

Jeremy Hilton

A methodology for modelling organisational governance: building the ‘Good Regulator’ model for organisations through the application of multiple systems methods.

Cranfield Defence and Security
PhD in Defence and Security

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Academic Year: 2015 - 2023

Supervisor: Dr Natalie Clewley
Associate Supervisor: Dr Matthew Healy
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Abstract

It is not disputed that organisations require good governance and management to be successful. However, identifying the factors that lead to successful organisational outcomes is not so straightforward. Indeed, enabling an organisation to be resilient to environmental turbulence requires a complete and coherent appreciation of organisational operations and the interdependencies between the organisation and its environment.

The purpose of this doctoral thesis is twofold. Firstly, to determine the requirements for a set of systems methods to appropriately model the multidimensional complexity of an organisation. Secondly, to develop a bespoke Reference Model of Governance for a Specific Organisation with multiple systems approaches and a methodology with which to inform a systemic structure for organisational governance and management.

By applying the 'Good Regulator' model as a foundation, this thesis initially explores the complexity of an organisation and its interaction with its environment to determine the requirements for a set of systems methods. Recent approaches to multi-methodology design and application are reviewed. A set of candidate systems approaches is reviewed. Angyal's systems framework is used to guide the selection of systems methods to ensure relevant human factors are incorporated. The resulting arrangement is mapped to the requirements set and used to instantiate a Reference Model of Governance for GroundsWell, a research consortium. Drawing on the literature, a tailored approach to validation is developed and successfully applied to the GroundsWell Reference Model of Governance.

The primary novel contribution to knowledge is the development of a methodology for the arrangement of multiple systems methods and their application to build a Reference Model of Governance for a Specific Organisation, including validation, for organisational governance and management. Other novel contributions include the layered application of methods to better reflect the hierarchy of purpose within an organisational context and an approach to Validation. In its application, I have successfully demonstrated the instantiated Reference Model of Governance for a Specific Organisation is sufficient to identify the factors that need regulating to ensure desired organisational outcomes and enable the organisation to be resilient to external and internal impacts.

Keywords: Complexity, complex systems, systems approach, systems thinking, critical systems practice, organizations, cybernetics, multiple perspectives, hierarchy of purpose.

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My journey started a long time ago when Peter Checkland taught me Soft Systems Methodology (SSM) and Geoff Coyle guided my learning of System Dynamics. Subsequently I'm indebted to Brian Wilson and Steve McIntosh for the development of my SSM practice across a number of large projects, and David Slater for guiding me in Dependency Modelling.

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Thank you, Hen, for your encouragement and support, and for feeding and watering me, especially through the intense months of writing up.

Most importantly, my thanks to Natalie for her wisdom and guidance as my supervisor throughout this research endeavour.

Caminante no hay camino

Se hace camino al andar[1]

Cantares Antonio Machado (1875-1939)

[1] This translates as: Walker – there is no road; the road is made as you walk.

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List of Abbreviations

C	The Context within the CMO (Context, Mechanism, Outcome) model
CATWOE	A mnemonic in SSM where ‘C’ is customer(s), ‘A’ is actor(s), ‘T’ is the transformation, ‘W’ is the weltanschauung, or worldview, ‘O’ is the owner, and ‘E’ is the environmental constraints.
CLD	Causal Loop Diagram
CPTM	Consensus Primary Task Model
CR	Critical Realism
CSH	Critical Systems Heuristics
CSP	Critical Systems Practice
CST	Critical Systems Thinking
D	With regard to Conant and Ashby’s Good Regulator Model, D is the set of primary disturbers that can cause events within the system S to drive the outcomes of the system out of G, the desired (good) outcome.
G	With regard to Conant and Ashby’s Good Regulator Model, G represents the desired “good” events, a subset of Z, achieved by good regulation
GMB	Group Model Building
H	With regard to Conant and Ashby’s Good Regulator Model, H represents the regulator
HAS	Human Activity System
IT	Information Technology
M	The Mechanism within the CMO (Context, Mechanism, Outcome) model
MBO	Management by Objectives
MPA	Multi-Perspective Approach
NCDs	Non-Communicable Diseases
O	The Outcome within the CMO (Context, Mechanism, Outcome) model
OKR	Objectives and Key Results
PQR	Checkland’s SSM guide to building root definitions: Do P, by Q, in order to contribute to achieving R.
R	With regard to Conant and Ashby’s Good Regulator Model, R is the set of events within the regulator, i.e., the choices the regulator has available to regulate the system.
r_1	An element of regulation within the regulator device R
RACI	RACI Model where ‘R’ is responsible, ‘A’ is accountable, ‘C’ is consulted, and ‘I’ is informed.

RD	(SSM) Root Definition
S	With regard to Conant and Ashby's Good Regulator Model, S represents the system subject to regulation
s_1	An element of the system S
SD	System Dynamics
SODA	Strategic Options Development and Analysis
SOSM	System of Systems Methodologies
SSM	Soft Systems Methodology
TSI	Total Systems Intervention
UGBS	Urban Green and Blue Space
UKPRP	UK Prevention Research Partnership. The funding body for the GroundsWell consortium research programme
VSM	Viable System Model
Z	With regard to Conant and Ashby's Good Regulator Model, Z is the total possible set of events

Terminology

The following meanings have been ascribed to certain words and phrases used and are included here to avoid confusion or misinterpretation in the context of this thesis. The phrases in italics are taken from the Oxford English Dictionary (Oxford University Press, 2007). They have been put in an order that enables later meanings to build on the earlier ones.

Organisation

An organized group of people with a particular purpose, such as a business or a government department.

Organisation is taken to mean a formally constituted association, company or public agency operating under a single constitution.

Enterprise

A project or undertaking, especially a bold or complex one; a business or company (from old French – something undertaken).

Enterprise is taken to mean a collection of organisations working together collaboratively, whether formally or informally where each is established under their own constitution but may operate under a collaboration agreement to achieve an agreed outcome.

Institution

An organization founded for a religious, educational, professional or social purpose; a large company or other organization involved in financial trading.

Institution is taken to mean a non-commercial organisation such as a public authority, government department, police force etc.

Management

The process of dealing with or controlling things or people.

This term is used with this meaning.

Manager

A person responsible for controlling or administering an organisation or group of people.

This term is used with this meaning. Managers comprise a range across and enterprise from Chief Executive to Team Leaders.

Governance

The action or manner of governing a state, organization, etc.

Governance is taken to mean the oversight (control) and direction (guidance) provided by the governing body of an organisation, as well as the framework for managing the organisation, frequently to ensure compliance with external regulations, extended through the senior management and across the organisation. The governing body includes the board of directors of a company, the governing body of an institution such as a school, hospital, or prison, or the steering group of a programme or project.

Therefore, there is an hierarchy of governance. That determined by a governing body, that determined by senior management to ensure compliance with governance requirements and translate them into internal governance, or management, which is then disseminated and expanded throughout the organisation.

Governance is exercised by management action (at all levels), processes, procedures, regulations, and documentation used within an organisation or enterprise to ensure the desired outcome of the organisation or enterprise is achieved. It equates to the internal management of the organisation or enterprise.

Regulation

A rule or directive made and maintained by an authority;

The action or process of regulation or being regulated (the regulation of financial markets, health provision, etc.)

Regulation is taken to mean the rules or directives that an organisation or enterprise must comply with as defined, for example, by an external regulator such as the Financial Conduct Authority or Care Quality Commission, as well as internal regulation mandated by the senior management of an organisation or enterprise to comply with external standards and other mandates.

Regulate

Regulate is taken to mean the control actions taken by managers to address variances from a defined goal, within acceptable tolerance, resulting from an unplanned disturbance (either internal or external). Management regulation equates to the subset of governance that shapes conditions (events) and behaviours as opposed to management (providing and distributing resources etc.).

Regulator

A person or thing that regulates something; a person or body that supervises a particular industry or business activity.

Within an organisation or enterprise, this comprises any manager or group of managers, or autonomic responder *(for example an Artificial Intelligence IT System)*, who is in a position to take control action to bring the organisation back into its desired tolerances when subject to an internal or external disturbance.

Such actions may be influenced or constrained by external bodies such as an industry regulator (e.g., Care Quality Commission) who sets regulations for the business, external and internal standards and processes, advisory groups/panels, company boards and boards of governors.

Cybernetics

From Ashby (1956, p.1), cybernetics means the art of steersmanship, with the related themes of co-ordination, regulation and control. Though it principally referred to steering a ship, Plato (1999, pp.230–231) used it as an analogy to steering the ship of state.

Requisite Variety

“Only Variety can destroy variety” (Ashby, 1956). “This means that actors have to balance their own complexity/variety with the contextual/situational complexity/variety. This can be achieved by simplifying external variety or amplifying actors’ own variety or both at the same time” (OECD, 2017, p.137).

System

“A set of interrelated elements, each of which is related directly or indirectly to every other element, and no subset of which is unrelated to any other subset.” (Ackoff and Emery, 2007, p.18)

““… in the modern systems approach, the concept of ‘system’ is used not to refer to things in the world but to a particular way of organising our thoughts about the world. [..] we consider the notion of ‘system’ as an organising concept …” (Flood and Jackson, 1991, p.2)

“A system can be said to be purposive if it is carrying out a transformation, and is termed purposeful if its purpose is internally generated.” (Flood and Jackson, 1991, p.6)

One type of system is a social system: “a system whose elements are purposeful individuals” (Ackoff and Emery, 2007, p.215). Within this thesis, I frequently refer to an organisation as a system.

This term is used with these meanings according to context.

Complexity

Complex comes from Latin *complexus*, past participle of *complector*, from *com-* (“together”) and *plectere* (“to weave, braid”). (Wiktionary, n.d.)

It is very difficult to unravel something entwined. You can see and understand part of it, but not its whole. Complexity is expanded in Section 2.2.

Complex System

A system where the arrangement of its components, their interactions between them and the interaction between the system and its environment are such that they cannot be fully understood.

Method

A particular procedure for accomplishing or approaching something, especially a systematic or established one.

This term is used with this meaning.

Methodology

A system of methods used in a particular area of study or activity.

This term is used with this meaning.

Model

1 A three-dimensional representation of a person or thing or of a proposed structure, typically on a smaller scale than the original;

3 A simplified description, especially a mathematical one, of a system or process to assist calculations and predictions;

This term is used with these meanings according to context.

Systems Thinking

“The phrase ‘systems thinking’ implies thinking about the world outside ourselves, and doing so by means of the concept ‘system’. . . [...] Systems thinking, then,

makes conscious use of the particular concept of wholeness captured in the word ‘system’, to order our thoughts.” (Checkland, 1999, pp.3–4)

“. . . systems thinking is founded upon two pairs of ideas, those of *emergence and hierarchy*, and *communication and control*”. (Checkland, 1999, p.75 italics in the original)

Systems Approach

“An approach to a problem which takes a broad view, which tries to take all aspects into account, which concentrates on interactions between the different parts of the problem.” (Checkland, 1999, p.5)

“Systems approaches refer to a set of processes, methods and practices that aim to effect systems change” (OECD, 2017, p.9).

Systems Methods

“are techniques which, if used correctly, should deliver a desired outcome for the analyst.“ (Jackson, 2021, p.597) Examples include: The Viable System Model, system archetypes, multi-perspective approach, cognitive mapping, conceptual modelling with root definitions.

Systems Methodology

“[t]ranslate[s] broad hypotheses about the nature of the world into recommendations for practical action.” Examples include Systems Engineering, Soft Systems Methodology, Critical Systems Heuristics, System Dynamics, Viable Systems Diagnosis and Design. (Jackson, 2021, p.597)

“ . . . is not *a method* but a set of *principles of method* which in any particular situation have to be reduced to a method uniquely suitable to that particular situation” (Checkland, 1999, pp.161–162 italics in the original)

Systems Models

“seek to capture the essence of a situation in ways that make it easier to understand and manipulate” (Jackson, 2021, p.597). Examples include The

Viable System Model, Rich Pictures, Conceptual Models, Causal Loop Diagrams and Dependency Models.

Reference Model of Governance for a Specific Organisation

A unique model of the organisation, at a sufficient level of detail to identify the activities that need to be regulated to enable the organisation to sustain its desired outcomes. It provides a complete and coherent understanding of what management actions are appropriate across the organisation such that it can be used as the basis of inquiry into the governance structure of the organisation. It is achieved by a set of systems models and is used to support decision-making within an organisation with regard to governance and management. This is a core novelty of this thesis.

Validation

The action of checking or proving the validity or accuracy of something;

The action of making or declaring something legally or officially acceptable

This term is used with these meanings according to context.

Evaluation

The making of a judgement about the amount, number, or value of something; assessment.

This term is used with this meaning.

Relevant Prior Publications

Hilton, J. (1996). Using systems techniques to define information requirements. The Open Group, Barcelona.

Hilton, J., Wright, C., & Kiparoglou, V. (2012). Building resilience into systems. 2012 IEEE International Systems Conference SysCon 2012, 1–8.

Wright, C., Kiparoglou, V., Williams, M., & Hilton, J. (2012). A Framework for Resilience Thinking. Procedia Computer Science, 8, 45–52.

Hilton, J., Riley, T., Mactaggart, I., & Wright, C. (2013). Improving decision-making and management by thinking about the enterprise through multiple dimensions. 2013 IEEE International Systems Conference (SysCon), 312–316.

Hilton, J., Riley, T., & Wright, C. (2013). Using multiple perspectives to design resilient systems for agile enterprises. 2013 IEEE International Systems Conference (SysCon), 437–441.

Hilton, J. (2020). A Summary Report on the Systems Approach to the development of The GroundsWell Consortium Case for Support. https://blogs.ed.ac.uk/groundswell/wp-content/uploads/sites/3722/2020/12/20201202-GroundsWell-Systems-Approach.pdf [Submitted as an accompaniment to the GroundsWell Case for Support.]

Hilton, J. (2021). Relating the Cultural Iceberg to Organisations and Information Warfare. 26th ICCRTS Proceedings.

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1 Background and Introduction

> "Those organisations who will succeed are those that evoke our greatest human capacities – our need to be in good relationships, and our desire to contribute to something beyond ourselves." (Wheatley, 2007, p.124)

> "The model inside the regulator *has* to be at least as complicated as the system regulated. It is the Law of Requisite Variety. It is obvious." (Beer, 2009, p.29)

> "I prefer to define a system's purpose as 'what it does'." (Beer, 2009, p.116)

1.1 Background

The OECD (2017) produced a report that makes the case for taking a systems approach within the public sector due to the increased prevalence of challenges that are complex, uncertain and ambiguous. In their context, "[s]ystems approaches refer to a set of processes, methods and practices that aim to effect systems change" (OECD, 2017, p.9). This was taken further in their report on the potential for taking a systems approach to addressing global policy challenges (2020). This is a significant acknowledgement of the necessity for governments, institutions and organisations to take a different approach to tackling complex systemic problems.

Organisations develop their management and governance models over time. Roles, responsibilities, policies, processes and procedures are added as required as the organisation grows, and as the organisation experiences challenges. Where multiple organisations come together to achieve a common purpose (project, collaborative provision of services, etc.) they establish ways of working to meet contractual commitments. However, there will always be situations not foreseen that requires management action to be taken to mitigate impacts that detract from achieving the desired organisational outcome.

Though it is important to ensure the internal coherence of management processes within organisations, the relationship between the organisation and its environment is an important aspect of the ongoing resilience and sustainability of

any organisation. An organisation shapes its environment and is shaped by its environment. Sommerhoff (1950) explored the impact the environment can have on a system in some depth, and Ashby (1956) incorporated this into his work on cybernetics, as did Conant and Ashby (1970) when they developed their theorem on the regulation of systems.

Emery and Trist have developed a range of environmental ‘causal textures’ with which to assess environmental impact (Emery and Trist, 1965; Trist, 1980). Within their research, they have recognised the contribution Angyal has made to organisational systems thinking through his systems model of the individual and note its relevance to the social aspects of organisations (Angyal, 1941; Emery, 1973; Trist, 1992). Angyal’s novel contribution was in considering the interdependence between system and environment as his starting point. This interdependence, and the inclusion of both organisation and environment as one, he calls the biosphere (Trist, 1992, p.116). Apart from Beer and his work on viable systems (Beer, 1981, 1994), this is an aspect rarely considered in contemporary systems thinking approaches. There is an increasing recognition, however, that this is a critical consideration for viability and sustainability for organisations and economies (Gurria, 2020).

Consequently, resilience and the ability to respond in anticipation of or response to internal and external disturbances is increasingly important. This requires executives to ensure appropriate management across the organisation as well as the information necessary for them to take appropriate action. If managers do not have access to relevant information, then it will be impossible for the enterprise to achieve its goals (Conant, 1969).

Within this thesis organisations are considered as complex systems and a set of methods are determined with which to model complex organisations such that they can be well regulated. Even if not fully understood, it will be shown that they can be regulated.

1.2 Complex Systems

It is necessary to establish complexity and complex systems as a key element of the background of this work on organisations.

> "Complexity is a poorly-defined notion, in which the subjective component so predominates that it is probably impossible to produce a definition, much less a measure, acceptable to all people in all circumstances. Yet few would disagree that there is a strong link between complexity and information; the more information one has to take in to "understand" the system, (i.e., its behavior [sic]), or to describe it, the more complex it seems.
>
> We speak of the complexity of a system as if it were a property of the systems, and that semantic usage obscures the fact that complexity is really a relation between the system and its observer [. . .]." (Conant, 1968, p.91)

With a complex system, the arrangement of its components, their interactions between them and the interaction between the system and its environment are such that they cannot be fully understood. Also, these arrangements and relationships are not fixed, but can change over time due to self-organisation. Complex systems are generally related to living beings such as the human body, the brain and language. Aspects of future artificial intelligence, the types that self-learn, not rule-based, may also be considered complex.

An organisational context places certain requirements on systems science to be able to create a model that describes the complexity of an organisation sufficiently. This is because the attributes of complexity contribute significantly to the requirements to be met by a variety of systems methods.

A complex system cannot be understood by analysing it because by segmenting it for analysis, one loses the essential relationships between the parts, and it destroys what one is seeking to understand. Computer modelling can simulate behaviour of complex organisations, but only by describing rules for the models, thereby pre-defining them and fixing their relationships, or by treating them as 'black boxes'. As a black box, one might simulate inputs and outputs correctly, but one loses any understanding of the workings of the system.

There are two important distinctions to be maintained (Cilliers, 1998, pp.2–3). The first is between simple and complex. Some systems seem simple, but when viewed closely reveal great complexity, such as a flower. Some systems such as a machine or building management systems appear complex but can be described quite easily. So the issue that is being dealt with is that you cannot identify what is specifically complex, because it emerges from the relationship between the components, “complexity is manifested at the level of the system itself” (Cilliers, 1998, pp.2–3).

The distinction between complex and simple comes from how we view the system – at what level of focus we have of it, the level of abstraction (Cilliers, 1998, p.3). In considering the aesthetics of a living room, an aquarium is a simple addition. However, when you look into an aquarium itself as a system, it displays great complexity. Therefore, systems are complex in and of themselves and not merely resulting from the perspective of the observer. This distinction between complex and simple is important because one can often mask the other.

Similarly, the distinction between complicated and complex is important and difficult to determine consistently. The British aircraft carrier as an engineered system with many components is complicated in that it can be explicitly described. Indeed, it has to so it can be built under contract to meet specific requirements. But with a full complement of crew, aircraft, and weapons and is operational at sea, it becomes a complex system. The situations likely to be experienced, and the appropriate response cannot be pre-determined, as opposition strategy and tactics cannot be foreseen. Some aspects of the operational tasks can be analysed and rehearsed, and they can be deemed complicated as a result. At another level of abstraction, when interactions with the broader context of the operation are considered (the environmental interactions), an equivalent analysis would be distorted as the complexity would be simplified to fit the analysis.

1.2.1 Characteristics and capabilities of complexity

Cilliers (1998, pp.3–4) offers 10 characteristics of complex systems (expanded in Section 2.2.1):

i. "Complex systems consist of a large number of elements.
ii. "A large number of elements are necessary, but not sufficient.
iii. "The interaction is fairly rich, i.e. any element in the system influences, and is influenced by, quite a few others.
iv. "The interactions themselves have a number of important characteristics.
v. "The interactions usually have a fairly short range, i.e. information is received primarily from immediate neighbours.
vi. "There are loops in the interactions.
vii. "Complex systems are usually open systems, i.e. they interact with their environment.
viii. "Complex systems operate from conditions far from equilibrium.
ix. "Complex systems have a history.
x. "Each element in the system is ignorant of the behaviour of the system as a whole."

Also, he cites as "two indispensable capabilities of complex systems, representing information and self-organisation (Cilliers, 1998, p.10). These result from the need for a complex system to interact with its environment to maintain itself. This makes demands on the resources of the system, requiring requisite variety to survive. This leads to the two capabilities needed, to store information about the environment for current and future use (corporate memory?) and to be able to adapt its structure as required resulting from structural coupling. Cilliers (1998, p.10) refers to the first of these as "the process of representation" and the second as "the process of self-organisation", having made the significant point of no *a priori* design of the internal structure of the system (or organisation in my context).

The capability of representation is considered in the context of an organisation as opposed to a general complex system. The interaction between the system and its environment, in the context of organisations, is not just regarding the information that is exchanged, but in the relationships between the elements, i.e.,

people. There is no single person who is the gatekeeper for the interaction, but many people have relationships across the boundary according to their activities. Therefore, knowledge of the interrelationships is distributed, as is the information that is exchanged or transferred. It is important that the system stores information for current and future use, and to have knowledge of its history. The information has to have *meaning* to the system and be relevant (Cilliers, 1998, p.58). What meaning and significance this information has to the elements, the people within the system, will vary according to their activities. The interactions are non-linear, are rich, and will have varying impact. It is because of this distribution of relationships according to activity, and that these activities have a large variety within an organisation, that it makes it difficult for an observer to be aware of them all. Also, characteristic 10 (Cilliers, 1998, p.4) states that "each element in the system is ignorant of the behaviour of the system as a whole" so no one person can know the whole. Consequently, describing the boundary of an organisation will always be derived according to a particular perspective or purpose.

The second capability, self-organisation, is also considered here in the context of an organisation. Cilliers (1998) focuses on self-organising systems such as the brain and language arguing the use of neural nets to model them. In this context there is no *a priori* design of the system. He defines self-organisation as:

> The capacity for self-organisation is a property of complex systems which enables them to develop or change internal structure spontaneously and adaptively in order to cope with, or manipulate, their environment."
> (Cilliers, 1998, p.90)

It is this self-organising capability that is missed by most systems analysts who are employed to develop organisational structures and processes, and this rarely includes the human component. Governance processes and structures are generally designed rather than being allowed to unfold. Also, there is pressure to look at an organisation at a point in time, rather than over the flux of time.

1.2.2 Implications for Systems Thinking

It has been stated that a characteristic of a complex system is that each element of a system is ignorant of the system-as-a-whole. From an organisational

perspective, this means no one person can understand the totality of the organisation. However, we are seeking a means whereby we can model a system such that we can provide a good regulator for that system. Therefore, when a conversation regarding regulation (as in management) takes place, each person will carry an internal description that is neither complete, nor similar to another's. This is equivalent to one person trying to describe their experience of a beautiful piece of music, a superb meal, or a fabulous holiday to another who has not heard the music, nor been on that holiday. A full description is not possible, the situation is too complex.

Spencer Brown (1969, p.77) suggests injunction rather than description is required. By injunction, he means the ability to re-create the experience. With music, the composer does not describe it, but codes it in a musical score so it can be played according to his intent. With food, the equivalent is a recipe. For a holiday, it would be the instructions to follow to have an equivalent experience. Once the second person has heard the music played, or played it, or eaten the food, then they can have a conversation to discuss it. Injunction in the systems thinking sense would be the systems approach taken, ideally by all those who wish to regulate the organisation, such that they can discuss it from the same level of understanding. Indeed, it may bring some of the multiple perspectives together in some level of consensus.

Therefore, we are not seeking an approach that can describe an organisation in all its complexity, but a way of gaining a common insight such that an organisation can be effectively managed in a holistic way at the organisational and sub-organisational levels.

1.3 Introduction

Complexity and uncertainty have grown over time and this has led to a move from a Taylorian approach to management (Taylor, 1919) to self-directed 'management by the knowledge worker through Information Technology (IT) systems. Such approaches reinforce the Taylorian approach and very few organisations consider any other approach now (Jaques, 2006; Wheatley, 1992). Sophisticated Information Technology (IT) was seen as the great enabler of

business success and national prosperity; much could be automated, and employees would be set free to enjoy new-found wealth. However, for many, this approach stultifies creativity and supresses individuals' engagement and contribution. Worse, it can impact negatively on their well-being and resilience, leading to reduced effectiveness and efficiency of organisations. Ironically, management response is usually to exert more control, tighter processes and more targets which further exacerbates the problem.

All this had been happening in a world that has become increasingly interconnected, dynamic, IT ('Cyber') enabled, whilst growing resource constraints, competition and rising costs must be met. New competition and ways of working abound, challenging the expensive legacy systems resulting in new business upstarts replacing the traditional companies who are too slow to change their ways. This complexity was foreseen by Emery and Trist when they were developing a conceptual social science basis for planning and predicting the future (Emery, 1977a; Emery and Trist, 1973).

In spite of this, businesses continue to trade and survive, some longer than others. What does it take for a business to be resilient in this era? What chance beyond serendipity does a business have? How can it decide the balance between technology and people to enable it to continue to thrive and adapt in a timely way to changing fashions, competition and technology? How does it decide where to invest and in what skills; when to enhance a product or service and when to let it go, spawning new ones in its place?

Management By Objectives (MBO) was introduced by Drucker (1954) to provide the basis for managing organisations. However, this has had some criticism, particularly Deming (2000) as the behaviours that can result from inappropriate objectives being set at the team and individual level that don't align to the corporate objectives. This, Deming argues, is because there is a lack of understanding of the corporate systems that frequently results in the selection of inappropriate objectives. In addition, MBO underemphasises the importance of context in setting objectives.

More recently, Andy Grove (at Intel in the 1970s) and refined by John Doerr in 1999 established OKR, Objectives and Key Results, as a revision of MBO that addressed its shortcomings (Doerr, 2018). The intention is that OKRs are shared across the organisation to enable aligned objective setting at company, team, and individual levels. Doerr quotes the Intuit CEO, Bill Campbell "When you're the CEO or founder of the company . . . you've got to say, 'This is what we're doing,' and then you have to model it. Because if you don't model it, no one's going to do it." (Doerr, 2018, p.49)

This approach is invaluable for corporate performance but, unless the organisation has the required resources in terms of skills, infrastructure, and ways of working, the organisation will not have the means of achieving the objectives. The challenge for an organisation is to ensure it has all the resources that it needs to achieve its corporate objectives and not an excess (Jaques, 2006). It needs to be able to adapt to changes and have the range of capabilities to enable it to do so (Hoebeke, 2000). Developing a systems model of the organisation is key for this, but one that is information-based and aligns to the organisational purpose, recognises the hierarchy of the organisation and its inherent complexity, links it to its wider set of stakeholders and customers, acknowledges the presence of competitors and changes in technology and social structures, and allows for adaptation (Ackoff and Emery, 2007; Emery, 1981, 1973, 1977b; Ward and Peppard, 2002). In essence, what is required is a hierarchical systems model of the organisation, or integrated set of models, including a dynamic element which is the focus of this thesis.

Adopting a systems model is seen to be beneficial in many contexts (Espejo and Gill, 1997; Haslett, 2011; Hoebeke, 2000; Leveson, 2015; Leveson et al., 2009; Ramírez-Gutiérrez, Cardoso Castro and Tejeida-Padilla, 2021; Ramírez and Selsky, 2016; Rezaee et al., 2018; Simmons, Iles and Yolles, 2005). There are a range of systems methods available for developing models of organisations, but each has different utility and focus. Some have been used singly, and some in conjunction with others. Indeed, it has been argued that multiple perspectives and, therefore, multiple systems methods are necessary to "develop a rich-

enough model of a system such that not only can we develop a consensus view of ‘what’ the system needs to do, without specifying how it should do it, but also build in the resilience and management (governance) perspectives?” (Hilton, Riley and Wright, 2013, p.1)

Many approaches to addressing complex systems, such as organisations or major programmes, involve assuming a single known purpose, or causal modelling, resulting in simplification, thus losing the essential nature of complexity that one is trying to understand in the first place. Organisations seek to adapt to change and, therefore seek to reduce the perceived complexity to enable them to cope (Angyal, 1965; Emery, 1973; Schneider, Wickert and Marti, 2017). This can lead to maladaptive responses, especially when the environment is rapidly changing and seen as ‘turbulent’ (Angyal, 1965; Emery, 1981, 1977a; Emery and Trist, 1973). Also, complexity is addressed in many different disciplines, and some concepts can travel to other disciplines to be used as metaphors or ways of thinking of complex interaction between people and technology; socio-technical systems. A key focus of this thesis is that of the organisation or enterprise, especially those where technology is increasingly seen as the way of improving delivery, value, and profit.

1.4 Governance, Regulation and Management

It is important to clarify how the terms governance, regulation, and management are used in this thesis. Figure 1 is a concept map describing the relationship between Governance, Regulation and Management, and is described in the following sections.

1.4.1 Governance

Governance is taken to mean the oversight (control) and direction (guidance) provided by the governing body of an organisation, as well as the framework for managing the organisation, frequently to ensure compliance with external regulations, extended through the senior management and across the organisation. The governing body includes the board of directors of a company,

the governing body of an institution such as a school, hospital, or prison, or the steering group of a programme or project.

Therefore, there is a hierarchy of governance. This begins with the Government establishing legislation and determining requirements for regulation. Next is the governance exercised by a governing body to provide oversight/control and direction to the Chief Executive, or equivalent, of an organisation or enterprise. Within the organisation, governance is enacted by senior management to ensure compliance with governing body requirements and translate them into internal governance, or management, which is then disseminated and expanded throughout the organisation.

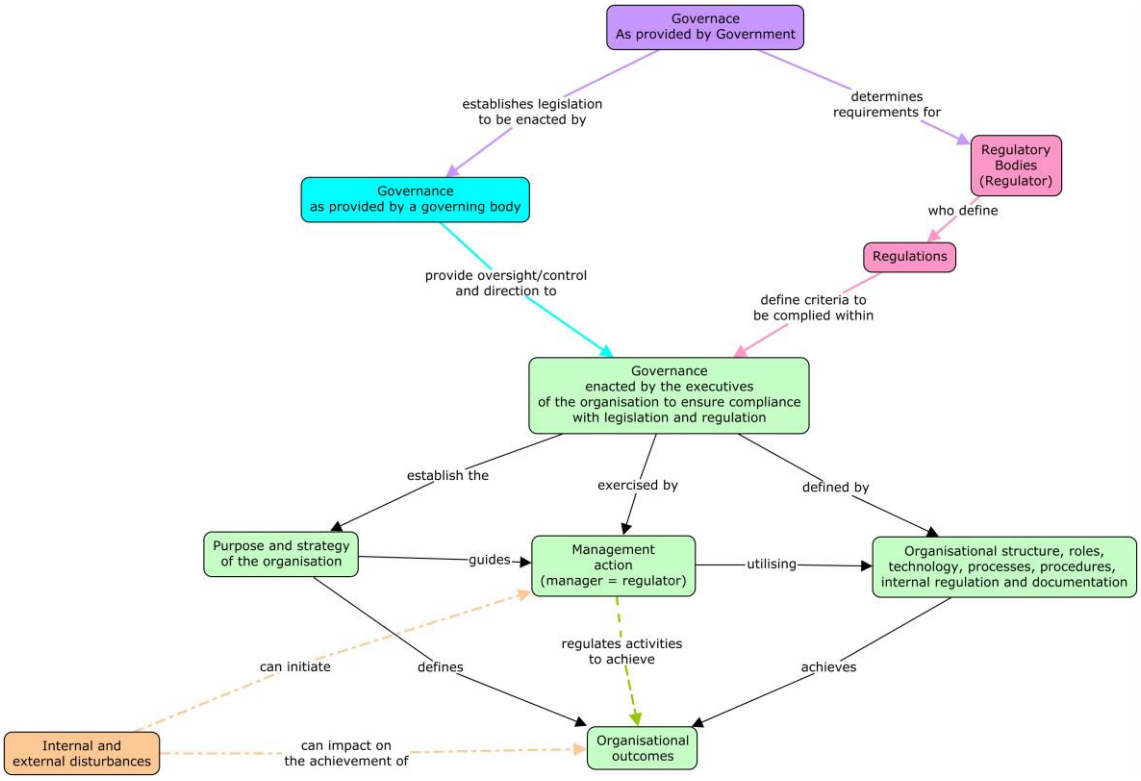


Figure 1 - Governance, Regulation and Management (Source: Author)

Governance is exercised by management action (at all levels), processes, procedures, regulations, and documentation used within an organisation or enterprise to ensure the desired outcome of the organisation or enterprise is achieved. It equates to the internal management of the organisation or enterprise.

1.4.2 Regulator

Within an organisation or enterprise, this is taken to comprise any manager or group of managers, or autonomic responder *(for example an Artificial Intelligence IT System)*, who is in a position to take control action to bring the organisation back into its desired tolerances when subject to an internal or external disturbance.

Such actions may be influenced or constrained by external bodies such as an industry regulator (e.g., Care Quality Commission) who sets regulations for the business, external and internal standards and processes, advisory groups/panels, company boards and boards of governors.

1.4.3 Regulation

Regulation is taken to mean the rules or directives that an organisation or enterprise must comply with as defined, for example, by an external regulator such as the Financial Conduct Authority or Care Quality Commission, as well as internal regulation mandated by the senior management of an organisation or enterprise to comply with external standards and other mandates.

1.4.4 Regulate

Regulate is taken to mean the control actions taken by managers to address variances from a defined goal, within acceptable tolerance, resulting from an unplanned disturbance (either internal or external). Regulation equates to the subset of governance that shapes conditions (events) and behaviours as opposed to management (providing and distributing resources etc.).

1.4.5 Management

The process of dealing with or controlling things or people.

1.5 Governance of Complex Systems

With regard to the governance of complex systems in the context of organisations, complex systems are deemed to have a range of attributes (Ackoff and Emery, 2007; Cilliers, 2001; Emery and Trist, 1973; Jaradat, 2015; Keating,

Katina and Bradley, 2014; Richardson, Cilliers and Lissack, 2001; Simon, 1996; Whitney et al., 2015). These include:

- There is a high level of interconnectivity between the elements within the organisations. This includes the people within the organisation and the other organisations within the organisation's ecosystem, the information flows, the dependant infrastructure of technology, process, and procedures.
- There are a variety of relationships and, due to the levels of management up through the organisation, a hierarchy that differentiates the purpose at each level within the organisation.
- There is ambiguity within the organisation and behaviour is unpredictable. However, behaviours and patterns emerge according to the structure, organisation, and arrangements in place within the organisation. Behaviours and outcomes emerge; the organisation is a system where "the whole is something beside the parts" (Aristotle, n.d. Part 6), more frequently referred to as 'the whole is greater than the sum of its parts' (Flood and Carson, 1993, p.14).
- The organisation operates within an uncertain environment and is structurally coupled to it; the organisation influences its environment and is influenced by it. Therefore, there is feedback, both positive and negative within the organisation as a result of managerial decisions, as well as from the environment as a result of the organisation's behaviour.
- There is a high level of interrelationships among the elements of the various systems that support the organisation, the processes and information technology, and these are subject to individual changes as technology evolves. The organisation is dynamic as a result and will reflect changes in its environment and market preferences.
- The organisation may demonstrate long periods of stability but may suddenly change due to the unforeseen interactions resulting from an internal or external insult.

Some enterprises, such as Infrastructure Mega-Projects (IMP) are extremely complex due to the size and scale of their endeavour, both in terms of cost and timescales. At a lesser, but still significant degree, multi-institution, multi-year research programmes display similar complexity. These projects span multiple organisations and comprise integrated inter-organisational teams. This results in team members having multiple managers and may be members of multiple teams. They may be subject to conflicting instructions and task priorities causing confusion and anxiety (Tannenbaum et al., 2015). Also, the teams are dynamic as their make-up changes during the project lifecycle. A governance approach is needed that is as sophisticated as the enterprise, and that has the variety that can match the enterprise's variety.

In order to address such organisational complexity, in many organisations efforts are taken to simplify it (Hoverstadt, 2022). Some of the notions that are becoming increasingly simplified include causality, or cause and effect, the motivation and drivers of people, and the complexity of the environment. These have a strong influence in socio-technical systems. In this thesis, inspiration is drawn from authors and researchers across a range of disciplines from anthropology to architecture, biology to management, mathematics to psychiatry, quantum theory to philosophy, and systems science to guide an approach to enable organisations to survive and thrive. Many of the same fundamental concepts and principles are covered within these disciplines, but each in their own language and in their own way; the multiple paradigms of thinking that Kuhn (1996) refers to. These include the scientific method of positivism and the social science approaches of interpretivism and constructivism. However, many of the underlying principles can be transferred between disciplines. Bringing buildings and conurbations into being has similarities to bringing organisations into being (Alexander, 1979). Morphogenesis (Sommerhoff, 1950), the structural changes at a cellular level within the early stages of a growing embryo, where cell specialisation begins to occur, also resonates with the growing pains of a young organisation as it grows beyond its initial enthusiastic cohort.

Building on these concepts, this thesis synthesizes the contribution from these disciplines and relates them to the approaches currently used to explore engineered socio-technical systems as considered by systems practitioners and enterprise systems engineers. This is a conceptual project, but with a practical application, focused on establishing appropriate governance and ensuring managers are able to effectively regulate the organisation when subject to internal and external disturbances, thus maintaining the profitability, internal communications, resilience, and sustainability of enterprises.

With regard to the governance of systems, Conant and Ashby (1970) posit that “Every good regulator of a system must be a model of that system”. Here the regulator of the system (where the system is the organisation) is taken to be management action exercising internal governance by utilising the organisational structure, roles, technology, processes, procedures, internal regulation and documentation, as well as regulating activities in response to an internal or external disturbance.

Though their proposition is applicable to any system, with regard to organisations and enterprises it is implied that the governance structure, the management roles, responsibilities, policies, processes, and procedures, must be a model of the organisation being regulated. Conversely, you need a model of the organisation to enable an appropriate governance structure to regulate that organisation; one that ensures sufficient information is available to the managers (regulators). Identifying the requisite variety of regulation needed, appropriate to the organisation in its context, cannot be determined by analysing how the organisation is currently being managed. One can assess whether things are being done correctly, but not whether the correct things are being done.

Therefore, a model of the organisation, sufficient to identify the activities that need to be regulated, (i.e., a Reference Model of Governance, specific to that organisation) is necessary to provide a complete and coherent understanding of what is appropriate such that it can be used as the basis of inquiry into the governance structure of the organisation. More importantly, such understanding amongst managers is important when anticipating or responding to internal or

external disturbances (i.e., regulating relevant activities across the organisation) to ensure the organisation continues to achieve its intended outcomes.

Also, it is recognised that organisations are hierarchical (Hoebeke, 2000; Kinston and Rowbottom, 1990; Rowbottom and Billis, 1987) and that they should be perceived as stratified or laminated systems (Bhaskar, 2017; Edwards, O'Mahoney and Vincent, 2014; Jaques, 1986). The purpose should be determined at each layer in the hierarchy to understand the governance relevant to each level. Any Reference Model of Governance for a Specific Organisation must recognise this.

There are a variety of systems methods that are applicable to the development of models of organisations (Jackson, 2019). However, no single systems method is sufficient (Jackson, 2021). To date, there has been considerable discussion regarding the use of multiple methods (Midgley, Nicholson and Brennan, 2015; Mingers, 2000; Munro and Mingers, 2002), though they are generally used in a serial mode, and rarely linked. They are selected for specific contexts (Jackson, 2019, p.155) and applied in distinct phases without the linkage of findings from one method into another (Mingers and Brocklesby, 1997).

The purpose of this thesis is to explore the application of multiple systems methods in a way that is appropriate to build the Reference Model of Governance for a specific organisation or enterprise. It will build upon the existing research on multiple methods, acknowledging the "paradigm wars" of the last few decades, and illustrate their application with a case study. In the development of this Reference Model of Governance for a Specific Organisation, it will incorporate the hierarchy of purpose (Jaques, 1986; Kinston and Rowbottom, 1990; Stamp, 1981) found within every organisation and enterprise and environmental interaction (Angyal, 1981; Emery and Trist, 1965; Emery, 1973).

1.6 Aim

The aim of this thesis is to propose a methodology for the combined application of multiple systems methods and demonstrate that it is suitable with which to establish a specific model of governance for an organisational or enterprise. Such

a model, referred to as a Reference Model of Governance for a Specific Organisation enables a check of coherence and completeness of regulation and is to support the establishment of appropriate governance for an organisation.

1.7 Objectives

The following objectives were identified as necessary to meet the aim:

1. Understand requirements for applicable systems methods. This will also provide validation criteria for the application of methods to a case study. This will provide the answer to Research Question 1.
2. Determine the current state of multi-methodology approaches and multiple methods use.
3. Identify a set of suitable methods that are candidates for the Reference Model of Governance for a Specific Organisation.
4. Design/justify a multimethod approach for the model of regulation. This will provide the structure the systems methods need to fit and map them to it.
5. Demonstrate an instantiation of a specific Reference Model developed for the GroundsWell Research Consortium, including its validation. This will provide the answer to Research Question 2.

1.8 Scope

The scope of the project comprises the application of a set of systems methods to build the Reference Model of Governance for a Specific Organisation (the “Good Regulator Model”) and the appropriate structuring of systems models to demonstrate their application. It will include the reasoning for the methods chosen and consider the competencies required to apply the methods, potentially touching on ways of developing them.

The scope is limited to the Reference Model of Governance for a Specific Organisation. It does not include a measure of ‘goodness’ of regulation, though it may indicate possible approaches. It will include an outline guide to build a Reference Model of Governance for a Specific Organisation for an organisation

but will not include a detailed guide as this would be subject to evaluation of use which is beyond the scope of this thesis.

Aspects of personality and individual behaviours are out of scope though it is recognised that individual motivations and agency will influence regulation. Social structures will be present, naturally, and this project will seek to include methods that can investigate and incorporate such structures and their influence with the governance of the organisation.

1.9 Approach

Angyal (1941) developed a systems model of the individual (organism) that is equally applicable to the organisation (super-organism) (illustrated at Figure 2 below) and is, in effect, 3-dimensional. In this thesis, it is used to guide exploration of the human factors of organisational complexity. It has a vertical, depth-to-surface, dimension which relates motivations and plans to actions taken (shown in red). It has a dimension of progression which relates, at the surface level, to the actions taken to achieve an outcome, but can also represent the logical steps in thought or instinct that guides these actions (shown in green). It has a transverse dimension which represents the coordination and prioritisation of the various lines of progression seen as visible actions, as well as the various thoughts and aspirations (shown in black). Finally, there is the biosphere, that area surrounding the organisation that represents the intangible boundary between the organisation and its environment (shown in blue).

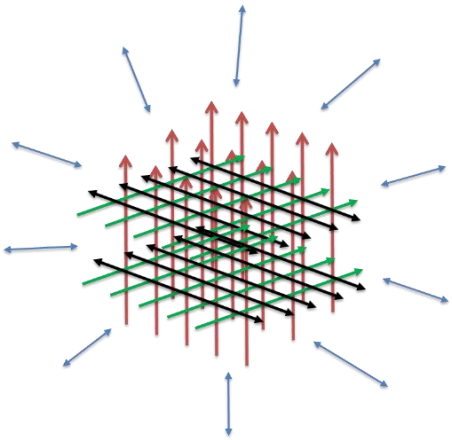


Figure 2 - Angyal's Dimensions (Source: Author)

It is helpful in ensuring related socio-technical elements are considered when building the Reference Model of Governance for a Specific Organisation, and to indicate areas of concern related to maladaptation within the organisation. Therefore, system methods will be selected to be applied to each of the dimensions to form a Reference Model of Governance for a Specific Organisation.

Conant and Ashby developed the theorem that every good regulator is a model of the system it regulates (illustrated in Figure 3). In an organisational context, the regulator (*R*) is the set of managers relevant to the organisation or enterprise (*S*). Consequently, if the organisation has the requisite variety to operate a good regulator, the organisation will maintain its achievement of good outcomes despite perturbations from the environment.

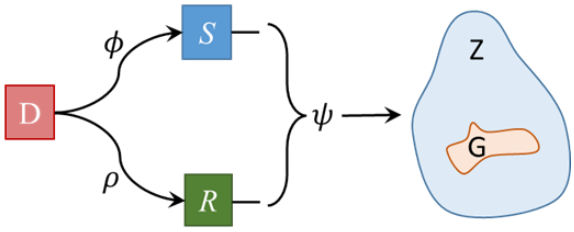


Figure 3 - Conant and Ashby's good regulator model (derived from Conant and Ashby, 1970, p.90)

Within this thesis, the Reference Model of Governance for a Specific Organisation equates to the “good regulator model”.

The Reference Model of Governance for a Specific Organisation, informed by Angyal’s system model, tuned to the regulation required for a specific organisation to achieve good outcomes in all cases, will support the development of requisite regulation (Hilton et al., 2013).

Following Peppard and Ward’s Competence to Capability model (Peppard and Ward, 2004) and generalising it beyond Information Technology (IT) and Information Systems (IS), Hilton et al. (2013) posited that it can be used as a guide to align resources to achieve some organisational outcome (illustrated at Figure 4). Business and technical skills, knowledge, and experience,

underpinned by the organisation's culture, are arranged into roles to undertake processes, some incorporating equipment, and placed in an organisational structure. This constitutes the competencies of the organisation. Appropriate investment in the competencies as required by the organisation's strategy determines the organisations capability, leading to an outcome or effect.

However, the desired effect is not always achieved. What is required is a way of thinking to determine what adjustments are to be made to close the gap between the outcome achieved and the desired outcome; the focus of Conant and Ashby's Regulator, and the purpose of the Reference Model of Governance for a Specific Organisation.

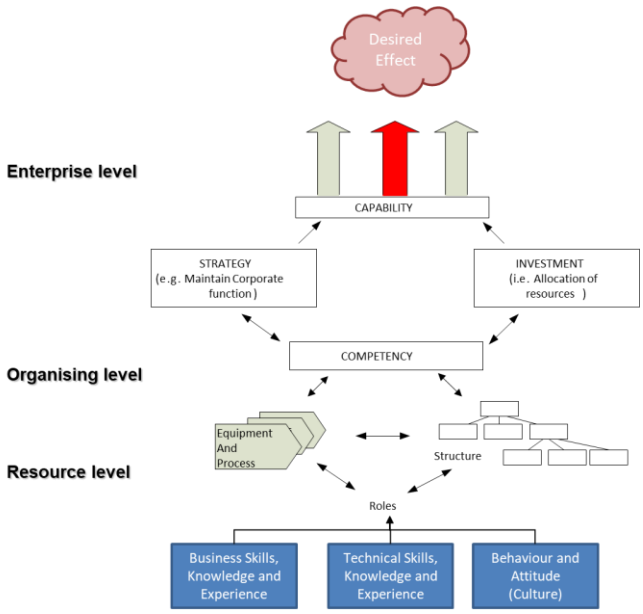


Figure 4 - Competence to Capability alignment (derived from Peppard and Ward, 2004, p.180)

Should you adjust the allocation of investment in competencies to achieve the change, or does it require a more structural change? (Illustrated in Figure 5.) The adjustments required, especially in responding to environmental disturbances, is the role of regulation as enacted by managers.

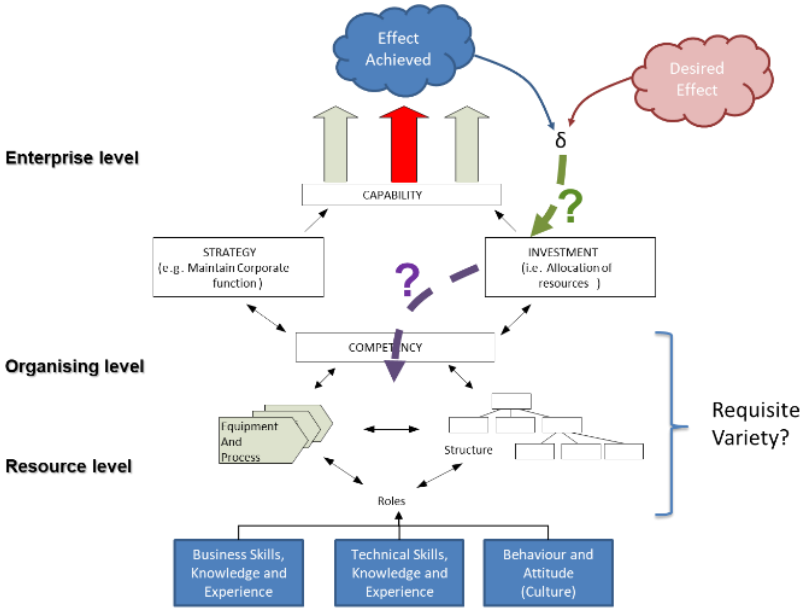


Figure 5 - Decision points to achieve the desired outcomes (derived from Peppard and Ward, 2004, p.180)

The challenge is to have in place the requisite variety of governance (regulation) in order to respond effectively and maintain the good outcomes required.

1.10 Research Questions

The lacuna for this research is the development of a rich model comprising multiple systems methods to enable the identification of the requisite governance (regulation) of an organisation to maintain its achievement of good outcomes. This leads to the research question of “Can you use a set of systems methods to build a model of regulation for an organisation?”

In order to meet the aim of the thesis, it is necessary to explore the factors that should be considered in determining the appropriate governance of organisations, and what this means in terms of requirements for developing a model suitable to determine the requisite variety of governance for an organisation. Due to the uniqueness of organisations in their environment, no single model will suffice. Therefore, an arrangement of systems models will be required and a methodology for their development for a specific organisation.

This leads to the following research questions to be addressed in this thesis.

RQ1: What are the requirements for a multimethod systems approach to model the requisite governance for an organisation?

RQ2: What is a suitable arrangement of systems methods that meets the requirements such that a model Reference Model of Governance for a Specific Organisation can be developed?

1.11 Summary of the approach

In summary, I will determine a set of perspectives relevant to considering the complexity of an organisation, map a systems methodology to each of them, describe an overall method to apply them that incorporates the perspectives, and develop a way of relating these to each other such that insights gained in one dimension (method) can act on another facilitated by a systems practitioner. Figure 6 illustrates the overall approach to this research.

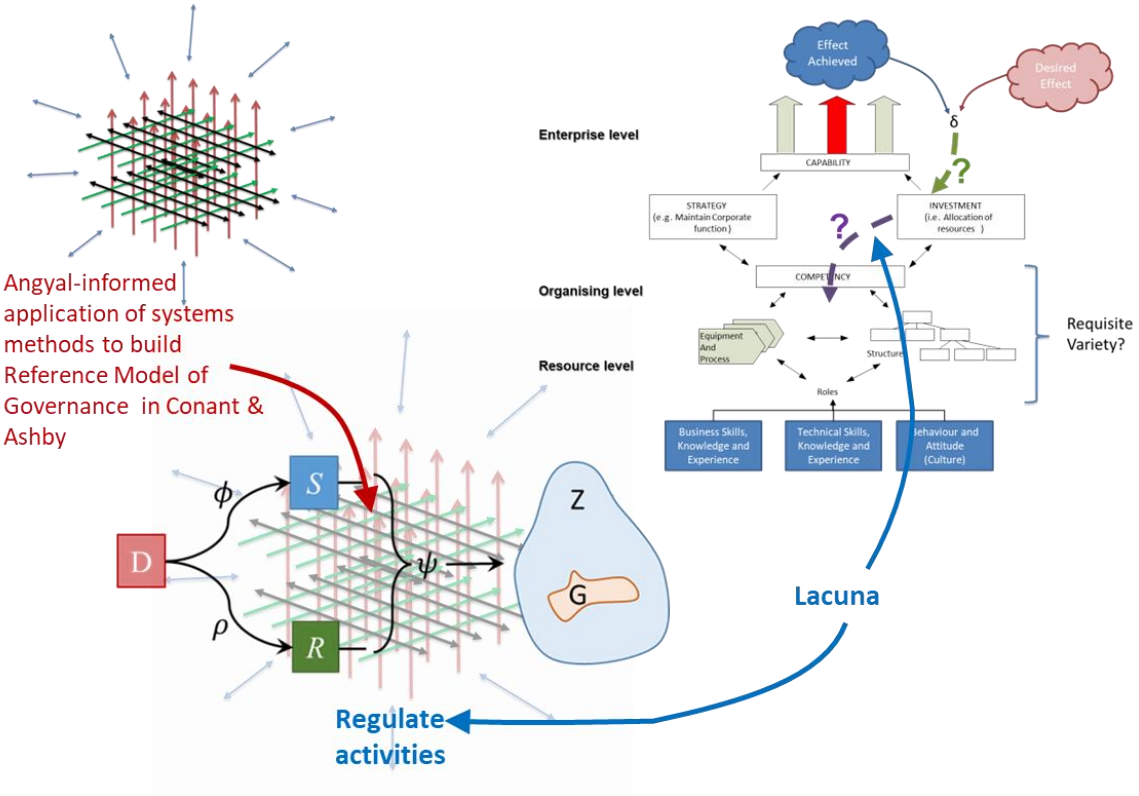


Figure 6 - Outline approach to the research (Source: Author)

1.12 Ethics

The majority of the research for this thesis is theoretical, so has no ethical risks. However, interviews were carried out with members of the GroundsWell research consortium. No personal data was collected, and all participants were able to provide their informed consent. Indeed, much of the GroundsWell Case Study work was undertaken by request of the directors and also contributes to the work package outputs of the work package I lead.

Evidence of ethics approval is included at Appendix A.

1.13 My assumptions

Within this thesis, organisation is taken to mean a single legal entity that comes under a single governance structure. Enterprise is taken to mean an endeavour that incorporates elements of multiple organisations that comes together under an agreement to achieve a short- or longer-term outcome. These terms are used interchangeably as it is the model of governance that is the focus, rather than the structure of the organisation or enterprise under consideration.

There are several categories of assumptions; about the enterprise, about systems thinking and about systems thinking and the enterprise.

1.13.1 About the Enterprise

1. An enterprise is taken to be the arrangement of people in an organisational structure undertaking defined roles, following processes and employing technology that comes together to achieve an agreed outcome – it may involve more than one discrete organisation or no specific organisation;
2. Enterprises are purposeful and may differ with regard to their governance and management approach, whether it is institutionally- or commercially-focused;
3. Enterprises exist in a dynamic, ever-changing environment, so must ‘adapt’ within it;

4. The enterprise has a culture (potentially with sub-cultures) and its environment is unique to the enterprise;
5. All enterprises are unique and you cannot think about them, design them, or build their 'regulator' model (Conant and Ashby, 1970) without a context/purpose.

1.13.2 About Systems Thinking

1. An approach is required that considers an enterprise from multiple perspectives and within its specific context;
2. Contemporary multi-method approaches are aimed at either problem structuring or resolving issues;
3. Another approach that is not systems engineering or problem structuring/resolving is required, but one should utilise existing methods and methodologies where possible;
4. One needs to recognise the various paradigms, acknowledge their impact, and work across them.

1.13.3 Systems Thinking and the Enterprise

1. An enterprise is hierarchical, or laminated;
2. With respect to enterprises, the focus should be on the combined purpose(s), at each level of the hierarchy, and then establish the requisite organisation and technology around them;
3. Context and motivation of individuals and enterprises are key factors;
4. An enterprise can be considered as a living system;
5. As a living system, an enterprise is autopoietic (Maturana and Varela, 1980) (self-sustaining) and has a natural life;
6. In the life of an enterprise, it follows the stages of organismic growth and, therefore, one can take a morphogenetic view of the enterprise in its early years of development;

7. “A system is what a system does” (Beer, 1985), therefore feedback and adjustment will be needed so that what the system does aligns with what is desired – hence the need for the regulator to be considered within systems science.

1.14 Concept Map of the Research Project

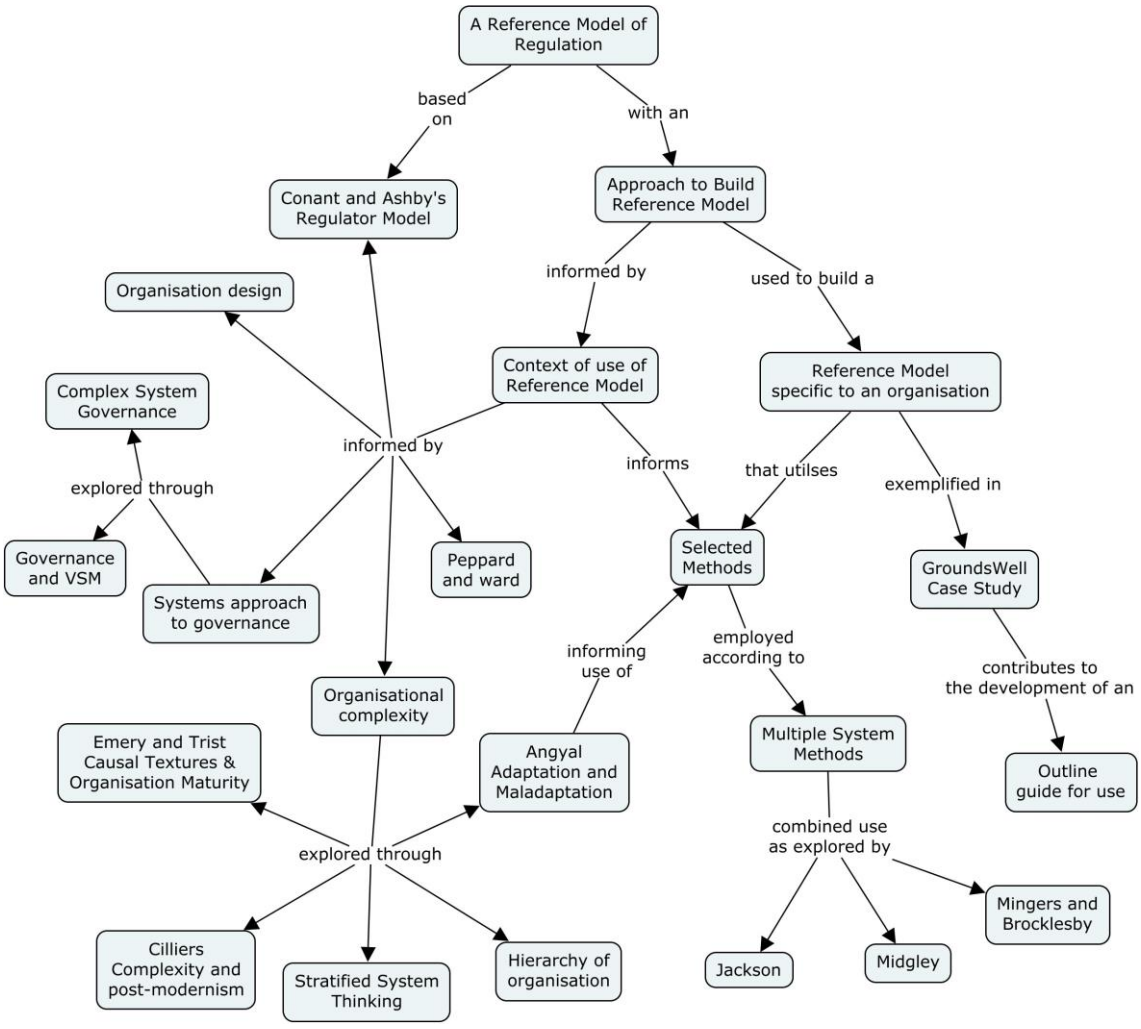


Figure 7 - Concept Map of Research Project (Source: Author)

The concept map at Figure 7 illustrates the research undertaken in this thesis. By ‘walking’ the arrows in the diagram, the overall scheme is described. It is intended to justify and build a Reference Model of Governance for GroundsWell, based upon Conant and Ashby’s regulator model, including an outline method to build the model.

1.15 Anticipated Contribution

It is anticipated that the following contributions will be made by this thesis.

1. A methodology for the application of multiple methods that complies with both Jackson's Critical System Practice and Midgley's Systemic Intervention.
2. A layered or laminated application of methods to better reflect the hierarchy of purpose and related regulatory requirements in an organisational context.
3. An arrangement for the application of a set of systems methods to build the "Good Regulator" model (the Reference Model of Governance for a Specific Organisation).

1.16 Structure of this Thesis

This thesis begins with a review of the literature regarding the key concepts and methods upon which this research is based. It includes a discourse on complexity, Conant and Ashby's Good Regulator Model, organisations as systems, laminated organisations, and environmental interactions. It concludes with a set of requirements for an approach to modelling organisations that addresses Research Question 1.

Chapter 3 explores approaches that have been taken for mixing methods and methodological approaches proposed for applying multiple methods. Methodology selection is summarised using the System of Systems Methodology (Jackson, 2019) and then the literature regarding lessons learned from mixing methods and applying methods in combination is considered, including a review of a range of the most commonly applied systems methods. In addition to popular systems methods, a range of methods used for building a common and shared understanding is considered.

In Chapter 4, the requirements developed in Chapter 2 in answer to Research Question 1 are drawn on and the development and building of the Reference Model of Governance for a Specific Organisation is covered. The need to build a

common and shared understanding amongst those involved in building a Reference Model of Governance for a Specific Organisation is discussed. The methodological approach is developed and then systems methods are mapped to the proposed framework by developing requirements for each of the 3-dimensions of the framework and mapping systems methods to them. In addition, an approach for utilising systems methods is proposed to adjust the performance of an organisation such that it aligned better to its desired outcome. The use of each major systems approach and the methods for understanding in the context of building the Reference Model of Governance for a Specific Organisation are reviewed and it is indicated how they can be shaped according to the organisation's environmental interaction and how additional generic systems models can be applied to augment the governance of an organisation with, for example, a need to improve resilience. A guide for building the Reference Model of Governance for a Specific Organisation is outlined, and the Reference Model of Governance for a Specific Organisation is validated against the requirements determined in Chapter 2 as well as applying the logical validation set of questions devised previously.

In Chapter 5 a specific Reference Model of Governance developed for the GroundsWell Consortium research programme is instantiated. The outline guide for building the Reference Model of Governance for a Specific Organisation is tailored to the context of GroundsWell and where it was in its development when I was asked to first support, then join the consortium. The approach taken is described and some of the artefacts developed in the understanding stage are shared, and then the Reference Model of Governance is developed. How it was used successfully to both improve the funding proposal, the Case for Support, which was successful and how it is being used to improve the ongoing governance of the consortium is then described.

In Chapter 6, the theoretical validation questionnaires, as well as an additional operational validation questionnaire are completed with the consortium directors to solicit their evaluation of the Reference Model of Governance for GroundsWell

regarding its utility in structuring the research programme and its ongoing governance. This answers Research Question 2.

Chapter 7 is a discussion of the results with regard to the literature and initial requirements set, Conant and Ashby's 'Good Regulator' model and with regard to achieving answers to the research questions.

Chapter 8 provides a discourse on the novelty achieved and outlines further work. It concludes with a personal reflection.

The appendices include more detail on the models and other relevant information. Appendix A contains my ethics approval. Appendix B includes an extract from prior work (Hilton, 1996) on using systems techniques to illustrate their ability to model complexity. Appendix C is a summary of literature regarding the use of systems methods in combination. Appendix D contains an update to the Resilience Model published in Wright et al. (2012).

2 Literature Review

> "We cannot regulate our interaction with any aspect of reality that our model of reality does not include [. . .] because, by definition, we cannot be conscious of it." (Beer, 1981a, p. 77)

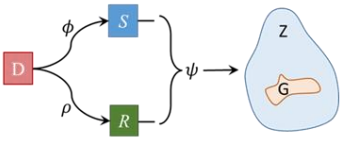
2.1 Introduction

This Chapter will review the literature with regard to the key concepts and methods upon which this research is based. Following a discourse on complexity in section 2.2, a discourse on Conant and Ashby's Good Regulator Model (Conant and Ashby, 1970) is provided in section 2.3 which provides the focus of the research. With the Regulator Model, means of determining the Environment, System and Regulator are required, so this will provide a focus for the remaining review of the literature.

In section 2.4, the context and three-dimensional nature of organisations as systems is explored. Systems stand in relation to their environment and are structurally coupled to their environment. This environmental interaction is not straightforward, and this exploration will determine what would be required of systems methods to ensure their complexity is incorporated into a governance model. Emery and Trist's Causal Textures (Emery and Trist, 1965) are reviewed together with Angyal's discourse on boundaries (Angyal, 1941).There is depth to an organisation, based on its culture and way of working that leads to the structures adopted, and a hierarchy of purpose that needs to be recognised. There are a multiplicity of processes and ways of working at the different levels, all of which need coordination, especially if some are operated by partner organisations. How they link together in this context is determined and the requirements of a model of integration are developed in section 2.5 which will inform the selection of systems methods. The discourse in this chapter leads to Research Question 2 at section 2.6. The scope of this chapter is summarised in Figure 8.



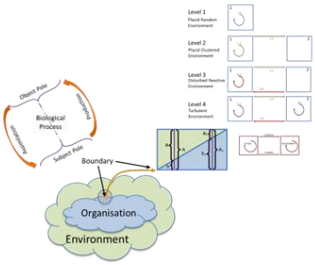
Complexity



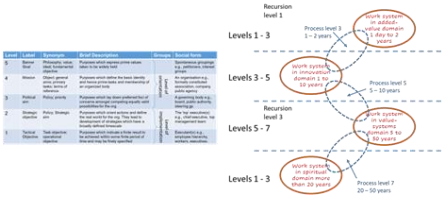
Conant and Ashby's Good Regulator Model



Organisations as systems



Environmental interactions



Laminated Organisations

Figure 8 - Focus of Chapter 2 Literature Review (Source: Author)

2.2 Organisational Complexity

2.2.1 Characteristics of complexity

As introduced above, Cilliers (1998, pp.3–4) offers 10 characteristics of complex systems:

i. "Complex systems consist of a large number of elements.
ii. "A large number of elements are necessary, but not sufficient.
iii. "The interaction is fairly rich, i.e. any element in the system influences, and is influenced by, quite a few others.
iv. "The interactions themselves have a number of important characteristics.
v. "The interactions usually have a fairly short range, i.e. information is received primarily from immediate neighbours.
vi. "There are loops in the interactions.
vii. "Complex systems are usually open systems, i.e. they interact with their environment.
viii. "Complex systems operate from conditions far from equilibrium.
ix. "Complex systems have a history.
x. "Each element in the system is ignorant of the behaviour of the system as a whole."

An example will be given to expand each of these characteristics in the context of a research consortium (fully described in Chapter 5). This is chosen as it comprises multi-organisational teams, each with a different research focus according to their discipline but they need to work in an integrated way to achieve the overall consortium research outcomes. In many respects, it has similarities to the issues in Infrastructure Mega-Projects, though on a smaller scale.

It is necessary to frame its description and in order to do this, one needs to consider the context of the system (the research consortium), its boundary, possibly its purpose. In Cilliers' terms, "what our 'distance' from the system will be: in other words, what level of detail we are going to consider" (Cilliers, 1998, p.5). The focus of the research consortium is public health, specifically to take a systems approach to improve the health impact of urban green and blue spaces.

Looking at this at distance, we could consider the general population and its engagement with urban green and blue spaces. At the other extreme we could look at an individual's use of urban green and blue spaces. The UK Prevention Research Partnership (UKPRP) is funding a number of consortium projects and has a vision "to improve population health, and reduce health inequalities, through the primary prevention of non-communicable diseases (NCDs) (UKPRP, n.d.)". The consortium research outcomes are intended to contribute to this.

The characteristics offered by Cilliers (1998, pp.3–4) are expanded in the context of the research consortium as follows:

i. **Complex Systems consist of a large number of elements.** With a small number of researchers, it would be possible to map their work and how it inter-relates across a group of researchers. However, with a large number this is no longer possible. The population being considered is numbered in the millions, and the number of researchers is numbered in the hundreds.
ii. **A large number of elements are necessary, but not sufficient.** Having a large number of independent researchers isn't a complex system. However, when they interact in a dynamic way, exchanging information, and these interactions change over time, then this constitutes a complex system. This research consortium has several work packages, where each

is the responsibility of a different academic institution. The constituent elements change over time as researchers join and leave the consortium. Our consortium also includes the local population and some local businesses.

iii. **The interaction is fairly rich.** Each element influences and is influenced by other elements. Across the UKPRP, a number of Communities of Practice foster relationships between the consortia. Within our consortium, each work package has a specific focus and within each work package, the researchers themselves have a different focus. However, there is a rich interconnection between them and a necessary exchange of information and knowledge, especially as we are taking an holistic approach based on systems science.

iv. **The interactions themselves have a number of important characteristics.** The interactions are non-linear in that some interactions have a greater effect than others. In our context, one researcher may determine some significant information that has a strong bearing on the work of other researchers in other work packages. Likewise, the output from a large work package may only have a small bearing on other work packages. This significance is not at the work package level, so one cannot simplify the interactions to a higher level of abstraction.

v. T**he interactions usually have a fairly short range.** Information is primarily received from neighbours, i.e., in our context, this might be within a work package or sub-element of a work package. Information is shared at a greater distance, but usually by a more formal process. This does not impact on the strength of influence of information at a greater distance, but the greater distance might result from information being passed through a number of intermediaries, thereby being changed in some way. It may be reinforced, diluted, even supressed or altered in a number of ways.

vi. **There are loops in the interactions.** The effect of an activity may feed back on itself and have a positive or negative effect. My work package in the consortium is intended to lead to an improved systems understanding, especially with regard to the relationship and knowledge exchange

between work packages. This may have a positive effect on the information that one can include in systems models and further reinforce the understanding and benefit of taking a systems approach. This feedback is important as it will enhance the quality of outputs at both a work package and consortium level. These loops are not always internal and will feedback from the environment contributing to the ongoing viability of the organisation and indicate any requirements for adaptation.

vii. **Complex systems are usually open systems.** Complex systems are open in that they interact with their environment. The interface with the environment is frequently difficult to determine and is addressed in more detail in Section 2.4.3. The boundary of a complex system is not a characteristic of the system itself but is derived by considering its purpose. This 'framing' is often influenced by the perspective, or mental model of the observer. As our mental models differ, and as researchers from different disciplines generally have differing ontological and epistemological perspectives, agreeing a purpose and deriving what is contained by a chosen boundary and, therefore, what the system comprises, is not a trivial task.

viii. **Complex systems operate from conditions far from equilibrium.** There has to be a constant flow of energy in and out of the system. In the research consortium context, this may be in terms of funding, information, knowledge, or researchers. There may be dynamic stability, but if new knowledge is not being developed, nor funding acquired, then the consortium will not persist, and the research programme closed down. As Cilliers says "Equilibrium is another word for death." (Cilliers, 1998, p.4)

ix. **Complex systems have a history.** Complex systems are ones that adapt and evolve over time. However, their prior behaviour, their history, also shapes the present and leads to future behaviours. Consequently, the aspect of time is an important element to consider in an analysis of a complex system. Within any research, the prior performance of a researcher is an important consideration for funders, and they prefer to fund Principal Investigators with a good track record. The reputation of their

employing institutions is also an important consideration. Findings from past research also influence the focus of research, as might the history of population health as it shaped the UKPRP vision.

x. **Each element in the system is ignorant of the behaviour of the system as a whole.** This results from interactions within a complex system generally having a short range and information is shared locally. As Cilliers writes (1998, pp.4–5):

> "This point is vitally important. If each element 'knew' what was happening to the system as a whole, all of the complexity would have to be present in that element. [. . .] Complexity is the result of a rich interaction of simple elements that only respond to the limited information each of them are [sic] presented with. When we look at the behaviour of a complex system as a whole, our focus shifts from the individual element in a system to the complex structure of the system. The complexity emerges as a result of the patterns of interaction between the elements."

These 10 characteristics help us describe complexity in a qualitative way, but does not enable us to quantify complexity, to give us a way of measuring it. Cilliers (1998) refers to Shannon's information theory, his mathematical theory of communication (Shannon, 1948 in Cilliers, 1998). Shannon relates information to entropy and, therefore, the greater amount of information in a message, the greater the entropy (1975, p.49 in Cilliers, 1998). He reinterpreted this as the incompressibility of information. Therefore, the more information that is required to describe a system, the more complex the system is (Conant, 1968).

> "[. . .] complexity is complex. A complex system cannot be reduced to a simple one if it wasn't simple (or perhaps merely complicated) to start off with" (Cilliers, 1998, p.9).

Conant (1968) also refers to Shannon regarding a measure of complexity, using entropy as a measure. He also relates the regulation (management) of complex systems to channel capacity:

> "The fact that regulation is so closely linked to the channel capacity between [the regulator] and its opponent has profound implications, for clearly unless a regulator has access to the relevant information (i.e., unless

there is an information channel linking [the regulator and the organisation] its goal will be impossible of attainment" (Conant, 1969, p.336).

This, in my mind, equates to the concept of requisite variety developed by Ashby (1956, 1958) and in the Conant and Ashby theorem "Every good regulator of a system must be a model of that system" (Conant and Ashby, 1970).

2.2.2 Self-organising Capability

Vickers (1965) and Checkland (2011) do emphasise the need to consider change over time in the appreciation of and resolution to a problematic situation. The history of an organisation is significant in developing this understanding, the history of environmental interactions as much as the history of those who worked in the organisation, influencing its growth from within. Cilliers (1998, pp.91–92) provides a number of general attributes of self-organising systems, and those that it is believed relate to organisations are included as it is believed they should be included in the requirements to be met by a systems approach to organisational governance.

i. "**The internal structure of a system can adapt dynamically to changes in the environment**". Within organisations, what constitutes dynamic may not be fast, but it needs to be at a pace close to the dynamics of the environmental occurrence signifying change. This capability needs to be present in an organisation, both to notice the change in the environment and to respond to it.
ii. "**Self-organisation is not merely the result of processes like feedback or regulation that can be described linearly**". Organisations grow and develop structures according to market opportunities, if a commercial organisation, or social needs if, say, a local government institution.
iii. "**Self-organisation is an emergent property of a system as a whole or (if large enough) sub-systems**". Each department, or operating unit of an organisation is frequently self-contained and operates locally. This includes central services such as finance and human resources as well as production units or research centres. One can determine the interactions at a local level, but it is only at the macroscopic level that complexity emerges.

iv. "**Self-organising systems increase in complexity**". Over time, and as organisations grow, they are learning from experience and need to remember - a corporate memory grows. This is more embedded in the people though much now resides in the IT systems. This enables the organisation to compare new situations with old ones to inform decision-making and assumes previous learning is remembered and accessible. Theoretically, the more 'previous' information is stored and accessed, the better the decisions that can be made. Complexity increases over time which requires ongoing management and information sharing. This tends to become saturated and become less effective, leading to aging or becoming structurally fixed, impacting on the ability to adapt to change.

v. "**Self-organisation is impossible without some form of memory**". Without memory, an organisation always has to 'learn' afresh. It will always be on the back foot following the environment. It is this memory where history is retained. However, just storing all information regardless makes it lose its value. It is only the information that is referred to that has any meaning and so information not accessed should be 'forgotten', as it is in the human brain. Not only does this make space in memory, it means the information retained has value and will be utilised.

2.3 A Model of Regulation – Conant and Ashby

> "Every good regulator of a system must be a model of that system"
> (Conant and Ashby, 1970)

Due to the ambiguity of the terms in their assertion, how they are used in the context of this thesis is defined. By system, we mean an organisation or enterprise of human endeavour that is goal directed; it is brought together for a purpose either as a legal entity in its own right, or a consortium of organisations brought together to achieve a shared goal such as a programme or project. It is dynamic and can exhibit state changes. The regulator relates to those managers within the organisation whose behaviours are goal directed and execute those behaviours to regulate activities within the organisation or enterprise to achieve an agreed outcome. The regulators may be human beings, or processes. Therefore, the system and regulator interact. The system (organisation) will

undertake activities and it is the regulator's (manager's) responsibility to regulate activities, and so direct the system to attain its goal despite any internal or external disturbances. By model, we mean a representation of the system as described by the regulator's actions. The greater the variety of the regulating of activities and the closeness of mapping to the activities undertaken within S, the better the regulator 'models' the system. Also, the reference to a 'good regulator' means that the "regulator in question is both optimal and maximally simple" (Scholten, 2010, p.4).

Before the Conant and Ashby model of regulation is considered, what is meant by Regulation and Requisite Variety is introduced, as well as Sommerhoff's Coenetic Variables which underpins the model of regulation.

2.3.1 Regulation

The use of the terms 'governance', 'regulation' and 'management' in this thesis were introduced in Section 1.4.

Regulation (as in regulating actions) is related to survival (Ashby, 1956). From a biological perspective, regulation is what is between an organism and any disturbances from the environment. Organisms have evolved to survive in their optimal environment. This includes maintaining an internal temperature within limits and responding to disease and 'insults' to the body. Some animals have a fixed means to contribute to survival, such as a shell to protect a body within, others may be more proactive. The steady state, then, is the organism living in its environment and maintaining itself within assigned (physiological) limits (homeostasis). Some are fixed such as the internal body temperature, whilst others are more flexible such as the amount of sustenance and water to maintain weight/muscles etc. These are essential variables. Survival of an organism may include loss of some elements such as a limb, whether leg or branch, or some cognitive capacity.

In Figure 9, E is the set of essential variables which need to be kept within a certain tolerance, D is the source of disturbances or danger from the environment, and F is that within the organism that protects E (Shell, brain, etc).



Figure 9 - Basic elements for survival (derived from Ashby, 1956, p.198)

F blocks the transmission of D to E to negate or mitigate the impact of D on E. It should be noted that E has a range of acceptable states that is a subset of all states it could be in. An organisation is similar. Once established, it has the essential elements for survival, managing its essential variables to achieve outcomes that lead to continuing survival.

Providing a block in the manner of a tortoise's shell is a fixed, or passive block and is effective for protection of the tortoise's delicate inner parts to make disturbances negligible. Another type of defence is by

> ". . . skilled counter-action – the defence that gets information about the disturbance to come, prepares for its arrival, and then meets the disturbance, which may be complex and mobile. This is the defence of the fencer, in some deadly duel, who wears no armour and who trusts to his skill in parrying. This is the defence used mostly by higher organisms, who have developed a nervous system precisely for the carrying out of this method." (Ashby, 1956, p.201).

It is this type of active defence that is the focus of regulation in organisations and is termed "cause-controlled regulation" (Conant, 1969, p.338).

Table 1 – Example of Table T, a set D of disturbances d_i can be met by a set R of responses r_i leading to the set of outcomes {a, b, d}.

		R			
		r_1	r_2	r_3	r_4
D	d_1	b	d	a	a
	d_2	a	d	a	d
	d_3	d	a	a	a
	d_4	d	b	a	b
	d_5	d	a	b	d

Table T (for example, Table 1) is the mapping of outcomes (in E) according to the choices open to R in responding to disturbances D. Therefore, for a disturbance D, say d_3, R will take a value determined by D's value, say r_3, to achieve an outcome that is either within E's acceptable set of outcomes η, or not. For each disturbance D, R will select another value and another outcome may occur. If R is a good regulator and is well-made, then R will ensure all outcomes at E fall within η. Here, both R and T act in concert as the barrier.

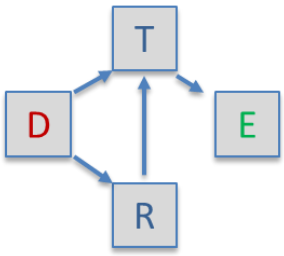


Figure 10 – Diagram of immediate effects in the regulator model (derived from Ashby, 1956, p.210)

The diagram at Figure 10 illustrates this. Here, the arrows are channels of communication. The variety of D determines the variety of R and both determine the variety in T. If R does nothing, in other words, keeps one value, then all disturbance will affect E. The management capability of an organisation, its governance, is the combination of R and T. T represents the 'levers' by which managers, R, can prevent disturbances D from causing outcomes at E to fall out of its limits, η.

Now let us consider the situation where the outcome is to be decided by a controller, C as illustrated in Figure 11. C's decision will affect R's choice within T. This results in 2 inputs, D and C. If R is a perfect regulator, then whatever target C chooses, then whatever disturbance, D, then E will take whatever value C has decided.

If D bypasses C and acts on E, whilst C is attempting control of E, then a suitable regulator R, which takes information from D and C will be able to form, together

with T, a 'compound channel' (F in Figure 9) that transmits directly from C to E and blocks, or negates, any input from D.

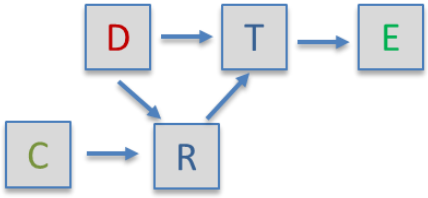


Figure 11 - The addition of control (derived from Ashby, 1956, p.213)

There are some examples where R is undertaken by a number of parts. The human body's thermoregulation mechanism is an example. As illustrated in Figure 12, we have conscious choice as R, (shown as blue block arrows) such as remove clothing, sit in a breeze, move to the shade, reduce exercise, drink water etc.

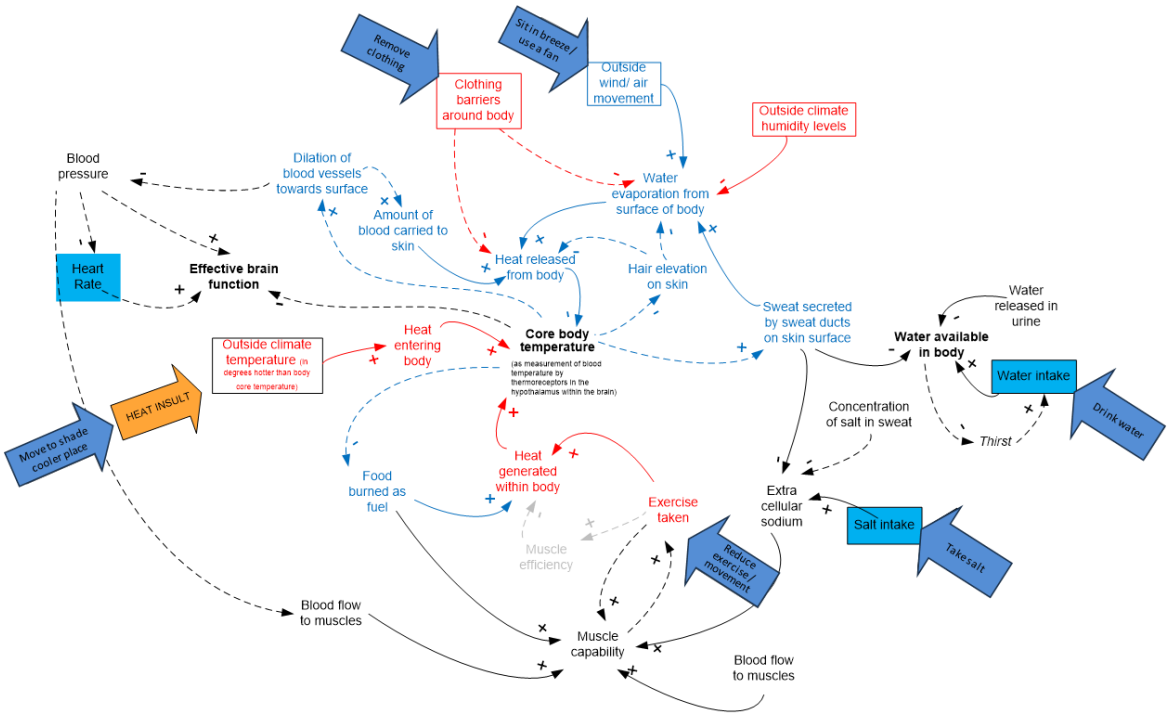


Figure 12 - Conscious decisions in thermoregulation (Source: Author)

However, the body itself makes decisions subconsciously in the hypothalamus, known as homeostasis. We have no conscious choice over these, but by not making additional decisions, the subconscious regulation may not be sufficient

by itself. These other decisions are shown below in Figure 13. They include increasing the size of blood vessels to bring heat out of the core of the body to the surface to be cooled, beginning to sweat at a lower temperature, increasing blood volume to maintain blood pressure, improving efficiency of muscles to reduce the need for food, thereby reducing heat generated within the body, etc. This requires coordination between the parts of R. In the same vein, D may have multiple aspects, and we are used to multiple things happening at once, especially across an organisation.

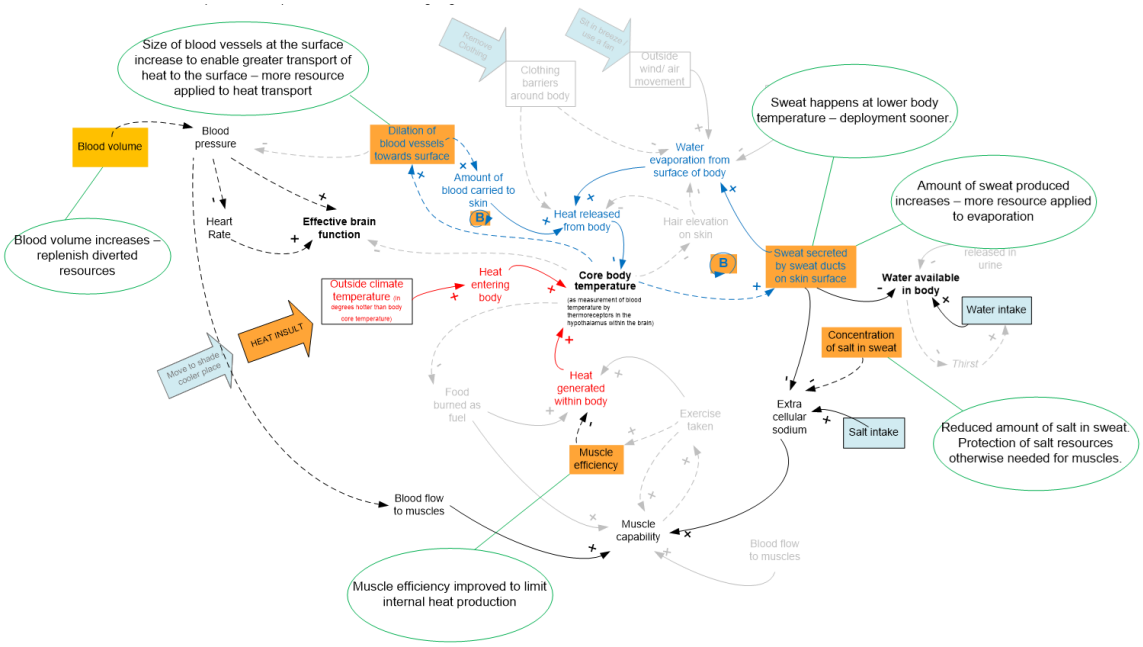


Figure 13 - Subconscious decisions in thermoregulation (Source: Author)

From a different perspective, regulation arises when we have been given or have determined the essential variables, E, and their acceptable range of limits, η, which must be maintained for the success or even survival of the organisation. As Ashby states (Ashby, 1956, p.219, italics in the original):

> "These two must be given before all else. *Before any regulation can be undertaken or even discussed, we must know what is important and what is wanted.*"

He continues:

> "*T* is usually given. It is the environment which the organism is facing together with those parts of the organism that have to be taken as given in

the regulation. It cannot be abolished, but can usually be manipulated. The problem of regulation is then, in general:

"*Given* E, η, T *and* D, *to form the mechanism* R *so that* R *and* T, *coupled, act to keep* E *within* η." (Ashby, 1956, p.220, italics in the original)

The regulator we have described above refers to those situations where we have information providing visibility of the disturbance D as in Figure 10 and we can minimise the impact on E. There are times, however, when R's capacity for transmission is impacted. Within the human body, this could be loss of sight or hearing. In an organisation, a computer may be unavailable, or phones have lost charge. It could be the language being used is not well understood or is misinterpreted due to the use of technical terms, perhaps not familiar to staff from another area of the organisation. It may be that information isn't passed quickly enough. It may have to pass through a number of people, and one might not pass it on due to absence, or overload. It may be possible to improve this, but this is not always possible, and regulation remains imperfect.

Consequently, it may only be when information about E indicates the selection within T is not effective. From a communication point of view, information is now passing from D through T to R rather than directly as illustrated in Figure 14 (a).

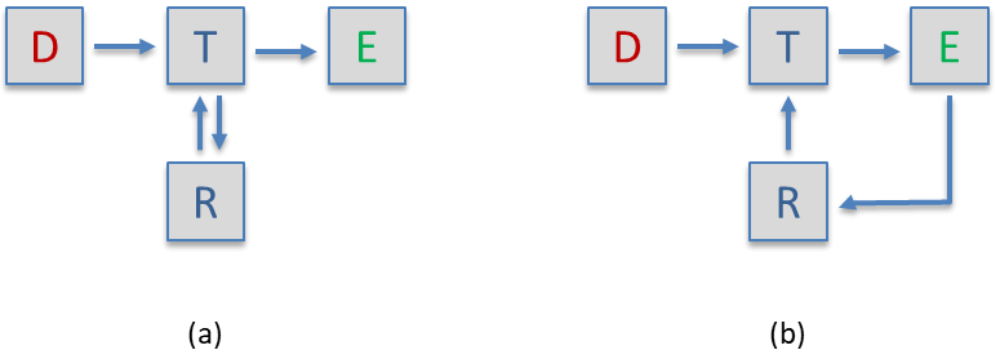


Figure 14 - Error-controlled regulation (derived from Ashby, 1956, pp.222–223)

In some instances, the communication may take longer and not be transmitted until η in E is out of tolerance as illustrated in Figure 14 (b). This is the error-controlled regulator, commonly present in organisations if only outcomes are measured, or lagging measures of performance are used. Here the organisation

may not know what (D) has caused the outcome to be out of tolerance. Consequently, selecting the appropriate response (from T) is challenging and it may require a number of attempts to return E to within tolerance, η.

Considering the types of regulation described above, it can be seen that in organisations better regulation will occur if there is information regarding D available during operation to enable proactive regulation, else knowledge of potential disturbances should be considered (scenario planning) such that steps can be taken to generally mitigate the effect of disturbances (equivalent to the tortoise's shell), thereby reducing the variety in D, and/or develop indicators that will speed the recognition of disturbances. These, associated with practiced responses, can reduce the variety required in R and mitigate the effect of 'surprises'. The main concern here is the range of disturbances that must be regulated against. Also, in large organisations, T can be very large, and it is the size of the variety in T that leads to the size of the variety of D as it is exposed to a great potential for being disturbed. Correspondingly, if R is much smaller than T, then regulation is limited no matter how it is re-arranged internally. This is because the Law of Requisite Variety states that "R's capacity as a regulator cannot exceed R's capacity as a channel of communication" (Goldstein and Ashby, 2011). More specifically:

> *" . . . only variety in R can force down the variety due to D;* **only variety can destroy variety**" (Ashby, 1956, p.207, italics and emphasis in the original)

2.3.2 Coenetic Variables

Ashby's diagram of immediate effects, Figure 10, shows a simple relation between the disturbance, D, and how it acts on the essential variables E, unless the regular R acts on T to prevent it. The relationship between these elements is more nuanced and is based on Sommerhoff's (1950) work on coenetic variables and directive correlation. Other authors (Beer, 1984; Emery, 2000) have also referenced Sommerhoff's directive correlation.

In his work, Ashby refers to Sommerhoff and compares his diagram of 'immediate effects' (Figure 10) with Sommerhoff's formulation for 'directive correlation'

(Sommerhoff, 1950, p.44). This is briefly explored because Sommerhoff introduces the notion of appropriateness of response (Sommerhoff, 1950, pp.38–46). It is something to be considered in the model of regulation, but the detail of it is considered to be out of scope.

There are 4 distinct 'primary and spatio-temporally linked' elements to consider in a response as shown in Figure 15. The environmental circumstances or events that act as a stimulus (disturbance) (St_0); the response (Rt_1); the environmental circumstances which the response meets during enaction, and which are necessary for success (Et_1); and the outcome, or goal of the response, resulting from the interaction between Rt_1 and Et_1 (Gt_2).

