2

CSGAF Metasystem Viewpoint - 5 Architecture Information Need 2 (MV-5 I2): Technical System Requirements for Policy & Identity



Technical System Requirement 1 (MV-5 I2.1): Placeholder.

Technical System Requirement 2 (MV-5 I2.2): Placeholder.

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MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 5* Architecture Information Need 2 (MV-5* I2): Technical System Requirements for System Context

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→ **Reference**
Requirements during Production of Metasystem Function Outcomes

→ **Maintain**
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Technical System Requirement 1 (MV-5* I2.1): Placeholder.

Technical System Requirement 2 (MV-5* I2.2): Placeholder.

CSGAF Metasystem Viewpoint - 5’ Architecture Information Need 2 (MV-5’ I2): Technical System Requirements for Strategic System Monitoring

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→ **Reference**
Requirements during Production of Metasystem Function Outcomes

→ **Maintain**
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Technical System Requirement 1 (MV-5’ I2.1): Placeholder.

Technical System Requirement 2 (MV-5’ I2.2): Placeholder.

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MV-3*
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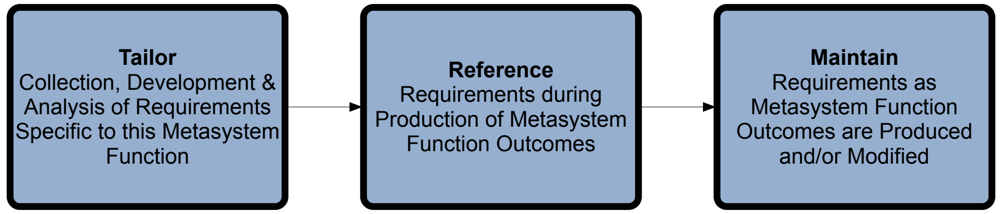

Technical System Requirement 1 (MV-4 I2.1): Placeholder.

Technical System Requirement 2 (MV-4 I2.2): Placeholder.

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MV-4
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MV-4'
MV-3
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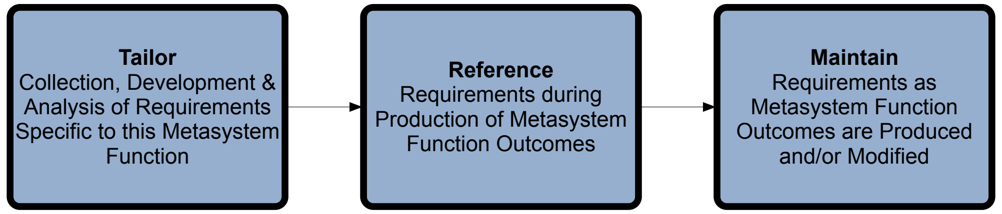
MV-2

CSGAF Metasystem Viewpoint - 4* Architecture Information Need 2 (MV-4* I2): Technical System Requirements for Learning & Transformation



Technical System Requirement 1 (MV-4* I2.1): Placeholder.

Technical System Requirement 2 (MV-4* I2.2): Placeholder.

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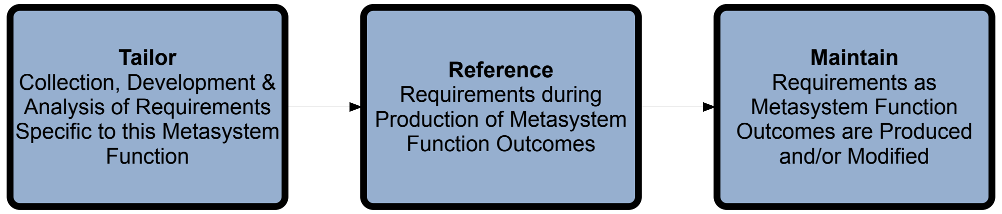
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 4’ Architecture Information Need 2 (MV-4’ I2): Technical System Requirements for Environmental Scanning



Technical System Requirement 1 (MV-4’ I2.1): Placeholder.

Technical System Requirement 2 (MV-4’ I2.2): Placeholder.

RM
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MV-5*
MV-5’
MV-4
MV-4*
MV-4’
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 3 Architecture Information Need 2 (MV-3 I2): Technical System Requirements for System Operations

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→

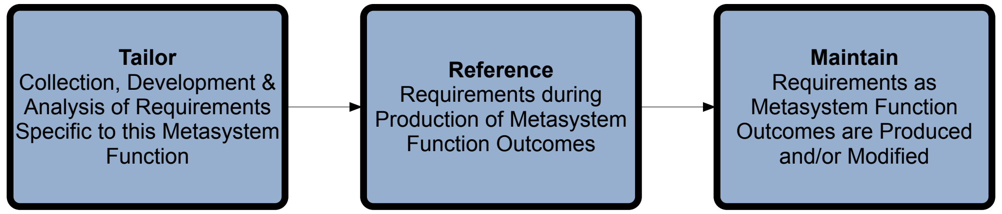
Reference
Requirements during Production of Metasystem Function Outcomes

→

Maintain
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Technical System Requirement 1 (MV-3 I2.1): Placeholder.

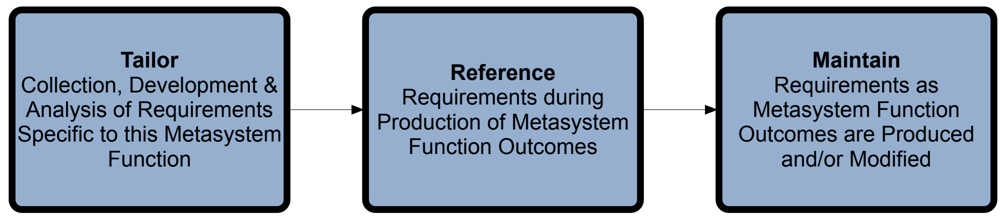
Technical System Requirement 2 (MV-3 I2.2): Placeholder.



Technical System Requirement 1 (MV-3* I2.1): Placeholder.

Technical System Requirement 2 (MV-3* I2.2): Placeholder.

CSGAF Metasystem Viewpoint - 2 Architecture Information Need 2 (MV-2 I2): Technical System Requirements for Information & Communications



Technical System Requirement 1 (MV 2 I2.1): Placeholder.

Technical System Requirement 2 (MV-2 I2.2): Placeholder.

RM
MV-5
MV-5*
MV-5'
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MV-4'
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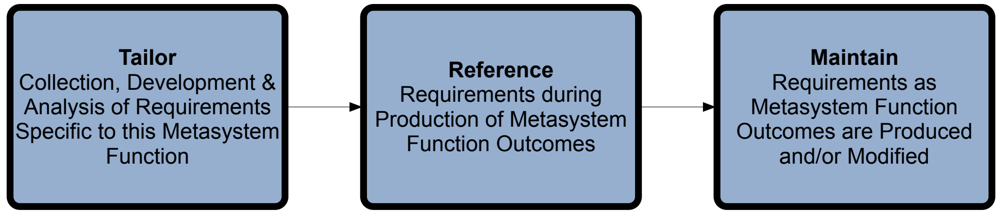
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 5 Architecture Information Need 3 (MV-5 I3): Integrated Human-System Requirements for Policy & Identity

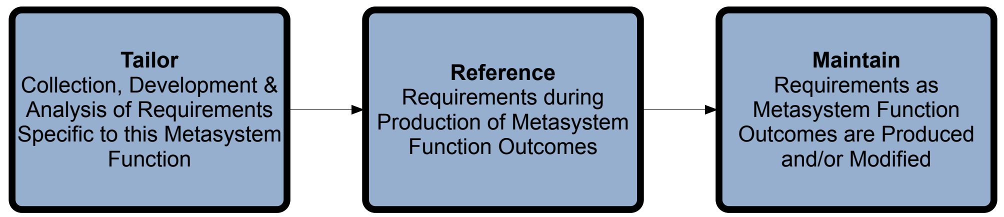


Human-System Requirement 1 (MV-5 I3.1): Placeholder.

Human-System Requirement 2 (MV-5 I3.2): Placeholder.

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 5* Architecture Information Need 3 (MV-5* I3): Integrated Human-System Requirements for System Context



Human-System Requirement 1 (MV-5* I3.1): Placeholder.

Human-System Requirement 2 (MV-5* I3.2): Placeholder.

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 5' Architecture Information Need 3 (MV-5' I3): Integrated Human-System Requirements for Strategic System Monitoring

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→ **Reference**
Requirements during Production of Metasystem Function Outcomes

→ **Maintain**
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Human-System Requirement 1 (MV-5' I3.1): Placeholder.

Human-System Requirement 2 (MV-5' I3.2): Placeholder.

CSGAF Metasystem Viewpoint - 4 Architecture Information Need 3 (MV-4 I3): Integrated Human-System Requirements for System Development

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→ **Reference**
Requirements during Production of Metasystem Function Outcomes

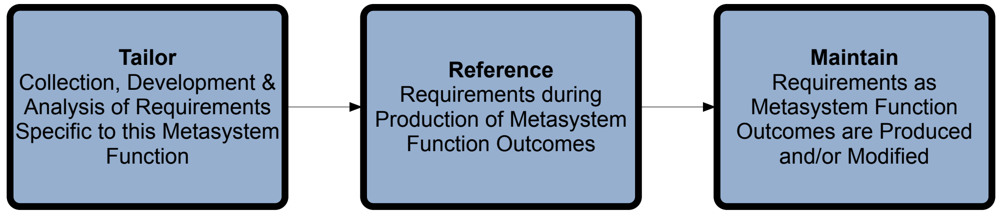
→ **Maintain**
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Human-System Requirement 1 (MV-4 I3.1): Placeholder.

Human-System Requirement 2 (MV-4 I3.2): Placeholder.

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 4* Architecture Information Need 3 (MV-4* I3): Integrated Human-System Requirements for Learning & Transformation



Human-System Requirement 1 (MV-4* I3.1): Placeholder.

Human-System Requirement 2 (MV-4* I3.2): Placeholder.

RM
MV-5
MV-5*
MV-5'
MV-4
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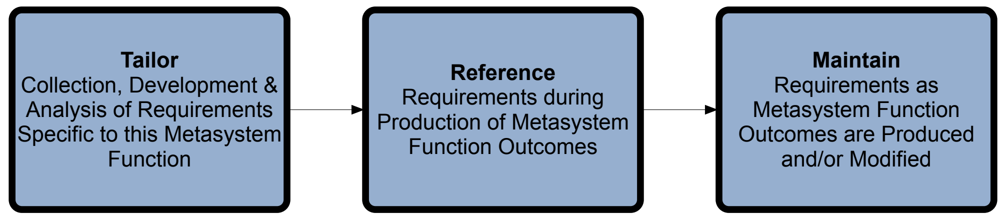
MV-4'
MV-3
MV-3*
MV-2

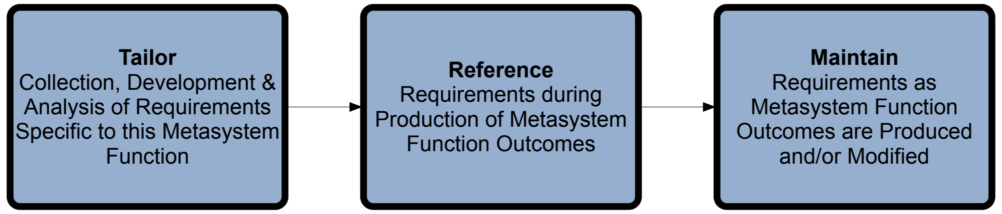
CSGAF Metasystem Viewpoint - 4’ Architecture Information Need 3 (MV-4’ I3): Integrated Human-System Requirements for Environmental Scanning



Human-System Requirement 1 (MV-4’ I3.1): Placeholder.

Human-System Requirement 2 (MV-4’ I3.2): Placeholder.

CSGAF Metasystem Viewpoint - 3 Architecture Information Need 3 (MV-3 I3): Integrated Human-System Requirements for System Operations



Human-System Requirement 1 (MV-3 I3.1): Placeholder.

Human-System Requirement 2 (MV-3 I3.2): Placeholder.

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 3* Architecture Information Need 3 (MV-3* I3): Integrated Human-System Requirements for Operational Performance

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→

Reference
Requirements during Production of Metasystem Function Outcomes

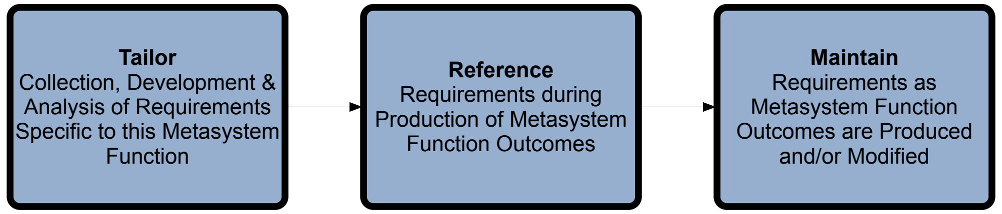
→

Maintain
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Human-System Requirement 1 (MV-3* I3.1): Placeholder.

Human-System Requirement 2 (MV-3* I3.2): Placeholder.

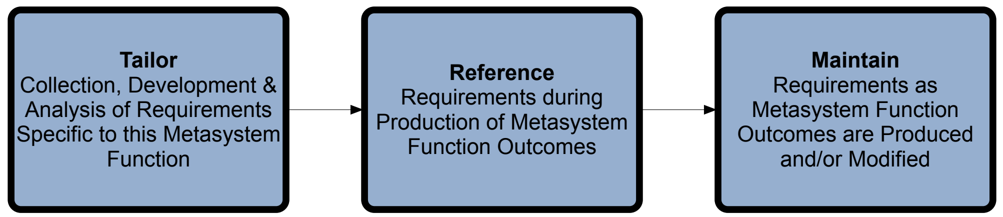
CSGAF Metasystem Viewpoint - 2 Architecture Information Need 3 (MV-2 I3): Integrated Human-System Requirements for Information & Communications



Human-System Requirement 1 (MV-2 I3.1): Placeholder.

Human-System Requirement 2 (MV-2 I3.2): Placeholder.

CSGAF Metasystem Viewpoint - 5 Architecture Information Need 4 (MV-5 I4): Environmental Requirements for Policy & Identity



Environmental Requirement 1 (MV-5 I4.1): Placeholder.

Environmental Requirement 2 (MV-5 I4.2): Placeholder.

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 5* Architecture Information Need 4 (MV-5* I4): Environmental Requirements for System Context

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→

Reference
Requirements during Production of Metasystem Function Outcomes

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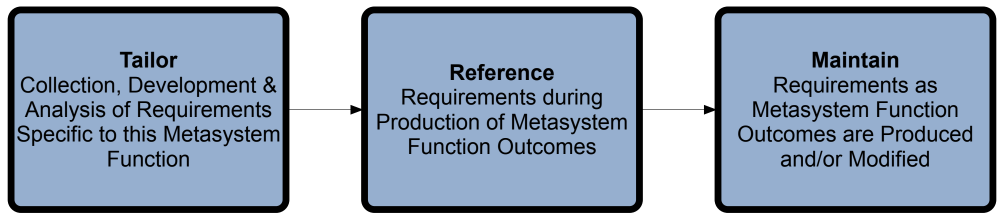
Maintain
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Environmental Requirement 1 (MV-5* I4.1): Placeholder.

Environmental Requirement 2 (MV-5* I4.2): Placeholder.

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

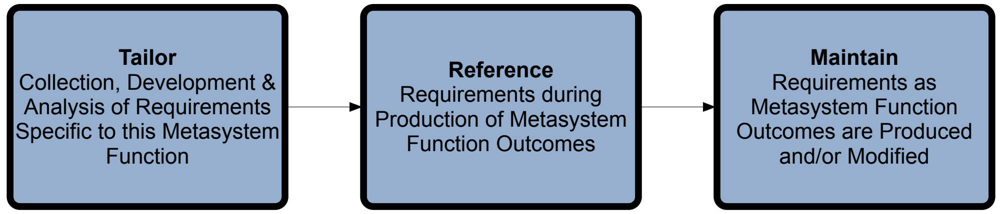
CSGAF Metasystem Viewpoint - 5' Architecture Information Need 4 (MV-5' I4): Environmental Requirements for Strategic System Monitoring



Environmental Requirement 1 (MV-5' I4.1): Placeholder.

Environmental Requirement 2 (MV-5' I4.2): Placeholder.

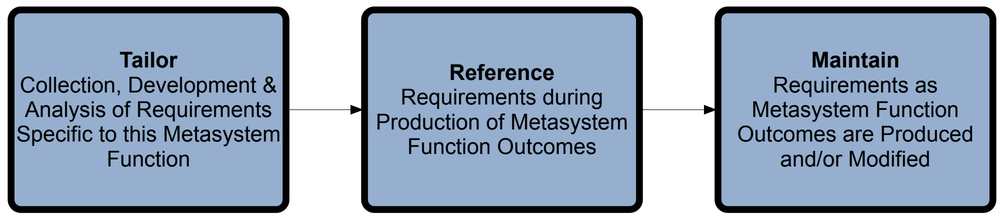
CSGAF Metasystem Viewpoint - 4 Architecture Information Need 4 (MV-4 I4): Environmental Requirements for System Development



Environmental Requirement 1 (MV-4 I4.1): Placeholder.

Environmental Requirement 2 (MV-4 I4.2): Placeholder.

CSGAF Metasystem Viewpoint - 4* Architecture Information Need 4 (MV-4* I4): Environmental Requirements for Learning & Transformation

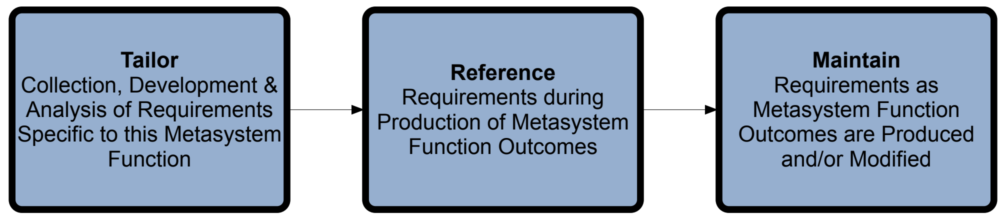


Environmental Requirement 1 (MV-4* I4.1): Placeholder.

Environmental Requirement 2 (MV-4* I4.2): Placeholder.

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 4’ Architecture Information Need 4 (MV-4’ I4): Environmental Requirements for Environmental Scanning



Environmental Requirement 1 (MV-4’ I4.1): Placeholder.

Environmental Requirement 2 (MV-4’ I4.2): Placeholder.

MV-5
MV-5*
MV-5’
MV-4
MV-4*
MV-4’
MV-3
MV-3*
MV-2

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

→

Reference
Requirements during Production of Metasystem Function Outcomes

→

Maintain
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Environmental Requirement 1 (MV-3 I4.1): Placeholder.

Environmental Requirement 2 (MV-3 I4.2): Placeholder.

CSGAF Metasystem Viewpoint - 3* Architecture Information Need 4 (MV-3* I4): Environmental Requirements for Operational Performance

Tailor
Collection, Development & Analysis of Requirements Specific to this Metasystem Function

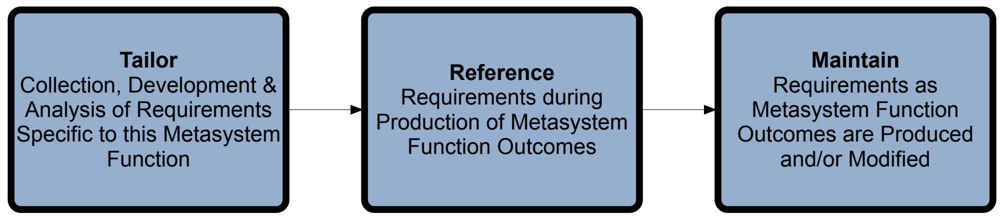
→ **Reference**
Requirements during Production of Metasystem Function Outcomes

→ **Maintain**
Requirements as Metasystem Function Outcomes are Produced and/or Modified

Environmental Requirement 1 (MV-3* I4.1): Placeholder.

Environmental Requirement 2 (MV-3* I4.2): Placeholder.

CSGAF Metasystem Viewpoint - 2 Architecture Information Need 4 (MV-2 I4): Environmental Requirements for Information & Communications



Environmental Requirement 1 (MV-2 I4.1): Placeholder.

Environmental Requirement 2 (MV-2 I4.2): Placeholder.

RM
MV-5
MV-5*
MV-5'
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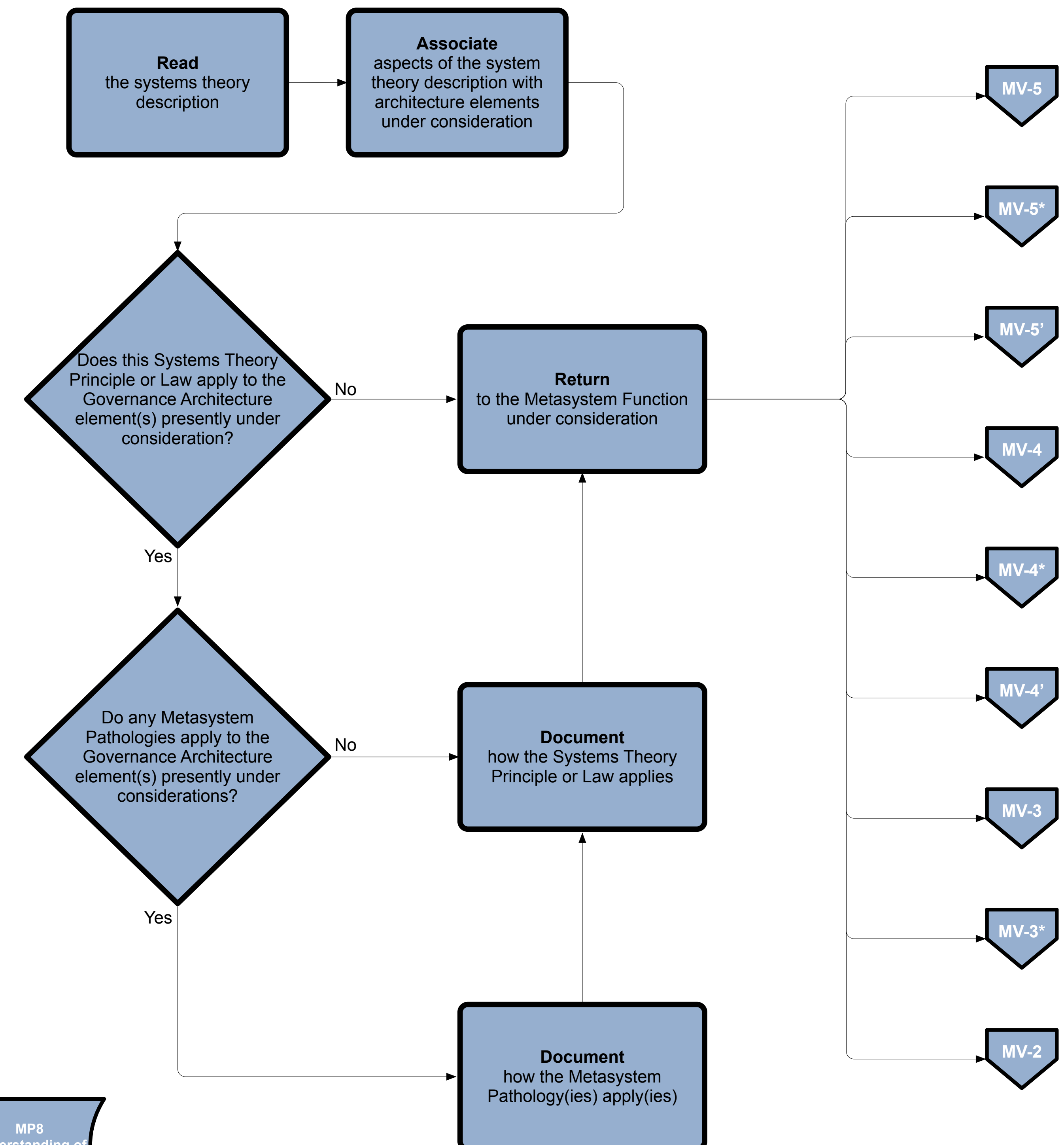
MV-4*
MV-4'
MV-3
MV-3*
MV-2

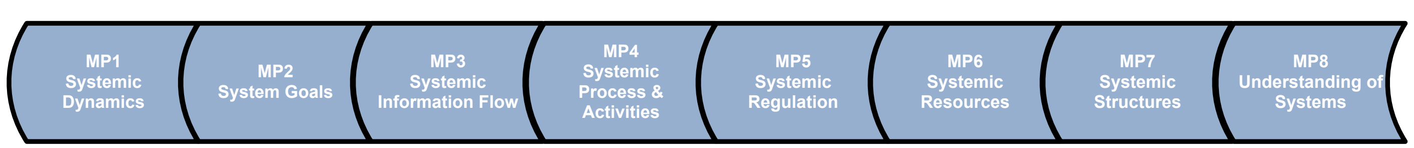
CSGAF Analysis of Systems Theory Principle of Circular Causality (ST1): Considerations for Complex System Governance Architectures

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

Reference: Polinpapilinho, K. F. (2015). *SYSTEMS THEORY-BASED CONSTRUCT FOR IDENTIFYING METASYSTEM PATHOLOGIES FOR COMPLEX SYSTEM GOVERNANCE.* (PhD Dissertation), Old Dominion University, Norfolk, Virginia, USA.



Metasystem Pathology Considerations for Architecture



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

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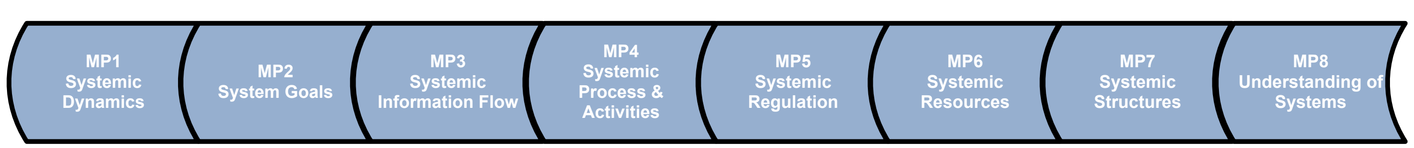
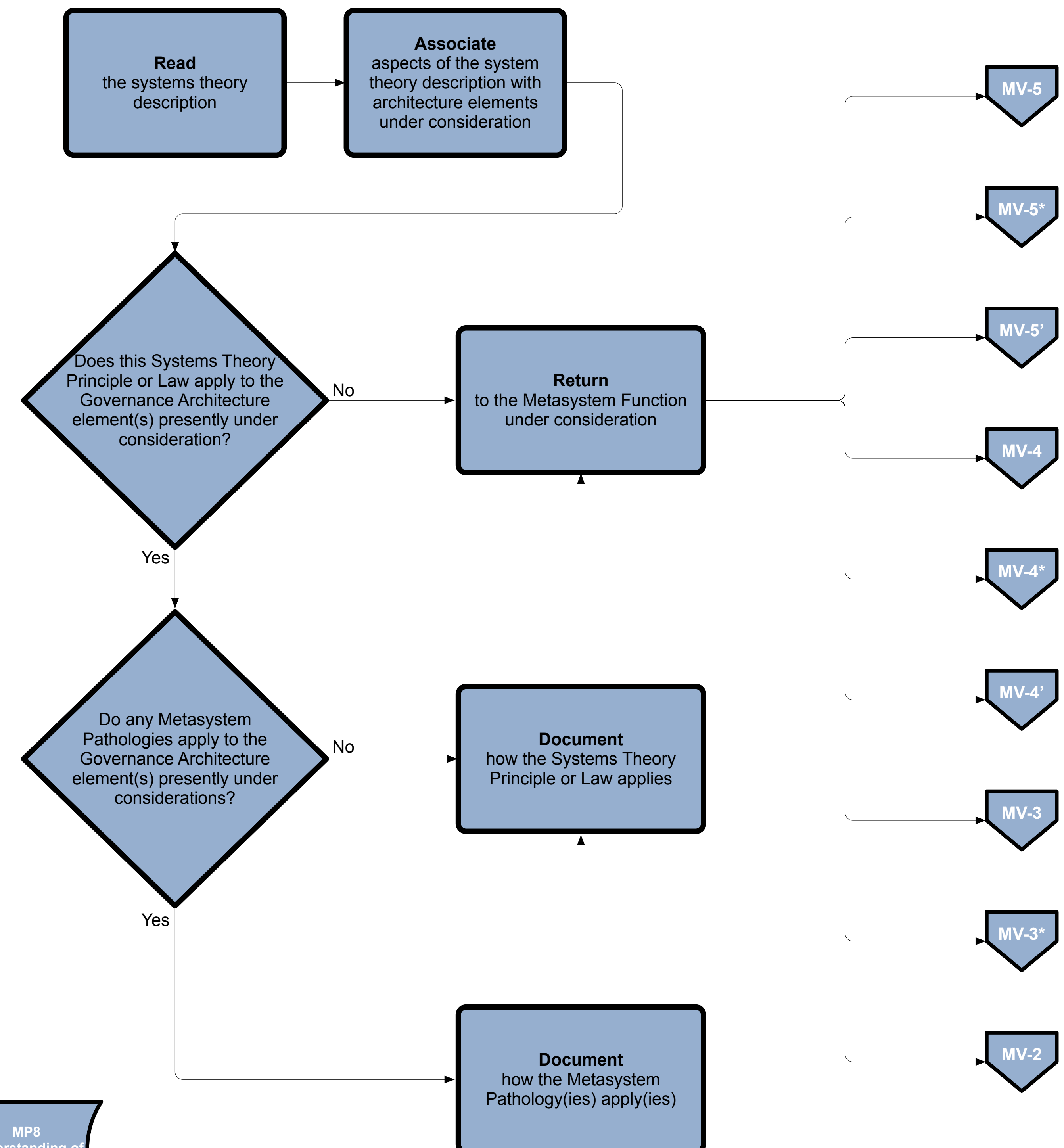
Metasystem Pathology Considerations for Architecture





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

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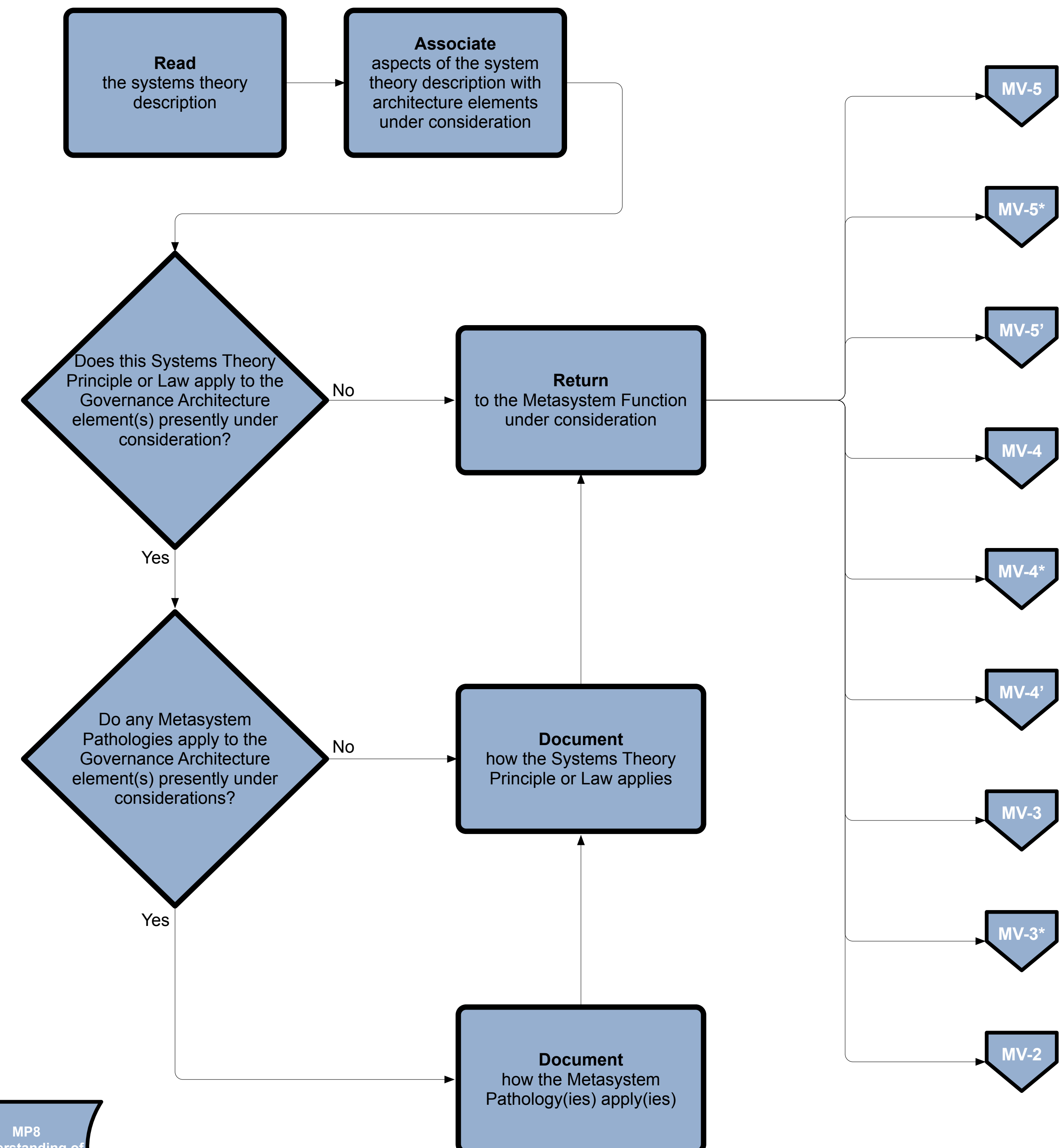
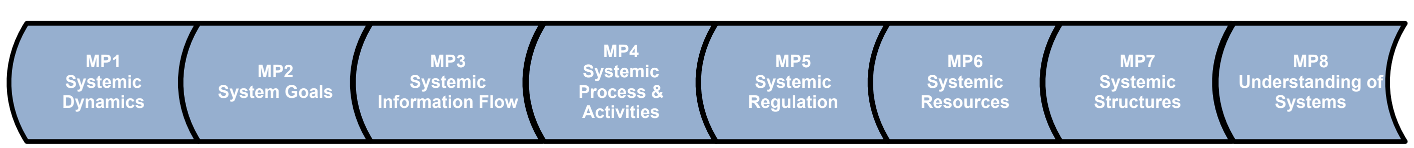


Metasystem Pathology Considerations for Architecture



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

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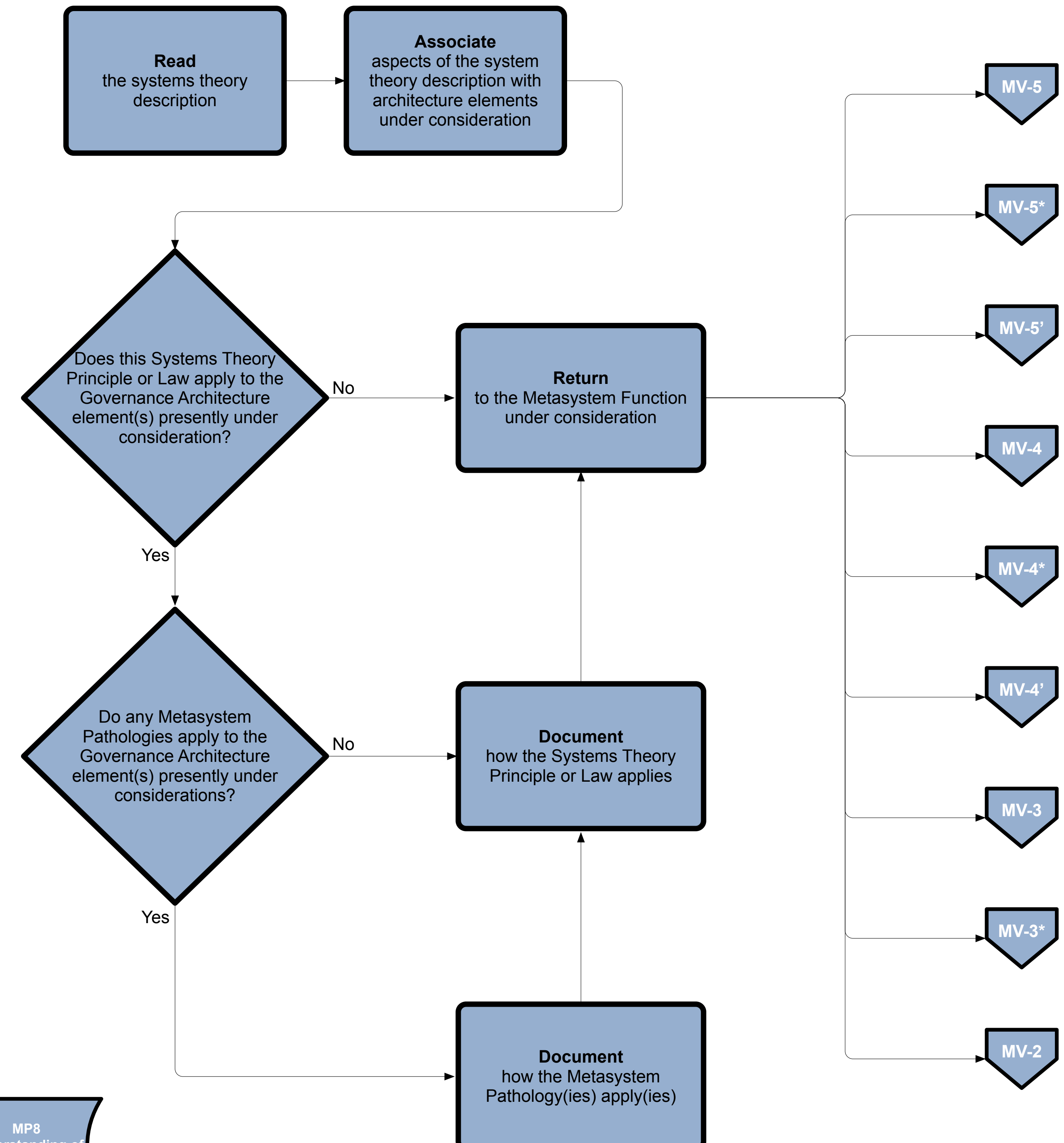
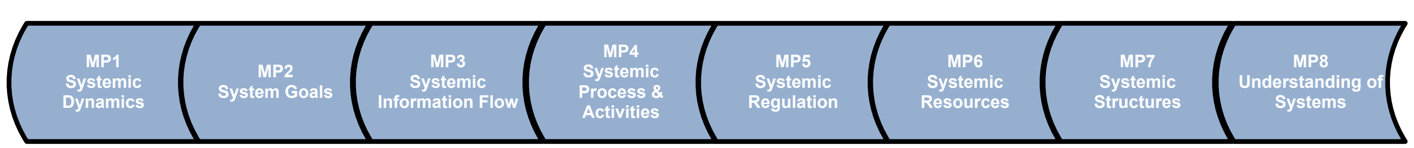


Metasystem Pathology Considerations for Architecture



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

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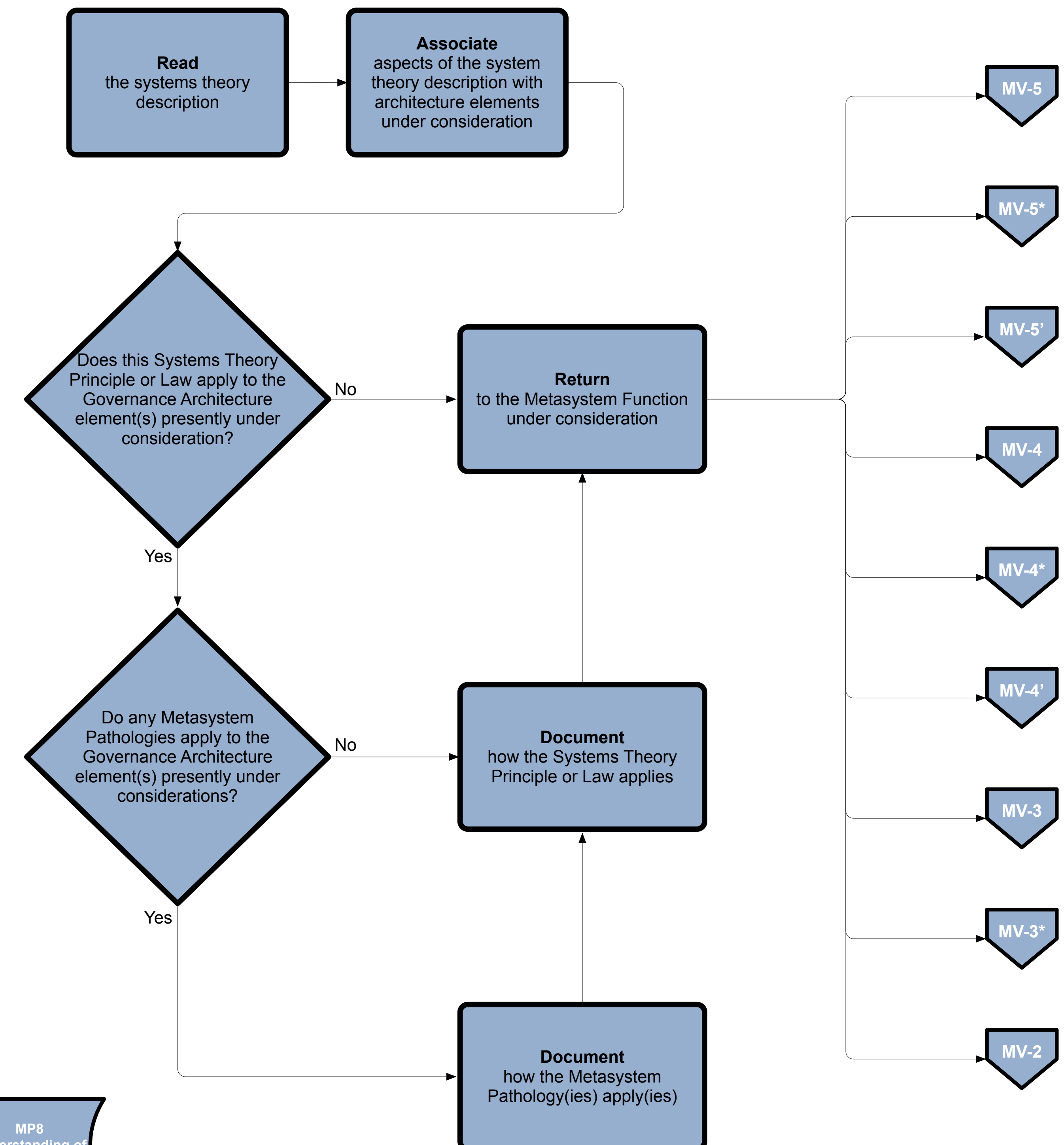
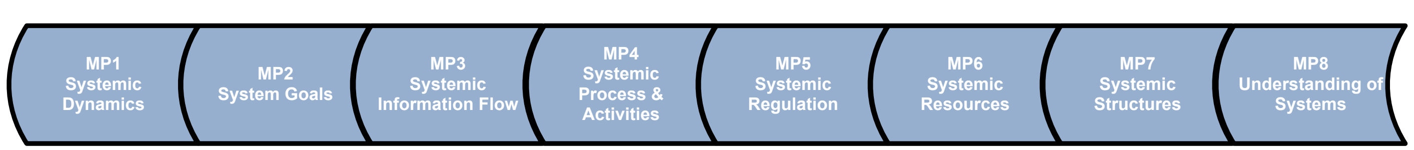


Metasystem Pathology Considerations for Architecture



CSGAF Analysis of Systems Theory Principle of Dynamic Equilibrium (ST6): Considerations for Complex System Governance Architectures

