A COMPLEXITY LEADERSHIP THEORY FRAMEWORK FOR ENGINEERING MANAGEMENT

A thesis submitted for the degree of Doctor of Philosophy

by

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Declaration

I hereby declare that I am the sole author of this thesis. This work in this thesis was carried out following the requirements of the University's Regulations for PhD and is the result of my own investigations and evaluations except where otherwise indicated by specific reference in the text. I can confirm that this work has not previously been accepted for any degree nor is it currently submitted and under consideration for any other academic award.

Chris Biggadike January 2025

i. Acknowledgements

ii. Abstract

Complexity Leadership Theory (CLT) views organizations as complex systems and proposes important implications for leadership theory. However, current research on CLT has focused mainly on its theoretical development, providing limited practical application examples for complex industries, such as that found in manufacturing engineering. To address this research gap, a complexity leadership framework was developed in collaboration with practitioners through an action research program in an engineering organization headquartered in the United Kingdom that specializes in aerospace and defence. The proposed framework builds on previous research that identified three leadership modes (i.e., Administrative, Enabling, and Adaptive) for complex engineering environments. Specifically, data were collected from 852 leaders, with action research involving 37 participants from the UK, USA, Canada, Australia, and Ireland. The proposed complexity leadership framework, titled "the 5-point framework", reflects the fundamentals of leading within the organization's complex engineering environment. The framework was validated through practitioner review and five independent elite interviews with leaders from diverse organizations. The study's results contribute to current literature by expanding the previously proposed three leadership modes to five modes (i.e., Direction, Strategic Administrative, Enabling, Tactical Administrative and Adaptive). The findings contribute to the current discourse by providing engineering leaders with a refined framework that addresses the multifaceted leadership requirements critical for navigating complex environments.

iii. List of Publications

Peer-reviewed Journal Articles

1. Biggadike, C., Pei, E. and Evans, R., *TBD*. Navigating complexity in multinational engineering organizations: A 5-Point leadership framework based on Complexity Leadership Theory. *IEEE Transactions on Engineering Management*. Under Review.

2. Biggadike, C., Evans, R. and Pei, E., 2022. Complexity leadership: on time, on budget. *IEEE Engineering Management Review*, 50(2), pp.12-16. Doi: 10.1109/EMR.2022.3152389.

3. Biggadike, C., Ahumada-Tello, E., Evans, R. and Wehde, M., 2023. Cultural hierarchies, leadership, and employee happiness. *IEEE Engineering Management Review*, 51(3), pp.8-12. Doi: 10.1109/EMR.2023.3275188.

Articles in Refereed Conference Proceedings

1. Biggadike, C., Pei, E. and Evans, R., 2023. Complexity Leadership: Expanding the Fundamental Leadership Modes. IEEE Conference on Innovation Management. Los Angeles, USA, 20 – 22 June 2023.

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6	Evaluation	Discuss results and compare to extant research
7		Present validation data
8	Reflection	Present conclusions

vii.   Glossary of terms

The following is a list of key terms used and their definition within the context of this thesis.

TERM	DEFINITION
Business	A legal entity which is set up to facilitate and administrate the sale of goods or services.
Complex System	A system which abides by the laws of complexity science. Such systems have broadly predictable patterns but are unpredictable in detail. The weather and the global finance market are examples.
Complexity	The inherent nature of a situation or system which is characterized by being beyond simple comprehension. Complex situations or systems do not lend themselves readily to modelling or prediction of future states. Complexity mathematics demonstrates that some systems cannot be entirely predicted, even as a mathematical model.

Complexity Leadership Theory	A leadership theory based on the ideas of complexity science which proposes methods and ideologies for leading within a complex organization (i.e. an organization which behaves as a complex system).
Deterministic	Has states which can be predicted confidently at all points in time, given a complete set of data for one point in time. A mechanical clock is an example of a deterministic mechanism.
Engineering Organization	An organization which is predominantly involved in engineering-based activities. Often design and manufacture or the supply of engineering services.
Leadership	An activity whereby an individual, who is invested with authority and responsibility by a group, communicates advice, plans and other information designed to organize the group, guide their activities and influence the environment to enable or simplify success.
Non-deterministic	Has future states which cannot be accurately modelled regardless of how much is known about the current and past states.
Organization	A legal entity, more complex than a business in administrative structure. May be a government entity, group of businesses etc.
Reductive thinking	The mindset which seeks to reduce highly complex situations into simple models.
System	A group of elements which are related and interact to give an effect or end result beyond the individual actions of the elements. For example, a clock is a system for showing the time, the lifeforms on an island create an ecological system which sustains life, the teachers and pupils in a school create a system for local education etc.

viii.   List of Acronyms

AD	Administrative Leadership
AI	Artificial Intelligence
APAC	Asia Pacific
AR	Action Research
BD	Business Development
BMC	Business and Management Consultant
BREXIT	Britian Exiting the European Union

CAD	Computer Aided Design
CAS	Complex Adaptive Systems
CEO	Chief Executive Officer
CFO	Chief Finance Officer
CLT	Complexity Leadership Theory
COVID 19	Coronavirus detected 2019
CSC	Canadian Surface Combatant
D	Direction Leadership
EMEA	Europe Middle East and Africa
EN	Enabling Leadership
ERP	Enterprise Resource Planning
GCS	Ground Control Station
GST	General Systems Theory
ID	Identity
IEEE	The Institute of Electrical and Electronics Engineers
INCOSE	The International Council on Systems Engineering
INNOCONF	Innovation Conference
IT	Information Technology
JISC	Joint Information Systems Committee
MFQ	Multifactor Leadership Questionnaire
MIT	Massachusetts Institute of Technology
MS	Microsoft
NPD	New Product Development
PD	Product Development
PLM	Product Lifecycle Management
PM	Project/Programme Manager
PMO	Project Management Office
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RFI	Request For Information
RFP	Request For Pricing
RTCA	Radio Technical Commission for Aeronautics
SA	Strategic Administrative Leadership
SAGE	A publishing group named after its founders (Sara Miller and George McCune)
SLT	Senior Leadership Team
STAR	Self Thought Achieve Results
SVP	Senior Vice President
TA	Tactical Administrative Leadership
TBD	To be determined
TD	Technical Director
TEMS	Transactions on Engineering Management Society
UK	United Kingdom
US	United States (of America)
USA	United States of America
VP	Vice President

1. Introduction

Chapter	Phase	Purpose
1	Exploration	Introduce research topic Research Aims, Objectives, Questions and Scope. Thesis structure

This chapter provides an introduction to the overarching theme of the research (1.1) and introduces the research aim and objectives (1.2) and the associated research questions (1.3). The scope of the research is also defined (1.4) and the thesis structure is illustrated (1.6).

1.1. Leadership in the 21st Century

> "For all those who argue that leadership doesn't matter, 2020 [and the COVID 19 pandemic] proves them wrong: leadership can be, literally, the difference between life and death" (Uhl-Bien 2021 p. 1).

The Oxford Dictionary of English defines Leadership as "the action of leading a group of people or an organization, or the ability to do this" (Oxford 2010). Wilson, on the topic of finding a prevailing definition of leadership in academic literature states:

> "There is no clear candidate, however, for a prevailing or even an influential definition. There have been a handful of interesting attempts in recent decades, but none has either established a foothold or generated much interest in the definitional project" (Wilson 2023 p. 1)

The challenges in defining leadership is also acknowledged by Bugaj (Bugaj and Sulyma 2022) who conducts a systematic literature review of academic papers containing a range of definitions. Recognizing these challenges, this study uses the following specific definition: *Leadership can be described as an activity whereby an individual, who is invested with authority and responsibility by a group, communicates advice, plans, and other information designed to organize the group, guide their activities and influence the environment to enable or simplify success.* A prototype of this definition was initially developed as part of the research (see 4.6) in the form of: *A leader is someone who influences others towards a goal. A leader modifies their influence in response to change and feedback.* It was then modified to better fit the specific context of the research and to include the need for the recognition of authority.

Behaviours, culture and context can all affect the methods used by the leader and the challenges they will face. For example, typically within engineering organizations, there is a common issue with technical leadership (leading with a strong technical element): leaders are often chosen for their technical prowess rather than their leadership skills. While an engineering leader does indeed need credible technical authority, arguably, their leadership skills can be more important for successful delivery. Within engineering, there tends to be a high level of complexity in both the products and the projects which adds to the challenge of leadership.

Engineering Leadership is a unique leadership situation containing common methodologies, rather than a single leadership methodology. There are many facets to the role of engineering leader: solving technical problems, co-ordinating groups of highly educated, technical experts, managing customer technical requirements, understanding safety and reliability, working to international standards, adopting new methods and technologies, managing changes in requirements or technical failures, people and performance management and co-ordinating the design to meet the customer needs with the design for manufacture and test requirements. Engineering Leadership is dominated by leaders who have achieved seniority through their technical achievements rather than their leadership capabilities, and who maintain their leadership position by developing leadership skills in-role (Gupta et al. 2023). For some, the burden of leadership is a necessary burden to enable career progression, rather than a goal in itself (Rottmann, Sacks, and Reeve 2015). It is generally executed using a combination of best-practice and established methodologies. Systems Engineering is a commonly employed framework for analysing and mapping requirements to a design and its supporting verification (INCOSE 2024). Programme Management is a widespread methodology which integrates planning and accounting methods for managing projects of any scale. Lean engineering is a manufacturing waste reduction system invented by Toyota (Kumar et al. 2022). Each of these methodologies, and others like them, control specific areas of interest to Engineering Leadership. They are well established and powerful they mostly provide control and governance rather than leadership and there is currently no commonly agreed framework for Engineering Leadership to bridge the gaps between these methods and to respond to issues which arise where the complexity of the situation makes such tools and methods difficult to use. This study focuses on Engineering Leadership because it is an excellent example of an area where a prevailing leadership methodology has yet to be established (Cárdenas-Figueroa et al. 2023) and its links to technology are forcing a rapid increase in complexity.

Complexity, as an abstract concept, exists on a sliding scale; we can speak of something increasing in complexity, without there being a specific unit of complexity to allow meaningful measurement. Within the context of this study, complexity is proposed as a measure of how difficult something is to be understood by a human brain to an acceptable level of accuracy or completeness for the task at hand. The challenge of comprehending complex situations is exacerbated when they are dynamic, as is often the case within organizations. Most leaders are expected to manage complex situations, often simultaneously. To render complex situations manageable, management tools and techniques are employed which reduce the apparent complexity by modelling them in a reduced way.

The use of reductive methods is common practice in organizational leadership, they are essential to allow leaders to make informed decisions quickly. For example, we make simplified functional diagrams of large organizations to simplify discussions and decision making and represent large projects with project plans and work-breakdown structures. Teams are given hierarchical structures to clarify the relationship between roles and their associated responsibilities. The use of such simplifying models can be described as an example of reductive methods. Similarly, in science, reductionism is the proposal that complex phenomena can be understood by reducing them to their simplest form or fundamental components (Grasso et al. 2021). Reductive methods are critical to the success of leaders as they allow decisions to be made quickly and can provide a common vocabulary between leaders engaged in a common cause, but they must be used with an understanding of their limitations: The more complex the situation being modelled, the greater the need for reduction to allow comprehension. As complexity increases, the reduced model becomes more and more abstracted from reality and the risk that important details are omitted grows. This risk becomes much greater when the situation being modelled behaves as a complex system (see 2.5). Such systems do not lend themselves well to simple, static models, especially if the associated models have not acknowledged complex system behaviour. It is for this reason that complexity has become a subject of academic study.

According to academics in the field of organizational complexity, business management thinking in the digital era is still dominated by reductive models and simplified thinking (Uhl-Bien, Marion, and McKelvey 2007 ; Joosse and Teisman 2021) which can be traced back to General Systems Theory (GST), as proposed in 1940 by Ludwig von Bertalanffy (Allen, Maguire, and McKelvey 2011 ; Von Bertalanffy 1951). GST sees systems as being completely described by a combination of the components or elements within the system and the interactions between those elements. This

approach is powerful when used to model deterministic systems (like aircraft, computers or clocks) but can become limited when the systems are complex (like organizations, the weather and financial markets).

When an engineering leader begins to become overly dependent on reduced model and starts to lose touch with the complexity beneath, they develop what could be described as a reductive mindset. In this mindset, the model reflects the world as it should be and deviations from that state are caused by errors in execution. To illustrate this mindset, an activity being managed is conceived as a simplistic flow of activities which are each described by a block (see Figure 1). By taking what is a complex and layered situation and reducing it to a simple model, the leadership approach is, at risk of lacking detail and understanding of the nuances involved. To take the example shown in Figure 1, the leader may say "I will ask the customer for their requirements, I will pass these to the design team and get them to design a product for that customer. The suppliers will then supply the parts for manufacture, and we'll start delivery to the customer". This being the case, the reductive leader only plans to undertake some simple communications to achieve their goal of selling product to the customer.
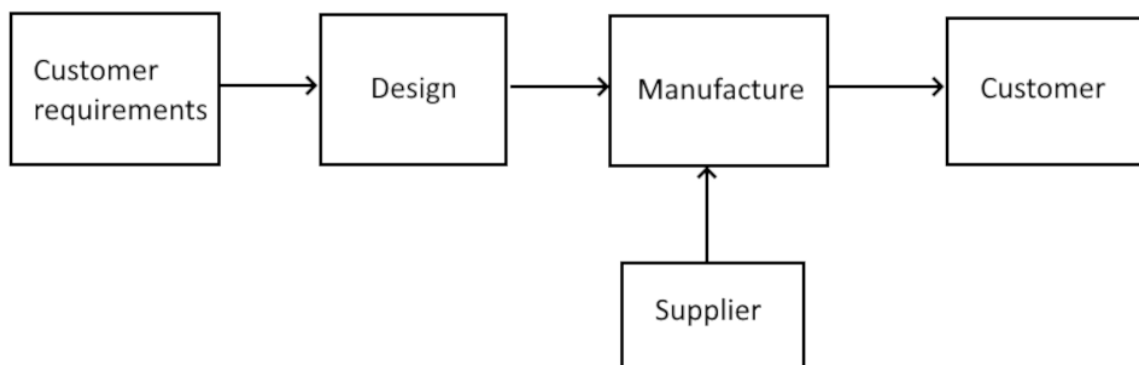
Figure 1 - Example of a reductive business model for a product design project

There are several limitations to this approach: First, it fails to examine any of the details involved (e.g., What if the customer requirements contradict or cannot be achieved? Does the design team possess the right skills and experience? Can our suppliers make that type of components? Etc.). Second, it fails to recognize the effects that the wider environment may have on the project. Third, it does not examine what to do when unexpected events occur. As all of these details will, inevitably, affect the project during its execution, the leader with the reductive mindset will often blame the team for late delivery / overspend or any other unexpected problems.

The prevalence of such methods is not, many find, supported by success (White and Fortune 2002). Often based on administration and centralised control with a single approach for all situations, such methods are failing globally to deliver the expected results (Nell, Kappen, and Laamanen 2017 ; Uhl-Bien 2021) and projects are often late and over-spent (Williams 2005 ; Odusanya et al. 2021). It is, therefore, common for there to be friction between the delivery team and the management team as frustrated Project Managers see events moving away from their plan and frustrated engineers who are trying to achieve challenging technical goals within a rigid governance framework while being blamed for not adhering to planned timescales and budgets. In the engineering industry, current based methods lead to many lost hours as managers try to control the uncontrollable and manage a lack of agility in the face of change. In fields such as technology management and engineering design, which have strong creative elements, these management practices can give rise to tension between the reductive worldview of managers and the complex lived experience and practice of engineers (Uhl-Bien, Marion, and McKelvey 2007). This tension may contribute to the high failure rate of engineering projects (Lévárdy and Browning 2009) as brittle plans meet fluid and complex reality.

These shortfalls of engineering leadership practice are greatly exacerbated by the increasing complexity of both the environment and the tools and techniques used by engineers. In 1980, engineering design was executed on drawing boards and microprocessor control, and its associated software was in its infancy. By the late 1990s, 3D CAD systems and other software tools were becoming commonplace (although very simplistic compared with those seen today) and the internet was beginning to replace libraries of technical reference books. Embedded software in electronics became standard practice. This rate of change driven by technology continued exponentially across the first quarter of the 21st century so that, by its end, artificial intelligence, cloud computing, 3D printing, advanced robotics and many other technologies which were considered science fiction in 1980 have become everyday reality. This change of complexity of the workplace is not limited to engineering but these changes in technology directly affect practice as engineers are expected to keep pace with and master each new technology as it arises. This change in the complexity of work practice has not been paralleled by equally dramatic changes in leadership methodology. Many of the most innovative and impactful leadership methods have come from the Japanese (e.g. Kaizen, Nemawashi, Ringi etc.), but can be difficult to apply outside of Japanese culture. Most organizations still rely on reductive models which, at their most sophisticated, are based on GST.

Within engineering, GST underpins the methods used to control the flow of data and link requirements to designs (Systems Engineering) and so it is often felt natural to try to apply these familiar methods to leadership and work-package management. Additionally, adjacent disciplines such as Programme Management and Manufacturing use management philosophies which often assume deterministic behaviour (e.g., Waterfall Project Management, LEAN, Six Sigma, etc.) and this can influence the leadership methods used for engineering. With the exception of Agile / Agile Scrum (e.g., Bäcklander 2019), there are very few established and respected methods for managing engineers during development programmes in a way which recognizes complexity.

Recognizing the limitations of current practice, this study examines the potential for Complexity Leadership Theory as an improved engineering leadership paradigm. The aerospace and defence industry is a highly regulated sector of the engineering industry with which it shares best-practice methods such as Systems Engineering, New Product Development (NPD) and Project Management. All aerospace and defence products must pass stringent internationally recognized tests (e.g., RTCA DO 160) and are executed to standards which define activities and governance in detail (e.g., RTCA DO 178C and RTCA DO 254). It is an industry in which a lack of appropriate leadership can quickly lead to spiralling costs, delays and, potentially, a risk to life. It is therefore proposed as a particularly complex example of an already complex industry and therefore highly suitable for participation in this research.

1.2. Aim and Objectives

The aim of this research is to develop a leadership framework which embraces dynamic and complex process flows by promoting a holistic and non-reductive approach that fosters adaptability and flexibility in leadership.

To achieve the above aim, the following objectives must be met:

(OBJ1): Investigate leadership within an engineering organization, in the context of CLT, through the use of informal interviews and action research.

(OBJ2): Develop leadership tools or techniques which can be used by leaders working in a complex environment through the use of action research and surveys.

(OBJ3): Examine the ways in which leadership can be usefully conceptually compartmentalized into modes or activities to aid analysis and comprehension through the use of action research and elite interviews.

(OBJ4): Engage a diverse range of leaders to increase the probability that the research output will be widely generalizable within an engineering organization.

1.3. Research Questions

This research proposes to contribute to the extant literature by answering the following questions:

(RQ1): Which leadership theory can be used as a sound basis for modern engineering leadership?

(RQ2): What form of leadership framework or leadership is suitable for general application in an aerospace and defence company?

(RQ3): What aspects of leadership can be improved by a Complexity Leadership Theory based approach?

(RQ4): To what extent is a solution which has been generated for one engineering organization likely to be generalizable to other similar organizations?

In Table 1, the relationship between the research questions and the objectives is shown along with the chapters where the topics are covered and the outcome of the objectives is shown.

Table 1 - Mapping of Research Questions to Objectives

Research Question	Objectives	Chapter(s)
(RQ1): Which leadership theory can be used as a sound basis for modern engineering leadership.	(OBJ1): Investigate leadership within an engineering organization in the context of a candidate leadership theory.	Chapter 2 Chapter 6
(RQ2): What form of leadership framework or leadership is suitable for general application in an aerospace and defence company?	(OBJ2): Develop leadership tools or techniques which can be used by leaders working in a complex environment.	Chapter 5

(RQ3): What aspects of leadership can be improved by a Complexity Leadership Theory based approach?	(OBJ3): Examine the ways in which leadership can be usefully conceptually compartmentalized into modes or activities to aid analysis and comprehension.	Chapter 6 Chapter 7
(RQ4): To what extent is a solution which has been generated for one engineering organization likely to be generalizable to other similar organizations?	(OBJ4): Engage a diverse range of leaders to increase the probability that the research output will be widely generalizable within an engineering organization.	Chapter 7

1.4. Research Scope

The scope of this research is developed in response to the research problem and associated aim. Working within the context of engineering leadership, the research examines the theoretical landscape of leadership theory in conjunction with practitioner perspectives. This scope has two key areas of activity: In the theoretical field, choosing a candidate leadership theory which can be used as the basis of an improved approach and understanding the current state of theoretical development which relates to the use of the chosen theory and its practical application. In the practical field, exploring how theory and practice can be harmonized and communicated to practitioners, and developing a leadership framework or similar toolset to embody the developed improved approach. This scope is illustrated in Figure 2.
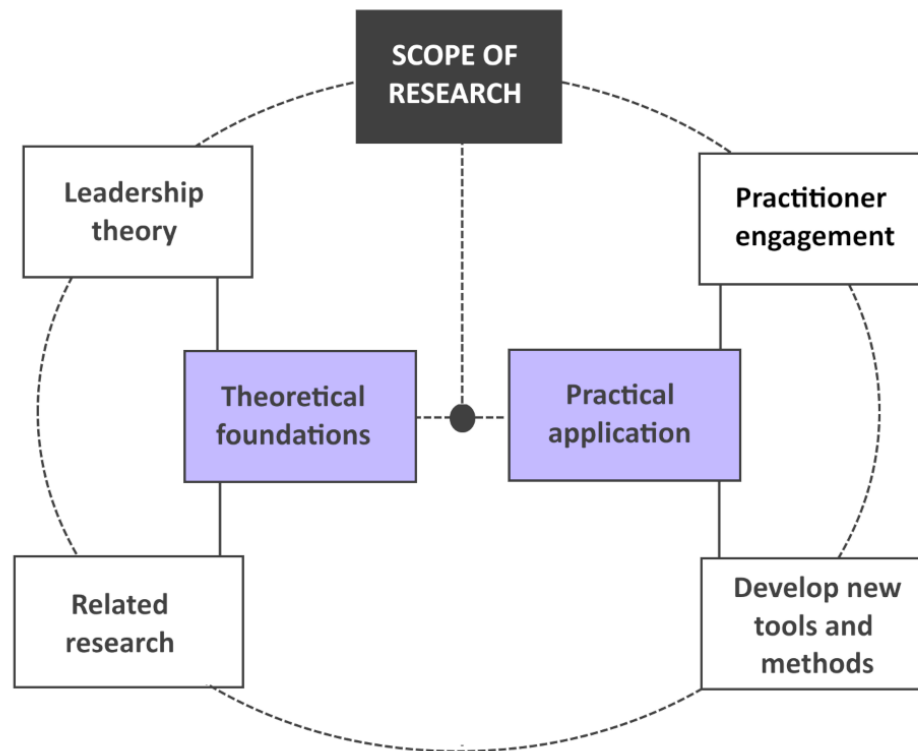
Figure 2 - Scope of research

1.5. Research contribution

This research delivers a leadership framework which takes a holistic view of leadership. It contributes to improved leadership practice by providing a catalyst for reflection on current leadership practice and a framework which can be used to understand and analyse cause and effect for leadership issues and success.

The main theoretical contribution is the delivery of a substantial, longitudinal study into the applicability of existing proposals for leading complexity. The output of this study contributes new ideas to the existing discussion, developing further the concept of using multiple leadership modes to achieve a balanced approach to leading in complex organizations.

1.6. Thesis structure

The chapter content is as follows:

Chapter 1 - Presents a thesis overview, including the rationale for selecting the research topic.

Chapter 2 – Presents a critical review of current literature, identifying key concepts and the research gap. This chapter also explores the impact and maturity of the selected theory using bibliometric analysis methods.

Chapter 3 – Defines the methodology for the research and the research design.

Chapter 4 – Presents the industrial investigation. The collaborating organization is described along with the demographic of the research population. The research outputs are presented with corresponding analysis.

Chapter 5 – The developed Complexity Leadership Framework is presented ("The 5-point framework").

Chapter 6 – A discussion showing how the research relates to parallel research in the same field. Presents multiple methods of validation for the developed leadership framework.

Chapter 7 – Presents validation activities for the research.

Chapter 8 – Concludes the thesis discussing limitations, contribution to knowledge and future areas for research. Links to the research questions are demonstrated.

The structure of the chapters and associated phase of research is illustrated in Figure 3.

Chapter	Phase	Purpose
1	Exploration	Introduce research topic Research Aims, Objectives, Questions and Scope. Thesis structure
2		Select theory Review current literature
3	Planning	Define the research methodology Validity and reliability of research
4	Investigation Development	Engage with research population Conduct research Develop framework
5		Present developed leadership framework
6	Evaluation	Discuss results and compare to extant research
7		Present validation data
8	Reflection	Present conclusions

Figure 3 - Thesis Structure

Chapter Summary

As the world has become more complex, primarily through the development of technology, leadership has failed to keep pace and is failing to deliver as hoped. The effects of this are highly visible within engineering organizations which must adopt new technologies to remain competitive. The research problem identifies reliance on reductive thinking and established management methods within engineering leadership as a potential source of poor performance in project delivery and other related activities. The research scope, aim, objective and research questions are presented as a response to this research problem. In Chapter 2, there will be an exploration of the extant literature which relates to the research problem, aim and objectives.

2. Literature Review

Chapter	Phase	Purpose
2	Exploration	Select theory Review current literature

This chapter presents the key themes, (2.1 and 2.2), the process for choosing a candidate leadership theory (2.3), and a critical review of current literature relating to the chosen theory (2.4 to 2.8).

2.1. Leadership Theory

Leadership is a natural social function which occurs in many situations where people interact. A leader influences others to achieve a desired effect by leveraging authority. This authority could be a result of social status or conferred by a position within a hierarchy. Writing on leadership is prevalent and diverse as can be seen in the "Bibliography of Significant Books on Leadership" which lists 7500 works and cites around 6000 directly which, in combination, are proposed as "a good place to begin one's exploration of what we know about leadership and leadership studies" (Goethals, Sorenson, and Burns 2004 p. Appendix 1). Leadership theories can provide a structured lens for leadership research by reducing the scope of discussion to certain leadership phenomena of interest. From an examination of the extant literature, it was seen that the leadership theories found are derived from empirical studies in the fields of psychology, sociology, and science. The aspects of leadership covered by the examined theories are Leader Style, Worldview, The Nature of Leadership and Behaviours and Interactions. Leader Style compares the relative success of approaches and interaction style of leaders. Worldview is defined as the conceptual and philosophical model an individual has which defines the world and their place within it. The Nature of Leadership is defined as an examination of leadership as a social phenomenon and Behaviours and Interactions are defined as the way an individual behaves in a specific social setting (i.e., a workplace) and examines the effects of that behaviour and associated interactions. With such a diversity of theoretical bases and topics of study, a focus on specific forms of leadership is required. As the scope of this research is engineering leadership, that will be the first area of exploration.

Formal leadership theories (see 2.3) are used in leadership research to analyse, categorize, or to explain the emergence and effectiveness of different leadership

styles, but a style itself (as a pattern of leader's behaviour) is distinct from a theory i.e., a style is what a leader does, whereas a theory seeks to explain why it happens or how it works. A leader's style may be unrelated to a theory, simply being derived from their personality or worldview, or it may be learnt behaviour, potentially in relation to a theory.

2.2. Engineering Leadership Theory

Engineering organizations, in the main, are structured around project delivery and new product development. With the rate of change in the technological landscape ever increasing (Ooi et al. 2023 ; Yu and Gong 2024), Engineering Leadership is "a concept in evolution" (Cárdenas-Figueroa et al. 2023 p. 4727) trying to keep pace with the demands of new technologies while coordinating teams to deliver technically challenging projects. For example, in 2025, Engineering Leaders must consider the impact and opportunities of technological developments, such as Artificial Intelligence (AI), Industry 4.0, knowledge management software etc. (Conti, da Silva, and de Andrade 2024 ; Ghannam, Ojiako, and Dweiri 2024 ; Yu and Gong 2024). None of these technologies existed 25 years ago when the internet and computing and communication technology was still in a relatively undeveloped state.

The most significant development in engineering management has been the introduction of Systems Engineering. Invented in the 1940s by Bell Telephone Laboratories and first taught by MIT in the 1950s, Systems Engineering is a rigid framework for planning, defining, designing and verifying within engineering projects (INCOSE 2024). While Systems Engineering provides a powerful tool for controlling the flow of requirements to a design and its verification data, it can be incredibly complex to execute within a large scale project and companies are still failing to use it well despite being long established (Moodley and Oosthuizen 2024). Ultimately, Systems Engineering is a method for organizing large data flows and associated activities. This is very important within Engineering Management, but it is far from all that is needed: Engineering Leaders need digital skills, professional skills (communication, negotiation etc.), leadership skills and empathy skills to be effective, which, for many, means bridging a significant skills gap (Kotha, Pradhan, and Cetindamar 2023). Furthermore, there is a fluid, uncertain element to be found within engineering projects which Systems Engineering cannot address (Kreye et al. 2019) which may be a function of the complexity of the project (Haneef and Sheraz 2022 ; Potts et al. 2022). Ultimately, a more holistic approach to engineering leadership is required which takes all of these factors into account (Vembu et al. 2024) and maintains

the rigour and structure of Systems Engineering while allowing for fluidity and complexity in a way which addresses the research problem. To pursue this goal in a structured way which has a strong theoretical foundation, it is proposed to examine extant leadership theories for an appropriate starting point for the research.

2.3. Choosing a leadership theory

To achieve a research output with a strong theoretical foundation, an extant leadership theory shall be chosen to form the basis of the developed leadership framework. This strategy is anticipated to give a developed research output which has the required level of generalizability and validity. For this approach to be successful, a robust strategy for choosing the leadership theory must be employed.

This review was conducted in May 2023 using the Web of Science database to find any entry listing one or more leadership theories. Web of Science was chosen as a suitable academic database because during the literature review, Web of Science and SCOPUS were found to have the greatest quantity of relevant journals and, during the duration of the research, the SCOPUS database was substantially restructured making it more difficult to use for this kind of study as results after the restructure were very different to those before.

The search term (ALL="Leadership Theory") returned 1,412 results. 81% were articles, 9% were conference papers, 8% were review articles and early access. The remaining 3% being editorial material and other data. Each was checked for reference to a relevant leadership theory using the following inclusion criteria: a) A specific leadership theory was mentioned in the title or abstract preview, b) The database gives access to the full article. During the search, one example for each theory was downloaded to check that the theory was linked to a citation within the work. Any publications, such as reviews or bibliometric analyses, which were focused on leadership theory were separately downloaded for review (in case they identified new theories). This approach ensured that only peer reviewed publications and theories were included in the list and any false positives could be eliminated. Once a list of theories was complied, each theory was searched for as a "topic". Hyphens and alternative names were accounted for in the search term (e.g. "full-range leadership theory" OR "multifactor leadership theory" OR "multi-factor leadership theory" OR "full range leadership theory"). For each, the number of items in the database was recorded, along with the oldest and newest entry. This allowed the citations per year to be calculated as a measure of influence.

One dilemma in this second search was the use of the word "theory" in the search term. In some literature, the word is omitted in discussions, making it a discussion of the leadership activity which relates to the theory rather than the theory itself (e.g. "Complexity Leadership" rather than "Complexity Leadership Theory"). Although there is a risk that some discussions on the theory are published with an assumption that the word "theory" is unnecessary, removing it from the search term was found to capture a large number of irrelevant publications and so "theory" was always included in the search term.

Results found n=42

Exclusion Criteria

An exclusion process was used to reduce the selection to credible candidate theories for further assessment:

First exclusion criteria: Lack of impact (theories with equal to or less than one publication per year in the database n=31).

Second exclusion criteria: Situational theories which cannot be applied to leadership in general and so cannot answer RQ1. (n=3)

Excluded theories are marked with a grey cell in the column where the exclusion criteria were applied.

The full list of identified leadership theories found by the analysis is shown in Table 2. The theories have been ranked by entries per year. Those in **bold** are also listed in a review by Dinh et al. (Dinh et al. 2014 p. 40 Table 2) which is a similar analysis conducted in 2013 using ten leadership journals as the source. The count column shows the number of articles found which reference each theory.

Table 2 - Web of Science leadership theories

Leadership theory (Topic)	Search count	Per year average	Scope
Leader member exchange	132	4.9	Situational
Transformational	148	4.5	Situational
Followership	33	3.3	Behavioural
Complexity	49	2.9	General
Servant	33	2.5	Behavioural
Authentic	48	2.5	Behavioural
Implicit	99	2.0	Behavioural
Ambidextrous	5	1.7	Situational

Full-range (also Multifactor)	35	1.7	Behavioural
Relational	25	1.5	Behavioural
Responsible	5	1.3	Worldview
Situational	45	1.0	Behavioural
Administrative	1	1.0	Behavioural
Crisis	1	1.0	Situational
Discursive	1	1.0	General
Emotional	1	1.0	Behavioural
Four-Frame	1	1.0	Behavioural
Lazear's	1	1.0	General
Life cycle	1	1.0	Behavioural
Paradoxical	3	1.0	Worldview
Distributed	17	0.9	Behavioural
Shared / Managerial	16	0.9	Behavioural
Ethical	13	0.9	Behavioural
Critical	6	0.9	General
Spiritual	17	0.9	Worldview
Shared	14	0.8	Behavioural
Adaptive	9	0.8	Behavioural
Evolutionary	6	0.8	Behavioural
Ecological	2	0.7	Situational
Balanced	3	0.6	Behavioural
Charismatic	18	0.6	Behavioural
Strategic	15	0.6	Behavioural
Functional	9	0.5	Behavioural
Bounded	3	0.4	Behavioural
Empowering	2	0.4	Behavioural
Flexible	5	0.4	General
Destructive	2	0.3	Behavioural
Self	10	0.3	Worldview
Resilient	2	0.3	Behavioural
Path-goal	11	0.3	Behavioural
Paternalistic	3	0.3	Behavioural
Contingency	5	0.2	Behavioural

Once theories had been removed from the list for either showing a lack of academic impact (per year publication average) or by being too specific in their area of interest (scope was situational), there were eight theories left which needed further

investigation before the strongest candidate theory could be selected: Followership, Complexity, Servant, Authentic, Implicit, Full-range/Multifactor, Relational and Responsible leadership theories. A definition of each is as follows:

Followership Leadership Theory

This theory posits the idea that the success of leadership is predicated on successful followership (Crossman and Crossman 2011). Conceived by Kelley (Kelley 1988), the initial theory defined various types of follower and their associated behaviours (e.g., Sheep, Alienated Followers, Effective Followers etc.). This theory examines behaviours and interactions between leaders and followers.

Complexity Leadership Theory

This theory draws on Chaos Theory, Network Theory and the theory of Complex Adaptive Systems to propose a framework for leading in complexity. Conceived by Uhl-Bien et al (Uhl-Bien, Marion, and McKelvey 2007), the theory is a rejection of reductive methods of leadership which are associated with the "industrial era".

Servant Leadership Theory

This basis of this theory is the idea that the primary goal of a leader should be the service of the team. Conceived by Greenleaf (Greenleaf 1977), this is a long standing theory which has spawned a number of variations. By promoting authenticity, strong communication, integrity, compassion, empowerment, continuous improvement, and putting others first, this leadership theory overlaps with other behavioural leadership theories such as Authentic Leadership Theory and Relational Leadership Theory.

Authentic Leadership Theory

The basis of this theory is that leaders must be perceived by their team as acting with authenticity if they are to be successful. By showing that they are making decisions based on personal values, a leader can achieve greater trust and engagement from the team. Proposed by George (George et al. 2007), the theory focuses on the effect of leader behaviours and interactions.

Implicit Leadership Theory

This theory proposes that followers will have an implicit set of expectations about leaders and their behaviour. Conceived by Rush et al, (Rush, Thomas, and Lord 1977 ; Lord et al. 2020) this theory examines the psychology of leader and followership.

Full Range Leadership Theory

Sometimes known as Multifactor Leadership Theory, this theory examines three leadership styles (laissez-faire, transactional and transformational) and their effects on efficiency and engagement. Conceived by Avolio and Bass (Avolio, Bass, and Jung 1999), the theory can be used for practical leadership analysis through the use of the related Multifactor Leadership Questionnaire (MFQ) to categorize a leaders' individual style and associated outcomes.

Relational Leadership Theory

Similar to Servant Leadership theory in concept, this theory proposes employees as a major stakeholder for all decisions. The object of this approach is to increase engagement and enjoyment of the employees. Proposed by Uhl-Bien (Uhl-Bien 2006), this theory looks at leader styles and behaviours and the effects on employee engagement.

Responsible Leadership Theory

Although generally attributed to Lewin (Lewin, Lippitt, and White 1939), the ideas in this theory can be traced to Greek philosophy and many other sources. Lewin identified three styles of leadership (Autocratic, Democratic and Laissez-faire) and the effects these styles have on society. Recent global events have triggered a resurgence in the discussions surrounding responsible leadership (Pless and Maak 2012). The focus of this theory is the ethics, accountabilities and responsibilities of leadership.

Examining these candidate leadership theories for suitability to address the research problem, some appear to be unrelated: As the identified problematic leadership trait is simplistic thinking in the face of complex challenges, leadership theories which focus on interactive behaviours (Followership, Servant, Authentic, Implicit and Relational Leadership theories) would seem ineffective as (for example) an authentic leader may still use reductive methods of leadership. Responsible Leadership theory examines the ethics of leadership, but the research problem is not one of ethics or accountability.

This leaves Complexity Leadership Theory and Full-range Leadership Theory. Complexity Leadership Theory would seem to be a perfect fit as a theory which aims to address the issue of reductive leadership. By comparison, the identified leadership styles in the Full-range Leadership Theory (laissez-faire, transactional and transformational) may exist within engineering management but it is difficult to see how they may relate to the research problem: Laissez-faire leadership is essentially a lack of direct influence from the leader, transactional leadership is leadership which does not go beyond the immediate responsibilities of the leader and followers (i.e., it contains

no engagement or inspiration) and transformational leadership is focused on enacting substantive organizational change, none of which seems directly relevant.

On that basis, this research will use Complexity Leadership Theory as its theoretical foundation.

2.4. Overview

In Q1 2021, an initial literature review was undertaken. The purpose of this review was to establish the research gap and contextualize the theoretical landscape relating to the research and the chosen leadership theory. In Q2 2024, a new literature search was conducted to augment this original search. The object of this second search was to create an update to the already gathered literature, bringing this literature up to date with the state research in 2024. The search strategies are shown in section 3.10 a). Findings of both searches are presented in this chapter. The scope of this review is an examination of the theoretical development of Complexity Leadership Theory and its supporting theories, and the current state of research on Complexity Leadership Theory.

2.5. Defining a Complex System

As the research problem has identified an issue with leading in complex situations (specifically, in an engineering organization), and the chosen leadership theory is Complexity Leadership Theory, which proposes that organizations can be seen as complex systems, this chapter presents a literature review which examines complexity, complex systems, CLT and leading in complexity.

Any group of things (or people) which interact can be considered a system. There is a great deal of science surrounding the behaviour of systems which can be very useful for the analysis and understanding of systemic effects which would otherwise be challenging to understand. CLT proposes that an organization can be seen as a complex system. The following is an exploration of that proposition:

Of considerable interest is the definition of what, within the context of organizational science, is considered a complex system. Building on the definition provided by Levy, (Levy 2000) we can synthesise a list of the attributes of a complex system as described by other authors:

Complex Systems (1) are dynamic (i.e., not in equilibrium) , (2) have multiple elements which interact with feedback loops, (3) have boundaries which shift and are difficult to define, (4) are sensitive to their own history, (5) Create emergent (non-linear) events, (6) have generally predictable patterns but very few predictable details, (7) have

attractors which affect the dynamic behaviour, and (8) are self-organizing (Arthur, Durlauf, and Lane 1997 ; Cilliers and Spurrett 1999 ; Eoyang and Oakden 2016 ; Preiser 2019 ; Woolcott et al. 2021).

An important distinction is made between Complex Systems and Complex Adaptive Systems when it comes to organizations (Stacey 1995). Organizations which are only complex are structured for control and efficiency (typically true in manufacturing-based organizations), whereas Complex Adaptive Systems are structured to adapt to changes in their environment.

2.6.   Complexity Leadership Theory: History

To understand the history and significance of CLT, it is worth first understanding the development of systems theories in general (as Complex Systems Theory is the basis of CLT). Thinking of groups of items which, collectively, create a whole with a purpose or function as a "system" began formally as an outcome of the work of Isaac Newton (1642-1727). His historic work *Philosophiae Naturalis Principia Mathematica (Newton 1934)* revolutionised physical science and spawned the concept that a system is the sum of its parts (in the context of Newtonian physics, this declaration has specific mathematical implications). This model of systems was not modified until the General Systems Theory (GST) was proposed (Von Bertalanffy 1951). Bertalanffy was writing in the field of natural science and his ideas took some time to be widely adopted as a trans-disciplinary observation on the nature of systems (Wolfgang and Matthias 2011). Whereas Newtonian Systems are described as being the sum of their parts, GST proposes that the interactions between those parts also forms a critical aspect of the system behaviour.

The ideas of GST resonate strongly with those trying to understand businesses and organizations: A business is not simply a list of the people that work there, it is the product of the way they interact. GST is still in active use today as a paradigm for organizational analysis (e.g. Nirwana, Sumando, and Susilo 2023). GST persisted as the latest in systems thinking until the creation of Chaos theory (Lorenz 1963). Despite its title, Chaos Theory is primarily a description of the behaviour of complex systems. Famously, the nature of such systems was summarized by Lorenz as "the butterfly effect" (whereby the flapping of a butterfly's wings in one place causes a storm in another). It should be noted that Chaos Theory does not wholly supersede GST in the same way that GST superseded Newtonian Systems Theory. The proposition of Chaos Theory is that *some* systems are complex in nature, making them impossible to fully model or predict (some, being deterministic, would still fit with GST).

Figure 4 shows a theoretical model for the development from Chaos Theory to Complexity Leadership Theory. In this theoretical framework, the original proposition of Chaos Theory is developed throughout the 1970s and 1980s into a mature and generalizable theory which describes the nature of complex systems (labelled here as "complexity theory"). Chaos Theory gained traction in the 1970s following a publication on fluid dynamics (Lorenz 1963) which described the nature of complex systems and associated mathematics. This work is increasingly adopted by branches of science and academia forming a set of disconnected fields of research known generally as the "complexity sciences" (often a subset of existing branches of science, exploring localized complex behaviour). As a part of this process, Organizational Science increasingly accepts that organizations are themselves complex systems. This leads to the creation of the theory of Complex Adaptive Systems (CAS) in the mid-1980s at the Santa-Fe Institute in New Mexico (e.g. Gell-Mann 1992 ; Holland 1992). At its inception, CAS was still largely grounded in complexity from a biological perspective, seeking insight which might allow computers to model societal systems beyond the realms of contemporary technology.
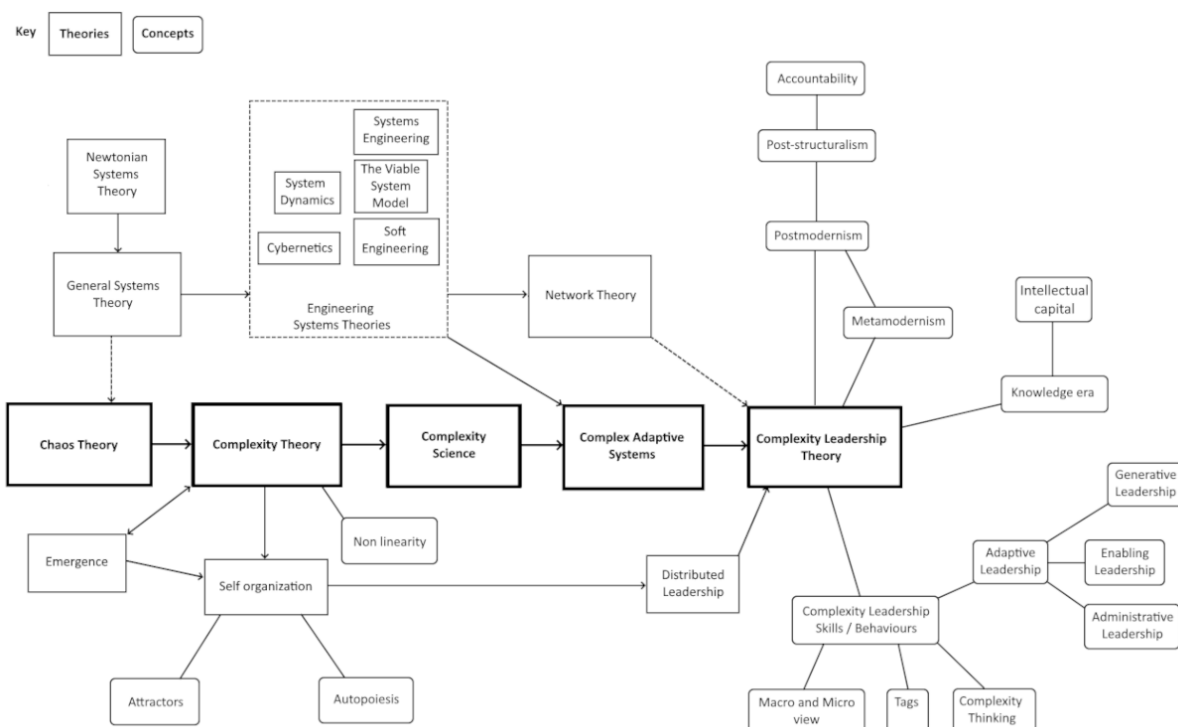
Figure 4 - Theoretical Model for Complexity Leadership Theory

The general applicability of observations on complex system behaviour led to its widespread adoption in many fields (generally termed "complexity sciences"). The idea that organizations can be seen as complex adaptive systems (i.e., complex systems which can learn) has been in discussion since the early 1990s and of significant

influence since 2004. CAS, the primary theoretical output from these discussions, has a broad scope and serves as a foundational theory upon which more focused theories can be developed. In trying to understand a whole organization as a complex system, CAS failed to come to any definitive conclusions. In response to the wide-ranging discussions of CAS, the proposition of CLT is to reduce the problem to a question of the implications for leadership. Essentially: the whole organization may be a complex system and may exist in an ecosystem which is itself complex, but if leadership is correctly structured to respond to this complexity then the outcome will be optimal.

Until the conception of CLT, the discussions on Complex Adaptive Systems (e.g., Anderson 1999 ; Varga and Allen 2006 ; Allen, Maguire, and McKelvey 2011 ; Alaa and Fitzgerald 2013 etc.) had been conceptualizing an organization as a complex system and trying to make sense of the myriad implications en-masse. This exercise yielded many valuable insights into the true nature of organizations, often through identifying the effects of emergence (Knowles 2017 ; Rook and Watson 2017) which itself became a substantial stand-alone field of research. Focus on emergence spawned, among other things, the journal "Emergence" which later became "Emergence: Complexity and Organization", the primary source of publications on this topic and complexity leadership in general between 2004 and 2018. Another branch of academic study was spawned at around this time, purely focused on the modelling of complex systems (e.g. Mees 1990 ; Odhabi, Paul, and Macredie 1997). CAS is still an area of active research and the proposition that businesses and organizations in general behave as complex adaptive systems is widely accepted in academia. The challenge with this proposition is that having accepted that organizations behave as complex systems, (meaning that any model of the organization can only give insight into the trends and patterns which *might* be observed, rather than knowledge of what *will* come to pass) what are we to do with this understanding? This is where Complexity Leadership Theory proposes a highly pragmatic solution: rather than trying to conceive the entire organization in all its complexity, accept that it is complex and develop a leadership strategy for leading complexity.

CLT is widely accepted as being first proposed in 2007 (Uhl-Bien, Marion, and McKelvey 2007) although, strictly speaking, Lichtenstein published an article coining the phrase a year earlier (Lichtenstein et al. 2006), although this is a discussion piece which lays out the complexity leadership philosophy and contains no leadership framework whereas a specific complexity leadership framework is proposed and detailed by Uhl-Bien et al. This framework gives insight into the mechanisms and behaviours of the organization as a system, allowing an understanding of emergent

events (such as innovation, opportunity and unexpected challenges), the effects of over-constraint (through too much centralised control or by micro-management), the benefits of distributed leadership and the realities of what can and cannot be known about the system at any one time. Specifically, CLT proposes that leadership should be seen as having three distinct modes (Administrative, Enabling and Adaptive), each with purpose and associated behaviours and interactions.

In essence, CLT can be thought of as the theory that a specific approach to leadership can be adopted which successfully navigates an environment which blends predictability with unpredictability in equal measures.
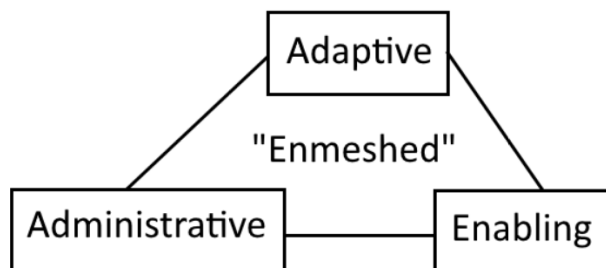
Figure 5 - The leadership modes as described by Uhl-Bien, Marion and McKelvey, 2007

The proposed complexity leadership framework draws heavily on extant leadership theory: Uhl-Bien et al. propose a model in which three types of leadership combine (adaptive, enabling and administrative) to create the balance between bureaucracy, creativity and emergence (Figure 5). It draws on previous research as follows: "Adaptive Leadership", as a term, was first coined by Rhoades (Rhoades Jr 1989) but Heifetz and Laurie's later description of Adaptive Leadership as an interactive, non-heroic and responsive mode of leading (Heifetz and Laurie 1997) is the commonly cited version (and is the version cited by Uhl-Bien et al). When Uhl-Bien et al. first introduce Adaptive Leadership, it is presented as equating to "generative dynamic" leadership. Generative leadership was originally conceived by Lane and Maxfield as part of a wider framework of organizational behaviours (Lane and Maxfield 1996). This was then later adapted by Surie and Hazy to better fit within a complexity leadership framework (Surie and Hazy 2006) and it is this variant which is then developed by Uhl-Bien et al. to give the proposed "Adaptive Leadership" of CLT. Adaptive Leadership was later described by Mahmood et al. (Mahmood, Faris, and Wadi 2019) as the emergent leadership which arises from the organization in response to problems which require adaptation of method. Simply put, Adaptive Leadership is the off-process leadership mode used to manage short-term emergent situations.

"Enabling Leadership" is proposed by Uhl-Bien et al. as a method of reduction in direct centralized control to enable the group to leverage the collective intelligence rather than relying on the ideas of a single leader (Uhl-Bien, Marion, and McKelvey 2007 p. 300). This concept is credited by the authors to cellular network theory (Miles et al. 1999) and is an example of the supporting relationship which network theory seems to have with complexity leadership theory and CAS. Certainly, mapping the network of interactions within an organization quickly illustrates the source of much of the complexity in any one area and complex adaptive systems are described as "neural-like networks of interacting, interdependent agents" (Uhl-Bien, Marion, and McKelvey 2007 p. 299).

Leaders as enablers rather than dictators is a regular theme within writing on complexity leadership (e.g., Nijs 2019) and Enabling Leadership is the model used in the Spotify case study to "manage for innovation and adaptability" (Bäcklander 2019 p. 42). This case study has a useful summary of six Enabling Leadership behaviours which are summarized here as 'increase sensitivity to context', 'boost and support other leaders', 'establish and remind of simple principles', 'observe team dynamics', 'make unseen more visible', and 'encourage constructive dialogue'. These behaviours are complimentary to three heuristics for leading complex systems as proposed by Preiser: "Adopt mindsets that cultivate complex systems thinking", "Assess systemic features and dynamics to understand and influence patterns of behaviour" and "Nurture complex systems-based capacities and practices" (Preiser 2019). The tone of these practices is certainly nurturing and collaborative. While the reports cited did not mention a 'no-blame culture', it seems implicit that Enabling Leadership would inherently deliver such a culture with its corresponding benefits (Koolwijk, van Oel, and Gaviria Moreno 2020).

Although the phrase "Administrative Leadership" predates CLT, it's prior use is generally linked to politics (e.g. Terry 1998). Within CLT, it's meaning is much more mundane, simply described as "formal acts that serve to coordinate and structure organizational activities" (Uhl-Bien and Marion 2007 p. 300) and is a recognition that the Enabling and Adaptive Leadership modes of Complexity Leadership still need a bureaucratic, process-based framework upon which to operate. Activities such as planning, procedure, and record-making, are typical of this leadership style. Any such bureaucratic framework would clearly need to be carefully applied so as not to conflict with the needs of the team as a complex system (another delicate balance for leaders of complexity to consider). It is posited that the goal of Administrative Leadership is to reduce the cognitive burden on the team by making the known or knowable,

deterministic elements of their working environment as consistent and clear as possible. This clarity then frees the team to focus on the unknown or non-linear elements of their work.

Very few publications (e.g., Bäcklander 2019 ; Jun and Suh 2008 ; Lévárdy and Browning 2009 ; McCarthy et al. 2006 etc.) examine the use of CLT within New Product Development and software development, and none were found which looked at its use in aerospace engineering. As such, there is no sign that a separate strand of CLT is being developed for use in engineering leadership. The existing literature suggests that the current thinking on CLT can be applied to engineering in much the same way as any other complex fields.

While CLT focuses on an understanding of the ways in which organizations work as complex systems, using leadership modes as a conceptual model for leadership, there are many aspects of leadership it does not address, such as leader behaviours, organizational culture, the differences between entrepreneurship and other forms of innovation, and the role of mentorship and training.

2.7. Complexity Leadership Theory: Recent Developments

This section examines the way in which Uhl-Bien has developed her thinking on complexity from her initial introduction, to the publication in 2007 which forms the basis of this research (Uhl-Bien, Marion, and McKelvey 2007) to the present day:

Uhl-Bien was first introduced to complexity in 2001 and was asked to translate the work of Marion (Marion 1999) into a leadership context. A large meeting of complexity and leadership scholars took place in 2005 where the scholars collectively agreed to pursue their research individually and see what developed (rather than collaborating on a single work). Uhl-Bien approached complexity research from a leadership practitioner perspective, Lichtenstein approached it from a complexity science perspective. Later, when they compared conclusions, they found that they correlated, giving strong triangulation. In their models of leadership within a complex environment, leadership is proposed as a "co-creation among individuals", a view of leadership which is not constrained to traditional hierarchies (Cranfield 2022).

Until its proposal by Uhl-Bien et al. (Uhl-Bien, Marion, and McKelvey 2007), discussions on complexity had yet to deliver an associated leadership framework. The proposed framework was a logical expansion of proposals for a new philosophy of leadership which was, in turn, the culmination of discussions within the field of CAS (Meyer, Gaba,

and Colwell 2005) and the first notion of what CLT might entail (Lichtenstein et al. 2006).

Significantly, CLT was now defined by a framework (developing the philosophy described by Lichtenstein et al. (Lichtenstein et al. 2006)). This framework was not proposed as an applicable method of leading within complex organizations. Instead, it is described as "a framework for studying emergent leadership dynamics in relationship to bureaucratic superstructures." (p.313). Accepting this limitation, the presence of a "leadership framework" within the theory showed potential for long awaited practitioner applicability and, for that reason, this publication was chosen as the basis for this research.

The 2007 publication by Uhl-Bien et al. synthesises many concepts within CAS (emergence, interaction, interdependency, tension, network dynamics, the law of requisite complexity and context) and combines them with extant leadership theory (Generative/Enabling Leadership, Administrative Leadership, knowledge as a primary asset, leadership as a dynamic force rather than a position of authority, the drive for agility etc.). This synthesis produced a theory which, at a high-level, is conceptually simple (i.e.: to lead in complexity, three modes of leadership are required) but which is difficult and somewhat contradictory in detail. For example, Administrative Leadership is described as containing the functions of planning and resource acquisition (p.305) but Adaptive Leadership is also allocated these functions at high levels in the organization later in the text (p.309). In Table 3, the different facets of the three proposed leadership styles of CLT are summarized.

Table 3 - Facets of the three leadership styles in CLT (Uhl-Bien, Marion, and McKelvey 2007)

Adaptive Leadership	Enabling Leadership	Administrative Leadership
Targeted at emergent change.	Structures and enables conditions	Based on traditional hierarchies.
Occurs in emergent active dynamics	Facilitates problem solving	Focused on alignment and control
Comprises adaptive, creative and learning actions.	Sets up the environment for Adaptive Leadership to succeed. This can be by making changes which disturb the routine and introduce new ideas.	The bureaucratic function
Used in response to "tension", "constraints" or "perturbations".	Manages "Entanglement" between the other two functions	Enacted by people in formal managerial roles

Not an act of authority.	Manage the flow of innovation from Adaptive into Administrative.	Create tasks, plans, build vision, allocate resource, manage crises and conflicts, manage organizational strategy.
Not a single person - a dynamic of people	Nature of the role varies with position in the organization	
The primary source of change within an organization	Create a general structure of networks in which complex interactions can occur	
emerges from asymmetric interaction (debate).		
Identified by significance and impact.		

The key points of the original complexity leadership framework are as follows: In order to lead effectively in a complex environment, the organization must increase its own complexity to match that of the environment, thus leveraging innovation and agility through the natural process of emergence within complex networks. To lead such an increase in the structural complexity of the organization, three modes of leadership are required: Administrative Leadership forms the traditional bureaucratic functions and is hierarchical in nature. Adaptive Leadership is a dynamic, non-hierarchical effect of network interactions. It produces innovation and change, often emerging from debate. Enabling Leadership sits between the other two styles and facilitates the integration of one to the other. It also creates the environment for Adaptive Leadership and problem solving.