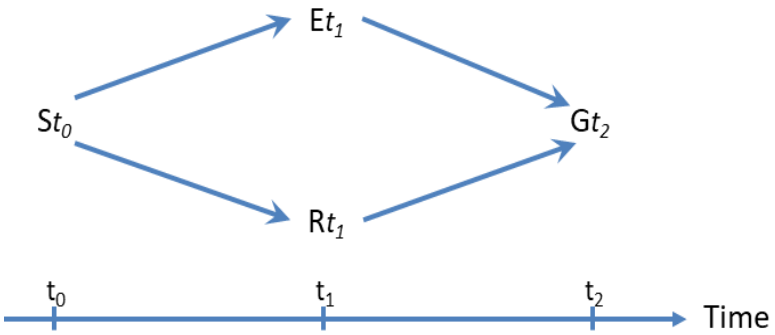


Figure 15 - Spatio-temporal relations in a response (derived from Sommerhoff, 1950, p.44)

Appropriateness arises if the response acting in that moment, with the environment as it is in that moment was most likely to achieve the intended goal. Appropriateness here, is not to be equated to effectiveness, i.e., actually achieving the goal, as there are many variables at play. Efficacy relates to a specific instance of response, as opposed to the general case due to the responder considering the variety around the stimulus and how it may impact accordingly. In other words, the responder is considering a probable range of alternative circumstances in E'_{t_1}, E''_{t_1}, E'''_{t_1},... and, therefore, a correlated set of responses in R'_{t_1}, R''_{t_1}, R'''_{t_1},…. Considering the appropriate response is a 'creative act of thought'.

Sommerhoff takes this further by relating appropriateness to adaptiveness. By this, he means that the system (organism, organisation, or technical system) has

adapted if each variation in E_{t_1} caused the appropriate R_{t_1} to achieve G_{t_2} in all cases.

> "[. . .] R_{t_1} is *adapted* to E_{t_1} in respect of G_{t_2} means that the organism or mechanism causally determining R_{t_1} is objectively so conditioned that if certain changed initial circumstances had caused the occurrence of any alternative member of the set $E'_{t_1}, E''_{t_1}, E'''_{t_1}$,… it would in each case also have caused the occurrence of the corresponding member of the correlated set $R'_{t_1}, R''_{t_1}, R'''_{t_1}$,… of appropriate responses." (Sommerhoff, 1950, p.50)

So far, there are only 2 causal connections related to adaption, involving 3 of the 4 elements, E_{t_1} to G_{t_2} and R_{t_1} to G_{t_2}. There is no causation between E_{t_1} and R_{t_1} as they occur in the same instant in time. Therefore, there is a prior state that provides the causal determination of both E_{t_1} and R_{t_1}, i.e., parallel effects. Sommerhoff defines this as the coenetic variable of the adaptation. The changed initial circumstances are "variations in the t_0 values of one or more coenetic variables of the adaptation" (Sommerhoff, 1950, p.52). Figure 15 is adapted in Figure 16 to reflect this.

Directive Correlation is an important concept in the viability and survival of an organism and, in the same sense, an organisation. It is a helpful way of expressing purposiveness and for exploring environmental interactions within a system in its wider context (Emery, 2000).

Sommerhoff (1950, pp.54–55) defines directive correlation as:

> "Any event or state of affairs R_{t_1} occurring at a time t_1 is *directively correlated* to a given simultaneous event or state of affairs E_{t_1} in respect of the subsequent occurrence of an event or state of affairs G_{t_2} if the physical system of which these are part is objectively so conditioned that there exists an event or state of affairs CV_{t_0} prior to t_1, and a set of possible alternative values of CV_{t_0} such that
>
> (a) Under the given circumstances any variation of CV_{t_0} within this set implies variations of both R_{t_1} and E_{t_1} ;
>
> (b) Any such pair of varied values of R_{t_1}, E_{t_1} (as well as the pair of their actual values) is a pair of corresponding members of two correlated

sets of possible values R'_{t_1}, R''_{t_1}, R'''_{t_1},... and E'_{t_1}, E''_{t_1}, E'''_{t_1},..., which are such that under the circumstances all pairs of corresponding members, but no other pairs, cause the subsequent occurrence of G_{t_2}.

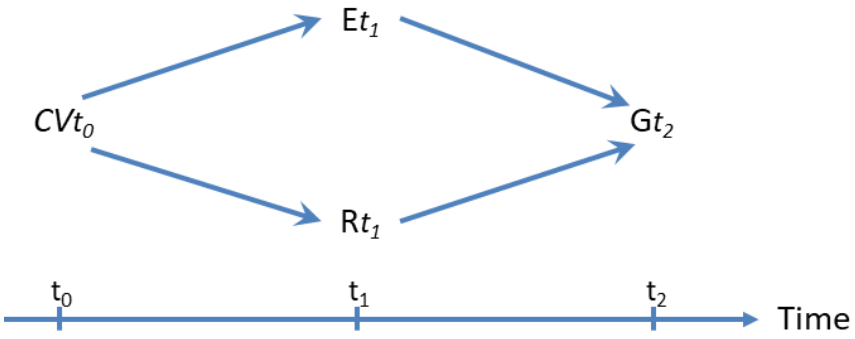


Figure 16 - Directive Correlation in Adaptation (derived from Sommerhoff, 1950, p.53)

In an organisational context, therefore, coenetic variables are the essential variables that an organism must monitor and respond to changes in, in order to thrive and survive. The response of the organisation must be directively correlated to the coenetic variable to achieve this. This capability must be built into the organism's way of being at a low level or undertaken subconsciously. Within an organisation, coenetic variables may be considered to be the Critical Success Factors an organisation must monitor and respond to in order to ensure a continued good outcome. These can be distributed throughout the organisation. Any systems approach to modelling organisational governance must be able to identify these variables, determine their indicators and measures of success and guide the organisation to acknowledge and ensure the capability to act on them.

2.3.3 Requisite Variety

Let us now explore requisite variety in more detail. Table 1 illustrated the mapping of outcomes (in E) according to the choices open to R in responding to disturbances D.

Table 2 (a) illustrates the situation where there is only one response. In other words, if R does nothing, then all disturbance will affect E. The variety of outcomes in E will be equal to the variety in D.

Table 2 - Varieties available for response to D

		R
		r_1
D	d_1	f
	d_2	a
	d_3	d
	d_4	c
	d_5	a

(a)

		R	
		r_1	r_2
D	d_1	f	d
	d_2	a	g
	d_3	d	h
	d_4	c	e
	d_5	a	a

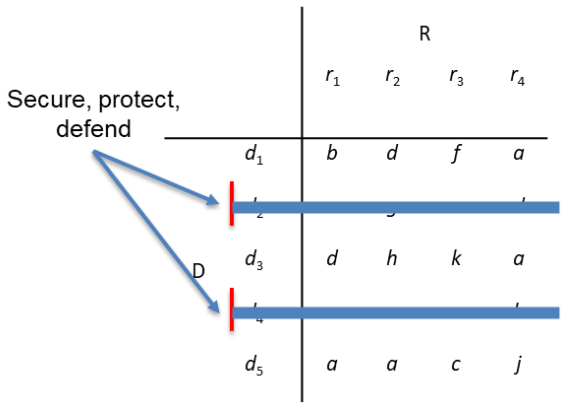
(b)

		R			
		r_1	r_2	r_3	r_4
D	d_1	b	d	f	a
	d_2	a	g	a	d
	d_3	d	h	k	a
	d_4	c	e	a	b
	d_5	a	a	c	j

(c)

Let us assume that within E, $\eta = \{f, k, j\}$. In this example, E only d_1 will be managed. Table 2 (b) has 2 responses, so halving the variety of outcomes (but not lower), but still only d_1 will be managed. Table 2 (c), with 4 responses by R has reduced variety of D by ¼ (but not lower); and so on.

Table 3 - Simple illustration of requisite variety



		R			
		r_1	r_2	r_3	r_4
D	d_1	b	d	f	a
	d_3	d	h	k	a
	d_5	a	a	c	j

(a)

		R				
		r_1	r_2	r_3	r_4	r_5
D	d_1	f	d	b	a	d
	d_2	a	g	a	d	f
	d_3	d	h	k	a	c
	d_4	c	e	a	b	k
	d_5	a	a	c	j	b

(b)

Table 3 (a) illustrates the situation where the variety in T, without any action by R, has been reduced by blocking some of the variety in D, equivalent to the shell of the tortoise. In an organisational context, this may be by physical protection, or controls within the IT system to prevent cyber-attacks, etc. in this simple example, there is a response to all values of D such that there is a choice of r that achieves an outcome in E within the set η. As Ashby states:

> "[. . .] variety (whether information or disturbance) comes to the organism in two forms. There is that which threatens the survival of the gene-pattern – the direct transmission by T from D to E. This part must be blocked at all costs. And there is that which, while it may threaten the gene-pattern, can be transformed (or re-coded) through the regulator R and used to block the effect of the remainder (in T)." (Ashby, 1956, p.212)

Alternatively, in Table 3 (b) there is a sufficient range of r_i that R has an effective response to all values of D, such that outcome in E will be within the set η.

Therefore, we need the requisite variety in T such that there is appropriate choice to 'block' all values of D. We also will need to have confidence in the responses 'blocking' D. For example, the organisation might have developed a contingency plan for an untoward event. What confidence is there that this plan might be effective. Has it been tested, is it resourced? Are current staff aware and trained in it? Is it kept up to date?

This links to the issue of staff managerial capability. Are there enough people who will actually make the choice of r_i and act on it? And, to enable this, has C defined E, especially the set η?

T equates to the ways of working in the organisation and how it is structured. Some are designed and some have evolved in response to experiences, all to ensure consistent outcomes of choice within the known, experienced or imagined values of D. They have survived and so are robust to shock.

Some r_i are non-conscious – staff know or have been trained to respond to certain indicators and some equipment is designed to respond to certain inputs. Processes and procedures are implemented to reduce the need for conscious regulation (management action). Out of band events and indicators require judgement to know which r_i to choose, and some require a new r_i to be developed '*in the moment*' requiring initiative as well as the capability within staff.

This is why technology is not enough. You cannot pre-determine a non-conscious choice or automated r_i in all values of D. The range of potential d_i is not knowable (Shackle, 1970), the range of D is simplified to design a response to all

(perceived) circumstances so the T may not have the requisite variety of responses r_i. The question also arises as to whether T is centrally determined. If so, by whom? No-one can have knowledge of the whole organisation, requiring T to be distributed along with R, with the necessary delegation and authority, to ensure requisite variety.

Therefore a model of the organisation, especially focused on its regulation, is important as it can be used to understand the potential range of impacts on the organisation as well as coordinate regulatory actions and responses to disturbances. Understanding the challenges of achieving requisite variety also underlines the importance of managerial capability as some of the requisite variety of responses will be achieved 'in the moment' as managers take decisions to act independently and in concert with others.

2.3.4 The model of regulation

The diagram below at Figure 17 illustrates the "Good Regulator Model". Within it, Conant and Ashby have mapped the terms used in Ashby's (1956) 'Immediate Effects' model (Figure 10) to Sommerhoff's directive correlation (Figure 16) differently by replacing 'T' with 'S'. This is because before, Ashby was referring to the Table 'T', whereas now they are referring to a system 'S' (equivalent to Sommerhoff's term E_{t_1}) and T is contained within R.

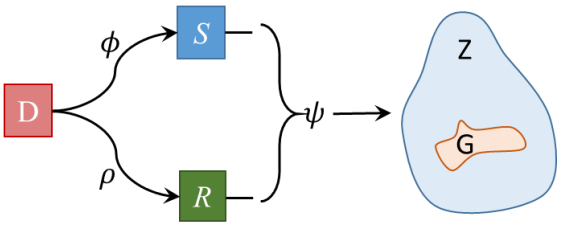


Figure 17 - Conant and Ashby's Good Regulator Model (Conant and Ashby, 1970, p.90)

They also map their term D to Sommerhoff's coenetic variables CV_{t_0}. In their immediate effects model, they show an information flow between R and T, this is now implicit in R, but that does include an interaction between S and R in their theorem to achieve the outcome in G.

Therefore, the illustration of the 'Good Regulator Model' at Figure 17 is a restatement of Sommerhoff's directive correlation in adaptation in a form aligned to a model of regulation. The model is described as follows. Within the total set of possible outcomes (regulated and unregulated), Z, we wish to ensure the 'good' outcomes, G, a sub-set of Z, by good regulation. D is the set of primary disturbers that can cause events within the system S which drive the outcomes out of G. R is the set of events within the regulator, H (i.e., the managers in a company) that are applied to direct behaviours to achieve the desired outcome G within the set of all possible outcomes, Z. (Here R incorporates the concept of the mapping table T described in Section 2.3.3. as the options available. The regulator, *H*, is distinguished from R deliberately to aid clarity.) S is the set of events in the rest of the system s that constitute the system and its behaviour.

Within a context of resilience, D represents all those factors in the environment that might cause disturbance in the company, such as interest rate changes, lockdown (due to COVID-19), flooding, competitive product entering the market etc. S consists of all the variables concerned with the operation of the business, other than those in the management team's mind. R are the variables the regulator H considers with regard to regulation, and G would be the outcome in which the company is resilient.

> "R is now a 'good regulator' (is achieving 'regulation') if and only if, for all values of D, R is so related to S that their interaction gives an event in G." (Conant and Ashby, 1970)

It is the interaction of R and S that can lead to a good outcome. Thus it is the mapping of R to S that leads to the regulator being a model of the system.

Conant and Ashby (1970) provides the proof for this. Their theorem has a number of outcomes:

- regulators need not necessarily be models of their regulands, but those which are not are unnecessarily complex;
- the best regulator is derived from within the mappings from S into R, so there is no need to explore elsewhere; and

- R should be “a homo- or isomorphism of S (since it has the same input as S and a mapping-related output)”.

Seligman et al. (2013) discuss whether the human navigates into the future or is driven by the past. They posit that ’prospection’ guides our decisions. Prospection is guidance by “present, evaluative representations of possible future states”. These could be ‘if – then – else’ conditionals, and the prospection process is the generation and consideration of these conditionals.

Putting this in the context of the Conant and Ashby ‘Good regulator’ theorem, they write:

> “Consider how a systems theorist might approach the challenges facing a living organism. The good regulator theorem (Conant & Ashby, 1970; Eykhoff, 1994) suggests that for the brain to be a good regulator of interactions with the environment, both physical and social, it must build and use a model of that environment. Part of such a model will be if–then conditionals, both about what to make of incoming information and about what acts would have what effects. Energy-wasting effort and costly surprises as the organism makes its way in the world will be minimized if the organism is guided by an accurate model of pairings of the form: “if in circumstance C and state S, then behavior B has outcome O with probability p.”
>
> “The challenge, then, is without an expert engineer to design it, how could an organism acquire such a model?” (Seligman et al., 2013, p.124)

Leveson et al. (2009) incorporate Conant and Ashby’s theorem into their Systems approach to safety in complex systems:

> “Another important concept in systems theory is process models. Any controller — human or automated — must contain a model of the system being controlled (Conant and Ashby 1970). For humans, this model is commonly known as a mental model. Accidents, particularly those arising from dysfunctional interactions among components, frequently result from inconsistencies between the model of the process used by the controllers and the actual process state; for example, the Mars Lander software thinks the lander has reached the surface and shuts down the descent engine; the Minister of Health has received no reports about water quality problems

> and believes the state of water quality in the town is better than it actually is and makes decisions on that basis; or a NASA Space Shuttle mission manager believes that foam shedding is a maintenance or turnaround issue only and underestimates the consequences of a foam strike on the Shuttle. Part of the modeling efforts using a systems approach to safety involves creating the process models, examining the ways they can become inconsistent with the actual state (e.g. missing or incorrect feedback), and determining what feedback loops are necessary to maintain the safety constraints and how to implement them." (Leveson et al., 2009, p.243)

This provides additional clarity regarding the meaning behind the model of regulation. The challenge is in determining the regulation required and what disturbances additional to operational variances should be considered.

The model that Conant and Ashby refer to is an isomorphic model such that there is a mapping of the regulation of the system to the system itself. In reality, though, the implemented regulation of an organisation is likely to be homomorphic. The Reference Model of Governance for a Specific Organisation proposed is unlikely to have the accuracy of an isomorphic model, so it will be a homomorphism. However, the Reference Model of Governance for a Specific Organisation should be isomorphic with the instantiation of regulation and can be used as a representation of the regulation or management of the system. Therefore, the Reference Model of Governance for a Specific Organisation is a model of Conant and Ashby's 'Good Regulator' which is a model of the system it regulates.

This was also argued by Beer (1984) in his discourse on the scientific modelling underpinning the Viable System Model as illustrated in Figure 18. It is described here in the context of my thesis. The left-hand side of the diagram represents the organisation (Managerial Situation) as perceived by the management team (their mental model) and formulated management processes, procedures, policies, roles and responsibilities. The right-hand side represents the organisation as perceived by the systems practitioner(s). In this thesis, this equates to this section of literature review leading to the requirements for a systems approach to modelling the organisation.

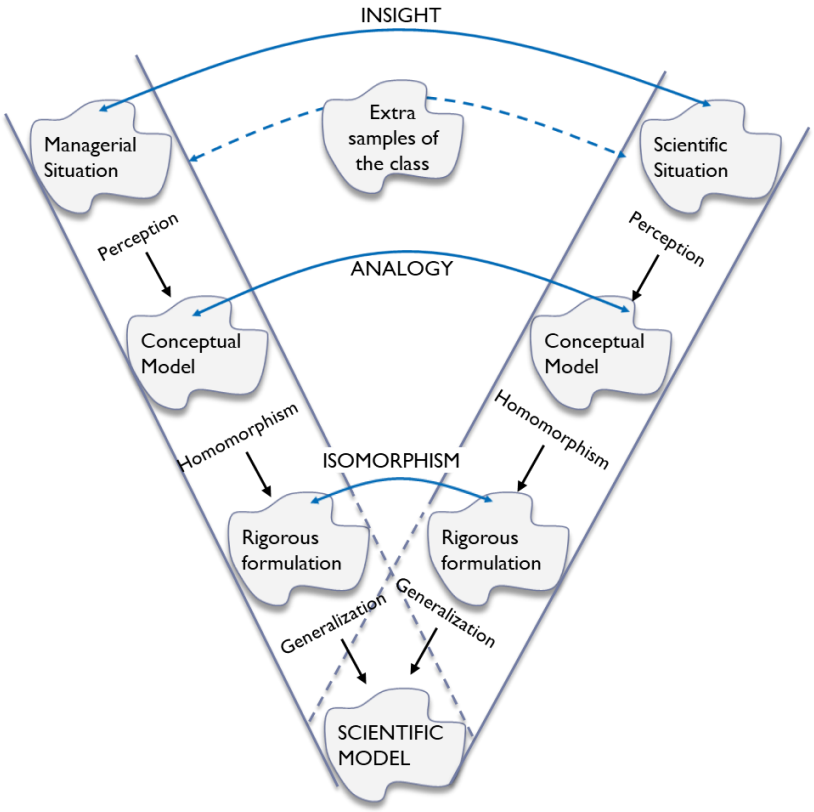


Figure 18 - Beer's account of scientific modelling (derived from Beer, 1984, p.9)

The rigorous formulation is the development of the Reference Model of Governance for a Specific Organisation, isomorphic to the regulation (management) in place in an organisation, and the Scientific Model is the Reference Model of Governance applicable to that specific organisation. The difference here is that I believe that a set of systems approaches provides a more detailed homomorphism of an organisational situation, thereby increasing the systemic variety represented.

However, an outstanding question is whether it is possible to build a generalisable scientific model as any scientific model, in this context, will be specific to an organisation. This question is out of scope of this thesis.

2.3.5 Implications for modelling

In their theorem, Conant and Ashby (1970) are referring to a generic regulator in action. In the context of the organisation, the regulator is the management actions being undertaken within the organisation to ensure the desired outcome

is achieved. Over time as the organisation has grown from an embryonic start-up, the management controls have improved according to need and to correct 'mistakes' that have emerged. Therefore, over time, the regulator becomes more complex, with increasing variety, and more closely aligned with the organisation and it's achieving its outcome, so becoming a better regulator. Consider the example of assembling an Ikea bookcase. I could take the box of bits home and assemble the pieces without reference to the assembly instructions. In this context, I am the regulator, with or without the instructions. Having never assembled an Ikea bookcase, I may make mistakes and the outcome may be a mess, i.e., I am a poor regulator. Having the assembly instructions to hand, however, would significantly improve the outcome. Conant and Ashby are not stating that we have to have instructions, but "that we must act *as-if* we had these [instructions]" (Scholten, 2010, p.43). Developing a technical specification can improve the 'good regulator' model and reduce the likelihood of costly mistakes, or failure to achieve the organisation's outcome. These technical specifications equate to an explicit control model used to build the good regulator model, as opposed to the model being developed in the management team and employees' heads, with the concomitant differences in perspectives regarding purpose and actions required to achieve the organisation's outcomes.

However, it is not possible to define a set of responses, T, for all circumstances. Some responses in T can be virtual and developed '*in the moment*' by a capable regulator R, who knows, understands and agrees to the outcome set G defined by the controller C such that they can know/decide/design/evolve/adapt a response to a new d_i.

With a simple or complicated system, T can be designed/developed for a broad range of d_i. Some may be shields such as physical barriers around the organisation's building, access controls for people, quality standards for goods inwards, quality checks for goods out, refinement and optimisation of services and minimising failure demand, are all examples of this. Yes, the greater the variety of r_i, i.e., the greater the internal complexity of the system, the greater the

reduction of variety in d_i and, therefore, the greater the chance of success and survival of the organisation.

Automated IT, Artificial Intelligence, etc., are all pre-defined rules for the choice of r_i, often defined by someone outside the organisation. They equate to a model of regulation. Consequently, it may or may not ensure the outcome E is within the set η (G in the Good Regulator Model), or does not even provide a value of η within E when chosen by R.

Also, if r_i is too great or too complex, will it be effective, especially if is dependent on other r_i? Is the system too large to know the outcomes of all choices of r_i, especially if they and R are distributed around the organisation with independent development? Is there confidence that, though choice r_i is designed to ensure an outcome in E within η, or has a new r_i impacting on it, especially if that is decided elsewhere within the organisation, it will be effective? Figure 12 provides an illustration of this showing a cascade of responses within thermoregulation. One response initiates another disturbance and so on. Because, within a complex system, no one person/team can have knowledge of the whole organisation/system in its entirety. So requisite variety is not a large T, it is the appropriate T such that there is an r_i that provides an outcome in E within η in all values of D.

One also needs to consider the choice of η within E by the controller (senior management). If it is too restrictive, too tight a tolerance, there will be an increased 'cost' in achieving it. The organisation may become too 'brittle' and open to failure. If it is too broad, then quality will fail, leading to failure demand increasing costs of operation, potentially causing the organisation to fail.

So there has to be a balance between choice of η by C and the design of R by C as defined in T in order to meet all values of D. But C cannot know the totality of operation of their organisation, as it is a complex system. Do they seek to simplify their concept of the organisation to a level they can understand – assume it is a complicated system that can be known such that they believe they can design R and T and choose a value of η, such that in all values of D, they achieve η? Then

they may be subject to a Black Swan event (Taleb, 2007), something unforeseen with potentially drastic consequences.

The organisation must seek to develop as good a model of the model of regulation to inform the development of R. Also, though, the organisation must develop the necessary managerial capability across the organisation to enable the requisite variety in R to provide a response to those unforeseen events in D.

The combined application of a set of systems methods is proposed such that an appropriate description or specification of a good regulator model for an organisation, that is unique to that organisation, can be generated. Conant and Ashby's theorem only states that the good regulator model is necessary (Scholten, 2010, p.42), that the 'management in action' is a model of the system. It makes no claim to needing the description or technical specification of such a system. However, due to the complexity of organisations, and the range of beliefs and values held by those operating the organisation, implicitly it makes sense to generate explicitly a common description or specification of a management system or good regulator model for that organisation to avoid "a protracted, blind and incremental struggle towards successful regulation" and "to bring about this regulatory representational relationship between the system and its regulator *explicitly*" (Scholten, 2010, pp.43–44).

2.3.6 Section summary

There are a number of points to take from section 2.3. A disturbance acts across many disparate elements of an organisation and a number of people will be involved in regulation to keep the organisation on track. This needs coordination as well as an appropriate range of responses.

You cannot build enough variety of responses into processes and procedures so you must empower people to act 'in the moment' to add variety of response. They need to have an understanding of the organisation as a system as well as be clear on the good outcome, G. This must be set by a controller as a cohering point.

Ashby's diagram of immediate effects (Figure 10), Sommerhoff's directive correlation (Figure 16) and Conant and Ashby's regulator model (Figure 17) are all relatively simple, but helpful structures with which to discuss regulation of organisations.

2.4 Organisations as a system-in-its-environment

> "Churchman and his associates pointed out "the tendency of conventional analytical patterns of thought to define and solve problems on their own basis rather than to include the problem environment." (Ulrich, 1988a, p.419)

The need to model systems has been identified in many disciplines, especially socio-technical systems. Safety engineering is one and there are many examples of failures due to assuming reliance on technical controls and not building in the human element. Again, this reinforces the need to consider managerial capability as part of the socio-technical model. This is because responses cannot be pre-determined for all situations, even though risk assessment/modelling seeks to introduce barriers which are designed to prevent as many impacts as can be identified. These may be technical, physical, procedural and cyber-related. There will always be the requirement for human judgement. Artificial Intelligence may help, but Artificial Intelligence is not capable of judgement, as most current implementations are rule-based, and probably will not for some time.

This section discusses the range of factors to be explored when considering organisations as systems. It draws on a range of thinkers, many who are not part of the contemporary set of systems thinkers. However, as will become clearer, all have a contribution to the complexity of organisations as systems and ensure the requisite complexity of organisations is included within models of systems to ensure requisite regulation.

Following the introduction of some basic concepts, it covers the people perspective in section 2.4.1, the laminated or hierarchical view of organisations in section 2.4.2, and environmental interactions in section 2.4.3. These will be added to aspects of complexity and regulations when developing a set of requirements for an approach to modelling organisations in section 2.5.

2.4.1 The people perspective

A starting point is the people perspective and how we think about organisations, the way we make assumptions that are involved in decision-making and how we make distinctions leading to considerations of organisational boundaries.

2.4.1.1 The transactional view

Luhmann contrasted the part-whole and system-environment paradigms in systems thinking, with his focus being on the latter. Part-whole, considered since Aristotle, is more related to Churchman's call to look for the system served, the larger system, the relevant whole (later taken up by Checkland (1999) and Wilson (1990)).

By considering the system-environment interaction, one does not need to determine the overarching system, especially as there may be a number of relevant other systems. This is relevant when considering the organisation sitting in a turbulent environment that is unknowable in its entirety. It continues to unfold as distinctions appear. With a stable environment, the organisation receives few strategic surprises. However, in a turbulent environment, an organisation's survival "becomes dependent on the correct identification of and dealing with different constellations of systems (stakeholders) in a then-different (organizational) environment" (Valentinov, Roth and Will, 2018, p.829).

In Luhmann's terms, a system is distinct from its environment, and it is this distinction that defines the system. An autopoietic system, an organisation, in its creation and maintenance, achieves a complexity differential. Reduced complexity internally as distinct from an unknowable and always more complex environment. Systems (organisations) and their environment co-evolve. Complexity reduction is the main function of autopoietic systems. Consequently, autopoietic systems (and social systems) are not able to digest all the signals from the environment. "Social systems reduce complexity by supressing most of these signals and thus avoid overburdening by environmental complexity and retain ability to orient themselves in the exceedingly complex environment" (Valentinov, Roth and Will, 2018, p.830).

Furthermore, systems build up their internal complexity in order to reduce the environmental complexity (Ashby, 1958) because "[e]very system must maintain itself against the overwhelming complexity of the environment" (Luhmann, 1995, p.182 in (Valentinov et al, 2018)). This autopoietic capability of organisations and distinction from its environment is termed "operational closure", and "the recursivity of their operations" (Luhmann, 1995, p.xxi in (Valentinov et al, 2018)). "… any autopoietic [system] maintains its border to its environment by connecting internal operations with other internal operations. All of its elements and structures are thus produced solely within the system itself" (Valentinov, Roth and Will, 2018, p.830).

This is the predominant view of systems, leading to the requirement for boundary consideration. Angyal has a different perspective regarding the distinction between the system and its boundary which is covered below at section 2.4.3.6.

Considering the system in its environment is important. Indeed, Ulrich remarks, referring to Churchman and his associates (1988a, p.419), "the tendency of conventional analytical patterns of thought to define and solve problems on their own basis rather than to include the problem environment". Valentinov et al. (2018, p.827) concludes "[t]his tendency is unfortunate because of the fact that "in any specific problem, one finds the connectedness to all the other problems" (Churchman, 1982, p13)." With regard to the complexity differential between an organisation's own reduced complexity as compared with the greater complexity of the environment, they state:

> "An implication of Valentinov's [. . .] critical dependence principle is that social systems are well advised to observe their own systems-environment relationships. Systems can do so by distinguishing between the observation of their environment and the observation of other systems in their environment. To better understand its critical dependence relationships, the concerned system needs to gain awareness of the environment populated with other systems. As soon as the systems in the environment are observed to be self-referential systems themselves, the only way the system can make sense of the environment is by means of communication." (Valentinov, Roth and Will, 2018, p.831)

Emery (2000) revised the work of Emery and Trist and their consideration of a system (which could be an organisation) in its environment, referred to as Causal Textures (Emery and Trist, 1965). Figure 19(a) illustrates the transaction between system and environment.

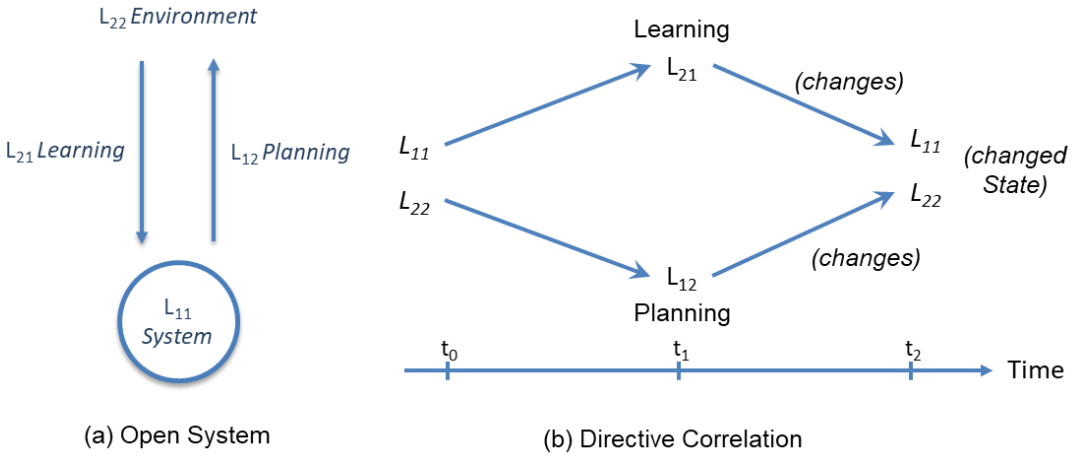


Figure 19 - The transaction of system and environment (derived from Emery, 2000, p.624)

All of the components are covered by Laws that govern their connections (L). The system (organisation) is designated “1” and the environment is designated “2”. When the system acts upon the environment, this may be considered the planning function (L_{12}). The system learns (L_{21}) when the environment acts upon the system. L_{11} and L_{22} represent the intrinsic nature of the system and environment respectively.

This transactional view is expanded upon below at Section 2.4.3.3, and the benefit of considering the Causal Textures related to this is exemplified there.

Emery (2000), however, includes the element of time, and change over time, and how this consideration should be included. She refers to this concept of Directive Correlation as illustrated in Figure 19(b). The significance of this is to accentuate the complexity of the system-environment relationship and the need for its considered exploration and not just see it as a simple relationship. Emery includes the following definitions which are relevant for later arguments in this thesis:

> "*A system* (L_{11}) is defined by its *system principle, unitas multiplex*, or construction principle (Angyal, 1941, p.259). This principle expresses the unique relation between the entity and the environment and governs the behavior of the system and the arrangement of its parts. Organizations may or may not be systems.
>
> "The Environment (L22) is a social field consisting of the changing values, expectations, and ideals of the human systems within it. It is formally defined as "the extended social field of directive correlations" (Emery, 1977a) with a causal texture which has changed over the course of human history (Emery and Trist, 1965). This conceptualization provides a framework for cultural change and its fluctuating adaptivity.
>
> "People are defined as *open, purposeful systems* who "can produce (1) the same functional type of outcome in different structural ways in the same structural environment and (2) can produce functionally different outcomes in the same and different structural environments." They display *will* (Ackoff and Emery, 2007, p.31) By constantly acting as active, responsible agents, they change the environment." (Emery, 2000, p.625 Italics in the original)

2.4.1.2 Interest and decisions

We are an inquisitive animal. We seek understanding of what is around us and, if not understanding, then knowledge or answers to questions; usually questions that relate to what we should do and how we should act. What we rarely consider is our motivation, what is driving our interest, at that point in time and how that will shape our inquiry and what we see and hear around us (Angyal, 1941). A simple example is in choosing a book to read, a film to watch, or an activity to undertake. We may consciously be aware of exactly what we will satisfy us, and have specific criteria, but generally we 'know' when we have made the choice that satisfies us.

Similarly, when we discuss with a group of friends a programme we watched last night, we may disagree strongly on how good it was and whether we liked it or not (Wilson, 2001, p.2). This can lead to a robust discussion, a variety of opinions, or even become heated, without really wondering why the others couldn't agree with us and see it from our point of view. It's this point of view that

is the starting point for discussion in this section. And this point of view can range from being deeply held as implied by the term 'Weltanschauung[2]'(Naugle, 1993), or it can be a transitory 'fad'. The point is that we often don't consider what it is within us that generates the particular 'inter-est[3]' (what is between me and the 'other') at that point in time.

In a more formal, decision-making environment, such as within a business context, the perspective, or interest relevant within the decision environment is important (Wilson and Van Haperen, 2015, p.17). This may be our own perspective, or that of others with a vested interest in the situation.

This depth of understanding, knowledge or answers being sought can vary from the deep thinking of a philosopher or scientist to the immediate, instinctive response required by someone in conflict or in a high-pressure trading situation. We have a constant interaction with our environment, and that context can change rapidly; usually we don't notice the change of context as we often act and react without conscious thought.

Another important aspect relevant to decision-making within organisations is context (Flood and Carson, 1993, p.74). An understanding of the position of the organisation within its environment, whether it is regarding its competitors, product or service opportunities, or the wider economic situation, is key to its ongoing success, resilience and sustainability (Johnson and Scholes, 2002; Ward and Daniel, 2006). Context is equally important when considering management and leadership at any level of the organisation. All staff across the organisation should be aware of the wider context of the organisation as well as the internal context of departments, teams and individuals. This relates to the coenetic variables and directive correlation (see Section 2.3.2) in that the coenetic variable is interpreted by the regulator in their context, and the regulator acts with their own personal understanding of the context of the organisation in its environment. Sommerhoff (1950, pp.51–53) argues that R and E are

[2] Taken to refer to deeply held values and beliefs that guide or drive our behaviour, generally sub-consciously.
[3] From Latin "inter" = between and "est"= be; literally "be between" (Oxford University Press, 2007)

independent of each other (Figure 16), and Ashby (1956, pp.209–211) argues that R interacts with T to mitigate the effect of D and it is D that Ashby equates to the coenetic variable.

So, decision-making should never take place without fully understanding the context within which the decisions are being made but, frequently, assumptions are made without a full understanding, and often without considering the context at all. Also, complexity can easily overwhelm managers whose focus is short-term, probably driven to focus on profit or cost minimisation, rather than on viability and sustainability.

From all that is observable, we select those aspects that interest us and interpret them in our personal context and give them meaning accordingly. We will draw conclusions having applied our existing assumptions, frequently without acknowledging them, and develop beliefs based on these conclusions. Finally, we take actions that seem right in our context. This is illustrated in Figure 20.

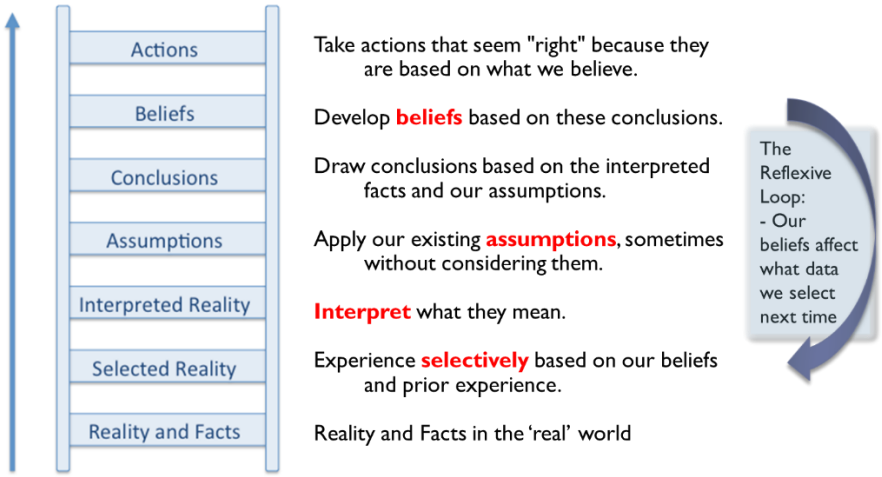


Figure 20 - The Ladder of Inference (derived from Senge et al., 1994, p.243)

The actions we may take will be from our personal repertoire according to the means available to us, the strength of our drive (motivation), and any constraints or restraints imposed on us (Dodd and Alston, 2009, p.12) as illustrated in Figure 21. Relating this to Ashby's regulator model discussed in Section 2.3.1 and illustrated in Figure 10, the repertoire of actions (choosables) equates to Ashby's

table ‘T’. Also, any such freedom of options is shaped by one or a number of coenetic variables.

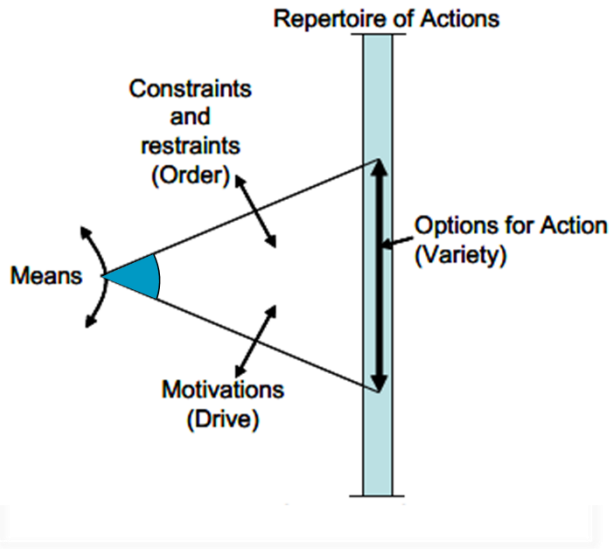


Figure 21 – Freedom of Options (derived from Dodd and Alston, 2009, p.12)

The scientist will take a structured approach relevant to the context of the problem and the discipline within which they research. The approach taken will fit the current paradigm[4] accepted by that scientific community (Kuhn, 1996); this Kuhn refers to as “Normal Science”[5]. The relation here is between the scientist and the puzzle the scientist is seeking to solve. However, the question is generally clear, and as the scientist is more than likely insulated from society (though increasingly research funding bodies are more specific in the research topics they will fund), they can generally choose a puzzle that is solvable. With an accepted paradigm to guide them, they will work within it and make progress.

In some areas of science, especially the emerging social and systems science domains, the communities are still seeking a dominant paradigm. Without a

[4] “[A] paradigm is an accepted model or pattern […]”. “In science […] a paradigm is rarely an object for replication. Instead, like an accepted judicial decision in the common law, it is an object for further articulation and specification under new or more stringent conditions.” (Kuhn, 1996, p.23)

[5] From Kuhn’s perspective “ ‘Normal Science’ means research firmly based upon one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice”(1996, p.10).

paradigm in place, or when the scientific community senses a crisis in the paradigm (Kuhn, 1996, p.77), some within the community will develop a new scientific theory that better fits the facts.

Where the community has no dominant paradigm to employ to address a puzzle, or the scientist is faced with an anomaly, a puzzle their training and accepted paradigm hasn't prepared them for, nor can guide them (Kuhn, 1996, p.86), the scientist will focus on the puzzle to try and give it more structure. He will apply current techniques and rules to understand what is going on, and eventually appear to try random experiments to see what happens. This may lead to new theories and generate a new paradigm.

Engineers in all their disciplines regularly utilise models and diagrams to capture and convey their understanding of the product or system, its requirements and design, especially when the system is a socio-technical system, and the human user is included. Frequently within these diagrams lines are drawn to indicate a relationship between things, but rarely is the line itself explicitly discussed and a common understanding agreed. This is particularly important in considering safety in complex situations (Leveson et al., 2009, p.243).

In a more practical situation, managerial capability is considered as being able to undertake tasks and achieve set objectives in line with organisational norms and values for the benefit of the owner(s) of the organisation. This requires the resolution of day-to-day issues as much as setting goals and plans for staff and managing them through to successful completion. There is a lot of focus on efficiency and cost-cutting with value and success generally thought of in financial equivalents. Doing the right thing, and in the most efficacious way, and engaging people to the best of their ability is often a secondary consideration.

Deciding the most appropriate strategy for the organisation to enable it to succeed in a world of changing fashions, rapidly evolving technological enablers and dynamically changing competition, and developing and adapting the organisation to suit, requires the ability to think relationally, and not just in a linear manner. One can't just decide a plan of action and prosecute it without

consideration of the context within which the organisation operates. The organisation lives within a set of relationships that are constantly changing.

However, in all these situations, the scientist, engineer or manager will be driven according to their particular interest or motivation, and this will affect what they choose to do and how they go about doing it.

2.4.1.3 Object of interest, or 'system'

When we point something out, we cannot do so without making a distinction (Spencer-Brown, 1969); the very fact that we point something out is to distinguish it from its surroundings.

The moment you think about something, or try to identify with something, there is a discrimination, a distinction. The thought separates you from what it is you are thinking about or observing. Often, when you observe a flower, the beauty of the land, or a member of your family, you tend to look at it/them with an image in mind and not necessarily really see what is there, in and of itself (Krishnamurti, 1966). You have to be quite attentive to let your mind be free to build an image, rather than refer to the one already stored in memory, to always try to see it for the first time.

The trouble is that we accumulate knowledge and need to do so, or we would never be able to function, either in our job, at home, or even speak a language. This knowledge is often recalled in images, and these stored images provide a shorthand to what we see. We may think we look at a tree, or a person, but if we have prior knowledge, we will bring out an image and refer to that rather than notice the tree or person 'in the moment' and see really what it/they are *in that moment*.

This approach has two main issues: it creates an 'us and them' division, putting us in the position of an observer, separated from what we observe; whilst also assuming others see the same as us. But we have all developed different knowledge through our own individual lived experiences, interests and beliefs. An artist will seek to take time to truly see and connect with what is there and represent it in the best way they can. The observer within me is "watching,

judging, censoring, accepting, rejecting, disciplining, controlling, shaping" (Krishnamurti, 1966). I, the observer, the thinker, is the result of thought. When I think, however, I watch that image in my mind, and make assumptions and decisions accordingly. It is one of the reasons why we respond differently to a similar event and, perhaps, be totally perplexed by the behaviour of others.

We take in significant amounts of visual, aural and sensual information and create our world from it. This doesn't happen passively "like a mirror which reflects the picture of the objects, but actively elaborates and constructs the perception" (Angyal, 1941, p.64). Our cognitive function discriminates certain objects and distinguishes them from the remaining background. That distinction from the surroundings has a boundary containing the elements of what is distinguished (the inside), as opposed from what is not contained by the boundary (the outside).

> "There can be no distinction without motive, and there can be no motive unless contents are seen to differ in value. If a content is of value, a name can be taken to indicate this value." (Spencer-Brown, 1969, p.1)

What we distinguish, we give a name to and, thereby bring into being. The notions of motive and value lead us to indicate something, though our different motives and values are often not explored or shared when seeking consensus or agreement. What we cannot discriminate is not even registered within us or causes confusion and results either in our attending to it to discern it, or to our letting it go and not considering it further.

Humberto Maturana, a biologist and neurophysicist, together with Francesco Varela (1980), was acknowledged with first defining and employing the term 'autopoiesis'. He spent some considerable time considering two questions: "What is the organization of living things?" and "What takes place in the phenomenon of perception?" Whilst considering the organisation of living things, he recognised the need to determine the fundamental distinction between organization and structure; the starting point being with what he calls a 'Unity'.

> "The basic cognitive operation that we perform as observers is the operation of distinction. By means of this operation we specify a unity as an entity distinct from a background, characterize both unity and

> background with the properties with which this operation endows them, and specify their separability." (Maturana and Varela, 1980, p.xix)

By recursively applying the operation of distinction, one can distinguish the components within it; referring to it as a 'composite unity' once having done so.

Angyal (1941) studied the living organism by taking an holistic approach, borrowing the term from (Smuts, 1926).

> "If we admit that the human being is more than the mere aggregation of physiological, psychological, and social functions, that is, if the person as a whole has attributes which are neither the sum of the attributes of the parts, nor deducible from the attributes of the parts, we must give up the hope that knowledge of the total person will ever emerge from segmental studies." (Angyal, 1941, p.4)

He developed a systems approach to considering the organism, an individual; an approach that is also applicable to superindividual units (i.e., including social groups and organisations) (Angyal, 1941, p.168). He makes the point that the organism is not a static structure, but grows, develops and adapts through life and environmental interactions. Therefore any study of it must be from a "dynamic point of view, that is, a process" (Angyal, 1941, p.50). Also, there is a constant interaction between the organism and its environment, such that it is not a static structure and any morphological distinction between the two is impossible. One can determine the distinction by considering those functions undertaken within and by the organism to sustain itself and considering the organism to comprise those. These self-governed functions undertaken by the organism (or organisation) Angyal refers to as "autonomous". However, the organism does not have total freedom. The environment will react and, potentially, resist the autonomous actions of the organism; these actions Angyal refers to as "heteronomous" (Angyal, 1941, p.94).

Therefore, when making the distinction between the organism and its environment, we do not ask whether an entity is part of the organism or the environment, we consider the dynamic process and ask whether it is organism-(system) determined, or environment-determined, i.e., autonomous or heteronomous. "Dynamically expressed, organism is self-government and

environment heteronomous influence" (Angyal, 1941, p.97). This duality Angyal expresses as the biosphere. ". . . not as interacting parts, not as constituents which have independent existence, but as aspects of a single reality which can be separated only by abstraction" (Angyal, 1941, p.100). This is the essence of relational thinking and not analytical, or object-based thinking. (See also Whitehead's (1978) process-relational thinking in Section 2.4.3.1.)

When considering concepts, such as the health, defence or education systems, organisations or engineered systems which, when combined with operators, provide a capability, those involved have a personal perspective of what is inside, or outside of such a system (Checkland and Scholes, 1990; Wilson and Van Haperen, 2015). Notions such as the biosphere, or a composite unity (Angyal, 1941; Trist, 1992) are challenging in their ambiguity, often resulting in confusion and leading to an analytical approach to seek understanding. Systems science and systems thinking are the disciplines employed to provide that understanding (Jackson, 2019). Broadly, systems thinking can be used to generate models of reality to be used to gain insight into the complexity of systems, and to provide ways of thinking about complex things, though some believe reality can be modelled and thus the behaviour of systems understood and, therefore, predicted. One can model, or simulate, the behaviour of engineered systems, for example modern fighter aircraft and computer systems, because, though complicated, their range of actions has been pre-determined. Indeed, there is a value in doing so as the result of the complicated design and build will lead to the exposure of unintended consequences, whose undesirable behaviour must be removed (Hitchins, 1992).

Systems thinking differs from analytical thinking, in that it seeks to retain the notion of the 'whole' and, therefore, the additional emergent properties that result from the system, but not from the sum of its constituent parts (Ackoff and Emery, 2007; Churchman, 1968). Systems Engineering is the discipline applied to the acquisition of technology to support capability, and a range of methods and tools are available for exploitation to support thinking about the others (Hitchins, 1992). However, at the basis of collaborative thinking is the benefit of sharing mental

models and recognising the assumptions and biases inherent in any conversation (Senge, 1992).

Relational modelling has at its heart relationships between objects, systems, people and organisations, with most relationships, or links, relating to some notion of causality or dependency (Dodd, 2019). Dynamic models created to simulate behaviour generally have causal links between objects, defined in the form of a mathematical equation to simulate the behaviour (Coyle, 1996; Sterman, 2000). Qualitative models such as causal loop diagrams, system architecture diagrams, Unified Modelling Language (UML) models and soft system models, rarely have the links and relationships explored in any detail (Kalawsky, 2009; Vandenbroeck, Goossens and Clemens, 2007; Whitehead, Scherer and Smith, 2015; Wilson, 2001). They are the result of conceptual thinking and are often based on unexpressed assumptions. The exception to this is cognitive mapping (Eden, Jones and Sims, 1983).

When considering problems, especially wicked problems, analytical, or object-based, observer-oriented thinking considers a problem ‘out there’; a problem where the observer is disassociated from it. Jacobs adds that the wickedness of problems stems from the inability of the decision-maker to make sense of the problem space, so “wickedness thus depends on both the problem and the problem-solver” (Jacobs, 2010).

The starting point of relational thinking, therefore, is not the relationships between the elements of the system, or even between the system and the environment, but between the problem-solver and the problem, or between the people involved in the on-going life of an enterprise or operation of the system (Schon, 1984). This is increasingly the case when considering socio-technical systems where the included human element within the system introduces unpredictable and unknowable behaviours within the system’s operation. This is in addition to the difficulty in either determining the root cause of problems, the requirements for the system, the purpose(s) the system should serve, and the differing motivations and priorities behind the need for the system, or the desire to solve the problem (Schon, 1987; Wilson and Van Haperen, 2015).

> "When a practitioner sets a problem, he chooses and names the things he will notice. In his road-building situation, the civil engineer may see drainage, soil stability, and ease of maintenance; he may not see the differential effects of the road on the economies of the towns that lie along its route. Through complementary acts of naming and framing, the practitioner selects things for attention and organizes them, guided by an appreciation of the situation that gives it coherence and sets a direction for action. So problem setting is an ontological process – in Nelson Goodman's (1978, cited in (Schon, 1987, p.4)) memorable word, a form of worldmaking." (Schon, 1987, p.4)

2.4.2 Laminated Organisations - Depth to Surface

This section will consider depth thinking (the consideration of non-visible influences) resulting from Hall (1989, 2010) and Schein's (1988, 2004) work, as illustrated as an iceberg by Meadows (Meadows, n.d.). Also it will discuss organisational capability (Peppard and Ward, 2004) and Levels of Work and Levels of Capability (Hoebeke, 2000; Jaques and Stamp, 1995; Kinston and Rowbottom, 1990; Stamp, 1981)

2.4.2.1 Iceberg

A way employed by many systems thinkers to think through the relationship between personal values and beliefs through to actions is the iceberg model, developed from the initial work by Hall (1989), further developed by Schein (2004) and Senge (1992) and taken into the systems world by Meadows.

> The iceberg model is a valuable tool to encourage systemic thinking and help you contextualize an issue as part of a whole system. By asking you to connect an event–a single incident or occurrence–to patterns of behavior, systems structures, and mental models, the iceberg allows you to see the structures underlying the event. Just like an iceberg, 90% of which is invisible beneath the water, these structures are often hidden below the surface. However, if you can identify them and connect them to the events that you are seeing, you may be able to develop lasting solutions that target the whole system rather than short term, reactive solutions. (Meadows, n.d.)

This is most significant within organisational development when seeking to support change in an organisation. Just forcing changes to process and structures will not lead to sustainable change. Because the underlying mental models have not been addressed, change is unlikely to persist (Meadows, 1999). Likewise, re-writing strategies and goals will effect short-term change, but sustained change is generally only achieved when the underlying assumptions, beliefs and values are surfaced and influenced. This cannot be forced onto people but may be addressed through conversation and involvement.

In Hall (1989), which was one of the contributions to Schein's work, the iceberg can be teased out into a little more detail as illustrated below in Figure 22.

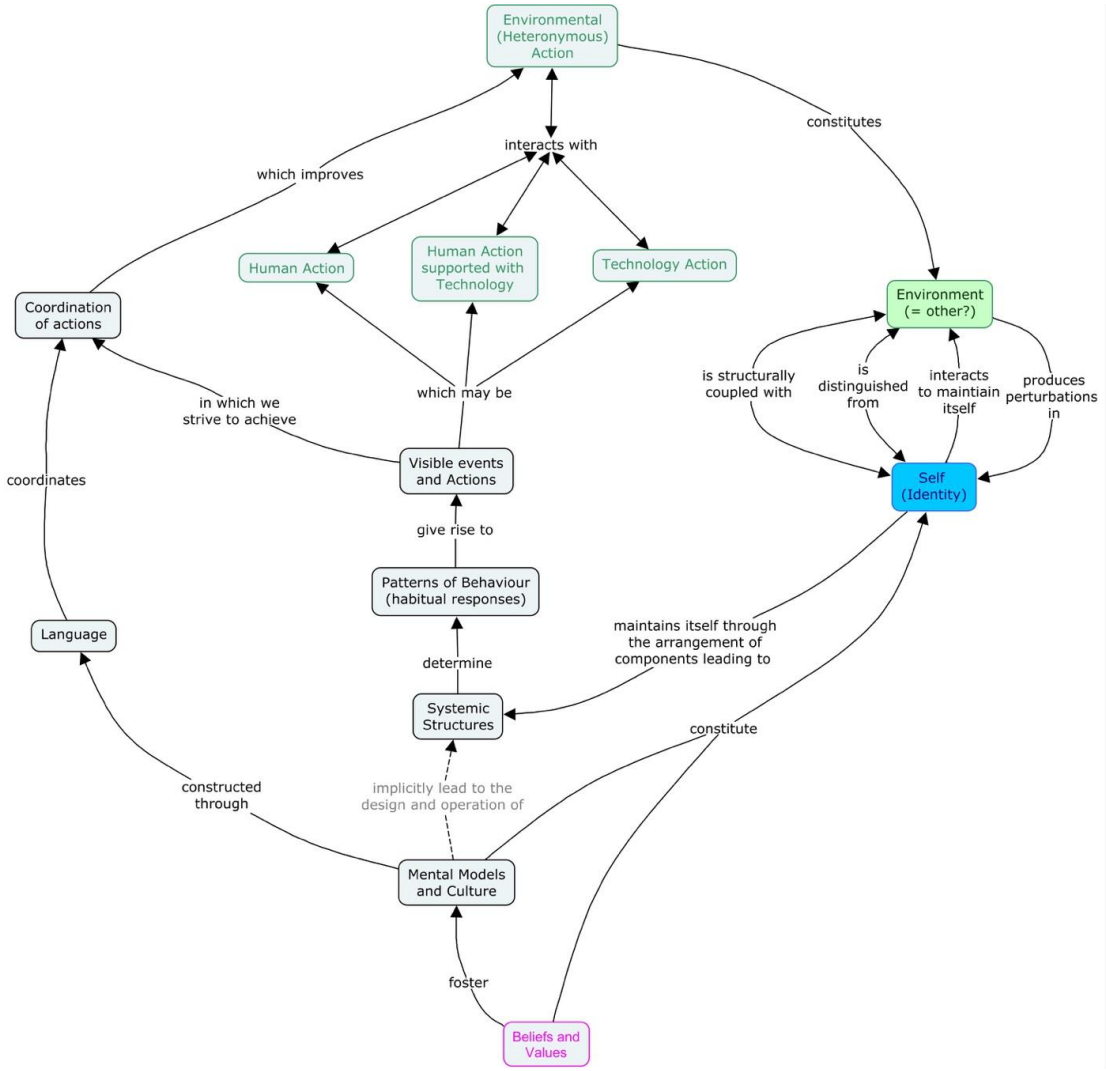


Figure 22 - Further development of the Iceberg after Hall (1989) (derived from (Hilton, 2021)

Our personal beliefs and values foster our mental models and culture (Hall, 1989; Hilton, 2021). When shared, these also apply to an organisation whether it is a commercial company, a government department or a social club. These, together, constitute our identity, or notion of self, and it is this ‘self’ that we defend when attacked verbally or our thoughts are criticised. Our identity distinguishes us from our environment, and we are structurally coupled with our environment. Indeed, we primarily interact with our environment to maintain our ‘self’ and respond to perturbations caused by our environment.

We, or the organisation, maintains itself through the setting and changing of systemic structures according to perceived need. These may be our network of family and friends, the structure of our day, our living arrangements or, from an organisational perspective, the organisational structures, business processes, enterprise architecture, etc. These will determine the habitual responses and give rise to our interaction with the environment through visible actions and events which may or may not involve technology. From an organisational perspective, there may not be human involvement, and the action is pure autonomous technology. Angyal includes the term heteronomous as in heteronomous action (Angyal, 1941) to denote that the environment isn’t passive, and will respond to the action undertaken, perhaps to ‘push back’ or resist it.

The final part of Figure 22 illustrates that we will express our mental models and culture implicitly through our language. We strive to achieve coordination of our visible actions and events and use our language to coordinate this coordination of actions.

Angyal (1941) argues that we can only interact with our environment and not directly with another (apart from a physical contact, that is). Hall (1989, p.100) notes that “it is impossible to separate the individual from the environment in which he functions”. Context is critical in sharing understanding. The elements of the environment which influences what someone perceives are “status, activity, setting, and experience, as well as culture” (Hall, 1989, p.101). When we talk to another, or instruct another, we have no idea how what we say is received. They will take in our words (or not) and position what we say along with their prior

knowledge, their own beliefs, values and mental models, and construct meaning accordingly (Smuts, 1926). The exchange may be followed by an action, but we cannot claim to have caused that action, because we have no knowledge of what led to the action being taken by another. It is possible that we have caused the other to reflect on their values and beliefs and change their mental models. This will lead to them re-constructing their 'self' (Smuts, 1926) leading to a change in patterns of behaviour and, thus, visible actions.

We create events and see events all around us. These are the visible actions in our environment which are the result of our and others' conscious and subconscious endeavours. These endeavours may be attributable to personal or organisational drives, or the outcome of an engineered physical or computing system. What is common to all is that the rationale behind the action is difficult to determine by observation alone. However, we will generally attribute some purpose behind the actions observed, probably based on our own perception of the situation. Let us consider this in more depth.

When we consider events from a personal perspective, it can be argued that there exists a series of connections between some deep desire within us through sub-conscious and conscious thought and planning to an action being taken in our environment, observable by others. Considering it this way, it is difficult to discern a boundary between self and environment.

With regard to the boundary, the patterns of behaviour are often initiated by an external stimulus (Sommerhoff, 1950). An action within the environment that will initiate a response by the individual or organisation. The range of potential responses is an indication of the variety available and the ease of shifting between sets (explained below in section 2.4.3.2).

2.4.2.2 Hierarchy of Organisation

> "Hierarchical systems evolve from the bottom up. The purpose of the upper layers of the hierarchy is to serve the purposes of the lower layers." (Meadows, 2008, p.85)

All organisations have a tier of management and, above the day-to-day management, there are often boards guiding them. For many, there may be a

regulatory body that governs their industry. Each level should have a different focus from setting the context and strategy of the organisation to managing day-to-day operations and tasks. This section will discuss the differing purposes that occur at different levels within the organisation hierarchy to identify requirements for systems methods to build the model of regulation.

Kinston (1986) proposed that organised social activity has 5 hierarchically-related notions of purpose and that each has a different structure to develop and implement their role. Included within this are the relationships between the levels and span of control across levels. Each has a value set related to it, and related work in BIOSS with Jaques, Stamp, Rowbottom and others explored the impact of this thinking (Jaques, 1986, 2009; Jaques and Stamp, 1995; Kinston and Rowbottom, 1990; Rowbottom and Billis, 1987; Stamp, 1981).

Kinston developed his theory through a long-term research programme with the British National Health Service. He worked with District Health Authorities in their role of governing body through to care and other services given to patients in wards. He states:

> "Eventually it emerged that the enormous number of explicit and implicit objectives, and the variety of surface classifications of objectives, were derived from a limited number of *formally distinct and specifiable* categories (or types) of purpose. To ensure organizational coherence, it was clear that suitable categories would have to be interconnected to form a structure, or system." (Kinston, 1986, p.148, italics in the original)

It is summarised in Kinston's Hierarchy of Purpose, an extract of which is shown at Table 4 which illustrates this in a broad context.

Table 4 - Summary of the hierarchical system of purpose (derived from Kinston, 1986, p.150)

Level	Label	Synonym	Brief Description	Ideal Format	Groups	Social form
5	Banner Goal	Philosophy; value; ideal; fundamental objective	Purposes which express prime values taken to be widely held	"We all believe in and want to . . ."	Level of orientation	Spontaneous groupings e.g., petitioners, interest groups
4	Mission	Object; general aims; primary tasks; terms of reference	Purposes which define the basic identity and hence prime tasks and membership of an organized body	"This firm/agency/association/ department has been set up to . . ."		An organisation e.g., formally constituted association, company, public agency
3	Political aim	Policy; priority	Purposes which lay down preferred foci of concerns amongst competing equally valid possibilities for the org.	"The important thing to reduce/ attack/improve/ignore/ concentrate on . . ."		A governing body e.g., board, public authority, steering group.
2	Strategic objective	Policy; Strategic aim	Purposes which orient actions and define the real world for the org. They lead to development of strategies which have a broadly defined timescale	"The situation/need/problem/ opportunity as we see it is X and over the coming months/year(s) we need to Y." (X = direction of work; Y = strategy)	Level of implementation	The 'top' executive(s) e.g., chief executive, top management team
1	Tactical Objective	Task objective; operational objective	Purposes which indicate a finite result to be achieved within some finite period of time and may be finely specified	"A is to be done by B." (A = specified project/task; B = time deadline.)		Executant(s) e.g., employee hierarchy, workers, executives.

The following paragraphs describe Kinston's hierarchy more specifically in terms of organisations.

The *banner goal* provides the societal orientation and opportunity for an organisation. Examples include the need to provide housing, to keep a community healthy, provide food, the need for insurance, etc. are examples of a fundamental need, or philosophy. *How* that is achieved is the opportunity developed by an organisation.

The *mission* is specific to an organisation. It defines the basic identity of the organisation which will determine the prime activities necessary to achieve it. It defines the overall purpose of the organisation and what it is legally constituted as in the organisation's Memorandum and Articles of Association if it is a commercial organisation.

The *political aim* is the particular way the organisation will go about its business. It's what makes the business unique and differentiates it from others. It will be defined by the organisation's board or, for a research programme, a steering group. It is aimed to keep the organisation on track. This can change over the life or an organisation. The board could choose to change direction of the

organisation in the light of new opportunities, such as technology developments, of in response to a major societal or environmental shift. The board's focus is generally on the best return on investment. A smaller owner-run organisation is likely to stay on one path for much longer as it will reflect their skills, knowledge and interests.

The *strategic objective* is where the senior management team, led by the chief executive or equivalent, will decide the strategic plan that shapes the activities and priorities across the organisation. It may have a 5 – 10-year timescale, though it will be updated during that time (Jaques, 2006). It provides the cohering direction which all parts of the organisation will adhere to in achieving the organisation's overall goals. The strategy will be aligned to a defined objective and should allocate resources and budgets accordingly to sub-elements of the organisation.

The *tactical objective* is where the heads of organisational units define their specific plans, over shorter periods, to actually get the work done. This might cover one or two levels in the organisation's hierarchy according to the organisational structure. Plans may be 3 – 12 months, though tasks and activities may be much shorter in duration (Jaques, 2006).

At each level in Kinston's hierarchical system of purpose, it can be seen that the focus at each level differs, as does the timescale of decision-making. However, the levels are interconnected, and reporting must be appropriate to that required by the higher levels to enable them to assess progress and outcomes (Kinston and Rowbottom, 1990).

There are examples where not all of the levels below the banner goal exist within an organisation. For example, the organisation may be subject to external regulation, or the political aim may be determined outside the organisation. This would be the case, for example, in the nuclear or safety-critical areas, where organisations are subject to external oversight.

Also, the organisation may become subject to conflicting *banner goals*. Protesters may object to new road or rail routes or the housing of migrants. These may

influence the mission of an organisation or, more likely, its *political aim* or *strategic objective*.

This is helpful when seeking to understand some of the observed behaviours in the organisation. There can be a variance, or 'shear' between the levels if there isn't consensus, or the communication between levels is poor. This shear can also arise when a strategic change is in progress, either at the level of the political aim, or strategic level. This situation would be symptomatic of poor engagement and communication across the levels.

Leveson et al (2009, p.243) have studied high reliability organisations and have a particular focus on achieving safety in complex systems taking a systems approach. They write:

> "Hierarchies, in systems theory, are characterized by control and communication processes operating at the interfaces between levels (Checkland 1981). The downward communication channel between levels in the hierarchy provides information necessary to impose behavioral [sic] constraints on the level below, and an upward feedback channel provides information about how effectively the constraints were enforced. [. . .] [C]ompany management has a role in the development of the safety control structure by providing a safety policy, standards, and resources to project management and, in return, receiving status reports, risk assessments, and incident reports as feedback about the status of the project with respect to the safety constraints."

Rasmussen and Svedung (2000, p.11) describe a hierarchical model of the levels of governance and control within a socio-technical system of risk management in a safety-critical environment (Figure 23).

It shows the reporting up the hierarchy both within and external to the company as well as the governance flowing down the levels, including from outside the company. In the diagram the hierarchical system of purpose is also mapped, showing that some aspects of purpose also lie outside of the organisation, though they still define aspects of structure, operation and governance.

Associated with the purpose at each level, and its differentiated focus, the work undertaken requires different capabilities of the people working there. This

includes span of control as well as the timescales of decision-making. These levels of work are explored in the next section.

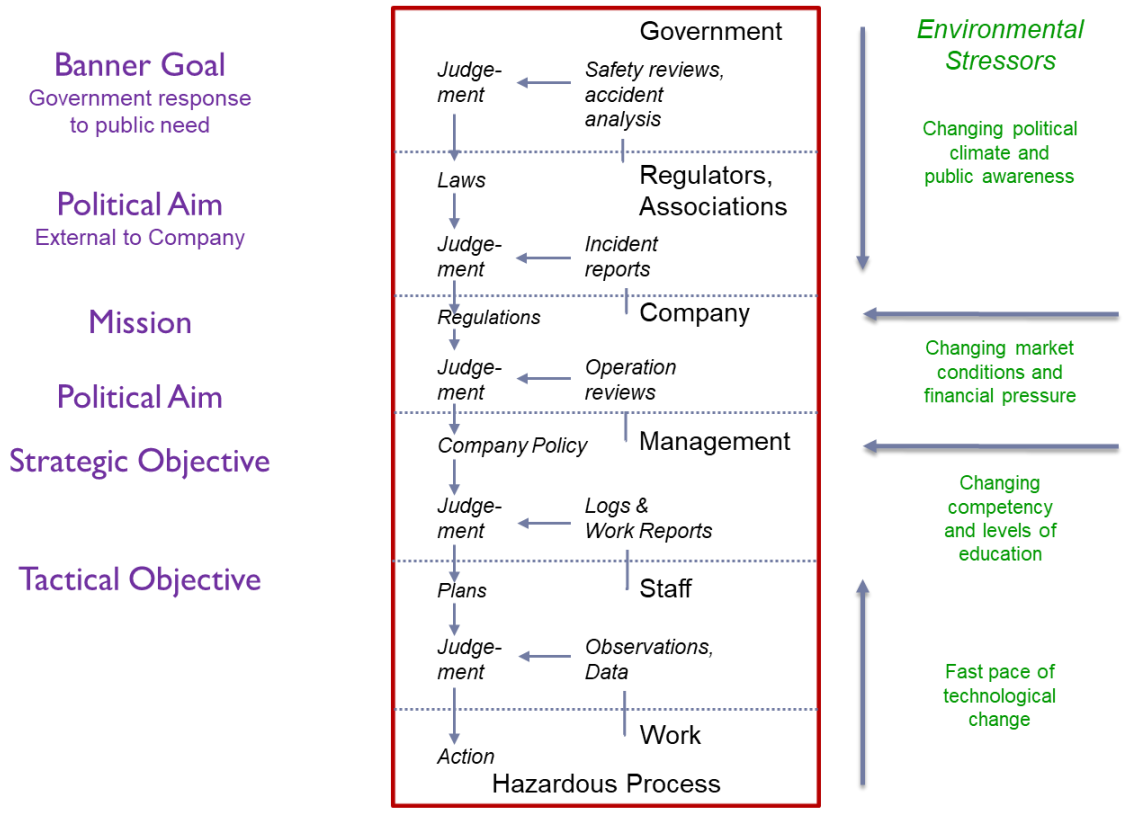


Figure 23 - Nested levels of decision-making (derived from Rasmussen and Svedung, 2000, p.11)

2.4.2.3 Levels of Work

Jaques (1986, 2006), Kinston (1986), Kinston and Rowbottom (1989, 1990) and Rowbottom and Billis (1987) undertook extensive research and developed a theory of organisational stratification and levels of work. This is summarised below in Table 5.

The strata indicate the type of work carried out in different levels in the organisational hierarchy and the associated span of responsibility. Each level has an associated timespan of decision-making. This is very much at the heart of Jaques' work on requisite organisation (Jaques, 2006), and helps to determine the capabilities required at each level of work.

Table 5 - Summary of work-strata (derived from Rowbottom and Billis, 1978, p.230)

Stratum	Description of Work	Upper Boundary
1	*Prescribed Output* – working towards objectives which can be completely specified (as far as is significant) beforehand, according to defined circumstances which may present themselves.	Not expected to make any significant judgements on what output to aim for or under what circumstances to aim for it.
2	*Situational Response* – carrying out work where the precise objectives to be pursued have to be judged according to the needs of each specific concrete situation which presents itself.	Not expected to make any decisions, i.e., commitments on how future possible situations are to be dealt with.
3	*Systematic Service Provision* – making systematic provision of services of some given kinds shaped to the needs of a continuous sequence of concrete situations which present themselves.	Not expected to make any decisions on the reallocation of resources to meet as yet unmanifested needs (for the given kinds of services) within some given territorial or organizational society.
4	*Comprehensive Service Provision* – making comprehensive provision of services of some given kinds according to the total and continuing needs for them throughout some territorial or organizational society.	Not expected to make any decisions on the reallocation of resources to meet needs for services of different or new kinds.
5	*Comprehensive Field Coverage* – making comprehensive provision of services within some general field of need throughout some territorial or organizational society.	Not expected to make any decisions on the reallocation of resources to provide services outside the given field of service.

The model has been applied to clarify roles and organisational structures within existing organisations and to help design new organisations. Any more detail is out of scope of this thesis, but it is an important consideration in ensuring an appropriate response to coenetic variables disturbing the organisation.

2.4.2.4 Levels of Managerial Thinking

Another important consideration, though again outside the scope of this thesis, is the managerial capability required at each level of work. Building on the experimental work of Isaac and O'Connor (1976), and extending Jaques' theories on timespan and capacity of decision-making (Jaques, 1986), Gillian Stamp developed a framework of the levels and types of managerial capability and a method to determine them in individuals (Stamp, 1981, 2004), summarised in Table 6.

Table 6 - Levels of managerial capability (timespans from Jaques, 1986)

Level of Capability	Level Description	Timespan
Level 1	Concrete threshold/rule as the basis for deductive choice when the subject can be discriminated from an object of direct activity. For example, having an internal skill to perform a contextualised action.	1 day – 3 months
Level 2	Ambiguous thresholding for objectives with inductive flexibility in application of rules for accounting and co-operation. For example, knowing when and how to apply rules and processes.	3 months – 1 year
Level 3	'System' is introduced for managing and projecting (e.g., using trends of serial instances) to establish a goal and a plan. For example, knowing how to look forward and manage planning forward in time.	1 – 2 years
Level 4	Abstraction and hypothesis building as rule-gaps, ambiguities and new perspectives appear as new duality. For example, able to appreciate abstract relationships between rules, people, values, etc.	2 – 5 years
Level 5	More universal theory construction for place in a wider enterprise for societal goals, with uncertainty as a given. For example, able to appreciate or establish balances to set own principles in and across a societal field.	5 – 10 years

These map to the levels of work, and also indicate the differences of capability required. When considering role definitions, career paths and managerial capability, these criteria should be borne in mind.

2.4.2.5 The Physical and Virtual Dimensions of Organisations

Organisations have become dependent on computer systems, frequently referred to as cyber systems. The development and integration of information systems, or cyber systems is such that this additional dimension is critical when considering organisational structure and design, especially resilience of organisations (Peppard and Ward, 2004).

Business processes are increasingly automated, and these processes can span numerous organisations within a supply chain, from supply to the organisations, internal processing and on to distribution to the end customer (Pasmore et al., 2019). This can include automated ordering, delivery, invoicing and payment. For some organisations such as IKEA, this can include completely automated manufacturing. Much of this activity takes place purely in the computing infrastructure, often referred to as cyberspace.

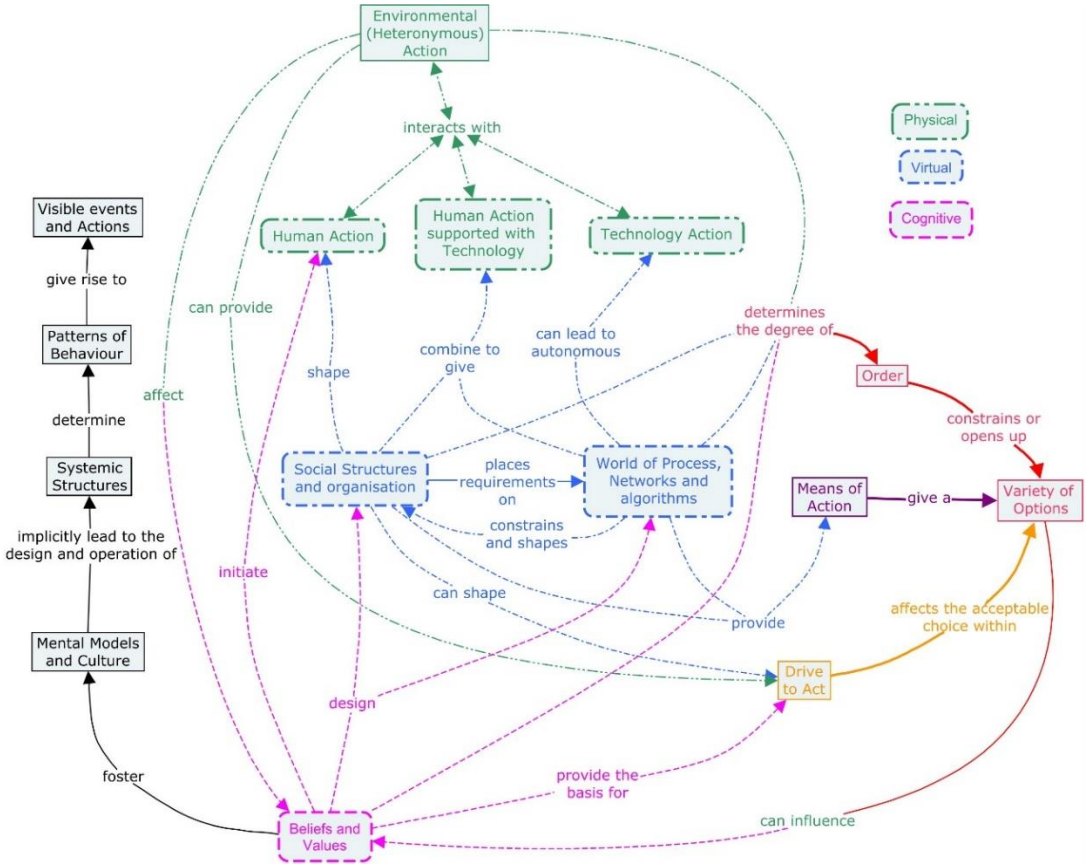


Figure 24 - Beliefs to action through choosables (derived from Hilton, 2021, p.3)

We can combine thinking about the iceberg above at section 2.4.2.1 and decisions as illustrated in Figure 21, leading to the structure at Figure 24 which is read as a concept map.

In this figure, the Iceberg is shown to the left. The mental models (beliefs and values) of the senior management of the organisation and the organisational culture will lead to the design of the organisational structures. Historically, the organisation would procure computer systems to support its operations. However, major computer-system suppliers design systems based on their own mental models of how organisations should function and market these to organisations. The organisation does not really have a choice now, and larger organisations are frequently reorganised by the large consultancy firms to fit the computing infrastructures available. This results in organisations not always being able to operate in the manner which suits their culture.

The computing infrastructure they employ provides the basis for their actions. Those organisations that employ Artificial Intelligence within their decision-making, for example, may not be in control of the decisions made if the algorithms are designed and built by others and introduced as ‘black boxes’. This can have a direct impact on the success and resilience of an organisation. This is often exacerbated by senior management not always having an understanding of their critical dependency on their computing and communications infrastructure, potentially outsourced to another to operate on their behalf. It is the resulting organisational structures and infrastructure that provides the means of action. Disturbances from the environment, and their impact on the organisation can provide the drive to action, whilst the same organisational structures, as well as regulation and legislation, determines the degree of order.

For management and structural reasons, organisations are generally divided into departments (or equivalent), each being further sub-divided. These are grouped into service functions such as finance or into product or service lines. Computer systems are designed and implemented along similar lines. This does not always reflect the way the organisation works, however, as teams form across these divisions.

2.4.2.6 An organisation is not a tree.

Christopher Alexander (1965) made the case that older, natural cities, were allowed to grow spontaneously and differ significantly to those that were deliberately created by planners and designers, which he calls artificial cities. He argues that there is some essential ingredient missing from artificial cities. A key contributor is the ordering, or segmentation the planners believed was necessary. There are shopping areas, residential areas, business districts all neatly laid out with appropriate links between them. Such cities can be decomposed neatly into these categories and can be described in a neat tree-like lattice. Alexander argues that the natural city, the city that feels alive, has integrated and overlapping functions. The ordering principle of a natural city is a semilattice, a complex network, as opposed to the tree structure of an artificial city.

This consideration applies also to organisations (Davis, 2015), in my opinion. Organisations are frequently designed around separated functions and the main conversation is about the organisational structure, presented as a tree. They are designed this way to indicate span of control of the various senior, middle and junior managers and for functional and budgetary control.

This approach does not necessarily consider the actual way people within an organisation work, nor does it reflect their interactions with other collaborating and contributing organisations within their value chain. However, it is a neat simplification that can be expressed simply in diagrams and serves a purpose in showing employees where they sit within an organisation.

Organisations are complex systems that cannot be represented as a tree. Taking Davis's (2015) points as an analogy, the building culture is not a tree:

> "But then I realized that there is, arguably, a strong analogy between a city of multiple and redundant connections, and a building culture, or building production process, in which multiple players with diverse views and ways of working, coming at issues and problems from different points of view, together contribute to the success, robustness and beauty of the built environment." (Davis, 2015, p.62)

This, to me reflects the situation in most organisations that develop and supply products and services, whether manufacturing, insurance, health, education etc. And in planning or developing these organisations, the approach is similar to building a city where one can take the city as an analogue for the organisation. System methods and approaches are applied when designing or developing organisations, and key ones are covered in this thesis. In many academic considerations, as opposed to practitioner application, the same issues Davis identifies regarding Alexander's methods can be identified:

> "From one point of view the article is a criticism of overly doctrinaire interpretations of Alexander's work. Some of these interpretations insist on rigidly-defined procedures and techniques, or claim that contemporary architectural and urban practice are altogether incapable of producing built environments of quality and deep feeling. I reject many of those interpretations, while at the same time continue to be guided by the vision

> of a world that has a fundamental respect for basic humanity and the often-lost sensibilities of the human heart." (Davis, 2015, p.64)

Within the application of systems methods, there is a focus on the method as opposed to the issue being addressed. There is a desire in the academic world to rely on scripts and repeatable processes (Howick and Ackermann, 2011). This prevents the facilitator/practitioner from being able to reflect the complexity and uniqueness of the organisation, and to bring in culture and other human aspects. It indicates a mechanistic view of an organisation, but one that is probably embedded in the management approach, based as it is on measures and a paradigm of "if you can't measure it, you can't manage it" (Deming, 2000; Seddon, 2003).

In saying an organisation is not a tree, I am not saying that an organisation is not hierarchical. It is, but a hierarchy of what? As Cilliers (2005) remarks, Simon (1962) argues "for the unavoidability of hierarchies in complex systems". And, "it is much more efficient for complex systems to be composed of sub-systems which are hierarchically organized. Hierarchy is not an accidental feature of complex systems, it is an essential one". It is not a simple hierarchy, however, as that would be decomposable and could be represented by a tree. There are many cross-cutting connections which makes them "nearly decomposable" and can be represented by a semilattice. Cilliers (2005) makes the point that the non-linearity of the cross-connections makes them difficult to predict and states:

> "Perhaps it is better to think of complex systems not as being nearly-decomposable, but as being decomposable and non-decomposable at the same time."

This way of thinking of hierarchies runs counter to Jaques' Stratified Systems Theory (2006, 2009), though his Managerial Accountability Framework equates to Simon's span of control (Simon, 1962). The requirement of a systems approach, therefore, is that these subsystems can be identified, both in and of themselves and in relation to others.

2.4.3 Environmental Interactions

Throughout this Chapter, the need to include consideration of the environment is a constant. Many authors argue that a system (organisation) cannot be differentiated from its environment ((Angyal, 1941; Babüroǵlu, 1988; Emery, 1973, 2000), but exploring the boundary is important. This section, beginning with Whitehead, discusses the contributions a variety of authors have made to these boundary considerations.

2.4.3.1 Whitehead

Here, Whitehead's (1978) Process-Relational thinking and how it means we should think about how we see and think is considered.

Our life is a process that we chunk up into moments that we call events. The choice of chunking being, potentially, arbitrary, but that chunking is what gives meaning to us. These we call experiences. All living things can experience, but we have a central organ of perception, a brain, that coordinates experiences that we use to inform our actions. "Complex animal bodies like yours are organized precisely to channel experience and organize it into a single individual who is able to achieve awareness and direct the whole organism away from harm and toward food, etc." (Mesle, 2008, p.38).

> "Experience is always experience of something. That something becomes part of – actually constitutes – the experience. It is impossible for experience to exist independently: Experience arises out of that which is lived. That which is experienced from "outside" us becomes "inside" us, or better, becomes part of us because it is taken up into our self as experiencer. Every drop of experience is a novel weaving of the world of preceding experiences out of which that drop arises. The many experiences constituting the world of the past are brought together into a new experience." (Mesle, 2008, p.43, italics in the original)

Within the world that is happening all the time, "[o]ur experience is that portion of it which is happening to us" (Kelly, 1955, p.170), and "[t]hings only happen to us when we behave in relation to them (Kelly, 1955, p.171). Consequently, if our thinking doesn't change in the light of things happening to us (in Kelly's terms,

our constructs are changed), nothing has been learned nor, therefore, has the individual had an experience.

Who we take ourselves to be, at any particular time, is a dynamic process. At any moment, we take all our past experiences and all of our current, new experiences and from those, create ourselves in that moment, deciding who we will be (Mesle, 2008, p.52). This implies that, in a team or organisational context, the team dynamics will be constantly adjusted, and who we take ourselves to be within the team will also change in the light of experiences. A common experience can have the effect of aligning its members in their shared context, as well as having an effect individually.

So, we can infer that knowledge of the world depends upon experience. And such experience has led many to associate the relationship between events as cause and effect. Hume pointed out that "[w]e cannot see (or otherwise sense) causation. We can see event A followed by events B and C, but we do not see causation." . . . "You *assume* or *infer* that the earlier events caused the later ones, but all you *see* is the sequence." (Mesle, 2008, pp.55–56, italics in the original).

Whitehead argued that because we create ourselves through our experiences, and that because we see ourselves as part of a causal web, we believe in causation. In fact, every scientific discipline, chemistry, physics, biology, etc. shares this experience of causal efficacy. "The world is a vast web of causal relationships – relational processes." (Mesle, 2008, p.59)

However, each person's experience of the actual world is from their own perspective, and all experience involves interpretation; interpretation involves an interpretation of that world, even if the world is a fictional one such as a play or a novel. "Even our interpretation of the fictional is enmeshed in the lived experience of the actual." (Mesle, 2008, p.59)

2.4.3.2 Personal constructs

Kelly (1955) explored personal constructs and how they set our thinking. Constructs are based on distinctions; similarities and differences. It is how we choose to make distinctions that leads to the differences in constructs between

people. Distinctions are an essential element of systems thinking and are discussed in some detail by George Spencer Brown (1969).

The minimum context for a construct is three things, two elements in agreement and one in opposition. At least two things that are alike and one that is different (Kelly, 1955, p.111). Without this, a distinction cannot be made. If the dichotomy of a construct is seen as polar, the two ends of the pole comprise the two perspectives, with likeness at each end of the pole. The relationship between the poles is the contrast across the dichotomy.

We, as humans, are set to anticipate the future, to predict and control. “All thinking is based, in part, on prior convictions” (Kelly, 1955, p.6). “[T]he universe is continually changing with respect to itself” (Kelly, 1955, p.7). This relates to the ladder of inference Senge et al refer to (Figure 20).

> “Man looks at his world through transparent patterns or templates which he creates and then attempts to fit over the realities of which the world is composed. The fit is not always very good. Yet without such patterns the world appears to be such an undifferentiated homogeneity that man is unable to make any sense out of it. Even a poor fit is more helpful to him than nothing at all.
>
> “Let us give the name constructs to these patterns that are tentatively tried on for size. They are ways of construing the world. They are what enables man, and lower animals too, to chart a course of behaviour, explicitly formulated or implicitly acted out, verbally expressed or utterly inarticulate, consistent with other courses of behavior or inconsistent with them, intellectually reasoned or vegetatively sensed.
>
> ”In general man seeks to improve his constructs by increasing his repertory, by altering them to provide better fits, and by subsuming them with superordinate constructs of systems.” (Kelly, 1955, p.9)

These constructs differ according to context and are developed over time. We adjust them though learning and experience. They can change during use in the light of feedback ‘in the moment’. These constructs are used to help predict, and we can often shape our constructs to suit a situation. It doesn’t mean that what we forecast will be accurate, but we may seek evidence to support our construct

and not see them as inaccurate. Frequently, however, we may adjust our constructs if there is immediate feedback regarding short-term events.

However, "[w]*e assume that all of our present interpretations of the universe are subject to revision or replacement*" (Kelly, 1955, p.15, italics in the original). We are allowed to change our minds (though some feel they can't) and there is always another way of seeing things. (This relates to Whitehead's Process-Relational philosophy; Mesle, 2008; Whitehead, 1978). These changing constructs with which we see events would be unsettling if they constantly changed. We would have no base to work from. Therefore, we have a deeper-set, higher-level or superordinate construct over a range of contexts, resulting in an "organized construction system" (Kelly, 1955, p.20). This, essentially, represents our basic beliefs that drives our behaviour; the depth to surface perspective that Angyal (1941) proposed.

> The universe is real; it is happening all the time; it is integral; and it is open to piecemeal interpretation. Different men construe it in different ways. Since it owes no prior allegiance to any one man's construction system, it is always open to reconstruction. [. . .] Thus, man comes to understand his world through an infinite series of successive approximations." (Kelly, 1955, p.43)

Though constructs are personal, once we become aware of them, we can begin to notice them in others. We can consider multiple perspectives and try to stand in the shoes of others. And, as Churchman says, "A systems approach begins when first you see the world through the eyes of another" (Churchman, 1968, p.231).

It is possible that two people can share the same experience, but because they interpret them differently, they will have a different experience. If they interpret them differently, "they will anticipate them differently and will behave differently as a consequence of their anticipations" (Kelly, 1955, p.90). Having said that, it does not require people to have had the same prior experiences in order to interpret a situation in a similar way, but to have the same construction of the situation. This suggests that by developing a common and shared understanding

of the situation (a shared construction), an alignment of action (behaviour) may result.

There are some contexts when we can anticipate the behaviour of another without necessarily understanding their perspective. This is when there is a convention for behaviour such as the Highway Code. We can rightly have expectations that people will drive according to it.

Alternatively, one may have a role within an organisation which carries with it certain responsibilities leading to certain behaviours such as leader, or the role played within a team, sporting or otherwise. Even then we each fulfil that role in our own way, with our own constructs.

This does open up the consideration that the perspective of the role isn't always mutually agreed. As Kelly states (1955, p.99) "[. . .] this definition of role does not insist upon commonality in the construct systems of the people involved in the social process or in the persons specifically involved in playing roles". This is reflected in (Casti, 1986, pp.149–150) in his consideration of complexity and the interaction between manager and those managed being a one-way interaction. Those being managed have their own perspective of the manager and may choose how they respond to it. Therefore, the perspectives (constructs) of the role differ according to whose perspective is considered. Consequently, the requirement of a systems approach must include these differing perspectives and potential tensions when determining purpose.

How the environment is perceived can influence the perspectives of those in the organisation. This will influence what roles and capabilities are perceived to be needed within the organisation. Emery and Trist's (1965) work, extended in (Emery, 1973, 1977b) described a range of environments and considered how organisations should adapt, as well as giving examples of maladaptation, drawing on Angyal (1981).

2.4.3.3 Emery and Trist's Causal Textures of the Environment

Emery and Trist's (1965) construct of the system and its environment was introduced above in Section 2.4.1.1. The same nomenclature is used here where

all of the components are covered by Lawful connections (L). The system (organisation) is designated “1” and the environment is designated “2”. When the system acts upon the environment, this may be considered the planning function (L_{12}). The system learns (L_{21}) when the environment acts upon the system. L_{11} and L_{22} represent the intrinsic nature of the system and environment respectively. They have devised a hierarchy of what they call Causal Textures. This was in response to a need to extend von Bertalanffy’s open system “formulation” that when considering the exchange processes between the organism, or organisation, and elements in its environment, it did not address all the processes in the environment.

Furthermore, I believe that the range of Causal Textures defined are also useful when considering the scale and/or maturity of the organisation, and what relative competencies it requires within it. It also relates to the hierarchy of purpose (section 2.4.2.2) and levels of managerial thinking (section 2.4.2.4). The causal textures are illustrated at Figure 25.

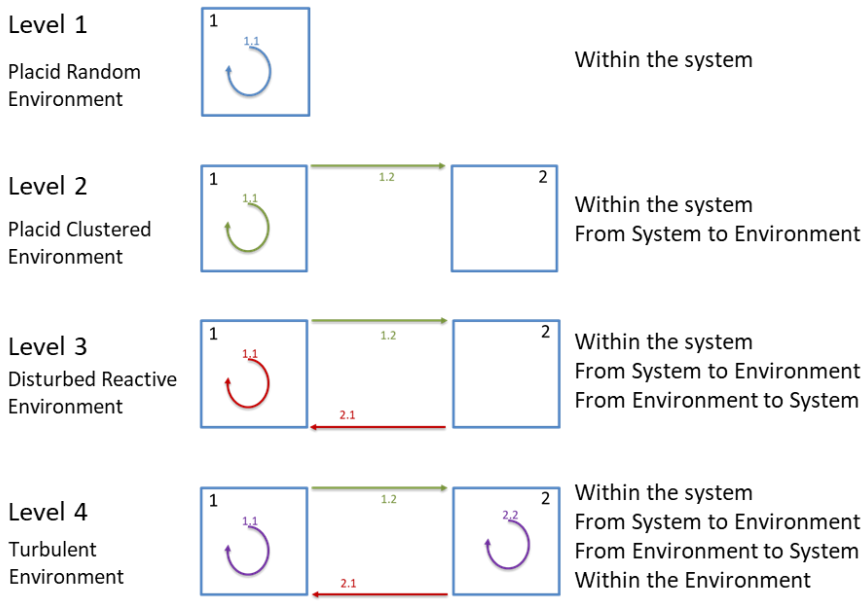


Figure 25 - Causal Textures (derived from Emery and Trist, 1965)

As Babüroğlu (1988, p.182) states “According to Ashby (1960), the system is invariably expected to differentiate to match the variety of its environment”. Consequently, by exploring the complexity of the environment according to the

organisation's level of maturity and context of operation, the requisite competencies can be identified. Initially, the Causal Textures are introduced and then the required competencies related to the organisation's perspective on the environment are briefly discussed.

1. Placid, Random Environment

   The simplest perspective an organisation can have of the environment is that termed the 'placid, randomised environment'. The organisation perceives opportunities as randomly distributed. This equates to a small organisation who responds to requests for products or services. There is no particular analysis of the market or even deciding to promote the organisation. Generally, this is a micro-organisation, or one-person organisation that might adapt as required to respond to customer demands. They probably rely on reputation and/or referral. The analogy here is a local builder who "grazes" for business, putting their signboard out whenever they undertake a project.