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

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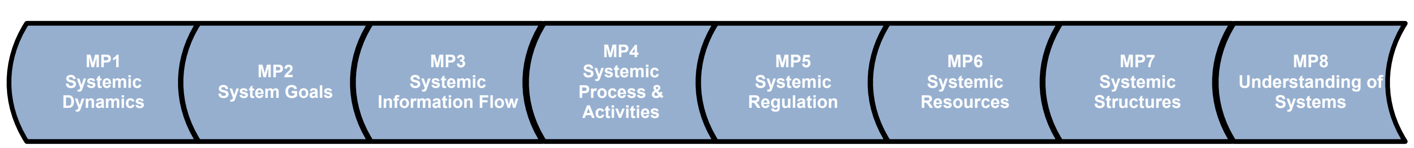
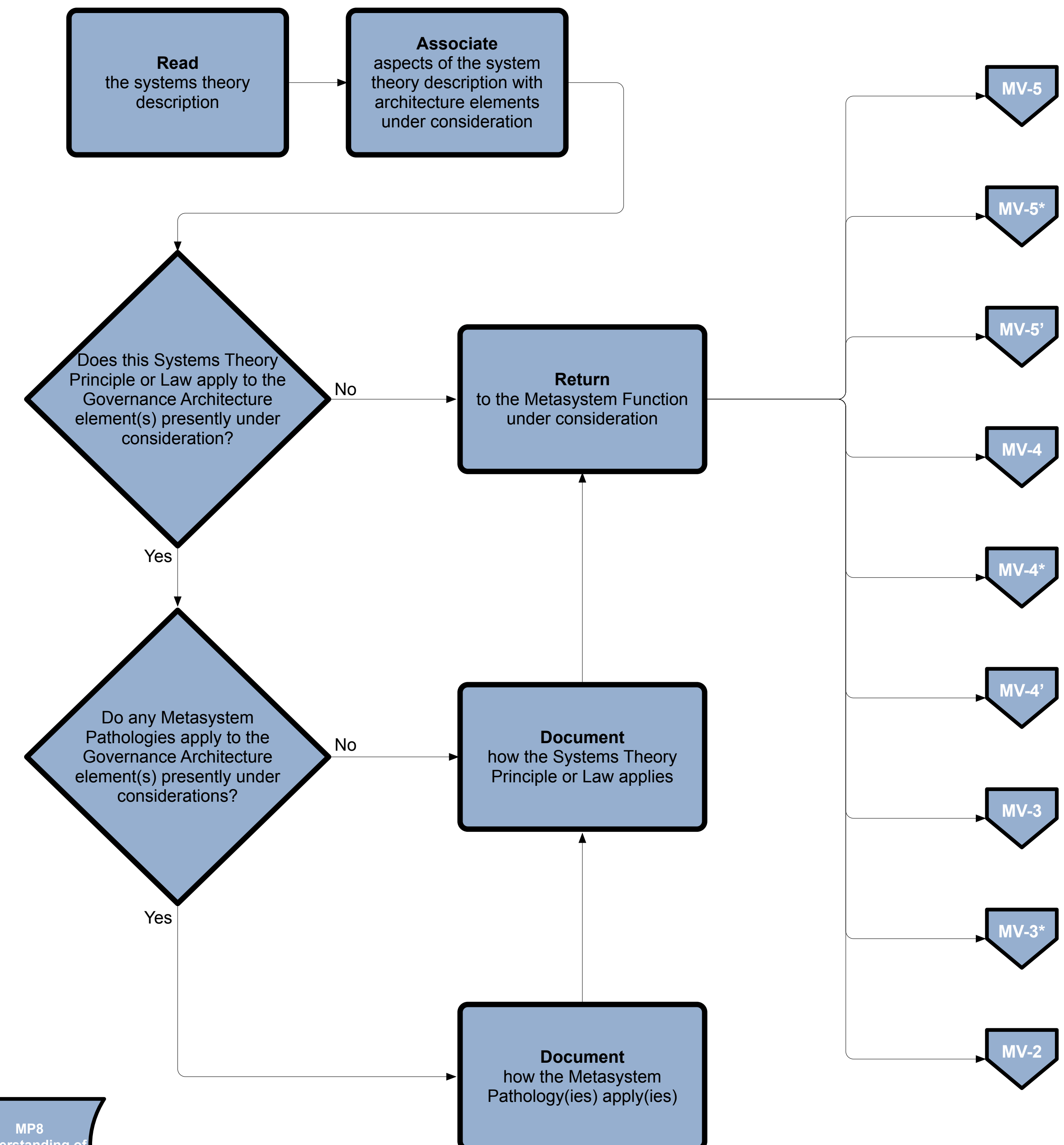
Metasystem Pathology Considerations for Architecture





CSGAF Analysis of Systems Theory Principle of Emergence (ST7): Considerations for Complex System Governance Architectures

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

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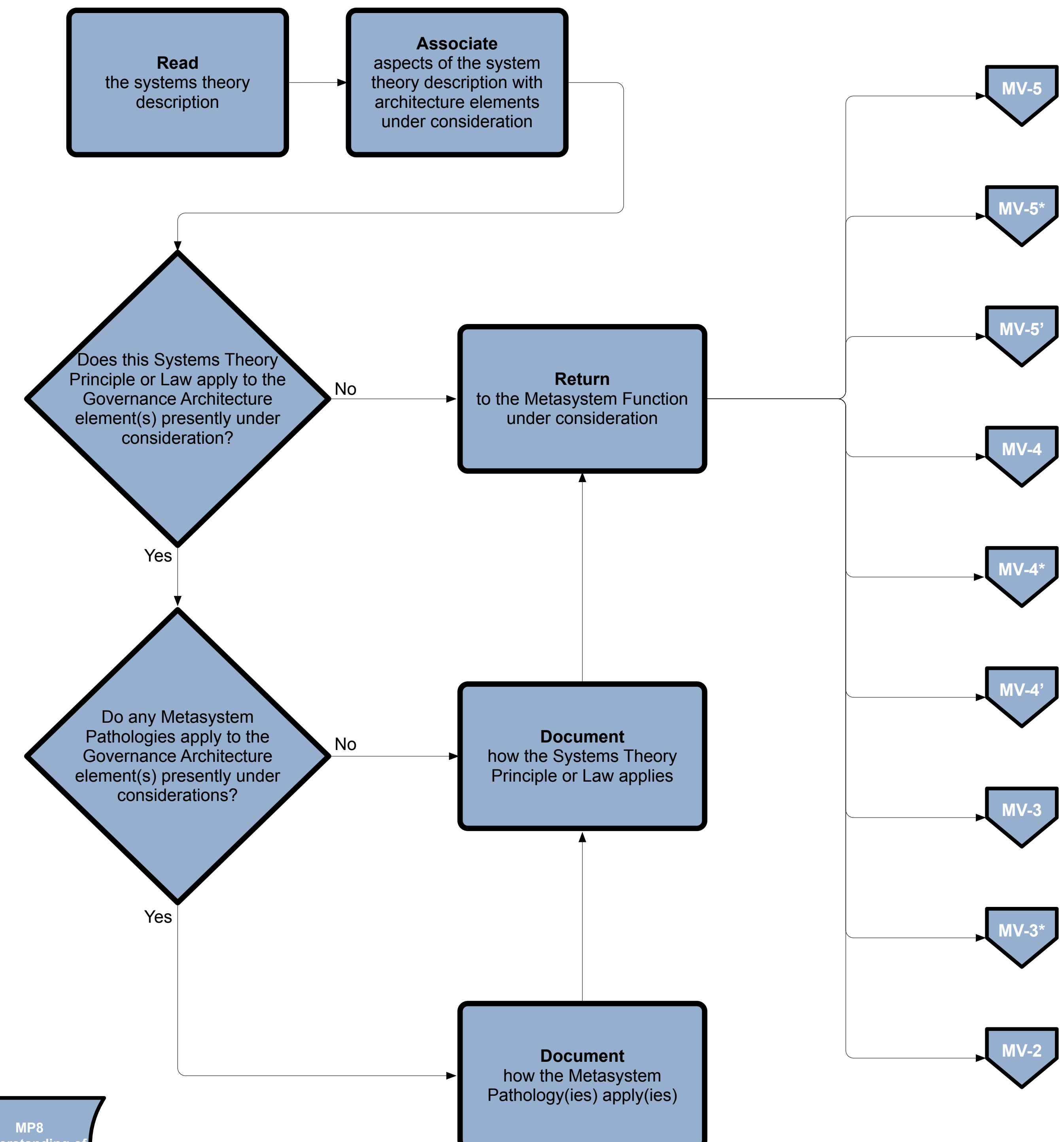
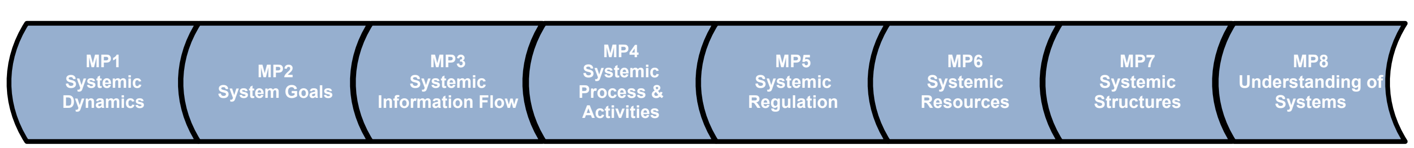


Metasystem Pathology Considerations for Architecture



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

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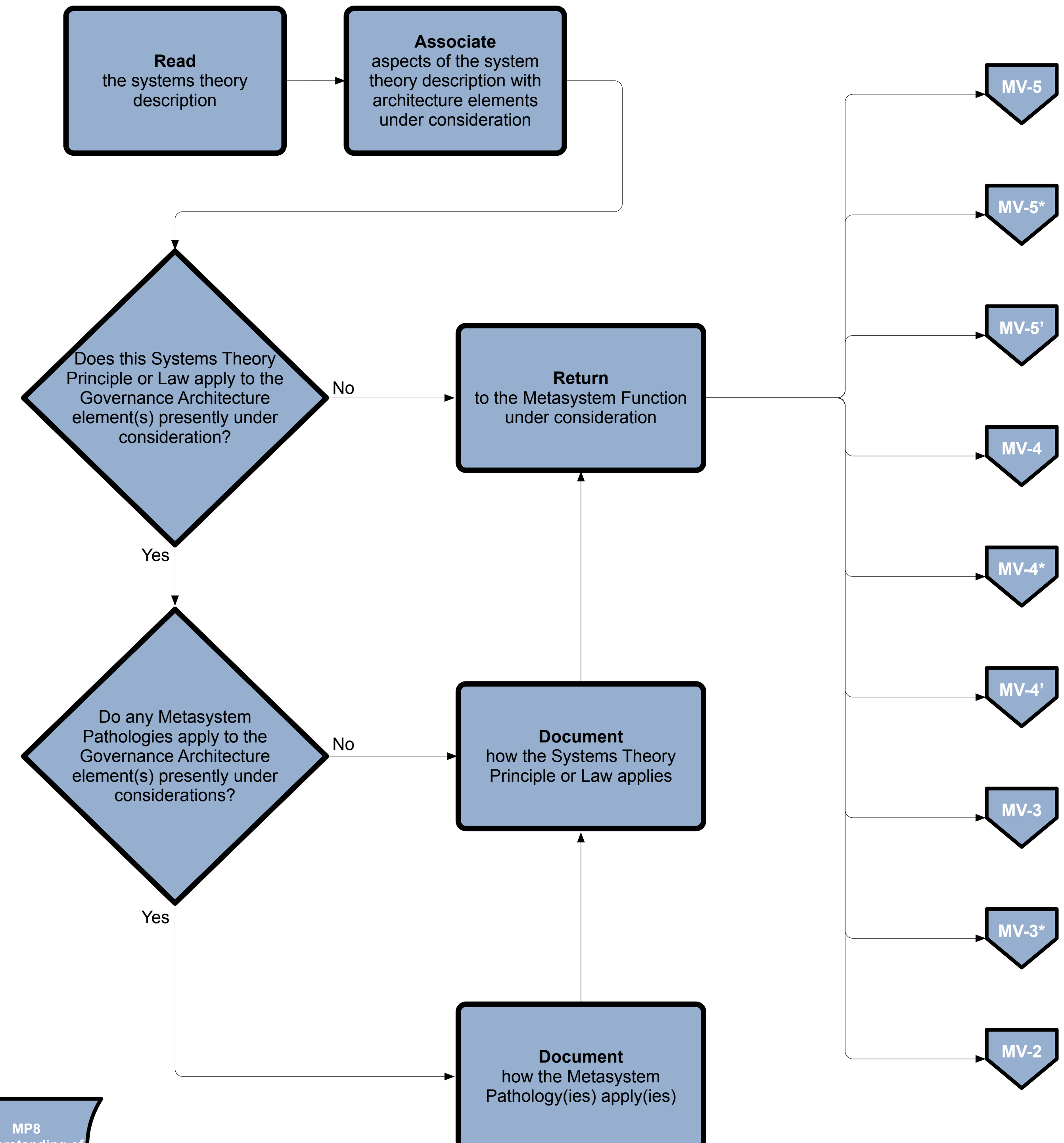
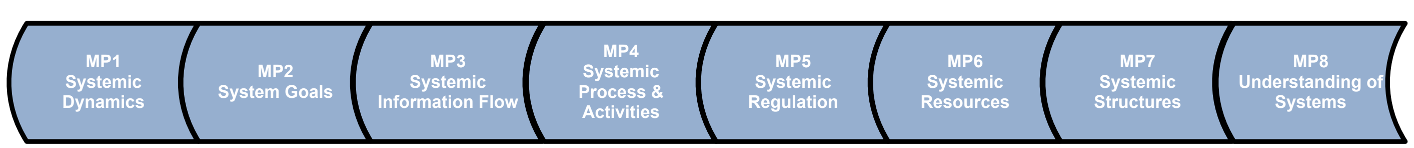


Metasystem Pathology Considerations for Architecture



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

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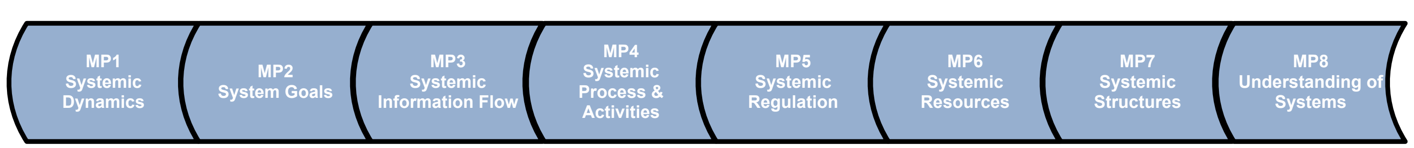
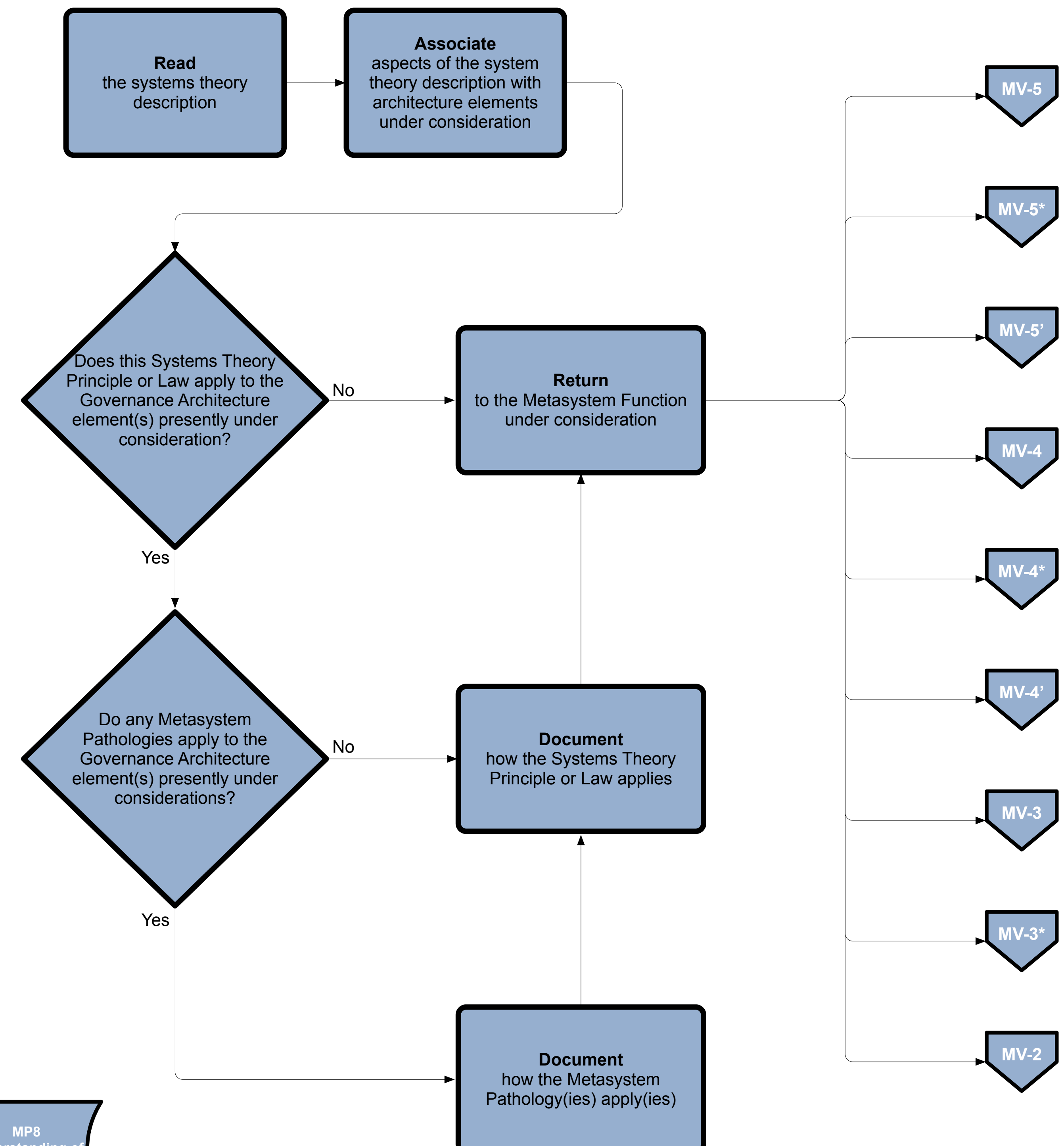
Metasystem Pathology Considerations for Architecture





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

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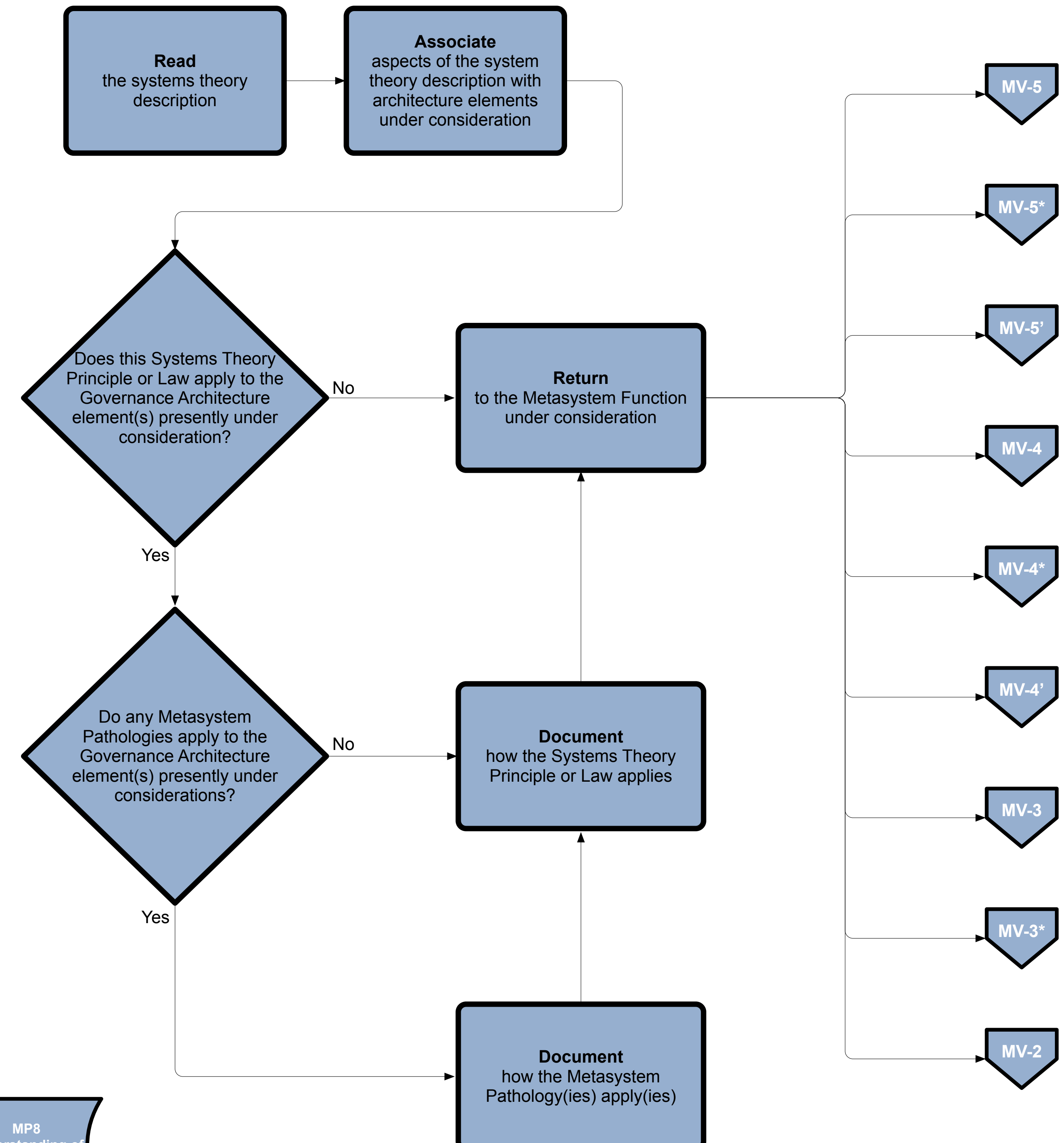

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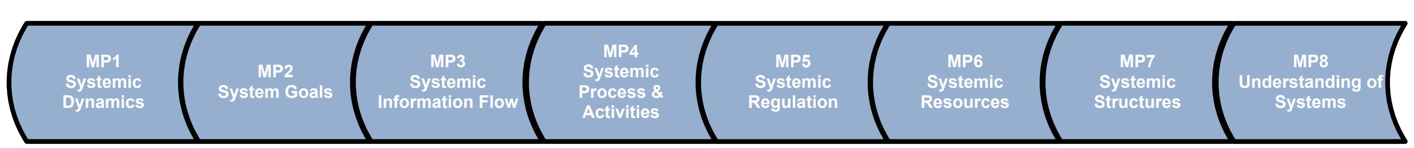

CSGAF Analysis of Systems Theory Principle of Holism (ST11): Considerations for Complex System Governance Architectures

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

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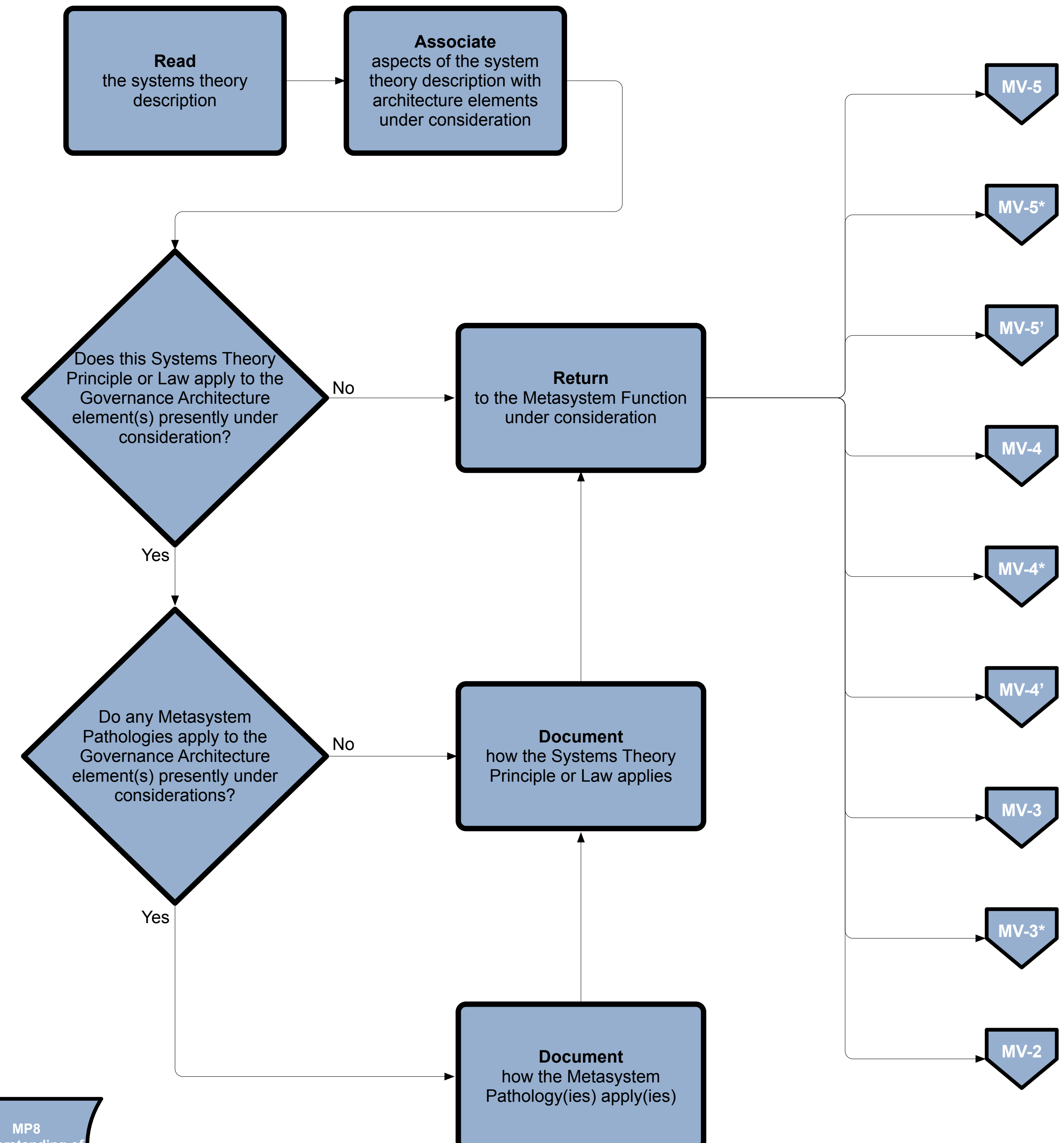

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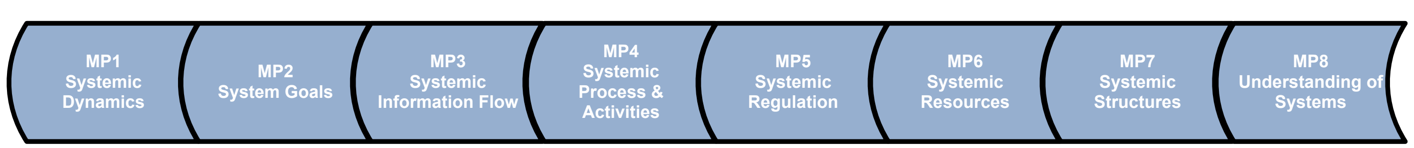

CSGAF Analysis of Systems Theory Principle of Homeorhesis (ST12): Considerations for Complex System Governance Architectures

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

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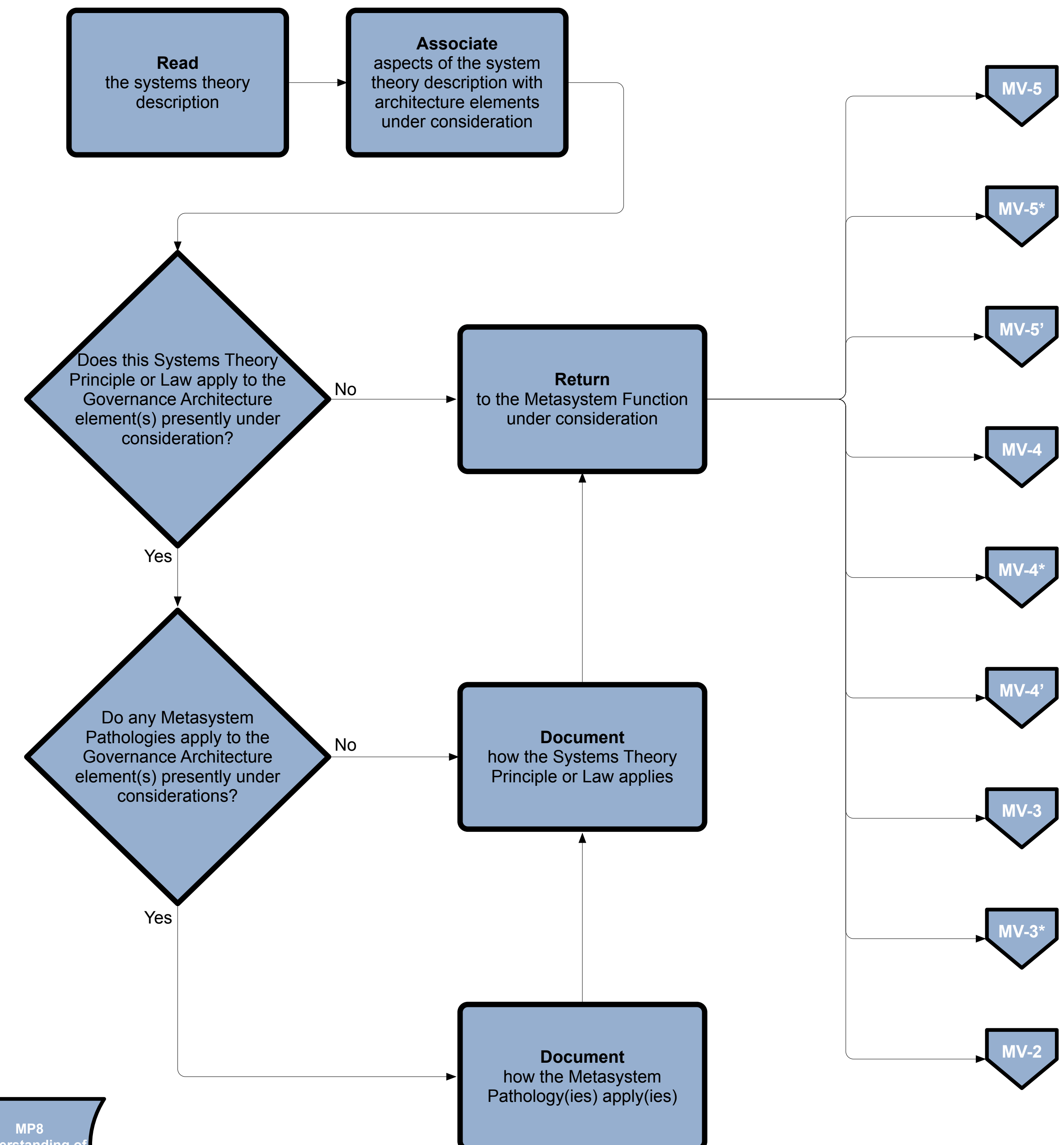

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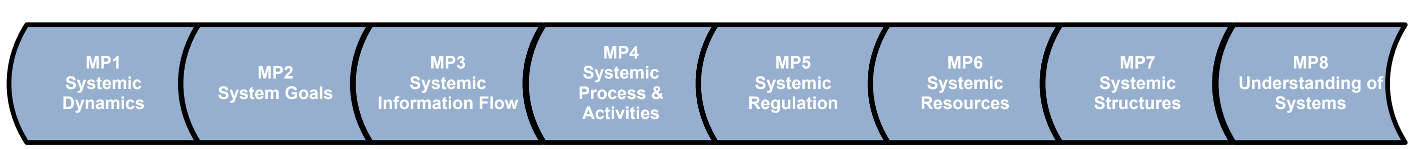

Principle of homeostasis	
Short description	'homeostasis'
Detailed description	"The property of an open system to regulate its internal environment so as to maintain a stable condition, by means of multiple dynamic equilibrium adjustments controlled by interrelated regulation feedback mechanisms" (Adams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

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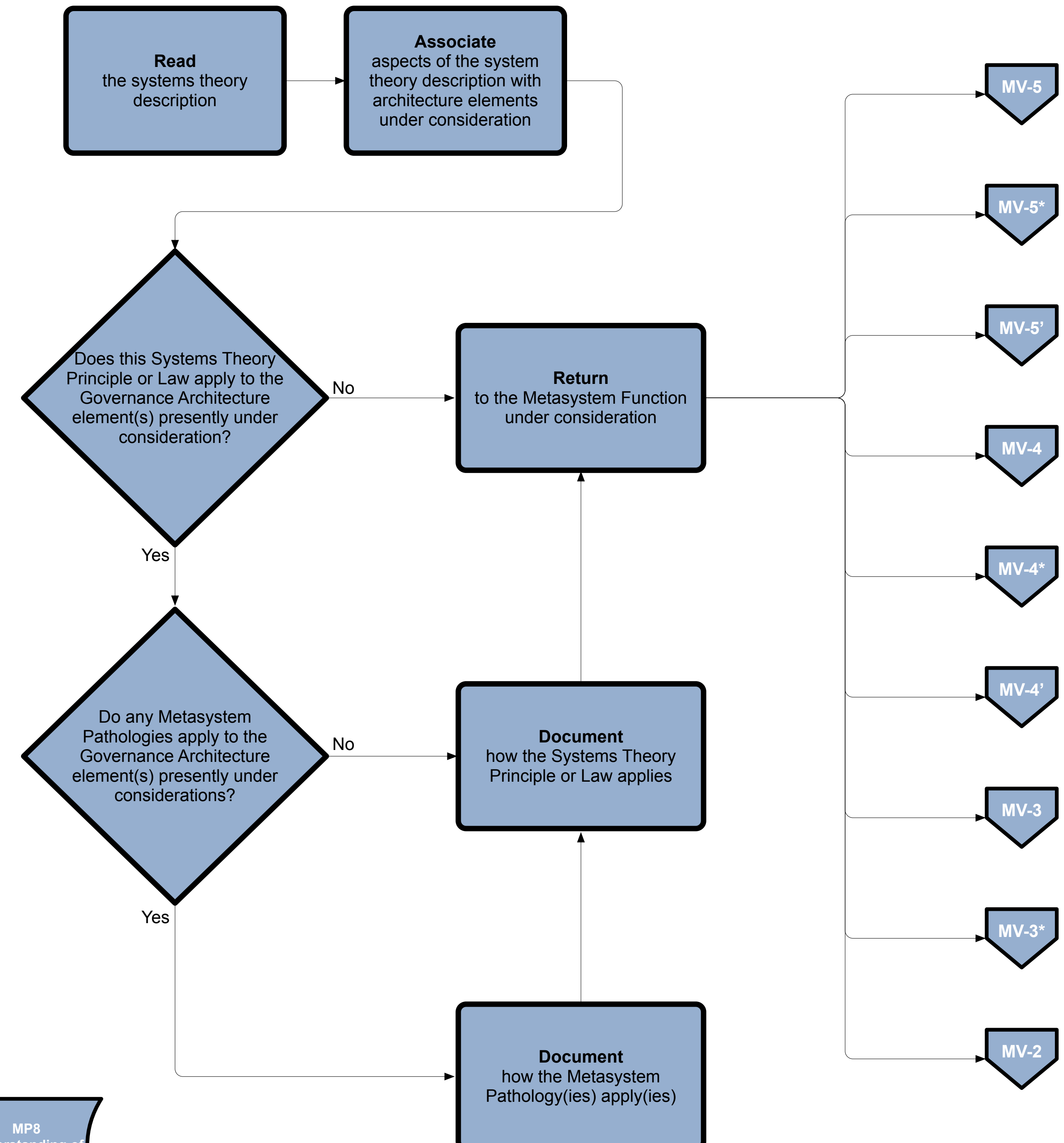

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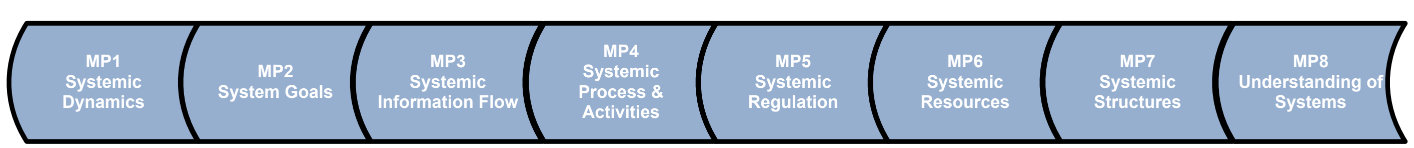

CSGAF Analysis of Systems Theory Theorem of Information Redundancy (ST14): Considerations for Complex System Governance Architectures

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

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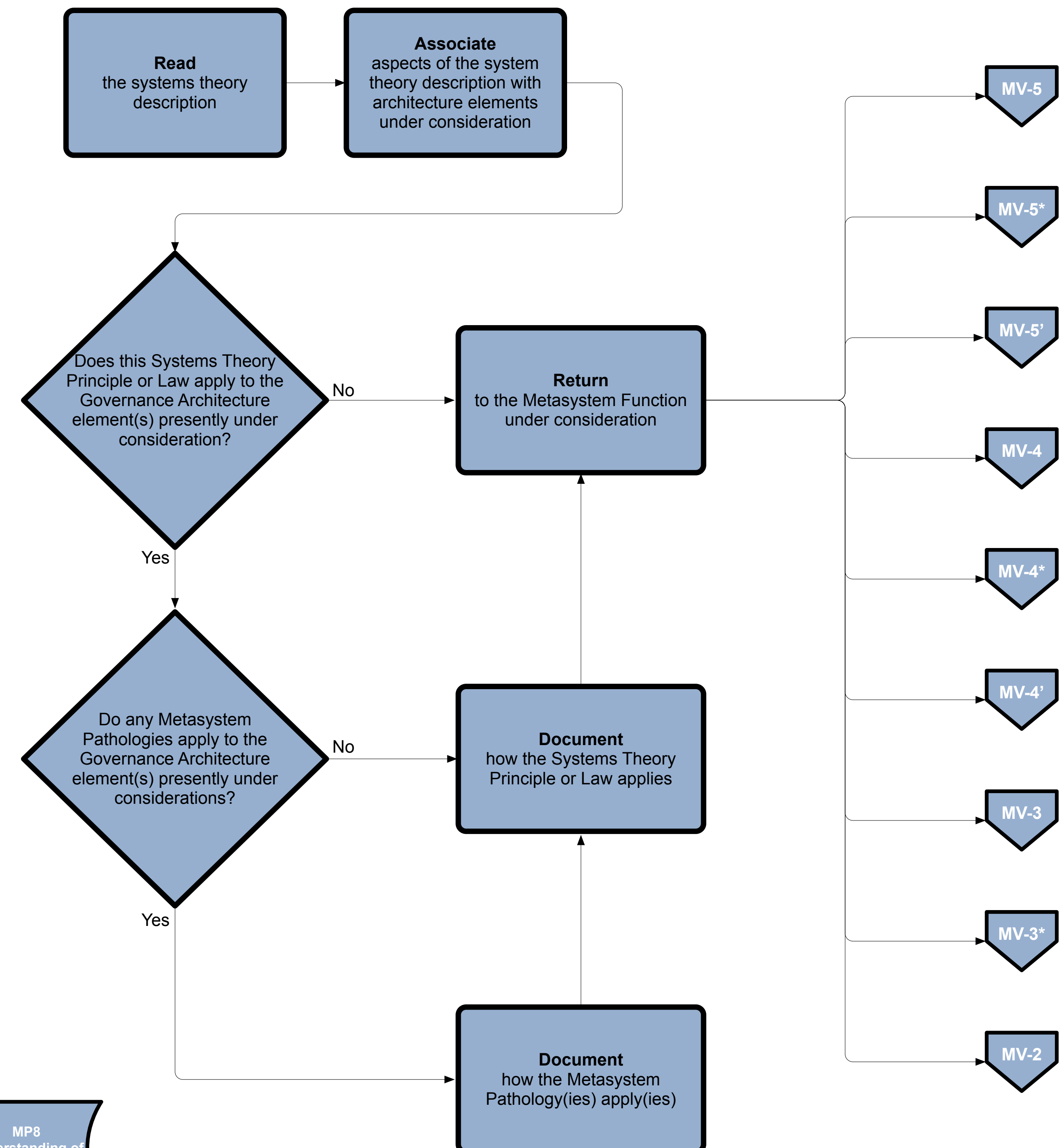

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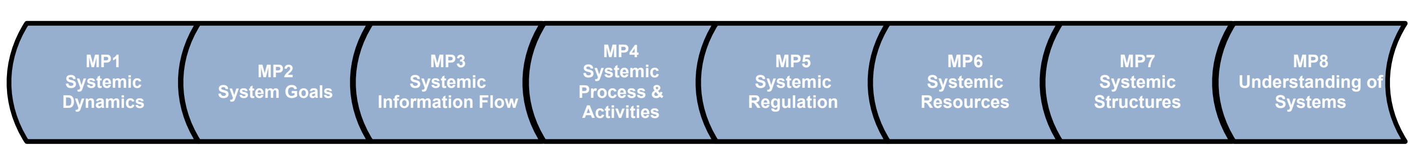

Principle of minimal critical specification	
Short description	'minimal critical specification'
Detailed description	This principle has two aspects, negative and positive. The negative aspect of the principles states that no more should be specified than is absolutely essential for design; the positive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

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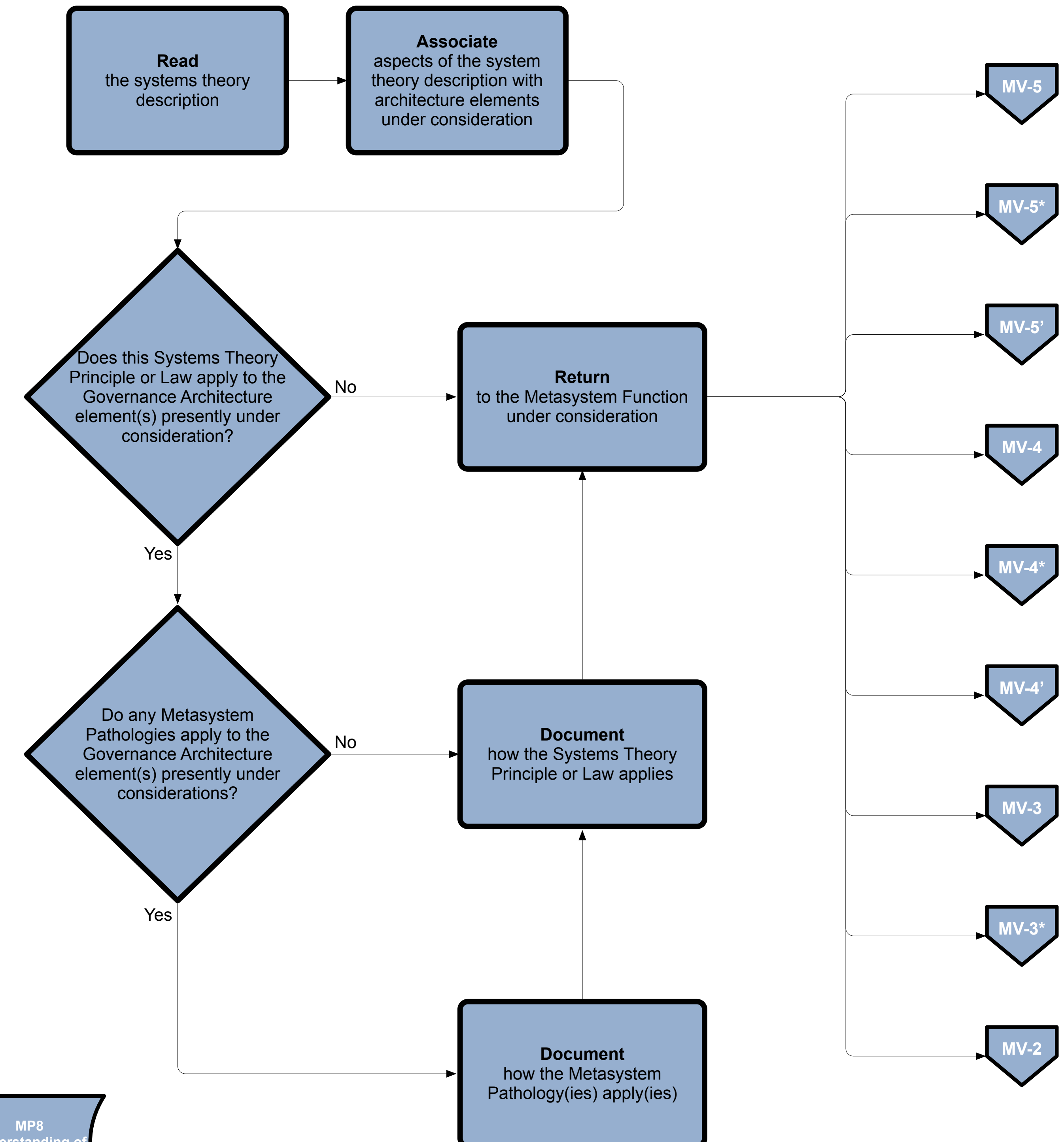