Following this initial framework, the idea of "The Adaptive Process" was developed during the next decade (Uhl-Bien and Arena 2017). This is an examination of the mechanisms of innovation or adaption. Using complexity science as a basis of understanding, the inherent tension or conflict between the need to innovate and the need to produce becomes the driving force for adaptive creativity. This is achieved by leadership which looks for the connections within the conflicting needs and it occurs conceptually within what is termed the "Adaptive Space". This is a communication or networking space where the required elements are combined for adaption which allows both innovation and productivity to occur.

Another development was the proposition of "a local" which is a localized network of relationships and actors which generate ideas (Uhl-Bien and Arena 2017 p. 13). This makes the point that specific solutions are seldom transferable between contexts, even in the same organization. Once an idea moves from a local space into the adaptive

space, it changes and may become lost if skilled leadership is not used to guide it into large scale operation through a process of iteration and change. Without an adaptive space for new ideas to grow in, innovation of approach will tend to fail in deployment. This is due to the tendency of the system to try and sustain equilibrium (embodied in the tendency of leaders to try and maintain the current order state). Once new ideas reach full scale, a new order is established.

In this adaptive process, Enabling Leaders are the facilitators who help navigation of the adaptive space. Often, they have a position of formal authority. During this navigation of adaption, the local idea is challenged and iterated towards a full-scale solution. Operational leaders assist this process by finding ways of integrating new ideas into the existing order by formalizing unstructured ideas, putting them into the language of the formal system. Their sponsorship is critical for moving ideas from the Adaptive Space into the Operational System.

Lichtenstein proposes Dissipative Structures as a critical area of interest for Complexity Leadership (Lichtenstein 2014). This proposition is derived from a wide review of complexity science (Cranfield 2022). Dissipative Structures are structures which form from an unstructured system when energy/pressure is applied (see Figure 6). This is seen as analogous to social systems like organizations and the adaptive process described above.
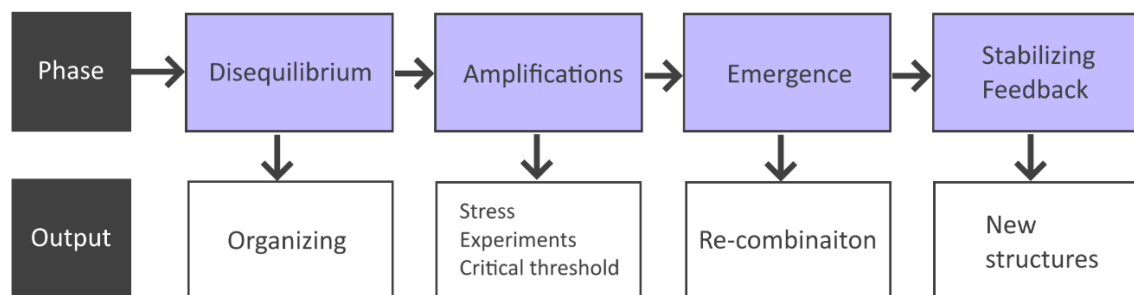
Figure 6 - Conditions for Dissipative structures (derived from Lichtenstein, 2020)

Uhl-Bien claims that, in recent years (post 2014), the validation case for CLT has grown to a point where it is no longer in doubt (Cranfield 2022), for example the "three circle model" which was proposed by Uhl-Bien and Arena (Uhl-Bien and Arena 2018 p. 97), and is illustrated in Figure 7. In this figure, the headlines show the complexity derived stages of adaptability ("need to innovate" etc.), the text below shows how the same idea as described by numerous leadership and strategy theories found in extant

literature. Such strong levels of correlation are proposed by Uhl-Bien as validation for the complexity derived leadership theory.
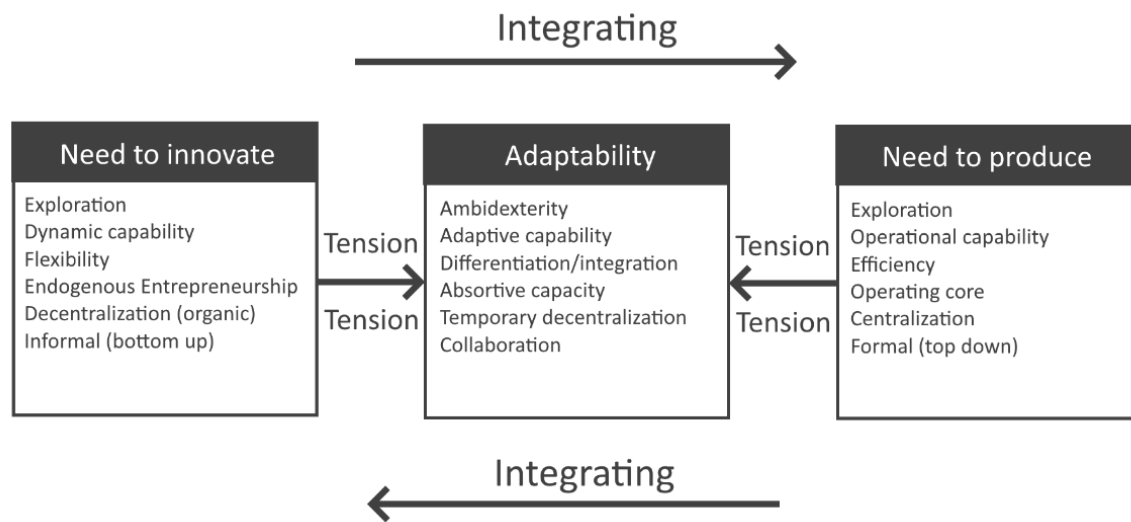
Figure 7 - Different terms in literature used for three circle model (derived from Uhl-Bien and Arena, 2018)

Where the original Complexity Leadership Framework is focused on Adaptive, Enabling and Administrative Leadership, the later work has moved to speaking of mechanisms for Adaptability and, significantly, now divides the leadership space into Entrepreneurial, Adaptive and Operational. This shift in focus is not a total departure from the original framework. The link between Operational and Administrative Leadership seems very clear, although Operational Leadership seems broader in scope: a desire for continuity moving beyond simple process. Enabling Leadership is still cited as being essential for success in the adaptive space and the connection between the Adaptive Leadership and Entrepreneurial activities seems clear. The change in nomenclature signals a change in focus. Whereas the original framework is aimed at looking at the role of leaders within a complex environment, the later work sees leaders as part of a network: "Complexity is a network theory, organizations operate as networks... we really need to start thinking about organizations as network dynamics" (Cranfield 2022).

According to Uhl-Bien, CLT improves on other situational leadership theories by providing an understanding of the dynamic at work in leadership. Once this is understood, a leader can use this knowledge to work appropriately within the situations. The most common approach seen in CEO (Chief Executive Officer) leadership today is a reductive, results-driven, short-term approach. Even when looking for agility/adaptability in the business, the measures for success are often performance measures not adaptability measures. There is an issue in the operational side of things

where innovation is shut down by an inherent bias to saying "no". The current leadership language can be incapable of addressing the necessary areas required to achieve agility. By looking for common ground rather than recognizing tension, the path to change is shut down (Cranfield 2022). Over time, the philosophy which underpins CLT has become defined: "Complexity really is its own ontology. It sees the world as a complex interactive dynamic and it occurs in relational interactions that [have] the constructivist element of relationality... but then includes individuals with it. There are individual agents occurring in interactions and the dynamic scale is scale-free... this dynamic occurs at all levels". (Cranfield 2022).

The Uhl-Bien and Arena model was further explored by Schulze and Pinkow (Schulze and Pinkow 2020) who ran a qualitative study where transcripts were thematically coded using codes derived from the model. This study provides nuance to the Uhl-Bien and Arena model by examining the detail of Enabling Leadership being used to realize the potential of Entrepreneurial Leadership in a real-world setting.

A different perspective on the Uhl-Bien and Arena model is provided by Howden et al (Howden, Beresford-Dey, and Martindale 2021) who decided to use CLT as a framework for reflection on the experiences of university Deans during the COVID-19 pandemic. This use of CLT suggests that a CLT framework can be used as a tool for analysis of leadership through the subdivision of leadership into modes which can then be examined individually in retrospect to for a new understanding of complex events.

Other research into the dynamics of complexity leadership based on the Uhl-Bien et al 2007 model can be seen in a model proposed by Hazy and Prottas (Callens 2023 ; Hazy and Prottas 2018). In this model, complexity leadership is defined by two primary modes, Generative Leadership and Administrative Leadership, where the role of Generative Leadership is to exploit emergent events to find advantage. These two modes are each subdivided into five activities which can be used to measure the level of complexity leadership within a population of leaders (the tool was validated by surveying a population of 290 adults). An important principal behind this study and the tool generated is the recognition that, in line with complexity theory, leadership is as much a collective effect as it is the result of an individual's efforts. A process for measuring leadership must, therefore, not focus on individuals but the overall pattern of leadership.

2.8.   The challenges of studying complexity

The multifaceted nature of discussions on complexity and complex systems brings a number of unique challenges (Preiser 2019). Even when the field of interest is reduced to complexity within organizations, the topic can still be bewildering in its breadth.

Studying complexity has become one of the most ambitious and all-encompassing intellectual challenges of recent times. (Nijs 2019 p. 44)

In 2009, Wallis identified eight variants of complexity theory and 47 separate concepts within those theories (Wallis 2009). According to Cramer (and simplified by McKelvey) there are three types of complexity: Newtonian, stochastic, and emergent. "Newtonian complexity" is mechanistic (a function of part count), "stochastic complexity" comprises random, probabilistic and deterministic chaos and "emergent complexity" is Newtonian structures emerging from stochastic systems (Cramer 1993 ; McKelvey 2008 p. 241). Framing these definitions within an organizational setting can be challenging, the very breadth of the problem-space has meant that theory maturity has been slow to achieve.

Despite its profound effect on virtually every aspect of modern life, full understanding and comprehension of complexity eludes us at every turn.(Chia 2011 p. 182)

The impact of complexity on organizations is considered a broad topic of discussion, much of which is focused on managing chaotic or complex situations and problems (e.g., "wicked problems") rather than concepts emerging from the complexity sciences. For such discussions, critical systems thinking (Jackson 2001) morphological analysis (Ritchey 2013), and other methods are presented by theorists. These topics and other broad discussions on the nature of general situational complexity are outside the scope of this research.

Complexity theory and complexity which comes from many moving parts are two concepts which appear similar, but which need to be differentiated before complexity leadership theory can be usefully understood. For example, the weather is a complex system which is non-deterministic whereas a computer or a large clockwork mechanism is deterministic in its behaviour despite being complicated.

Complex systems are "on the edge of chaos" (Lewin 1999) and exhibit a mixture of deterministic (linear) and chaotic (non-linear behaviour). This non-linear aspect can be positive (and even necessary) and is commonly known as "emergence" (De Wolf and Holvoet 2004: 2). Into this maelstrom of new and challenging concepts, the idea of Complexity Leadership as a strategy for leading in complexity has been delivered. The proposed leadership framework (Uhl-Bien, Marion, and McKelvey 2007) is one of the

earliest attempts to define a methodology for the real-world application of "complexity thinking" (Hager and Beckett 2019 ; Richardson 2008 ; Chia 2011). Complexity thinking (withing the context of organizational science) is, in essence, thinking which accepts the paradox generated by the demand for control and understanding which resides in organizational leadership, and the recognition that complex systems are, to some extent, unknowable and unpredictable. All advocates of complexity thinking propose the rejection of the orthodoxy of reductionism which prevails in the late 20th and early 21st century. Chia's proposed approach is a philosophical one focused on changes in the mindset which, over time, may lead to enlightenment (Chia 2011), Richardson speaks of the balance between recognizing a lack of complete control and achieving what control is realistic (Richardson 2008). In more recent publications, complexity thinking is referred to as a "tradition" (Ika, Love, and Pinto 2020 p. 3310). This shift from radical to traditional would suggest that ideas relating to Complexity Leadership are becoming embedded in organizational science, but this is appearance may be deceptive as explored in the next section.

2.9.   Worldview

The second key theme identified within the current literature is the importance of worldview. Discussions on the way that complexity science and worldview interact date back to the mid-1980s. Most pro-CLT literature begins with two declarations: First, traditional leadership methods are outdated and fail to meet our needs, (e.g., Uhl-Bien 2021). Second, CLT can provide the answer by addressing the complexity of the world as it is today, e.g. (Nijs 2019). The seminal work of Uhl-Bien et al. (Uhl-Bien, Marion, and McKelvey 2007) for example, makes this second point seven times in the opening paragraphs. In the early stages of development, complexity writing seemed to be stuck in a thematic loop: "it is becoming rather monotonous continually reading articles that tell us how the concept of and the requirements for the modern organization are changing, how these are more complex than ever, and how a paradigm shift is necessary in order to facilitate our continued analysis, and management, of such entities" (Richardson, Cilliers, and Lissack 2001).

These proposals for change reflect a historically recent shift in the prevailing worldview within organizational science and global business. Since the industrial revolution, science has not only transformed the world we live in but, as a natural consequence, changed the way in which we see that world, and our place within it. Worldview is fundamental to the way decisions are made and theories and methods are assessed and discussed (Nijs 2019). Dent stated "a difficulty in capturing the [traditional

worldview] and [emerging worldview] underlying assumptions… is that the worldviews cannot be simply stated" (Dent 1999). Dent then moved on to list 41 pairs of traditional and emerging worldview perspectives. No doubt, many more have emerged since that list was published.

One of the challenges CLT has in gaining widespread acceptance is its predication on (what might be described as) a 21st century worldview. Woermann et al. (Woermann, Human, and Preiser 2018) stated that "…our understanding of complex phenomena are deeply related to general philosophical issues." If researchers and practitioners, inflexible in their reductive worldview, try to use quantitative modelling methods to investigate or implement complexity, they will fail and they will, inaccurately, conclude that complexity leadership fails (Poulis 2020 ; Rosenhead et al. 2019).

General publications on the topic of Complexity Theory date back to 1989 (Lange 1988). It is posited that the theory alone is not globally significant per se, rather, it is the relationship between the theory, the prevailing worldview and the global social situation which bestows significance. The importance of the worldview context to the complexity sciences is clear to many authors, and many start their introductions with statements to that effect. Murray (Murray 2020) reacts to the prevalence of such observations, stating "it is now practically a platitude that 'we live in a complex and fast-changing world,' …requiring humanity to step up to the challenge by increasing the complexity of our thinking and collaborative problem solving. In this narrative, complexity must be met with complexity." The fact that this message has been repeated in academic discourse over the last 25 years suggests that first, it is felt that the turmoil of the modern world is showing no sign of abating and second, that no universal real-world approach has yet been established to manage the complexity.

The relationship between complexity science and worldview is also discussed by Dent (Dent 1999) who stated that "the rise of complexity science has paralleled an increase in dissatisfaction with the [worldview (Capra and March 1982)]… this dissatisfaction [is] a crisis of perception …[which] occurs when people hold to a mental model that no longer achieves their standards of accuracy." It seems that such a crisis of perception is occurring in many organizations as traditional project management methods are increasingly delivering disappointing results (Williams 2005).

Speaking of the search for a legitimate worldview to underpin management research, McKelvey (McKelvey 2003) stated that "underlying the legitimacy problem… is the failure of management researchers to find plausibly true theories that work. This failure has become the launching pad for various "POST" positivisms." It is proposed that the

worldviews of interest can be characterized as either reductionist (e.g., modernist, structuralist) or post-reductionist (e.g., post-modernist, poststructuralism, metamodernist).

For some (e.g., Baranger 2009 ; Kirkbride, Durcan, and Obeng 1994 ; Anderson 1999 ; Levy 2000 etc.), the implications of chaos and complexity theory heralded a welcome and timely revolution: "The twenty-first century is starting with a huge bang… one aspect of this bang is the complexity revolution, which is changing the focus of research in all scientific disciplines" (Baranger 2009).

"Complexity thinkers" (Hager and Beckett 2019 ; Richardson 2008 ; Chia 2011) have adopted the teachings of the "new science" (Wheatley 2011) and began formulating recommendations for new thinking and practice which has moved beyond the reductionism of the 20th century. However, the adoption of complexity thinking is far from unilateral. Many are still wedded to the modernist, reductive viewpoint and, unable to adapt their worldview, set about the task of either reducing and simplifying complexity or discrediting complexity theory. What is perhaps unexpected is the extent to which many of those who ostensibly are promoting complexity theory are using reductive, modernist methods which arguably contradict or ignore its scientific foundations (Tourish 2019). It is not simply our current methods which are declared to be falling short by the pro-CLT theorists, it is also the thinking on which those methods are based. Reductionism is found particularly lacking as a method for understanding knowledge (Styhre 2010 ; Levy 2000) and as a universal method of scientific analysis (Clevenger et al. 2016). Some sources see the application of standard scientific method, which is inherently reductive, as the route to gaining credibility and all-round acceptance for complexity theory (McKelvey 1999), while others see the very purpose of complexity theory as the rejection of the reductive method (Levy 2000). According to Lissack (Lissack 2004), "the more we learn of the complex systems… the greater the observed uncertainty and the greater the desire for the very reductions we sought to overcome".

There has, according to Uhl-Bien, been a noticeable shift in the collective readiness to accept the concepts of CLT into organizational leadership within the last ten years. When the first CLT framework was proposed in 2007 (Uhl-Bien, Marion, and McKelvey 2007), it's authors found the ideas struggled for acceptance by the academic and practitioner communities. This initially began to change in 2010 at the time of the Global Financial Crisis. This event made it clear to many that we are living in a complex world. In 2014 there seemed to be a collective feeling that the previous (non-complex) norms

and expectations no longer applied. For example, when Donald Trump was elected to office as President of the USA in 2016, his success (which flew in the face of previous norms of a Bush/Clinton duopoly) could be explained by complexity theory but not by traditional theories of leadership (Cranfield 2022).

2.10. Paradox

Complexity theory is rich with paradox. This topic is widely explored by Braathen (Braathen 2016) who examined paradoxes caused by the simplified organizational worldview in the face of increasing environmental complexity. While Braathen (Braathen 2016) makes a convincing argument, it is posited that complexity leadership theory contains a more striking paradox than those they list: to better understand the nature of organizations, one must let go of the idea that they can be fully understood. This mindset is described by Chia (Chia 2011) as both an embracing of the existence of complexity and a relaxing of existing "habits of thought". This paradox, and the difficulty it causes, is discussed by Stacey et al:

> ...if one holds the paradox of predictability and unpredictability, it requires a continuing exploration of what control means in such situations. What it is unlikely to mean, of course, is that powerful individuals can be "in control" of their organization. This is at least unpalatable to many and anxiety raising to most, both leaders and led. (Stacey, Griffin, and Shaw 2000 p. 154)

This central paradox links to Parry's (Bryman et al. 2011) leadership paradox which posits that true leadership and structural leadership are disconnected. This also links to 'self-organization' within complex systems and, somewhat, to the 'paradox of rationalism' (Turner 2016) which proposes that the modern quest for meaning has generated an over-constrained order in which true meaning can no longer be found. In precis, complexity reveals the paradox of the co-existence of structure and fluidity, of external control and freedom of action.

Leaders, it is proposed, should accept, and adapt to paradoxes if they are to succeed ((Werhane and Painter-Morland 2011 ; Smith and Tushman 2005)).

> ...the dynamics of the edge of chaos are not at all the dynamics of crisis, but rather, of paradox and ambiguity: this connotes a mature ability to hold a difficult position, not a state of crisis. (Stacey and Mowles 2015 p. 290)

Table 4 presents a list of paradoxes found in complexity literature.

Table 4 - Paradoxes described in complexity literature.

Paradox	Summary	Citation
Paradox of organizing	Simultaneous demands for both control and flexibility.	(Braathen 2016)
Paradox of learning	The organization fails to notice or react to changes in the environment leading to conflict and confusion	(Braathen 2016)
Paradox of dilemma	A choice between two uncomfortable options (e.g. reduce prices or reduce staff).	(Colbert 2004)
Paradox of dichotomy	A paradox treated as a choice of options (e.g. increase quality or reduce costs).	(Colbert 2004)
Paradox of duality	Two apparently conflicting goals (e.g. think globally and act locally).	(Colbert 2004)
The "Red Queen Paradox"	Companies in fierce competition need to evolve (co-evolve) faster and faster just to stand still relative to one and other	(McKelvey 2002)
Paradox of leadership	Leading by not leading (but by allowing). Both part of the people and apart from the people.	(Regine and Lewin 2000)
Paradox of control	The managerial truth of being "in control" and "not in control"	(Streatfield 2001)
Paradox of instability	If organizations are complex systems existing on the boundary between stability and instability, then they will contain both stability and instability	(Stacey 1995)
Paradox of CLT research	The CLT theorists often align with Functionalist thinkers who are in fact in contradiction with the principles of complexity	(Tourish 2019)
The paradox of rationalism	In trying to make sense of the world, one oversimplifies and loses contact with reality	(Turner 2016)

2.11. Self-organization and Distributed Leadership

Self-organization and distributed leadership are two related aspects of CLT. Emergence and Self-Organization are often presented together. De Wolf and Holvoet (De Wolf and Holvoet 2004) argue that self-organization is an emergent property of complex systems which aligns to the views of Cilliers and Spurrett (Cilliers and Spurrett 1999) who promote the definition of emergence as 'self-organized criticality'. It is

tempting to think of self-organization, when viewing complex systems through the lens of organizational behaviour, as people within a group organizing themselves to achieve a task, rather than being organized by centralized leadership; this would be more properly thought of as distributed leadership. Self-organization is, instead, the natural tendency for complex systems of all types to generate structure over time (Soria Zurita and Tumer 2017 ; Lichtenstein 2014). To give an example: A group of 100 strangers are put in a large space for a day. Over time, they naturally form groups and social structures. This is self-organization. If they are then given a goal, the leadership may or may not be distributed, depending on the behaviours and attitudes of that group. For example, potential distributed leaders may decline the 'opportunity' of leadership, wary of the risks, or lack of reward (Zhang and Hu 2020). Within an organization, the social structures are likely to bear little resemblance to the leadership structures although both may contain self-organization.

Studies which describe self-organization may sometimes infer distributed leadership as a natural outcome. Mutebi et al. (Mutebi et al. 2020) found that self-organization was strongly related to the success of inter-organizational communication and the adaptability of the organization. In a study of leadership methods for Knowledge Workers (i.e., those pertinent to our lens of engineering leadership), Issahaka and Lines (Issahaka and Lines 2020) found strong evidence that self-leadership and distributed leadership (shared/team-based leadership) had positive effects on Knowledge Workers including the reduction of perceived work complexity and an increase in innovation capability. These findings from a parallel field of research seem to support the idea that those working in complex teams benefit from distributed leadership, as does their organization.

Distributed Leadership is a stand-alone theory which has seen a lot of interest in some arenas, such as education and tourism (Naumov, Ramkissoon, and Hristov 2020 ; Gronn 2002 ; Fu and Liu 2018 ; Tian, Risku, and Collin 2016) and, as a stand-alone theory, it has been criticized for falling short of applicability (Harris 2007). Within CLT, distributed leadership perhaps makes more sense as the natural embodiment of emergent self-organization within organizations and, in the CLT context, it is perhaps expected to take a different form.

2.12. CLT Implications for Leadership

Rosenhead et al. (Rosenhead et al. 2019) listed ten titular approaches to complexity leadership. They proposed this variance as a potential weakness in the theory, seeking a rigorous relationship between the findings of the natural sciences and the application

within organizational science. Contrary to this position, this paper proposes that it is natural and appropriate for researchers and practitioners to determine which aspects of the findings of complexity science are most relevant to their organization or field, and which complexity leadership methods are the most deserving of focus.

The following section examines various facets of engineering leadership which have been discussed within the literature:

Leading Innovation

Thinking about organizations, or projects within organizations, as complex adaptive systems (i.e., complex systems which can learn) has direct implications for the way we think about organizational structure and the role of the leader (Marion and Uhl-Bien 2001 ; Nijs 2019 ; Uhl-Bien, Marion, and McKelvey 2007 ; Burnes 2005). This is proposed to be especially true when the organization has a strong creative element such as can be seen in the field of engineering, or when a particularly disruptive emergent event occurs, such as the COVID19 pandemic (Cecchi et al. 2022). Uhl-Bien (Uhl-Bien 2021) proposed that complexity in organizations comes in a situation with the following characteristics: (1) a problem with no known solution, (2) new working relationships, (3) conflicting views among participants, and (4) highly independent agents. Anyone familiar with high-value engineering projects will know that they meet these criteria with complexity to spare (e.g., multi-business collaboration, cross time-line communication, complex legislation and so on).

A problem with no known solution demands innovation. Considering that "…creativity and destruction, order and disorder, are inextricably linked in the creative process." (Stacey, Griffin, and Shaw 2000 p. 8), this can present a leadership challenge. Complexity science, it is proposed, gives us unique insights into the mechanisms of innovation. "Complexity leaders are like gardeners that create the conditions in which living systems can flourish" (Nijs 2019 p. 50). Bäcklander's Spotify case study (Bäcklander 2019) is an example of an organization attempting to balance these competing tensions using complexity leadership methods. The case study concluded that complexity leadership theory can bring balance, richness and nuance to practitioner leadership methods like Agile Scrum.

Applying CLT

Despite the article by Uhl-Bien, Marion and McKelvey (Uhl-Bien, Marion, and McKelvey 2007) containing one of the first example of a complexity leadership framework, it is a long way from a practitioner's 'how to' guide and was not intended for direct application.

In 2017, Uhl-Bien published an updated view on CLT and how it was being applied. Google, Mayo Clinic and W.L.Gore are cited as being notable for generating effective adaptive spaces and therefore, consciously or unconsciously, are applying one of the key ideas in CLT (Uhl-Bien and Arena 2017 p. 14).

Some research has looked at aspects of practical application of CLT in the engineering related activities of New Product Development (NPD) and Engineering Management. For example, in the context of NPD, Lévárdy and Browning (Lévárdy and Browning 2009) reviewed the impact of complexity on NPD from a project management perspective (which would be classed as Administrative Leadership under CLT). They stated that three quarters of software development projects either fail or are compromised against their original goals, often because those goals and the associated plan are set out before the project has started, when many unknowns (i.e., uncertainties and ambiguities) still exist. They then moved to propose a new ethos of project management based on complexity; an 'adaptive PD process'. Their approach for project planning and leadership has the following key attributes: (1) Develop model (i.e., activities, contingent activities, and deliverables) to identify what is known and what is not when planning, (2) Discuss the model to reveal unknown unknowns where they are "actually known by someone", (3) Avoid focus on single or critical path thinking, (4) Use iteration as a leadership option rather than a pre-panned event, (5) Activities connect to deliverables in the process plan; these may change as the project changes. The process is dynamic, and the plan is adaptive. Finally, (6) Project control is based on monitoring internal and external events and using the knowledge gained to modify the process plan.

Furthermore, Jun and Suh (Jun and Suh 2008) proposed an NPD model which could be complimentary to Lévárdy and Browning's approach for project management. As with Lévárdy and Browning, their model recognizes the inherent uncertainty in NPD and is based upon complexity theory. By defining several types of iteration in detail, Jun and Suh add richness to the concepts later outlined by Lévárdy and Browning by describing an NPD model with 20 element types, numerous relation types and a high level of complexity. Their model is intended to show the NPD process more accurately, but the detailed model they proposed would appear to lose the dynamic flexibility demanded by a complex adaptive system.

In addition, McCarthy et al. (McCarthy et al. 2006) sought to identify the novelty and value of viewing NPD with a complexity lens. They concluded that such a perspective gives unique insights and greater flexibility to the process. They suggested implications

for leaders: "Managers will need to consider how their traditional methods … affect future process congruence and performance… if the rules and procedures from past NPD projects are simply applied to future projects that have new innovation and market expectations, then this contingency ignorance is likely to lead to… innovation outcomes that are inappropriate in terms of cost, time, and level of novelty" (McCarthy et al. 2006 p. 453).

Within the field of engineering management, Abatecola and Surace (Abatecola and Surace 2020) examined the impact of complexity theory on engineering management. This examination was built solely upon publications within the IEEE Transactions on Engineering Management Journal, considered by the authors as the preeminent journal in this field, and so was somewhat limited in scope. Despite the restricted database, they presented a detailed analysis of 20 years of engineering management using complexity theory, and concluded that CT has primarily influenced NPD, Programme Management and Supply Chain Management. Although many methods used under the auspices of CT are non-linear (i.e., fuzzy logic, stochastic modelling etc.), they also found that adherence to the ideas of complexity theory has been sporadic in some cases. If, as McKelvey (McKelvey 1999) proposed, complexity thinking is in danger of becoming a 'fad' in organizational science, such inconsistency of approach could perhaps be explained by lip-service implementations of the theory.

Levels of Control

One aspect of CLT which forms a part of the proposed model for leadership is the idea of a reduction in control or, perhaps, the need to avoid over-constraint or 'micro-management'. This is paired with the observation that traditional methods of management and control are not delivering the expected results. Certainly, writing based on traditional management philosophy seems to be proposing more and more complicated methods for controlling complex projects (e.g.,Maqsoom et al. 2020) when compared to those based on CLT (e.g., Mamédio and Meyer 2020).

Taking the synthesized attributes of a complex system (section 2.5), the list of aspects of a complex system can be adjusted to a list specific to projects behaving as complex systems: (1) Are dynamic. The structure at the start is not the structure at the end; (2) Have multiple people, tools, organizations, departments, and processes which interact and give feedback; (3) Have boundaries which shift and are difficult to define; (4) Are influenced by the experience of the people within them; (5) Contain opportunities, creativity, problems, and other unexpected events which can create sudden leaps forward or step-growth; (6) Have a generally predictable form at a big picture level but

are unpredictable at a detail level; (7) Have goals which affect the development process; and (8) Have distributed leadership.

The extent to which a specific project can be thought of as an adaptive complex system is reliant on the project itself and the leadership style. If too much control is applied to a naturally complex adaptive project, it will become over-constrained and will cease to behave in an adaptive way. Addressing the topic of over-constraint, we can adjust the previous list to propose the features of projects as an extreme example of an over-constrained system: (1) Are dynamic but the planned structure tries to prevail in the face of change, causing conflict and a lack of agility; (2) Have multiple people, tools, organizations, departments, and processes but many are not accounted for in the simple project model; (3) Acts as if the boundaries are fixed and known; (4) Ignores or assumes the experience of the team; (5) Makes it difficult to be creative or act on opportunities. Is powerless to prevent unpredictable problems but less able to react to them; (6) Assumes all details can be planned at the start of the project; (7) Makes unnecessary commitments by over-planning; (8) Has centralized leadership and micromanagement; and finally, (9) Is linear and will not produce step-growth.

This description of an over-constrained project, in combination with the proposed models of leadership (McCarthy et al. 2006 ; Lévárdy and Browning 2009 ; Burnes 2005 ; Jun and Suh 2008) clearly highlight levels of constraint as one of the key leadership concerns of CLT. This is analogous to the proposal that, for organizations to be adaptive, they must first create an adaptive space where the conflicting needs of innovation and structure can both be accommodated (Uhl-Bien and Arena 2017).

Modelling and Planning

The world of organizational leadership has been tying itself in knots for decades trying to find mathematical models which can predict and control what we now recognize as complex systems. As previously stated in this review, these efforts have only been partially successful and have led to frustration at poor success rates, particularly in the field of project management (e.g. White and Fortune 2002). That said, we still need to plan, estimate, and measure progress and expenditure. Bolaňos and Barbalho (Bolaňos and Barbalho 2021) generated a complicated model for project estimating which accounts for project complexity. Liu, Tong and Sinfield (Liu, Tong, and Sinfield 2020) proposed a business model based on the theory of Resilient Complex Adaptive Systems. Complexity leadership theory would propose that while a model is needed for project estimating or business planning (i.e., Administrative or Operational leadership), day to day reality is unlikely to reflect such a model and the actual

relationship between project duration and product complexity is somewhat fluid. The tension between the need for models, plans, and processes, and the recognition that the future state of complex systems cannot be accurately modelled, is proposed as one of the key Administrative/Adaptive Leadership challenges and an area for future research.

A recent theoretical branch in CLT is Project Complexity Theory which is focused on the implications of complexity on the leadership of projects. Where this branch of the theory diverges from the core complexity theory is in its interest in quantifying the "complexity levels" of a given project. This area of research seems to oscillate between applying the ideas of Complexity (CAS / CLT etc.) within a project management environment (e.g. Cicmil et al. 2017) and creating a new branch of Complexity Theory by setting out to model the numerical level of complexity in a given project (Zhang et al. 2022). Hennig, Topcu and Szajnfarber (Hennig, Topcu, and Szajnfarber 2022) make a study of the second type. In their article they begin by stating the current existence of over 50 published methods of measuring complexity within programmes, they then set about characterizing various examples of complexity measurement.

The basic premise of Project Complexity Theory seems to be based on the following logical progression:

1)   Projects do not come in on time and budget because they are complex.

2)   The more complex they are the less predictable they are.

3)   We therefore need to measure their complexity.

While this may initially seem rational, it could be argued as fallacious when a) reviewed against the characteristics of complex systems and b) reviewed against the reality of project management. It could be argued that as a system is either complex, chaotic or deterministic then "more complex" is not a valid proposition as regardless of how many "moving parts" a project has, a truly complex project will always show emergent behaviour. It also seems to be implausible that high value, long term projects are being run by people with no sense of the relative complexity (and associated risk) or otherwise of this project in general or in comparison to others. It seems to be the ultimate goal of this theory is that a model will be created which reliably defines the knowability of a programme so that an appropriate budget and timescale can be set. As Hennig et al. so clearly state, we have over 50 models so far with no sign of that goal being reached. As the enterprise seems aimed at knowing the unknowable by

modelling the un-modellable so that the uncontrollable can be controlled, the current success rate is likely to continue.

2.13. Research gap

In order to understand the significance of the gap in research, some context on the relationship between complexity theory and societal complexity must first be established: The excitement with which ideas on organizations as complex adaptive systems was met was substantial (Kirkbride, Durcan, and Obeng 1994 ; Thietart and Forgues 1995 ; Thietart and Forgues 2011 ; Tivnan 2005 ; Levy 2000) because it came at a time where organizational science was becoming disenchanted with the status quo of leadership methodology (Eisenhardt and Henning 2011). A new journal was launched (Emergence: Complexity and Organization) in which robust discussions on how complexity and its associated behaviours (such as emergence) could best influence leadership and the way we manage organizations (McKelvey 1999 ; Rand 1999 ; McKelvey 2003).

Most of these discussions came under either the banner of the theory of Complex Adaptive Systems, or discussions on Emergence. Trying to use either to directly influence changes in practice was challenging as seeing an organization as a complex system is incredibly conceptually challenging and emergence is a small part of the whole of organizational complexity and so difficult to treat as a stand-alone concept which might influence practice. When CLT was first proposed, it promised to bridge the gap between the bewildering scope of CAS and the limited applicability of Emergence.

The original definition of CLT (Uhl-Bien, Marion, and McKelvey 2007) presented a leadership framework intended for use in research. That framework has not been directly developed for application by practitioners. While there are several examples of applied practice which has been influenced by CLT and more recent theoretical development is becoming aligned to application, the theory is a long way from a directly applicable form which could be adopted by an engineering organization. The two known examples of a complexity leadership framework making the transition from theory to practice are Health Care (Crowell and Boynton 2020) and public services where it has been renamed Systems Leadership Theory (Bolden 2025). The fact that these applications of CLT by huge, complex organizations exist and continue to develop is testimony to the potential of the theory but an examination of Systems Leadership and Complexity Leadership for Healthcare will see that the methods they describe are heavily tailored to those industries and not generalizable to engineering.

In all the literature reviewed there were no examples of a fully developed version of the leadership framework proposed by Uhl-Bien et al which could be directly applied by practitioners in the engineering industry or any other industry other than that proposed for healthcare (Crowell and Boynton 2020) which has been highly customized and is considered not generalizable. The closest any studies came to proposing an applied Complexity Leadership framework which might be useful in engineering was in the form of using Complexity Thinking to modify existing leadership methods such as Agile Scrum (Bäcklander 2019), New Product Development (Lévárdy and Browning 2009 ; Jun and Suh 2008) and Project Management (Ika, Love, and Pinto 2020 ; Cicmil et al. 2017). This observation is supported by a study conducted by Abatecola and Surace (Abatecola and Surace 2020). Examples of applied complexity leadership were occasionally presented with results but without details of the specific leadership framework which was applied (e.g. Surace 2019). Emergence has been a topic of intense focus among complexity researchers but emergence within specific fields, such as engineering, has not been explored. Despite a large number of references to Paradox in the extant research on Complexity Theory, it seems to have been deliberately ignored in the creation of CLT. While the existence of paradox per se may not be directly relevant to the creation of a leadership framework, the surrounding leadership philosophy needs to account for complex behaviour, which must include paradox.

In summary, in the 16 years since the initial proposal of a framework for leading complexity, there are still no fully developed leadership frameworks which can be applied to a wide scope of leadership within a complex organization. During this time, the complexity of society and the challenges of managing engineering have grown significantly. It is now common for engineering teams to work remotely, AI is becoming an increasingly large part of the technological landscape and cloud computing and machine learning have become normalized as engineering methodologies. In addition to that, there are very few examples which discuss Complexity Theory in the context of engineering leadership. On that basis, this research was instigated with the objective of closing that gap, or contributing to the closing of that gap.

2.14. Chapter Summary

The research problem identifies an issue within engineering leadership which fails to recognize the complexity of engineering projects, using reductive thinking to simplify the leadership task without allowing for the limitations of the models produced. In order to pursue the research aim of creating a leadership framework which addresses this

problem, Complexity Leadership Theory has been chosen as the catalyst for the research. Writing on Complexity Leadership Theory and related complexity theories describes organizations as complex systems and lists a set of characteristics which can be seen within organizations due to that complexity. The writing goes on to list a series of important characteristics of leadership relating to complexity. This literature review has focused primarily on Complexity Leadership Theory and, to a lesser extent, Complex Adaptive Systems Theory. This lens excludes large areas of Complexity Theory, most notably research on complexity science which originally inspired CAS and CLT. Research on Project Management complexity has been examined to a small extent but has been excluded from the in-depth studies as it only relates to a sub-part of engineering leadership.

While the discussion on the nature of complexity within organizations is rich in nature, there is an identified lack of development in the field of applicable leadership frameworks for leading complexity. This forms the gap which this research is targeted at contributing to filling.

3. Methodology

Chapter	Phase	Purpose	Method
3	Planning	Define the research methodology Validity and reliability of research	Research Design

This chapter outlines the selected primary research methodology and details the validation for its selection (3.4). It describes the demographic of the research population (3.7 and 3.8). The overarching research conception (3.9), the details of individual studies (3.10) and the design of research tools and processes is outlined (3.13). The design process for the communication tools is also shown (3.14).

3.1. Research Philosophy

This research is based on an interpretivist pragmatist epistemology and ontology. This was chosen as most appropriate as the subject of the research is the experience and perspectives of individuals which is inherently subjective and requires data interpretation to turn discourse into structured theory. Rather than measuring a single reality, the research seeks to draw on the many different perceived realities of the participants, looking for patterns and insights which relate to the research problem. The interpretation of data is executed with an eye to practical application. This lens is applied throughout to ensure results can be realised in practice. The researcher is an active participant, adding their own perspectives to those of the participants. Data is gathered and analysed using qualitative research methods (discussed in this chapter).

Despite the drive for practical application of the research output, the theoretical basis of the research must be robust, valid and verifiable. The research is designed to deliver output which references and is directly traceable to established theory (See 5.1).

3.2. Research Strategy

Several options were examined before finalizing the research strategy. In line with the research philosophy, a qualitative research approach was chosen. The initial method considered was to use interviews and focus groups to gather commentary from practicing leaders which could be thematically coded to derive a theoretical construct (Gibbs 2007). This method was considered only partially appropriate because it relies on the participants having a knowledge and understanding of areas directly relevant to the research problem. While they could be expected to discuss issues with current practice, and they could be asked questions about possible alternatives to practice, it

seemed unlikely that this approach would lead to a proposal for an improved leadership framework, which is the research aim. In order to generate more focused and purposive data, Action Research (AR) was chosen as the primary research methodology (MacDonald 2012). This methodology is similar to that originally considered but it has the advantage that participants can be given tasks before the discussions to better allow them to formulate opinions on the topics of interest. This decision allowed the gathering of data which is a reaction to current theory as well as a reflection on current practice. AR is a pro-active research methodology (Azhar, Ahmad, and Sein 2010) commonly used in engineering research (e.g., Torre and Bonamigo 2024 ; Bertolini et al. 2024 ; Ahmeti et al. 2024) and is designed to allow the participants to be given specific actions or activities during the research.

3.3. Data collection and analysis strategy

In line with the research philosophy, qualitative research methods were used to address the research questions and the associated data collection methods were linked to both the research questions and the theory under investigation.

The research questions inform the detail of the data collection strategy. RQ1 asks for an appropriate leadership theory and RQ2 requests the output of the research be in the form of a leadership framework. These are the research questions which influence the research strategy. As Complexity Leadership Theory was chosen as the most appropriate leadership theory to address the research problem (see 2.3), the data gathering will need to be structured around this theory.

Figure 8 illustrates the relationship between the different data gathering activities and associated validation. Each of the steps illustrated is detailed as follows:

The research philosophy (see 3.1) informs which established methods can be used in the research (see 3.2). The leadership theory which has been chosen as the basis of the research guides the structure of the initial survey questions and AR activities (see 2.6). The objective of the primary research is to answer RQ2 by generating a leadership framework by analysing the relationship between the chosen leadership theory and the working practices and views of the research population. The surveys used 5-point Likert Scales. There is a proposal that a 7 point Likert Scale is better from a statistical analysis perspective (Joshi et al. 2015), but experiments in presenting descriptions for seven levels of agreement to the research topics showed that too much granularity was confusing to the research population who were accustomed to 5-point Likert scales as the industry norm.
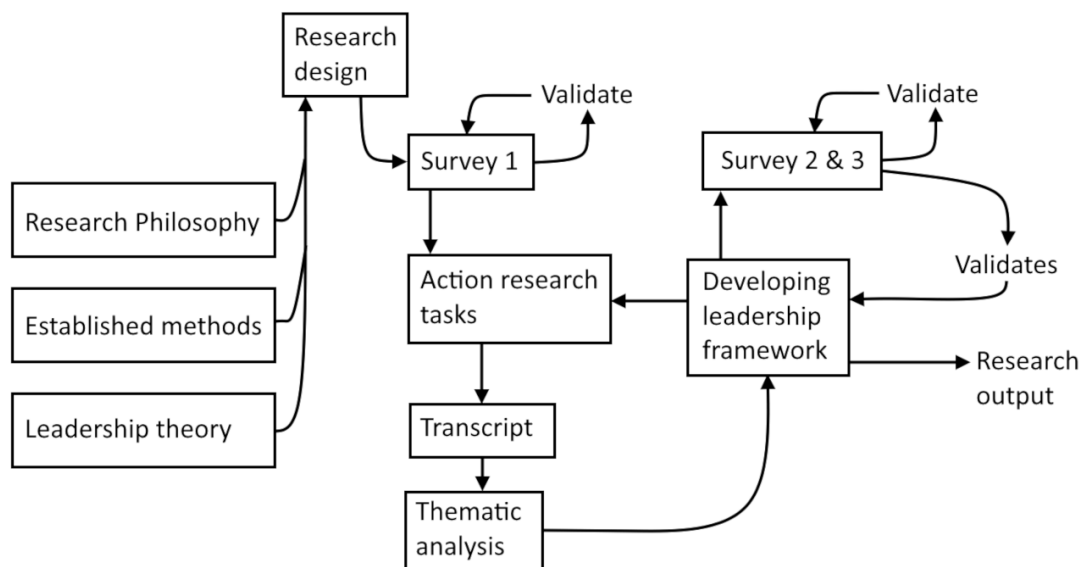
Figure 8 - Research data gathering design

The steps used to create and evaluate the surveys is illustrated in Figure 9. This structured process is based Boateng et al (Boateng et al. 2018) which has the advantage of providing methods discussed individually in many sources as a single framework. The last three stages in their method have been omitted for these surveys as they were not intended to be conducted at longitudinal periods.
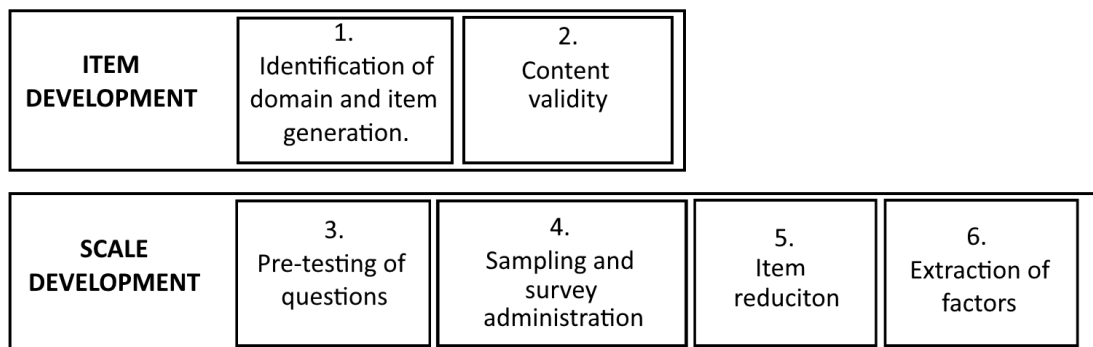
Figure 9 - Phases and steps of scale development and validation (based on Boateng et al. 2018 p. 2 fig.1)

First Survey evaluation

For the first survey, the specifics of each step are as follows:

Step 1. Identification of Domain and Item Generation:

Selecting Which Items to Ask

The survey domain is the leadership practice of the research population (n=852), primarily aspects of leadership which may be used to indicate the relevance of CLT. No existing survey tool was found during the literature search which could be used to

generate this data. Informal interviews had been used prior to the creation of the survey to identify an appropriate approach to discussing CLT with the research population.

Step 2: Content Validity:

Assessing if the Items Adequately Measure the Domain of Interest

The validity and quality of the questions were evaluated by representatives of the research population (n=5) who reviewed the questions in the context of the survey objective, giving feedback on clarity and relevance of the questions. The content was adjusted as required by the feedback.

Step 3: Pre-testing Questions:

Ensuring the Questions and Answers Are Meaningful

The survey questions were presented to a small representative group (n=5), For each question they were asked if a) the question was clear and unambiguous b) the felt confident that they could assign a response value from the scale. Adjustments were made as required by the feedback.

Step 4: Survey Administration and Sample Size:

Gathering Enough Data from the Right People

The survey was sent to the research population (n=852). This population had been pre-screened for suitability (e.g. they were all line managers within the collaborating organization). 223 surveys were completed with 29 questions giving 6467 data points. This is far in excess of the sample size required for statistical validity.

Step 5: Item Reduction:

Ensuring Your Scale Is Parsimonious

The goal of reduction / parsimony is to ensure that the survey is reduced to its smallest scale to achieve the desired measurement. The survey results were checked for correlation between questions. A strong correlation may mean that two questions are measuring the same thing. The greatest correlation seen was 0.544, not a strong value. Most values were much lower with an average correlation of 0.181. The two statements with the closest correlation were: "I work in a highly collaborative environment" and "I work with an agile and responsive team", both statements of agility.

An analysis was made to show the extent to which the survey was differentiating the leadership mode bias of the respondents (See Figure 10, Figure 11 and Figure 12).

For each group which were predicted by the survey to have a specific leadership bias, their score for the other two leadership modes was compared. The analysis for each shows a clear differentiation between each mode for an individual for Enabling and Adaptive leadership bias. For those predicted to have an Administrative Leadership bias, the distinction is marginal to the next most notable leadership bias. Those with an Adaptive Leadership bias are the most distinct.
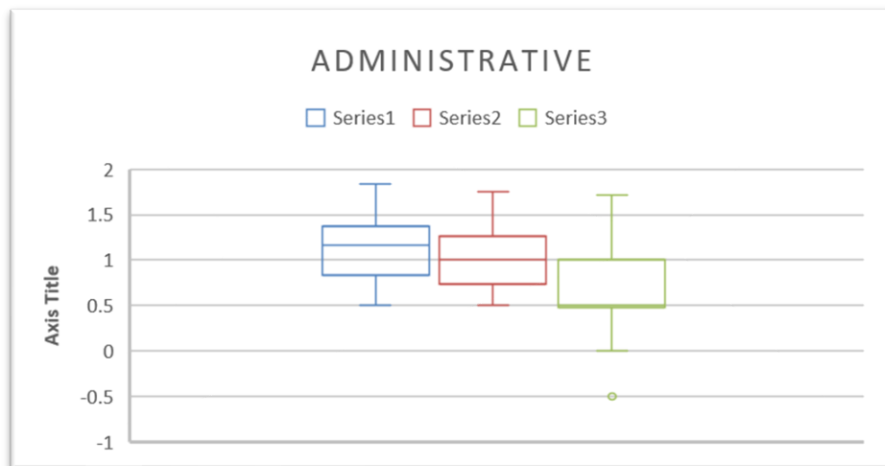
Figure 10 - Data spread analysis for predicted Administrative bias
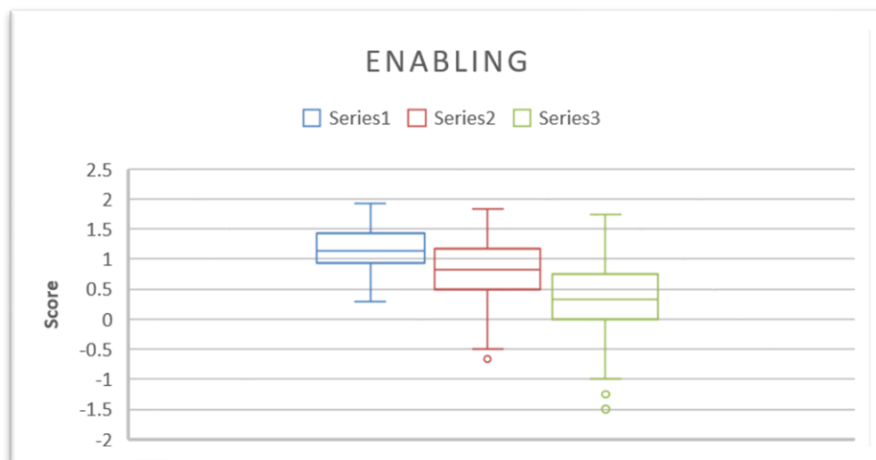
Figure 11 - Data spread analysis for predicted Enabling bias
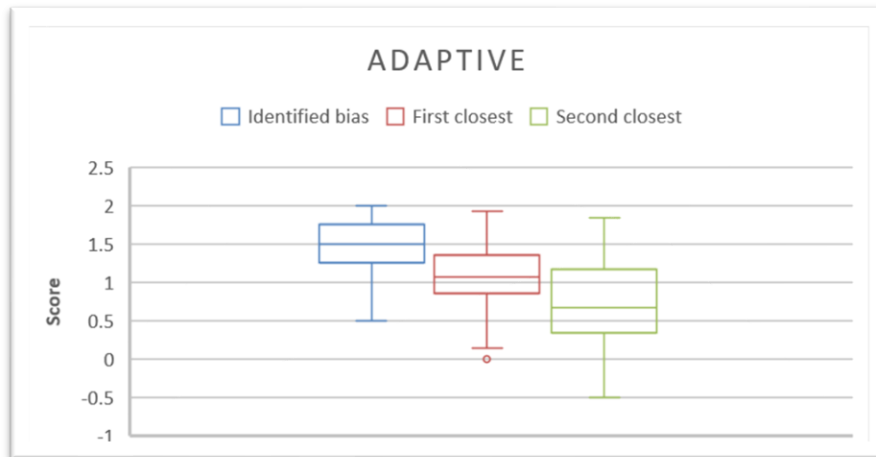
Figure 12 - Data spread analysis for predicted Adaptive bias

Step 6: Extraction of Factors:

A factor analysis was performed to confirm the number of constructs in the survey. The tool used was IBM SPSS Statistics. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was measured at 0.807 which indicates this analysis method is appropriate in this data set.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.807
Bartlett's Test of Sphericity	Approx. Chi-Square	1477.282
	df	378
	Sig.	<.001

Figure 13 - KMO for factor analysis

A Scree plot was generated to indicate the number of latent constructs in the survey.
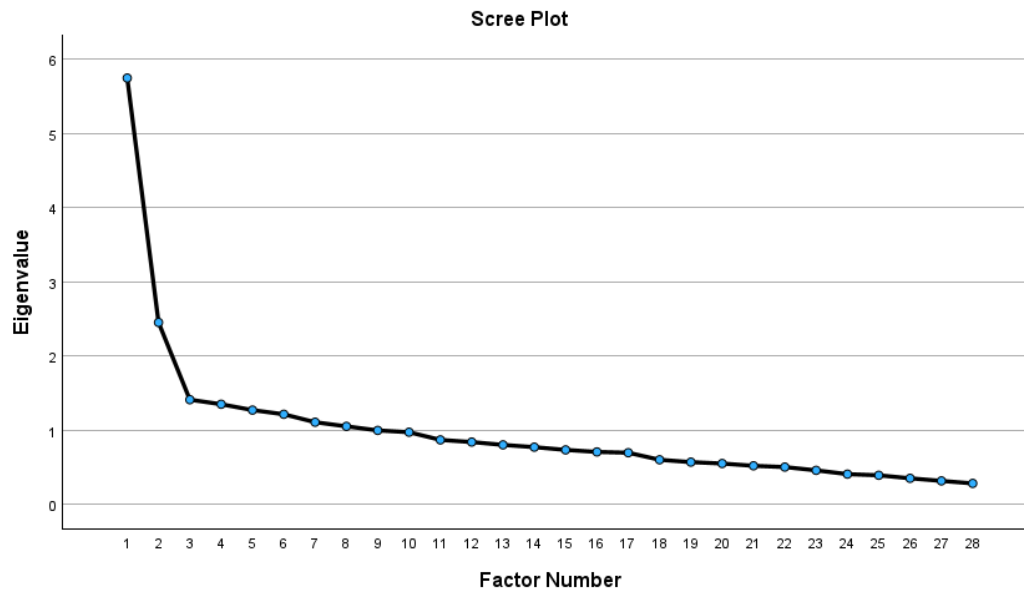
Figure 14 - Scree plot of survey 1 data

A parallel analysis was also generated using random data of the same matrix size. By comparison to the 95th percentile Eigenvalues generated, the first two factors are significant. By the third factor, the random data is producing similar results to the analysed survey data. This seems to correlate with the observations made in Step 5.

Matrix from parallel analysis

Run MATRIX procedure:

PARALLEL ANALYSIS:

Principal Components

Specifications for this Run:
Ncases   223
Nvars   28
Ndatsets 100
Percent   95

Random Data Eigenvalues

Root	Means	Prcntyle
1.000000	1.723570	1.825871
2.000000	1.611136	1.683180
3.000000	1.530681	1.591384
4.000000	1.461172	1.515998
5.000000	1.402308	1.447549
6.000000	1.342259	1.385289
7.000000	1.289750	1.333225
8.000000	1.242079	1.282233
9.000000	1.192998	1.225999
10.000000	1.147783	1.188947
11.000000	1.102753	1.136472
12.000000	1.061648	1.092710

Figure 15 - Parallel analysis data (first 12 values)

The same process was used to assess Surveys 2 and 3. The full analysis data set for all three surveys is presented in Appendix A. Functional validity of the surveys is discussed in Session 6 of section 4.6.

Second and Third Survey Evaluation

Step 1. Identification of Domain and Item Generation:

Selecting Which Items to Ask

The survey domain is the leadership practice of the AR participants (n=37) through the lens of the developing leadership framework. Informal interviews, Survey 1 and previous AR sessions (these surveys were used in session 6) had been used prior to the creation of the surveys to identify an appropriate approach to discussing CLT with the research population. Although presented as two surveys, they form a contiguous data set and the results were combined for the following assessment.

Step 2: Content Validity:

Assessing if the Items Adequately Measure the Domain of Interest

The validity and quality of the questions were evaluated by representatives of the research population (n=5) who reviewed the questions in the context of the survey objective, giving feedback on clarity and relevance of the questions. The content was adjusted as required by the feedback.

Step 3: Pre-testing Questions:

Ensuring the Questions and Answers Are Meaningful

The survey questions were presented to a small representative group (n=5), For each question they were asked if a) the question was clear and unambiguous b) the felt confident that they could assign a response value from the scale. Adjustments were made as required by the feedback to both the survey questions and the tool to present the results in a logical pattern to assist analysis.

Step 4: Survey Administration and Sample Size:

Gathering Enough Data from the Right People

The survey was sent to the research population (n=37). This population was already participating in the AR programme. 23 surveys were completed with a total of 121 questions giving 2783 data points. This is in excess of the sample size required for statistical validity.

Step 5: Item Reduction:

Ensuring Your Scale Is Parsimonious

The developing theory featured five leadership modes, each having an associated list of objectives for that mode. Each objective was used to generate four statements to be responded to in a 5-point Likert scale in the contexts of the respondent's current practice, how they would like the practice to be, how successful the leadership they experienced was and how balanced the leadership they experienced was. With respect to parsimony, fidelity and traceability to the theory was prioritized over strict parsimony. A correlation analysis shows small pockets of correlation where questions are referring to different aspects of the same leadership mode. The greatest level of correlation was 0.886. This was between: "When there is a change in requirement, we always do an impact assessment" and "Our plans will be adjusted as events unfold". Both examine different details in Project Management practice.