   Consequently, there is no need for any sales or marketing competence, nor is there any need for market analysis. Competition is not of a particular concern. It is likely there is no strategic thought, everything is at purely a tactical level. The organisation has all the tools and expertise within it to undertake projects, or they will collaborate with known partners to provide the range of competencies required. All competencies support their internal L_{11} needs without planning or learning.

2. Placid, Clustered Environment

   This is a more complicated, but still placid environment. Within the placid, clustered environment, the organisation recognises the 'clustering' of opportunities, and that some consideration should be given to the promotion of the organisation and the location of potential customers. This requires the organisation to consider its location as well as advertising. For example, where to site a coffee shop, a small bookkeeping or accountancy firm, a convenience store, or where to promote a consulting business.

This leads to the development of a strategy, as distinct from tactics, and the need to increase the range of competencies within the organisation. The organisation begins to grow and develop a hierarchy within it with a tendency for centralised coordination and control. All the resources are aligned to the purpose and a “distinctive competence’ emerges. Competencies now support internal L_{11} needs and L_{12} planning, but without learning.

3. Disturbed-reactive Environment

The environment has become more complex as the disturbed-reactive environment now includes competitors, and competition is the dominant characteristic of this environment. As the other organisations have the same competence, it requires the organisation to introduce a focus on operations in addition to tactics and strategy. This is because not only does the competition seek the same opportunities, but what the organisation knows is known by others. Therefore, the organisation may seek to undermine the opposition to create an advantage, but also must recognise the opposition will seek to do the same to them. It is this ‘dance’ that requires the development of an operations competence to deal with this.

The flexibility required to follow a campaign of a series of tactical initiatives to overcome the opposition, whilst seeking to intercept anticipated counter-initiatives by the opposition, includes a level of decentralisation and puts at a premium speed of decision-making as well as maintaining a good level of quality. This requires competencies to be added that address the learning required from the environment, L_{21}, in addition to further development of the L_{11} and L_{12} competencies.

These competencies include seeking market intelligence, the internal ability to meet competitive challenge through absorbing smaller organisations or aligning with and/or collaborating with others. Additionally, the organisation may seek to engender an element of stability in the market, for example though interest groups and lobbying governments. It is about shaping conditions and not going toe-to-toe with competitors.

4. Turbulent Fields

   This is the most complex environment as it now includes changes within the environment in and of itself, beyond that of competition. This might result from the interaction of competitors re-shaping the market, or new technology emerging. It might be a global financial crisis, or war.

   All of these will have an impact on organisations according to their area of interest, though the economic, political, and rapid technology changes will probably impact on all organisations to some extent.

   The additional competencies here relate to thinking within the environment itself, L_{22}. This includes, for example, scenario thinking and scenario planning as developed initially by Shell (Chermack, 2011; Kahane, 2004). Here the organisation envisages plausible futures and decides accordingly on courses of action, requiring organisation-wide involvement, impact assessments and adaptive responses by the organisation.

It is due to the organisation's perception of the increasing complexity of the environment, and their capacity to deal with it, that leads to my view of organisational maturity. An organisation has to grow and develop the required competences, and these will develop over time. The required competences arise from the choices the organisation makes, and the sector the organisation sits within.

Traditionally, universities, for example, sought grants to undertake research and taught courses as a result of that. Arguably, this equated to a placid, clustered environment. Academics had tenure and primacy over their research interests. However, the university environment has changed. Those organisations awarding grants, usually aligned to centralised government policy, now determine the areas of research interest, and there is a lot of competition for students. This equates to a disturbed-reactive environment, and universities have had to adjust their competencies to remain viable. Some have been more successful than others and change within universities has been difficult as it has had the effect of changing university culture.

More recently, broader social and financial changes have challenged university viability and competencies required by the turbulent environment should be incorporated. This, I believe, will take time and not all universities will develop these capabilities.

2.4.3.4 Daft and Weick's model of organisations as interpretation systems

Taking the learning perspective of organisations (L_{21} above) Daft and Weick (1984) propose a model of organizations as interpretation systems. This has been further developed to consider Management Control Systems and inaccuracy of management cognition within decision-making (Chatterjee, 2023; Malmi, Kolehmainen and Granlund, 2023; Nakanishi, 2023; Rupčić, 2023).

This depth of analysis is out of scope of this thesis as it is not considered specifically by the main systems methodologies. However, it warrants further research to support the exploration of the organisation-environment interaction. Malmi et al. (2023) documents the salutary tale of the decline of Nokia through their management not responding to a disruptive technology-focused environmental change. Nakanishi (2023), for example, explores the need for organisational learning, specifically the importance of learning that "spans the organisational, intra- and interteam, manager/leader and individual member levels".

Daft and Weick (1984, pp.285–286) have 4 working assumptions:

- Organisations need the capability to monitor the environment to detect changes and trends regarding "events, competitors, markets, and technological developments relevant to their survival";
- It is individuals who interact with the environment, not organisations, but it is the organisations that "preserve knowledge, behaviors, mental maps, norms, and values over time" resulting in information being shared amongst managers who converge on an approximate interpretation, but with a "thread of coherence";
- It is the relatively small number of top-level managers who determine the whole organisation's interpretation of the environment, synthesising the

contributions from individuals across the various parts of the organisation often without informing subordinates about the issues that pertain to the organisation as a whole;

- Organisations are specific and dissimilar in their interpretation of the environment and these variations, based on organisational and environmental influences, lead to differences in "strategy, structure and decision making".

There are 3 components to the interpretation of the environment, scanning (data collection), interpretation (data given meaning), and learning (action taken). Also, there are 2 perspectives that can explain the organisation's differences in interpreting the environment. These are the "management's beliefs about the analyzabilty of the external environment" and "the extent to which the organization intrudes into the environment to understand it" (Daft and Weick, 1984, p.287). Furthermore, they argue that organisations are complacent about the environment, taking it as given, and will only respond when a crisis occurs. They propose that:

> "New, young organisations typically begin their existence as test makers. They try new things and actively seek information about their limited environment. Gradually, over time, the organization interpretation system begins to accept the environment rather than searching or testing its boundaries. New organizations are disbelievers, they are unindoctrinated, and have less history to rely on. They are more likely to dive in and develop a niche that established organizations fail to see. But as the organization grows and as time passes, the environment may be perceived as less threatening, so search will decrease." (Daft and Weick, 1984, p.288)

Organisations vary according to their beliefs and in the extent that they engage with their environments. Consequently, they can be categorised according to their interpretation modes as illustrated in Table 7.

This perspective is not continued further in this thesis but should be considered when exploring organisation-environment interactions.

Table 7 – Model of organizational interpretation modes (derived from Daft and Weick, 1984, p.289)

ASSUMPTIONS ABOUT ENVIRONMENT	Passive	Active
Unanalyzable	UNDIRECTED VIEWING Constrained interpretations. Non-routine, informal data. Hunch, rumor, chance opportunities	ENACTING Experimentation, testing, coercion, invent environment. Learn by doing
Analyzable	CONDITIONED VIEWING Interprets within traditional boundaries. Passive detection. Routine, formal data	DISCOVERING Formal search. Questioning, surveys, data gathering. Active detection

ORGANIZATIONAL INTRUSIVENESS

2.4.3.5 Boundary Conundrum

There is a need for an element of design of organisations and the systems that operate within them, especially to enhance resilience. The structure of the organisation and the functions carried out within it are determined by the environment the organisation is operating within, and its purpose. Also, its culture and personality will contribute significantly. Consider here the impact of the organisation's vital computing and communications infrastructure being designed and, perhaps, operated for them by another organisation.

Organisations today operate within a dynamic, turbulent world, so rigid structures may not be the most helpful. In today's more complex world, less control and a simpler way of operating, can be seen to be more effective as it allows the organisation to respond and adapt more quickly to its environment (Wheatley, 1992; Wheatley and Kellner-Rogers, 1996). This ability depends on the capability, engagement and support of staff.

Organisations have a significant dependence on technology, especially computing technology and many of the functions are either semi- or fully-automated. Indeed, it is more likely that the computing processes and structures now shape the organisation so when considering resilient organisational design, the spectrum from pure human interaction to pure computing interaction must be considered.

Therefore, to what degree can you design, as a design can often lead to rigidity, and what organisational structures do you allow to emerge according to demand; constant creation and novelty? Organisations may appear to remain in a consistent environment according to their products and services, but the environments themselves will be changing. Also, as the organisation develops, matures and grows, its perception of its environment will change, and additional functions will be required.

The motivations of people can vary, and these need to be aligned to the purpose of the organisation. Indeed, this will lead to the notion of a collective motivation at an organisational level and the role of organisational culture can have a significant contribution to the structure and processes of the organisation.

How can you accommodate all these aspects when considering the design of resilient organisations? What systems methods and tools are suitable to support this thinking and design? The Reference Model of Governance for a Specific Organisation proposed in this thesis provides a framework for this. Incorporating the organisation within its environment is an important consideration in this thinking and is explored further in the next section.

2.4.3.6 The Boundary

The boundary of an organisation cannot be simply delineated. Nor can it easily be determined by observation. There is a relationship between the organisation and its environment, and one needs to determine at what level within the organisation this relationship is manifested. Indeed, as Trist (1992, p.115) states, “The organism earned a living by making a net profit in the value of its imports over its exports, a process called negative entropy by Bertalanffy (1950).” A simple illustration is at Figure 26 which shows the indivisibility of subject and object and the indeterminate boundary. Angyal’s definition of a system (Angyal, 1941) exposes the nature of the system problem “A system is a distribution of constituents with positional values in a dimensional domain.” By this, he implies that a system cannot be determined, or modelled, based upon its functions and the concept of functional relationship as functional relationship is a concept within reductionist thinking.

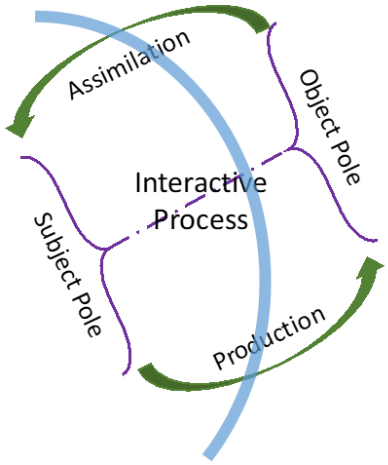


Figure 26 - The indivisibility of subject and object (derived from Angyal, 1941, p.21)

From his perspective, the value of a part of an organisation is what is does for the whole. Their function is the maintenance of the whole and to make relations with the environment in order to achieve this. Angyal is concerned with the living organism and includes within this concept a super-organism such as an organisation. Indeed, Angyal was the first person "to make a distinction between system connectedness and functional relations and between positional values and relevant attributes" (Trist, 1992, p.114). Treating an organisation as a living entity brings another, richer perspective. Both Beer (1981, 1994) and Miller (1965, 1973) took this conscious approach in their approach to systems thinking.

Trist continues:

> "Once the property of "negentropy" became established other properties could follow, such as capacity for growth and "equifinality". Greater closure of part systems could permit greater openness of the whole so that more complex systems could establish ranges of adaptation far greater than simpler systems. They could extend into wider and richer environments and at the same time absorb the increased uncertainty and variance. The capacity to encode and decode information became critical. On this depended regulation through negative feedback, so that directions could be taken or held, or avoided or discontinued. Otherwise no "terms of reference" could be set, no missions undertaken. The organism being incomplete – a necessary consequence of being open – had actively to establish and maintain environmental conditions – a domain – which permitted its continued existence." (Trist, 1992, p.115)

Angyal had independently included this in his thinking as illustrated in Figure 26. This is his diagram that explores the “closed circle of life” (Angyal, 1981, p.21). On the one side the organism (circle) is open to receive, for assimilation, whilst on the other side, following some internal transformation by the organism, is the production. These exchanges in both directions are on multiple levels, physical, psychological and sociocultural.

Angyal’s consideration of the interdependence between the system and its environment led him to drop the terms “system” and “environment” and relate to them in “interactionist” terms, initially using “universe” to include them both. He used the term “biosphere” as, for him, life takes place in the biosphere rather than inside the organism (or organisation).

> “I propose to call the realm in which the biological total process takes place the “biosphere”, that is, the realm or sphere of life. The biosphere includes both the individual and the environment, not as interacting parts, not as constituents which have independent existence, but as aspects of a single reality which can be separated only by abstraction.” (Angyal, 1941, p.106)

Angyal develops this notion of the abstraction process and, due to its significance, is quoted at length below:

> “The biosphere, although an undivided unit, still is not structureless. It is differentiated along various dimensions. In the biosphere two definite directions can be distinguished: autonomous determination or environmental government. These two directions do not exist independently but only within the biospheric happenings, in other words, as components of the biological total process. Both directions extend to the very limit of the biosphere. At one pole of the biological total process, the autonomous determination is the more potent one, and it extends to the opposite pole in the way of a gradient of decrease. At the other pole the heteronomous factor is the prevailing one which extends as a gradient of decrease towards the opposite pole. The two trends are like two currents of opposing direction, inseparably united in the total dynamics of the biosphere.
>
> “According to the dominance of one or the other determinant the biosphere is roughly differentiated into two fields. Those factors which are prevalently under autonomous government constitute the organism or self

or subject, while the factors which are prevalently under heteronomous government from the objects or the environment. The words “subject” and “object” express very aptly the difference which I have in mind. “Subject” is that factor which governs, “subjects”, the raw environment. “Object” means that which is “thrown before” the subject, but also that which opposes, offers resistance, i.e., “*objects*” to the subject’s influences. It is the non-system-determined, heteronomous factor. The differentiation of the biosphere into subject and object is the basic organization of the biosphere and forms the foundation for further structuralizations.

“The single factors have no fixed position in the biosphere. Processes which, at a given moment, stand prevalently under environmental government may at the next moment come under prevalently organismic government.

“Strictly speaking, one cannot generalise and state to what extent a given type of biological occurrence is organismically or environmentally governed. The exact value of this ratio can be determined only in specific instances. There is, in other words, a continuous flux between the two poles of the biosphere.” (Angyal, 1941, pp.101–102)

This is illustrated below at Figure 27, and is a significant concept to consider within organisational governance, simply because no one person can understand the whole of an organisation and, therefore, its boundary. Nor can any assumptions be made about the ability of the organisation to act on its environment; this must be considered on a case-by-case basis, relevant to each part of the organisation under consideration, and its context at that time.

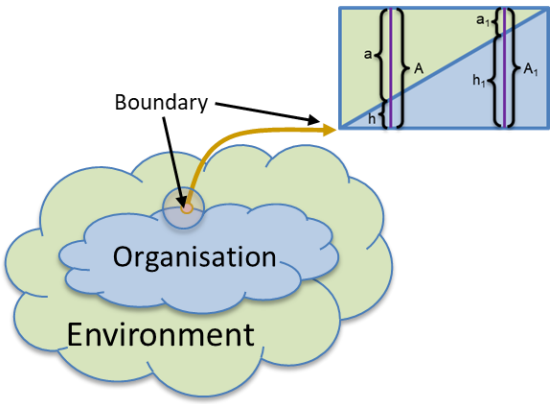


Figure 27 - Organisational boundary (derived from Angyal, 1941, p.95)

Within the diagram (Figure 27) The ‘a’ and ‘h’ refers to the ratio of autonomy (self-governed functions undertaken by an individual or organisation) to heteronomy (the reaction or resistance of the environment). In studying the biological total process in the context of an organisation, there is no process that is determined wholly by the organisation or wholly by the environment; it is always a result of the two and can be expressed as a ratio of “autonomous and heteronomous government (*a:h*) active in them” (Angyal, 1941, pp.94–95).

The vertical lines A and A_1 in Figure 27 represent 2 instances of biological processes. The proportions *a*:*h* and a_1:h_1 express the dynamic relation between the organisation and its environment. In both instances, organisation and environment contribute to the interaction (biological process).

The organisation acts on its environment, but also reacts to its environment. In acting on its environment, it doesn’t have total freedom as the environment is also party to that action and determines its part in it. Indeed, Zeleny (1996, p.133) defines the boundary as:

> All social systems, and thus all living systems, create, maintain, and degrade their own boundaries. These boundaries do not separate but intimately connect the system with its environment. They do not have to be just physical or topological, but are primarily functional, behavioral [sic], and communicational. They are not “perimeters” but functional constitutive components of a given system.

2.4.3.7 Organisational adaptation

Previously, in section 2.4.2.1, the iceberg was introduced as a metaphor to support thinking about the cultural and structural aspects of an organisation that determines it behaviours and actions. Following the development of this by Hall (1989), illustrated in Figure 22, we can combine it with the Peppard and Ward models, relating them to an organisation’s boundary. This can help us support decision-making by identifying mechanisms for adaptation and where a systems approach can contribute. This is illustrated in Figure 28 below.

Organisationally, the mental models and culture are represented by the business and technical skills knowledge and expertise and organisational culture. The

systemic structures are created by the organisation of resources through processes and technology (either equipment or IT systems), roles and responsibilities and their arrangement in the organisational structure, generating the set of organisational competencies. The patterns of behaviour are shaped by the explicit or implicit strategy and the allocation of resources (including money, time and people). The resulting capabilities result in the visible actions and the noticeable effects or outcomes achieved.

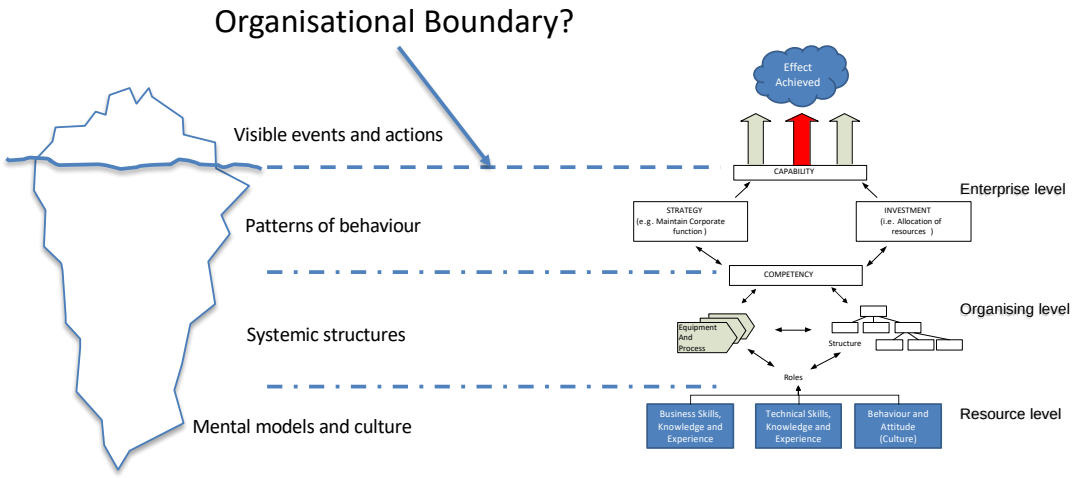


Figure 28 - Extended Organisational Boundary (Source: Author)

Where there is a difference between the effect achieved and the effect desired, then the organisation may choose to reallocate resources or, deeper within the organisation, adjust process and roles and/or develop additional skills and knowledge. An element not often explicitly considered is the underlying culture within the organisation and how this might be impacting on the outcomes achieved by the organisation. This is expanded in more detail in Section 4.2.2.

However, when you consider the work activities undertaken to achieve the organisational outcomes, there is such a close dependency amongst a range of organisations that it is not always easy to determine the organisational boundary. This is illustrated in Figure 27 above. The organisation sits within its environment, and we often draw a line to represent the boundary. However, the distinction is not clear, and may be determined by the range of autonomous and heteronomous actions within the boundary activity; what Angyal refers to as a dynamic process

within the biosphere. The ratio of a/h, where a refers to the autonomous action of the organisation, and h is the heteronymous push back by the environment, which includes one or a number of partners/competitors/ clients/people etc, relates to the relative contribution within the dynamic process.

2.5 Requirements for an approach to modelling organisations

The preceding sections contribute to the development of a list of requirements to be met by a set of systems methods that can support an injunctive approach to understanding organisations. This set of systems models will constitute the Reference Model Governance for a Specific Organisation.

A complex system is not knowable, but a level of understanding can be achieved at a point in time, and enough of its general structure can be modelled to guide decision-making. This will need to be 'refreshed' periodically. Such periodicity will be related to the speed of change in the organisation's particular context.

Building on an understanding of complexity (Cilliers, 2002) in section 2.2, a range of factors when considering organisations as systems was explored in section 2.4, drawing on a range of thinkers, many who are not part of the contemporary set of systems thinkers. Their contribution to my understanding of the complexity of organisations as systems and in ensuring the requisite complexity of organisations is included within models of systems to ensure requisite regulation has been fundamental in the development of a set of requirements for an approach to modelling organisations and to answer RQ1

As explored in section 2.4.3.6, the challenge is to decide conceptually the boundary of the system. In reality, the boundary of an organisation is generated by the inter-relationships and interactions between those 'inside' the organisation and those 'outside. So, the boundary will be generated by conversation and agreement on the resulting distinctions.

R1. The Reference Model of Governance for a Specific Organisation must enable boundary analysis.

Time and learning were explored in section 2.2.1. Time is relevant, whether it is the increase in complexity in the organisation as it adapts to the changing environment, or the decay the appropriateness of procedures through non-adaptation. Learning needs to be meaningful and timely, so what loses value must be forgotten. Changes and relevant experiences, especially those related to decisions on purpose, should be stored in an accessible way, not just filed in an IT system somewhere and never remembered.

R2. It must be possible to see the effects of history, corporate memory and drives to act.

R3. Changes within the system (organisation) can be identified regarding necessary activities as the organisation adapts to environmental changes.

As discussed in section 2.4.1, from a more personal perspective, our perception of the environment and what we take a system to be is very much driven by our motivation and interests, frequently unacknowledged. Our beliefs and values equate to our Weltanschauung which explains why weltanschauung is more fundamental that 'worldview'. People rarely reflect on their "*weltanschauungen*" or consider why they think differently to others. In contemporary usage, weltanschauung is used in the shallower context of how we perceive things, whereas it actually shapes our behaviour and interactions with others.

R4. The Reference Model of Governance for a Specific Organisation must be able to represent 'frames', the perspective taken by the relevant management team according to differing levels of abstraction. The Reference Model of Governance for a Specific Organisation is likely to be recursive (nested) with increasing granularity both horizontally and vertically.

Again, explored in section 2.4.1, coming to an agreement on the purpose of the organisation involves choice and judgement. However, by surfacing the various mental models and perspectives, and by building system models to record, to a limited level of granularity, the combined understanding, a consensus can be

reached regarding the purpose of the organisation (as a system) and how it sits within its environment.

R5. The Reference Model of Governance for a Specific Organisation must be able to determine holistically activities relevant to the agreed frames but maintain logical dependencies and capture the richness of interaction.

As explored in section 2.4.2, another way of considering the Depth-to-Surface perspective of an organisation is the differing perspectives at each level of the hierarchy of an organisation. Normally, when looking at an organogram of an organisation, the senior team are sitting at the top, and the working level is seen at the bottom. Therefore, at each level there will be a different focus, or purpose. However, it is the senior level that sets the culture, or values of the organisation, and seeks to design the organisation in terms of structures and processes to achieve the desired outcomes through undertaking work. This leads to the design of the organisation's regulator and means of regulation which should be distributed down the hierarchy and across the levels of the organisation. It has to be considered in 3 dimensions. Not only is there a different focus, or purpose at each level of the hierarchy, but the decision-making differs. These are also referred to as levels of work and involve reducing timespans of decision-making as you move from strategic senior-level thinking and planning, to the lower levels of scheduling end operations.

One of the challenges when considering the lamination, or hierarchy of an organisation is that it is frequently represented as a tree structure, each level decomposed into sub element in the level below. This represents a partial view of the organisation, but there are some systems, or elements of the organisation that collaborate across a range of levels and elements and, indeed, to other organisations. A simple example is matrix management where staff are organised by skill groups but operate as multi-skilled teams.

R6. Sub-organisations within the organisation or enterprise can be identified that have their own discrete properties (purpose).

Environmental interactions and boundary considerations were explored in section 2.4.3. The organisation is embedded within its environment, both shaping it and being shaped by it. An ongoing ‘dance’, not fully understood by anyone, but where all regulators play a partial role. This requires relational or systems thinking in addition to analytical thinking. It must include an understanding of the arrangement of the elements of the organisation in its environment, their inter-relationships and the plausible behaviour over time that may result. Actions and judgements must be relevant and timely to maintain the desired outcome of the organisation. The problem-solver requires ways of thinking to enable them to make sense of the wickedness of problems. They need the variety of thought and ways of thinking to match the variety of the situation to avoid reducing their perspective of it to it just being a complicated, even simple problem.

R7. It should be possible to determine clusters of elements collaborating at short range as well as indicate the longer-range inter-relationships.

R8. Dependencies between elements must be captured.

R9. Measures of performance can be identified.

As explored in section 2.4.3.1, we learn through experience, and each one of us experiences differently, so learns differently. In learning we change, which leads to a change in our beliefs, though our values remain fixed and guides how we engage in our experience. Who we take ourselves to be is a dynamic process, meaning a team needs to maintain a good level of communication to retain coherence. Also, the assimilation of a new team member, and the loss of a team member will also have an impact on the team and the team must be supported in its journey of being as it, too, is within a dynamic process.

We infer knowledge through this shared experience and this is what leads, in a team or organisational sense, to the collective beliefs and values that underpins everything within the organisation. The relationships between members and between teams and organisations is not linear, and this needs to be understood.

These must all be considered in interactions and the inter-relationships between people, teams, organisational units and organisations.

These lead to the ‘autonomic’ response to events, often referred to as “this is how it is done around here”. This may be inculcated through deliberate training and development, but also arises from culture.

R10. The Reference Model of Governance for a Specific Organisation must be able to represent the non-linearity of relationships.

R11. The Reference Model of Governance for a Specific Organisation can capture the feedbacks within the system, between the system and environment and within the environment.

As explored in sections 2.4.2.3 and 2.4.2.4, another important consideration is the competencies required within an organisation to ensure the required capability to enable the organisation to survive and thrive in its environment. The ‘lawful connections’ should be explored as appropriate to the level of maturity or scale of the organisation. This includes not only a recognition of the range of competences relevant to the causal texture of the environment acknowledged as being appropriate, but also the means of interpreting the environment. This was explored in sections 2.4.2.5 and 2.4.3.3.

R12. The Reference Model of Governance for a Specific Organisation must enable one to capture / integrate the environmental inter-relationships as well as internal peer-peer inter-relationships.

This returns us to the boundary conundrum introduced above and leading to R1. Finally, therefore, following the discussion in sections 2.4.3.6 and 2.4.3.7, we have the following requirement.

R13. The organisation can be modelled in its wider context.

The finalised list of requirements to be met by an integrated set of systems methods that can support an injunctive approach to understanding organisations is at Table 8. This set of systems methods will enable the development of a Reference Model of Governance for a Specific Organisation.

Table 8 - Requirements to be met by a set of systems methods that a Reference Model of Governance for a Specific Organisation will comprise.

R1	The Reference Model of Governance for a Specific Organisation must enable boundary analysis.
R2	It must be possible to see the effects of history, corporate memory and drives to act.
R3	Changes within the system (organisation) can be identified regarding necessary activities as the organisation adapts to environmental changes.
R4	The Reference Model of Governance for a Specific Organisation must be able to represent 'frames', the perspective taken by the relevant management team according to differing levels of abstraction. The Reference Model of Governance for a Specific Organisation is likely to be recursive (nested) with increasing granularity both horizontally and vertically.
R5	The Reference Model of Governance for a Specific Organisation must be able to determine holistically activities relevant to the agreed frames but maintain logical dependencies and capture the richness of interaction.
R6	Sub-organisations within the organisation or enterprise can be identified that have their own discrete properties (purpose).
R7	It should be possible to determine clusters of elements collaborating at short range as well as indicate the longer-range inter-relationships.
R8	Dependencies between elements must be captured.
R9	Measures of performance can be identified.
R10	The Reference Model of Governance for a Specific Organisation must be able to represent the non-linearity of relationships.
R11	The Reference Model of Governance for a Specific Organisation can capture the feedbacks within the system, between the system and environment and within the environment.
R12	The Reference Model of Governance for a Specific Organisation must enable one to capture / integrate the environmental inter-relationships as well as internal peer-peer inter-relationships.
R13	The organisation can be modelled in its wider context.

2.6 Research Question arising

Having answered Research Question 1, we now look to consider what methods can be applied to meet the requirements set and what their arrangement should be.

RQ2: What is a suitable arrangement of systems methods that meets the requirements such that a Reference Model of Governance for a Specific Organisation can be developed?

2.7 Summary

This chapter has reviewed the literature regarding the key concepts and methods upon which this research is based. It has covered a wide range of factors not normally considered in contemporary organisational systems thinking and related them to the complexity and variety required to be explored by systems methods when determining appropriate organisational governance. It includes a discourse on complexity, Conant and Ashby's Good Regulator model, organisations as systems, laminated organisations and environmental interactions. It concludes with a set of requirements for an approach to modelling organisations.

In the next Chapter, we review current multimethodology approaches and a set of candidate systems methodologies and methods.

3 Candidate Methods for the Reference Model of Governance for a Specific Organisation

> "The fundamental tenet of multimethodology is the importance of combining together methods or sometimes methodologies in dealing with real-world situations, whether the purpose is pure research or a practical intervention . . . The first argument in favour of multimethodology is that the real world is complex and multi-dimensional, while particular research or intervention methodologies focus on specific aspects . . . The second . . . is that research and intervention is not a discrete event but a process that has phases (or, rather, different types of activities) that will predominate at different times . . . A third argument . . . is that it encourages triangulation or research and generates more interesting and stimulating results."
>
> (Mingers, 2014, pp.184–187)

This section will review the literature on multimethodology approaches and suitable methods for the Reference Model of Governance for a Specific Organisation. Following a discourse on the relationship between complexity theory and systems thinking in Chapter 2, it reviews the structures proposed regarding mixing methods, and a summary of the philosophical considerations. It then considers alternative frameworks that may be considered relevant in the organisational context.

A literature review focused on the use of systems methods in combination was undertaken. The search terms used, and a summary of findings is included at Appendix C. Next is a review of the literature with regard to the combinations of methods before outlining the methods themselves. In Chapter 4 a methodology for their combined application is proposed.

Approaches to combing methods are considered in section 3.2, and relevant systems methods are considered in section 3.3. In Section 3.4, the practitioner dimension is introduced and then the methods' suitability for building the Reference Model of Governance for a Specific Organisation is assessed in section 3.5. Though the Reference Model of Governance for a Specific Organisation will comprise models from a set of systems methodologies and methods, when building the Reference Model of Governance for a Specific

Organisation, in Section 3.6 an additional set of methods used to develop collaboratively a common and shared understanding of an organisational situation is explored. This is a necessary precursor to building the Reference Model of Governance for a Specific Organisation as this stage will address many of the requirements generated in Chapter 2. The range of systems and understanding approaches is illustrated in Figure 29.

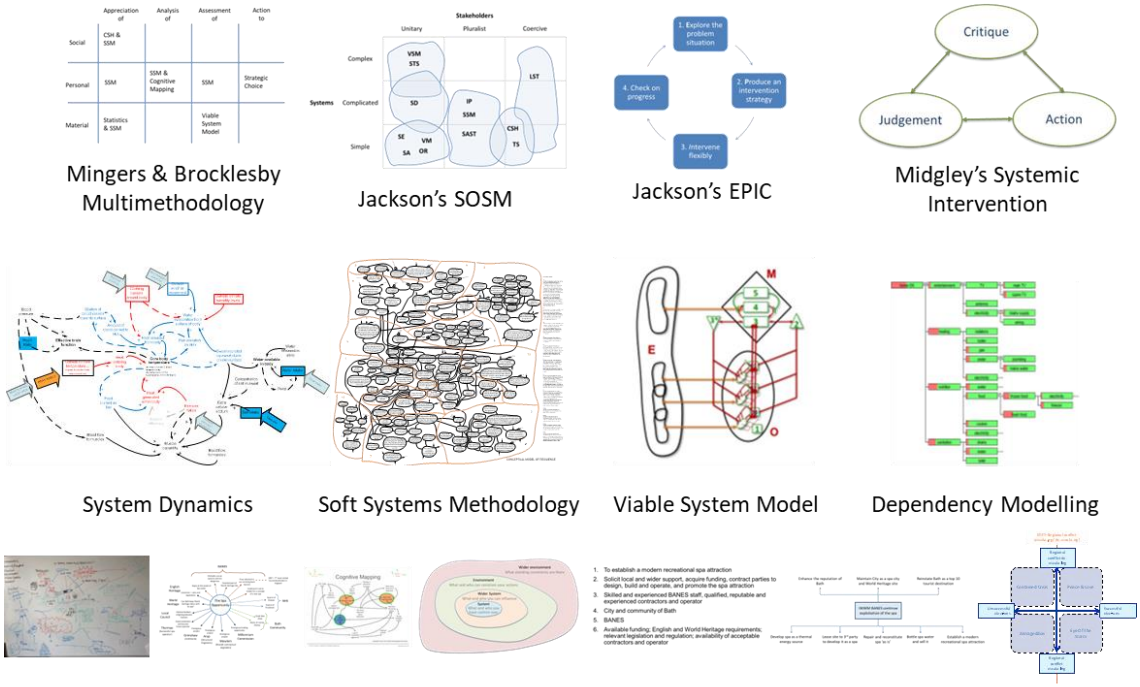


Figure 29 - Focus of Chapter 3 (Source: Author)

3.1 Complexity Theory and Systems Thinking

Midgley (2016) considers the journey systems thinking academics and practitioners have taken over the years. The years in the late 1980s and early 1990s were marked by concerns regarding the underpinning paradigms of the methods and the 'paradigm wars' that resulted (Jackson, 1987). These, to a certain extent, have subsided due to the recognition of the inability to define an overarching theory of systems methods and the need for a pragmatic approach.

Previously in the 1940s,1950s and 1960s, there was a consolidation of systems science (Angyal, 1941; Bertalanffy, 1956; Boulding, 1956), cybernetics (Ashby, 1956, 1960; Rosenblueth, Wiener and Bigelow, 1943; Wiener, 1961) and

complexity science (Simon, 1962). Many of these became embodied into the systems field within methodologies to support systems design and social change. They included system dynamics (Coyle, 1996; Forrester, 1961, 1989), systems engineering (Jenkins, 1969) and the Viable System Model (Beer, 1981, 1994). Each of these authors were primarily practitioners who saw the need for the modelling of real-world complex problems by experts.

Academics during the 1960s and 1970s were critical of the assumptions built into these methods, leading to the emergence of new methodologies in the 1980s. This new paradigm with its own methodologies (Checkland, 1988, 1999; Jackson, 1982) was based on very different assumptions. It introduced the softer, qualitative aspects of problems reflecting the involvement of people. Also, the expert was replaced by the facilitator to surface the different perspectives held by different stakeholders (Churchman, 1968, 1974; Churchman and Emery, 1964). It was focused on a better understanding between stakeholders (Checkland and Scholes, 1990; Cooperrider, Whitney and Stavros, 2008; Varey, 1998; Vickers, 1972), dialogue (Isaacs, 1999) and learning (Ackoff, 1979; Senge and Sterman, 1992; Sterman, 1994; Ulrich, 2003a).

This new paradigm did not replace the old and the paradigm wars that followed were divisive for a while before a new paradigm of ‘critical systems thinking’ and ‘methodological pluralism’ emerged (Brocklesby, 1994; Flood and Jackson, 1991; Frandberg, 2003; Gregory, 1992, 1996; Jackson, 2000, 2003a; Jackson and Keys, 1984; Midgley, 1992a, 2003, 1992b; Mingers, 2000, 2004, 2005; Mingers, J. and A. Gill, 1997; Oliga, 1988). Mingers (2004) also proposed that the philosophy of Critical Realism can provide a way forward.

In more recent years, further development of mixing methods has been explored and the following sections explore these.

3.2 Combinations of methods

Most references to the application of methods refer to the method as though it can only be deployed in a specific way. They do not appear to consider the perspective and capability of the practitioner deploying the method. This is

important as the practitioner then puts the focus on the method, rather than the problem situation. The application of methods should be put into the wider context of an approach to resolving the problem situation which itself impacts on the assessment of the application of methods (Midgley et al., 2007). The discourse that follows mainly considers the methods themselves as covered by the literature, Towards the end of the Chapter, we consider the impact of practitioner familiarity and skill in application of the methods.

3.2.1 Mixed Methods

Much of the literature on mixed methods considers social science methods as opposed to mixing systems methods (Anguera et al., 2018; Archibald et al., 2015; Bazeley, 2004; Creswell and Creswell, 2018; Doyle, Brady and Byrne, 2009). This is because they have emerged as separate disciplines in academic research. There are examples of researchers rightly focusing on the underlying philosophies and ensuring this is considered when mixing methods (Mertens, 2010). Others focus on making paradigms meaningful, and are looking to establish mixed methods formally as an addition to quantitative and qualitative research methods (Burke Johnson, Onwuegbuzie and Turner, 2007; Burke Johnson and Onwuegbuzie, 2004; Onwuegbuzie, Burke Johnson and Collins, 2009; Shannon-Baker, 2016). Finally, researchers have developed guidelines for conducting mixed methods research, indicating that it is an accepted approach and the paradigm commensurabilities can be managed (Venkatesh, Brown and Sullivan, 2016).

The guidelines for conducting mixed method research developed by Venkatesh et al. (2016) are the most relevant for consideration when combining systems methods, but they are not helpful. They debate and propose criteria, but do not relate these to any example methods, nor do they consider the underlying philosophical approaches. This is because the practice of social science, in the main, sits within either in the positivist or interpretivist paradigm, based on the use of specific methods, so their philosophical position is taken for granted (Blaikie and Priest, 2017). Also, the methods mainly under consideration are social science methods and not systems methods per se (Jackson, 2019). The

one systems method that is practiced is causal loop mapping (Hovmand et al., 2012; Rutter et al., 2017; Siokou, Morgan and Shiell, 2014; Vandenbroeck, Goossens and Clemens, 2007) which sits within the positivist and post-modern paradigms.

Some development in systems approaches in public health research is emerging (Egan et al., 2019a), the principle method being 6SQuID (Wight et al., 2015). This creates a challenge when introducing multiple systems methods into public health research because there is rarely time to introduce new methods that are both unfamiliar and have different philosophical underpinnings. A Critical Realist approach is beginning to emerge in social science and public health research (Edwards, O'Mahoney and Vincent, 2014; Longhofer and Floersch, 2012; Mingers and Brocklesby, 1997; Pawson, 2002; Porter, 2015; Shannon-Baker, 2016), but the prime systems method is still the use of Group Model Building and Causal Loop Modelling to explore mechanisms.

3.2.2 Multiple Methods

This section reviews the main literature on the structures that can be used to combine use of multiple methods. It draws on the work of Mingers (Mingers, 2000; Mingers and Brocklesby, 1997), Jackson (Jackson, 1982, 2020a, 2020b, 2021, 2022b, 2022a) and Midgley (Midgley, 2011, 2016; Midgley, Nicholson and Brennan, 2015).

Interest in multimethodology, the use of a combination of methodologies and methods, possibly from different paradigms, and pluralism emerged in the 1980s (Jackson, 1987; Jackson and Keys, 1984). It continued to develop through the 1990s (Midgley, 1992b; Mingers, J. and A. Gill, 1997; Ormerod, 1997) and by 2002 the use of multiple methods by Operational Research/Management Science practitioners was widespread (Munro and Mingers, 2002).

There are five main reasons why multimethodology thinking and practice is desirable and has become widespread (Jackson, 2019, p.532):

1. The social context within which problematical situations exist is multidimensional (Mingers and Brocklesby, 1997). Different paradigms

focus on different aspects, each highlighting some and omitting others, indicating the benefit of using a variety of methodologies.

2. Interventions are generally phased with stages on discovery, approach design, execution and review. Each stage will incorporate different tasks and perspectives, each benefitting from a different methodology or method (Mingers and Brocklesby, 1997).
3. Postmodernism argued against “grand narratives” where “the truth” can be determined (Jackson, 1997; Mingers and Brocklesby, 1997).
4. The lack of success of traditional methods and methodologies to resolve issues in practice leading to the consideration of new ways of thinking and entertaining the thought of multiple methodologies (Jackson, 1997).
5. Mingers (2014) argued that multiple methodologies enabled a form of ‘triangulation’ that provided more confidence in findings if the same results were obtained from different methodologies.

This is why there is continued research into multi-methodologies and the desire to bridge or accommodate multiple paradigms. White and Taket (1997) identify two interpretations of multimethodology:

- “Multimethodology as metamethodology, which we find to be another version of the “will to methodology”, and which we find in many other OR/systems writings ...”;
- A strategy of mix and match, adopting a flexible and adaptive stance, and operationalising “what feels good.”

The majority of academics/practitioners feel most comfortable with the second interpretation making this one the most prevalent as it seems to allow a pragmatic approach to combining methods. However, the consideration of multimethodology resulted in protracted discourse on paradigm incommensurability from which the systems world is only just emerging (Bowers, 2011; Carrizosa and Ortegon, 2007; Gregory, 1992; Midgley, Nicholson and Brennan, 2015; Mingers and Brocklesby, 1997; Pollack, 2006; Zhu, 2011). However, to ensure the integrity of use of systems methods and to ensure they

remain within their own paradigm in use, a methodological approach to combing systems methods appropriate to a particular context still needs to be developed.

Jackson (2006) developed Critical Systems Thinking which is a metamethodology for bringing together multiple methods. Midgley (2000) developed Systemic Intervention, which is a methodological approach for approaching an intervention. Both Jackson and Midgley leave the selection of methodology to the practitioner but provide guidance on thinking about the philosophical underpinnings of the methodological choice, as well as other aspects to be considered when planning and undertaking an intervention.

Mingers and Brocklesby (1997) developed a framework for selecting methods within a project, showing where system methods can be used at different stages of a project and to consider the project according to Habermas' three perspectives. They do not explain how you transfer findings from one method to another, so one must assume it is through the knowledge gained by the practitioner.

However, the approaches proposed by Mingers and Brocklesby, Jackson and Midgley are intended primarily for problem structuring and resolution, not for a whole enterprise design, and they do not discuss how the artefacts produced by the various methods are 'joined up'. It is implied that this happens in the investigator's mind and therefore there is no audit trail of thought or means of expressing how the investigator 'joined up' the methods. This limits the defensibility of any findings and recommendations for change. A range of other authors have blended methods (Azadeh et al., 2014; Checkland and Haynes, 1994; Gregory, 2009; Lane and Oliva, 1998; Mingers and White, 2010; Rodriguez-Ulloa and Paucar-Caceres, 2005; Schwaninger and Ríos, 2008; Small and Wainwright, 2016; Zolfagharian, Romme and Walrave, 1995), but not shown how outputs (artefacts) from one method can become inputs to another, or how the methods stand in relation to each other.

An examination of the sample of systems methods contained in Table 9 illustrates their variety of underlying philosophies and, therefore, the challenge in linking the findings from the different systems methods (incoherent ontologies,

epistemologies and axiologies). A critical area to cover is the discourse around multiple methods and their perceived incommensurability (Bowers, 2014; Carrizosa and Ortegon, 2007; Midgley, Nicholson and Brennan, 2015; Zhu, 2011).

Table 9 - Comparison of Systems Methods (Wright, 2012)

Method	Ontology	Epistemology	Axiology
Soft Systems Methodology	Systems cannot be assumed to exist. Social worlds of meaning-attribution	Separation of real-world and conceptual world. Use of systems concepts	Learning not optimisation. Change brought about through debate and developed understanding.
Viable System Model	Exceeding complex systems which are unknowable. Reality may not exist but is not knowable. Personal or social relativism. System and meta-system dichotomy.	Use of systems concepts. Separation of real-world and conceptual world. Organisation as an organism. "Systems are to be recognised subjectively, and their purpose exists only in the mind of an observer (or group of observers who have themselves agreed on the conventions of their joint observation)".	Organisations as adaptive goal-seeking entities. Optimisation. Improvement of goal-seeking and viability. Efficiency and efficacy.
System Dynamics	Reality exists and reality is relative. Critical Realism.	Models as representations of the real world and models as representations of views of the real world. Behaviour results from underlying flows, delays, information, and feedback relations. Provides access to the underlying structures which determine system behaviour.	Optimisation and control

3.2.2.1 System of Systems Methodologies

To enable the choice of multiple methods, Jackson and Keys (1984) proposed the need for research into a System of Systems Methodologies (SOSM) to address the need for establishing the relationship between different systems methodologies. Jackson has continued to refine this framework (Jackson, 2019) leading to the structure illustrated below at Figure 30.

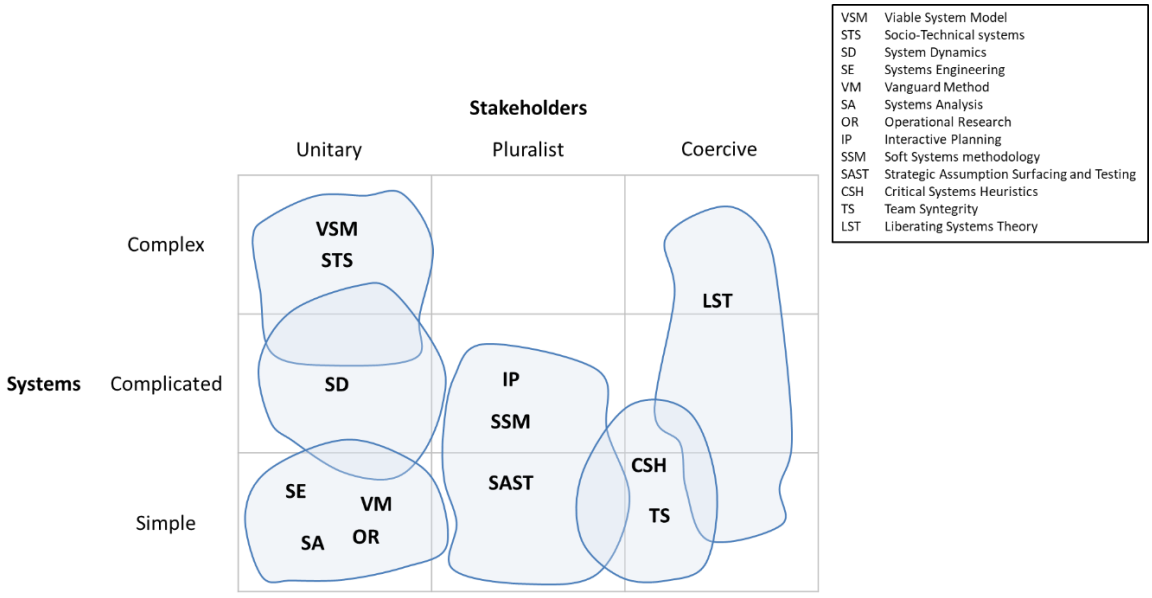


Figure 30 - System of Systems Methodologies (derived from Jackson, 2019)

He has mapped a range of systems methods/methodologies onto a 3x3 matrix that comprises degrees of complexity on the 'Y' axis (simple, complicated, complex) and types of stakeholders on the 'X' axis (unitary, pluralist, coercive).

Jackson explores each of the methods from their philosophical standpoints and maps them to each of the cells in the SOSM matrix (Jackson, 2019; Jackson and Keys, 1984). The SOSM has a problem focus, not an organisational focus, though it can be considered when approaching problems in organisations. Also, the aim of the SOSM is to ensure the analyst considers each problem context on its merits and not apply their favourite method each time. This is important to ensure problem situation is explored and resolved in the most appropriate way (Blaikie, 2007). The SOSM does not, however, consider how you might link methods when applied together.

3.2.2.2 Multimethodology – a framework for mixing methodologies

Using the SOSM to select appropriate methods is a start, but there has been much research into combining and mixing methodologies and methods. Mingers and Brocklesby (1997) proposed that, at the time, the choice of a single method using SOSM (Flood and Jackson, 1991; Jackson and Keys, 1984) is insufficient

to address the complexity of problem situations. They argue for the use of multiple methods, in whole or in part.

They argue that in any situation, there is a need to view it through different paradigms as this will illuminate different aspects of the inherent complexity. In addition, they argue it is important to recognise the 'three worlds' present, the personal world (of our own thoughts, experiences, beliefs and emotions), the social world developed through our engagement with others, principally through language, and the material world, that which is independent of human beings (Figure 31). This illustrates the ontological and epistemological differences that should be considered when addressing problem situations and selecting suitable systems methods. Each of the worlds have a different perspective and require different systems methodologies.

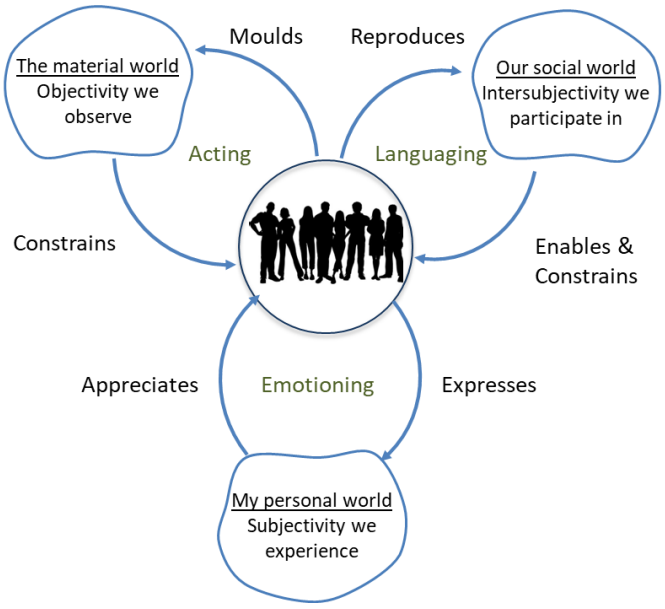


Figure 31 - Three dimensions of a problem situation (derived from Mingers and Brocklesby, 1997, p.493)

In the development of their framework (Figure 32), Mingers and Brocklesby (1997) positioned the three dimensions of a problem situation on the Y-axis and the stages of an intervention along the X-axis. It is against this framework that the characteristics of various systems methodologies can be mapped. Each cell contains questions to be addressed regarding different aspects of the intervention.

	Appreciation of	Analysis of	Assessment of	Action to
Social	social practices power relations	distortions, conflicts, interests	ways of challenging power structure	generate empowerment and enlightenment
Personal	individual beliefs, meanings, emotions	differing perceptions and Weltanschauung	alternative conceptualisat-ions and constructions	generate accommodation and consensus
Material	physical circumstances	underlying causal structure	alternative physical and structural arrangements	Select and implement best alternatives

Figure 32 - A framework for mapping methodologies (derived from Mingers and Brocklesby, 1997, p.501)

Figure 33 illustrates their tentative mapping of two systems methodologies against the framework. Soft Systems Methodology (SSM) and the Viable System Model (VSM) are described later in sections 3.3.2 and 3.3.3 respectively. For this discussion, it is sufficient to recognise they have different applications and strengths. Different shading indicates the relative strength of the method, darker being stronger. This mapping is, however, quite subjective, but can be derived from the literature (e.g., (Jackson, 2019)). The difference in colour of shading is to represent the differing values of utility of the method in that cell.

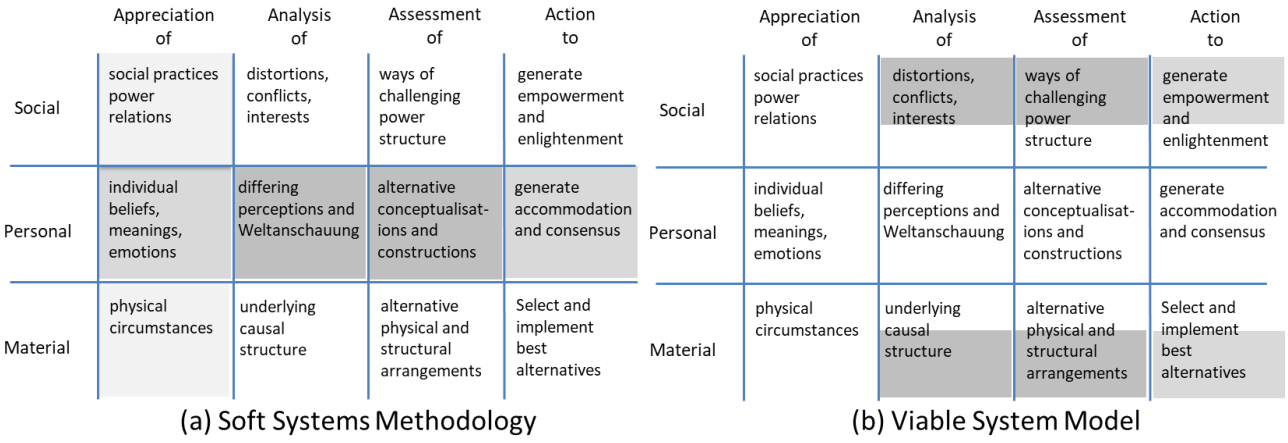


Figure 33 - A mapping of selected methodologies (derived from Mingers and Brocklesby, 1997, p.502)

Also, the mappings illustrated “reflect the standard, intended, use of particular methodologies” (Mingers and Brocklesby, 1997, p.502). From this, a multimethodology can be derived as illustrated at Figure 34.

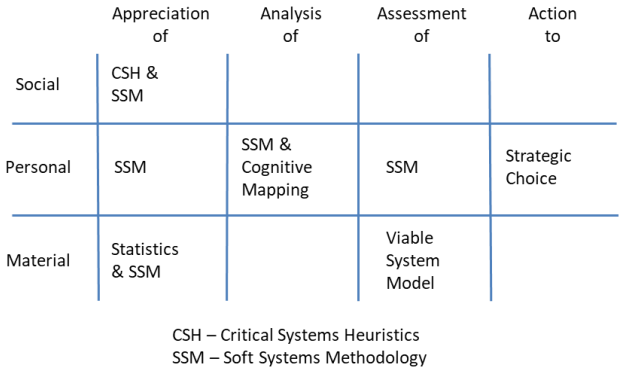


Figure 34 - A possible multimethodology design (derived from Mingers and Brocklesby, 1997, p.503)

However, inherent in their framework is the dominance of a particular paradigm according to the lead systems methodology used. This is not helpful when seeking to integrate methods from different paradigms. They decompose methodologies and create a collage of disconnected elements of the methodologies (Figure 35).

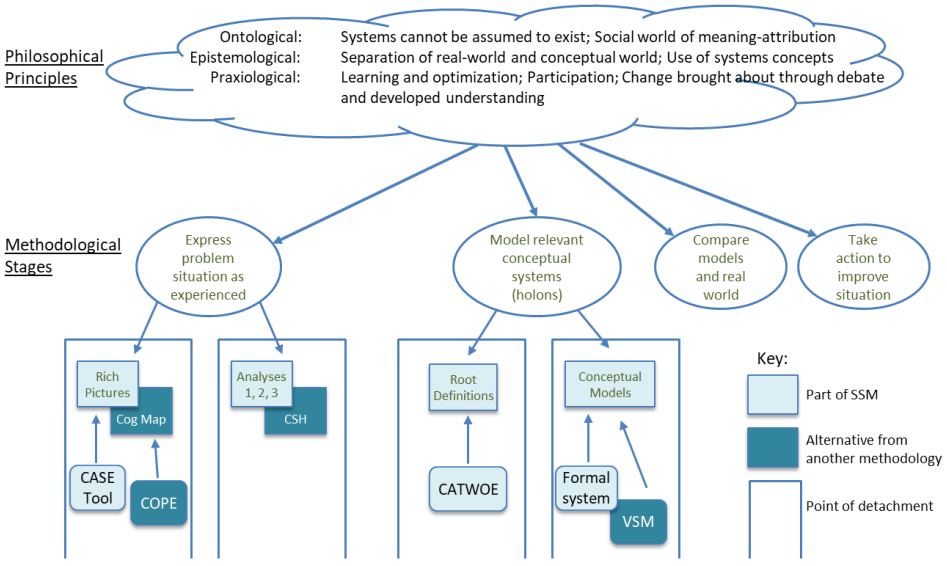


Figure 35 - A decomposition or (Checkland's) SSM to show possible disconnection of techniques (derived from Mingers and Brocklesby, 1997, p.505)

They propose that the multimethodology thus derived is specific for each intervention, and is not a generic design (Mingers and Brocklesby, 1997, p.503).

This approach may be suited to understanding a problematical situation, leading to the development and implementation of an intervention, but is not particularly suited to the development of a blueprint for an organisation such that you can determine the governance and management needs. However, it may be how the practitioner chooses to combine the methods that might enable this approach to be effective.

There is no consideration of how the findings from the methods are linked. The implication is that findings inform the thinking of those involved and are carried through in mental models, though each will have findings structured according to the methods. The issue that results is that there is no check on the consistency of findings, not explicit connections or data sharing between methods. This limits validation and lends the findings and recommendations open to challenge by the problem owners.

3.2.2.3 Total Systems Intervention / Critical Systems Practice

Similarly, Flood and Jackson (1991) considered the stages of an intervention and the criteria by which one should consider methodologies. They make the point that methodologies are complementary and make different assumptions about the problem situation. They do not, however, suggest how the analyst might bring together their findings and integrate the methodologies. Total Systems Intervention (TSI), the precursor to Critical Systems Practice, and which Flood and Jackson (1991) called a meta-methodology, is an approach that “is said to embrace three “phases” of intervention: creativity, choice and implementation” (Midgley, 2000, p. 222).

Critical Systems Practice (Flood and Jackson, 1991; Jackson, 1991) is an iterative approach and is very much aimed at complex situations that seeks to ensure the philosophy and principles therein are maintained throughout, even though the four stages are independent. Jackson (2020a) claims Critical Systems

Practice can be used both for diagnosis and design through iteration and provides an example of bringing a Business School into being.

Since its inception in 1991, critical systems thinking has been developed in different ways by Flood (1995, 1999), Jackson (2000, 2003b, 2019), Mingers (2014), and Midgley (2000). However, Jackson (2020a) claims “it retains a strong identity and common themes, recognizable in its commitments to ‘systems thinking’, ‘critical awareness’, ‘pluralism’ and ‘improvement’. It is these commitments that must be respected in translating critical systems thinking into CSP”.

Latterly, Jackson (2020a, 2021, 2022b, 2022a) has continued his development of Critical Systems Practice with regard to a multimethodological intervention. In this series of papers, he provides a discourse on the four stages of Critical Systems Practice: Explore (the problem situation), Produce (a strategy for the intervention), Intervene (to achieve the desired result of the intervention) and Check (the outcome), collectively referred to as EPIC. It includes the exploration of the physical and material elements, social elements including culture and power, and other deeper elements including beliefs, values, and emotions.

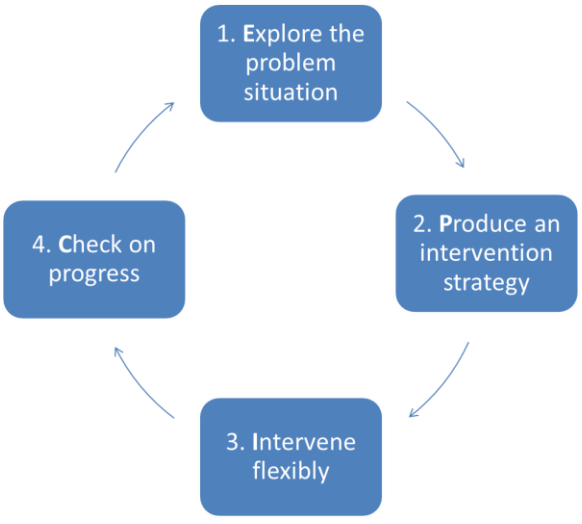


Figure 36 - The EPIC CSP Approach (derived from Jackson, 2020a)

Within the Explore phase of a problem situation, Jackson believes many approaches fail on providing an in-depth exploration and a failure of breadth that might restrict the focus. His criticism of methods is, in my opinion, based on a

very strict and narrow application of them and the implication that only one method may be applied. He does not consider the ability of a practitioner to recognise the complexity of the situation and incorporate other methods and techniques to surface the multiplicity of perspectives and issues. He still believes in the paradigm incommensurability of methods and that one method will dominate the others. He states (Jackson, 2020a, p.843) "[t]here is a loss of breadth. I have never come across an attempt to integrate systems methodologies when it has not been obvious which methodology, and associated worldview, is dominant". He criticises both Mingers and Midgley for their approaches (Midgley, 2000; Mingers, 2014) to embrace the pluralism that critical systems thinking has. For the former, he believes that starting with boundary judgements as the starting points will limit the breath of exploration, and for the latter, that Critical Realism is not prevalent in social theory. Again, he does not allow for the capability of the practitioner to allow the boundaries of the different perspectives to emerge and be considered, nor can he apparently consider Depth or Middle Range Realism to have value, even if it, in his opinion, does not have strong support in social considerations. Much of social science uses empirical mixed methods, and therefore does not seem to consider critical systems thinking anyway (Anguera et al., 2018; Archibald et al., 2015; Bazeley, 2004; Creswell and Creswell, 2018; Doyle, Brady and Byrne, 2009; Mertens, 2010; Venkatesh, Brown and Sullivan, 2016). He also criticises Mingers and Brocklesby's multi-methodology approach (1997) to linking methodologies stating they are "imperilling breadth" (Jackson, 2020a, p.844).

The value I perceive in Jackson's (2020a) EPIC methodology is that during the Explore stage, it requires a situation to be viewed through five 'systemic perspectives' to explore all aspects of a problem situation. These have been developed from Pepper's four adequate 'world hypotheses' (Pepper, 1942 in Jackson 2020a) (labelled 'formism', 'mechanism', 'contextualism', and 'organicism') and from Morgan's (1997) metaphors described in his 'Images of Organization'; machines, organisms, brains, cultures, political systems, psychic prisons, flux and transformation, and instruments of domination. Jackson's (2020a) five systemic perspectives are: 'machine', 'organism', 'cultural/political',

‘societal/environmental’ and ‘interrelationships’. Jackson doesn’t suggest any particular approaches, merely that “the various ‘systemic perspectives [are] always kept in mind and that the problem situation [is] constantly observed through the different lenses they provide” (Jackson, 2020a, p.855).

With regard to the Produce stage, he does not provide specific guidance on the selection of appropriate methodologies as the Explore stage achieves a widening of systemic perspectives and, as a result, the analyst/practitioner/participants should “appreciate the variety of systems approaches” [relevant to the situation. This guides the choice of] appropriate systems methodologies [which, in turn, will provide guidance on their use]; choose appropriate systems models and methods; and to structure, schedule and set objectives for the intervention” (Jackson, 2021, p.597). This is because there is no general methodology within CSP that is applicable in all circumstances, and is why we have developed a methodology suited to apply multiple systems methodologies, methods and models to organisational governance.

Within the Intervene stage of EPIC, Jackson again doesn’t provide any guidance beyond:

> “Appropriate models and methods from the systems field, or elsewhere, will also have been identified with a view to tailoring the methodology or methodologies to the particular context. The intervention can begin according to the guidelines offered by the methodologies and the requirements of the models and methods.” (Jackson, 2022a, p.3)

He also refers to his book (Jackson, 2019), stating:

> “In Jackson (2019), 10 theoretically grounded and well-tested systems methodologies are presented and critiqued, related models and methods are discussed, real-world examples of use are provided and original sources are referenced.” (Jackson, 2022a, p.3)

These are discussed as individual methodologies with no consideration for linking their application. Consequently, much is left for those undertaking the intervention to remain flexible in the choice and application of methods apart from following a pragmatic philosophy.

3.2.3 Methodological selection using System of Systems Methodology

Flood and Jackson developed the System of Systems Methodology SOSM (Flood and Jackson, 1991; Jackson, 2019) to enable the choice of method according to the context of the intervention. It was not an arbitrary choice. Quantitative methods were seen as most suited to unitary contexts as in a unitary context there is agreement over the issues. In the pluralist context, where there are different perspectives on the issues, but without pressure or coercion from anyone, then methods suited to discourse and conversation are helpful. Finally in a coercive environment, discursive and dialogue methodologies are not suitable as open disagreement is difficult to surface and address. This is where a method such as Critical Systems Heuristics is helpful. (Midgley, 2000)

Jackson has developed the SOSM to indicate the potential use of methodologies such that a practitioner can consider the underlying philosophies and choose the one most suited to their particular concerns. It is the practitioner who determines the grid square of interest as a starting point for selection. The skill, knowledge and expertise of the practitioner can enable flexibility in the use of the methodologies and allow extended use whilst remaining within their paradigms. Reynolds and Holwell (2010, p.12) observe that “there may be different opinions on where different systems approaches ‘fit’ based upon actual experiences of using the approach”. This is true in my experience where using Wilson’s (2001) approach to SSM is more extensive than Checkland’s and covers the complex unitary space, and Beer’s (1985) Viable System Model (VSM) can be used in a pluralist space by creating a range of VSMs to diagnose an organisation. Similarly, System Dynamics is applied more as a qualitative approach with Causal Loop Modelling, extending it into the pluralist space. This is illustrated in Figure 37.

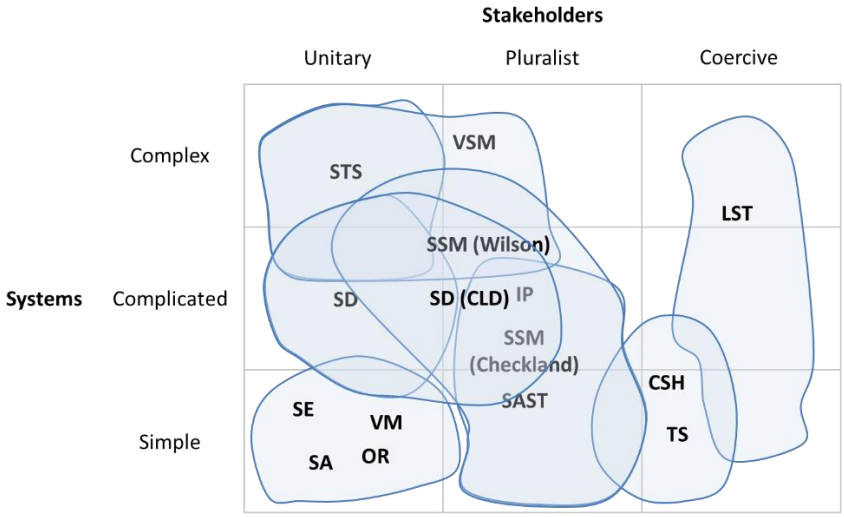


Figure 37 - Extending methodological choice (derived from Jackson, 2019, p.592)

Jackson defends the SOSM principally by stating:

> "[. . .] it provides an aerial map of how the main social scientific and systems traditions of thought have pictured social reality. The SOSM does its job if it helps explicate the nature of the different systems approaches and points to their different strengths and weaknesses." (Jackson, 2019, p.165)

Extending the points made by Reynolds and Holwell (2010, p.12) above, one can add that the perceived strengths and weaknesses of each method will differ according to the expertise and familiarity of the practitioner deploying them.

Within the context of the Reference Model of Governance for a Specific Organisation, we are dealing with complex systems where some aspects can be considered complicated, and with both unitary and pluralist stakeholders. In the organisational context, coercive stakeholders are deemed out of scope, though aspects of power will be considered within the mapping and understanding of stakeholder perspectives.

The methodologies and methods considered for the Reference Model of Governance for a Specific Organisation are taken from the SOSM due to its broad support in the systems community. Consequently, the key methodologies (as determined by the IfATE (2023) Systems Thinking Practitioner standard) being considered are Soft Systems Methodology, the Viable System Model and System

Dynamics. Critical Systems Heuristics is included for the exploratory stages to take into account the views of staff and others contributing to the organisational context. A summary review and justification is included below at section 3.5.

During the early stages of the development of the System of Systems Methodology, within TSI, Flood and Jackson claimed the methodologies aligned with a particular metaphor of an organisation (Flood and Jackson, 1991; Jackson, 2019) using Morgan's (1997) metaphors. The methodology alignment to metaphors have been further refined by Jackson (2021), who refers to them as 'systemic perspectives', and included within the Explore phase of EPIC (Jackson, 2020a). Thinking about the metaphors is valuable as it initiates the exploration of multiple perspectives and helps in the selection of appropriate systems methodologies and methods. These systemic perspectives are discussed below.

3.2.3.1 Mechanical systems

System Dynamics (Coyle, 1996; Forrester, 1961), incorporating stock and flow diagrams and simulation, is used by practitioners who implicitly consider organisations as machines. With this approach they will seek to optimise performance and inform policy through quantitative modelling. Though one must consider the reliability of the models, they are commonly used to predict future behaviour, whereas we prefer to state that they can give an indication of potential future behaviour. This is because it is very difficult to evidence causality in social systems, nor is it possible to identify all mechanisms that cause organisational outcomes (Blalock, 1961; Pawson, 2000; de Souza, 2013).

Due to its derivation from the work of Deming (2000), the Vanguard Method (Seddon, 2003, 2008) is also applied by practitioners who consider organisations as machines. It is a systems approach aimed at removing waste from an organisation's service offerings and ensuring alignment to customer needs.

Whilst remaining in the mechanistic metaphor, Bayesian belief models or dependency models are developed to identify critical areas of dependency and, therefore, those areas desirable for control or, at the least, monitoring.

3.2.3.2 Organismic systems

The organismic metaphor considers organisations (systems) as living systems reacting to influences upon them to ensure survival. Aspects of the sociotechnical systems approach, especially with regard to the “causal texture of the organisation’s environment” (Emery and Trist, 1965) are included within this metaphor. Beer (1981, 1994) developed the Viable System Model (VSM) based on cybernetic principles and the human being, and incorporated the need for viability through regeneration, growth and adaptation. VSM comprises the essential subsystems as functional areas of the model with which to position the activities of the organisation as well as to capture the communication between functional areas within a layer of the hierarchy and between layers of hierarchy. It can be used in diagnostic mode and design mode, enabling it to be used within different kinds of methodology.

3.2.3.3 Purposeful systems

Purposeful Systems (Ackoff and Emery, 2007) apply to the cultural/political metaphor. Recognising that change is constant, and that individuals hold different perspective of both the world and an organisation’s purpose, Churchman (1968, 1971, 1979) and Checkland (1999; 2006), also influenced by Vickers (1965, 1972), developed approaches that were designed to surface a consensus amongst stakeholders as to the current ‘purpose’ of a social context. Differences are ‘dissolved’ through conversation and an agreed resolution developed. This may be an organisational context but includes other social situations. These approaches were focused on determining the boundary of the system of interest.

The principal methodology considered here is the Soft Systems Methodology (SSM), a purpose-focused method that can be decided and applied to each layer in the governance hierarchy used as a means of learning. Though Checkland’s approach is more of a problem (dis)solving methodology, Wilson (1990) developed it further, based on his engineering origins, to derive a blueprint for an organisation.

3.2.3.4 Emancipatory systems

Emancipation applies to the societal/environmental perspective. The intent is to ensure all those involved in an intervention are considered and have a voice in the intervention. It is recognised that some within interventions have no voice as they may not be included in the mental models of those designing and undertaking the intervention. Similarly, it may be assumed not possible to include them in the discourse. Critical Systems Heuristics (Ulrich, 1996, 2005) ensures not just boundary critique, but that the practical and ethical considerations of system designers are surfaced. This ensures that those impacted by the system design, but not involved in it, are fully accommodated.

3.2.3.5 Interrelationships

System Dynamics (SD) (Meadows, 2008; Senge, 1992), particularly Causal Loop Modelling and the consideration of archetypes (Stroh, 2015, p.67), addresses the interrelationships metaphor. It is used to identify the dynamics between activities and for more detailed capacity modelling if required (though this is more within the machine metaphor).

The arrangement of parts, and their interrelationships is considered a core element of systems thinking. Jackson (2019), however, suggests that System Dynamics is not suited to complex situations as only partial truths can be determined, and there is much argument over the ability to evidence causal relationships with which to validate quantitative models such that they represent reality (Blalock, 1961).

Causal Loop modelling, generally developed within Group Model Building workshops (Andersen et al., 2007; Vennix, 1996) does have value in sharing mental models and exploring the interrelationships within a situation, complex or otherwise. It is used to surface mental models of causation and a causal loop model can help identify places to intervene (Meadows, 1999) and, therefore, help identify upstream measures of performance by identifying enabling factors. This is valuable when building a governance model.

3.2.4 Systemic Intervention

Following Mingers and Brocklesby's multimethod approach (section 3.2.2.2) and Jackson's CSP (section 3.2.2.3), the third approach to methodological pluralism or multimethodology to consider is that proposed by Midgley (2000) in his development of Systemic Intervention. Within this, he argues not just for pluralism at the methodological level, but also for pluralism at the level of methods. With methodological pluralism, he argues that we may learn from others with regard to their insights and incorporate them into our own methodological approach. With pluralism of methods, we can take methods originally developed for use within other methodologies and incorporate (perhaps reinterpreting them) them into our own methodology.

> "This means that, if we are using a systems methodology, even methods developed outside systems paradigms can be used as part of systemic intervention." (Midgley, 2000, p.215)

Within Systemic Intervention, Midgley includes three aspects, Critique, Judgement and Action (Midgley, 2000, pp.129–133) as illustrated in Figure 38.

With intervention defined as "purposeful action", he adds that "systemic intervention is purposeful action by an agent to create change in relation to reflection on boundaries".

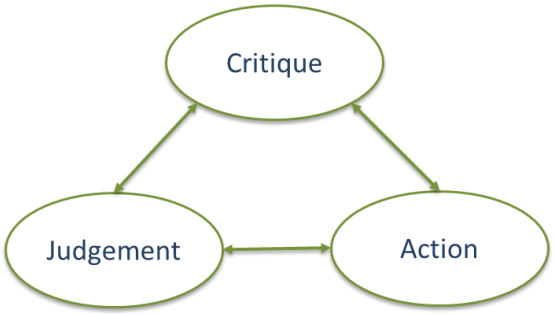


Figure 38 - Three aspects of a methodology for Systemic Intervention (derived from Midgley, 2000, p.132)

His outline of a methodology for systemic intervention incorporates:

> " [. . .] explicit foci on boundary critique (reflection on, and choice between, boundaries); judgement concerning appropriate theories and methods; and action for improvement." (Midgley, 2000, p.133)

Embedded within this methodology, particularly regarding boundary critique, is what he terms "Process Philosophy". This stems from the proposition by Maturana (1988) that pure objectivity is impossible and his theory of autopoiesis explains this. In essence, the term 'autopoiesis' means self-producing. An autopoietic system acts to maintain its internal organisation when it interacts with its environment to maintain itself. Indeed, the actions it takes are determined by its current structure. This interaction, especially with others is not just the action of one party but includes coordination. The basis of this coordination is language, and it is with language that we coordinate the coordination of our actions (Midgley, 2000, p.55). This is reflected in my expansion of the iceberg illustrated at Figure 22.

Much of boundary critique is based upon distinctions (Spencer-Brown, 1969). When Midgley uses the term 'process', he uses it in a different way to Whitehead in his process-relational thinking. Midgley is referring to the process of bringing knowledge into being as opposed the knowledge actually generated which he calls 'content philosophy'. He sees that "making distinctions is a *process*, and the subject is *content*" (Midgley, 2000, p.79. Italics in the original). This is important and relates to the underlying epistemological perspective each systems methodology and method has. Careful consideration of how knowledge is surfaced and brought into being is necessary and should be included in any methodology for applying multiple methods.

Midgley asserts that one can make boundary judgements in two ways, looking out of the system to the environment, which he denotes a first-order distinction, and looking back at the 'knowledge generating' system that makes a first-order distinction which he denotes a second-order distinction.

Midgley's process philosophy is, to me, a systems way of considering the biosphere as developed by Angyal (1941), in which the subject-object relationship is taken to be a 'unitas multiplex', a united whole with an

indeterminate boundary. Hence boundary critique must be a fundamental aspect in exploring systems, especially social systems and is included in my work.

Midgley (2000) also argues that process philosophy can incorporate all three aspects of ontological thought, realism, idealism and social constructionism, thereby being an approach that can accommodate a variety of methodologies. Because different theories can lead to the identification and analysis of different boundaries, he also argues (2000) that boundary critique leads to both theoretical and methodological pluralism. In any intervention, therefore, the practitioner can propose a methodology appropriate to the circumstances and incorporate an appropriate range of methods with which to undertake the intervention. This necessary judgement is the second aspect of his 'systemic intervention'. The final aspect is the action taken as a result.

3.2.5 Lessons Learned from Mixing Methods

Howick and Ackermann (2011) undertook an analysis to determine if there were lessons to be learned from mixing operational research methods in practice. Though many of the methods were not systems methods per se, their findings are useful in guiding the development of a methodology for applying multiple systems methodologies and methods.

Their results are summarised as: lack of paradigm consideration; some facilitators combined methods by themselves; becoming an expert in more than one method is time consuming and demanding, possibly leading to the use of scripts; a multidisciplinary background was the norm for facilitators mixing methods; and mixing is familiarity led. They also determined that both the client and the facilitator must see the benefits of mixing methods, and this is not easy to determine as the benefits may come primarily from one method, or simply through the process of good facilitation. The role of the facilitator/modeller is important and should not be underrated (Schwartz, 2017).

Howick and Ackermann (2011) caveat their findings with some limitations. Journals that publish systems methods are limited, and the papers published are generally submitted by academics and cover successful interventions. The

results of practitioners (non-academics) are not included. Practitioners are generally more adept at facilitation and in the application of methods. Academics frequently only apply the early (easier) stages of a methodology (Hoverstadt, 2022), which may also limit the perceived success of systems methodologies.

Mingers and Brocklesby (1997) identify a set of inherent problems to be addressed. The philosophical problem of paradigm incommensurability they believe is resolved with their approach to positioning methods within their framework. The cultural problem of an organisational and/or academic reluctance to engage in multi-paradigm work cannot be generally resolved. It is their choice. Increasingly, arguments are being made for the acceptance of multi-paradigm work, but this is also impacted by the third problem. This is the cognitive problem of agents moving between the paradigms and being proficient in a variety of systems methodologies. A fourth problem is that of linking the methodologies or parts of methodologies in a systemic way. Again, they argue that this is resolved through the use of their framework.

3.2.6 Conclusions on multi-methodologies and mixing methods

Mingers and Brocklesby (1997) and Flood and Jackson (1991) both developed frameworks with which to determine suitable methodological approaches to an intervention. Both position methodologies in relation to each other but did not address how to integrate them across an intervention. Mingers and Brocklesby (1997) chose Habermas' perspectives of the social, personal and material worlds on the y-axis, and the standard stages of an intervention on the x-axis. They suggested a dominant methodology and then suggested the augmentation of this with methods and models from other methodologies. This excluded the conscious consideration of methodological approaches, leaving it to the practitioner to build an intervention approach.

Jackson's (2019) System of System Methodologies places the range of system complexity on the y-axis (simple, complicated, complex) and the range of perspectives on the x-axis (unitary, pluralist, coercive) and mapped

methodologies accordingly. The practitioner is invited to determine the appropriate cell for the intervention, hence methodological approach.

Mingers and Brocklesby (1997) and Flood and Jackson (1991) have positioned the methodologies on a narrow theoretical basis and assumed a pure application, not considering any ongoing development. For example, neither consider Wilson's approach to SSM, or the use of VSM in a development mode.

Both Midgley (2000) and Jackson (2019) committed to critical systems thinking, though each developed it in their own way. Whilst expanding System of Systems Methodology, Jackson (2020a) has proposed his Critical Systems Practice to design new systems and diagnose issues within existing ones. The four-stage approach, Explore, Produce, Intervene, and Check, provides the structure. From a methodological perspective, the practitioner should select appropriate systems methodologies, methods and models according to the context of the problem being addressed, then intervene. Within the Explore stage, he suggests the practitioner explores the situation form 5 systemic perspectives and also suggests methodologies and methods to suit the 5 perspectives. This appears to replace SOSM as a means of selecting an appropriate methodology as the practitioner potentially would apply multiple methodologies as well as methods.

Midgley's Systemic Intervention begins with Boundary Critique, akin to Jackson's Explore stage, then suggests the practitioner uses their judgement to devise an appropriate methodological approach and choose systems methods accordingly. Again, to be followed by action to intervene.

My approach is more akin to Midgley's Systemic Intervention, but augmented with aspects of Jackson's Critical Systems Practice, taking what I believe is the best of both approaches. I will propose a methodology that ensures Boundary Critique, considers the 5 systemic perspectives and links systems methods. The limitations are in reflecting the findings from the understanding phase within the systems models to inform decision-making. This will always be dependent on the practitioner who is supporting the intervention being skilled in facilitation and in all the systems methodologies and methods involved.

3.3 Review of the main systems methods and method combinations

Most of the methods considered here were developed from first principles by their original authors, or derived from prior research (Checkland, 2000; Eden, Jones and Sims, 1983; Forrester, 1961; Meadows, 2008; Slater, 2016; Ulrich, 1983; Vennix, 1996; Wilson and Van Haperen, 2015). Each of these authors/practitioners developed them according to their own philosophical perspectives; they were not particularly concerned with the ontological basis at the outset of their work. It is only in the subsequent years where others have considered the methods and sought a rigorous underpinning, and the potential combination of methods with the associated view of paradigm incommensurability, that the paradigm wars ensued and eventually diminished.

3.3.1 System Dynamics

> "If a factory is torn down but the rationality which produced it is left standing, then that rationality will simply produce another factory. If a revolution destroys a government, but the systematic patterns of thought that produced that government are left intact, then those patterns will repeat themselves. . . . There's so much talk about the system. And so little understanding." (Pirsig, 1999)

System Dynamics was developed as a method to model and simulate the dynamics within situations and organisations by representing how the related elements interact and change over time.

As Meadows states:

> "System structure is the source of system behaviour. System behaviour reveals itself as a series of events over time." (Meadows, 2008, p.89)

These elements may be physical elements, information or the influence of behaviours. It originated in MIT through the work of Jay Forrester (1961), but was further developed by others (Coyle, 1979; Morecroft and Sterman, 1994; Sterman, 2000). Others developed a more qualitative use of System Dynamics through the exploration of causal loop diagrams and generated a range of patterns, or archetypes to represent typical behaviours (Meadows, 2008; Senge,

1992; Stroh, 2015). An example of this type of use within an organisation is included at Appendix B, Figure B-3.

Coyle (1979) describes System Dynamics as an approach that deals with the time-dependent behaviour of managed systems with the aim of describing the system and understanding, through qualitative and quantitative models, how information feedback governs its behaviour, and designing robust information feedback structures and control policies through simulation and optimization.

Group model building has emerged as the principal method for developing an understanding of the dynamics in a situation, especially in public health research, leading to the collaborative generation of causal loop models. This was originally proposed by Vennix (1996) and has continued to be refined (Andersen et al., 2007; Andersen and Richardson, 1997; Eden et al., 2009; Egan et al., 2019b; Hovmand et al., 2012).

Whereas cognitive maps (Eden, 1988, 2004) are relatively unstructured representations of personal perspectives on the dynamics at play, System Dynamics is more structured and is bounded by an agreed context, there should be a purpose behind the model. It is a positivist, empirical systems method, so one must be thinking in variables that can be quantified in order to support the claim of pairwise causality between variables. The classical example used is that of a thermostat controlling the heating in a house (Figure 39).

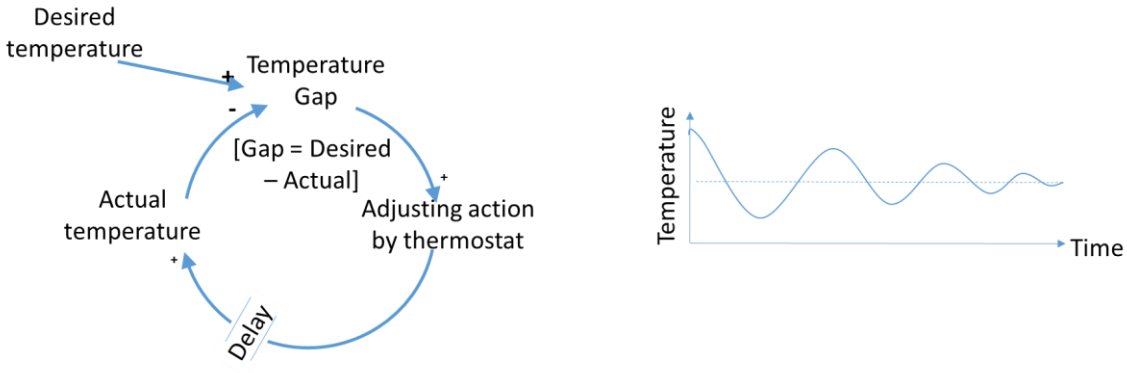


Figure 39 - Causal relationships in central heating control (Source: Author)

In this example, the desired temperature is set (see also the horizontal dotted line in the right-hand image in Figure 39). The '+' sign on the arrow between the Desired temperature and the Temperature Gap implies there is a positive correlation between the two. It represents the state that when the Desired temperature goes up, the Temperature Gap goes up. Also, if the Desired temperature is reduced, the Temperature Gap is reduced. If the Temperature Gap is increased, the '+' sign on the arrow to Adjusting action by thermostat implies that this increases, presumably initiating the boiler to heat the radiators. After a period of time, the Actual temperature increases, thereby reducing the Temperature Gap, as indicated by the '-' sign on the arrow showing a negative correlation between the variables.

Due to the delay indicated between the Adjusting action of thermostat and the Actual temperature, the adjustment will probably overshoot the desired temperature, leading to 'hunting' as indicated by the right-hand diagram in Figure 39. The desired temperature is reached over time. Frequently, it is the delays in the system that lead to unexpected behaviours in systems as we often cannot perceive all the dynamics at play in our minds (as explained by Miller (2001)).

System Dynamics enables one to build an understanding of the behaviour of a system within a situation and, once validated, can provide an indication of future behaviour. I specifically state that and not claim the ability to forecast as there will be some elements not included due to the complexity of the real world and our inability to identify and represent them all. Generating causal loop diagrams and, where helpful, simulation models, makes it possible to expose mental models, build a shared understanding and communicate this easily and effectively with stakeholders.

Problem resolution may come from an understanding of the problem through the generation of causal loop diagrams, and then considering the potential benefit of changes. These can be developed with causal loop diagrams before action is taken, or through the development of simulation models to indicate the effects of different policy changes.

For example, Maani and Kavanagh (2000) describe a situation in an insurance company where they were unable to reduce the backlog of claims, thus not meeting their contractual commitments. Staff were becoming burned out and leaving, leading to less time being spent on assessing claims, paying out more than necessary, and losing money. This is indicated below at Figure 40.

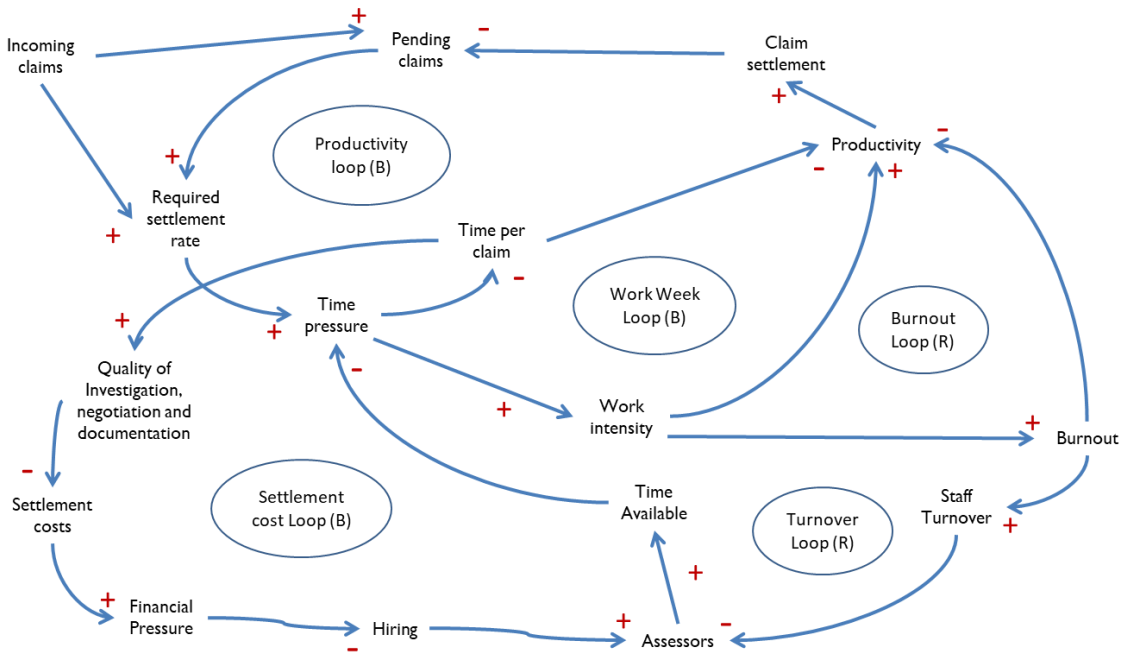


Figure 40 - Causal loop model of the insurance company problem (derived from Maani and Cavana, 2000)

The loops identified help to explain different causal effects. A reinforcing loop ('R') suggests the behaviour will increase/decrease rapidly, whereas a balancing loop ('B') suggests the behaviour will return to a stable state. It took the company some time to develop the model until they felt it represented the situation being experienced. They then explored potential resolutions by further development of the causal loop model as indicated in Figure 41.

Though the resolution of hiring more staff would require an initial investment at a time when money was tight, it did resolve the issue by reducing time pressure allowing the quality of investigations to increase, reducing settlement costs and reducing the financial pressure.

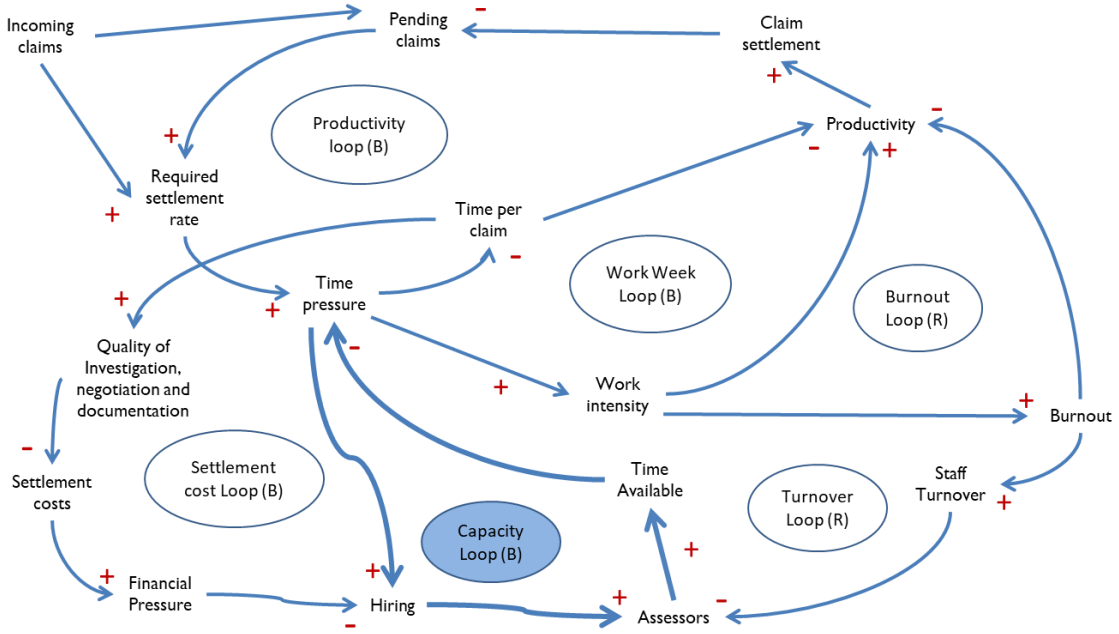


Figure 41 - Resolution to the insurance company problem (derived from Maani and Cavana, 2000)

Once the system was stable, they then developed an approach that would enable them to respond to surges in claims through the use of temporary staff, or reallocating staff to claims assessment for short periods of time.

For even more specific contexts, and where quantifiable variables can be determined, simulation models can be developed to allow decision-makers to explore a range of options before implementing change (Coyle, 1996). The quantified models also support optimization so optimum resources, rates of workflow, etc. can also be explored.