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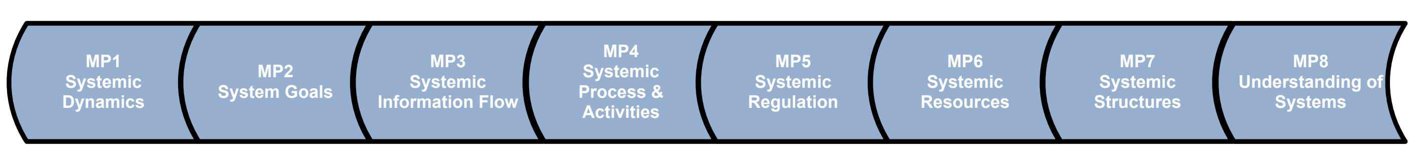

Principle of multifinality	
Short description	'multifinality'
Detailed description	"Radically different end states are possible from the same initial conditions" (Adams et al. 2014, p. 118)
Seminal author(s)	Buckley, 1967
Inclusion criteria	This principle can be used in understanding and development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

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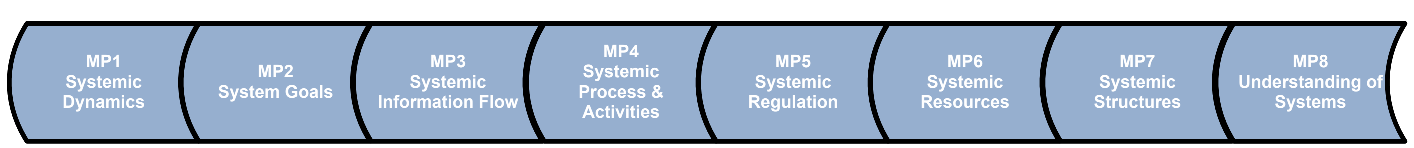

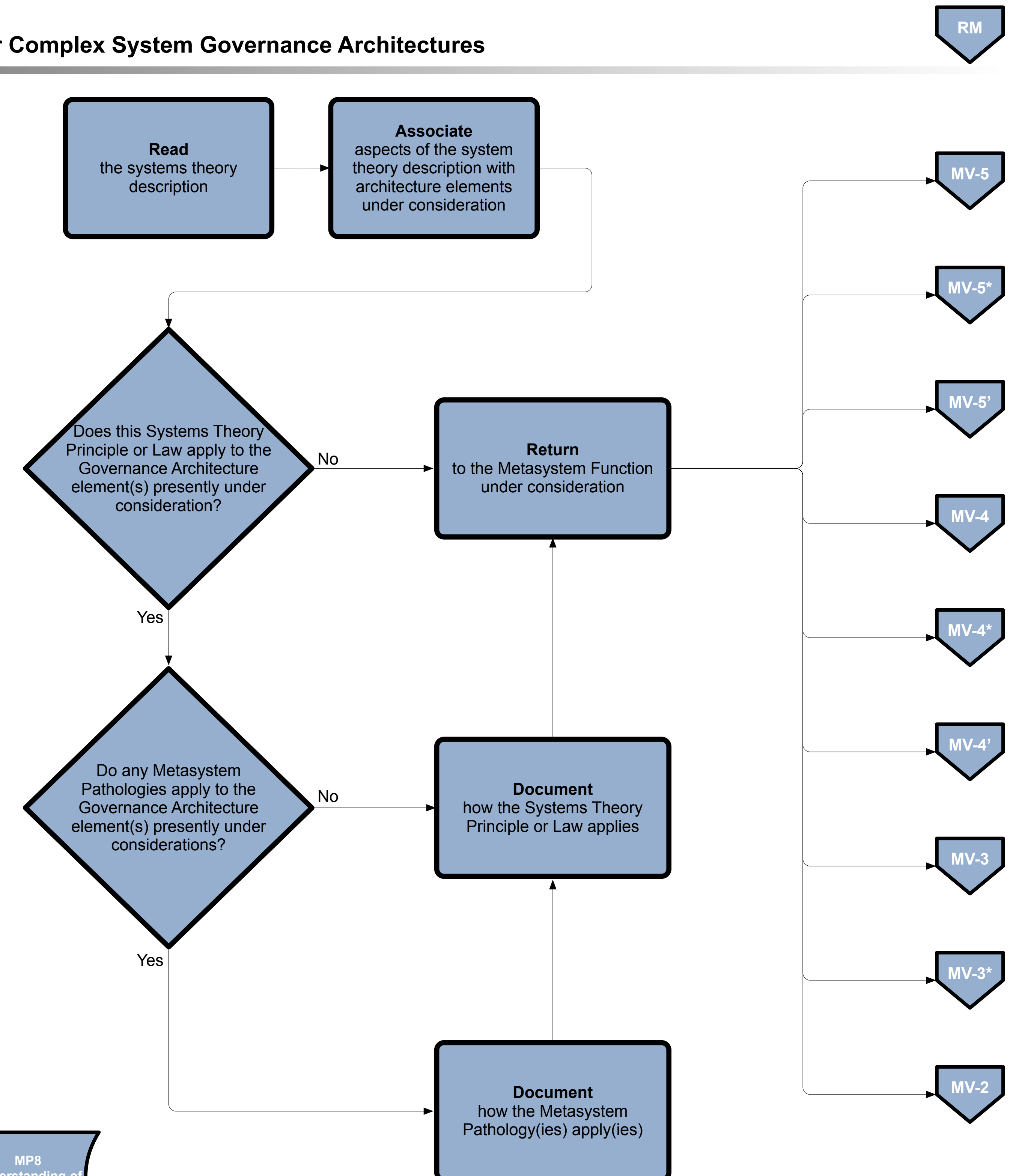

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Principle of Pareto	
Short description	'Pareto'
Detailed description	In any large complex system, eighty percent of the outputs or objectives will be achieved (produced) by only twenty percent of the system means (Adams et al. 2014)
Seminal author(s)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

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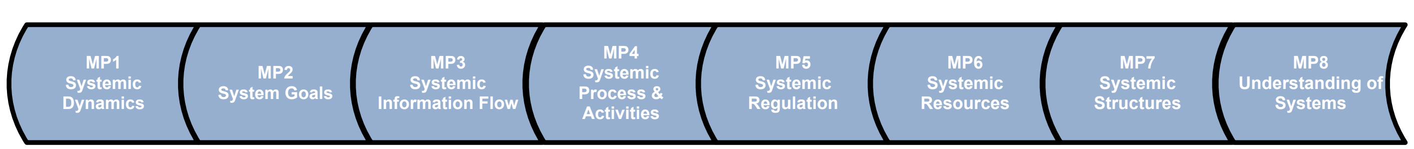

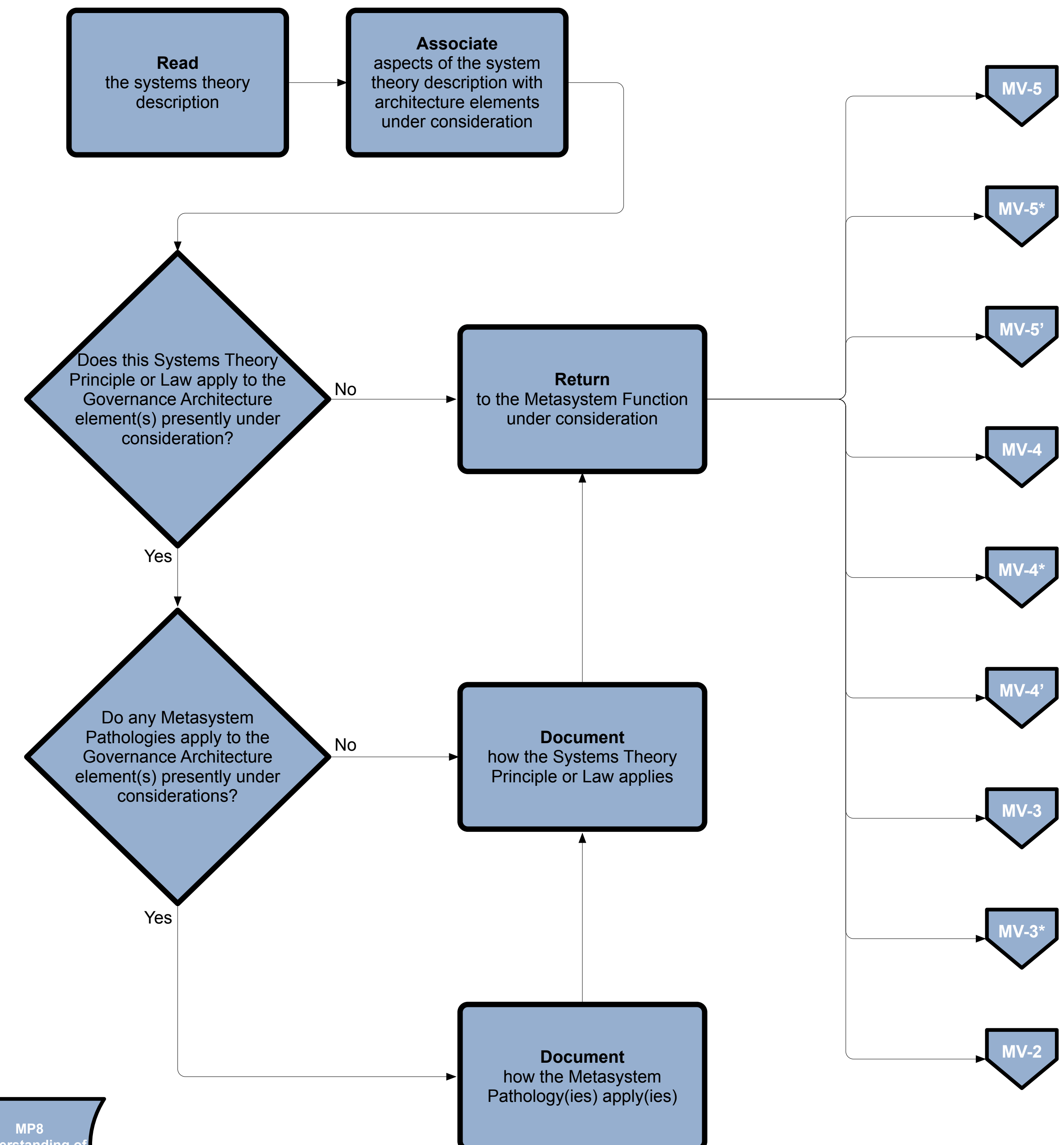

Theorem of purposive behaviorism	
Short description	'purposive behaviorism'
Detailed description	"Purposeful behavior is meant to denote that the act or behavior may be interpreted as directed to the attainment of a goal – i.e., to a final condition in which the behaving object reaches a definite correlation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

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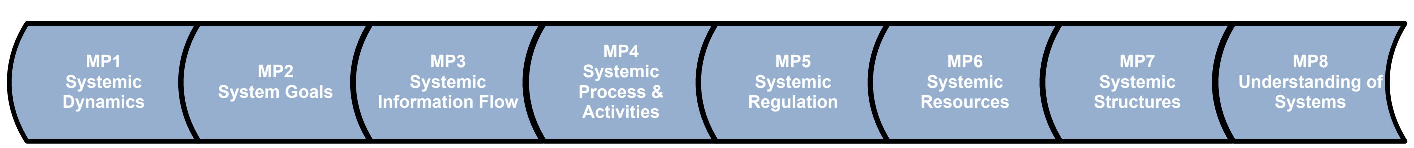

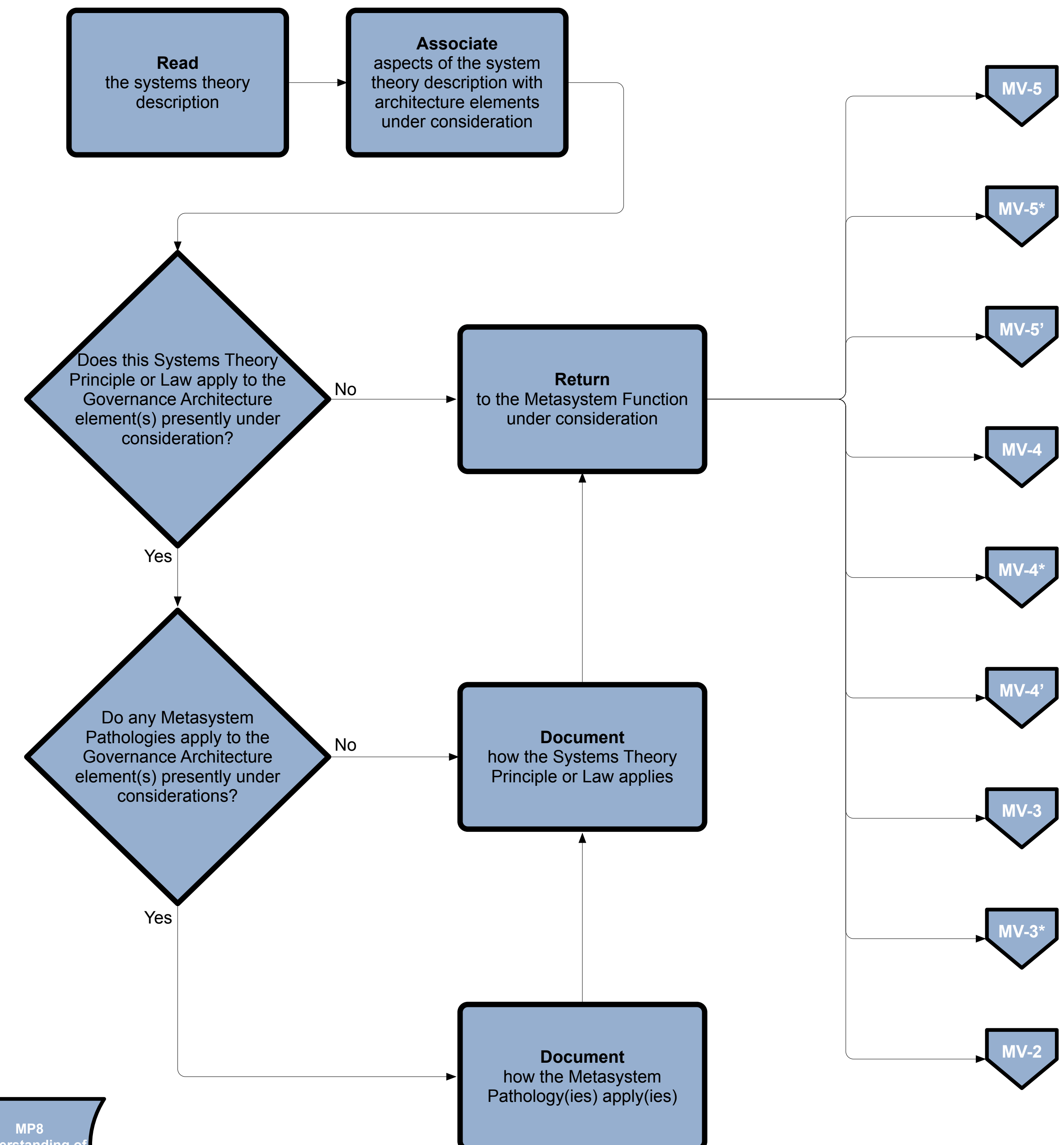

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Theorem of recursive system	
Short description	'recursion'
Detailed description	if a viable system contains a viable system, then the organizational structure must be recursive; in a recursive organizational structure, any viable system contains, and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

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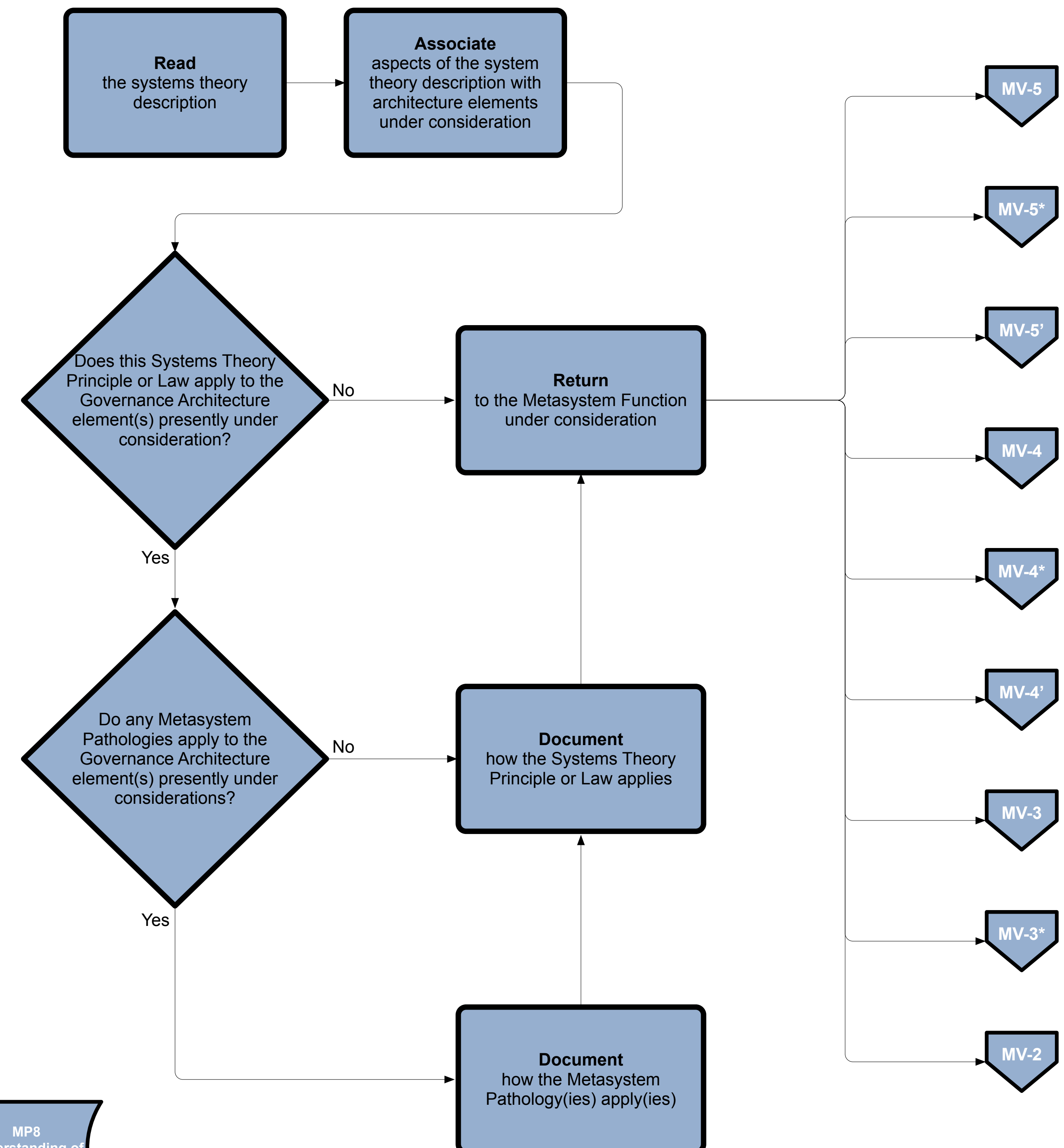

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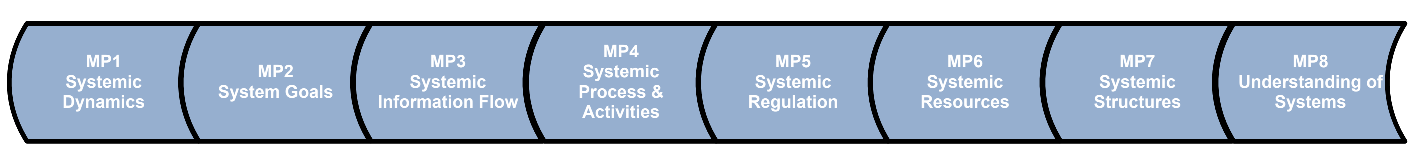

Theory of redundancy	
Short description	'redundancy'
Detailed description	"Means of increasing …safety and reliability [and stability] of systems by providing superfluous or excess [critical] resources" (Adams et al. 2014, p. 118)
Seminal author(s)	Pahl et al., 2011
Inclusion criteria	This principle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

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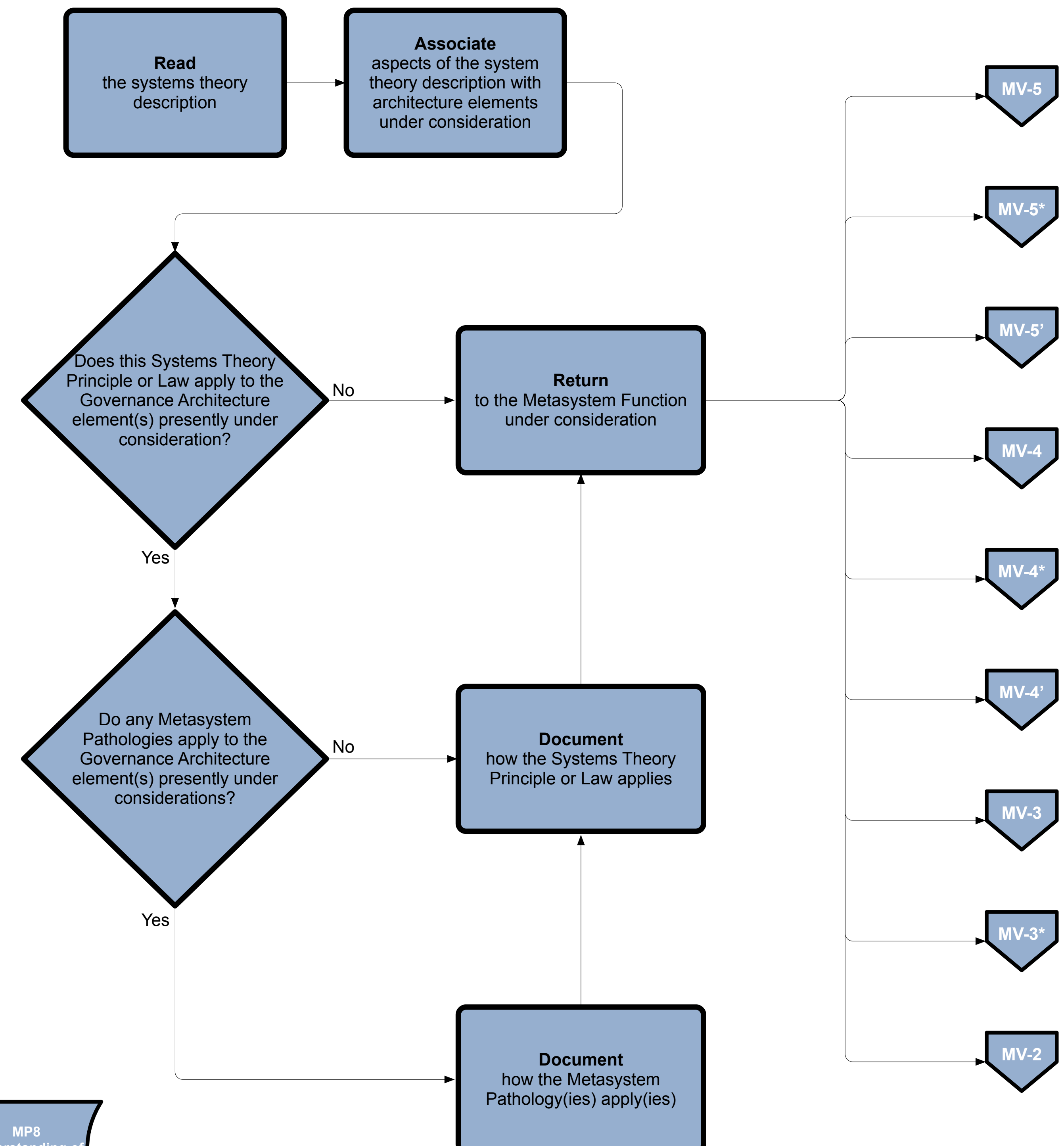

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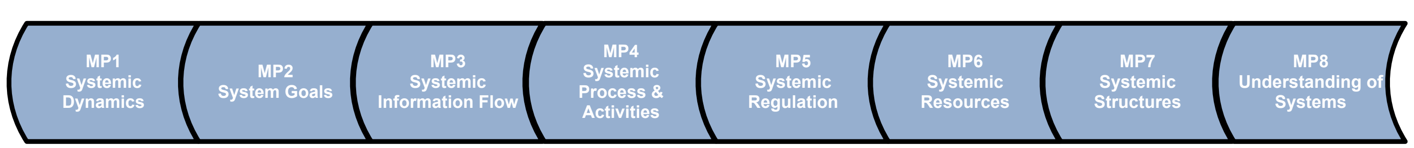

CSGAF Analysis of Systems Theory Principle of Redundancy of Potential Command (ST21): Considerations for Complex System Governance Architectures

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

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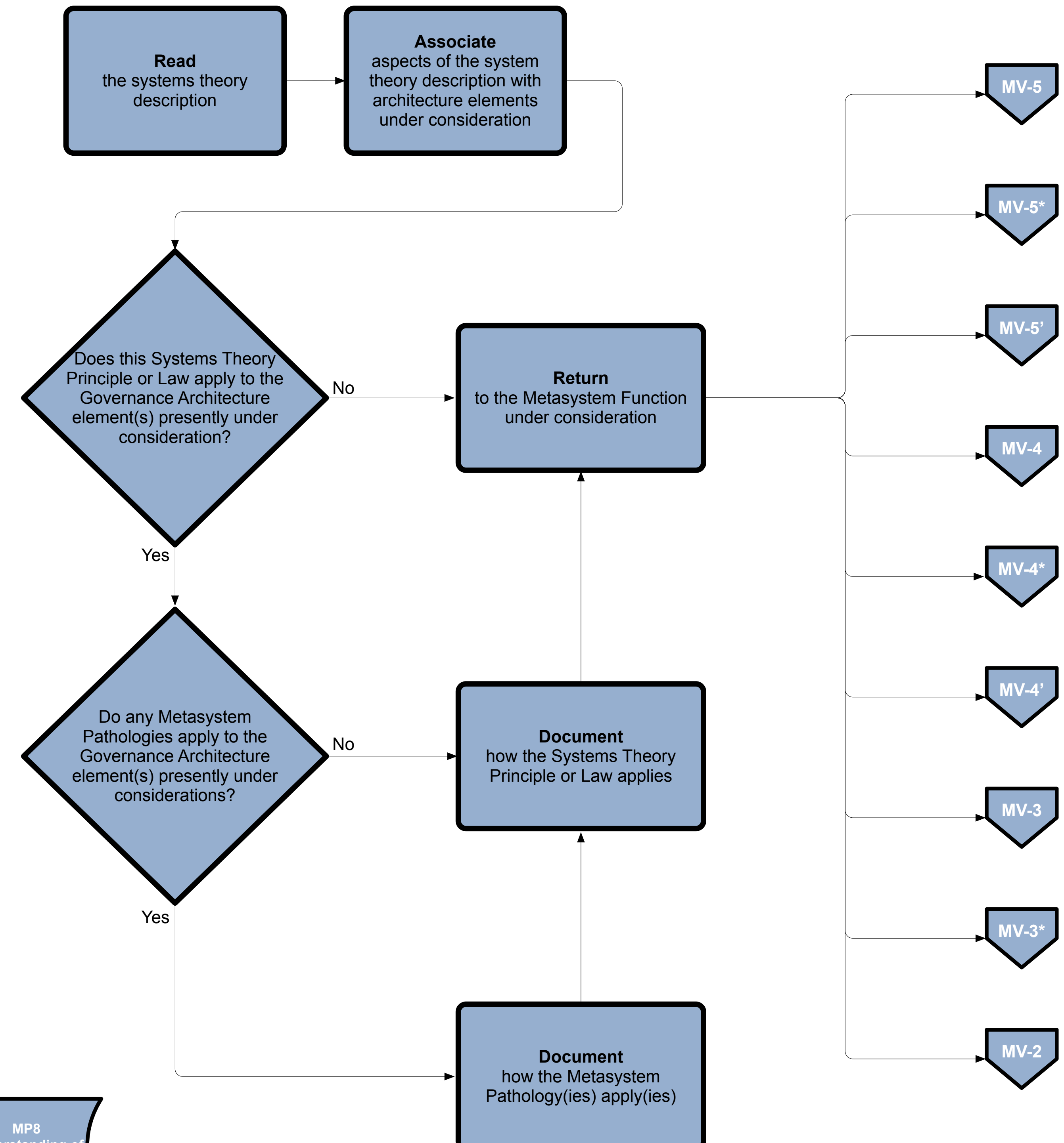

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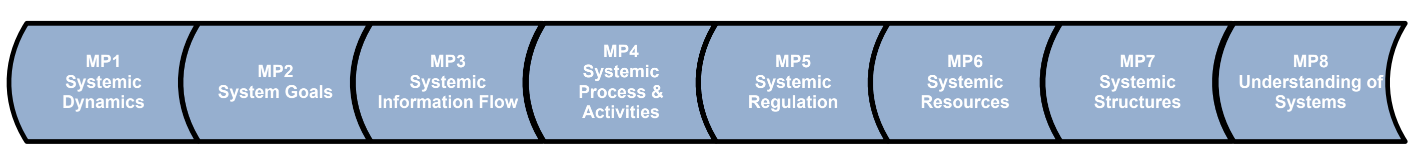

CSGAF Analysis of Systems Theory Principle of Relaxation Time (ST22): Considerations for Complex System Governance Architectures

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

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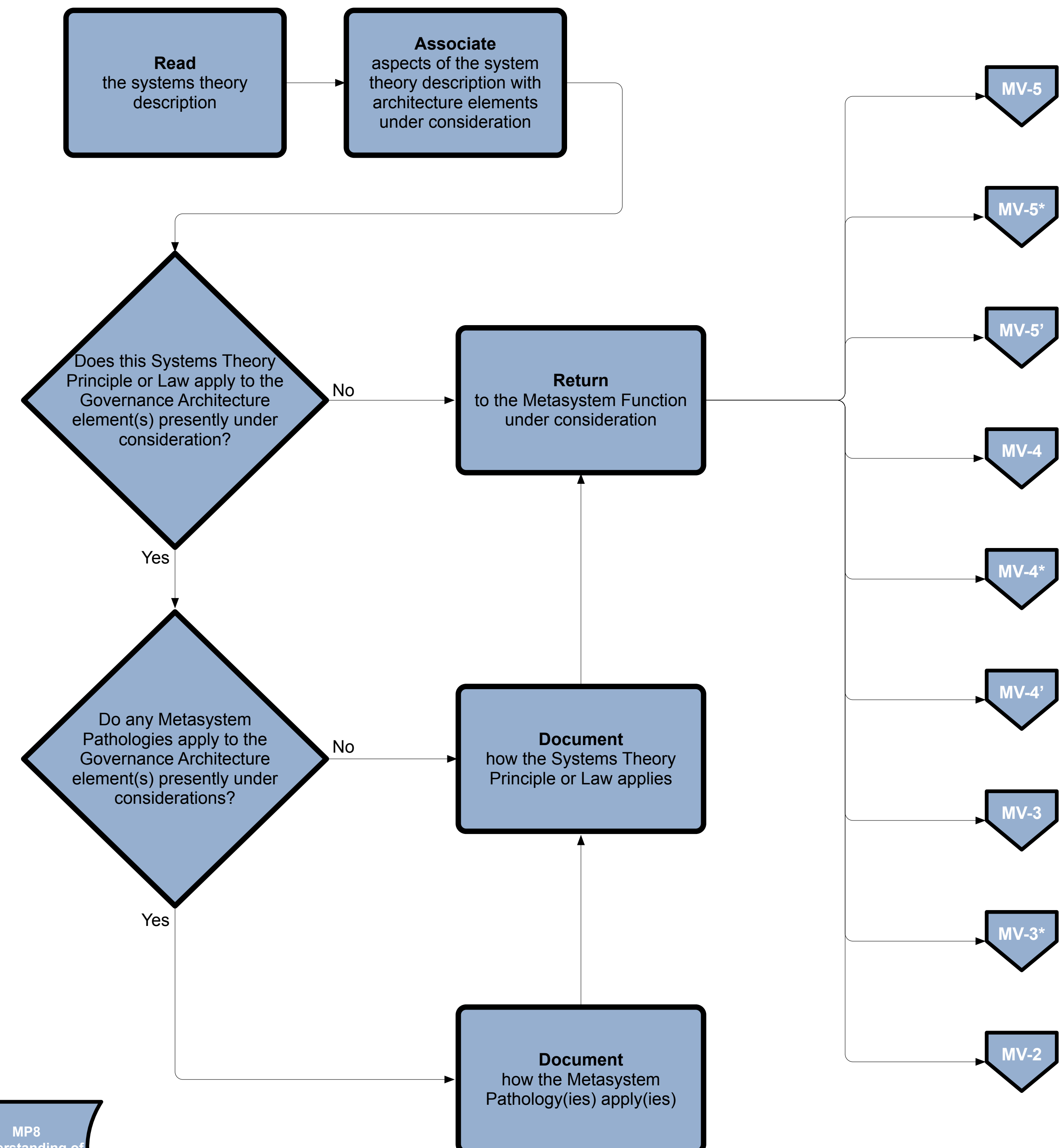

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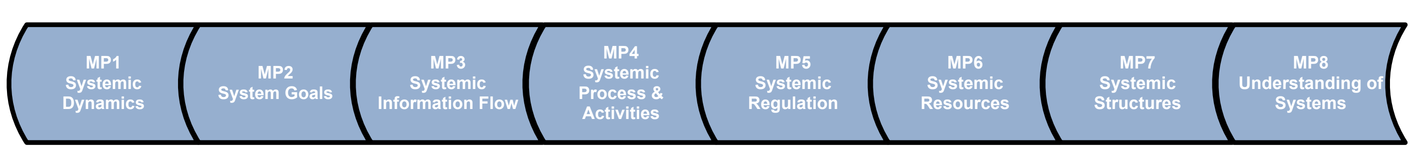

CSGAF Analysis of Systems Theory Law of Requisite Hierarchy (ST23): Considerations for Complex System Governance Architectures

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

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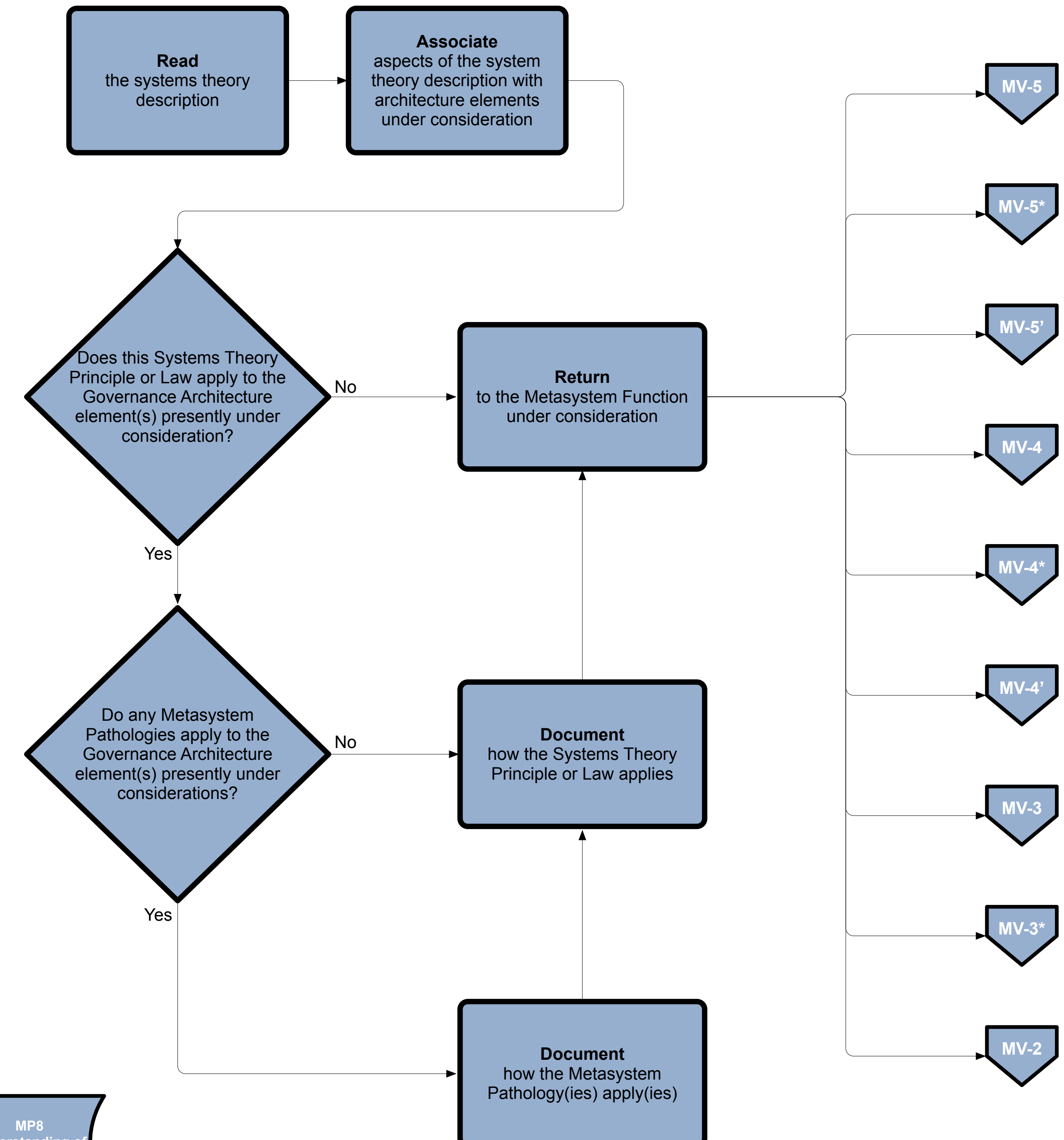

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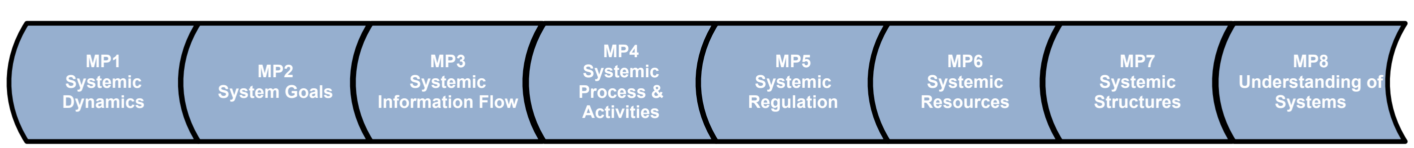
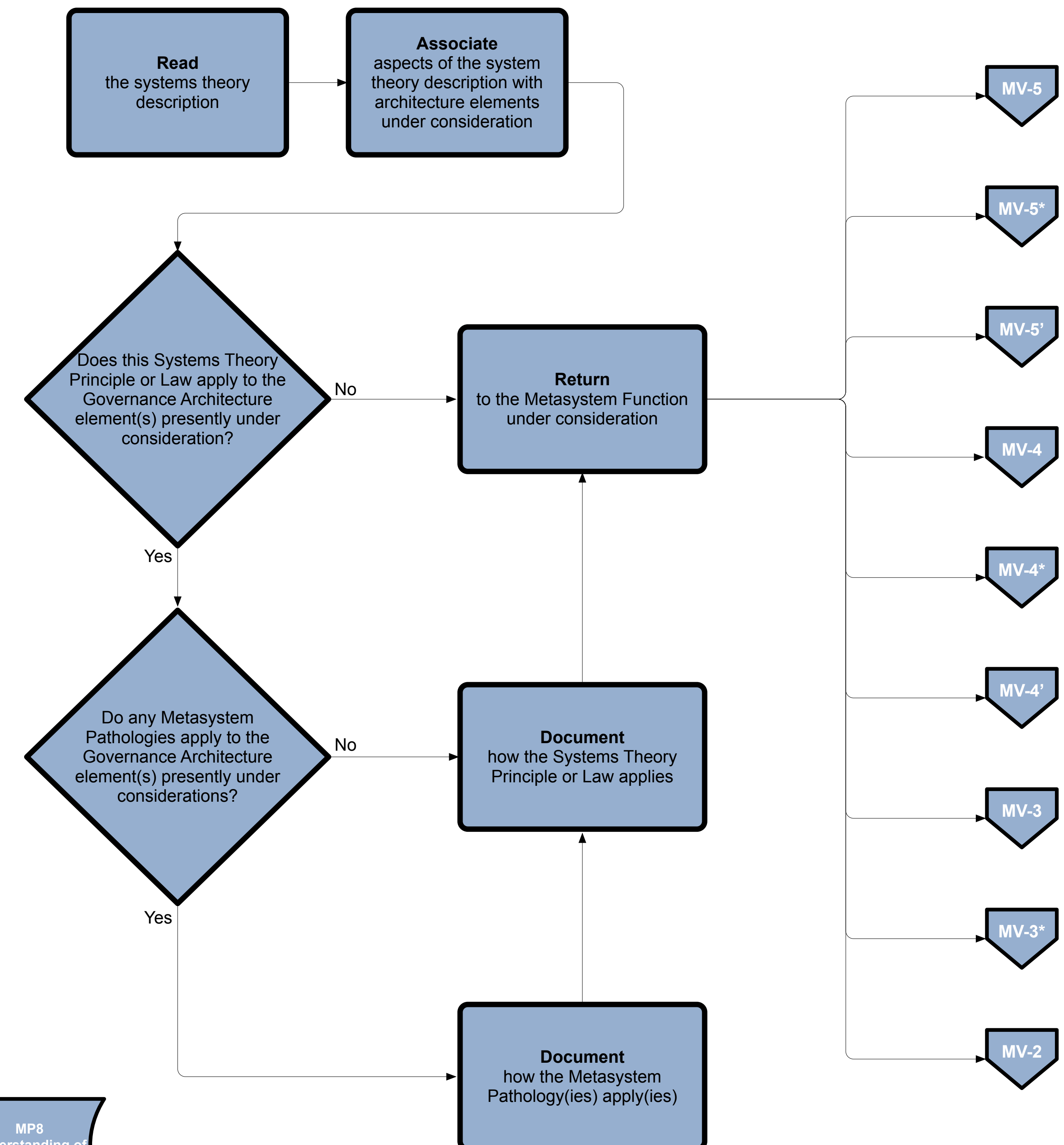
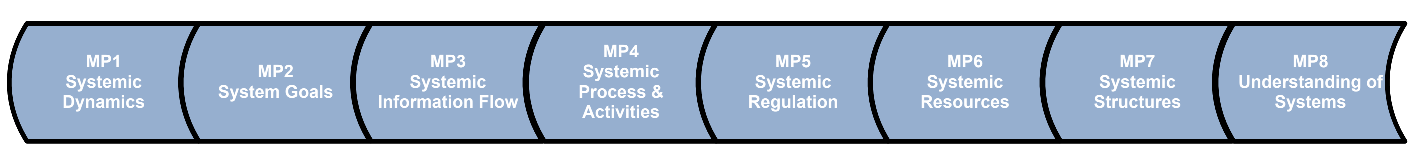


Law of requisite parsimony	
Short description	'requisite parsimony'
Detailed description	"Human short-term memory [brain activity] is incapable of recalling more than seven plus or minus two items" (Adams et al. 2014, p. 118)
Seminal author(s)	Miller, 1956; Simon, 1974
Inclusion criteria	This principle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

Reference: Polinpapilinho, K. F. (2015). *SYSTEMS THEORY-BASED CONSTRUCT FOR IDENTIFYING METASYSTEM PATHOLOGIES FOR COMPLEX SYSTEM GOVERNANCE.* (PhD Dissertation), Old Dominion University, Norfolk, Virginia, USA.