Step 6: Extraction of Factors:

Exploring the Number of Latent Constructs that Fit Your Observed Data

A Scree plot was generated for the combined data set. As the survey contains five constructs (the five leadership modes of the 5-point framework) and each mode is examined in four scenarios (current practice, preferred practice, received leadership balance and received leadership success), the total number of constructs is expected to be 20. The scree plot shows a total of 21. The parallel analysis shows that all 21 are distinct from their randomly generated counterparts. This additional construct may be a reflection of the high levels of correlation seen in some patches of the correlation matrix.
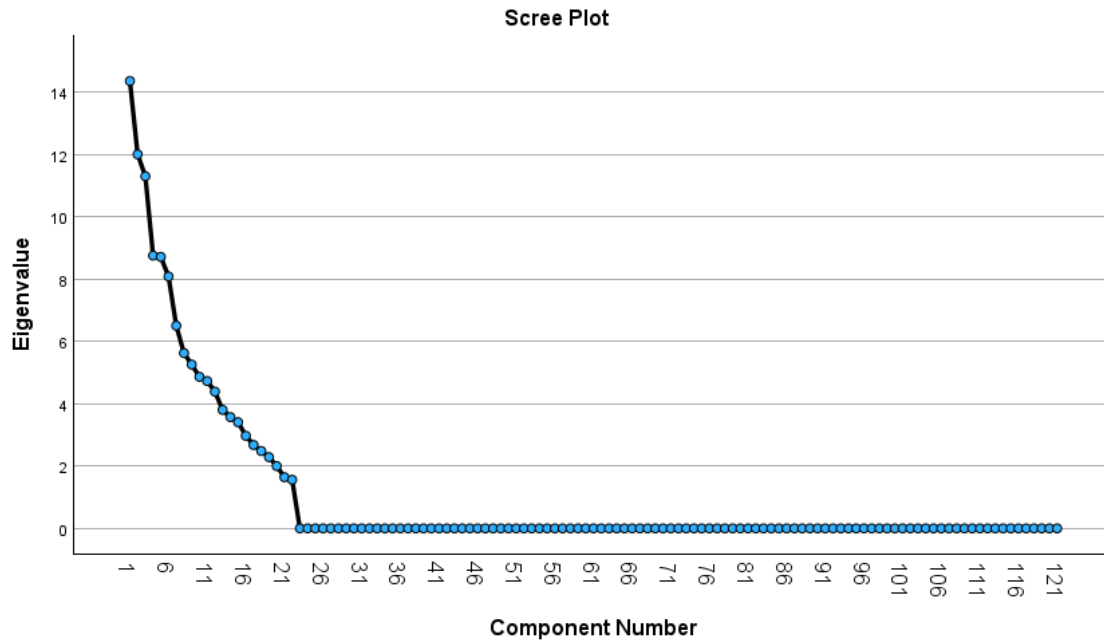
Figure 16 - Scree plot of survey 2+3 data

➡ **Matrix for parallel analysis**

Run MATRIX procedure:

PARALLEL ANALYSIS:

Principal Components

Specifications for this Run:
Ncases   121
Nvars   23
Ndatsets 100
Percent 95

Random Data Eigenvalues
Root	Means	Prcntyle
1.000000	1.886082	2.026119
2.000000	1.728894	1.833701
3.000000	1.621533	1.710307
4.000000	1.515383	1.605704
5.000000	1.420101	1.500685
6.000000	1.330833	1.396491
7.000000	1.262744	1.335556
8.000000	1.192666	1.255005
9.000000	1.127157	1.181110
10.000000	1.063228	1.105936
11.000000	1.001394	1.053278
12.000000	.940179	.989312
13.000000	.881994	.929201
14.000000	.828104	.876440
15.000000	.779138	.826412
16.000000	.729150	.771317
17.000000	.676143	.721195
18.000000	.632097	.671766
19.000000	.577444	.626405
20.000000	.530078	.570623
21.000000	.481445	.520806
22.000000	.429453	.473201
23.000000	.364760	.408902

Figure 17 - Parallel analysis for Survey 2++3

3.4.   Action Research

Action research (AR) is a long established research methodology which was first conceived by Lewin (Lewin 1946). It is a collaborative, democratic process which

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engages participants in active discussion aimed to develop understanding and knowledge with a specific purpose. Rather than seeking to measure what *is,* AR is targeted at exploring what *could be*. Its primary purpose is transformative change within organizations.

> Action research may be defined as an emergent inquiry process in which behavioural science knowledge is integrated with existing organizational knowledge and applied to solve real organizational problems. It is simultaneously concerned with bringing about change in organizations, in developing self-help competencies in organizational members, and in adding to scientific knowledge. Finally, it is an evolving change process which is undertaken in a spirit of collaboration and co-inquiry. (Shani and Pasmore 1982 p. 208)

Action Research takes place in a natural setting (i.e., the workplace) and targets specific issues through collaboration and co-enquiry which involves the researcher first hand. It is a process of mutual education where the structure of the AR process unlocks information from the minds of the participants. It also develops self-help competencies within the participants through reflection and the transfer of knowledge. AR is targeted at improvements in the organizational systems or processes and should lay the foundations of a learning system (Shani and Pasmore 1982).

An AR methodology has been selected to investigate the research problem. This is considered appropriate for the following reasons: (1) the research is intended to facilitate transformational change and AR is designed for this purpose (McNiff and Whitehead 2000), (2) to develop the theory, and the way it is presented to practitioners, feedback loops are required. These create iterations which not only form part of the research data but also ensure high levels of engagement by the participants. AR features multiple iterative feedback loops, each further developing the theory (Coghlan 2019). (3) It is considered unlikely that a successful practical framework could be developed through non-participatory methods.

Prior to selecting AR as a methodology, other qualitative research methods were also considered. The most appropriate alternative to AR was considered to be the use of workshops or focus groups, the transcribed output of which being subjected to thematic analysis through the use of coding or other analytic methods. This approach could be expected to reflect perceived issues with the current leadership approach but could not be expected to develop improvements or explore new ideas within the leadership practitioner context which could be used to improve practice.

As a research methodology, AR has some drawbacks and challenges. Demonstrating academic rigour for AR research can be much harder than for other methodologies due to the fluid nature of the data produced. To overcome this, the AR design shall be structured and clearly defined, the AR tasks and briefings shall be well documented and established methods for demonstration validity of research design and analysis of results shall be implemented.

The "Action" in Action Research refers to the execution of planned steps. First, there is a constructing phase where the general objective of this cycle of AR is decided, then a planning phase where the activities are defined. This is followed by the action itself where whatever structured discussion or group activity was planned is enacted. This action is then evaluated where the success of the action and the knowledge gained are evaluated. This evaluation then informs the next construction, and so on in a cyclic sequence (Figure 18).
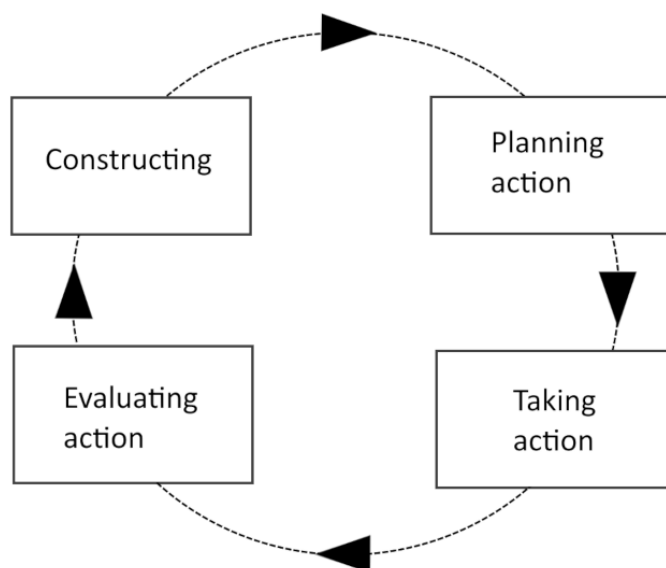
Figure 18 - The action research cycle (Based on Coghlan 2019 Figure 1.2)

The overarching goal of the action research is to develop an applicable Complexity Leadership Framework by engaging the intended users in activities which enabled them to question their practice in the context of complexity leadership and test some analytical tools to see if they added insight and value. The catalyst for this research was the Complexity Leadership Framework proposed by Uhl-Bien et al. (Uhl-Bien, Marion, and McKelvey 2007) augmented by the wider theoretical understanding which was the result of the first literature review. Rather than present the whole theory to the participants, elements of the theory were explored in each session. The participants

were given an exercise (the Action) to do before each session. This not only gives some direct experience of the ideas under discussion but can allow the wider group to discuss their findings in a more informed manner. The participants quickly learnt that not completing the exercise before the session put them at a disadvantage in the discussion and the rates of participants not completing the exercise was very low.

The AR model used in this research has been specifically designed to work with the research population and deliver results which are directly applicable to the case study organisation. Looking at recent analyses on the use of AR (Davison, Martinsons, and Malaurent 2021 ; Naslund and Norrman 2022), this approach is similar in philosophy in that it uses the fundamental principles of AR in a framework which has been tailored to suit the application.

Action research seems to sit somewhat uncomfortably within the conventional research philosophy framework. This is discussed at some length by Somekh who lists a long set of contradictory philosophies relating to AR. These culminate in an inherent uncertainty of the philosophical position of AR within the research canon (Somekh 2005 p. 11-30). Coghlan and Brannick make the case for AR to sit with critical realism (Coghlan 2019). Although this is logical, the wide-ranging nature of AR would suggest that there will be examples which are difficult to fit with this model. Bradbury and Reason's Handbook of Action Research (Bradbury 2015) contains many discussions on philosophies relating to AR without declaring a conclusive best-fit solution. The variety of methodologies which reside under the umbrella of AR would seem to be the cause of this debate. Reason states that "Action research is partly a family of practical methodologies for engaging people in dealing with key issues in their lives" (Reason 2006 p. 198) but quantifying the key members of the "family" does not seem to be a task which the extant literature has undertaken.

Philosophical foundations	Critical realism and action research	Positivism	Hermenuetics and postmodernism
Ontology	Objectivist	Objectivist	Subjectivist
Epistemology	Subjectivist		
Theory	Particular	Generalizable	Particular
Reflexivity	Epistemic	Methodological	Hyper
Role of researcher	Close to data	Distanced from data	Close to data

Figure 19 - Research Paradigms and Action Research

(Derived from Coghlan 2019 p. 41 table 3.1)

Coghlan presents a table of research paradigms which relate to AR (Figure 19). Using this table as a guide, it is proposed that the AR approach for this research has the following philosophical foundations:

Ontology = Subjectivist. This research is designed to uncover the individual truths held by the participants and is not based on the philosophy that a central truth exists which can be uncovered. Subjectivism is considered more aligned to complexity theory which rejects reductive perspectives.

Epistemology = Interpretivist. This proposes that any discoveries are a result of, and subject to change by, the environment and context of the research that produced them. Only by looking at patterns in multiple data points and interpreting those patterns into meaning can knowledge be gained.

Theory = Complexity Theory. Specifically, complexity leadership theory in the context of Complex Adaptive Systems theory. Both being derived from, and informed by, chaos theory.

Reflexivity = Epistemic. The relationship between the researcher and the research is based on the beliefs of the researcher, most notably the beliefs which relate to what constitutes good leadership practice. While these beliefs are challenged and modified by the research, their starting state dictates the starting state for the research and its design.

Role of researcher = Close to data. The researcher is deliberately embedded in the research process. Some of the data gathered is a direct record of the researcher's responses to the Action Research process and the data gathered by it.

To achieve validation of approach, the Action Research is augmented with surveys. The purpose of these surveys is not to generate statistics on the research population, rather to demonstrate that, for an individual leader, the developed framework can be understood and gives insight into their lived experience.

The texts used to inform the AR design were chosen as either giving a good overview of AR methods or because they specifically focused on AR within an organization (Bradbury 2015 ; Coghlan 2019 ; Dadds, Hart, and Crotty 2001 ; McNiff and Whitehead 2000 ; Reason 2006 ; Somekh 2005). While these texts are not immediately contemporary with the research, given the maturity of Action Research (which was conceived by Kurt Lewin in 1944) they do represent modern thinking on AR and were found to be more relevant to this research than any later publications.

The contents of these texts were analysed for techniques which might inform the design of the AR. An interpretive approach was chosen whereby the Participant group "undertake their action enquiries into their workplace practice, supported by researchers, acting perhaps as coaches..." (McNiff and Whitehead 2000 p. 201) and through this process, the response to the action enquiries is, in the context of the target transformation, interpreted to develop a new method or process. Consistent throughout the literature on AR is the idea of iterative change driven by a sequence of action enquiries (e.g, McNiff and Whitehead 2000 p. 205; Coghlan 2019 p. 10 etc.). The model shown in Figure 20 was the one chosen for this study.
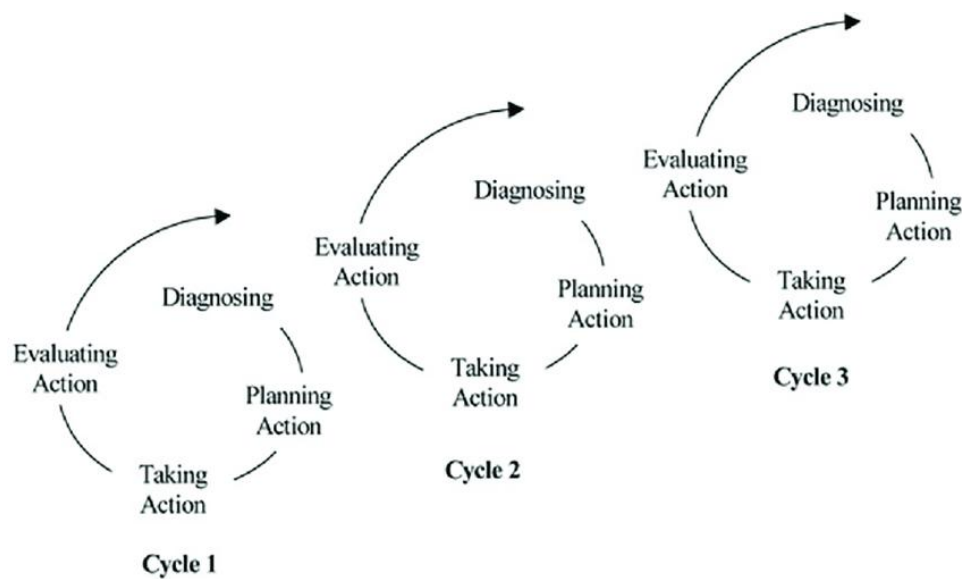
Figure 20 - Coghlan, D., 2019. Doing action research in your own organization (Sage). Figure 1.3, p.10

The measure of AR quality proposed by Reason was adopted (Reason 2006). This measure is summarized by Coghlan and Brannick as the ability to answer the set of questions shown in Table 5 which is paraphrased from Coghlan and Brannick (Coghlan 2019 p. 14). The answers which relate to this research are included in the table.

Table 5 - Quality and rigour in AR

	Question	Answer
1	How did you engage in multiple and repetitious action research cycles and how were those steps recorded?	AR split into 8 sessions, each containing 4 discussions. Each session adds to the developing theory and informs the subsequent sessions. Design is recorded herein. Discussions were recorded and transcribed then fed into an output document (section 4.5)
2	How did you challenge and test your own assumptions and interpretations of what	The output document for each session, which was interpreted by me, was then

	was happening so that your closeness to the issues was exposed to critique?	sent to the participants for review to validate my interpretation. The final framework has been tested for validity as part of this research.
3	How did you access different views of what was happening which probably both confirmed and contradicted your interpretations?	The theory which led to the 5-point framework was collaboratively developed and repeatedly reviewed as part of the AR sessions and subsequent validation exercises.
4	How are your interpretations grounded in scholarly theory and how are your outcomes challenged, supported or disconfirmed in terms of the underpinning theories?	The starting point for the research was an academic theory and the AR discussions were interpreted using a theoretical lens. The research outcome has been compared to parallel independent research and close agreement can be seen.

3.5. Data Analysis

Thematic analysis was used to analyse the AR workshop transcripts (Braun and Clarke 2021). The purpose of the analysis was to understand the interplay between CLT, the research questions and the participants practice, views and experience. As the research objective (OBJ2) is targeted at developing a leadership framework or similar tool which can encapsulate the developed theory, the primary object of the thematic analysis was to identify themes which could inform the development of the framework.

Using the NVIVO 12 Plus software tool, the transcripts were initially automatically coded to identify all thematic codes in the data (see Figure 21). This coding captured the desired codes as well as some codes which were not related to the research question (e.g. common phrases) which were manually deselected before the final data output (see Figure 22). The initial quantity of codes per session is shown in Table 6. To find the thematic logic of these codes, they were manually grouped into themes. These themes were linked to related codes which were divided by session. The reason for this delineation is that, as AR is an iterative process with multiple feedback loops, the division by session allows the development of concepts to be seen in the codes. The themes identified were: The drive for success, transformation, administration and financial control, new thinking, leadership and the talent pool, people and skills. These themes and their associated codes were then used to inform the development of the leadership framework. The link between the coded themes and the framework is described in 4.7 and the data is presented in Appendix A.
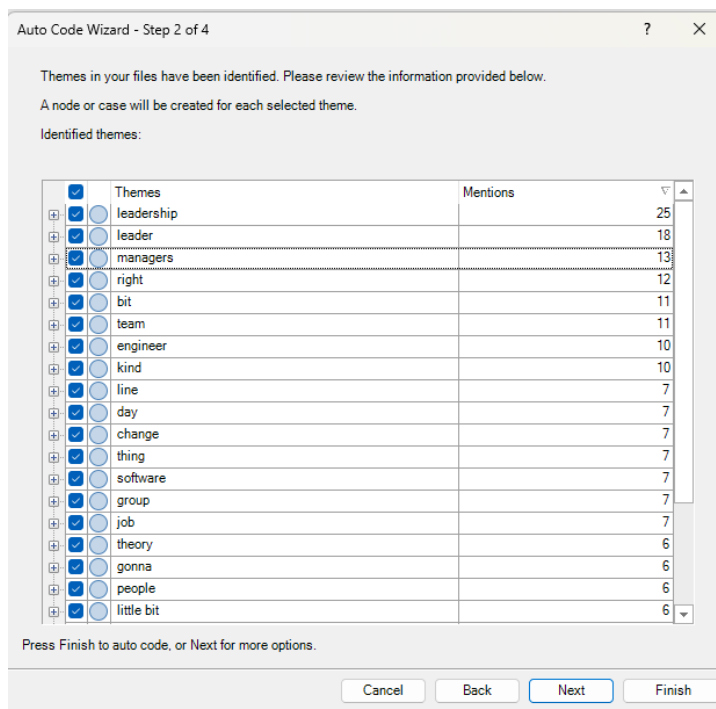
Figure 21 - Example of automatically generated codes
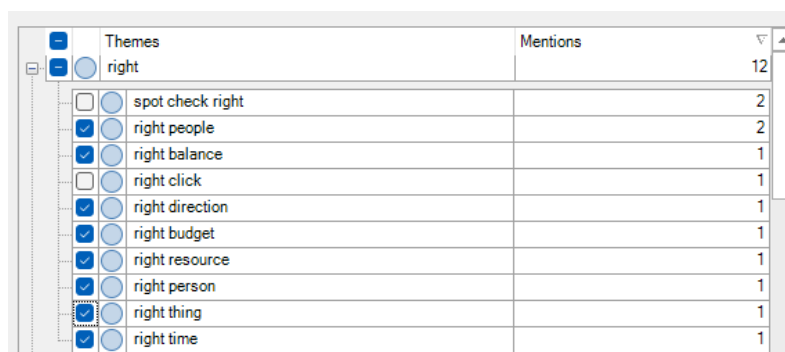
Figure 22 - Example of deselecting irrelevant codes

Table 6 - Codes per session

Session	Codes accepted	Codes discarded
1	14	9
2	38	10
3	43	7
4	38	19
5	55	18
6	9	10
7	27	10

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In addition to the thematical analysis, which captures the themes of the discussion, a more narrative review of the transcripts was made. This was done to enable a narrative summary of the sessions to be fed back to the participants (who would not be able to interpret the thematic analysis), allowing them to respond with corrections or areas where they thought an important point had been missed. The method used for this is described as discourse analysis, although it is not classic Discourse Analysis (e.g., Gill 2000) which focuses on linguistic analysis. This method of discourse analysis is performed on the transcripts, with points made being logged as a list of notes. These notes culminate to form a collective summary of the points made in the group which is then fed back into the group to allow the participants to correct any misconceptions or bias. This method involves the manual reading and re-reading of transcripts in order to gain insight into the common or underlying thematic trends and key insights (Alejandro, Laurence, and Maertens 2023 ; Alejandro and Zhao 2024). This method does not allow for the analysis of large data sets, but as the research design was scaled to accommodate a manual analysis method, this limitation was not a problem. The benefit of this method is that it allows for a deeper understanding than might be gained from methods like thematic coding or more automated methods which look at data such as word count, as they can be somewhat removed from the context of the discussion and struggle to produce useful data when the topics of discussion are wide-ranging around a theme. This method was made simpler by the participants in the discourse having a common context and vocabulary.

The key points in the discussion were individually compiled into a feedback sheet. The decision not to use coding for feedback is based on the summarized nature of codes which missed some nuances captured in this more manual process. Often, a point from one participant is made across many lines of text which can be recorded by manual review but it will tend to generate multiple codes (Alejandro, Laurence, and Maertens 2023). Through the use this method where the transcripts are read and points spanning many lines or pages of text can still be captured, a more usable output was created (see Figure 23).
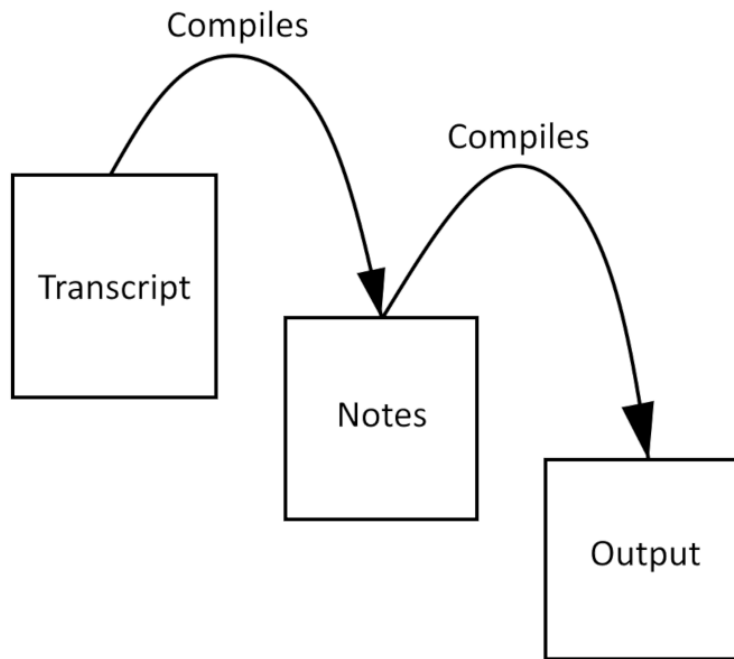
Figure 23 - Steps of discourse analysis for AR transcripts

3.6.   Designing the Action Research activities

This section describes the method and rationale for the design of the AR activities which were used in the research. The activities and their output are detailed in section 4.6. For the sake of consistency and maintaining records of the research, it was decided to prime each activity with a written brief, often involving some work to be done before the group session.

Prior to the start of the research, ethical approval was gained (ID: 31672-LR-Dec/2021-36672-2) for the research design and an invitation to participate was created to ensure informed consent to participate (see Appendix B). The data used was anonymized prior to publication and personal details stored were limited to business email, job description and high-level personal data. All personal data is to be deleted once the research is completed.

As AR is a highly interactive form of research and some of the ideas within Complexity Leadership Theory can be difficult to convey. The written briefs for the AR activities built upon the developed communication methods which are described in section 3.13. In addition to this, the participants, being professionals working in an engineering organization, had prior knowledge of presentation, communication and analysis tools: Methods such as mind-mapping, spreadsheets, online surveys and organograms were all familiar to them and could be integrated into the activities without the need for

explanation or training. They were also very experienced in the use of video conferencing tools, with regular access to MS Teams.

The process used for creating the briefs and other material to be used in the group discussions was as follows: The last session is evaluated to inform which area to explore in the next session plus any areas of improvement on the structure and design of the sessions (the first session does not have this step). The general construction of the activities is then considered. The discussion needs to link the real-world experience of the participants to the concepts within the theory being explored. It needs enough structure to be efficient but without too much constraint on the flow of conversation. These construction ideas are then turned into a detailed plan for the next session. An activity is set in a brief to prepare the participants for the session. This could be an exercise, an analysis of an aspect of their practice, or a simple thought exercise where they note their thoughts on a topic. This exercise is described in a brief. Other material may also be prepared for use during the group discussion (session). This material was normally in the form of scenarios relating to the chosen theme to which the participants were asked to respond. The dates and times of the sessions are then planned to account for the participant's local time zones and the brief and invitations are sent out.

Figure 24 illustrates this process in an expanded version of the action research cycle shown in Figure 18.
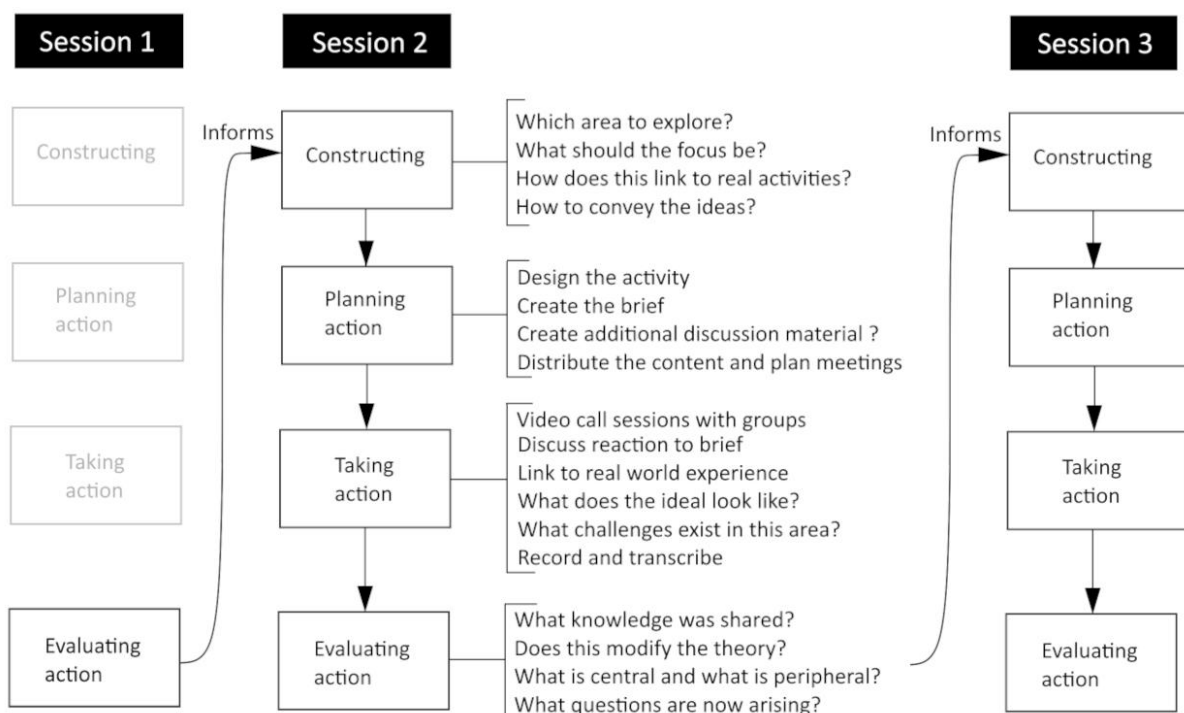
Figure 24 - AR session design

The briefs for each session and their rationale are as follows:

Session 1

Task: Consider the idea of distributed leadership (how team members without nominal leadership responsibilities may still play an important part in the overall leadership). Draw a simple diagram which shows the leadership roles and influence lines within your team:

1. Draw a small circle for each person in the team, arranged in a ring.
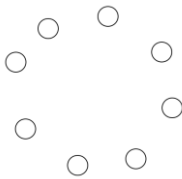
2. Shade in the circle which represents the nominal leader (or leaders if top level leadership is shared)
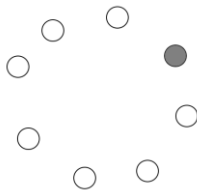
3. With a plan for which circle is which team member (write initials if it helps), draw a line for "regular interaction" between the circles. This should be based on what really happens, not a hypothetical ideal.
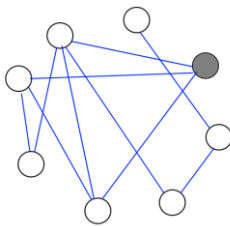
4. Draw a thicker outline around any team member who has distributed leadership. This could be leading a small group or another induvial, responsibility for external interfacing or anything which needs leadership of others.
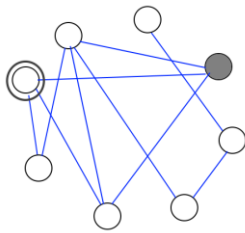
Compare what the diagram shows with the current empowerment within the team – are the people with the most influence the ones empowered with distributed or formal leadership?

Rationale: Distributed leadership is an important concept within CLT and is an idea not commonly discussed within engineering leadership. Starting with this concept, which is likely to be new to many of the participants, gives them new knowledge and insight into their own teams and lays the foundations of the discussions to come. This diagram is simple to draw using a pen and paper and, by drawing the team in a circle, there is a deliberate departure from the hierarchical diagrams the participants will be familiar with in organograms.

Session 2

Task: Examine Administrative Leadership. The primary concept in this task is that Administrative Leadership lays the foundations for work activities by creating a capability. It also can monitor the work activates, but that is a secondary function.

The participants were asked to draw a mind map with the word "Capability" at its centre. The map is to list all of the things which have been done or are being done to enable the team to perform their tasks (an example is provided, see Figure 25). They were also asked to add in a red pen, the things they would like to do in the future to increase the team's capability and their associated dependencies.
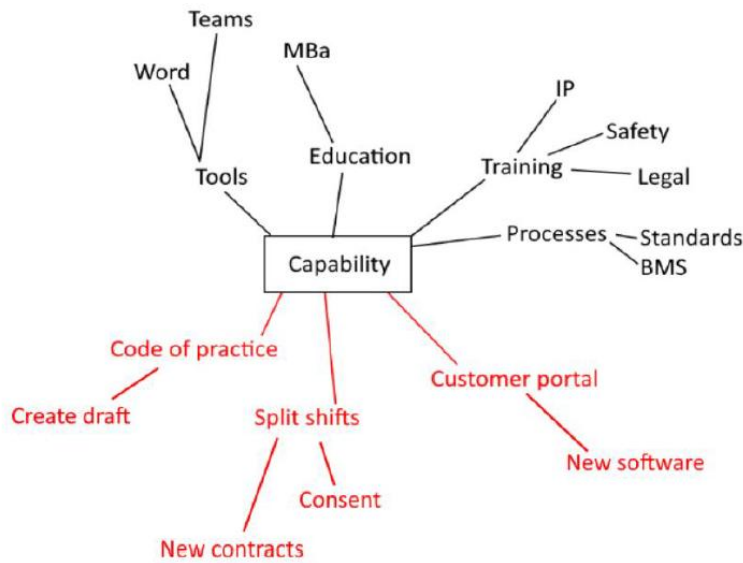
Figure 25 - Example provided of a mind map

Rationale: Administrative Leadership is a fundamental leadership mode within CLT but it gets very little attention from engineering leaders as a topic in itself. A mind map has a number of advantages for this task: The participants are familiar with the method, it is simple to create, only needing a pen and paper, it ties into the CLT concept of networks, it has no natural boundary so also illustrates the CLT concept of complex systems having undefined boundaries.

Session 3

Task: Examine Enabling Leadership and the ways in which it can encourage innovation. The participants were asked six questions about the ways in which innovation is encouraged within their teams:

- What situations would you expect might stifle innovation within your team?
    - Can you control them?
    - Do you cause any of them?
- How might you ensure that innovation naturally occurs during normal operations?
    - How would you capture it?
    - Would you reward it?
- When considering a potentially useful new idea from a team member, what would you consider to be your top three assessment criteria?
    - Would this be a formal process?
    - How would you discuss your conclusion?

- Do you think that everyone has the same potential to innovate or are some people more innovative than others? How does your answer to that question influence your strategy for nurturing innovation?
- How successful do you think activities like structured off-site team meetings are for generating innovation?
    - Do they generate ideas?
    - Do those ideas turn into implemented solutions?
- Looking back at the last time you or someone around you came up with a really good new idea for how you do things, when did it happen?
    - A casual conversation?
    - A flash of inspiration?
    - A structured effort to find a solution?
    - Something else?

They were asked to record their immediate answers to these questions which were then discussed in depth within the session.

Rationale: Enabling Leadership is a key leadership mode within CLT and is often recognized as lacking within engineering management. Encouraging innovative thinking is an aspect of Enabling Leadership which lends itself readily to discussion without needing to be specific about projects and individuals or other details which may be sensitive. By opening the definition of innovation to include continuous improvement and problem solving, these questions can be related to any function within the organization. The questions encourage an examination of how leaders treat new ideas and where those ideas might come from.

Session 4

Task: Consider managing paradox. The briefing gives examples a common paradox seen within organizations which is the centralization/decentralization paradox. In this paradox, the more centralized the functions within the organization become, the greater the drive for decentralization. The more decentralization is achieved, the greater the push for centralization. The participants are asked to think about paradoxes they have seen in their own roles and strategies they use to find balance between contradictory but desirable states.

Rationale: Paradox is a constant theme within writing on complexity although it is a subject not addressed in the Uhl-Bien et al CLT framework. It is also a subject not commonly discussed within engineering leadership.

Session 5

Task: Examining methods for conveying ideas. The participants are asked to look back over their career and the training they have had and examine which format of training works the best for them.

Rationale: A key aspect of Action Research is the passing on of knowledge to the organization. The purpose of this research has always been the application of leadership and so the question of how best to convey the outcomes of the research to the intended audience is an important one.

Session 6

Task: Complete two surveys on leadership, one a self-assessment, the other looking at the leadership in your environment. An online survey tool was used to create the surveys. The surveys were trialled with two engineering leaders and some minor modifications were made prior to launch. The design of the surveys was taken directly from the developed leadership framework (the *5-point framework*) with each questions relating directly to a proposed key aspect of each leadership mode. For example, in Table 7 statements for leadership activities and behaviour have been created to reflect a list of key aspects of the Direction leadership mode. In this example it can be seen that very few aspects of a leadership mode have both an associated activity and behaviour:

Table 7 - Survey design example

LEADERSHIP MODE	KEY ASPECT OF MODE	LEADERSHIP ACTIVITY	LEADERSHIP BEHAVIOUR
DIRECTION	Creates a vision for the future	Deliver a vision of the future which is accepted and used by the business for strategy planning	
DIRECTION	Contextualizes the current situation		When delivering my vision, I contrast our current state with my vision for the future
DIRECTION	Enables priority setting in a wide context	Create a vision for high-level priority setting	
DIRECTION	Sets strategic goals	Set strategic goals which will contribute to achieving the organizational vision	

DIRECTION	Credible authority (to self) for direction	Deliver strategic direction	
DIRECTION	Actions and words in tandem		I make sure that the actions of my team and I are in line with my stated vision and strategy
DIRECTION	Evolution not revolution	Monitor the global business environment and adjust strategies for success	I make sure our strategies evolve gradually over time

The self-assessment leadership survey (survey 2)

This survey was in two parts: The first looked at the day-to-day activities of the leader, the second looked at their behaviour. The statements related to each of the five identified leadership modes (Direction, Strategic Administration, Adaptive Leadership, Enabling Leadership and Tactical Administration). Both were given a 5-point Likert scale for capturing responses to statements. The Likert scale labels for the activity statements were "This is an important part of what I do, I do this from time to time, I might do this occasionally, I rarely do this, I never do this". The Likert scale labels for behaviour statements were "Strongly Agree, Agree, Somewhat agree, Don't agree, Doesn't apply to me". Not all aspects of the five leadership modes could be matched to both an activity and a behaviour. The complete survey is shown in Appendix A.

The leadership environment survey (survey 3)

This survey examines the leadership environment. The term "leadership environment" refers to the leadership experienced directly or indirectly by a leader or team member. This may be from their line manager but will include direction from the senior leadership team, interaction with supporting departments such as Human Resources, IT, Finance and managers of collaborating teams. All aspects of experienced leadership combine to create an overall leadership environment.

This survey was also in two parts: The first looked at the balance of the five leadership modes, the second looked at the perceived success of each leadership mode. The 5 point Likert scale labels for balance statements were "Too often, A bit too often, The right amount, Not quite often enough, Not often enough" and for the success statements were "Strongly Agree, Agree, Somewhat agree, Don't agree, Doesn't apply to me". The complete survey is shown in Appendix A.

Presenting the results

A spreadsheet was created to show the results for each responding participant in the form of four graphs (two for each survey). The purpose of the spreadsheet was to show the measured responses to each of the four aspects of leadership surveyed for one leader (leadership activity, leadership behaviour, environmental leadership balance and environmental leadership success).

Rationale: As the sessions have progressed and aspects of CLT have been examined, a leadership framework has been in development using the output of the sessions to modify and expand the original Uhl-Bien et al. CLT framework (Uhl-Bien, Marion, and McKelvey 2007). By this point in the research, the developed framework seemed stable and this was felt to be a good point to put it to the test, with time for further improvements if needed. A Likert Scale survey was chosen as this is a suitable method for measuring responses to qualitative experiences. Leader survey responses were presented back to the leader as a tool for discussion. This allowed patterns in responses which related to roles and leadership issues to be identified.

As one of the key aspects of CLT is the balance and interaction of the leadership modes, the results were presented with all five leadership modes together for each of the surveyed aspects of leadership. This facet of CLT gives greater nuance of analysis than might be provided by a more conventional leadership survey. While both may identify a lack of Direction, the CLT approach might show (for example) that while there is a lack of Direction, this is being somewhat mitigated by a high level of Enabling Leadership (as both leadership modes give guidance).

Session 7

Task: Discussing leadership support networks. The brief describes the ways in which many leaders around the organization can be important for the success of a single leadership task. Examples are given in the context of engineering leadership and a simple spreadsheet is provided with an example showing how to fill out the details. The following is from the briefing sheet:

Instructions for filling out the spreadsheet:

The blank sheet looks like this:

Leaders in order of regular interaction	Direction	Strategic Admin	Adaptive	Enabling	Tactical Admin
1					
2					
3					
4					
5					
6					
7					
8					

Colour code

(green)	Working well
(yellow)	Hit and miss
(orange)	Falls short

For each column, fill in a role title for each leader who you need to support you, in the order of need/interaction. Then colour code the cell using the colours on the right.

When complete, it should look like the example below:

Order of regular interaction	Direction	Strategic Admin	Adaptive	Enabling	Tactical Admin
1	Director of IPT	HR Manager	Director of IPT	Director of IPT	Senior Programme Manager
2	VP Engineering	HR Director	Senior Technical Authority		Lead Engineer
3		Finance Director	Senior Programme Manager		
4		Quality Manager			
5		Engineering Process Manager			
6					
7					
8					

Colour code

(green)	Working well
(yellow)	Hit and miss
(orange)	Falls short

Rationale: An important aspect of CLT is dynamic networking and this exercise looks at how this concept can be applied to leadership within an organization. This is an area not explicitly covered in the 5-point framework or the original Uhl-Bien et al. CLT framework (Uhl-Bien, Marion, and McKelvey 2007) and, as an important aspect of Action Research is the sharing of knowledge, this was added to the sessions to enrich the discussion.

Session 8

Task: The participants were given a presentation which showed the 5-point framework which had been developed through the Action Research sessions. They were asked to critique the presentation and discuss how it might be deployed to the wider organization.

Rationale: An important aspect of AR is enacting change within the organization. This requires a suitable method of training or communication and this task allowed the participants to influence the form that this would take.

3.7. The Action Research groups

For the Action Research, four groups of seven participants were created (n=28). The four groups allowed for different time-zones to be accommodated and some cross referencing between discussions. Seven participants allowed for a manageable video-call size which could tolerate some non-attendance without the structure of the meeting getting lost. Before each AR meeting, a task would be circulated to be performed ready for discussion in the call. The calls were recorded and automatically transcribed. An improved leadership framework was to be developed as the AR sessions progressed.

3.8. Research population

The collaborating organization is a multinational engineering organization which specializes in aerospace and defence (but which has many other disciplines in its portfolio) and is described in detail in section 4.2. With around 4000 employees it has approximately 850 leaders (852 at the start of the research) in 16 business units based in the UK, USA, Canada, Australia, South Africa, Thailand and Ireland. These leaders are identified as the research population for this study. From that group, 90 participants came forward to take part in the Action Research. 28 participants (four groups of 7) were initially selected to participate. The sampling strategy was purposive: the inclusion criteria used for selecting study participants was diversity. First, geographic diversity was prioritized, and time-zones were established for grouping. Within those, an even balance of men and women was the aim, with a preference for different business units and roles as far as possible.
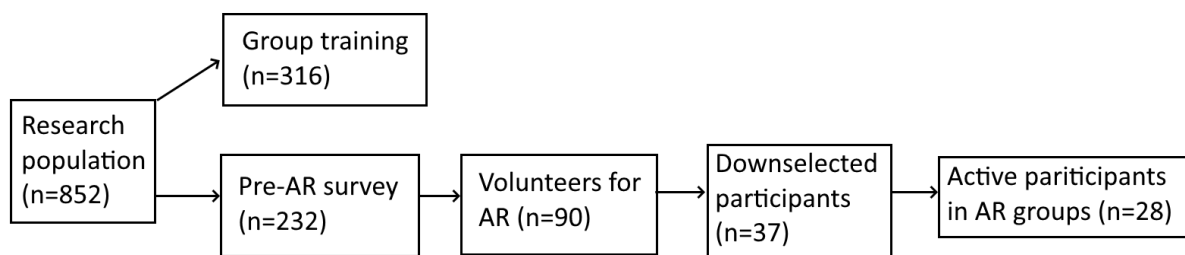
Figure 26 - Participant breakdown

Leadership roles in the Participant group range from Vice President (VP), through Head of Department to Senior Engineers and managers of small teams. During the research, 26 people left the business from the original list of 90 participants. If any gaps arose in the 28 Action Research participants, the opening was advertised within the original group of 90 (or what remained of that group) and the gaps were quickly filled giving a total of 37 participants in all by the conclusion of the AR.

Research population demographic

At an early stage in the research, the research population (852 leaders) were invited to take part in a survey which was presented as part of a leadership training programme. This survey had 223 respondents (26% response rate). 30.7% of the respondents were female. Only 8.3% stated that they considered themselves ethnically different to the majority in their workplace.
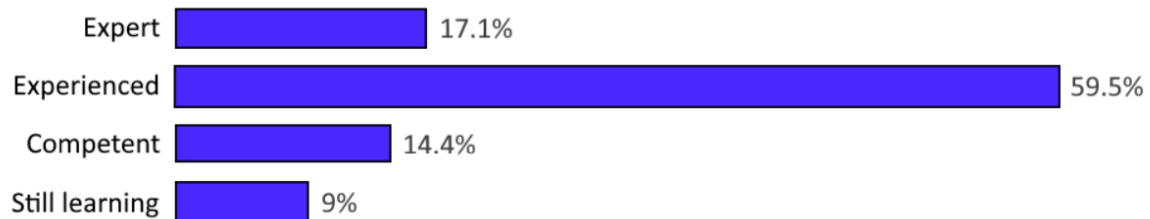
Figure 27 - Leadership experience - Research Population

The declared leadership experience levels are shown in Figure 27 and the geographic demographic is shown in Figure 28. Most of the respondents being experienced leaders based in the UK, USA and Canada.
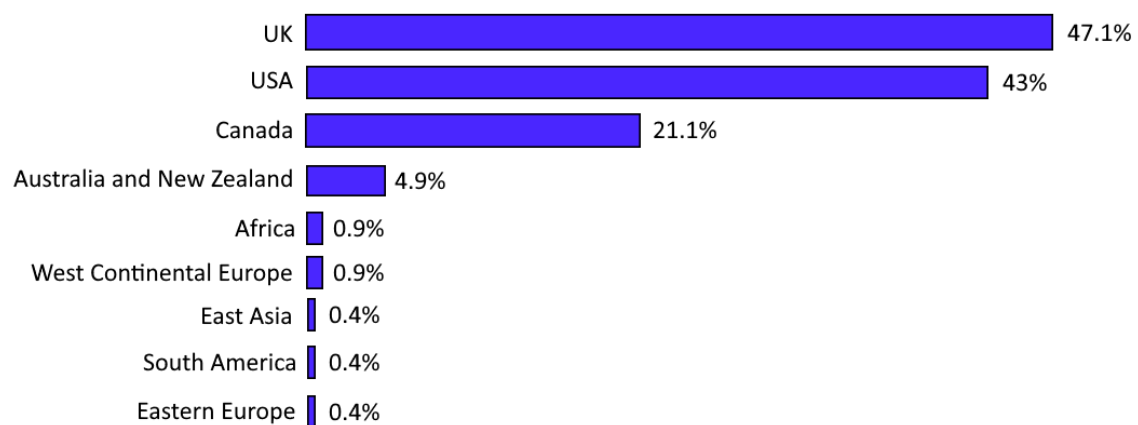
Figure 28 - Leader demographic - Research population

The education background of the respondents is shown in Figure 29. The majority (80%) having an educational background in engineering or business.
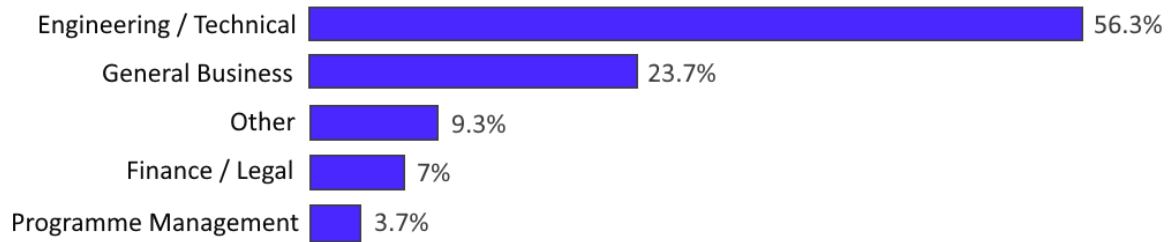
Figure 29 - Educational background - Research population

From within this initial set of respondents, participants were requested to take part in the Action Research. 91 participants came forward. With a nominal capacity of 27 participants in the AR plan, a purposive sampling strategy was used to try and achieve a good geographic spread and a close balance of male and female leaders within the selected participants. The widest spread of geographic locations was also an inclusion factor, along with the need to group participants by similar time zones to make the meetings more practical.

The complete list of job titles for the Participant pool is shown in Table 8. It contains many Directors and other senior leaders. The list of potential candidates was generated by the Human Resources system using the criteria of any employee who is also a line-manager. This ensured that the leaders selected had direct responsibility for people rather than a capability or technology.

Table 8 - Job titles for all AR participants

BIS Manager	Functional Manager - Mechanical	Programme Manager
Business Area Director	Functional Manager - Software	Programme Manager
Business Area Director	Functional Manager - Systems	Programme Manager
Business Change Lead	GCS Systems Manager	Project and Systems Engineering Manager
Chief Engineer	Global Category Manager	Project Manager
Chief Engineer	Global Procurement Process Owner, Group Procurement	Project Manager
Chief Engineer	Global SVP Human Resources	Project Manager
Director Business Development	Group Program Director	Quality Assurance Manager
Director of Business Transformation and Continuous Improvement	Head of Commercial	Quality Systems Manager
Director of Business Transformation and Continuous Improvement	Head of Consultancy & Compliance	Regional HR Manager
Director of Contracts	Head of Electronics and Electrical	Senior Chief Engineer
Director of CSC Engineering	Head of Engineering	Senior Director C2 and Intelligence Solutions (Sales)
Director of Engineering	Head of Repairs	Senior Functional Lead
Director of Engineering	Head of Systems	Senior Human Resources Business Partner

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Director of Global Benefits	Head of Trade Compliance	Senior Program Manager
Director of Manufacturing Engineering	HR Business Partner	Senior Program Manager
Director Of Operations	Manager - Systems Engineering	Senior Programme Manager
Director of Operations Planning	Manufacturing Engineering Manager	Software Development Team Leader
director of PMO	Manufacturing Services Director	Stores & Logistics Manager
Director of Programs / Site Lead	Manufacturing Services Director	Stores & Logistics Manager
Director of Tax (US)	Operational and 3rd Line Support Manager	Supply Chain Manager
Electrical & Electronic Engineering Manager	Ops Manager, EMEA and APAC	Supply Chain Manager
Electrical Engineering Manager	Planning Manager	Talent Acquisition Manager
Engineering & Innovation Director	President	Talent Acquisition Operations Manager
Engineering & Innovation Director	President Strategy and Corp Dev	Team Lead, Validation
Engineering Manager	Production and Support Services Manager	Technical Compliance Team Leader
Engineering PLM Manager	Production Supervisor	Technical Manager
Functional Lead	Program Manager	Trade Compliance Manager
Functional Manager	Program Manager	Vice President
Functional Manager	Programme Manager	Vice President Engineering
		Warehouse/Inventory Supervisor

The job titles for the group selected for AR is shown in Table 9. By comparing the two lists, it can be seen that a wide variation in job titles has been maintained during the sampling process.

Table 9 - Job titles for those selected for AR

Programme Manager	Director of Operations Planning
Functional Manager	Senior Programme Manager
Director of Tax (US)	Sr. Director C2 and Intelligence Solutions (Sales)
Project Manager	Programme Manager
Project Manager	Manufacturing Services Director
HR Business Partner	Quality Systems Manager
Senior Chief Engineer	Vice President
Director of CSC Engineering	Technical Compliance Team Leader
Director of Contracts	Head of Commercial
Quality Assurance Manager	Stores & Logistics Manager
Chief Engineer	Engineering & Innovation Director

Director of Programs / Site Lead	Supply Chain Manager
Electrical Engineering Manager	Business Area Director - Radar Programs
	Ops Manager, EMEA and APAC
Programme Manager	

The rest of the demographic data for the AR participants is as follows: Female leaders are 46% of the group. By country, UK (41%), USA (33%), Canada (19%), Ireland (4%), Australia (4%). This shows a similar geographic spread to the overall research population, but a much more balanced male/female spread.

3.9. Research conception

As the research aim is to generate a complexity leadership framework which can be applied in a complex engineering organization, the research has been designed to result in an applicable framework which can be used by practitioners. To achieve this, a staged approach was used as illustrated in the following diagram (Figure 30):

Figure 30 - Research Design

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The research activities were sequenced as illustrated in Figure 31. In this figure (which is sequenced left to right) the research activities are shown above the theoretical development. Arrows indicate feedback to and from the theory to the research.
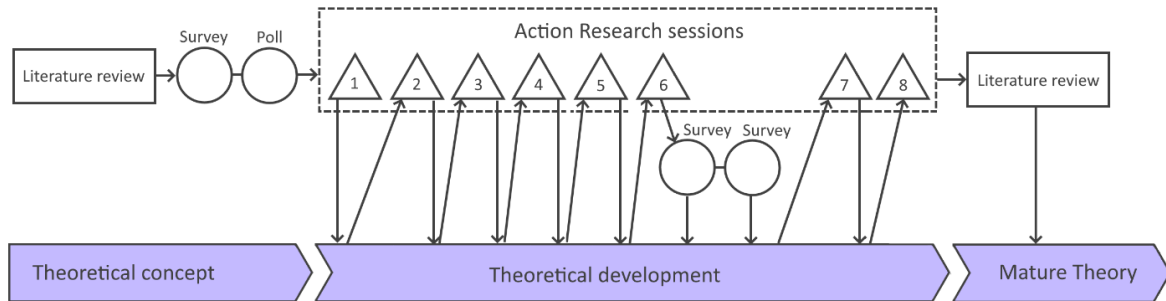
Figure 31 - Research sequence

The AR was split into 8 sessions (Figure 31) represented as triangles. These took place using MS Teams conferencing software over two years from May 2022 until November 2023. Session 6 involved two surveys, shown as circles, which then fed new information into the developing theory. After the research, the literature review was updated to reflect changes in the developing theory. The AR Participant group was split into four. Each group's responses were fed into the next (where relevant) and the sequence of the groups was changed each session so that no one group was always receiving the output of the other three.

For each session, the four groups received a task relating their leadership to a concept within the theory (e.g., Enabling Leadership, managing paradox etc.). The task required them to investigate an area of their leadership practice. They then brought the output of the task to the group session to discuss the results. The cumulative feedback from the four groups was then documented. The document was then circulated to the Participant groups so that they could check that that it was an accurate reflection of the session. The output documents were not intended as minutes (the sessions were recorded and transcribed already), rather they were intended to compile the insight from all four sessions. Sometimes this would produce an update to the developing theory, sometimes a stand-alone model relating to the area of leadership which was the focus of the session.
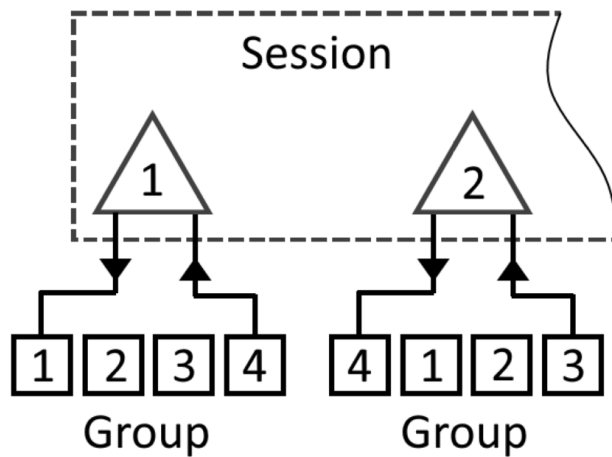
Figure 32 - AR Session Design

For each group, a video conference was set-up where 30 minutes was spent discussing the task and any insights it may have given to their role as leaders. If the topic being discussed did not fill the hour, in the concluding 30 minutes the group were presented with pre-prepared discussion material (often in the form of scenarios) and asked to respond. Both the task and prepared material were intended to provoke a discussion on an aspect of Complexity Leadership Theory, comparing the theory to the experience and responses of the participants. Once all four discussions were complete, the transcripts were reviewed for themes and insights which were then used to create an output document. This document was then sent to the participants for review to ensure an accurate reflection of the discussions.

3.10. Individual Studies

This section contains the methods used in individual studies within the report.

a) Literature Reviews

The following studies are presented in Chapter 2. The search strategy for each is presented in turn:

Leadership and Engineering Leadership (p.22)

This review was conducted using SCOPUS and Web of Science databases for bulk data gathering. The SAGE Knowledge: Business and Management Collection was also examined for expert publications. These databases were found to be good sources of relevant, peer reviewed data.

Database	Search Strategy	Number of articles

SCOPUS & Web of Science	Search within keywords in SCOPUS and TOPIC in WoS: "Engineering Management" OR "Engineering Leadership" between 2021 and 2025	2,098 found in WoS 592 found in SCOPUS
SAGE Knowledge: Business and Management Collection	"Engineering Management" OR "Project Management" OR "Programme Management"	556 results

Literature Review – first search

The literature review was conducted in two phases. The exploration in phase 1 was primarily a systematic literature review and was conducted in 2021, (see PRISMA flow diagram in Figure 33). This was wide ranging and designed to capture as full an understanding of the theoretical context as possible. The literature review shown in Chapter 2 herein is an updated version of this original review and does not use a systematic approach as it was felt that any constraint on material sources would be counterproductive at this stage of the research. Where the initial review was an exploration from which a research gap and direction could be determined, this later revision is more focused on delivering a narrative for the context of the research as it developed to become.
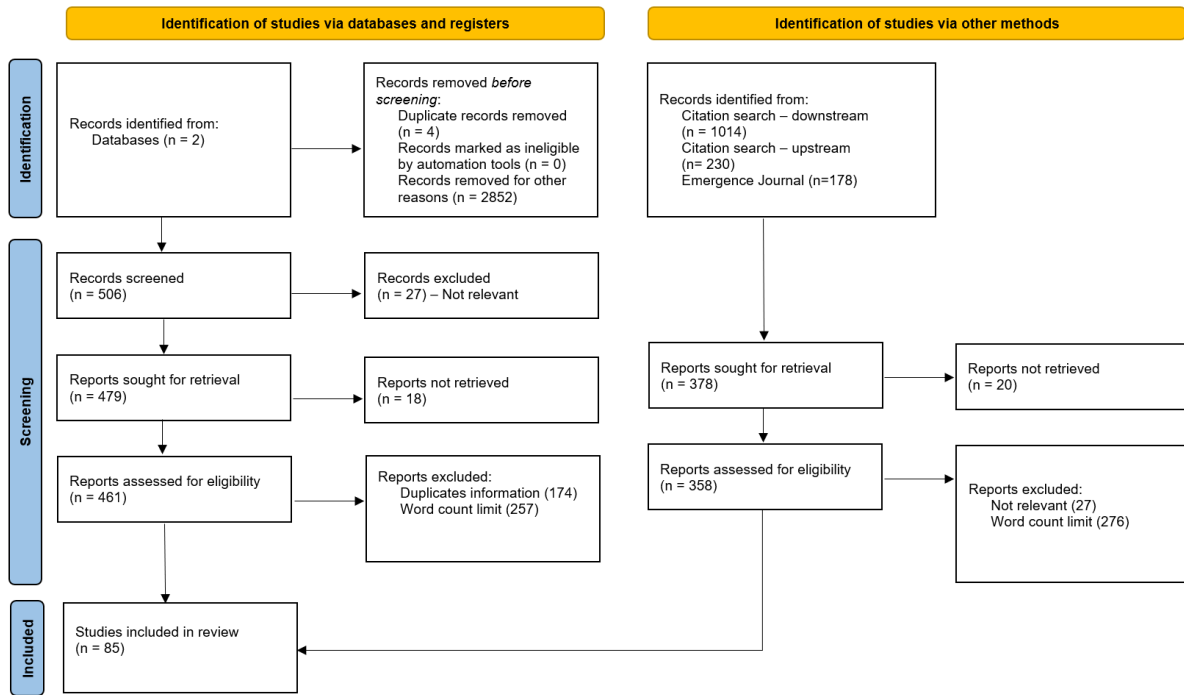
Figure 33 - PRISMA flow diagram for initial literature review

The search strategy used was as follows:

The search terms were focused on finding literature which examined the interplay between complexity and leadership (or management). "Complexity Leadership" or "Complexity" AND "Leadership" was effective in finding articles relating to Complexity Leadership Theory. "Complex Adaptive Systems", being the parent theory for CLT was another area of interest. "Complexity" AND "management" was targeted at finding more general discussions on managing complexity. "Complexity" AND "Engineering" was intended to find articles which were parallel to the research in both theory and research population. "Complexity" AND "Success" was intended to find discussions on the relative merits of different strategies for leading complexity. Journal articles, conference proceedings and books were found by the search. Books were rejected if they were not accessible for review (in Brunel digital library or by purchase at a modest cost). Journal articles were rejected if download for review failed. This initial search strategy resulted in a total of 997 retrieved publications (4 of which were physical books, the rest digital downloads). Journals such as The Leadership Quarterly, Emergence: Complexity and Organization and IEEE TEMS were found to regularly feature commentary on complexity leadership and emergence.