A number of typical patterns were identified within problem situations and these were refined into a set of archetypes to guide practitioners in problem resolution (Meadows, n.d., 1999, 2008; Senge, 1992; Senge et al., 1994; Stroh, 2015). These are outlined below in Table 10.

Table 10 - Summary of System Archetypes (derived from Stroh, 2015, p.67)

Title	Description
Reinforcing loops (virtuous/vicious cycles)	Amplification and reinforcement: a reinforcing effect that produces success or disaster
Balancing loop	Correction, will try to close the gap
Fixes that fail	Unintended consequences: the long-term negative consequences of a quick fix
Shifting the burden	Unintended dependency: the quick fix we become addicted to
Limits to growth	Unanticipated constraints: the limiting mechanism on spiralling growth
Success to the successful	Winner takes all: your success produces my failure
Accidental adversaries	Partners who become enemies: two parties want to cooperate, but each sees the other undermining its success
Drifting goals	Inadvertent poor performance: actual and desired performance levels gradually fall.
Competing goals	Conflicting or multiple commitments: trying to satisfy conflicting goals or achieve too many can lead to accomplishing none
Escalation	Unintended proliferation: the harder you push, the harder the competitor pushes back
Tragedy of the commons	Optimizing each part destroys the whole: everyone takes advantage of a resource that doesn't belong to anyone
Growth/underinvestment	Self-created limits: we push on the growth side and underinvest on the capacity to grow

3.3.2 Soft Systems Methodology (SSM)

The next methodology to explore is SSM. The current form of SSM is the result of more than 30 years of practical research into the application of systems thinking in organizations. In the 1960s, Gwilym Jenkins was working at the Department of Systems Engineering at Lancaster University when he had the idea of applying the methods of systems engineering to management problems (Jenkins, 1969).

Jenkins was given some funding by ICI to develop his idea and recruited Peter Checkland, who was then working for ICI, to carry out the research with him. They

began tackling real-life problems in organizations outside the University together with Brian Wilson, previously a Control Systems Engineer, who was also in the Department of Systems Engineering (Wilson and Van Haperen, 2015).

It soon became apparent that systems engineering could not deal with the kind of complexity that they were confronting. It was fine for hard problems where there is a perceived need and a system that can then be engineered to meet that need. However, in management situations or in tackling soft problems, part of the actual problem is trying to define the need.

Therefore, they used the principles of action research, working on problematic situations in organizations and seeking to bring about improvement. At the same time, they organised their thinking and developed a methodology to help them work through these situations. Working through the situation does not necessarily mean solving a problem, defining a need and then meeting a need. Rather, they came up with an approach based on a systemic process of learning and "*an organized way of tackling perceived problematical (social) situations*" (Checkland, 2008).

SSM takes on board the complexity of real-life problematic situations. It recognizes that they contain a number of people engaged in purposeful activity. It also recognises that these problematic situations are never static. However, SSM also acknowledges that purposeful activity needs a generally acknowledged belief or interpretation in order to make it purposeful. For example, this thesis has been written in the belief that you will read it, engage with it, learn from it and possibly change your thinking or actions as a result.

3.3.2.1 Two philosophies underpinning the application of SSM

Brian Wilson and Peter Checkland took their research and practice in slightly different ways.

a) Checkland

Checkland, who had managed ICI's research centre, was more focused on surfacing problematical situations within an ever-changing

environment. He focused on surfacing different perspectives, considered as Holons (Checkland, 1999, p.82), to realise underlying issues and develop an appropriate resolution that was accepted by the stakeholders. From an organisational point of view, Checkland's was an approach that could be undertaken by managers to check their courses of action were on target to address current issues the organisation might face.

Checkland aligned his philosophy of SSM to Vickers' ongoing process of life and, therefore, constant change (Vickers, 1965). As such, organisations would need to continually review their purpose and realign the organisation and its processes to changes, thus remaining structurally coupled. I hypothesise that this was valid in the 1970s, probably the 1980s and maybe into the 1990s. However, due to the structuring of organisations by Enterprise Information Technology infrastructures, process flow and automation, not to say Artificial Intelligence-based computing, means that the orthodox view on management science dominates; a view that is simpler and less ambiguous.

There may be socially constructed views of problems, issues of power and decision-making but, in many organisations, the view is about alignment to purpose and efficiency of operation – linear thinking. Evidence-based policy, based on natural science methods, dominates intervention design. Theory of Change, etc. and measures of change may reinforce this. But it is only when you accept the dichotomy between the ebb and flow/flux of life as a process, and ongoing change, versus infrastructure policy, structure and technology constraints, can you accept the need for a new way of thinking. To blend the perspectives, yet clarify current purpose, and consider the infrastructure needs (especially with automated processes spanning the value chain but include adaptability. Such adaptability is necessary to allow for the change resulting from the structural coupling of an organisation to the ever-changing environment, reflecting the process of life – being shaped by and shaping the environment.

Therefore, the biosphere – the subject-object relationship – is of crucial importance and a focus here is more important than ever before. Such a

relationship includes aspects of power, as well as autonomy and heteronomy.

SSM, influenced by Vickers is illustrated in Figure 42.

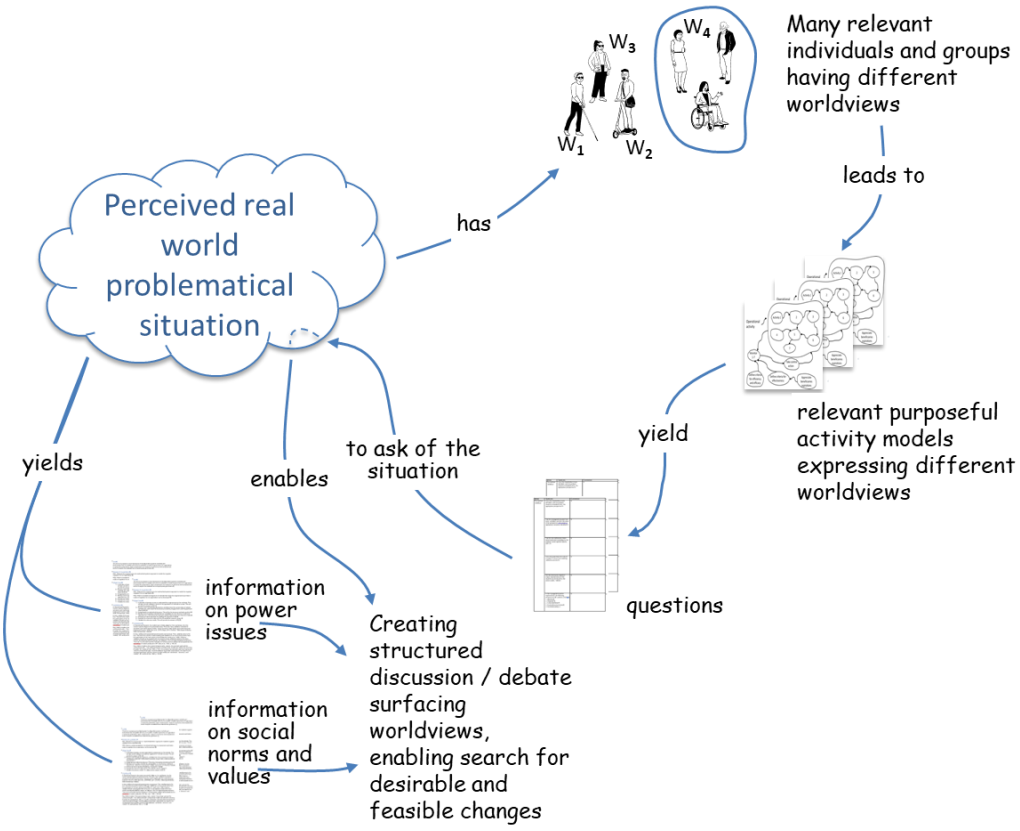


Figure 42 - SSM (Checkland) Basic Process (derived from Checkland and Poulter, 2006, p.12)

It results in:

> "the action to improve the problem situation is always thought about in terms of managing relationships – of which the simple case of seeking a defined goal is the occasional special case" (Checkland, 1999, p.A55)

This, in my opinion, provides a link between the two philosophical approaches to applying SSM. Checkland goes on to write:

> "It has been argued here that the models of organization and management that have been useful since the 1950s need to be enriched. It has been argued that appreciative systems theory and SSM can help with such enrichment. They do not replace the earlier

> functionalist and goal-seeking models. They enclose and enhance them in ways more appropriate to institutional life at the end of the century." (Checkland, 1999, p.A58)

b) Wilson

Wilson (1990, 2001), and with van Haperen (2015), on the other hand, was more interested in building an organisational infrastructure aligned to the organisation's purpose. It is much more of a practitioner's view, though it broadly followed the Lancaster methodology they all contributed to. With Wilson's approach (2001), a consensus purpose, or primary task is developed in greater detail, and more comprehensive system models are developed. These are then analysed to consider information needs, process inputs and outputs, measures of performance and organisational roles and responsibilities. The assumption here, is that, though the environment may change, the organisational purpose and, therefore, its infrastructure, would not change that often even if their ways of working and technology used, did evolve over time. Blalock (1961) also states that "if we are ever to understand the nature of the real world, we must act and think as though events are repeated and as if objects do have properties that remain constant for some time, however short" (Blalock, 1961, p.7). Therefore, the Wilson approach is suitable for the "occasional use" described by Checkland, in that it is "seeking a defined goal". Here, the utility of SSM conceptual modelling is not to design the blueprint for a static, fixed organisational structure, but to guide what we should incorporate into our Reference Model of Governance for a Specific Organisation to enable an adaptive, living organisation. To identify the 'what' and not the 'how'. To give us an idea of the information we should be seeking in our environmental interactions and so not attenuate the essential information, especially with regard to learning from the environment.

3.3.2.2 General approach of SSM

From a process perspective, Wilson's approach to SSM looks like this:

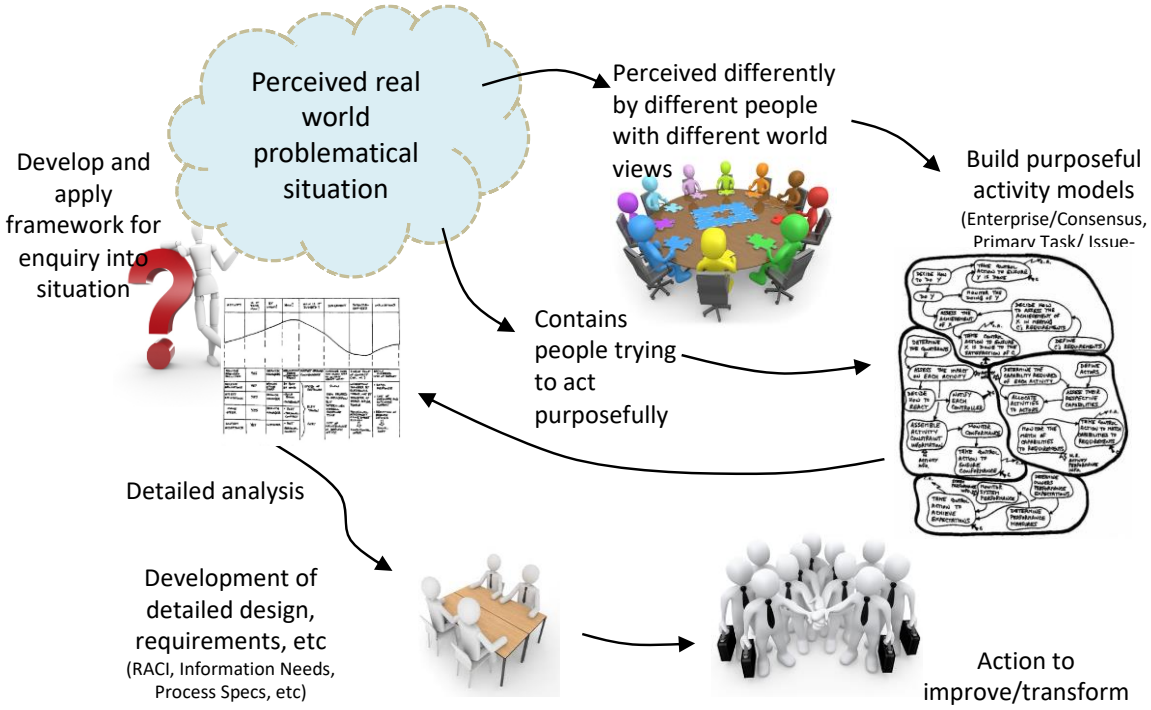


Figure 43 - An approach to applying SSM (after Wilson) (Source: Author)

The first stage of SSM takes place in the real world and the purpose is to gain an initial understanding of the situation and the wider organisation. The point is not to find and solve the problem, but to develop a clearer picture of what is going on and the factors that influence the situation. Naturally, the problem is perceived differently by the people involved as they all have their own individual perspectives of the situation. The underlying assumption is that all people involved are acting purposefully, and their behaviour is not random.

In order to apply SSM, we have to understand that Human Activity Systems (HAS) are pluralist and complex: there are many different views of the purpose of the activity that people are undertaking. Therefore, while there is nothing to engineer, there is accommodation to be reached. We can share our views and debate them to reach a common view. We may or may not establish a need as part of this process. This is where a Checkland-style application of SSM is useful

as it may be used to enable the different perspectives of people to be drawn out and, through dialogue, a resolution reached.

The basic premise of SSM is that there is a division between the real world on the one hand and ways of thinking about the world (systems thinking) on the other (Checkland, 1999, p.149; Wilson and Van Haperen, 2015, p.6). We can explore and express the real-world situation for each different perspective, then think about an idealized HAS. A gap analysis is then carried out between the two to identify desirable and feasible actions in order to move towards the idealized and improved situation.

In finding out about the problematical situation, ways of examining the issues, the culture and the power of the overall situation are provided. From this examination, some relevant purposeful activities are selected, and each is modelled.

Therefore, the resulting models are not of the real world but are views of the real world (Wilson and Van Haperen, 2015, p.8). They provide further tools to explore the real world and are used to question it further, providing a coherent structure through which to debate the situation (Checkland, 1999, p.162). The real world and the ideas for changing the real world are brought together during this debate. The purpose is to find changes that are both desirable and feasible. This is a learning cycle and, as it is a group process, it follows that it leads to group learning.

With Wilson's approach, however, the starting point is once you have reached a consensus on purpose, so we consider the HAS as unitary, though complex. This may have been achieved through the application of a Checkland-style SSM approach but, quite possibly, other methods and tools have been applied to develop through induction a common and shared understanding of the context.

When reviewing the failures of business process re-engineering or re-design, Wilson argues that the essence is in determining alternative ways ('hows') of undertaking business processes ('whats'), in more effective, efficient and efficacious ways (Wilson, 2001, p.60). He posited that by taking a top-down approach to determine the vision (potential futures) of the organisation and

modelling it to determine relevant activities (‘whats’), it would be possible to incorporate the knowledge within the organisation to develop the ‘hows’. This would achieve alignment to the organisation’s mission (purpose) and be confident in not only being able to ensure processes are done correctly, but only the correct processes (with regard to alignment to purpose) are done. I am not aware of another method that has the equivalent logical argument.

Once identified and agreed with the appropriate managers as being relevant, not only does the set of activities describe what is inside the system boundary, the conceptual model provides confidence that the set of activities is complete and coherent. These activities can be analysed according to the purpose of the inquiry (Wilson, 2001, p.65). This may be for process specifications, organisational roles and responsibility definition, information needs, etc. (Table B-1). The conceptual model can also be used to provide a ‘map’ of the organisation so people can understand their contribution but, more importantly, improvement initiatives can be conducted on a part of the organisation in the context of the whole organisation. An example is included in Figure B-2.

It is not feasible to generate enough variety of activities to model an organisation with a single conceptual model, so Wilson developed an approach to incorporate multiple root definitions and generate a consensus primary task model. These can have hundreds of activities. He outlines 4 approaches to building such a model (Wilson, 2001, pp.74–75), the most popular of which is the Enterprise Assembly approach (Wilson, 2001, pp.111–140). This is useful when a consensus regarding the organisation can be achieved. Even if the purpose isn’t fully agreed, Wilson has developed an approach to incorporating multiple Weltanschauungen called the W-decomposition approach (Wilson, 2001, pp.79–90). This is helpful when multiple purposes are identified as valid, and all could be incorporated into the final model. For example, consider a prison. Its purpose may be believed to be rehabilitation, or protecting society, for punishment, or for keeping prisoners safe whilst they serve the time imposed through the courts by society.

For this reason, I assess the Wilson approach to SSM to be more helpful in developing an understanding of the governance and management needs of an organisation than Checkland's approach. Consequently, even though there is no literature covering Wilson's approach beyond his own books, Wilson's approach is included in the development of the Reference Model of Governance for a Specific Organisation.

3.3.3 Viable System Model

The Viable System Model (VSM) was created by Stafford Beer over 40 years ago and has extensive use as a diagnostic tool. It is frequently used to improve the resilience and continued viability of organisations. It is used quite extensively and is regaining popularity in organisational design and improvement.

Beer explicitly linked VSM to Ashby's law of requisite variety to instil confidence in the model as a way of managing complexity as he perceived that complexity "threatens to overwhelm the system's regulators" (Beer, 1984, p.10). He incorporates "directive correlation" and Ashby's law of requisite variety in support of his model, implying his model, once completed, will enable a homomorphic mapping to the organisation and, therefore, support diagnosis of organisational pathologies. These structural patterns indicate symptoms of potential underlying problems, similar to the archetypes in SD (Table 10). His model, he states:

> "was devised from the beginning (the early 'fifties) in terms of sets of interlocking Ashbean homeostats. An industrial operation, for example, would be depicted as homeostatically balanced with its own management on one side, and with its market on the other. But both these loops would be subject to the Law of Requisite Variety." (Beer, 1984, p.11).

Beer clarifies that what makes the VSM distinct is that the requisite variety in the homeostats within it apply in 3 distinct ways: the homeostatically-related blocks of variety, the information communication channels between them and the transducers that convey information across the boundaries.

He (Beer, 1984) includes a short discourse on 2 perceived weaknesses in the VSM. One concerns the variety of people and that they have freewill. He acknowledges this, but states that, in organisations, peoples' behaviour is

generally related the role they undertake, so the variety involved is that of the number of roles, not the number of people. The second concerns the inheritance of acquired characteristics in social groupings such as organisations. In the human being, evolution has enabled the organism to adapt to changing circumstances, and these are carried through to subsequent generations. He argues that, in society (therefore in organisations) similar inheritance occurs through the history, indicated by changing social and organisational norms, or through regulatory feedback such as the introduction of new laws, and amendments of old ones. This equates to the relationship between the R and T in Ashby's model (Figure 10). Within his VSM, the System 2 function (covered later) provides damping mechanisms to prevent uncontrollable oscillations.

It is, however, quite a challenging methodology to grasp as it is not intuitively easy. It does not consider organisations in the usual, organogram way, but from a functional management perspective, viewed in a recursive hierarchical manner. This enables a three-dimensional perspective, looking at each layer of the organisational hierarchy, but with the opportunity to break out peer subordinate elements of the organisation. The value of this is that you consider not only the different focus of each layer of management, but also how the organisation joins up across the layers and what coheres the organisation.

It is derived from a biological analogy based on the human body. Quite simply, we have a brain, a coherent, collaborative set of organs and we live in an environment that we interact with. This leads to the three main elements of the VSM as shown below in Figure 44. These are the operation and management elements, and the environment in which the organisation operates.

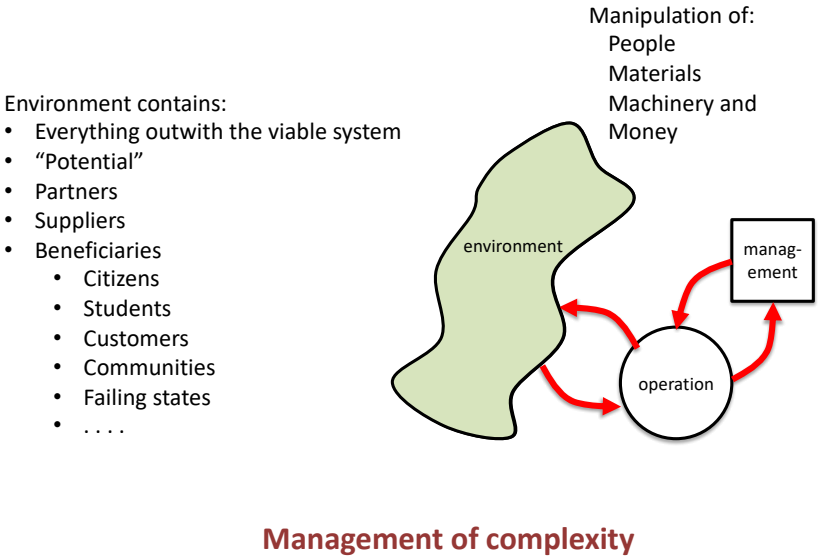


Figure 44: Basic Elements of VSM (derived from Beer, 1985)

The operational and management elements are considered through 6 Systems in the Viable Systems Model as shown below in Figure 45 (3 and 3* can be considered as two different systems).

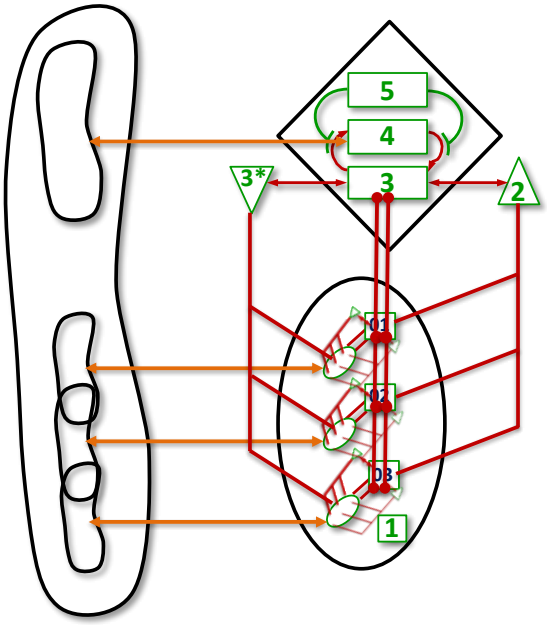


Figure 45: The 6 Systems of the VSM (Source: Author)

Management includes the leadership and strategic management as System 5, the future-looking and research aspect as System 4 and the day-to-day management as System 3.

System 2, coordination and conflict resolution across the operations arms of the business are essential, as is System 3* which includes periodic reviews and audits of the operating element by the senior management which bypass the local operational-level management.

The operating units, Systems 1, are identified and included. These are the parts of the business that add value, as opposed to the support elements such as personnel, finance, etc which sit in System 3. The Systems 1 need to be able to operate in their environments as freely as possible as they add the value to the organisation. The remaining systems serve them. Consequently, each will have its own internal policy, development, operational control, coordination and monitoring, hence the recursive nature of the model.

The Systems 1 need to be viable in their own right but, as they are sub-units within the organisation, they are subject to organisational policies and direction. They will receive goals and priorities from System 5, refined by System 3 into tasks. This is via the resource negotiation vertical channel. They will be subject to the higher level's System 2 coordination and conflict resolution, adding their own specifics, and will be subject to the higher-level System 3* audits. They will report back on their performance to System 3.

The VSM structure developed by Lambertz (2017), illustrated at Figure 46, was chosen as the most helpful way of mapping findings to the VSM. Also, due to the need to include a focus on the environment, the iO Environment Model (Lambertz, 2017) at Figure 47 is more helpful.

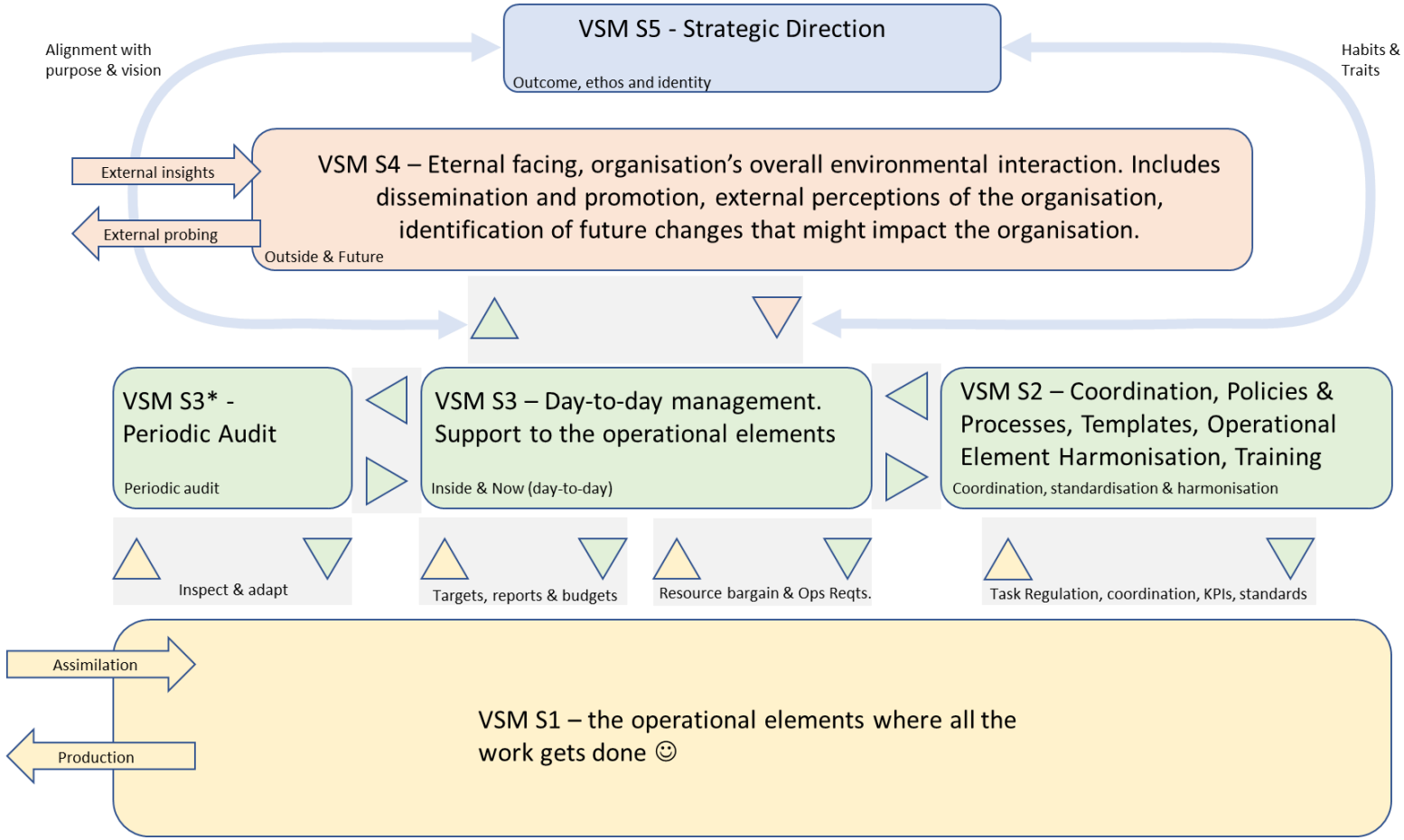


Figure 46 - VSM Structure (derived from (Lambertz, 2017))

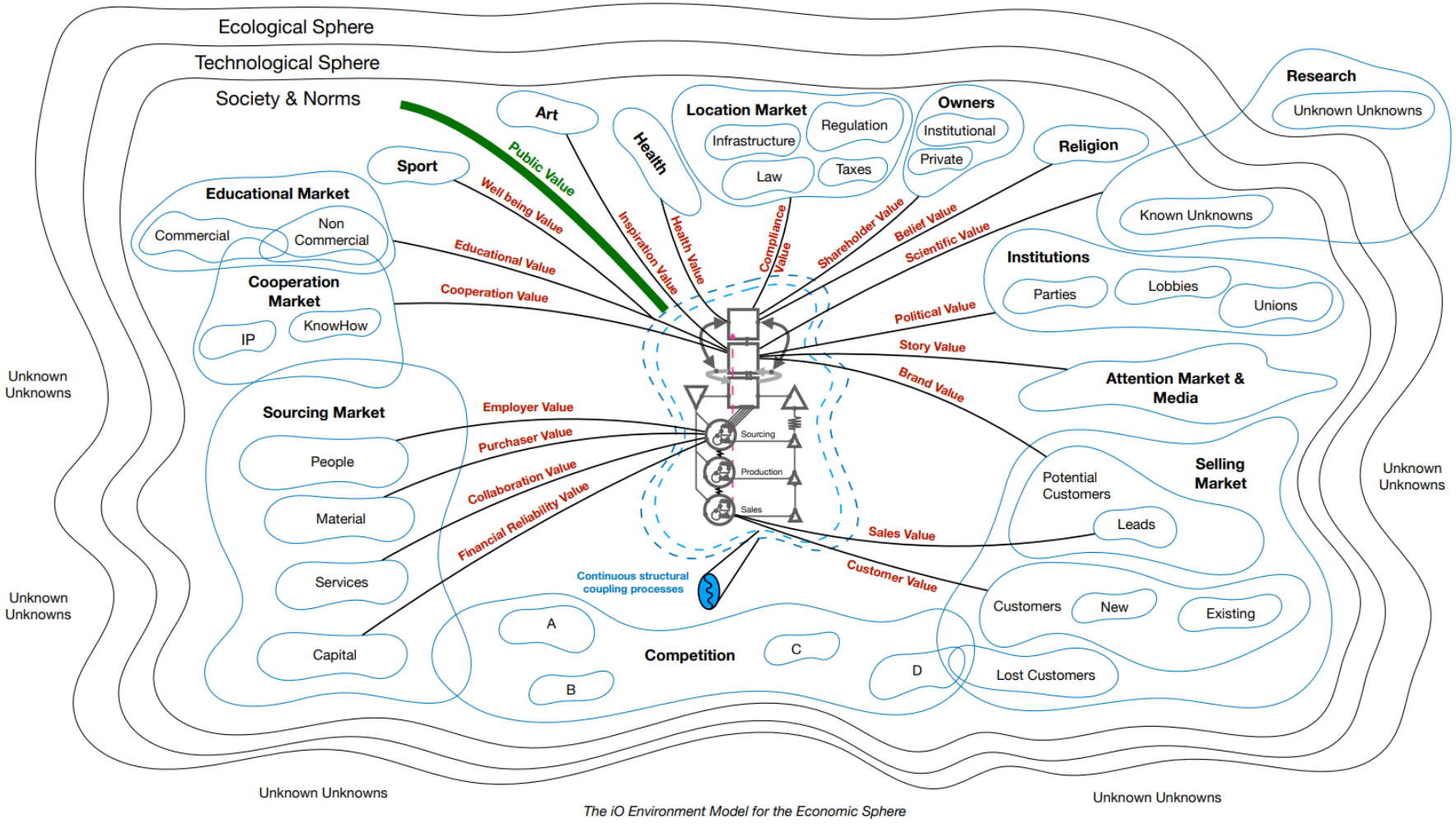


Figure 47 - A VSM within its environment (Lambertz, 2017)

In a similar approach to the archetypes in System Dynamics, as expressed in causal loop diagrams, organisational pathologies have been identified in VSM (Beer, 1984; Cardoso Castro and Espinosa, 2019; Perez Rios, 2012; Schwaninger, 2006). These are grouped under Structural pathologies, functional pathologies and information systems and communication channels pathologies. All the pathologies have been aggregated in (Cardoso Castro and Espinosa, 2019).

3.3.3.1 Structural Pathologies

Table 11 - Structural pathologies in VSM (derived from Perez Rios, 2012, pp.142–144)

Title	Description
Non-existence of vertical unfolding	The organisation is excessively large and it is rendered difficult for the organisation to deal with the total variety it faces.
Lack of recursion at the first level	There is an absence of the first level of the organisation that can deal with the complexity of the whole organisation
Lack of recursion levels (Middle levels)	There is not a level of the organisation that can manage the variety of a section of the environment and provide focus. It is too fragmented and uncoordinated.

3.3.3.2 Functional Pathologies

Table 12 - Functional pathologies in VSM (derived from Perez Rios, 2012, pp.146–166)

Title	Description
System 5-related – Identity not defined or is ill defined	
Ill-defined identity	A poor design or functioning of System 5 leads to no clear idea within the organisation as to its identity. This leads to a lack of agreement on purpose and no alignment of products and services to the external image of the organisation.
Institutional schizophrenia	Two or more different conceptions of the organisation exist within it leading to them pulling in different directions.
System 5 collapses into System 3	This may result from a weak or non-existent System 4. The result is a lack of distinction between the

Title	Description
	functions of System 5 and System 3, and System 5 keeps intervening, or taking over the management of the organisation.
Inadequate representation at the higher levels	System 5 is unable to represent the whole of its organisation to the higher level to which it belongs.
System 4 related	
Headless chicken	System 4 fails to modify, when appropriate, products and services offered by the organisation, excessive time is taken to adjust products and services to changing market desires, and the introduction (or not) of the wrong products and services. This ineffectual System 4 may impact on the future survival of the organisation.
Dissociation between System 4 and System 3	If there is a poor connection between Systems 3 and 4, then, though the Systems function correctly, and the organisation continues, in time it will fail. System 4 is not aware as the current status of the System 1 is not conveyed to Systems 4 and 5, so they don't know what is currently going on internally, so their interaction with the environment is based on flawed thinking. System 3 is not aware of beneficial innovations, or emerging threats to the organisation, so the correct adaptations to System 1 don't happen.
System 3 related	
Inadequate management style	Excessive intervention by System 3 into the operations of System 1, through being too authoritarian will lead to an overload of the System 3 functions and a loss of autonomy in the System 1.
Schizophrenic System 3	The functions within System 3 in dealing with System 1 and System 4 are disjointed. This reduces the possibility of adaptation and may lead to internal tension in System 3
Weak connection between System 3 and System 1	The operational units hold the power and System 3 has lost control. This can lead to a loss of coordination and coherence in System 1. They behave anarchically.
Hypertrophy of System 3	System 3 becomes bloated and attempts to control all without developing both Systems 3* and 2. System 3 becomes too involved in System 1 and resource hungry.
System 3* related	
Lack of or insufficient development of System 3*	Poor or insufficient monitoring systems, and possible micro-management. Inappropriate actions in System 1 are not addressed.

Title	Description
System 2 related	
Disjointed behaviour in System 1	System 2 does not exist or is poorly implemented so that each operational unit operates independently with no coordination or coherence.
Authoritarian System 2	System 2 may be seen to be enforcing certain working methods without engaging with System 1. This will impact on its ability to provide coordination and coherence in System 1.
System 1 related	
Autopoietic “Beasts”	An operational unit becomes self-determining and self-interested. It dominates the other operational units and ignores the role of System 2 and 3.
Dominance of System 1	The operational units dominate the organisation and operate as a federation, ignoring the other Systems, and will follow their own individual aims and compete amongst themselves.
Complete system related	
Organisational autopoietic “Beasts”	The systems that should be in support of System 1 become self-serving and obsessed with their own goals related to growth and power. Examples include exaggerated bureaucracy. Service departments such as IT, programme office and organisational development become self-serving to the detriment of operational effectiveness.

In addition, there are pathologies related to information systems and communication channels. These include the lack and/or fragmentation of information systems, lack of key communication channels, lack of, or insufficient algedonic channels (where issues (‘pain’) can be communicated directly to System 5 to be addressed), and communication channels which are incomplete or of inadequate capacity. Frequently, the ‘links’ in the VSM diagrams are not considered, only the ‘boxes’. It is important that these, too, are addressed in the analysis of the VSM, as intended by Beer, to explore the capacity and mechanisms present in them. The capacity and mechanisms in each of the links will attenuate incoming information simply because the amount of information is potentially so great. This flow of information needs to be assessed to ensure he correct information is being received and that it is understood. The links can also

be assessed to explore the mechanisms used to amplify information back out to all those who are intended to receive it.

3.3.4 Critical Systems Heuristics

Critical Systems Heuristics (CSH) is an important method as it explores the boundaries of a problem situation and explicitly includes those affected by, but not included in developing an appropriate intervention. Ulrich built on concepts initially generated by Churchman (1968, 1971, 1979) to develop an approach to boundary critique, specifically to bring to the fore opposing tensions in stakeholders and to accommodate those affected but not involved in an intervention. This he termed Critical Systems Heuristics and states it “is a philosophical framework to support reflective practice” (Ulrich and Reynolds, 2010, p.243). It is, essentially, a set of 12 questions with which you can build a ‘reference system’ of a situation either in the ‘as is’ state, or in the ‘to be’ state. The intent is to support the judgement required to resolve situations. The 12 questions are shown at Table 13

CSH is intended to critique boundary discussion by considering a range of perspectives. The sources of motivation perspective helps to clarify amongst stakeholders the purpose of the intervention and how it might improve the situation, the beneficiary and, to make it more explicit, to draw out the measures of success. Collectively, these both enable the expression and discussion of differing perspectives and mental models, as well as support the development of a consensus.

The sources of control perspective explicitly draws out the power structures at play, to clarify the ‘owner’ of the intervention, the aspects of control they command as well as those decisions that should be retained by others, perhaps to avoid an excess of power, or to reduce conflicts of interest.

The sources of knowledge perspective explores the knowledge and skills required and explicitly who has them. Critically, it asks questions regarding guarantees of success – who or what gives confidence in the outcome being achieved?

Table 13 - The boundary categories and questions of CSH (derived from Ulrich, 1996, p.44)

Sources of influence	Social roles (Stakeholders)	Specific concerns (Stakes)	Key problems (Stakeholding issues)	
Sources of motivation	1. *Beneficiary* Who ought to be/ is the intended beneficiary of the system (S)?	2. *Purpose* What ought to be/is the purpose of S?	3. *Measure of improvement* What ought to be/is S's measure of success	The involved
Sources of control	4. *Decision maker* Who ought to be/is in control of the conditions of success of S?	5. *Resources* What conditions of success ought to be/are under the control of S?	6. *Decision control environment* What conditions of success ought to be/are outside the control of the decision maker?	
Sources of knowledge	7. *Expert* Who ought to be/is providing relevant knowledge and skills for S?	8. *Expertise* What ought to be/are relevant new knowledge and skills for S?	9. *Guarantor* What ought to be/are regarded as assurances of successful implementation?	
Sources of legitimacy	10. *Witness* Who ought to be/ is representing the interests of those negatively affected by but not involved with S?	11. *Emancipation* What ought to be/are the opportunities for the interests of those negatively affected to have expression and freedom from the worldview of S?	12. *Worldview* What space ought to be/ is available for reconciling differing worldviews regarding S among those involved and affected?	The affected

Finally, the sources of legitimacy perspective explicitly addresses those not involved but who may be impacted by the decisions being made. How will their perspective and needs be incorporated?

Success in applying the method very much depends on the facilitation of the processes of conversation and discussion. This is because some important issues may be difficult to surface in a group conversation due to the influence of some of the stakeholders and possible coercion. They may be perceived to be more powerful and influential by others which limits open conversation. Some may not wish to be perceived as 'whistleblowers' if they appear to be critical of more senior people.

3.3.5 Dependency Modelling

Though not one of the core systems methods, dependency modelling has proven valuable in understanding what successful organisational goals depend on. It is

included as the insight gained is an important contribution to governance to mitigate the impact of disturbances.

Dependency modelling (Slater, 2016; The Open Group, 2012), in this context, was developed as a risk management tool, based on the premise that risk comes through issues within dependencies. The success of an enterprise arises from all its elements working well, and each of these has dependencies to that they rely on to be able to work well. Some dependencies are external to the organisation (utilities, supplies, outsourced service providers, etc.), and the likely success of these also needs to be understood. It is of great benefit when understanding risk, or knowing where to prioritise resources, that the critical dependencies are understood, in order of criticality.

The Open Group Standard on Dependency Modelling (2012) proposes an approach that supports the assessment of risk by considering positive outcomes and their dependencies. It enables the incorporation of a wide spectrum of dependencies across the organisation that can include technical components, financial aspects, compliance states, and the availability of skilled resources. It isn't constrained by organisational boundaries, precedents or knowledge of potential threats.

The same logic can be applied to understanding the current state of an organisation across its dependencies and also to indicate the spread of impact, should a disturbance occur, and its potential propagation through the organisation, as well as indicate the overall impact on the organisation's outcomes.

Figure 48 provides an illustration of part of a Bayesian-based dependency model. A larger image can be seen in Figure 88. Within each element, which The Open Group Standard calls a 'paragon', the probability of success or failure is indicated.

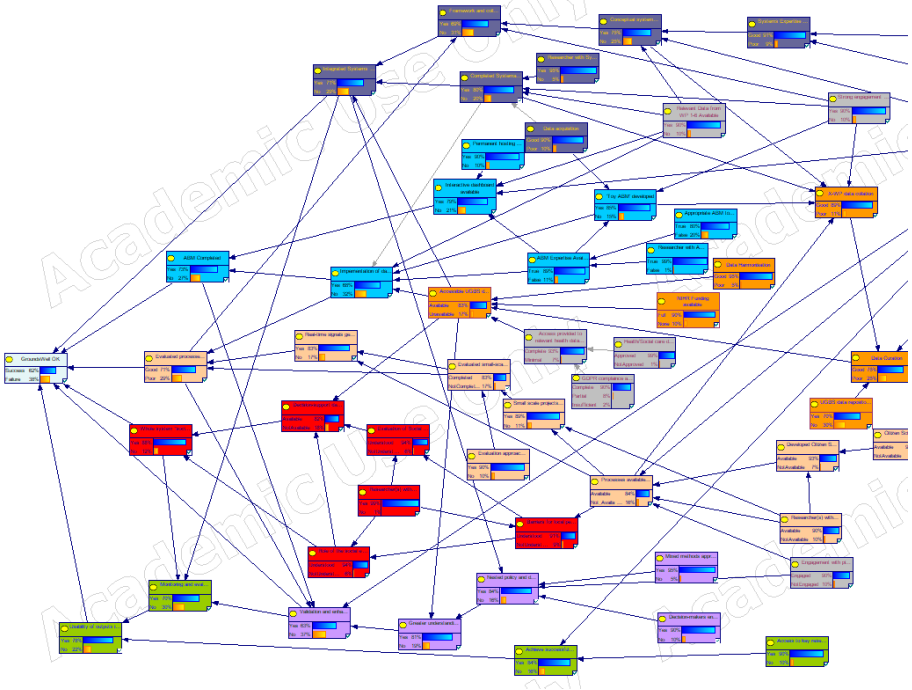


Figure 48 –Illustration of a partial dependency model (Source: Author)

Across the model, the probabilities are coded in conditional probability tables (because the probability of an event occurring, given that another event has already happened, is a conditional probability), and the leaf nodes, the child nodes that have no dependencies, have values applied. These are subjective, and it is the Bayesian mathematics that calculated the likelihood of success of each paragon, that rolls up to the overall likelihood of success of the organisation in achieving its goal as indicted by the single paragon to the left in Figure 48.

The approach to building a dependency model may seem straightforward, but it does require a concerted group effort. It does not necessarily need to be built as a monolithic model as the organisation's sub-goals can be determined, and dependency models for these can be built independently and then joined up. Specialized software is available for modelling and conducting what-if simulations to support decision-making.

The key steps are:

- Establish the top-level paragon by defining the goal to be achieved. This may be at the overall organisational level, or a business unit of the

organisation. This will require bringing together all the key stakeholders to accommodate their different viewpoints, akin to SSM.

- Each stakeholder considers “What do the business goals depend on?” Answers should ignore risk but focus on the key factors contributing to success.
- This is then repeated for each factor, where the same question is considered.
- Once all the dependencies have been determined and the paragons linked, those present agree, subjectively, and allocate the probability to each state of the goal, successful or not successful.

The value of this approach is gained when undertaken collectively by the stakeholders. They are built on shared belief, and it avoids an excessive probability claim being made by one person as well as enabling all involved to gain an overview of what the organisation depends on for success. Consequently, this, too, should be included in the Reference Model of Governance for a Specific Organisation to inform decision-making.

3.4 The Practitioner Dimension

The practitioner has an important role in Systems Thinking Practice. Clewley et al. (2022) proposed a framework combining Method, Philosophy and Practice. Their perspective being:

> “Systems research is conducted in an environment with often *competing influences* on how research problems are *defined and investigated,* against a background of *personal preferences* and a multitude of *external pressures*.” (Clewley et al*.,* 2022 italics in the original)

Their rational for this being that systems thinking does not have its own specific paradigm; that philosophical perspectives are not now considered to be incommensurable; meaningful, trustworthy and generalisable knowledge can be achieved by linking philosophical assumptions with problem contexts; and practitioners facilitate conversations and can differentiate between approaches and “craft general systems methods into bespoke applications” (Clewley et al., 2022). The Framework is shown at Figure 49.

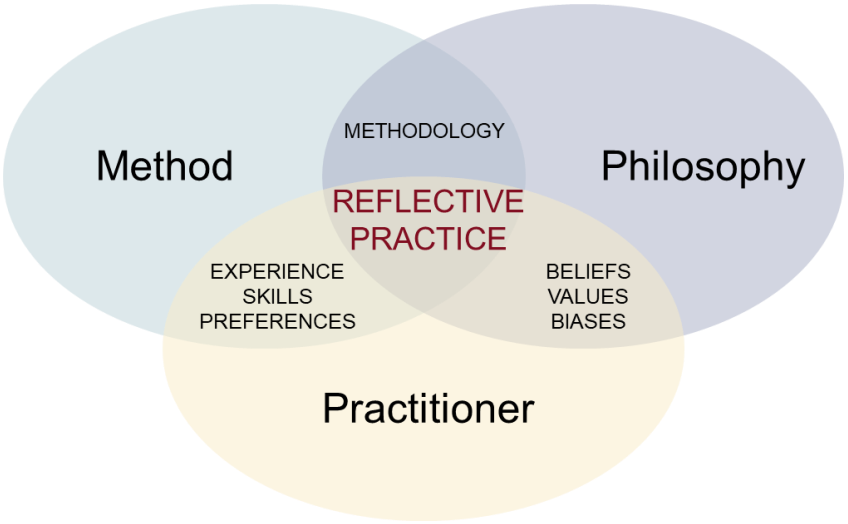


Figure 49 - Framework of Systems Thinking Practice (derived from Clewley et al., 2022)

The intersection of Method and Philosophy derives a methodology to link ‘whats’ and ‘hows’ (Checkland, 1999, p.163). It ensures that practitioners have an awareness of the underlying philosophy of method, such that they are applied correctly, and practitioners can make an informed choice. The intersection of Method and Practitioner generates experience and skills, recognising preferences. The practitioner should judge their selection of methods in light of their level of skill, experience of application and be aware of their preferences to avoid bias. The intersection of Practitioner and Philosophy illuminates the need to be mindful of personal preferences and beliefs that might inhibit our appreciation of others’ perspectives. The resulting combination, when present in a practitioner, enables reflective practice (Schon, 1987).

The methods described in the previous sections require attention and practice to be effective. Within the literature, it is apparent that many applications are only cursory and single method, a point brought out by Hoverstadt (2022) and Howick and Ackermann (2011). Academics can rarely publish papers describing the use of multiple methods and rarely have the time to practice them in research projects (Howick and Ackermann, 2011). This lack of methodological familiarity and skill results in a formulaic application of methods, and the use of scripts (Andersen and Richardson, 1997; Hovmand et al., 2012), especially with Group Model

Building. Practitioners rarely publish, and generally have a preference for a single method in which they have developed their expertise.

Within this thesis, my focus is on the organisation rather than the pure application of systems methods. Therefore, they are intended to be used as much as is necessary to resolve the situation being addressed. When taking a problem-focused approach, practitioners are more pragmatic and can flex the use of methods, provided they understand the ontological and epistemological issues. This emphasises the importance of practitioners being reflective to avoid bias in their work and to include validation in their intervention approaches.

3.5 Choice of methods

Studies of social situations are necessarily deeply conceptual. It is difficult to imagine how the world we perceive can be understood without the help of ideas and models to simplify and clarify what is observed. Such research is iterative, moving between conceptual thinking and application of ideas (i.e. retroduction). The social science researcher does not have any preconceptions about what causal mechanisms may be at work, so requires appropriate methods to surface them in a collaborative, social context.

Drawing on a review of the literature, Appendix C, Table 14 summarises an assessment of the main systems methodologies and their use in combination with other system methodologies. One of the main methods used in combination is Checkland's SSM approach and there are no papers found that describe Wilson's SSM approach being used, either singly or in combination. Checkland has published widely and Wilson has not, which has likely led to his approach to SSM being more accessible and familiar. Wilson's approach to SSM has not been used in combination with others apart from use of his Maltese Cross technique (Wilson and Van Haperen, 2015, pp.51–52) to determine information system requirements.

VSM and SD have been used in combination. Schwaninger (2004) and Schwaninger and Rios (2008) proposed the use of SD to model the content of a

problem and to use VSM to model the context of a problem, though they show a CLD and not a quantified model.

Ulrich (1996, 2005) has proposed that CSH complements VSM and SSM in an approach to health systems reform. VSM to look at structural issues, SSM to develop mutual understanding amongst stakeholders and CSH to check the interests of all parties were taken into account.

Table 14 - Assessment of Systems Methodologies

Method	Contribution	Observations from the literature and from practitioner experience	Currently combined with
SSM (Checkland, 2000; Checkland and Poulter, 2006; Checkland and Scholes, 1990)	• Used to enable conversations to surface the variety of mental models regarding purpose. • Consensus obtained via dialogue. • Assumes ongoing flux and change in the environment (Vickers, 1972). • Can help determine organisational boundary.	• Simple root definitions • Requires facilitation. • Simplistic conceptual models • Greater resolution obtained by recursively developing root definitions of activities, leading to disconnected conceptual models. • Doesn't consider environmental interactions. • Doesn't aid identification of measures of performance. • No software tool to manage information	• VSM to name systems, though CATWOE has been changed to TASCOI (Espejo and Reyes, 2011) • VSM to name systems and then describe organisational adjustments (Ramírez-Gutiérrez, Cardoso Castro and Tejeida-Padilla, 2021) • System Dynamics, using SSM to identify problem situation (Lane and Oliva, 1998) • System Dynamics to model the dynamics of the 'problematic situation' (Rodriguez-Ulloa and Paucar-Caceres, 2005)

Method	Contribution	Observations from the literature and from practitioner experience	Currently combined with
SSM (Wilson, 1990; Wilson and Van Haperen, 2015)	• Development of large-scale enterprise conceptual models once purpose has been agreed. • Identifies logical dependencies between activities. • Detailed activity analysis is possible. • Analysis of links is possible. • Information needs analysis. • Process specifications • RACI definition • Complete and coherent models • Persistent activity models of 'Whats' that are relevant whilst purpose remains. • Can consider the environmental interactions if 'system served' is modelled. • Can help determine organisational boundary	• Requires practitioner expertise. • Requires consensus on purpose to have been achieved (unless 'W' Decomposition approach). • Assumes a relatively stable organisation, and adaptation according to a change in purpose is resource intensive. • Two-dimensional model of organisation. • No software tool to manage information.	• VSM where Maltese Cross has been used to develop information system requirements (Espejo and Reyes, 2011)

Method	Contribution	Observations from the literature and from practitioner experience	Currently combined with
VSM (Beer, 1985; Espejo and Reyes, 2011; Perez Rios, 2012)	• Diagnosis of organisations • Development of 3-dimensional organisational structures • Explores 'as is' and 'to be' organisational functions • Consideration of links between management functions • Can explore information flows • Can identify organisational pathologies through reflection on archetypes (Cardoso Castro and Espinosa, 2019; Perez Rios, 2012)	• Requires practitioner expertise • Requires facilitation • Systems 1 need to be determined and agreed • Current use doesn't consider the environmental interactions • No software tool to manage information	• System dynamics to model the content of a problem situation (Schwaninger, 2004, Schwaninger & Ríos, 2008) • SSM (Checkland) to name systems (Clemens, 2009; Espejo and Reyes, 2011; Kinloch et al., 2009) • SSM (Checkland to name systems and describe organisational adjustments, VSM to identify organisational pathologies (Ramírez-Gutiérrez, Cardoso Castro and Tejeida-Padilla, 2021) • SSM (Wilson) – use of Maltese Cross to identify information needs (without prior conceptual modelling) (Espejo and Reyes, 2011) • SSM mapping of activities (not derived from a Checkland RD) (Bustard et al., 2006)

Method	Contribution	Observations from the literature and from practitioner experience	Currently combined with
Group Model Building (Causal Loop Diagrams) (Vennix, 1996)	• Capture the perceived dynamics of a context as understood by those involved • Helps identify underlying patterns (Galea, Riddle and Kaplan, 2010; Vandenbroeck, Goossens and Clemens, 2007)	• Requires expert facilitation • Frequently depends on the use of scripts • Based on unsurfaced mental models of those involved, therefore different mental models • Requires a prior consensus on purpose to be agreed (but rarely is) • Inconsistency in defining variables often results in inconsistent levels of abstraction • Difficulty of validation	• System Dynamics – a pre-cursor to building stock and flow models (Diez Roux, 2011) • Agent-based modelling?
System Dynamics Modelling	• Quantified system models based on stocks and flows • Optimization of dynamics in an organisation • Simulation of potential future behaviour of a system	• Requires variables to be identified • Careful iterative model-building required to avoid model failures • Difficulty of validation • Frequently seen as models of prediction	• SSM to identify problem situation (Lane and Oliva, 1998) • SSM to model the dynamics of the 'problematic situation' (Rodriguez-Ulloa and Paucar-Caceres, 2005) • VSM to model the context of a situation (Schwaninger, 2004; Schwaninger and Ríos, 2008)

Method	Contribution	Observations from the literature and from practitioner experience	Currently combined with
Critical Systems Heuristics (Ulrich, 1996, 2005)	• Helps clarify purpose, beneficiaries and measures of performance – only method to be explicit about that. • Specific inclusion of those not involved but impacted. Can surface coercive behaviour. • Considers both 'as is' and 'ought to be' Reference Models of Governance for a Specific Organisation for discussion. Considers span of authority and control. • Explicitly used for boundary critique. • Good means of summarising and clarifying a proposed intervention	• Stand-alone approach to Critical Systems Thinking (Ormerod, 2016). • To be used to structure the problem prior to intervention planning (Ulrich, 2003a, 2003b) • But Jackson doesn't agree as there are various forms of boundary critique depending on methodological choice (Jackson, 2003c)	• SSM to support SSM analysis 3 (Mingers and Brocklesby, 1997) • Proposed combination of SSM, VSM and CSH in health systems reform – VSM to look at structural issues, SSM to develop mutual understanding amongst stakeholders and CSH to check the interests of all parties were taken into account.
Dependency Modelling (The Open Group, 2012)	• Builds an understanding of the organisation's dependencies for success. • Enables the identification of critical dependencies for risk management purposes. • Enables an integrated view across the organisation and enables prioritisation of mitigation and response.	• Dependency modelling is used mainly within technical or product infrastructures and does not integrate the spectrum of roles in an organisation. • Examples of use in Industrial control systems and cyber environments. (Cherdantseva et al., 2015) • Principle use in disaster investigation of probable cause.	• None

3.6 Methods for shared understanding

As introduced in the discourse on EPIC (Section 3.2.2.3) and Systemic Intervention (Section 3.2.4), the Explore and Critique stages in an intervention are a vital preliminary exercise. Many practitioners use CSH or Checkland's SSM to achieve this but, due to the range of perspectives to be considered, and to support an injunctive approach with stakeholders, it is proposed to employ a range of tools. These are introduced below.

3.6.1 Rich Picture

Rich pictures have been employed to communicate the strategy for an organisation and produced by a professional artist. In this context, however, Rich Pictures are a way of building a picture of the collective views and perspectives of those involved (Checkland, 2000). Using images and metaphors is helpful and will prompt those involved to expand their thoughts as well as providing a reminder of what the conversations have covered. By building a 'big picture' collaboratively, and then standing back from it helps to see what issues and challenges emerge, as well as initial thoughts as to their relationship with each other.

3.6.2 Multi-Perspective Approach

The Multi-Perspective Approach (MPA) (Gareth Morgan's 'Pig Model' (Morgan, 1993)) is the first step in capturing what the group imagines to the be views of the various stakeholders regarding the situation. It is intended to help them consider who has an interest in the situation being considered and what their perspective might be. I.e., what does the situation mean to them, what is important to them. If they are present, they can answer the question. If not, then the group will imagine what their perspective might be, checking later if it is necessary and feasible.

Initially the perspectives of those present are captured, then the group imagines what the perspectives of others might be. An understanding of how the various stakeholders see a situation is important to ensure the range of perspectives is

considered, and that these perspectives are represented and accommodated within the programme of work.

It is very much metaphorically about taking your own shoes off and trying to stand in the shoes of another. This technique is about surfacing values, as best as you can. The extended MPA is further developed later to consider what the impact of decisions might be on key stakeholders.

3.6.3 Extended Multi-Perspective Approach (EMPA)

The Multi-perspective Approach (MPA) in section 3.6.2 was extended by Dodd and Alston (2009) to construct the range of perspectives of stakeholders to provide insight into their specific motivations or drivers for action in a defined context. It is a means of incorporating the full range of perspectives to enable the adjustment of an intervention, and to shape communications with stakeholders.

For each stakeholder, building on the MPA, you identify their specific lines of perspectives. For each you ascertain (hypothesise, or ask) where they currently think they are, and where they would like to be. The difference (δ) is their potential drive to act. This is repeated for each relevant stakeholder. Once completed, recognising that stakeholders are likely to have different viewpoints, you can consider how your option might affect others, and shape your decision accordingly.

3.6.4 Cognitive Maps

Originally developed through research by Ackerman and Eden in the 1980's (Eden, 1988), cognitive maps are relatively unstructured graphical tools for representing relationships between a series of ideas, issues and concepts, and begins to introduce the notion of cause-and-effect linkages between system elements. They were derived from Kelly's (1955) work on personal constructs and enables the surfacing and visualisation of stakeholders' mental models and perspectives which underpin their actions.

They are used in an ‘influence’ context, regarding how different elements of a system influence each other and to enable analysts and problem owners to explore the behaviours and interactions of people.

Crucially, they enable you to build a picture of the ‘dynamic’ map you hold as a mental model such that you can discuss it with others. Also, you can only hold so many ideas in your mind at once (Miller, 2001), so you can build a bigger picture on paper.

3.6.5 Context Diagram

Drawing a context diagram, or a context analysis, is a way of organising thinking about factors that characterise a ‘problematic situation’ and is prepared from the perspective of a particular actor, normally “you”. First developed by Flood and Carson (1993), a context diagram can help to develop shared mental models and understanding of responsibilities across different stakeholder groups within the system being studied. It aids appreciation of boundaries, i.e., what can be controlled or influenced, what constrains your (or the actor’s) options and/or actions.

It is developed from a particular perspective. It might be the organisation itself, or a role within the organisation. The intent is to surface and share an understanding regarding the agency or span of control of the organisation or individual. In a competitive environment, you might consider developing a context diagram from the perspective of your competitor. It is helpful to develop agreement with regard to the boundaries. Who or what do you have control and authority over? Who or what can you influence? What are the constraints with regard to the current situation? What are the general standing constraints for all situations? It challenges assumptions, e.g., do “you” really have the power to influence? Also, dependency relationships can be added between factors.

3.6.6 Six Cohering Questions

Six Cohering Questions is a technique that employs questions to focus the dialogue on the purpose of one’s own intent (the ‘we’), seeking consensus, and

makes explicit the thinking about what it might take to achieve the declared purpose. I developed this whilst working as a practitioner when using SSM to address problem situations. It is inspired by the CATWOE mnemonic, but as that is mainly designed to be a check of a root definition, and doesn't, by itself easily support a conversation, I found the questions engendered a more constructive conversation with stakeholders. I recognised that most were concerned with what they wished to be done and, holding in mind a root definition construct, I would gently ask what they wanted to achieve by doing that, what outcome did they wish for? For many, it was something they had not really considered. The remaining questions followed, and I could construct a root definition with their answers, in their own words. It led to root definitions they took ownership of.

The same set of questions can be used to imagine the purpose of others involved in the situation (the 'they'). This exercise surfaces the many mental models present, as well as the different perspectives of the differing skill sets and experiences of the stakeholders. Its main value is to ensure shared understanding, specifically that an individual's understanding is not limited by their personal perspective and can be extended to incorporate the knowledge and views of others.

The origin of these questions lies in the work of Churchman (1971), Checkland (1999), Wilson (1990) and Ulrich (2010). However, this light-touch approach is valuable in guiding conversations at an early stage to surface the differing perspectives present, such that they can be confirmed and considered. It is an alternative to Checkland's use of the PQR formula (do P, by Q in order to help achieve R) and the simple root definition it produces, and it actively considers the owner or responsible person as well as considering environmental constraints. All of these questions surface mental models and can either enable alignment of thinking or lead to the need for further conversation to achieve and accommodation of views, if not a consensus.

At this stage, it is useful to explore whether those in the conversation agree on the problem or purpose of the system being discussed. All the thinking captured by the previous techniques contributes to this.

The set of simple questions that can be used are:

1. **What are we/others trying to achieve?** Assuming it has been agreed who the ‘we’ or ‘others’ actually is, this question helps to bring out the various perspectives of those involved in the conversation. Generally, the initial understanding stage will have aligned thinking, or the purpose of problem may be ‘given’. Uniquely, for this question, we record only one answer for each set of 6 questions. If there are a number of plausible answers, then you would create a set of 6 questions for each one. The intent of this question is to cohere the thinking of the group to a single purpose or outcome from which the rest of the thinking is derived.
2. **What do we/they need to have done to achieve that?** This question draws out the differing belief and value systems of those involved as we all, though our differing experiences, will have a different view of what it takes to achieve the purpose, or address the problem agreed in the previous question. There will be a number of answers to this question and the intent is to gain consensus on the resulting set, or at least an accommodation where those who may not agree with some activities do not disagree. It is a more tangible approach to explore the various weltanschauungen present amongst people. This is because their ‘W’ is expressed in the range of what individuals believe is necessary to be undertaken.
3. **Who benefits from any potential outcomes?** This represents the beneficiary(ies) such that you can agree that the outcome is the benefit desired and considered of value. It is also useful to explore who might disbenefit as well, such that you might consider ways of mitigating the impact – unless, of course, they are intended to be a dis-beneficiary such as a criminal or adversary. Considering appropriate measures of success helps to identify the primary beneficiaries as frequently secondary and tertiary beneficiaries are identified and included. It is the primary beneficiaries that are of interest.
4. **Who is going to get these things done?** This helps to consider who will actually do the activities identified above. They are not necessarily all from

the same organisation, and some may not be under your control. Prior thinking using the context diagram helps in this consideration.

5. **Who owns it?** This identifies the 'owner' of the problem or system, the one who is accountable for the system's performance. Ideally this is a single person and not a committee! The owner considered here is the one who has control and authority over the resources to achieve the desired outcome or can be allocated control and authority. Within a consortium, this may require formal agreements to be established between the members and the agreed consortium lead. This thinking also identifies additional measures of performance that reflect the owners' desires and approach to achieving the outcome. In this consortium situation, all parties contributed to this thinking even though the consortium lead partners are deemed to be the owners of the research programme.
6. **What are the constraints (for us and others)?** This is often a key question as it will identify limitations that have to be considered and acted within. They will constrain decision-making and often provide system boundaries.

3.6.7 Ladder of abstraction

At times it is necessary to confirm the problem or question being considered is the right one. It is very easy to set off on a track and plough a narrow furrow towards a particular goal. The Ladder of Abstraction (Isaksen, Dorval and Treffinger, 2011), is a particularly helpful method to confirm the focus of the problematical situation. Initially, a model problem statement is derived, generally from the answer to Question 1 from the 6 cohering questions above. It will have an invitational stem "In what ways might", followed by a problem owner, then an action verb, and finally an objective.

To ladder up, ask "why might this problem exist?" and also ask "why else?" to generate a set of more abstract concepts. To ladder down ask, "how might this problem manifest itself?" and also ask, "how else?" to generate a more concrete set of problems. This ladder could be extended upwards or downwards. You may need to ladder down a few times to move from Sources to Factors; it is not an

automatic ‘one-shot’ operation and judgment must be applied in distinguishing the level at which you identify Factors. Whilst considering ‘why else?’ and ‘how else?’, you can go as far left and right as is helpful. This helps one ladder up and down to the appropriate level of abstraction as well as thinking ‘left’ and ‘right’. The important point is to phrase the central question beginning with ‘In what ways might. . .’ in order to open up thinking.

3.6.8 Scenario Thinking and Scenario Planning

For larger organisations, it is important for them to understand, as well as possible, the wider environment within which they operate in order to try to minimise the potential impact of any turbulent changes. This is routinely undertaken in financial planning, but not necessarily undertaken in the development of strategic plans.

The approach involves the development of 4 plausible future scenarios that can open up thinking to consider the need for any mitigation to be put in place, and activities undertaken to shape conditions to be more beneficial for the organisation, or whether any indicators or warnings need to be considered. The approach (Cairns and Wright, 2011; Chermack, 2011) was developed by Shell in the 1970’s and is quite straightforward to apply. The challenge is in ensuring the range of expertise is available and involved in the process, as well as the information necessary.

3.6.9 RACI Analysis

RACI (Jacka and Keller, 2009) is an acronym for the various roles involved in achieving successful actions. They stand for:

Table 15 - Role and responsibility mapping

Responsible	Who is responsible for carrying out the action?
Accountable	Who is accountable for ensuring the action is carried out?
Consulted	Who is consulted in the progress of the action?
Informed	Who is informed of the outcome of the action?

An example is shown below at Table 16.

Table 16 - Example RACI Matrix

Activity	CEO	Finance Director	Ops Director	Risk Manager	XXX	YYY	ZZZ
Develop knowledge of indicators of events and stress happening	A	C	R	C	C	I	I
Assemble intelligence about possible hazards, disruption and stress	I	I	A	R	C	C	C
Imagine and develop scenarios of what may happen or be achieved	A	C	R	C	C		

From an activity focus, the horizontal perspective, the matrix enables the identification of a single point of accountability, the clear allocation of responsibility to undertake the activity and, if it is to be shared, then who with. Also, if too many people are to be consulted, the impact can be determined and, finally, to consider who is to be informed of the outcome.

From a role focus, the vertical perspective, the matrix enables visibility of the range and volume of responsibilities for each role, whether there are conflicts of interest, too much is required of the role and what criteria are required of the individual for them to be able to effectively undertake the role.

3.7 Summary

With regard to the use of multiple methods for developing the design blueprint for an enterprise, there is little in the literature. Most is focused on problem understanding and improvement through engagement and dialogue. Checkland's SSM is the only SSM approach considered in the literature, though VSM has been proposed for organisational design.

Also, though the use of multiple methods has been discussed, either with regard to where to use them in an intervention, or their paradigm commensurability, there is little evidence of the exchange of artefacts between methods, or method integration.

4 Building the Reference Model of Governance for a Specific Organisation

> "The men who struggled to establish what later became recognizable as systems theory were primarily concerned with a methodological problem – what is the most appropriate method of studying any complex entity or system? Ludwig von Bertalanffy, undoubtedly a key pioneer in the field, has written of his realization during the 1930s that the traditional methods of science "had proved insufficient to deal with theoretical problems, especially in the biosocial sciences" (Bertalanffy, 1956, p.11); [. . .] (Phillips, 1972, pp.469–470)
>
> "Our scientific thinking consists prevalently in the logical manipulation of relationships. That the structure of wholes cannot be described in terms of relationships has, however, been repeatedly pointed outby many writers. [. . .] Here the attempt will be made to demonstrate that there is a logical genus suitable to the treatment of wholes. We propose to call it *system*. (Angyal, 1981, p.27 Italics in the original.)
>
> "What matters is not "knowing everything" about the system in question but understanding the reasons and possible implications of our inevitable lack of comprehensive knowledge." (Ulrich, 1988a, p.342)

4.1 Introduction

In previous chapters, requirements for systems methodologies and methods for modelling organisations (section 2.5) have been derived. Systems methodologies and methods suitable for building the Reference Model of Governance for a Specific Organisation have been identified (section 3.3) and as have suitable methods to generate a shared understanding of a problem situation (section 3.6).

This chapter will describe the approach taken to build a Reference Model of Governance for a Specific Organisation. It is informed by Midgley's Systemic Intervention (Midgley, 2000), Jackson's Critical Systems Practice, particularly (Jackson, 2020a, 2021), and Angyal's dimensions (Angyal, 1941, 1981; Phillips, 1972). The basis of Angyal's work was to "develop some concepts which may be useful for the understanding of the structure of wholes" (Angyal, 1941, p.243). It is for this reason, and not for his work on Personality, that his systemic model is considered.

4.2 Methodological Approach

The overall methodological approach is an injunctive approach based on generating a common and shared understanding of the context of the organisation, considering the social and human factors aspects to include, informed by considering Angyal's systemic dimensions, and applying systems approaches accordingly. The systems approaches are not integrated but are applied pragmatically and in the context of the specific application to an organisation. Within this thesis, they are applied to the GroundsWell research consortium.

This enables a picture, however vague, of the whole organisation to provide a common basis to inform an appropriate governance structure. It is a synthetic method that provides a conceptualisation of the key control factors, enabled by the use of a set of systems approaches, each with a different ontology and epistemology. These are captured within systems models allowing information to be linked between the models, and, as Conant (1969, p.336) states, "regulation demands abundant transinformation".

This section initially introduces Angyal's model and then considers the methods suitable to map to the dimensions. Each method retains its philosophical base, and this provides the important range of perspectives identified by Jackson and Midgley within their approaches. The means of linking information across the methods is described, especially SSM, VSM and SD/CLD, developed from experience by extending the SSM activity analysis table. This is a novel aspect of this thesis that has not be offered before, though it may have been implied.

Though Angyal's model defines how the methods may be applied and knowledge shared across them, it does not help with how you might bring methods to bear to adjust the outcome achieved by the organisation in order to achieve its desired outcome. For this, it is proposed to use the model developed by Peppard and Ward for aligning IT/IS competencies to provide the capability required by an organisation. It is argued that it is equally applicable at the organisation level at the next level of recursion up from an IT/IS department.

4.2.1 Angyal

A number of authors have acknowledged the contribution Angyal has made to systems thinking (Babüroǵlu, 1988; Hughes, 1975; Phillips, 1972; Trist, 1992; Wright, 2012),

though only certain aspects have been considered. These relate to maladaptation within systems (Babüroǵlu, 1988; Emery, 1973; Trist, 1979).

The systems approach that he developed (Angyal, 1941) has merit when seeking to understand an organisation. It provides a multi-dimensional framework with which we can determine what needs to be understood regarding an organisation and against which we can map methodologies. Also, his consideration of the subject/object relationship as a whole, a “Biosphere”, can be considered equivalent to Midgley’s process philosophy.

In his systems approach, Angyal (1941) proposed 3 dimensions in addition to the totality of the individual/organisation within its environment, the “Biosphere”. These three dimensions are the vertical dimension considering depth, the horizontal dimension considering progression and the transverse dimension considering breadth and coordination.

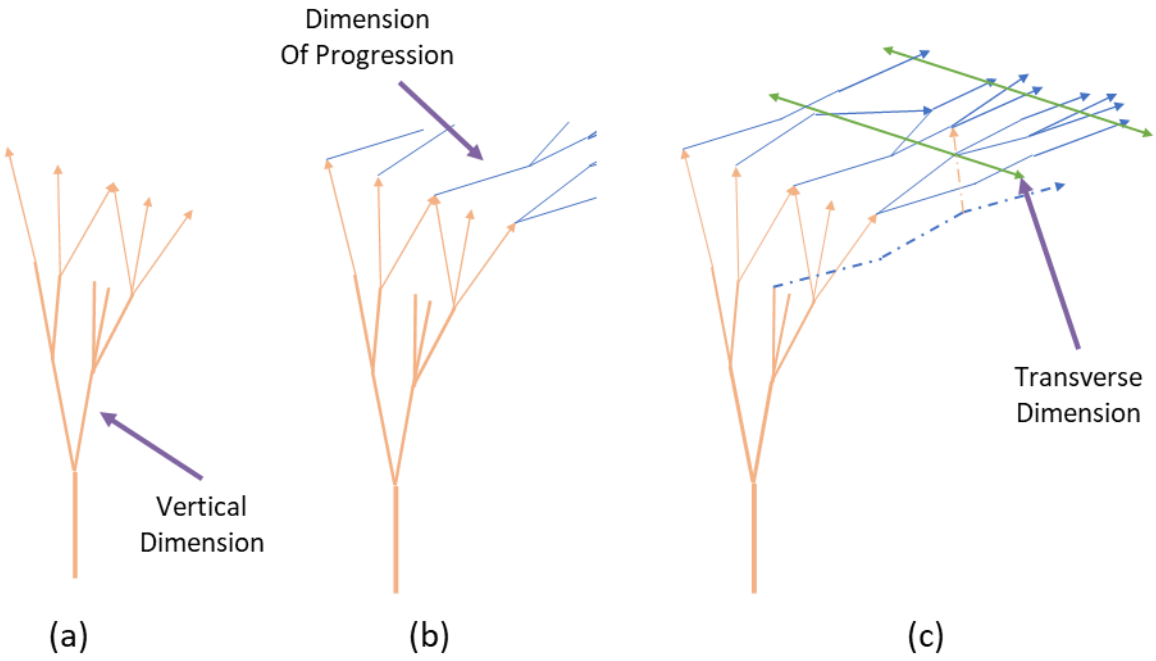


Figure 50- Angyal's Dimensions (Source: Author)

Angyal’s systems approach to the individual has been applied to an organisation. It is contended that as an organisation comprises individuals working towards a common goal in collaboration (or through coercion), the patterns identified at the level of the individual will also be identified in the organisation, and that the perspectives proposed by Angyal are relevant also to the organisation.

In Section 2.4.2, the lamination of organisations is described, particularly using the metaphor of the iceberg and also the hierarchy of purpose. This equates to Angyal's depth perspective. The dimension of progression equates to processes and ways of working, and the transverse dimension equates to managerial control. Section 2.4.3 discussed environmental interactions which equates to the biosphere as well as aspects of the dimension of progression.

The following sections discuss the individual dimensions.

4.2.1.1 The vertical dimension

The vertical dimension (Figure 50 (a)) represents the association between the goals of the organisation as defined by its controlling board or owner and its operations. It incorporates its culture and ways of working. Some of these are explicit, others, implicit. Indeed, some institutions can be very fixed in this respect, whilst other, more entrepreneurial organisations may be much more adaptable. Douglas (1987) provides a discourse on 'How Institutions Think' which can give an indication of drivers of action for some organisations, and Jacobs (1992) distinguishes two syndromes within organisational behaviour, that of the commercial syndrome and that of the guardian syndrome. These equate to 2 different moral stances that (generally) may be taken by organisations which will influence their behaviour and, therefore, the visible actions taken.

These can be considered as attitudes, which Angyal describes (1941, p.136) as "The readiness to behave in certain ways". As the organisation develops, its individuality grows from the centre upwards to take more deliberate actions and downwards to develop increasingly firmly held views.

This dimension of depth can be informed by Kelly's personal construct theory and also ensures a consideration of Kinston's (1986) hierarchy of purpose and Rowbottom and Billis's (1987) levels of work when extending this thinking to an organisation.

4.2.1.2 The dimension of progression

The dimension of progression (Figure 50 (b)) represents the means-end processes of achievement. It is the series of observable actions that an organisation might undertake to achieve, or not, its goals.

It may be taking place as observable behaviour but can equally be unobservable and represent strategic plans and intent.

It is this dimension that really focuses on boundary critique and Midgley's (2000) process philosophy. Consequently, it is one of the most complex dimensions to consider.

4.2.1.3 The transverse dimension

The transverse dimension (Figure 50 (c)) represents the breadth of multiple concurrent actions and the necessary coordination between them. Within the organisation, it could be the individuals in a team, the various departments that need to work together to achieve successful service delivery, or the coordination of service deliveries and business units for optimal resource utilisation, or work packages within a research programme.

From a depth perspective, it could be cross-market intelligence, the relationship between policies, the coordination of processes and the developmental needs of employees to ensure the necessary combination of capabilities for the organisation to be successful.

4.2.1.4 The Biosphere

The biosphere (illustrated at Figure 51) is the integration of the 3 perspectives placed within its environment and considered as a single reality. It is considered that there is no distinction between them, and they can only be separated by abstraction. This is the boundary critique proposed by Midgley. This abstraction incorporates both autonomous determination and environmental government "like two currents of opposing direction, inseparably united" (Angyal, 1941, p.101).

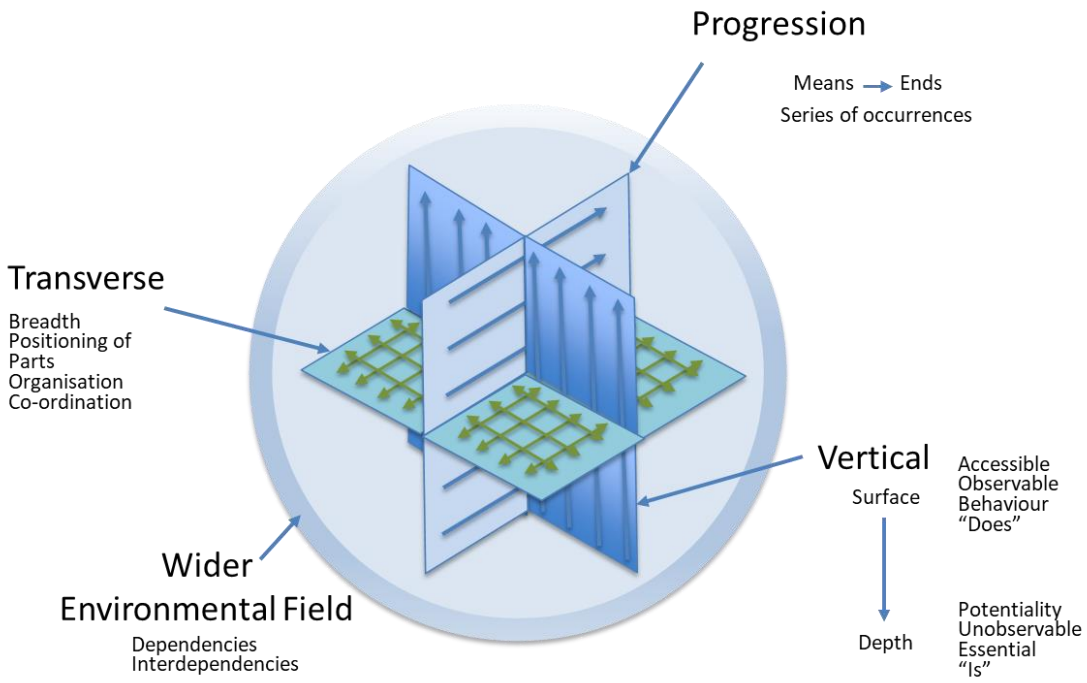


Figure 51 - The Biosphere (Source: Author)

4.2.1.5 The Maladaptive perspective

Though Angyal used his thinking to support his treatment of patients, Emery (1977b) and Babüroǵlu (1988) believed his work applied to organisations and they used Angyal's (1965) "theory of disturbances of integration" to indicate an organisation's passive maladaptation when it struggles to come to terms with a turbulent environment. This is illustrated in Figure 52.

The vertical dimension is the most challenging one to determine within the organisation. Generally, it is through building an understanding or the patterns of observable behaviour in the dimension of progression and the transverse dimension that the individual and collective priorities can be elucidated.

The organisation can receive interference in a number of ways (Angyal, 1941, p.309), the results of which can be observed through symptoms of pressure, intrusion and mutual invasion. This can lead to the segregation of systems (here described with respect to the dimensions) (Angyal, 1941, pp.321–324).

A block or break in the vertical dimension can indicate repression and be observed by the superficiality of action, or dogma. A block or break in the dimension of progression

can lead to frustration and prevents closure. A block or break in the transverse dimension can lead to disassociation and a lack of coordination.

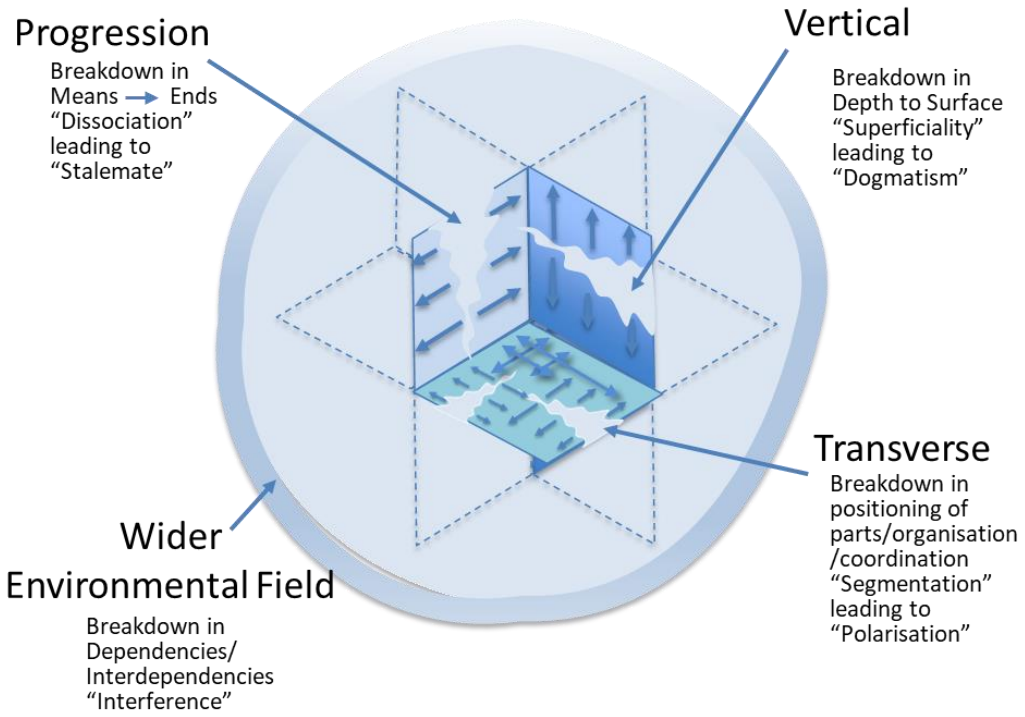


Figure 52 - Maladaptation in the Biosphere (Source: Author)

> "Also, the segregation of systems [leads to] the fragmentation and disintegration of the total function. Sub-ordinate goals become independent and lose contact with the main goal of activity." And "[s]egregation in one dimension is usually followed by segregation in the other dimensions." (Angyal, 1941, p.324)

Crucially he states that "[t]he dynamic nature of life requires the viewing of personality as it passes through time – the present state of the personality is significantly determined by its past" (Angyal, 1941, p.343). Therefore, building an understanding of the history of the organism through narrative and stories is necessary (Cilliers, 1998; Emery, 2000; Mesle, 2008).

It is the three perspectives of the Angyal model that will provide the basis for the thinking when developing the Reference Model of Governance for a Specific Organisation and for linking information between systems methods.

4.2.2 Organisational Capability

This section introduces the Competence to Capability model, illustrated at Figure 53, developed by Peppard and Ward (2004) for enterprise IT/IS and how it is also relevant to the whole enterprise. It is proposed in order to provide a mapping of systems methods that can guide the adjustment of competences and capabilities to ensure the organisation continues to achieve its desired outcomes. It is an additional perspective of how systems methods contribute to the alignment of an organisation's resources to its desired outcomes.

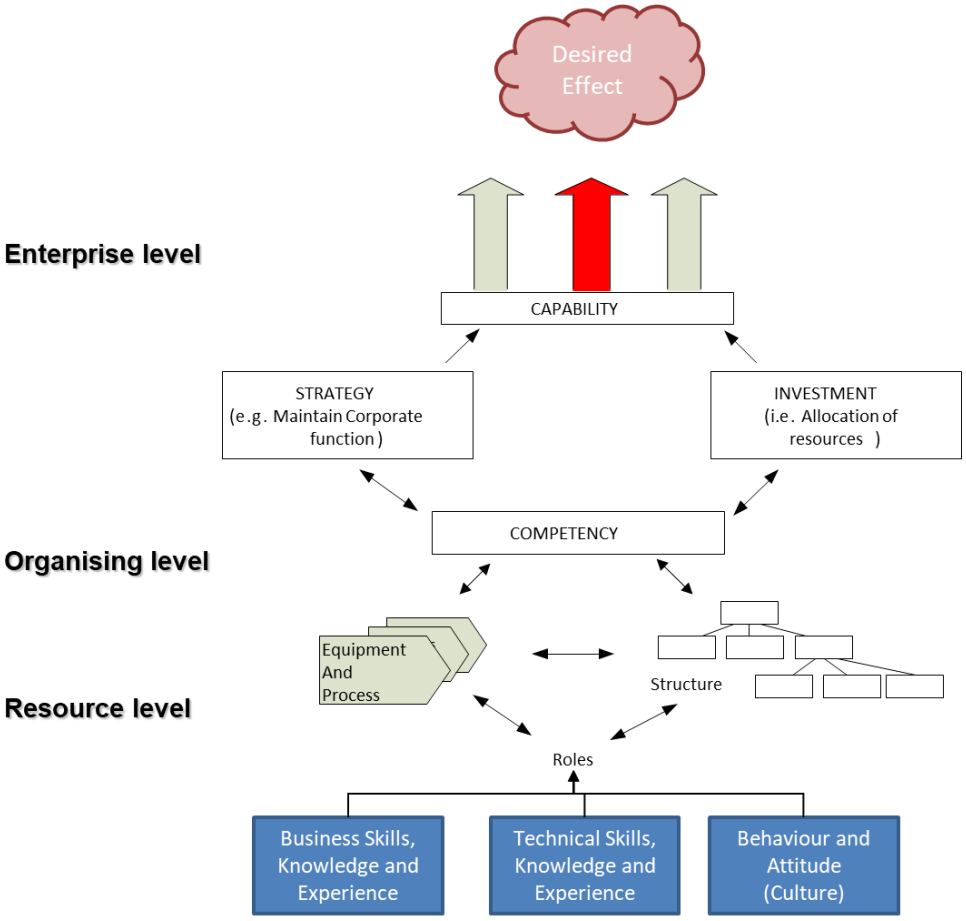


Figure 53 - Peppard and Ward's IS Competency to Capability Model (derived from Peppard and Ward, 2004, p.180)

The people in the organisation have business skills and behaviours, technical skills and behaviours and there is a predominant culture. These are organised into roles within an organisational structure, with processes, procedures and supporting technology, whether information technology and/or machinery. This collectively provides the competencies of the organisation.

The capability of the organisation arises from its strategy, supported by the allocation of resources through investment. Thus, the organisation achieves its purpose, preferably as defined in its strategy. However, the effect will unfold from the operations of the organisation and may not achieve the desired outcomes.

This high-level structure illustrates simplistically the dynamics and adjustable elements. Assuming the strategy is 'correct', associated measures of performance can be monitored to measure the organisation's success in achieving its strategy. If there is a variance, then the initial response may be to adjust the investment in resources (Figure 54 (a)).

If this is not successful, then deeper changes may be required in the organisation. This may be in the change of processes, technology, organisational design and role specification. At an even deeper level, this may require the development of additional or alternative business skills and behaviours and technical skills and behaviours. At the deepest level, the organisational culture may need to be addressed (Figure 54 (b)).

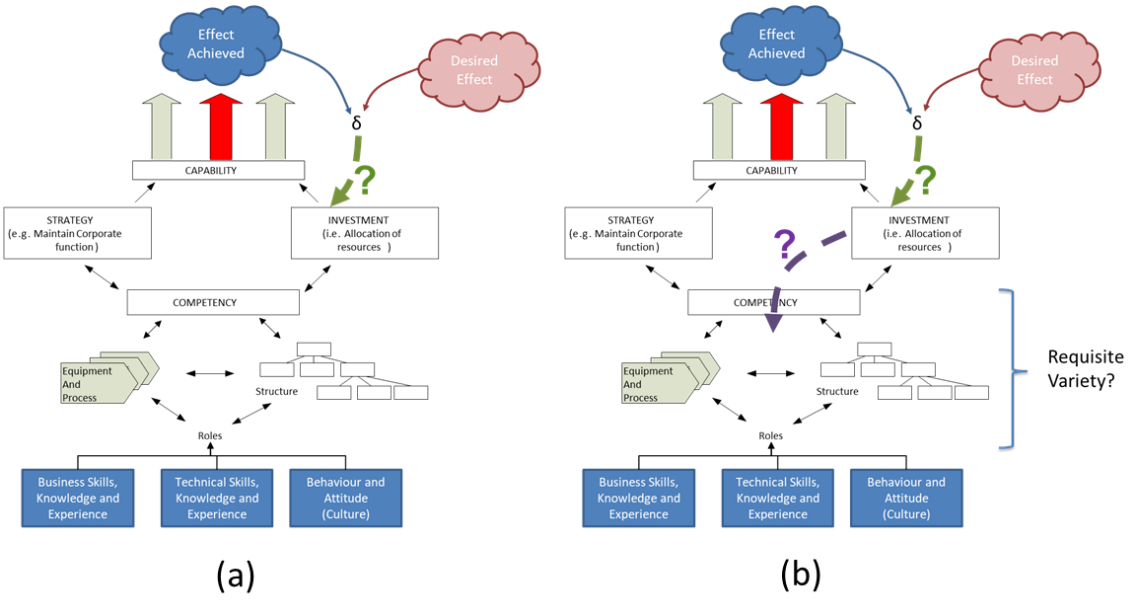


Figure 54 - Organisational foci for adjustment (Source: Author)

The developed Peppard and Ward (2004) model at Figure 54 guides the approach to be considered within the Reference Model of Governance for a Specific Organisation for regulating the outcome of the organisation. Methods are proposed below in Section 4.4 to support this.

4.3 Mapping methods to Angyal's three perspectives

The requirements expressed below, and met by the methods proposed comprise the systems methods to employ when considering an enterprise through the dimensions described by Angyal.

4.3.1 Requirements

4.3.1.1 The vertical dimension

The vertical dimension requires an approach that can relate observable actions to the strategy and goals of the organisation, possibly to the accepted ways of working within that organisation. It should also enable the mapping of opportunities, through plans to action including for potential development or an indication of possible future activity.

It should enable the potential impact of an event or impact to the organisation and how it might rearrange the culture and goals as a result. As Angyal states (1941, p.283) "stimulus does not cause a response, but prompts the organism to respond to it in its own characteristic fashion" and (1941, p.285) "[b]ehaviour, as a rule, involves in various degrees both the manipulation of environmental actors and an adaptive rearrangement of the subjective factors, for the purpose of meeting the situation adequately". Therefore, the method(s) to support this dimension must be able to link to or share knowledge with the method(s) that support the dimension of progression. (This also equates to Sommerhoff's Directive Correlation(Sommerhoff, 1950).)

4.3.1.2 The dimension of progression

Progression, or activity, follows when the organisation does something as a result of its strategy and plans. Therefore, one can argue that there is directed activity if the purpose is well defined, or poorly directed if the purpose is ill-defined. Taking Angyal's means-end description, the desired end corresponds to the purpose, and any systems method should contribute to an understanding of the appropriate means; an acceptable means being congruent with the inner goals and culture of the organisation.

It is important to recognise the significance of this dimension as it stands at the heart of boundary critique. The outcome desired is relevant to each level of the hierarchy in an organisation (Section 2.4.2) through the interactions external to the organisation at that level and will reflect the mental models of those in control at that level or, possibly,

the level above. Mental models here are applicable from two perspectives. First, with regard to what is considered the right outcome at that level and second, what needs to be done to achieve that outcome. These conversations are rarely held, thus leading to confusion at best, and tension and failure at worst.

The organisation does not have complete autonomy, the environment, possibly represented by a competitor, pushes back. Also, aspects of the environment are completely indifferent to the organisation's behaviour. Emery and Trist's (1965) work on Causal Textures informs thinking in this respect. This homonomous action can limit or shape the organisation. Including the customer in this consideration, for example, may be critical to ensure the products and/or services of an organisation remain attractive and are delivered in the most beneficial way, optimised to minimise waste in the organisation and provide the greatest satisfaction to the customer.

4.3.1.3 The transverse dimension

The transverse dimension explores the breadth of activity undertaken; the need for coordination at each level of the hierarchy within the organisation and between levels of the hierarchy. The method(s) should enable the alignment of efficacious activities in parallel and/or in series to ensure a successful outcome. In addition, it should enable the coordination of multiple activity sets across the organisation enabling the identification of arrangements that will impact on the overall success of the enterprise.