Metasystem Pathology Considerations for Architecture



CSGAF Analysis of Systems Theory Law of Requisite Saliency (ST25): Considerations for Complex System Governance Architectures

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

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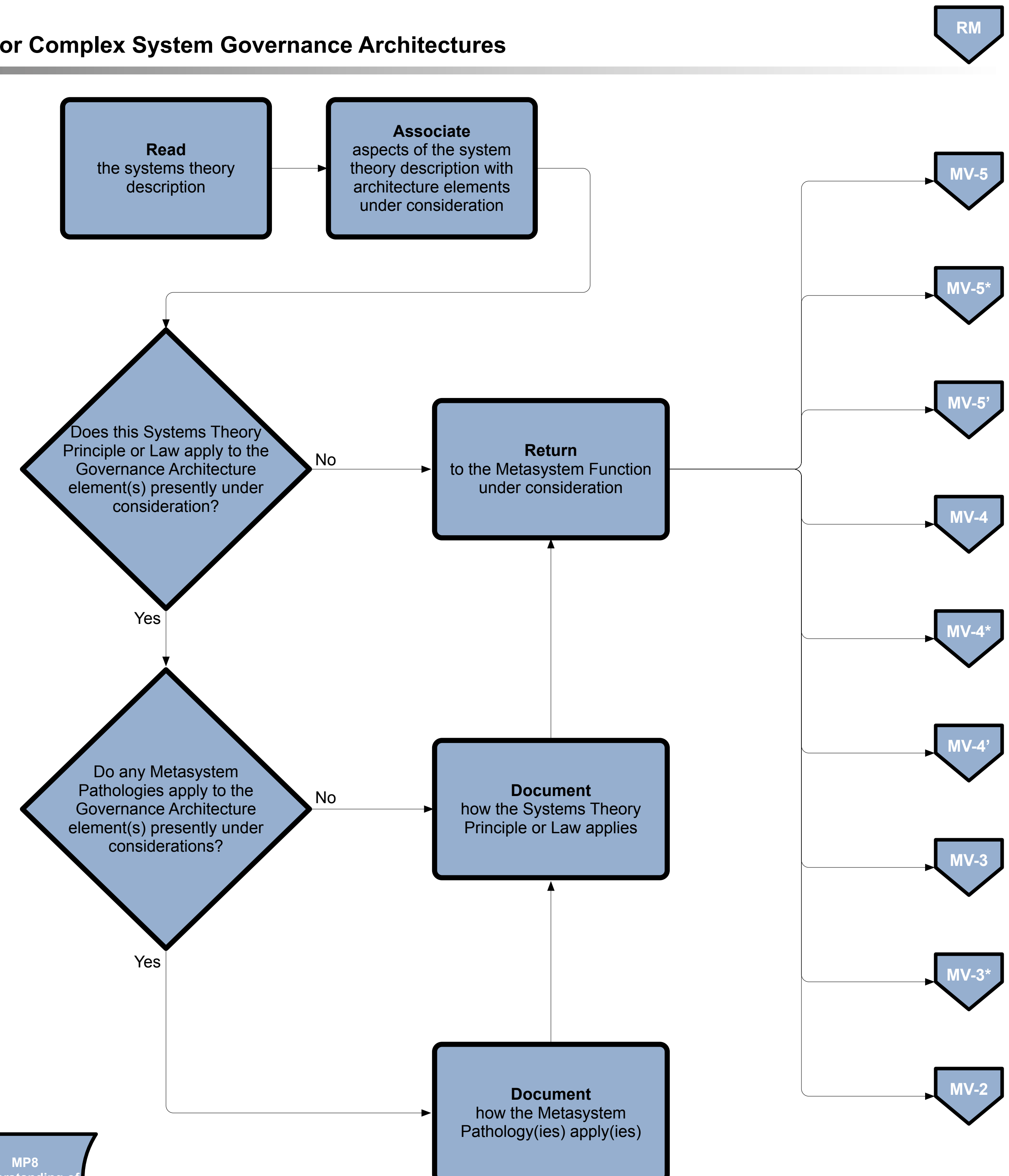
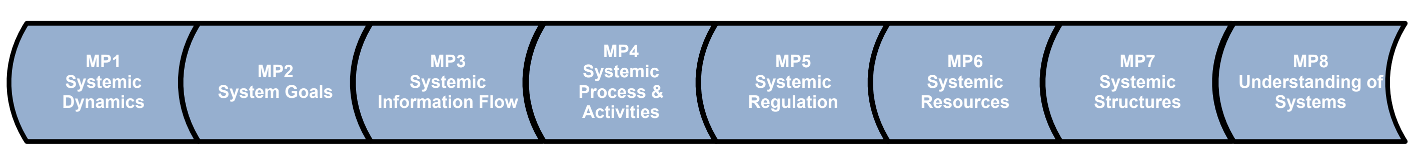


Metasystem Pathology Considerations for Architecture



CSGAF Analysis of Systems Theory Law of Requisite Variety (ST26): Considerations for Complex System Governance Architectures

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

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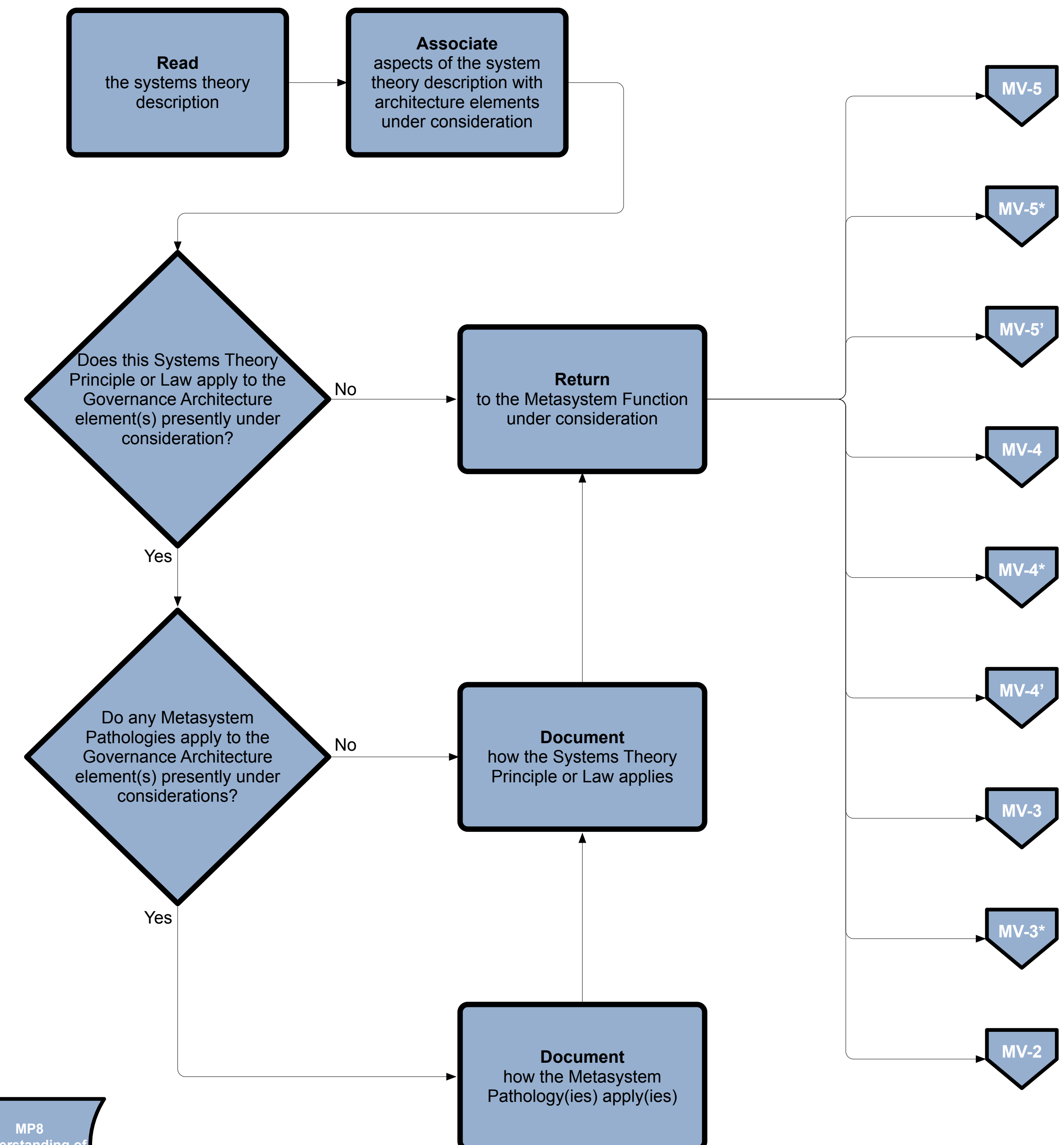

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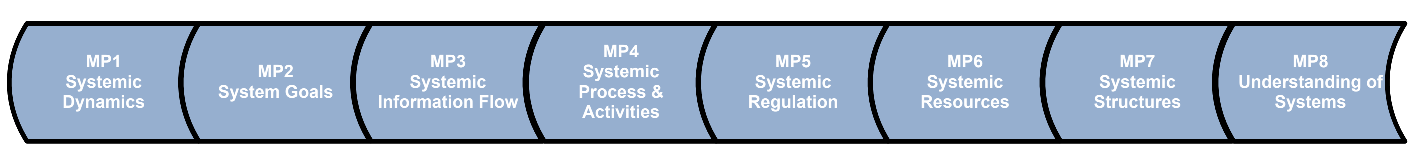

CSGAF Analysis of Systems Theory Principle of Satisficing (ST27): Considerations for Complex System Governance Architectures

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

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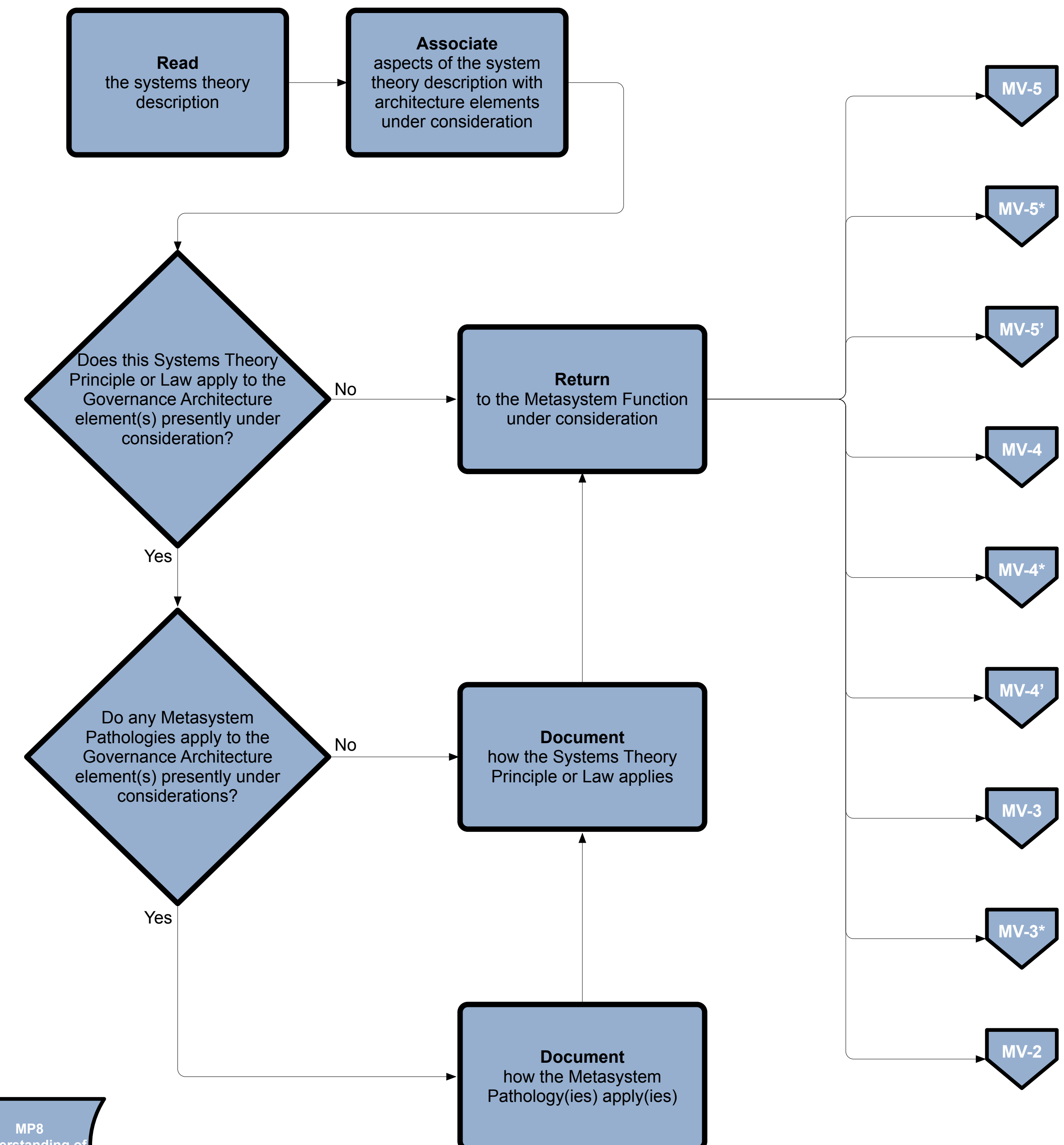
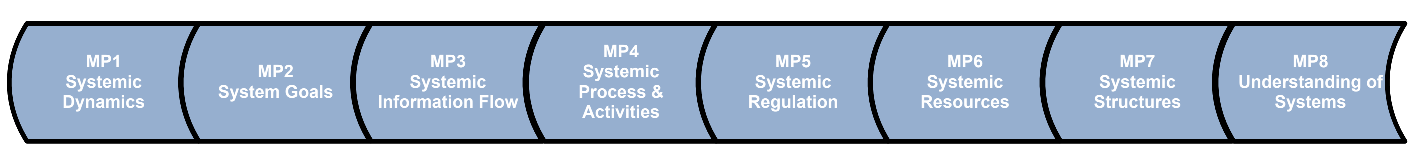


Metasystem Pathology Considerations for Architecture



CSGAF Analysis of Systems Theory Principle of Self-Organization (ST28): Considerations for Complex System Governance Architectures

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

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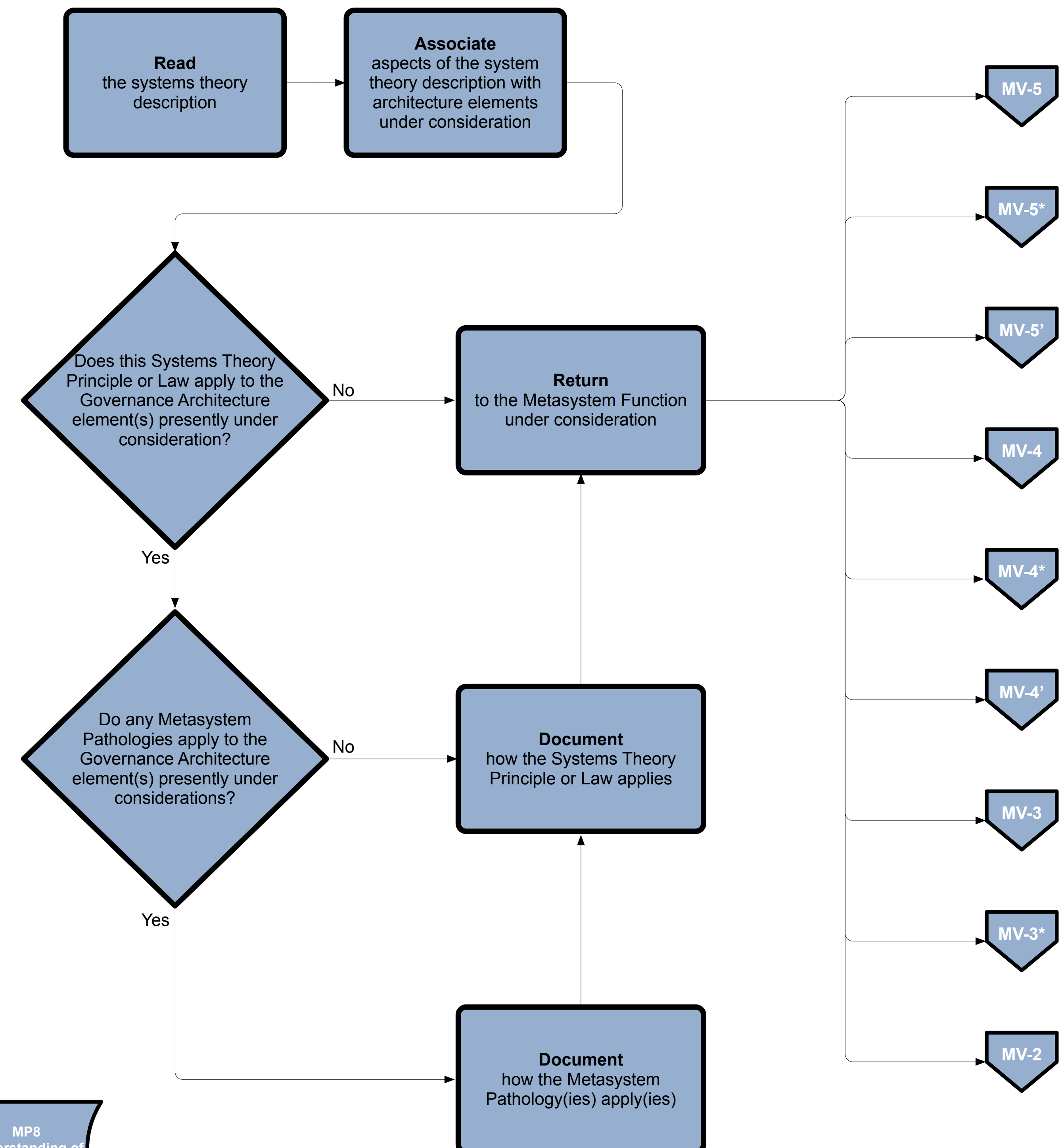
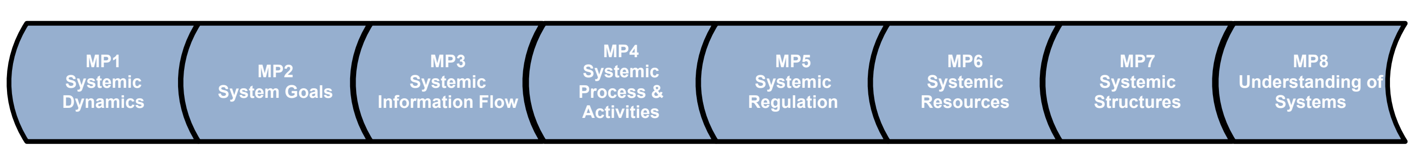


Metasystem Pathology Considerations for Architecture



CSGAF Analysis of Systems Theory Principle of Sub-Optimization (ST29): Considerations for Complex System Governance Architectures

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

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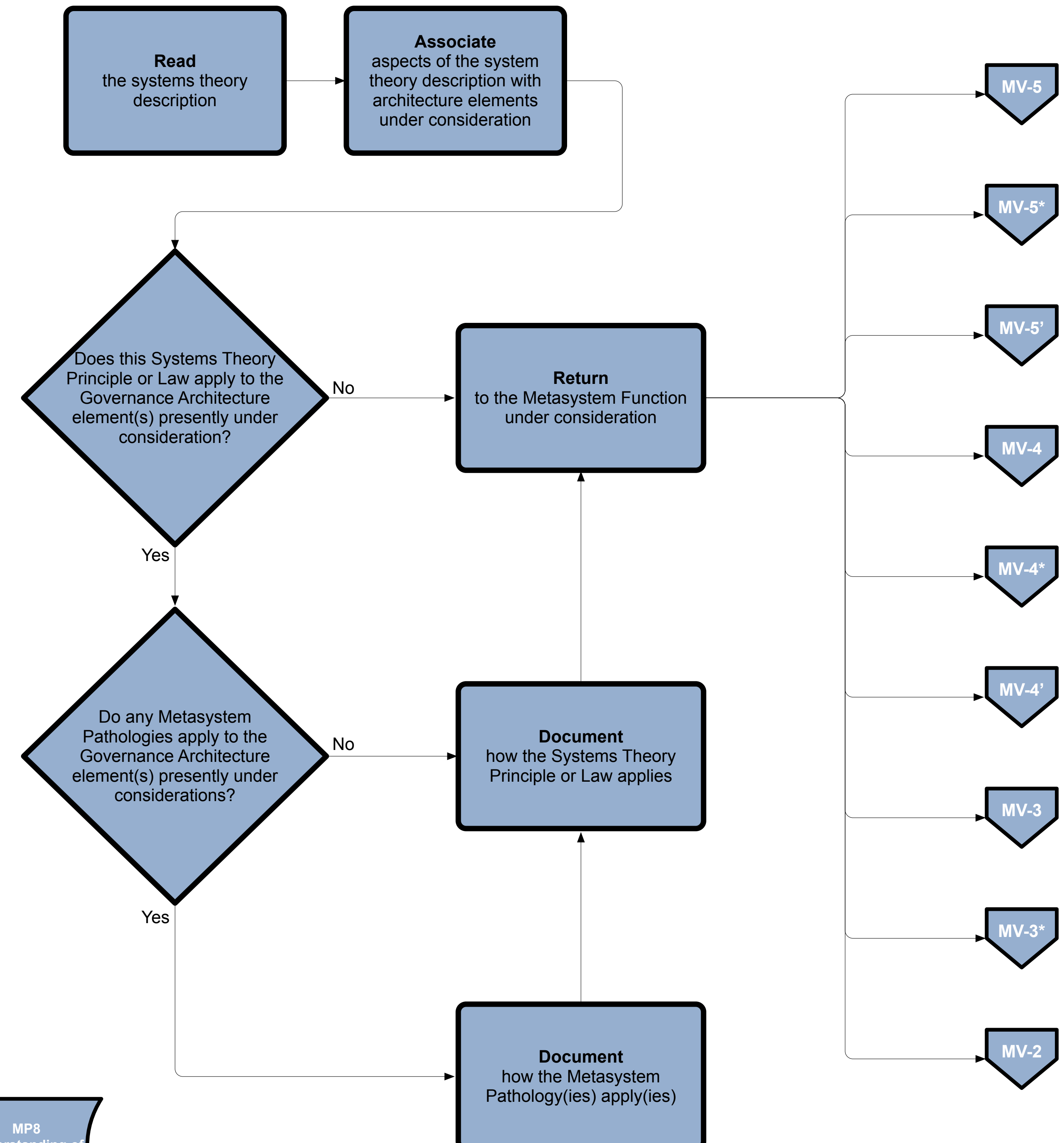
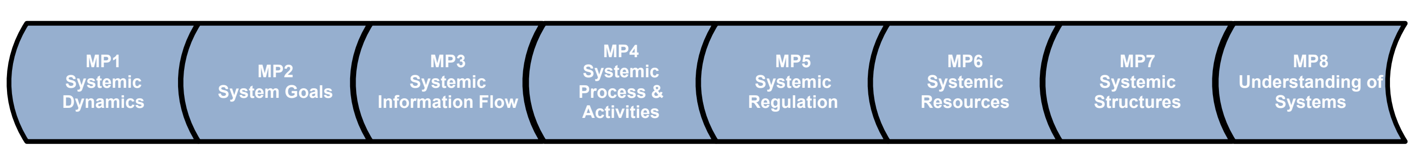


Metasystem Pathology Considerations for Architecture



CSGAF Analysis of Systems Theory Principle of Viability (ST30): Considerations for Complex System Governance Architectures

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

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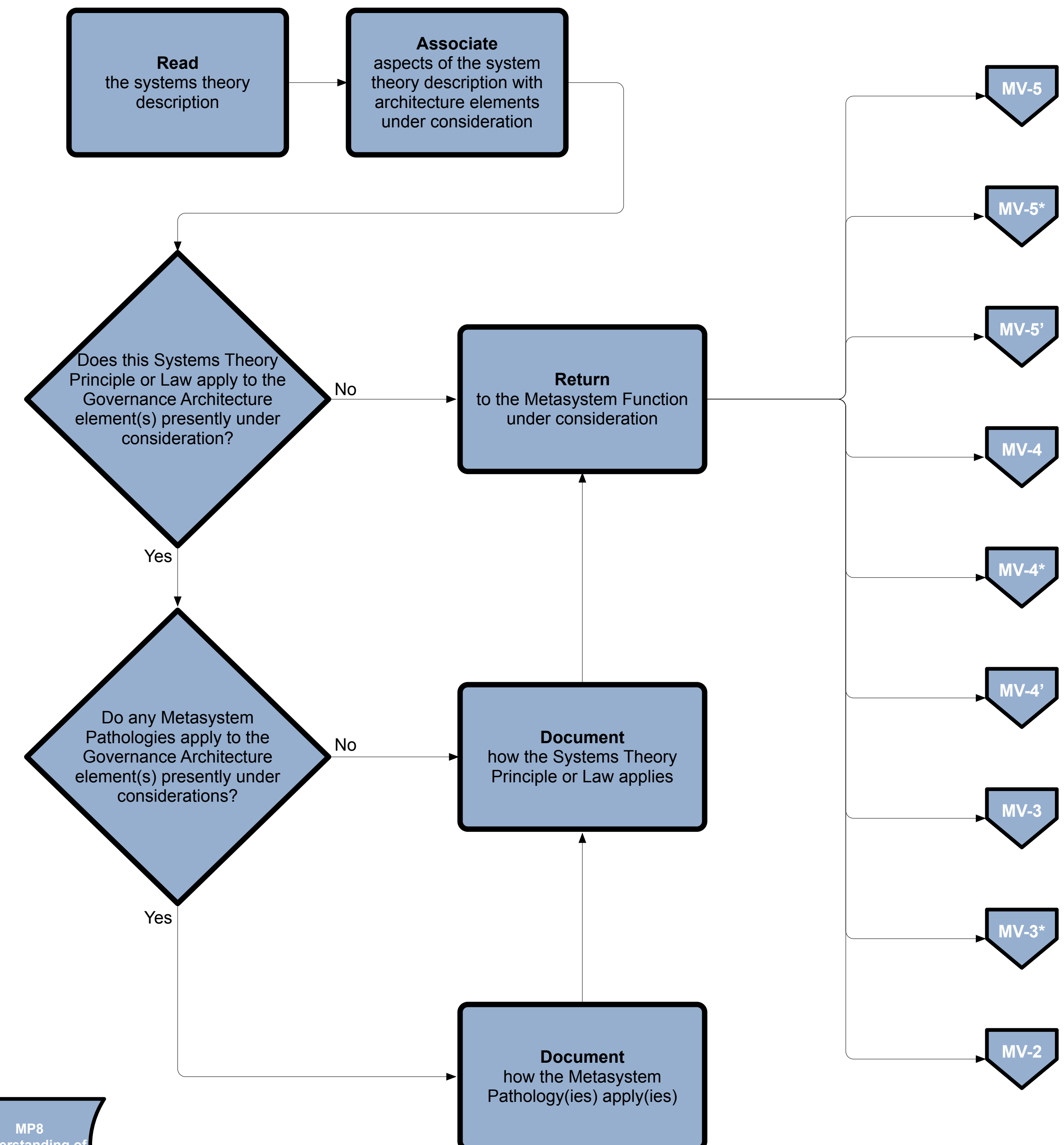
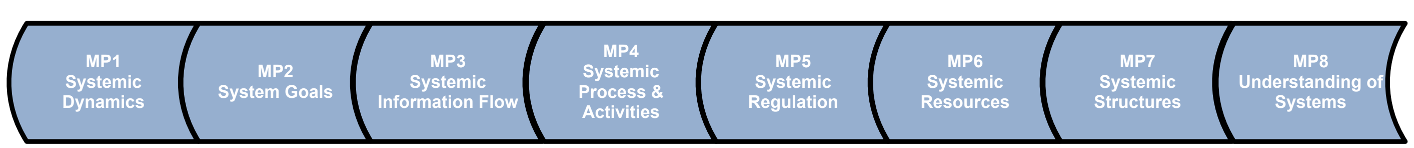


Metasystem Pathology Considerations for Architecture



CSGAF Analysis of Systemic Dynamic Metasystem Pathology (MP1): Considerations for Complex System Governance Architectures

Pathology of Adaptation: System is unable to change its structure in response to external disturbances or it is unable to influence environment and its changes.

Pathology of Dynamic Equilibrium: There is imbalance in interaction in exchange of resources between system and that which is external (system and environment).

Pathology of Emergence: Assumptions that behaviors of the system as a whole can be directly inferred through the examination of properties of subsystems, independent of their interaction.

Pathology of Environmental-Modification: System fails to undertake efforts to influence its environment to reduce the extent of fluctuations.

Pathology of High-Flux: The rate of arrival of resources to systems is less than that necessary to address failures. Resources need to arrive as soon as failure occurs.

Pathology of Morphostasis: System stability is reduced through resistance to change (preferring the *status quo*).

Pathology of Over-Specialization: System becomes too specialized to initiate changes or accommodate other system demands.

Pathology of Polystability: Managing a system as though system level equilibrium is similar to that of its subsystems.

Pathology of Punctuated Equilibrium: The long periods of stasis (i.e., relative calmness) creates a false sense of safeness for a system until a catastrophic event is experienced.

Pathology of Relaxation Time: A system experiences too many changes at the same time; becomes incapable of assimilating change; becomes chaotic.

Pathology of Safe Environment: System fails to create a permanently stable environment.

Pathology of Self-Organization: Failure to work with the self-organizing tendencies of complex systems; global patterns of organization dominate instead of fostering local interactions.

Pathology of Steady State: Focus is placed on steady state (i.e. capability) of a system whole while ignoring capabilities of subsystems.

Pathology of System Environment: Failure to understand lines of demarcation such that there is confusion as to what is part of the environment and what is not.

Pathology of the Red Queen: System fails to survive because of inability to compete with other systems in the same environment. Beyond adapting, a system must expend all its energy to stay in the same place.

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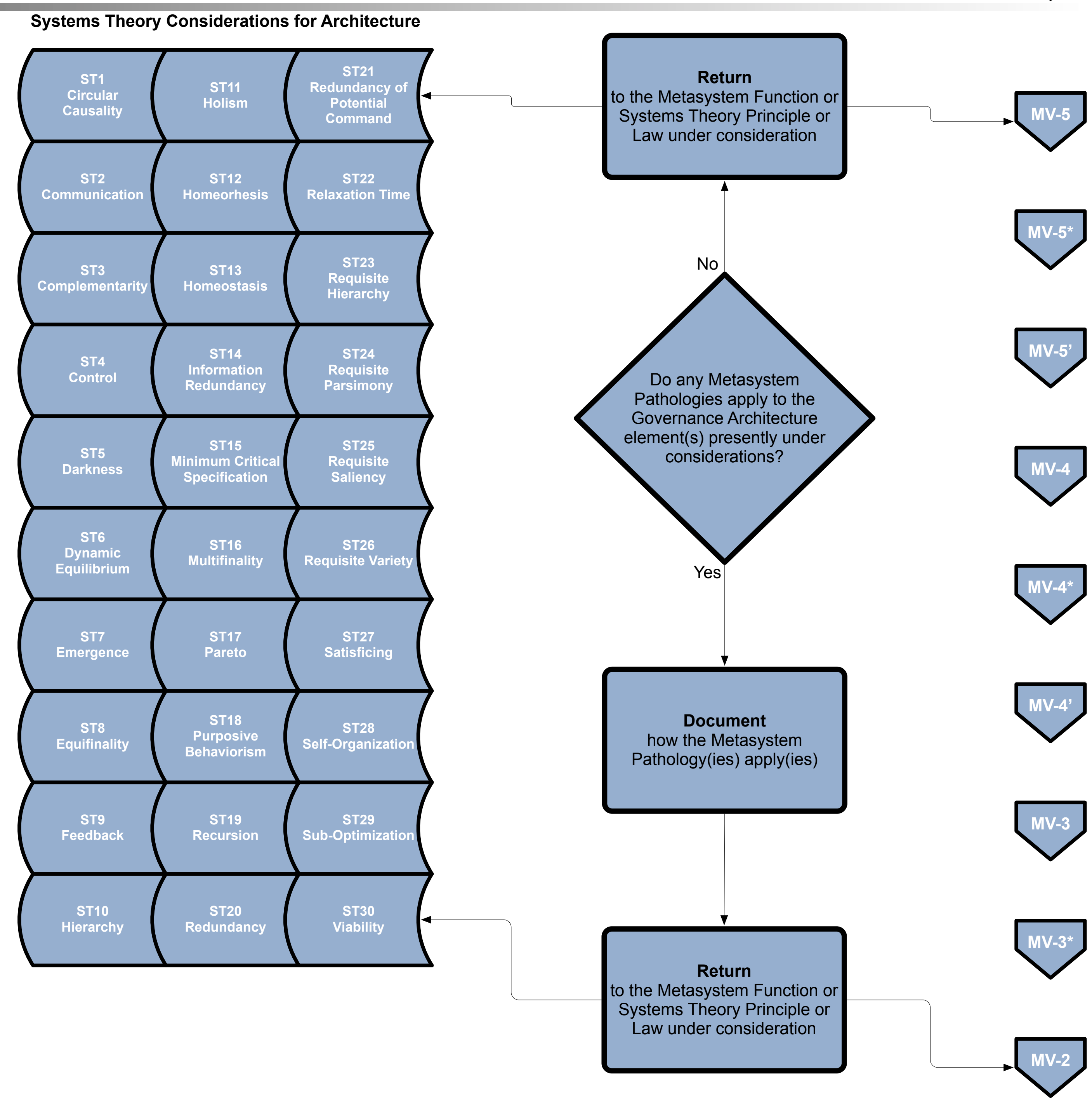

CSGAF Analysis of Systemic Goal Metasystem Pathology (MP2): Considerations for Complex System Governance Architectures

Pathology of Equifinality: Managing a system with the belief that there exists only one approach/method to achieve a final desired state - including goals, missions, and objectives.

Pathology of Multifinality: Tendency to draw premature conclusions based on previous experiences; a particular conclusion is reached since initial operation conditions of a system of interest appear to be similar to another situation.

Pathology of Purposive Behavior: System purpose is unguided (i.e., not goal-oriented) and primarily based on intended results as opposed to what the system is actually producing, including outcomes that are indirectly related that are experienced as unintended consequences.

Pathology of Satisficing: The management team actively searches for the best possible solution (i.e., optimization) instead of searching for appropriate solution(s) in a given situation withe the information at hand; a good-enough solution.

Pathology of Unity: Lacking a clear purpose that serves to internally unify and externally distinguish the system.

Pathology of Viability: Key system parameters are not controlled and maintained within their physiological limits; Productive subsystems lack capability to survive as independent systems.

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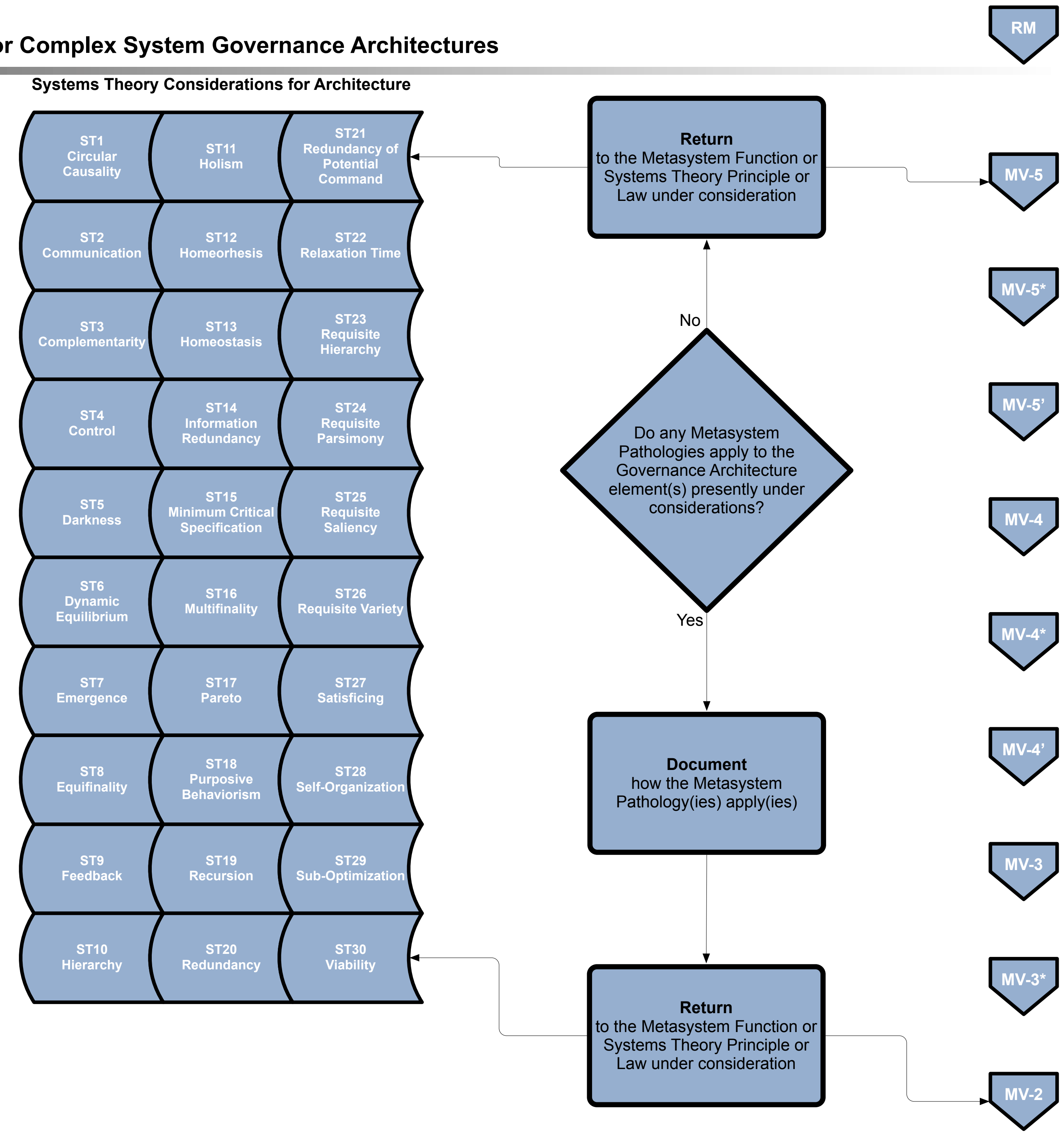

Pathology of Channel Capacity: Ineffectiveness in transmitting different messages; channel needs to be modified to transmit; does not account for noise (i.e., disturbances) in transmission; information not received in a timely manner.

Pathology of Communication: Receiver of information is unable to receive information as intended by the sender; it involves issues emanating from communication mechanisms that enable processing, storing, and retrieval of information.

Pathology of Equivocation: Inefficiency in delivering intended concealed messages from one point to another so that only the intended receiver can decipher and understand its meaning; even though the message is a secret, anyone getting hold of the message is able to decipher and understand the secret.

Pathology of Information Redundancy: Information transmission (i.e., communication) is not enhanced though redundant information transmission; redundant information transmission is viewed as a waste of resources since it is repetitive and requires extra channel capacity; inability to combat noise which works to reduce efficiency (i.e., bits of information per second that can be sent and received) and accuracy (i.e., clear reception of message).

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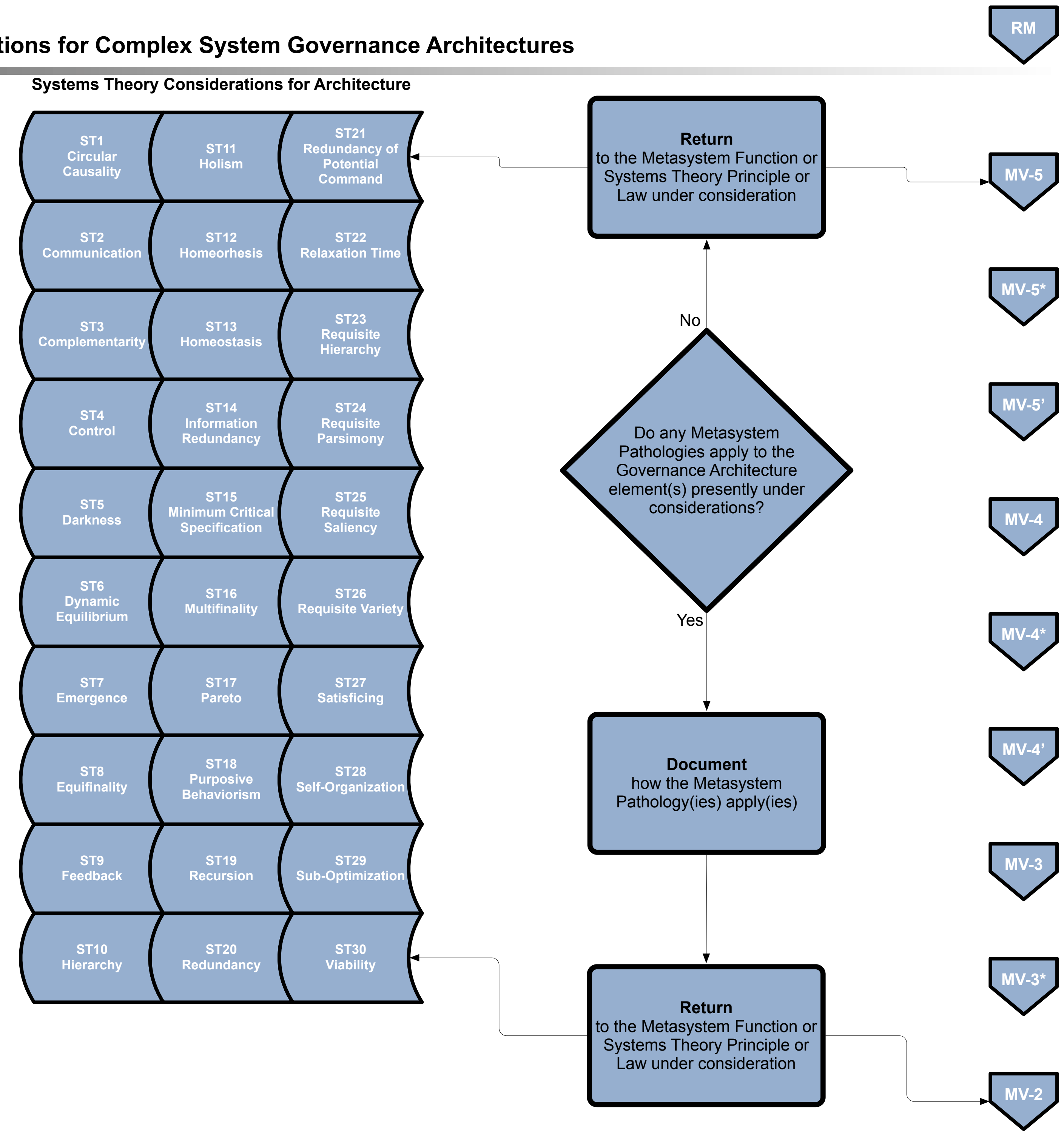

CSGAF Analysis of Systemic Process Metasystem Pathology (MP4): Considerations for Complex System Governance Architectures

Pathology of Consequent Production: Failure to focus on the underlying processes/relationships in the system responsible for producing the results (desirable/undesirable); focus is increasingly placed on the outcome/outputs themselves as opposed to the producing system.

Pathology of Diminishing Returns: Mistakenly assuming that productivity can be increased simply by increasing the number of workforce; investing in better technology or improving the skills of the existing workforce are ignored.

Pathology of Events of Low Probability: Expecting a system to process and accommodate all scenarios without differentiation; attempting to account for all possible scenarios is too complex to be workable and jeopardizes those fundamental processes and scenarios critical to system survival.

Pathology of Maximum Power: System is able to take in and transform information but lacking in the ability to increase the transformation capacity to accommodate increases; the system is slow to keep up with the information being generated.

Pathology of Sociotechnicality: Preference is placed on either the social (i.e., soft/human) or the technical (i.e., technology) aspects of the system as opposed to a joint optimization of both social and technical; one aspect is promoted as more important than the other.

Pathology of Sub-Optimization: Making independent improvements to processes in subsystems to improve performance of the system whole; optimizing subsystems rather than trying to design and create a process that supports system level performance.