Table 10 – Initial Search Strategy

Database	Search Strategy	Number of articles

Web of Science SCOPUS	Search All Fields with: "Complexity Leadership" OR "Complex Adaptive Systems" OR "Complexity" AND "leadership" OR "Complexity" AND "management" OR "Complexity" AND "Engineering" OR "Complexity" AND "Success" Then add filters which select the date ranges 1990-present and categories as: Engineering Aerospace Engineering Multidisciplinary Management Business The results were then ordered by most cited first and reviewed for relevance, initially by title, then by abstract if the title looked relevant.	Search Q1 and Q2 or 2020 3358 found 506 selected for closer review 479 retrieved 461 eligible after duplicates removed
Researchgate.net	Searching for specific publications cited in publications of specific interest where not available in the SCOPUS or Web of Science databases and not already retrieved.	1014 found 378 relevant to research 358 retrieved
Emergence Journal	All available articles and editorials.	178 articles retrieved

The search terms used were successful in finding a wide range of literature relating to complexity leadership but two of the search terms were almost entirely redundant: "Complexity" AND "Engineering" returned a lot of literature on the general problems of managing large engineering projects but no articles relating leadership theories to solving that problem (with perhaps one exception which was based on using CLT in aerospace supply chain management). "Complexity" AND "Success" was similar in that the search returned many off-topic results and none of the hoped-for content.

Literature Review – second search

The second search was conducted in 2024. Initially, it was intended that this second search would be targeted at publications between 2020 and 2024 to update the initial search results. During the search, it was discovered that some highly relevant publications from earlier dates were now visible to the search method where previously they had not been found (either by a search or by a citation review) and so the date range was expanded to include articles publications from 2000 to 2024 found during an updated citation search. The strategy for this updated search is shown in Table 11.

Table 11 - Update search strategy

Database	Search Strategy	Number of articles
SCOPUS & Web of Science	Search within Title, Abstract, keywords: "Complexity Leadership" OR "Complexity" AND "leadership" OR "Complexity" AND "management" OR "Complexity" AND "Engineering" Then add filters which select the date ranges 2020-present and either "Engineering" or "Business Management and Accounting" as a subject area. Only new and relevant journal articles were retrieved.	14,362 results (WoS) 8,654 results (SCOPUS) 15 retrieved.
Review of citations in new downloaded publications	Check all citations for relevant articles which were not found in the original search. All date ranges. Criteria for inclusion as per the original search strategy in Table 10.	16 items retrieved.

b) Investigation - Informal interviews

During the investigation in phase 1, work was done to condense the widespread and diverse discussions on complexity and CLT into concepts which could be explained to the target audience (i.e., an engineering organization). In order to do this, a single specific idea was chosen as the catalyst for the research, namely the leadership framework presented by Uhl-Bien et al (Uhl-Bien, Marion, and McKelvey 2007). The ideas in this framework were then presented in informal (exploratory) interviews. These

were held during 2020 and the first half of 2021 with programme managers (n=2), Chief Engineers (n=2), senior engineering leaders such as VPs (n=3), high ranking employees involved in transformation at group level (n=3) and the CEO and CTO of the group (n=2). These interviews brought clarity showing which ideas were readily understood, which were difficult to convey, which were misunderstood and where there were concerns raised.

When the Action Research was underway, occasional informal discussions would naturally take place outside of the structured group discussions. Occasionally these informal discussions would generate critical insight into the relationship between theory and practice. Such insights were recorded as part of the industrial investigation.

3.11. Planning and Ethical Approval

Phase 2 was designed to create a solid foundation for the primary research. During the planning stage, formal ethical approval was obtained for the research from Brunel University London (ID: 31672-LR-Dec/2021- 36672-2) and from the collaborating organization. To maximize the research population, the CEO of the group which contained the collaborating organization was formally approached for approval to conduct research activities with leaders across the entire group of companies (n=852). After some negotiation, this approval was granted. This enabled the research to be international as the leaders were based in the UK, USA, Canada, Ireland and Australia. The aim and objectives were developed to address the research questions in the context of achieving improvements in the effectiveness of leadership as an overall goal. The research methodology was developed to form a conceptual structure. As the research topic is leadership, it was always known that there would be a strong human element to the research and early concepts for research methodology were primarily based on qualitative research. This was then refined to a dominantly AR based approach as this methodology is considered highly suitable for affecting organizational transformation.

3.12. Multi-method research approach

A multi-method research approach is one where research is conducted using more than one method of primary data collection. Although the principal method used in this research is Action Research, this has been augmented by surveys and a poll which were used before the AR to validate the research scope, and during the AR to validate the developing framework as an analytical tool. The purpose of these additional methods is to gain additional verification that the Complexity leadership concepts are both understandable and useful. The research structure is show in Figure 34 below.
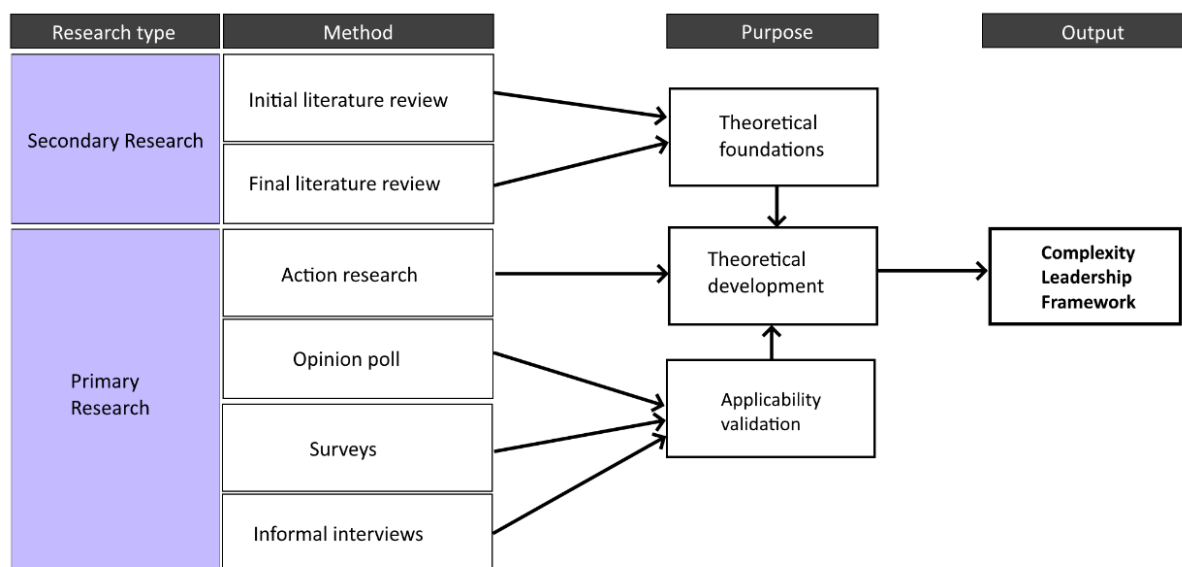
Figure 34 - Research Structure

Figure 35 shows how the multiple research methods work together to generate a robust theoretical development which culminates in a mature complexity leadership framework.

3.13. Research detailed design

Throughout the research, surveys were used to validate certain assumptions, learn more about the way the theory relates to leaders or to trial the developed theory. In all, three surveys and an opinion poll were used in this way. All surveys used the Jasc Online Survey tool and the opinion poll used an inbuilt polling function in the Zoom web-conferencing tool.

Survey 1

The purpose of the first survey was to give a pre-research view of both the perceived health of leadership within the collaborating organization and the balance of the leadership modes (i.e., Administrative, Enabling and Adaptive). This was based on an initial concept that a certain leadership environment could be measured for leadership imbalance.

The survey was presented in the form of an online questionnaire. It employed a four-point Likert Scale with 28 positively phrased statements. For example, statements such as "When leading (or co-leading) a new project or team activity, I have confidence in future success" were aimed at giving a general measure of leadership health, whereas statements such as "Our contracted responsibilities are well understood by me and the team" were intended to give an indication of the presence of Administrative Leadership.

In total, 232 survey responses were collected (27% of research population of 852). The Likert scale was chosen as it is particularly suitable for qualitative responses which have no scalar value (i.e. comparative responses). The sampling strategy was purposive. The inclusion criteria was all leaders identified within the organization as having responsibility for one or more employees.

Surveys 2 and 3

These surveys are a part of the Action Research, the design is described and are detailed in section 4.6, session 6. As these surveys were part of the AR, the sampling strategy was purposive: all AR participants were invited to complete the surveys. The surveys were intended to measure the leadership situation for a specific leader. Survey 2 measured the leader's current distribution of leadership bias for the five leadership modes using 54 questions. This bias was measured for their current leadership role and for their personal ideal situation. Survey 3 measured the leadership environment which the leader was experiencing using 58 questions. This was a separate survey to enable any individual to measure their leadership environment regardless of being a leader.

Both surveys were presented as on-line five-point Likert scales with questions divided into sections which correspond to each leadership mode (Direction, Strategic Administration etc.). The Likert scale was chosen as it is particularly suitable for qualitative responses which have no scalar value (i.e. comparative responses). The meaning of the responses in relation to the survey goal (e.g. balance, quality, current modes, preferred modes) was derived in the later discussions during the AR sessions. All questions asked were traceable to the developing theory.

Figure 35 shows an example of the survey design. In this example you can see the way that the Likert scale is changed depending on the context of the questions. This gave a more relevant set of scales than could be achieved with a more generic scale. One Likert scale was used for each aspect of leadership being measured (Behaviour, Action, Balance and Success).

Figure 35 - Example of survey design (Survey 2)

Poll Design

The research population were invited to training sessions in the form of group video conferences using the Zoom software. During this training, they were introduced to the three leadership modes in detail, using the models presented in section 3.14 (see also Biggadike, Evans, and Pei 2022). For each, the required competencies, challenges, goals, and tools were presented along with signs of imbalance. Polls were then taken asking which leadership modes they see most often and which they would like to see more of. In total, 316 responses were received to the poll (37% of research population). The primary purpose of the polls was to engage the participants in a discussion which used the leadership framework for comparison to their lived experience. What was apparent from this exercise is that, although leadership analysis for any given area of an organization may take time to undertake, the concepts in the complexity leadership framework were quick and easy to understand and the leaders in the training were quick and enthusiastic to use the vocabulary to discuss issues in their workplace which they may have previously struggled to articulate.

3.14. Design and development of the research communication tools

As this research uses an inclusive participatory methodology (i.e. Action Research), it was considered important to first design ways of communicating CLT which were readily understood by the target participants. This was important both from the perspective of the teaching element which the research entails but also critical for gaining high level support within the organization for the research activities.

It was originally envisaged that action research would be used to introduce complexity leadership theory at a theoretical level, developing it iteratively into a working complexity leadership framework over time. In line with the ethos of the methodology, repeated discussion and collaboration was used to validate this initial proposition (using informal interviews). Through this process, it became clear that this approach would not be successful as the research participants were not accustomed to using theory to influence their practice. For some, the theories in CLT felt close to their own thinking making the conceptual leap relatively simple, but they were still left with questions on how the ideas could be applied. For others, arguably the target audience for transformation, CLT was too dissimilar to their current worldview to allow assimilation and adoption of the theory as a set of ideas. Ultimately, it became clear that the most practical route to gaining support for the research was the development of an initial training pack which outlined a model for the application of CLT using a familiar presentation style. The sequence of development for this communication tool is shown below in Figure 36.
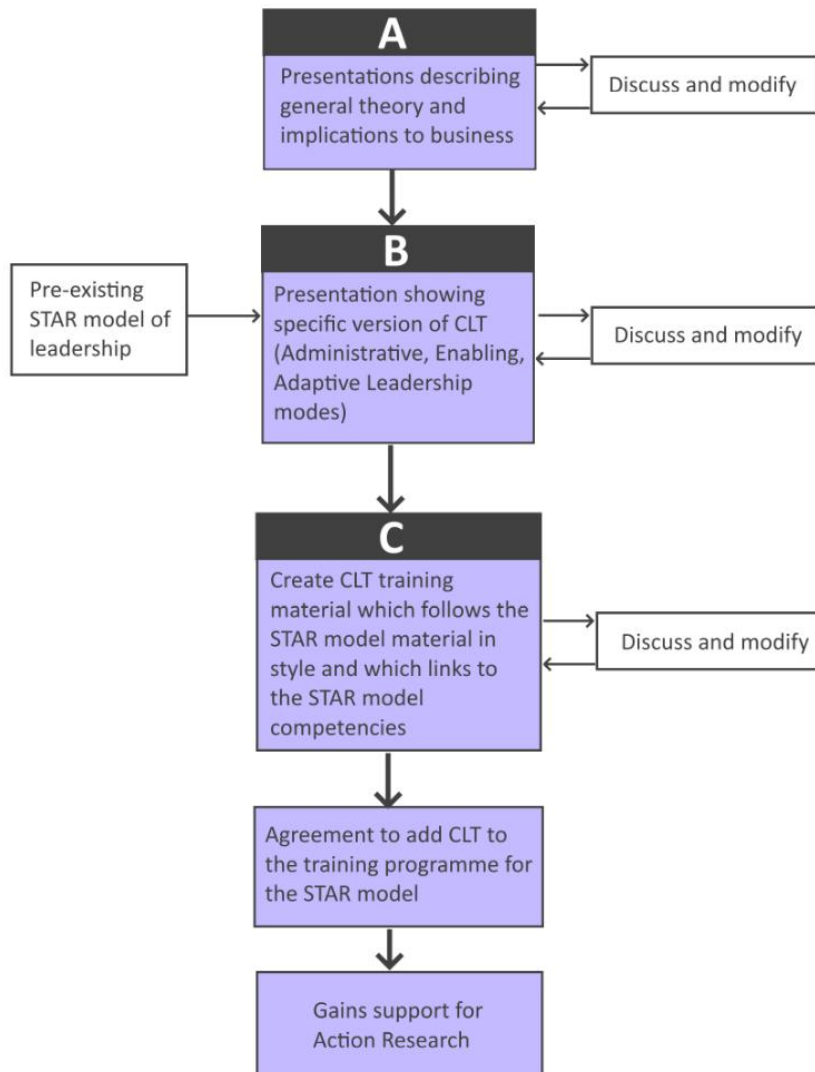
Figure 36 - Development of a CLT training tool

The first presentation ("A" in Figure 36) presented a collection of CLT concepts which was inspired by the literature review. These concepts were intended to build a picture of the theory and the way it related to an organization. Images from this early presentation are shown in Figure 37 and Figure 38.

The second presentation ("B" in Figure 36) presented the leadership model proposed by Uhl-Bien and Marion (Uhl-Bien, Marion, and McKelvey 2007). This introduced the idea of three types of leadership (Administrative, Enabling and Adaptive) being important for leading complexity. Images from this presentation are shown in Figure 39 and Figure 40.
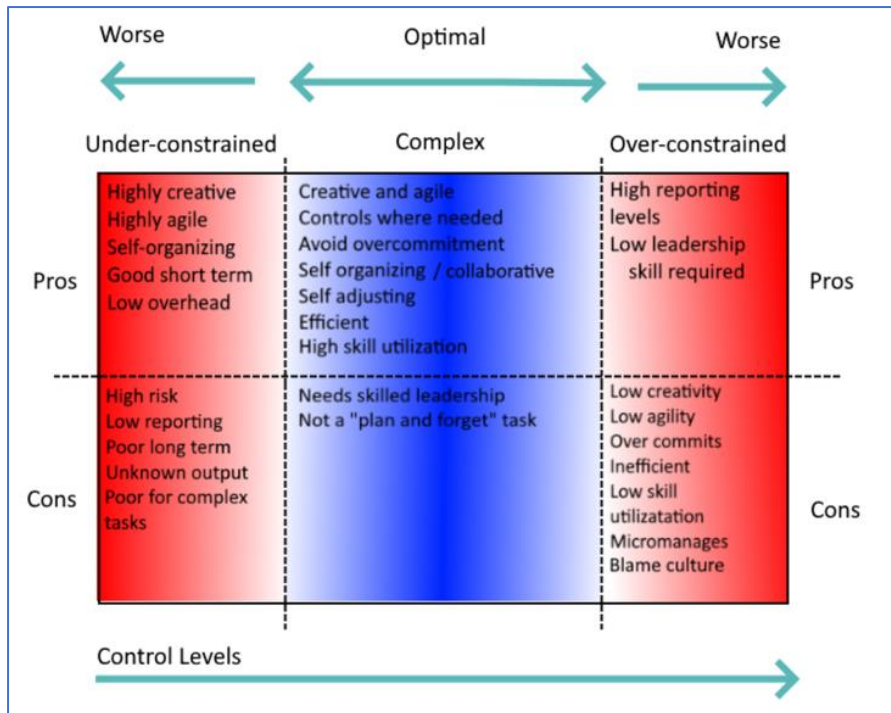
Figure 37 - Image from presentation A
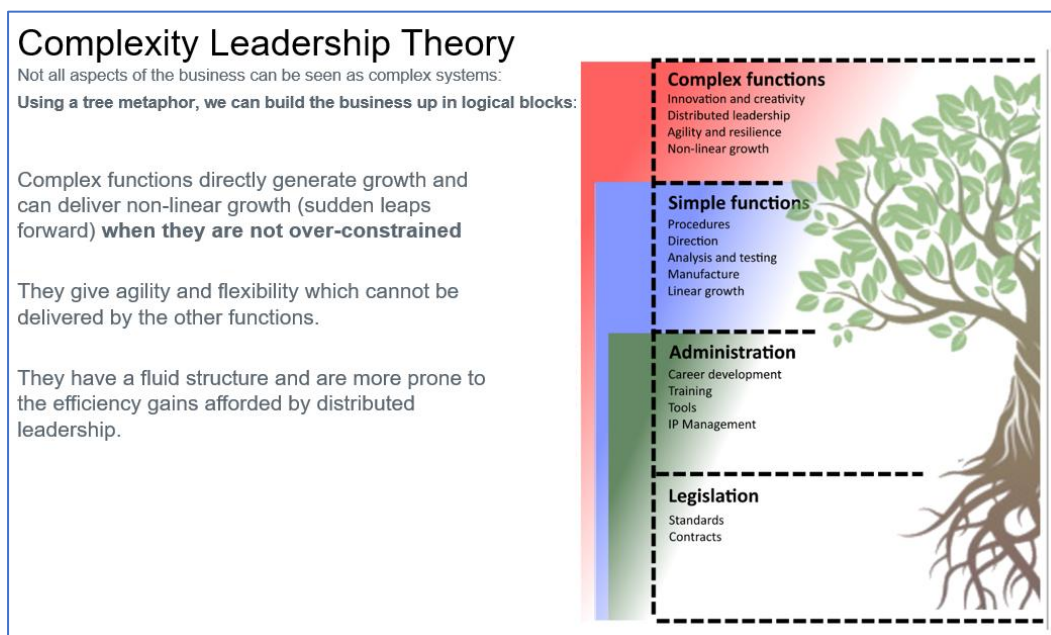
Figure 38 Image from presentation A

From discussions and presentations, it was felt that second presentation (B) was focused and simple enough to allow a meeting with the CEO and Senior Executives. The purpose of the meeting was to gain support for the research and to ask if the research should be combined with other current transformation initiatives or kept as a stand-alone activity.

Figure 39 - Image from presentation B
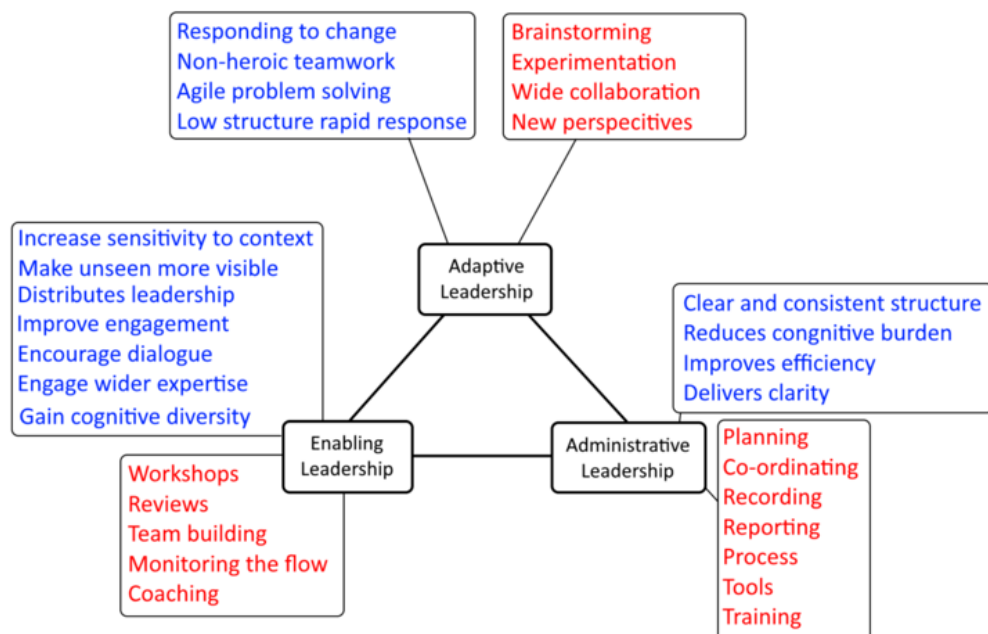
Figure 40 - Image from presentation B

The Chief Executive Officer (CEO), Chief Finance Officer (CFO) and Group Human Resources Director were the audience. As the highest authorities within the organization, they had the power to authorize or deny group-wide support for the research. Without their buy-in, the research would be confined to a single business unit with around 300 employees.

They understood the ideas presented but did not want the research to be run as a stand-alone thread of activities within the business; this was because there were already many transformation threads active across the business and the cost and disruption of adding another was unpalatable. In response to the need to integrate the research into one of the existing activities, presentation B was expanded and modified

to fit the style of the pre-existing "STAR leadership model". The STAR model (a custom-built leadership model commissioned by the organization) is a list of 12 leadership competencies which the business had identified as important. The researcher could see no conflict between the STAR model and CLT and was able to map one to the other to form presentation C. In summary, the STAR model speaks of competencies while CLT defines the combination, balance and deployment of those competencies when managing complexity. Presentation C is shown in figures Figure 41 and Figure 42.
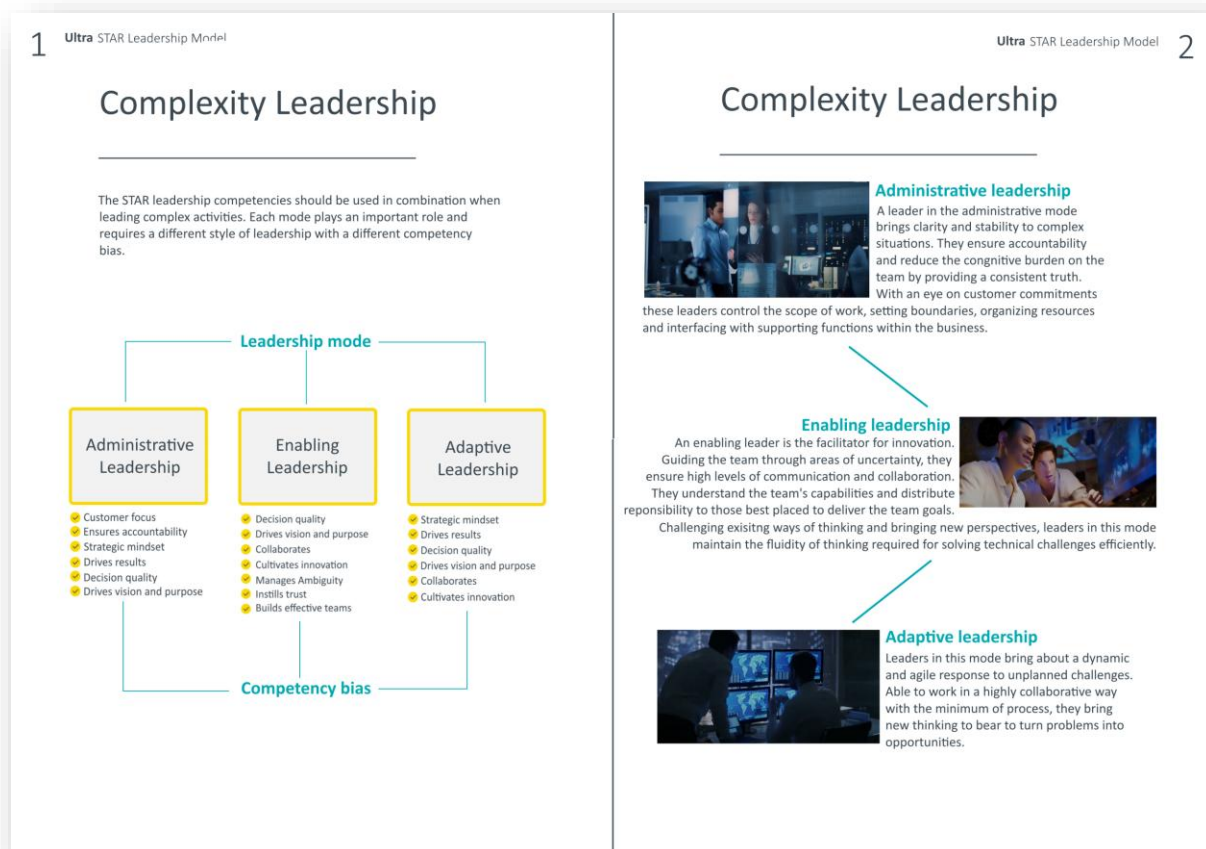
Figure 41 - Image from presentation C

The style of layout, font, colour scheme and illustration style used in presentation C all match the material which had been professionally generated for explaining the STAR model. By using the corporate scheme, the message of the presentation became unhindered by style preferences and the overall feel was much more professional. When presentation C was shown to the CEO, CFO and Group HR Director they became convinced that the ideas of CLT could be integrated into the existing work on transforming leadership.

The graphical summary sheets shown in Figure 42 were designed to get many ideas across to the audience in a single image. These images, one per leadership mode (3 modes in total at that time) could be presented and talked through with a pointer to explain different facets of each mode. The introduction of "balance check" was a development of the statement in the original publication that achieving a balance between complexity dynamics and bureaucracy is a challenge (Uhl-Bien, Marion, and McKelvey 2007 p. 304). While this idea was lightly delivered in the Uhl-Bien et al. paper, the idea of the importance of balance struck a chord and has remained an important part of the developed framework.

Figure 42 - Image from presentation C

Figure 43 - Enlarged view of presentation C (i)
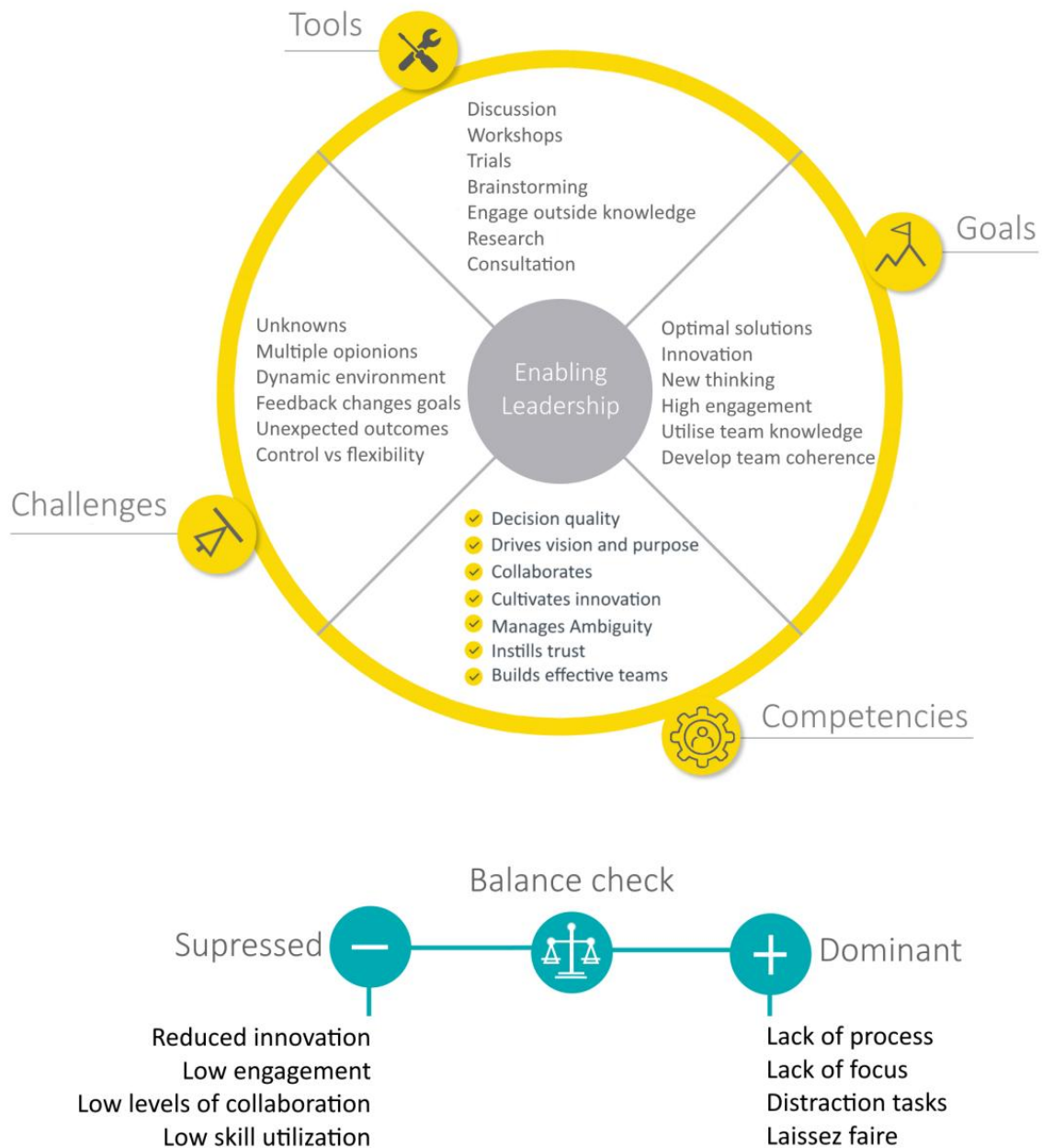
Figure 44- Enlarged view of presentation C (ii)

Figure 45- Enlarged view of presentation C (iii)

Complexity Leadership

Administrative leadership

A leader in the administrative mode brings clarity and stability to complex situations. They ensure accountability and reduce the congnitive burden on the team by providing a consistent truth. With an eye on customer commitments these leaders control the scope of work, setting boundaries, organizing resources and interfacing with supporting functions within the business.

Enabling leadership

An enabling leader is the facilitator for innovation. Guiding the team through areas of uncertainty, they ensure high levels of communication and collaboration. They understand the team's capabilities and distribute reponsibility to those best placed to deliver the team goals. Challenging exisitng ways of thinking and bringing new perspectives, leaders in this mode maintain the fluidity of thinking required for solving technical challenges efficiently.
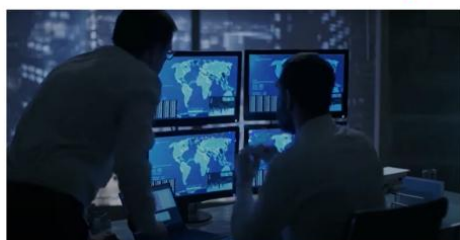
Adaptive leadership

Leaders in this mode bring about a dynamic and agile response to unplanned challenges. Able to work in a highly collaborative way with the minimum of process, they bring new thinking to bear to turn problems into opportunities.

Figure 46 - Enlarged view of presentation C (iv)

3.15. Trustworthiness

The research is examined for exhibiting a sufficient level of credibility, dependability and reliability from the perspective of a qualitative research study with the primary research method being Action Research. The measure of overall trustworthiness is achieved with four criteria: credibility, transferability, dependability and confirmability. Each is examined in detail using the criteria defined by Lincoln and Guba (Lincoln and Guba 1985):

Credibility

Credibility refers to the extent to which methods have been used which demonstrate the discovery of underlying truths. This study achieves credibility by using mixed methods which triangulate results. The surveys are validated using quantitative analysis as well as review and feedback methods. The results of the surveys triangulate with the results of the AR. Data gathered in the AR is subjected to thematic analysis and a manual review with feedback from participants. The resulting leadership framework was trialled with independent businesses as well as the participating organization. The research is compared to parallel studies for supporting findings or contradictions. The primary research method uses multiple groups of participants over a longitudinal period. The credibility of the research design is examined in section 3.15.

Transferability

Transferability is the extent to which the results of this study can be applied (generalized) to other situations. This study demonstrates transferability by a trial with independent businesses of varying size and type. It also demonstrates transferability through the use of a large number of participants from different business units spread geographically across UK, Ireland, Canada, USA and Australia.

Dependability

Dependability is a measure of the extent to which the research could be repeated with similar results. This study achieves dependability by having a clearly documented and structured research design. All of the briefings for the AR are presented in full. The surveys used are also presented in full, with validating analysis methods.

Confirmability

Confirmability is a measure of the objectivity of the study, looking for the avoidance of researcher bias. Triangulation is the primary method used in this study to avoid researcher bias. Specifically, the use of validated surveys to examine correlation with

AR data (which is naturally open to influence by the researcher) and cross referencing with parallel research demonstrate that researcher bias has not unduly influenced the research.

3.16. Chapter Summary

The research design has been generated to achieve the research aim and objectives. The primary research methodology is Action Research. This methodology has been chosen as the most appropriate way of developing new practice through research and is targeted at all five objectives (see section 1.2):

The AR is augmented by surveys and an opinion poll. These are intended to validate and inform the action research plan. One of the most critical aspects of this research is the design for communicating the ideas of complexity leadership to the research population. These methods of communication have been repeatedly iterated throughout the research to create an effective visual language to compliment the developed theory. Underpinning the primary research is the secondary research in the form of Literature Reviews and Bibliometric analyses. These both identify gaps in the existing research and ensure a firm theoretical foundation for the developing theory. The following chapter will show how the research methodology was deployed in the form of an industrial investigation.

4. Industrial Investigation

Chapter	Phase	Purpose	Method
4	Investigation Development	Engage with research population Conduct research Develop framework	Action Research, Surveys

This chapter is intended to provide a detailed view of the environment in which the research was conducted of the participants and the research results and output. Starting with an overview of the research context (4.1) and the details of the collaborating organization (4.2), it describes the potential impact of the research (8.4) and presents the demographic of the research population (4.5). It then moves to present the results or outcomes of the various elements of the research in chronological order (4.3 to 4.5 inclusive). It concludes by presenting some of the feedback from the Action Research participants which was given at the end of the two-year programme of research (4.8).

4.1. Overview

This section contains each aspect of the industrial investigation with an associated output. The research was conducted within the collaborating organization, a multinational engineering organization with sites in several countries. From an initial research population of 852 leaders, different elements of the research were conducted with different sub-sets of that population. The culmination of this industrial investigation is a new complexity leadership framework.

4.2. Collaborating organization

The collaborating organization has around 4500 employees and, at the start of the research, identified 852 of these as leaders. The definition of "leader" used was a person with identified line-management responsibilities. Although the organization has an engineering focus, this is facilitated by a diverse range of departments such as commercial, purchasing, operations (manufacturing), HR, IT, quality, customer services and business development as well as engineering. The organization has large sites in UK, USA, Canada, Ireland, Australia and some small subsidiaries in other parts of the world. The work undertaken by the organization is diverse: Civil aerospace, military aerospace, military land, soldier systems, anti-submarine technologies, maritime, forensic science, airport security and so on.

For logistical reasons, the financial sponsorship of the research was undertaken by an individual business unit within an international group. The formal sponsorship was through the group head office.

4.3.   First Survey Results

Survey goals

The first survey was designed to achieve two goals: First, to gain a general measure of the overall state of leadership in the collaborating organization. Second, to see if the balance of three leadership modes (Administrative Leadership, Enabling Leadership, Adaptive Leadership) could be meaningfully measured.

General observations

Of the 852 leaders invited to participate in the survey, 223 responded (26%). There was a strong bias towards positive answers (84.4%) despite the statements reflecting different and sometimes conflicting philosophies (Figure 47).
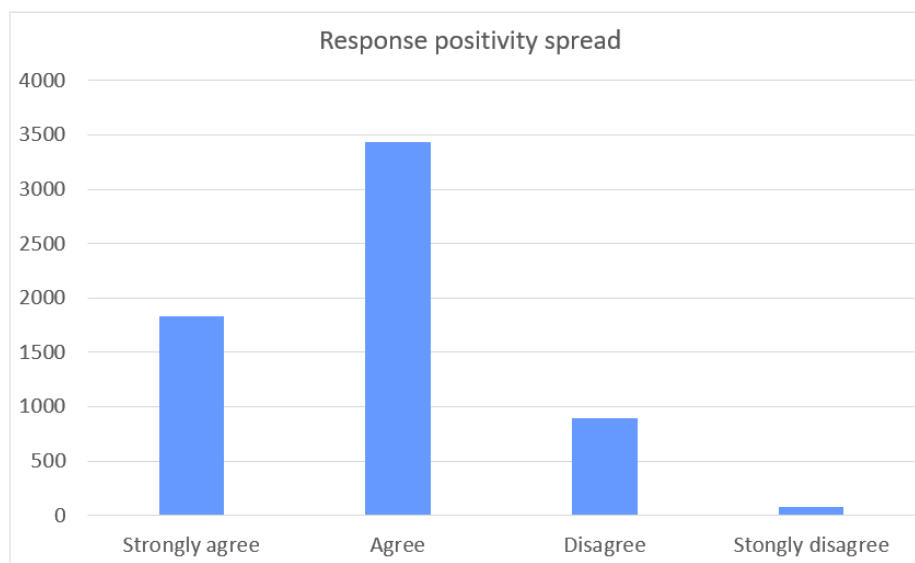
Figure 47 - Response positivity spread

Leadership Mode Bias

To understand the leadership bias of an individual, the strength of positivity for questions which indicated each of the three leadership modes was compared.

Administrative Leadership Bias: Statements proposing planning, accountability, and the importance of contracts were used to determine alignment to Administrative Leadership. For example, the statement "With a detailed plan and the right budget, we can achieve anything" is designed to appeal to those with this bias. 15.2% of

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respondents answered more strongly in favour of Administrative Leadership biased statements.

Enabling Leadership Bias: The Enabling Leader sees the team as individuals who collaborate and work together to find the optimal path to the goal. Examples of statements designed to appeal to this leadership bias are "I really understand the team and the challenges they are working to overcome" and "My role is setting the goals and deliverables for the team, it's down to them how they achieve the goals. They are the experts." 51.1% of those surveyed responded strongly in favour of Enabling Leadership biased statements.

Adaptive Leadership Bias: The positive side of Adaptive Leadership is that it is dynamic and agile. Adaptive leaders use techniques not needed in the normal project environment to solve unexpected problems. A high level of Adaptive Leadership in an organization suggests a situation either where planning is very difficult or where planning levels are less than is needed. Statements like "The best results come from our response to highly challenging situations" demonstrate Adaptive Leadership bias. 33.6% of respondents showed this to be their bias.

Self-image of leadership bias: One of the statements was uniquely structured with a choice of three responses to complete the statement "When things start going wrong in a team that I am leading, I normally...". The available responses were either "Increase the communication to gain a better understanding of the issues", "Create a Tiger Team / War Room to give a rapid response" or "Increase the level of planning and reporting to try and regain control". Each response was designed to be strongly aligned to a specific leadership bias (i.e., Enabling, Adaptive and Administrative, respectively). With this statement being very direct, the responses were anticipated to reflect either a self-image or perceived correct answer. The response distribution for this question was very different to those for the indirect questions with 84.8% choosing Enabling Leadership, 10.3%, Adaptive Leadership, and 4.9% Administrative Leadership, as shown in Figure 48.
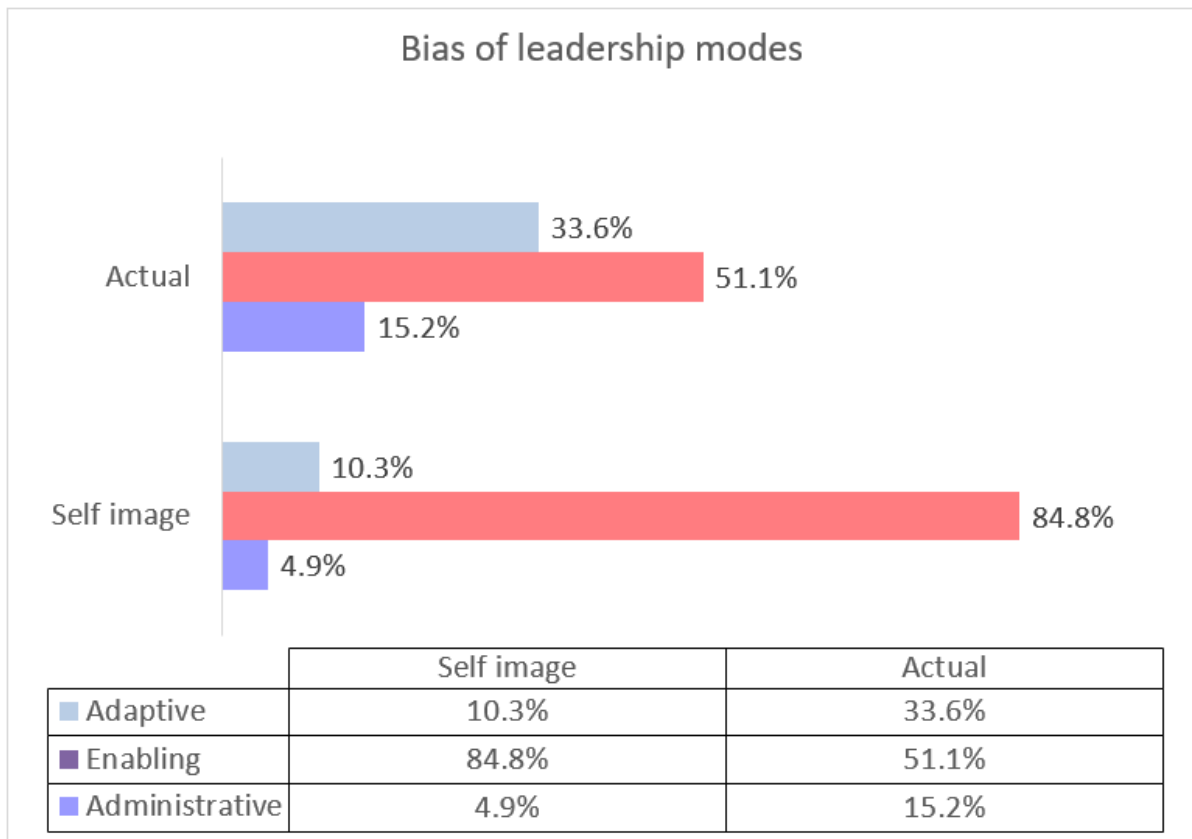
Figure 48 - Leadership bias - first survey

State of Leadership

Four statements were intended to measure the general state of leadership within the collaborating organization. The statement "My job involves leading a team to deliver in the face of challenges and uncertainty" received a 98.2% positive response indicating an acknowledgement of the complex nature of the leadership environment. The 97.3% positive response to "When leading (or co-leading) a new project or team activity, I have confidence in future success" would seem to be a direct contradiction to the more modest 56.5% positive response to "If something begins to go wrong, we always understand what to do to correct it". The statement "I am supported to deliver success" also received a less definite response at only 78% positive. Overall, the bias was towards an optimistic outlook.

Poll Results

During the delivery of training, leaders were first introduced to the concept of the three complexity leadership styles (a presentation and subsequent discussion) then polled with two questions: "Which leadership style do you see most often?" and "which would you like to see more often?"

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Poll goal

As the participants had only just been introduced to the concepts of the leadership modes some minutes earlier in the training session, the poll was not expected to deliver a detailed analysis. It was hoped that the ideas were readily understood and that the poll and subsequent discussion would demonstrate this.

General Observations

The participants were much more energized and enthusiastic about the training on Complexity Leadership than they had been in the first half of the session which was going through the STAR model of leadership (a list of competencies required by leaders within the organization). The vocabulary was quickly picked up in discussions and it could be seen that the participants were able to quickly use the language of CLT to articulate issues they saw within the leadership in their area.

A comparison between the poll results and the results of the first survey shows inconsistencies. In the first survey, the indirect questions showed a bias towards Enabling Leadership and the direct question showed an even stronger bias. This contradicts the poll results from the first survey despite the two surveying the same research population. It is clear that it is felt that there is a lack of Enabling Leadership experienced in the workplace despite the claims made by leaders in the first survey that this was their dominant leadership mode.

Leadership bias

Adaptive Leadership was declared as the most prevalent leadership style (63.6%). Administrative Leadership was the most seen style for 30.7% of those polled. Only 5.7% said that Enabling Leadership was their most common experience.

When asked which leadership style they would like to see more of, Enabling was the clear favourite with 77.5%. Only 17.1% of respondents wanted to see more Administrative Leadership. Only 5.4% of those polled wanted an increase in Adaptive Leadership.
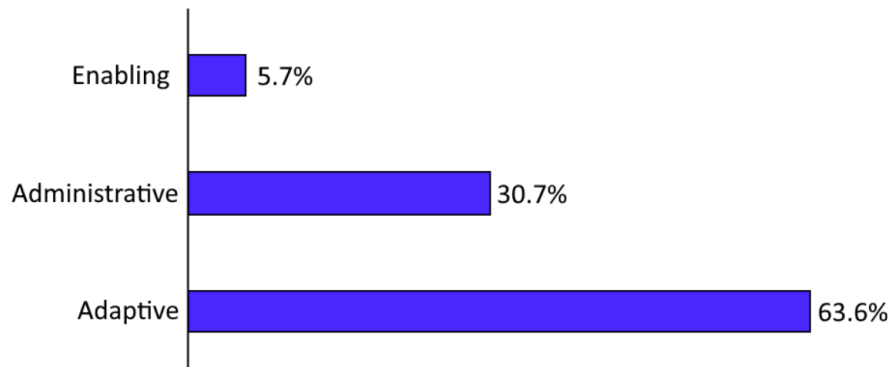
Figure 49 - Leadership style most seen - Poll
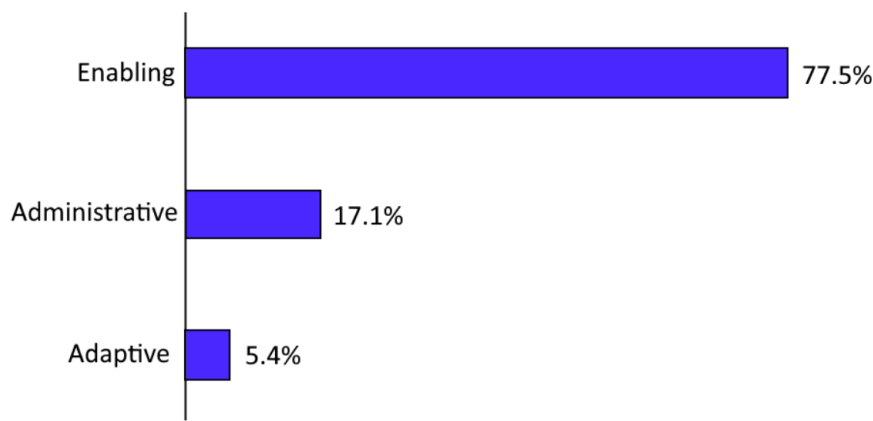
Figure 50 - Leadership style most wanted – Poll

4.4. Informal discussions during the research period

As the research progressed, informal discussions would naturally occur between those involved and the researcher. One of these discussions had a significant impact on the developing framework and, therefore, is recorded here:

Two of the senior business leaders who had supported the research and had been following the development of the theory wanted to discuss some of the ideas with the Senior Leadership Team (SLT) within the organization. As the SLT are mostly directors, they asked which of the three leadership modes fitted with direction (initially proposing Enabling Leadership). As the conversation continued and each of the (then) three leadership modes were examined in turn, it became clear none of the existing modes could be matched to the Direction leadership and that Direction was a unique leadership mode which needed to be added to the framework if it was to be holistic. While that informal conversation was not transcribed, the idea of Direction being an important leadership mode for complexity was then fed into the AR sessions for discussion by the participants.

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4.5. Action Research participants

This section details the activities in the Action Research element of the research.

Overview

The AR element of the research spanned two calendar years (commenced March 2022 and completed in November 2023). During this time, some leaders left the collaborating organization, some found they no longer had time to commit to the AR and other participants were brought in to fill gaps. Table 13 shows a record of attendance across the eight sessions.

Each Participant has been given a code which consists of a number showing the group they were in and a sequential letter. The details of each Participant are shown in Table 12.

Table 12 - Action Research participants

	Identifier	Business unit	Job title	M/F	Country
Group 1	1A	Maritime	Programme Manager	Female	UK
	1B	Maritime	Functional Manager	Female	Canada
	1C	Electronics Defense Inc.	Director of Tax	Female	United States
	1D	Energy	Project Manager	Female	United States
	1E	Intelligence & Communications	Project Manager	Male	Canada
	1F	Naval Systems & Sensors	HR Business Partner	Female	USA
	1H	Electronics	Director Of Operations	Male	United States
	1G	Control Systems	Senior Chief Engineer	Male	UK
Group 2	2A	Sonar Systems	Director of CSC Engineering	Female	Canada
	2B	Cyber Security	Director of Contracts	Female	USA
	2J	Maritime	Director of Business Transformation	Male	Canada
	2C	Command and Control	Quality Assurance Manager	Female	United States
	2H	Electronics Forensic Technology	President	Male	Canada
	2I	General Business Services	Talent Acquisition Operations Manager	Female	United States
	2D	Control Systems	Chief Engineer	Male	UK
	2E	Command and Control	Director of Programs / Site Lead	Male	United States
	2F	Maritime	Electrical Engineering Manager	Male	USA
	2G	Maritime	Programme Manager	Male	UK
Group 3	3A	Maritime	Director of Operations Planning	Female	Canada
	3B	Control Systems	Senior Programme Manager	Female	UK
	3C	Command and Control	Senior Director	Female	United States
	3D	Control Systems	Programme Manager	Male	UK
	3E	Control Systems	Manufacturing Services Director	Male	UK
	3F	Maritime	Quality Systems Manager	Female	USA
	3G	Communications	Vice President	Male	Canada
Group 4	4A	Nuclear Control Systems	Technical Compliance Team Leader	Male	UK
	4B	Control Systems	Head of Commercial	Female	UK
	4J	Group Head Office	Group Program Director	Male	United States
	4C	Maritime	Stores & Logistics Manager	Male	UK
	4D	Electronics	Engineering & Innovation Director	Male	United Kingdom
	4E	Control Systems	Supply Chain Manager	Male	UK
	4H	Control Systems	Head of Trade Compliance	Female	UK
	4I	Maritime	Functional Manager - Systems	Female	UK
	4L	Maritime	director of PMO	Male	UK
	4K	Maritime	Production and Support Services Manager	Male	Australia
	4F	Maritime	Business Area Director - Radar Programs	Male	United States
	4G	Forensic Technology	Ops Manager, EMEA and APAC	Male	Ireland

Table 13 - Attendance pattern within AR sessions

	Leader	Session 1	2	3	4	5	6	7	8
Group 1	1A	A	A	A	X	A	A	A	X
	1B	A	A	X	A	X	A	A	X
	1C	X	A	A	X	A	A	X	X
	1D	X	X	X	A	X	A	X	X
	1E	A	A	A	X	A	A	A	A
	1F	X	X	X	A	X	A	X	X
	1G	A	A	A	A	A	A	A	A
	1H	A	X	X	X	X	X	X	X
Group 2	2A	A	X	A	X	X	X	X	X
	2B	X	X	X	X	X	X	X	X
	2C	X	X	X	X	A	X	A	A
	2D	A	A	X	A	A	X	X	X
	2E	A	A	X	X	X	X	X	X
	2F	X	X	X	X	X	A	A	A
	2G	A	A	X	X	X	X	A	A
	2H	A	X	A	X	X	X	X	X
	2I	A	X	A	A	X	X	X	X
	2J	X	X	X	X	X	X	X	X
Group 3	3A	A	A	A	X	X	A	X	X
	3B	A	X	X	X	X	X	X	X
	3C	X	X	X	X	X	X	X	X
	3D	X	A	A	A	X	X	X	X
	3E	A	A	X	X	X	X	X	A
	3F	X	X	X	A	X	X	X	X
	3G	A	X	A	X	A	A	A	A
Group 4	4A	X	X	X	X	X	A	A	X
	4B	A	A	A	A	X	A	A	A
	4C	X	X	X	X	A	X	X	X
	4D	X	X	X	X	X	X	X	X
	4E	A	A	X	A	A	X	X	X
	4F	X	X	X	X	X	A	X	X
	4G	X	X	A	A	X	X	A	A
	4H	A	X	A	A	X	X	X	X
	4I	X	X	X	X	X	X	X	X
	4J	A	X	X	X	X	X	X	X
	4K	A	A	A	A	X	X	X	X
	4L	A	X	X	X	X	X	X	X
	Total attendance per session	21	14	14	13	9	13	11	9

Key

A (blue)	Attended
X (white)	Did not attend but in group
X (red)	Not in group

From Table 13 we can see that some participants (5) did not attend a single session. These non-attenders did still benefit from the research as they would always be sent the output. Table 13 shows leavers and joiners as well as attendance.

4.6. Output from the AR sessions

The flow of information in each session is illustrated in Figure 51. In this diagram there are two optional elements: The discussion scenarios were not used if the research task generated enough discussion for the whole discussion (1 hour). The developing theory was not necessarily modified by each session but where it was, this was captured in the output sheet.
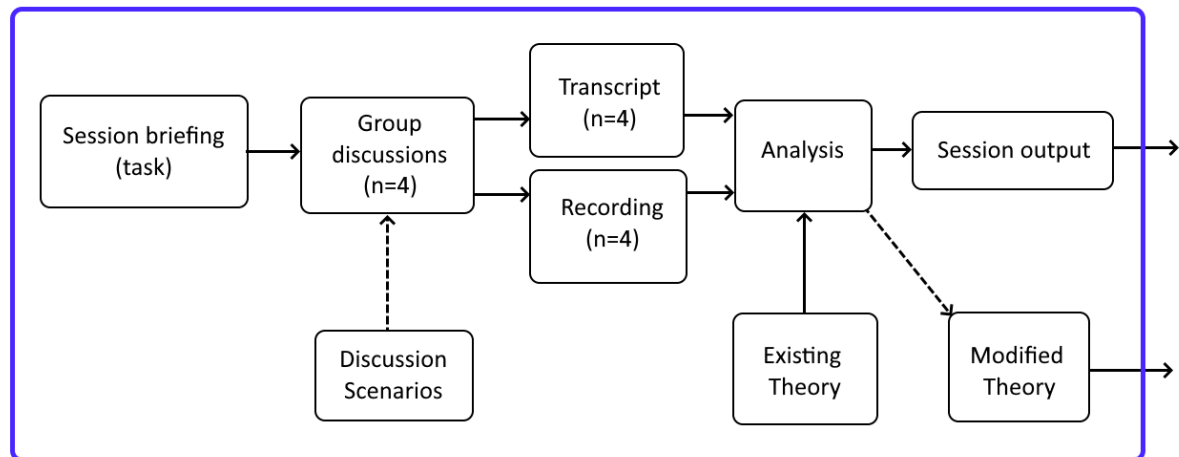
Figure 51 - Data flow for a single AR Session

The following is a description of the output from each AR session in chronological order. First, a brief description of the objective of the session is presented, then the post-session feedback to the participants is shown interwoven with quotations which show a sample of the discussion which generated the feedback.