At a deeper level within the organisation, planning, research and development, service improvement activities and staff development and training will all need to be aligned and coordinated to maintain the viability of the organisation. This extends beyond just the services and products of the organisation. It also ensures resilience and sustainability.

4.3.1.4 The Biosphere

The biosphere focuses attention on the organisation within its environment as an integrated whole. It makes no assumptions about a defined boundary but supports thinking according to context and perspective (see Section 2.4.3.5 and 2.4.3.6). For example, it includes external dependencies and inter-dependencies on other organisations for supply, distribution, and utilities. It also includes customer

experience, competition, and wider environmental factors that may directly and indirectly act on the organisation.

4.3.2 Candidate methods

The main methodologies identified are not sufficient in themselves to address all aspects of the 3-dimensional model as they do not necessarily reflect the wider contextual understanding of the organisation in its environment as discussed in section 2.4. Indeed, each methodology addresses multiple aspects of the model. There are also a variety of other systemic methods and tools that are available to be applied to enable the complexity of the organisation to be recognised and requisite governance to be established.

In addition to the main methodologies described above, additional methods and tools are proposed to augment the required thinking as identified within the requirements set derived in Chapter 2, repeated below at Table 17.

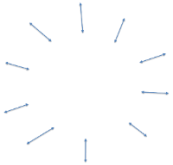
Table 17 - Methods requirements set

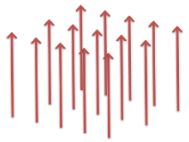
No	Requirement Statement	Source
R1	The Reference Model of Governance for a Specific Organisation must enable boundary analysis.	Section 2.4.3.6
R2	It must be possible to see the effects of history, corporate memory and drives to act	Section 2.2
R3	Changes within the system (organisation) can be identified regarding necessary activities as the organisation adapts to environmental changes.	Section 2.2
R4	The Reference Model of Governance for a Specific Organisation must be able to represent ‘frames’, the perspective taken by the relevant management team according to differing levels of abstraction. The Reference Model of Governance for a Specific Organisation is likely to be recursive (nested) with increasing granularity both horizontally and vertically.	Section 2.4.1
R5	The Reference Model of Governance for a Specific Organisation must be able to determine holistically activities relevant to the agreed frames but maintain logical dependencies and capture the richness of interaction.	Section 2.4.1
R6	Sub-organisations within the organisation or enterprise can be identified that have their own discrete properties (purpose).	Section 2.4.2
R7	It should be possible to determine clusters of elements collaborating at short range as well as indicate the longer-range inter-relationships.	Section 2.4.3
R8	Dependencies between elements must be captured.	Section 2.4.3

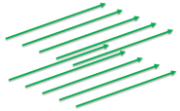
No	Requirement Statement	Source
R9	Measures of performance can be identified.	Section 2.4.3
R10	The Reference Model of Governance for a Specific Organisation must be able to represent the non-linearity of relationships.	Section 2.4.3.1 Section 2.4.3.2
R11	The Reference Model of Governance for a Specific Organisation can capture the feedbacks within the system, between the system and environment and within the environment.	Section 2.4.3.1 Section 2.4.3.2
R12	The Reference Model of Governance for a Specific Organisation must enable one to capture / integrate the environmental inter-relationships as well as internal peer-peer inter-relationships.	Section 2.4.2.5 Section 2.4.3.3
R13	The organisation can be modelled in its wider context.	Section 2.4.3.6 Section 2.4.3.7

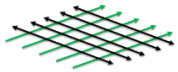
Table 18 - Allocation of Systems Methods to Dimensions

The allocation of methods to requirements is derived from the discussion of methods in Chapter 3, summarised in section 3.5 and my experience as a practitioner.

Orientation	Match to Requirements	Suitable Systems Method	Use of Method	Secondary contributions
Biosphere 	R1. The Reference Model of Governance for a Specific Organisation must enable boundary analysis.	Extended MPA 6 Questions / SSM (Checkland)	Capture perspectives Develop consensus on purpose and key high-level activities ('what' should be done to achieve purpose)	Use of Appreciative Inquiry in a World Café construct.
	R3. Changes within the system (organisation) can be identified with regard to necessary activities as the organisation adapts to environmental changes.	SSM (Wilson) Dependency Modelling	Re-model CPTM with revised Root Definitions. Enables identification of activities no longer relevant and additional activities to be include. Map the internal and external dependencies contributing to the organisation working well	May result from periodic re-visit of Purpose (6 Questions, SSM (Checkland) PQR. Specific events captured by CLD Scenario Thinking/Planning exercise
	R10. The Reference Model of Governance for a Specific Organisation must be able to represent the non-linearity of relationships.	SSM (Wilson)	Logical dependencies between activities	
		VSM	Exploration of the environmental interactions and internal connections	Consideration of Angyal's autonomy and heteronomy.
	R11. The Reference Model of Governance for a Specific Organisation can capture the feedbacks within the system, between the system and environment and within the environment.	System Dynamics	Causal Loop Diagrams	Informed by E&T Causal Textures

Orientation	Match to Requirements	Suitable Systems Method	Use of Method	Secondary contributions
	R12. The Reference Model of Governance for a Specific Organisation must enable one to capture / integrate the environmental inter-relationships as well as internal peer-peer inter-relationships.	SSM (Wilson)	Modelling 'System Served' and detailed analysis of logical dependencies.	
		VSM	Exploration of the environmental interactions and internal connections	Consideration of Angyal's autonomy and heteronomy. Informed by E&T Causal Textures
	R13. The organisation can be modelled in its wider context.	SSM (Wilson)	Modelling 'System Served'	
Vertical Dimension 	R2. It must be possible to see the effects of history, corporate memory and drives to act.	Cognitive Maps	With respect to personal constructs (Kelly) seek to capture the organisational constructs	Kinston's Hierarchy of purpose Explore stories
	R4. The Reference Model of Governance for a Specific Organisation must be able to represent 'frames', the perspective taken by the relevant management team according to differing levels of abstraction. The Reference Model of Governance for a Specific Organisation is likely to be recursive (nested) with increasing granularity both horizontally and vertically.	Extended MPA 6 Questions / SSM (Checkland)	Capture perspectives Develop consensus on purpose and key high-level activities ('what' should be done to achieve purpose)	Small group conversations
		Cognitive Maps	With respect to personal constructs (Kelly) seek to capture the organisational constructs	Kinston's Hierarchy of purpose
	R11. The Reference Model of Governance for a Specific Organisation can capture the feedbacks within the system, between the system and environment and within the environment.	System Dynamics	Causal Loop Diagrams	informed by E&T Causal Textures

Orientation	Match to Requirements	Suitable Systems Method	Use of Method	Secondary contributions
Progression Dimension 	R3. Changes within the system (organisation) can be identified with regard to necessary activities as the organisation adapts to environmental changes.	SSM (Wilson) Dependency Modelling	Re-model CPTM with revised Root Definitions. Enables identification of activities no longer relevant and additional activities to be include. Map the internal and external dependencies contributing to the organisation working well	May result from periodic re-visit of Purpose (6 Questions, SSM (Checkland) PQR. Specific events captured by CLD Scenario Thinking/Planning exercise
	R5. The Reference Model of Governance for a Specific Organisation must be able to determine holistically activities relevant to the agreed frames but maintain logical dependencies and capture the richness of interaction.	SSM (Wilson)	Consensus Primary Task Model, either Enterprise Model or 'W' Decomposition	MPA, 6 Questions, Cognitive Maps Dependency models?
	R7. It should be possible to determine clusters of elements collaborating at short range as well as indicate the longer-range inter-relationships.	SSM (Wilson)	RACI analysis	Mapping to VSM
		VSM	Initial construction of relevant VSMs	Informed by SSM analysis
	R8. Dependencies between elements must be captured.	SSM (Wilson)	RACI analysis	Mapping to VSM
		VSM Dependency Models?	Initial construction of relevant VSMs	Informed by SSM analysis
	R9. Measures of performance can be identified.	SSM (Wilson)	Activity Analysis	Also consideration of metrics SD modelling might inform up-stream and down-stream points of measurement and optimisation
	R10. The Reference Model of Governance for a Specific	SSM (Wilson)	Logical dependencies between activities	

Orientation	Match to Requirements	Suitable Systems Method	Use of Method	Secondary contributions
	Organisation must be able to represent the non-linearity of relationships.	VSM	Exploration of the environmental interactions and internal connections	Consideration of Angyal's autonomy and heteronomy.
	R11. The Reference Model of Governance for a Specific Organisation can capture the feedbacks within the system, between the system and environment and within the environment.	System Dynamics	Causal Loop Diagrams	informed by E&T Causal Textures
Transverse Dimension 	R3. Changes within the system (organisation) can be identified with regard to necessary activities as the organisation adapts to environmental changes.	SSM (Wilson) Dependency Modelling	Re-model CPTM with revised Root Definitions. Enables identification of activities no longer relevant and additional activities to be include. Map the internal and external dependencies contributing to the organisation working well	May result from periodic re-visit of Purpose (6 Questions, SSM (Checkland) PQR. Specific events captured by CLD Scenario Thinking/Planning exercise
	R4. The Reference Model of Governance for a Specific Organisation must be able to represent 'frames', the perspective taken by the relevant management team according to differing levels of abstraction. The Reference Model of Governance for a Specific Organisation is likely to be recursive (nested) with increasing granularity both horizontally and vertically.	Extended MPA 6 Questions / SSM (Checkland)	Capture perspectives Develop consensus on purpose and key high-level activities ('what' should be done to achieve purpose)	Small group conversations
		Cognitive Maps	With respect to personal constructs (Kelly) seek to capture the organisational constructs	Kinston's Hierarchy of purpose
	R6. Sub-organisations within the organisation or enterprise can be	SSM (Wilson)	Consensus Primary Task Model, either Enterprise Model or 'W' Decomposition	MPA, 6 Questions, Cognitive Maps Mapping to VSM

Orientation	Match to Requirements	Suitable Systems Method	Use of Method	Secondary contributions
	identified that have their own discrete properties (purpose).	VSM	Discrete VSMs within the VSM 'set'	Informing and informed by SSM
	R7. It should be possible to determine clusters of elements collaborating at short range as well as indicate the longer-range inter-relationships.	SSM (Wilson)	RACI analysis	Mapping to VSM
		VSM	Initial construction of relevant VSMs	Informed by SSM analysis
	R8. Dependencies between elements must be captured.	SSM (Wilson)	RACI analysis	Mapping to VSM
		VSM Dependency Model?	Initial construction of relevant VSMs	Informed by SSM analysis
	R10. The Reference Model of Governance for a Specific Organisation must be able to represent the non-linearity of relationships.	SSM (Wilson)	Logical dependencies between activities	
		VSM	Exploration of the environmental interactions and internal connections	Consideration of Angyal's autonomy and heteronomy.
	R11. The Reference Model of Governance for a Specific Organisation can capture the feedbacks within the system, between the system and environment and within the environment.	System Dynamics	Causal Loop Diagrams	Informed by E&T Causal Textures
	R12. The Reference Model of Governance for a Specific Organisation must enable one to capture / integrate the environmental inter-relationships as well as internal peer-peer inter-relationships.	SSM (Wilson)	Modelling 'System Served' and detailed analysis of logical dependencies.	
		VSM	Exploration of the environmental interactions and internal connections	Consideration of Angyal's autonomy and heteronomy. Informed by E&T Causal Textures

4.3.3 Summary of mapping

The diagram below at Figure 55 summarises the methods as mapped to Angyal's perspectives.

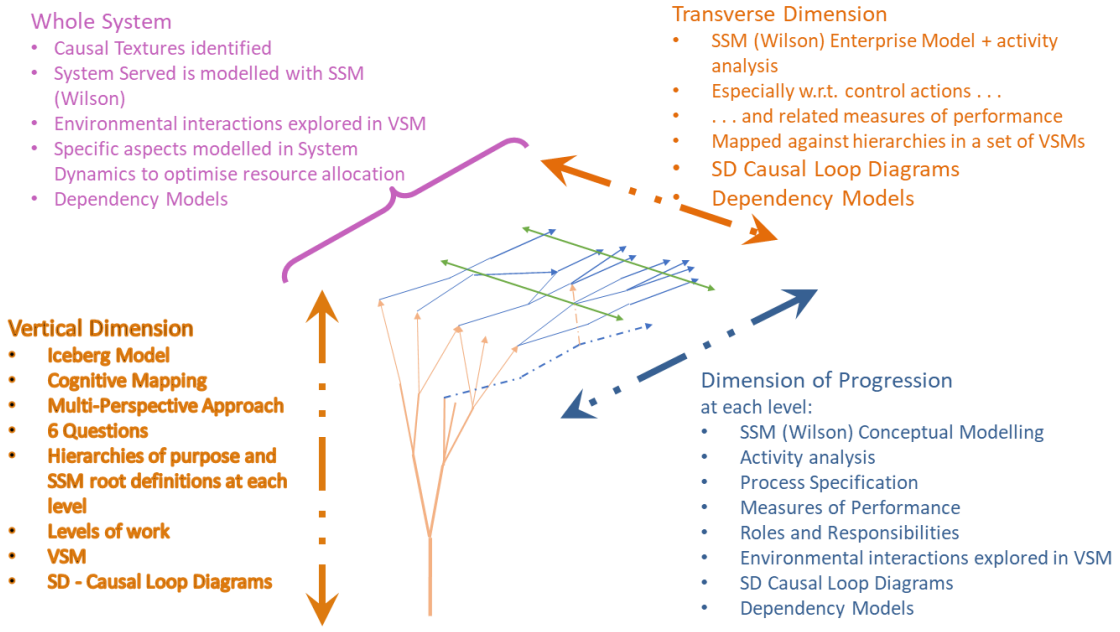


Figure 55 - A summary of the methods mapped to Angyal's perspectives (Source: Author)

4.4 Positioning Methods against Peppard and Ward's Competence to Capability Model

Prior research on a systems approach to resilience had identified the value of Peppard and Ward's Competence to Capability model (Hilton, Wright and Kiparoglou, 2012) and an SSM conceptual model defined (Wright et al., 2012).

4.4.1 SSM

An SSM Consensus Primary Task Model (CPTM) can be developed and should be congruent with the strategy and culture of the organisation and so lead to the desired outcome. The activities can be analysed to determine the necessary variety of resources, including process specifications, roles and responsibilities

and information needs. Ideally it will ensure the requisite variety for the organisation to cope with disturbances. This is illustrated in Figure 56

Effective analysis of the activities, and engagement with the organisation should ensure that the organisation is both undertaking its activities effectively, efficiently and efficaciously, according to its own criteria, and it should be confident it is doing the right things, no more or less.

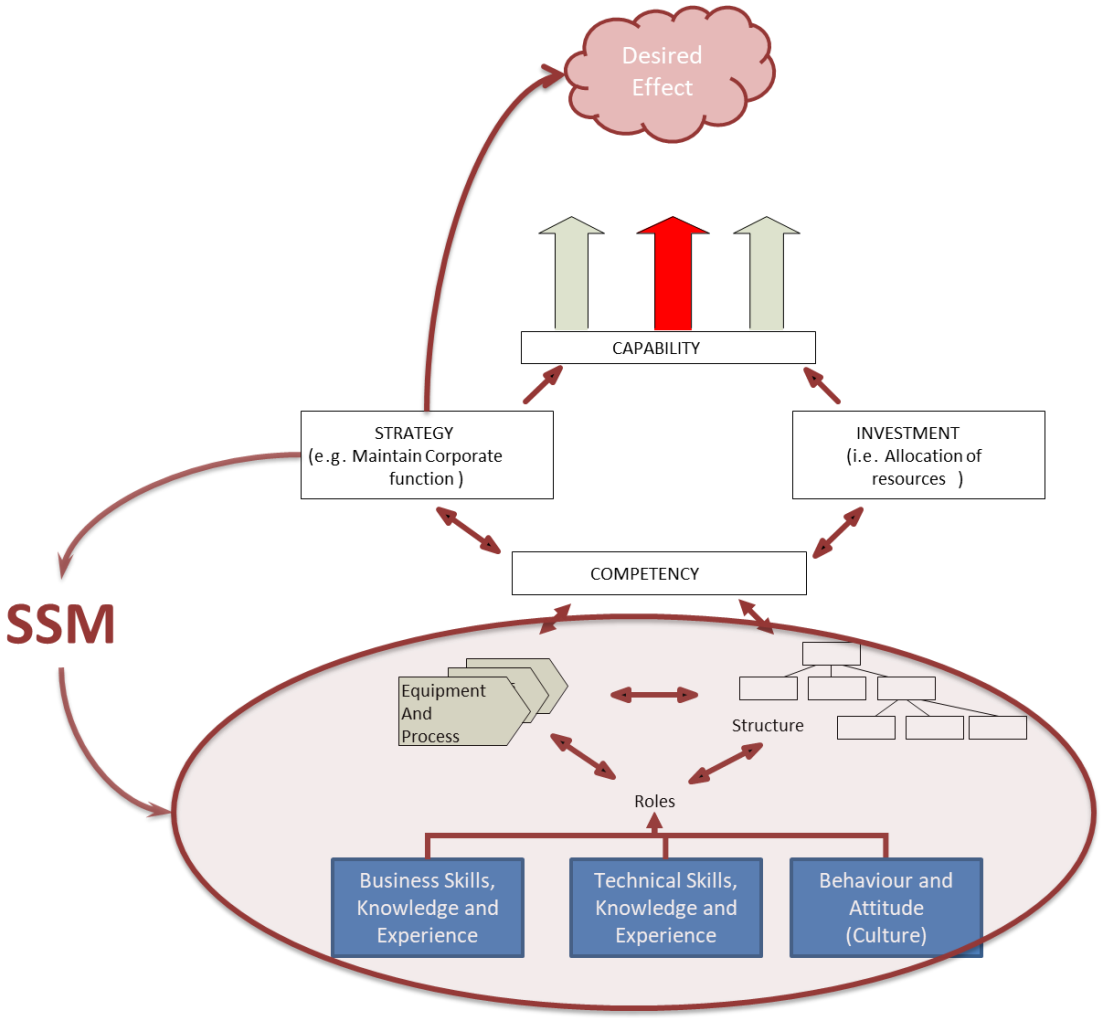


Figure 56 - Aligning resource to strategy (purpose) (Source: Author)

The benefit of this approach, using Wilson's more detailed method (Wilson, 2001), takes an interpretivist perspective based upon the agreed purpose of the organisation. Basing this on the organisation's strategy should achieve this. However, if the desired effect is not being achieved, the organisation may need

'tuning' to optimise its competencies, or it may not have sufficient competencies to achieve its desired outcome.

4.4.2 System Dynamics / Dependency Model

When it comes to optimising the allocation of resources then a positivist approach is beneficial. A Causal Loop Diagram (CLD) can provide an indication of the dynamics and, potentially, counterintuitive behaviours Illustrated in Figure 57. The system archetypes may help in identifying poor behaviours. If optimisation is required, then a quantitative System Dynamics (SD) model can be developed. This will utilise performance data and provide a means of adjusting policy and resource allocation without impacting on operations. Once a potential adjustment has been identified, this can be put into practice.

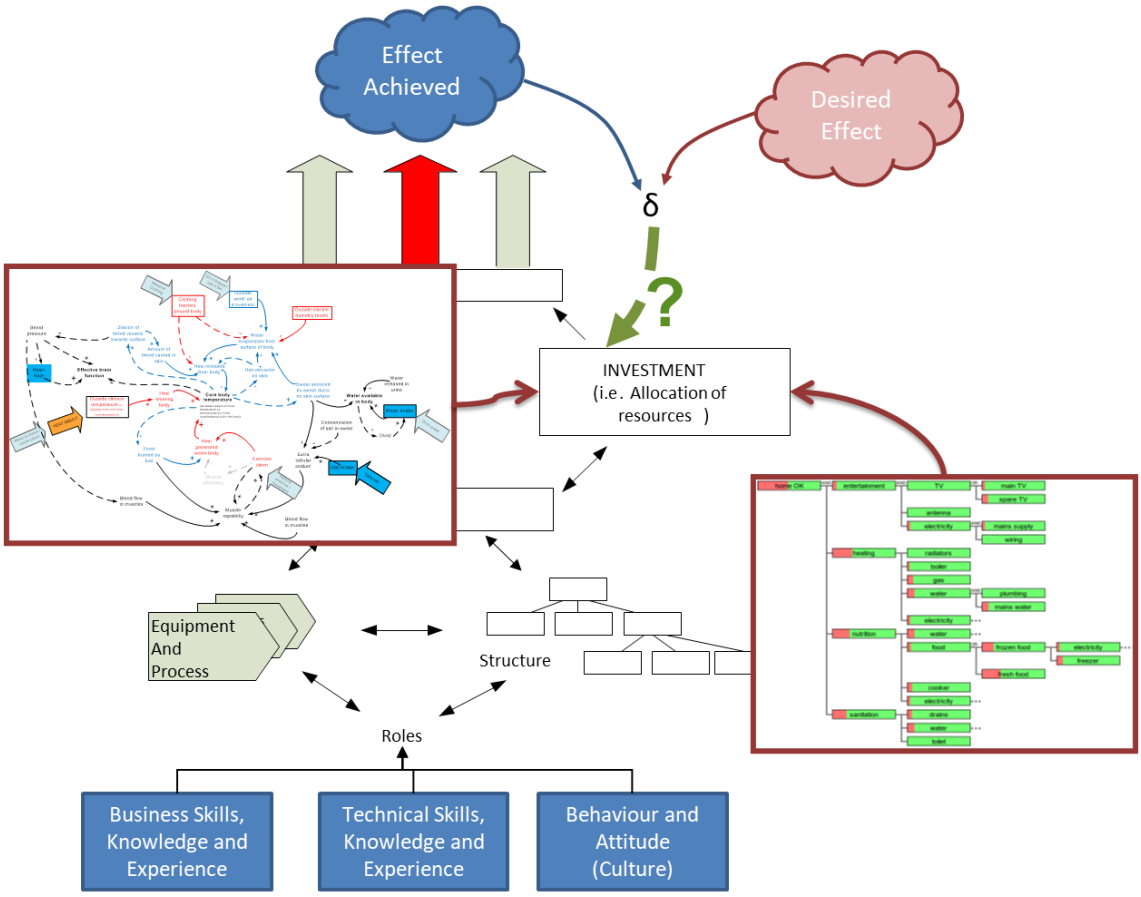


Figure 57 - Methods for adjusting and optimising performance (Source: Author)

A CLD of the organisation's environment to understand the wider environmental field and its impact on the organisation can be developed, as can a CLD of the

organisation itself. Thes two CLDs can then be analysed to determine the optimal upstream and downstream measures of performance.

Another option is to build a dependency model to understand the critical dependencies within the organisation and indicate areas of risk and or concern. These can then be reviewed, and any issues addressed.

4.4.3 VSM

If improvements still remain elusive, then the competencies themselves may need further investigation. Further SSM activity analysis may identify potential areas of improvement, else the organisational structure should be reviewed. VSM is valuable in diagnosing the organisation (illustrated in Figure 58). Aligning it with the SSM CPTM will indicate what should potentially be taking place, and using the VSM as a means of inquiry will enable further analysis.

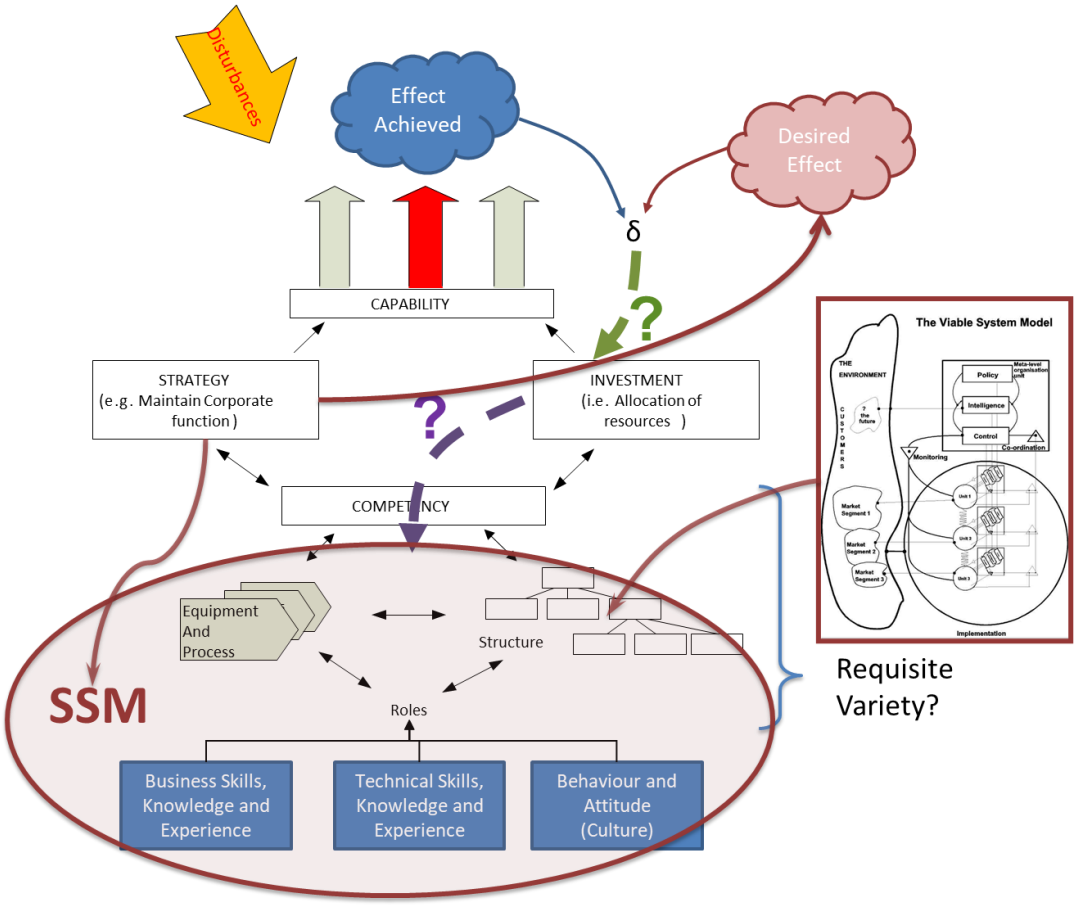


Figure 58 - Re-assessing competencies with SSM and VSM (Source: Author)

Once populated, the VSM can be explored to identify any potential organisational pathologies leading to poor performance.

4.5 Linkage between Methods

Each of the methods provides a different perspective of the problem and linking them to provide coherence is valuable. Each method was developed according to a different ontological perspective according to an independent methodology and was not intended to be linked to another. However, the proposed novel methodology for modelling organisations provides a context for sharing information between the systems methods which is achieved with the SSM activity analysis table. The methods have been introduced above in section 3.3 and will be further expanded below, with a description of a detailed approach to link the methods.

4.6 Review of the use of each Method

This section is divided between how the candidate methods for building a shared understanding across the stakeholders may be used (section 4.6.1), and the main systems methods from within the System of Systems Methodologies introduced in sections 3.2.2.1 and 3.2.3 (section 4.6.2).

4.6.1 Methods for Understanding

The starting point for reviewing any situation, including the governance of an organisation, is to confirm a shared understanding of the wider context of the organisation and the desired purpose and identity of the organisation. This is because we all bring our own perspectives to bear on the situation (section 2.4.3). By this, one means an agreement on what differentiates the organisation from its competition.

An organisation exists to make money and be profitable or, at least in most cases, not operate at a loss. It is intended to provide a return on investment, either to its shareholders, or its owner(s), or both. This is not always the most helpful way of thinking about the organisation. Also, an institution such as a local authority, school, hospital or emergency service does not have an owner or shareholders

per se. They exist to serve the community. What is common, however, is that both have a purpose and cannot be operated at a financial loss.

Building this shared understanding of context and purpose is an active injunctive exercise. Everyone involved will have their own perspective, generally developed from their position and role within the organisation. There are approaches for enabling large group conversations and providing the opportunity for everyone's voice to be heard which include World Café (Brown, Isaacs and Community, 2005) and Appreciative Inquiry (Cooperrider, Whitney and Stavros, 2008). The consideration of these is out of scope, but all of the understanding techniques may be used within them. Generally, building a shared understanding would be undertaken with the key stakeholders and the inclusion of a wider group in a conversation may be considered when deciding to take action for change.

The understanding phase is very much focused on drawing together the knowledge and perspectives of the key stakeholders. Not for any discussion of solutions or to develop a way forward, but to surface what each person thinks is occurring that is relevant to the organisational context. All of the diagrams produced are living diagrams, updated as the conversation develops, and it is helpful to develop them in parallel. The contribution of each understanding technique is considered next.

The Rich Picture (section 3.6.1), Multi-Perspective Approach (MPA) (section 3.6.2) and Context Diagram (section 3.6.5) are frequently used to begin the development of shared understanding of a problem situation. Generally, guided by facilitation, the group would iterate between the methods to explore and share different perspectives. The intent here is not to change anyone's perspective, or seek a resolution, but to build a collaborative understanding of the context and wider environment.

Experience has shown that it is important that someone in the group is always capturing the conversation as ideas and thoughts need to be captured immediately as they are quickly forgotten and cannot be brought back to mind later. Bringing humour into the pictures is helpful, as this begins to involve the creative side of the brain in addition to the analytical side.

Continuing on the theme of surfacing mental models and perspectives, the Cognitive Map (section 3.6.4) is used to draw out, in an unstructured way, the factors and dynamics present and how they are perceived by those present. It helps to surface what they see as significant and how it contributes to the situation, both positively and negatively.

The 6 Cohering Questions (section 3.6.6) can be used formally, or informally, as a convergent technique to begin to align thinking. In formal use, you would consciously work through the questions, bearing in mind that you only wish to have a single answer to question 1. If there is more than one answer, then you would have multiple sets of 6 questions.

With informal use, you would hold the 6 questions in mind during a conversation and use them to guide your conversation to elicit answers. The informal use is often much easier to use with senior managers as it is not so intrusive, and the conversation can flow more naturally. In my experience, managers tend to talk in terms of what needs to be done and tasks are set, without confirming, or even considering what the purpose is, or what is to be achieved. For clarity of action, an agreement on the purpose or outcome is important.

It is helpful to briefly apply a divergent thinking technique, the Ladder of Abstraction (section 3.6.7) to check the purpose and confirm it is at the most appropriate level of abstraction. This checks it is not too strategic, not too tactical. It is helpful also as it should align to the hierarchy of purpose and the level at which the VSMs are developed.

4.6.1.1 Scenario Planning

Finally, though this may not always be relevant at the initial stages of developing a shared understanding of an organisational situation, Scenario Planning (section 3.6.8) may be considered. This is relevant when surfacing potential issues in the environment that might impact on the organisation. This will surface the need for additional preparation and governance within the organisation as well as inform the organisation’s strategy.

4.6.2 The main systems methods

All the prior thinking, clarification and agreements contribute to the next stage to develop the Reference Model of Governance for a Specific Organisation with the main systems methods.

4.6.2.1 Soft Systems Methodology

The primary application of Checkland's approach to SSM (section 3.3.2.1) is to foster dialogue between stakeholders within a problem context in order to allow a resolution to be unfolded. In the organisational context, where it is more of a unitary, or agreed purpose, I have proposed this is achieved with the understanding techniques, specifically through the 6 Cohering Questions, Multi-Perspective Approach and Context Diagrams as it supports a richer conversation. Within the Reference Model of Governance for a Specific Organisation, the method of employing SSM is based on Wilson's approach (section 3.3.2.1), following prior agreement on the purpose of the organisation in the understanding phase.

A Consensus Primary Task Model (CPTM) will be developed using the Enterprise Model Assembly approach (Wilson, 2001, p.75). Once the activities have been identified and validated, they will be analysed against the criteria below at Table 19. The main focus will be on the assess, monitor and control activities because it is a Reference Model of Governance for a Specific Organisation. However, all activities may be drawn upon to guide the operation of the organisation to ensure all activities are aligned to its declared purpose and each level of the organisation's hierarchy.

The Analysis Table will also be the integration point between SSM, VSM and SD/CLD. The following headings will be used:

Table 19 - SSM activity analysis table headings

Activity ID	Activity	Root Definition	Subsystem	Org Unit	Output	Quality Criteria	How Achieved	Who By?

Variable(s)	Measure of Performance	Metric(s)	Dependencies	Organisational Unit (VSM)[6]					
				S1	S2	S3	S3*	S4	S5

Where:

Table 20 - Description of SSM activity analysis table headings

Column Heading	**Description**
Activity ID	A unique reference number for the activity.
Activity	The activity from the Consensus Primary Task Model.
RD	The originating root definition to allow tracking and an audit trail of thinking should the purpose change. This allows the related activities to be identified and changed if required.
Subsystem	The activity cluster that the activity belongs to. A Subsystem is identified by the span of control of the 'Take Control Action' activity.
Org Unit	The organisational unit that undertakes the activity. This provides the link to the set of related VSMs, to guide the diagnosis with VSM.
Output	The product of the activity.
Quality Criteria	The criteria by which the activity is assessed.
How Achieved	What is undertaken to achieve the activity.
Who By?	Who undertakes the activity.
Variable(s)	A variable associated with the activity to provide a link to the CLD and System Dynamics model should one be developed.
Measure of Performance	The measure of performance of the activity. This should relate to the quality criteria and may be related to the variable.
Metric(s)	The specific metrics required by the measure of performance. These should be a product of the activity where possible.

[6] There may be a number of Organisational Units, so these columns will be repeated accordingly.

Column Heading		Description
Dependencies		Those activities upon which the activity being analysed depends upon in meeting its goal/output.
VSM of Organisational Unit	S1	The operational unit of the VSM
	S2	Coordination, coherence and conflict resolution across the operational units
	S3	Day-to-day management of the Organisational Unit
	S3*	Periodic audit by S3 of the operational units
	S4	The external-facing elements of the operational units
	S5	The strategic management/direction-setting of the operational unit.

Where appropriate, this method of SSM will be repeated at each level of the organisation's hierarchy of purpose. A VSM will be developed at each level in the hierarchy, together with a CLD. Linkages across the hierarchy will be identified in the set of VSMs and, potentially, in the CLD.

4.6.2.2 Viable System Model

VSM is employed to position the activities within the functional areas of the model and to indicate the communication between functional areas within a layer of the hierarchy and between layers. It provides the capability to position the SSM activities into a 3-dimensional representation of the organisation according to the levels of the organisation.

A relevant set of VSMs will be constructed from the SSM activity analysis to guide the diagnosis or design of the organisation's governance. If the intent of the Reference Model of Governance for a Specific Organisation is to inform the design of the organisation, then the SSM activities will be used to construct a blueprint for the organisation's development. If the intent is to review the organisations governance, then the SSM activities, once mapped to the VSMs, will be used to support the diagnosis and provide a basis for enquiry.

4.6.2.3 System Dynamics, including Causal Loop Modelling

It is important to capture the dynamics at play both within the organisation's wider context and within the organisation itself. As well as informing the environmental interactions, it helps to identify potential upstream and downstream measures of

success. It relates to the cognitive mapping undertaken in the understanding phase, and in scenario planning, but generally is more detailed.

With ‘Soft SD’ you are modelling a notion of causality, you are seeking an understanding of the interrelationship between variables, so now the variables are defined such that they can be quantified. This is so you can consider the pairwise interactions and determine the correlations between them with regard to the behaviours.

Developing a CLD of the wider context places the organisation within its environment (see Figure 59 below) so you can explore the impact of wider factors and determine suitable indicators of potential disturbances. In line with scenario planning, appropriate responses can be developed to mitigate their impact.

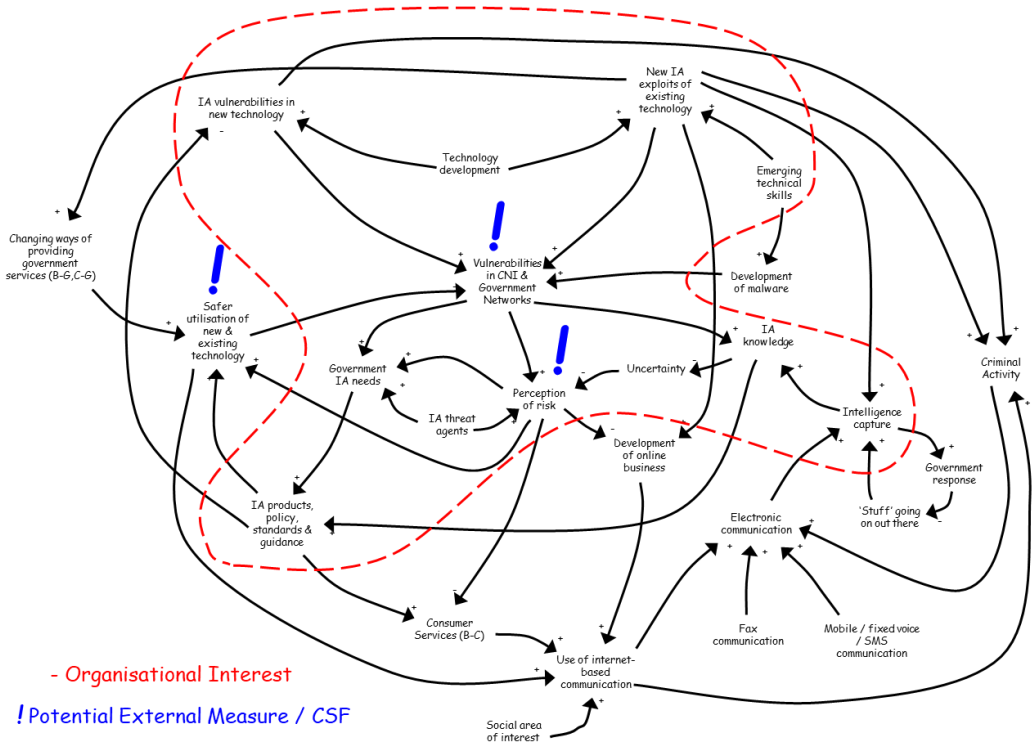


Figure 59 - Modelling the organisation in its environment (derived from Hilton, 1996)

Following this, when you develop the CLD of the organisation, you can incorporate relevant external variables as illustrated below in Figure 60 (and Figure B-3).

Moving from Causal Loop modelling, specific feedback loops can be explored. One particular loop has been highlighted in Figure 61 and this can be modelled quantitatively to explore stocks and flows and optimise the organisation accordingly.

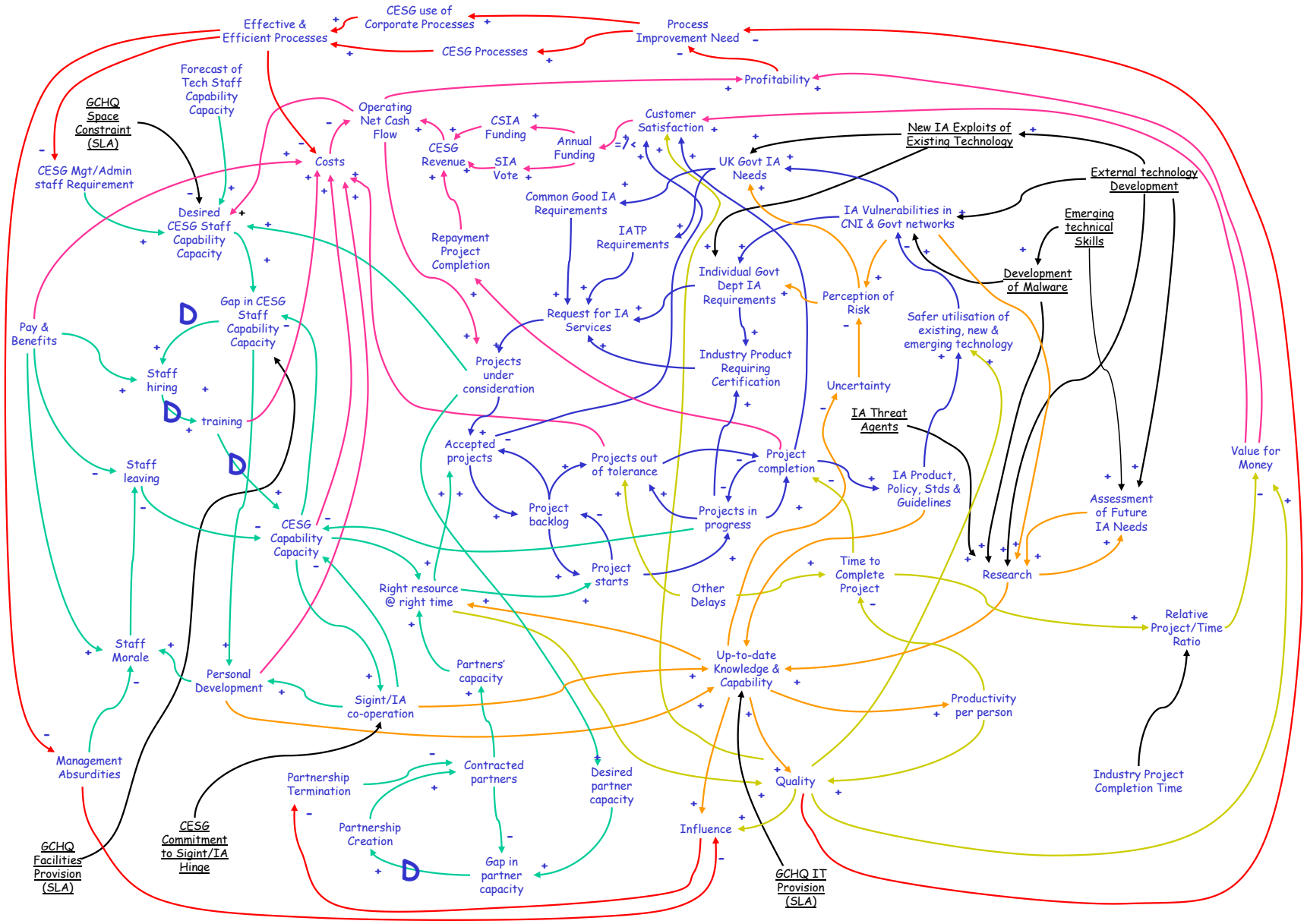


Figure 60 - The CLD of an organisational department (derived from Hilton, 1996)

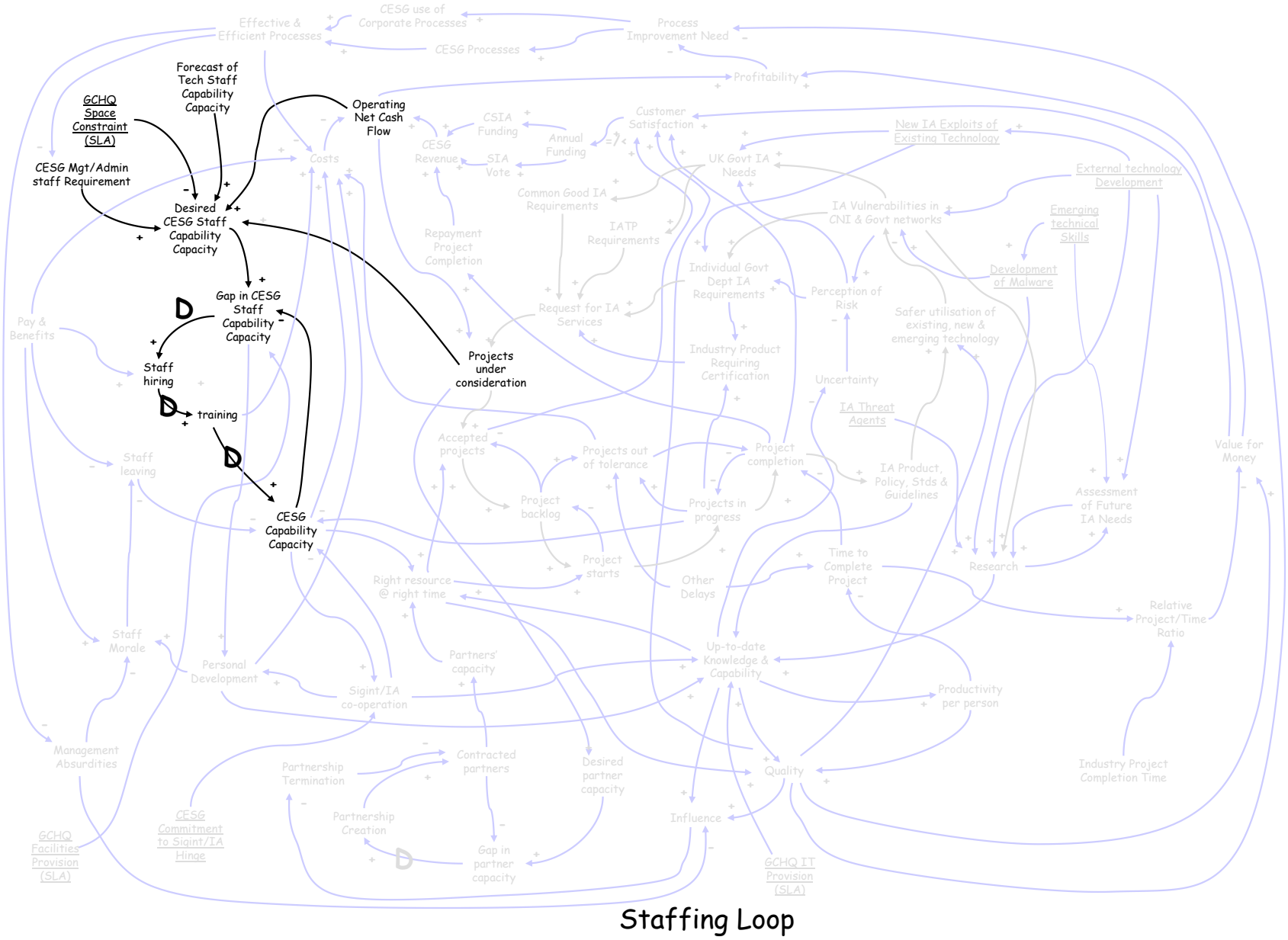


Figure 61 - Investigation of a specific feedback loop (derived from Hilton, 1996)

4.6.2.4 Dependency Modelling

Dependency modelling is useful should you wish to identify the areas of critical dependence for the success of the organisation and, therefore, to identify critical areas of control. It enables all areas of the organisation to be incorporated, including external dependencies such as suppliers, distributers, utilities, cash flow, skills availability for recruitment, etc.

4.7 Shaping with respect to Emery and Trist

Emery and Trist's Causal Textures were introduced above at Section 2.4.3.3, and illustrated in Figure 25. It is important to consider the causal texture relevant to the organisation at its size, scale and level of maturity. As Ashby argues (1960), the system (organisation in this context) inevitably differentiates by developing internal variety to match the variety of its environment. A small organisation may not require a marketing department and research and development section. A large organisation will, and will also need the requisite variety to adapt to the turbulence in the environment.

The consideration of maladaptation to a turbulent environment was discussed above and illustrated in Figure 52. Babüroǵlu addresses this and makes the following points.

> "Active adaptation to turbulence depends on the emergence of values that have overriding significance for the members of the social field as a whole. Members of the social field will have to seek, design, and pursue superordinate values, or ideals, to guide their efforts."
>
> "Only after valued ends and desirable future directions are designed collaboratively can strategies and tactics become meaningful" (Babüroǵlu, 1988, p.182)

I argue that SSM, as I propose to use it, combined with causal loop modelling, following the employment of the understanding techniques, enables such collaborative design and the positioning of their organisation according to its superordinate goals.

4.8 Augmenting thinking with Generic SSM Models

An advantage of Wilson's SSM approach is that generic conceptual models can be developed. For example, within the EPSRC-funded IDEAS Factory – Curative Resilience Scoping Study project (EP/I005919/1), a conceptual model of resilience was developed. This model can be analysed by any organisation to consider what additional activities in addition to those relevant for its primary purpose, may be relevant to improve resilience. (Hilton, Riley and Wright, 2013; Hilton, Wright and Kiparoglou, 2012; Wright et al., 2012)

The model was revised and updated as part of this research (see Appendix D and the subsystem model is included at Figure 62.

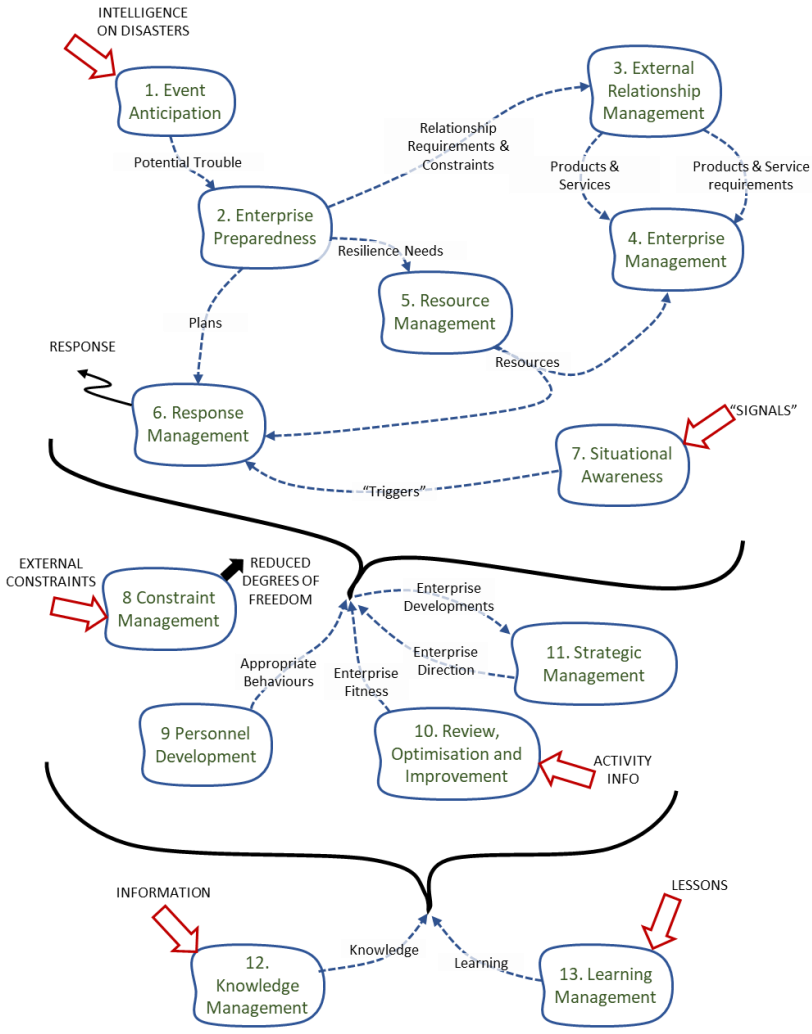


Figure 62 - An SSM Sub-system model of resilience (updated from Wright et al., 2012)

The activities identified can be used as a means of exploring the organisation's level of preparedness in addition to the capability to meet their organisational goals.

4.9 Validating the Reference Model of Governance for a Specific Organisation

4.9.1 Model Validation

Jackson (2022b) provides a discourse on evaluation as part of his Critical Systems Practice (CSP) multimethodology. One of the challenges involved in any multimethodology approach is that each has its own approach to evaluation and validation. Jackson (2022b, p.9) concludes that CSP "seeks to provide order by organizing and employing systems methodologies, models and methods according to the five systemic perspectives". These perspectives are machine, organism, cultural/political, societal/environmental, and interrelationships. He argues that CSP enables evaluation by relating individual systems methodologies, models and methods to these perspectives when evaluating them in their use in a CSP approach. This ensures their theoretical rigour and to ensure their proper application. Jackson (2022b, p.10) concludes that, as CSP is action research, it is iterative. What CSP is intended for is "to achieve and demonstrate improvement viewed from the range of systemic perspectives and their associated measures.

Evaluation consideration is relevant to the use of the Reference Model of Governance for a Specific Organisation in determining 'what governance mechanisms are required to maintain a viable organisation and ensure it achieves its desired outcomes?'. Therefore, the methodology employed to build the Reference Model of Governance for a Specific Organisation is an instance of CSP, so its evaluation should address the points raised by Jackson.

However, my concern is to validate the Reference Model of Governance for a Specific Organisation, to check its validity and acceptability, rather that assess the outcome of its use. In exploring the literature on model validation, relevant to the Reference Model of Governance for a Specific Organisation, especially as it

has a theoretical basis, Validation in Operational Research provided the most useful foundation.

In earlier systems approaches employed within Operational Research, the models were initially judged on their usefulness, then the concern was the degree of representativeness. There are many validation methods for simulation and mathematical models, mainly focused on data quality and model behaviour (Cabrera and Trochim, 2006; Eker et al., 2019; Olaya, 2014; Oreskes, 1998; Saysel and Barlas, 2006; Schwaninger, 2004).

In time, validity and representativeness became synonymous. Then, usability came to the fore (Landry, Malouin and Oral, 1983). This led to the need for model building and validation to run concurrently and to have the participation of the main actors involved. However, validation should not be equated with correctness as two validated models of the same context, developed by different groups, can disagree. From an epistemological perspective, “there are no universal scientific methods nor formal criteria of validity that can guarantee the scientificity of models produced in OR” (Déry, Landry and Banville, 1993, p.180).

Roy (1993) considers three epistemological paths, realism, the axiomatic path and the constructivist path. The realist perspective considers that “models are valid at the level they fit reality” (Landry and Oral, 1993, p.163). He considers the axiomatic path less helpful and “with the constructivist path, 'recommendations' supersede 'prescriptions', the search is for 'working hypotheses' and the criteria of model validity are 'usefulness', 'relevance', and 'viability'” (Landry and Oral, 1993, p.163).

Oral and Kettani (1993) have renamed the entities defined in (Landry, Banville and Oral, 1996) into their context of managerial situation, conceptual model, formal model and decision, otherwise their context remains. They have also described the 4 entities to satisfy a more general use.

‘Managerial situation’ encompasses the problem situation, but also includes the assessment of the manager’s or organisational situation, the assessment of future scenarios and planning for them (some might refer to this as prediction),

strategizing, assessing the environment, etc. For these, there is not necessarily a solution, but a decision might be required. All of these provide ‘intelligence’ to help cope with future opportunities and/or threats.

The conceptual model is the exploration and consensus around the situation under review. It will bring together the various perspectives, preferences, value judgements and knowledge of those involved, as well as a consensus on what should be included, excluded, constraints and assumptions, etc. It might include multi-perspective models, cognitive maps, and rich pictures, etc.

The formal model is a structured representation of the conceptual model. In the systems context, this may be a mathematical model (as within Operational Research), or one of the many systems methodologies in use. In this context, this includes multimethodologies. It might include simulation models if optimisation is desired, scenario thinking and planning models, conceptual models and Viable System Models.

From these, a conclusion and/or decision may result. The models rarely provide the decision, but would inform the decision, allowing judgement to be applied, especially as the models cannot fully represent reality or accurately predict an outcome.

They have taken Landry et al’s 2-dimensional model and constructed a 3-dimensional view (shown at Figure 63) which re-examines the validation stages and introduces new types of validation derived from the facets. Therefore, the 5 aspects of validation are not included as these are replaced by the 4 facets.

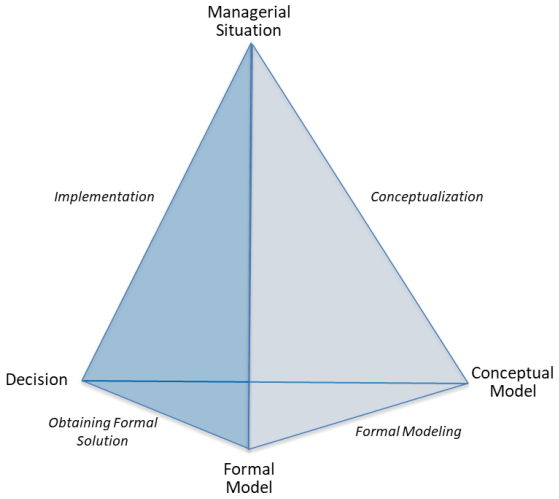


Figure 63 - The quartet of the modelling-validation process (derived from Oral and Kettani, 1993, p.217)

The 4 facets are the Descriptive Facet, the Theoretical Facet, the Prototype Facet and the Pragmatic Facet as illustrated at Figure 64.

The Descriptive Facet is concerned where there is not a particular decision to be made, but a clarification of the situation. Here the priority is on ‘managerial situation’, ‘conceptual model’ and ‘formal model’. Each of the edges of the facet is associated with a particular approach or role. The ‘managerial situation-conceptual model’ edge is concerned with exploring the context in order to generate a common and shared understanding and to surface the relevant aspects for consideration. The role is more of facilitation and analysis. The ‘conceptual model-formal model’ edge is concerned with building structured models of the context to provide a formal basis for description and resolution. The role is to model using relevant systems models. The third edge is ‘formal model-managerial situation’. This is concerned with the explanatory and/or behavioural capacity of the ‘formal model(s)’ and “the extent to which the ‘formal model’ represents the ‘managerial situation’; the credibility, reliability, usefulness, usability, strengths and weaknesses of the ‘formal model’ as well as its contribution to a better understanding of the ‘managerial situation’” (Oral and Kettani, 1993, p.220).

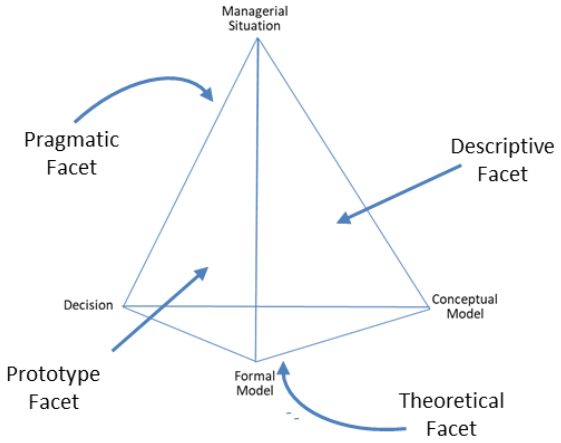


Figure 64 - Positions of the facets (derived from Oral and Kettani, 1993)

The Theoretical Facet is concerned with more abstract concepts and is more of a basic research focus. The ‘conceptual model’ is assumed to be a good representation of the ‘managerial situation’, so it is more about constructing a ‘formal model’ corresponding to the ‘conceptual model’ and developing a set of solution techniques. Here, the ‘conceptual model’-‘formal model’ is the same as described in the descriptive facet. The ‘formal model’-‘decision’ edge is mainly focused on developing solutions from the ‘formal models’ and the role is that of solver. The ‘decision’-‘conceptual model’ edge is concerned with whether the solution corresponds with and is meaningful to the ‘conceptual model’ and the role is more that of verifier.

The Prototype Facet is where the problem is straightforward and ‘known’, one that doesn’t need to be conceptualised. It can be easily formalised and solutions generated for implementation. The ‘managerial situation’-‘formal model’ edge is the construction of a formal model of the situation by a ‘formulator’ role. The ‘formal model’-‘decision’ edge is focused on solutions by a ‘solver’ role as in the theoretical facet. The ‘decision’-‘managerial situation’ edge corresponds to the implementation of the decision/solution.

The final facet is the Pragmatic Facet. It is associated with those contexts where a quick solution/decision is required due to time pressures or is too complex for a ‘formal model’ to be developed. A pragmatic approach needs to be taken, relying on informal or mental models of the ‘conceptual model’ being applied to

develop solutions and support decision-making. The ‘managerial situation’-‘conceptual model’ and ‘decision’-‘managerial situation’ edges have been covered above. Even though the ‘decision’-‘conceptual model’ edge has been covered in the Theoretical Facet, it differs here as it corresponds to those who mainly formulate decisions from conceptual models. The role of prescriber is given as the decisions are formulated from mental models and not formal models where the solver is the role given.

4.9.1.1 Validation types

The facets of modelling and validation described above will provide the basis of validation for the resulting instantiation of the Reference Model of Governance for a Specific Organisation.

Data (common to all types) is used in a broad context and includes not just empirical, quantitative (numerical) data as a subset of written (qualitative and quantitative) data, but also mental data which is the richest. Mental data include the experience, knowledge, perspectives, perceptions. Data validation includes: sufficiency, accuracy, appropriateness, availability, maintainability, reliability, cost and the judgement and creativity of those involved.

Table 21 - Facets and validation types (derived from Oral and Kettani, 1993, p.222)

Facet	**Validation**								
	Unique to facet				Partially common				Com-mon
	*F	L	A	V	E	O	C	G	D
Prototype	1	0	0	0	1	1	0	0	1
Pragmatic	0	1	0	0	0	1	1	0	1
Descriptive	0	0	1	0	0	0	1	1	1
Theoretical	0	0	0	1	1	0	0	1	1

* F:Formulation, L:Legitimational, A:Aptness, V:Verificational, E:Experimental, O:Operational, C:Conceptual, G:Logical, D:Data

The facet relevant to the development of the Reference Model of Governance for a Specific Organisation is the Theoretical Facet. This is because there is no specific managerial situation being addressed, but a solution is proposed for the conceptual model of regulation.

4.9.1.2 Validation for the Theoretical Facet

In addition to data, there are three interdependent types of validation, Verificational, Logical and Experimental (see Table 21 and Figure 65).

Because this facet is dissociated from the managerial situation, there is a concern regarding its relevance to the real-life application of the formal model(s) thus requiring the justification of the potential usefulness of the models and solutions. Therefore, this requires the confirmation that the formal model and related solutions actually conform to a real-life managerial situation.

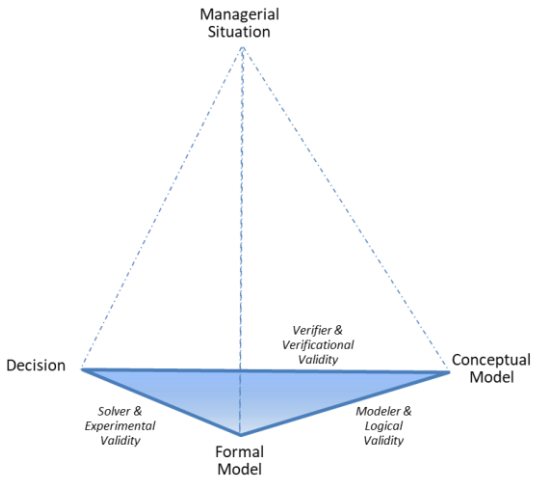


Figure 65 - Validation for theoretical facet (derived from Oral and Kettani, 1993, p.231)

Another aspect of verificational validation regards the merits of the formal model.

> "More specifically, the technical aspect of verificational validation deals with issues such as (i) the extent to which the `formal model' represents the intended `conceptual model' ; (ii) the advantages of the `formal model' compared to other suggested models in terms of gaining new insight ; (iii) the superiority of the solution techniques developed and their accessibility; (iv) the quality and nature of the solutions obtained ; (v) the level of contribution to the extension of pertinent knowledge; and (vi) data requirements." (Oral and Kettani, 1993, p.232)

Logical Validation is concerned with the transformation of the conceptual model into the formal model (Oral and Kettani, 1993, p.228). "Logical validity is therefore the attribute indicating the extent to which the process of formal modelling is correctly and faithfully carried out" (Oral and Kettani, 1993, p.228).

Experimental validation is concerned with “the quality of solutions, the types of solutions, the nature of solution techniques, and the efficiency of solution procedures” (Oral and Kettani, 1993, p.224). It includes the level of understanding and insight into the managerial problem, the sensitivity to changes in values within models, the levels of acceptability and applicability, and the level of usefulness in informing a decision. Types of solution include implicit or explicit solutions and whether the solution is optimal or satisfices the situation. The nature of the technique includes whether it is exact, iterative or trial and error. Finally, efficiency is measured in terms of time, effort and cost.

The development of the Reference Model of Governance for a Specific Organisation in this thesis is theoretical, so these three aspects of validation are most suitable as a basis.

4.9.2 Validation approach for this project

The conceptual model is derived from the literature and forms a set of requirements to be met by the formal model. The logic of the literature review provides the confidence in the basis of the conceptual model. Because the conceptual model is not derived from a specific managerial situation, but one derived from the literature, there is no additional validation of the conceptual model.

The logical validation of the Reference Model of Governance for a Specific Organisation includes the review of systems thinking methods and the multimethod arrangement based on Angyal’s dimensions.

The experimental validation will include the application of the Reference Model of Governance for a Specific Organisation to the GroundsWell research consortium. The three co-directors and Work Package 1 and 2 research PIs/CIs will be solicited for their feedback.

The verificational validation will review the case study models with respect to the conceptual model described in the initial set of requirements.

The validation criteria are described in in section 4.10 and questions derived from these are in section 4.11. The criteria are derived from Oral and Kettani (1993) as discussed above. In addition, aspects from Jackson (Jackson, 2022b) are included. The conceptual model upon which the Reference Model of Governance for a Specific Organisation is derived is the set of requirements listed at Table 8. Therefore, the verificational validity will verify the Reference Model of Governance for a Specific Organisation against these requirements.

In addition to the evaluation of the systems methods and validation of systems models according to their own criteria, the validation of the Case Study will include the conceptual validity of the Conceptual Models.

4.10 Validation criteria

Table 22 - Validation Criteria

Aspect	Criteria	Approach
Data validity	• Sufficiency; • Accuracy; • Appropriateness; • Availability; • Maintainability; • Reliability; • Cost.	These will be with regard to the methods used and related to the Experimental and Verificational validation
Logical validity	• the extent to which the process of formal modelling is correctly and faithfully carried out.	These will be with regard to the methods used. The approach used for each method will be described and related to the guidance provided by experienced practitioners, generally the developers of the method. Variations will be explained and justified.
Experimental validity	This considers: • quality of solutions; • types of solutions; • nature of solution techniques; • efficiency of solution procedures. • level of understanding and insight into the managerial problem; • sensitivity to changes in values within models; • levels of acceptability and applicability; • level of usefulness in informing a decision.	The Reference Model of Governance for a Specific Organisation will be applied to a case study to the degree required. Each method applied will be subject to their related validation criteria. The findings will be discussed with the owners of the case study, and these criteria will form the basis of that discussion.

Aspect	Criteria	Approach
Verificational validity	Provides confirmation that the formal model and related solutions actually conform to a real-life managerial situation. • the extent to which the `formal model' represents the intended `conceptual model'; • the advantages of the `formal model' compared to other suggested models in terms of gaining new insight; • the superiority of the solution techniques developed and their accessibility; • the quality and nature of the solutions obtained; • the level of contribution to the extension of pertinent knowledge.	This will be established with the owners of the case study using the criteria listed. The approach has also been applied in a research project and the model will be reviewed by the co-investigators of that project. In addition, the formal model may be discussed with a team of systems practitioners in a commercial organisation.
Conceptual validity	• Have the stakeholders been identified, and the problem situation considered from the appropriate perspective? • How the managerial situation has been 'unfolded' and the relevance of the perspective with regard to appropriate solutions; • Has the root definition(s) been determined and ownership by the problem owner agreed (Wilson, 2001)? • The formulation of goals on which to focus the modelling-validation process, • Are the constructs (cognitive maps) representative of the situation as perceived by the actors (Eden, 1988)? • Is the managerial situation explored from the following perspectives (Jackson, 2020a)?: – Machine; – Organism; – Cultural/political; – Societal/environmental; – Interrelationships.	These will be with regard to the methods used and co-created in workshops to provide the conceptual basis for progression.

4.11 Validation Questions

The Reference Model of Governance for a Specific Organisation has been partially validated through the mapping of methods to the dimensions and aligned to the requirements set. The Theoretical Facet validation approach (section 4.9.2) will be applied to complete the validation. It is not possible to properly validate the Reference Model of Governance for a Specific Organisation until it is instantiated as it needs to be completed according to the specific organisational context. The Conceptual Model the Reference Model of Governance for a Specific Organisation is based on has been validated by meeting the requirements defined in Chapter 2, repeated at Table 17 and mapped to the dimensions in Table 18. Consequently, following the instantiation of a Reference Model of Governance for a Specific Organisation, the validation of the formal modelling of the Reference Model of Governance for a Specific Organisation will be by applying the Logical Validity questions:

Table 23 - Logical Validity Question Set

Area	Question
Logical Validity	Does the Reference Model of Governance for a Specific Organisation capture and reflect the relevant range of perspectives within the situation as reflected and are the following metaphors considered? • Machine; • Organism; • Cultural/political; • Societal/environmental; • Interrelationships.
	Have the boundaries of the situation been explored and agreed?
	Are the interrelationships identified (these may differ according to methodology/method)?
	Has the hierarchy of purpose (emergence) been established?
	Have the dynamics at each level and between levels been identified?
	Have the management communications and controls been identified as related to purpose/emergence and leach level of the hierarchy?

The utility of the Reference Model of Governance for a Specific Organisation will be validated with the Experimental Validity questions:

Table 24 - Experimental Validity Question set

Area	Question
Experimental Validity	Does the Reference Model of Governance for a Specific Organisation enable an appropriate level of understanding and insight into the managerial problem?
	Is the Reference Model of Governance for a Specific Organisation sensitive to changes in values within models?
	What is the level of acceptability and applicability of the Reference Model of Governance for a Specific Organisation?
	How useful do you think it is/could be in informing a decision?

The final set of questions from the Theoretical Facet are the verificational validity questions. These complete the validation by returning to the conceptual model as represented by the initial requirements set.

Table 25 - Verificational Validity Question Set

Area	Question
Verificational Validity	To what extent does the `formal model' represent the intended `conceptual model'?
	What are the advantages of the `formal model' in terms of gaining new insight (perhaps compared to other models)?
	How superior do you think the solution techniques developed might be and how accessible do you think they are?
	What is the quality and nature of the solutions obtained?
	What is the level of contribution to the extension of pertinent knowledge?

4.12 A schematic of the Reference Model of Governance for a Specific Organisation

The diagram at Figure 66 illustrates the arrangement of the methods, around an organisational context (shown as a blue cube).



Figure 66 – Schematic of the Reference Model of Governance for a Specific Organisation (Source: Author)

The organisational context may be viewed through the different systems lenses, but they are derived from a common data set derived by the approach described in the next section.

4.13 Guide for Building the Reference Model of Governance for a Specific Organisation

This section outlines the approach to be taken to build the Reference Model of Governance for a Specific Organisation.

Considering the organisation as a ‘system’, and applying some simple soft systems methods, it is possible to achieve consensus and arrive at a basis for discussion. However, there is the initial challenge of gaining an accommodation of perspectives of those contributing to the model building, sweeping in the broader context of the situation and recognising the patterns and structures that might be leading to the behaviours observed, the complexity involved (Geary et al., 2021). For ill-structured, ill-defined and fuzzy problems, softer systems methods such as Soft Systems Methodology (Checkland and Poulter, 2006; Wilson and Van Haperen, 2015) and Critical Systems Heuristics (Carey et al., 2015; Ulrich, 2005) have been employed. It has been demonstrated, however, that a single systems approach can rarely address situations effectively, leading to a critical systems thinking approach, where multiple methods may be employed (Jackson, 2019).

The outcome is learning and gaining a better understanding rather than a ‘solution’. However, learning about and understanding the system should help us to see more clearly where computers can be used to improve processes. Critical here is the boundary discussion, determining by consensus or accommodation what is inside the boundary and what is outside (Churchman, 1979; Spencer-Brown, 1969; Ulrich, 1988b, 1996). This requires time spent sharing and exploring the range of mental models and perspectives present amongst the stakeholders and participants to the conversation.

In outline, the following steps enabling an injunctive approach are undertaken to build a Reference Model of Governance for a Specific Organisation.

1. Ensure a common and shared understanding of the organisation amongst key decision-makers.

1. Develop detailed models in SSM and VSM.

2. Explore boundary interactions, especially with respect to VSM S4s including identifying key stakeholders, and VMS S1s to identify key interactions and dependencies.

3. Develop a causal loop diagram for the organisation including its environment and the internal aspects of the organisation. The aim is to identify key control areas, and to identify upstream and downstream measures of success. Then map them to the enterprise model.
4. Build the dependency model.
5. Throughout, continue to iterate the models as additional learning is identified, resulting in the Reference Model of Governance for GroundsWell.
6. Validate the formal models and the Reference Model of Governance for a Specific Organisation set with the Logical Validation question set and the Experimental Validation question set.

4.13.1 Ensuring a common and shared understanding

The initial stage is to bring together the key decision-makers and relevant staff to draw out their knowledge and perspectives and generate a common and shared understanding of the organisation, or organisational unit if the whole organisation is not being considered, in order to frame thinking around the organisation within its environment. The understanding techniques should be used as previously described to build this understanding. It is preferable to work in multiple groups of 4-5 people in the room together as this engenders conversation between all present.

The intention at this stage is to surface all the perspectives amongst the staff, as well as their understanding of those other stakeholders outside the organisation, but relevant to the organisation's success. It is also to collate knowledge, experiences and potential constraints.

The outcome, captured in a range of conceptual models and notes, will be the agreement and clarification of the purpose of the organisation. What differentiates it from others? What is its uniqueness? There will be agreement of the key external stakeholders and their perspectives, the major factors that impact on the organisation and key issues to be considered. This stage lays the groundwork for the formal systems modelling stage to follow.

4.13.2 Developing the Reference Model of Governance for a Specific Organisation

The Reference Model of Governance for a Specific Organisation is derived from linking of SSM, VSM, CLDs and Dependency Modelling through shared information. Therefore, this stage is the generation of the formal models in an integrated way. This implies that the practitioner(s) must be proficient in the application of the systems methods, as well as having a clear understanding of their philosophical basis to understand the knowledge gained and how it will contribute to improved decision-making. The Reference Model of Governance for a Specific Organisation is a coherent source of information about the organisation for decision-making. It does not, by itself, provide answers, but is to be used to inform decision-making and providing answers to questions. It enables an injunctive approach to be taken to build a shared understanding and capturing it.

Though the methods are discussed sequentially, this may be only the starting point as they will be applied in parallel and iteratively as one method informs and updates others.

4.13.2.1 Soft System Methodology

From the understanding stage and boundary considerations, there will be agreement on the purpose of the organisation and the organisation's relationship and interconnections with the environment. The initial stage will be to develop a Consensus Primary Task Model (CPTM) either of the organisation, or of the wider system served by the organisation.

If modelling the organisation, then the subsystems can be mapped to the relevant levels within a set of Viable System Models (VSMs). This initial mapping is used to guide the diagnosis of the organisation with VSM and to determine appropriate VSM System 1s. When engaging with managers across the organisation, they will describe what they believe is relevant and having an initial mapping from SSM ensures that all relevant aspects are covered. Relevant in terms of alignment to the purpose of the organisation. The initial SSM mapping will also begin to highlight relevant levels in the organisation, allowing a discussion on the differing purposes at each level.

If modelling the system served, the wider context of the organisation, then the CPTM is reviewed to determine the activities relevant to the organisation, and an overarching purpose of the organisation derived. Following this, the approach described above is then followed.

A simple example to consider is if the organisation is in the motor trade. It could develop a CPTM for a garage and incorporate the mental models of the decision-maker as to what their garage is. Alternatively, the wider transport system could be modelled, and those activities chosen by the organisation would determine what they would take a garage to be. This ensures a direct incorporation of the organisations within its environment from the outset.

Whichever approach is taken, the final set of activities is analysed according to Table 19 above. The governance activities are the primary interest, so the analysis table is filtered to just show these. The full activity set will have utility for other purposes. This analysis table provides the link between the methods to ensure coherence. Consequently, the type and format of data within each of the columns is relevant to the method it links to.

In addition to the CPTM developed for the purpose of the organisation, the activity table can be augmented by other generic CPTMs such as the Resilience CPTM mentioned above and included at Appendix D. It is likely that many of the activities within that model are already taking place within the organisation, but it can generate a useful conversation to improve the requisite variety of management capabilities to deal with disturbances.

4.13.2.2 Viable System Model

From the analysis table, the subsystems are initially positioned within a hierarchy of VSMs in order to build a relevant set of VSMs. The Monitor and Control Action activities from the SSM subsystems are mapped to the relevant VSM to guide a conversation with managers to diagnose exactly what and how they manage the organisation. the findings are added to the VSM and incorporated in the SSM activity analysis table to ensure completeness and coherence of the Reference Model of Governance for a Specific Organisation.

Some of this data would describe how the management action takes place, by whom and what information is used for management. The SSM activity analysis will include the criteria related to the management of the business and potential metrics. Conversations with managers when diagnosing the organisation will confirm this or correct it. Where the activity does not take place, a discussion can be held as to whether the activity should be introduced.

4.13.2.3 Soft System Dynamics – Causal Loop Modelling

The SSM activity analysis and Diagnosis with VSM will surface variables that can then be used to generate a Causal Loop Model. This is best undertaken in a Group Model Building (GMB) exercise to incorporate the views of the key stakeholders when building the Causal Loop Diagrams (CLDs) as well as share an understanding of the factors relevant to the business and their potential impact on the organisation and on the behaviours within the organisation.

CLDs should be generated both for the wider organisational environment as well as within the organisation.

4.13.2.4 Dependency Modelling

The final model to develop is a dependency model. This will also be generated in a collaborative way as it is important that all key stakeholders are involved. This is because the discussion successively decomposes those factors that the organisation depends upon to successfully meet its goals. The level of dependency requires a subjective agreement on the likelihood of success at each successive layer of the model.

The CLDs (of the wider environment and internally to the organisation) and the logical dependencies in the CPTM provide a starting point for building the dependency model, but it is the hierarchy of successful goals and subgoals that have to be surfaced and not just variables.

4.13.3 Exploring the boundary interactions

An adjunct to building shared understanding is the focus on the boundary interactions. As discussed in the section on complexity (Section 1.2), no one

person can understand the entirety of the organisation, so there cannot be a clear determination of the boundary of the organisation. The illustration at Figure 67 indicates which methods can be used to explore the boundary interaction.

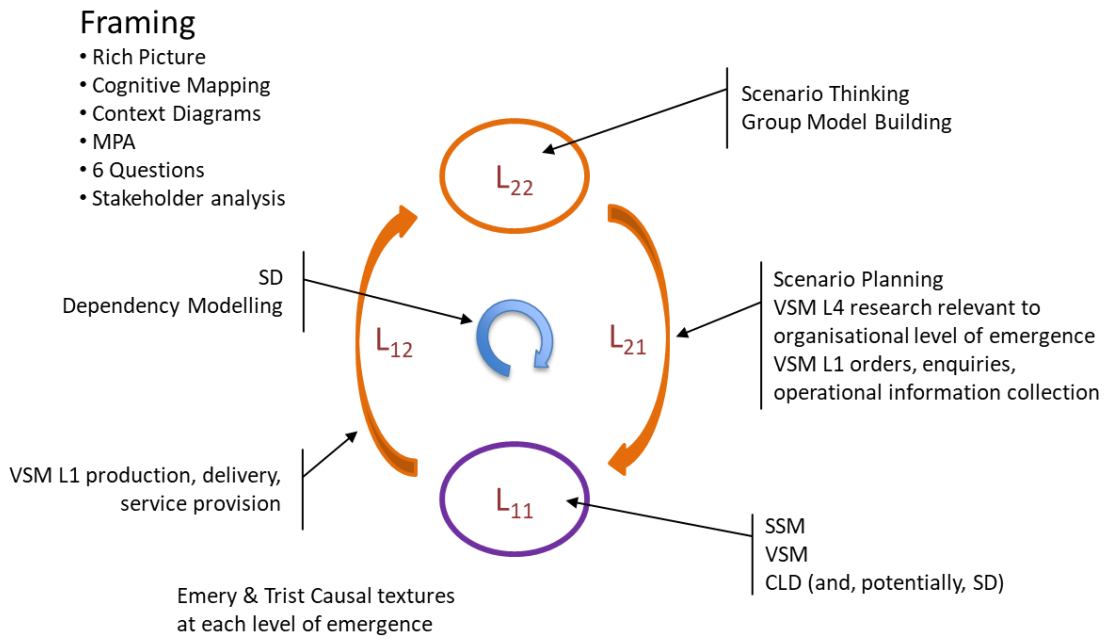


Figure 67 – Boundary Consideration - methods mapped to the system-environment (Source: Author)

Most applications of systems thinking tend to consider the organisation internally as something distinct from its environment (Midgley, 2000). Therefore, due to the indeterminacy of the boundary, starting by considering the organisation within its environment enables the exploration of the key interactions relevant to the success of the organisation. Therefore, it is necessary to involve managers from all aspects of the organisation in the conversation, and development of a shared understanding of the system-environment interaction.

A consideration of the Emery and Trist Causal Textures (1965) (section 2.4.3.3) provides a helpful reference when considering the level of complexity relevant to the organisation. Following this, a consideration of what is produced and shared with others in the environment and what is assimilated from the environment is necessary. It might also be appropriate to explore the turbulence within the environment itself through scenario thinking and planning.

This stage is necessary in order to build that shared view of the complexity of the organisation-environment interactions to support the formal modelling stage that follows.

4.13.4 Validation

Each system method has its own internal validation approach to provide confidence in the development of the system models. The Reference Model of Governance for a Specific Organisation is validated against the requirements set and logical validation question set.

4.13.4.1 SSM Validation

The use of the formal systems model to validate an SSM conceptual model has been denigrated in recent years due to the use of CATWOE and that it "blurs the distinction between the real world language of problem situations and the language of systemic thinking about the real world" (Checkland and Scholes, 1990, p.41).

> "The question of technical validation is now faced by asking whether a pairing of root definition and model is defensible. Each phrase in the root definition should lead to particular activities in the model; each activity in the model should be traceable back to a particular word or concept in the root definition. The measures of performance for the efficacy, efficiency and effectiveness of the model must be linked to the words of the root definition and the Weltanschauung it expresses. If such links can be demonstrated and defended then the model can be regarded as good enough to be used in the comparison phase."(Checkland, 1995, p.53)

He continues by saying the distinction between hard and soft model validation is that the hard model must be validated by showing the model represents reality, whereas the soft model only has to be internally valid. (Checkland, 1995)

4.13.4.2 VSM Validation

VSM itself has been validated over time, mainly through homomorphic mapping, to be a useful construct with which to either diagnose an organisation's pathologies, or to structure problems. (Beer, 1984; Lowe, Espinosa and Yearworth, 2020)

VSM is based on cybernetic principles and Beer was very much involved in operations research. Therefore, the OR validation approach in (Oral and Kettani, 1993) is relevant. The challenge is to ensure the identification of the variety in the environment and its communication into and within the organisation is not underestimated. Also, the attenuation and amplification across the lines must be considered and not just the elements within the boxes representing the VSM systems at each level of recursion. (Beer, 1984)

As with SSM, people within viable systems are considered to be purposeful and will contribute to the intent of the organisation according to their role. They have the choice to stay or leave, but that is not an issue provided their role can be replaced by another capable incumbent.

4.13.4.3 System Dynamics Validation

Validation methods for simulation and mathematical models are mainly focused on data quality and model behaviour. Therefore, the initial causal loop model can be confirmed with others knowledgeable of the context and who have developed a shared understanding of the purpose of the model and the factors relevant to the model. In other words, the ‘managerial situation’-‘conceptual model’ edge, leading to the development of the causal loop diagram which is the related conceptual model for that method. The related System Dynamics model can be validated with historical data to provide confidence in the behaviour of the model within the context of modelling, as described by the causal loop model.

4.13.4.4 Validation of the Reference Model of Governance for a Specific Organisation

Table 26 below maps the Reference Model of Governance for a Specific Organisation against the requirements set.

Table 26 - Validating the Reference Model of Governance for a Specific Organisation against the Requirements Set

ID	Requirement	How Fulfilled
R1	The Reference Model of Governance for a Specific Organisation must enable boundary analysis.	Capture perspectives with MPA/6 Questions / SSM (Checkland), informed by E&T Causal Textures. Consensus on purpose developed and key high-level activities ('what' should be done to achieve purpose and by whom, for whom). Achieved by use of Appreciative Inquiry in a World Café construct.
R2	It must be possible to see the effects of history, corporate memory and drives to act.	Cognitive maps will capture and indicate the organisational constructs and influences. This is informed by the hierarchy of purpose and relevant stories recounted in collaborative workshops. Over time, changes in the Enterprise set of root definitions and associated CPTMs and activity analysis, as well as changes to the VSMs will show the effects of change over time.
R3	Changes within the system (organisation) can be identified with regard to necessary activities as the organisation adapts to environmental changes.	Re-defining the Enterprise set of root definitions and re-modelling the CPTM. Enables identification of activities no longer relevant and additional activities to be included. This may result from a periodic re-visit of Purpose (6 Questions, SSM (Checkland) PQR, specific events captured by CLD, and/or a Scenario Thinking/Planning exercise
R4	The Reference Model of Governance for a Specific Organisation must be able to represent 'frames', the perspective taken by the relevant management team according to differing levels of abstraction. The Reference Model of Governance for a Specific Organisation is likely to be recursive (nested) with increasing granularity both horizontally and vertically.	Use MPA/6 Questions / SSM (Checkland) to capture perspectives. Develop consensus on purpose and key high-level activities ('what' should be done to achieve purpose). Undertaken in small group conversations, or World Café style large group conversations. Develop cognitive maps, with respect to personal constructs (Kelly) to capture the organisational constructs, informed by the hierarchy of purpose.

ID	Requirement	How Fulfilled
R5	The Reference Model of Governance for a Specific Organisation must be able to determine holistically activities relevant to the agreed frames but maintain logical dependencies and capture the richness of interaction.	Building on MPA, 6 Questions, Cognitive Maps, develop an SSM (Wilson) Consensus Primary Task Model (CPTM), either Enterprise Model or 'W' Decomposition.
R6	Sub-organisations within the organisation or enterprise can be identified that have their own discrete properties (purpose).	Achieved with an SSM CPTM, either Enterprise Model or 'W' Decomposition, informed by MPA, 6 Questions, Cognitive Maps and mapped to VSM. Clarified with organisational diagnosis with VSM.
R7	It should be possible to determine clusters of elements collaborating at short range as well as indicate the longer-range inter-relationships.	The subsystems in the SSM CPTM, and the RACI analysis shows these clusters. Also, construction if the VSMs informed by SSM analysis will show these clusters and the longer-range inter-relationships.
R8	Dependencies between elements must be captured.	Analysis of the CPTM logical dependencies between activities identifies dependencies between elements, as does dependency modelling, the VSMs and the links within and between the VSMs.
R9	Measures of performance can be identified.	SSM CTPM Activity analysis will help identify measures of performance. In addition, SD/CLD modelling will inform up-stream and down-stream points of measurement and optimisation.
R10	The Reference Model of Governance for a Specific Organisation must be able to represent the non-linearity of relationships.	Analysis of the CPTM logical dependencies between activities provides insight into the non-linearity of relationships. Exploration of the environmental interactions and internal connections within the VSMs also provides insight into the non-linearity of relationships. Include consideration of Angyal's autonomy and heteronomy.

ID	Requirement	How Fulfilled
R11	The Reference Model of Governance for a Specific Organisation can capture the feedbacks within the system, between the system and environment and within the environment.	Causal Loop Diagrams, informed by E&T Causal Textures capture the feedbacks within the system, between the system and environment and within the environment.
R12	The Reference Model of Governance for a Specific Organisation must enable one to capture / integrate the environmental inter-relationships as well as internal peer-peer inter-relationships.	Use SSM (Wilson) to model 'System Served' and detailed analysis of logical dependencies. Exploration of the environmental interactions and internal connections with VSM. Include consideration of Angyal's autonomy and heteronomy, and informed by E&T Causal Textures
R13	The organisation can be modelled in its wider context.	This is achieved by SSM modelling of the 'System Served' and a high-level CLD and VSM of the organisation in its wider context.

In addition, the logical validity question set is addressed (Table 27). This validates the Reference Model of Governance for a Specific Organisation prior to its use for determining the requisite variety of management responses.

Table 27 - Logical Validation of the Reference Model of Governance for a Specific Organisation

ID	Requirement	How Fulfilled
11	Does the Reference Model of Governance for a Specific Organisation capture and reflect the relevant range of perspectives within the situation as reflected and are the following metaphors considered? • Machine; • Organism; • Cultural/political; • Societal/environmental; • Interrelationships .	• **Machine**: The goal is agreed during the understanding phase and coded in the Enterprise set of Root Definitions. The necessary parts are identified in the SSM Subsystem model and recorded in a set of VSM which can demonstrate their organisations. SSM activity analysis can explore how activities are being undertaken and their level of quality. A Dependency model can indicate the likelihood of success of the subgoals and overall goal of the organisation to indicate the status of organisational activities. • **Organism**: Subsystems are identified through the SSM Subsystems and mapped to a set of VSMs. These can determine the level of autonomy and ability to adapt to external shocks (VSM S3/S4 performance and interaction). A CLD internal to the organisation is used to inform this. Resilience can be enhanced by overlaying the SSM Resilience model to explore additional relevant activities. • **Cultural/political**: Building on the understanding stage, the Enterprise set of Root Definition records the agreement regarding what needs to be done at a high level, and then modelled in detail in the CPTM. • **Societal/environmental**: Activities derived from the Enterprise set of Root Definitions will ensure all stakeholders have been identified and the VSM in its environment is used to maintain a current understanding of who they are and how they interact. A high-level CLD of the organisation in its environment will capture the dynamics of the environmental interaction. • **Interrelationships** are captured in the high-level and internal CLDs, as well as the logical dependencies within the SSM CPTM. Detail can be augmented by specific stock and flow diagrams and a dependency model.

ID	Requirement	How Fulfilled
2	Have the boundaries of the situation been explored and agreed?	The boundaries are explored in the understanding stage, and recorded as the boundaries indicated by the VSMs, the VSM in its environment, the boundary around the activities within the SSM CPTM, and the links between the organisation and wider components as captured in the high-level CLD.
3	Are the interrelationships identified (these may differ according to methodology/method)?	Interrelationships are captured in the interactions between VSMs, the logical dependencies in the SSM CPTM and the CLDs.
4	Has the hierarchy of purpose (emergence) been established?	This is established in the understanding stage and recorded in the hierarchy of VSMs, informed by the differing purposes at each level recorded as root definitions and conceptual models.
5	Have the dynamics at each level and between levels been identified?	These are identified within the hierarchy of VSMs in the VSM set and the high-level and internal CLDs.
6	Have the management communications and controls been identified as related to purpose/emergence and leach level of the hierarchy?	These are captured in the SSM conceptual model at each level and in the hierarchy of VSMs in the VSM set.

4.14 Summary

This chapter has developed a novel 3-dimensional structure, based on Angyal's system approach to understanding the organisation, for the combined use of systems methods. The requirements developed in Chapter 2 were mapped to the structure together with suitable methods. The resulting Reference Model of Governance for a Specific Organisation was then validated against the requirements.

An outline approach for building the Reference Model of Governance for a Specific Organisation was proposed, describing how the methods would be applied. This was both for the initial phase of developing a common and shared understanding amongst stakeholders of key aspects and then how the build the models. The seven stages are:

1. Ensure a common and shared understanding of the organisation amongst key decision-makers.

2. Develop detailed models in SSM and VSM.
3. Explore boundary interactions, especially with respect to VSM S4s including identifying key stakeholders, and VMS S1s to identify key interactions and dependencies.
4. Develop a causal loop diagram for the organisation within its environment and then one for the internal aspects of the organisation. The aim is to identify key control areas, and to identify upstream and downstream measures of success. Then map them to the enterprise model.
5. Build the dependency model.
6. Throughout, continue to iterate the models as additional learning is identified, resulting in the Reference Model of Governance for GroundsWell.
7. Validate the formal models and the Reference Model of Governance for a Specific Organisation set with the Logical Validation question set and the Experimental Validation question set.

A novel contribution, and a key component, is the SSM activity analysis table which is the knowledge sharing point of all of the Reference Model of Governance for a Specific Organisation elements. It is designed to ensure the integrity and coherence of information across all the system models. It can also provide a single place for updates, though currently they have to be manually applied to each of the system methods.

5 Case Study – GroundsWell

5.1 Introduction

The GroundsWell Consortium has been assembled to undertake a large and complex programme of work to enable a community-engaged and data-informed Systems Transformation of Urban Green and Blue Space for Population Health (UKPRP, 2021). The initial GroundsWell Case for Support, submitted before my involvement, was based around a series of work packages which, when executed together, would lead to a reduction in Non-Communicable Diseases (NCDs). The proposal is complex with many dependencies, including the funders and the consortium leads who were equally keen to develop the necessary understanding of critical dependencies and measures of performance.

During the development of my thesis, I was engaged to run a series of systems workshops to develop a shared understanding across the consortium in preparation of the final case for support. As a result, I was asked to apply additional systems methods to shape the governance of the consortium, and to lead a work package to develop a systems framework to cohere the research findings and make them accessible. Consequently, with the agreement of the consortium directors, I have used GroundsWell as the context to instantiate the Reference Model of Governance for a Specific Organisation.