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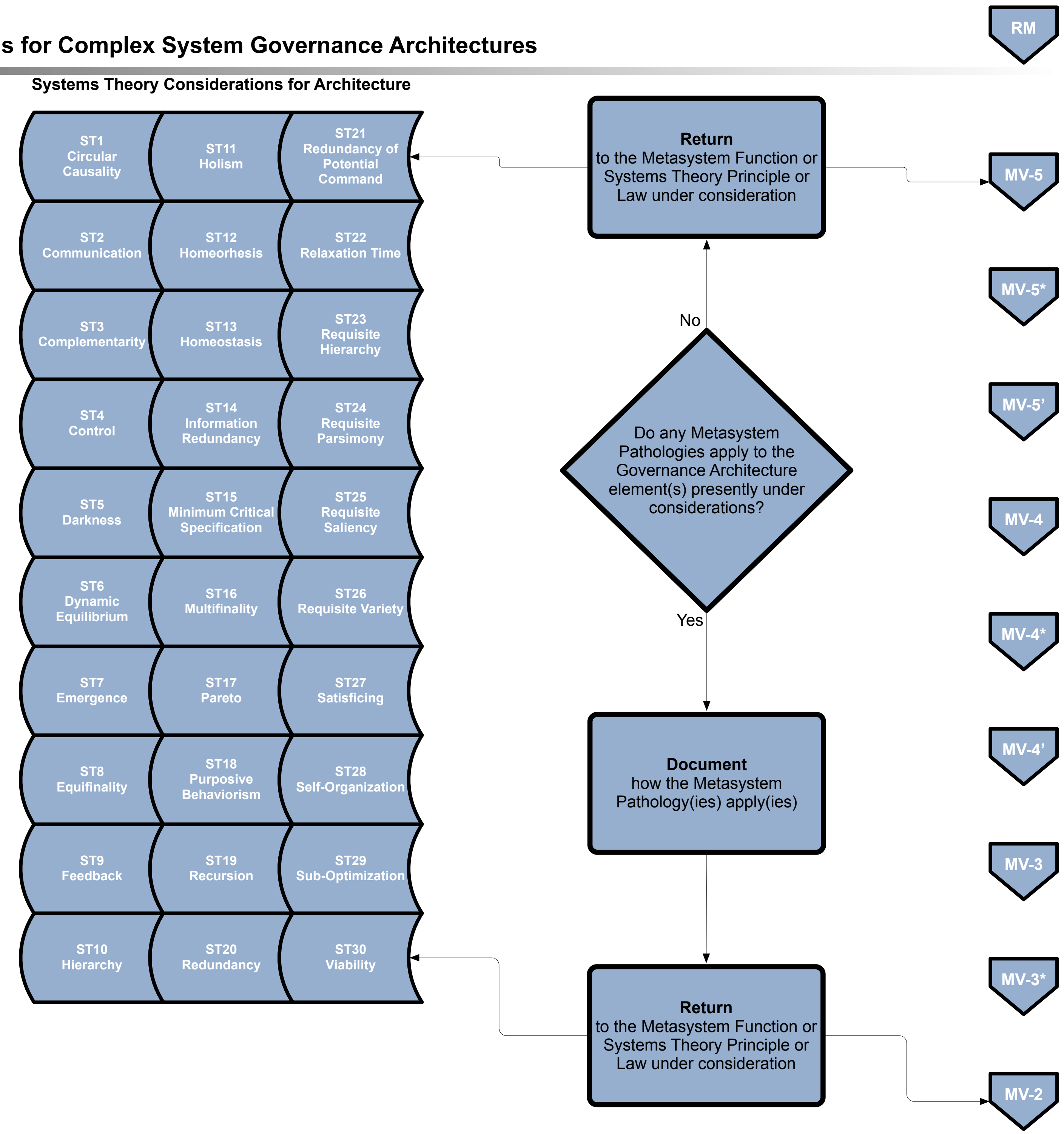

CSGAF Analysis of Systemic Regulatory Metasystem Pathology (MP5): Considerations for Complex System Governance Architectures

Pathology of Autonomy: Subsystems are not afforded the ability to act independently with respect to taking actions and making decisions; they are over-constrained by a higher system.

Pathology of Balance of Tensions: Lacking a governing structure that must relieve tension among different subsystems; finding the right balance between independence of subsystems and integration of the whole, self-organization and structured design, and maintaining a balance between system stability and change.

Pathology of Control: Lacking effective control mechanisms to preserve system identity; inability to remove inappropriate or incompatible goals; inability to consistently achieve intended goals; inability to efficiently utilize resources; inability to effectively contribute to the higher-level system purpose.

Pathology of Cybernetic Stability: Lacking a sufficient number of external connections to the external environment; a system lacks a broad sense of self and responsibility; does not exchange information or develop effective controls to provide self-governance.

Pathology of Dialecticism: Lacking the ability to reflect on errors and deploy efforts to correct detected errors; recommendations can be made, but the system lacks ability to implement the recommendations.

Pathology of Feedback: Lacking the ability to improve system behaviors using scanning mechanisms; scanning mechanisms are incapable of feeding back information to reduce fluctuations; small effects are ignored and in time produce devastating effects on the system.

Pathology of Frame of Reference: Lacking an explicit and consistent standard by which system performance can be judged; presuppositions and assumptions are not made explicit.

Pathology of Homeorhesis: Lacking mechanisms to guide and enable a system to return to its pre-set path of trajectory following an environmental disturbance.

Pathology of Homeostasis: Lacking monitoring mechanisms that are used to alert of any external changes affecting system such that essential internal variables are not maintained.

Pathology of Iteration: Lacking means to enable continuous comparison of first iteration to the normal and subsequent measures for error detection; the iteration process is overly long, overly elaborate, and performing only one iteration.

Pathology of Least Effort: Electing to progress by selecting a path of high resistance; using methods and tools that are convenient and necessarily effective; least efforts are not compatible with desired results.

Pathology of Minimum Critical Specification: Activities that must be undertaken are overly prescribed as to how they must be done; there is no room for creativity or flexibility.

Pathology of Pareto: Undertaking significant efforts inconsistent with the '80/20 production' curve; assuming the existence of a direct 'causal-interrelationship' in system performance.

Pathology of Redundancy of Potential Command: Subsystems and their elements are lacking the 'freedom' to decide and act on behalf of the system as a whole; the speed at which the system responds to novel events, information, trends, threats, and opportunities is reduced.

Pathology of Requisite Hierarchy: Lacking an effective multi-regulatory system body designed to handle variety at each level of the system.

Pathology of Requisite Knowledge: Lacking a system regulator that is well-informed of relevant knowledge essential for viability; regulator lacks ability to select the right actions from a knowledge base to address perturbations; taking actions on the basis of *trial and error* in hopes of eventually solving system issues.

Pathology of Requisite Variety: The variety of the regulator is not equal to the variety of the situation to be controlled; lacks sufficient capacity to match variety of situations being controlled.

Pathology of Subsidiarity: Preferring to defer to a higher authority on local issues; elevating subsystem issues (i.e., local) to a higher system level; subsystems should only seek system level solutions when they have exceeded their capacity to deal with issues.

Pathology of The First Cybernetic Control: Lacking ability to compare system behavior against a set standard; if the comparison is done, the system might lack mechanisms to continuously undertake commensurate corrective measures and actions.

Pathology of The Second Cybernetic Control: Control is a function of communication; a system might go out of control it its communications are incapable of proving sufficient regulatory capacity to address variety.

Pathology of The Third Cybernetic Control: Attempting to bring a system into control that hasn't gone out of control; if a system is performing, 'tinkering' may make performance worse.

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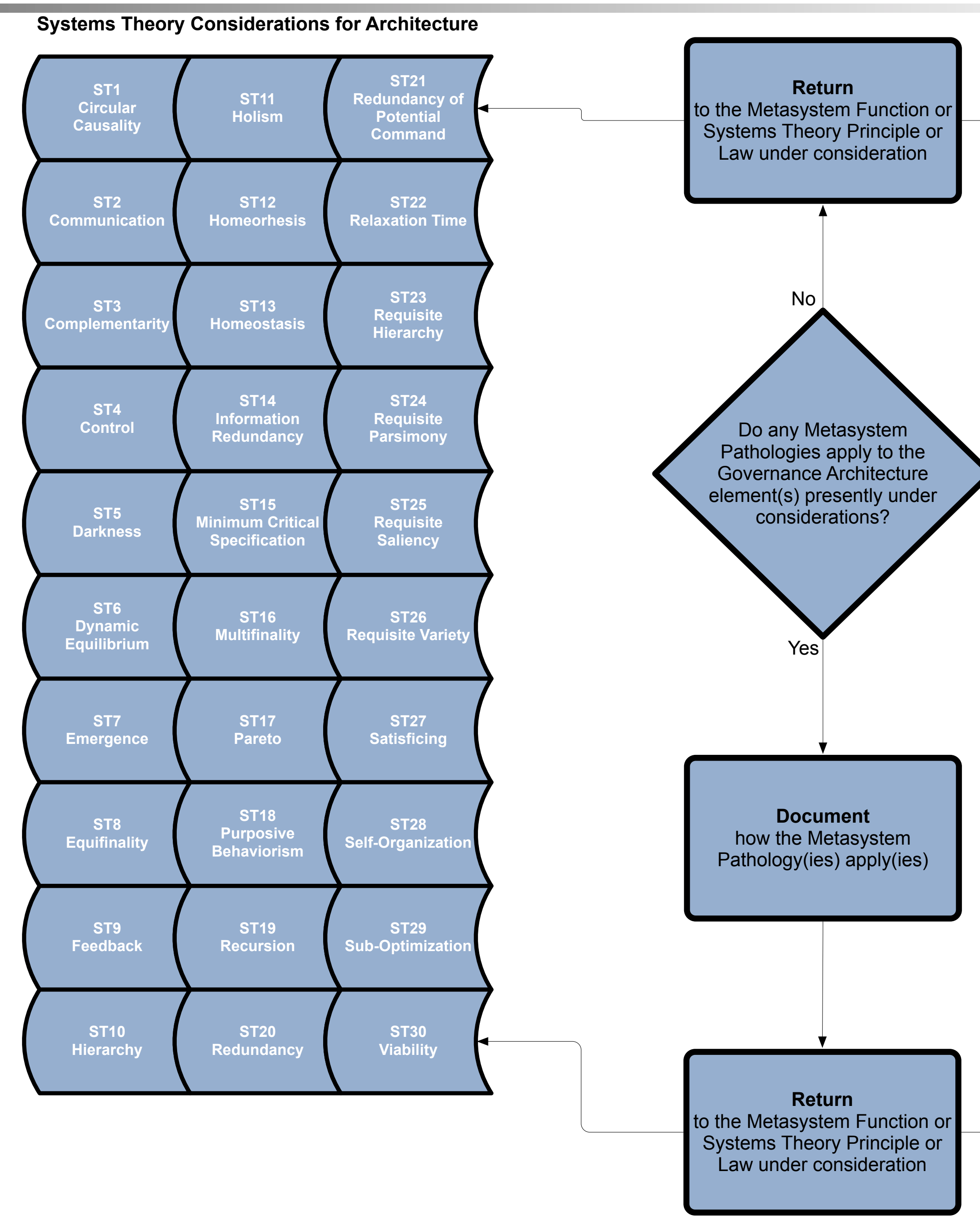

CSGAF Analysis of Systemic Resources Metasystem Pathology (MP6): Considerations for Complex System Governance Architectures

Pathology of Buffering: Lacking a surplus of resources; operating a system without sufficient slack; unaware that unused resources become waste and take up space.

Pathology of Pareto Optimality: Undertaking a measure (e.g., allocation of resources) to improve one part of a system without knowing the adverse effects to other parts of the system; it's not possible to make one part of the system better without making another part worse-off; the resources being used have to come from somewhere.

Pathology of Patchiness: Lacking ability to consume a variety of resources available from the environment; counter to the pathology of Omnivory where internal structure can only consume one type of resource; failure to *acquire* test to determine use of different resources; despite presence of many resources, a system only consumes one type of resource.

Pathology of Redundancy of Resources: Subsystems lacking 'freedom' to decide and act on behalf of the system; a well-designed system will provide subsystems the independence necessary to seize opportunities; decision making is not conferred to the system level that first receives information and can most expeditiously respond, instead deferring to the chain of command.

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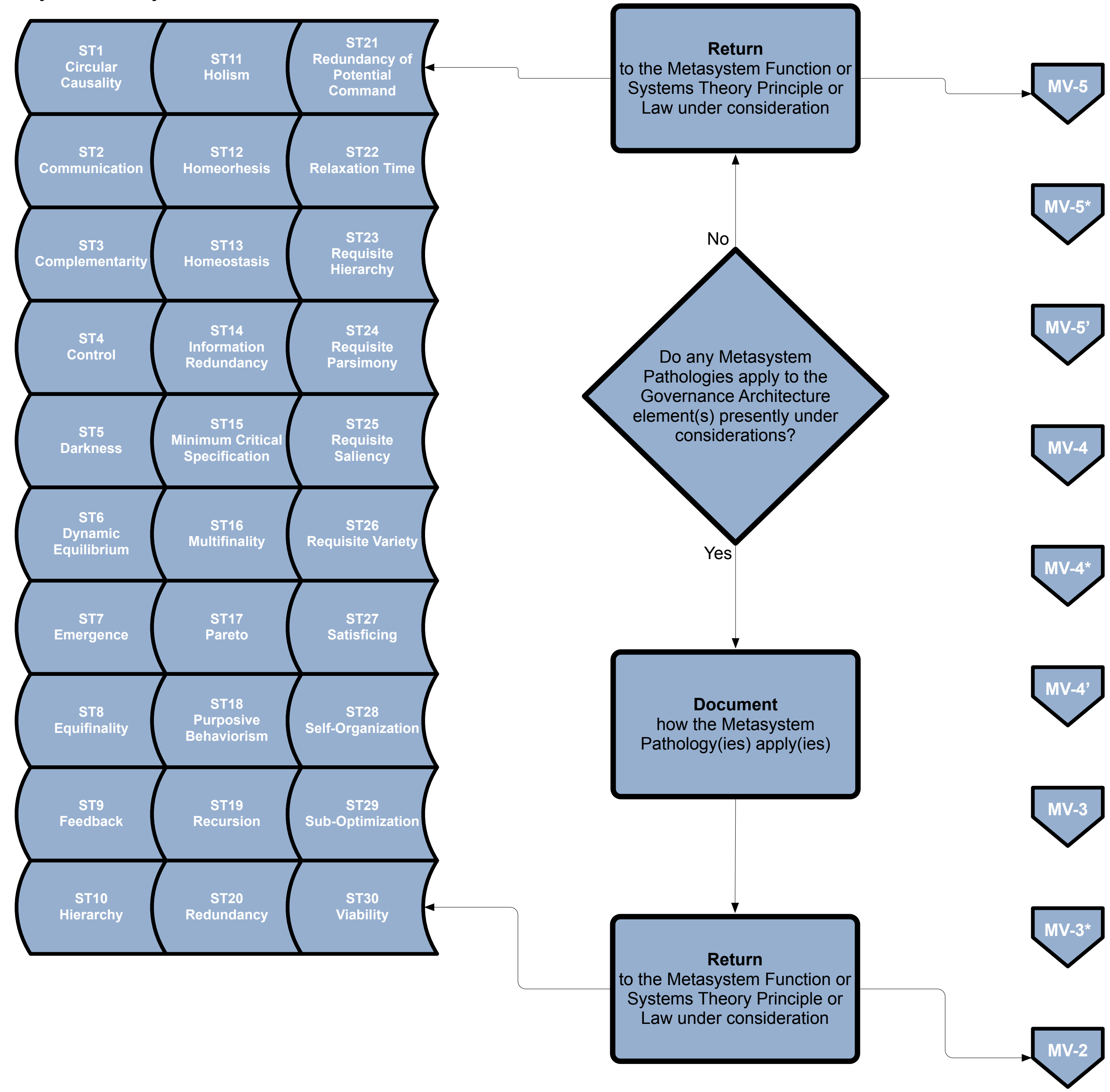
Systems Theory Considerations for Architecture



CSGAF Analysis of Systemic Structure Metasystem Pathology (MP7): Considerations for Complex System Governance Architectures

Pathology of Flatness: The governance structure is an inverted pyramid; a system has a larger number of administrators relative to that of producers; everyone can't be an administrator.

Pathology of Hierarchy: Lacking a basic structure of a hierarchy; organization and people are not organized into an integrated system with appropriate levels of hierarchy that permit regulation necessary to provide appropriate control; using the same regulations at all levels of a hierarchy.

Pathology of Internal Elaboration: Overemphasizing policy development and procedural elaboration to manage in the system; limited efforts are directed toward purposeful system development.

Pathology of Morphogenesis: Failing to create new and potentially radically different structures that support existing structures; frequently allowing new changes without allowing old changes to take hold.

Pathology of Omnivory: Having internal structures (i.e., pathways) that cannot easily be modified to increase their capacity to take in a variety of resources.

Pathology of Organizational Closure: Lacking a unified structure that provides an unambiguous identity for the system; system goals and those of subsystems are not complementary; having subsystems that are too autonomous to support a unified system acting as a whole; extrinsic purpose/goal might exist but system lacks a set of relationships that unify subsystem to system and to the environment.

Pathology of Recursiveness: Incapable of defining self as containing viable systems and being embedded in a larger viable system.

Pathology of Resilience: Inability to withstand disturbances; temporarily failing and then unable to return to previous configuration; only resilient to a narrow range of external fluctuations.

Pathology of Robustness: Lacking ability to use simple or complex mechanisms to withstand environmental changes without modifying system structure; system not being accustomed to coping with large and sudden changes.

Pathology of Separability: Being too tightly coupled together such that a small disturbance is reflected throughout the system; a single breakdown can have a major effect on the system as a whole.

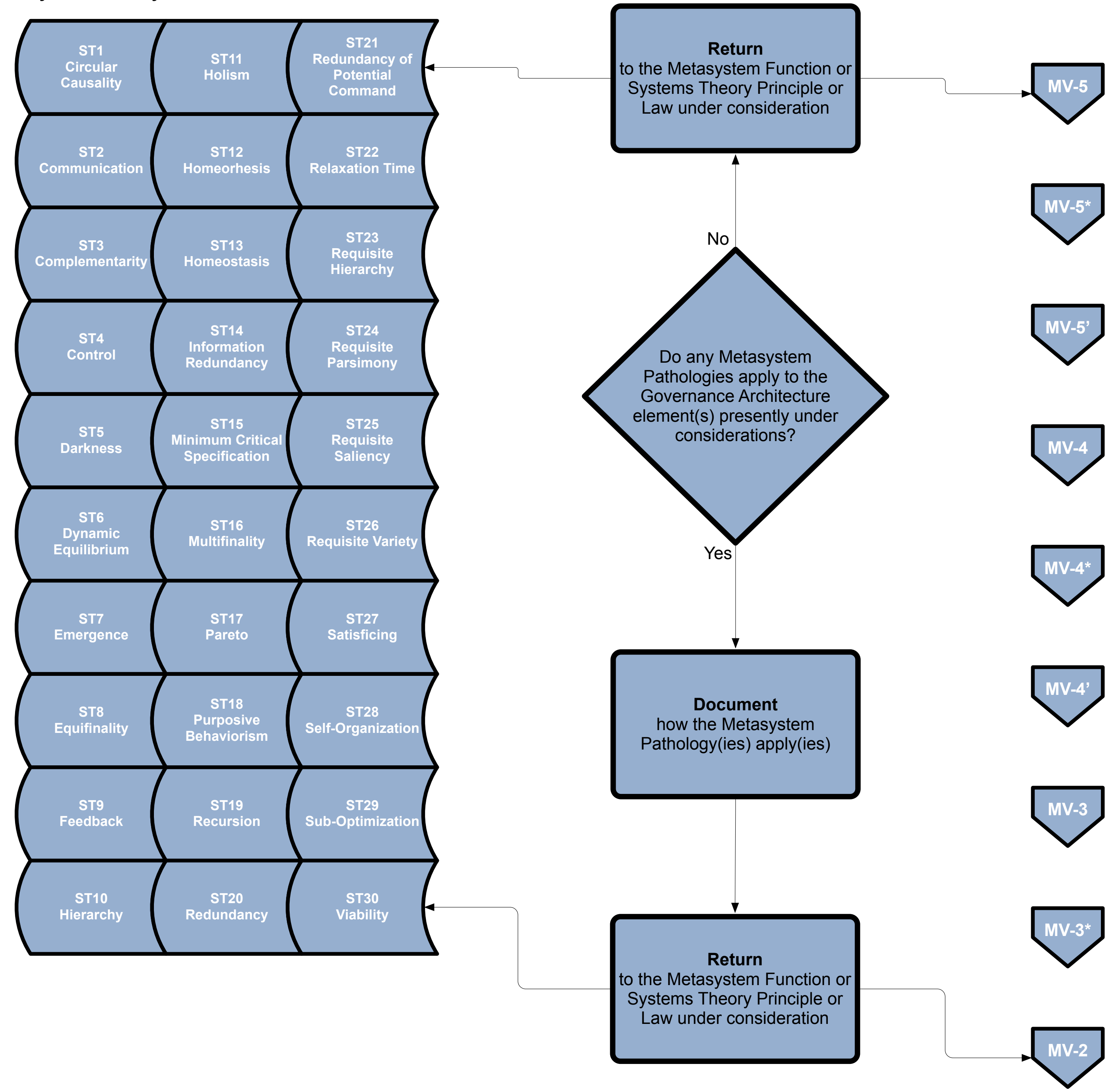
Pathology of Genesis of Structure: Lacking initiative that maintains information flow between a forming structure and the system; not allowing sufficient time for a new structure to take shape.

Pathology of System Boundary: Having a fuzzy defined line of demarcation that delineates a system and its environment; lacking minimum description distinguishing the system.

Pathology of System Context: Attempting to address a system independent of the context within which it is embedded; not accounting for conditions or patterns that enable and/or constrain system solution development, system solution deployment, or interpretation.

Reference: Polinpapilinho, K. F. (2015). *SYSTEMS THEORY-BASED CONSTRUCT FOR IDENTIFYING METASYSTEM PATHOLOGIES FOR COMPLEX SYSTEM GOVERNANCE.* (PhD Dissertation), Old Dominion University, Norfolk, Virginia, USA.

Systems Theory Considerations for Architecture



CSGAF Analysis of Systemic Understanding Metasystem Pathology (MP8): Considerations for Complex System Governance Architectures

Pathology of Basins of Stability: Reduction in system stability as attributed to inability to recognize different system configurations or their transition periods; assuming that each configuration uses the same resources and produces different consequences; difficulty in initiating a required move from one basin to the next; inability to direct the system - letting it gravitate toward a least energy state.

Pathology of Circular Causality: Using a traditional (linear) causality model of thinking without recognizing the intricate interrelationships in a complex system; assuming it is not possible to have a wide range of conditions leading to the same result; focusing on cause rather than processes and patterns; assuming simple cause-effect relationships rather than mutual or multiple causality.

Pathology of Complementarity: Ignoring alternative perspectives/models that are not entirely compatible with the established-predominate perspectives including missions, goals and objectives; assuming there is only one 'right' perspective; shunning different perspectives and the insights they contain; not making different perspective explicit.

Pathology of Darkness: Operating under the assumption that all relevant aspects, including behaviors, are known; striving to know all aspects of a system including elements as well as their interactions; focusing on crucial aspects of a system while avoiding irrelevant details.

Pathology of Eudemony: Placing precedence on financial profitability above all other measures; lacking the right balance in material, technical, physical, social, nutritional, cognitive, spiritual, and environmental aspects.

Pathology of Holism: Operating under assumption that behaviors of an integrated system are possessed in parts of the system; assuming that understanding of a system can be maintained even past a particular point of reduction; system level behaviors can be deduced from behaviors of the parts.

Pathology of Incompleteness: Operating under the assumption that the traditional terms of discourse/from of reference of organization is both consistent and complete; assuming that the framework of reference considers all possible events including unforeseen ones; assuming all problems are solvable in current frame of reference.

Pathology of Reification: Distorting reality by confusing abstract ideas with concrete physical entities; confusing parameters of subjectivity and objectivity accorded to systems, their operation, or their representations.

Pathology of Requisite Parsimony: Assigning more responsibilities beyond what the human element of the system can reasonably handle; going beyond seven plus/minus two elements for human processing and still expecting sound reasoning.

Pathology of Requisite Saliency: Failing to differentiate between different missions/objectives of the system; emphasizing the wrong elements, out of proportion to what they deserve; system members are creating more issues rather than solving them; not operating using a common knowledge base; creating unfocused dialog, unjustified decisions, and arbitrary design outcomes that are not understood or even actionable by a diverse workforce.

Pathology of Synchronicity: Ignoring meaningfully related events because they are impossible to explain in terms of cause-effect language; assuming that current methods and tools can discern all relationships in a complex system.

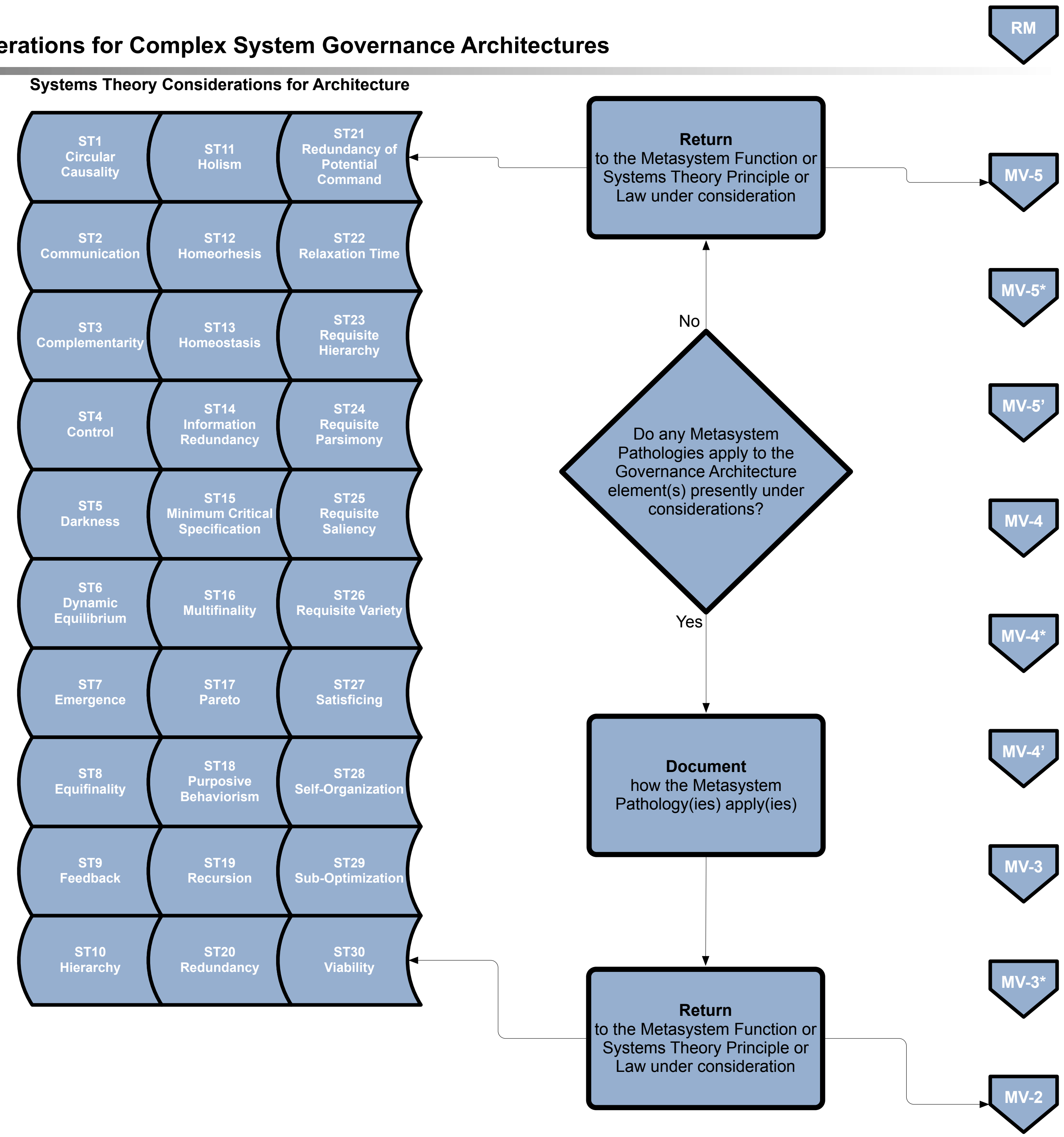
Pathology of Transcendence: Operating under the assumption that stability and viability of a system is only achievable within the confines of reality as defined by the objective realm of scientific/physical laws; the universe simply organizes itself in dimensions of physical space-time frame; human logic is powerful enough to understand all complexity; faith is neglected.

Pathology of Ultra-Stability: Designing a system to fend off anticipated disturbances but not designed to fend against unknown disturbances; designing for both requires modifying one's view of stability and system structure.

Pathology of Undifferentiated Coding: Attributing reality and knowledge only to directly observable results; involving traditional human sensors of sight, hearing, taste, smell and touch; inferring reality and developing knowledge from indirect communication is rejected.

Reference: Polinpapilinho, K. F. (2015). *SYSTEMS THEORY-BASED CONSTRUCT FOR IDENTIFYING METASYSTEM PATHOLOGIES FOR COMPLEX SYSTEM GOVERNANCE.* (PhD Dissertation), Old Dominion University, Norfolk, Virginia, USA.

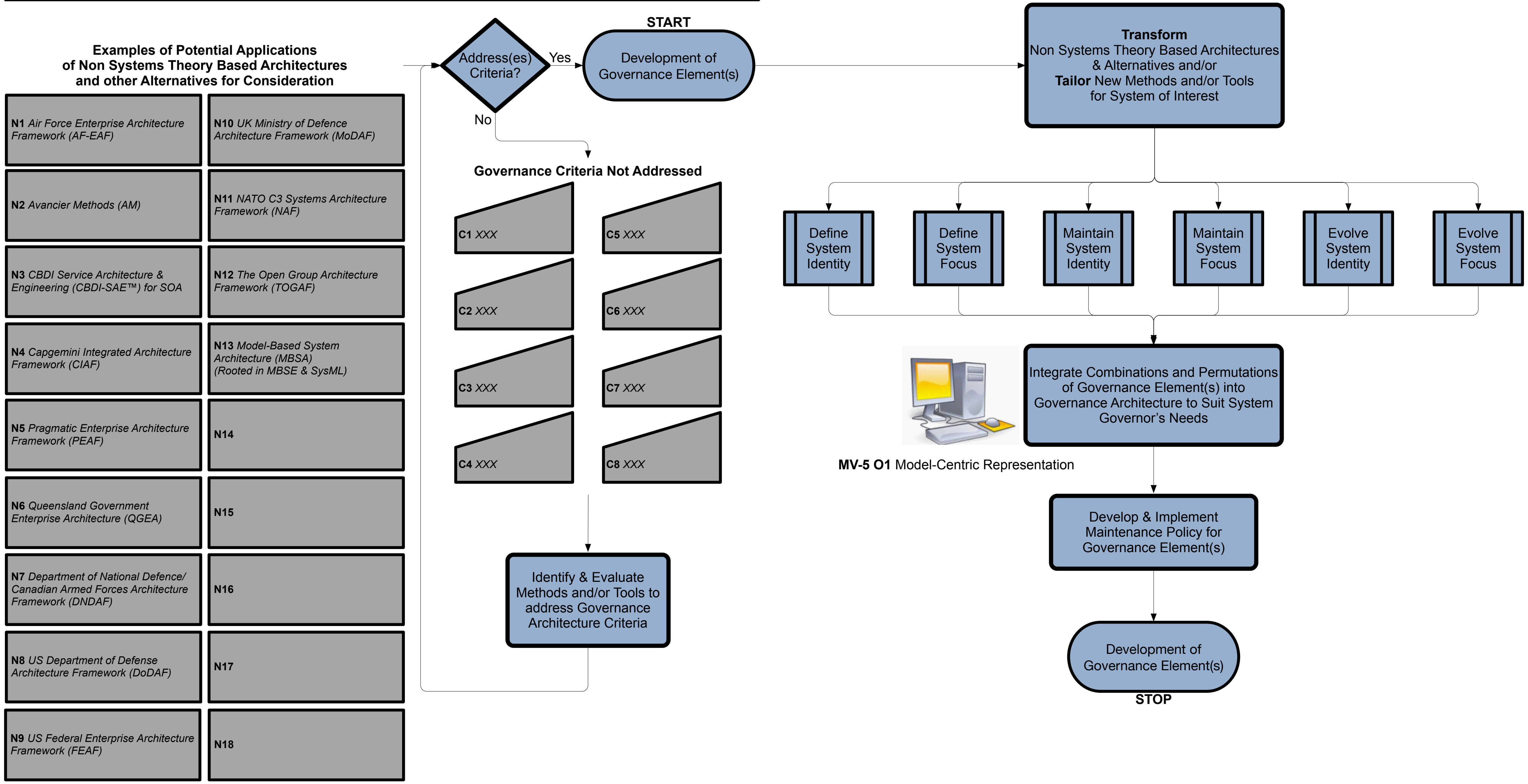
Systems Theory Considerations for Architecture



CSGAF Metasystem Viewpoint - 5 Outcome 1 (MV-5 O1): Forums & Mechanisms to Define, Maintain, & Evolve System Identity & Focus

MV-5 O1 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define system identity & focus
2 maintain system identity & focus
3 evolve system identity & focus.



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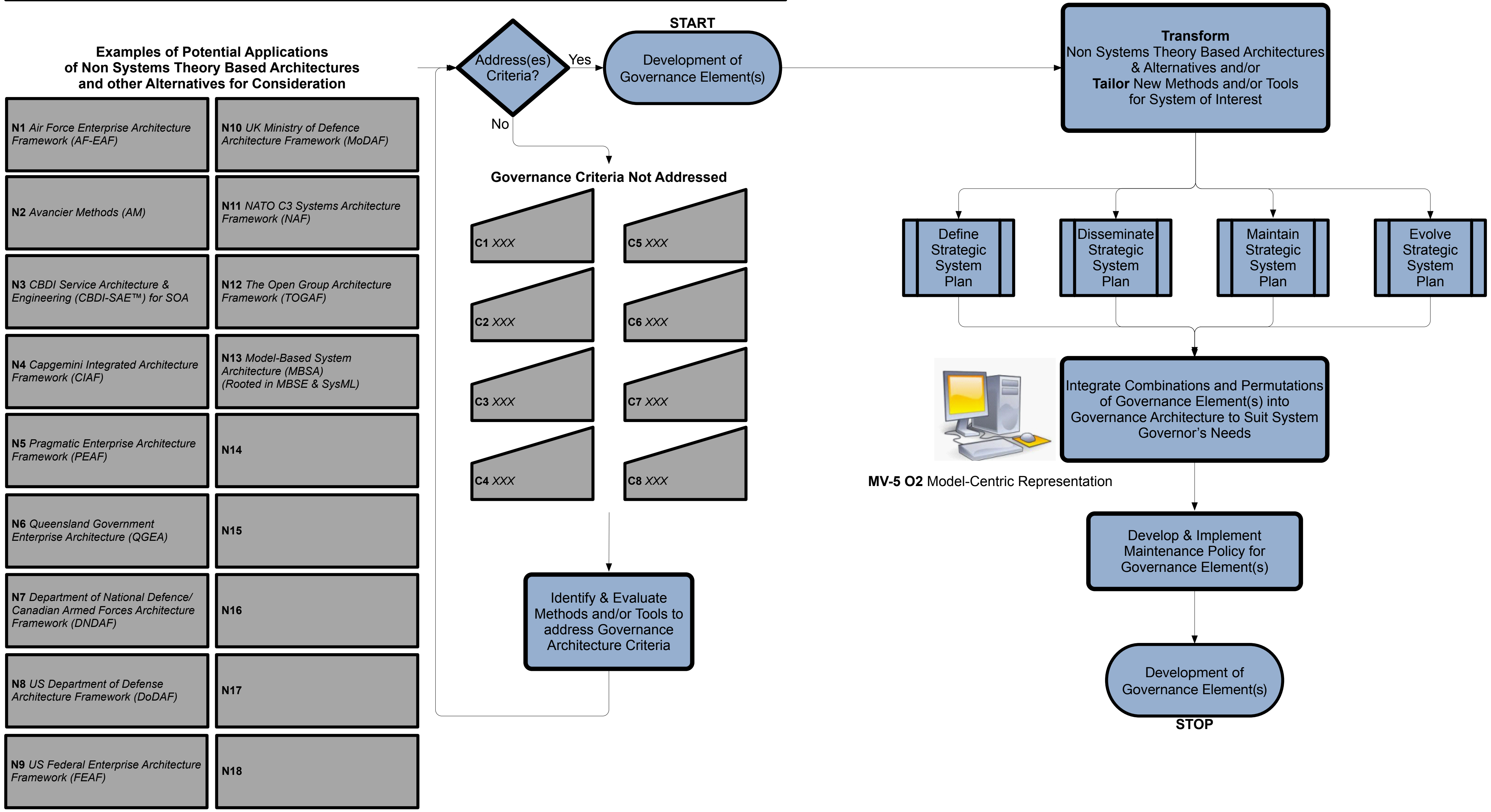
CSGAF Metasystem Viewpoint - 5 Outcome 2 (MV-5 O2): Strategic System Plan

MV-5 O2 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define & disseminate the strategic system plan
2 maintain the strategic system plan
3 evolve the strategic system plan.



CSGAF Metasystem Viewpoint - 5 Outcome 3 (MV-5 O3): Public Relations Plan Execution & Performance Monitoring

MV-5 O3 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define the public relations plan
2 execute the public relations plan
3 evaluate & evolve the public relations plan.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

START

Address(es) Criteria? — Yes → Development of Governance Element(s)

No →

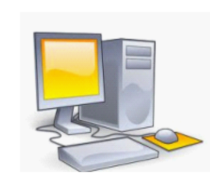
Governance Criteria Not Addressed

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

Define Public Relations Plan | Execute Public Relations Plan | Evaluate Public Relations Plan | Evolve Public Relations Plan



MV-5 O3 Model-Centric Representation

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

STOP

CSGAF Metasystem Viewpoint - 5 Outcome 4 (MV-5 O4): Marketing Plan Execution & Performance Monitoring

MV-5 O4 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define the marketing plan
2 execute the marketing plan
3 evaluate & evolve the marketing plan.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

Address(es) Criteria?

Yes → START: Development of Governance Element(s)

No → **Governance Criteria Not Addressed**

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

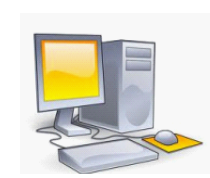
Define Marketing Plan

Execute Marketing Plan

Evaluate Marketing Plan

Evolve Marketing Plan

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs



MV-5 O4 Model-Centric Representation

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

STOP

MV-5 O5 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 map integrated system elements
2 display integrated system mapping
3 evolve integrated system mapping and display.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

START

Address(es) Criteria? — Yes → Development of Governance Element(s)

No → **Governance Criteria Not Addressed**

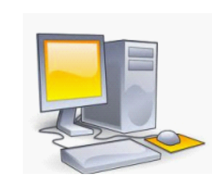
C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

- Identify System Elements
- Identify Links & Nodes
- Map Elements, Links & Nodes
- Evolve Integrated System Map

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs



MV-5 O5 Model-Centric Representation

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

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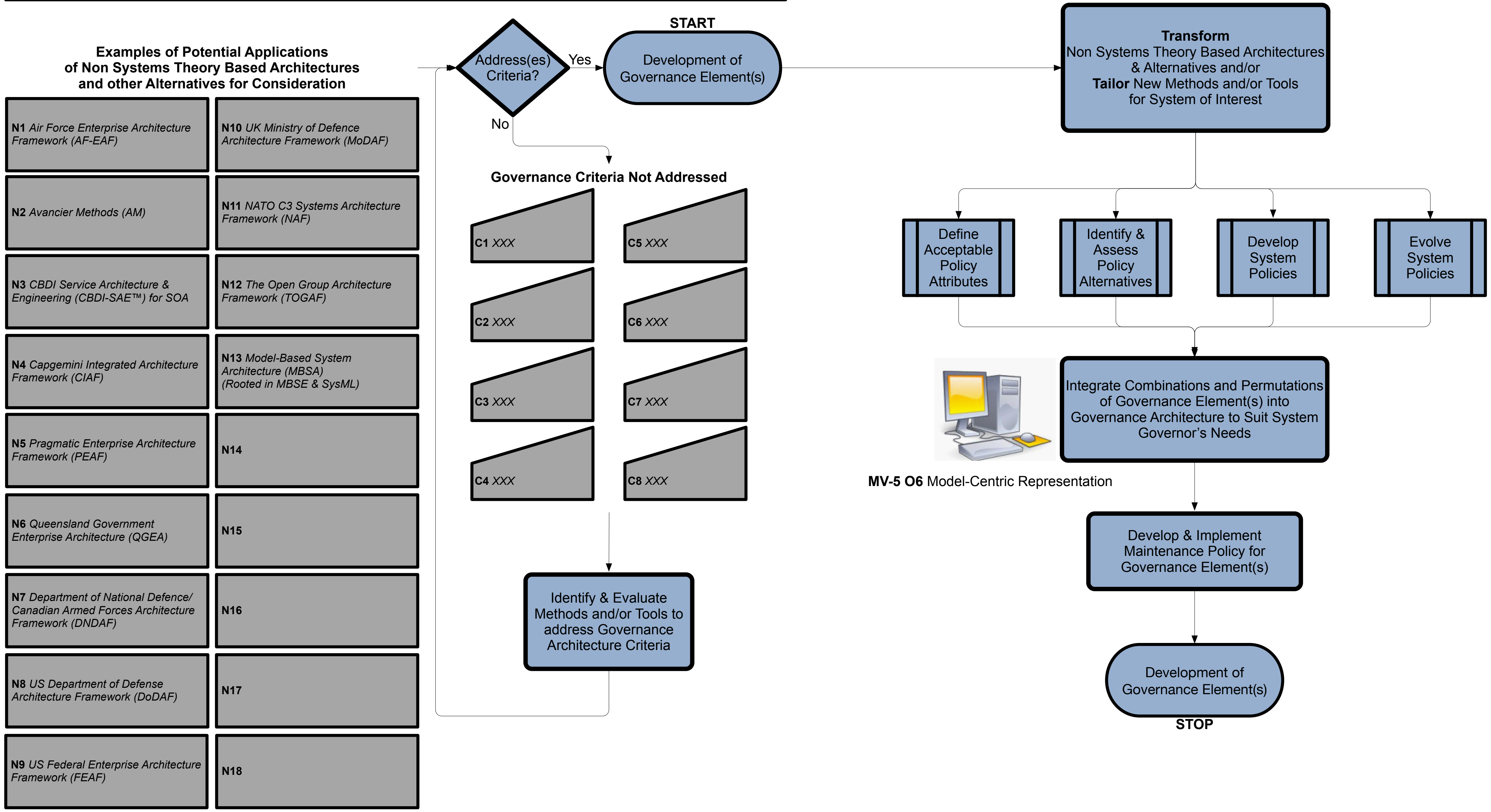
CSGAF Metasystem Viewpoint - 5 Outcome 6 (MV-5 O6): Satisficing System Policies

MV-5 O6 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

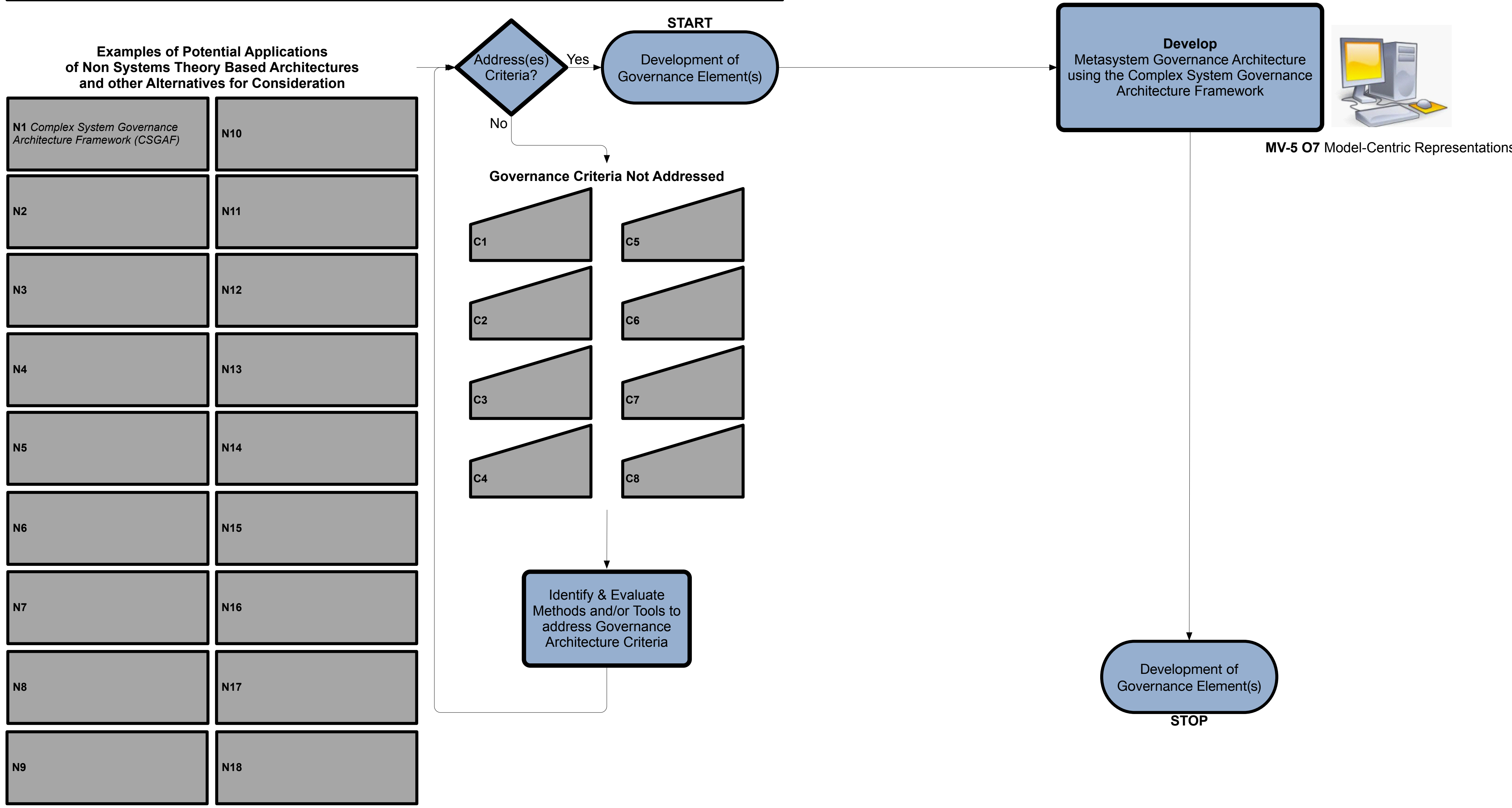
1 define attributes of acceptable system policy alternatives
2 identify & assess system policy alternatives on system impacts
3 develop & evolve satisficing system policies.