Session 1

This session explored the following ideas:

1. Distributed Leadership (identifying and analysing)

2. The undefinable nature of the system boundary

3. Leadership as a function of influence

4. Distributed Leadership as a mechanism for advancement

5. The nature of service-providing teams (are they chaotic?)

Note: Idea 1 and 2 were proposed to the group within the pre-discussion briefing. The other ideas were generated through group discussion and fed-forward into following groups.

Key points in the discussions

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The following are excerpts from the transcripts which show the discussions and key points raised.

The diagrams pose questions to the leaders about their team structure and they begin to understand the extent to which leadership is distributed in their teams and the purpose of distributed leadership:

Participant 1H:

… I think you made a comment… which was interesting. Obviously, our process engineers have a lot of people going to them because they have information. So, they're not really leading, but they provide a lot of technical information and I would not think about putting a filter on them… I wouldn't want to add a layer, but I have to rethink. Is that the right approach?

Researcher:

It's an interesting question, isn't it? And. And you know, and I'm not proposing one thing's good or bad. I'm just saying it's an interesting question.

Participant 1H:

…they are all leaders… because people are going to them by default.

Researcher:

That's it. That's what I'm thinking is, if enough people come to you, you end up being a de facto leader.

Participant 1H:

You know what? This tool is helping me…to look at how much volume of communication is going through these individuals and what we're not…do they have the tools to succeed?

Participant 1B:

…I empowered one of my more junior people to be that technical lead…I said, "hey, it's a good opportunity". If someone wants to step up and do this sort of thing. But yeah, it was, it was really good. I thought it was really great. I think it went well.

Researcher:

So, in that example, you basically didn't have the time to do the job properly, so you just found someone who did?

Participant 1B:

Yeah.

Participant 2A:

I think what was interesting to me is that very recently we changed the structure of the of the engineering group I'm leading and what I did is [for this exercise], I looked at this as

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what we had as to compared to what we changed it to. [This was] validating because what we did see before was a lot of people who were shown [in our organograms] as leaders having lines to all the other areas, yet they didn't have any leadership role so to speak. When we did change the structure, we did recognize that. I think we [made] some improvements in that area, but it was interesting to see... I wish I had done this a couple of months ago would have made it a lot easier to see how we could change the setup a little bit.

Participant 2G:

…where we've had sort of projects with up to sort of 30 or 40 engineers on them, it's not an environment where we can pull everybody together, so we do need that distributed leadership to be able to, to pull it together… A one-hour meeting for 30 to 40 people is a big resource drain, whereas actually if you can pull that together and bring the leaders together, five or six people, it's a much more efficient way of managing it.

Participant 2D:

I mean actually the… diagrams that we just drew I think are quite powerful… I've shown with these series of the different phases within the project, how things [were] broken and how things [were] mended. And if you can draw what is required and what is, what's the ideal, then you, you, you have to be able to say, "OK, the person that's gonna be in this role has to liaise with all these people and take responsibility for it", and therefore they have to have this leadership potential, but not only leadership potential but the capability and the willingness to do it. Otherwise, the drawing looks like this. [shows a diagram which is shown in detail below]

Which is fragmented and everything going to a certain person at the top. So, I actually think that's quite a good mechanism to show what is required for a project or a team or a business.

[These observations are detailed below]

Participant 3A:

And I would also say that [this exercise has] been highly valuable to me. I'm new to [the company]. This is my third month and what I would describe our system so far, it just in terms of the transition we're going through right now in [the business unit]. I would say that it is chaos. And so having an activity like this helps me figure out, OK, who am I go to people because I did it in a couple of different situations and scenarios and it's helped me identify those go-to people so that I can get up to speed faster in my role. So, I thought it was highly valuable. And it's not something I've done before.

The idea of expanding the team diagram out to supporting interfaces is posed. This links to the CLT idea of undefined boundaries and help the participants to understand the true environment they are leading in:

Participant 1H:

[responding to an earlier discussion about the boundaries of the team diagram]…I was talking before is that I have this little [diagram] for this project, but if I expand it because we're doing a partnership with the A company in India, then you will double the size of this graphic because each of them talked to specific person in India to make sure that they're doing the job correctly … then we can see that this company in India will have another interaction with supplier… we need to talk to them at some point. So, this graphic and become very, very large and this is probably the thing that I've never done in this could lead me some information that could help at some point. You [would be able to] see where there's too much information flow or if I can distribute some [leadership] within the team.

Participant 2E:

It was quite a challenge that I found myself adding more and more dots. The more that I started drawing lines [the more complex it became].

On the limitations of distributed leadership:

Participant 1A:

…what we've been talking is kind of the positive and negative facets of leadership. So, I think some of the things that I feel like it's OK to distribute other positive bits. The getting to make recommendations and the coming up with solutions and being the go-to person, but the bits about taking blame when it goes wrong and being accountable and kind of being the last port of call, I feel like that stuff doesn't distribute very well. I think it's not fair to a lot of the people in a lot of these positions to expect them to pick up those sides of things.

…I think quite a lot of people will only make a recommendation in a in a safe space of "look, I want to hear what you think because you're the expert here, but I will make the final decision and I'll take the fall for it"…and then they'll speak more openly and then they'll make better recommendations…But I feel like that that part of sort of creating protected space for people to do that thing is not always distributable either.

Participant 1H:

Just like to add one point to this: the negative part, because when you distribute responsibility, you also have to distribute power that goes with it. And this is sometimes the part

that is more difficult to give away because at the end, you will be responsible…

Participant 2E:

I think one of the biggest challenges that we have… with distributed leadership is you're really trying to lead without any true authority. So, you are leading a matrix team or you're leading a team of people that don't officially or formally report to you and you in the… grand scheme of things, you don't actually have the published authority to do that. So, whenever there's challenges, there are unknowns, one of the one of the biggest jobs of the leader is whenever you're in a state of unknown and you have to move forward. You're the one that that has the ultimate responsibility to say, "hey, this is the best path, that this is the optimal path to move forward" and go forward with it.

Participant 2D:

…We gave somebody that title of leader effectively for a particular aspect of [a] project. They were empowered. They had the capability, but they did not have the willingness to do it and therefore they sort of devolved that leadership down to somebody that was not empowered… and did not have the capability to do that.

Researcher:

…would you agree that, at the end of the day, the leadership has to go somewhere?

Participant 2H:

Yes, definitely… and you know with these distributed leadership models, I think one of the challenges is to identify those areas where the teams are struggling a bit, you know and… the challenges and the complexity of the situation.

Observations and discussions: Distributed Leadership (identifying and analysing)

The concept of distributed leadership was not unfamiliar to the groups. For clarity, the agreed useful definition was informal leadership responsibilities, possibly temporary, which were conferred on a team member my mutual agreement with a view of streamlining the communication structure.

The participants were asked to generate a diagram showing the communication lines in their team. The diagram was circular to avoid the classic hierarchical tree (which dictates a communication structure which may not reflect reality). On the diagram, formal leaders (solid fill) and distributed leaders (double outline) were identified. The

finished diagrams looked like Figure 52 when the group has an effective structure. Note, the initials within the circles represent the names of team members. In the diagrams which were generated the distributed leaders were shown with a double circle. The expected logical relationship between those distributed leaders and the lines of influence/communication was that they would normally be expected to be a node where multiple lines converged. In this way, they manage lines of leadership which reduces the burden on the nominal leader and leverages their intellectual capital.
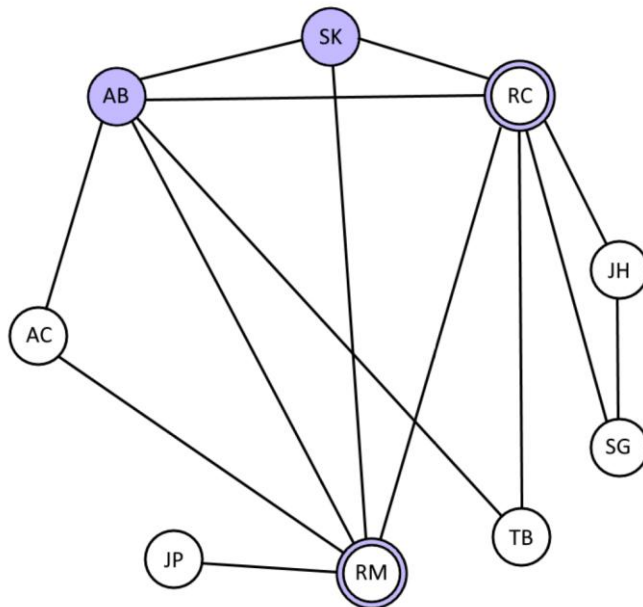
Figure 52 - Distributed leadership diagram - functional

Drawing this diagram for a well-established and high performing group normally shows little new information (except that it confirms a logical influence network) but the participants found the diagram very useful for understanding problems in less well established or high performing groups.

Things to look out for (it was found) were:

a) Nodes (people) with lots of lines of influence but no conferred distributed leadership rights.

b) Nodes with no links at all

c) The number of nodes between the nominal leader and some nodes (i.e. how filtered is the communication from some nodes to the nominal leader).

An example was provided (by Participant 2D) of the diagram in Figure 53 which was drawn when there were issues in the team.
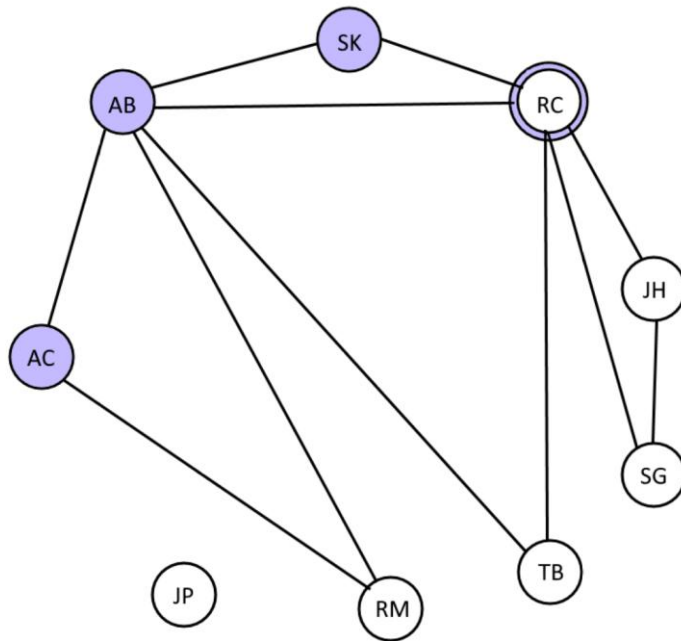
Figure 53 - Distributed leadership diagram - dysfunctional

In this example (Figure 53) there is a node with no lines of influence and a generally low level of influence lines across the team. In this real example, the planned distributed leader who was meant to be interfacing to the lone node was unavailable so the individual spent months working without guidance or mentoring which ended in a lot of wasted effort causing cost and delay. Although other team members did talk with that individual, they did not have the background to give them guidance or review their work. On that basis, their communication was casual and doesn't get shown on this diagram as it's not considered true leadership.

On the use of this analytical tool, other participants also said that this diagram showed new information or would have helped them quickly identify issues in the past (issues which, without a suitable analysis tool, went without solution for a long time).

Observations and discussions: The undefinable nature of the system boundary

These diagrams were initially drawn to show the immediate nominal team. Of course, the team interfaces with others both within and outside of the organization. At a different scale, the business unit networks with suppliers, customers and other Ultra business units in a macroscopic (business level) network. Each node on that large scale network containing a similar internal team network. The two related points are made:

1. The question of where to draw the boundary of a team is not always obvious. Too much simplification may miss important information while too much detail can be confusing.

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2. The real complexity of the whole system of interaction (whether drawn or not) explains why one group can only make plans with a certain degree of accuracy and confidence in future direction. With so many people and businesses in the whole network, the unexpected becomes inevitable.

The groups had no problem with these ideas because their lived experience supports them. After considering the influence on their nominal team, some participants decided to modify their diagram and expand it one more level.

Observations and discussions: Leadership as a function of influence

It was proposed to the groups that a reasonable definition of leadership is:

The influencing of others towards a goal or goals.

This proposition was accepted. On that basis, identifying people within a team or network who are influencing many others is a way of identifying the (potentially unrecognized) leaders in that network. Conversely, you could logically infer that a nominal leader who was found to have very few links of influence within the network, could only be exerting a small percentage of the total leadership at play.

It was proposed (but not discussed at length) that each group has a certain leadership requirement (decisions need to be made, mentoring is required etc.) and this leadership must come from somewhere. As the day-to-day leadership from the formal leaders reduces, so the distributed leadership must increase (either by design and delegation or by a filling of the leadership vacuum). If neither of these occurs, then the total leadership will be below that required, and the team will become dysfunctional.

Observations and discussions: Distributed Leadership as a mechanism for advancement

The groups identified two types of distributed leader:

1. Someone with valuable skills or knowledge but with no desire for the perceived burden of a formal leadership position.

2. Someone keen to show they can do more.

This highlighted distributed leadership as valuable to the business for the following reasons:

1. It allows the use of the intellectual capital in types 1 and 2.

2. It allows the development of the type 2 people to the point where they can be promoted.

The following caveats were discussed and agreed:

- It is quite arbitrary which team member is seen as having distributed leadership abilities. A change in leadership can see a change in who is given distributed leadership responsibility.

- Any blame culture (or general lack of trust) will reduce the chance of using distributed leaders.

Observations and discussions: The nature of service-providing teams (are they chaotic?)

A recurring theme in these sessions and in previous similar discussions (during group leadership training) was the nature of leadership in service-providing teams. The leaders of those teams often described the situation of their teams as sometimes chaotic and that they were unable to plan because they never knew who would come to them next. Reflecting on the three types of leadership already discussed (Administrative, Adaptive and Enabling), these leaders often claimed to be forced into a permanent state of Adapting leadership due to the unpredictable nature of their work. These notions of chaotic unpredictability were discussed and conceptually challenged.

> **Participant 4H:**
>
> What you were talking about the leadership styles and the adaptive leadership being sort of the firefighting element and I think sadly that is a lot of what we do. We would like it to be different, but we actually find where sometimes being pushed into… I think it's probably because we're so used to things being unpredictable in a way, but we know who's going to deal with that unpredictability generally. I think we're quite clear if something comes up.
>
> You know who within the team would be the right person to either speak to, for advice or who would deal with it. So, I don't think its chaotic in that respect.
>
> **Participant 4B:**
>
> …a lot of what [4H] has gone through resonates with my team too… where it's a support function. In the commercial team [we] have a relatively small team and within which we, we've absolutely have got distributed leadership, everyone is clear on their roles and responsibilities. We've got quite clear delegation of authority, so, each team member at their level

understands what they're able to sign off and approve or negotiate. I think the one exception is possibly where we're managing our interactions with other teams. Unlike [4H], I think we have a greater ability to define and assign individuals within our team to other teams so that that distributed leadership is quite clear and individuals have their own sort of programs and that they're or contracts that they're responsible for.

Participant 4J:

I would hope we started with a plan at some point.

Researcher:

But, but would you? But do you recognize that actually for some groups where basically they're there to support people?

Participant 4J:

I think it somewhat depends. I mean we all start with a base level I. I guess I would think that at the support level. There's some aspect of steady state and then beyond that is that reactive need. If that makes sense. So, I'm kind of thinking of it in layers. So, the there's a base plan, right? And there's things that you have to do that are regular that you that are part of the plan that everybody does and it's just business as usual. And then there's the other aspect of, OK, today this part of the business had a problem and it's being part of the service support I have to react to that particular thing. So, I think it's kind of a mix of both.

Researcher:

You'd think that there would be a plan to provide support. So, a plan for the structure that that's provide support you know we need people with these skills, we need this many people…So that then again becomes interesting so you go OK you're in the support function but actually there's two layers that there's you've got the foundation or infrastructure of the support capability and we expect that to be planned and led in a way that any other normal project or task would be. And then you've got the function of supporting which you may not be able to plan but it sits above that, that foundation.

Participant 4J:

Yeah.

The finding of these discussions are as follows: A service providing team has two distinct leadership situations: Capacity and Capability to deliver the service. This is an activity away from the unpredictable customers. It can be planned and measured. What is the service demand we are planning to meet? How many staff do we need? What skills. What tools? What processes? What training. This is very much in the Administrative Leadership mode with some Enabling Leadership in the form of mentorship. Once the service capability is established then the service can be

provided. It is true that you cannot plan what demands will be made of the team at a given time, but you do know your actual capacity and so the primary leadership task in this Service arena is the balancing of priorities (Enabling Leadership) to make sure the critical demand is met by your capacity as far as possible.

Only when something never envisaged in the capability or capacity development arises is there a need for Adaptive Leadership.

When a leader takes over a pre-existing service providing team, this duality of leadership can be difficult to see as the capability design is historic and may be perceived as "how we do things" – an immutable truth rather than a set of options chosen by a leader no longer in post.

Session 2

This session was an examination of Administrative Leadership. The definition used as a starting point was the one used in the extant literature. The pre-session task was to create a mind-map around the word "Capability". From this stem word, a map was created listing all the things which have been done or are being done to enable the team to perform their current tasks. Then, in a red pen, a list of new things which could be done to increase the team capability.

The purpose of this exercise is to find areas where each leader can use Administrative Leadership to increase the capability of the team. There was an additional, optional task to repeat the exercise focusing only on the leader and their own capability.

> ***Participant 3D:***
>
> I found it quite useful, so I work in program management so I have to take quite a helicopter view of things anyway and but I found this was useful in the sense that it got me thinking about all the other areas that would link into my link into any program that I would be working on and will either support or diminish my ability to deliver a program.

> ***Participant 2D:***
>
> I think certainly on the main project that I'm on at the moment, if we'd looked at this and said what capabilities have we been given in order to perform this project, we would have gone back to the business and said "no way. We can't do it"…

I addition to this task, a two-part scenario was generated to aid in the discussion. The scenario showed a dilemma of Administrative Leadership (an expense claim conflict) which exercised the participants leadership skills.

From the four discussions in Session 2, the following Administrative Leadership theory was devised. In this theory, the originally proposed Complexity Leadership Framework was modified to split Administrative Leadership into two distinct modes.

> **Participant 2E:**
>
> So, if I look at my entire engineering staff and if I look at my program managers, if I have everybody in the right place, if I have the right people sitting in the right seats to execute our programs, I don't necessarily need the KPIs.
>
> But on the flip side, I have to have the KPI's, that way I can report back up to the business and that way I can report to my customer and then I can use those as kind of a leading indicator to know where teams where people where programs need some additional support where I can pull people and where I can fill people in before a project either goes red or schedule quality, cost, whatever.
>
> Umm, so you'll notice that those are two kind of conflicting answers and it's because **it's two types of role**. I'll say the strategy for the company or the higher-level program execution for the company versus day-to-day kind of tactical where you know where we need help.

This original proposal by participant 2E was then described in more detail and fed back to the participants as a recorded observation.

Observations and discussions: Administrative Leadership

1   Overview

Administrative Leadership is an anticipatory (pro-active) leadership mode: Activities in this mode are designed to put in place mechanisms today which influence the way the world will be tomorrow. This leadership sub-divides into two categories:

Strategic Administrative Leadership

This mode of leadership builds the administrative framework for whole businesses or departments. Such frameworks control activities within the business which need to be controlled for legal, regulatory or best-practice purposes. They aim to give clarity and consistency without bureaucracy. They measure and report where there is a defined need for and known response to the data gathered. Where possible, these frameworks allow for flexibility of approach to preserve the agility of the business and to reduce the need for framework change as the world and the business changes. When change is needed, this is done with careful consideration of all stakeholder's needs, lessons learnt, industry best practice and the future growth of the business.

Processes, procedures, codes of conduct, policies, communication and IT infrastructures, the general structure of the business and departments within it. These are all examples of artifacts generated by this leadership mode which combine to produce the administrative framework.

Because Strategic Administrative Leadership, and the framework it generates, has an influence which is wide and not time-limited, changes must be made with great care. The leader in this mode identifies and engages with stakeholders, considering their views and the ramifications of the change. Key skills for a Strategic Administrative Leader are gaining stakeholder engagement, create a compelling case for change, facilitation of clear and authentic communication, continuous improvement skills (e.g., transformation and change management)

Tactical Administrative Leadership

While still anticipatory rather than reactive, this mode delivers targeted Administrative Leadership for a specific temporary situation (like a project or event). Plans, action lists, work breakdown structures and resource planning are all examples of this mode.

The activities of this mode conceptually sit on top of the procedural frameworks created in the Strategic Administrative Leadership mode. They respect the Strategic Administration framework without influencing it. Although this mode deals with tactical situations, it is, in general, still abstracted from the detailed specifics of execution (which are the domain of the Enabling leader). While activities in this mode anticipate successful delivery of the agreed goals, they do not influence *how* these goals will be delivered. Only Enabling Leadership can do that.

Tactical Administrative Leadership activities are focused on transient situations and activities such as projects. They are targeted at a specific audience and are primarily designed to be used by Enabling Leaders and the team in the execution of the planned activity. They follow methods and practices described in the Administrative Framework. They do not modify the administrative framework.

When a project requirement arrives, the Tactical Administrative Leader creates a plan in collaboration with the Enabling Leader and the other stakeholders. This collaboration is essential if those executing the plan are to buy-into it. Without buy-in, the plan will fall into disrepute.

Clearly, other models of Tactical Administrative Leadership can be imagined. In all examples, the same criteria will be seen: the situation being led is timebound; there is a specific group of people being led; there are specific goals which, once achieved, will

signal the end of the activity; the methods used will be in line with the Administrative Framework, the activity will not modify the Administrative Framework; the Administrative Leader will interface to (or also be) an Enabling Leader; the Enabling Leader will co-own the plans developed; the Enabling Leader will work with the team to execute the plans.

Key Skills for a Tactical Administrative Leader are as follows: Close and effective collaborative working with Enabling Leader; ability to assimilate large amounts of data into a clear plan; ability to work in an agile way to flex the plan as events emerge while adhering to the administrative framework; ability to negotiate the correct resource and budget for the team; clear and accurate reporting to the business governance function; maintaining the support of the customer and wider business; communicating with the equivalent functions of the customer; accurate time and cost accounting; management of unplanned emergent events through a flexible planning approach.

Session 3

This session was an exploration of Enabling Leadership. Enabling Leadership is the most multi-faceted of the leadership modes. To focus the discussions, only the innovative aspect of Enabling Leadership was explored. The type of innovation facilitated by Enabling Leadership is iterative and small in scale, often in the form of problem solving to overcome obstacles and resolve unknowns within a project-type activity.

The participants were given a set of 6 questions relating to innovation within a team environment, an example is shown in Figure 54:

> 4. Do you think that everyone has the same potential to innovate or are some people more innovative than others? How does your answer to that question influence your strategy for nurturing innovation?

Figure 54 - Example question in Session 3 activity briefing.

Having prepared their observations on innovation within their teams, the four groups explored the topic within the discussions. In addition to this activity, two scenarios were prepared to further expand the discussion. An example is shown in Figure 55.

Scenario 1

You lead a team who think of themselves as process followers rather than innovators. You need them to come up with new ways of doing things as everyone agrees the current system isn't working. The solution needs to come from them.

You need to find a way of getting them to think more innovatively about the work that they do.

Do you:

a) Run a brain-storming meeting
b) Hold an off-site with challenge activities
c) Run weekly discussions
d) Something else

?
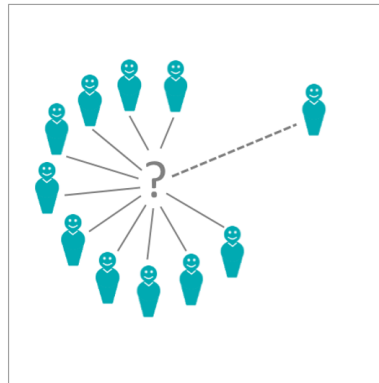
Figure 55 - Example of a discussion scenario - Session 3

Observations and discussions: Enabling Leadership and Innovation

The following were quotes from the transcripts for this session, making observations on the way leadership enables innovation:

> ### *Participant 3A:*
>
> I would say that right now my team is in firefighting mode. So just with supply chain challenges and with resource challenges and operations planning and it's just continuously reactive. And so, I this really prompted some good thinking time on my part to ask myself, OK, what do I need to do as a leader to change that within my team? And I think it starts with setting that expectation that we all own innovation. So, we own it as a team, but we each have individual accountabilities to give ourselves time to make sure that we're considering how can we do things better.
>
> So actually, after working through these questions, it really did get me thinking about this more because I'm still pretty new to the company and it's when you're new, you put you in a position where you can make change without people questioning it too much. And so, at the beginning of a team meeting last week, I took five minutes to play a game with the team, and it's not something that had been done before. It didn't take long to do it. But everyone said, "Wow, that was really fun". And I feel like going into problem solving mode for a few things that we're working on right now, I feel like I'm in a better position to do it versus bringing or whatever was on my mind from the last meeting I was in bringing that into this current meeting and still thinking about it. Having that five-minute game at the beginning of the meeting really kind of disrupted people's headspace in a good way.

The previous session had resulted in changes to the developing Complexity Leadership Framework. Combined with the idea of adding Direction which came from

the informal interviews, these changes were put into the feedback from Session 3 showing an illustration of the framework as it had become before moving onto the observations for the session. By feeding the developing leadership framework back into the participants, it was hoped to gain feedback or for the framework to influence the discussions.

Complexity Leadership model

This model has been developed following various conversations with the groups and others in the business. You will see that Administrative Leadership has been split into two. Direction has been added as a leadership style. The idea of an environment of business culture is introduced [and later dropped from the 5-point model. Although culture is still considered important and linked to Direction, it can be perhaps thought of as a result of the overall effect of guidance from Direction and Enabling leadership modes]. Team culture is also added. This is the point at which the 5-point framework was conceived, albeit in an early form.
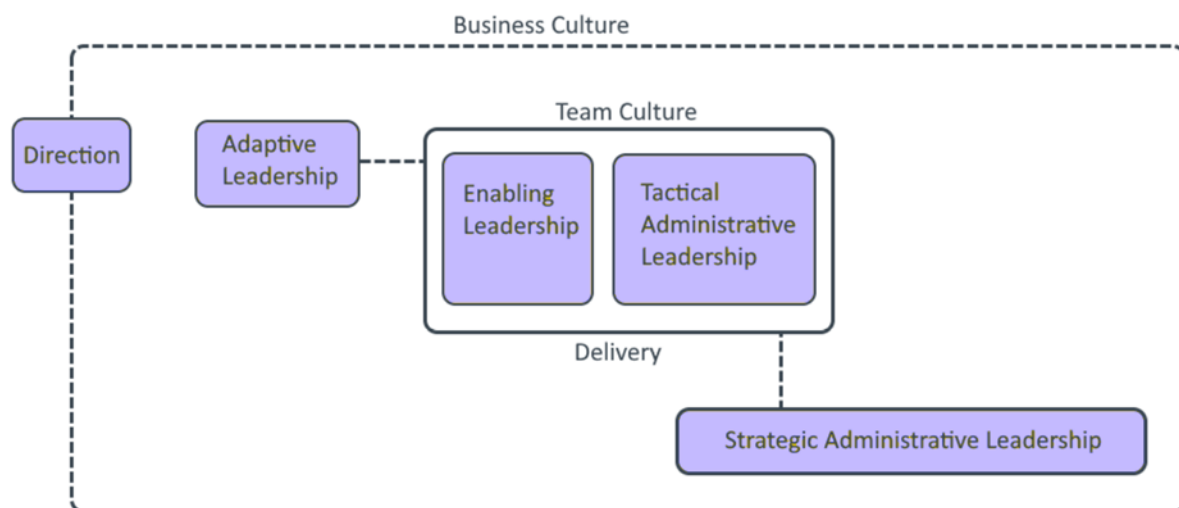
Figure 56 - CLT Framework at the stage of AR Session 3

In this model:

Direction: This form of leadership is in the form of a broadcast which comes from a position of high authority. It is generally a statement of intent, a general goal or identified strategy. It can also be a declaration of impending change in direction. It is not a discussion. This leadership style, or the lack of it, is one of the main drivers for the business culture.

Adaptive Leadership: An off-process mode of leadership which is short term. Its goal is to lead the business to adapt to an emerging situation for which normal practice has no solutions or coping strategies.

Enabling Leadership: The enabling leader leads a team towards a goal. They do this in collaboration with the Tactical Administrative Leader. The Enabling Leader understands the team as individuals with strengths and weaknesses. They help guide the team around obstacles and they look for areas of the delivery which have stalled.

Tactical Administrative Leadership: This leadership contains the planning, resource management, processes and rules of governance which are specific to the goal being delivered (normally a project). The framework of plans and methods is created for this project using methods dictated in the Strategic Administrative Leadership arena. Changes in this area do not affect the business beyond the project boundaries.

Strategic Administrative Leadership: This is the wider list of rules and processes which persist across projects and activities and which govern the wider business. They include legislation and general administration such as financial reporting, HR process etc. Changes in this area affect the whole business (or large portions of it).

Managing Innovation

Change through emergent events is a key element of Complexity and the managing or leading of emergence is a critical aspect of Complexity Leadership (as discussed in chapter 2). Innovation is simply the act of having new ideas for what things could be, how we might do things, how things could be improved. Although there are different types of innovation, they share a lot of fundamental principles.
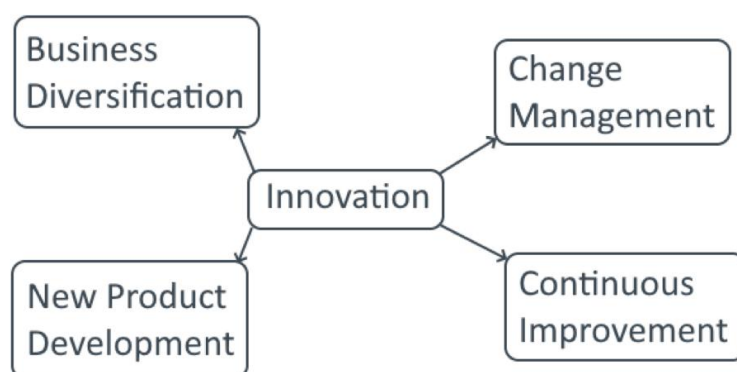
Figure 57 - Examples of innovation

As a leader, achieving high quality innovation, which is well implemented with the minimum of cost and disruption, is a serious challenge.

The spider's web of things

The discussions in this session began to identify an issue with improvement project which links to the CLT idea of dynamic networks:

> **Participant 3G:**
>
> …we have to look at teams that are able to support multiple innovations happening in parallel, ideally, especially in our in our market where things move very, very quickly.
>
> **Participant 3A:**
>
> I would agree in the sense that sometimes when you look at the magnitude of how much has to happen for an improvement initiative and we're undertaking some really large changes to how we use ifs and we had workshops last week and the team I could, I could tell the team was feeling a little bit overwhelmed with the extent to which we have to change and everything is connected

This collective agreement on the complexity of interplay between elements affected by change projects was compiled into the following descriptive feedback:

As leaders in complexity, we recognize that the organization is a complex system and the interaction between each element is not always obvious, nor is the cause and effect propagated by change.
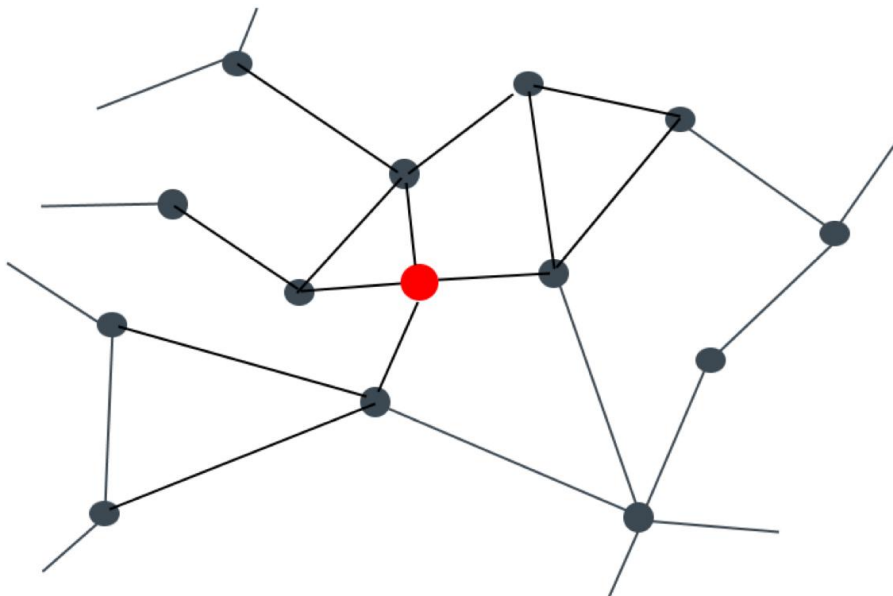
Figure 58 - Dynamic network

When one node moves or is replaced, those around are also affected and, in turn they affect others. Some of these effects can be anticipated by discussions with stakeholders. They give us a perspective from a different part of the network where the

relationship between the nodes (affected elements or people) may be better known. Quality of communication with stakeholders is critical. High levels of engagement are needed – classically we speak of "burning platforms" (a reference to an event where an oil rig was on fire, forcing fast and immediate action) as a communicated common need. Certainly, a "burning platform" compelling argument may be needed where major upheaval (revolution) is planned but networks tend to respond better to gradual incremental change (evolution) so the effect of each change can be reflected in a slightly modified network before the next change is planned.
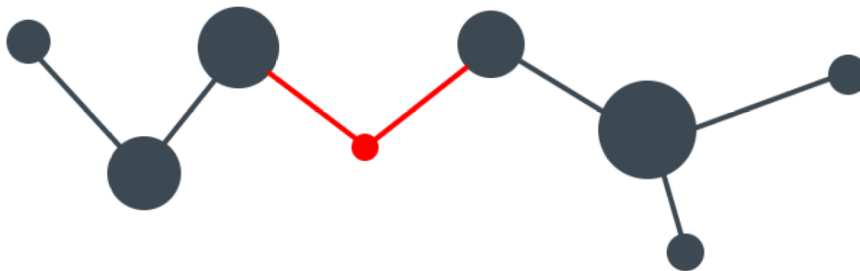
Figure 59 - A leader as a small link in a chain

If you are in a chain of process as an individual or a leader of a small team (illustrated above) you may find it almost impossible to instigate improvements which affect the whole chain. Without the critical mass to drive the change (or the desire to change becoming widespread), it may be difficult for your voice to be heard. In this scenario, you may need to form alliances with more of the chain before attempting the change (below).
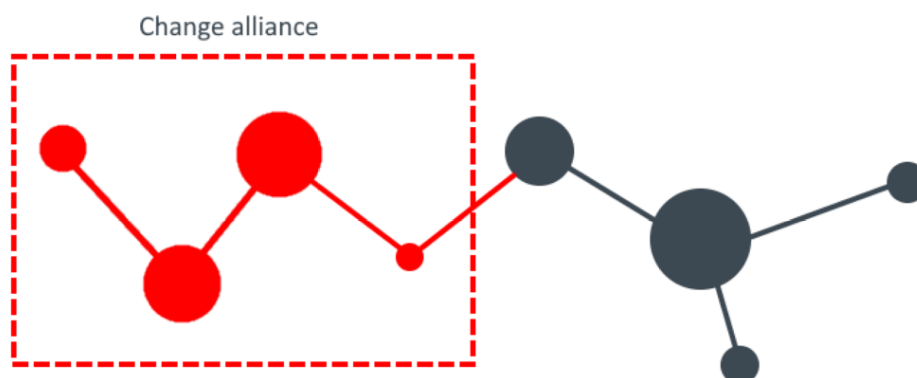
Figure 60 - A change alliance
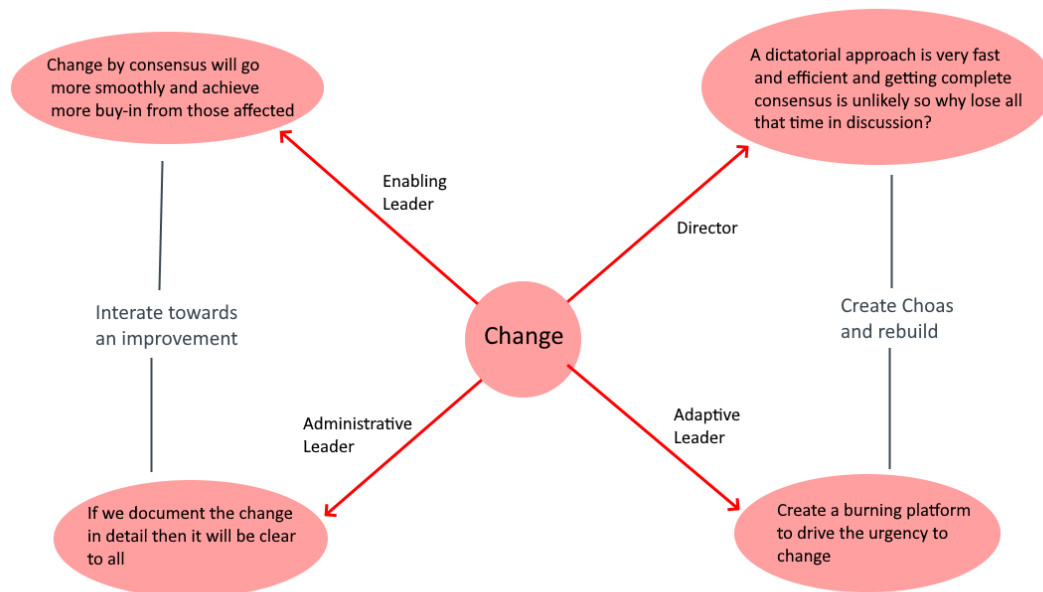
Figure 61 - Change philosophies and leadership modes

The illustration above (Figure 61) shows different philosophies to achieving change within an organization, each is linked to a leadership mode we have identified. They each have their pros and cons.

> ### Participant 2H:
>
> …it's important within the business to generate a bit of that chaos that would challenge that that element.

Here are some thoughts on important topics relating to innovation, often in the form of change in the way people do things.

Semantics

The semantics around innovation can frame the approach and people's attitude. Is it innovation, problem solving, continuous improvement or something else? Each of these describe innovation (i.e. thinking about things in a new way) but each has a different context and associated perceptions and processes. The choice of language in innovative activities can have a significant effect on the attitude of participants towards the activity.

> ### Participant 1G:
>
> I don't like the idea of going off and being "innovative". I like the idea of going off and "solving problems" …

Time

Time is a critical factor in innovation from many different perspectives: You need time to innovate, it takes time to engage and consult the stakeholders, the ideas generated then take more time to implement.

> **Participant 4B:**
>
> I've attended a couple of things this year offsite that they're great opportunities to have time away from the office to give yourself space and time to have those innovative thoughts and particularly where there's multifunctional teams as well it it's getting real breadth of ideas from different perspectives, but that that sort of follow up after the event is so important. We held it as sort of just a functional off site a couple of years ago and spent a lot of time after the event prioritizing the actions and we haven't got through everything that came out of that event yet.
>
> So, that's a couple of years [ago], but some of those priorities there might be in quick wins or they might have been prioritized in terms of we can't live without. These changes they have been implemented, so I think the other, the other piece is you know be realistic about what you can achieve when you've gone back to the day job. And I think that prioritization exercise was really valuable, but what I haven't done is gone back to the team to say well, listen you, you gave us these ten ideas. We've only been able to implement or if them, how do you feel about the remaining six that is still not done?

The environment and the business are changing all the time so every delay changes the context of the change and every change modifies the business and/or the environment. Often, organizational innovation is designed to deliver efficiency, often in the form of time saving, but it takes time to deliver a change. Once the change has been delivered, will it still be relevant or up to date? Will it save more time than it tool to create?

Because of time challenges, small, quick, iterative changes will tend to be the most successful if they can achieve the desired goal.

The "no change" option

It seems an obvious statement but keeping things as they are is a valid option if all the change options are unpalatable. Better options may arise later so unless there is a "burning platform" forcing change (almost at any cost), leaving an "OK" situation alone while a "Very Good" solution has yet to be discovered is a pragmatic solution.

> ***Participant 2H:***
>
> You know people that have a lot at stake for things not to change, you know… I mean and they might have very good reasons, you know from their perspective not to.

The bigger picture of the change

A process which is time consuming and difficult for a very small number of people and highly convenient and effective to many will pose a dilemma. Perfect solutions don't exist, so how do we weight the merits of each option and where is the line of acceptability drawn?

Many in the AR sessions report that the changes which never get made are the ones which do not sit comfortably into the existing business processes. An important part of negotiating change is modifying the planned change to suit the rest of the organization.

> ***Researcher:***
>
> Sometimes when people are trying to implement ideas and innovation, they're going to get hung up on trying to make that implementation perfect in the first iteration.
>
> ***Participant 3D:***
>
> No, that's certainly can be. That certainly can be in a reason why innovation is stifled for sure. I think even just working up to a preliminary solution draft solution, because that's what we do in engineering, right? We work up to a preliminary design initially. If we were always working towards a perfect design solution we wouldn't get anywhere.
>
> ***Participant 4H:***
>
> …are we actually plugging a gap somewhere in our processes or in our compliance somewhere? But also, does this have an impact on other parts of our business because … we could be running away with something. This is great for us, but it causes loads of work elsewhere… people don't understand what's happening, why we're doing it.

Making a business case

Not all innovation needs a business case. Solving a known problem may not need any notable investment, it could simply allow people to move forward from a stalled position. There may already be an agreed budget which covers the activity. A small group may decide to work differently and if no other stakeholders exist outside the group, that can be a stand-alone decision.

Where a business case needs to be made for investment in change, the business case will need to make a pragmatic estimate of the cost and time needed, which stakeholders need to get involved, what needs to be purchased, who will manage the change etc. At this point the change effectively becomes a small project. Money is being spent and needs to be accounted for. Progress needs to be tracked. Resource needs to be negotiated. This need for project management may take it outside of the area of expertise for the group driving the change and so wider business support will be needed.

> ***Participant 2H:***
>
> …when you look, just validating initially ideas you're trying to stay at a high level, you know and determine cost and benefits with the "good enough" approach. I think that's our strength as a business, and if you have your stakeholders involved and you've done that "good enough" high-level analysis, priorities will start coming out. The next step will be validating that idea from a cost-benefit perspective.

Procedures for change

Having a process for change can be valuable as it gives a common approach to evaluating the cost/benefit of each change. Such processes need to be as flexible and unbureaucratic as possible to avoid stifling innovation.

> ***Participant 2H:***
>
> You know, people dedicated to this and then a more formal process that we review, you know, and we provide certain tools and guidance to help us generate this sort of momentum outside just the research group. And then and that's quite important. We had a couple of ideas started to go through this process now… it has generated interesting ideas which we have in our innovation pipeline funnel of ideas for us to look at in strategic planning.

Session 4

This session was focused on the idea of managing paradox. While not a part of the original Complexity Leadership Framework (Uhl-Bien, Marion, and McKelvey 2007), paradox is a common theme in the wider discussions on the nature of complexity. Mary Uhl-Bien stated that she had deliberately avoided discussion paradox in her work of complexity (Cranfield 2022) for fear of entangling her research with the work of others in Paradox Theory in Management.

The pre-session task was for the leaders to identify paradoxes in their current roles and strategies used to balance conflicting demands. Two scenarios were generated to fuel the discussion (example shown in Figure 62 below)

Scenario 2 (paradox of dilemma)

Your sales team are telling you that our prices are too high and they are getting rejected at every turn.

Two factors have been identified which could reduce the prices:

a) Reduce the profit we make to below the standard rate
b) Reduce headcount so that the overhead recovery is lower and our prices will reduce.

You don't like either of these options – what do you do?

Figure 62 - Scenario for session 4

During the discussions, which were entirely centred on lived experience, two kinds of paradox were identified and a proposed model for leadership interaction was developed.

Observations and discussions: Managing paradox.

Paradoxes within leadership

The world of business is rife with paradox and leading within paradox is a natural facet of Complexity Leadership (as discussed in 2.10). These paradoxes fall into the following two categories:

True Paradox: Two contradictory states which cannot co-exist and are both necessary.

> ***Participant 3D:***
>
> > [speaking on the paradox of needing to manage a team to do work which they are unfamiliar with but which you, as the leader, can do quickly but shouldn't because it's not your job and the team needs to learn] …there's been instances where I've asked someone to do something. It would drag on for - days and it would just get to Friday and we have to deliver it now and I'll just end up doing it because…
>
> ***Researcher:***
>
> …and you do it in minutes?
>
> ***Participant 3D:***

Yeah, right. But … they've never worked on this task, or this activity before? They've put it on a bit of a pedestal. So, for [them] to start this activity is going to take X amount of brain power and it's going to require so, much effort. So, [they're] going to keep putting it off, whereas obviously I know how to do it. So, for me it takes a lot less effort, right? Just to get it done.

Apparent Paradox: A situation being presented as a paradox or as a choice between two contradictory extremes when the reality is that there are other options available if time is taken to find them.

Researcher:

Your sales team are telling you that our price is too high and they're getting rejected at every turn. Two factors have been identified which could reduce the prices. We could reduce our profits or we could reduce the headcount so that the overhead goes down. You don't like either of these options, but what do you do?

Participant 2D:

Thing you need to know is what's the market price? ...you need to [understand] from your customer why you weren't picked, and it's not just price. They might just not like the way you put the numbers together. You might be difficult [to deal with], because of [your terms and conditions] or whatever.

Researcher:

Good leaders must always be able to recognise and lead paradoxical situations. Because if it's not paradoxical, all it is as a priority call.

Participant 2I:

Yep.

The leadership behaviour for both is different but, first, the type of paradox needs to be determined. The easiest way to determine a true paradox is to try and treat it as an apparent paradox and look for more alternatives. If the situation is fundamentally binary then this will become apparent quite quickly.

Identified examples of Paradoxes within the sessions

1. You must train people to make them feel valued and to increase their skill in their job but you may be making it easier for them to leave and work somewhere else plus they may now find much of their job boring.

2. In theory, the most senior person does the most important work but, for a given team, the very senior person may have little interaction whereas the least senior person may be more directly critical for a goal being met.

3. On the one hand, the least experienced member of the team arguably needs the most focus from the leader, on the other hand, they are likely to be working on low priority work and so should see the least focus from the leader.

4. On the one hand, as humans, we tend to hold a simplified model of the world and the organization in our minds and we use that to make decisions quickly. On the other hand, organizations are complex systems and cannot be accurately represented by models.

5. On the one hand, a leader with a detailed experience in the area they are leading will make knowledgeable decisions, on the other hand, they can tend to micro-manage and sometimes a leader with no background in what the team are doing is better at trusting the team and empowering.

Session 5

One of the main challenges with developing a new leadership framework is finding the best way to deliver the ides of the framework to the target audience. The goal of this session was to explore training methods. The task for this session was for the leaders to review training they had experienced during their career and rank that training by effectiveness. They were asked to prepare responses to the following questions:

1. Since you began your career, what training have you received from an organization which you found to be effective in changing your mind, behaviour or understanding of something?

2. When you think about effective training you have received, which aspects of it do you think made it successful?

3. To what extent do you think the following are important?

   a. The chance to ask questions and discuss

   b. Having some written material to refer to later

   c. Physically active during the sessions

   d. Having pictures and diagrams

   e. Learning in a group

   f. Being able to challenge the material

4.   If you were to decide to learn something new in your own time, what you be your preferred method? Is it different to learning for work?

Observations and discussions: Training styles

There was unanimous agreement that face-to- face training was the most effective.

> ***Participant 2C:***
>
> So depending on what it is, I personally prefer face to face meetings.
>
> ***Participant 3G:***
>
> Always face to face in person, in person. What happens when you're using [a digital] medium between the people is things become more strictly rational [with] less [of] the emotional component, which often is 50% of… whatever you want to look at. Using digital media, it can work but I don't think it's as deep as meaningful as a face to face in person at all.

Beyond this, there were several other factors which it was felt contributed to the success of the training. Comments are as follows:

a.   The enthusiasm and knowledge of the trainers really matters. Passion comes across.

> ***Participant 2D:***
>
> I think if it's a face-to-face thing, It's the skill of the person running it. It's a bit like, you know, a comedian: They tell a joke, it doesn't work. They tell another one that works. They then tune into that.

b.   The delegate choices really matter – people need to be engaged. The mix should reflect the real user base.

> ***Participant 2C:***
>
> I personally think that you're much better off if you have a very diversified audience because getting other people's opinions opens your mind. It opens you up to other ways of looking at something that you might not have had otherwise If everyone in the room already thinks the same way you do.

c.   The wrong pace of delivery can be frustrating.

> ***Participant 4A:***
>
> …that style of delivery where I'm forced to read it, at the pace that you're giving it and only showing part of it means that

I'm not in control of it. I can't rewind it. I can't see you all of it. I don't know what you're going to ask me next on it. So yeah, I don't like it.

d.   The ability to discuss things with others in training sessions can be valuable

      i.   Allow us to reconsider our views.

      ii.   Keeps everyone on the same page.

      iii.   No-one gets left behind

e.   The ability to scale the training to suit experience is valuable. With face-to-face teaching, the delivery can be adjusted to the audience. Software can do it too but that is very difficult to create.

Participant 3G:

In French we say… "too much is like not enough", right?
If you have too much, well, don't give me anything…Forget it.

f.   Multiple methods of communication at once are important – image, words, someone speaking. Process flow charts. Diagrams.

Participant 2C:

I don't know whether or not I'm a visual person, but I'm definitely…a process person. And if you want me to understand something, if you put it in a stepwise fashion. I'm gonna get it every time… a flow chart, you know, I'm very visual, but it's really breaking a complex thing down [in a] step-by-step fashion. Understand this point first, then this point, then this point.

g.   Having the chance to fail then be quickly picked back up in the face-to-face sessions gets the ideas across better

h.   There are many learning styles

      i.   Some people like to take notes.

      ii.   Some people like something printed to annotate.

      iii.   Some don't want any material.

Participant 4A:

… you picked up on my character trait there. I do write things down. I do listen and write things down. And that's just the way I kind of learn… because I write and that's how I input data into my head. I like to have something that's printed as well. I don't like to see it all on the screen, but I do like something printed. I like to write notes. I like to scribble my own things that I correct in my head. That's just the way I've learned over the years.

i. Real examples are engaging and powerful (emotional content).

Participant 3G:

What sticks is the emotional part of it… your feeling of being heard or having been heard or understanding… and feeling what they wanted to tell you and what they're telling you. That's what sticks… What makes things real is the is the humanity behind it.

Participant 4D:

I particularly liked the user stories or examples or case studies. It's all very well, somebody saying the theory, but it's quite good to have examples of how the theory was applied either successfully or where it went horribly wrong and how they recovered it.

j. Getting people to physically implement the ideas is powerful.

Participant 4A:

I've done what [training on] ultra high vacuums. You learn the theory behind how the kit works and how your joints work and stuff. And then we had opportunities to then immediately go put into practice where you're given a system where its leaking and they're like "find out where the leak is"….so that's a really good. OK, I've got the theory: Immediately put it into practice.

k. Getting people to present their ideas on the course is powerful.

Participant 4A:

I do like it where you have set groups that have to do something and then present and explain their rationale.

l. Timing and structure of the sessions should be tightly defined, people don't want to feel that there is padding or that the course is drifting around.

Participant 4A:

…some of it's really valuable, I think it's always an assessment as to whether it's actually going to be beneficial for what you're trying to do. Some of it I found little bit just padding,

it's not been [useful] I'd much prefer those situations to go away.

Session 6

For this session, the participants were asked to complete two surveys (see also 3.13) for survey design). These surveys were based on the developed 5-point framework and combine to give four different views of leadership entitled Actions, Behaviours, Balance and Success. The percentages are cumulative scores from the Likert scale responses (so every question relating to a leadership mode being given the most positive response would give a score of 100%, the most negative scoring 0% with a linear scale in between):

Actions – This section surveyed the leadership activities performed by the leader in their role. Each of the five leadership modes within the 5-point framework was surveyed separately and presented side by side for comparison (see Figure 63).
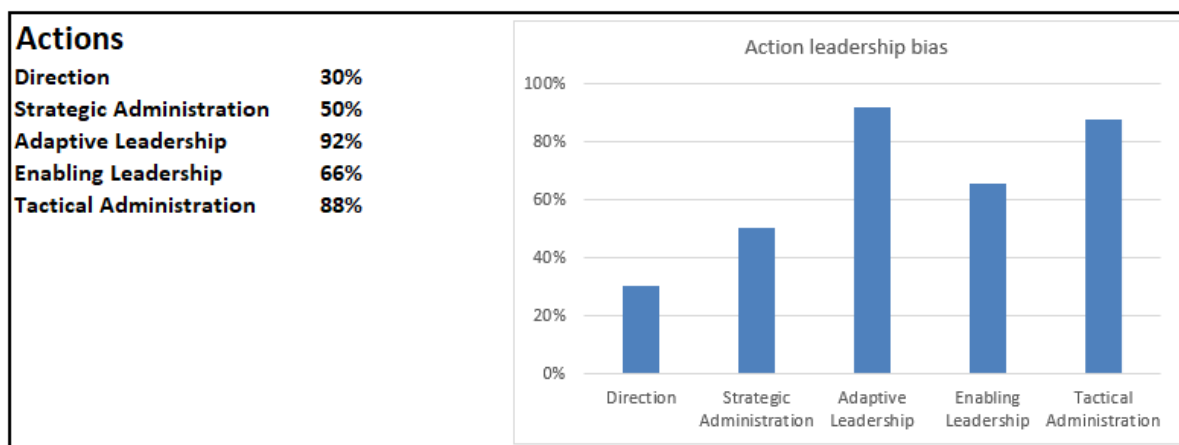
Figure 63 - Graph for Action leadership bias

Behaviours - This section surveyed the leadership which the leader felt most aligned to. Each of the five leadership modes within the 5-point framework was surveyed separately and presented side by side for comparison. The green lines in the graph (Figure 64) are the responses to the Behaviours aspect of the survey and the black dots are the responses to the Actions survey (repeated data from the graph shown in Figure 63) which allows an easier comparison between the two responses. This was useful as a comparison between the work someone performs in their role versus the work they would ideally be doing is posited as an indicator of development potential and job satisfaction.

Behaviours

Direction	86%
Strategic Administration	0%
Adaptive Leadership	91%
Enabling Leadership	77%
Tactical Administration	84%
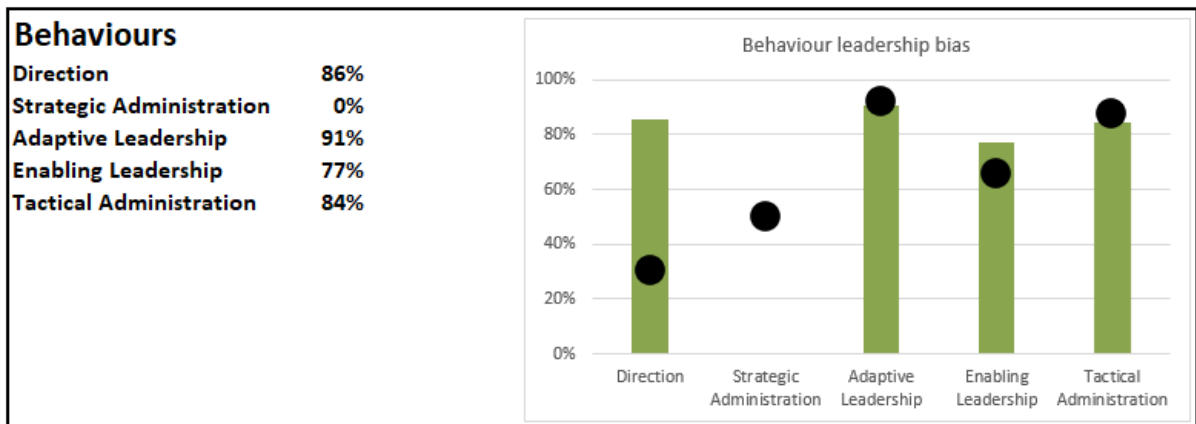
Figure 64 - Graph for Behaviours leadership bias

Balance – This survey looks at the balance of leadership experienced by the leader from the perspective of balance (i.e., too much, not enough). Each of the five leadership modes within the 5-point framework was surveyed separately and presented side by side for comparison.

The scoring directly reflects the Likert scale with the "About Right" central position scored at zero.

Balance

Direction	0
Strategic Administration	1
Adaptive Leadership	0
Enabling Leadership	-1
Tactical Administration	0
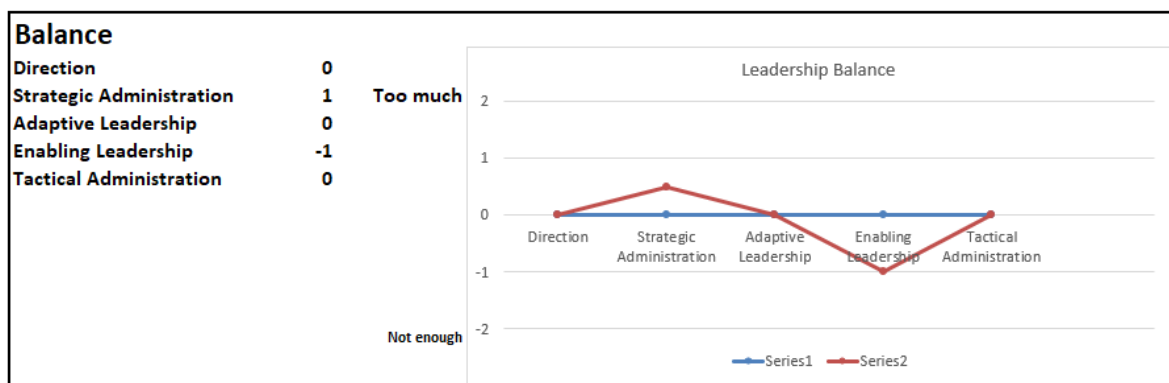
Figure 65 - Graph for Leadership Balance

Success – This survey looks at the perceived success of the leadership experienced by the leader. Each of the five leadership modes within the 5-point framework was surveyed separately and presented side by side for comparison. The bars were colour coded to make interpretation easier. The bars are shown green for 75% or more, amber for 50%-75% and brown for between 30% and 50% and red for below 30%.