5.2 GroundsWell

Urban environments are powerful contexts that influence lifelong health and wellbeing. These environments include rivers, parks, woodlands and lakes, and are collectively referred to as Urban Green and Blue Spaces (UGBS). They can significantly contribute to the reduction in Non-Communicable Diseases (NCD), thus improving population health (Hunter et al., 2022). They are not consistently nor equitably beneficial for communities, driving social inequalities in NCD (Geary et al., 2021). Interdisciplinary researchers, collaborating with stakeholders and citizens, will use UGBS as an exemplar to optimise innovative systems-based approaches that work with, and for, communities at high risk of NCD.

GroundsWell aims to transform social interaction with UGBS through improvements to their design and management to benefit all communities, especially those with poor

health. It will achieve this through taking a systems approach to transform the systems used to plan, design, evaluate and manage UGBS. GroundsWell has 4 guiding principles: 1) addressing issues of health and equity (including social and environmental/climate justice); 2) creating a virtuous cycle of research, policy, implementation and active citizenship; 3) co-producing, co-implementing, co-evaluating and co-translating; and 4) acknowledging complexity of urban 'life' (i.e., inclusive of the whole urban environment and how communities live their lives in such environments). These principles are woven throughout each Work Package (WP) and are underpinned by 4 priorities: i) data and methodological innovation; ii) complex systems thinking; iii) democratisation of the research and policy processes; iv) empowerment and advocacy.

GroundsWell intends to utilise systems and community approaches to create urban environments optimising health and co-benefits, while reducing inequalities. Initiating a step change in inclusive research and policy, GroundsWell will work towards the democratisation of research and evidence use. Communities as partners will enable delivery of optimal solutions to inform and innovate action on health inequalities and NCD prevention. GroundsWell will co-produce a whole systems approach to UGBS, aiming to improve population health and reduce inequities.

Whole system mechanisms of action will be determined through interconnected work packages:

1. co-developing a systems-oriented framework of how UGBS impacts NCD;
2. agent-based modelling to simulate complex adaptive systems to explore how UGBS transformations will reduce inequalities in NCD;
3. working with communities and stakeholders to co-develop and evaluate local UGBS interventions using citizen science approaches;
4. curating a shared data repository with UGBS features valued by policy and communities, developing health and NCD indicators at multiple scales to inform and evaluate UGBS interventions;
5. generating evidence on economic impacts of UGBS interventions;
6. identifying pragmatic, systems-level actions to improve policy- and decision-making for equity and sustainability;

7. implementing a stakeholder-informed impact strategy.

A cross-cutting health inequalities theme will embed the consideration of inequalities throughout GroundsWell. Groundswell will be shaped and developed in three pioneer cities (Belfast, Edinburgh, Liverpool), with embedded translational mechanisms to ensure UK-wide and global reach.

5.3 Instantiating the Reference Model of Governance for GroundsWell

I have applied my approach (described in Chapter 4) to instantiate a Reference Model of Governance to inform the consortium design and to support the directors' decisions on appropriate governance. Consequently, the approach taken has been modified to suit, as not all aspects are relevant. However, the lead director was keen to ensure the research programme was well founded and coherent. The following steps were taken.

1. Ensure a common and shared understanding of the organisation amongst key decision-makers.
2. Develop detailed models in SSM and VSM.
3. Explore boundary interactions, especially with respect to VSM S4s including identifying key stakeholders, and VMS S1s to identify key interactions and dependencies.
4. Develop a causal loop diagram for the organisation including its environment and the internal aspects of the organisation. The aim is to identify key control areas, and to identify upstream and downstream measures of success. Then map them to the enterprise model.
5. Build the dependency model.
6. Throughout, continue to iterate the models as additional learning is identified, resulting in the Reference Model of Governance for GroundsWell.
7. Validate the formal models and the Reference Model of Governance for a Specific Organisation set with the Logical Validation question set and the Experimental Validation question set. This is contained in Chapter 6.

5.4 Ensuring a common and shared understanding

This section comprises the models derived within the workshops and development effort between and following the workshops. Some of this was written as part of a report (Hilton, 2020) that accompanied the Case for Support.

5.4.1 Rich Pictures

The rich pictures included at Figure 68, developed by the programme directors, were presented at the first workshop and successfully initiated a rich conversation amongst participants. Thereafter, further topics unfolded. The use of images and the metaphors contained within them conveyed much more of the context of the programme and its intended outcome than the written word, or through just talking to the participants could have. They also provided an element of an icebreaker to initiate conversation and interaction.

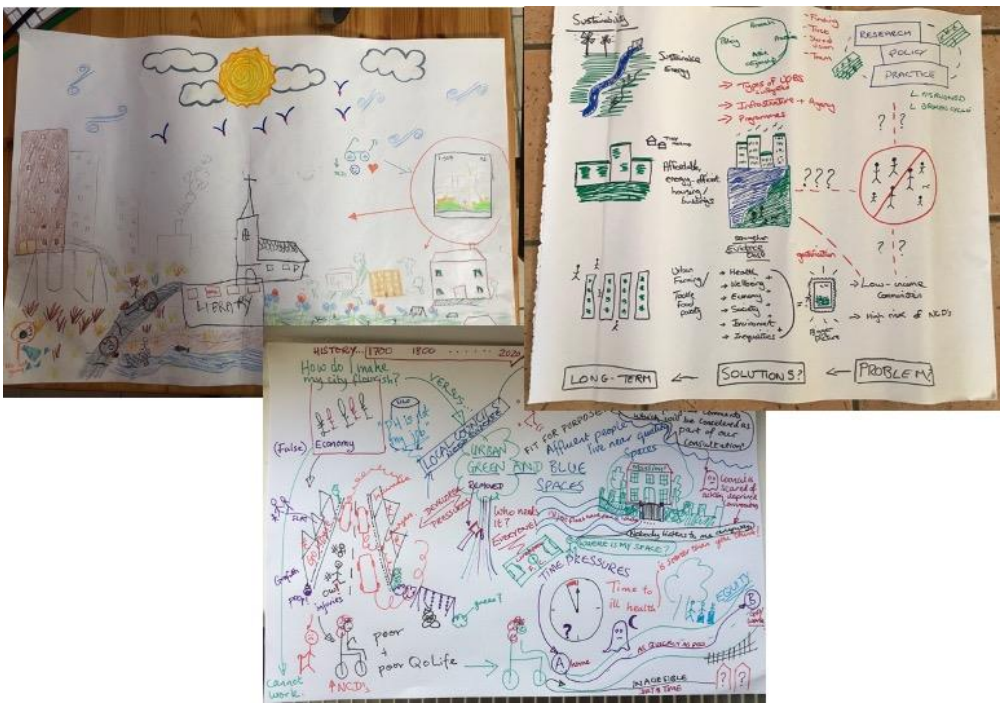


Figure 68 - Rich Pictures

Many were concerned that they could not draw, but images rather than words did open up the conversations and, as some interpreted the images differently, additional and valuable perspectives were uncovered.

5.4.2 Multi-Perspective Diagram

Resulting from one of the group breakouts, Figure 69 identifies the stakeholders and their related perspectives that were identified during a group discussion in the workshops. This is included as an example of the result of a multi-perspective diagram:



Figure 69 - Stakeholders and their perspectives

A point noted for further development was the range of perspectives within the communities as well as other citizen groups such as the elderly, young families, and youth. They cannot be clustered into a small set of stakeholders as the necessary variety of perspectives will not be identified, nor can they be divided into too many as the result would be too complicated and intervention design become unmanageable.

5.4.3 Cognitive Map

Cognitive maps were developed at two scales; one at the level of the work package and one at programme level. Figure 70 was derived by the Work Package 3 Lead to identify the relationships and dependencies in the data context and was used to facilitate a discussion with the consortium members.

This again led to a rich conversation which is very similar to group model building. The difference here is that this is more an illustration of the Work Package Lead's mental model, and it enabled these thoughts to be shared and further developed by the group.

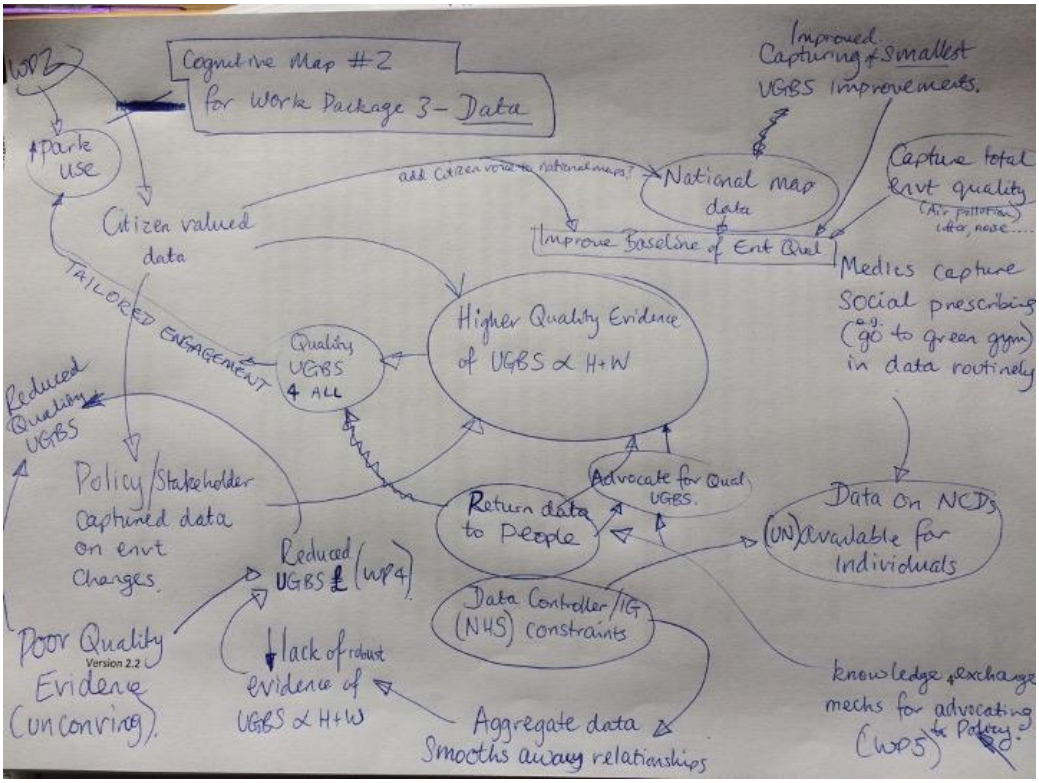


Figure 70 - Cognitive Map of Data WP

A cognitive map at the programme level was developed to inform the theory of change as well as build a shared understanding of the relationship between the work packages. This is shown below at Figure 71.

5.4.4 Context Diagram

As an example of the thinking within the work package 3 conversation, a context diagram from the perspective of the consortium with regard to data is shown below at Figure 72. The centre lozenge illustrates what is perceived to be under the control and authority of the consortium directors, the middle tier represents who and what they perceive they can influence. The outer tier represents the constraints perceived with regard to fulfilling the work package outcomes, and the space surrounding the tiers represents global impacting constraints.

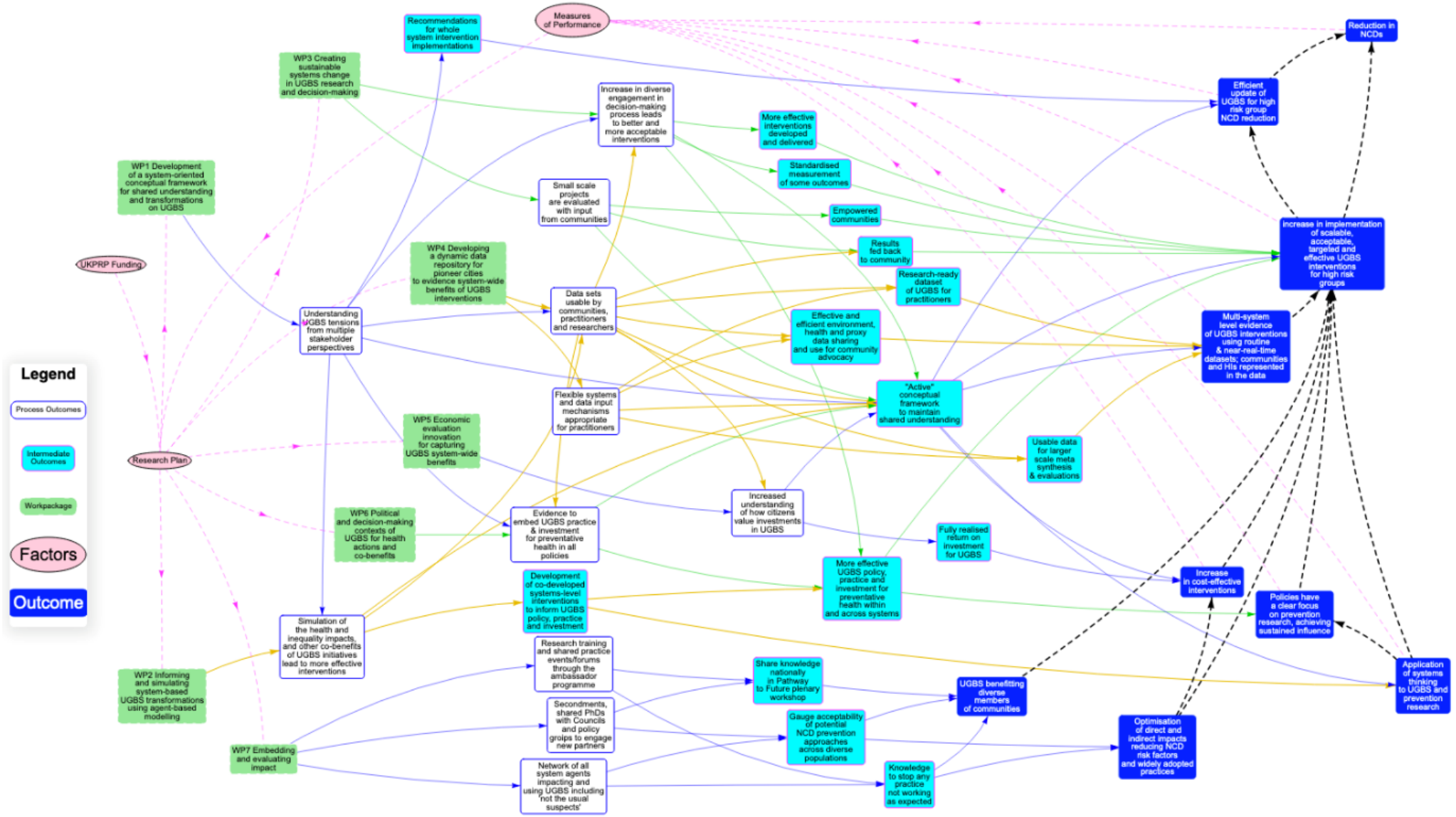


Figure 71 - Programme-level Cognitive Map

The resulting conversation, also undertaken by other work packages, clarified the span of control of each work package, as well as to identify the relationships between them and other factors; whether to be able to influence, or recognise a constraint. It also helped work package leads identify and agree the additional aspects of governance that might be required over and above that of work package governance to ensure a coherent programme of work packages. Some of the actions required of the consortium leaders is to address these to ensure the success of the research programme. The benefit was to highlight these at an early stage so they could be included in the programme governance.

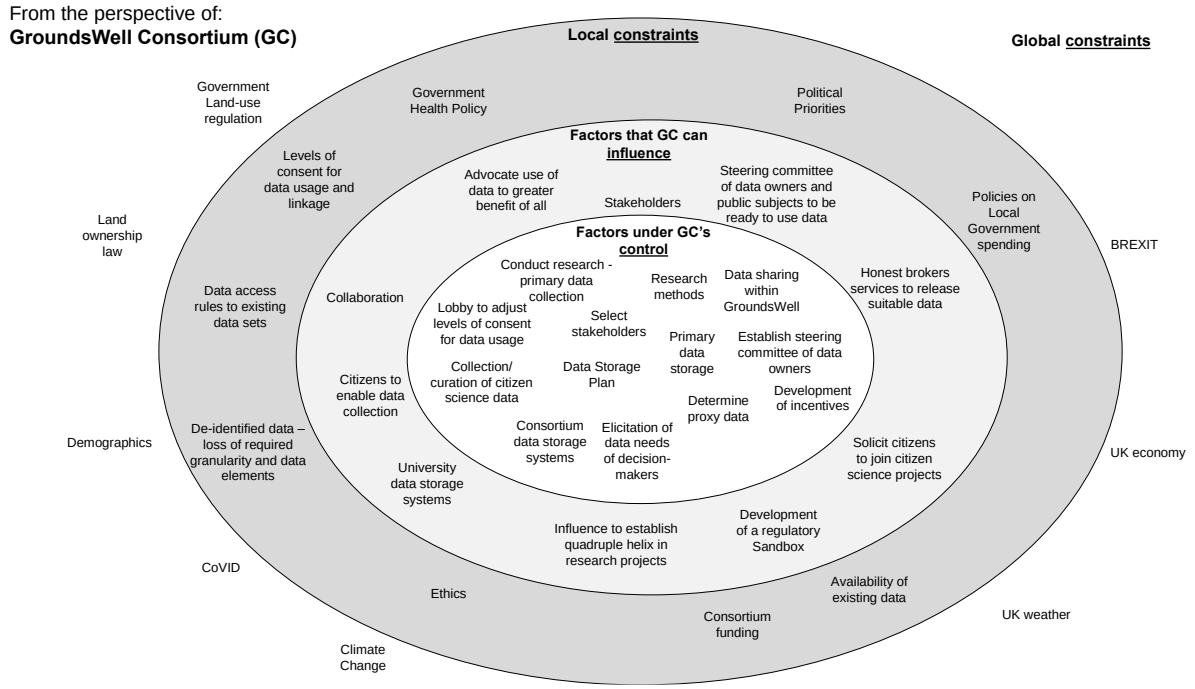


Figure 72 - Context Diagram from the perspective of the Consortium

5.4.5 Summary

The workshops resulted in a very good, shared understanding and renewed commitment across the consortium. There was clarity regarding the issues being addressed and this provided a firm basis for now confirming the consortium activities.

5.5 SSM Modelling

Following the workshops, a more formal systems approach was taken to develop a complete and coherent set of activities relevant to the purpose of the research

programme in order to confirm the coverage of the various work packages and the governance aspects.

5.5.1 Consensus Primary Task Model

The first stage was to develop a Soft Systems Model (SSM) employing Wilson's Enterprise approach as a structure for thinking about a set of Root Definitions (RDs) relevant to the organisational situation (Wilson, 2001, p.111). This enables a much more detailed understanding of the activities relevant to achieving the range of purposes than could be achieved by taking Checkland's approach (Checkland and Poulter, 2006).

5.5.2 Systems Identified

The following Enterprise Model set of Root Definitions were identified which covered the systems shown in Figure 73 below. Each of these was then developed into a Root Definition.

Core Transformation Root Definition

Core 'T': A system, owned by the GroundsWell PI Collective, operated by the GroundsWell Consortium through collaborative working with researchers, clinicians, practitioners (such as Urban Designers), policymakers, and citizens, to Improve population health and reducing health inequalities through the primary prevention of Non-Communicable Diseases (NCDs), by identifying poor quality and underused spaces through citizen-led approaches, working to develop and/or modify outdoor spaces so they are high quality and fit for purpose, work to identify ways in which we can promote such spaces for everyone; ensure local communities are fully involved in decisions about what they want and be involved in the evaluation of these actions, testing a range of different methods and approaches, collecting large amounts of data and predict what could be effective over a much wider area, and understand what will not work, and informing future policies and programmes, for the benefit of all communities, but recognising the impact of UKPRP funding, the need for support from essential agencies and communities, and consortium capability and availability.

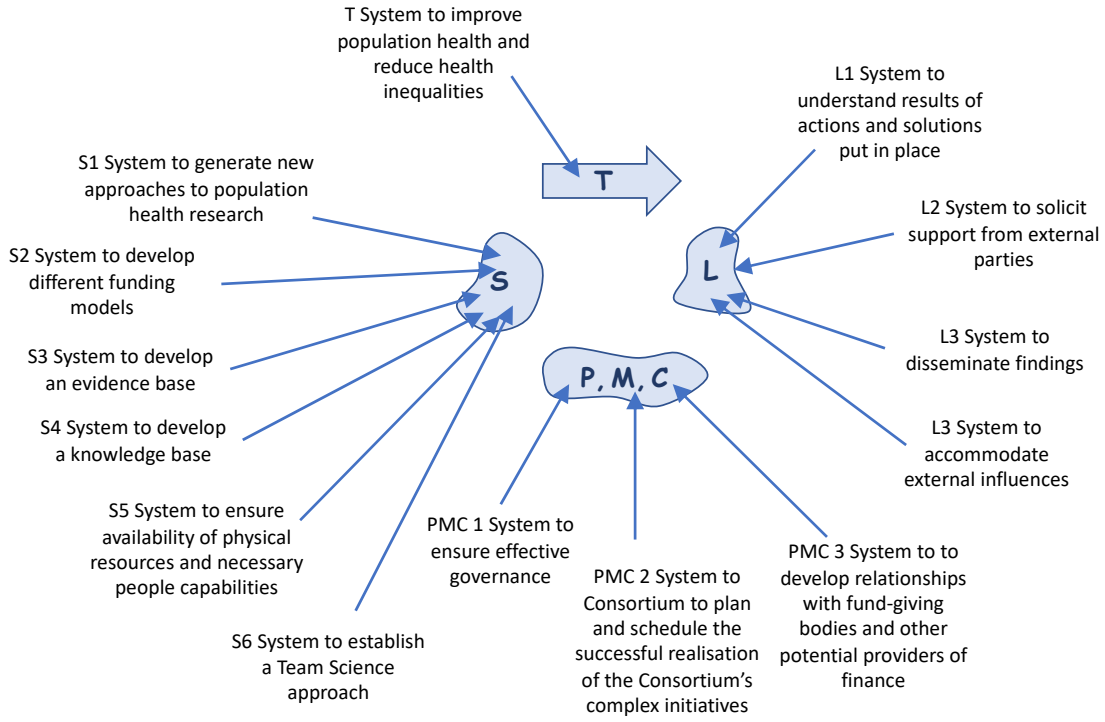


Figure 73 - Systems Relevant to the Groundswell Programme

Supporting Systems Root Definitions

S1: Within the need to develop new approaches to population health research (particularly with respect to preventing NCDs and reducing inequalities in health), generate new knowledge that meets the needs of potential users and beneficiaries of the research in order to drive broad changes to trigger realignment of health interventions by developing solutions, policies and strategies which are sustainable, replicable, feasible and affordable recognising the capabilities and scope of the GroundsWell programme.

S2: A system to develop different funding models for green/blue space infrastructure and programmes for the benefit of Owners and implementers of actions and solutions put in place to improve population health and reduction of NCDs through looking at social economy approaches, community assets, micro-interventions and recognising local authorities and government won't have funding to support large scale infrastructure investment, and to sustain the GroundsWell Consortium endeavours.

S3: A system to develop an evidence base that leads to improved outcomes and decisions by decision-makers within agencies investing in the interventions, policy makers and industry partners by making better use of well-curated administrative data,

including innovative ways to involve citizens and develop new methods that link real-time and community-rich data sources.

S4: A system to develop and maintain a current knowledge base to support all activities for the benefit of the GroundsWell Consortium members and selected external partners, which allows learning from previous history together with the external information to provide that knowledge by acquiring processing and making available information as needed and by providing the source for reporting and auditing as required but recognising the constraints arising from defined access requirements, the need to protect intellectual rights, current technology and required technical standards.

S5: A system to ensure that the physical resources available including space, utilities and the human resource capabilities available match the requirements of all activities and enable the execution of defined activities in a collaborative manner, while exploiting developments in technology and related best practice as a means of enhancing overall performance but recognising appropriate technical standards and current technical constraints.

S6: A system operated by appropriately skilled and experienced Team Science practitioners, to establish a Team Science approach for the benefit of the GroundsWell programme and its sustained outcomes by developing GroundsWell Consortium capabilities including facilitation, applying the key design principles of integrative networks into the ways of working of the GroundsWell programme, establishing group rules of interaction, having a diverse and inclusive membership, a core-periphery network structure and the core network utilising integrative decision-making but recognising the accommodation of existing ways of working and time available.

Linking Systems Root Definitions

L1: A System to understand the results of actions and solutions put in place to determine their success such that they lead to improved population health and reduction of NCDs by the same data across the different actions, establishing a way of bringing together multiple sources of data to effectively determine what works across multiple projects and settings, involve citizens in collecting data, exploit other data on health, wellbeing and the environment that is routinely collected by councils

and governments to understand what works for whom and why across the cities, use the knowledge to predict what could be effective over a much wider area, and also what does not work, make decisions about what is good value for money, and what is not within the limits of technological capacity, funding, level of citizen and community contribution and access to local councils and relevant government departments.

L2: A system to solicit support from selected communities, citizens, practitioners and policymakers for the benefit of the GroundsWell programme of interventions by promoting the GroundsWell programme through social media, community engagement, available networks of practitioners, communities and local agencies, and specified events.

L3: A system to disseminate project findings by submitting papers for publication in selected journals, producing reports for appropriate audiences and making presentations at relevant conferences.

L4: A system to accommodate external influences arising from the specific setting of the Consortium, developments in related legislation and other potential sources so that opportunities may be exploited to the benefit of the Consortium initiatives and risks to the Consortium's activities minimised through appropriate contingences and procedures.

Planning, Monitoring and Control Root Definitions

PMC1: A system owned by the GroundsWell PI Collective and operated by the GroundsWell Consortium to undertake effective governance of the GroundsWell Consortium that leads to sustainable impact and meets the needs of providers, policy makers and industry partners, communities and citizens by altering the perception of UGBS and changing development focus from infrastructure to community usage, employing radical systems-thinking approaches, including cross-sectoral dynamic knowledge to identify upstream levers and drivers for systems-level interventions delivering solutions for large-scale and cost-effective improvements in health and NCD prevention, all contributing to the design and implementation of interventions, and can jointly evaluate and translate evidence seamlessly into practice whilst ensuring the appropriate relationship between agency and structure within the Consortium.

PMC2: A GroundsWell PI Collective owned system operated by the GroundsWell Consortium to plan and schedule the successful realisation of the Consortium's complex initiatives through implementing a development-evaluation-implementation process within the programme, recognising the resources available, agreed timescales and funding awarded and commitment of supporting agencies and the communities.

PMC3: A system to develop relationships with fund-giving bodies and other potential providers of finance, in order to provide the finances necessary to sustain the Consortium and its ongoing initiatives, which are planned to contribute to the development aims of the Consortium, though good consortium communication, capacity building, an ambassador programme and team science, the establishment of appropriate structures and approaches, validation of findings and solicitation of comments, while undertaking such partnership and other activities that will ensure the required contribution to the Consortium's total financial need.

5.5.3 Sub-System Conceptual Model

The activities were clustered into subsystems and aligned as closely as possible to work packages as described in the outline case for support. This is illustrated at Figure 74. This level of detail was sufficient for the directors to determine the coverage of the programme-level governance and consider the alignment of the work packages. As can be seen in the diagram, a number of sub-systems are uncoloured. These prompted the directors to introduce additional activities and responsibilities into the consortium governance and these were added to the case for support.

Each of the subsystems has one or a small number of "Control Action" activities. For each of these, an analysis can be undertaken to identify the quality criteria for the activity (i.e., how would you determine how well the activity was carried out) as well as measures of performance of the relevant aspect of the system (research programme element) under control of that activity. Also, using the RACI technique, one can determine the role that is Accountable for ensuring the programme element achieves its desired outcome, who is Responsible for taking action to ensure the outcome is achieved, who might be consulted in the process of taking action and who should be informed of the outcome.

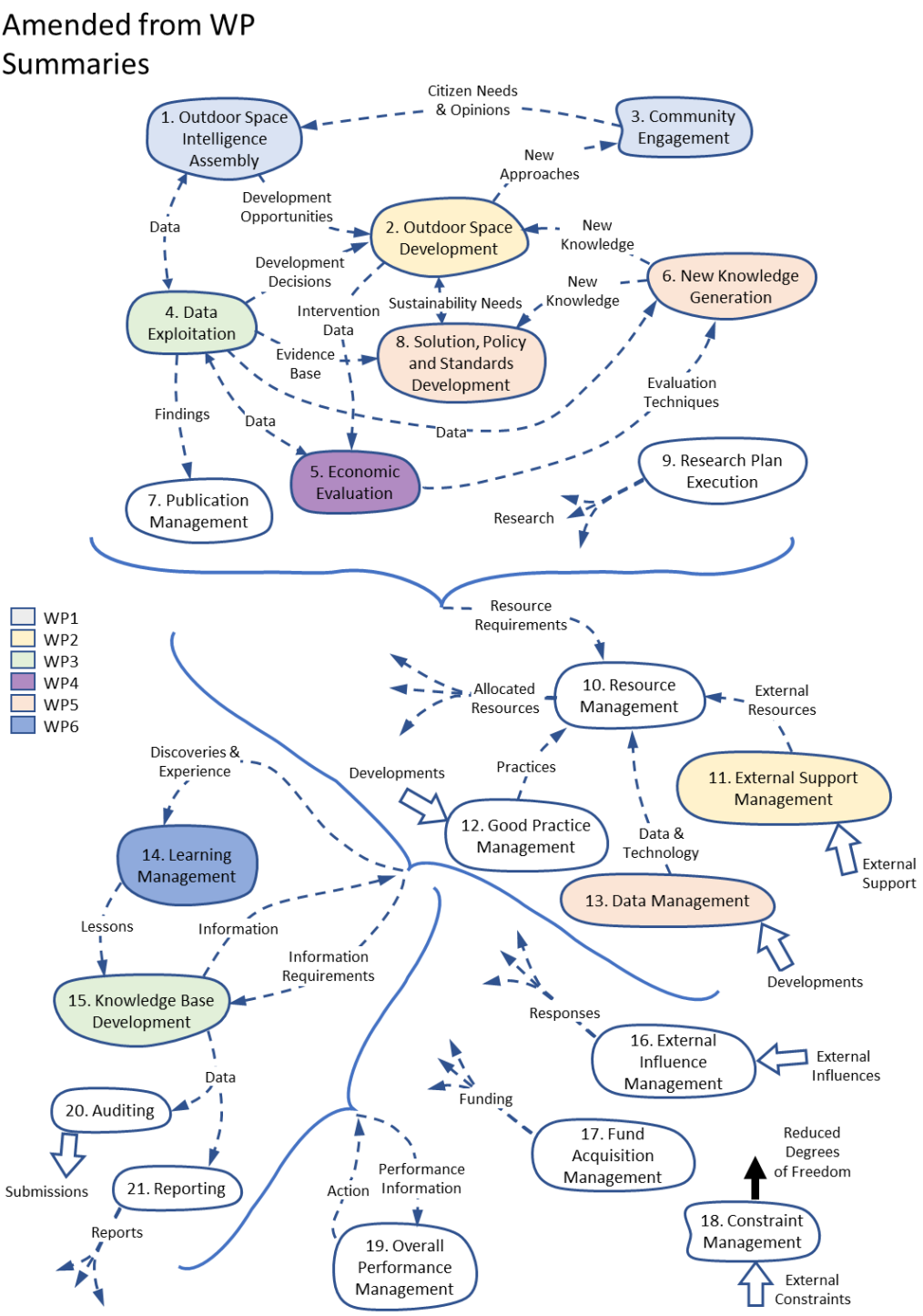


Figure 74 - GroundsWell Sub-System Model Mapped to Work Packages

5.6 The GroundsWell Consortium represented by a VSM

Figure 75 shows the mapping of the SSM subsystems to a VSM. It provided an initial perspective of what high-level activities should be carried out, and by whom as well as an initial perspective of overall governance needs. Also, the VSM was used to

diagnose additional aspects of the programme that should be included in the full Case for Support.

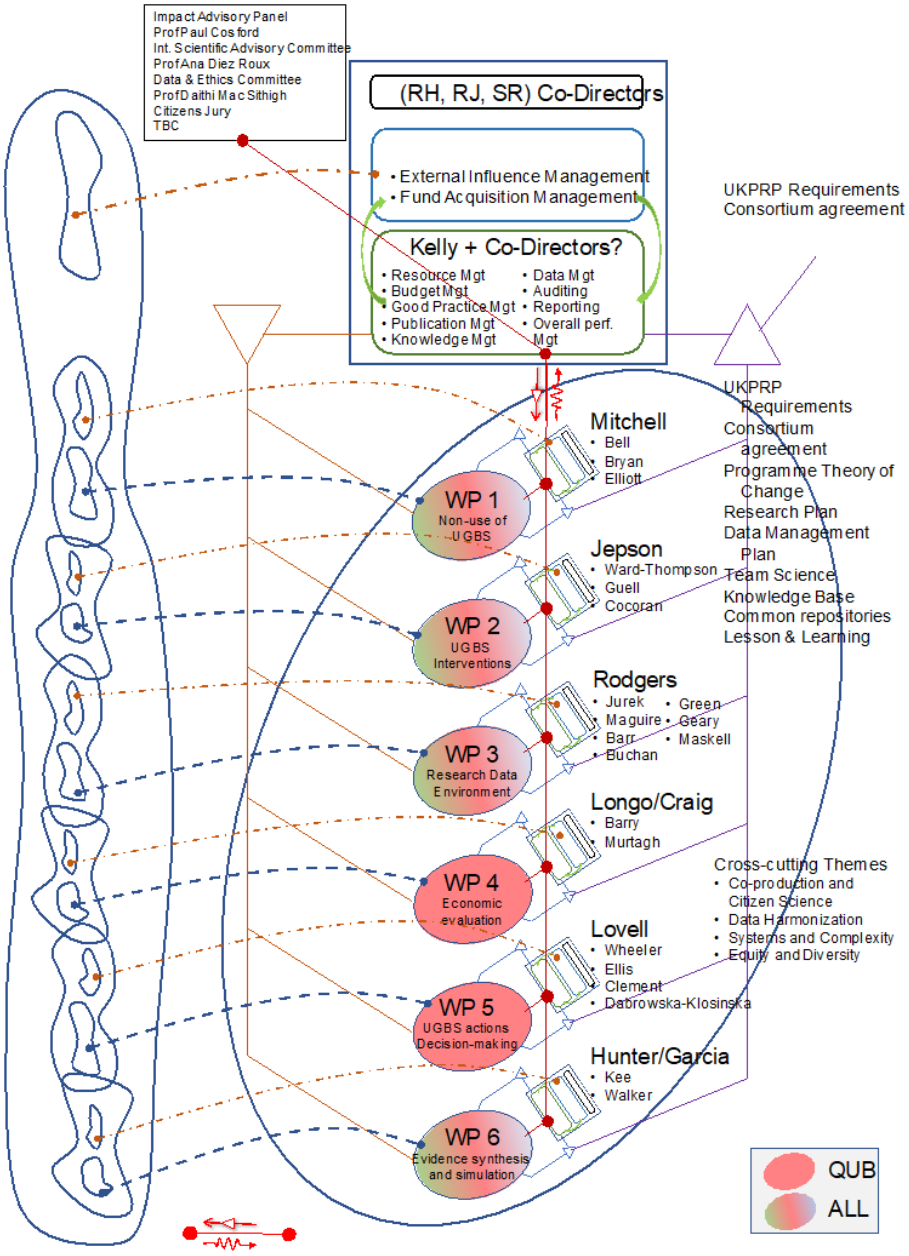


Figure 75 - VSM of GroundsWell

5.6.1 Analysis of VSM with regard to governance

The analysis of the VSM for GroundsWell surfaced a range of governance questions, some of which are listed below. This was used to inform the development of the Case for Support, particularly the structure of the GroundsWell Consortium, work package integration, co-production, and sustainability.

5.6.1.1 System 3

1. What should the contractual arrangements be between universities and with UKPRP?
2. What resource is required and what is the associated funding allocation?
3. Tasking? Is it defined in proposal?
4. Who defines/agrees variations in tasking?
5. Who will manage the research plan, and is responsible for day-to-day management and receipt of reports?
6. What periodic audits do you think might be relevant?
7. What are the measures of performance for work-packages? Interventions? Etc?
8. How will you ensure the consortium work programme is seen as coherent from the outside (external parties may engage with more than one work-package)?

5.6.1.2 System 4

1. Who will monitor the outside environment and recommend variations to the research programme and priorities?
2. Will you be guided by an external stakeholder group?
3. Will work-packages be adjusted during their life? Who will do this? Is it at the work-package level?

5.6.1.3 System 2

1. How will you manage inter-work package coordination, conflict resolution?
2. Are there to be common ways of working?
3. Will there be a common data /knowledge repository?
4. How will you keep the consortium up to date?

5.6.2 Mapping to VSM

5.6.2.1 Mapping Control Actions

The SSM activity analysis included a mapping of the control activities to the VSM as shown below in Figure 76 and Figure 77.

This enabled us to utilise the diagnostic capability of VSM to explore the necessary governance aspects of GroundsWell as well as consider the additional elements required to enable the viability of Groundswell. The key elements for viability that were identified, in addition to the System 3 (day-to-day management) elements, include the System 4 and System 2 elements.

The System 4 elements of External Influence Management and Fund Acquisition Management are important at the consortium level to determine how GroundsWell is being perceived and manage expectations as well as acquiring future funding to ensure the continued outcomes of the programme beyond the initial funded period.

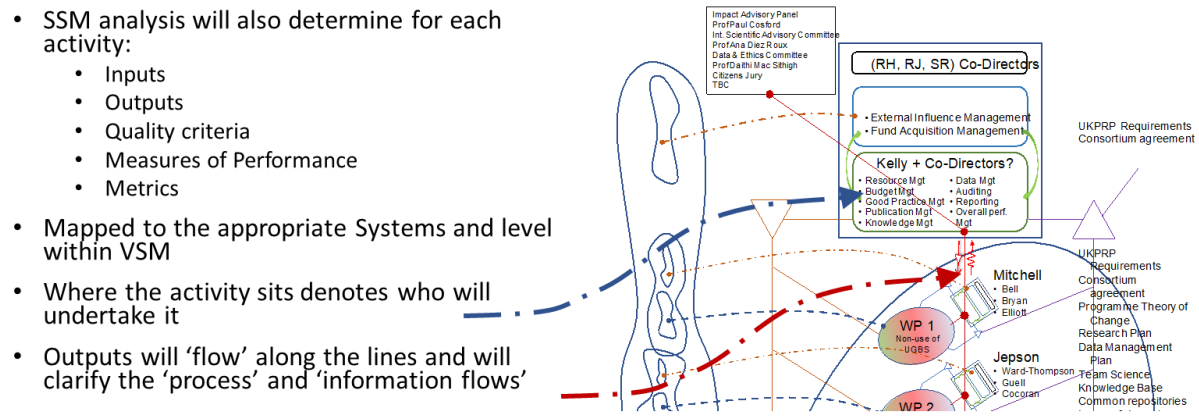


Figure 76 - Mapping SSM to VSM

The System 2 elements as listed in the diagram at the right-hand side of Figure 75 are necessary to cohere, coordinate the programme and mitigate any inter-work package conflicts. It is quite common in research projects for work packages to become autonomous and lose their linkages. In the consortium, this would have a seriously detrimental impact as there are dependencies between the work packages, the potential for duplicating work and confusing the communities and citizens involved in various work packages.

The System 3 elements relate to the governance activities required to ensure the consortium maintains coherence across the work packages, adheres to the research plan, but also is able to respond to unforeseen issues as well as learning, and adjust accordingly. Key is the development and monitoring or relevant and appropriate measures of performance that will not only indicate progress towards the consortium's

research outcomes, but also ensure the wider academic contribution and enable the ongoing sustainability of GroundsWell beyond its initial 5-year funding.

Also, the analysis of the SSM activities informed the requirements and measures of performance (leading to metrics) that will indicate the success or otherwise of the various work packages, thus indicating the overall likelihood of success of the programme. This level of thinking also informed the risk assessment and risk map of the programme which will be maintained for the duration of the programme both for programme governance and reporting to UK PRP on an annual basis.

Should they wish, each of the work packages could develop their own VSMs as it is a hierarchical model. This would enable each work package lead to establish conditions for ongoing viability, monitoring and risk reporting.

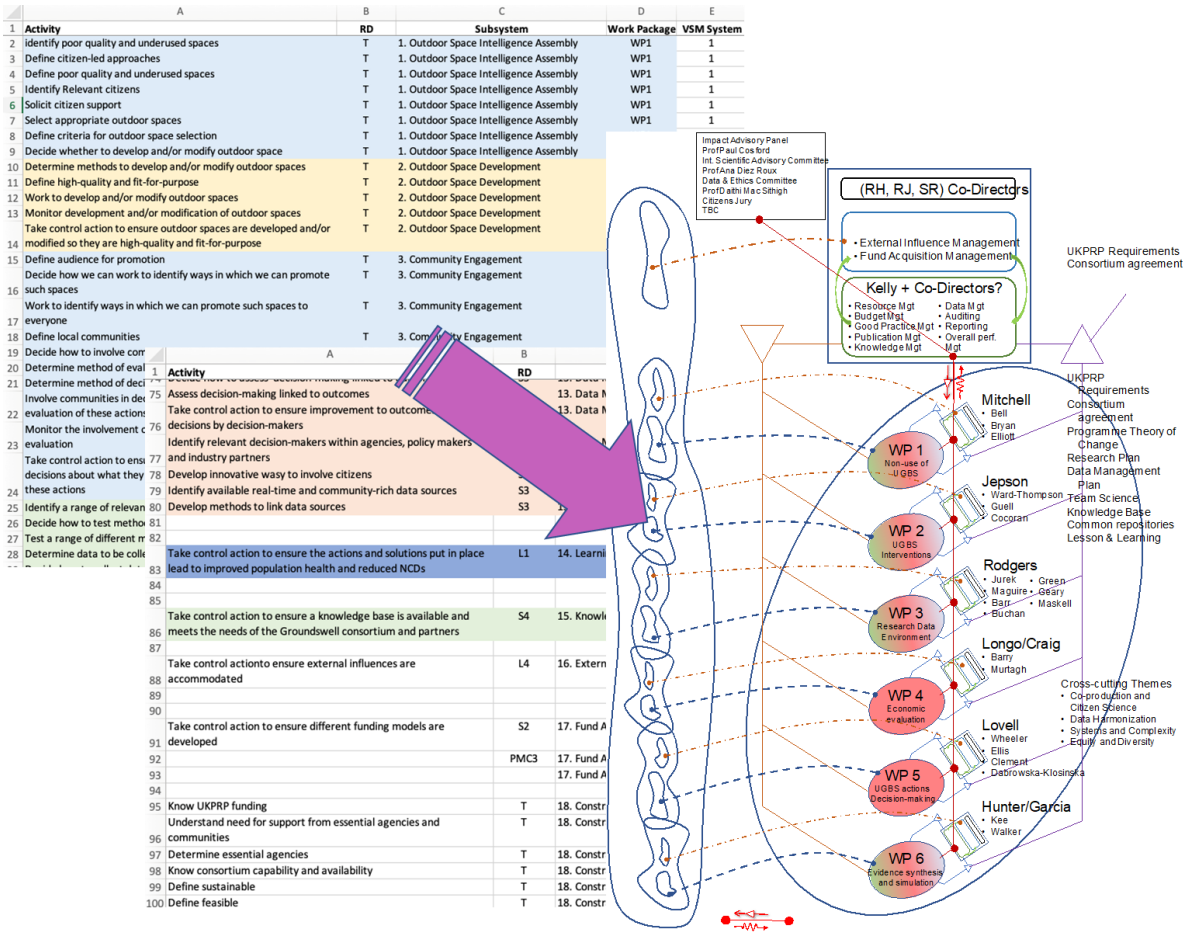


Figure 77 - Mapping the SSM activities to the VSM

5.7 . Development of the full case for Support

Following the development of these models it was recognised that various aspects of governance had not been explicitly included in the outline Case for Support. These can be seen in the uncoloured subsystems in the subsystem model above at Figure 74. This led to a revised set of root definitions as follows. The changes have been highlighted and is an example of how the Reference Model of Governance for a Specific Organisation can be kept current and capture aspects of the history of an organisation.

5.7.1 Revised Systems Identified

An understanding of the necessary and relevant systems was established, and the set of root definitions revised capturing the change in perspective following the understanding phase and the initial SSM sub-system model. This is shown Figure 78 and in the following section.

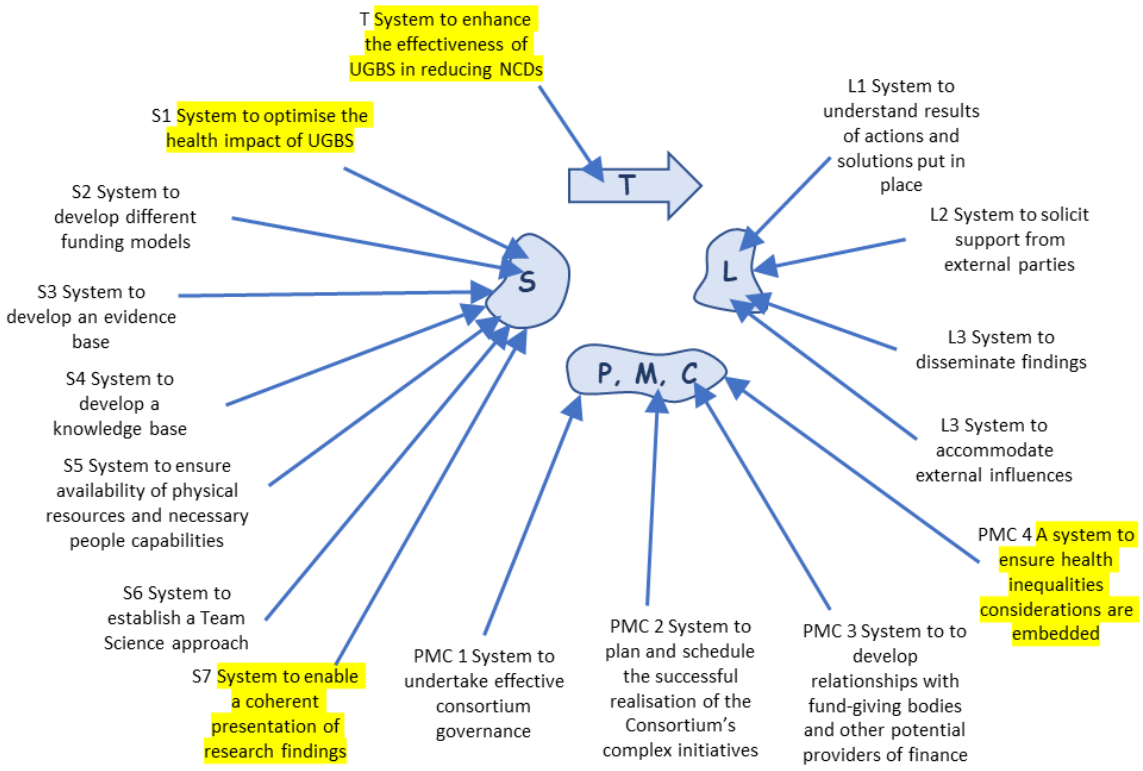


Figure 78 - Systems Relevant to the Groundswell Programme

5.7.2 Root Definitions

Text highlighted denotes the change in root definitions from the initial root definitions leading to development of the final Case for Support.

Core Transformation

T A system, owned by the GroundsWell PI Collective, operated by the GroundsWell Consortium members through collaborative working with researchers, clinicians, practitioners (such as Urban Designers), policymakers, communities, and citizens, to enhance the effectiveness of UGBS to positively impact on Non-Communicable Disease (NCD) risk factors by connecting systems together through co-production, data sharing and community engagement using transdisciplinary, problem-solving approaches that accelerates and optimises community collaborations among citizens, users, implementers, policymakers and researchers to impact research, policy, practice and active citizenship, determining how UGBS systems impact on health and other co-benefits and how these systems can be transformed, ensuring the development, implementation and evaluation of UGBS interventions is community and systems focused, determining the economic costs and benefits of UGBS, informing political and decision-making contexts, and implementing a data repository to aid the development and evaluation of UBGS system-level interventions for the benefit of all communities but ensuring the impact of GroundsWell for broader efforts to improve population health, NCD prevention, and reduce health inequalities, whilst recognising the impact of UKPRP funding, the need for support from essential agencies and communities, and consortium capability and availability.

Supporting Systems

S1. Within the need to optimise the health impact of UGBS (particularly w.r.t. preventing NCDs and reducing inequalities in health), generate systemic, transdisciplinary problem-solving approaches that meets the needs of potential users and beneficiaries of the research in order to develop parallel innovations in community-engagement and data-informed adaptive systems and to accelerate and optimise community collaborations, recognising the capabilities and scope of the GroundsWell programme.

S2. A system to develop different funding models for green/blue space infrastructure and programmes for the benefit of Owners and implementers of actions and solutions put in place to improve population health and reduction of NCDs through looking at social economy approaches, community assets, micro-interventions and recognising local authorities and government won't have funding to support large scale infrastructure investment, and to sustain the GroundsWell Consortium endeavours.

S3. A system to develop an evidence base that leads to improved outcomes and decisions by decision-makers within agencies investing in the interventions, policy makers and industry partners by making better use of well-curated administrative data, including innovative ways to involve citizens and develop new methods that link real-time and community-rich data sources.

S4. A system to develop and maintain a current knowledge base to support all activities for the benefit of the GroundsWell Consortium members and selected external partners, which allows learning from previous history together with the external information to provide that knowledge by acquiring processing and making available information as needed and by providing the source for reporting and auditing as required but recognising the constraints arising from defined access requirements, the need to protect intellectual rights, current technology and required technical standards.

S5. A system to ensure that the physical resources available including space, utilities, and the people capabilities available match the requirements of all activities and enable the execution of defined activities in a collaborative manner including the necessary support, training and development of staff as required, while exploiting developments in technology and related best practice as a means of enhancing overall performance but recognising appropriate technical standards and current technical constraints.

S6. A system operated by appropriately skilled and experienced Team Science practitioners, to establish a Team Science approach for the benefit of the GroundsWell programme and its sustained outcomes by developing GroundsWell Consortium capabilities including facilitation, applying the key design principles of integrative networks into the ways of working of the GroundsWell programme, establishing group rules of interaction, having a diverse and inclusive membership, a core-periphery

network structure and the core network utilising integrative decision-making but recognising the accommodation of existing ways of working and time available.

S7. A system to enable the coherent presentation of research findings by developing a systems-oriented conceptual framework that integrates multiple, layered, interconnected pieces of evidence, building a shared understanding of the mechanisms linking UGBS and NCD that informs systems transformations of UGBS.

Linking Systems

L1. A System to understand the results of actions and solutions put in place to determine their success such that they lead to improved population health and reduction of NCDs by the same data across the different actions, establishing a way of bringing together multiple sources of data to effectively determine what works across multiple projects and settings, involve citizens in collecting data, exploit other data on health, wellbeing and the environment that is routinely collected by councils and governments to understand what works for whom and why across the cities, use the knowledge to predict what could be effective over a much wider area, and also what does not work, make decisions about what is good value for money, and what is not within the limits of technological capacity, funding, level of citizen and community contribution and access to local councils and relevant government departments.

L2. A system to solicit support from selected communities, citizens, practitioners and policymakers for the benefit of the GroundsWell programme of interventions by promoting the GroundsWell programme through social media, community engagement, available networks of practitioners, communities and local agencies, and specified events.

L3. A system to disseminate project findings by submitting papers for publication in selected journals, producing reports for appropriate audiences and making presentations at relevant conferences.

L4. A system to accommodate external influences arising from the specific setting of the Consortium, developments in related legislation and other potential sources so that opportunities may be exploited to the benefit of the Consortium initiatives and risks to the Consortium's activities minimised through appropriate contingences and procedures.

Planning, Monitoring and Control

PMC1. A system owned by the GroundsWell PI Collective and operated by the GroundsWell Consortium to undertake effective governance of the GroundsWell Consortium that leads to sustainable impact and meets the needs of providers, policy makers and industry partners, communities and citizens by employing radical systems-thinking approaches, including cross-sectoral dynamic knowledge to identify upstream and downstream indicators for the evaluation of short-, medium- and longer-term impacts, embedding measures of impact in monitoring and evaluation plans that demonstrates the impact of the programme, meeting UKPRP monitoring and reporting requirements, whilst ensuring the appropriate relationship between agency and structure within the Consortium.

PMC2. A GroundsWell PI Collective owned system operated by the GroundsWell Consortium to plan and schedule the successful realisation of the Consortium's complex initiatives through implementing a development-evaluation-implementation process within the programme, recognising the resources available, agreed timescales and funding awarded and commitment of supporting agencies and the communities.

PMC3. A system to develop relationships with fund-giving bodies and other potential providers of finance, in order to provide the finances necessary to sustain the Consortium and its ongoing initiatives, which are planned to contribute to the development aims of the Consortium, though good consortium communication, capacity building, an ambassador programme and team science, the establishment of appropriate structures and approaches, validation of findings and solicitation of comments, while undertaking such partnership and other activities that will ensure the required contribution to the Consortium's total financial need.

PMC4. A system to ensure health inequalities considerations are embedded across GroundsWell research, and continue into any resulting UGBS policy and practice by integrating and monitoring health inequalities considerations in all Consortium activities, increasing competency, capability and awareness of health inequalities across staff, partners and communities, filling gaps in our understanding of how UGBS systems create or maintain inequality in access and/or use, and evaluating and reporting GroundsWell's impact on health inequalities

5.7.3 Revised Sub-System Conceptual Model

The revised conceptual model identified additional activities to be included and those activities which were no longer required. As before, these are clustered into subsystems as illustrated in Figure 79 and then mapped to a revised VSM of the consortium as illustrated in Figure 80.

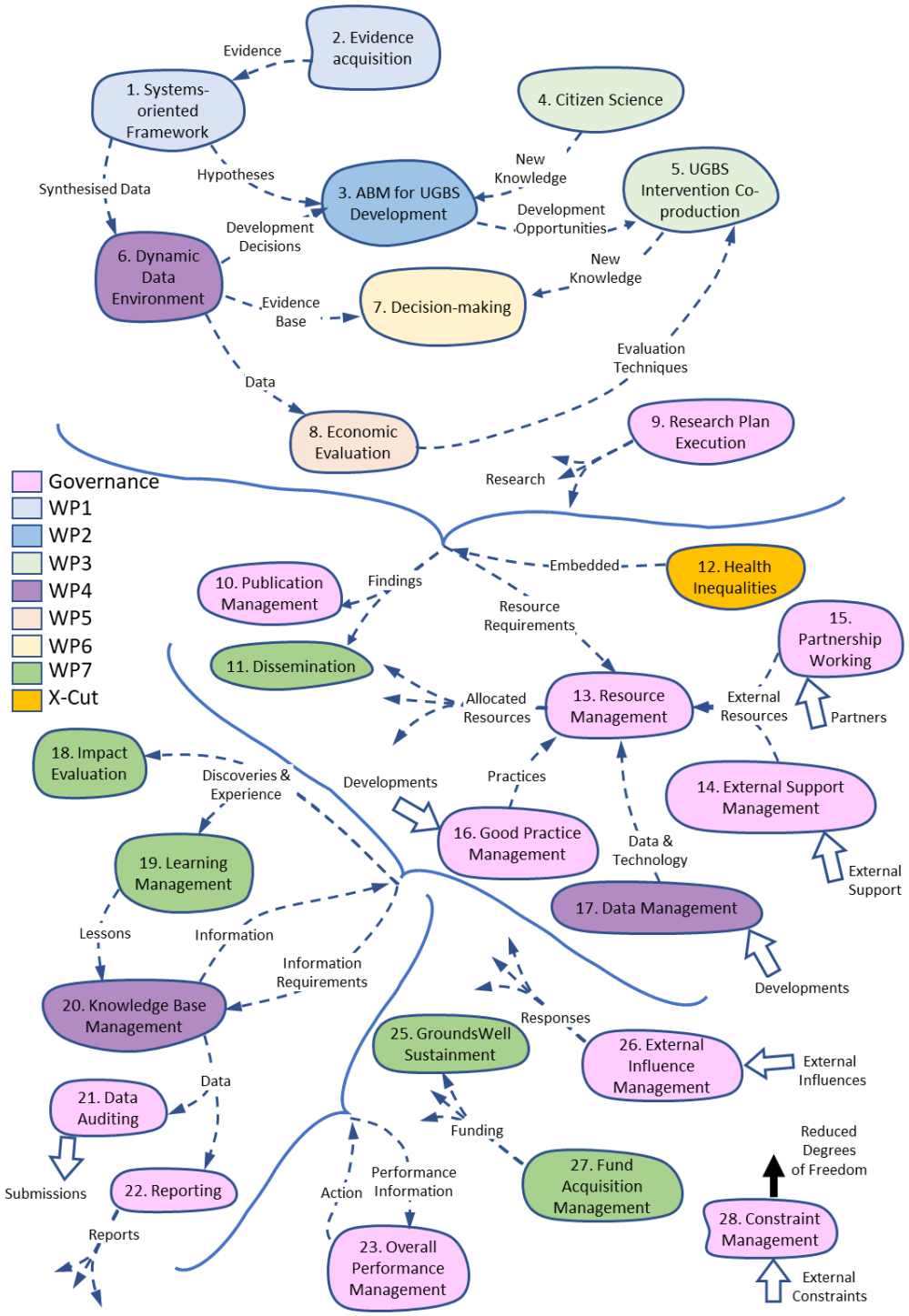


Figure 79 - Revised GroundsWell Sub-System Model Mapped to Work Packages

5.7.4 The Revised GroundsWell Consortium represented by a VSM

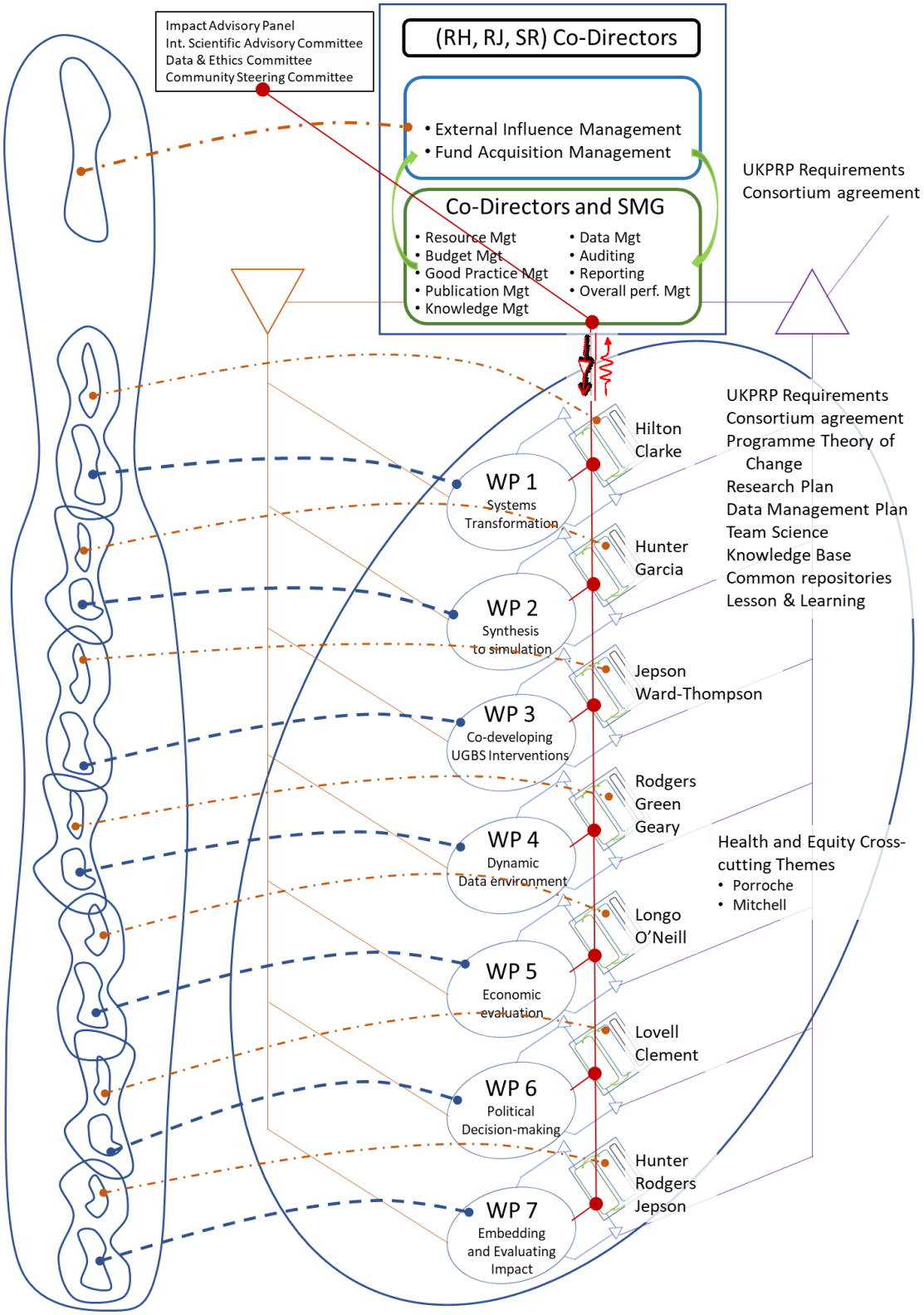


Figure 80 - Revised VSM of GroundsWell

5.7.5 Development of the VSM

The next stage was to analyse the governance-related activities in the SSM activity analysis table. This was to support a conversation to diagnose the management approach to GroundsWell. By this time, GroundsWell had been operational for a period of time and the directors wished to review their approach to consortium management.

Conversations were held with the lead director. The notes from this conversation are at Section 5.7.6.The SSM subsystem model and more detailed activity analysis were used as the basis of the conversation. Much of the conversations' findings is documented in the analysis table as comments and in the mapping to VSM. An extract is included in Table 28.

The responses are also mapped onto a consortium-level VSM as included at Figure 81 (based on the VSM canvas included at Figure 46). The activities coloured red are those that are not currently being done, but it was recognised that they should be. What passes along the links between the VSM Systems is indicated alongside the directional arrowheads between the systems.

Subsequent VSMs illustrated at Figure 82 and Figure 83 show lower-level recursions of WP1 showing the detail relevant to the governance of their elements, integrated not the consortium level governance.

There are a number of areas still to be considered by the directors. These are highlighted in red and are:

1. System 5: Directors have oversight of papers in remit by the consortium. Though paper proposals are submitted for review and approval, noting conflict of interest or duplication, the directors wish to review their final publication format, and author inclusion, to ensure the paper is in line with the GroundsWell focus and relevant authors across the consortium are included. Also, to check the credit statement, terminology / technical correctness to endorse papers to represent GroundsWell.
2. System 3: Publication management. There is a gap that there is no system for managing publications. Three to four have been published but there is no mechanism to update a list of publications.

3. System 3*: There is currently no research governance evidence audit. Also, there is no audit of health inequalities being embedded within research across the work packages.
4. System 2: There is still a lack of work package harmonisation/integration. It is being considered to propose the mechanism should be the city hub case studies in Belfast, Liverpool and Edinburgh.

5.7.6 Notes from the discussion with the Lead Programme Director

Programme measures of success:

- Published papers;
- Leveraged funding;
- Impact at local and national level;
- Development of stakeholder relationships;
- Capacity building;
- Development of staff.

N and E have impact trackers for work packages, and a guiding framework to monitor impact.

Not yet looked at the opportunity to come together to enhance WP outputs or to feed into an overarching GW impact.

GW came from a failed EU bid and people came together to add to it. Integrated in Belfast in CCG case study (R to go through what QUB have done to date). Therefore, integration is CCG case study. (our WP to join QUB Hub or Connswater Working Group?) Integration of Systems Models and ABMs.

Across WPs and GW knowledge mobilisation to be addressed

Constraint – WP3 Delphi survey of indicators to give guidance on NCD risk factors and irregularities.

How do you keep WPs on track? Directors input because WP6 is a UK-wide level and not at a city level, therefore Directors do not have the same input. Otherwise, RH: 1,2, 5 & 7, SR: 4, and RJ: 3. Bulk of work done at a city level.

N and E – impact trackers – WP impact & comms.

If WP work is going out of scope, directors will have discussions. E.g., WP3 Hydrogen buses is out of scope of GW. SR and RJ would say small greening to make bus stops more attractive is in scope. RH seeking to shape that. Leads to Director-level discussion and justification/defence. Important as these may suck up large resource commitments.

WP Interconnections? Encouraged by Directors.

Belfast see it as a case study – impact of CCG on local community.

WP Integration is not visible. Connswater Working Group is in place and aim to establish a working group around the Edinburgh Hub.

Good Practice? Seen in pockets. A for Equity; Green City Partnerships; QUB N promulgates this; RJ – good practice in community engagement and co-production – has a framework.

Publication Management? J admin and process. Collect and return proposals to authors. GAP in updating system WRT publications. 3-4 are published but there is no mechanism to update. Comms via the newsletter. Directors have oversight of papers in remit of consortium, noting conflict of interest or duplication. Don't have a mechanism for authors (need recommendations to also send a draft to review collaborating authors (WP6?). also see credit statement, terminology / technical correctness to endorse papers to represent GW.

Work to be done with Liverpool team regarding what a systems approach means.

Knowledge Management/data management. R is the data manager for the consortium. He will create a dashboard of types of data and how to access them.

For WP1, we need to begin to store our data around the CCG case study at QUB. Each city will probably do the same for their Hub/case study.

E/R/S to consider where to store and how to access.

Research Governance Evidence audit – Queens Governance for all QUB research monitors Queens. None yet identified. N/E have impact trackers (fed by WPs) where data is being collected to demonstrate impact.

Research Ethics – S/R and the Data Governance Committee.

Reporting?

- ResearchFish – A/I need a coherent system for it.
- Annual Report – J is Administrator and nudges WPs etc. RH will make up the 2-year template, J will chase.
- Directors will compile report and submit + interviews.

Overall performance management – N/E will compile information (expect funding pots)

Funds acquisition management – funding for different elements. DTGs / Bids? / using GW for interventions / natural experiments. Not yet at consortium level, possibly end of yr3 / start of year 4. Largely 3 Directors @ higher level for funding in Hubs.

Lack of funding for interventions – impact on Hubs, therefore Directors to address.

External influence – E, N. Comms out, but do they seek information of how GW is perceived? Could get info from SIPHER and SPECTRUM – may not change what we do but might constrain. (Feedback through International Scientific Advisory Panel?)

Community Steering committee – all 3 Hubs represented. Chair is MB. Local citizens, local community reps. Meets 3-4 times per year to keep relevance to community. I.e., cost of living impact – cuts to the community & voluntary investment from GW. Innovation fund £80k/city in addition to consortium

funding received (was Directors' discretion fund). Putting together a small grant scheme for small research / interventions / events. CSG guidance and sits on funding review panel.

Data Governance Committee meets 3-4 times per year. Chair IB in Liverpool. Representation across nations. Governance around admin data and linkage – admin and health data issues. Scope to broaden it. Belfast City rep working on citizen science data and include qualitative data.

Impact Advisory Committee meets 2 times per year. GE, urban planner in QUB. Representatives from the 3 regions. Community, local authority, local governance, practitioners, planners, designers, public health. Provides advice and guidance on impact. Where could work fit into NI, Greenspace strategy in Scotland. How would our work fit in?

International Scientific Advisory Panel. Last meeting postponed. Reps from scientific disciplinary perspective and will meet possibly 2 times per year. Chair is SA (systems science). C does new urban health and systems. All the other UK PRP consortium leads attend, + GW directors. Where can GW fit in a more international context.

WP7 meetings – WP1 (JH) to be invited to attend.

RH would like a summary of findings and have recommendations regarding governance gaps.

5.8 Environmental Interactions

Work has begun on modelling the consortium within its environment as shown in Figure 84. This is to aid the understanding of the environmental interactions not just at the consortium level but will enable the directors to have insight into the interaction and priorities at the lower levels of the work packages, and individual activities within the work packages. It is proposed that this is further developed within each of the work packages, and a consolidated view maintained.

Table 28 - Example of mapping activities to subsystems, work packages and VSMs

Activity ID	Activity	RD	Subsystem	Work Package	Outputs	Quality Criteria	Consortium VSM System						WP1 VSM System						WP2 VSM System						WP3 VSM System						WP4 VSM System						WP5 VSM System						WP6 VSM System						WP7 VSM System					
							1	2	3	3*	4	5	1	2	3	3*	4	5	1	2	3	3*	4	5	1	2	3	3*	4	5	1	2	3	3*	4	5	1	2	3	3*	4	5	1	2	3	3*	4	5	1	2	3	3*	4	5
8	Monitor the development of systemic trans-disciplinary problem solving approaches	S1	1. Systems-Oriented Framework	WP1											X																																					
9	Take control action to ensure systemic trans-disciplinary problem solving approaches are developed and that they meet the needs of potential users and beneficiaries of the research	S1	1. Systems-Oriented Framework	WP1	1. A Soft Systems conceptual model demonstrating the hierarchy of purposes and integrated through the application of the Viable Systems Model.				X						X			X																																		
15	Assess the development of the systems-oriented framework	S7	1. Systems-Oriented Framework	WP1											X																																					
16	Take control action to ensure a systems-oriented conceptual framework is developed and that it integrates mutiple, interconnected pieces of	S7	1. Systems-Oriented Framework	WP1	3. A clear, comprehensive, multi-perspective basis to inform hypothesis generation, and data collection and analyses in WPs 2-6, as well as the interpretation and integration of their				X						X			X																																		
24	Monitor knowledge acquired	T	2. Evidence acquisition	WP1											X																																					
25	Take control action to ensure knowledge is acquired and mobilised according to the needs of the WPs	T	2. Evidence acquisition	WP1	2. A new method to facilitate dynamic collective learning, synthesis and knowledge mobilisation able to incorporate new data, and informed deliberations using double-loop learning, triangulation, and citizen juries.				X						X			X																																		
30	Assess the level of understanding achieved	S7	3. ABM for UGBS development	WP2																	X																														
31	Take control action to ensure a shared understanding of the mechanisms linking UGBS and NCDs is achieved	S7	3. ABM for UGBS development	WP2	1. Stylised ABM for guiding hypothesis generation and data collation. 2. Data-informed ABM for informing the development of future UGBS initiatives. 3. Interactive dashboard for end-users for people's empowerment of our Consortium.				X												X			X																												
33	Monitor the development of parallel innovations in community engagement and data-informed adaptive systems	S1	4. Citizen Science	WP3																							X																								
34	Take control action to ensure the systemic trans-disciplinary problem solving approaches developed accelerate and optimise community	S1	4. Citizen Science	WP3	4. Citizen science guidance and tools for co-producing and evaluating the health impact of UGBS.				X																	X			X																						
37	Monitor results of actions and solutions put in	L1	5. UGBS Intervention Co-	WP3																						X																								
38	Take control action to ensure the actions and solutions put in place lead to improved population health and reduced NCDs	L1	5. UGBS Intervention Co-development	WP3	2. Evidence (from citizen science and co-produced evaluations) of what works, for whom and why.				X																	X			X																						
47	Monitor the impact that the connection of UGBS systems has on research, policy, practice and active citizenship connection of UGBS systems	T	5. UGBS Intervention co-production	WP3																						X																								
48	Take control action to ensure that connecting systems together through co-production, data-sharing and community engagement impacts research, policy, practice and active citizenship	T	5. UGBS Intervention co-production	WP3	2. Evidence (from citizen science and co-produced evaluations) of what works, for whom and why.				X																	X			X																						
52	Monitor the incorportation of a community and systems focus within intervention development, implementation and evaluation	T	5. UGBS Intervention co-production	WP3																						X																								
53	Take control action to ensure that the development, implementation and evaluation of UGBS interventions is community and systems	T	5. UGBS Intervention co-production	WP3	3. A set of standardised outcome indicators to be used at a community level for NCD prevention.				X																	X			X																						
61	Monitor exploitation of data on health, wellbeing and the environment that is routinely collected by councils and	L1	6. Dynamic data environment	WP4																														X																
62	Take control action to ensure data on health, wellbeing and the environment that is routinely collected by councils and governments is exploited such that it leads to improvd population health and the reduciton	L1	6. Dynamic data environment	WP4	2. Open source small area aggregate NCD and UGBS data resource. 3. Longitudinal UGBS and NCD collation for evaluation of large scale interventions.				X																										X			X												
65	Implement a data repository to aid the development and evaluation of UBGS system-level interventions for the benefit of all	T	6. Dynamic Data Repository	WP4																													X																
66	Take control action to ensure the implementation of a data repository to aid the development and evaluation of UBGS system-level interventions for the benefit of all communities	T	6. Dynamic Data Repository	WP4	1. Accessible UGBS data repository to guide need for high risk NCD access to and use of UGBS				X																									X			X												
71	Take control action to ensure improvement to outcomes and decisions by decision-makers	S3	7. Decision-making	WP6	1. Greater understanding and articulation of where responsibility, accountability and agency sit in UGBS decision-making, to inform the conceptual framework and simulations to confirm leverage points and measures of success that would lead to increased UGBS use by high risk				X																																					X			X		
79	Assess the informing of political and decision-making contexts	T	7. Decision-making	WP6																																									X					
80	Take control action to ensure political and decision-making contexts are informed	T	7. Decision-making	WP6	2. Validation and enhancement of intervention simulations demonstrating value to policymakers; understanding where and how to modify decision-making systems for UGBS co-benefits. 3. Tools and approaches for meaningful involvement of				X																																					X			X		

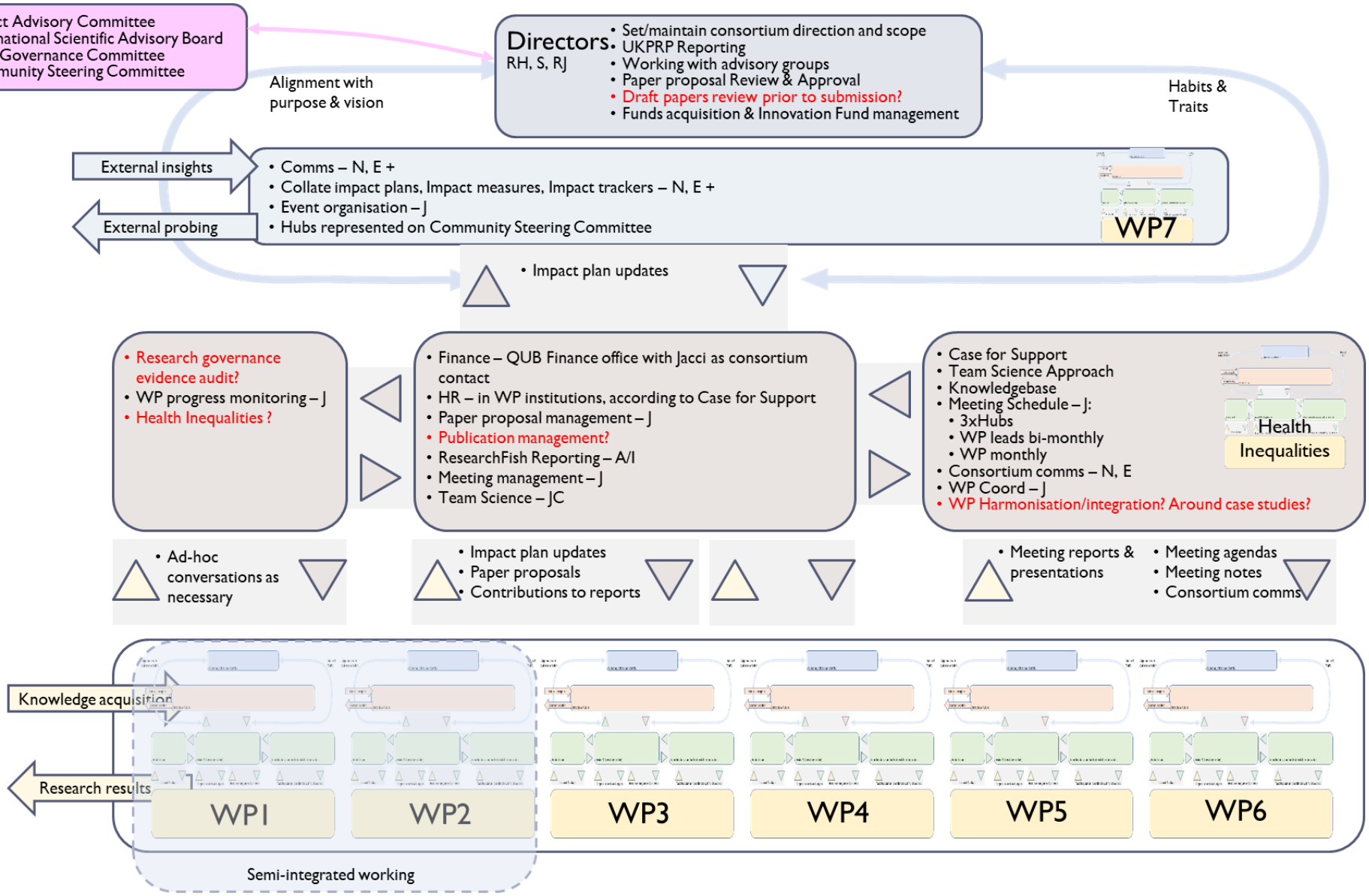


Figure 81 - VSM at the consortium level

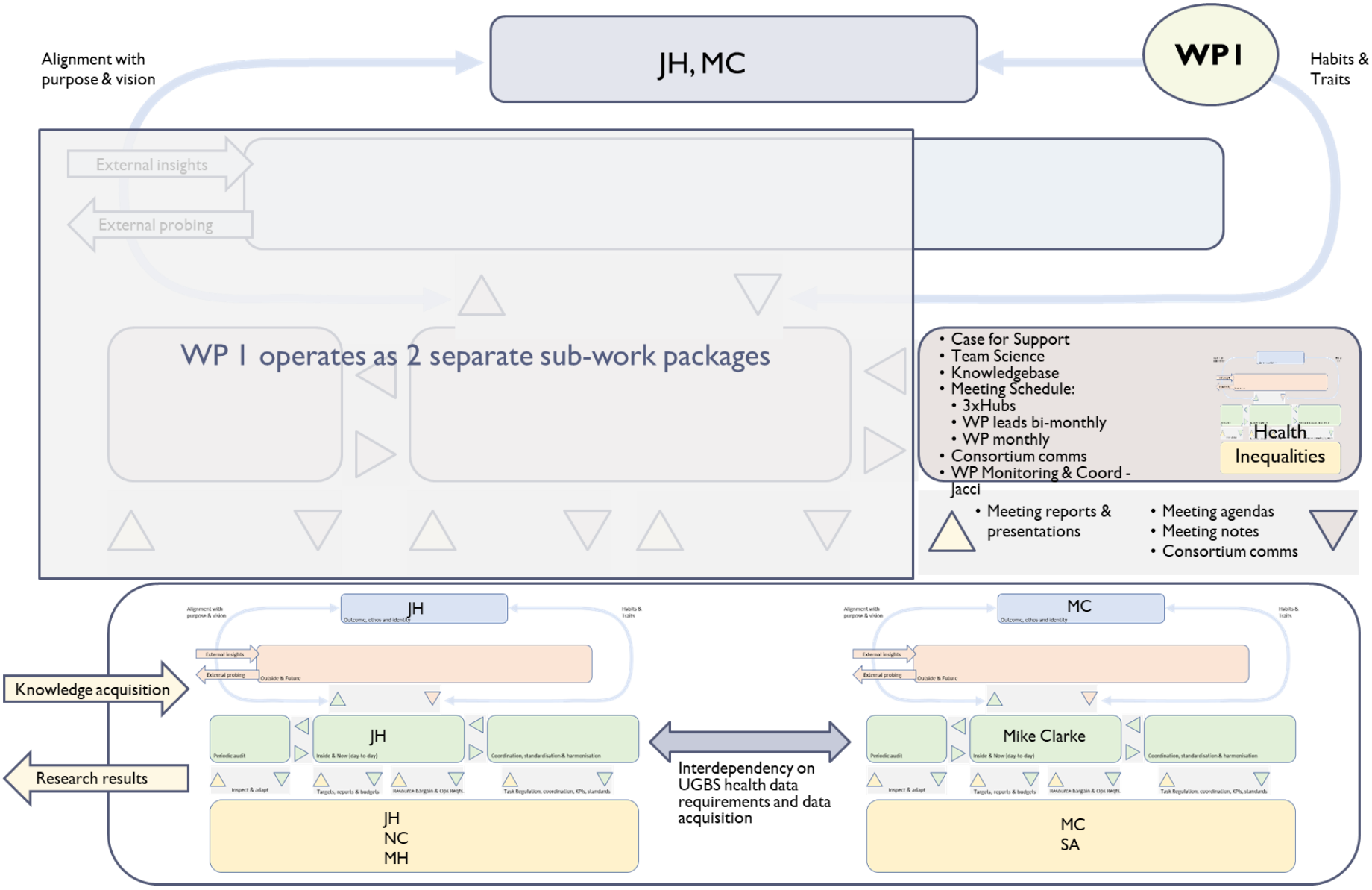


Figure 82 - VSM at Work Package 1 level

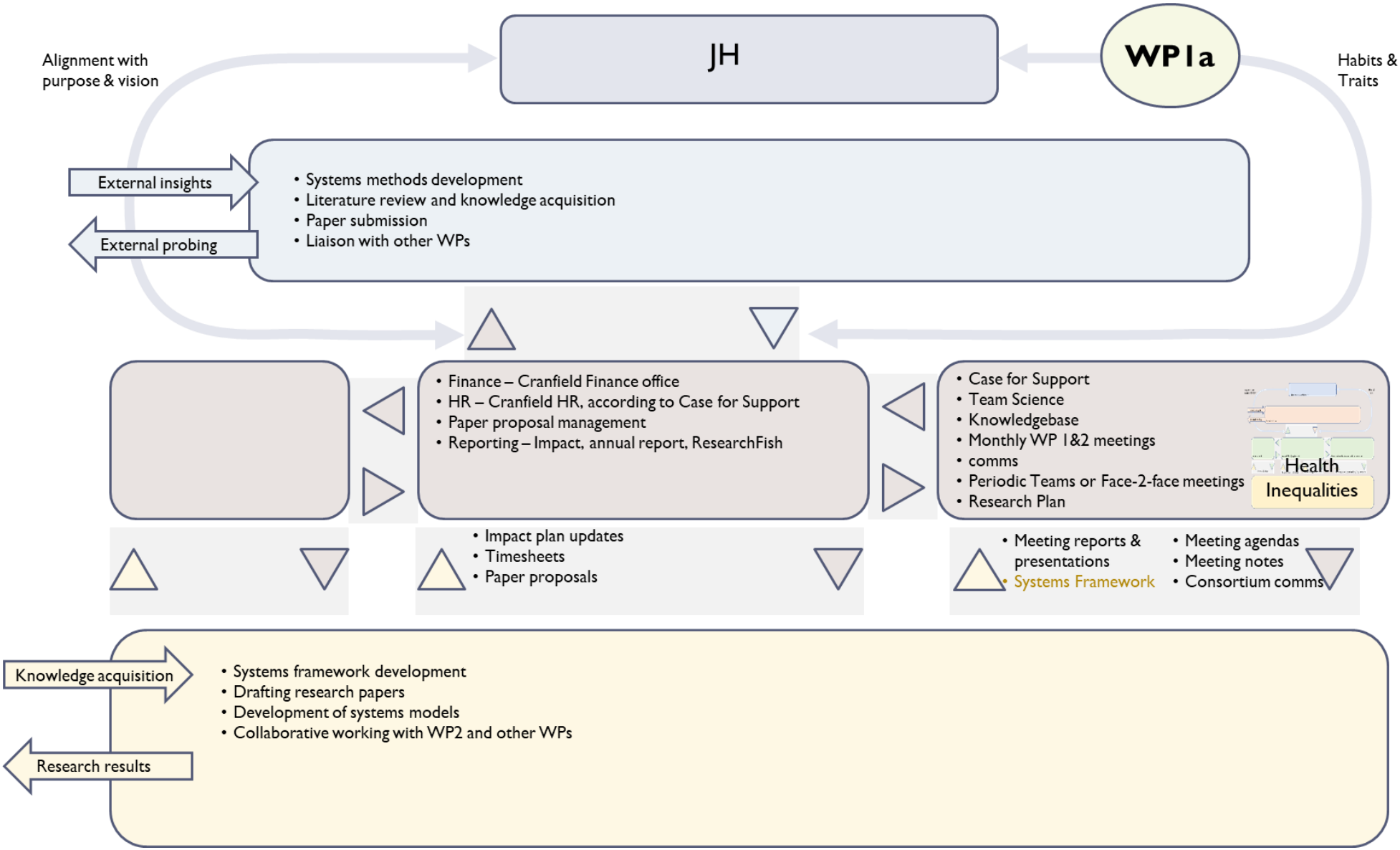


Figure 83 - VSM at Sub-Work Package 1a level

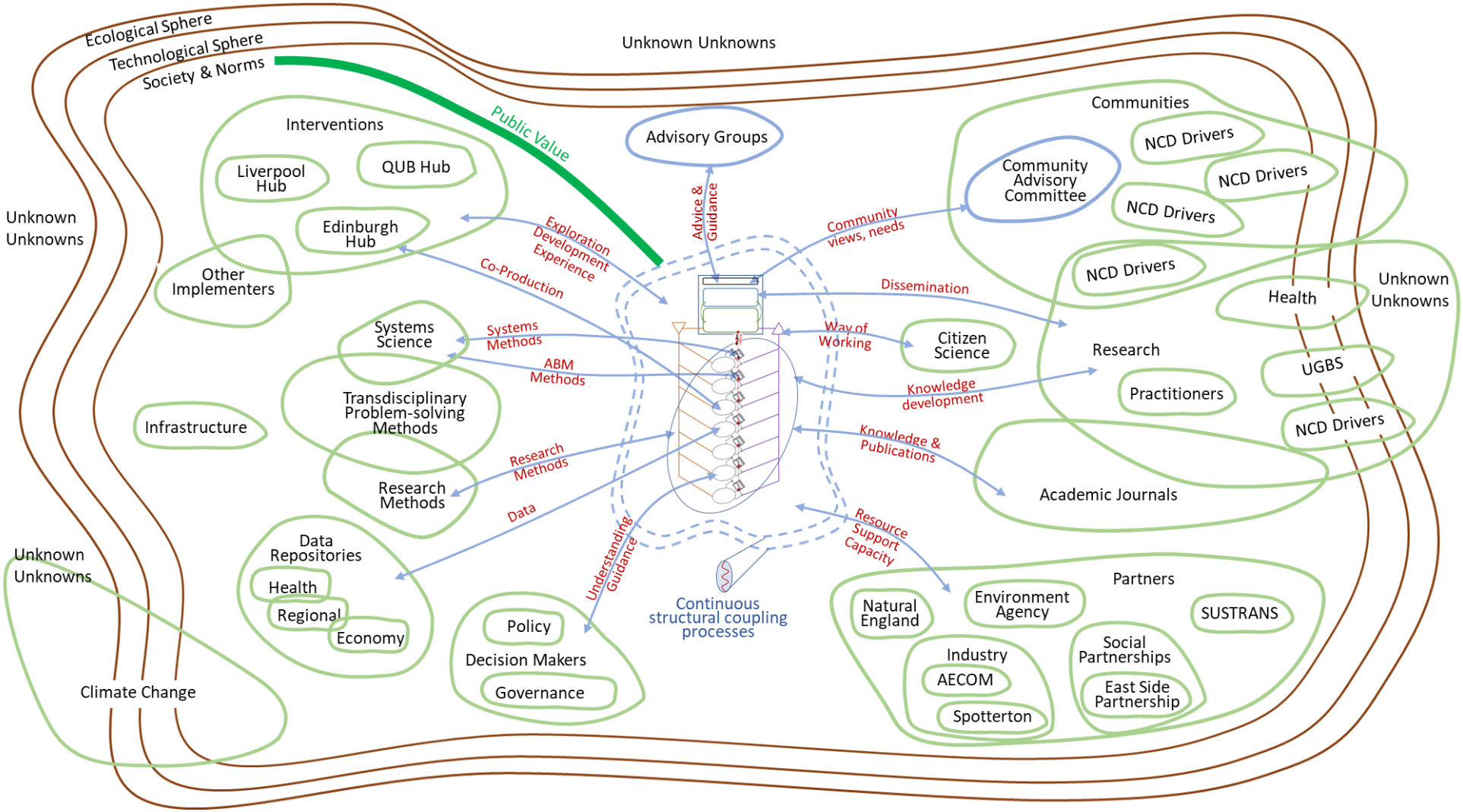


Figure 84 - Environmental interactions at the consortium level

5.9 Development of the Causal Loop Diagram

Working from the outputs of the initial workshops, the activity analysis table, the conversations with the senior programme manager and director, as well as referencing the UKPRP measures of performance (UKPRP, 2018), a CLD was developed as illustrated at Figure 85.

With the UKPRP measures of success incorporated, related consortium upstream indicators of success can then be determined as indicated in Figure 86. This is awaiting ratification and will inform the measures of success for GroundsWell. The UKPRP ones are included, as are the initial ones defined by the directors. In addition, proposed upstream indicators/measures of success have been identified.

These will be agreed and mapped to the SSM activity analysis table and on to the relevant VSM. The next stage is to build a CLD of the programme itself and then identify work package-level measures of success.