CSGAF Metasystem Viewpoint - 5 Outcome 7 (MV-5 O7): Governance Architecture for the Metasystem

MV-5 O7 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define the metasystem
2 model the metasystem
3 evaluate & evolve the metasystem model.



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CSGAF Metasystem Viewpoint - 5* Outcome 1 (MV-5* O1): Stakeholder Analysis

MV-5* O1 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 identify stakeholders
2 define stakeholder interests & concerns
3 evaluate & monitor stakeholder strengths, weaknesses, opportunities & threats (SWOT).

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
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N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
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N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

START

Address(es) Criteria? — Yes → Development of Governance Element(s)

No →

Governance Criteria Not Addressed

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

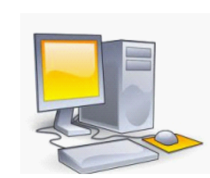
Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

Identify Stakeholders

Define Stakeholder Interests & Concerns

Evaluate Stakeholder SWOT

Monitor Stakeholder SWOT



MV-5* O1 Model-Centric Representation

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

STOP

CSGAF Metasystem Viewpoint - 5* Outcome 2 (MV-5* O2): Contextual Mapping

MV-5* O2 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 map contextual system elements
2 display contextual system mapping
3 evolve contextual system mapping and display.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
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N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

Address(es) Criteria? — Yes → START: Development of Governance Element(s)

No →

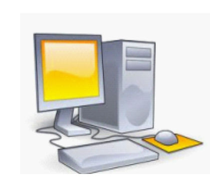
Governance Criteria Not Addressed

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

Identify Contextual Elements | Identify Links & Nodes | Map Elements, Links & Nodes | Evolve Contextual System Map



MV-5* O2 Model-Centric Representation

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs

Develop & Implement Maintenance Policy for Governance Element(s)

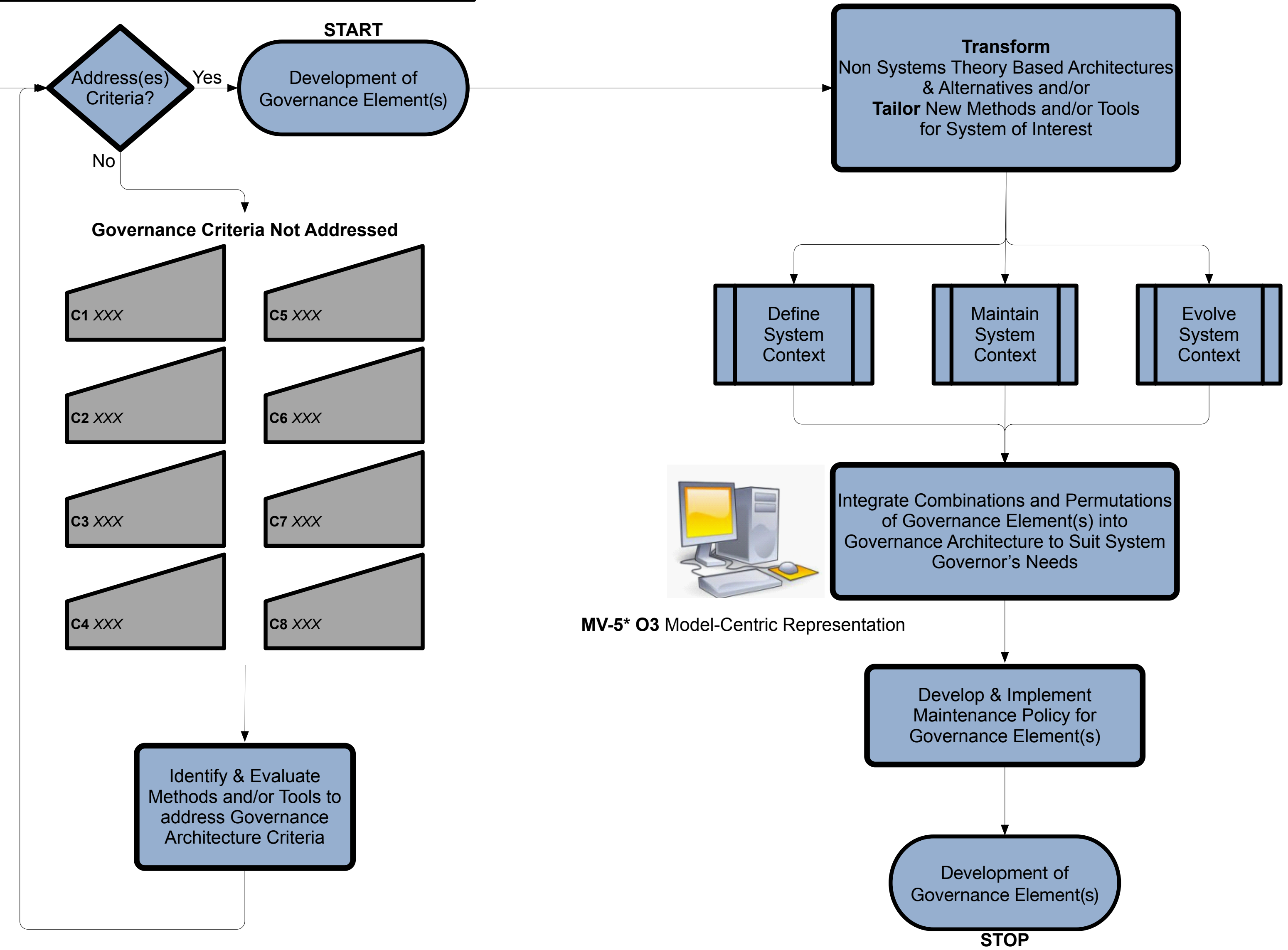
Development of Governance Element(s)
STOP

MV-5* O3 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define system context
2 maintain system context
3 evolve system context.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**



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CSGAF Metasystem Viewpoint - 5’ Outcome 1 (MV-5’ O1): Dashboard Measures for Strategic System Performance

MV-5’ O1 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define strategic system performance measures of interest & baselines
2 capture strategic system performance indicators
3 display strategic system performance measures.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

Address(es) Criteria?

Yes

No

START

Development of Governance Element(s)

Governance Criteria Not Addressed

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

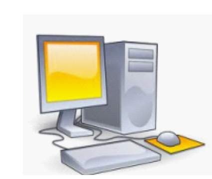
Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

Define Performance Measures & Baselines

Capture Performance Indicators

Display Performance Measures

Evolve Performance Dashboard



MV-5’ O1 Model-Centric Representation

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor’s Needs

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

STOP

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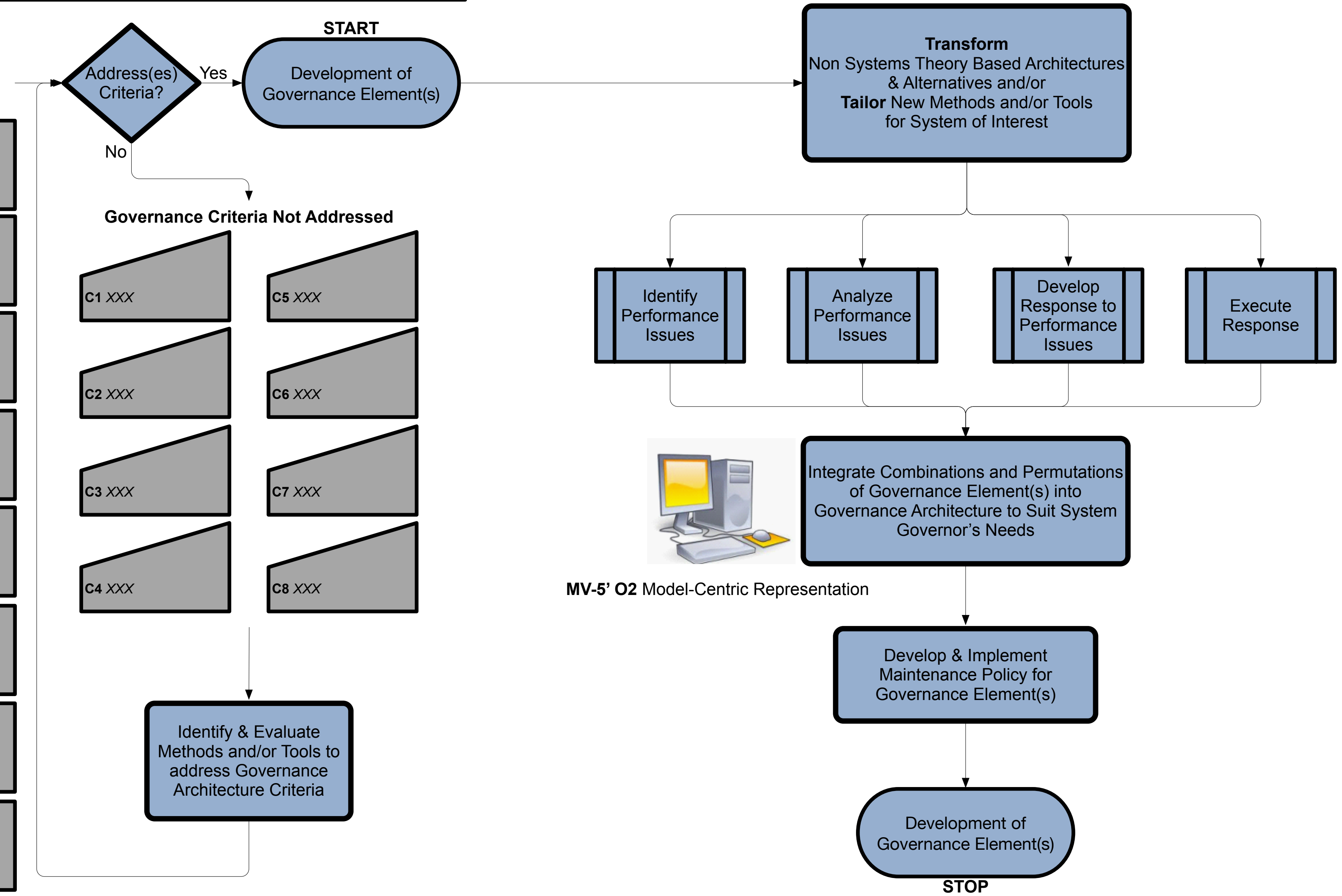
MV-5' O2 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 identify performance issues
2 analyze performance issues
3 respond to performance issues.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**



CSGAF Metasystem Viewpoint - 5’ Outcome 3 (MV-5’ O3): Recommendation for Continuance, Modification, or Deletion of Performance Measures

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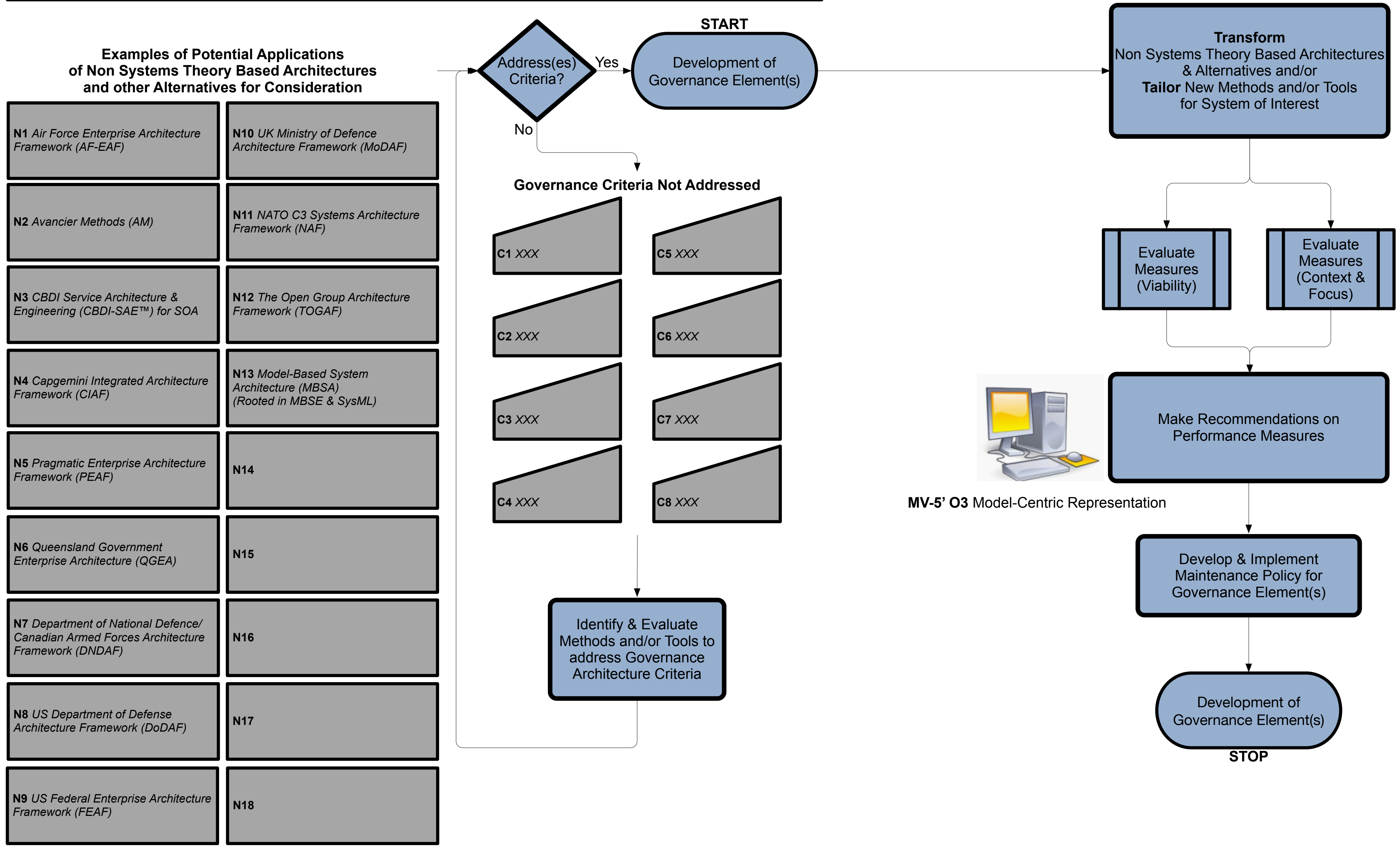
MV-2

MV-5’ O3 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

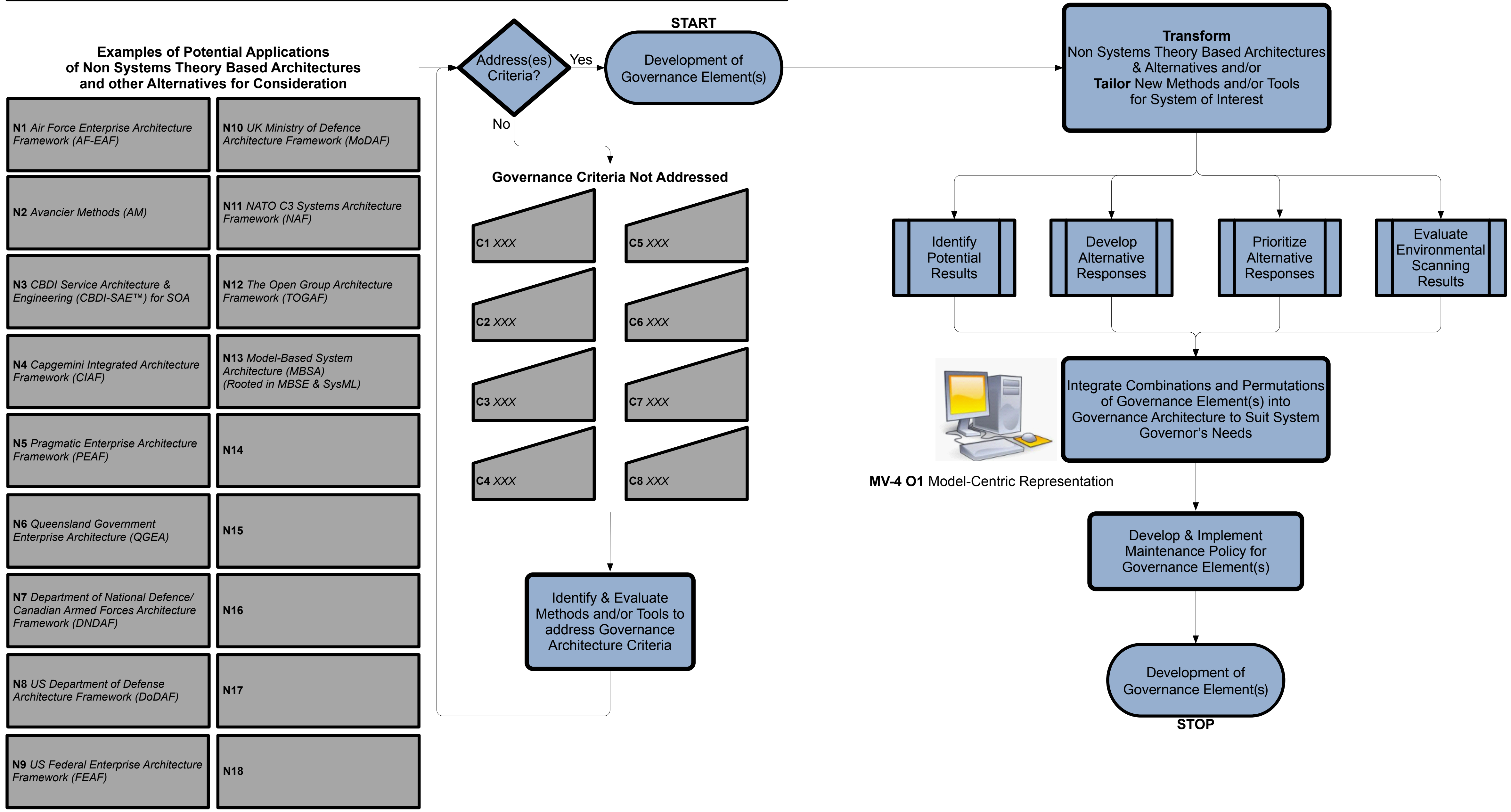
1 evaluate performance measures for usefulness in monitoring system viability
2 evaluate performance measures for conflict with system context & focus
3 make recommendations on continuance, modification, or deletion of performance measures.



CSGAF Metasystem Viewpoint - 4 Outcome 1 (MV-4 O1): Planning for Response to Environmental Scanning

MV-4 O1 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

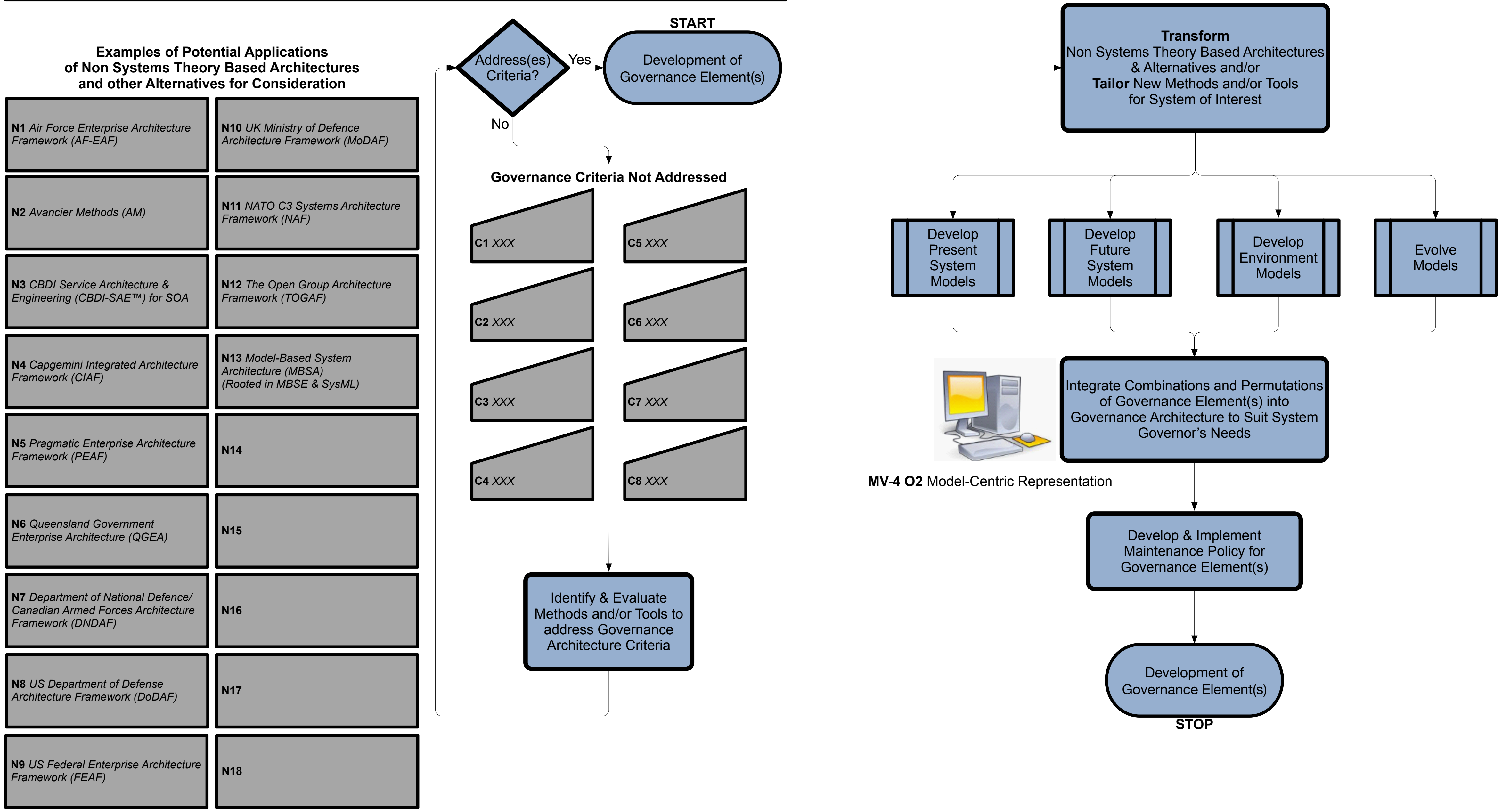
1 identify potential environmental scanning results
2 develop & prioritize alternative response plans to environmental scanning results
3 evaluate environmental scanning results.



CSGAF Metasystem Viewpoint - 4 Outcome 2 (MV-4 O2): Models of the Present, Future, & Environment for the System

MV-4 O2 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 develop models of present system
2 develop models of future system
3 develop models of environment.



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MV-5'
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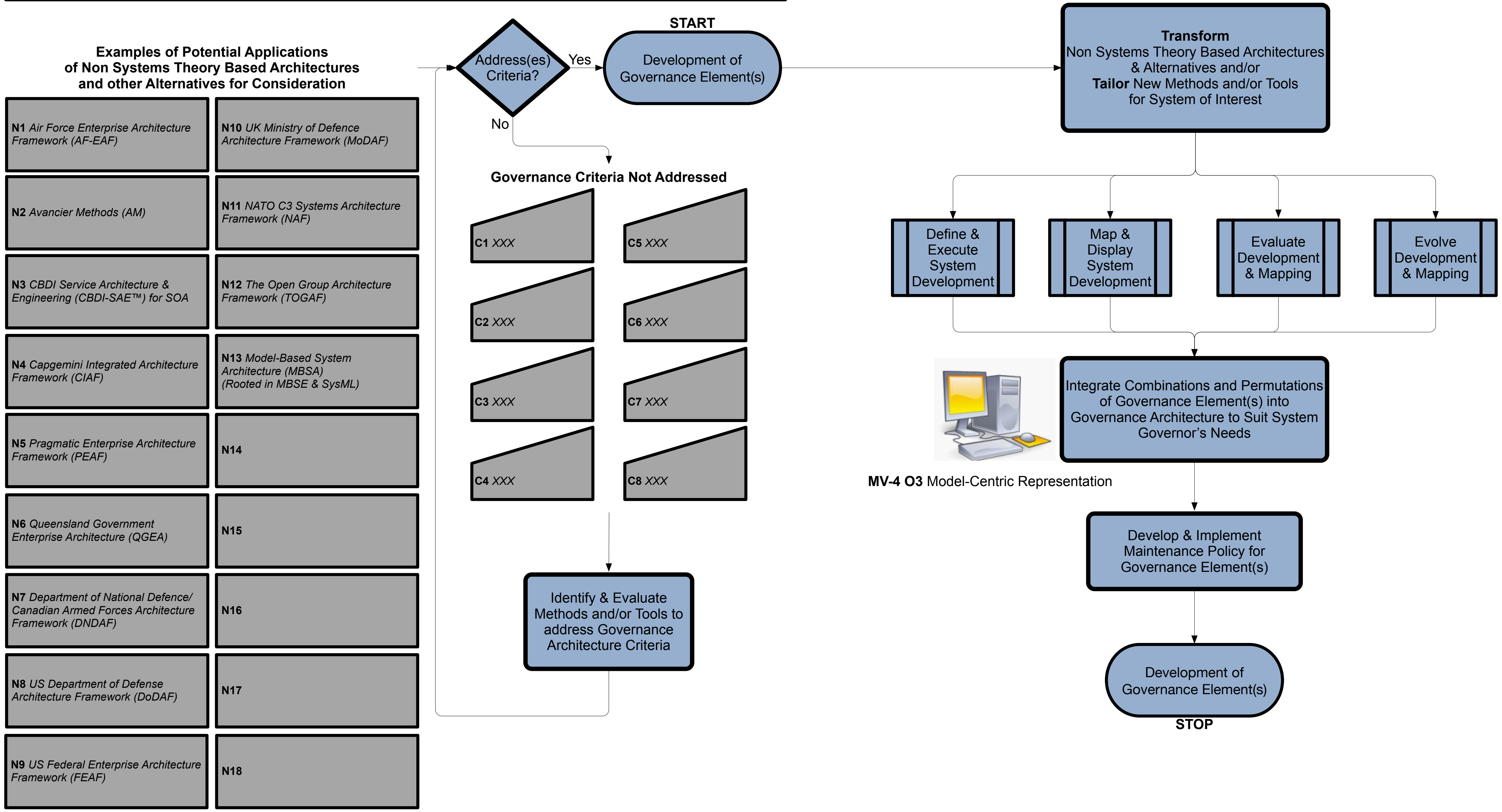
MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 4 Outcome 3 (MV-4 O3): Strategic System Development Plan & System Development Map

MV-4 O3 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define & execute the strategic system development plan
2 map & display system development
3 evaluate & evolve strategic system development plan, mapping & display.



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MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 4* Outcome 1 (MV-4* O1): Design for Second Order System Learning

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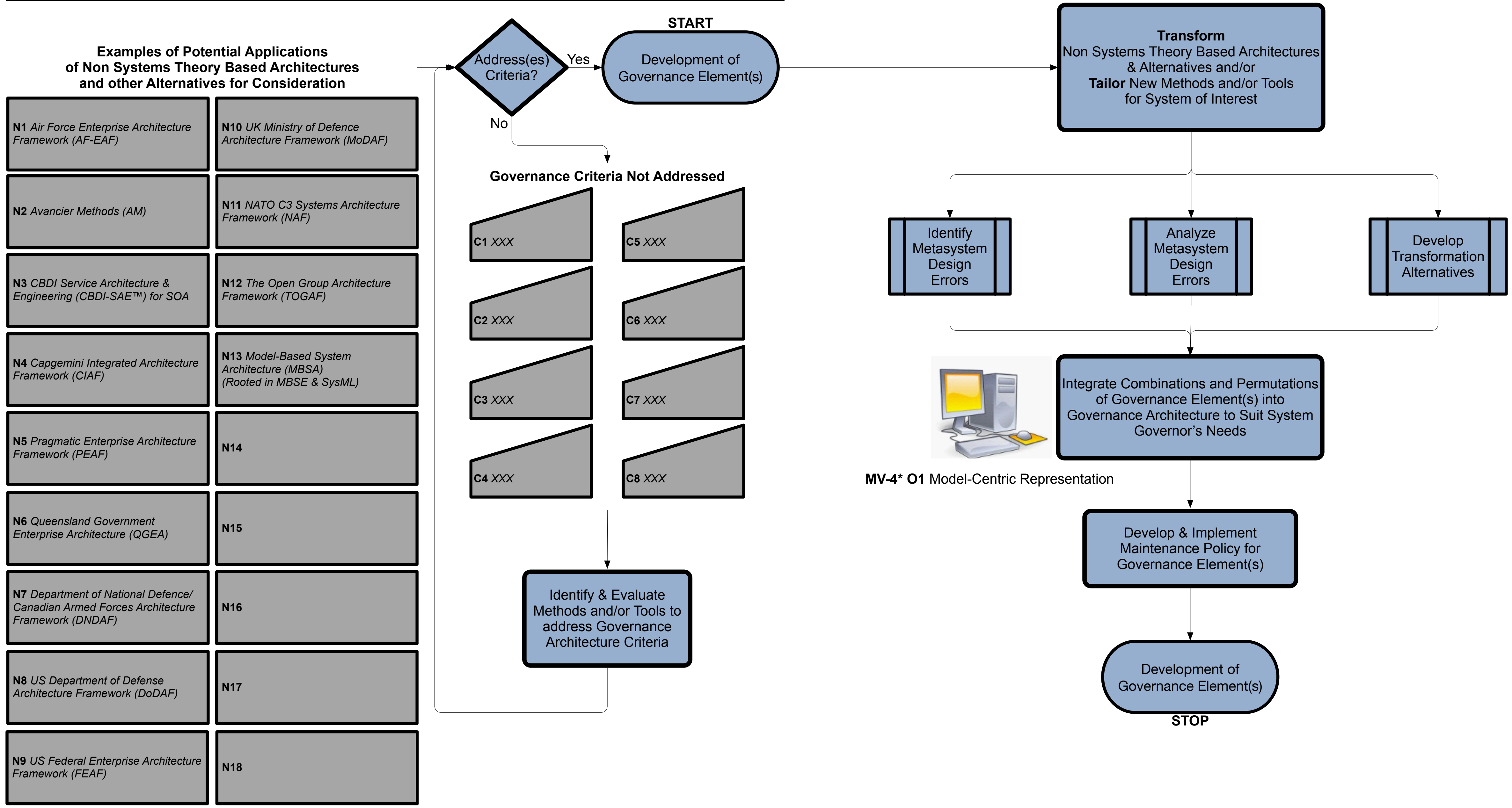
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

MV-4* O1 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 identify metasystem design errors
2 analyze metasystem design errors
3 develop alternatives for transformation.



MV-4* O2 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 identify potential design modifications & prioritization
2 determine transformation strategy activities
3 develop system transformation strategy.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
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N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

START

Address(es) Criteria? — Yes → Development of Governance Element(s)

No → **Governance Criteria Not Addressed**

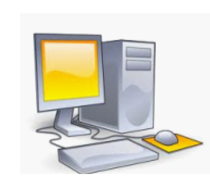
C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

- Identify & Prioritize Potential Modifications
- Determine Transformation Strategy Activities
- Develop System Transformation Strategy

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs



MV-4* O2 Model-Centric Representation

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

STOP

CSGAF Metasystem Viewpoint - 4* Outcome 3 (MV-4* O3): Dissemination of Learning Results, Implications, & Opportunities

RM

MV-4* O3 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 verify transformation strategy identifies learning results, implications & opportunities
2 disseminate transformation strategy
3 confirm transformation strategy informs development of strategic plan.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

START

Address(es) Criteria?

Yes → Development of Governance Element(s)

No → **Governance Criteria Not Addressed**

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

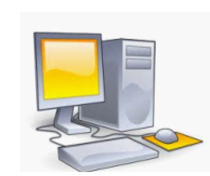
Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

Verify Transformation Strategy

Disseminate Transformation Strategy

Confirm Transformation Strategy Informs SP



MV-4* O3 Model-Centric Representation

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

STOP

MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 4’ Outcome 1 (MV-4’ O1): Design for Environmental Scanning Including Objectives, Organization, Execution, & Performance Monitoring

MV-4’ O1 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define environmental scanning objectives & organization
2 develop & execute environmental scanning activities
3 evaluate environmental scanning performance.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

START

Address(es) Criteria? — Yes → Development of Governance Element(s)

No →

Governance Criteria Not Addressed

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

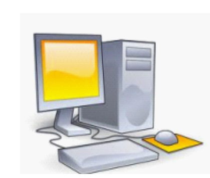
Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

Define Scanning Objectives & Organization

Develop & Execute Scanning Activities

Evaluate Environmental Scanning Performance



MV-4’ O1 Model-Centric Representation

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor’s Needs

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

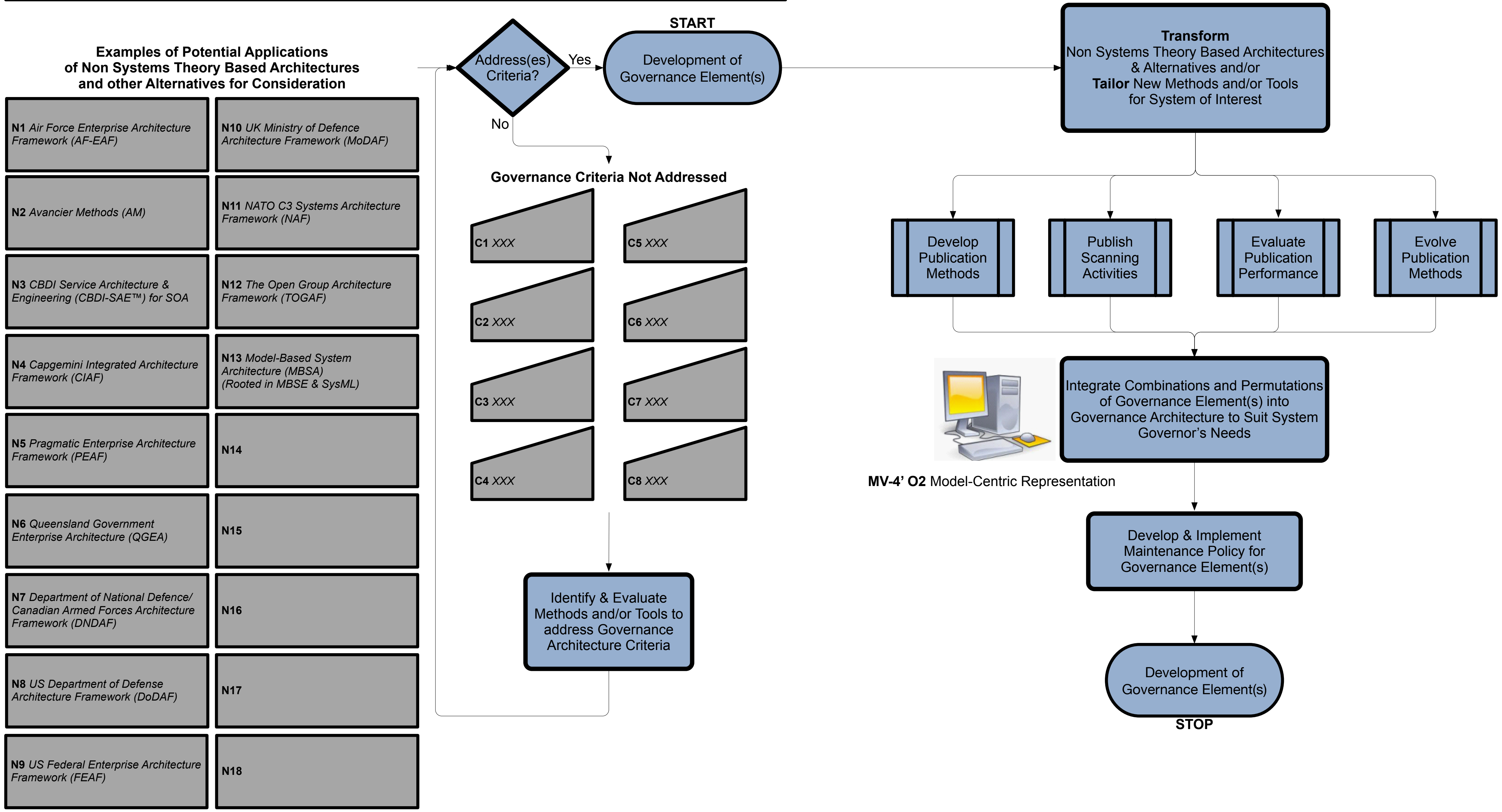
STOP

RM
MV-5
MV-5*
MV-5’
MV-4
MV-4*
MV-4’
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 4’ Outcome 2 (MV-4’ O2): Publication of Environmental Scanning Activities Enabling Coordination of Targets, Execution, Data Capture & Analysis

MV-4’ O2 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 develop environmental scanning activity publication methods
2 publish environmental scanning activities
3 evaluate performance of publication & evolve methods.



RM
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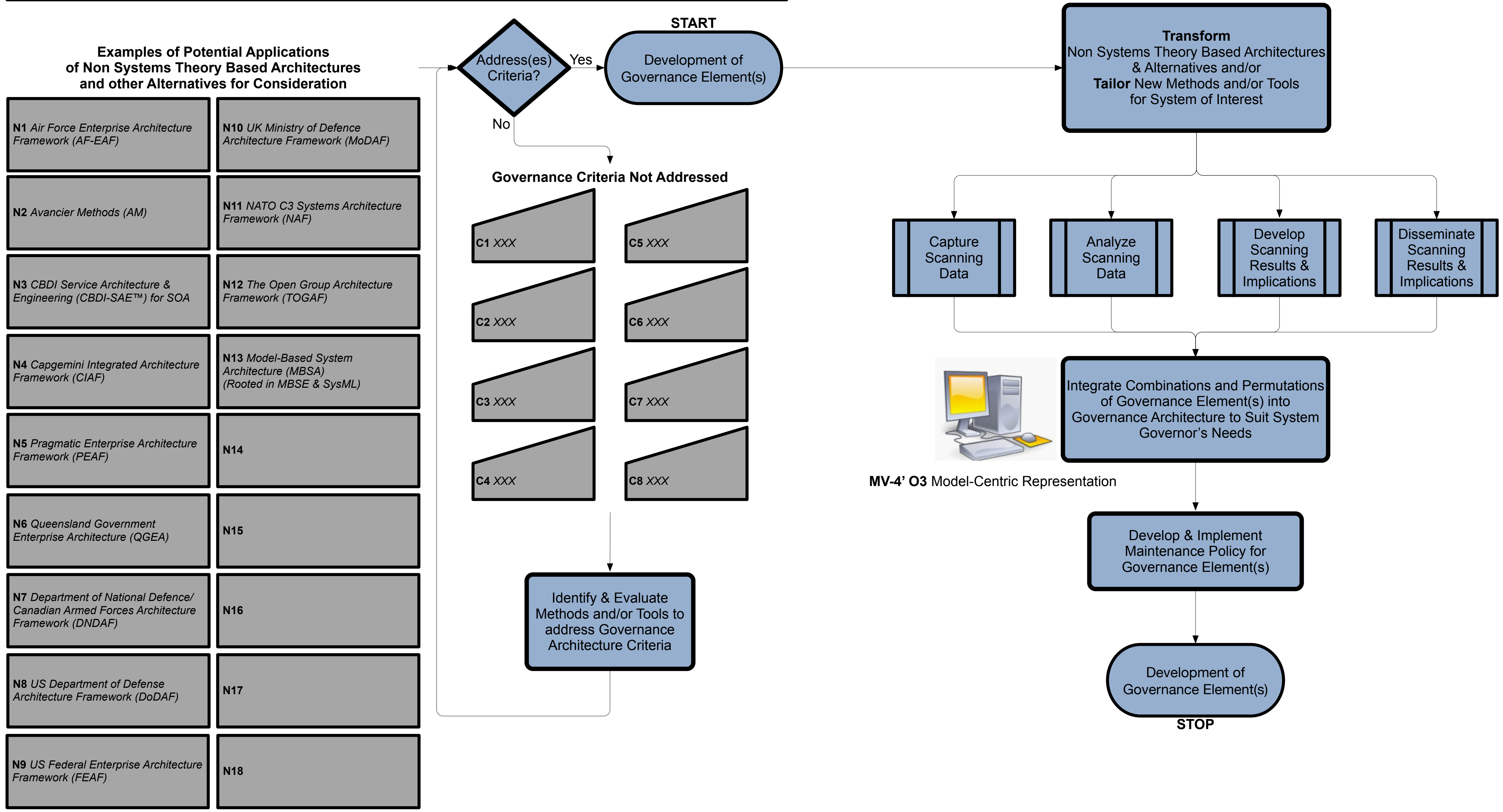
MV-5*
MV-5’
MV-4
MV-4*
MV-4’
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 4’ Outcome 3 (MV-4’ O3): Dissemination of Scanning Results & Implications of Patterns, Trends, Threats, Events, & Opportunities for the System

MV-4’ O3 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 capture & analyze environmental scanning data
2 develop environmental scanning results & implications
3 disseminate environmental scanning results & implications.



RM
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MV-5’
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MV-4’
MV-3
MV-3*
MV-2

CSGAF Metasystem Viewpoint - 3 Outcome 1 (MV-3 O1): Operational Plan for System Production that Generates Value

MV-3 O1 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define value criteria for system production operations
2 develop operational plan for system production
3 evaluate & evolve operational plan.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
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N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

START

Address(es) Criteria? — Yes → Development of Governance Element(s)

No ↓

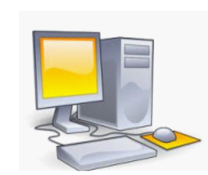
Governance Criteria Not Addressed

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

Define Operational Value Criteria | Develop Operational Plan | Evaluate Operational Plan Performance | Evolve Operational Plan



MV-3 O1 Model-Centric Representation

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

STOP

CSGAF Metasystem Viewpoint - 3 Outcome 2 (MV-3 O2): Execution Forums for Ongoing Operational Maintenance

RM
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MV-4'
MV-3
MV-3*
MV-2

MV-3 O2 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define operational maintenance goals & performance measures
2 identify opportunities & methods for execution forums
3 execute & evaluate execution forums.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
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N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

START

Address(es) Criteria? — Yes → Development of Governance Element(s)

No

Governance Criteria Not Addressed

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

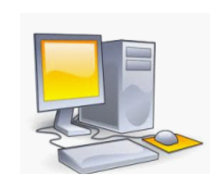
Transform
Non Systems Theory Based Architectures & Alternatives and/or
Tailor New Methods and/or Tools for System of Interest

Define Maintenance Goals & Measures

Identify Forum Opportunities & Methods

Execute Operational Maintenance Forums

Evaluate Execution Forums' Performance



MV-3 O2 Model-Centric Representation

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs

Develop & Implement Maintenance Policy for Governance Element(s)

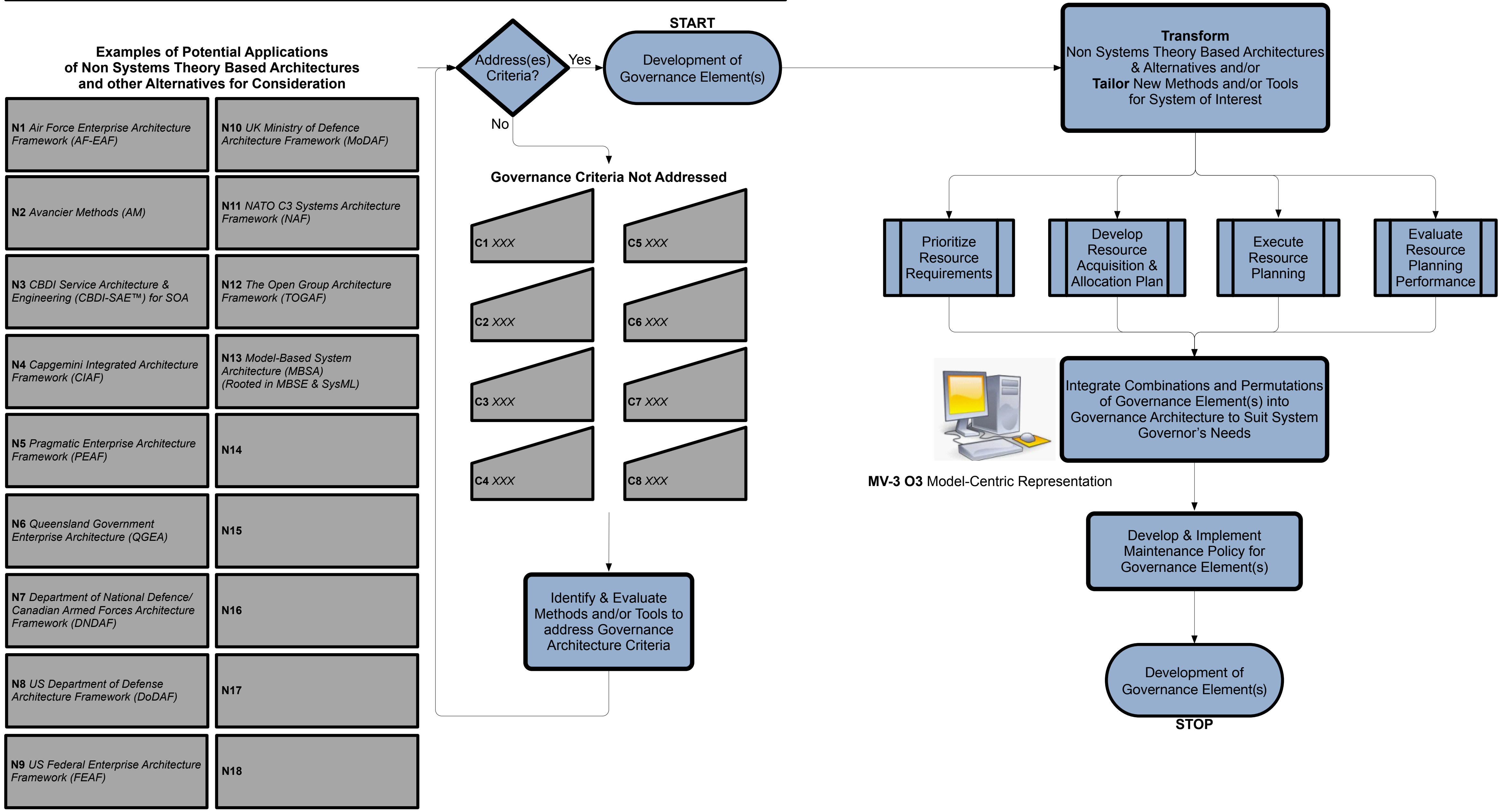
Development of Governance Element(s)

STOP

CSGAF Metasystem Viewpoint - 3 Outcome 3 (MV-3 O3): Resource Planning for Operational Requirements

MV-3 O3 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 identify, characterize & prioritize resource requirements
2 develop resource acquisition & allocation plan
3 execute & evaluate resource planning.