Success

Direction	36%
Strategic Administration	39%
Adaptive Leadership	72%
Enabling Leadership	60%
Tactical Administration	58%
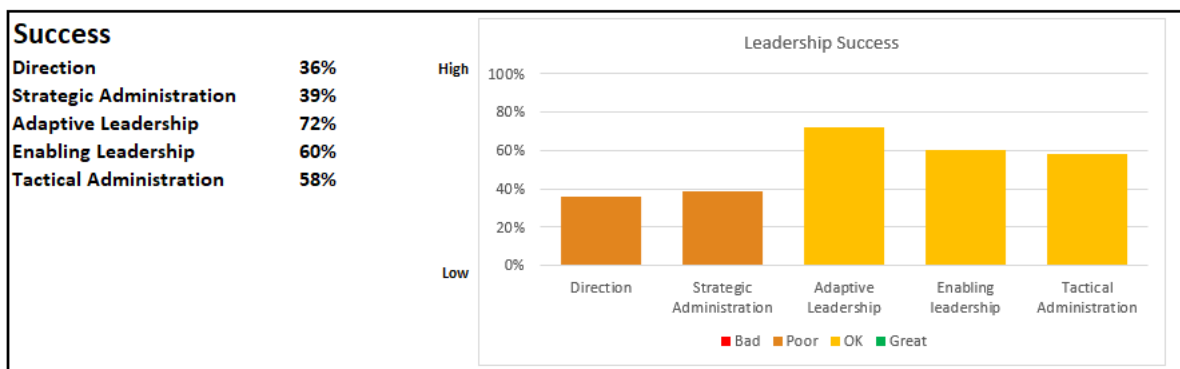
Figure 66 - Graph for leadership success

These surveys are designed to give individual analysis of a leader and their situation. The decision to keep the results individually was in response to a critical review of the earlier surveys which raised questions on the value of generating average or group leadership data. By surveying multiple leaders individually, large scale patterns can be differentiated from local effects.

Survey 2 is a leadership self-assessment survey (measuring Actions and Behaviours). The questions are derived directly from the developed theory which specifies the purpose of each leadership mode. Survey 3 looks at the leadership environment (i.e. the leadership which the respondent experiences) and creates the Balance and Success graphs.

The overall goal of the combined surveys is to give a holistic view of the state of leadership which relates to a single leader.

General observations

The survey data was exported into an MS Excel spreadsheet and analysed to give four result graphs (Figure 63 to Figure 66 inclusive). Certain patterns became quickly apparent, some of these patterns were seen as relationships between graphs rather than within a single graph.

A total of 24 leaders submitted both surveys. Their personal graphs were presented to them and the results discussed. After a few such discussions, it became clear what information could be derived from patterns in the graphs. To validate the accuracy of the graph interpretations, the last ten leaders were first presented with the interpreted diagnosis of their leadership situation before discussion. Only one leader was not in complete agreement with the diagnosis (this seemed to be a function of the way they had answered the survey rather than a flaw in the general method of analysis).

Participant 1D:

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Yeah, I found it a very interesting exercise and helpful…

Participant 1A:

Yeah, I think it's definitely an interesting discussion going around all of these, …this is how I'd like to be, how I'd like to be doing my job.

The following are examples of discussions where the pattern of leadership bias was used to determine the role and situation of the participant:

Example 1:

Researcher:

The purpose of this exercise is to see if this is if I'm able to actually tell things from this that you haven't necessarily told me… If I was guessing, I don't know anything about what you do... If I was guessing, I would say that's the profile of a programme manager…who is struggling a bit. Um, it might not be you. It might not be your situation, but…

Participant 2F:

Close. I'm a project engineer. It's more, but it's very similar.

Researcher:

I think this is where we're gonna see why you've got so much adaptive leadership in your life. It's cause there's nowhere near enough strategic administration which means that there's not enough processes or not enough work being done on the processes. Not enough structure in the wider business and what that tends to mean, it doesn't necessarily lead to adaptive leadership, it does lead to inefficiency. So it just means you're having to reinvent the wheel every single time, every time you try to do something… is that your experience? Is that right?

Participant 2F:

Yeah, that's spot on.

Example 2:

Researcher:

So, this is your day job… immediately, you know where I'm going with this, mostly tactical administration, but a fair amount of enabling and adaptive… again, this is a kind of programme manager… profile.

Participant 1E:

Yeah. So, I'm a project manager.

Researcher:

…there's still too much adaptive stuff… it's too much a part of what you're doing. Definitely too much reacting given all the planning you're putting in. Which is likely to be environmental. Kind of middle, middle ground direction and strategic administration… now you've hit another pattern and see if you agree with this: When all of the bars are fairly high that suggests to me that you're taking on more than would be ideal. So, in other words, there's not enough people to delegate to or maybe it's a bit of a small team so you're having to do a lot.

Participant 1E:

Yeah.

Researcher:

Is that fair?

Participant 1E:

And that's very fair.

Example 3:

Researcher:

Tactical ministration is really high. So, that looks like someone who's doing a lot of planning type activities. And to be honest, most everyone in our business that does that kind of planning to that extent is some kind of programme manager type person. So, what is it that you do?

Participant 3A:

So, I'm the Director of Operational Planning.

Researcher:

There you go… And it's also it's also makes a lot of sense that that's not actually the classic profile for a PM. You've got a strong planning, but also a fairly strong business side. So, you know, there's a decent amount of direction there, decent amount of strategic administrative stuff, that's all business-focus stuff.

So, then we go to the environment…. nowhere near enough process and look how badly… It's totally unsuccessful… makes me think that's decades of lack of process are now coming home to roost.

Yes, I that that resonates very well. So, we are working through a stabilisation programme right now and looking for ways to better align our business processes with our ERP. So very much broken processes.

Leadership survey (Survey 2 and 3) results – patterns in data analysis

Rather than present results from individual leaders, this section presents the patterns seen in the discussion of the graphs, how the balance of leadership modes in each of the four areas relate to their role, issues seen and overall experience.

Abbreviations:

D – Direction

SA – Strategic Administration

AD – Adaptive

EN - Enabling

TA – Tactical Administration

The Action leadership bias graph
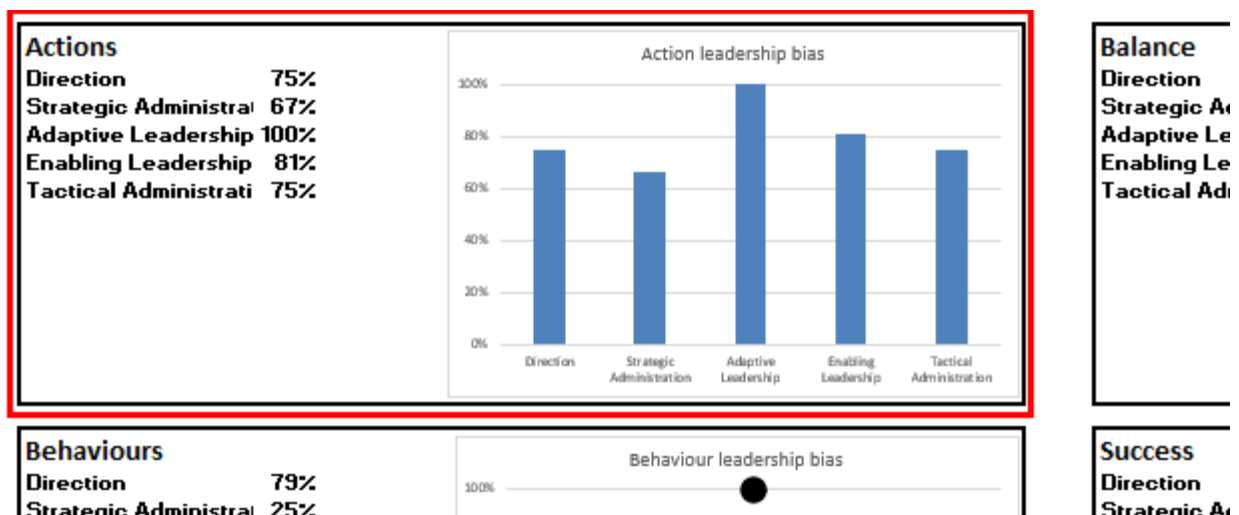
Figure 67 - Action Leadership bias graph

This graph looks at the leader's current job and how they lead it. There are various significant patterns to be seen in this graph. The centre column (AD) can be seen as a divider between two major aspects of leadership (business administration on the left and delivery on the right). Four types of leaders were identified in the sessions through

a consistent pattern of leadership mode bias for their roles: Project managers, business administrators, people managers, business leaders. Each are discussed in turn:

Project managers:

When the bias is in the right two columns only (EN, TA), this indicates a delivery focused leader. If TA is dominant, this indicates a project/programme manager or similar role. If the EN is dominant, this would a team leader who is doing some planning to keep things on track (i.e. a leader of the type "general people leaders" – see below).

In the pattern for these leader types, the D and SA need to be noticeably lower than the EN and TA. If they are similar, then that indicates is a different leader type. The AD column indicates the extent to which this leader is dealing with the unexpected. As a general rule, the idea of their job is to reduce the AD bar to a manageable level (around 50% or lower). If the AD bar is high and the environment is positive, this indicates that this leader's strategies or specific situation are not working to achieve control. If the environment is not positive, they may be unable to achieve control due to the environment despite their best efforts.
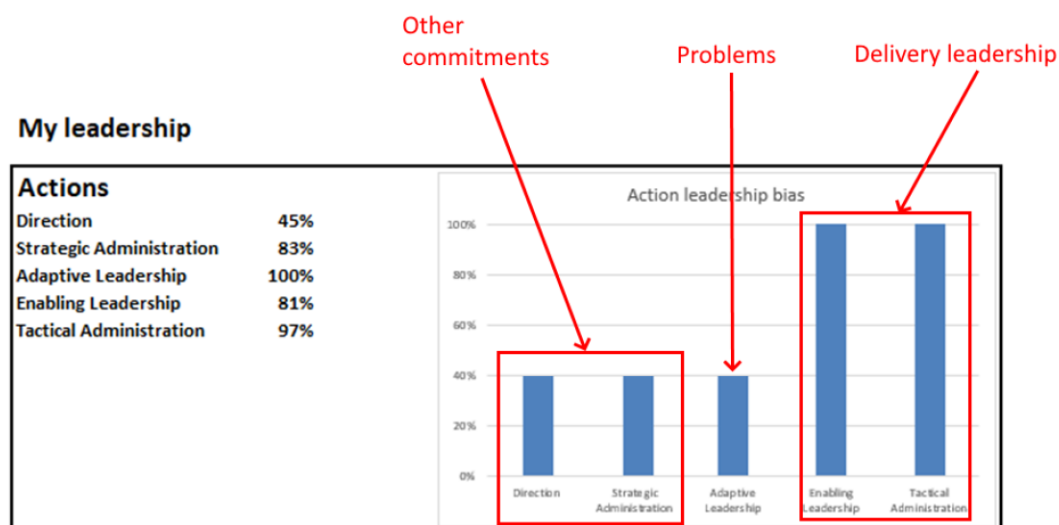
Figure 68 - Action leadership bias: Delivery focused leader

Above (Figure 68) is a simplified example. Real data for this type tends to look like the examples below which are all taken from surveys from real Project Managers:

My leadership

Actions

Action	
Direction	50%
Strategic Administration	75%
Adaptive Leadership	83%
Enabling Leadership	94%
Tactical Administration	100%
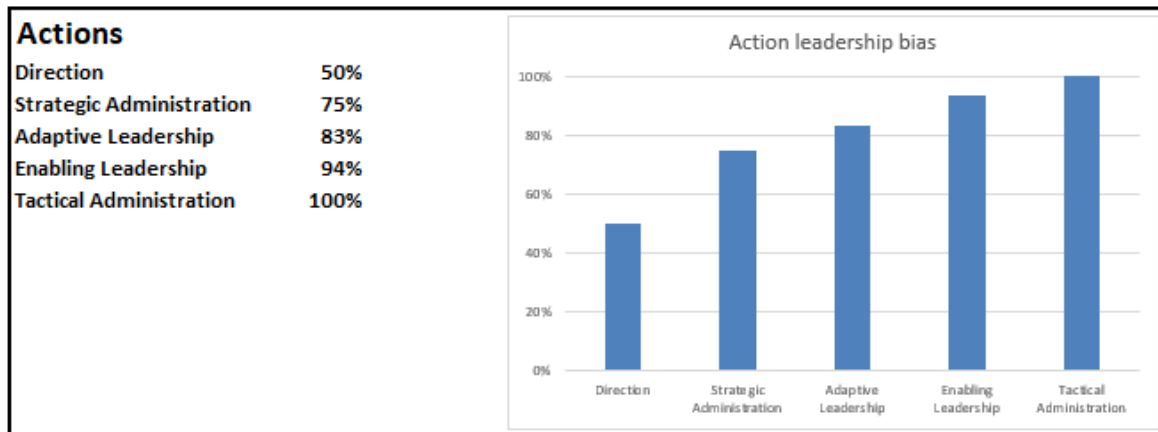
Figure 69 - Project Manager example 1

My leadership

Actions

Action	
Direction	60%
Strategic Administration	67%
Adaptive Leadership	67%
Enabling Leadership	88%
Tactical Administration	97%
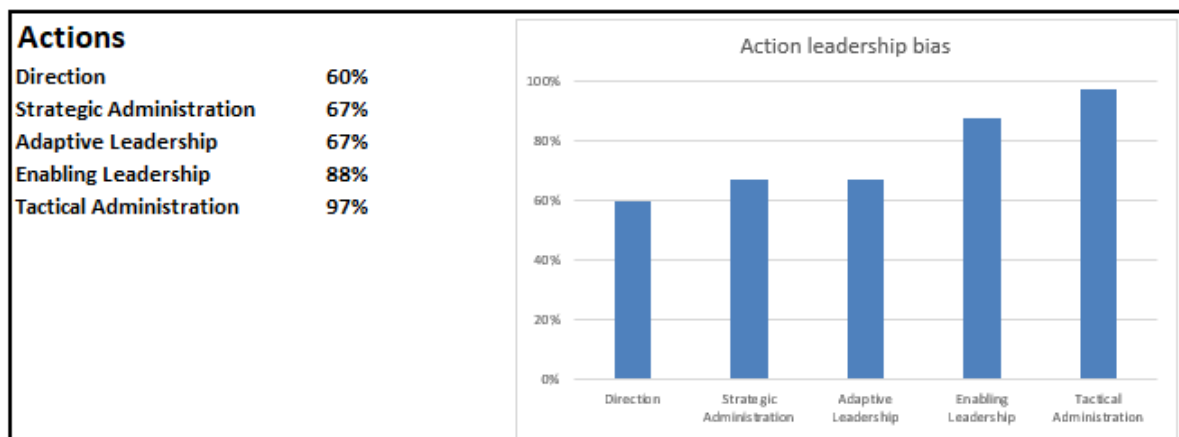
Figure 70 - Project Manager example 2

My leadership

Actions

Action	
Direction	70%
Strategic Administration	75%
Adaptive Leadership	92%
Enabling Leadership	91%
Tactical Administration	100%
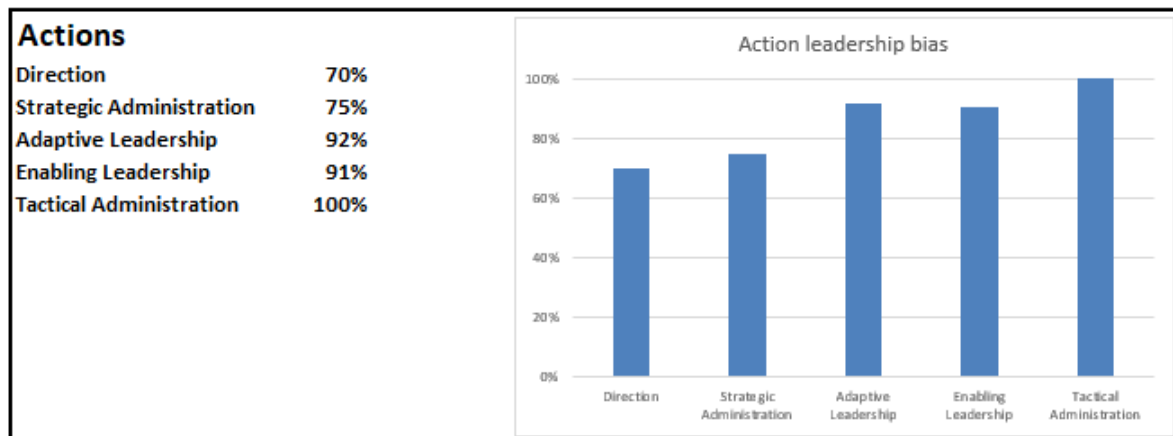
Figure 71 - Project Manager example 3

The AD value will never be at or near 0% for Project Managers but above 80% is too high for comfort as this shows a very high level of reactive leadership in a role which should be primarily pro-active. 50-60% would seem to indicate a high level of control in this environment as it is naturally volatile. If we examine the real examples above (Figure 69 to Figure 71), the middle example (Figure 70) is far more in control than the other two, even though numerically the difference looks subtle.

Business administrators:

Business administrators have a pattern of leadership which is the mirror image of the delivery focused leaders. Much of the same logic applies to interpreting their graphs. Where these leaders have content in the AD, EN and TA columns, this indicates a broad scope of leadership which is likely to be more senior within the business than an example highly biased to the left of the graph.

A business administrator may need EN to get stakeholder engagement for the business processes or to coordinate the creation of processes. The unplanned activity seen in AD should not be caused by the processes and policies themselves, but rather the process of creating them. A good example of a business administrator expected to see high levels of AD is one moving into an area which has previously had low levels of process control.
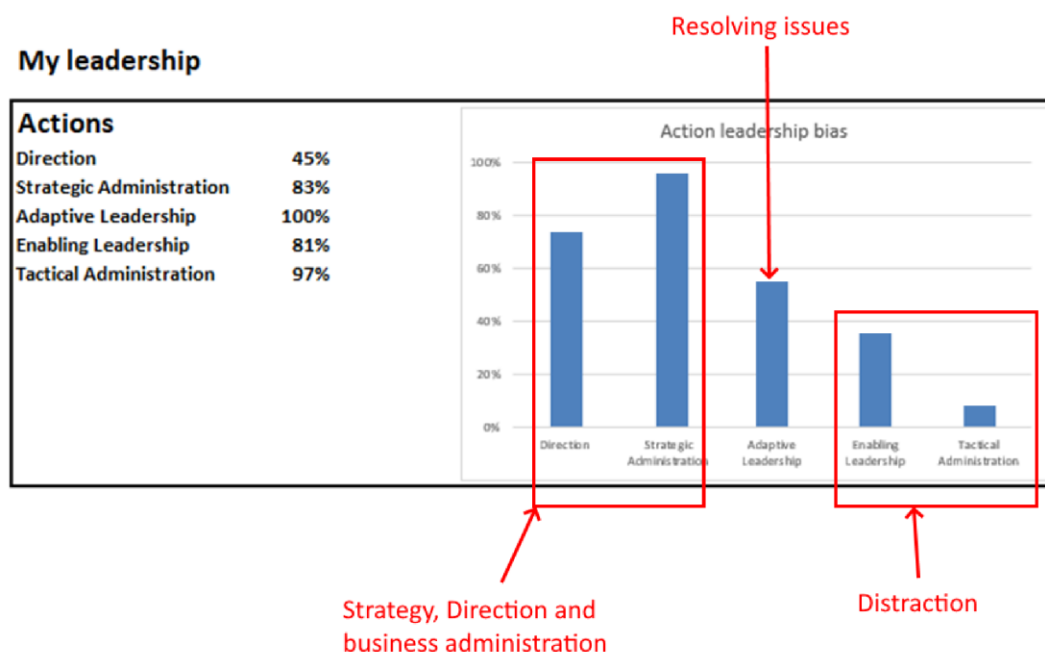
Figure 72 - Business administration profile – Action leadership bias

People managers

A bias towards the central three bars on this chart suggest that the leader is a people manager. The SA element gives day to day process for the team, the AD is resolving issues within the team and the EN is getting the team to work together effectively. Below is a real example:
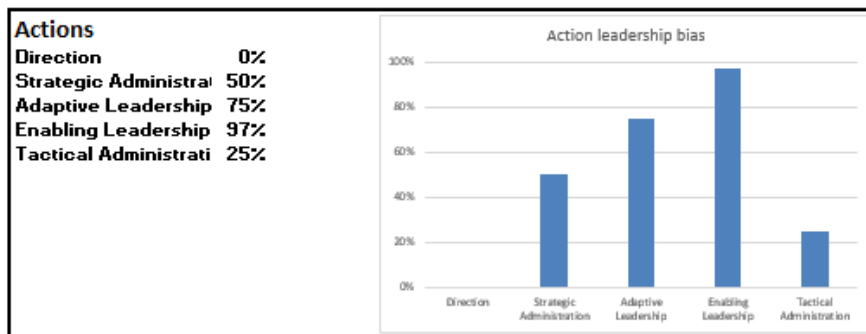
Figure 73 - People manager profile - Action Leadership bias

In theory, a people manager could do no SA (as this could be 100% delegated) but, in practice, they often need to get involved with the generation of processes as they understand the way the team works and the issues the process is trying to mitigate.

Business leaders

The interesting thing about "business leaders" (i.e. people at the head of a group who have strategic responsibility) is that they all show a pattern which makes no real logical sense until you take personality into account.

In theory, a business leader profile should look a lot like a business administrator profile, with a greater bias towards direction. This is because (again, in theory) these leaders are expected to delegate enough day-to-day delivery leadership away from themselves to allow them more time to focus on strategy, direction and resolving business-level issues.

What we see instead is that business leaders have even bias right across the graph (real examples are shown in Figure 74 and Figure 75):

Actions
Direction   100%
Strategic Administrat   88%
Adaptive Leadership   100%
Enabling Leadership   100%
Tactical Administrati   91%
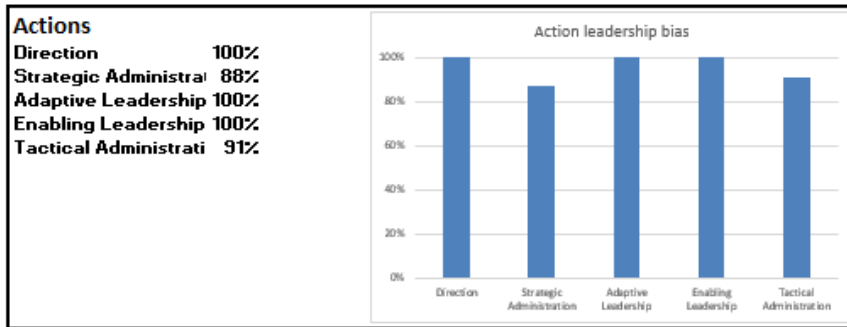
Figure 74 - Business leader example - Action leadership bias

We also see a similar pattern in people who have been business leaders in the past but who may be in a different role now:

Actions
Direction   75%
Strategic Administrat   67%
Adaptive Leadership   100%
Enabling Leadership   81%
Tactical Administrati   75%
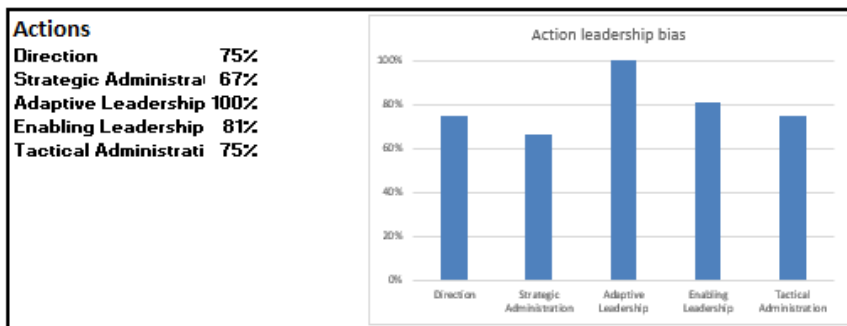
Figure 75 - Previously a business leader example - Action leadership bias

It is difficult to be certain the root cause of this multi-hatted leadership is without further research but a number of possibilities suggest themselves: It could be the tendency of a business leader to want to maintain high levels of control in all areas. It could also be a symptom of the fact that it is difficult to be a successful business leader without having skills in both the business and delivery areas. Even business leaders who are happy to delegate may find that the capacity of their team does not allow complete hand-over of some areas of leadership. Whatever the cause, the pattern was consistent. The AD levels are always likely to be high for business leaders as issues within the business tend to be escalated to them.

The leadership behaviour graph

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Figure 76 - The behaviour leadership bias graph

This graph is intended to be compared to the one above to compare the leader's current role to their natural behaviour. If the two look very similar they are considered likely to be a good fit for the job profile (they may also have moulded the job to their skills) and they are more likely to feel happy in that role. The black dots in the graph are a repeat of the levels in the graph above to enable easier comparison.

Discrepancies between the two action and behaviour graphs can have different implications depending on which leadership trait and in which direction.
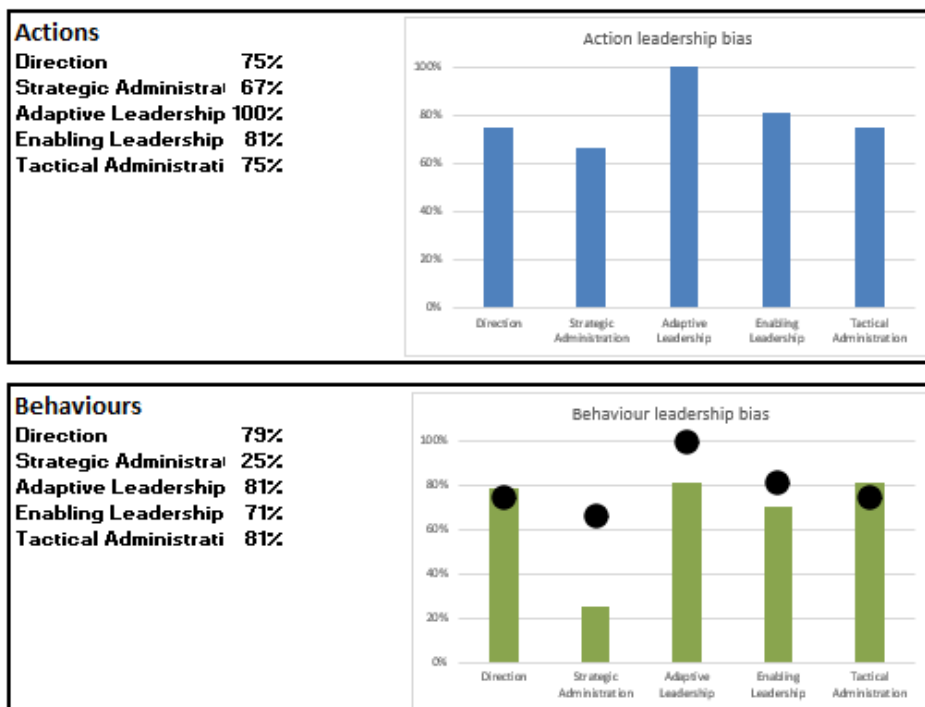
Figure 77 - Real example - Behaviour leadership bias

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In the graphs below (Figure 78), we have a business leader (actual role – Director), but the behaviours show that much of the work they are doing is not something they would naturally choose. Only D and EN are where they would like them to be.
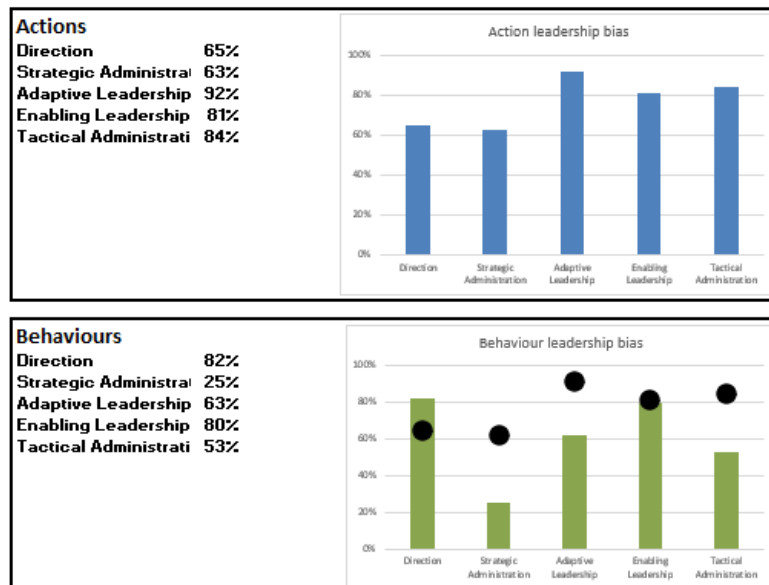
Figure 78 - Example of a Director - Behaviour leadership bias

The general interpretation for levels of D (Direction) being lower in actual job than would be ideal for the leader is that this is someone who would be comfortable in a more senior role, or someone who is in a senior role but distracted from their primary tasks. A real example is shown below (Figure 79) for someone in a Team Leader role.

Figure 79 - Team leader example - Behaviour leadership bias

As a rule, any area of imbalance between what a leader would naturally like and what their role entails can be interpreted as an external effect on their leadership, either

being forced to do activities they would not naturally wish to do or being blocked from actives they would like to undertake.

The leadership balance graph

This graph looks at the leadership balance in the respondent's environment. In this context "too much" does not mean too much good quality leading, it means that the leadership has become turbulent or chaotic. "Not enough" means that the leadership output / involvement in this area is less than would normally be hoped or expected.

Figure 80 - The Leadership balance graph

This graph relates to all others in some way: To the top-left graph (Action bias), it indicates areas where the leader may be forced to fill-in, or may become ineffective, due to an imbalance of leadership in the environment. To the bottom-left (Behaviour bias) graph, the relationship between the natural bias of the leader and bias in the environment may be significant. (e.g., if they cannot counteract an imbalance in the environment then the impact may be greater). To the bottom-right (Success) graph, the success of a leadership mode is influenced by balance. Sometimes "not enough" is still successful (as the team carry on without the leadership, using their experience) – sometimes "too much" leads to poor performance although, for example, it seems that being in a constantly adaptive mode makes you highly adaptive (often to the detriment of other leadership modes). It's the whole picture which is important.

The leadership success graph

This graph reports the perceived success of the leadership environment (i.e., the leadership which the leader experiences, directly or indirectly). This graph is useful as part of the big picture for a leader but it becomes potentially very powerful when the people being led are themselves surveyed, giving a more detailed view of the Leader's effectiveness by linking the results for a leader with those for their team.
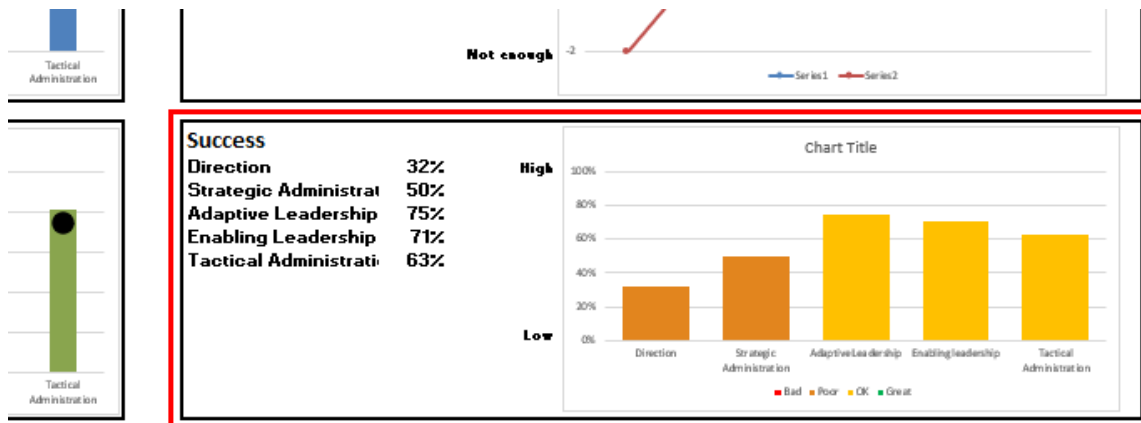
Figure 81 - The leadership success graph

The graphs are colour coded to the following score logic:

Great = 75%-100% - Green

OK = 50% - 75% - Amber

Poor = 30% to 50% - Orange

Bad = 0% to 30% - Red

The banding was confirmed as accurate to perception during the sessions. This graph (Figure 82) was one of the most positive seen:
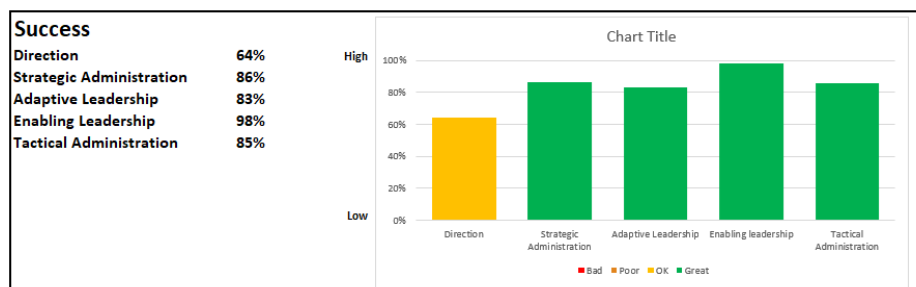
Figure 82 - Example of a positive success graph

The examples below were very low scoring. They are presented with the "Balance" graph to show how closely they correlate.

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Balance

Direction	0	Too much
Strategic Administration	-2	
Adaptive Leadership	-1	
Enabling Leadership	-1	
Tactical Administration	-1	Not enough

Success

Direction	46%	High
Strategic Administration	25%	
Adaptive Leadership	53%	
Enabling Leadership	42%	
Tactical Administration	50%	Low

Figure 83 - Example of poor success and associated balance graph

Balance

Direction	-2	Too much
Strategic Administration	0	
Adaptive Leadership	0	
Enabling Leadership	-1	
Tactical Administration	0	Not enough

Success

Direction	25%	High
Strategic Administration	72%	
Adaptive Leadership	69%	
Enabling Leadership	54%	
Tactical Administration	67%	Low
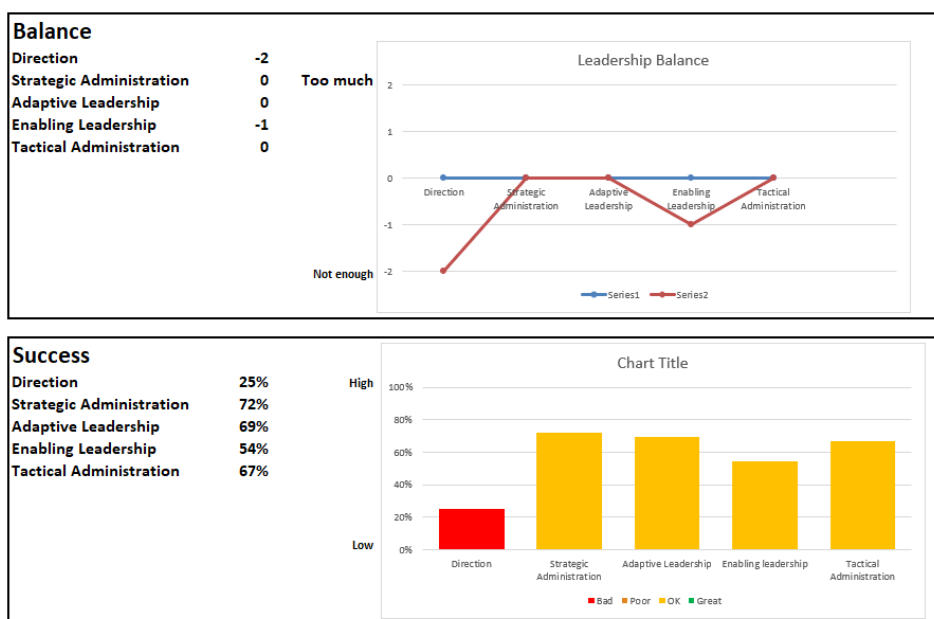
Figure 84 -Example of poor success and associated balance graph

Session 7

Building on the previous session which examined (in part) the idea of the leadership environment for a given leader, this session looked in more detail at the support that a leader received from other leaders in the network.

The participants were sent a spreadsheet to complete. An example of a completed one is shown in Figure 85. In this sheet, leaders were asked to explore were they get

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different modes of leadership from. They were also asked to indicate the success levels of each leadership source.

Order of regular interaction	Direction	Strategic Admin	Adaptive	Enabling	Tactical Admin
1	Director of IPT	HR Manager	Director of IPT	Director of IPT	Senior Programme Manager
2	VP Engineering	HR Director	Senior Technical Authority		Lead Engineer
3		Finance Director	Senior Programme Manager		
4		Quality Manager			
5		Engineering Process Manager			
6					
7					
8					

Colour code	
	Working well
	Hit and miss
	Falls short

Figure 85 - Example of leader support sheet - Session 7

Observations and discussions: Leader support network

This exercise revealed a lot of different aspects of leadership which are often neglected: Many participants found it hard to list all the leaders they relied upon without prompting. For one Participant, they didn't list a link to a leader because it was completely missing from the current organization structure – but it was needed and its absence was causing problems.

One of the most unexpected outcomes was the comparison between Direction in the BD/Sales/Marketing domain and Direction in other domains. Direction in the sales domain can be highly dynamic as it is primarily focused on generating strategies which align to future markets. The outlook can seem very different from month to month and can be dramatically affected by global events. Direction in this area can also come from a greater number of leaders within the business as so many factors are being considered (the future market influence, the global purchasing environment, loadings and capabilities within Engineering etc.).

> ***Participant 1E:***
>
> We are doing a Sprint to make sure that we will influence all the RFI and RFP [Request for Information and Request for Price]. So, there's one [Sprint] for every demo for every client meeting. So, this is why we need to realign every time and we have the big vision that could change a little bit. But it's all depending on where we are and what we have been able to accomplish and the result of the demo.
>
> ***Researcher:***
>
> So, some of some of this [uncertainty] is the fact that because you're working in the future. Some of this is people recalibrating what they think the strategy needs to be. So,

here's obviously where direction becomes weakest, isn't it is when it's trying to predict the future and especially when the future is quite dynamic and you're getting new data about what the future might look like…it's an important insight actually, that direction starts to breakdown as soon as you start trying to predict too far into the future or direct strategy that goes too far into the future.

Another key finding was the complexity of the Strategic Administration support network. So many departments (IT, Finance, HR, Purchasing etc.) have a supporting relationship with the wider business which exists in the realm of Strategic Administration. Every one of these supporting functions need to be well-led and effective if the business is to be efficient. For this to happen, their influence and contribution needs to be recognized.

> ### *Participant 3G:*
>
> [if a support department collapses] …you can survive. You can go into your emergency mode, but it's emergency mode, right? So, but in our in our case, interestingly enough, our IT group is actually led by finance, which is telling.
>
> ### *Researcher:*
>
> Yeah, that's always interesting. Yeah, that's because someone decided that I the IT people were spending too much money at some point?
>
> ### *Participant 3G:*
>
> Exactly which is it comes across as it's a cost only and people don't see the value it generates until you lose it… So, there's something about that organisation which is not working for us.

Discussing the links between leaders and the cause and effect of each leader's actions on one and other gives improved clarity for prioritization of organization structure improvements.

Limitations:

Some participants struggled to remember the definitions of leadership types which made the task a little harder. Some of them had not had time to do the analysis task before the call. For those people, the analysis could be performed verbally during the call. The task would have been improved by including a summary of the leadership types in the briefing.

Session 8

As this task was the last in the series, it was used as a first attempt to bring together the developed Complexity Leadership Framework into a first attempt at a training presentation. As the session task, the participants were asked to review the slide pack (created in MS Word) for discussion in the session. Specifically, the following questions were asked:

1. Is it understandable?
2. Is it engaging?
3. Is it missing anything?
4. Do you think, with perhaps some one-to-one training, it could be rolled out in the wider business?

This session was the culmination of the research to date and the design of the training material was influence by many factors including the output from Session 5 (training methods). The slides were very simplistic in their design, using a simple colour palette and AI generated illustrations along with the infographics which were designed using simple paint software (Paint.NET). Examples of the slides are below (Figure 86 to Figure 91).
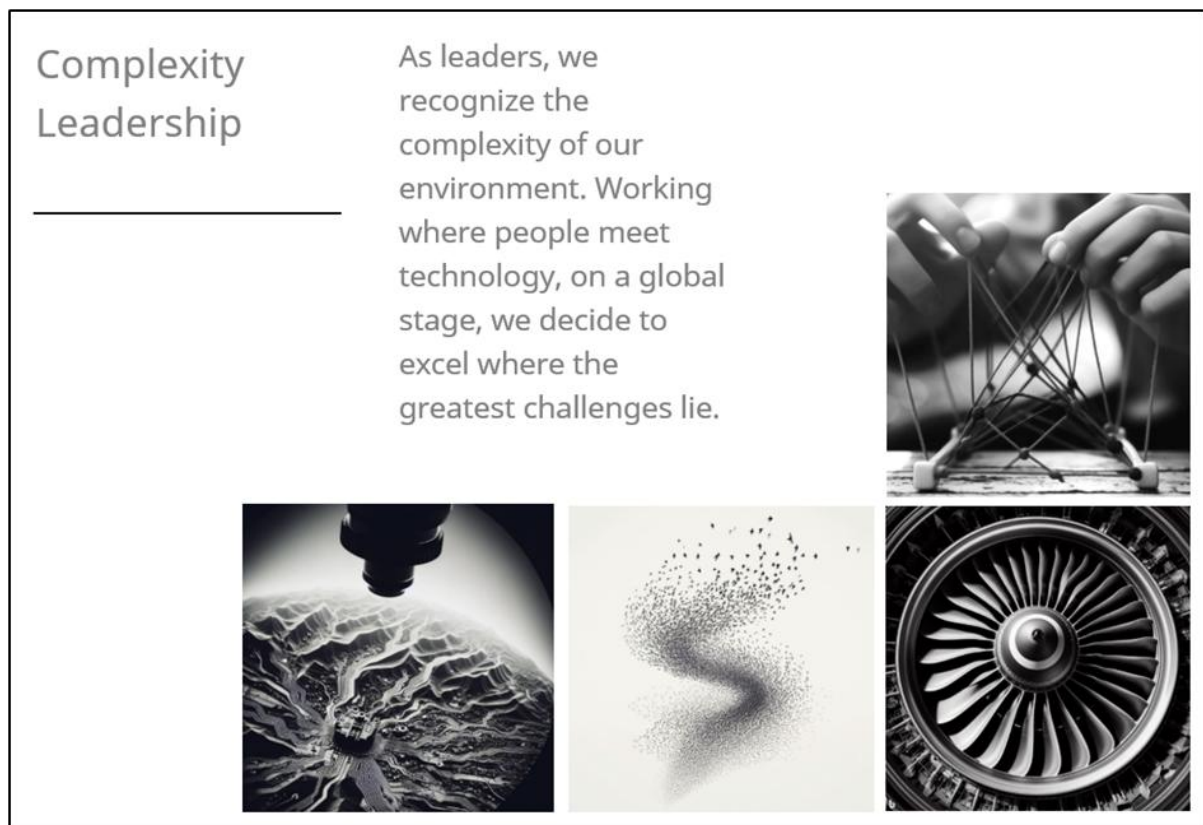
Figure 86 - Example of draft training material - Session 8

The 5 Leadership Modes

By splitting leadership into distinct modes, analysis of role functions and current leadership strategies becomes possible.

Adaptive

Directing

Enabling

Business Administration

Delivery

Strategic Administrative

Tactical Administrative
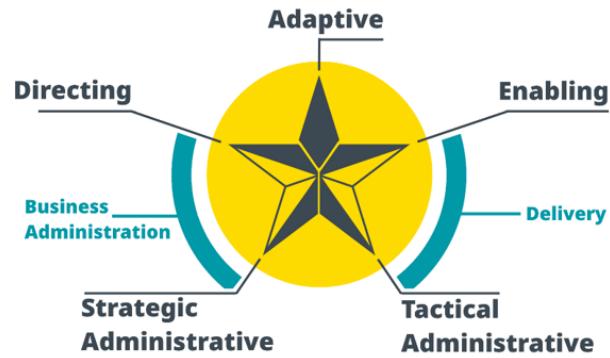
Each of these modes is distinct, used for different reasons, in unique ways. Each requires a different philosophy and approach. Together they provide all the leadership needed to succeed in a complex environment.

Figure 87 - Example of draft training material - Session 8

Directing Leadership

Answers the "why"?

This leadership could come from any leader who understands or generates the strategic vision.

Delivered to groups, a broadcast, independent of audience. Top level, low on detail. Normally a highly consistent message.

Purpose

Gives context. Enables priority calls, planning and decision making. Gives a sense of greater purpose and of a planned destination. Efficiency and effectiveness gained by cohesion.

Effect of not enough

Decisions will be deferred or made arbitrarily. Reduced sense of purpose. Reduced coherence across groups.

Effect of too much (rapid change)

Sense of chaos. Highly inefficient. Low engagement. Low trust in leadership. Lack of cohesion.

Context

Part of Business Administration (with Strategic Administrative Leadership). Business-wide. Long term.

Communication Form

Figure 88- Example of draft training material - Session 8

Distributed leadership

The strength of the team is leveraged through distributed leadership.

Not all heroes wear capes and not all leaders have important sounding titles. Mentors, role models, facilitators, inspirational figures or just simply the right person at a time of need are all part of the success of your team.

Figure 89- Example of draft training material - Session 8

Mapping your leadership

The circle is used to avoid a hierarchy tree. These show you what is true in theory, not in practice.
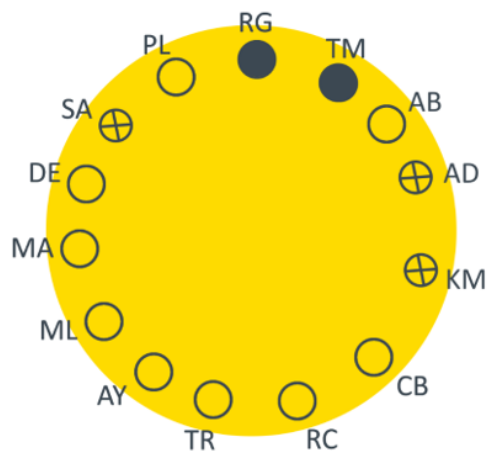
Colour the rings solid for each of the nominal leaders (those with official leadership positions). Put a cross for all of the distributed leaders that you know of (those who have some area of responsibility beyond themselves).

Figure 90- Example of draft training material - Session 8
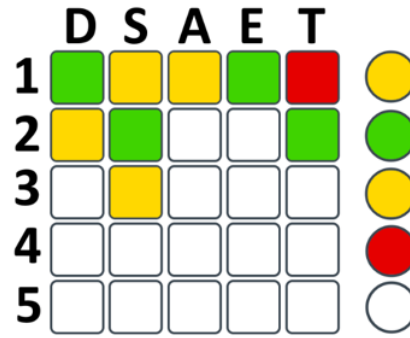
Figure 91- Example of draft training material - Session 8

Observations and discussions: Complexity Leadership Framework – Training material

The combined feedback from the transcripts was collated and was as follows:

1. Not enough "why" to link the three sections. Need to answer the "so what?" question.
2. What will leaders do differently after this?
3. What is the "pay back" for doing this stuff?
4. The last two sections are not as engaging as the first one.
5. Needs to be understandable without pre-training.
6. The distributed leadership exercise is very complicated and its not clear why it's worth doing.
7. The multiple layers in the distributed leadership is open to misinterpretation.
8. In the star graphic – Adaptive should have an explanation as to when its used.
9. Needs an "elevator pitch" at the outset and between each section.
    a. Suggestion: "This knowledge will help you adapt your leadership style to the context you are in".
    b. Suggestion: "It will give you the ability to analyse a leadership situation"
    c. Gives a vocabulary of leadership.
    d. To excel at leadership, you must first understand it.
    e. Prepare your network to use the correct leadership in any kind of situation when needed.
10. The "too much" explanations need more work – The Enabling one is wrong. Tactical Admin should be "micro-management". Enabling should be "distract and annoy".
11. Need a gap between each topic in the presentation.
12. The leadership support diagram is far too complicated for what it is.
13. Using hypothetical scenarios to explain would be easier.
14. The last two exercises need much more "why are we doing this"?
15. Suggestion about the narrative:

"Hey, now you understand the framework, you're going to go on a journey of getting better as a leader. These are the steps you're going to follow. You're going to understand your style. You're going to understand your team style. You're going to map your leadership. You're going to do this. So, you then got a story which says you're going to do these things. And then here's your outcome right now."

16. Rotate the columns on the leadership support analysis.
17. Can we relate the diagrams for the third and second section? To tie it together?
18. Can the conclusion move to the beginning?
19. Can we have "how to avoid it" in with the "too much, not enough" for the leadership styles.
20. Clarify that people can jump between styles.
21. Give examples in the diagram for distributed leadership. Different scenarios.
22. Explain that the 5 leadership styles are not people types.

In summary: The presentations need to present a compelling case for the training and they need to be clear and not open to misinterpretation.

4.7. Thematic analysis results

The transcripts from the AR sessions were thematically analysed as described in section 3.5. These themes were used to influence the form of the developed leadership framework. A summary of the links between the themes and the framework is presented below in Table 14.

Table 14 - Themes and their influence on the framework

Theme	Main concepts from codes	Influence on framework
The drive for success	The need to develop capability, structure, process and an exploratory mindset.	The framework presents a balance of structure and process (in the form of administrative leadership modes and Direction) and leadership modes to support agility and innovation (Adaptive and Enabling leadership).
Transformation	The potential for chaotic change without structure. The necessity of change. The need for people to change with process. The need for balance during change.	The framework presents Adaptive Leadership and Enabling Leadership, both having a joint role in producing change which is agile but mindful of the context and impact on

		people. These two modes create new structures which are then embodied using Strategic Administrative leadership.
Administration and financial control	A huge focus is on managing costs, making sure risks and benefits are balanced and good quality governance.	The framework recognizes the importance of business administration and local control of spending. These are embodied in Direction, Strategic Administrative and Tactical Administrative modes.
New thinking	There is a real need for new ways of thinking, the understanding of complexity and paradox, the understanding of emotional content as well as technical content. The recognition of niche or unusual functions and other diversities which play an important role.	The framework embodies the ideas of complexity leadership theory which is a new development in leadership thinking. Paradox and complexity are recognized and accounted for in the theory and in the teaching which surrounds the framework.
Leadership	Leadership is a multi-faceted activity which, in recognition of the diversity of required approaches, needs a range of modes.	The framework presents five leadership modes which, while they do not cover every aspect of leadership, define the core leadership elements required to run an engineering business.
The talent pool, people and skills.	People are diverse and need a range of skills. The leader needs to gather and manage the right set of skills within the resource pool. The team needs to be developed and assessed.	The Enabling Leadership mode is presented as the mode which recognizes and develops team members and which manages resourcing. By creating a defined mode which covers these activities, a distinction is made from the processes of Human Resource management to

		the associated leadership activities of people management.

The coding and themes are presented in Appendix A.

4.8. AR Participant feedback

As part of the final session, the participants were asked what they had gained from participation. Transcripts from the responses are as follows (the identities of the participants are coded as shown in Table 12):

Participant 1G – Senior Chief Engineer – Male - UK:

So, for me, the big difference is the language that it provides. I struggle with administrative leaders because it's not my natural style and I find that style constrictive and irritating, but [the framework] depersonalizes that irritation [by] putting it in context of the reason they're there... So, I think it gives you language which helps you to appreciate other leaders with very different styles and to understand how they might help you and you might help them. It's the depersonalization of that thought process it it's not because you're a "bad leader", It's because your style is not appropriate to this scenario, which I think is always very positive way of looking at problems.

Participant 1E – Project Manager – Female - Canada:

...that helped me to identify leaders that not are not, like, part of the small team and try to build better relation[ship] with them. To make sure that it's Enabled stuff or their Strategic stuff, that when you need to work with them, at least you have a good relationship. Or before then… because when you need something and you don't have this relation[ship], it's more complicated... so, this is the thing I get it from it, to start to build relationships and networking.

Participant 2C – Quality Assurance Manager – Female - USA:

Actually, I've enjoyed it very much. You know, it's a lot of food for thought. It's a lot of interesting ways of looking at [leadership]. I'm looking forward to you sending out the slide deck and sending it... to the person that I report to and the person who reports to me. Those were the two people interested. Just to open a conversation with them, because the more they understand about the different styles of leadership, you know, the more I kind of understand better about what their needs are.

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Participant 2G – Programme Manager – Male - UK:

…I think [finding the time to learn about CLT] was going to be one of the key things: unless [the priority] comes down to from a senior level to say "we will do this", it's going to be quite hard for a lot of people to really spend a bit of time looking at [it]. And I think that would be really good coming on the back of that to say, yeah, OK, this is important.

Participant 2F – Electrical Engineering Manager – Male - USA:

So, I got "Participated" and I was like, what is this? But no, I think it's been good. I think it's... I've enjoyed the structured way of thinking about leadership because it is a very nebulous topic. I haven't had a lot of formal training in it, not in a long time, at least. So, it got me thinking about how I lead my team and teams and each one differently. And I am looking forward also to seeing the final slide deck. And I think if someone on my team wants to take some sort of leadership position, whether it be formal or not, I would like to pass them this sort of material and say look this is something to consider when you're leading.

Participant 3G – Vice President – Male - Canada:

I like the process of identifying clearly the types of leadership. And its again [a] succinct way [of looking at leadership] and the bridging to [leaders] and like this exercise here. I think this could be worth digging into further because … what you could do is make a link between the mapping of the leadership and the types of leaderships that are lacking or that are in excess like start bridging those two things more tangibly together and say, OK, well, this exists because there's a lack of Directive leadership, or this exists because there's too much Administrative Leadership, whatever, right. And sort of make that connection that's the one thing that I think. That, you know, at least it's putting some of that language together. I'm going to make use of the types of leadership, for sure. I will also probably add in my own assessment as to if you look at your organisation and you are, for example, you know you've distributed your decision making to your team that's you know, now your [Direction] leadership is good. You know that your [Strategic Administrative] leadership is good. You know so that tells you certain things that are good. But if you are in a different situation where you're the centre of all decisions… "these are the areas of leadership that are lacking" and so I think that's what that's how I will use this. I will take it and maybe dissect it in a way that I can use within my team.

Participant 3E – Manufacturing Services Director – Male - UK:

It's really good… and I think things like this, we just need, we need to do these things… to bring it out of people as well to, to educate people and to… I think so.

Participant 4B – Head of Commercial – Female - UK:

Firstly, I can't believe it's been two years. That's amazing! How does time fly? It absolutely has been useful and… I think running it in parallel with that other course actually, they've both been very complimentary to each other and I think some of the models that we've worked through, if I was sort of refreshing my memory, I think some of them have stayed with me more than others.

Thinking about that whole. You know, sort of matrix. That's the that's the wrong word, but. The leadership environment piece I found that exercise incredibly helpful because I think it… has told me a lot more about who I ought to be networking and talking to because those leaders influence the environment that I'm working in. So, I guess that that's been the one take away from me is sort of thinking trying to think or get time to think a bit more strategically about who [I should] be talking to in the organisation to sort of influence this or that in this particular project or scenario.

Participant 4G – Operations Manager – Male - Ireland:

[The leadership support model] threw up a lot of questions for me. I can see where this approach's kind of highlights those unsung heroes, you know, because you tend to think structurally as opposed to, you know, who's actually facilitating the job that you do, as you say. Yeah, actually, I went through an interesting exercise recently because there's a lady in our organisation here in Dublin... she approached me a while ago and said, look, I think my job title is wrong and OK, that sparked off a whole, you know, analysis of what a real job function was. And you know, she's been with the company and it's about 13 years so when we sat down and analysed it, they said, well, we need to review your job description. And when we did that, there was, like, she was doing, like, I don't know twice, easily twice, 250% more than was in her original job title, you know. And you know, again, this is why I use that term. It's kind of an unsung hero because she kind of just it's like you said, because she does things flawlessly every time. You kind of take it for granted. She's a victim of her own best [intentions], you know?

4.9. Chapter Summary

The Action Research sessions have consistently challenged the researcher and the participants to examine their own practice and mental models of leadership using the lens of Complexity Leadership. As the sessions progressed, the Complexity Leadership Framework was modified through a process of review and comparison (i.e., the feedback from the sessions was compared to the current framework and, where they deviated, the framework was modified to accommodate the feedback). Also under development was the method of describing the framework or teaching its use. Different designs and descriptions were used throughout the AR sessions in a search for the

most effective communication method. The sessions produced a large amount of data and observations on leadership. Not all of this made it into the final framework. The framework shows modes of leadership and how they interact, many valuable insights on leadership exist outside leadership modes but the modes are considered foundational and non-situational whereas many of the observations are specific in nature and so considered less useful for a leadership framework.