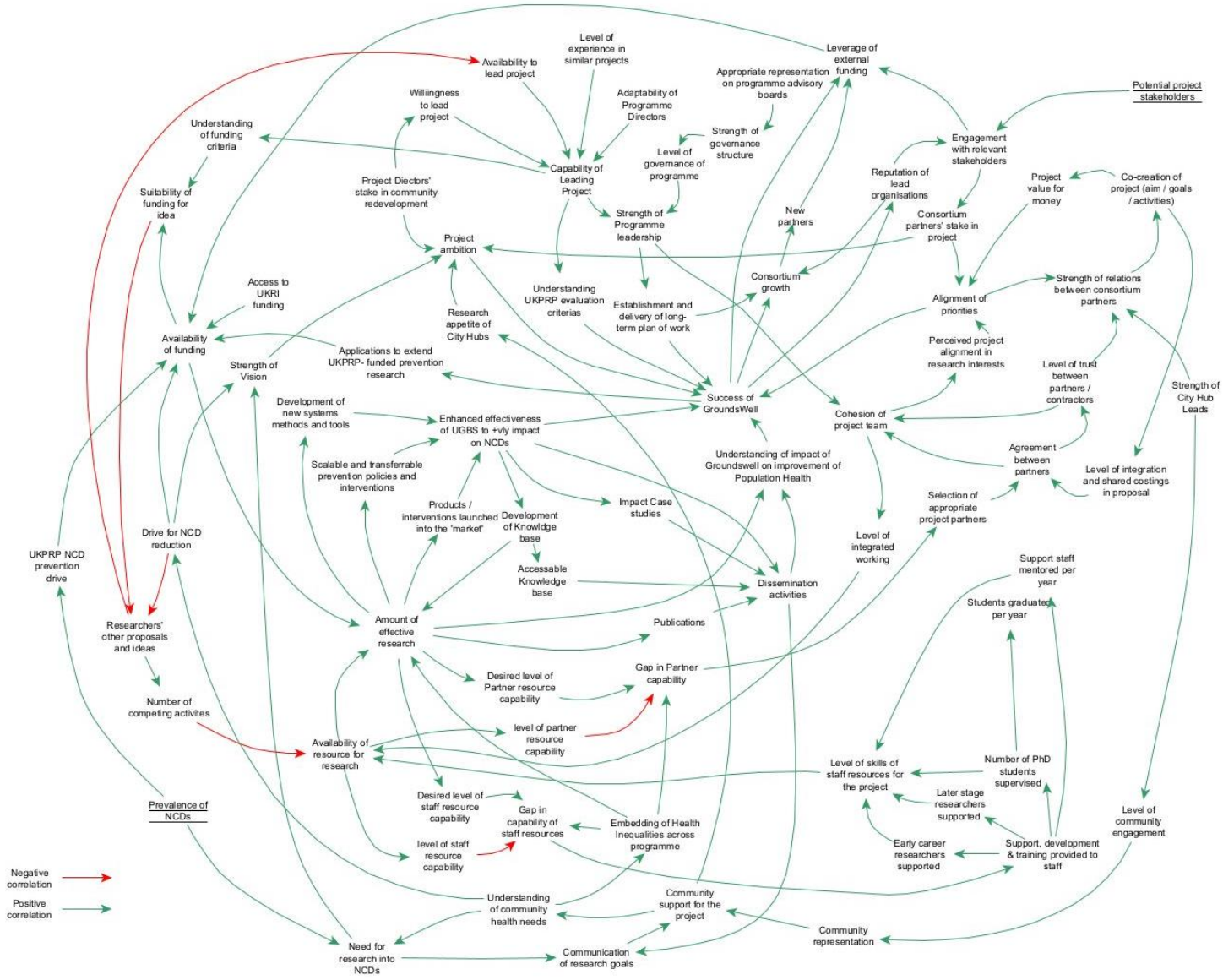


Figure 85 - GroundsWell Consortium Causal Loop Diagram

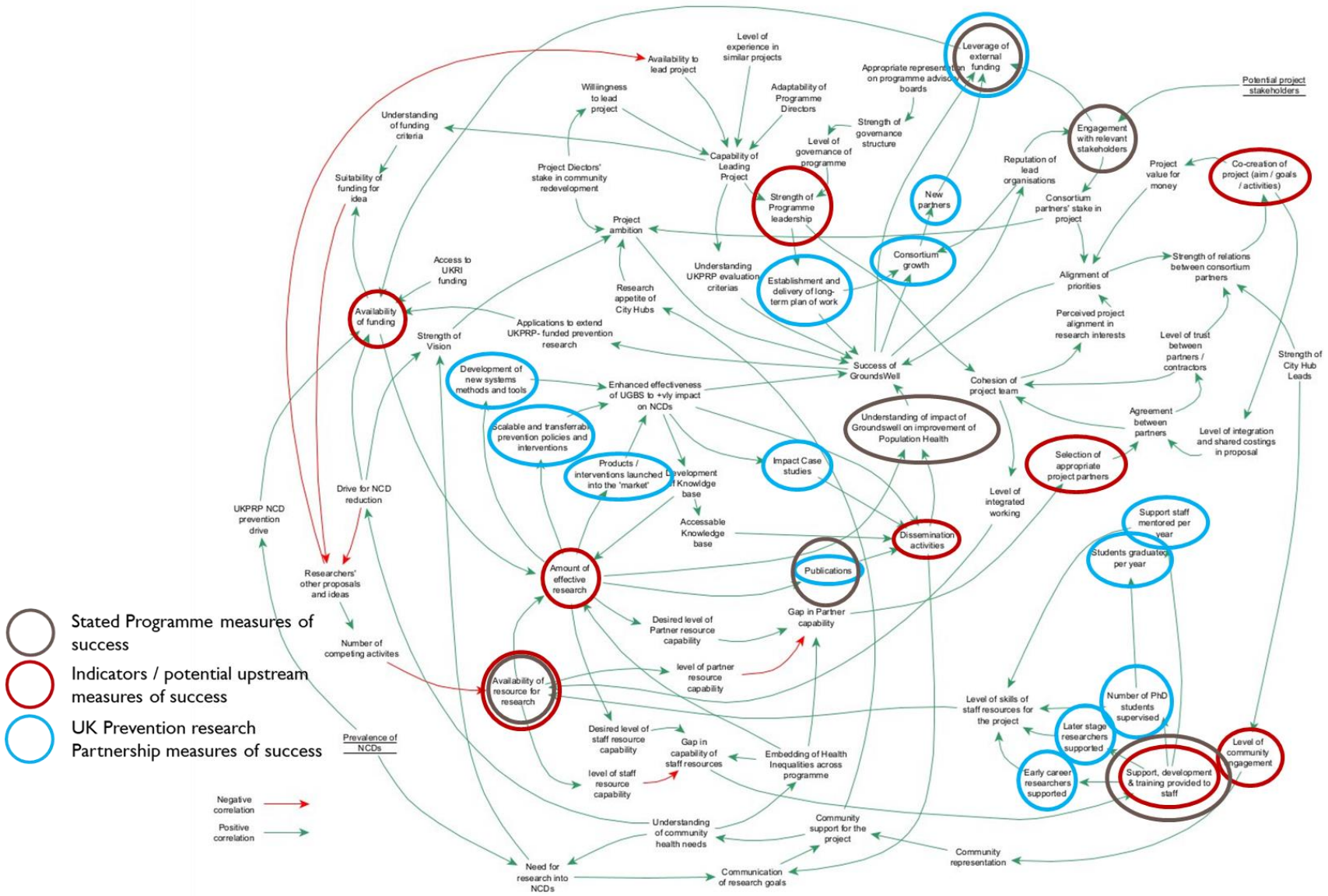


Figure 86 - CLD of GroundsWell within its environment (Source: Author)

5.10 Dependency Model

Due to the complexity of the programme and the variety of the work packages, the need for a dependency model was agreed. This would provide a better understanding amongst work package leads of who they need to collaborate and share information with, as well as to inform the directors of critical activities.

The initial dependency model is illustrated at Figure 87, and a different view of it, showing key dependencies, is at Figure 88. This has now become a specific output of my work package, work package 1. All of the work package leads have been engaged to state what they depend on and which other work packages they believe depends on their output.

This is currently being further developed within the project within my work package, and with consultation of all the work package leads. It is currently being finalised.

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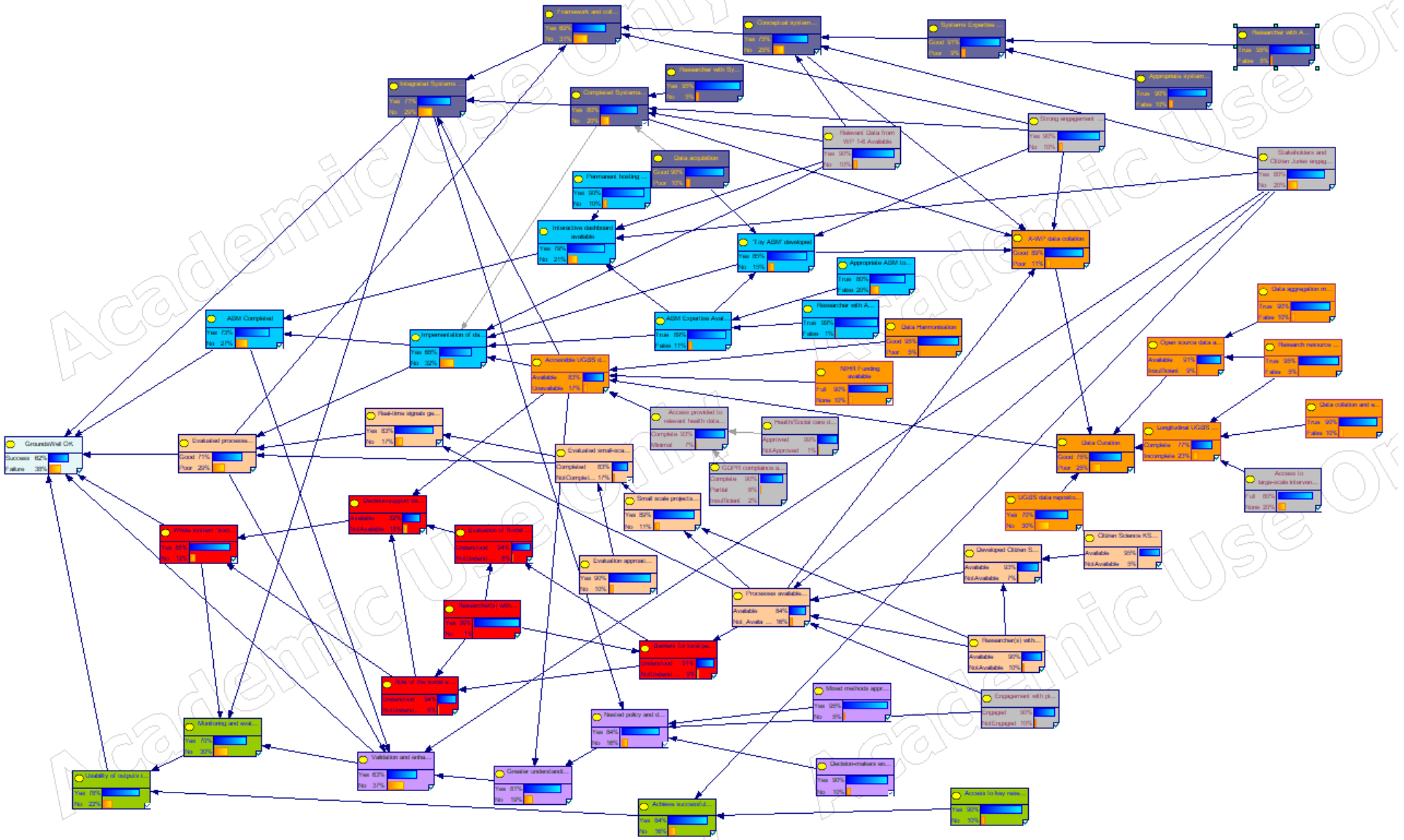


Figure 87 - Initial dependency model

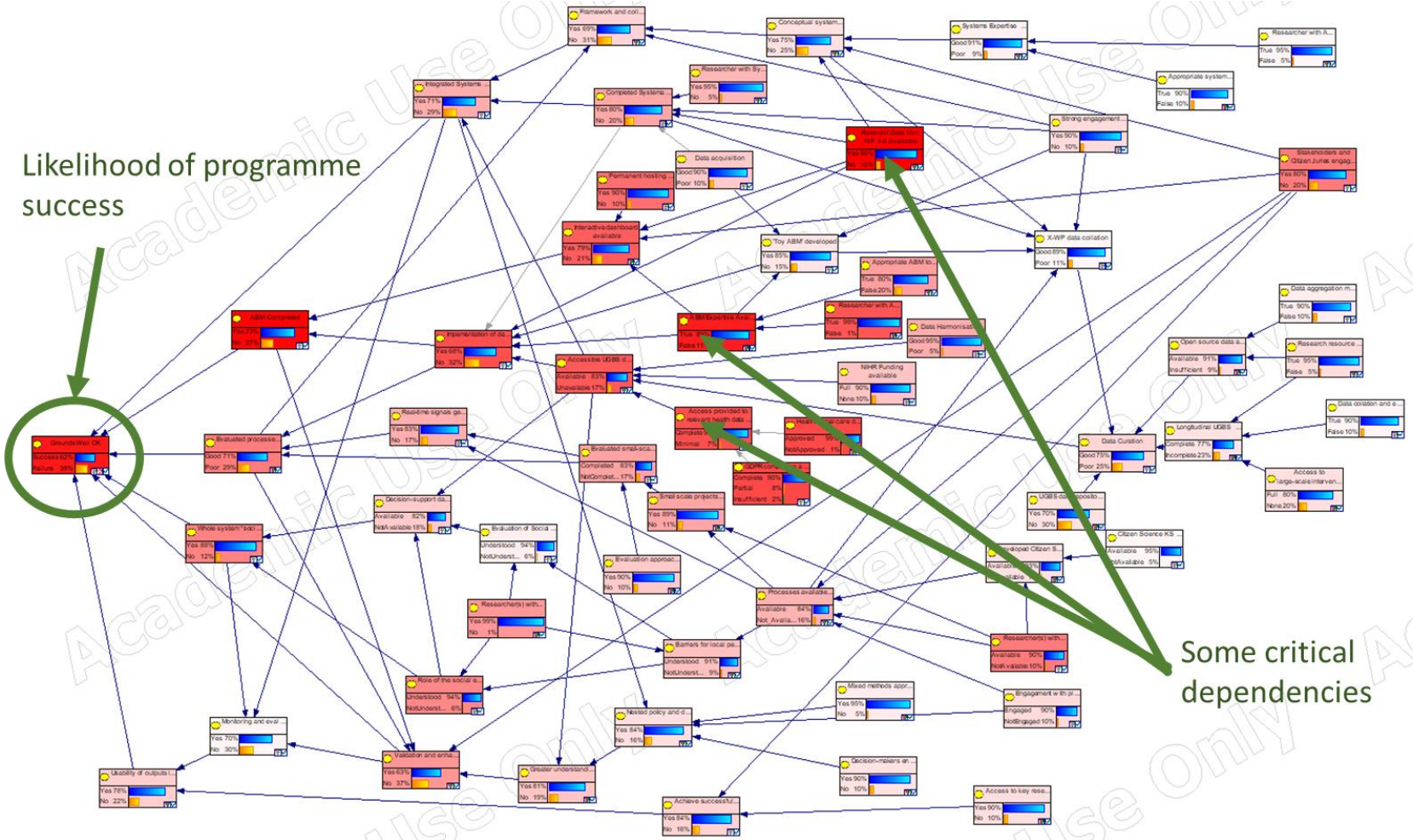


Figure 88 - Initial Dependency Model showing key dependencies (Source: Author)

5.11 Summary

This Chapter has provided an instantiation of the Reference Model of Governance for a Specific Organisation to illustrate its application in context and to enable additional validation. The Reference Model of Governance for a Specific Organisation comprises the measures of performance, the related control activities, policies and procedures, standards and reporting. The final model of Governance will be recorded and maintained in a VSM.

It is not complete as it is in development with the directors of the GroundsWell research programme and is being developed in accordance with their interest and concerns.

The case study also helped to develop the detail in the coordinating activity analysis table, especially regarding variables and measures of performance linked to the CLD. Consequently, I did not need to review my approach and have augmented the detail included in the Reference Model of Governance for a Specific Organisation.

The next Chapter discusses the validation of the instantiated GroundsWell Reference Model of Governance.

6 Validation of the GroundsWell Reference Model of Governance

6.1 Conceptual Validity

Technically, though not part of the theoretical facet (section 4.9.1.2) validation set, it is helpful with regard to the case study to validate the conceptual model derived for informing the Reference Model of Governance. This is because the instantiated Reference Model of Governance actually has an organisational context whereas the Reference Model of Governance for a Specific Organisation structure has a theoretical basis.

Table 29 - Conceptual Validation Questions

Question	Comments
Have the stakeholders been identified, and the problem situation considered from the appropriate perspective?	Yes. Stakeholders are identified in the initial understanding phase, and mapped to the VSM environment model
Has the managerial situation has been 'unfolded' and the relevance of the perspective with regard to appropriate solutions identified?	Yes. All the integrated models capture the perspectives according to their theoretical basis and provide guidance on relevant solutions.
Has the root definition(s) been determined and ownership by the problem owner agreed (Wilson, 2001)?	Yes. The enterprise set of root definitions have been agreed by the Directors
Have the goals been formulated on which to focus the modelling-validation process?	Yes. These are the requirements set initially, then incorporate the UKPRP evaluation criteria and finally the Directors decisions.
Are the constructs (cognitive maps) representative of the situation as perceived by the actors (Eden, 1988)?	Yes. These have been surfaced in a range of workshops and maintained in ongoing Work Package Lead updates.

Question	Comments
Is the managerial situation explored from the following perspectives (M Jackson, 2020)?: • Machine; • Organism; • Cultural/political; • Societal/environmental; • Interrelationships.	• **Machine**: the goal is agreed in the understanding phase and represented in the Core 'T' in the Enterprise set of Root Definitions; • **Organism**; 6 Cohering Questions may identify the key activities allowing an initial diagnosis with VSM, also enabling organisational pathologies to be identified; • **Cultural/political**: what needs to be done is explored in the understanding phase, established with the 6 Cohering Questions and Laddering. • **Societal/environmental**: These are explored in the understanding phase with the Multi-Perspective Approach and context diagram. Specific consideration may be given if CSH is utilised to confirm the understanding. Environmental issues may also be identified Rich Picture and in Scenario Planning, if undertaken. • **Interrelationships**: these are explored with Cognitive Maps and CLDs

6.2 Logical Validity

Table 30 - Logical Validation Questions

Question	Comments
Does the Reference Model of Governance for a Specific Organisation capture and reflect the relevant range of perspectives within the situation as reflected and are the following metaphors considered? • Machine; • Organism; • Cultural/political; • Societal/environmental; • Interrelationships.	• **Machine**: The goal is agreed during the understanding phase and coded in the Enterprise set of Root Definitions. The necessary parts are identified in the SSM Subsystem model and recorded in a set of VSM which can demonstrate their organisations. SSM activity analysis can explore how activities are being undertaken and their level of quality. A Dependency model can indicate the likelihood of success of the subgoals and overall goal of the organisation to indicate the status of organisational activities. • **Organism**: Subsystems are identified through the SSM Subsystems and mapped to a set of VSMs. These can determine the level of autonomy and ability to adapt to external shocks (VSM S3/S4 performance and interaction). A CLD internal to the organisation is used to inform this. Resilience can be enhanced by overlaying the SSM Resilience model to explore additional relevant activities. • Cultural/political: Building on the understanding stage, the Enterprise set of Root Definition records the agreement regarding what needs to be done at a high level, and then modelled in detail in the CPTM. • Societal/environmental: Activities derived from the Enterprise set of Root Definitions will ensure all stakeholders have been identified and the VSM in its environment is used to maintain a current understanding of who they are and how they interact. A high-level CLD of the organisation in its environment will capture the dynamics of the environmental interaction. • Interrelationships are captured in the high-level and internal CLDs, as well as the logical dependencies within the SSM CPTM. Detail can be augmented by specific stock and flow diagrams and a dependency model.

Question	Comments
Have the boundaries of the situation been explored and agreed?	The boundaries are explored in the understanding stage, and recorded as the boundaries indicated by the VSMs, the VSM in its environment, the boundary around the activities within the SSM CPTM, and the links between the organisation and wider components as captured in the high-level CLD.
Are the interrelationships identified (these may differ according to methodology/method)?	Interrelationships are captured in the interactions between VSMs, the logical dependencies in the SSM CPTM and the CLDs.
Has the hierarchy of purpose (emergence) been established?	This is established in the understanding stage and recorded in the hierarchy of VSMs, informed by the differing purposes at each level recorded as root definitions and conceptual models.
Have the dynamics at each level and between levels been identified?	These are identified within the hierarchy of VSMs in the VSM set and the high-level and internal CLDs.
Have the management communications and controls been identified as related to purpose/emergence and leach level of the hierarchy?	These are captured in the SSM conceptual model at each level and in the hierarchy of VSMs in the VSM set.

6.3 Experimental Validity

Table 31 - Experimental Validation Questions

Question	Comments
Does the Reference Model of Governance for a Specific Organisation enable an appropriate level of understanding and insight into the managerial problem?	Yes. It supported discussion with the directors, the principal programme manager and other staff.

Question	Comments
Is the Reference Model of Governance for a Specific Organisation sensitive to changes in values within models?	Yes. The activity analysis table is the point of integration enabling changes in one perspective to be promulgated throughout the rest and changes identified. The Case study has demonstrated how a change in overall purpose can be modelled and changes in activities etc. identified.
What is the level of acceptability and applicability of the Reference Model of Governance for a Specific Organisation?	There is good acceptability of the model. It has already informed the structure of the consortium leading to successful funding and has identified areas of improvement of the ongoing governance of the consortium. The Reference Model of Governance for a Specific Organisation approach and structure is also becoming the basis of the systems framework to support the research being undertaken by the consortium, as well as informing the structure of other research organisations and business cases for support.
How useful do you think it is/could be in informing a decision?	It has already proved useful in informing decision-making. The gaps identified in the Consortium-level VSM have been addressed and a full dependency model is being developed as a progress monitoring and governance tool for the directors

6.4 Verificational Validity

Table 32 - Verificational Validation Questions

Question	Comments
To what extent does the `formal model' represent the intended `conceptual model'?	The formal model (Reference Model of Governance for a Specific Organisation) represents the conceptual model well as it has the same perspectives, and the methods are coherent. The key link is the understanding generated in the understanding stage and the use of the 6 Cohering Questions technique to provide continuity through to the Reference Model of Governance for a Specific Organisation.

Question	Comments
What are the advantages of the `formal model' in terms of gaining new insight (perhaps compared to other models)?	The Reference Model of Governance for a Specific Organisation integrates systems methods with different perspectives drawing out different knowledge, including that from positivist, interpretivist and social constructionist philosophical perspectives, It provides a visible linkage between systems methods and the whole is integrated through a bespoke methodology relevant to the purpose of organisational governance. Being a type of system of systems approach and being integrated, it enables insights that are more than (different to) the sum of systems methods.
How superior do you think the solution techniques developed might be and how accessible do you think they are?	Superiority is difficult to evidence. However, it has already proven superior to the standard research programme design approach and to the structuring of complex research consortia by the improvements to the case for support, and the ongoing governance of the programme. Accessibility of the systems methods, and their combination will require experienced facilitators and practitioners familiar with the methods used. Following a script will not suffice as a theoretical understanding of the philosophical basis of the methods is necessary to ensure they are used appropriately and achieve the desired outcomes.
What is the quality and nature of the solutions obtained?	The quality and nature of the solutions obtained is dependent on the skill of the practitioner(s) and the detail to which it is deemed useful to develop the models.
What is the level of contribution to the extension of pertinent knowledge?	The level of knowledge within the consortium regarding the complexity of the programme and the requisite set of governance mechanisms has been significantly extended. Ongoing development of the Reference Model of Governance for a Specific Organisation, especially when applied to provide the basis of the systems framework will enhance the integrated systems understanding and meet the requirement to improve the systems approach to reducing NCDs through UGBS.

6.5 Operational Validation

Though outside the scope of validating the theoretical basis of the Reference Model of Governance for a Specific Organisation, these questions, derived from (Oral and Kettani, 1993, p.226) (Table 33), were used to solicit the views of the directors with

regard to the usability and usefulness of the Reference Model of Governance for a Specific Organisation in informing decisions with regard to the governance of the GroundsWell consortium.

This was through the result of my presentation of the Reference Model of Governance for a Specific Organisation to the directors via MS Teams, and the associated discussion.

Table 33 - Operational Validation Questions

	Question	**Comments**
Usability	What is the level of resource availability for implementation?	Directors and WP leads, but limited time. Perhaps needs some preparation to make best use of available time.
	To what extent is the model is understood by the relevant actors?	Of the 3 directors, 2 were comfortable and understood them well. One did not find conceptual thinking easy but would like to work through an example in their own context to gain a better understanding.
	What is the degree of willingness and readiness of those who are responsible for and in charge of implementation?	All 3 directors are very willing and excited by the opportunities this approach can bring. Not just for the governance of the research programme, but also to provide a systems framework for the research case studies being developed in each of the 3 city research hubs, Belfast, Liverpool and Edinburgh. Also, they are keen to publish this as a way of establishing a sound foundation to research programmes and public health interventions.
	What is the level of availability, obtainability, and reliability of the data required by the model?	This will be better understood once the system models are fully developed. At present, there is enough to exemplify the approach such that they can better understand the Reference Model of Governance for a Specific Organisation. The data required will be according to the level of detail the directors wish to go to, the level that is useful.

	Question	Comments
Usefulness	To what extent has the `managerial situation' been removed or resolved?	To date, the full case for support was significantly improved by the development of and use of the systems models. Their ongoing development has informed the directors and they have been able to develop better their governance of the research programme. Therefore, achieving the desired funding is evidence that the initial situation was resolved successfully. Progress to date indicates the ongoing governance of the programme is being improved. The Reference Model of Governance for a Specific Organisation and its development approach will be included in this year's report to the UK PRP.
	What level of understanding and insight has been gained?	The directors have gained a very good insight into the complexity of the research programme and the need to ensure good integration of the work packages. Consequently, they have decided to re-consider the collaboration in each of the city hubs and ensure there is representation of all work packages in each one. At the moment, how the data will be collected, recorded, stored and made available is not decided. This is the focus of one of the work packages, and now there is a structure and framework that captures the variety, currency and integration needs for data management. The proposal is to develop a knowledgebase for work package and sider stakeholder access. At this stage, the work package leads have not been made aware of this research, so their level of understanding cannot be assessed. It is understood that due to their variety of philosophical perspectives, not all will 'get' the systems approach initially.
	What degree of enhancement has been achieved in communication between the stakeholders?	This is difficult to determine at this stage as the Reference Model of Governance for a Specific Organisation has only recently been fully introduced. The understanding methods we used in the early workshops significantly improved the communication and understanding across the consortium, leading to a coherent Case for Support.

	Question	Comments
	To what extent is the coordination of managerial efforts realised?	Management coordination amongst the directors is good, though this was already in place as they work closely together, meeting on a weekly basis. They have recognised, however, that coordination with the work package leads and their management approaches needs to be reviewed and better coordination achieved.
	In what way are the relevant people motivated to resolve the `managerial situation' using the model?	The directors are fully motivated to use the Reference Model of Governance for a Specific Organisation to improve governance across the consortium. They plan to introduce it to the bi-monthly work package leads meeting and develop the work package level VSMs, as well as augment the current thinking inherent on the CLD. They also intend to extend the CLD thinking in to the work packages so that work package measures of performance can be developed, coherent with the overall consortium-level measures of performance.
Time dimension	How quickly can solutions be obtained?	It is perceived that solutions in terms of appropriate governance will emerge according to usefulness. This is likely to take another year to be fully in place.
	How much time is required to update and maintain the model, etc?	As yet, this cannot be estimated. It will also depend on the data management solution put in place.

	Question	Comments
Synergism	How well does the contribution of the current `decision' complement previous decisions?	This can be seen in the change between the initial research proposal and the final Case for Support. It has enhanced prior decisions there. With regard to the governance and management put in place, the VSM slide indicates the contribution brought by the Refence Model. It has complemented and improved previous decisions. Specific areas identified are the addition of: • Research Governance • Evidence Audit • Health Inequalities • Publication management • Harmonisation within work packages • Integration of case studies • How papers are reviewed prior to submission
Cost dimension	What is the cost of implementation such as fees paid to consultants, salaries of in-house personnel, equipment expenditures, cost of obtaining and processing data, etc?	The 'cost' of implementation has been covered mainly within the scope of Work Package 1 for the systems approach, and Work Package 4 for the data management. The ongoing development and maintenance of the Reference Model of Governance for a Specific Organisation will be covered by the time allocated to the bi-monthly work package leads meeting and the weekly directors' meeting. Specific costs, therefore, are difficult to determine, so the benefit or otherwise (value) of this approach cannot easily be determined.

6.6 Summary

This Chapter has discussed the validation of the instantiated example of a theoretical Reference Model of Governance for a Specific Organisation. It is not complete as it is in development with the directors of the GroundsWell research programme and is being developed in accordance with their interest and concerns.

The presentation, though the systems models are not fully complete, provided enough context and information for the directors to judge its utility. This was important for the data scientist amongst them who has a bias towards practical instantiations, rather than conceptual ones.

The directors are very positive of the ongoing utility and value of the Reference Model of Governance for a Specific Organisation and the methodology to build it. All of the research hubs within GroundsWell, Belfast, Liverpool and Edinburgh wish to take this approach to collecting and managing data in their interventions.

7 Discussion

This project has developed an approach whereby a Reference Model of Governance for a Specific Organisation can be instantiated (illustrated at Figure 89) that enables the Good Regulator Model discussed in Conant and Ashby's Theorem (1970). This chapter will discuss the findings with regard to the research aim and objectives, the literature and the GroundsWell case study.



Figure 89 - Schematic of the instantiated Reference Model of Governance for a Specific Organisation for GroundsWell (Source: Author)

7.1 Introduction

The aim of this thesis is to propose a methodology for the combined application of multiple systems methods and demonstrate that it is a suitable methodology with which to establish a specific model of governance for an organisational or enterprise. Such a model, referred to as a Reference Model of Governance for a Specific Organisation, enables a check of coherence and completeness of

regulation and is to support the establishment of appropriate governance for an organisation.

This research has followed a number of stages. It began with a review of the literature regarding complexity, the Conant and Ashby model of regulation and the perspectives of an organisation in its environment which should be considered when taking a systems approach to modelling organisations resulting in a set of requirements (Table 8). These introduced the need to consider organisations as systems, the significance of environmental interactions and the laminated view of organisations involving an hierarchy of purpose.

The next stage reviewed the current body of knowledge for approaches taken to multi-methodology (Section 3.2) and the selection and organisation of systems methods, followed by a review of relevant systems methods in Section 3.3. In Section 3.4, I introduced the practitioner dimension and then assess the methods' suitability for building the Reference Model of Governance for a Specific Organisation in Section 3.5. Though the Reference Model of Governance for a Specific Organisation will comprise models from a set of systems methodologies and methods, when building the Reference Model of Governance for a Specific Organisation, in Section 3.6 I explored an additional set of methods used to develop collaboratively a common and shared understanding of an organisational situation.

In the next stage, an approach to instantiating the Reference Model of Governance for a Specific Organisation was developed based on Angyal's systems approach (Section 4.2). Systems methods were then mapped to this 3-dimensional approach (Section 4.3, summarised in Table 18), and mapped to the Peppard and Ward model (Section 4.4).

A Validation approach was developed (Sections 4.9 to 4.11), and a methodology for applying instantiating the Reference Model of Governance for a Specific Organisation was developed (section 4.13). This was then validated against the requirements derived for taking a systems approach to modelling organisations (section 4.13.3).

The approach was then applied to the GroundsWell research consortium providing a case study to illustrate the instantiation of a Reference Model of Governance for a Specific Organisation (Chapter 5). This was validated according to the validation approach developed (Chapter 6).

7.2 Discussion of results with respect to Conant and Ashby

In their paper, Conant and Ashby (1970, p.89) state:

> "a theorem is presented which shows, under very broad conditions, that any regulator that is maximally both successful and simple must be isomorphic with the system being regulated. [. . .] Making a model is thus necessary.
>
> "The theorem has the interesting corollary that the living brain, so far as it is to be successful and efficient as a regulator for survival, must proceed, in learning, by the formation of a model (or models) of its environment."

Thus, the literature presented in Chapter 2 is significant in determining what should be considered when seeking to understand the organisation and its environment in order to develop a model of the regulator and to determine the additional criteria required of people within the organisation for the regulation to be actioned. I would argue that it is a significant challenge to build an isomorphic model of a complex organisation, especially one of any size. One can consider the governance and management in place as an isomorphic model, but how do we judge how 'good' or appropriate it is. Hence the need to develop a specific Reference Model of Governance for the organisation against which the model as described by the governance and management in place can be evaluated. Following Beer's (1984) argument, the governance and management in place may be a homomorphic model of the organisation. Our Reference Model of Governance for a Specific Organisation also needs to be a homomorphic model of the organisation, but one which is isomorphic to the model described by the governance and management in place. This thesis proposes a methodology to build such a homomorphic model of an organisation.

I will restate the Good Regulator Model here (first presented in section 2.3) to support the discussion.

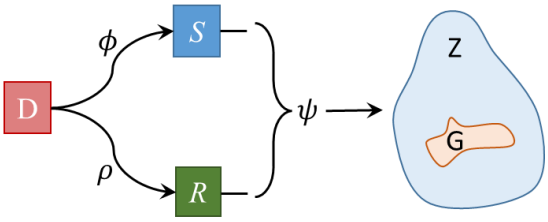


Figure 90 - Good Regulator Model (derived from Conant and Ashby, 1970, p.90)

Where:

- S is a system in operation represented by a set of values. In the context of this thesis, it is the organisation going about its business with the required regulation and, hopefully, achieving its intended 'good' outcomes denoted by the set G.
- D is the set of disturbances (the set of values of the coenetic variables) that might act on S causing the outcome to not be good and may lie in the wider set of all possible outcomes, Z.
- R are the options available to the regulator H of the system that are applied in response to D to maintain the outcomes in G. Here they distinguish the regulator as an object from the set of events, the options available to the regulator.

There are also 3 mappings in Figure 90 shown in Equation 1.

$$\varphi: \mathrm{D} \rightarrow \mathrm{S} \qquad \rho: \mathrm{D} \rightarrow \mathrm{R} \qquad \psi: \mathrm{S} \times \mathrm{R} \rightarrow \mathrm{Z}$$

Equation 1 - Mappings within the good regulator model

Conant and Ashby (1970, p.92) state "then 'R is a good regulator (for goal G, given D, etc., φ and ψ)' is equivalent to"

$$\rho \subset [\psi^{-1}(G)] \circ \varphi$$

Equation 2 - ρ shows directive correlation in respect of D, φ, ψ, and G.

Conant and Ashby (1970) have developed a proof of this theorem which has stood the test of time. However, what is not discussed is how the regulator is established within an organisation, how it might operate, nor its measure of

goodness beyond its level of isomorphism to the organisation. What they do state in their discussion is (Conant and Ashby, 1970, p.96):

> "The first effect of this theorem is to change the status of model-making from optional to compulsory. As we said earlier, model-making has hitherto largely been suggested (for regulating complex dynamics systems) as a possibility: the theorem shows that, in a very wide class (specified in the proof of the theorem), success in regulation implies that a sufficiently similar model must have been built, whether it was done explicitly, or simply developed as the regulator was improved."

A question that emerges, then, is how is the regulator brought into being? I am not considering organisations here as being new and embryonic. Organisations are operating and have been for many centuries. Regulation, governance and management have evolved in that same time. Technology development and other factors have increased the turbulence of the environment, and it can be argued that organisations today are not evolving (nor is society) at the same pace. This may adversely affect the viability of the organisation and, possibly, society.

That an organisation is still operating suggests its governance and management is sufficient, and that it is working successfully towards a goal. Whoever established the management structures was, in that context, acting as a regulator which implies a regulator is most likely established by another (existing) regulator (Ashby, 1956). The structure of the regulator will evolve over time to meet new demands and equates to natural selection in the animal kingdom. If the evolution of the regulator is fit for the evolving environment, the organisation will survive and thrive. A comparison can be seen between Nokia, Ericsson and Motorola (Alliger et al., 2015; Wright et al., 2004), where in the same situation, one thrived and the other suffered. If it does not evolve, or changes are not fit for the evolving environment, the organisation most likely will fail and there are numerous examples of this in business. Nokia suffered through management inertia and lost its place in the mobile phone market (Malmi, Kolehmainen and Granlund, 2023)

Within the commercial and government world, the Project Management Body of Knowledge (Project Management Institute, 2021) is the foundation for

programme and project management. Many books are also available (e.g. Lock, D. and R. Wagner, 2020; Zwikael and Smyrk, 2019). However, though these provide structures and guidance, they do not provide ways of deciding what activities are relevant for a particular project and how to align them to the overall purpose of the project or programme. Few take a systems approach, and the need for further research into complex systems governance has been identified (Keating, C. B. et al., 2022; Keating, Katina and Bradley, 2014).

For some enterprises, such as a major research programme, the requisite governance and management emerges as the research programme is developed, most likely based on prior experience of running research programmes. Due to the tightness of funding, it is unlikely to be managed by a professional project manager leaving governance and management to be distributed across the Principal Investigators and Co-Investigators. It will incorporate practices applied elsewhere by the programme leads and is probably similar to that put in place in a small start-up company. It unfolds according to need.

In the context of this thesis, therefore, the organisation (S) is what it is set up to be and operates within its environment. In order to understand the necessary regulation (governance and management), we need to understand the biospheric processes of the organisation operating and identify the relevant activities in progress within the organisation and between the organisation and its environment. We need to have some knowledge of these interactions and interrelationships in order to have some insight into the impact of disturbances.

Conant and Ashby have incorporated Sommerhoff's Coenetic Variable and Directive Correlation which adds a depth of meaning when considered in the context of an organisation. φ (see Equation 1) is the mapping of the coenetic variable onto the organisation in its environment. A disturbance may happen within the organisation's environment, or within the organisation. However, the disturbance must have an effect on the operation of the organisation that has the potential to move the outcome out of the good outcome G to necessitate a regulator's response. Therefore, the mapping ρ (see Equation 1) is important as

this represents the perception the regulator has of the disturbance and whether they believe it requires a response. The regulator then must notice the disturbance, have some understanding of its potential effect on the organisation in operation at that moment in time and whether, in their opinion, a response is required, which response would be appropriate in that context, and then action the response. This is the mapping ψ which is the set of ordered pairs, one of which is appropriate to maintain the outcome in G. There must also be confidence that the response is feasible in that moment and the necessary resources and capability are available to respond. The net effect is an adaptation of the organisation.

R comprises a variety of potential responses to the perceived variety of disturbances D. This necessitates a consideration of potential disturbances and the development of a variety of responses. Some responses may be incorporated into the operating procedures of the organisation enabling an 'automated' regulator response under certain conditions or 'rules'. Some identified disturbances may be identified that require permanent protection to be implemented, whether physical, or electronic (IT/Cyber). Others will require judgement by the regulators.

What we have, therefore, is an organisation which can be considered to be within a set of alternative circumstances $E'_{t_1}, E''_{t_1}, E'''_{t_1}, \ldots$, (in Sommerhoff's terms) and a correlated set of effective responses $R'_{t_1}, R''_{t_1}, R'''_{t_1}, \ldots$, where the members of these sets will be in a one-to-one correspondence such that under given conditions only one pair will maintain the outcome in G. For the organisation's benefit, managers (*H*) must have the capability to select an appropriate response. Let us remember one of the characteristics of complex systems:

x. "Each element in the system is ignorant of the behaviour of the system as a whole."

The response by an element of *H* (one of the regulators) will potentially vary according to their knowledge, discipline and role. A member of the finance team, for example, may or may not notice a disturbance D acting on the operations part of the organisation. It may become apparent to them as an increase in costs, or

reduction in revenue; very much a lagging measure. Also, they are likely to select a response that, to them, seems appropriate, but may be ineffectual in its outcome. It is also why there might be a variety of responses preferred by a management team, leading to some discussion regarding the most appropriate one. This may cause an unacceptable delay. Consequently, the regulators H'_{t_1}, H''_{t_1}, H'''_{t_1},…, need to have access to a model of the organisation within its environment and a model of responses available to them, thus enabling a common and shared understanding. Maintaining such understanding is a constant process requiring good communication, especially as the organisation is continually adapting to its environment.

Another aspect to be considered is that the selection of an appropriate R by the regulator H is not teleological. It is not to direct the organisation to a good outcome, but to prevent a disturbance D from affecting the organisation such that the outcome does not remain in G.

We can develop Figure 24 to include selected options as shown in Figure 91. The regulator can select a range of options. They can choose to change the environmental interactions whether it is pure human action, action supported by technology, or autonomous (machine) action.

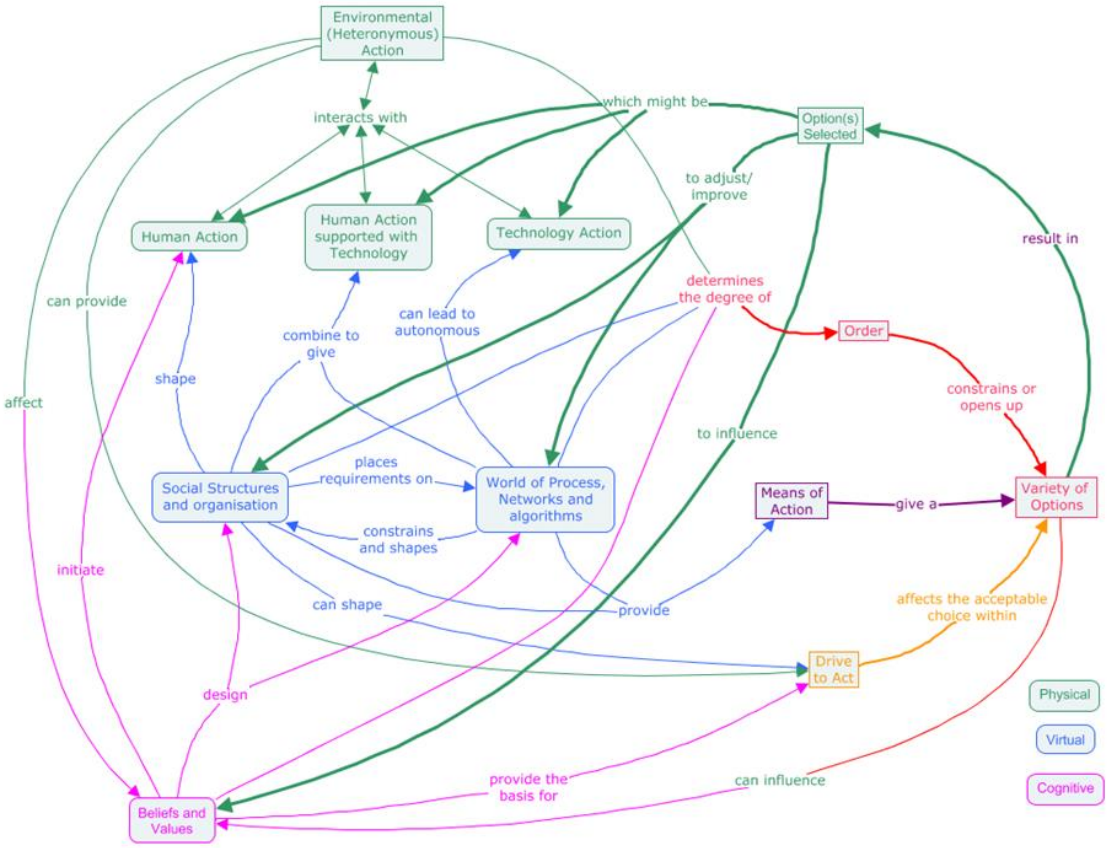


Figure 91 - Beliefs to action including options (Source: Author)

They might change the structure and arrangements within the organisation. I.e., reallocate resources, invest in new ones, adapt processes, etc. They may choose to change their infrastructure, principally their IT infrastructure in this context. Finally, they may seek to change ways of working and influence employees' beliefs and values.

It is possible to map Conant and Ashby's good regulator model to this as shown in Figure 92. D equates to the environmental (heteronomous) action. S is the organisation as a system in all aspects, cognitive, virtual and physical. It includes people, structures, ways of working and technology, as well as the organisation operating in its environment, whether human action, human action supported by technology, or pure autonomous action. R is the choices available to management, the regulator H. They have a means of action, a drive to act and some imposition of order which constrains or opens up their options.

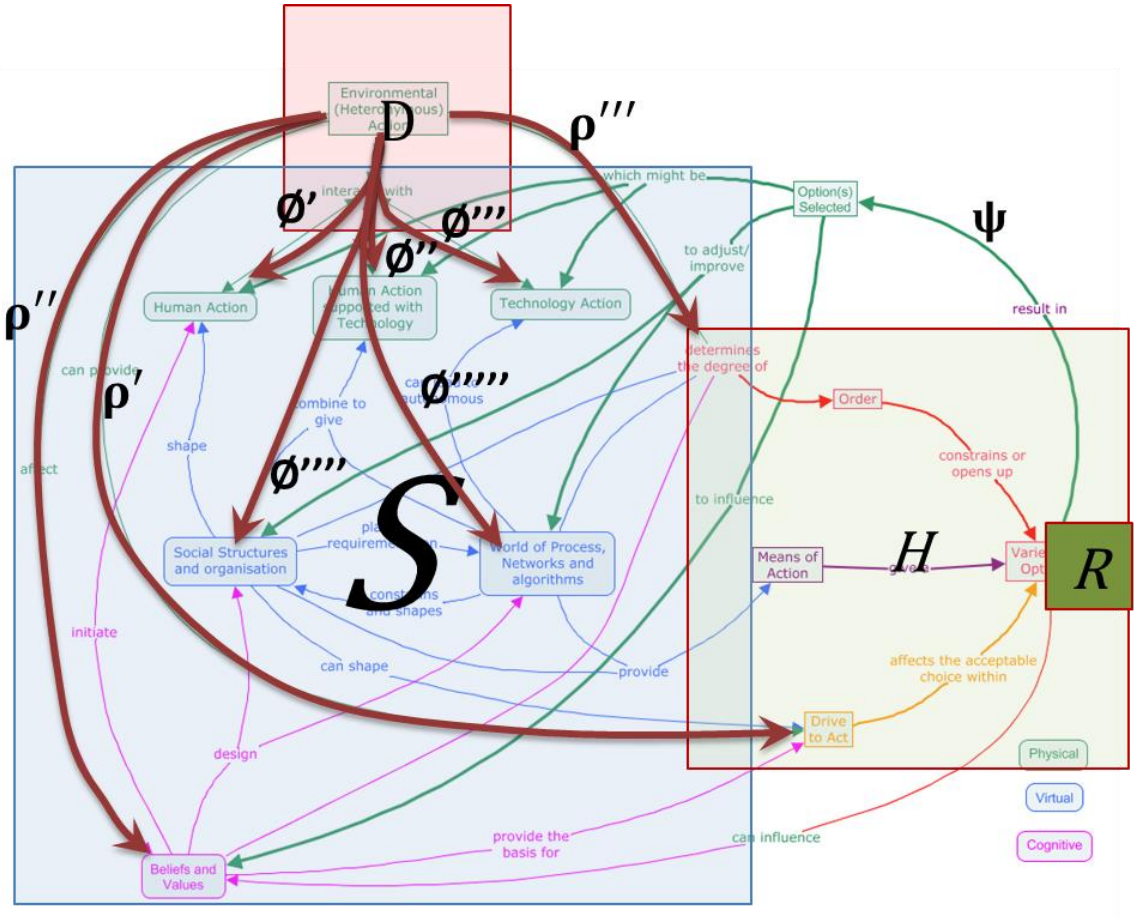


Figure 92 - Overlaying Conant and Ashby (Source: Author)

φ is the set φ'_{t_0}, φ''_{t_0}, φ'''_{t_0},…, acting on the system S, and ρ is the set ρ'_{t_0}, ρ''_{t_0}, ρ'''_{t_0},…, acting on R. However, I believe it acts on R through H, the regulator who has choice of R out of the set R'_{t_1}, R''_{t_1}, R'''_{t_1},… Their choices are shown by ψ and will be the set ψ'_{t_1}, ψ''_{t_1}, ψ'''_{t_1},…, hopefully resulting in G_{t_2}.

This illustrates what Sommerhoff (1950, pp.59–60) refers to as the focal condition. By focal condition, Sommerhoff means the end state of the system once adapted as a result of a response to a coenetic variable, such that the system meets its goal. Also, the situation is likely to be more complicated as there are likely to be more than 2 multiple coenetic variables and more than 2 directly correlated variables. Figure 93 shows the directive correlation between 5 correlated variables, one coenetic variable and one focal condition.

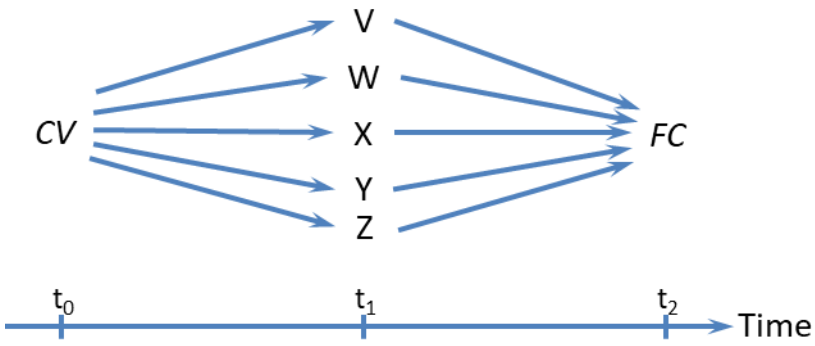


Figure 93 - Focal Condition (derived from Sommerhoff, 1950, p.60)

Sommerhoff (1950, p.60) states:

> "The peculiar property of any focal condition is that the directive correlation with which it is associated imparts to it a special kind of independence from the effects of events which have entered into its history."

Even though the focal condition is causally connected to the variables V, W, X, Y, Z, and they are causally connected to the coenetic variable, the focal condition is independent of the coenetic variable. Therefore, in an organisational context, the adapted state of the organisation results from regulator action in response to a coenetic variable and not the coenetic variable itself. Also, there is additional complexity in the case of multiple coenetic variables acting on the organisation, being responded to by multiple regulators, leading to a focal condition that is unknowable in advance. This is likely to result in additional error-controlled regulation being required, even if proactive regulation took place in response to the disturbance.

Due to the complexity of the organisation, without a good understanding of the dynamics and dependencies within the organisation, and within its wider environment, regulatory action may initiate a cascade of subsidiary events that are themselves coenetic variables requiring a regulatory response. This is illustrated in the thermoregulation example at Figure 13. An organisation with good communication channels, with the necessary channel capacity may be able to quickly respond and adapt accordingly. Those without such communication channels may fail. Therefore, the capacity and capability of the regulator, the

channel capacity for communication and the requisite variety of responses are all required for an organisation to deal effectively with disturbances.

Restating Conant and Ashby, we are seeking a regulator that is isomorphic to the system being regulated, so we need to make a model of the system, or organisation in this context. Therefore, isomorphism (a) is at the heart of the diagram in Figure 94 .

We now need to build an isomorphic model of the system. The degree of isomorphism, perhaps homomorphism, will relate to the complexity of the organisation. I have considered the governance and management in place within the organisation to be homomorphic to the organisation, and the Reference Model of Governance for a Specific Organisation I have instantiated in the case study to be homomorphic to the organisation but is isomorphic to the governance and management in place.

The organisation (S) sits within the causal texture of its environment (b) but cannot be distinguished from its environment, so is considered holistically as a biosphere (c), with variable autonomy and heteronomy (d).

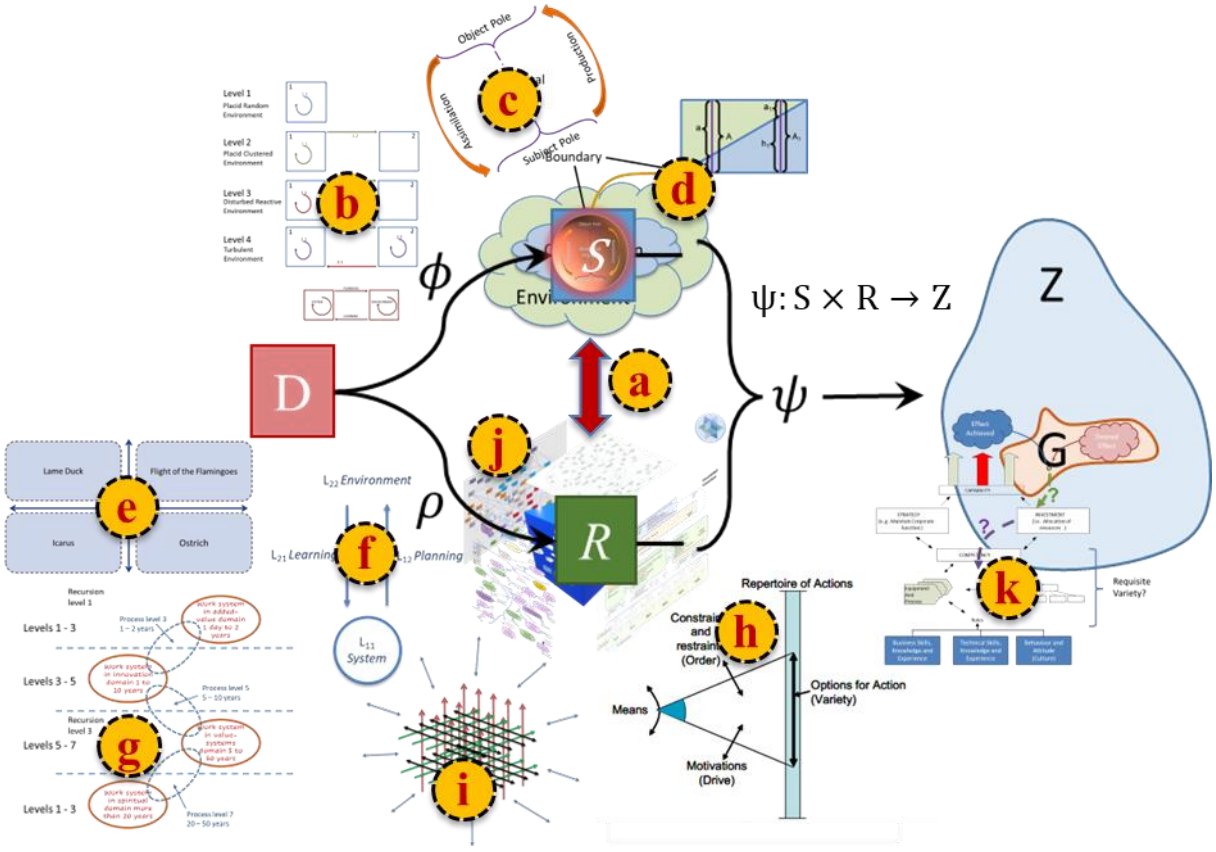


Figure 94 - Mapping ways of thinking to gain insight for the Good Regulator Model (Source: Author)

We can consider potential disturbances through scenario planning (e) to determine appropriate indicators and warnings and resource needs for resilience. This will include pre-determined responses and disaster recovery plans. The understanding gained from this exercise provides knowledge of the environment to enable consideration of the causal textures (f). According to the scale and maturity of the organisation, competencies can be developed as required to enable planning, learning and appropriate adaptation to environmental changes.

Levels of work (g) and a hierarchy of purpose will be established, and a repertoire of actions developed (h). This is the core of regulation and is not a trivial task as indicated in Figure 91 and Figure 92 above.

Bringing this knowledge together and to provide the basis of the methodology for implementing a Reference Model of Governance for a Specific Organisation, I adopted Angyal's (1941) systems approach (i). When applied to a specific

organisation, a multi-method-derived Reference Model of Governance for a Specific Organisation, isomorphic to the governance and management in place, but homomorphic to the organisation in operation, can be built (j). This will achieve a focal condition and an outcome in Z. The final model considered is the Peppard and Ward model (k) to guide the use of methods to make necessary adjustments to achieve outcomes in G.

In section 3.6.6, I introduced the 6 Cohering Questions, and mentioned that managers frequently decide what they want to do, but without considering the outcome they are seeking to achieve by it. This happens at any level, including at Government level as identified by Sir John Chilcott (2016) in his Iraq Inquiry. For the Ministry of Defence (2017). This led to the publication of guidance on 'appropriate challenge' to try to address this.

Bringing this into research generally, and reflecting on GroundsWell, in light of Ashby's (1956) description of regulation and the Good Regulator Model (Conant and Ashby, 1970), the following questions emerged:

1. Is social science and research such as GroundsWell seeking to define a requisite variety of responses, Table T (within R), but without knowing the desired outcome G (or even Z), also without considering coenetic variables, D, or the regulators R? Is it in pure error control mode?

   Being research, there is an intended outcome, but it may not be clear at the beginning of the research programme. With multi-disciplinary research, the differing terminology can cause confusion between researchers, affecting the clarity of purpose. Therefore, governance has to adapt during the life of the programme as understanding becomes clearer.

2. Is government policy (as the controller C), assuming an R, seeking to define Table T with or without determining Z (let alone G)? Therefore, it is ignoring D and putting R in error control mode?

   Policy is, by definition, general, and there will be a range of options to meet it. Its purpose is to cohere action, often from unknown actors, to achieve a

government outcome. It will be left to the actors to determine their outcome G in light of the policy, and to implement R, mindful of D in their context.

3. Agent-Based Modelling (ABM) is used to simulate behaviour in complex adaptive systems to try to understand the potential outcome of agents interacting in a certain context. GroundsWell is using ABMs to determine the potential behaviour of citizens in how they may use Urban Green and Blue Spaces (UGBS) in response to certain policy decisions.

   Is the ABM in GroundsWell seeking to model S such that a range of responses can be developed (Table T) to enable R to select an r_i to achieve G, but without considering a set of D to work with? Does the ABM need it? How do you define an appropriate variety of agents (persona)?

   Using the regulator model as a construct for developing and exploring ABMs and what they can inform is helpful. It indicates what parameters should be set and what assumptions are made, enabling the research to determine a level of confidence in their findings.

4. Can the ABM provide an understanding of S such that you can determine Table T? and does the ABM provide a 'good enough' representation to give confidence in Table T?

   This is a philosophical question that is potentially unanswerable. From a positivist perspective, do ABMs model reality sufficiently with all its variety, especially many unknowns? Can one determine the underlying mechanisms leading to the behaviour identified, or can one only observe symptoms based on the assumptions made in building the ABM?

These will be discussed in the future with the relevant work package leads within GroundsWell and is out of scope of this thesis.

7.3 Discussion regarding the arrangement of Systems Methods

In Section 3.2.2, I reviewed the literature on multiple methods. Combinations of methods in multimethodology is becoming more common, but what has emerged is that there is no overarching approach that can integrate multiple methods.

However, there is a requirement to ensure the integrity of use of systems methods and to ensure they remain within their own paradigm in use. As mentioned above, Jackson (2006) developed Critical Systems Thinking which is a metamethodology for bringing together multiple methods. Midgley (2000) developed Systemic Intervention, which is a methodological approach for approaching an intervention. Both Jackson and Midgley leave the selection of methodology to the practitioner but provide guidance on thinking about the philosophical underpinnings of the methodological choice, as well as other aspects to be considered when planning and undertaking an intervention.

These multimethodological approaches have informed this research and I have employed Angyal's systems approach to guide the selection and arrangement of multiple methods for building an instance of a Reference Model of Governance for a Specific Organisation. However, this still doesn't address how knowledge gained from one method can be linked to another due to their ontological and epistemological differences. Primarily, this linkage is within the mind and understanding of the practitioner and is not generally made explicit.

Within the approach to build the Reference Model of Governance for a Specific Organisation developed in this thesis, each systems approach is used and validated within its own philosophical context. This requires the practitioner(s) to be able to stand in each paradigm whilst using each method. In the context of building a Reference Model of Governance for a Specific Organisation, knowledge gained from one systems approach can be used to inform the use of another. The CPTM analysis table (see Table 28) has been used (in a simplistic way so far) to capture the data explicitly shared between approaches. It is intended to expand this table to reflect the actual data as it is used within each approach. This enables an audit trail of thinking and interpretation of the data as applied, enabling clarity and consensus to be achieved across those involved. It is important that they have all been included in the injunctive approach from the outset so they have a shared understanding of the context and a common basis for discussion and decision making.

The activities contained within the CPTM identify what activities are relevant, but do not state how they are undertaken. Therefore, they can be used for enquiry. Once positioned within the relevant VSM, they can support diagnosis and discover who/how the activities are actioned and what information is used/communicated and how the organisation actually works. This illustrates a linkage between the interpretive approach of SSM and the positivist approach of VSM.

Within the same CPTM analysis table, when determining the quality criteria, measures of performance/success are identified. These correlate to factors and variables that may be captured in a CLD and, potentially, modelled in SD. This illustrates a linkage between the interpretive approach of SSM and the positivist approach of SD. It is important to remember, however, that the logical dependencies in a CPTM are not the same as the time-related relationship between factors as expressed in a CLD and SD model. The activities in a CPTM are considered to be ongoing all the time, but not in a process or sequence as they express what activities should be being done, not how they are actually implemented.

This is the extent of the linkage between system approaches. Only specific elements of the data derived by each approach are linked, thus making the Reference Model of Governance for a Specific Organisation very specific to an organisational context, and not providing a general Reference Model of Governance. The data chosen to be linked is that which is required to inform thinking and decision-making regarding governance within a specific context. Different models and different data may be relevant to other applications.

7.4 Discussion of Results with respect to the Research Questions

7.4.1 Research Question 1

What are the requirements of a multimethod systems approach to model the requisite regulation for an organisation?

Section 2.5 lists the requirements to be met by a Reference Model of Governance for a Specific Organisation that is homomorphic to an organisation and isomorphic to the governance and management of an organisation.

The model itself is the combined perspectives from a set of systems methods that provides insight into the governance and management of an organisation, such that it can inform its appropriate regulation. Figure 94 demonstrates the ways of thinking that both inform the Reference Model of Governance for a Specific Organisation and enable a common and shared understanding amongst the regulators, provide they are engaged in its development and maintenance.

R1 The Reference Model of Governance for a Specific Organisation must enable boundary analysis.

This is an important requirement due to the complexity of an organisation and the indeterminacy of the boundary. The boundary is created by the interactions and inter-relationships of staff as they undertake their activities to meet the organisation's outcomes.

Therefore, the model must be able to capture the range of perspectives and allow the boundary to be discovered and represented in a way that others can be informed of the collective boundary, as well as the interactions, inter-relationships and dependencies. This is to enable the discovery of the system in its environment (S), necessary to enable judgement of the impact of potential coenetic variables (D).

R2 It must be possible to see the effects of history, corporate memory and drives to act.

Learning is important to ensure prior history is included when selecting a response, especially as the organisation may have adapted as a result of a previous use of the same response as implied by Sommerhoff's Directive Correlation. New managers would also benefit from learning from prior history to speed up a response and to ensure alignment with other managers.

Corporate memory, especially that passed on via 'water cooler' conversations and the sharing of stories appears to have diminished, in my opinion, through the insistence for communication being electronic (emails, documents, etc.).

Being able to capture what motivates actions is important, especially when you are considering how another might respond to your actions. This could be in a competitive environment, or in organisational adaptation. Appreciating the perspective of the other, and how it differs from your own, can indicate another's motivation, potentially influencing your choice of action.

R3 Changes within the system (organisation) can be identified regarding necessary activities as the organisation adapts to environmental changes.

This links to the previous requirement as this often requires reference to a prior state captured in the organisation's history. State changes in the organisation's structure and processes need to remain aligned to the organisation's desired outcomes, and there will be activities that should be stopped as well as new ones introduced.

Identifying changes in activities can ensure the coherence of the organisation and determine what knowledge remains meaningful and so what information should be archived.

R4 The Reference Model of Governance for a Specific Organisation must be able to represent 'frames', the perspective taken by the relevant management team according to differing levels of abstraction. The Reference Model of

Governance for a Specific Organisation is likely to be recursive (nested) with increasing granularity both horizontally and vertically.

This requirement is not so much related to the different perspectives of individuals, but that within the hierarchical structure of an organisation (lamination) there is (or should be) a different focus of governance and management. If this is not the case, then higher-level managers can get too involved in lower-level operations ("the long screwdriver") to the detriment of the organisation.

Each level within the hierarchy will also have differing levels of work and time-horizon in decision-making. Different capabilities are required of managers at different levels and this needs to be identified and reflected in appointment of managers.

R5 The Reference Model of Governance for a Specific Organisation must be able to determine holistically activities relevant to the agreed frames but maintain logical dependencies and capture the richness of interaction.

It is necessary to be able to identify activities relevant to the span of control at each level and between levels so that coherence can be established within governance and management. Roles and responsibilities need to be clarified accordingly so that there is coherent coverage, (i.e., no gaps), conflicts of interest can be identified, work capacity can be kept to an acceptable level, and inter-relationships and dependencies understood.

This is necessary in those situations where there may be a variety of impacts on the organisation resulting from a change in the environment (a coenetic variable) impacting on multiple elements of the organisation and responded to by a variety of managers (regulators). The variety of responses must be coherent and avoid damaging countereffects in order to maintain the desired outcome of the organisation.

R6 Sub-organisations within the organisation or enterprise can be identified that have their own discrete properties (purpose).

People benefit from knowing where they fit within an organisation and their contribution. Also, as no one can know the totality of the organisation, it is important to have a model to ensure the relevant resources and capabilities, as well as capture the dependencies and inter-relationships is important. The model can act as a reference and guide to managers.

R7 It should be possible to determine clusters of elements collaborating at short range as well as indicate the longer-range inter-relationships.

This is necessary to determine the appropriate span of control of managers (roles and responsibilities) as well as ensuring the necessary channels of communication. It will help develop appropriate organisational structures as well as information system needs. It will help determine the potential impact of a disturbance and how it might propagate.

R8 Dependencies between elements must be captured.

This is important as it helps to identify critical dependencies, including ones that are often counter-intuitive, such that they are understood and attended to. This is valuable when prioritising resources and in risk management. It also informs managers of their important inter-relationships and the possible impact of a cascade of effects. It contributes to understanding the organisation in its wider environment and can indicate what external variables the organisation is sensitive to.

R9 Measures of performance can be identified.

This seems a statement of the obvious. However, it is not unusual, in my experience, that organisations use the data available as measures of performance, rather than seek relevant measures, or proxy measures.

Measures of performance drive behaviours. Therefore, measures of performance must be coherent as a set and aligned to the organisation’s success.

R10 The Reference Model of Governance for a Specific Organisation must be able to represent the non-linearity of relationships.

Power and influence are strong drivers of behaviours and performance. These may be internal relationships, external relationships or both. Imbalances between organisational departments, for example, can lead to inappropriate resource allocation to the detriment to the organisation as a whole. Imbalances in external collaboration can drive an organisation into poor decisions. Dominant individuals can be valuable in an organisation achieving success, but can also have very negative effects, resulting in inequalities in the workplace.

R11 The Reference Model of Governance for a Specific Organisation can capture the feedbacks within the system, between the system and environment and within the environment.

It is necessary to understand the feedbacks as these will indicate the behaviour of the organisation and the potential impact of the environment. These may be amplifying behaviours as well as controlling behaviours. More importantly, however, is how these feedbacks interact and the resonance that results.

Understanding the dynamics is valuable to give an indication of future behaviours within the organisation as well as the wider environment and to provide the ability to inform decisions in the context of the wider organisation.

R12 The Reference Model of Governance for a Specific Organisation must enable one to capture / integrate the environmental inter-relationships as well as internal peer-peer inter-relationships.

This will inform managers of how the organisation is sitting within its environment and is important as it will lead to accepting the indeterminacy of the organisational boundary. Ambiguity will remain but, at a local or individual level in the organisation, there will be clarity. By collating these across the organisation, a coherent view of the dynamics at play can inform appropriate decisions.

R13 The organisation can be modelled in its wider context.

This is different to R1 in that understanding the wider environment is a pre-cursor to boundary analysis. Without understanding the wider environment, it is not possible to understand how the organisation fits into it, so cannot easily identify opportunities and threats.

7.4.2 Research Question 2

What is a suitable arrangement of methods that meets the requirements such that a model of regulation for an organisation can be developed?

In meeting the requirements, the methods identified are a combination of the major systems methods (principally SSM, VSM, SD and Dependency Modelling), linked through the SSM analysis table, and methods and techniques used in the inquiry stage and to build a common and shared understanding. This development of understanding is a critical injunctive precursor for building the systems models that the Reference Model of Governance for a Specific Organisation comprises. Naturally, there will always be iterations and developments in understanding, some of which maintain the history of change and adaptation, but also means there must be active adaptation of the models as the organisation adapts to a changing environment.

First, I discuss the fulfilment of the requirements set by the Reference Model of Governance for a Specific Organisation and the methodology used to build it. Then I discuss the logical validation of the case study.

Requirement R1: The Reference Model of Governance for a Specific Organisation must enable boundary analysis.

Capture perspectives with MPA/6 Questions / SSM (Checkland), informed by E&T Causal Textures. Consensus on purpose developed and key high-level activities ('what' should be done to achieve purpose and by whom, for whom). Achieved by use of Appreciative Inquiry in a World Café construct.

The activities within the SSM Consensus Primary Task Model (CPTM) denote what is in the organisation (system) according to the purpose(s), as captured in the agreed set of root definitions, thereby distinguishing the boundary of the system. As the activities as derived from the root definitions are conceptual, i.e., what the modeller would expect to see being undertaken according to their understanding of the root definitions, these will be confirmed with the organisation. All other activities are deemed to be outside of the organisation (system). Once the activities are mapped to the organisation, as some activities, or subsystems, may be allocated to other organisations, activities relevant the organisation are decided. Logical dependencies within the CPTM indicate the dependencies and information or resource exchanges between subsystems and, if relevant, organisations.

These activities, when mapped to a set of VSMs representing the hierarchy or purpose and levels of work, will enable the mapping of system-boundary interactions and inter-relationships with other organisations. These boundaries can then be explored in greater detail with those working at the boundary to capture their understanding.

The Causal Loop Diagram (CLD) of the organisation in its wider environment can capture the dynamic interactions as perceived by those in the organisation and, potentially, include partners outside the organisation. This also informs boundary analysis.

Requirement R2: It must be possible to see the effects of history, corporate memory and drives to act.

Cognitive maps will capture and indicate the organisational constructs and influences. This is informed by the hierarchy of purpose and relevant stories recounted in collaborative workshops.
Over time, changes in the Enterprise set of root definitions and associated CPTMs and activity analysis, as well as changes to the VSMs will show the effects of change over time.

This is embedded in the Reference Model of Governance for a Specific Organisation and not explicit. The Reference Model of Governance for a Specific Organisation will be stored, ideally, in a knowledgebase, so iterations and prior stages of models will be available. History of changes can also be kept through

maintaining currency in the models. Some effects resulting from deliberate changes to the organisation will be captured in amendments to the root definitions and resulting re-modelling. The δ in activities (additional new ones, retired old ones) will provide some knowledge on the effects of history.

Lessons identified, and hopefully learned by being acted upon, will result in changes. These may be proactive in recognising an unfolding disturbance, or reactive once the disturbance has announced its arrival. These may be captured in the VSM set and also in updated CLDs.

Drives to act may be surfaced through the development of cognitive maps, and these may be retained in the knowledgebase. However, the organisational cognitive map (agreed through consensus) contributes to and is coded in the root definitions used to determine activities relevant within the organisation to align it to its purpose. Also, the cognitive maps contribute to the CLDs in terms of the variables included as relevant, both within the organisation and in its interaction with the wider environment and in the wider environment itself.

Requirement R3: Changes within the system (organisation) can be identified with regard to necessary activities as the organisation adapts to environmental changes.

Re-defining the Enterprise set of root definitions and re-modelling the CPTM. Enables identification of activities no longer relevant and additional activities to be included.
This may result from a periodic re-visit of Purpose (6 Questions, SSM (Checkland) PQR), specific events captured by CLD, and/or a Scenario Thinking/Planning exercise.

Many methods and tools are available to optimise an organisation and ensure what activities it undertakes are done well, “doing things right”. I argue, however, that only SSM can determine what are the right things to do to align to an agreed purpose. When there is agreement to a deliberate change in an aspect of the organisation, a change in service, or product, or even just confirmation the organisation has not drifted from its prior agreed mission (purpose) the root definitions can be revisited and remodelled. This is illustrated in the case study. Because the analysis table links activities to their originating root definition, when changes are made to the root definition new activities are added, and ones no

longer required can be removed. The resulting changes can be propagated to the other system models through the analysis table, either mapping to the VSM set, the variables linked to the CLD, or the outcomes linked to the Dependency Model.

Management decisions in response to disturbances can be modelled in the VSM set and or CLDs and then linked back through the CPTM activity table to assess the impact on activities recorded. This might be a change in how something is undertaken (the activity table lists what should be done, not how), a change in the measure of performance and metrics, a change of role/responsibility, etc. The CPTM activity table is the coordinating and coherence mechanism between the methods. I use the table as an actual artefact, but it may be a metaphor for information stored in a knowledgebase.

Requirement R4: The Reference Model of Governance for a Specific Organisation must be able to represent 'frames', the perspective taken by the relevant management team according to differing levels of abstraction. The Reference Model of Governance for a Specific Organisation is likely to be recursive (nested) with increasing granularity both horizontally and vertically.

Use MPA/6 Questions / SSM (Checkland) to capture perspectives.
Develop consensus on purpose and key high-level activities ('what' should be done to achieve purpose). Undertaken in small group conversations, or World Café style large group conversations.
Develop cognitive maps, with respect to personal constructs (Kelly) to capture the organisational constructs, informed by the hierarchy of purpose.

The hierarchy of purpose is captured in root definitions relevant to each level of the hierarchy. The activities are mapped to the equivalent level in the VSM set to inform the diagnosis or design at that level in the hierarchy. In the analysis of the activities and in analysis of a related CLD, measures of performance and metrics are identified. The recursive nature of the VSM set, linked to the conceptual models and CLDs, provides clarity of the perspective taken, or purpose, at each level and across the elements of the organisation at each level. The VSM set also captures the inter-relationships and dependencies vertically and horizontally within the organisation and between the organisation and its wider environmental interactions.

Requirement R5: The Reference Model of Governance for a Specific Organisation must be able to determine holistically activities relevant to the agreed frames but maintain logical dependencies and capture the richness of interaction.

Building on MPA, 6 Questions, Cognitive Maps, develop an SSM (Wilson) Consensus Primary Task Model (CPTM), either Enterprise Model or 'W' Decomposition.

The CPTM contains the logical dependencies between activities, and the Dependency Model maps the critical dependencies across the organisation and between the organisation and those it depends upon and those who depend upon it. The activity table provides the coherent and comprehensive record of activities and provides the information that links the models. The table is a flat record but is put into 3 dimensions by the VSM set. The frames are represented by the VSM Systems 5 at each level in the organisation's hierarchy.

The richness of interaction is represented within the VSM set at a level of detail that is appropriate and the CLD also captures the richness of interaction.

Requirement R6: Sub-organisations within the organisation or enterprise can be identified that have their own discrete properties (purpose).

Achieved with an SSM CPTM, either Enterprise Model or 'W' Decomposition, informed by MPA, 6 Questions, Cognitive Maps and mapped to VSM. Clarified with organisational diagnosis with VSM.

The Systems 1 in each VSM, at the appropriate level in the hierarchy of VSMs, indicate the sub-organisations. These may be developed from the CPTM, and/or amplified by a root definition for each sub-organisation.

Requirement R7: It should be possible to determine clusters of elements collaborating at short range as well as indicate the longer-range inter-relationships.

The subsystems in the SSM CPTM, and the RACI analysis shows these clusters. Also, construction of the VSMs informed by SSM analysis will show these clusters and the longer-range inter-relationships.

Diagnosis with VSM will determine the communications between clusters of elements. The clusters will generally be the lower-level VSM Systems 1, and their interactions and communication with their System 3, 3* and 2 at the higher level.

Specifically, if required but not represented in the Reference Model of Governance for a Specific Organisation, these clusters can be determined by Social Network Analysis.

Requirement R8: Dependencies between elements must be captured.

Analysis of the CPTM logical dependencies between activities identifies dependencies between elements, as does dependency modelling, the VSMs and the links within and between the VSMs.

The SSM CPTM captures the logical dependencies between activities conceptually, but it is the construction of Dependency Models that captures the critical dependencies across the whole organisation, focused on what needs to be working well for the organisation to be successful and working well.

The elements of the Dependency Model are related to the activities in the CPTM, and the activities within the VSM set, but are described differently. It is not sufficient for the element or activity to be present, the thinking underpinning the development of the Dependency Model is to determine what child dependencies must be working well for the parent element's goal to be achieved. The ultimate parent, the root element of the Dependency Model is generally the organisation itself.

Requirement R9: Measures of performance can be identified.

SSM CTPM activity analysis will help identify measures of performance.
In addition, SD/CLD modelling will inform up-stream and down-stream points of measurement and optimisation.

The analysis of the activities in the CPTM enable the discussion, conceptually, of what are the quality criteria for each activity, and the associated measures of performance and metrics. Furthermore, the source of the measures and metrics can be identified and linked to the relevant IT application or process that will capture it.

Inspection of the CLD can also provide an indication of appropriate measures of performance as both downstream and upstream measures can be identified. The downstream measures will often be identified in the organisation's wider environment through the impact their products and/or services have in the marketplace, and the upstream measures will relate to those activities, resources and capabilities required to produce and/or deliver them.

Requirement R10: The Reference Model of Governance for a Specific Organisation must be able to represent the non-linearity of relationships.

Analysis of the CPTM logical dependencies between activities provides insight into the non-linearity of relationships.
Exploration of the environmental interactions and internal connections within the VSMs also provides insight into the non-linearity of relationships.
Include consideration of Angyal's autonomy and heteronomy.

The non-linearity of relationships is not explicitly presented within the Reference Model of Governance for a Specific Organisation. It can be identified during the understanding phase and captured in Cognitive Maps. Aspects will be included in the CLD and in the logical dependencies between activities in the CPTM.

Detailed consideration of the links in the VSMs will enable the exploration of the balance between amplification and attenuation of communication. Where appropriate and helpful, this can also represent the non-linearity of communications and, therefore, relationships between organisations, sub-units within organisations as well as individuals within and between organisations. This will be beneficial in considering environmental dynamics and competition, whether for supplies required for the development and production of products or competition for customers in the marketplace.

Requirement R11: The Reference Model of Governance for a Specific Organisation can capture the feedbacks within the system, between the system and environment and within the environment.

Causal Loop Diagrams, informed by E&T Causal Textures capture the feedbacks within the system, between the system and environment and within the environment.

The Causal Loop Diagram and, if more specific analysis is required, System Dynamics models, are the main elements of the Reference Model of Governance for a Specific Organisation to capture feedback. The purpose of the CLD/SD model is important, in terms of what dynamics are at play and, therefore, feedback is desired to be understood.

Developing reliable models in which there is confidence, will require substantiation with evidence and, for more specific System Dynamics models, comparison with historical behaviour. Building such CLDs will depend on prior surfacing of mental models and will best be preceded with cognitive mapping.

Relevant expertise and market/environmental intelligence appropriate to the organisation's situation will need to be incorporated, and such models also need to be maintained to remain relevant and accurate enough to support decision-making.

Requirement R12: The Reference Model of Governance for a Specific Organisation must enable one to capture / integrate the environmental inter-relationships as well as internal peer-peer inter-relationships.

Use SSM (Wilson) to model 'System Served' and detailed analysis of logical dependencies.
Exploration of the environmental interactions and internal connections with VSM.
Include consideration of Angyal's levels of autonomy and heteronomy and informed by E&T Causal Textures.

Modelling the system served, i.e., the higher system within which the organisation sits, enables the identification, not only of the boundary of the organisation, but also some of the environmental interrelationships and internal peer-to-peer relationships according to the purpose and level of hierarchy being studied. In a similar vein, analysing the VSM in its environment at the hierarchical level of interest, especially by involving those operating at that level, will identify peer-to-peer relationships and environmental inter-relationships.

Requirement R13: The organisation can be modelled in its wider context.

This is achieved by SSM modelling of the 'System Served', a high-level CLD of the organisation in its wider context, and the VSM modelled in its environment.

This is an important requirement and goes beyond the previous requirements, specifically R1, R11 and R12. It is the modelling of the biosphere and supports exploration of the Turbulent and Disturbed Reactive Causal Textures. One aspect is to model the system served with SSM following an exploration of the wider purpose or contribution of the system, to determine why it exists. Another aspect is to develop a CLD through Group Model-Building to capture the wider dynamics as perceived by the stakeholders, and the final aspect is to explore the links to the elements in the wider environment with VSM. From a strategic planning perspective, the CLD can be examined for those factors that shape the landscape the organisation sits within to support a scenario planning exercise.

All of these approaches will contribute to the regulation of the organisation, such as relevant indicators and warnings of potential disturbances, measures of performance and effect as perceived in the organisation's wider environment as well as ensuring activities align to the levels of work and support the resilience and viability of the organisation.

7.5 Discussion of the Validation of the Reference Model of Governance for a Specific Organisation

In this section, I discuss the validation of the GroundsWell Reference Model of Governance. I will draw on the GroundsWell case study and reflect on the instantiation of GroundsWell's Reference Model of Governance as well as the state of the model so far. This is because the development of the model is matching the directors' development of the governance and management of GroundsWell. The questions are the Logical Validation set as described in Section 4.11.

1. Does the Reference Model of Governance for a Specific Organisation capture and reflect the relevant range of perspectives within the situation as reflected and are the following metaphors considered: Machine; Organism; Cultural/political; Societal/environmental; and Inter-relationships.

The machine, cultural/political and societal/environmental metaphors are considered through the consensus development of purpose during the initial

understanding phase which is then developed in a set of root definitions and a CPTM developed. This may be clarified with CSH to ensure all perspectives are considered. Activity analysis of the resulting CPTM can determine the elements required to achieve the organisation's goal. Their arrangement can be evaluated with the VSM set and their efficiency modelled in SD if required. At the least, a CLD will inform thinking. The absence of any necessary elements can be determined by diagnosing the system with the VSM set. The current indication of the likelihood of success of the organisation in achieving its goal can be assessed with a Dependency Model.

In considering the organism metaphor, the VSM can clarify the subsystems following the mapping of the activities from the SSM CPTM. This will also help determine their level of autonomy. Exploring boundary interactions and considering links between the organisation and its environment, including with respect to causal textures, can identify necessary capabilities for adaptation. By assessing the organisation with the generic resilience model will enable activities appropriate to organisational resilience are incorporated. However, though the necessary activities and processes etc. may be present within the organisation, it does not mean the whole organisation is adaptive to the environment and resilient to shocks. This will require the necessary capabilities to be developed in people across the organisation. The state of preparedness can be reflected by a Dependency Model, but this will only reflect the subjective views of managers.

Interrelationships are considered through cognitive mapping in the understanding phase and developed in more detail in the organisational CLD. Exploration of this will support the identification of leverage points for bringing about improvement and to anticipate possible effects of disturbances and, the knock-on effects of an intervention in one part of the organisation.

2. Have the boundaries of the situation been explored and agreed?

The situation being considered here is the organisation. The boundaries are explored and agreed in the understanding phase and then codified in the SSM Enterprise Model and related CPTM, and mapping to the VSM set. Within GroundsWell, it is recognised that this will constantly unfold as research extends

into the communities and additional partners join the endeavour. Also, each work package will have its own boundaries according to their particular focus, and this will be captured in the VSM-environment model and updated on a regular, possibly 6-monthly basis.

3. Are the interrelationships identified (these may differ according to methodology/method)?

Interrelationships are initially identified through the logical dependencies and clusters of activities within and between subsystems in the SSM CPTM. They are further clarified when mapped to the VSM set, which also begins to indicate the hierarchy of purpose. Exploring the CLD of the organisation in its wider environment contributes to the identification of interrelationships.

For each of these models, exploring the links and determining how they work, the information exchanged, spans of control, the capacity of the links, etc., will clarify the nature and criticality of the interrelationship.

4. Has the hierarchy of purpose (emergence) been established?

During the understanding phase, the purpose of the organisation or organisational unit is established. The hierarchy of purpose is fully established when the activities are mapped to the VSM set, and, if required, the purpose can be confirmed at each level and activities mapped accordingly. For example, within GroundsWell, the purpose of UKPRP is known as they declare it. The purpose of GroundsWell was established during workshops and documented in the case for support. This was modelled, and the work packages identified. Each of these had their purpose clarified and documented in the case for support.

5. Have the dynamics at each level and between levels been identified?

The dynamics present are identified in the CLDs, both at the level of the organisation in its environment, and within the organisation. Additionally, the VSM set allows the exploration of the links across the hierarchy of the organisation, including peer-to-peer entities, and between each level and their relevant links with the environment.

6. Have the management communications and controls been identified as related to purpose/emergence and each level of the hierarchy?

These are identified in the Monitor and Control Action activities within the CPTM and analysed accordingly to determine measures of performance and metrics, as well as roles and responsibilities if required. They are then mapped to the VSM set which enables the addition of information flows. Using the VSM set to diagnose the organisation, or to establish the reality of a new one, clarifies the controls in place and the need to establish additional ones if relevant.

The VSM set clarifies the controls at each level of the hierarchy and between levels to ensure completeness and coherence.

7.6 Utility of the Reference Model of Governance for a Specific Organisation

Developing and maintaining the Reference Model of Governance for a Specific Organisation requires a broad range of systems thinking knowledge and skills, including facilitation. Senior managers in the organisation must agree to develop and use the Reference Model of Governance due to the commitment required to develop and maintain it. Once established, however, using it to inform decision-making and as an information source to provide clarity and understanding of organisational structures is more straightforward.

Though the models can be developed in isolation, the initial development adds significant value if undertaken collaboratively as its injunctive approach contributes to a common and shared understanding across the organisation as well as aligning mental models and achieving consensus on the organisation's purpose.

The Reference Model of Governance for a Specific Organisation is not something that can be built quickly, or without practitioner knowledge and skills. Also, the practitioner must be familiar and proficient with a range systems methods and tools, which is not commonly found. At Cranfield, on our Systems Thinking Practice Apprenticeship programme, designed to meet the IfATE Systems Thinking Practitioner Apprenticeship Standard (IfATE, 2023), we develop this

range of skills and abilities in our apprentices. They develop knowledge and skills in all the concepts, methods and techniques included for both the understanding phase and in building the Reference Model of Governance for a Specific Organisation.

There are other training providers teaching to the same Apprenticeship Standard, so there will be a growing Systems Thinking Practitioner community available to support organisations in building their own Reference Model of Governance.

The major limitation, currently, is the lack of computer software tools to support many of the systems methods, and the interconnection between models is through the CPTM activity analysis table. This is manually maintained and requires an element of configuration management between the models to maintain their currency. The Reference Model of Governance for a Specific Organisation provides the basis for the systems framework within my work package, and the intent is to develop some software support for this, if not for the wider models.

There are collaborative whiteboard software tools to support and capture graphically the workshop results (I use Miro (Miro, 2011)). There are graphics packages that can be used for developing the CPTM and CLDs (I am currently using yEd (yWorks, 2024)). I am using MS PowerPoint to capture the VSM set and MS Excel for the activity analysis. Many other graphics tools and spreadsheet programmes are available.

Maintaining the currency of the Reference Model of Governance for a Specific Organisation must be a structured review process, and this will only be committed to if the instantiated Reference Model of Governance itself adds value to the organisation. Therefore, it may be an annual exercise to work through the instantiated Reference Model of Governance, following an renewed understanding phase to determine and changes in purpose, and to capture changes in people and the environment.

I have used the Reference Model of Governance for a Specific Organisation in establishing the governance for the GroundsWell consortium. The directors have

acknowledged the value in both the development of the case for support and in identifying governance needs for the ongoing programme. Initial feedback, therefore, is positive.

7.7 Summary

This chapter has discussed the results of my research with regard to Conant and Ashby's Good Regulator Model and in answering the research questions. I discussed the validation of the Reference Model of Governance for a Specific Organisation and its utility.

In the final chapter, I will address my achievements with respect to the aim and objectives, novelty and impact, the limitations of my research and consider further work.

8 Conclusions

So, how did I do?

8.1 Achievement with respect to the Aim, Objectives

8.1.1 Aim

The aim was to propose a methodology for the combined application of multiple systems methods and demonstrate that it is suitable with which to establish a specific model of governance for an organisational or enterprise. Such a model, referred to as a Reference Model of Governance for a Specific Organisation enables a check of coherence and completeness of regulation and is to support the establishment of appropriate governance for an organisation.

This aim has been met in full. The combination of methods is novel due to the linking of elements of data between the systems methods, and the inclusion of Wilson's approach to SSM as opposed to Checkland's. Its suitability is demonstrated in its application to the GroundsWell Consortium where the completeness and coherence of governance can be considered by senior management, SSM provides the measure of completeness related to the organisation's purpose, and the coherence is provided by SSM and VSM in combination. CLDs indicate appropriate indicators and measures of success and Dependency Models illustrate critical dependencies. The appropriateness is decided by the senior management team.

8.1.2 Objectives

The objectives were:

1. Understand requirements for applicable systems methods. This will also provide validation criteria for the application of methods to a case study. This will provide the answer to Research Question 1.
2. Determine the current state of multi-methodology approaches and multiple methods use.

3. Identify a set of suitable methods that are candidates for the Reference Model of Governance for a Specific Organisation.
4. Design/justify a multimethod approach for the model of regulation. This will provide the structure the systems methods need to fit and map them to it.
5. Demonstrate an instantiation of a specific Reference Model of Governance developed for the GroundsWell Research Consortium, including its validation. This will provide the answer to Research Question 2.

All of the objectives have been met:

- Objective 1 is covered by Chapter 2. This comprises the literature review and results in a set of requirements at section 2.5.
- Objective 2 is covered by Chapter 3 section 3.2, where I address multi-methodology approaches.
- Objective 3 is covered in Chapter 3, section 3.3, which addresses the proposed multi-method structure.
- Objective 4 is covered as follows. In Chapter 4, section 4.2 where I introduce the social perspectives relevant, based on Angyal's system structure and in Section 4.3 where I map the methods to the structure. In Section 4.4, I map the methods to Peppard and Ward's structure. In Section 4.6, I review the use of each method, showing in Section 4.8 how the Reference Model of Governance for a Specific Organisation can be augmented with generic SSM Models. I introduce an approach to validation in Section 4.9 to Section 4.11 and outline a guide for building the Reference Model of Governance for a Specific Organisation in Section 4.13.
- Objective 5 is covered by the instantiation of a specific Reference Model of Governance developed for the GroundsWell Research Consortium in Chapter 5, and its validation in Chapter 6.

8.2 Achievements with respect to novelty

8.2.1 Anticipated novelty

In this section, I review the anticipated novelty of this research with respect to the novelty achieved.

1. A methodology for the application of multiple methods that complies with both Jackson's Critical System Practice and Midgley's Systemic Intervention.

The methodology that I developed is specifically for instantiating a Reference Model of Governance for GroundsWell. It is specific to this context and is not a generic Reference Model as the methods used may be tailored differently and other methods used.

I achieved this by taking Angyal's systems framework and mapping to it the requirements for modelling an organisation as derived in the literature review. This defined what the methodology should achieve. I then mapped the systems methods reviewed in Chapter 3 to these dimensions. This defined how I would apply the methods in combination and how they interrelated.

The methodology included an 'understanding stage' that follows an injunctive approach necessary to explore the range of perspectives present and build consensus around purpose, and to surface relevant factors influencing the dynamics involved in the organisational situation. This stage equates to Jackson's 'Explore' stage in his EPIC methodology and Midgley's 'Critique' aspect of his Systemic Intervention. The mapping of methods to the requirements set equates to Jackson's 'Prepare' stage and Midgley's 'Judgement' aspect. Building a Reference Model of Governance for a Specific Organisation equates to Jackson's 'Intervene' stage, and validation equates to his 'Check' stage. Both of these stages equate to Midgley's 'Action' aspect.

2. A layered or laminated application of methods to better reflect the hierarchy of purpose and related regulatory requirements in an organisational context.

The review of the organisation with regard to their hierarchy of purpose (also expressed as levels of work) informs the root definitions constructed during the

understanding stage and subsequently modelled and mapped to the VSM set. Each layer in the hierarchy can be modelled with SSM if desirable. Subsequently, navigation across the layers is achieved via the VSM set.

The outline guide for building the Reference Model of Governance for a Specific Organisation describes how to undertake the laminated application of methods.

3. An arrangement for the application of a set of systems methods to build the "Good Regulator" model (the Reference Model of Governance for a Specific Organisation).

The arrangement for the application of a set of systems methods is the instantiated Reference Model of Governance for a Specific Organisation and is aligned to Angyals' systems approach. It compromises Wilson's approach to Soft Systems Methodology (SSM) (particularly the CPTM and activity set), Causal Loop Diagramming of the organisation and the organisation in its wider environment (and, potentially System Dynamics modelling), a Viable System Model (VSM) set, a Dependency Model, and the VSM within its wider environment. The integrating element is the SSM activity analysis table, with columns of analysis included to map to VSM and variables in the CLDs.

The resulting Reference Model of Governance for a Specific Organisation was validated against the requirements set and the logical validation question set.

8.2.2 Additional novelty achieved

A number of additional aspects of novelty emerged during my research.

1. I incorporated a variety of non-systems concepts and approaches into systems thinking and Critical Systems Practice, particularly in the understanding stage as they have a significant contribution to the understanding of the organisational situation and in applying the systems methods. They include:

    a. Complexity – Cilliers;
    b. Holism – Smuts;
    c. Distinctions and injunction – Spencer Brown;

d. Biospheric integration, indivisibility of subject and object – Angyal;
e. Causal textures & environmental interaction – Emery M, Emery F, Trist;
f. Decomposability – Alexander;
g. Analytical biology – Sommerhoff;
h. Culture – Hall, Schein;
i. Social systems theory – Luhmann;
j. Stakeholder theory – Valentinov;
k. Process-Relational thinking – Whitehead;
l. Biology of cognition – Maturana;
m. Personal Constructs – Kelly;
n. Levels of work and levels of managerial thinking– BIOSS (Jaques, Stamp, Rowbottom, Billis, Kinston);
o. Competence to capability framework – Peppard & Ward;
p. Safety-critical systems thinking – Leveson, Rasmussen & Svedung.

2. I have indicated how Conant and Ashby's Good Regulator Model can be instantiated as an organisational governance model.
3. I have expanded the basis of Sommerhoff's coenetic variables, directive correlation and focal condition within Ashby's Law of Requisite Variety and Conant and Ashby's Good regulator Model in the context of organisations.
4. I have provided a basis for other systems approaches to be linked, such as Agent-Based Modelling and Social Network Analysis, as well as to link to financial modelling approaches for impact valuation.
5. I have proposed and applied a validation approach to be used in the application of systems methods in an organisational context. Validation is not explicitly addressed in Jackson's Critical Systems Practice, Midgley's Systemic Intervention or Mingers and Brocklesby's multi-method approach.
6. I have demonstrated Wilson's SSM approach in conjunction with other systems methods, especially how it complements VSM as it introduces

alignment to purpose, completeness and coherence which VSM cannot demonstrate.