CSGAF Metasystem Viewpoint - 3 Outcome 4 (MV-3 O4): Operational Goals in Relationship to Strategic Performance Objectives

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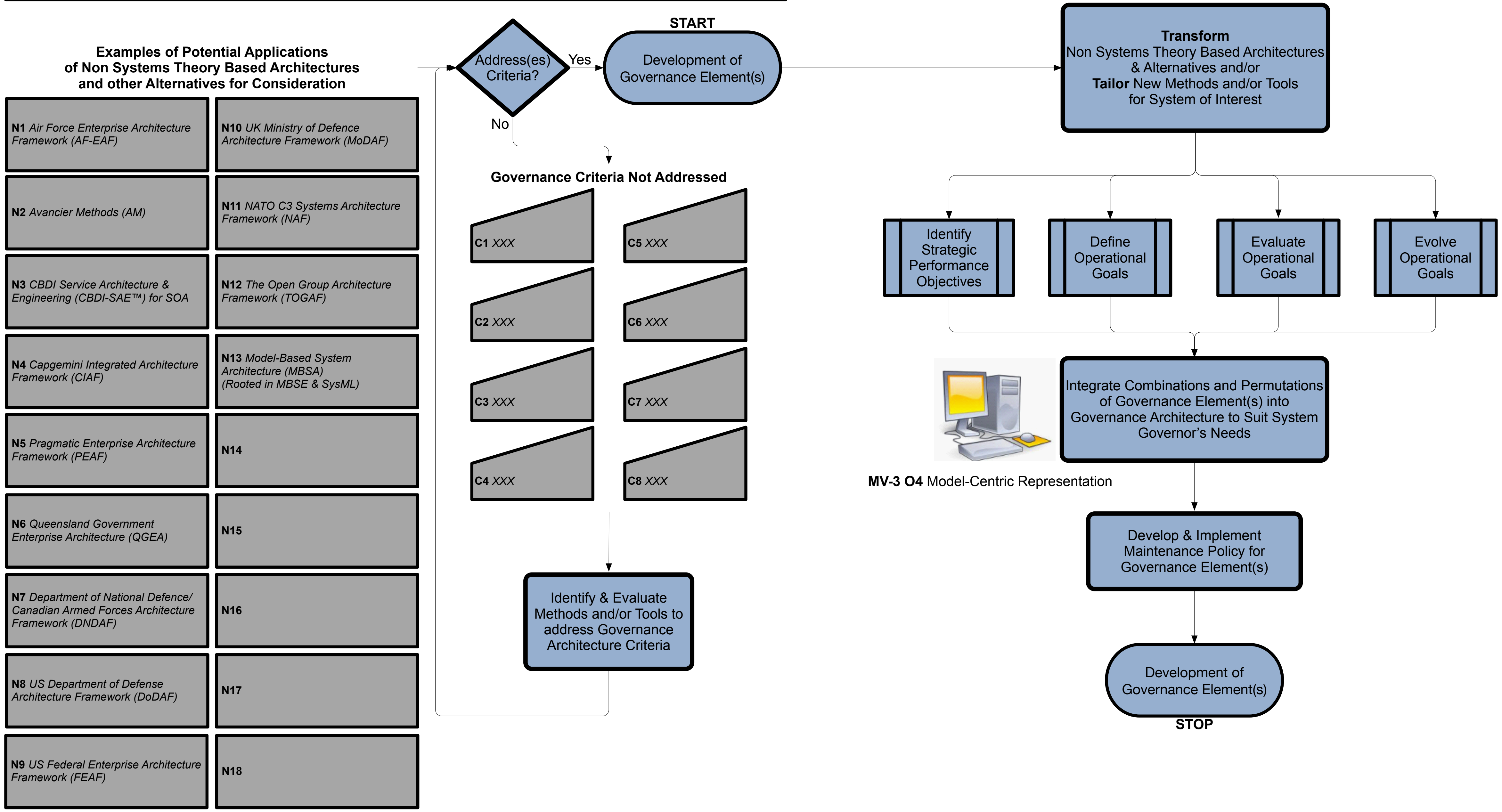
MV-3*
MV-2

MV-3 O4 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

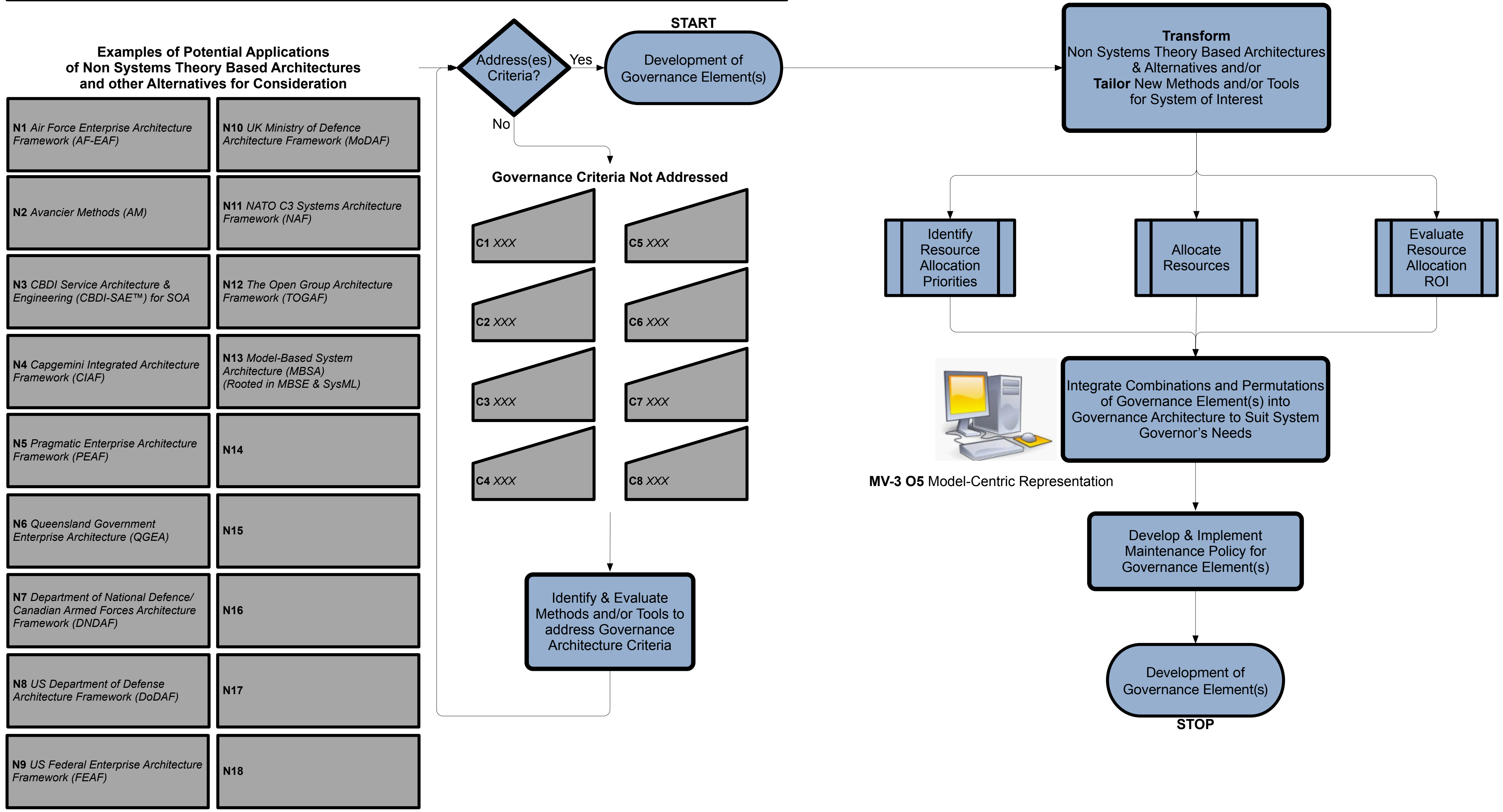
1 identify strategic performance objectives
2 define operational goals to support objectives
3 evaluate & evolve operational goals.



CSGAF Metasystem Viewpoint - 3 Outcome 5 (MV-3 O5): Priority & Resource Allocation for Operational Support Activities & Investments

MV-3 O5 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 identify operational support activity & investment priorities
2 allocate resources
3 evaluate resource allocation return on investment.



RM
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MV-3*
MV-2

MV-3 O6 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define performance measure targets
2 identify performance measure indicators
3 develop performance measure collection & analysis plan.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
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N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
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N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

START

Development of Governance Element(s)

Address(es) Criteria?

Yes

No

Governance Criteria Not Addressed

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

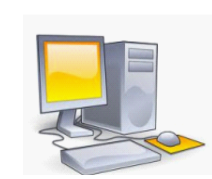
Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

Define Performance Measure Targets

Identify Performance Measure Indicators

Develop Performance Measure Collection Plan

Develop Performance Measure Analysis Plan



MV-3 O6 Model-Centric Representation

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs

Develop & Implement Maintenance Policy for Governance Element(s)

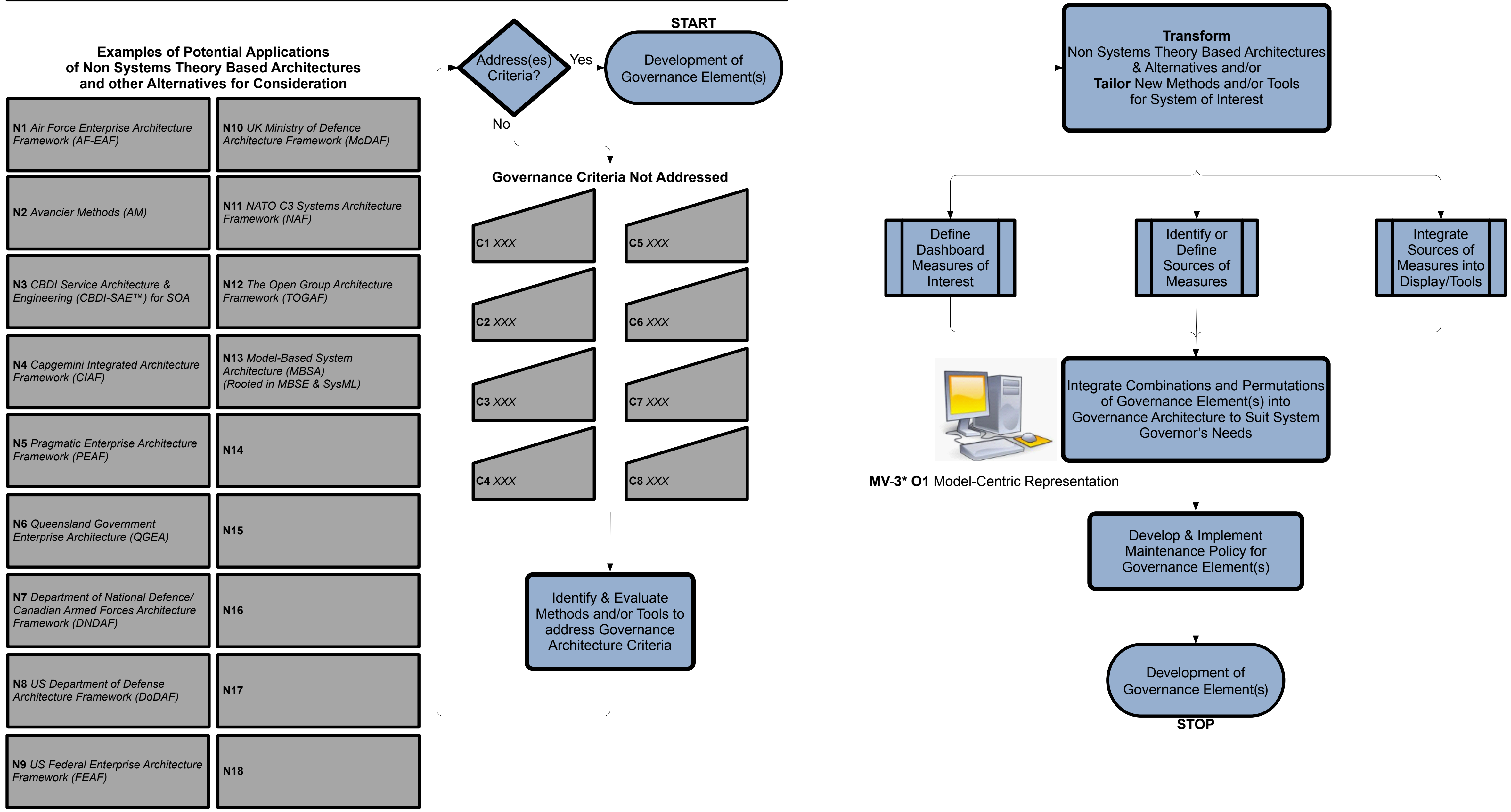
Development of Governance Element(s)

STOP

CSGAF Metasystem Viewpoint - 3* Outcome 1 (MV-3* O1): Dashboard Measures for Operations

MV-3* O1 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

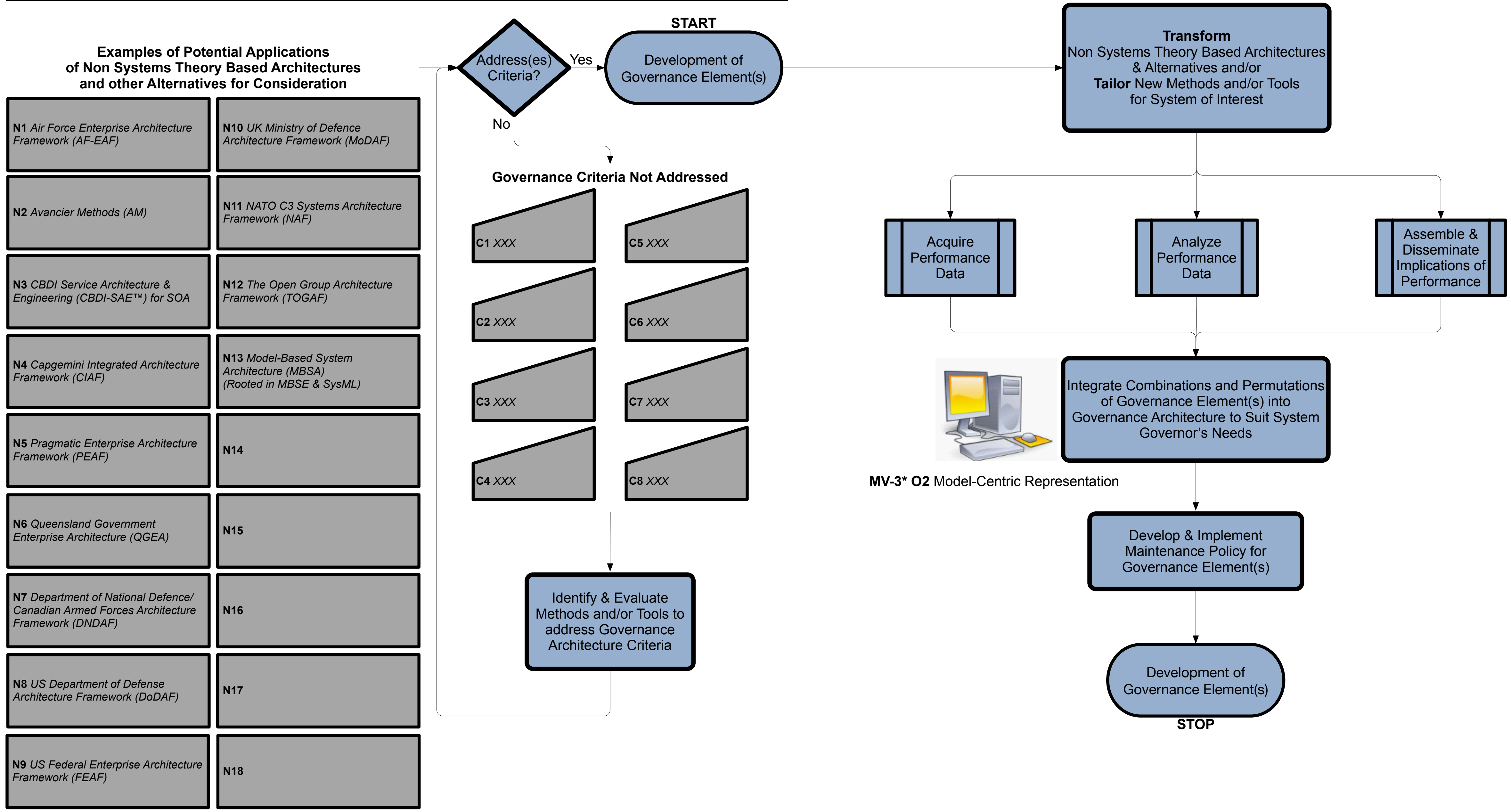
1 define dashboard measures of interest
2 identify or define sources of dashboard measures
3 integrate sources into dashboard display(s) and/or tools.



CSGAF Metasystem Viewpoint - 3* Outcome 2 (MV-3* O2): Results of Inquiry & Analysis of Performance Issues

MV-3* O2 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

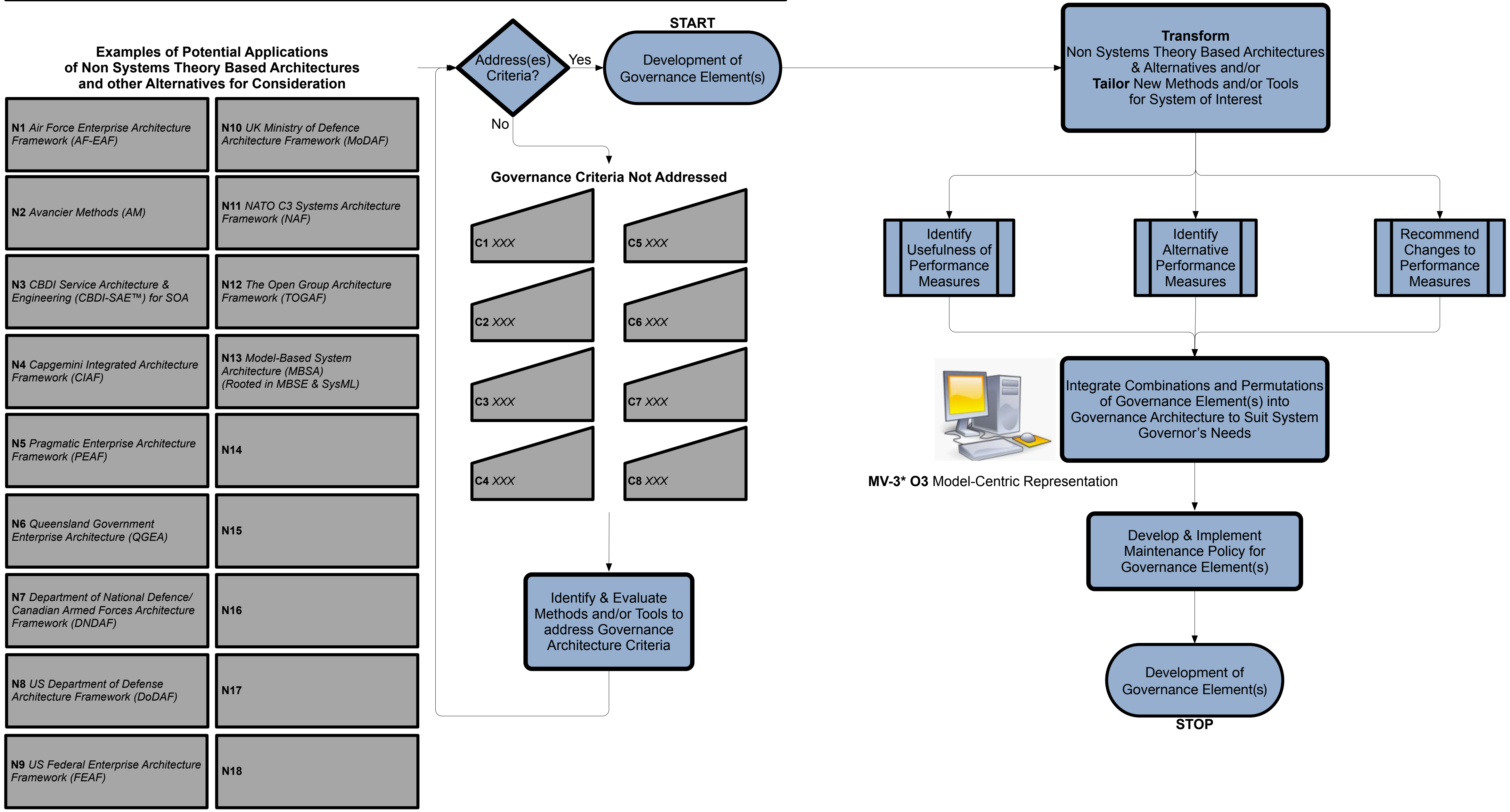
1 facilitate acquisition of performance data
2 analyze performance data
3 assemble & disseminate implications of performance issues.



CSGAF Metasystem Viewpoint - 3* Outcome 3 (MV-3* O3): Recommendation for Continuance, Modification, or Deletion of Performance Measures

MV-3* O3 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

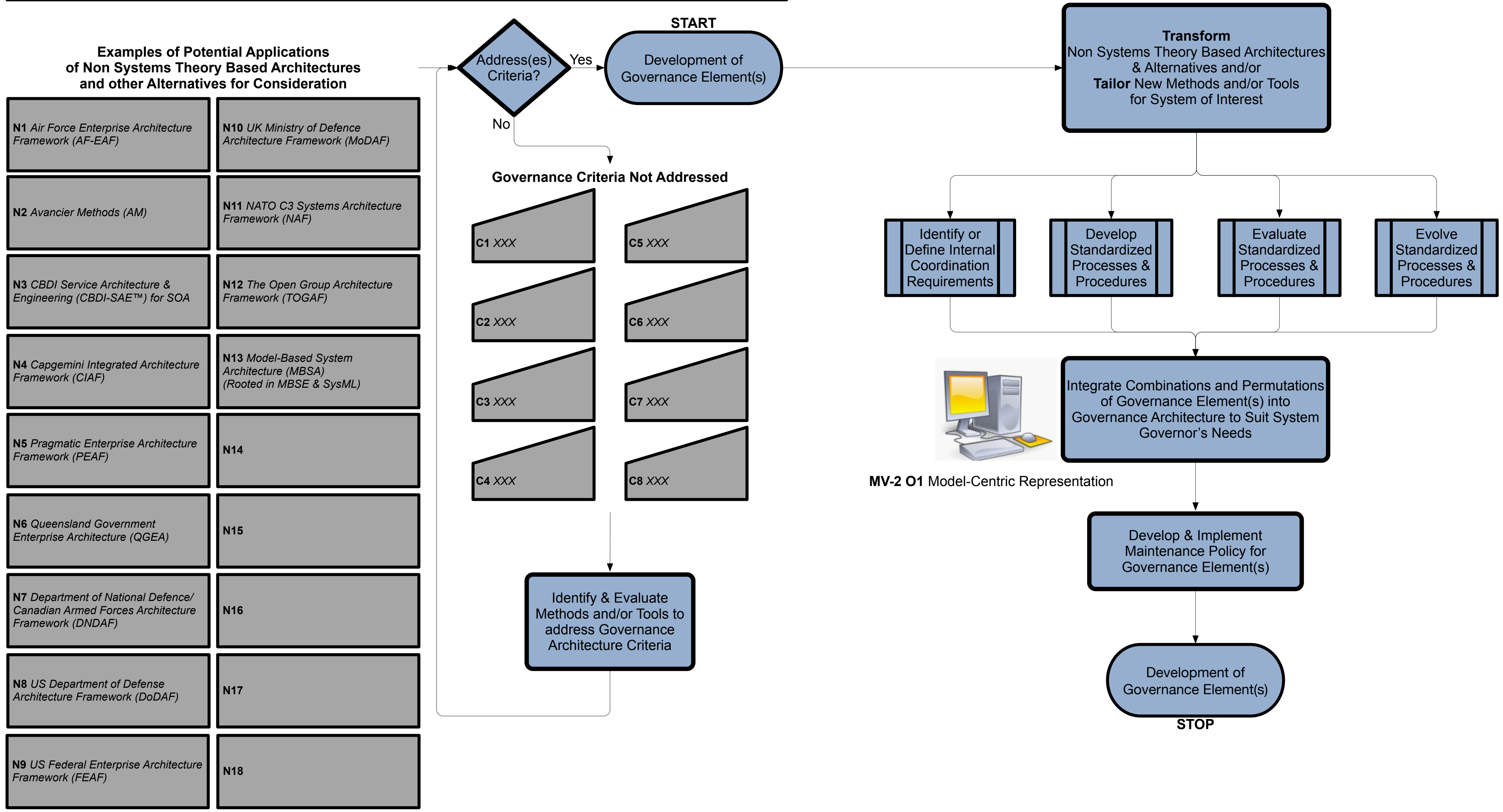
1 identify usefulness of performance measures
2 identify alternative performance measures
3 recommend changes to performance measures.



CSGAF Metasystem Viewpoint - 2 Outcome 1 (MV-2 O1): Standard Processes & Procedures for Internal Coordination of the System

MV-2 O1 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 identify or define internal coordination requirements
2 develop standardized processes & procedures to meet requirements
3 evaluate & evolve standardized processes & procedures.



CSGAF Metasystem Viewpoint - 2 Outcome 2 (MV-2 O2): Communications Architecture for the Metasystem

MV-2 O2 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define metasystem communication requirements
2 identify metasystem communication links & nodes
3 model metasystem communication links & nodes.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
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N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

START

Address(es) Criteria? — Yes → Development of Governance Element(s)

No → **Governance Criteria Not Addressed**

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

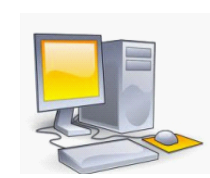
Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

Define Metasystem Communication Requirements

Identify Metasystem Communication Links & Nodes

Model Metasystem Comunication Links & Nodes

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs



MV-2 O2 Model-Centric Representation

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

STOP

CSGAF Metasystem Viewpoint - 2 Outcome 3 (MV-2 O3): Defined External Coordination Vehicles Necessary for Support for the System

MV-2 O3 Governance Architecture Design Criteria: Governance Architecture Elements in support of this Outcome must describe in whole or in part (based on modeling technical limitations and cost constraints) the elements necessary to:

1 define external coordination requirements
2 identify existing or develop new coordination vehicles to meet requirements
3 facilitate use of external coordination vehicles.

Examples of Potential Applications of Non Systems Theory Based Architectures and other Alternatives for Consideration

N1 *Air Force Enterprise Architecture Framework (AF-EAF)*	**N10** *UK Ministry of Defence Architecture Framework (MoDAF)*
N2 *Avancier Methods (AM)*	**N11** *NATO C3 Systems Architecture Framework (NAF)*
N3 *CBDI Service Architecture & Engineering (CBDI-SAE™) for SOA*	**N12** *The Open Group Architecture Framework (TOGAF)*
N4 *Capgemini Integrated Architecture Framework (CIAF)*	**N13** *Model-Based System Architecture (MBSA) (Rooted in MBSE & SysML)*
N5 *Pragmatic Enterprise Architecture Framework (PEAF)*	**N14**
N6 *Queensland Government Enterprise Architecture (QGEA)*	**N15**
N7 *Department of National Defence/ Canadian Armed Forces Architecture Framework (DNDAF)*	**N16**
N8 *US Department of Defense Architecture Framework (DoDAF)*	**N17**
N9 *US Federal Enterprise Architecture Framework (FEAF)*	**N18**

Address(es) Criteria?

Yes

No

START

Development of Governance Element(s)

Governance Criteria Not Addressed

C1 *XXX*	**C5** *XXX*
C2 *XXX*	**C6** *XXX*
C3 *XXX*	**C7** *XXX*
C4 *XXX*	**C8** *XXX*

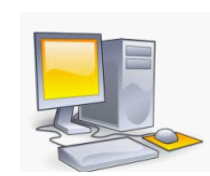
Identify & Evaluate Methods and/or Tools to address Governance Architecture Criteria

Transform Non Systems Theory Based Architectures & Alternatives and/or **Tailor** New Methods and/or Tools for System of Interest

Define External Coordination Requirements

Identify of Develop Coordination Vehicles

Facilitate Use of Coordination Vehicles



MV-2 O3 Model-Centric Representation

Integrate Combinations and Permutations of Governance Element(s) into Governance Architecture to Suit System Governor's Needs

Develop & Implement Maintenance Policy for Governance Element(s)

Development of Governance Element(s)

STOP

RM

MV-5

MV-5*

MV-5'

MV-4

MV-4*

MV-4'

MV-3

MV-3*

MV-2

APPENDIX B

NON-SYSTEMS THEORY BASED ARCHITECTURE FRAMEWORK ASSESSMENT

(CODING)

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
AF-EAF	Air Force Enterprise Architecture Framework	X			Guidance (policy) and standards for developing and integrating Air Force IT architectures	Potential, system dependent, MV-5
AFIoT	Architecture Framework for Internet of Things	X			a standards pursuit/effort	
AGA	Australian Government Architecture Framework	X			Taxonomy for IT investments and transforming government; lives at the reference model level)	
AGATE	Atelier de Gestion de l'ArchiTecturE des Systemes d'Information et de Communication	X			for modeling computer or communication systems architecture	
AGILE	Agile Enterprise Architecture			X	operational management focus (S1)	
AM	Avancier Methods			X	Process and methodology for architecture development	All - lives at a process / method level for developing architectures
AM for EA	Avancier Methods for Enterprise Architecture	X			strategic	
AM for SA	Avancier Methods for Solution Architecture	X			tactical	
ARCHI	Archimate	X			visual modelling notation for describing and understanding gaps between business and IT	
ARIS	Architektur Integrierter Informationssysteme	X			business to IT synchronization	
ARCON	A Reference Architecture for Collaborative Networks	X			networking enterprises	
ATAM	Architecture Tradeoff Analysis Method	X			technique for analyzing software architectures	

Reference: Carter, B. (2016). *SYSTEMS THEORY BASED ARCHITECTURE FRAMEWORK FOR COMPLEX SYSTEM GOVERNANCE.* (PhD Dissertation), Old Dominion University, Norfolk, Virginia, USA.

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
AUSDAF	Australian Defence Architecture Framework	X			a variant of DoDAF, see DoDAF	
AAF	Automotive Architecture Framework	X			rooted in DoDAF, see DoDAF	
BCA	Business Capability Architecture	X			None - business enterprise foundation to enhance accountabilities and improve decision-making	
BCEA	Business Centered Enterprise Architecture			X	Describes how to assess, plan, and manage business change, how to connect desired business outcomes to the implementation of processes, systems, resources, and governance.	Potential, system dependent, M-4
BDAF	Big Data Architecture Framework	X			IT, data management	
BEAM	Business Enterprise Architecture Modeling	X			little information; contacted Ken Orr Institute - no response	
Blue Ocean Strategy				X	creating market space	
BMC	Business Model Canvass			X	snapshot (canvass) depiction of a business model	
BMM	Business Motivation Model			X	captures business requirements across different dimensions to rigorously capture and justify why the business wants to do something, what it is aiming to achieve, how it plans to get there, and how it assesses the result	
Bolman and Deal Four Frame Model				X	a leadership framework	
BPEAM	Best Practice Enterprise Architecture Management Method	X			information systems mapped to supported business processes and their informatin flows	
BSIMM	Building Security in Maturity Model Framework	X			None - software security framework	

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
CA	Causal Architecture			X	Align enterprise strategy with entreprise architecture using system dynamics (causal loop diagram models) and Zachman framework	Potential, system dependent; also see Zachman
CAFCR	Customer Application Functional Conceptual Realization	X			None - a functional decomposition approach to developing architecture requirements	
CAFEA	The Common Approach to Federal Enterprise Architecture			X	None - structure that seeks to achieve commonaility in architectures across Federal Government (frameowrk level only)	
CBDI-SAE	CBDI Service Architecture and Engineering	X			a structure for traceability of services back to business requirements	
CEA	A Service Oriented Enterprise Architecture Framework			X	uses a service oriented roadmap and classification schema to manage services and make business deicsions	
CEAF	Commission Enterprise IT Architecture Framework	X			an IT framework to promote IT to enable business activities - non-IT business segments are not addressed	
CGRM	Canadian Governments Reference Model			X	Describes government progams and services	
CIAF	Cap Gemini Integrated Architecture Framework			X	similar to E2AF and Zachman	Potential, system dependent; also see Zachman
CIF	Continuous Improvement Framework	X			None - a framework within which an enterprise can manage the adoption of Scrum, control the risks, and optimize its investment	
CMMI	Capability Maturity Model Integration			X	None - process and project management	
COBIT	Control Objectives for Information and Related Technology	X			None - IT management and governance	

Reference: Carter, B. (2016). *SYSTEMS THEORY BASED ARCHITECTURE FRAMEWORK FOR COMPLEX SYSTEM GOVERNANCE.* (PhD Dissertation), Old Dominion University, Norfolk, Virginia, USA.

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
COSTA	COSTA Mental Framework			X	six types of systems that are used in every business, way to understand how a system is configured, built off Zachman	Potential, system dependent; also see Zachman
COSO	Committee of Sponsoring Organizations of the Treadway Commission			X	None - development of frameworks and guidance on enterprise risk management, internal control and fraud deterrence	
C4ISR AF	Command, Control, Computers, Communications, Intelligence, Surveillance, and Reconnaisance Architecture Framework	X			followed TAFIM, led to DoDAF	Potential, system dependent; also see DoDAF
DAD	Disciplined Agile Delivery	X			None - software development	
DDD	Domain Driven Design	X			None - software development	
DoDAF	Department of Defense Architecture Framework			X	Multiple views are related to CSG.	Potential, system dependent
DNDAF	Department of National Defence/Canadian Armed Forces Architecture Framework			X	rooted in DoDAF	Potential, system dependent; also see DoDAF
DRAGON1	Dragon1 EA Method			X	development of a variety of architectures, such as enterprise, governance, business, information and technical architecture, solution architecture, reference architectures and security architecture	Potential, system dependent
DSDM / Atern	Dynamic Systems Development Method			X	None - project management level	

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
DYA	Dynamic Architecture	X			centered on facilitating change in business, information and technical doamins of an enterprise	
EAAF	OMB's Enterprise Architecture Assessment Framework	X			IT investment decision making	
EAB	Enterprise Architecture Blueprinting	X			a notational system for drawing and maintaining IT architectures	
EA^3 Cube Framework™	EA Strategy Business Technology Approach			X	None - governance at the system/organization level versus metasystem governance	
E2AF	Extended Enterprise Architecture Framework			X	similar to Zachman	Potential, system dependent; also see Zachman
EAM-PC	Enterprise Architecture Management Pattern Catalog			X	Experiences from academia and practice have been collected, structured, and made available for future reuse as an EAM catalog of 164 EAM patterns and two EAM anti patterns.	
EBAF	Enterprise Business Architecture Framework			X	Business architecture and strategy - Integrates with EBCF	
EBCF	Enterprise Business Culture Framework			X	Modelling, anlayzing, assessing, aligning business culture	

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
EBMM	Enterprise Business Motivation Model			X	a specification for supporting business decisions in changing environment - To capture decisions about reaction to change and the rationale for making them, with the intent of making them shareable, increasing clarity and improving decision-making by learning from experience. - To reference the outcomes of the decisions to their effect on the operational business (e.g. changes made to business processes and organization responsibilities), providing traceability from influencer to operational change.	Potential, system dependent, MV-4*
EIF	European Interoperability Framework		X		communications between governments / nation states	Potential, system dependent, MV-2
EPCAF	The EPC Global Architecture Framework	X			None - collection of interrelated standards for hardware, software, and data interfaces	
ESAAF	European Space Agency Architecture Framework	X			rooted in TOGAF and MODAF; space domain specific	
ESSAF	Essential Architecture Framework	X			a baseline/minimal framework to facilitate use of an open source toolset for architecture development	
eTOM	enhanced Telecom Operations Map			X	captures process descriptions, inputs and outputs	
EXAF	Extreme Architecture Framework	X			a minimalist approach in matrix and more recently mandala form for addressing data, information, software, and activitity aspects	
FCAPS	Fault, Configuration, Accounting, Performance, Security Framework	X			None - a network management framework	
FDIC	Federal Deposit Insurance Corporation Framework	X			rooted in FEAF and Zachman	Potential, system dependent; also see FEAF and Zachman

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
FEAF	US Federal Enterprise Architecture Framework			X	interrelated reference models	Potential, system dependent
FESS	Framework of Enterprise Systems and Structures	X			None - an instrument for capturing fundamental work elements and boundary objects of a system	
FFLV+GODS	Functions-Flows-Layers-Views Governance-Operations-Development-Supports			X	FFLV describes business, technology, people, stakeholders views. GODS represents the generic business architecture of an enterprise.	
FMLS-ADF	FMLS Architecture Description Framework	X			rooted in NAF	Potential, system dependent; also see NAF
Fragile to Agile Integrated Architecture Framework				X	the alignment of business and technology through the use of councils and boards to ensure intent and design are cohesive	
FSAM	Federal Segment Architecture Methodology	X			None - process for developing and using segment architectures	
GA	Garland and Anthony	X			None - software development method	
GAME	Good Enough Architecture Methodology			X	a simplified approach using "as-is", "to-be", and a roadmap to transition	
GEA	Government Enterprise Architecture			X	Now QGEA	
GEAF	Gartner's Enterprise Architecture Framework			X	a top-down, strategy-driven approach to integrating business strategy with information and technology	
GERA	Generic Enterprise Reference Architecture	X			identifies concepts of enterprise integration	

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
GERAM	General Enterprise Reference Architecture and Methodology	X			business process engineering through identification of 8 main components recommended for enterprise engineering	
GOPP	Goal Oriented Project Planning			X	AKA LFA (a problem/goal - solution focused approach)	
HEAF	Health Enterprise Architecture Framework	X			rooted in TOGAF	Potential, system dependent; also see TOGAF
Hibernate		X			open source Java persistence framework project	
IADS	IBM Architecture Description Standard	X			model driven software engineering standard	
IAF	Integrated Architecture Framework			X	see Cap Gemini / CIAF	
iCODE	iCode Security Architecture Framework	X			approach for developing security architectures	
IDEAS	International Defence Enterprise Architecture Specification	X			None - focused on developing a data exchange for military EA.	
IT-CMF	IT Capability Maturity Frameowrk	X			focused on managing IT like a business, managing the IT budget, Capability, and business value	
ITIL	Information Technology Infrastructure Library	X			for identifying, planning, delivering and supporting IT services to the business	
JADE	Java Agent Development Framework	X			software development	
KAOS	Knowledge Acquisition in Automated Specification / Keep All Objects Satisfied	X			software development	

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
Krutchen 4+1		X			describe architecture of software intensive system	
LEAD	Layered Enterprise Architecture Development			X	works across layers and domains through practice of decomposition/composition	
LEAF (Freeborders)	Light Enterprise Architecture Framework	X			technology supporting business through capabilities mapping	
LEAF (Lattice)	Lattice Enterprise Architecture Framework	X			systems integration and interoperability	
LFA	Logical Framework Approach			X	AKA GOPP (a problem/goal - solution focused approach)	
LITEEA	Light Enterprise Architecture			X	focuses on notional, practical and daily EA from vertical, horizontal, and circular approaches to draw out more "enterprise" than "architecture"	
LMO	Living Mindmap of the Organization	X			uses a mindmap to describe orgnaization resources, processes, and projects	
MACCIS		X			Technical info-structures and their environment	
McKinsey 7-S Framework				X	a question-based worksheet approach to developing as-is / to-be analysis	
MEGAF		X			used for developing architecture descriptions, an extensible repository of viewpoints, views, model kinds, architecture models, system concerns, and stakeholders	
MIKE2.0	Method for an Integrated Knowledge Environment			X	set of information management solutions (models) for driving change	
MODAF	Ministry of Defence Architecture Framework			X	Supports planning and change management activities by capture and presentation of information in a comprehensive way that aids the understanding of complex issues	Potential, system dependent
MOF	Microsoft Operations Framework	X			None - software development focus	

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
MDA	Model Driven Architecture	X			None - application development related	
MSF	Microsoft Solutions Framework	X			approach to delivering solutions for project types of varying complexity	
MSP®	Managing Sucessful Programs Framework			X	None - a program mangement approach	
NAF	NATO C3 Systems Architecture Framework			X	rooted in DoDAF, MODAF	Potential, system dependent; also see DoDAF, MODAF
NCR EAF	NCR Enterprise Architecture Framework	X			systems development for clients	
NIF®	Network Centric Operations Industry Consortium (NCOIC) Interoperability Framework	X			top-level net-centric and interoperability guidance for system architects designing and building systems and systems-of-systems	
NIST-EAM	National Institute of Standards Enterprise Architecture Framework			X	illustrates the interrelationship of enterprise business, information, and technology environments (foundation for FEAF)	
NORA	Nederlandse Overheid Referentie Architectuur		X		considered a checklist of principles for processes and systems to be interoperable, with public service optimization in mind	
OBASHI	The OBASHI Business and IT Methodology and Framework	X			facilitates capturing, modelling, analyzing cost / value of data flows	
OEAF	Oracle Enterprise Architecture Framework			X	rooted in TOGAF, FEA, and GEAF	Potential, system dependent; also see TOGAF

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
OIAm	Open Infrastructure Architecture Methodology	X			supports design of IT infrastructures	
OIO EA	Offentlig Information Online Enterprise Architecture		X		Denmark's national EA rooted in TOGAF and EIF, addressing strategy, business, techniques, gap analysis, change, trends, and governance	
OSGi	Open Services Gateway Initiative Alliance	X			None - specifications for Java development	
P3O	Portfolio, Program, and Project Offices			X	aligned with PRINCE2, intended to facilitate management	
Panorama 360	Panorama 360 Enterprise Business Architecture Framework			X	Planning, managing business processes and technology for insurance and investment organizations	
PEAF	Pragmatic Enterprise Architecture Framework			X	the overarching approach to the meta frameworks described below	Potential, system dependent
PEDF	Pragmatic Enterprise Operation Framework			X	PEDF (part of PEFF) is a Meta Framework - It sits above and around all other frameworks related to the DIRECTION of Enterprises.	Potential, system dependent, MV-5
PEFF	Pragmatic Enterprise Family of Frameworks			X	PEFF provides a coherent context for all Enterprise Frameworks.	Potential, system dependent, MV-5*
PEOF	Pragmatic Enterprise Operation Framework			X	PEOF (part of PEFF) is a Meta Framework - It sits above and around all other frameworks related to the OPERATION of Enterprises.	Potential, system dependent, MV-3, MV-3*
PESF	Pragmatic Enterprise Support Framework			X	PESF (part of PEFF) is a Meta Framework - It sits above and around all other frameworks related to the SUPPORT of Enterprises.	Potential, system dependent
PETF	Pragmatic Enterprise Transformation Framework			X	PETF (part of PEFF) is a Meta Framework - It sits above and around all other frameworks related to the TRANSFORMATION of Enterprises.	Potential, system dependent, MV-4*