5. The Proposed Framework: A 5-point Complexity Leadership Framework

Chapter	Phase	Purpose	Method
5	Investigation Development	Present developed leadership framework	Data analysis, Iterative development

This chapter presents the developed framework, starting with an overview explaining how the framework links to Complexity Theory (5.1). The 5-point framework is outlined (5.2) then the roles of each of the five leadership modes are explained in detail (5.3 to 5.7 inclusive). The research also identified some key skills which a leader in complexity would need and these conclude the chapter (5.8).

5.1. Overview

This section presents the 5-point Complexity Leadership Framework which has been created as an output of the research. It is named the "5-point" framework to differentiate it from the original proposed framework and because it features five leadership modes.

A leadership framework is a model showing different elements of leadership and their interaction. The purpose of a leadership framework for an organization is that it provides a common frame of reference for the understanding, analysis and planning of leadership (specifically *leading complexity* in the instance of this research). The start point for this research was the Complexity Leadership Framework proposed by Uhl-Bien et al. (Uhl-Bien, Marion, and McKelvey 2007) but many other examples exist (e.g., Cao et al. 2021 etc.; Samimi et al. 2022). The 5-point framework links directly to complex systems theory by setting defining leadership modes to address the needs of organizational leadership within the context of organizations as complex systems. Looking back at the definition of a complex system in section 2.5, the leadership modes map to the characteristics of a complex system as follows:

Complex Systems…

…are dynamic:

All leadership relates to change (either a desire for change or a response to it). The five leadership modes each address the dynamic nature of the system in a unique way. Direction seeks to influence the dynamic towards strategic goals. Strategic Administration creates a framework upon which the dynamic exists. Adaptive

Leadership responds to the disruptive elements of the dynamic. Enabling Leadership guides the dynamic towards the desired goal and Tactical Administration creates temporary structure to constrain short term dynamic networks which have been created to serve a temporary purpose.

…have multiple elements which interact with feedback loops:

The definition of a leader used when creating the 5-point framework is:

> *A leader is someone who influences others towards a goal. A leader modifies their influence in response to change and feedback.*

Each leadership mode receives feedback in a different way but each is based on feedback as a fundamental function of leadership.

…have boundaries which shift and are difficult to define:

None of the leadership modes has a defined set of boundaries which might constrain its sphere of influence. Throughout, the extensive nature of the network which contains the leaders and team members has been shown to be undefinable.

…are sensitive to their own history:

This aspect of complex systems is fundamental to human behaviour and is connected to learning. Each mode is sensitive to the history of the organization in a different way: Direction uses history to inform the future strategies. Strategic Administration records the history of best practice in the form of processes and policies. Adaptive Leadership deliberately moves away from history to enact change. Enabling Leaders use history in the form of their own experience and that of the team. This experience guides the team along the path of least resistance to the goal. Tactical Administrative Leaders use history to estimate the methods and resources needed to execute a project.

…create emergent (non-linear) events:

The 5-point framework recognizes two forms of emergent events: Expected and disruptive. Enabling leaders expect emergent events and negotiate new paths which accommodate them. Disruptive emergent events, which cannot be accommodated within the limits of normal flexibility, are managed by Adaptive Leaders who work away from standard process.

…have generally predictable patterns but very few predictable details.

This is accommodated by Tactical Administrators whose plans are as flexible as can be accommodated. By planning at a high level for all but the near future, the Tactical

Administrators outline the expected pattern without trying to tie down unnecessary details.

…have attractors which affect the dynamic behaviour.

Enabling leaders guide the team away from the distractions and "rabbit holes" (areas which look like they will be simple to explore but which take up too much time). They understand that the goal is not the only attractor which can influence the team.

…are self-organizing.

This is reflected in the recognition of distributed leadership as an important part of Complexity Leadership. Allowing the team to self-organize brings efficiency benefits and leverages their intellectual capital.

5.2. 5-point Complexity Leadership Framework

Throughout the research, a complexity leadership framework has been constructed using an iterative feedback method (in the form of AR) in collaboration with participants from the target audience. Using the original CLT Framework (Uhl-Bien, Marion, and McKelvey 2007) which describes three modes of leadership as a theoretical foundation, the baseline framework was modified and expanded to include five identified leadership modes. The two extra modes were arrived at by splitting Administrative Leadership into two distinct modes (Strategic and Tactical Administrative Leadership) and by the addition of Direction which was not a feature of the original framework. These leadership modes are proposed as distinct with no overlap; each is performed with a different mindset, goal, and communication method. They work together to form a framework as illustrated in Figure 92. The specifics of the way that the leadership modes are portrayed in the framework diagram arises from an analysis of the function of each mode and the ways in which they interact. The blue vertical arrows link leadership modes by their combined purpose within the organization (i.e., Direction and Strategic Administration work together to give Business Administration). The red arrows indicate the connection between modes which gives a common leadership effect (e.g., Direction and Enabling Leadership combine to give guidance). Adaptive Leadership is unique in that it links to all other leadership modes (as the leadership response to unplanned emergent events) but, as it is purely reactive, it has no day-to-day pro-active leadership purpose within the organization.
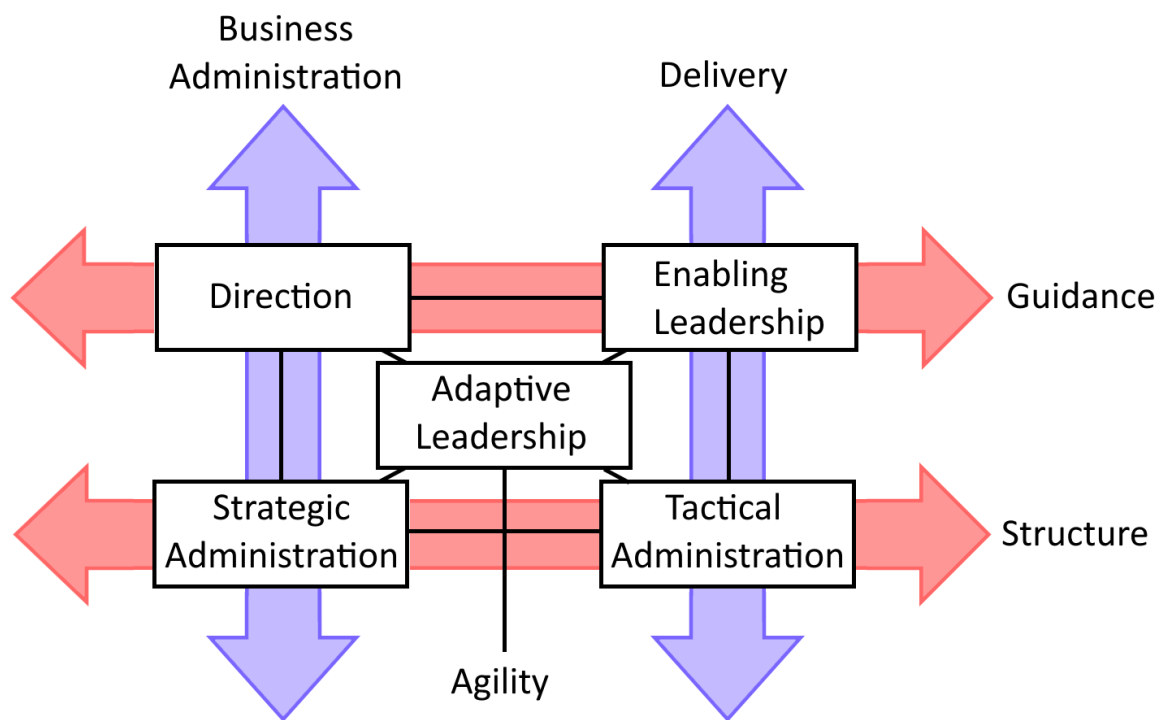
Figure 92 – 5-point Complexity Leadership Framework

Each of the leadership modes must be delivered in a balanced way and must have sufficient leadership content to fulfil the requirements of the team. This idea of balance refers to a scale where no examples of a leadership mode activity are seen at one end and a chaotic state of leadership churn exists at the other. In the middle of this scale is a measured level of leadership activity which changes quickly enough to keep pace with fluctuations in the environment and emergent events, but slowly enough to allow the team to follow the last communication before receiving another.

5.3.   Direction

The purpose of this mode is to set the strategic goals for the organization. These goals, and the narrative which surrounds them, give the global context for decision making. They also give a sense of greater purpose and of planned destination. These all combine to deliver high level efficiency by achieving departmental cohesion: if all the departments share a strategic vision there will be a greater chance that they will pull together and support each other.

The communication method for this mode is broadcast. With little modification in the message for different audiences, the message is delivered consistently, normally evolving over long periods of time. If the levels of Direction are below optimum, there will be a lack of certainty in some areas of the organization. Leaders will begin to make

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arbitrary local decisions which may not contribute to the global direction of travel. If Direction is completely absent there will be a lack of faith in the Senior Leadership Team (SLT) and in the future of the organization. Without a sense of purpose, the teams will become unhappy. If the levels of Direction are more frequent than optimum, with changes in message, efficiency levels will go down as plans are modified and stress and frustration begin to grow. As the changes in Direction message become more and more chaotic, there will be an overall feeling of chaos within the organization. Engagement and trust in the SLT will become very low.

5.4. Strategic Administrative Leadership

Administrative Leadership is well established within the literature and was proposed as part of the original CLT framework (Uhl-Bien, Marion, and McKelvey 2007), in this research, Administrative Leadership is divided into two leadership modes, both adhering to the general profile for Administrative Leadership but one (Strategic) dealing with long-term, general administration and the other (Tactical) specializing in short-term plans and other administration needed for projects.

The purpose of this leadership mode is to facilitate the generation of the processes, policies and methods which are used by the organization day to day. These processes may be documented or they may be verbally agreed and shared. In either case, the overall objective of this leadership mode is the streamlining of day-to-day activities, ensuring that they fit within the existing administrative structure.

The communication method for this mode of leadership is a combination of training and documentation. Methods which need to be audited require documents, as do those which are too complex to be easily remembered. Simple norms and traditions can be passed-on verbally forming a greater level of coherence than could be achieved by documents alone. Stakeholder engagement is an important part of this leadership mode. Care must always be taken when modifying the Strategic Administrative structure as any aspect which is too far from optimal will cause repeated problems for large numbers of the organization.

When there is insufficient activity in this leadership mode, efficiency gains from streamlined processes are not realized and tasks which should be simple can become burdensome. A complete lack of Strategic Administrative Leadership will leave the organization at risk of not meeting legislation, feeling very unprofessional. Too much activity in this leadership mode, perhaps in a misguided attempt to control short term effects with long term measures, will be frustrating to the team as more and more changes in process are rolled out. Without enough time for each process to become a

norm before another change arrives, efficiency gains are lost and, again, processes which should make task simpler become a burden in themselves. Taken to an extreme, the processes will fall into disrepute and the team will find "work-arounds" to bypass the process by mutual consent.

5.5. Adaptive Leadership

The purpose of this leadership mode is to create agility across the organization. This mode is always re-active and should be connected to short-term activities to respond to or facilitate change. The change can be in the form of an emergent event which is outside of the boundaries of expectation (emergent events should be expected within certain boundaries, both in the environment and the normal organizational activities). In short, this mode facilitates the generation of innovative responses to unexpected events or the mechanism for incorporating a disruptive change.

The communication method for this mode of leadership tends to be in the context of ad-hoc meetings and the pulling together of groups of experts or stakeholders to determine a way forward. A sense of controlled urgency characterizes this leadership mode. The leader themselves may not be an expert in the area of concern. Instead, they must have the skill and authority to bring together the right ad-hoc team to deliver a solution.

When there is insufficient activity in this leadership mode, leaders will either ignore unexpected events (hoping they go away by themselves) or try to use standard approaches to address non-standard challenges.

> "Studies could explore what type of psychological response is typical under complexity pressures, and why some leaders, followers and organizations turn to adaptive responses while others fall back on an 'order' response (Uhl-Bien and Arena 2017) by denying reality and wishing the challenge away (e.g., Donald Trump's repeated statements that the virus will 'magically' disappear)."(Uhl-Bien 2021 p. 2)

Too much Agile Leadership (a common complaint by participants in the research) is a sign of insufficient control, often caused by laissez faire leadership. By not enacting other leadership modes which could reduce the levels of unwanted emergence, the leader forces a state of constant reaction. While this is stressful and inefficient, it does have potential benefits to the leader: It requires no skill in planning or day-to-day management (i.e., Tactical Administration or Enabling Leadership). It gives the leader an opportunity to "save the day" by joining the team in their efforts to resolve the

resultant emergent issues. It frees up the leader to undertake work they want to reserve for themselves which, in turn, makes them less easy to replace as they retain unique knowledge.

5.6. Enabling Leadership

The purpose of this leadership mode is to engage with the team members as individuals, assisting with the removal of blockers through mentoring or facilitating collaboration. This leadership mode is responsible for generating engagement. It is a mode which strives to create the ideal environment for the success of the team as they pursue delivery activities, aiming to reach a collective goal. The Enabling Leader understands the strengths and weaknesses of each team member and how to get the best from them. They are responsible for allocating tasks and dealing with performance issues. Enabling leaders are normally closely paired with Tactical Administrative Leadership as the two, in combination, ensure delivery of complex team tasks.

The communication method for this leadership mode is normally face-to-face and conversational. While the conversations may be in the context of the plan and budget, they will be targeted at gaining an understanding of the challenges and successes each team member is experiencing. This mode often involves the generation or facilitation of innovation and problem solving.

When there is not enough of this mode of leadership (a common complaint from participants during the research) the team are forced to be self-sustaining. As time passes, the accumulation of local decisions made by team members without a co-ordinating leader causes drift from the optimal path to the goal. Under-supported, the team feel like they are being left to fail. Engagement and happiness will be low.

When there is an excess of this leadership mode, it is normally in the form of micro-management. Constantly asking the team how they are doing becomes frustrating if not enough time has passed since they were last asked the same question. This can feel oppressive and overbearing.

5.7. Tactical Administration

The purpose of this leadership mode is the planning and resource management of a team with a specific, time-bound task (i.e., a project). The Tactical Administrative Leader is normally responsible for the financial performance of the team whereas the Enabling Leader is responsible for their technical performance (i.e., the quality of their work). While the administrative methods used by the Tactical Administrative leader are of a commonly used type (project plans, action lists, work packages, forward load

projections etc.) the specifics will be created to suit the individual project, modified if needed during the project and put aside once the project is completed. The temporary nature of these administrative artifacts, combined with the small number of people who need to use them, gives a much higher level of agility than seen in Strategic Administration.

Communication style for this leadership mode tends to be in the form of regular, formal or semi-formal reviews; regular meetings with the team to check progress against plan. This leadership mode does not help the team resolve issues at an individual level (that is Enabling Leadership) but it does negotiate with other teams and organizations to co-ordinate necessary resources and communications. The Tactical Administrator reports financial status and progress to internal and external customers.

If the level of Tactical Administration is lower than needed, the plan will gradually become less and less useful as events deviate from expectation. If the plan loses credibility with the team, they will ignore it and proceed with tasks in whatever sequence feels right. This will lead to missed delivery dates and important tasks being forgotten. If reporting is ongoing, the accuracy of the data will be low. If this leadership mode is absent, teams delivering a complex task will be uncoordinated and inefficient. Such teams will not be tracking their financial performance or progress and will almost certainly take a very large amount of time and money to achieve the delivery, if they ever do.

If the Tactical Administrative Leadership is overactive, this can become a distraction for the teams. Too many reviews will drain the time available for the teams to deliver. They will feel that there is a lack of trust and that they are being micro-managed. The burden of reporting progress will begin to become a frustration. If the plan is being updated too regularly, it may lose credibility. Constantly revising the estimated delivery, especially to later dates, will frustrate internal and external customers. Instead of creating a greater level of control, churn in Tactical Administration will culminate in a lack of control.

5.8. Key skills for a Complexity Leader

The fundamental requirement for a Complexity Leader is the recognition of the complex nature of their leadership environment. This recognition requires a rejection of reductive thinking. Knowing that you can only control some of your environment, some of the time, ensures that the mindset of the leader is flexible. Such a mindset does not deny or ignore change, instead it seeks to gain advantage by it.

Understanding the way that leadership networks within an organization is critical. Both distributed leadership and leader support networks give insight to the leadership eco-system that the Complexity Leader inhabits. Rather than seeking to dominate and monopolise the team, the Complexity Leader leverages the team's knowledge and experience, sharing responsibility to gain efficiency.

Paradox is a natural part of the complex environment and the Complexity Leader is skilled at identifying paradox and finding the required balance where it arises.

5.9. Chapter Summary

The output of this research is the 5-point Complexity Leadership Framework which gives a holistic view of leadership in a complex organization. This framework has been developed through a process of Action Research, working with practitioners. It outlines five leadership modes and expands the originally proposed Complexity Leadership Framework (Uhl-Bien, Marion, and McKelvey 2007) away from a framework which is intended for academic study, towards a framework designed to be applied to real-world leadership practice. This expansion of the original framework was in response to identified gaps in the original framework when used to examine the methods and experiences of the participating practitioners. This study introduces the idea of balance for each mode, identifying the symptoms of too little or too much of each and proposes ways in which the leadership modes combine to produce certain business leadership functions. This is intended to enable practitioners to analyse issues in their current leadership and move towards a functional leadership structure and practice.

Alongside the five leadership modes described, there are key skills and behaviours which the Complexity Leader requires. Ultimately, these come down to a recognition of the complex nature of their organizational environment and the mindset needed to adapt to it.

6. Discussion

Chapter	Phase	Purpose
6	Evaluation	Discuss results and compare to extant research

This chapter summarizes the key research findings in the primary research, and how it builds on the secondary research. This includes an exploration of the relationship between this research and other, independent research in the same field. Starting with an overview to give context (6.1), it compares the 5-point framework to four other models of complexity leadership (6.3). The meaning and implications of the research output is discussed within the context of the research scope. The possibility of wider implications is also explored.

6.1. Overview

This research identified a weakness in the methodology and training of engineering leadership leading to poor performance in engineering projects. Engineering businesses need leaders with high levels of technical understanding, even in supporting departments. This reliance on a leader's technical capability reduces the pool of potential leaders and often comes at the expense of leadership skills (such skills are harder to quantify than technical skills without an established leadership framework and therefore consistency of approach in assessing leadership is challenging to achieve). This problem is compounded by the prevalence of reductive and outdated leadership methodologies (e.g., Hierarchical Leadership, modelling the organization as a machine, using manufacturing methodologies in non-manufacturing leadership etc.) in the engineering industry and much of the rest of the world, and a rapid increase in societal complexity, most notably since around 1990. With the increasing prevalence of Artificial Intelligence (AI), cloud computing and global communications via social media, the global complexity levels are set to rise exponentially for some time to come. The particular weakness of these reductive management techniques is that they ignore complexity which, as societal and technological complexity increases, makes these techniques less relevant and increases their potential for harm.

Solutions to issues of leadership are challenging to find due to the sheer breadth of the subject. Leadership, being a fundamental human behaviour, is diverse and multifaceted with a rich history of research theory and discussion. Even reducing the scope of research to Engineering Leadership presents a similar challenge. While the

research in this area is more focused, engineering is a huge field which covers construction, software, electronics, mechanical engineering, materials science, medical equipment design, systems engineering, fluid dynamics and many other fields of endeavour. Leadership for these fields is constantly affected by emergent technologies, increasing complexity of projects, increasing complexity of the environment, pressures to reduce environmental impact and many other factors which are less obvious in many other fields. Accepting the need to focus the research further, a leadership theory was selected with the potential to address the issues caused by reductive thinking while remaining relevant in the face of rapid change.

The research problem can be characterized as the need for greater capability in leading complexity. To achieve the research aim, an understanding of both complexity itself and complexity leadership was required. It was found that not only was the engineering environment gaining in complexity through the repeated addition of technological developments to the field of application, the engineering organization could itself be considered as a complex system. Complex systems, regardless of form, all have a consistent set of characteristics: they are dynamic, have multiple elements which interact with feedback loops, have boundaries which shift and are difficult to define, are sensitive to their own history, create emergent (non-linear) events, have generally predictable patterns but very few predictable details, have attractors which affect the dynamic behaviour, and are self-organizing. Some of these characteristics are to be expected when any group of people work together as a collective (i.e., we know people are self-organizing, are sensitive to their history and interact with feedback loops), but others link very closely to the research problem: if the engineering organization is dynamic, has boundaries which are difficult to determine and is subject to emergent events then it is logical to expect that reductive, over-simplified conceptual models will not provide useful management tools.

Complexity Leadership Theory was conceived as a response to this specific problem and so was chosen as the starting point for the research. CLT could not be applied directly to engineering leadership as it was proposed for academic discussion rather than application by practitioners. This gap in the research required a further development of the framework proposed for CLT, working with practitioners to develop a leadership framework which forms an effective tool for leadership within a complex system.

The complexity leadership framework ("the 5-point framework") which was the result of this research looks at the underpinning leadership modes which are needed for

successful leadership in a complex organization. The modes it describes are foundational, and are not proposed as comprehensive. Mentorship, training, recruitment, performance management and other leadership activities which are important for success are not explicitly covered in the framework. There is also no mention of leader behaviours and characteristics (empathy, emotional intelligence, communication skills, charisma etc.) which are also important. There is a great deal of theory relating to leadership related behaviours (e.g. Authentic Leadership Theory, Followership Theory, Servant Leader Theory, etc.) and this research does not propose to interact in that theoretical space. One area which seems to yet to be addressed by the work on leader behaviour theory is the practicality of applying behavioural frameworks in practice (i.e., can an ideal behaviour set be prescribed to leaders?), this would seem to be an area which would benefit by further research.

6.2. Key results

Using Action Research, the Complexity Leadership Framework, as proposed by Uhl-Bien, Marion and McKelvey in 2007 was examined for potential applicability by the researcher and practicing leaders. The framework, which proposes leading with a combination of three leadership modes (Adaptive, Enabling and Administrative Leadership) was understandable to the practitioners but, as more real-world leadership scenarios were compared to the framework, it was found that some modification was required.

The original theory describes the three leadership modes as "enmeshed" and provides blurred boundaries between some of the definitions of the modes. This lack of clarity was confusing to the practitioners who wanted to understand what each mode did without ambiguity. The first change, therefore, was a clearer definition of modes, moving to a distinct set, each with a different, purpose, mindset and communication method. Minor shifts were made to the definition of the leadership modes. Within the original theory, Adaptive Leadership is used to enact change on the organization and Enabling Leadership facilitates problem solving and mediates between Adaptive and Administrative modes. Within an engineering organization, where innovation is a planned activity, some finer distinction between types of emergent change was required (expected emergent change requiring a different leadership approach to unexpected emergent change). Also, as engineering organizations tend to be project-based, the leadership to deliver projects needed to be considered.

To better describe project leadership, Administrative Leadership was split into Tactical Administrative Leadership and Strategic Administrative Leadership, both modes being

very different in character. The short-term planning and budgeting needed for a project (Tactical Administrative Leadership) was considered too different to the creation of business processes and financial accounting (Strategic Administrative Leadership) to keep the two together. Similarly, the activity of Direction could not be characterized by any of the three proposed leadership modes. Uniquely, Direction is communicated as a broadcast communication (although it may be conceived in collaboration) and its purpose has nothing in common with the other modes. As Direction can be linked to the aspect of Complex System behaviour which creates *attractors which affect the dynamic behaviour,* it was considered an important addition; by setting the overall directional drive for the whole organization, Direction biases the dynamic flow of activities.

Once the five leadership modes had been established, it was noted that they had specific interactions: Enabling Leadership and Tactical Administrative Leadership were both used collaboratively to deliver projects. Direction and Strategic Administration were the key components to business administration, forming the foundational business platform upon which projects could be delivered.

Once the interaction of the leadership modes was considered, Adaptive Leadership was found to be unique in many ways: First, Adaptive Leadership can be needed in any context, for any scale of event (either within a task, a project or at a business or organizational level). Second, Adaptive Leadership is used for reacting to unexpected emergent events where there is no established process which will restore equilibrium, it is also used to drive disruptive improvements into the business process. This means that it is the mode which is responsible for agility. Third, Adaptive Leadership may be enacted by any appropriate person and does not necessarily confer long-term authority. Fourth, a high level of skill in Adaptive Leadership within a team or organization can be a sign of poor overall leadership. The purpose of the other four leadership modes is to achieve the strategic goals with the minimum of unplanned emergence. In most situations, the natural level of unplanned emergence requiring Adaptive Leadership is fairly low. Laissez faire leadership (a general lack of pro-active leadership) raises this level to an almost constant flow. This creates a high stress environment in which Adaptive Leadership skills are used to fill in the gaps in other leadership modes.

Another key development within the research was the explicit description of the effects of each leadership mode activity being either too low or too high. High levels of activity in any mode generally relates to chaotic leadership behaviour (either

micromanagement or constant change in direction or process). This chaotic leadership always has a negative effect on morale and performance. Low levels of activity generally align to laissez faire leadership but the specific effect depends on the mode, or combination of modes. Direction and Strategic Administrative Leadership are both pro-active, long-term leadership modes and so a short period of inactivity in these modes will have little effect. The other modes are more reactive to the dynamic flow and so a lack of activity in these modes will have a rapid impact on performance and morale. While the original CLT framework described the need for the leadership modes to be in balance, specific descriptions of the effect of different types of imbalances were found to be crucial to the framework's utility in application as it facilitated the analysis of existing leadership issues or the planning of future leadership structures.

6.3.　Comparisons to contemporary research

Much of this research has been targeted at answering the first research question (RQ1) which asks which leadership theory can be used as a sound basis for modern engineering leadership? The best-fit leadership theory was found to be Complexity Leadership Theory, as proposed by Uhl-Bien, Marion and McKelvey in 2007, and its associated leadership framework. As this framework was not proposed for practitioner application, the applicability of this leadership framework was unknown. This research has shown that, while the Uhl-Bien framework provides a useful starting point for the development of an applicable leadership framework, it requires modification to align with the lived experience of the target user group. While this research has been developing, other parallel research has also been further exploring and expanding ideas of CLT. These parallel theories were examined to see to what extent a correlation can be seen with the 5-point framework.

The Uhl-Bien and Arena model

Looking at the ongoing research of Uhl-Bien in this area, changes of approach can be seen. In a work published a decade after the original CLT framework (Uhl-Bien and Arena 2017), Uhl-Bien presents a developed version of her original complexity leadership model (Figure 93). The 5-point Complexity Leadership Framework presented herein was developed without reference to the 2017 publication, yet there is a large amount of synergy between the two leadership models. In the Uhl-Bien and Arena model, three areas of leadership are recognized: The Entrepreneurial System, The Adaptive Space and The Operational System. The mapping of the Uhl-Bien and Arena model to the 5-point Framework is as follows (see also Figure 94):
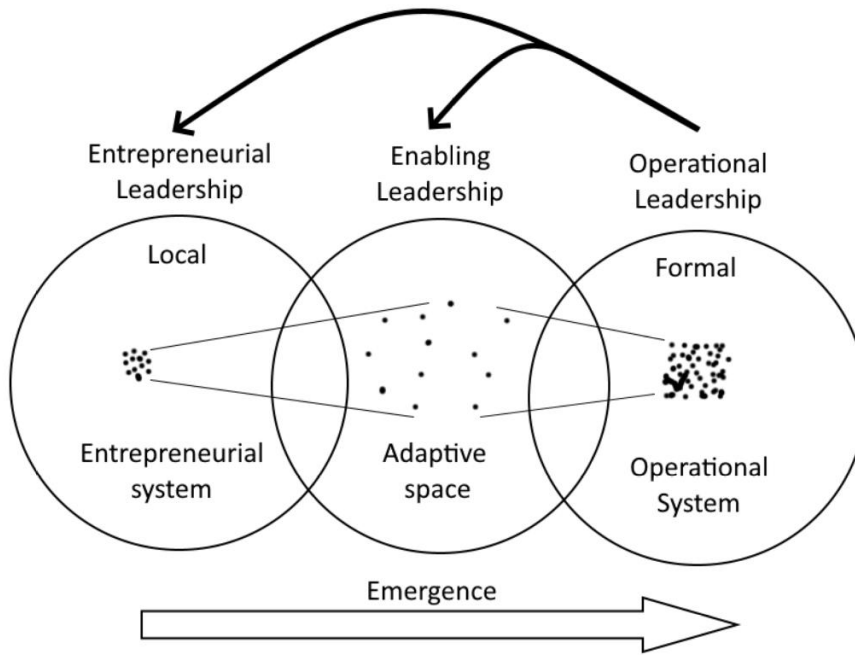
Figure 93 - The Complexity Leadership Model.

(Based on Uhl-Bien and Arena 2017 p. 15 Figure 3)

The Entrepreneurial System equates to the Delivery System (Figure 94) which comprises Tactical Administration and Enabling Leadership. This area of leadership is described as "Local" in both models. The Operational System equates to Business Administration (Figure 94) which comprises Direction and Strategic Administration. This is described in the Uhl-Bien and Arena model as "Formal" and as "Global" in the 5-point model. The Adaptive Space in the Uhl-Bien and Arena model naturally aligns with Adaptive Leadership in the 5-point model although the leadership is described by Uhl-Bien and Arena as Enabling. This highlights a different definition of Enabling Leadership in the two models.
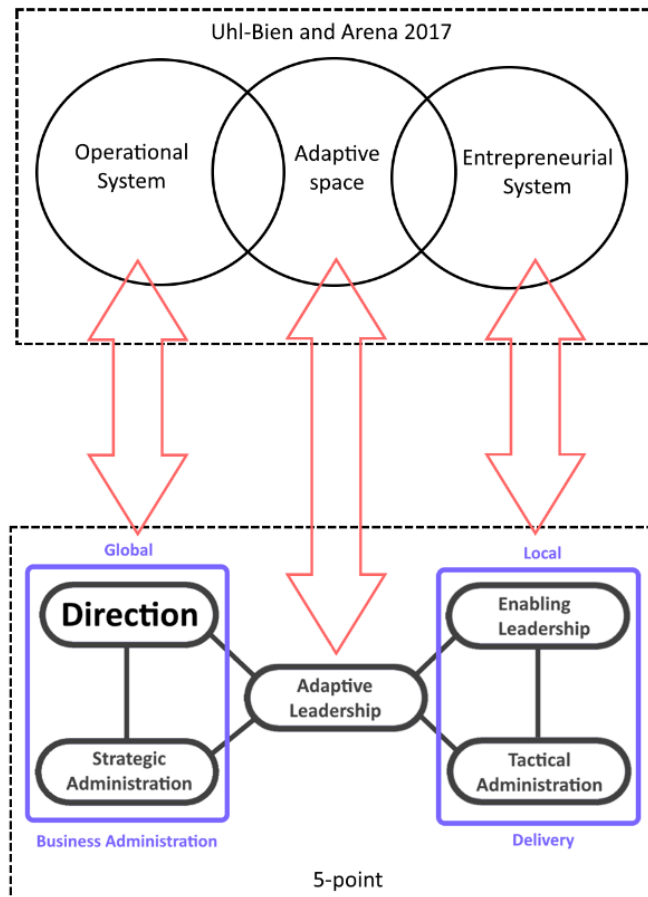
Figure 94 - Comparison of Complexity Leadership Models

As the underlying theoretical framework is identical for both models, these differences lie in the aspect of Complexity Leadership which they are aimed at modelling or clarifying. While the 5-point model is a holistic organizational leadership model, the Uhl-Bien and Arena model is purely focused on representing the innovative or entrepreneurial process with a complex organization (Figure 93). Their model represents the emergent drive for change which pushes changes from the local, Entrepreneurial System to the Operational System. A drive which is facilitated within the Adaptive Space.

The Hazy and Prottas model

Recent research by Callens (Callens 2023) uses a model for complexity leadership proposed by Hazy and Prottas (Hazy and Prottas 2018) to examine complexity leadership in public sector innovation. In this model, two modes of leadership are identified: Generative Leadership and Administrative Leadership. The role of Generative Leadership is to exploit emergent events to find advantage (i.e. novelty, innovation etc.) and Administrative Leadership is structure and control as proposed by Uhl-Bien et al (Uhl-Bien, Marion, and McKelvey 2007). The mapping of this model to

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the 5-point framework is proposed to be as illustrated in Figure 95. In this mapping, Generative Leadership maps to Adaptive and Enabling Leadership as they both relate to managing emergent events. Administrative Leadership maps to both Strategic and Tactical Administration and Direction. The need for direction and the recognition that direction is a distinct leadership mode is unique to the 5-point framework. The rationale for mapping Direction in the 5-point framework to Administrative Leadership in the Hazy and Prottas model is that it comes under pro-active control rather than reactive innovation.
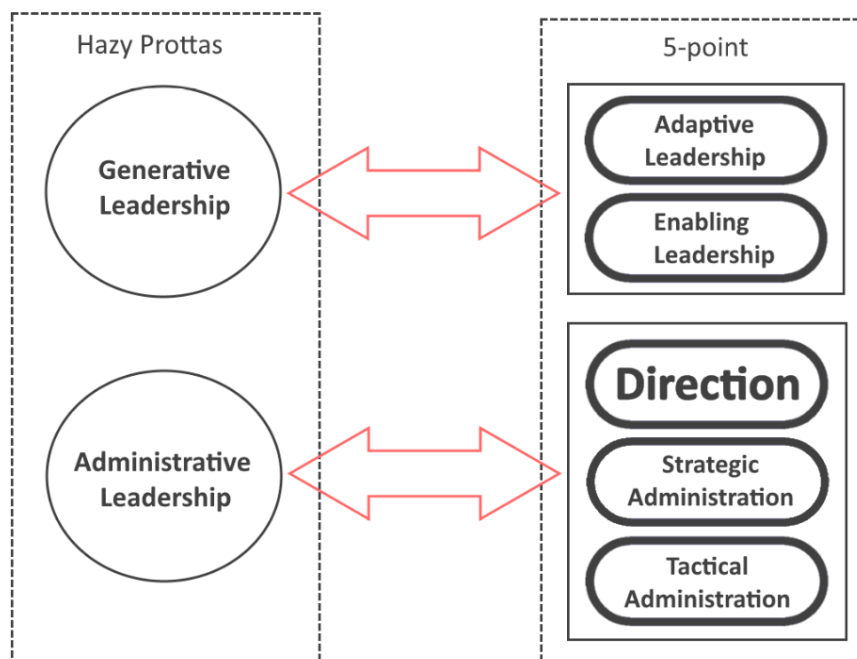
Figure 95 - Mapping from Hazy and Prottas model to 5-point framework

The Hazy and Prottas model is clearly highly simplified when compared to the 5-point model (even when compared to both models proposed by Uhl-Bien) but as all this model is targeted at research rather than application, this simplicity is perhaps advantageous from a data collection perspective as it reduces the risk of misidentification of leadership activities.

A parallel case study

Concurrent with this research, a parallel case study was run by Howden et al (Howden, Beresford-Dey, and Martindale 2021) which used Complexity Leadership Theory as a framework of analysis and reflection for the experiences of associate university deans during the COVID-19 Pandemic. While their research aim is very different to this study, the methodology has strong parallels. The CLT model they used was the Uhl-Bien and Arena model (Uhl-Bien and Arena 2017).

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As with this study, they found that using CLT as the framework for discussion and analysis gave insights which would not be expected had the discussions been ad-hoc.

> CLT offered us a reflective framework that illuminated insights into what was and was not happening and make sense of feelings; it drew out the significance of context, others, and control, also showing loss of control as potentially valuable. (Howden, Beresford-Dey, and Martindale 2021 p. 124)

They concluded with suggesting a critical development of CLT to enhance it as a tool for reflection and learning. This shows a parallel to the goal of this research has also been to persuade leaders to use the 5-point framework as a mechanism for reflection on their current leadership practice and learning new ways of thinking about leadership.

Exploration of Adaptive Leadership

Another study which cites the Uhl-Bien and Arena leadership model (Uhl-Bien and Arena 2017) is an exploration of organizational adaptability by Schulze and Pinkow (Schulze and Pinkow 2020). This study takes the Uhl-Bien and Arena model and tries to move beyond its academic boundaries by undertaking qualitative research in consulting firms. As with this study, the aim of the Schulze and Pinkow research is to take the complexity leadership theory and compare it to real-world practice. They adapt the Uhl-Bien and Arena model as shown in Figure 96. In this adaption the authors move from the idea of an "adaptive space" between the Entrepreneurial Leadership and the Operational Leadership (Figure 93) to simply stating Enabling Leadership as the intermediate mechanism.

Figure 96 - Adapted model of organizational adaptability.

(Based on Schulze and Pinkow 2020 p. 5 figure 1)

The 5-point framework proposes two potential leadership modes as interfacing between the Entrepreneurial Leadership which generates the proposed changes and the Operational Leadership which oversees the control framework: In a scenario where the change can be managed using standard processes or normal methods, the 5-point framework would also propose Enabling Leadership as this leadership aids collaborative creation of new solutions. However, if the proposed change from the Entrepreneurial Leadership is disruptive in nature, then the 5-point framework would propose Adaptive Leadership as a more dynamic and flexible interface to Organizational Leadership. Once again, it is difficult to see where Direction fits within the Schulze and Pinkow model which would seem to be due to the model showing a specific interaction within an organization rather than the wider leadership framework.

7. Research output and validation

Chapter	Phase	Purpose
7	Evaluation	Present validation data

The Research Aim requires the creation of a leadership framework which respects the non-reductionist philosophy of CLT. The 5-point leadership framework is presented as the output of the research which fulfils that aim. This chapter details the validation activities which are targeted at two goals: first, to demonstrate that the 5-point framework is understandable and can be delivered efficiently to a target audience and second, that the 5-point framework is generalizable to organizations of any size and type, not just large engineering multinationals.

This chapter also describes the various methods used to validate the research. Starting with an overview to give context, it first describes the development of online training material (7.1) to allow prospective users to familiarize themselves with the framework at their own pace (7.2). A series of semi-structured elite interviews (7.3) explore potential use of the 5-point framework beyond the scope of this research.

7.1. Development of the training material

Towards the end of the Action Research sessions, the 5-point leadership framework was reaching a mature state of readiness for application, but it was still not clear what the best format for distribution would be. The initial proposal was to create a training pack with a short presentation (MS Powerpoint) and some training activities to cement the key ideas. There would also be an associated "handbook" which would detail the underlying theory, give examples and show methods of analysis. The premise for this proposal was that trainers would read the handbook then create a training session (with the presentation plus some practical activities) which, if needed, could then be augmented by giving a copy of the handbook to attendees. This proved problematic to implement. While it may seem conceptually simple to summarize the 5-point framework in a presentation, simplifying the description too far risks removing some critical details. Also, creating a presentation which requires a skilled trainer to deliver seems to be a high-risk approach and was considered likely to give mixed results.

After further consideration, it was decided to create a series of short training videos which could be shared with anyone (using the Youtube online video streaming platform)

allowing practitioners to watch the content at a time convenient to them. If required, these videos could then be augmented with face-to-face discussion. Once again, the problem became one of design as a suitable design was needed for the training content, as well as a toolset for its creation.

7.2. Training material

In response to OBJ2 (*Develop leadership tools or techniques which can be used by leaders working in a complex environment through the use of action research and surveys*), training material was created as a tool to explain the framework and how to use it.

The training material was ultimately created as a sequence of short (5-20 minute) videos with a voice-over and infographics which use animated transitions to assist with conveying the ideas of the framework. In total eight videos were created (listed in Table 15 below) with a combined total of 1 hour and 24 minutes running time. It was decided to use the video creation function of MS Powerpoint to generate the videos. This software allows audio to be created for each slide and, when each is of an acceptable quality, an MP4 video file is automatically created by the software embedding the presenter's speech and allowing features like transitions and animations to be embedded in the presentation.

Table 15 - Training Video List for 5-point framework

Part #	Title	Running time
1	Introduction	7:40
2a	Leadership modes - Balance	21:05
2b	Leadership modes - Structure	6:14
3	Distributed Leadership	6:13
4	Leader support networks	3:54
5	Application	10:38
6	Emergence and Paradox	9:51

7	Organization Scale Effects	18:31

The initial videos were reviewed by independent reviewers and then a new set was created with improved sound quality and better timing of the audio between slides (as the software does not record audio when an animation or transition is in progress, it is easy to clip the sound by accident). Each video is summarized in the following subsections:

Introduction (Part 1)

This video summarizes the historic context of Complexity Leadership Theory both in terms of the societal shifts which occurred between 1990 and the present day, and the prevailing leadership strategies of the late 20th Century which still prevail to this day. It then outlines the key ideas of Complexity Leadership without specifically describing the 5-point leadership framework.

Leadership Modes – Balance (Part 2a)

This video is the first of a two-part section. It introduces the core concept of the 5-point leadership framework: the five leadership modes. For each leadership mode it details who uses the mode, the style of communication, the business context, what the mode achieves when it is balanced and the effects of too much and not enough activity in this leadership mode.
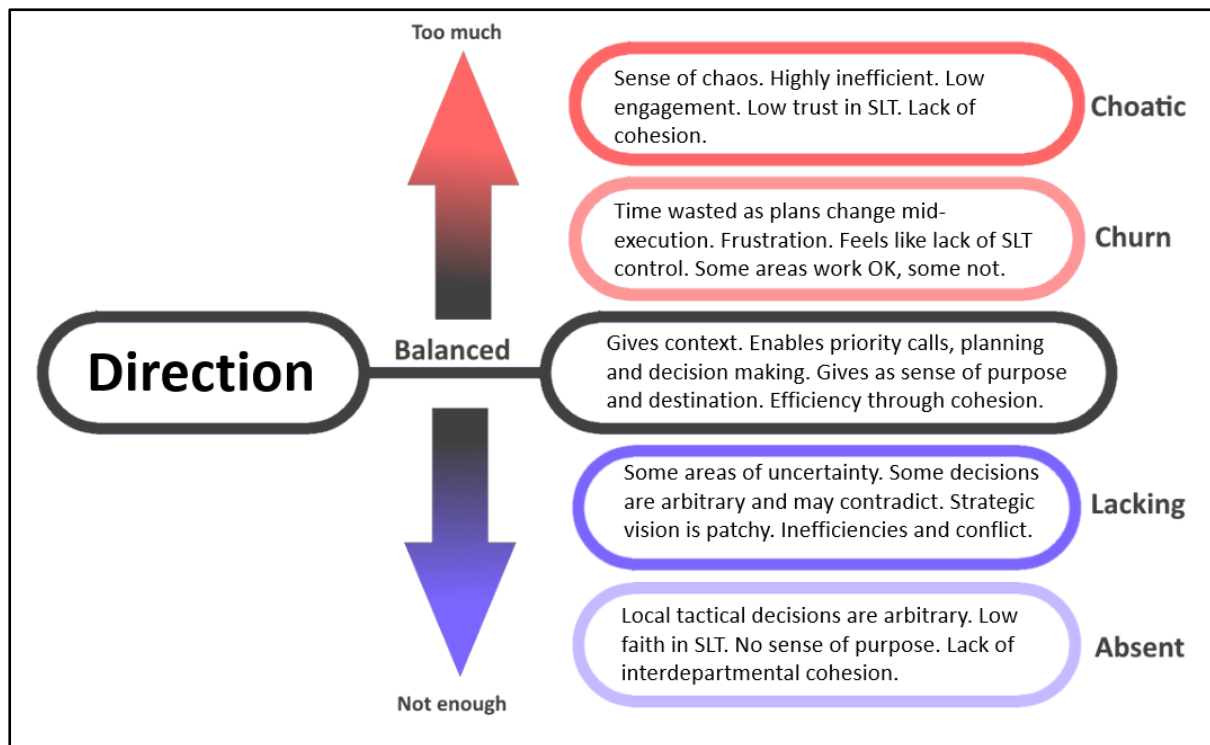
Figure 97 - Slide from training video Part 2a

Figure 97 shows a slide which is illustrating the differences between balanced Direction (one of the Leadership Modes) and unbalanced Direction where too much or not enough activity causes issues in the organization.

Leadership modes – Structure (Part 2b)

The second of the videos on Leadership Modes, this video looks at the way that the five modes form a framework structure. The 5-point diagram has a multi-axis symmetry of purpose for the four outer modes with Adaptive Leadership at the centre in a unique and important position of facilitation of change through agility. In Figure 98 the link between Direction and Enabling Leadership in giving guidance is illustrated. Strategic Administration and Tactical Administration are shown as giving control in the same axis. In the other axis, Direction and Strategic Administration work together to give Business Administration and Enabling Leadership and Tactical Administration combine to give delivery. This idea of leadership modes combining within the framework is another unique concept which is not seen in any of the other leadership frameworks or theories.

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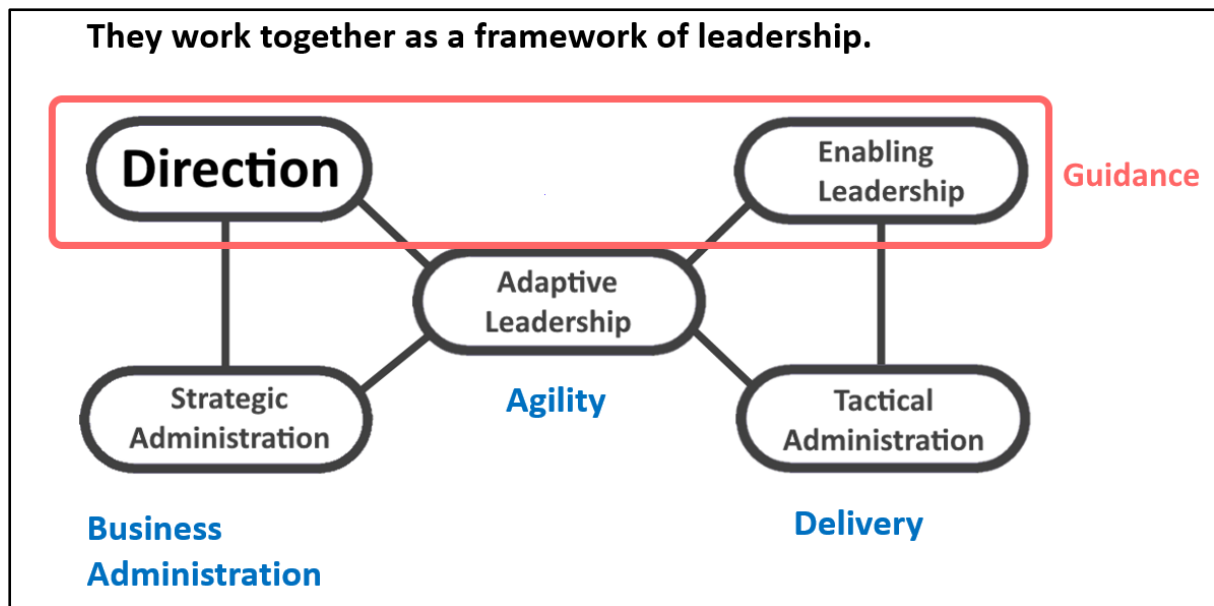
Figure 98 - The 5-point leadership mode diagram from Part 2b

Distributed Leadership (Part 3)

Having established the leadership framework, the following videos explore some important supporting ideas which bring richness to the framework. Part 3 explores Distributed Leadership as a concept. The way that the 5-point framework characterizes leaders is in line with other CLT research but quite distinct to more traditional leadership theories which are often hierarchical in nature and tend to think of a single leader for a team.
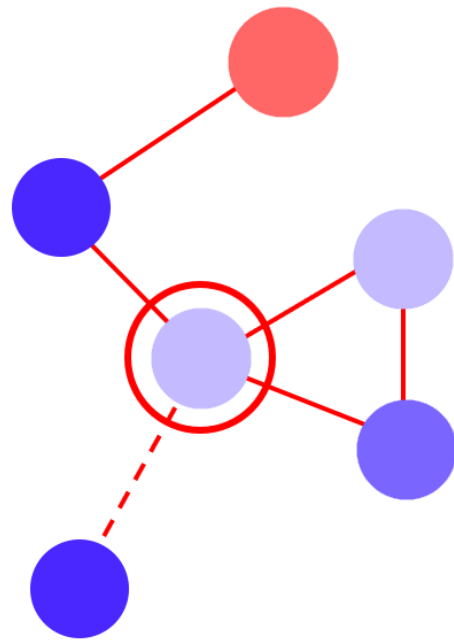
Figure 99 - Example of the leadership network for a single person in a team

In this video, an example shows how leadership can be distributed and, in this example, if there is no conscious understanding of how the leadership is being distributed, gaps or other issues can arise.

Leader Support Networks (Part 4)

As Complexity Leadership Theory recognizes that an organization is a dynamic network, this training video expands the conceptual leadership network to include the leaders who support the focal-point leader in the wider network. This support often comes in the form of leading support functions (IT, commercial, HR etc.) but it could be any other leader in the organization whose team will be needed to support the goals of the focal-point leader.
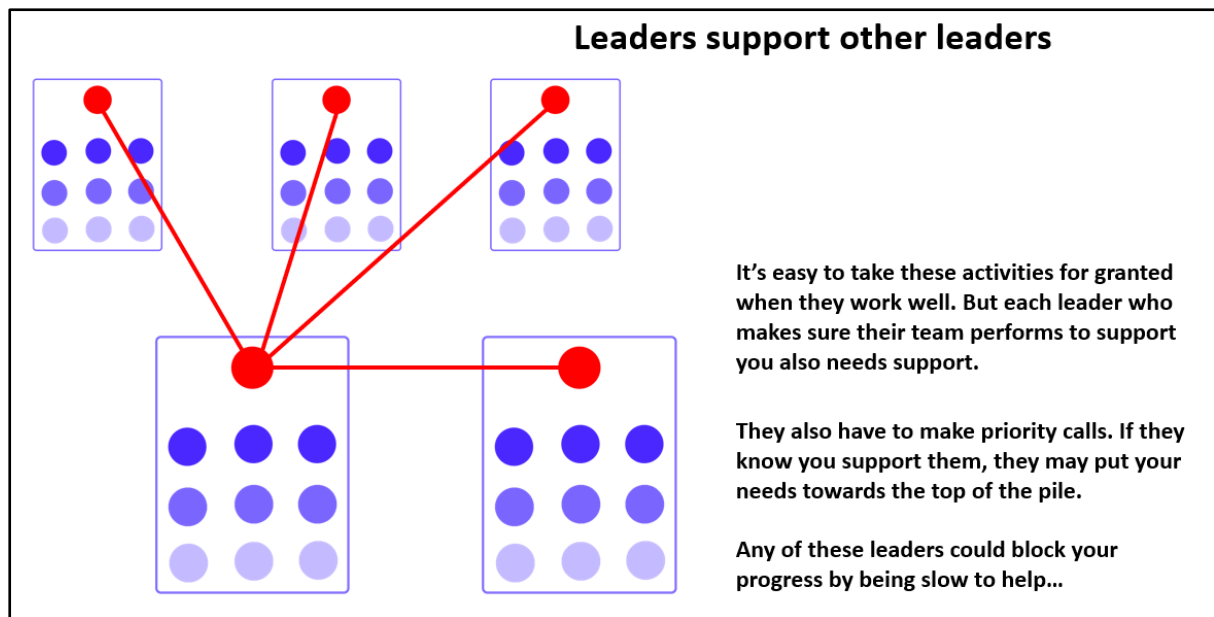
Figure 100 - Leader support networks (Part 4)

Figure 100 shows the infographics which were used to show the leaders of various teams supporting the focal-point leader. As can be seen in this chapter, the colour scheme and graphical style is consistent across the videos with red dots being used to denote leaders and shades of blue and red denoting seniority of team members.

Application (Part 5)

In this training video, which looks at the application of the 5-point Framework, a new lens is applied to the leadership modes: pro-active versus reactive leadership. This lens provides a new grouping for the five modes as illustrated in Figure 101. The video presentation moves through examples of the framework being applied to different types of team to give logic to the leadership structure and activities.

During the Action Research, a lot of confusion surrounded methods for leading service teams (i.e. teams which do not deliver to external customers but which provide support or expertise to the organization).
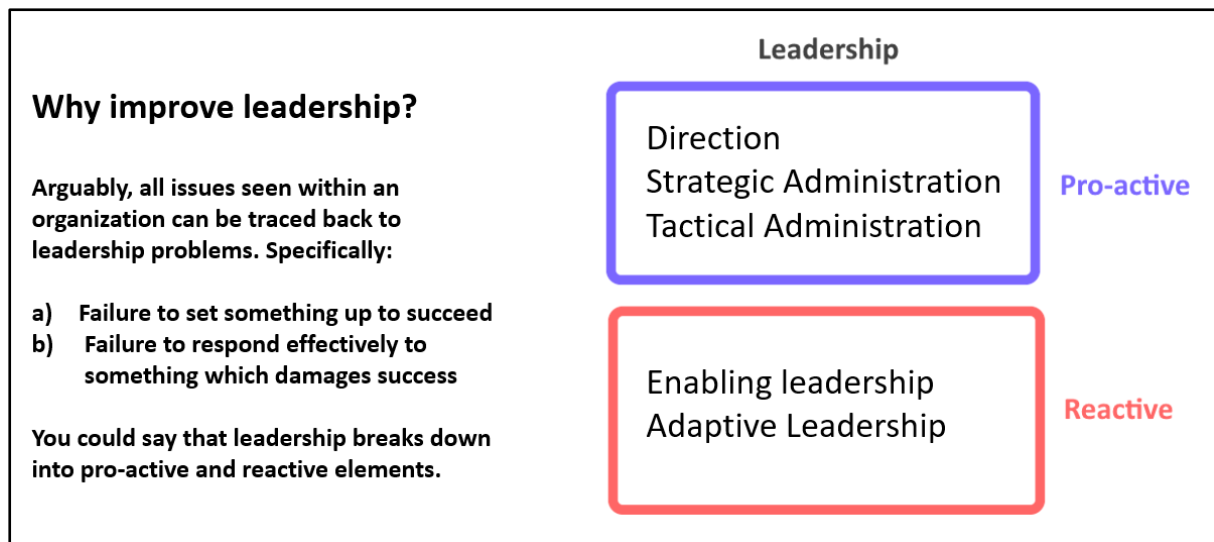
Figure 101 - Pro-active and Reactive Leadership (Part 5)

Much of this confusion came from the idea that, as the service teams do not know who will ask them for help next, they cannot plan and so (it was proposed) must always be in a reactive state. I this training video, the leadership strategy for service teams (using the 5-point framework) is explained. In Figure 102, the team situation is illustrated using green dots for the internal customers, blue dots for the team and a single red dot for the leader.
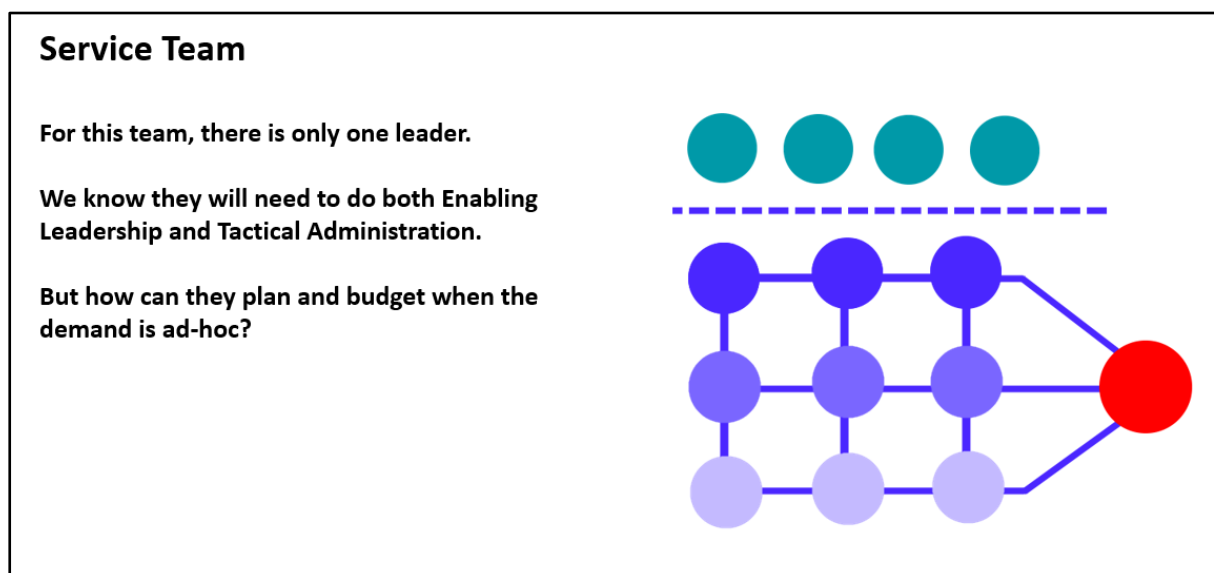
Figure 102 - Examples of using the 5-point framework (Part 5)

The proposed method for leadership of a service team is to plan for a specific capability and capacity which is targeted at the needs of the organization. Having achieved this capacity, if the demand becomes greater than expected, Enabling Leadership can be used to make priority calls and allocate tasks to team members based on individual skills (see Figure 103).

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Summary

Enabling Leadership
Help the team resolve issues. Seek outside help if needed. Look for efficiency gains, improved methods, tools etc. Propose changes into other leadership modes as needed. Allocate to tasks based on competency.