8.3 Impact

My research has already had impact. Much of the knowledge and understanding gained has underpinned the teaching and development of apprentices on Cranfield University's Systems Thinking Practice Apprenticeship and MSc Degree Programme. Also, apprentices have taken explicitly some of my findings and are applying them in their organisations, specifically in military command and control research and in organisational change.

Within the GroundsWell Consortium, my research significantly enhanced the case for support that achieved over £8M funding for a 5-year multi-institution research programme. It has enabled improvements to consortium governance and is providing the systems framework which coheres the work package outcomes and is the basis of the consortium's key outcome, which is a systems approach to improve the use of urban green and blue spaces in achieving reductions in non-communicable diseases. A further development is to incorporate a financial model to support cost-benefit decision-making. Also, the approach is being considered in the establishment/refinement of other research consortia such as GALLANT.

The approach is being taken to establish the Academic Resilience Industry, Suppliers Community network, currently chaired by Cranfield University. The design of the network, and its proposed mode of operation and governance, is a major part of the funding application. This has endorsed the approach as being helpful in providing rigour in the design, establishment and operation of consortium research programmes.

8.4 Limitations

Due to the current progress of GroundsWell, I have not been able to illustrate how Peppard and Ward's structure can be used to guide internal organisational adjustments to ensure good outcomes are met. This would be an example of

regulation by feedback according to Ashby's model of error-controlled regulation (see Figure 14 (b)).

Though Conant and Ashby refer to the 'Good' regulator, I have not addressed the 'goodness' of regulation. At this stage, the Reference Model of Governance for a Specific Organisation can suggest areas of regulation to be included and the senior management decide what they choose to implement. They determine a subjective measure of goodness. Also, though Ashby suggests that the measure of requisite variety equates to goodness, and considers entropy as a measure, this does not include the competence of managers within the organisation to act as regulators. Therefore, I believe there is an additional measure of management capability that contributes to the measure of 'goodness' in organisational regulation.

The Reference Model of Governance for a Specific Organisation has been theoretically validated and it has been illustrated with a small-scale case study where it is seen as beneficial. It has not yet been fully applied to an organisational unit, either to review its governance, or to develop a governance model from scratch. Consequently, the extent of data sharing between systems approaches (through interpretation and re-phrasing) has not been fully explored.

My familiarity with the methods and experience in applying them to organisations has enabled me to develop the Reference Model of Governance for GroundsWell. I am aware that to instantiate a Reference Model of Governance for a Specific Organisation requires a range of knowledge, skills and behaviours that are not often found amongst system practitioners. The outline guide to building the Reference Model of Governance for a Specific Organisation probably does not contain enough guidance for use by others at this stage, though some of the apprentices graduating from Cranfield University's Systems thinking Practice Apprenticeship/Degree Program will have the competencies to do so.

8.5 Further work

The following further work is proposed:

1. Apply the approach to instantiate a Reference Model of Governance for a Specific Organisational unit as opposed to a research consortium, particularly an enterprise comprising multiple organisations, each with their own approaches to governance. An opportunity may arise in the establishment of the Academic Resilience Industry Suppliers Community network, led by Cranfield University, which is currently at a very early stage of sourcing funding. Another opportunity being explored is in the development of the East Side Partnership in Belfast which has a focus on the ongoing sustainability of the Connswater Community Greenway.
2. Complete a full evaluation of the usability of the Reference Model of Governance within GroundsWell and other aspects of operational validation.
3. Demonstrate the application of Peppard and Ward's structure in error-controlled regulation.
4. Developing a measure of 'goodness' for the model of governance.
5. Explore in more detail the social science aspects of regulation. In Chapter 2, I introduced the notion of the model of organizations as interpretation systems and referenced the salutary tale of the decline of Nokia through their management not responding to a disruptive technology-focused environmental change. I noted that this is not considered specifically by the main systems methodologies and that this depth of analysis is out of scope of this thesis. This warrants further research as it might address the managerial competence aspect of regulation.
6. Explore in greater detail the extent to which data can be linked between systems methods and the approach to interpretation and re-phrasing. Specifically considering what is lost when doing so.
7. Further explore organisation – environment interactions and develop an approach to capture them.

8. The development of a repository for the contents of the activity analysis table that will connect the methods and extend this to link directly to tools available to apply systems methods.

8.6 Personal Reflection

Systems practice cannot be learned from a book, nor does proficiency come without practice. I have been very fortunate to work with some wonderful thinkers, Brian Wilson particularly. I admired his ability to develop and absorb multiple root definitions with the Enterprise Approach, and then construct a Consensus Primary Task Model in one sitting!

Following my learning SSM from Peter Checkland, it was many years before I was in a situation to try it myself. I would certainly not share those early endeavours now, but it helped me design my part of a new organisation; it was helpful. Building Causal Loop Models came more easily, but turning those into System Dynamic models was always a challenge. I began as a practitioner.

Coming into academia brought a different perspective. Working with Steve Mcintosh at Cardiff University where he led the development of the Information Systems-based courses at undergraduate and postgraduate level provided the opportunity to teach what I practised. This was another big learning curve that started my journey of a deeper understanding, not only of the underpinning theory, but also of how to help others develop systems practice skills. I discovered that not everyone is comfortable with thinking in systems.

A research project in resilience whilst at Cardiff led to my initial thoughts of bringing multiple methods together, but it wasn't until recent years that I could begin to research this in earnest. One of the main challenges was to find a focus to explore what is a very large and multi-disciplinary way of thinking. System thinking is not new, and it has developed in parallel tracks in a many different disciplines. I wanted to find a construct to bring them together, legitimately.

My interest and experience have been in understanding organisations, especially with a focus on information security – now referred to as cyber. Though not technical, my area of expertise was in Information Security Strategy and Policy,

where the strategy must be aligned to the organisation's business strategy and the technical controls must handle the organisation's critical information securely, but also support the organisation's way of working. A systems approach was, to me, the only way to achieve this effectively and ensure alignment with the organisation's purpose.

I discovered that most systems practitioners have expertise in one of the methods and are very method focused. Academics on the other hand, rarely have a chance to develop the skills and understanding of the methods, because research appears to be mainly in researching and comparing methods, not in their use in combination. I believe this stems from a focus on the philosophical paradigms that are allocated to the methods, despite the fact that the original developers of the methods were practitioners who developed methods that supported their way of thinking.

I do consider, however, that SSM did have an academic development path as it was deliberately developed to approach problems differently because it moved away from a positivist empirical stance to a constructivism stance and grew out of action research. From an organisational perspective, however, I believe Wilson's approach is more helpful, despite it requiring more of a practitioner expertise.

The people dimension and the accommodation of the variety of perspectives that results, as well as the increasing complexity that is now recognised, has generated a need to think differently. However, it must have a way of being incorporated into systems methodologies and methods. Each system methodology/method has a different range of contributions. SSM, for example, produces a 2-dimensional view of activities, whereas VSM enables a 3-dimensional view. Neither SSM nor VSM really consider the dynamics present. Checkland's approach to SSM produces small, high-level conceptual models that are not as helpful in determining organisational governance. Even with Wilson's approach to SSM, though you can identify areas of control, the dependencies or identification of upstream/downstream measures cannot be determined. It is for

these reasons, that I have long believed multiple systems methods are required to produce an appropriate model of an organisation.

During that time, the paradigm wars ensued which seemed to prevent the application of multiple methods. As a practitioner with experience of applying a range of methods, I had developed the insight and dexterity to use the methodologies and methods correctly according to their underlying paradigms, but in conjunction.

Jackson's and Midgley's approaches of CSP and Systemic Intervention provided a way of developing a theoretical basis for bringing multiple methods together. Discovering Angyal's systems approach provided the inspiration I needed to develop a way for selecting and arranging multiple systems methods when seeking to understand the needs of an organisation's governance, specifically to consider relevant human factors. The key perspective was his vertical dimension which includes consideration of the 'hidden' factors that guide structures and patterns of behaviour. It seemed to relate to Hall's work as well as the work that came from Jaques' research team at Brunel. It was through Emery and Trist that I discovered Angyal, though they had only really considered the environmental interaction (the 'unitas multiplex') and maladaptation. Beer's development, related to Ashby, and the notion of requisite variety led me to explore Conant and Ashby's Good Regulator Model, and this provided the inspiration to this thesis. Conant's PhD thesis and early work provided greater insight into the theories underpinning the Good Regulator Model. Adding Cilliers' work on complexity seemed to complete the range of literature I should consider when developing a set of requirements for systems methods with which to build a Reference Model of Governance for a Specific Organisation. The path was truly made as I walked it.

You cannot consider the use of methods without a context. It is the context that determines the selection of methodologies and methods, and then you have to decide on your methodology for bringing the methods together. Those involved in the situation must first be given the opportunity to hear each other and build a common and shared understanding and an injunctive approach is important in

achieving this. This is something I have learned from the military when they consider operational planning. However, though they have doctrine that requires this, they do not have a way of doing it collaboratively. Therefore, this is an important pre-cursor for building the Reference Model of Governance for a Specific Organisation. Checkland's rich pictures and root definitions are intended to achieve this, as is CSH. In our Complex Systems Governance Group at Cranfield University, we have accumulated a range of techniques and tools to support collaborative conversations, even at scale with the World Café construct for conversations, and Appreciative Inquiry. Once this understanding is achieved, then a Reference Model of Governance for a Specific Organisation can be instantiated. Without this initial understanding stage, coherence across the systems models is challenging.

I struggled to find a context until I was asked to contribute to GroundsWell. Then I had a context and was able to influence the thinking in the consortium. There was an element of teaching as well as facilitation. As the research develops, skills transfer across the work packages has been built in as there is a desire to avoid overdependence on a small team of systems-skilled academics. This will also be required for the use of the Reference Model of Governance in GroundsWell in order to continue the currency and accuracy of the data therein.

I am aware that being proficient with all of the systems methods and in facilitation is a necessary capability to instantiate a Reference Model of Governance for a Specific Organisation. This might make the 'cost' too great. Skilled multi-method practitioners and academics are very rare. It is an emerging discipline as evidenced with the IfATE Apprenticeship standard. Many Training providers are contracting a range of practitioners to teach methods individually. Some direct their apprentices to learn from a book. In my experience, embryonic systems practitioners need coaching and guidance on they use of the methods, especially in the early periods of practice.

I conclude with some summary thoughts.

What went well?

As a practitioner with some years' experience, I believe the workshops for the GroundsWell stakeholders went well and the understanding techniques were well received. The consortium members engaged in the workshops and a good level of shared understanding was developed. The resulting Case for Support for GroundsWell is testimony to this as it was reshaped successfully as a result of the workshops.

I achieved the aim and objectives. The application of the systems methods and development of systems models was successful, developed as they were to the level of detail that was helpful to the directors. Therefore, the approach to building a Reference Model of Governance for GroundsWell was successful at the stage it is. The SSM subsystem model was well received, based on a core 'T' root definition endorsed by the directors. The mapping to VSM was successful in leading a conversation that identified aspects of governance not considered, and subsequently included. Building the CLD was more challenging but incorporating the UKPRP measures of performance and the lead director's measures of success were incorporated and this led to a model the directors could develop further. They were successfully integrated through the SSM activity analysis table.

What were the challenges?

For me, being a practitioner, identifying and underpinning my approach with the relevant theory and philosophy was challenging. I have a felt appreciation of what worked but needed to justify this. I found that I had to work back through the literature to original sources, such as Ashby, Conant, Angyal, Emery, and Sommerhoff, as well as the original thinking of Beer, Vickers, Churchman and Checkland. This was important as their concepts had suffered aspects of Chinese whispers over the years, and the multiple re-telling by researchers. This has led, in my opinion, to their original thinking becoming lost.

Mapping across disciplines such as anthropology, biology, psychology, cybernetics and systems was a challenge as concepts appeared related but used

different terms. Specifically, biological analogies appeared very relevant to organisations, and I had to search hard to find the same links in the literature as I wanted to build on prior works. This was because my focus was on the use of multiple methods, but I had to justify the way of linking them in an organisational governance context.

Writing it down. Having ideas and a felt understanding of concepts and the combination of systems methods that I believed was useful worked for me as a practitioner. But then translating this into words that conveyed my thoughts adequately and with a valid argument that made sense to others was difficult.

What did I learn?

A significant amount. I really wish I had undertaken this thesis much earlier in my career. The depth of understanding I developed is invaluable. Much of this came from going back to original sources, whether in the mid-20th century or earlier. Imagining some of those authors discussing their ideas and building on each other was very exciting and helped me make links between them. Where are today's thinkers? I do believe that, as a result of computers, there is much less thinking about concepts and foundational ideas as computers have changed the narrative. I can 'Google' an answer! Artificial Intelligence is seen as the way the way forward, despite its lack of judgement. We have lost that art of conversation, turning together and building a shared understanding. I believe we are losing social cohesion as a result.

I confirmed my belief that systems practitioner skills and facilitation skills are vitally important for this work and that people in organisations want to be involved. They want to contribute to organisational success and not just serve the computing machine. However, this way of thinking is a cognitive challenge for managers, at all levels, who are motivated and driven by different mental models.

Finally, I do believe that the IfATE Systems Thinking Practitioner Standard is the beginning of the development of a new generation of thinkers who will add great value to organisational success in the future as they support decision-makers in complex managerial situations.

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Appendix A Ethics Approval



2 April 2019

Dear Mr Hilton ,

Reference: CURES/7908/2019
Title:

Thank you for your application to the Cranfield University Research Ethics System (CURES).

We are pleased to inform you your CURES application, reference CURES/7908/2019 has been **approved**. You may now proceed with the research activities you have sought approval for.

If you have any queries, please contact CURES Support.

We wish you every success with your project.

Regards,

CURES Team

Appendix B Using systems techniques to define information requirements.

This appendix, derived from (Hilton, 1996) is an example of the use of Wilson's SSM to define process specifications, measures of performance, and metrics, such that information requirements can be derived for a division of a government organisation. It also includes the development of a Causal Loop Diagram to understand the dynamics of the wider environment as well as the dynamics within the organisation to support decision-making regarding critical success factors, upstream and downstream measures of performance.

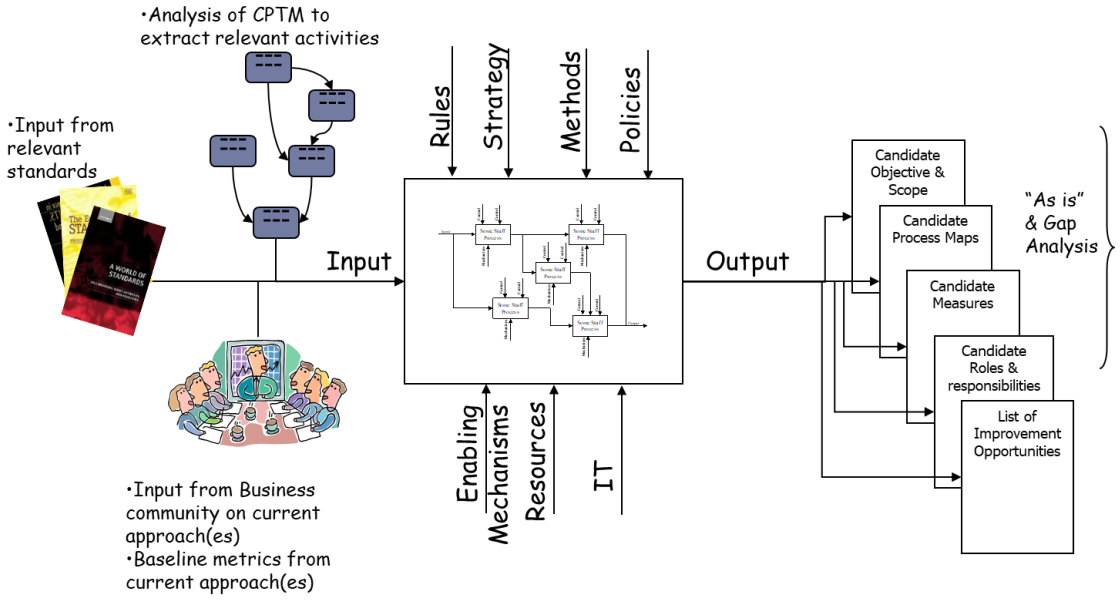


Figure B-1 Approach used to derive information requirements (Hilton, 1996)

The organisation had identified a number of process issues that were adversely affecting its performance. They chose to use SSM as a basis for undertaking a gap analysis between the (conceptual) 'ideal' and the current processes. They didn't want to focus on the whole organisation's processes, but certain key ones and wished to assess these in the light of the whole organisation.

The consensus Primary Task Model (CPTM) was constructed from 19 root definitions taking the Enterprise Modelling approach. This resulted in approximately 850 activities. In order to be able to manage this number, and to

make the model accessible to the senior management team, I chose to develop a 3-tier quasi-process model using the ICOM notation (Input, Constraints, Output, enabling Mechanisms) as this was a style familiar to the organisation.

The activities were sorted into the 6 high-level process areas, then again into the high-level processes within each area, and again within those to be able to produce candidate process specifications at 2 levels of abstraction. These were augmented by including relevant activities from standards the organisation complied with, as well as interviews with a range of senior stakeholders. This is shown at Figure B-2.

I developed a Causal Loop Diagram (CLD) of the organisation in its context, and then expanded this to understand the dynamics within the organisation. This was linked to their stated critical success factors and was used to consider more appropriate upstream and downstream measures of success. This is shown at Figure B-3.

Table B-1 is an extract from the activity analysis table which was used to develop the ‘to be’ processes. It relates the key decisions to be made by senior managers according to the critical success factors, the information required to answer the question, the main and sub-processes that would generate the information needed. This helped identify the important processes. These activities were then analysed with regard to inputs, outputs, information needs and quality criteria. Finally, measures of performance and metrics were proposed. Finally, a RACI table was generated for the proposed roles and responsibilities.

Figure B-4 summarises the approach taken.

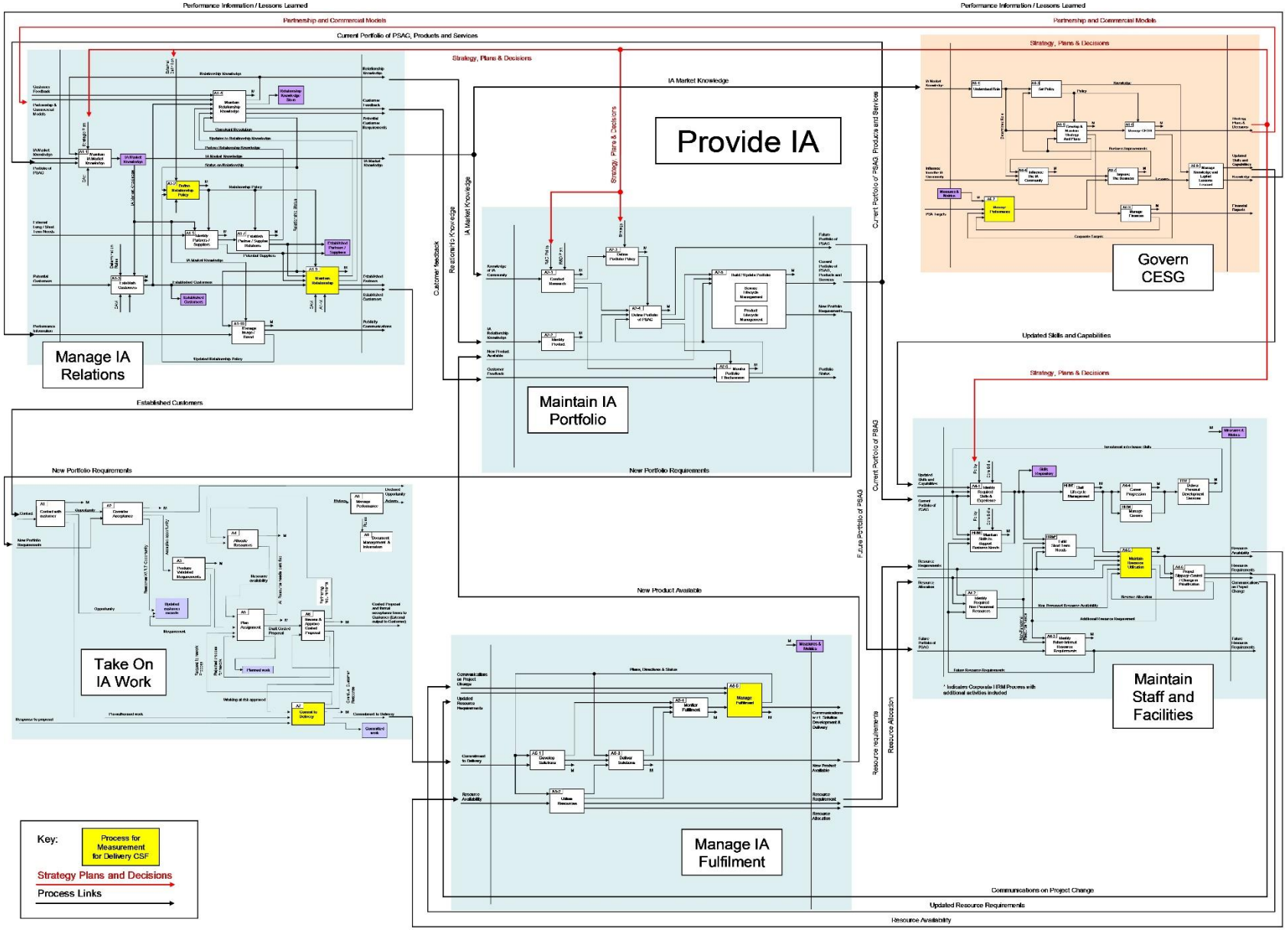


Figure B-2 - CPTM formatted as an outline Candidate Process Model (Hilton, 1996)

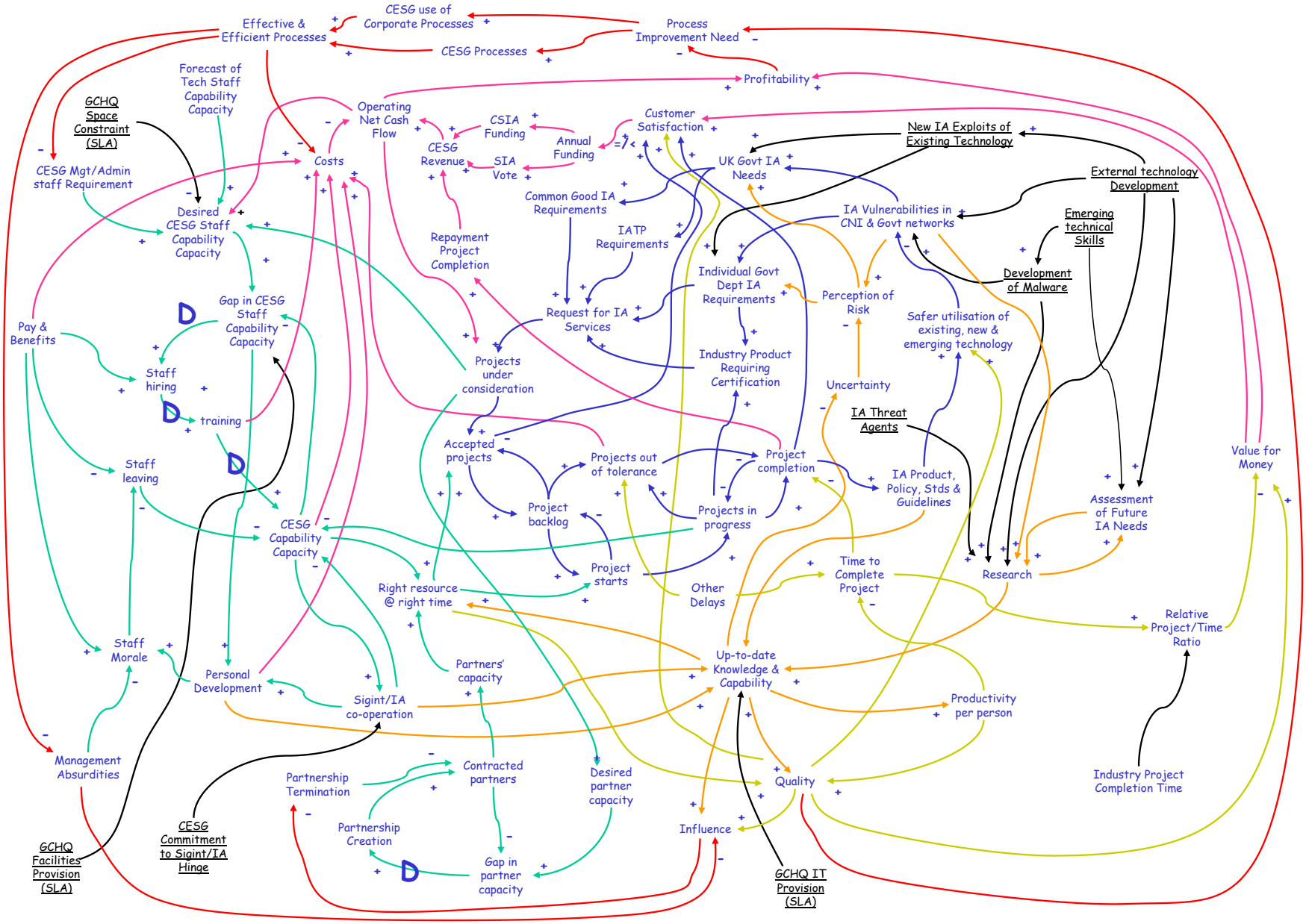
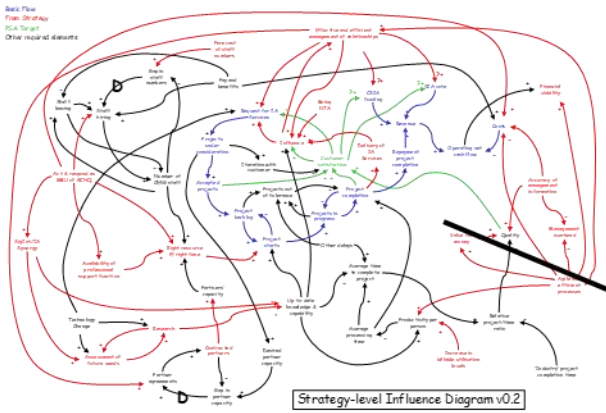


Figure B-3 - CLD of the organisation (Hilton, 1996)

Key Decisions[1]	Information Requirement	Process	L4 Processes	Input	Output	Quality Criteria	Information Needs	Measures of Performance[2]	Metrics
What constraints are we and our customers working under?	Relevant rules, regulations & legislation	A1-2 Define Relationship Policy	Identify external bodies, regulations and rules	•Relevant legislation, regulation •Intelligence needs	•Identified external bodies, regulations and rules	• List of potential bodies, regulations and rules	•Knowledgebase of products and services •Rules and regulations relating to products and services	• List of external bodies, regulations and rules is maintained	• Frequency of updates
What projects have we committed to (on the books	List of projects committed to	A3-7 Commit to Delivery	Set up on Compass Point	•Acceptance by Customer •Work proposal •Method	• Project/task set up on Compass Point •Commitment to delivery	• List of projects committed to	•	• List of projects committed to is maintained	• Frequency of updates to list committed to projects
What is the status of current projects[3]?	•List of projects in progress •List of projects committed to, but not yet started •List of projects, including their schedule; identifying those late starting •Definition of 'key customer'; •Project status reports •List of projects allocated to partners; •Project status reports •Specific IATP Progress against milestones	A5-5 Manage Fulfilment	Control	•Plans and directives •Fulfilment status •Assessment reports	•Plans •Directives •Project status •Outcomes •Requests for re-planning	• List of projects that are in progress • List of projects that are in the backlog • List of projects delayed • Project progress – work done • Project progress - time • Partner projects out of tolerance	•Capability for communicating and taking actions	• List of projects that are in progress maintained • List of projects that are in the backlog maintained • ∂t – delay in projects • List of projects delayed maintained with delays • Work completed so far % • ∂time – delay in project progress • ∂% out of tolerance • PSA 5/12 • PSA 8/18 & 21	• Frequency of updates • Project predic start date • Actual start d • Work required total • Work complet far • Estimated milestone date • Actual Milesto Date • Set % tolerand • Actual % toler

[1] As determined by observation and from Influence Diagram

Table B-1 Extract from activity analysis table (Hilton, 1996)



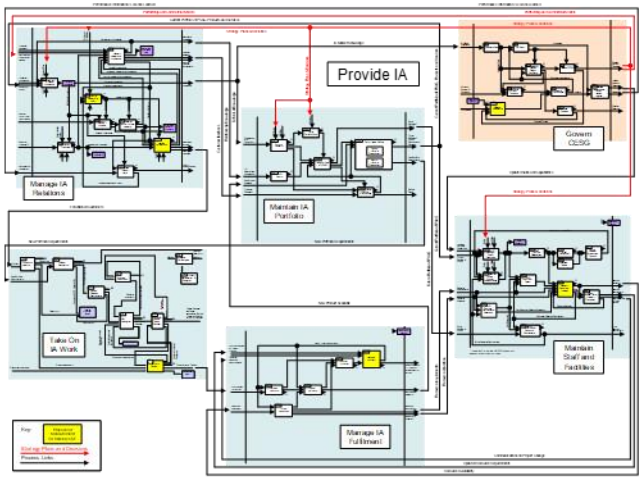
1. Key questions for Delivery identified from influence diagram and current Delivery Goals

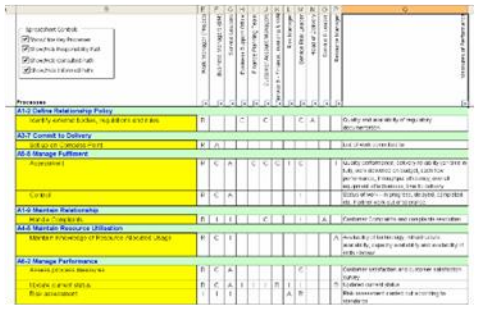
3. Quality Criteria, Measures & Metrics identified



Delivery CSF Table

2. Relevant process identified in CESG process model





4. Key processes are analysed to identify information needs

5. RACI completed for job roles

Figure B-4 Combining CLD, CPTM and analysis table (Hilton, 1996)

Appendix C Main systems methods combinations

C.1 Search Terms

The following search terms were used to source relevant literature:

SCOPUS

1. Soft Systems Methodology + System Dynamics + Viable Systems Model + Multi*method
2. Soft Systems Methodology + System Dynamics + Multi*method
3. Viable Systems Model + Multi*method + System Dynamics
4. ((multi*method) AND ("systems thinking")) AND (paradigm) AND (LIMIT-TO (SUBJAREA,"BUSI") OR LIMIT-TO (SUBJAREA,"SOCI") OR LIMIT-TO (SUBJAREA,"ECON")) AND (LIMIT-TO (EXACTSRCTITLE,"Journal Of The Operational Research Society") OR LIMIT-TO (EXACTSRCTITLE,"ACM Transactions On Management Information Systems") OR LIMIT-TO (EXACTSRCTITLE,"Emergence Complexity And Organization") OR LIMIT-TO (EXACTSRCTITLE,"Enacting Research Methods In Information Systems Volume 3") OR LIMIT-TO (EXACTSRCTITLE,"European Journal Of Information Systems") OR LIMIT-TO (EXACTSRCTITLE,"Government Information Quarterly") OR LIMIT-TO (EXACTSRCTITLE,"Information And Organization") OR LIMIT-TO (EXACTSRCTITLE,"Journal Of Management") OR LIMIT-TO (EXACTSRCTITLE,"Journal Of Strategic Information Systems") OR LIMIT-TO (EXACTSRCTITLE,"Sage Handbook Of Organization Studies") OR LIMIT-TO (EXACTSRCTITLE,"Systems Practice"))
5. "critical systems thinking" AND multi*method* AND (LIMIT-TO (AU-ID,"Midgley, Gerald" 8849715000) OR LIMIT-TO (AU-ID,"Jackson, Mike C." 7404069644) OR LIMIT-TO (AU-ID,"Mingers, John C." 7004763639) OR LIMIT-TO (AU-ID,"Flood, Robert Louis" 7006012205) OR LIMIT-TO (AU-ID,"Reynolds, Martin" 7202325195) OR LIMIT-TO (AU-ID,"Ormerod, Richard J." 7004553786) OR LIMIT-TO (AU-ID,"Ulrich, Werner" 7103028361) OR LIMIT-TO (AU-ID,"Zhu, Zhichang" 7404803647) OR LIMIT-TO (AU-ID,"Córdoba, José Rodrigo" 14065819800) OR LIMIT-TO (AU-ID,"Brocklesby, John" 6602506209) OR LIMIT-TO (AU-ID,"Gregory, Wendy J." 7103281382) OR

LIMIT-TO (AU-ID,"Flood, Robert L." 57025723300) OR LIMIT-TO (AU-ID,"Khisty, C. Jotin" 7004093743) OR LIMIT-TO (AU-ID,"Yearworth, Mike" 6602655577) OR LIMIT-TO (AU-ID,"Espinosa, Angela" 9943594500) OR LIMIT-TO (AU-ID,"Pollack, Julien" 7101673366) OR LIMIT-TO (AU-ID,"Cabrera, Derek A." 12761020400) OR LIMIT-TO (AU-ID,"Cavana, Robert Y." 6602396681) OR LIMIT-TO (AU-ID,"Davis, Anne Powel" 56496061200) OR LIMIT-TO (AU-ID,"Gregory, Amanda J." 26029378200))

6. (TITLE-ABS-KEY("organi*ation* design")) AND (((system* method*))) AND (multi*method*) AND resilience AND (EXCLUDE (SUBJAREA,"ENGI") OR EXCLUDE (SUBJAREA,"MEDI") OR EXCLUDE (SUBJAREA,"NURS") OR EXCLUDE (SUBJAREA,"EART") OR EXCLUDE (SUBJAREA,"ECON"))

   Returned 22

7. ((TITLE-ABS-KEY(organi*ation*)) AND (((system* method*))) AND (multi*method*)) AND (("viable system model") AND ((SSM) OR (Soft W/1 systems W/1 method*)) OR (System W/1 Dynamics)) AND (LIMIT-TO (SUBJAREA,"BUSI ") OR LIMIT-TO (SUBJAREA,"MULT ") OR EXCLUDE (SUBJAREA,"ENGI ") OR EXCLUDE (SUBJAREA,"MEDI ") OR EXCLUDE (SUBJAREA,"NURS ") OR EXCLUDE (SUBJAREA,"EART ") OR EXCLUDE (SUBJAREA,"ECON "))

   Returned 48

Web of Science:

8. **TOPIC:** ("organi*ation* design"); **Refined by: TOPIC:** ("system* method*"); **Timespan:** All years. **Indexes:** SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

   Returned 5

These were then reviewed for relevance to multimethods, SSM, VSM, SD, CSH and Cybernetics. Specifically, for SSM, I was less interested in the use of Checkland’s approach to SSM as I proposed the use of Wilson’s approach as it is more suited to the development of a blueprint. A summary of the resulting findings is below in section C2.

C.2 Summary of findings

Table C-1- Main systems methods combinations - summary of findings from the literature

Author	Multi-methods	SSM	VSM	SD	CSH	Cybernetics	Findings
(Armstrong, 2019)		X					Explores adopting a Critical Realist approach to SSM. Based on the Checkland approach to SSM. Takes SSM to be Interpretivist and sees SSM as a way of thinking about the world, specifically a problematic situation. SSM was mapped to the CR RRRIEC process, and it is the CR approach to SSM that is argued, not how SSM can be applied within a CR study. It does say that CR has no specific methods and that SSM amongst others can be used. The author always seeks to bring external theory into determining a resolution as opposed to Checkland's view that the resolution should evolve from within those involved. Identified a difficulty in using SSM to identify mechanisms that drive the events seen, and that "there is therefore an opportunity to incorporate other methods to facilitate this process.
(Bustard et al., 2006)		X	X				A naïve use of Checkland SSM to produce a conceptual model with a root definition. The conceptual model contains real-world activities, and includes the 'T' from the RD. There does not appear to be an intellectual link between the RD and CM. Also, the control action is to achieve the 'W'! Activities are then mapped to VSM in order to identify gaps so the CM can be augmented. References Wilson with regard to Information Systems but doesn't use it. States difference between Checkland and Wilson is cosmetic!
(Cameron, 2011)	X						Problems with resources, tools and publishing. Appears to be a slow take-up in businesses, and poor quality. Researchers seem reluctant to extend beyond their single method approaches. Quant methods dominate (76%).
(Castellini & Paucar-Caceres, 2019)	X	X					Uses Mingers and Brocklesby's (1997) framework for multiple use of problem structuring methods. They re-situated the range of methods as a result of their research according to a real-world/conceptual world split. They critique M&B's link to Checkland and propose to align the 4As to Checkland's stages of problem structuring (as they refer to it). For me, M&B are proposing the 'what's and Checkland's approach is 'how'. It suggests to me a lack

Author	Multi-methods	SSM	VSM	SD	CSH	Cybernetics	Findings
							of real understanding of SSM. They also didn't consider M&Bs mapping of SSM to their matrix, and whether they agreed. SSM seems to be the wrong approach to the problem anyway. SD or VSM might have been more appropriate. They have also included Failure Mode and Effects Analysis (FMEA). It seems an optimization issue. It would have been good if they had mapped the methods they used to the M&B Matrix.
(Clemens, 2009)		X	X			X	A sequential use of SSM and VSM. SSM to set the context and focus of environmental scanning and then VSM to explore the governance and control of the environmental scanning.
(Midgley et al., 2007)	X	X					Evaluation of methods
(Midgley et al., 2013)	X	X		X			A further development of the Midgley et al 2007 paper for evaluating methods
(Gregory, 2009)		X		X			A systems approach to evaluation
(Hart & Paucar-Caceres, 2014)		X			X		Using CSH to guide second order critique of systemic practice
(Ing, 2013)	X	X	X	X			Development of systems thinking over the years. Includes SD and SSM as methods, as techne (craft). Includes Appreciative Systems as practice, as phronesis (prudence, common sense).
(Mingers, 2003)	X	X	X	X			A classification of the philosophical assumptions of management science methods. Useful to position methods against epistemology
(Mingers, 2006)	X	X		X			Critique of statistical modelling in management science
(Mingers, 2000)	X						Variety is the spice of life - combining methods. Includes examples through reference to papers, though nothing post-2000.

Author	Multi-methods	SSM	VSM	SD	CSH	Cybernetics	Findings
(Pollack, 2009)	X	X		X			Serial application of methods versus parallel application of methods; grafting and embedding. Serial application is the more common.
(Mingers & Brocklesby, 1997)	X	X	X		X		Classical paper on mixing methodologies according to stage of a project and differentiated by Habermas three worlds; material, social and personal.
(Mingers & White, 2010)	X	X		X	X	X	Development of methodologies, individually, and then examples of application in single method use.
(Pollack, 2006)	X	X		X	X		"This paper is written from the perspective of a practitioner-researcher coming to terms with methodologically or theoretically pluralist practice. Common depictions of the relationship between the hard and soft paradigms are discussed, including the influence of the problem of paradigmatic incommensurability. The consequences of different ways in which this relationship is depicted are examined, in light of various perspectives on the relationship of Critical Systems Thinking to these paradigms. Alternative models of this relationship are provided, followed by discussion of how these models can be extended to combinations of other paradigms in different contexts."
(Khan, 2013)	X	X	X	X	X		Within an Enterprise Architecture context, used rich pictures, conceptual maps [sic] and root definitions to co-evolve an understanding and description of the context. VSM used to develop an overall organizational model that could indicate systemic and communication gaps in terms of viability. Stakeholders that were interviewed/observed during the projects were analysed using CSH. The boundary critique of CSH revealed the sources influence clearly as well as an appreciation of the author's own selectivity towards the situation. Cognitive Mapping was used in a Participative Design Workshop to identify issues and emergent goals Being an EA approach, it has very little focus on the environment. He also recognises there is a need to integrate ST approaches internally to reduce the fragmentation within the ST space.

Author	Multi-methods	SSM	VSM	SD	CSH	Cybernetics	Findings
(Kinloch et al., 2009)		X	X				Linking the what from an SSM conceptual model to the how of VSM. Still using old 7-stage process of Checkland's SSM.

Appendix D Full Enterprise Model of Resilience

This appendix reviews the definitions of resilience and updates the definitions incorporated into those incorporated into the CURESS Project (Wright et al., 2012). Ruiz-Martin et al (2018) presented a literature review, the goal of which was to “identify how organizational resilience is conceptualised and assessed”. They reviewed over 50 definitions of resilience and over 110 references to identify the elements or attributes of resilience. It incorporates (Hilton, Wright and Kiparoglou, 2012; Wright et al., 2012) and is used, therefore, to evaluate the continuing validity of the CURESS Conceptual model of resilience. Additional relevant definitions of resilience have been added and the conceptual model re-generated.

D.1 How organisational resilience is understood

Table D-1 - Comparison with revised definitions of resilience

	Ruiz-Martin et al	(Wright et al., 2012) Ref	Comment
Resilience as a feature of an organization			
	An ability (or capacity or capability – treated as synonyms), to deal with internal and external changes, risks or jolts	T1: . . .to ensure an enterprise has the current and ongoing capacity and capability to continue to achieve its specified (or unspecified) purpose(s) in the face of predicted and unpredicted exposure to hazards, disruptive events and continual stress which may originate externally . . .	Included, so nothing to add.
	As a process to recover from disruptions	T1: . . . and recovering . . . S3: A system to recover from shocks by assessing damage, securing necessary resources, repairing and renewing as appropriate	Included, so nothing to add.
	As a quality to respond to significant change	T1: . . . responding expediently to minimise the extent, duration and cost of any disruption . . .	Included, so nothing to add.
	A function of 3 (cap-) abilities: adaptive capacity, situation awareness, and management of keystone vulnerabilities	T1: . . . adapting . . . S2: A system to reduce to an acceptable level exposure to identified hazards, disruption and stress by identifying possible, imminent and happening events and stress that may have an impact on key activities, reducing vulnerabilities and implementing countermeasures as appropriate. L1: A system to detect imminent and happening relevant events and stress . . . monitoring and interpreting associated signals . . .	Included, so nothing to add.

	Ruiz-Martin et al	(Wright et al., 2012) Ref	Comment
	Attributes include enterprise flexibility, adaptability, agility, and efficiency	T1: . . . adapting . . . responding expediently . . . PMC1: A system to enable adaptation by identifying lessons learned and acting upon them as appropriate. PMC3: A system to balance efficiency losses against protection gains by identifying efficiency levels and protection levels and making decisions about trade-offs Agility is implied by T1	Included, so nothing to add.
	(cap-)abilities include adaptability, responsiveness, sustainability and competitiveness	T1: through anticipating, preventing, mitigating, responding expediently to minimise the extent, duration and cost of any disruption, learning, adapting and recovering whilst recognising any potential hierarchy of purposes and emergent behaviour within the enterprise, balancing efficiency losses against protection gains	Included, so nothing to add.
	Operational resilience is understood as a way to bounce back after a crisis	S3: A system to recover from shocks by assessing damage, securing necessary resources, repairing and renewing as appropriate	Included, so nothing to add.
	Strategic resilience not only means to bounce back but also turn threats into opportunities.	PMC1: A system to enable adaptation by identifying lessons learned and acting upon them as appropriate	Implied in PMC1, but this could be made more explicit.
	Cognitive resilience enables the organization to be noticing, interpreting, analysing and formulating responses that go beyond survival	PMC2: A system to ensure enterprise developments and principles lead to continued survival and that it operates within legal and ethical constraints	Included, so nothing to add.

	Ruiz-Martin et al	(Wright et al., 2012) Ref	Comment
	Behavioural resilience is an engine that makes to organization work – requires a complex and varied action inventory (having a number of alternatives to deal with different scenarios) and the functional habits or routines	L2: A system to identify possible hazards, disruption and stress by imagining and developing scenarios of what may happen or be achieved and assembling this intelligence together with intelligence about historical events and lessons learned and storing, processing and making available this information as required	Included, so nothing to add.
	Contextual resilience is the framework where cognitive and behavioural resilience take place – includes social capital and broad resource network	The broad resource network is included in: L4: A system to ensure the continued provision of required service levels from systems upon which the enterprise is dependent by assigning appropriate authority and responsibility, establishing and maintaining appropriate arrangements between the enterprise and the systems upon which it is dependent, whilst taking into account the requirements of systems which are dependent upon the enterprise.	Social capital is an aspect of enterprise management that should be brought out. People should be encouraged to take responsibility and act. This will require the appropriate culture and behaviours to be positively developed and reinforced.
Resilience as an outcome of an organization			
	The maintenance of positive adjustment under challenging conditions such that the organisation emerges from those conditions strengthened and more resourceful	T1: . . . through anticipating, preventing, mitigating, responding expediently to minimise the extent, duration and cost of any disruption, learning, adapting and recovering whilst recognising any potential hierarchy of purposes and emergent behaviour within the enterprise, balancing efficiency losses against protection gains . . . S1: . . . having the necessary capacity and capabilities, making them ready in response to identified imminent events and stress, and applying them expediently in response to detected happening events and stress.	Included, so nothing to add.

	Ruiz-Martin et al	(Wright et al., 2012) Ref	Comment
	Able to achieve its objectives and realized opportunities in the face of predicted or unpredicted disruptive events	T1: . . . to ensure an enterprise has the current and ongoing capacity and capability to continue to achieve its specified (or unspecified) purpose(s) in the face of predicted and unpredicted exposure to hazards, disruptive events and continual stress . . .	Included, so nothing to add.;
Resilience as a measure of the disturbance that an organisation can tolerate			
	The level of disturbance an organization can tolerate and still survive		The CURESS project did not consider measures of resilience or disturbance that could be tolerated.

D.2 Organisational Resilience and its attributes

The following table maps the most cited attributes or elements of a resilient organisation to the root definitions to identify changes.

Table D-2 - Revision of Root Definitions

	Ruiz-Martin et al	(Wright et al., 2012) Ref	Resilience high-level model	Comments
1.	Situation awareness	L1: A system to detect imminent and happening relevant events and stress by developing knowledge of precursors to events and stress and indicators of events and stress happening, monitoring and interpreting associated signals and communicating this information in a timely manner	Situational awareness sub-system	Included, so nothing to add.
2.	Managing organization's vulnerabilities	L2: A system to identify possible hazards, disruption and stress by imagining and developing scenarios of what may happen or be achieved and assembling this intelligence together with intelligence about historical events and lessons learned and storing, processing and making available this information as required.	Event anticipation sub-system Enterprise preparedness sub-system	Included, so nothing to add.
3.	Having resources	S3: A system to recover from shocks by assessing damage, securing necessary resources, repairing and renewing as appropriate PMC4: A system to ensure capacity and capability align with current enterprise purpose by reviewing enterprise purpose, determining requirements and acquiring, developing and disposing of capacity and adjusting capability as appropriate	Resource management sub-system Strategic management sub-system	Included, so nothing to add.

	Ruiz-Martin et al	(Wright et al., 2012) Ref	Resilience high-level model	Comments
4.	Improvisation capacity		Response management sub-system	Improvisation was not explicitly considered. This should be included.
5.	Ability to anticipate events	T1: . . . anticipating . . .	Event anticipation sub-system Strategic management sub-system	Included, so nothing to add.
6.	Agility	Agility is implied by T1: . . . ensure an enterprise has the current and ongoing capacity and capability to continue to achieve its specified (or unspecified) purpose(s) in the face of predicted and unpredicted exposure to hazards, disruptive events and continual stress . . . responding expediently to minimise the extent, duration and cost of any disruption. . .	Enterprise management sub-system Resource management sub-system Response management sub-system	Included, so nothing to add.
7.	Learning capacity	PMC1: A system to enable adaptation by identifying lessons learned and acting upon them as appropriate.	Learning management sub-system Knowledge management sub-system	Included, so nothing to add.
8.	Collaboration	L4: A system to ensure the continued provision of required service levels from systems upon which the enterprise is dependent by assigning appropriate authority and responsibility, establishing and maintaining appropriate arrangements between the enterprise and the systems upon which it is dependent, whilst taking into account the requirements of systems which are dependent upon the enterprise.	External relationship management sub-system	Included, so nothing to add.

	Ruiz-Martin et al	(Wright et al., 2012) Ref	Resilience high-level model	Comments
9.	Resiliency of individuals			Resilience of individuals was not considered and should be included.
10.	Flexibility	PMC4: A system to ensure capacity and capability align with current enterprise purpose by reviewing enterprise purpose, determining requirements and acquiring, developing and disposing of capacity and adjusting capability as appropriate	Enterprise management sub-system Review, optimisation and improvement sub-system	Included, so nothing to add.
11.	Robustness (i.e. is designed to cope and absorb a set of known disturbances)	Robustness is implied by T1: . . . ensure an enterprise has the current and ongoing capacity and capability to continue to achieve its specified (or unspecified) purpose(s) in the face of predicted and unpredicted exposure to hazards, disruptive events and continual stress . . . responding expediently to minimise the extent, duration and cost of any disruption. . . S1: . . . making them ready in response to identified imminent events and stress . . .	Enterprise preparedness sub-system	Included, so nothing to add.
12.	Redundancy	T1: . . .to ensure an enterprise has the current and ongoing capacity and capability to continue to achieve its specified (or unspecified) purpose(s)	Enterprise preparedness sub-system	Included, so nothing to add.

D.3 Discussion

The aspects of resilience that were not explicitly or implicitly included are:

D.3.1 To not just bounce back, but turn threats into opportunities

This takes a positive view of the opportunities offered by disturbances, but that can only really be exploited by being resilient. This relates to the view in (Ruiz-Martin, Lopez-Paredes and Wainer, 2018) when they refer to the most mature level an organisationally resilient organisation can be; anti-fragile. They state "[a]n antifragile organization is able to not only to [sic] survive, but also to prosper or thrive in turbulent environments". It is in this context, we believe, that an organisation would turn threats into opportunities.

Consequently, **S2** is revised to be: A system to reduce to an acceptable level exposure to identified hazards, disruption and stress by identifying possible, imminent and happening events and stress that may have an impact on key activities, reducing vulnerabilities and implementing countermeasures as appropriate, **whilst recognising and developing any opportunities that may arise**.

The four-level maturity model proposed by (Ruiz-Martin, Lopez-Paredes and Wainer, 2018) (fragile, robust, resilient, antifragile), can be mapped to the causal textures proposed by Emery and Trist (1965): Placid, Randomised; Placid, Clustered; Disturbed, Reactive; and Turbulent. This will be explored elsewhere.

D.3.2 Improvisation capacity

Improvisation capacity is not explicitly included, so **T1** is revised to be: A system to ensure an enterprise has the current and ongoing capacity and capability to continue to achieve its specified (or unspecified) purpose(s) in the face of predicted and unpredicted exposure to hazards, disruptive events and continual stress which may originate externally from the environment, via interdependent system connectivity and/or internally through anticipating, preventing, mitigating, responding expediently, **including improvisation where required,** to minimise the extent, duration and cost of any disruption, learning, adapting and recovering

whilst recognising any potential hierarchy of purposes and emergent behaviour within the enterprise, balancing efficiency losses against protection gains. and a propensity to improvise is also to be encouraged within individual's behaviour in response to disturbances.

D.3.3 Contextual resilience, considering social capital, and resilience of individuals

The original thinking around those relevant aspects of resilience to be included in the framework for resilience thinking (Wright et al., 2012) included the self-reliance of individuals. This is included in a number of the statements:

> S1: A system to reduce to an acceptable level the extent, duration and cost of any disruption **by having the necessary** capacity and capabilities, **making them ready in response to identified imminent events and stress, and applying them expediently in response to detected happening events and stress**
>
> L1: A system to **detect imminent and happening relevant events and stress** by developing knowledge of precursors to events and stress and indicators of events and stress happening, **monitoring and interpreting associated signals and communicating** this information in a timely manner; and
>
> PMC4: A system to **ensure capacity and capability align with current enterprise purpose** by reviewing enterprise purpose, determining requirements and acquiring, **developing** and disposing of **capacity** and **adjusting capability as appropriate**.

However, we believe the need to set conditions for the right culture and behaviours in the organisation, as well as foster the development of self-belief and self-reliance in individuals such that they act in response to indicators of disturbance, communicating to whoever as appropriate, needs to be explicitly included. Consequently, S4 is added to the set of root definitions:

S4: A system to enable individuals to build an adequate level of self-reliance through providing opportunities for self-development, setting conditions to develop and maintain an appropriate organisational culture, delegating and empowering individuals accordingly, build social capital

and ensure relevant behaviours such that individuals are receptive to indicators and warnings of hazards, disruptive events and continual stress, and respond as appropriate; thus contributing to the ongoing success and resilience of the organisation.

D.4 Revised Model of Resilience

A new enterprise SSM model was developed from the revised set of Root Definitions. The subsystem model is illustrated below at Figure D-1 and the full Enterprise Primary Task Model is at Figure D-2. The difference at this level of abstraction is the additional subsystem focused on Personnel development. This results from the additional root definition S4. This is to ensure the appropriate behaviours are encouraged across the enterprise such that individuals are encouraged to notice signals indicating something out of the ordinary, and then act on them. This may result in action, but more importantly, the individuals respond, even if just to report what they have noticed.

D.5 Conclusions

The aspects of resilience that were not explicitly or implicitly included are:

1. To not just bounce back, but turn threats into opportunities; S2 was revised accordingly;
2. Improvisation capacity was not explicitly included, so T1 was revised accordingly; and
3. Contextual resilience, considering social capital and resilience of individuals was not explicitly included, so a new root definition, S4, was added.

These were added to the CURESS definitions, and a new conceptual model was developed.

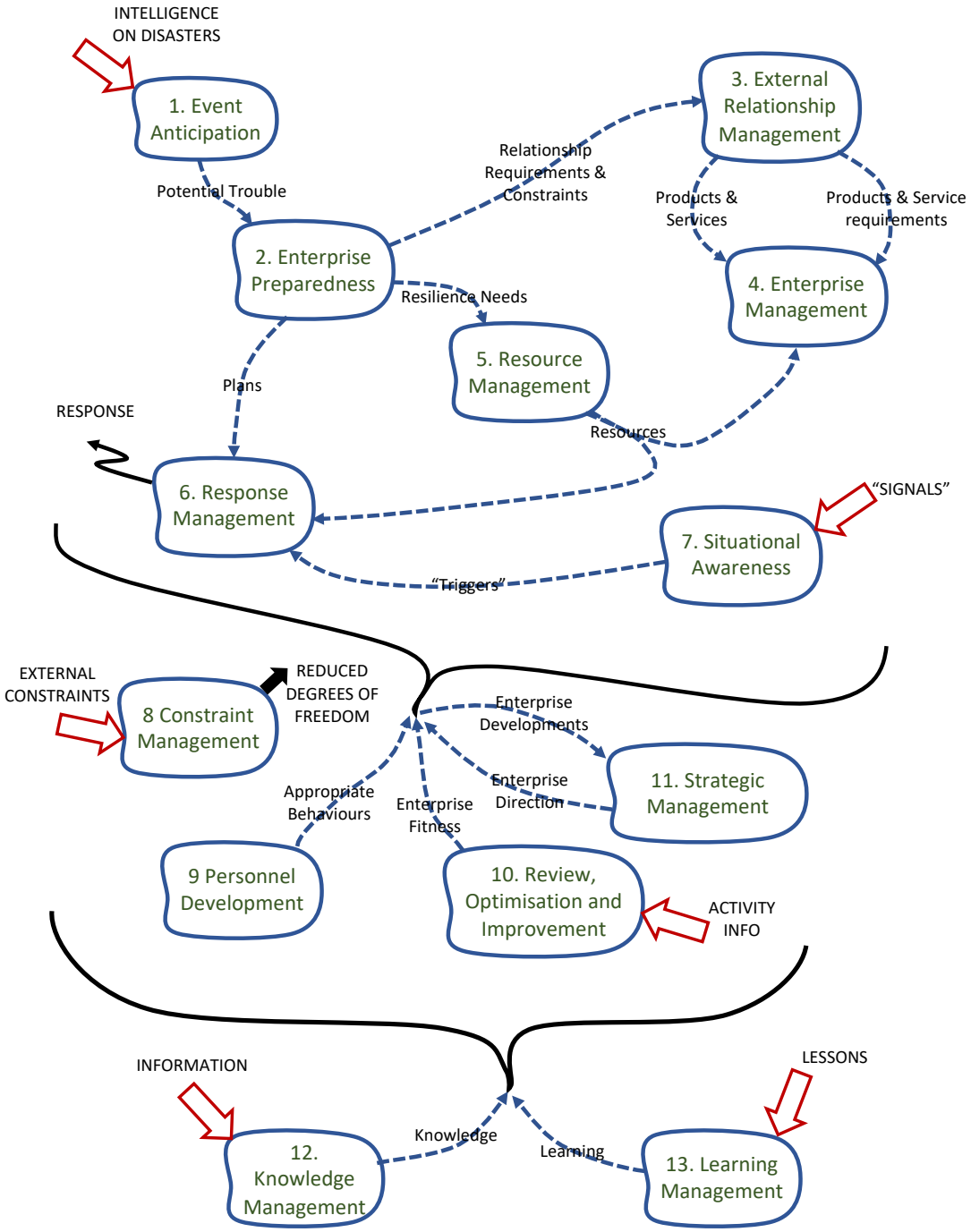


Figure D-1 – Revised high-level resilience model (Source: Author)

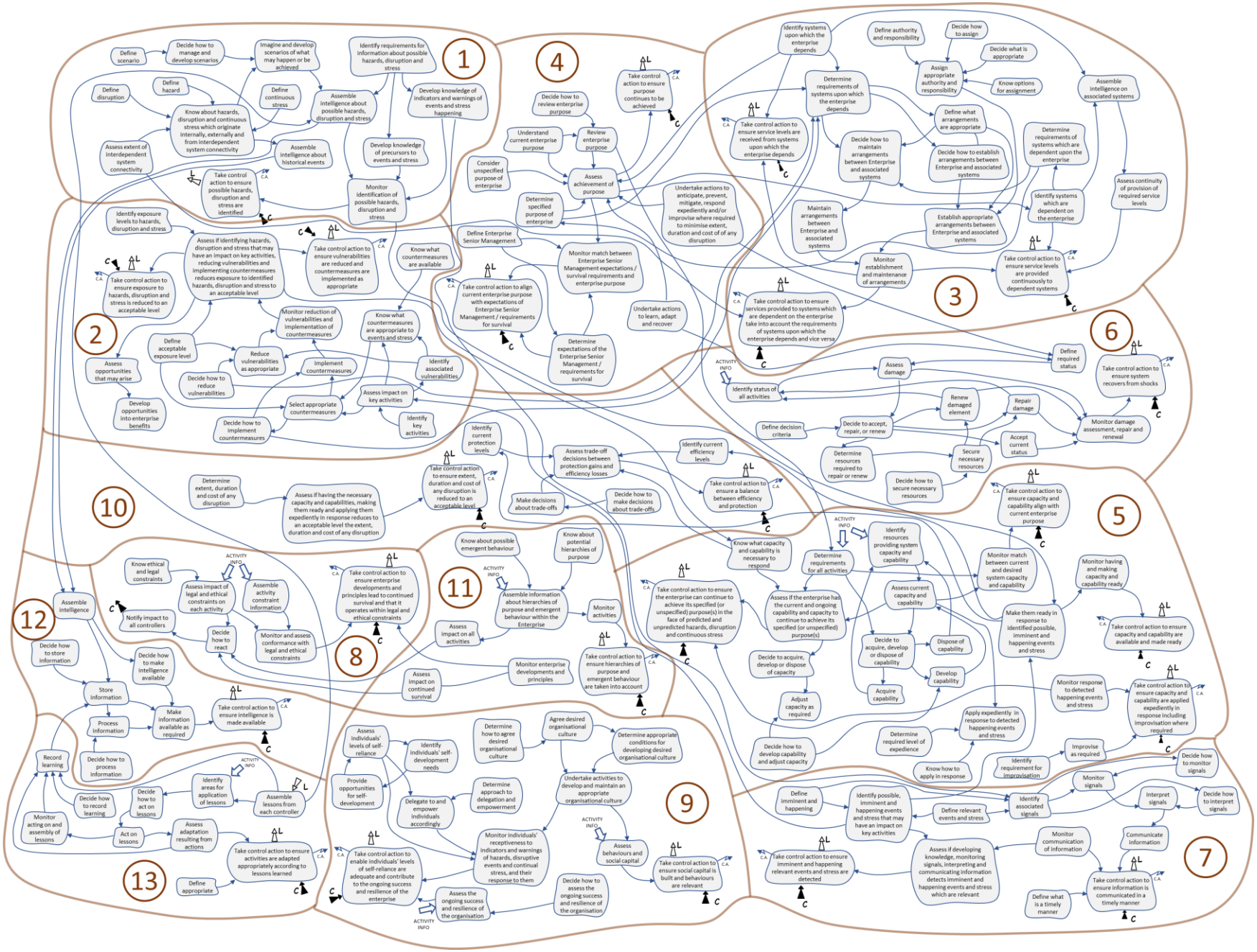
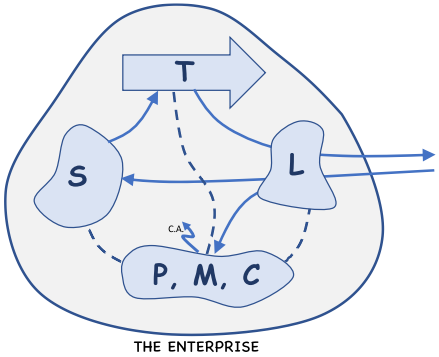


Figure D-2 - Resilience CPTM (Source: Author)



T – CORE TRANSFORMATION
S – SUPPORT
L – LINKING
P, M, C – PLANNING MONITORING & CONTROL
– INFORMATION, PRODUCT FLOW
– PERFORMANCE INFORMATION
C.A. – CONTROL ACTION

T1: A system to ensure an enterprise has the current and ongoing capacity and capability to continue to achieve its specified (or unspecified) purpose(s) in the face of predicted and unpredicted exposure to hazards, disruptive events and continual stress which may originate externally from the environment, via interdependent system connectivity and/or internally through anticipating, preventing, mitigating, responding expediently including improvisation where required, to minimise the extent, duration and cost of any disruption, learning, adapting and recovering whilst recognising any potential hierarchy of purposes and emergent behaviour within the enterprise, balancing efficiency losses against protection gains.

S1: A system to reduce to an acceptable level the extent, duration and cost of any disruption by having the necessary capacity and capabilities, making them ready in response to identified imminent events and stress, and applying them expediently in response to detected happening events and stress.

S2: A system to reduce to an acceptable level exposure to identified hazards, disruption and stress by identifying possible, imminent and happening events and stress that may have an impact on key activities, reducing vulnerabilities and implementing countermeasures as appropriate whilst recognising and developing any opportunities that may arise.

S3: A system to recover from shocks by assessing damage, securing necessary resources, repairing and renewing as appropriate.

S4: A system to enable individuals to build an adequate level of self-reliance through providing opportunities for self-development, setting conditions to develop and maintain an appropriate organisational culture, delegating and empowering individuals accordingly, build social capital and ensure relevant behaviours such that individuals are receptive to indicators and warnings of hazards, disruptive events and continual stress, and respond as appropriate; thus contributing to the ongoing success and resilience of the organisation.

L1: A system to detect imminent and happening relevant events and stress by developing knowledge of precursors to events and stress and indicators of events and stress happening, monitoring and interpreting associated signals and communicating this information in a timely manner.

L2: A system to identify possible hazards, disruption and stress by imagining and developing scenarios of what may happen or be achieved and assembling this intelligence together with intelligence about historical events and lessons learned and storing, processing and making available this information as required.

L3: A system to provide required service levels to systems which depend upon the enterprise by assigning appropriate authority and responsibility, establishing and maintaining appropriate arrangements between the enterprise and the dependent system, whilst taking into account the requirements of systems upon which the enterprise is dependent.

L4: A system to ensure the continued provision of required service levels from systems upon which the enterprise is dependent by assigning appropriate authority and responsibility, establishing and maintaining appropriate arrangements between the enterprise and the systems upon which it is dependent, whilst taking into account the requirements of systems which are dependent upon the enterprise.

PMC1: A system to enable adaptation by identifying lessons learned and acting upon them as appropriate.

PMC2: A system to ensure enterprise developments and principles lead to continued survival and that it operates within legal and ethical constraints.

PMC3: A system to balance efficiency losses against protection gains by identifying efficiency levels and protection levels and making decisions about trade-offs

PMC4: A system owned by enterprise senior management to ensure capacity and capability align with current enterprise purpose by reviewing enterprise purpose, determining requirements and acquiring, developing and disposing of capacity and adjusting capability as appropriate.

Sub-systems

1. Event Anticipation
2. Enterprise Preparedness
3. External Relationship Management
4. Enterprise Management
5. Resource Management
6. Response Management
7. Situational Awareness
8. Constraint Management
9. Personnel Development
10. Review, Optimisation & Improvement
11. Strategic Management
12. Knowledge management
13. Learning Management

Figure D-3 - Resilience Enterprise Root Definitions and Subsystems

D.6 Activity List sorted by Subsystems

Table D-3 - Activity list for the Resilience CPTM

No	Activity	RD	Sub-System	Description/Question
1.1	Identify requirements for information about possible hazards, disruption and stress	L2	Event Anticipation	Know what information is required about possible hazards, disruption and stress, in what format, how often, to what accuracy and who by.
1.2	Monitor identification of possible hazards, disruption and stress	L2	Event Anticipation	Monitor the activities providing identification of possible hazards, disruption and stress to make sure they happen and identification is made
1.3	Develop knowledge of indicators and warnings of events and stress happening	L1	Event Anticipation	Develop an understanding of any changes which occur to indicate events and stress are happening
1.4	Assemble intelligence about possible hazards, disruption and stress	L2	Event Anticipation	Gather together all knowledge of historical events and imagined scenarios, and what is meant by hazards, disruption and stress
1.5	Assemble intelligence about historical events	L2	Event Anticipation	Gather together all knowledge of historical events which caused or had the potential to cause hazards, disruption and stress
1.6	Take control action to ensure possible hazards, disruption and stress are identified	S2	Event Anticipation	Make corrective actions within this sub-system of activities to ensure that possible hazards, disruption and stress are identified as required
1.7	Develop knowledge of precursors to events and stress	L1	Event Anticipation	Develop an understanding of things that happen prior to events and stress which indicate events and stress will happen in the future
1.8	Know about hazards, disruption and continuous stress which originate internally, externally and from interdependent system connectivity	S2	Event Anticipation	What are the hazards etc and where do they come from?

No	Activity	RD	Sub-System	Description/Question
1.9	Assess extent of interdependent system connectivity	T	Event Anticipation	Assess to what extent the system depends upon other systems which may also at the same time depend upon it, and vice versa
1.10	Imagine and develop scenarios of what may happen or be achieved	L2	Event Anticipation	Imagining future scenarios related to new events which could happen
1.11	Decide how to imagine and develop scenarios	L2	Event Anticipation	The selection of a method by which scenarios are imagined and developed
1.12	Define hazard	L2	Event Anticipation	What is a "hazard"?
1.13	Define disruption	L2	Event Anticipation	What is a "disruption"?
1.14	Define continuous stress	L2	Event Anticipation	What is "continuous stress"?
1.15	Define scenario	L2	Event Anticipation	What is meant by "scenario"?
2.1	Reduce vulnerabilities as appropriate	S2	Enterprise Preparedness	Take action to reduce system weaknesses to specific threats
2.2	Implement countermeasures	S2	Enterprise Preparedness	Take action to avoid the occurrence of events and stress
2.3	Decide how to implement countermeasures	S2	Enterprise Preparedness	The selection of a method by which avoidance of events and stress can be achieved
2.4	Take control action to ensure vulnerabilities are reduced and countermeasures are implemented as appropriate	S2	Enterprise Preparedness	Make corrective action in the relevant sub-system to ensure that vulnerabilities are reduced, and countermeasures are implemented
2.5	Take control action to ensure exposure to hazards, disruption and stress is reduced to an acceptable level	S2	Enterprise Preparedness	Make corrective actions in the relevant sub-system to ensure that exposure to hazards, disruption and continuous stress is reduced to a level which the system can accept

No	Activity	RD	Sub-System	Description/Question
2.6	Monitor reduction of vulnerabilities and implementation of countermeasures	S2	Enterprise Preparedness	Monitor the activities which reduce system weakness against threats and avoid hazards, disruptive events and stress
2.7	Assess if identifying hazards, disruption and stress that may have an impact on key activities, reducing vulnerabilities and implementing countermeasures reduces exposure to identified hazards, disruption and stress to an acceptable level	S2	Enterprise Preparedness	Assess if exposure has been reduced to an acceptable level as a result of taking relevant actions in response to identified hazards, disruption and stress
2.8	Identify exposure levels to hazards, disruption and stress	S2	Enterprise Preparedness	Measure the actual level of exposure to hazards, disruption and stress
2.9	Know what countermeasures are available	S2	Enterprise Preparedness	Know ways in which events and stress can be avoided
2.10	Know what countermeasures are appropriate to events and stress	S2	Enterprise Preparedness	Have an understanding of which countermeasures are appropriate/effective when applied to deal with specific events or continuous stress
2.11	Identify associated vulnerabilities	S2	Enterprise Preparedness	Identify system vulnerabilities associated with key activities in relation to the identified possible, imminent and happening events and continuous stress
2.12	Identify key activities	S2	Enterprise Preparedness	Identify those activities within the whole system (enterprise) which are critical to purpose and survival
2.13	Assess impact on key activities	S2	Enterprise Preparedness	Assess the impact of potential, imminent and happening events and stress upon the critical activities of the whole system
2.14	Decide how to reduce vulnerabilities	S2	Enterprise Preparedness	The selection of a method by which system weaknesses are reduced

No	Activity	RD	Sub-System	Description/Question
2.15	Select appropriate countermeasures	S2	Enterprise Preparedness	The selection of countermeasures against possible, imminent and happening events and stress
2.16	Define acceptable exposure level	S2	Enterprise Preparedness	What is an acceptable level of exposure to hazards, disruption and stress?
2.17	Assess opportunities that may arise	S2	Enterprise Preparedness	Assess any opportunities that might arise whilst assessing impacts and implementing countermeasures
2.18	Develop opportunities into enterprise benefits	S2	Enterprise Preparedness	Undertake activities to develop such opportunities identified into benefits for the organisation
3.1	Take control action to ensure service levels are provided continuously to dependent systems	L3	External Relationship Management	Make corrective actions in the relevant sub-system to ensure service levels are provided
3.2	Take control action to ensure service levels are received from systems upon which the enterprise depends	L4	External Relationship Management	Make corrective actions in the relevant sub-system to ensure service levels are received
3.3	Decide how to establish arrangements between Enterprise and associated systems	L3, L4	External Relationship Management	Select a method by which arrangements for interacting with other systems are established.
3.4	Establish appropriate arrangements between Enterprise and associated systems	L3, L4	External Relationship Management	Take action to establish arrangements with other systems
3.5	Decide how to maintain arrangements between Enterprise and associated systems	L3, L4	External Relationship Management	Select a method by which arrangements for interacting with other systems are maintained on an ongoing basis
3.6	Maintain arrangements between Enterprise and associated systems	L3, L4	External Relationship Management	Take action to maintain arrangements with other systems as appropriate
3.7	Define authority and responsibility	L3, L4	External Relationship Management	Specify what is meant by "authority" and "responsibility" for interaction with dependent and systems depended upon

No	Activity	RD	Sub-System	Description/Question
3.8	Decide how to assign	L3, L4	External Relationship Management	Selection of the method by which authority and responsibility is assigned to appropriate system elements
3.9	Know options for assignment	L3, L4	External Relationship Management	Know what the available choices are for type, level and positioning of authority and responsibility (for interaction with other systems)
3.10	Assign appropriate authority and responsibility	L3, L4	External Relationship Management	Assign appropriate authority and responsibility for interacting with other systems
3.11	Define what arrangements are appropriate	L3, L4	External Relationship Management	Define what arrangements are required by the system when interacting with other systems
3.12	Monitor establishment and maintenance of arrangements	L3, L4	External Relationship Management	Have an ongoing awareness of arrangements between the system and other systems, both being established and being maintained
3.13	Determine requirements of systems which are dependent upon the enterprise	L3	External Relationship Management	Identify what arrangements are required by other systems which depend on the enterprise
3.14	Determine requirements of systems upon which the enterprise depends	L4	External Relationship Management	identify what arrangements are required by other systems which the enterprise depends upon
3.15	Identify systems upon which the enterprise depends	L4	External Relationship Management	What does the enterprise depend upon from external suppliers/utilities for its ongoing operations?
3.16	Identify systems which are dependent on the enterprise	L3	External Relationship Management	Who depends upon our enterprise products and services and what are we contractually committed to?

No	Activity	RD	Sub-System	Description/Question
3.17	Take control action to ensure services provided to systems which are dependent on the enterprise take into account the requirements of systems upon which the enterprise depends and vice versa	L3	External Relationship Management	Make corrective actions wherever in the enterprise to ensure continuity of supply in order to meet enterprise commitments.
3.18	Decide what is appropriate	L3, L4	External Relationship Management	Define what type, level and positioning of authority and responsibility is right for the system
3.19	Assemble intelligence on associated systems	L3, L4	External Relationship Management	Undertake all relevant activities which lead to the delivery of system purpose
3.20	Assess continuity of provision of required service levels	L4	External Relationship Management	Assess how well suppliers are consistently meeting their contractual commitments
4.1	Assess achievement of purpose	T	Enterprise Management	Assess how well the system is achieving its purpose
4.2	Take control action to ensure purpose continues to be achieved	T	Enterprise Management	Make corrective actions anywhere in the system to ensure that the system continues to achieve its specified or unspecified purpose
4.3	Review enterprise purpose	PMC4	Enterprise Management	Undertake activities as agreed to review and confirm the purpose of the enterprise
4.4	Decide how to review enterprise purpose	PMC4	Enterprise Management	Decide what approach is to be taken to periodically review and confirm the purpose of the enterprise.
4.5	Monitor match between Enterprise Senior Management expectations / survival requirements and enterprise purpose	PMC4	Enterprise Management	Have an ongoing awareness of the alignment between senior managers' expectations with regard to survival needs and the enterprise purpose
4.6	Determine expectations of the Enterprise Senior Management / requirements for survival	PMC4	Enterprise Management	Understand senior managers expectations with regard to resilience/survival of the enterprise.

No	Activity	RD	Sub-System	Description/Question
4.7	Understand current enterprise purpose	PMC4	Enterprise Management	Understand the purpose of the enterprise in terms of what it is actually achieving
4.8	Determine specified purpose of enterprise	T	Enterprise Management	Confirm the expectation of senior management with regard to the stated purpose of the enterprise
4.9	Consider unspecified purpose of enterprise	T	Enterprise Management	Identify any drift from the intended purpose of the enterprise and determine its benefit to the enterprise
4.10	Take control action to align current enterprise purpose with expectations of Enterprise Senior Management / requirements for survival	PMC4	Enterprise Management	Make corrective action wherever in the enterprise to align the current purpose of the enterprise to its stated purpose and the enterprise needs for survival.
4.11	Define Enterprise Senior Management	PMC4	Enterprise Management	Agree who is to be considered as senior management
4.12	Undertake actions to anticipate, prevent, mitigate, respond expediently and/or improvise where required to minimise extent, duration and cost of any disruption	T	Enterprise Management	Undertake actions to anticipate, prevent, mitigate, respond expediently and/or improvise where required to minimise extent, duration and cost of any disruption
4.13	Undertake actions to learn, adapt and recover	T	Enterprise Management	Undertake actions to learn, adapt and recover
5.1	Make them ready in response to identified possible, imminent and happening events and stress	S1	Resource Management	Make capacity and capability ready in response to possible, imminent and happening events and stress (readiness)
5.2	Apply expediently in response to detected happening events and stress	S1	Resource Management	Apply the resources (capacity and capability) in response to detected happening events and stress
5.3	Know how to make capacity and capability ready	S1	Resource Management	The selection of a method by which capacity and capability is to be prepared in readiness to potential events and stress

No	Activity	RD	Sub-System	Description/Question
5.4	Know how to apply in response	S1	Resource Management	The selection of a method by which capacity and capability is to be deployed in response to a happening event or stress
5.5	Take control action to ensure capacity and capability are applied expediently in response including improvisation where required	S1	Resource Management	Take corrective action in the relevant sub-system to ensure that capacity and capability are available and applied in an appropriate and timely manner in response to events and stress
5.6	Take control action to ensure capacity and capability are available and made ready	S1	Resource Management	Make corrective actions in the relevant sub-system to ensure system readiness for potential events and stress
5.7	Determine requirements for all activities	PMC4	Resource Management	Decide what capacity and capability is needed for every system activity
5.8	Take control action to ensure capacity and capability align with current enterprise purpose	PMC4	Resource Management	Make corrective action in the relevant sub-system to ensure that capacity and capability of the system are suitable to enable achievement of the system purpose
5.9	Decide how to develop capability and adjust capability	S1	Resource Management	Select the method by which system capacity is acquired
5.10	Acquire capability	PMC4	Resource Management	Undertake actions which acquire capability
5.11	Develop capability	PMC4	Resource Management	Undertake actions which develop capability and/or adjust the ability of the system to bring forth that capability when required
5.12	Dispose of capability	PMC4	Resource Management	Undertake actions which dispose of capability
5.13	Adjust capacity as required	PMC4	Resource Management	Undertake actions which adjust the level of capability
5.14	Decide to acquire, develop or dispose of capability	S1	Resource Management	Decide to acquire additional capability, or to develop resources to improve capability or to dispose of unwanted capability

No	Activity	RD	Sub-System	Description/Question
5.15	Monitor response to detected happening events and stress	S1	Resource Management	Monitor what actions are taken in response to happening events and stress
5.16	Monitor having and making capacity and capability ready	S1	Resource Management	Monitor the activities related to readiness
5.17	Identify resources providing system capacity and capability	S1	Resource Management	Identify what parts of the system contribute to the capacity and capability to respond to events and stress
5.18	Monitor match between current and desired system capacity and capability	S1	Resource Management	Identify the difference between what capacity and capability is required of the system and what is currently available
5.19	Assess current capacity and capability	S1	Resource Management	Assess the current capacity and capability of the system
5.20	Decide to acquire, develop or dispose of capacity	S1	Resource Management	Decide to acquire additional capacity, or to develop resources to improve capacity or to dispose of unwanted capacity
5.21	Assess if the enterprise has the current and ongoing capability and capacity to continue to achieve its specified (or unspecified) purpose(s)	T	Resource Management	Has the enterprise all that it requires in order to continue operating?
5.22	Know what capacity and capability is necessary to respond	S1	Resource Management	Know what capacity and capability is necessary to respond to possible, imminent and happening events in order that impact can be "absorbed"
5.23	Determine required level of expedience	S1	Resource Management	How quickly and effectively should a response be carried out, especially in relation to the potential impact upon key activities and interdependent systems?

No	Activity	RD	Sub-System	Description/Question
5.24	Take control action to ensure the enterprise can continue to achieve its specified (or unspecified) purpose(s) in the face of predicted and unpredicted hazards, disruption and continuous stress	T	Resource Management	Make corrective actions anywhere in the system to ensure purpose is achieved in face of disruption etc.
5.25	Identify requirement for improvisation	T	Resource Management	Is there a shortfall in enterprise capability and capacity impacting on the enterprises ability to survive that requires improvisation to enable continued operation in face of a disruption?
5.26	Improvise as required	T	Resource Management	Undertake actions to improvise as necessary
6.1	Accept current status	S3	Response Management	Decide to accept the current (damaged) status of the system section or resource.
6.2	Repair damage	S3	Response Management	Decide to repair the current (damaged) system section or resource to improve its status.
6.3	Renew damaged element	S3	Response Management	Decide to replace the current (damaged) system section or resource to achieve an acceptable status.
6.4	Take control action to ensure system recovers from shocks	S3	Response Management	Make corrective actions in the relevant sub-system to ensure that the systems recovers appropriately from shocks
6.5	Determine resources required to repair or renew	S3	Response Management	Determine what resources are needed to undertake system repairs or renew system elements
6.6	Secure necessary resources	S3	Response Management	Acquire the resources necessary to undertake system repairs or renew system elements

No	Activity	RD	Sub-System	Description/Question
6.7	Decide to accept, repair, or renew	S3	Response Management	A decision about accepting the current (damaged) status of the system or resource, or repairing the damage, or renewing the section of the system or replacing resources, depending on what is appropriate
6.8	Define decision criteria	S3	Response Management	What criteria is used when deciding whether to accept damaged status, repair damaged elements or renew damaged elements?
6.9	Monitor damage assessment, repair and renewal	S3	Response Management	Monitor the activities which assess damage, make decisions and undertake repair and renewal
6.10	Assess damage	S3	Response Management	Assess how much damage the system has sustained from a disruptive event or continuous stress
6.11	Identify status of all activities	S3	Response Management	Be able to tell the status of all system activities
6.12	Define required status	S3	Response Management	Decide what normal activity status for all system activities should be
6.13	Decide how to secure necessary resources	S3	Response Management	selection of the method by which resources for undertaking system repairs or system element renewals are acquired
7.1	Assess if developing knowledge, monitoring signals, interpreting and communicating information detects imminent and happening events and stress which are relevant	L1	Situational Awareness	Assess if relevant imminent and happening events and stress are detected effectively by the activities associated with developing knowledge, monitoring signals, interpreting and communicating information.
7.2	Monitor communication of information	L1	Situational Awareness	Monitor the activities relevant to communicating information about future and happening events and stress to ensure they happen

No	Activity	RD	Sub-System	Description/Question
7.3	Define what is a timely manner	L1	Situational Awareness	How timely does information need to be?
7.4	Define relevant events and stress	L1	Situational Awareness	What are "events", what is "stress" and which ones are relevant to purpose and survival?
7.5	Define imminent and happening	L1	Situational Awareness	What is meant by "imminent"? What is meant by "happening"?
7.6	Monitor signals	L1	Situational Awareness	Monitor the signals identified as being related to events and stress occurring or about to occur
7.7	Interpret signals	L1	Situational Awareness	Decide the meaning of signals related to events and stress about to occur or occurring
7.8	Identify associated signals	L1	Situational Awareness	Decide which signals are related to events and stress occurring or about to occur
7.9	Communicate information	L1	Situational Awareness	Pass the information about signals received and what they mean to the relevant parties
7.10	Take control action to ensure information is communicated in a timely manner	L1	Situational Awareness	Make corrective actions in the relevant sub-system to ensure that information about events and stress which are about to occur or are occurring are communicated appropriately and in time
7.11	Take control action to ensure imminent and happening relevant events and stress are detected	L1	Situational Awareness	Make corrective actions in the relevant sub-system to ensure that events and stress about to happen or happening are detected
7.12	Decide how to monitor signals	L1	Situational Awareness	The selection of a method by which signals are monitored
7.13	Decide how to interpret signals	L1	Situational Awareness	The selection of a method by which signals are interpreted

No	Activity	RD	Sub-System	Description/Question
7.14	Identify possible, imminent and happening events and stress that may have an impact on key activities	S2	Situational Awareness	Identify events or continuous stress which are happening right now, or which are about to happen, or which have potential to happen at any time in the future, and are relevant to the key activities of the system
8.1	Notify impact to all controllers	PMC2	Constraint Management	Notify all system control and change mechanisms of the impact legal and ethical constraints have on activities relevant to their area of control
8.2	Monitor and assess conformance with legal and ethical constraints	PMC2	Constraint Management	Have an ongoing awareness of the system's conformance with constraints
8.3	Know ethical and legal constraints	PMC2	Constraint Management	Are there any ethical or legal constraints upon the way the system operates?
8.4	Assess impact of legal and ethical constraints on each activity	PMC2	Constraint Management	Assess impact of any legal and ethical constraints on each activity
8.5	Take control action to ensure enterprise developments and principles lead to continued survival and that it operates within legal and ethical constraints	PMC2	Constraint Management	Make corrective actions anywhere in the system to ensure that all policy decisions and changes made within the system continue to support system survival but also operate within legal and ethical constraints
8.6	Decide how to react	PMC2	Constraint Management	Decide how to react to the impact potential hierarchies of purpose and possible emergent behaviour may have on the system
8.7	Assemble activity constraint information	PMC2	Constraint Management	Consolidate information of all the constraints the enterprise is subject to (contractual, legal, regulation, finance, etc.)
9.1	Identify individuals' self-development needs	S4	Personnel Development	Assess individual performance and determine if there are self-development needs

No	Activity	RD	Sub-System	Description/Question
9.2	Provide opportunities for self-development	S4	Personnel Development	Make available opportunities for self-development, including the required time and access to courses, etc.
9.3	Agree desired organisational culture	S4	Personnel Development	Undertake actions to agree the desired organisational culture
9.4	Determine how to agree desired organisational culture	S4	Personnel Development	Decide how and who within the enterprise will determine and agree the desired organisational culture
9.5	Determine appropriate conditions for developing desired organisational culture	S4	Personnel Development	Undertake activities to decide what are the appropriate conditions for developing desired organisational culture
9.6	Undertake activities to develop and maintain an appropriate organisational culture	S4	Personnel Development	Undertake activities to develop and maintain an appropriate organisational culture
9.7	Determine approach to delegation and empowerment	S4	Personnel Development	Senior managers to determine what level of autonomy they wish to provide to whom within the enterprise and agree an approach to delegation and empowerment
9.8	Delegate to and empower individuals accordingly	S4	Personnel Development	Undertake actions to delegate to and empower individuals accordingly
9.9	Assess behaviours and social capital	S4	Personnel Development	Assess behaviours and social capital
9.10	Take control action to ensure social capital is built and behaviours are relevant	S4	Personnel Development	Make corrective actions were necessary in the system to ensure social capital is built and behaviours are relevant
9.11	Monitor individuals' receptiveness to indicators and warnings of hazards, disruptive events and continual stress, and their response to them	S4	Personnel Development	Have an ongoing awareness of staff acknowledgement of and response to indicators and warnings of hazards, disruptive events and continual stress
9.12	Assess individuals' levels of self-reliance	S4	Personnel Development	Assess individuals' levels of self-reliance

No	Activity	RD	Sub-System	Description/Question
9.13	Take control action to enable individuals' levels of self-reliance are adequate and contribute to the ongoing success and resilience of the enterprise	S4	Personnel Development	Make corrective actions where possible to develop individuals' levels of self-reliance such that they contribute to the ongoing success and resilience of the enterprise
9.14	Assess the ongoing success and resilience of the organisation	S4	Personnel Development	Have an ongoing awareness of the current state of the enterprise with regard to its achievement of purpose and its resilience.
9.15	Decide how to assess the ongoing success and resilience of the organisation	S4	Personnel Development	decide how to maintain an ongoing awareness of the current state of the enterprise with regard to its achievement of purpose and its resilience
10.1	Take control action to ensure extent, duration and cost of any disruption is reduced to an acceptable level	S1	Review, Optimisation & Improvement	Take corrective action in the relevant sub-system to ensure that the extent, duration and cost of any disruption is minimised to a level which the system is able to accept
10.2	Take control action to ensure a balance between efficiency and protection	PMC3	Review, Optimisation & Improvement	Make corrective action in the relevant sub-system to ensure that there is an appropriate balance between efficiency and protection
10.3	Assess trade-off decisions between protection gains and efficiency losses	PMC3	Review, Optimisation & Improvement	Assess if there is an appropriate balance between system efficiency levels and system protection levels.
10.4	Assess if having the necessary capacity and capabilities, making them ready and applying them expediently in response reduces to an acceptable level the extent, duration and cost of any disruption	S1	Review, Optimisation & Improvement	Evaluate the reduction of disruptions in terms of extent of disruption, duration of any disruption and cost of disruption and if the activities being conducted are achieving a reduction

No	Activity	RD	Sub-System	Description/Question
10.5	Determine extent, duration and cost of any disruption	S1	Review, Optimisation & Improvement	Be able to measure the extent, duration and cost of any disruption to the system caused by exposure to events and/or continuous stress
10.6	Identify current protection levels	PMC3	Review, Optimisation & Improvement	Have an ongoing awareness of the system's strengths (or weaknesses) relative to possible hazards, disruption and continuous stress
10.7	Identify current efficiency levels	PMC3	Review, Optimisation & Improvement	Have an ongoing awareness of system efficiency
10.8	Decide how to make decisions about trade-offs	PMC3	Review, Optimisation & Improvement	Develop and agree and approach to making decisions about trade-offs between protection gains and efficiency losses
10.9	Make decisions about trade-offs	PMC3	Review, Optimisation & Improvement	Make decisions about trade-offs between protection gains and efficiency losses
11.1	Take control action to ensure hierarchies of purpose and emergent behaviour are taken into account	T	Strategic Management	Make corrective action in the relevant sub-system to ensure that all activities take into account the impact of hierarchies of purpose and emergent behaviour
11.2	Monitor activities	T	Strategic Management	Have an ongoing awareness of how all activities take into account hierarchies of purpose and emergent behaviour
11.3	Know about potential hierarchies of purpose	T	Strategic Management	Are there related systems or subsystems which may have their own purpose out of alignment with the system in focus' purpose?
11.4	Know about possible emergent behaviour	T	Strategic Management	What behaviour emerges from collections of systems and sub-systems, which is not visible when looking at individual systems or system elements, but is visible when looking at them in combination?

No	Activity	RD	Sub-System	Description/Question
11.5	Assess impact on all activities	T	Strategic Management	What is the impact of potential hierarchies of purpose and possible emergent behaviour upon the system activities?
11.6	~~Notify all controllers~~	~~T~~	~~Strategic Management~~	
11.7	Assemble information about hierarchies of purpose and emergent behaviour within the Enterprise	T	Strategic Management	Assemble information about hierarchies of purpose and emergent behaviour including how to react
11.8	Monitor enterprise developments and principles	PMC2	Strategic Management	Have an ongoing awareness of the policy decisions and changes which are made within the system
11.9	Assess impact on continued survival	PMC2	Strategic Management	Assess the impact of enterprise developments and principles upon continued system survival
12.1	Store information	L2	Knowledge management	Keep the intelligence about possible hazards, disruption and stress for future use
12.2	Process information	L2	Knowledge management	Process the information about possible hazards, disruption and stress into a form suitable for use
12.3	Make information available as required	L2	Knowledge management	Make information about possible hazards, disruption and stress available whenever it's required
12.4	Decide how to store information	L2	Knowledge management	The selection of a method by which information about possible hazards, disruption and stress is kept for future use
12.5	Decide how to process information	L2	Knowledge management	The selection of a method by which information about possible hazards, disruption and stress is processed into a suitable form for use
12.6	Assemble intelligence	L2	Knowledge management	Collect and collate knowledge with regard to possible hazards, disruptions and stress

No	Activity	RD	Sub-System	Description/Question
12.7	Take control action to ensure intelligence is made available	L2	Knowledge management	Make corrective actions where necessary across the enterprise to ensure intelligence is made available across the enterprise
12.8	Decide how to make intelligence available	L2	Knowledge management	Decide what processes, procedures, technology and responsibilities are required to make intelligence available
13.1	Decide how to record learning	PMC1	Learning Management	Decide what processes, procedures, technology and responsibilities are required to record learning
13.2	Record learning	PMC1	Learning Management	Implement the approach to record learning
13.3	Monitor acting on and assembly of lessons	PMC1	Learning Management	Have an ongoing awareness of the assembly of lessons and the extent to which staff act on them
13.4	Identify areas for application of lessons	PMC1	Learning Management	Understand what lessons are applicable where.
13.5	Assemble lessons from each controller	PMC1	Learning Management	Ensure lessons are collected and collated from all managers
13.6	Assess adaptation resulting from actions	PMC1	Learning Management	Assess what changes are made resulting from actions in response to lessons
13.7	Act on lessons	PMC1	Learning Management	Undertake activities in response to lessons
13.8	Define appropriate	PMC1	Learning Management	What is an appropriate way to react to learning?
13.9	Decide how to act on lessons	PMC1	Learning Management	Decide what measures to take in light of any perceived impact to activities identified as a result of learning
13.10	Take control action to ensure activities are adapted appropriately according to lessons learned	PMC1	Learning Management	Make corrective actions anywhere in the system to ensure that adaptation occurs appropriately to the lessons learned