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
PERA	Purdue Enterprise Reference Architecture			X	reductionist approach to describing human, organizational, planning, operations, and IT in industry and manufacturing	
PERDAF	Purpose-oriented Enterprise System Decision-making Architecture Framework	X			facilitates quality of service evaluations; designed explicitly to capture the information that is needed to analyze the quality of an enterprise's information systems	
Porters 5 Forces				X	None - for analysis of business and industry competition	
PPOOA	Processes Pipelines in Object Oriented Architectures	X			for software intensive architectures; based on UML activity diagrams; highlights causal flow of activities	
PRINCE2	Projects in Controlled Environments			X	project management/governance framework	
PRISM	Partnership for Research in Information Systems Management	X			first report preceeds Zachman; describes an overall framework starting point	
Proact BOST	Proact Business Operations Systems Technology Framework			X	architecture development methodology through 4 generic views	Potential, system dependent
QAW	Quality Attribute Workshop			X	method for eliciting requirements	Potential, system dependent
QGEA	Queensland Government Enterprise Architecture			X	ICT policies and associated documents that guides agency ICT initiatives, formerly GEA	
RASDS	Reference Architecture for Space Data Systems	X			None - unique to space data systems	
Red Ocean Strategy				X	None - choosing differentiation or low cost strategy	

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Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
RM-ODP	Reference Model of Open Distributed Processing	X			None - computer science reference model for open distributed processing	
RWSSA	Rozanski and Woods	X			None - software systems architecture	
S4V	Siemens 4 Views	X			None - process for software architecting	
SABSA	Sherwood Applied Business Security Architecture	X			security services designed, delivered and supported as an integral part of business and IT management infrastructure	
SAFe	Scaled Agile Framework			X	highlights the individual roles, teams, activities and artifacts necessary to scale agile from the team to program to the enterprise level	
SAGA	Services Architecture for Groupware Applications	X			None - comprised of a set of web services in support of asynchronous notification of events	
SAM	Solution Architecting Mechanism	X			Non - heavy IT focus	
SAPEAF	SAP Enterprise Architecture Framework	X			based on / extension of TOGAF	
SASSY	Self-Architecting Software Systems	X			None - automated software architecture development and selection tool	
SCOR	Supply Chain Operations Reference Model			X	None - operations management focus	
SCRUM		X			None - agile software development model	
SDLC	System Development Life Cycle	X			None - software / system development	
SDS	Scientific Data Services Framework	X			None - data management	
SFIA	Skills Framework for the Information Age			X	2-D skills to responsibility level mapping	

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
SGCAF	Smart Grid Conceptual Architecture Framework	X			rooted in TOGAF	
SID	Shared Information and Data Model	X			information required to implement use cases based on eTOM processes	
SOA	Service Oriented Architecture	X			None - software development	
SOEAF	Service Oriented Enterprise Architecture Framework			X	None - business layer focus	
SOMA	Service Oriented Modeling and Archtiecture	X			None - service modeling necessary to design and create SOAs	
SOMF	Service Oriented Modelling Framework	X			None - software development	
SPIRIT Platform Blueprint 3.0	Service Providers' Integrated Requirements for Information Technology Platform Blueprint 3.0	X			focused on facilitating agreement between vendor and user side technology selections; rooted in TOGAF	Potential, system dependent; also see TOGAF
SSM	Soft Systems Methodology			X	approach for process modeling and change management	
TAFIM	Technical Architecture for Information Management	X			cancelled by DoD in 2000.	
TAM	Telecom Application Map	X			None - application mapping to achieve common language	
TEAF	US Treasury Enterprise Architecture Framework			X	perspectives adopted from ZF, views related to management and when appropriately applied related to governance	Potential, system dependent; also see Zachman

Appendix B: Non-Systems Theory Based Architecture Framework Assessment (Coding)						
Classification of Architecture Framework MAIN Focus (Open Coding)					Domain Linkages (Axial Coding)	Governance Function Application (Selective Coding)
Identifier	Name	Technical / IT	Governance	Management	Linkages / Descriptors	Related CSG Function(s) and/or Outcome(s)
The 42 Way	Enterprise Architecture Capture Framework			X	for enterprise concept capture, visualization and analysis	Potential, system dependent (MV-5, MV-5*)
TOGAF	The Open Group Architecture Framework			X	the Business Architecture type (out of four types) is the most relevant linkage with management cybernetics and governance	Potential, system dependent
TRAK	The Rail Architecture Framework	X			general systems-based enterprise architecture framework aimed at systems engineers based on MODAF 1.2	
UAF	Unified Architecture Framework (For System of Systems Modeling)	X			MBSE approach to layered model of models (MOM). Intended to improve discovery and reuse of architectural artifacts	
UADF	Universal Architecture Description Framework	X			None - combines multiple models to facilitate systems engineering requirements definition	
UDEF	Universal Data Element Framework	X			None - a taxonomy development method	
UPIA	UML Profile-based Integrated Architecture	X			None - similar to SysML but will export to standard XML/PES format	
UKRA	UK Government Reference Architecture			X	defines business, information, applications, and technology requirements for government; rooted in MODAF	Potential, system dependent; also see MODAF
VALIT	Enterprise Value Governance of IT Investments	X			organising framework—with practical guidelines, principles, processes and supporting practices	
VSM	Viable Systems Model		X		requisite organizational structure of any viable or autonomous system, facilitates metasystem level understanding	
xAF	Extensible Architecture Framework			X	a framework development concept suggesting there exists a base framework and extensible frameworks that can be added	
ZF	Zachman Framework			X	considered an ontology for shaping architecture	All - lives at an ontological level for developing architectures

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APPENDIX C

SAMPLE MAPPING OF EXISTING ARCHITECTURAL VIEWS TO COMPLEX SYSTEMS GOVERNANCE ARCHITECTURE FRAMEWORK (APPLYING SELECTIVE CODING)

RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)

Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
FEAF ZAF	AA	Application(s) Architecture	Human and Machine Boundaries / Interfaces Controls, Mechanisms, Inputs, Outputs of Functions / Processes	MV-5 O7 MV-2 O1	Needs field study
TOGAF	ACD	Application Communication Diagram	Mapping of Communications Between Applications Components, Interfaces, Data Entities, and Business Services	MV-5 O7 MV-2 O1	Needs field study
MoDAF	AcV	Acquisition View	Dependencies and timelines for achieving solutions	MV-5 O7 MV-2 O3 MV-3 MV-4* O2 MV-4	Needs field study
MoDAF	AcV-1	Acquisition Clusters	Acquisition projects groupings (portfolio)	MV-5 O7 MV-2 O3 MV-3 MV-4* O2 MV-4	Needs field study
MoDAF	AcV-2	Program Timelines	Project timelines and dependencies	MV-5 O7 MV-2 O3 MV-3 MV-4* O2 MV-4	Needs field study
TOGAF	AIM	Application Interaction Matrix	Communication Relationships	MV-5 O7 MV-2 MV-4' MV-4* O3 MV-5 O5 MV-5 O7	Needs field study
DNDAF	AISM	Aggregated Information Security Matrix	List of system data exchanges with potential for security violations	None	
TOGAF	AMD	Application Migration Diagram	Baseline to Target Application Components	None	
TOGAF	APC	Application Portfolio Catalog	List of Applications Helps Define Scope of Change Initiatives and Establish Standard Set of Applications	None	
TOGAF	ARM	Actor/Role Matrix	Which actors perform which roles	MV-5 O7 MV-5 O1	Needs field study
TOGAF	AULD	Application and User Location Diagram	Geographic Distribution of Applications Where Applications are Hosted, Used, Developed, Tested, and Released	MV-5 O7 MV-2	Needs field study
DoDAF MoDAF	AV	All Viewpoint	Information pertinent to architecture description (scope, context) Description and glossary of architecture contents	MV-5 O7 MV-5* O2	Needs field study
DoDAF MoDAF	AV-1	All View - 1 Overview & Summary Information	Overview / Summary System Context Life Cycle Management	MV-5 O7 MV-5*	Needs field study

Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)

Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
DoDAF MoDAF	AV-2	All View - 2 Integrated Dictionary	Taxonomy System Context Life Cycle Management	MV-5 O7 MV-5*	Needs field study
TOGAF	BD	Benefits Diagram	Classification of Opportunities by Size, Benefit and Complexity Selection, Prioritization and Sequencing of Decisions for Opportunties	MV-5 O7 MV-4 O3	Needs field study
TOGAF	BFD	Business Footprint Diagram	Links Between Goals, Units, Functions and Services Mapping / Traceability of Technical Components to Goals and Ownership of Services	MV-5	Needs field study
TOGAF	BIM	Business Interaction Matrix	Relationships Between Organizations and Functions	MV-3	Needs field study
FEAF ZAF	BLS	Business Logistics System	Node Types and Locations Connection Types	MV-5 O7 MV-2	Needs field study
ZAF	BP	Business Plan	Business Objectives / Strategies Operational Decision Basis	MV-5 O7 MV-5	Needs field study
FEAF ZAF	BPM	Business Process Model	Structured Methods Actual Business Processes	MV-5 O7 MV-5	Needs field study
ZAF	BRM	Business Rules Model	Intent Constraints	MV-5 O7 MV-5	Needs field study
DNDAF	BSAM	Business Strategy & Motivation	Strategic Direction Alignment of Changing Environment to Vision	MV-5	Needs field study
TOGAF	BSFC	Busines Service/Function Catalog	Functional decompositions that can be searched, filtered, and analyzed (not graphical)	MV-3	Needs field study
TOGAF	BSID	Business Service/Info Diagram	Information Needed and Sources Data Consumed and Produced	MV-2	Needs field study
TOGAF	BUCD	Business Use-Case Diagram	Adds Richness to Capability Description, Showing How / When Used Relationsihps Between Consumers and Providers of Services	MV-3 O4	Needs field study
DNDAF	CapV-1	Capability View - 1 Capability Taxonomy	List of Capabilities and Activities	MV-5 O5	Needs field study
DNDAF	CapV-2	Capability View - 2 Capability Scenario Analysis Matrix	Capability Goals and Available Mission Effects Development of Strategic Capability Roadmap and Outlook	MV-4* O2	Needs field study
TOGAF	CD	Class Diagram	Relationships Between Data Entities	MV-2	Needs field study
TOGAF	CED	Communications Engineering Diagram	Protocol and Capacity, NOT Format or Content Means and Methods of Communication	MV-2	Needs field study
TOGAF	CHD	Class Hierarchy Diagram	Who is using particular data and how, why and when it is used	MV-2 O2	Needs field study
TOGAF	CMC	Contract/Measure Catalog	Master list of service level agreements	None	
ZAF	CS	Control Structure	Expression of System Events and Process Cycles	MV-3	Needs field study
DNDAF	CSAM	Capability Scenario Analysis Matrix	Activities, capability goals, effects, avaialable to managers for developing the strategic capability roadmap and outlook	MV-5 O2	Needs field study
DoDAF	CV	Capability Viewpoint	Goals Related to Overall Vision and Strategic Context General, High-Level Scope	MV-5	Needs field study

Reference: Carter, B. (2016). *SYSTEMS THEORY BASED ARCHITECTURE FRAMEWORK FOR COMPLEX SYSTEM GOVERNANCE.* (PhD Dissertation), Old Dominion University, Norfolk, Virginia, USA.

Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)

Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
DNDAF	CV	Common View	Over-Arching Aspects Related to All Views Scope, Context and Taxonomy	All	Needs field study
DNDAF DoDAF	CV-1	Common View - 1 Overview & Summary Information Capability View - 1 Capability Vision	Scope, Purpose Intended Users, Environment, Analytical Findings	MV-5 MV-5*	Needs field study
DNDAF DoDAF	CV-2	Common View - 2 Integrated Data Dictionary Capability View - 2 Capability Taxonomy	Hierarchy of Capabilities Capability Specifics, Taxonomy	MV-4 O2	Needs field study
DoDAF	CV-3	Capability View - 3 Capability Phasing	Planned Evolution of Capabilties Timeline for Capability Evolution	MV-4 O2	Needs field study
DoDAF	CV-4	Capability View - 4 Capability Dependencies	Groupings of Capabilities Dependencies Between Planned Capabilities	MV-4 O2	Needs field study
DoDAF	CV-5	Capability View - 5 Capability to Organizational Development Mapping	Planned Deployment of Capabilities Interconnections of Deployments	MV-4 O3	Needs field study
DoDAF	CV-6	Capability View - 6 Capability to Operational Activities Mapping	Mapping of Required Capabilities to Supported Operational Activities Capability Gaps	MV-4 O3	Needs field study
DoDAF	CV-7	Capability View - 7 Capability to Services Mapping	Mapping of Capabilities to Services Capability Gaps	MV-4 O3	Needs field study
FEAF	DD	Data Definition	Data objects specified by the Physical Data Model	None	
TOGAF	DDD	Data Dissemination Diagram	Physical Layout of Components Relationships Between Data, Services, and Application Components	None	
TOGAF	DEBFM	Data Entity/Business Function Matrix	Mapping that Enables Identification of Ownerships and Data and IX Requirements Relationships Between Data Entities and Business Functions	MV-2	Needs field study
TOGAF	DECC	Data Entity/Component Catalog	List of Data Use Data Entities and Components, Where Stored; Supports IM, Data Governance Policy, and Sharing/Re-use	MV-2	Needs field study
DNDAF	DESM	Data Element Security Matrix	List of data elements used by architecture and their respective security parameters	None	
TOGAF	DGOC	Driver/Goal/Objective Catalog	How an organization meets its drivers through goals, objectives, and measures	MV-3*	Needs field study
DoDAF	DIV	Data & Info Views	Operational and business information requirements, rules, constraints	All	Needs field study
DoDAF	DIV-1	Data & Info View - 1 Conceptual Data Model	High-Level Data Concepts Relationships	None	
DoDAF	DIV-2	Data & Info View - 2 Logical Data Model	Data Requirements Process Rules	None	

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Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)

Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
DoDAF	DIV-3	Data & Info View - 3 Physical Data Model	Physical Data Model System Capabilities, File Structures, Formats	None	
TOGAF	DLD	Data Lifecycle Diagram	Managing data through its lifecycle, includes events/rules/triggers for change in state	None	
TOGAF	DMD	Data Migration Diagram	Visual Representation of Data Sources and Targets; Tool for Auditing and Traceability Flow of Data from Source to Target Applications	MV-2	Needs field study
TOGAF	DSD	Data Security Diagram	Identifies Which System Element(s) can Access Specific Data Matrix of Granted Accesses	None	
TOGAF	ED	Event Diagram	Relationships Between Events and Processes	None	
TOGAF	ELD	Environments and Locations Diagram	Locations of Host Applications, Applications and Typical Users Environments and Boundaries	None	
TOGAF	EMD	Enterprise Manageability Diagram	Filter for ACD; how an application interacts and supports solution management	None	
TOGAF	FDD	Functional Decomposition Diagram	Single Page Organizational Capability Description Discussion of Organizational What versus How	MV-3	Needs field study
FEAF	GDA	Geographic Deployment Architecture	Model of Business Logistics System Implementation Types of System Facilities, Controlling Software	MV-3	Needs field study
TOGAF	GOSD	Goal/Objective/Service Diagram	Defines How a Service Helps the Vision or Strategy	MV-3 MV-5	Needs field study
ZAF	HIA	Human Interface Architecture	Expression of Workflow Roles, Responsbilites, Work Products	MV-3	Needs field study
DNDAF	IAM	Information Accountability Matrix	Accountabilities of information and data owners	None	
TOGAF	IC	Interface Catalog	Scope and Document Interfaces Between Applications Scoping as Early as Possible	None	
DNDAF	IV	Information View	Definitions of information required to make decision and manage resources (exists in all views and provides an information accountability matrix)	All	Needs field study
DNDAF	IV-1	Information View - 1 Strategic Information Model	Relationships Between Groups of Data and Applicable Rules and Constraints	None	
DNDAF	IV-2	Information View - 2 Information Accountability Matrix	Accountability of Information and Data Stewards Relationships Between Subject Areas and Accountability	None	
FEAF ZAF	LBA	List of Business Objects (Assets)	High-Level description of business objects (assets)	MV-5 O7 MV-5	Needs field study
ZAF	LBE	List of Business Events	High-Level description of business events	MV-5 O7 MV-5	Needs field study
ZAF	LBGS	List of Business Goals/Strategies	High-Level description of busines goals/strategies	MV-5 O7 MV-5 MV-5*	Needs field study
FEAF ZAF	LBL	List of Business Locations	High-Level description of business locations	MV-5*	Needs field study

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CSGAF Non-Systems Theory Based Architecture - 5 (N5): Page 5 of Mapping - Needs Field Study / Application Testing

Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)					
Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
ZAF	LBO	List of Business Organizations	High-Level description of business organizations	MV-5*	Needs field study
FEAF ZAF	LBP	List of Business Processes	High-Level description of business processes	MV-3	Needs field study
TOGAF	LC	Location Catalog	Locations where operations occur or where assets are	None	
DNDAF DoDAF FEAF NAF ZAF	LDM	Logical Data Model	System Data Requirements and Process Rules Attributed Relationships and Intent	None	
ZAF	MS	Master Schedule	P.E.R.T. Charts or Senge Model Business Cycle Modelling and Timing(s)	MV-3 MV-4'	Needs field study
FEAF ZAF	NA	Network Architecture	Node Addresses and Line IDs	MV-2	Needs field study
NAF	NAV-1	Overview & Summary Information	Executive level summary information	MV-5 O7 MV-5	NATO views center on operational planning but may be useful for initial referencing.
NAF	NAV-2	Integrated Dictionary	Definition of terms in architecture	All	NATO views center on operational planning but may be useful for initial referencing.
NAF	NAV-3a	Architecture Compliance Statement	Certification statement of compliance with external requirements	None	
NAF	NAV-3b	Metadata Extensions	Deviations from standard view guidelines	None	
TOGAF	NCHD	Networked Computer/Hardware Diagram	Application Components as Currently Distributed Web, Application, Data Storage Layer Planning	None	
NAF	NCV-1	NATO Capability View - 1 Capability Vision	Strategic Context for Capabilities High-Level Scope	MV-5 O7 MV-5*	NATO views center on operational planning but may be useful for initial referencing.
NAF	NCV-2	NATO Capability View - 2 Capability Taxonomy	List of Capabilities and Taxonomy	MV-5 O7 MV-4 MV-4*	NATO views center on operational planning but may be useful for initial referencing.
NAF	NCV-3	NATO Capability View - 3 Capability Phasing	Representation of Available Capabilities Timing of Availabilities	MV-4* O2	The military tactical operations aspect/intent is recognized, but the representation techniques may be of interest
NAF	NCV-4	NATO Capability View - 4 Capability Dependencies	Logical Groupings of Capabilities Dependencies Between Capabilities	MV-4* O2	The military tactical operations aspect/intent is recognized, but the representation techniques may be of interest
NAF	NCV-5	NATO Capability View - 5 Capability to Organizational Deployment Mapping	General Resource Deployments and Specific System Deployments	MV-4* O2	The military tactical operations aspect/intent is recognized, but the representation techniques may be of interest
NAF	NCV-6	NATO Capability View - 6 Capability to Operational Activities Mapping	Mapping of Capabilities to Operations	None	
NAF	NCV-7	NATO Capability View - 7 Capability to Services Mapping	Mapping of Capabilities to Services	None	

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RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)

Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
NAF	NOV-1	NATO Operational View - 1 High-Level Operational Concept Description	Architecture, Elements and Operations in Simple Terms	MV-5* O2 MV-5 O5	Needs field study
NAF	NOV-2	NATO Operational View - 2 Operational Node Connectivity Description	Operational Node Connectivity Operational Information Exchange Requirements	MV-2	Needs field study
NAF	NOV-3	NATO Operational View - 3 Operational Information Requirements	Operational Information Requirements Who, What, Why, and Quality of Information Exchanged	MV-2	Needs field study
NAF	NOV-4	NATO Operational View - 4 Organizational Relationships Chart	Organizational Relationship Chart Relationships Between Key Elements / Players	MV-2	Needs field study
NAF	NOV-5	NATO Operational View - 5 Operational Activity Model	Operational Activity Model Operational Tasks, Inputs, Outputs	MV-3	Needs field study
NAF	NOV-6	NATO Operational View - 6 Operational Activity Sequence & Timing Description	Operational processes in terms of sequencing and timing of subordinate activities	MV-3	Needs field study
NAF	NOV-6a	NATO Operational View - 6a Operational Rules Model	Operational Rules References and Guidelines for Defining Behaviors and Detailed Rules	MV-3	Needs field study
NAF	NOV-6b	NATO Operational View - 6b Operational State Transition Description	Operational State Transition Sequencing of Activities	MV-3	Needs field study
NAF	NOV-6c	NATO Operational View - 6c Operational Event-Trace Description	Operational Event-Trace Time-Ordering of Information Exchange	MV-3	Needs field study
NAF	NOV-7	NATO Operational View - 7 Information Model	Concept Model	MV-5 O7 MV-5	Needs field study
NAF	NPV-1	NATO Program View - 1 Program Portfolio Relationships	Specific to NATO capabilities	None	
NAF	NPV-2	NATO Program View - 2 Program to Capability Mapping	Specific to NATO capabilities	None	
NAF	NSOV-1	NATO Service Oriented View - 1 Service Taxonomy	Service Taxonomy Translation Across Domains or Architectures	None	
NAF	NSOV-2	NATO Service Oriented View - 2 Service Definitions	Service Definitions Delineate Services in Terms of Supporting Operational Activities	None	
NAF	NSOV-3	NATO Service Oriented View - 3 Services to Operational Activities Mapping	Services to Operational Activities Mapping Traceability of Services Supporting Operational Activities	None	
NAF	NSOV-4	NATO Service Oriented View - 4 Service Orchestration	Service Orchestration How Services Support Operational Processes and Activities	None	
NAF	NSOV-5	NATO Service Oriented View - 5 Service Behavior	Service Behavior Function and Behavior of Services	None	

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Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
NAF	NSOV-6	NATO Service Oriented View - 6 Service Composition	How Services Can Be Combined and Sequenced to Provide Higher Level Services	None	
NAF	NSV-1	NATO Systems View - 1 System Interface Description	System collaboration in support of information exchange needs	MV-2	Needs field study
NAF	NSV-2	NATO Systems View - 2 System Communications Description	Communications	MV-2	Needs field study
NAF	NSV-2a	NATO Systems View - 2a System Port Specification	Ports and protocols	MV-2	Needs field study
NAF	NSV-2b	NATO Systems View - 2b System to System Port Connectivity	Physical connections	MV-2	Needs field study
NAF	NSV-2c	NATO System View - 2c System Connectivity Clusters	Requirements for connectivity between nodes	MV-2	Needs field study
NAF	NSV-2d	Systems View - 2d Systems Communication Quality Requirements	Quality requirements of communications between systems	MV-2	Needs field study
NAF	NSV-3	NATO Systems View - 3 Systems to Systems Matrix	Interface chracteristics in matrix form (from NSV-1)	MV-2	Needs field study
NAF	NSV-4	NATO Systems View - 4 System Functionality Description	System functional hierachies	None	
NAF	NSV-5	NATO Systems View - 5 System Function to Operational Activity Traceability Matrix	Mapping of operational activities to system functions and identification of operational needs transformed into system responsibilities	MV-3 O4	Needs field study
NAF	NSV-6	NATO Systems View - 6 System Data Exchange Matrix	System data characteristics exchanged between systems	None	
NAF	NSV-7	NATO Systems View - 7 System Quality Requirements Description	Current & expected quality characteristics & requirements of systems, interfaces and functions	None	
NAF	NSV-8	NATO Systems View - 8 Systems Evolution Description	Plans for evolving system over time	MV-4 MV-4* O2	Needs field study
NAF	NSV-9	NATO Systems View - 9 Technology Forecast	Emerging technologies which may impact the current or planned architecture	MV-4	Needs field study
NAF	NSV-10	NATO Systems View - 10 System Function Sequence & Timing Description	System characteristics	MV-5*	Needs field study
NAF	NSV-10a	NATO Systems View - 10a Systems Rule Model	System behavioral constraints	None	
NAF	NSV-10b	NATO Systems View - 10b Systems State Transition Description	Sequencing of system interactions	None	
NAF	NSV-10c	NATO Systems View - 10c Systems Event-Trace Description	Time-phased sequencing of system data exchanges in given scenarios	None	

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Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
NAF	NSV-11	NATO Systems View - 11 Data Model	Data characteristics	None	
NAF	NSV-11a	NATO Systems View - 11a Logical Data Model	Information model to data model mapping	None	
NAF	NSV-11b	NATO Systems View - 11b Physical Data Model	Instantiation of Logical Data Model in a given product	None	
NAF	NSV-12	NATO Systems View - 12 Service Provision	Which systems contribute to the provision of which services	None	
NAF	NTV-1	NATO Technical View - 1 Technical Standards Profile	List of standards and constraints for implementing systems per NATO System Views	None	
NAF	NTV-2	NATO Technical View - 2 Technical Standards Forecast	Identifies emerging, weak or outdated standards and assesses impact	MV-3	Needs field study
NAF	NTV-3	NATO Technical View - 3 Standard Configurations	Standardized configurations for the architecture	MV-5 O7	Needs field study
TOGAF	OAC	Organization/Actor Catalog	Listing of humans who interact with IT (users and owners)	None	
TOGAF	ODD	Organization Decomposition Diagram	Links between humans, functions and position in an organization chart	None	
DNDAF DoDAF	OV-1	Operational View - 1 High Level Operational Concept Graphic	Concept of Operations System Context	MV-5*	Needs field study
MoDAF	OV-1a	Operational View - 1a High Level Operational Concept Graphic	Mission, operational concepts, operational nodes	MV-5* O2	Needs field study
MoDAF	OV-1b	Operational View - 1b Operational Concept Description	Explains details of OV-1a	MV-5* O2	Needs field study
MoDAF	OV-1c	Operational View - 1c Operational Performacne Attributes	Capabilities needed to fulfill operational requirements	MV-4' O3	Needs field study
DNDAF DoDAF MoDAF	OV-2	Operational View - 2 Operational Node Connectivity/Relationship Description High-Level Operational Concept Graphic Operational Resource Flow Description	Nodes, connectivity, information exchange needs, resource flow needs, human flows, energy flows	MV-2 MV-3	Needs field study
DNDAF DoDAF MoDAF	OV-3	Operational View - 3 Operational Information Exchange Matrix Operational Resource Flow Matrix	Information & Resouce Exchange System Context	MV-5*	Needs field study
DoDAF MoDAF	OV-4	Operational View - 4 Organizational Relationships Chart	Organizational characteristics of an acrhitecture	None	

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Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
DNDAF	OV-4a	Operational View - 4a Organizational Relationships Chart	Organizational characteristics between organizations	MV-2 O3	Needs field study
DNDAF	OV-4b	Operational View - 4b Organization to Role/Skill Matrix	Roles of organizations	MV-2 O3	Needs field study
MoDAF	OV-5	Operational View - 5 Operational Activity Model	Process / Functional Flow System Context	MV-5*	Needs field study
DNDAF DoDAF	OV-5a	Operational View - 5a Functional Model Operational Activity Decomposition Tree	Tasks to accomplish mission Hierarchy of operational activities	None	
DNDAF DoDAF	OV-5b	Operational View - 5b Operational Process Model Operational Activity Model	Procedures to accomplish mission Relationships between operational activities, costs of activities, input/outputs	None	
DNDAF DoDAF	OV-6	Operational Activity Sequence and Timing Description	Operational processes in terms of sequencing and timing of subordinate activities	MV-3	Needs field study
DNDAF DoDAF MoDAF	OV-6a	Operational View - 6a Operational Rules Model	Business rule constraints	MV-3	Needs field study
DNDAF DoDAF MoDAF	OV-6b	Operational View - 6b Operational State Transition Description	Business process responses to events Sequencing of operational activities	MV-3	Needs field study
DNDAF DoDAF MoDAF	OV-6c	Operational View - 6c Operational Event Trace Description	Operational activity traces	None	
DNDAF MoDAF	OV-7	Data & Info View - 7 Operational View - 7 Logical Data Model Information Model	System data requirements, business process rules Information types, characteristics and relationships	MV-5* O2	Needs field study
ZAF	PA	Presentation Architecture	Work flows, human ergonomics, product presentation formats	None	
TOGAF	PECPC	Process/Event/Control/Product Catalog	Hierarchy of processes and their triggers, outputs from processes, controls applied to processes (supplementary to process flow diagrams to facilitate search/filter/analysis)	None	
TOGAF	PC	Principles Catalog	Business & architecture principles for evaluation of architecture governance	MV-5 O7	Needs field study
TOGAF	PCD	Project Context Diagram	Scope of work for projects supporting transformation	MV-4* O2	Needs field study
TOGAF	PD	Processing Diagram	Component groupings for deployable solutions within an architecture, their interconnections and impacts on other technology components	MV-3 O2	Needs field study
TOGAF	PDD	Platform Decomposition Diagram	Technology platform, specifications, versions	None	

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CSGAF Non-Systems Theory Based Architecture - 10 (N10): Page 10 of Mapping - Needs Field Study / Application Testing

Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)					
Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
DoDAF FEAF NAF ZAF	PDM	Physical Data Model	Message formats, file structures, how information requirements are implemented Class hierarchy Logical Data Model instantiations	None	
TOGAF	PFD	Process Flow Diagram	Sequences of activities, their controls, ownerships, products and associated events	MV-3	Needs field study
TOGAF	PLD	Product Lifecycle Diagram	Lifecycles of key/critical system elements and/or products	MV-3 O1	Needs field study
ZAF	PS	Processing Structure	System events and processing cycles associated as triggers for transition between valid states	None	
TOGAF	PSRD	Process/System Realization Diagram	Sequencing of activities in multi-application based processes	None	
DoDAF	PV-1	Project View - 1 Project Porfolio Relationships	Dependencies and relationships between organizations and projects	None	
DoDAF	PV-2	Project View - 2 Project Timeline	Timeline milestones and interdependencies of projects	None	
DoDAF	PV-3	Project View - 3 Project to Capability Mapping	Mapping of targeted capabilities to projects supporting their pursuit	MV-3 O4	Needs field study
TOGAF	RC(1)	Role Catalog	Listing of authorization levels within an organization	None	
TOGAF	RC(2)	Requirements Catalog	Requirements to achieve objectives Benchmark for architecture quality assessment	All	The fundamental reason for linking Outcomes to Responsibilities in the CSGAF™ Metasystem Views
ZAF	RD	Rule Design	Physical specifications of business rules (policy specifications, procedural codes)	MV-5 O7 MV-5	Needs field study
ZAF	RS	Rule Specification	Out-of-context specifications of business rules	MV-5 O7 MV-5 MV-5*	Needs field study
TOGAF	RSM	Role/System Matrix	Relationships between systems and Roles using them	MV-3 O4	Needs field study
ZAF	SA	Security Architecture	Out-of-context specifications of work flows including humans accessing the system and their authorized work	MV-3 O3	Needs field study
TOGAF	SCD	Solution Concept Diagram	High level view of solution(s) for initial investigation & analysis	MV-5 O7 MV-4'	Needs field study
FEAF ZAF	SD	System Design	Methods, structure, or actions	None	
TOGAF	SDD	Software Distribution Diagram	How and where applications are distributed	MV-5 O7 MV-2	Needs field study
TOGAF	SDM	System/Data Matrix	Relationship between systems and data accessed by those systems	None	
DNDAF	SecV-1	Security View - 1 Risk Assessment	Security risk mitigation controls for threats and vulnerabilities	None	
DNDAF	SecV-2	Security View - 2 Data Element Security Matrix	List of architecture data elements and security implications and parameters	None	

Reference: Carter, B. (2016). *SYSTEMS THEORY BASED ARCHITECTURE FRAMEWORK FOR COMPLEX SYSTEM GOVERNANCE.* (PhD Dissertation), Old Dominion University, Norfolk, Virginia, USA.

CSGAF Non-Systems Theory Based Architecture - 11 (N11): Page 11 of Mapping - Needs Field Study / Application Testing

Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)					
Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
DNDAF	SecV-3	Security View - 3 Aggregated Information Security Matrix	List of sytem data exchanges with potential for security violations	MV-5 O7 MV-2	Needs field study
TOGAF	SED	Software Engineering Diagram	Decomposed applications (packages, modules, services), for analysis of impact due to changes	None	
TOGAF	SFM	System/Function Matrix	Relationship between systems and business functions	MV-5* O2	Needs field study
FEAF ZAF	SM	Semantic Model	System objects and relationships at the objective/strategy level	MV-5 O7 MV-5 MV-5*	Needs field study
TOGAF	SMM	Stakeholder Map Matrix	Stakeholders and their influence, questions, concerns and issues that must be addressed by the architecture	MV-5 O7 MV-5*	Needs field study
TOGAF	SOM	System/Organization Matrix	Relationship between systems and organizational units	MV-5* O2	Needs field study
MoDAF	SOV-1	Services View - 1 Service Taxonomy	Taxonomy of services, service characteristics and relationships between services	None	
MoDAF	SOV-2	Services View - 2 Service Interface Specification	Service interfaces, operations and parameters	None	
MoDAF	SOV-3	Capability View - 3 Services View - 3 Capability to Service Mapping	Services mapped to capability they help achieve	None	
MoDAF	SOV-4	Service Sequence & Timing Descriptions	Service characteristics	None	
MoDAF	SOV-4a	Services View - 4a Service Constraints	Constraints in implementing services	MV-4	Needs field study
MoDAF	SOV-4b	Services View - 4b Service State Model	Service states and transition between service states	None	
MoDAF	SOV-4c	Services View - 4c Service Interaction Specification	Interactions between services and external agents, sequencing of interactions and dependencies	MV-2 O3	Needs field study
MoDAF	SOV-5	Services View - 5 Service Functionality	Functionality expected of an implemented service	None	
DoDAF	SSvM	Systems-Services Matrix	Relationships Between Systems and Services	None	
DNDAF	SSyM	Systems-Systems Matrix	Relationships Between Systems	None	
DoDAF	StdV-1	Standards View - 1 Standards Profile	Technical Standards System Capabilities	MV-4 O1	Needs field study
DoDAF	StdV-2	Standards View - 2 Standards Forecast	Technical Standards Forecast Life Cycle Management	MV-4 O2	Needs field study
TOGAF	STM	System/Technology Matrix	Mapping of systems to technology platform (decomposed)	MV-4 O3	Needs field study
DNDAF	StratV-1	Strategic View - 1 Business Strategy & Motivation Subview	Strategic direction response to changing environment	MV-5' MV-4'	Needs field study

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Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)

Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
MoDAF	StV-1	Capability View - 1 Enterprise Vision	Strategic context for groups of capabilities Outlines vision for capability groups over time High level goals & strategy achievement in capability terms	MV-4*	Needs field study
MoDAF	StV-2	Capability View - 2 Capability Taxonomy	Hierarchy of capabilities	MV-4*	Needs field study
MoDAF	StV-3	Capability View - 3 Capability Phasing	Capability availability timeframes	MV-4*	Needs field study
MoDAF	StV-4	Capability View - 4 Capability Dependencies	Dependencies between capabilities & groups of capabilities	MV-4*	Needs field study
MoDAF	StV-5	Capability View - 5 Capability to Organization Deployment Mapping	Where capabilities are deployed	MV-4*	Needs field study
MoDAF	StV-6	Capability View - 6 Operational Activity to Capability Mapping	Capabilities required - mapped to operational activities that capabilities support	MV-4*	Needs field study
TOGAF	SUCD	System Use-Case Diagram	Interaction between humans and their functions in applications	MV-2	Needs field study
DNDAF DoDAF MoDAF	SV-1	Systems View - 1 System Interface Description Resource Interaction Specification	System Interfaces System Capabilities	MV-2	Needs field study
DNDAF DoDAF	SV-2	Systems View - 2 System Resource Flow Description System Communications Description	System Communications System Capabilities	MV-2	Needs field study
NAF MoDAF	SV-2a	Systems View - 2a System Port Specification	Specifies Ports and Interface Protocols for Communication	MV-2	Needs field study
NAF MoDAF	SV-2b	Systems View - 2b System Port Connectivity Description	Systems and their communication ports & links	MV-2	Needs field study
NAF MoDAF	SV-2c	Systems View - 2c System Connectivity Clusters	How links between ports are associated within parent groupings	MV-2	Needs field study
DNDAF DoDAF MoDAF	SV-3	Systems View - 3 Systems-Systems Matrix Resource Interaction Matrix	System Matrix System Capabilities	MV-4	Needs field study
DNDAF DoDAF MoDAF	SV-4	Systems View - 4 System Functionality Description Functionality Description	System Functionality System Capabilities	MV-4*	Needs field study
DNDAF MoDAF	SV-5	Systems View - 5 Operational Activity to System Traceability Function to Operational Activity / Service Function Traceability Matrix	System Function - Operations Trace System Capabilities	MV-3* O2	Needs field study

Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)					
Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
DoDAF	SV-5a	Systems View - 5a Operational Activity to System Function Traceability Matrix	System activities to operational activities mapping	MV-3	Needs field study
DoDAF	SV-5b	Systems View - 5b Operational Activity to Systems Traceability Matrix	Systems to capabilties or operational activities mapping	MV-3 O4	Needs field study
DNDAF DoDAF MoDAF	SV-6	Systems View - 6 System Resource Flow Matrix Systems Data Exchange Matrix	System Resource Flow System Capabilities	MV-3 O3 MV-3 O5	Needs field study
DNDAF DoDAF MoDAF	SV-7	Systems View - 7 Systems Measures Matrix Resource Performance Parameters Matrix	System Performance Measures System Capabilities	MV-3*	Needs field study
DNDAF DoDAF MoDAF	SV-8	Systems View - 8 Systems Evolution Description Capability Configuration Management	System Evolution Life Cycle Management How capability configurations change over time	MV-4	Needs field study
DNDAF DoDAF MoDAF	SV-9	Systems View - 9 Systems Technology & Skills Forecast Technolgy & Skills Forecast	System Technology Forecast Life Cycle Management Trends in technology and technical personnel	MV-4	Needs field study
MoDAF	SV-10	Systems view - 10 System Function Sequence & Timing Description	System characteristics	MV-5*	Needs field study
DNDAF DoDAF MoDAF	SV-10a	Systems View - 10a Systems Rules Model Resource Constraints Specification	Constraints on system functions due to design or implementation of the architecture	MV-5 O6	Needs field study
DNDAF DoDAF MoDAF	SV-10b	Systems View - 10b Systems State Transition Description Resource State Transition Description	System functionality, responses of system to events, relates events to resource states and their transitions	MV-4*	Needs field study
DNDAF DoDAF MoDAF	SV-10c	Systems View - 10c Systems Event-Trace Description Resource Event-Trace Description	System Timing / Sequences System Capabilities	MV-3	Needs field study
DNDAF MoDAF	SV-11	Systems View - 11 Physical Schema	Message formats, file structures, how information requirements are implemented	MV-2	Needs field study
MoDAF	SV-12	Services View - 12 Service Provision	Resource configurations and the services the resources can provide in a given environment	None	
DoDAF	SvcV	Services Viewpoint	System, service and interconnection functionality in support of operational activities	MV-3	Needs field study

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Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)

Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
DoDAF	SvcV-1	Services View - 1 Services Context Description	Interconnections Between Services and Service Items	MV-5* O2	Needs field study
DoDAF	SvcV-2	Services View - 2 Services Resource Flow Description	Resource Flows of Services	MV-3 O3	Needs field study
DoDAF	SvcV-3	Services View - 3 Services Relationships	Relationships between services and between services and systems	MV-5 O5	Needs field study
DoDAF	SvcV-3a	Services View - 3a Systems-Services Matrix	Relationships Between Systems & Services in an Architecture	MV-5 O5	Needs field study
DoDAF	SvcV-3b	Services View - 3b Services-Services Matrix	Relationships Between Services in an Architecture	MV-5 O7	Needs field study
DoDAF	SvcV-4	Services View - 4 Services Functionality Description	Functions performed by services and their respective data flows	MV-2	Needs field study
DoDAF	SvcV-5	Services View - 5 Operational Activity to Services Traceability Matrix	Mapping of services to operational activities	MV-3 O1	Needs field study
DoDAF	SvcV-6	Services View - 6 Services Resource Flow Matrix	Service resource flow elements being exchanged between services and the attributes of the exchange	None	
DoDAF	SvcV-7	Services View - 7 Services Measures Matrix	Measures of Services Model elements	MV-3 O6	Needs field study
DoDAF	SvcV-8	Services View - 8 Services Evolution Description	Planned steps toward improving efficiency of a suite of services	MV-3 O6	Needs field study
DoDAF	SvcV-9	Services View - 9 Services Technology & Skills Forecast	Emerging technologies, products, or skills expected to affect future service development	MV-4	Needs field study
DoDAF	SvcV-10	Services View - 10 Services Sequence & Timing Description	Category of architecture views that describe services in terms of sequencing	MV-3	Needs field study
DoDAF	SvcV-10a	Services View - 10a Services Rules Model	Service functionality by identifying constraints due to system design or implementation	None	
DoDAF	SvcV-10b	Services View - 10b Services State Transition Description	Service functionality by identifying responses of services to events	None	
DoDAF	SvcV-10c	Services View - 10c Services Event-Trace Description	Service functionality by identifying service-specific refinements of critical sequences of events	None	
FEAF ZAF	TA	Technology Architecture	Visual description of technology for the system	MV-5 O7 MV-4	Needs field study
ZAF	TD	Timing Definition	Interrupts & Machine Cycles	None	
TOGAF	TPC	Technology Portfolio Catalog	List of all technology in the system Basis for forming standards	MV-5 O7 MV-4	Needs field study
TOGAF	TSC	Technology Standards Catalog	Standards for technology (lifecycles, versions)	MV-5 O7 MV-4	Needs field study

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RM
MV-5
MV-5*
MV-5'
MV-4
MV-4*
MV-4'
MV-3
MV-3*
MV-2

Appendix C Sample Mapping of Existing Architectural Views to Complex System Governance Architecture Framework (Applying Selective Coding)					
Originating EA Framework(s)	Identifier	Name(s)	Purpose, Identifies, Provides, Supports, or Describes	Related CSG Function and/or Outcome(s)	Additional Notes on CSG Utility
DNDAF MoDAF	TV	Technical View	Minimum standards for implementation, interaction, and interdependences Promote efficiency and interoperability Planning for evolution	MV-5 O7 MV-4	Needs field study
DNDAF MoDAF	TV-1	Technical View - 1 Standards Profile	Describes emerging standards and potential impact to SV elements List of standards for SV elements	MV-5 O7 MV-4* O2	Weak application potential, but should be assessed
DNDAF MoDAF	TV-2	Technical View - 2 Standards Forecast	Anticipated changes in technology standards (in TV-1) Lists emerging or evolving standards	MV-5 O7 MV-4 O1, O2, O3 MV-4* O1, O2, O3 MV-4' O1, O2, O3	Moderate potential for application in MV-4* and MV-4'; High potential application in MV-4
TOGAF	VCD	Value Chain Diagram	High level view of interactions with outside world High level functional and organizational context Used to align stakeholders	MV-5 O7 MV-5 O3, O4, O6 MV-5* O1, O2, O3 MV-5' O1 MV-4 O1, O2, O3 MV-4' O1, O2, O3 MV-3* O1 MV-2 O2, O3	Widespread, high utility in development of CSG Viewpoints and Models
ZAF	WFM	Work Flow Model	Allocation of responsibilities, work outputs, org charts	MV-5 O7 MV-2 O2	Very low probability of usefulness, consider other options before exploring this one.

VITA

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Project Manager – Technical Training Systems	
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PUBLICATIONS

Carter, B., Moorthy, S., Walters, D. (2016). Enterprise architecture view of complex system governance, *International Journal of System of Systems Engineering, 7*(1/2/3), 95-108.

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Walters, D., Moorthy, S., **Carter, B.** (2014). System of systems engineering and enterprise architecture: Implications for governance of complex systems, *International Journal of System of Systems Engineering, 5*(3), 248-262.