Tactical Administration
Plan for the capacity and capability of the team. Monitor demand vs capacity and replan if needed. Make priority calls based on capacity.
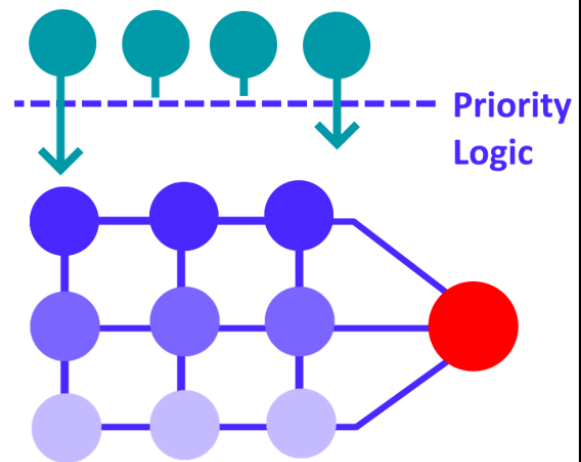
Figure 103 - Proposed method for leading a service team (Part 5)

Emergence and Paradox (Part 6)

This training video is the first to talk in terms of Complexity Science as well as leadership. By this point in the course, the trainees are felt to be ready to be more technical in their understanding of complex systems. One of the principals of Complexity Leadership Theory is that leaders should understand the complex nature of their working environment. Arguably, the most critical idea in Complexity Science is Emergence. This is a feature of all complex systems and manifests itself in sudden unexpected events arising from seemingly unrelated background activities. This video describes the difference between apparent paradox and true paradox and outlines leadership strategies for both. The example used for a true paradox is the drive for both centralization and decentralization within large organizations. The sequence of centralization decaying to decentralization and back again is illustrated in Figure 104.
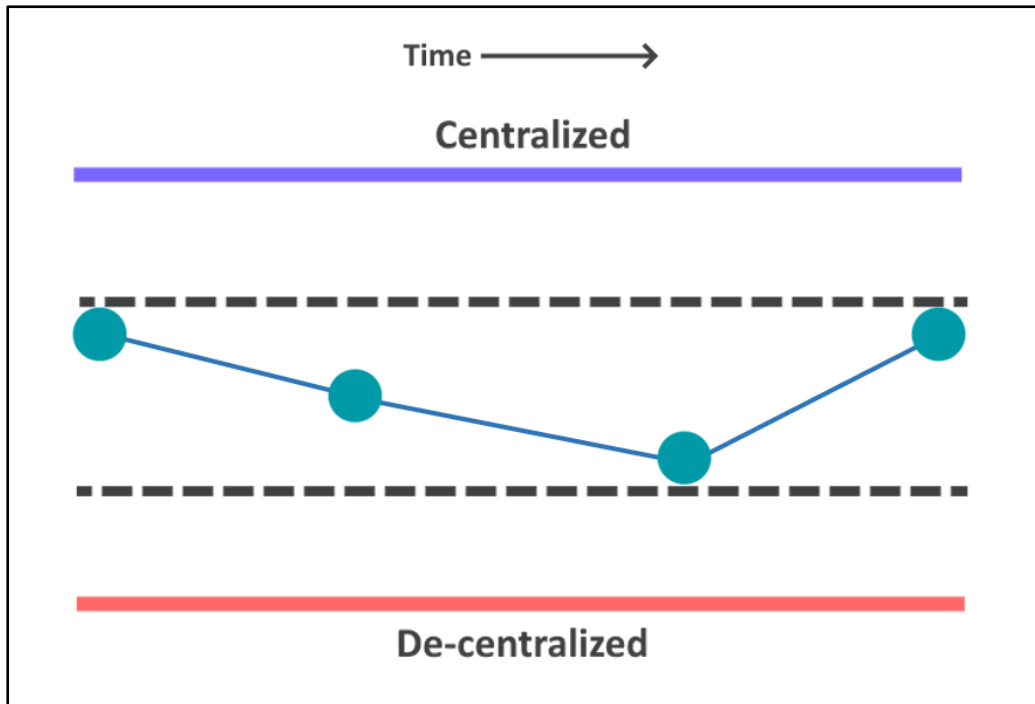
Figure 104 - True Paradox example (Part 6)

Organization Scale effects (Part 7)

Although the 5-point framework is completely scalable to organization size, much of the training material uses examples which pertain to medium or large organizations. To rebalance this, and to explore the ways that the scale of an organization modifies the profile of the five leadership modes, this training video was created.

Rather than define the size of the organization by employee numbers, the size was defined in terms of the levels of outsourcing versus the internal capabilities of the organization. It is proposed that small businesses tend to be highly specialized and, by necessity, outsource services such as IT, HR, legal advice etc. As the critical mass of the organization grows, so these services become integrated changing the leadership environment. For each scale of business, a natural profile of leadership modes is proposed (see Figure 105). These profiles represent the ease with which each leadership mode can be applied at the different scales of organization. For example, the Direction leadership mode should be simple to execute in a small business because the focused nature of the business lends itself to a clear and compelling strategy and vision. This leadership mode becomes much more challenging in a large business (which may comprise multiple small and medium sized business merged into a group) because the variety of skills and areas of interest can make it challenging to create a coherent vision for the overarching business. The video concludes with a proposal that by creating a strong culture within the organization, these leadership mode profiles can

be modified away from the norm to achieve greater levels of leadership where a mode would naturally be weak. For example, small businesses are naturally weak on Strategic Administration because their small size means that many of the business processes can be executed without detailed documentation.
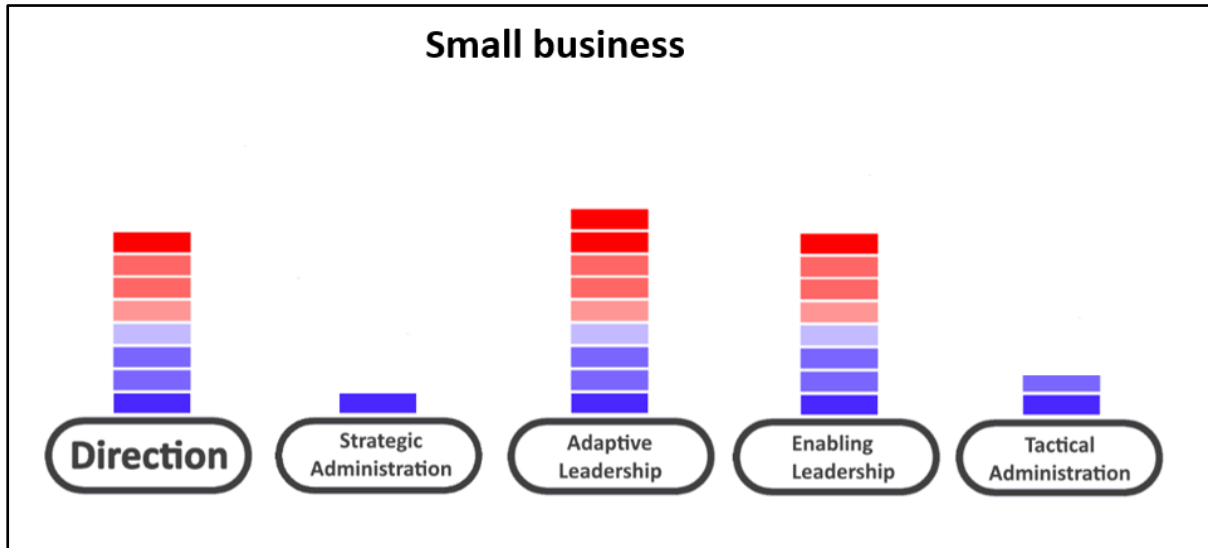
Figure 105 - Leadership profile for small business (Part 7)

If, however, a small business makes a strong statement of intent that they will maintain a high level of internal regulation (as a differentiator within their market sector, for example) then this conventionally weak area can become a strength. Such a strength comes at a cost but if there is a tangible advantage to imposing such a culture then this cost may be worth bearing.

7.3. Exploration of wider applicability

While the scope of this research is an examination of leadership within an engineering organization, there exists a question of the potential for wider applicability outside of that domain which has arisen throughout the research. As the 5-point leadership framework was derived from complexity theory rather than directly from engineering practice, it would seem logical to assume that it has potential for use in any organization or business where complexity exists. To explore the capacity for further generalization of the 5-point framework, five semi-structured elite interviews were held. The interviews were in the form of one-to-one video conference meetings (using MS Teams) and were recorded. Each started with the interviewee describing their business including what they felt were their strengths and weaknesses. A presentation showing an introduction to the researcher and the research, and explaining the 5-point framework was used to familiarize the interviewee with the concepts of the five leadership modes and their interaction. This was explained in the context of the interviewees business. The rest of

the interview (around an hour) was used to explore the interviewees business in detail using the 5-point framework as a catalyst for discussion and analysis. The sampling strategy for the interviews was purposive. The criterion for selection is that the organization, business or enterprise which the interviewees represented should be demonstrably different in nature or structure to the collaborating organization (which specializes in aerospace and defence engineering and comprised multiple business units in a multinational group). Following the interview, the interviewees were asked to complete a feedback sheet (using JISC online surveys). A summary of the interview and the results of the feedback sheet is as follows:

Interview 1

Managing Director, Female, Small marketing business, Scotland, UK.

The first interviewee is a female Managing Director (MD) of a marketing business based in the borders of Scotland (a rural area). The business was set up by the MD when she noticed a lack of local marketing suppliers. The business currently has four employees although it has had up to eight in the past. Three of the four employees are immediate family (the MD, her mother and daughter). Each family member is highly qualified for their role in the business.

Financially, the business is at or around capacity for client work but has only just started to make enough money for the MD to take a full (if modest) wage.

Insights gained from the discussion (using the 5-point framework) were primarily around the lack of success in employing a larger team. A number of issues were seen but the source of these issues seemed to be the discrepancy between the commonly promoted description of the business as "a family business" (a description which comes with connotations of business culture which is relaxed and nurturing) and the underlying reality which is that this business is a fast-paced professional environment where employees are expected to be highly pro-active and go the extra mile on a regular basis. This discrepancy appeared to be the source of a miscommunication when hiring new employees, both resulting in inappropriate hires and poor performance. The mismatch between new hire profile and business requirements was further exacerbated by the MD's lack of interest in people management. Using the 5-point framework to explore this (Figure 106), the MD's strengths and interest reside in the left side of the framework which relates to Business Administration. Day-to-day people management resides on the right side of the framework where Enabling Leadership and Tactical Administration work together to give Delivery.

With no one suitable to delegate person management to and a group of employees who had joined a "family business" expecting a very nurturing and people focused environment and finding that, instead, they needed to be self-reliant and pro-active, the larger team failed and the headcount was reduced to the family members and a single contractor who primarily works from home. This is quite a setback for a business which has just purchased a property large enough to comfortably house a team of 12 or more. By sticking with the current resource level (which was the stated plan of the MD), the business is turning away work and lacks the critical mass to allow specialization within the team and the efficiencies which that can bring.
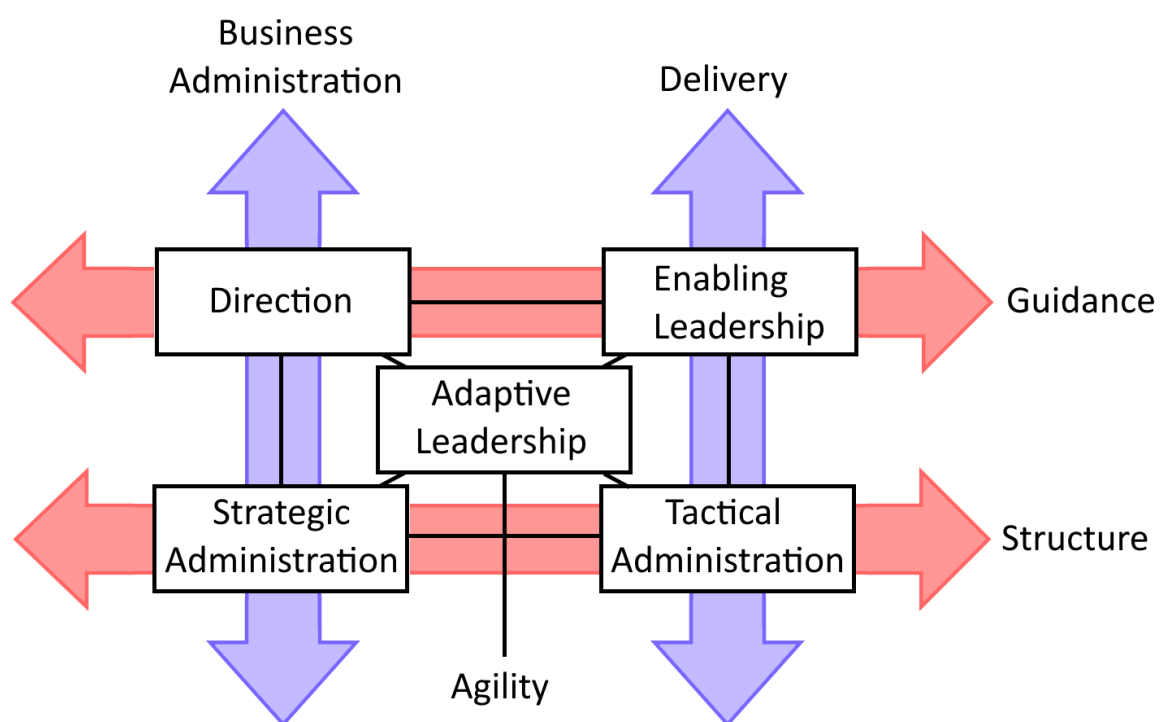

Figure 106 - The 5-point framework

Following the session, the feedback from the MD was provided, the 5-point framework was rated on a scale 1-5 where 5 is the most positive:

Table 16 - Feedback from Elite Interview 1

Attribute of the framework	Score out of 5
Understandable	5
Usefulness	5
Impactful	5
Novel	3

Insightful	4
Adds value to your organization	4

No comment was left in the comment box.

Interview 2

Business and Management Consultant, Male, Australia.

The second interview was with a male Business and Management Consultant (BMC) based in Australia. Operating as a lone entrepreneur, he has worked with large finance institutions, government bodies and commercial organizations such as Jaguar Land Rover. At the time of the interview, he was at the early stages of a large project which involved working with the government in Barbados and an academic in the field of chemistry to set up a scheme to turn a mass of invasive seaweed which is blighting the Caribbean into biofuel and other useful products. The BMC stated that his strengths were an ability to see paths to efficiency and other improvements within business, overseeing transformative change on a number of occasions in the Australian finance sector. He also has shares in businesses he developed which delivers a steady income. The weakness he identified is a lack of leverage in persuading collaborating actors to deliver on their promises.

In this discussion, the 5-point framework was used to identify his role and the specific role of his collaborators. The conclusion of this analysis was that he delivers Adaptive Leadership in the form of troubleshooting, business analytics or entrepreneurial opportunity generation. This then migrates into a role of Direction, co-ordinating collaborating individuals and organizations with a high-level vision of the desired end state. He outsources Strategic Administration to a business accountancy firm who provide a wide range of services. Although they can trigger change (e.g., through reacting to changes in legislation) he provides the Direction for the specific response to these changes. While he is skilled in Tactical Administration and has exercised Enabling Leadership when required, these are not leadership objectives for him and would ideally be delegated.

Following the session, the feedback from the BMC was provided, the 5-point framework was rated on a scale 1-5 where 5 is the most positive:

Table 17 - Feedback from Elite Interview 2

Attribute of the framework	**Score out of 5**

Understandable	5
Usefulness	5
Impactful	5
Novel	4
Insightful	5
Adds value to your organization	5

The following feedback was given in the comments field: "Very interesting perspectives, viewpoints and insights."

Interview 3

Technical Director, Female, Waste Management, England, UK.

This waste management business is based in the south of England and offers two main services: It organizes the disposal of green or organic waste (mainly for county councils in Lincolnshire, East Anglia) and it also provides training and certification on waste management to a range of standards. The interviewee is the Technical Director (TD). She originally joined the business to run the accounts but in 2014, then took over the business with another colleague from the incumbent owner. The two owners split acrimoniously around 2022 and the TD has been the sole business owner ever since. The business has always had around 4 employees. Since 2014, the turnover has grown from around £350k per annum to around £1.5M per annum without an increase in employees. Three of the team are in the same family. The TD is the mother to the person with responsibility for business tools and processes (female) and an apprentice (male). Unlike the business in Interview 1, she does not describe the business as a "family business", perhaps because it has had a long and varied history of employees and was not started by the family.

While the business has many strengths and no major issues, there is an identified risk in terms of future resiliency: With only four team members, skill overlap is low and one person leaving or unable to work would remove 25% of the team. Having achieved a previous goal of diversifying the portfolio of services (from only green waste management which is seasonal), the current goal is to get the business to a point where the TD can retire or sell the business as a going concern. With so many single points of failure, this could not be done with the business as it is. The nervousness around this plan is that it probably needs more employees to work and (as with Interview 1) there have been problems in the past when trying to remove under-performing staff.

The 5-point framework was used to explore the different modes of leadership within the business and how these relate to the strengths and weaknesses. Direction is challenged as the desired direction has no identified path to success (without expanding the staff, which contradicts another Directive in place of maintaining head count). Agile leadership is managed by the TD. This could easily be more widely delegated as the team have shown themselves capable in her absence. Strategic Administration is handled well and, as it is a slow change leadership mode, could handle change in personnel. Tactical Leadership is performed as needed, it doesn't sound like a key strength but also, the business is not highly sensitive to it. The biggest gap in capability is seen in Enabling Leadership. This seems to be completely absent. This lack of collaborative leadership needs to be addressed if the current team are to find and address issues early, if the apprentice is to thrive, and if the team should ever need to be expanded. An interesting example of the impact of this shortfall is shown with the declaration that the business has recently instigated an employee well-being process. Without Enabling Leadership, there is little chance that a well-being process could ever be effective as each employee is effectively left to their own devices, with the only cross-communication being that forced by the need to deliver and general social interplay. In this environment, a team member whose work is not going well could easily get into a crisis state before it was noticed.

The culture of the business was also explored. The TD was asked to describe the business culture. This seemed to be quite challenging. She got the apprentice to join the call and they both spent some time trying to quantify what it was. Understanding your own cultural expectations is critical to both direction (which should ideally support the cultural underpinnings of the business) and recruitment: If you cannot define a role by the behavioural (cultural) expectations of the business, it is very difficult to recruit employees who are a good fit.

The remainder of the interview was taken by discussing strategies for low-risk recruitment. If the 5-point framework had not shown a conflict between the two key directives issues by the Direction Leader (i.e., to both make the business more resilient to change and to keep the head count at 4 people), then this critical discussion may never have happened.

Following the session, the feedback from the TD was provided, the 5-point framework was rated on a scale 1-5 where 5 is the most positive:

Table 18 - Feedback from Elite Interview 3

Attribute of the framework	Score out of 5
Understandable	5
Usefulness	5
Impactful	5
Novel	5
Insightful	5
Adds value to your organization	5

The following feedback was given in the comments field: "Chris guided me through the framework step by step which helped me to fully understand and appreciate the depth that the concept could offer to my current business and also what the future could look like."

Interview 4

Chair of Engineering function, Male, Large private healthcare provider, USA.

This interviewee is the Chair of an Engineering capability within a large private healthcare provider based in the USA. With between 80,000 and 90,000 employees. They operate primarily in the states of Minnesota, Iowa and Wisconsin and the Chair is based in Minnesota. The organization is divided into three primary functions: Healthcare ("clinical practice"), Clinical Research and Education. The largest of these by far being the Healthcare, the others feeding into delivering excellence in that field. Within this very large organization is a small applied-engineering team (around 70 engineers) who make devices and medical equipment. They serve the entire organization, supporting innovation and new product development, and so need to interface effectively with many stakeholders.

One of the Chair's roles is going out into the wider business and networking with leaders in other functions to seed effective collaboration.

Using the 5-point network to discuss the effectiveness of leadership seen by the Chair, Direction was the first leadership mode to be analysed. Generally seen as a strength, the Direction from the central leadership is clear and has been reliably so for many years. The challenge with such a large organization is effective translation of the central Direction to a message which is relevant to local groups. Some of the local leaders translate the message well and others ignore it and follow their own agenda. This could

lead to friction and inefficiency in delivering the core directive although, overall, this leadership mode is not seen as a weakness.

Strategic Administration is seen as an area which can be problematic. Having had a lack of process control in the past, the level of bureaucracy has become problematic in recent years. One of the major challenges being the successful combination of a robust process which covers most occasions and the flexibility for leaders to decide when the process is not appropriate. The drive to standardize and control expenditure has overridden empowerment and trust in leadership which causes inefficiency in a number of areas.

Adaptive Leadership is an area with mixed success. Some leaders being very open to accepting emergent events or changes in the environment and reacting in an agile manner. Other leaders pretending that change can be avoided without consequences.

Tactical Administration is generally seen as a strength. The biggest challenge identified was with Enabling Leadership. Although the day-to-day Enabling Leadership activities were seen as a strong point with active encouragement of this leadership mode by the organization, the interaction between the Enabling Leaders and the other leadership modes could be problematic. Enabling Leaders were the most likely to suffer from over-activity in Strategic Administration causing bureaucracy.

Following the session, the feedback from the TD was provided, the 5-point framework was rated on a scale 1-5 where 5 is the most positive:

Table 19 - Feedback from Elite Interview 4

Attribute of the framework	Score out of 5
Understandable	5
Usefulness	5
Impactful	5
Novel	5
Insightful	5
Adds value to your organization	5

The following feedback was given in the comments field: "I really enjoyed the framework because it is both thought provoking AND also reflects the reality of working in a complex organization. The one thing it is missing is a clear link between the three outer boxes and enabling leadership. As we discussed, a big failing I've seen is in communication between those functions. Not within the function itself but in how

information is passed between them. So, another layer of complexity (an information flow or an influence diagram) might be helpful."

Interview 5

CEO, Male, Patient data gathering software, Healthcare, Canada.

This interviewee is the CEO of a small start-up business which is developing software to improve the ease with which patient data is entered within the Canadian healthcare system. The business currently has two employees although they have used contractors in the past.

The business is currently trying to balance the objective of developing a quality software product with the various options of funding which, they have found, can be disruptive and potentially counterproductive if not handled carefully.

The 5-point framework was used to explore the various leadership modes within the business: Direction was strong. This was evidenced by the decision to move away from grants and other funding streams which came with an overhead of tight schedules and onerous reporting regimes. While these had been used to some effect in the past, they tended to distract from the primary objective of developing a quality product. Turning down offers of funding is not an easy decision but with clear Direction, the decision was confidently made. Strategic Administration was developing well. The need to provide users with good documentation, plus operating in a highly regulated field has given a strong incentive to get this aspect of leadership right. Enabling leadership is not needed in large quantities at the present but it is the favoured leadership mode of the CEO and so there is no reason to think that this will be a weakness moving forward. In the next phase of active development, when the team grows by bringing contractors on-board, Enabling Leadership is doing a lot more work than perhaps might be expected because the decision has been made to minimize the Tactical Administrative Leadership until the business becomes too complex to sustain that approach. This strategy is aimed at minimizing the overhead of planning and reporting which is a legitimate strategy as the business is so small and the costs can, for now, be all considered overhead. With no Tactical Administration keeping track of progress, this needs to be monitored as part of the Enabling Leadership mode. At some point, if the business grows and becomes more complex, a more formal Tactical Administration structure may need to be introduced. Adaptive Leadership was explored but with the business being so small and agile, this was not an area for concern.

Following the session, the feedback from the TD was provided, the 5-point framework was rated on a scale 1-5 where 5 is the most positive:

Table 20 - Feedback from Elite Interview 5

Attribute of the framework	Score out of 5
Understandable	5
Usefulness	5
Impactful	5
Novel	5
Insightful	5
Adds value to your organization	5

The following feedback was given in the comments field: "The framework provides an assessment of leadership which transfers the analysis from a traditional subjective and vague analysis to an objective based analysis. It also provides insights into potential strengths and weaknesses of a leadership style. This framework will enable me to approach issues with a rational approach"

Conclusions for elite interviews

Used as a tool for discussion and analysis, the 5-point framework delivered some useful insights and observations for businesses which are highly different to the collaborating organization. Only one of the interviewees was in the field of engineering (in a very different field to the collaborating organization) and the scale of the businesses were widely varying, from 1 to 90,000 employees. The framework was quick and easy to apply to a business with two to four employees. It was more challenging to apply to a single consultant / entrepreneur as their leadership network extends into other organizations and is highly fluid. With larger organizations, the short interview length did not achieve as much depth as with the small businesses as the complexity of the organization really needed longer to get to the detail. Even with these challenges, the interviewees all found the discussion very useful. This exercise has provided evidence that the 5-point framework is generalizable outside of the context of a multinational engineering organization. This would potentially suggest either that complexity exists to some extent in all organizations, or complexity leadership methods have value in all organizations, even where the complexity level is relatively low. This is an area for further research.

Table 21 – Overall average of feedback scores

Attribute of the framework	Score out of 5
Understandable	5.0
Usefulness	5.0
Impactful	5.0
Novel	4.4
Insightful	4.8
Adds value to your organization	4.8

Table 21 shows the combined average scores for feedback for the 5-point framework.

7.4.   Chapter Summary

Following the completion of the Action Research and theoretical development, this study has been compared to other parallel research and, while different biases and terminologies can be seen, there seems to be no fundamental contradictions in any of the CLT based theories. The 5-point framework presented herein contains some unique features: First, it is a holistic framework which is not specific to a given situation or scale of team or business context. Second, it is the only CLT based framework to recognize the importance of Direction (largely due to its more holistic perspective). Third, it is the only leadership theory to examine in detail the effect of "too much" versus "not enough" of a given leadership mode. Fourth, it is the only CLT based leadership framework to propose that Administrative Leadership comprises two distinct leadership modes within a project-based organization. Fifth, the leadership modes described in the 5-point theory are very specifically defined and have no overlap or fuzzy edges. Sixth, while the 5 modes are distinct, the 5-point framework shows how they interact to form wider leadership functions. This cross-supporting element makes the framework a true framework rather than a list of leadership activities.

During the research development, two key unexpected features of the leadership framework became clear: First, the importance of the design for communicating the framework to practitioners. Second, the extent to which the world was due to change (COVID-19 Pandemic, Brexit, war in Europe, political upheaval in the UK and US, war in Palestine, the increasing severity of the climate crisis etc.) could not have been predicted. These global changes made more compelling the proposition that we move forward with complexity leadership as a realistic approach for real-world solutions rather than academic discourse.

The research output was embodied into a series of training videos which were published on the Youtube Channel. These videos provided a useful teaching tool or an expansion on one-to-one discussions. They also structured the thinking of the researcher in a way which made the elite interviews, conference presentations and other communication more structured and effective. The elite interviews demonstrate that the 5-point framework is generalizable to any size or type of business or organization. It is perhaps most useful when there is an existing leadership structure for review but this is not mandatory for the framework to deliver valuable insight.

8. Conclusion

Chapter	Phase	Purpose
8	Reflection	Present conclusions

This chapter concludes the study, starting with an overview for context (8.1) it begins by looking at the way the approach to the research evolved as it progressed (8.2). The practical implications for leaders are presented (8.3) along with the contribution to knowledge. The chapter culminates in outlining the research limitations (8.7) and areas for future research (8.8).

8.1. Overview

This research aimed to develop a complexity leadership framework for use in an engineering organization. It was also hoped that such a framework would be generalizable to a wider audience.

Throughout this research, Complexity Leadership Theory has remained in a strong phase of development with some interesting work in complexity leadership frameworks. Despite this, the gap in research which was the catalyst for this study remains, and the extant writing on Complexity Leadership which was examined is grounded in academic study rather than application by practitioners (with the exception of a few small case studies).

The 5-point Leadership Framework presented here is considered novel: As the outcome of two years of Action Research with an international group of leaders, it has a much stronger foundation in practitioner interaction than any other known study. This has lent the resulting framework features which are not seen in any of the comparable CLT based frameworks or models.

A leadership framework can be used in many ways (e.g., as a basis of academic study, to derive a greater understanding of how things are, to provide an optimal model for leadership etc,). The 5-point framework is presented as a tool for applied leadership and is anticipated to be used in two ways: First, as an analysis tool which allows a leadership situation to be better understood in terms of both cause and effect and paths to improvement. Second, as a conceptual framework to assist in the design of new leadership structures.

8.2. Changes in approach during the research

During the research, various tools and techniques were used to explore the application of the developing theory with the participants. The most successful of these was a pair of surveys (Survey 2 & 3, section 4.6) and associated analysis tool. These surveys were developed using lessons learnt from a previous survey which was predicated on the assumption that trend data for a group of leaders would give an insight into the state of leadership within the group. This idea may have some merit but the results were not convincing and, as was shown by survey 2 and 3, a leadership mode profile for an individual leader or their environment gives much greater insight.

The survey analysis gave a large amount of data on where, within the 5-point framework, a leader and their leadership environment resided. Patterns quickly began to emerge like fingerprints of leadership traits. For example: the set of graphs below belong to Participant 4B (Figure 107). The leadership balance graph shows a strong bias towards Adaptive Leadership. This pattern of leadership in the environment became known as "the Witches hat" and indicates laissez faire leadership in their environment. The effects of this leadership style can then be seen in the other graphs. The leadership success graph shows success. This is rated "Poor" for all aspects of leadership apart from Adaptive Leadership which was rated "OK". Laissez faire leadership involves no pro-active leadership, forcing Adaptive Leadership when emergent events arise (as they will tend to do with great regularity). This constant adaptive response tends to achieve good skills in "fire-fighting" which shows up in the graphs as good Adaptive Leadership success. This graph is, perhaps, not showing as much success in Adaptive Leadership as might be expected and this indicates that the team is overloaded and struggling to cope with the constant state of reaction.

My leadership

Actions

Direction	60%
Strategic Administration	100%
Adaptive Leadership	83%
Enabling Leadership	84%
Tactical Administration	88%

Behaviours

Direction	86%
Strategic Administration	88%
Adaptive Leadership	69%
Enabling Leadership	81%
Tactical Administration	81%

My leadership environment

Balance

Direction	-1
Strategic Administration	-1
Adaptive Leadership	1
Enabling Leadership	-1
Tactical Administration	-1

Success

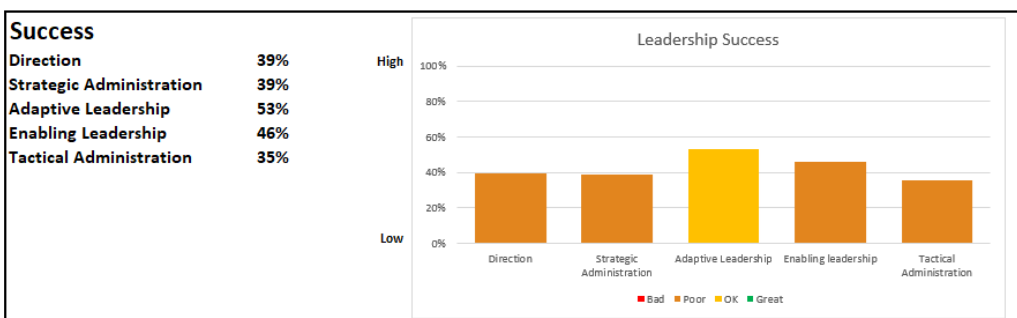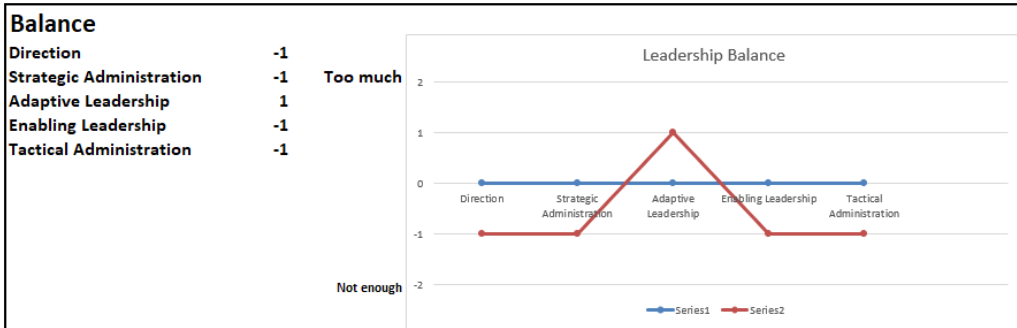|	
Direction	39%
Strategic Administration	39%
Adaptive Leadership	53%
Enabling Leadership	46%
Tactical Administration	35%

Figure 107 - Example of Survey 2 & 3 results for 4B

Looking at Participant 4B's graphs (on the left) show that they are engaged day-to-day in a very wide range of leadership modes. This profile is close to that found for members of the Senior Leadership Team (e.g., CEO, Directors etc.). This shows that for this Participant there is an unexpected advantage to the laissez faire leadership they are receiving: It allows them to sharpen their leadership skills in an environment which is out of the spotlight compared to the SLT. The fact that, at the time of survey, they were engaged in a large amount of Strategic Administrative Leadership despite wanting to do almost none (as shown in the leadership behaviour graph where the green line is what they would like to do and the black dot is what they are doing) suggests that there is limited or no opportunity to delegate this work. Participant 4B validated the interpretation of this graph and expressed the opinion that some of their behaviour could be due to leading a new team (which would limit delegation). The ability to conduct a detailed analysis of an existing complexity leadership situation from the results of two short surveys is very powerful and unique to this research.

8.3. Practical Implications

The 5-point framework can be used to inform leadership practice in many ways. Using the framework to improve the leadership in an existing organizational structure, the first use-case is the analysis of the current practice. This can be done by surveying the perceived strengths and weaknesses of the existing structure and categorizing each by the leadership modes in the framework (Direction, Strategic Administration, Adaptive Leadership, Enabling Leadership and Tactical Administration). This gives an immediate view of which modes are currently effective and ineffective. By comparing this pattern with the existing leadership structure, systemic issues can be separated from leadership performance issues. A modified structure can then be proposed which has a clear path for the delivery of the requisite leadership modes. The 5-point framework can also be used for planning the leadership structure for newly formed teams. By having a clear demarcation of leadership mode responsibility, new structures gain clarity of purpose. Even where leaders are tasked with delivering multiple leadership modes, there is an acknowledgement that each mode requires different tools, mindset and communication methods and so, even with a single leader delivering them all, mode segregation is still required.

As an understanding of complexity is embedded within the 5-point framework, leaders using the framework will naturally be better equipped to anticipate and manage emergent events, paradox and other non-deterministic leadership activities. This understanding allows a more effective critical evaluation of plans and business models.

When a leader is engaged in a leadership mode, the 5-point framework enables them to not only understand which mode they are using, but also the purpose of the mode and the effects of insufficient or chaotic leadership in that mode.

Given the critical importance of leadership to organizational success, any improvement in the effectiveness of leadership will yield benefits. By providing a holistic leadership framework, the opportunity for widespread leadership coherence and effectivity can be realized.

8.4.   Potential impact of the research

Many of the engineering programmes within the organization are critical for safety, security or defence. The software or equipment designed has a high impact when in service and, should anything go wrong, a serious impact if they fail to perform as expected in service or cannot be delivered when needed. Leadership is fundamental to the success of the engineering development programmes and the ongoing production and support in service. With large sums of money at stake (often tens of millions of dollars per programme), any improvement in leadership efficacy will show a substantial financial benefit.

This research is also anticipated to impact the development of the complexity leadership theory. Longitudinal research programmes are rare in CLT and the insights gained by conducting this research in an organization which includes innovation as an embedded process are expected to be valuable to the maturity of the theory.

8.5.   Answers to Research Questions

At the outset of the research, four questions were posed (RQ1,2,3 and 4) which the research has wholly or substantially answered. The findings are tabulated below in the context of the related research question and associated literature. Key aspects of these findings are then discussed below.

Table 22 - Answers to research questions

Research Question	Findings	Literature
RQ1	Leadership theories were analysed for a fit to the research problem and CLT was found to be the closest fit.	(Levy 2000 ; Thietart and Forgues 1995 ; Colbert 2004 ; Uhl-Bien, Marion, and McKelvey 2007)
	Informal interviews with the research population showed that the whole of	(Uhl-Bien, Marion, and McKelvey 2007)

	complexity leadership theory could not be used as a starting point to develop a leadership framework for engineering. It was found that the CLT framework proposed by Ul-Bien et al (2007) was a suitable starting point for development.	
	Surveys showed that the alignment to the leadership modes in the Uhl-Bien CLT framework could be measured in the research population.	
	AR transcript analysis and feedback from the AR sessions showed that the Uhl-Bien CLT framework, which proposed three leadership modes, did not fully describe the leadership areas of interest and so the framework was expanded to five leadership modes.	
	The output of the AR sessions added rich detail to the developing leadership framework. This detail is useful when using the framework to analyse leadership situations as it gives a model of balanced and productive leadership for comparison.	
RQ2	Those leadership theories considered reductive examine a specific element of leadership rather than leadership as a whole. Five of the identified leadership theories meet the non-reductive criterion by examining leadership in general: Complexity, Discursive, Lazear's, Critical and Flexible.	
	Complexity Leadership Theory could be used in an engineering organization as it examined leadership structures normal in that environment.	(Levy 2000 ; Thietart and Forgues 1995 ; Colbert 2004 ; Uhl-Bien, Marion, and McKelvey 2007)
	Discursive leadership Theory examines communication between leaders and followers which does not align well with the research problem as it does not address the approach and structure of the leadership.	(Fairhurst 2010 ; Kosonen and Ikonen 2022 ; Minei 2015)
	Lazear's Leadership Theory seeks to explain why some leaders are more successful than	(Lazear 2012)

	others, which does not align well with the research problem which seeks to improve the current situation rather than explain it.	
	Critical Leadership Theory (also known as Critical Leadership Studies) is a method for examining leadership, seeking to challenge the status quo and make transformative change. While it may be a credible approach for improving leadership, it is not a theory of how to lead.	(Horkheimer 1972)
	Flexible Leadership Theory examines the response of leaders to a diversity of situations. This may be useful in the context of the research question and the research problem but it does not seem well suited to the development of an engineering leadership framework.	(Kaiser and Overfield 2010)
	Complexity Leadership Theory seems the closest fit to the research problem and research question and at 2.9 publications per year was the most impactful, the others having 1 or fewer citations per year.	
RQ3	CLT models organizations as complex systems then proposes leadership modes to address the identified system behaviours such as emergence, a lack of boundaries etc. (see 2.5). These modes are primarily an attempt to balance the need for structure and flexibility; to take disruptive innovative elements and structure them into transformative change. CLT represents a non-reductive philosophy which recognizes the paradox between the need to model situations and the limits of the generated models. CLT seeks balance between leadership modes rather than proposing a single approach.	(Cilliers 2001 ; Anderson and Stein 1987 ; Hazy and Uhl-Bien 2014)
	Given the focus of CLT, a leadership framework derived from the theory should improve the balance between administrative structures and innovative or people-centric	

	leadership. It should also improve the recognition of the inherent limitations of models and reductive thinking (despite its necessity).	
RQ4	By examining other leadership methodologies which are based on CLT it can be seen that there is a limit to which a leadership framework which is optimized for one situation can be generalized for others.	(Bolden 2025 ; Crowell and Boynton 2020)
	Accepting this, the 5-point framework has been shown to be effective in a small trial with a diverse range of businesses which were not all explicitly technical or engineering based. This suggests that the framework can be useful beyond engineering organizations.	

This research contributes to the extant body of knowledge by substantially shifting the discussion on Complexity Leadership from the academic arena to the practitioner and applied theory arena.

(RQ1): Which leadership theory can be used as a sound basis for modern engineering leadership?

Answer 1: The Complexity Leadership Framework as proposed by Uhl-Bien, Marion and McKelvey in 2007 is the best fit but requires modification.

Having examined a wide range of leadership theories for alignment to the research problem, CLT was found to be the best fit. Within the literature on CLT, the original Complexity Leadership Framework proposed by Uhl-Bien et al (Uhl-Bien, Marion, and McKelvey 2007) was found to give a clearly defined starting point for development. In trying to apply the framework to an engineering organization, it was discovered that this theory needed to be modified to be useful to that demographic. In applying theory to a whole business, it has been found that a more holistic and tightly defined version of the leadership framework was required. In a project-based organization, grouping all administration under a single Administrative Leadership mode is not useful as the administration of projects is too different in approach from general business administration to allow for this grouping to be useful. In discussion, gaps in the original framework meant that direction-based leadership could not be categorized. These gaps were confusing to the practitioners who are looking for a framework which defines

all the leadership they encounter, rather than a situational framework (such as the Uhl-Bien and Arena model which looks at organizational change). The definitions of Adaptive and Enabling leadership modes were also slightly altered, although the core principals are consistent with all the Complexity Leadership writing which was reviewed. These differences in the definitions of some of the leadership modes are critical to creating a framework which fits leadership modes together logically and without gaps, blurred boundaries or contradictions.

(RQ2): What form of leadership framework or leadership methodology has a non-reductive philosophy and is suitable for general application in a complex engineering organization?

Answer 2: A leadership framework which incorporates response to emergence and which recognizes the uncertainty of complexity by incorporating a blend of rigidity and flexibility will be suitable for application in a complex engineering organization.

When presenting new ideas on leadership to experienced leaders, care must be taken to not propose methods which could contradict their experience or personal philosophy. This consideration sits well with presenting an understanding of Complexity Leadership in the form of a leadership framework as a leadership framework does not tell a leader how to lead. Instead, it allows an understanding of the purpose and interconnectivity of leadership activities which, in turn, allow reflection and analysis. Another consideration is the level of detail to be presented: too much detail is confusing and difficult to assimilate, especially for busy executives with limited time (and patience), but the detail is important if the framework is to be more than some high-level statements.

The 5-point framework is presented as a series of simple ideas which, in combination, build to form a rich understanding of the nature of the interaction between leadership and complexity. Simple and consistent infographics have been used to illustrate concepts in an accessible way. Each presentation in the set of training materials builds on the previous lessons so that, by the end, ideas which would be very difficult to explain in one session have been presented in a consistently simple way.

(RQ3): What aspects of leadership can be improved by a Complexity Leadership Theory based approach?

Answer 3: The agility, balance and overall success of leadership can be improved by a Complexity Leadership based approach.

The greater the levels of complexity which exist in society, the greater the benefits of adopting a leadership approach which recognizes complexity. In a society where change is slow and organizations can make plans for the next five years with a high degree of confidence that the world today will look very similar by the time those plans conclude, reductive models can work well enough to be useful. As we move through the 21st century, the traditional five-year business plan is at risk of becoming irrelevant as the speed of change makes two years seem like a very long time. It could be argued that the 20th century saw many great upheavals and societal shifts (two world wars, a pandemic, the invention of computers and global travel etc.) and perhaps we always needed leadership which understood complexity. A significant difference between the two eras is the extent to which traditional, reductive leadership is failing to deliver. In the present day, failing to understand emergence, the importance of agility and the tension between leadership for control and leadership for change, is a recipe for failure.

When this research commenced, there was debate about the validity of the proposal that organizations were complex systems, that society is a complex system and that leadership needs to increase in complexity as a response. By the conclusion of the research, there seems to be little doubt, in academic circles at least, that these things are true. The picture varies in industry and the public sector. It is proposed that part of the problem with adopting CLT based methods is the tendency of academics to study businesses from the safety of their own circles rather than publish methods which have stood the test of real-world application. Complexity Leadership is competing against traditional leadership methods which come with a bountiful supply of tried and tested methods, handbooks, training programmes and so on. At this time, leader seeking to adopt CLT based methods into their organization will need to invent ways of doing so. This research seeks to move towards redressing the balance in favour of CLT. Ultimately, the benefit of a CLT based approach, specifically the benefit of the 5-point framework, is that it doesn't contradict best practice on behaviour, tools, control, process, entrepreneurship or any of the other aspects of business which we find work well. Instead, it presents a framework which explains why they work well (when they do) and why they might not always be appropriate. It is a framework which shows cause and effect in a dynamic network, understanding the nature of complexity and, rather than fighting it or pretending it doesn't exist, used that complexity as a tool for agility, innovation and growth.

(RQ4): To what extent is a solution which has been generated for one engineering organization likely to be generalizable to other similar organizations?

Answer 4: The 5-point framework has been developed with leaders from an international group of business units, each with a different technological focus, history and culture. On that basis, it is expected to be generalizable to most engineering organizations.

The participants for the Action Research were based in business units involved in the following fields of engineering: Sonar, Nuclear Energy, Secure Communications, Aerospace, Military Land Vehicles, Soldier Systems, Cyber Security, Command and Control and Forensics. These businesses were based in the UK, Ireland, Canada, USA and Australia and although they were owned by a single holdings company, they each maintained a very different history and culture.

To further examine the potential generalization of the 5-point framework, it was presented to a range of businesses chosen to be different to those used in the original study. With employees ranging from 1 or 2 employees to 90,000, the ideas embodied in the framework have been shown to be highly relevant and insightful to all five. The 5-point framework is a tool for reflection and analysis. By simplifying the complexities of leadership in a way that maintains a recognition of complexity, it can be used to quickly find the limitations in existing leadership networks and propose improvements.

The apparent complexity of a business or organization does not seem to dramatically affect the applicability of the framework which may suggest that all organizations are in some way complex and all operate in a complex environment.

8.6. Contribution to knowledge

This research aims to address the identified research problem: a shortfall in engineering leadership effectiveness caused by reductive thinking which ignores the complexity of engineering projects and their environment.

Discussions and theories relating to leadership and engineering leadership are numerous and wide ranging. There are also many leadership theories and, within them, a number of leadership frameworks (e.g., Arena and Uhl-Bien 2017 ; Hazy and Prottas 2018 ; Uhl-Bien and Marion 2007 etc.). Some studies were identified exploring practitioner application of CLT (Schulze and Pinkow 2020 ; Bäcklander 2019) but these tend to be small in scale and not prescriptive of methods of application. Overall, the existing research was found to contain little that would assist a practitioner to improve engineering leadership in a way which effectively addresses complexity.

This study attempts to fill this gap by collaborating with practitioners to develop a Complexity Leadership Framework using an Action Research methodology.

Theoretical Contributions

CLT has been in discussion and development since 2007. This paper seeks to add a tangible addition to the canon of theory by adding a leadership tool which is based directly on CLT and which has been developed for practice through a longitudinal study.

It was found by the researcher that very few studies of CLT have been made in direct relation to Engineering Organizations. Specifically, most of the transition to practice has been made in the field of Healthcare and Public Services. As engineering is an area which is has a high impact on society and where a high level of complexity exists, this is proposed as a valuable arena for further Complexity Leadership research, particularly as research identifies issues with the current engineering leadership methods which, it is proposed, CLT has the potential to improve upon. This research extends the existing theory by expanding the identified leadership modes required to lead complexity. This is significant because it enables the theory to span a wider range of leadership activities than before, making the resulting framework more holistic. The originally proposed Administrative Leadership is proposed to be split into Strategic and Tactical Administrative Leadership modes. This (for example) allows programme management to be accounted for as a distinct activity from business administration as one is short term and localized while the other is long term and generalized. Direction is also added as an important leadership mode which links directly to complexity theory (as creating attractors for the activity flow). Beyond the expansion of identified leadership modes, greater detail has been added to the leadership framework. This detail is focused on application but it ties directly to theory, supporting the theoretical proposals of CLT with real-world embodiment of the concepts it contains.

Additionally, survey tools have been created and validated which can be used to measure alignment to CLT leadership modes. These have been initially validated within the context of this research but could be used and developed further for other, similar research.

The literature reviews contained in this study add to the existing secondary research, adding a new perspective.

Practical Contributions

Providing a leadership framework which embodies the concepts of CLT and is designed for use in an engineering organization has the potential to influence leadership practice. Within the duration of this research, articles showing the research have been published in an academic journal which is aligned to practitioner

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engagement (IEEE EMR). While this is a small step towards influencing engineering practice, it demonstrates interest in the research which may lead to more widespread distribution of the 5-point framework.

The 5-point framework has been used a number of times within the participating organization for both analysis of existing leadership practice and the design of hierarchical leadership structures. It has also been used in a limited trial to analyse and propose improvements to a group of businesses, with success.

It is posited that by dividing complexity leadership modes into activities which are not only distinct from a theoretical perspective, but which have a different method of communication, mindset and purpose, the 5-point framework lends itself to the analysis of existing leadership and the planning of future leadership to a greater extent than any of the known alternatives examined within the extant literature.

By describing the interplay of collaborative leadership across an organization, the developed complexity leadership framework gives leaders a wider perspective than can be seen in more situational leadership theories.

This research provides a leadership framework which can be used as the foundation of structured analysis of existing leadership within complex engineering organizations. It can also be used to inform the planning of new leadership structures by defining the foundational leadership modes which the new structure will need to accommodate. This is proposed as potentially useful for engineering leaders, business Directors, project managers, business analysis and others involved in the planning and continuous improvement of engineering leadership. There is also some evidence that the developed framework has potential application outside of engineering leadership. Given the role of engineering to socially important projects such as combatting climate change, national defence, medical services, transport, communication and construction, any contribution which could improve the leadership of engineering projects could have a potentially significant impact on quality of life and the economic use of public resources.

The creation of a set of on-line training material, which is publicly available, also opens the door to wider impact on leadership practice. This research has also enlivened the awareness of the importance of leadership within the participating organization where regular leadership training is now in place for all line managers.

8.7. Limitations

The limitations of this research can be characterized as being in the categories of theoretical foundation, data collection, research population and validation.

This research is specifically based on developing the content of a single publications (Uhl-Bien, Marion, and McKelvey 2007), albeit in the context of and with reference to a wider body of research. By using this one paper as the catalyst for the generation of a new framework, there remains a question of what might have been achieved had another foundation been chosen for the research. Certainly, the global discussion on organizations as complex adaptive systems and the subsequent implications for leadership is wide ranging and, no doubt, other researchers would have started at a different point with different outcomes.

The research uses Action Research as the principal method of primary data collection. This limits the data sources to a group of participants of a manageable size. Allowing for availability, some of the AR sessions were conducted with very few participants. It could be argued that a larger body of participants would produce data with a greater statistical chance of being generally representative. A greater use of quantitative methods to augment the primarily qualitative methodology may have produced more repeatable data which, in turn, would be more open to independent validation.

The data collected was primarily in the form of transcriptions of free-form discussions. Such data requires interpretation, looking for patterns and themes. The steps used to move from the raw transcription data to the interpreted output were not systematic in nature, relying on the skills and experience of the researcher. This would be difficult to replicate for another researcher.

As the research was to be conducted within a single organization, and with one researcher, the question of potential bias arises. While the participants work for the same parent organization, they are based in business units which are globally distributed. Each business unit has a different history and culture meaning that a range of perspectives were brought to the AR discussions. Very few of the participants knew each other prior to the start of the research. There was no budget assigned to the AR which meant that each individual had to reconcile the time spent within their own administration system. There was no promise or indication that participation in the research would provide benefits beyond an educational exploration of their role as a leader. To reduce the risk of unconscious bias by the researcher, the output from each AR session was submitted to all participants for validation (with no corrections proposed at any time). To demonstrate that the overall research output was not biased

to suit the collaborating organization, it was subsequently presented to five independent leaders, in unrelated organizations and small businesses, for validation.

The bulk of the research was dedicated to the formulation of the leadership framework leaving limited opportunity for validation in a range of organizations. This limitation has been somewhat addressed by engaging with a body of leaders from different industries to discuss ways in which the 5-point framework could be useful to them. This limitation would be usefully addressed by future research.

Contradictions

A notable contradiction in this research is the premise that leadership issues caused by reductive models can be solve by a leadership framework, which is itself a reductive model of leadership. Models for complex situations are necessary for cognition; all leadership theories and methods involve models of a more complex situation. This research proposes that models become problematic in organizational leadership when the limitations of the model are not acknowledged and accounted for in their use.

While no distinct contradiction was found to this research in the existing literature and parallel research, the emphasis and bias of this research is notably different. The only significant example of a drive to apply the concepts of CLT were in public services and healthcare (Crowell and Boynton 2020 ; Bolden 2025), these being very different in approach to thus research.

Alternative interpretations

An alternative interpretation of the research problem could be that the existing methods of engineering leadership (project management, systems engineering, Lean etc.) are simply not being applied correctly in the examples where projects are failing. Perhaps it is not necessary to use a new leadership theory to balance the existing leadership paradigm. Alternatively, a method like Critical Leadership Studies (Horkheimer 1972) or a qualitative analysis of the participating organization which used inductive methods to derive proposals for change without being linked to a specific leadership theory could produce good results.

Another researcher analysing the data generated in this study may have come to different conclusions about the relationship between CLT and the practice and experience of the participants. Even if the conclusions were similar, a different leadership framework could be generated.

CLT incorporates the philosophies of Distributed Leadership Theory (Brown and Hosking 1986), Network Theory (Miles et al. 1999) and Chaos Theory (Lorenz 1963). If this research were to use those foundational theories as a basis instead of CLT, the conclusions could be very different.

Survey and poll limitations

Limitations of first survey

Much of the first survey was intended as an exploration of what aspects of complexity leadership might be measured. The idea that averaged or group trend data for leadership is insightful is arguably flawed: why would the success of collective leadership be a function of the trend or average in the group? This is especially true for localised leadership such as Enabling Leadership. It could be argued that there is some value in a big-picture view of these leadership modes, but we can see inconsistency in responses (Figure 48) which depend on the way the question is posed which also cast doubt on the validity of this approach. There is also an additional concern that Enabling Leadership is seen as archetypal leadership and therefore there will be a bias for leaders to claim that as their dominant behaviour, even if it is not. Ultimately, the most useful aspect of this first survey was its influence on the development of the later surveys.

Limitations of surveys 2 and 3

This survey requires manual interpretation to deliver an analysis of a leadership situation. Unlike a survey which can be statistically analysed, this requires more work and each analysis is individual to a respondent. This limitation does come with advantages which cannot be achieved by group surveys, most notably it delivers targeted insight for a given leader.

Limitations of the Poll

The poll was conducted with participants who had only just been introduced to the ideas of different leadership modes and who had not had time to refine that understanding through discussion with an experienced teacher. During the discussions, it seemed that Adaptive Leadership had become synonymous with fire-fighting and chaotic behaviour. There was a risk that, due to inexperience with the theory, laissez faire leadership was being confused with too much Adaptive Leadership (the symptoms do look similar and laissez faire leadership can force adaptive leadership through a lack of pro-active prevention of risk) The desire for more Enabling Leadership was, however, clear and unambiguous.

Developments during the research period

The research was conducted during a particularly turbulent time: The UK left the European Union ("BREXIT") in January 2020 as the research began. Shortly afterwards (March 2020), the outbreak of the COVID 19 pandemic began to affect businesses in western society (mandatory work from home, "lockdown" etc.). The collaborating organization performed well in these conditions with no employees moved to "furlough" (a UK government scheme to pay wages when workers could not work due to the pandemic). In June 2022, the collaborating organization went from being publicly owned (listed on the London Stock Exchange) to being wholly owned by a private equity firm. The change in ownership saw the dissolution of almost all the centralized functions which had coordinated the organization as a group of subsidiary businesses. It was this group "head office" function which had initially approved this research and allowed access to the global network of leaders. Despite this change, the participants persisted with attending the action research sessions, allowing the research to be concluded as originally planned (although some left the business, either losing their jobs in the reorganization or through normal attrition, and had to be replaced with other participants). Although these changes did not derail the research, they did force a change in validation strategy: Originally, a large exercise was planned within the collaborating organization with two independent teams in separate business units. Around the start of 2024, it became clear that there was no longer a path to allow that to happen and the strategy for validation was modified to that presented in chapter 2.

8.8. Future research

This research was aimed at producing a Complexity Leadership Framework which could be applied to an engineering organization. Aligned to the research limitations, the proposed areas of future research are in the categories of theoretical foundation, data collection, research population and validation.

By using a different complexity leadership framework as a start point, further research could give insight into how much of the 5-point framework is reflective of the fundamental elements of complexity leadership and how much is governed by the framework from which it was derived. Parallel research which using a different methodology would give greater validity to this research. An obvious alternative approach would seem to be to derive a leadership framework through the thematic analysis of qualitative data, although many other valid approaches might be used. By using new methods to research the same area of leadership, in the context of Complexity Leadership, new insights can be gained which add further richness to this

research. Replicating this study in a wide range of industries and sectors which have been chosen for their variance in leadership structures (e.g. healthcare, biomedical, education, government) would give valuable insight into the way that the pre-existing leadership norms bias the research population and, ultimately, the generated leadership framework. This research has generated a leadership framework designed for application. A valuable next step would be to generate a longitudinal study of the 5-point framework being applied to different leadership scenarios in different organizations. With the framework already in place, such a study could potentially use qualitative methods to measure the effectiveness of the framework.

One of the areas which challenge complex organizations is the tension between the need to create plans and models, and the recognition that a complex system cannot be accurately modelled. This topic has been identified but not investigated in this research and any future research which developed potential solutions in this area would be highly complementary to the proposed leadership framework.

Several papers have been published which relate directly or indirectly to this research (see List of Publications).

8.9. Chapter Summary

As the deliverable output of this research, the 5-point framework answers the research questions and delivers an important tool for the application of Complexity Leadership in the engineering industry and other industries which use broadly similar methods. The limitations of this research present themselves as opportunities for future research which, if carried out, would increase the validity of this research and further underpin Complexity Leadership Theory as the candidate of choice for leadership methodology in the 21st century. The research has also led to several published articles (See List of Publications) and has been presented at internationally renowned conferences, such as the IEEE Conference on Innovation Management (INNOCONF) 2023 and the IEEE Latin American Industrial Forum in 2024.

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10. APPENDIX A

This appendix contains the details of the surveys and their analysis.

Survey 1:

The statements in the survey are as follows:

7.1. My job involves leading a team to deliver in the face of challenges and uncertainty

7.2. When leading (or co-leading) a new project or team activity, I have confidence in future success.

7.3. I work in a highly collaborative environment

7.4. I work with an agile and responsive team

7.5. I am supported to deliver success

7.6. There is a strong level of accountability in the projects I am involved in

7.7. If something begins to go wrong, we always understand what to do to correct it.

7.8. We react to sudden unplanned events effectively and positively

7.9. The best results come from our response to highly challenging situations

7.10. With a detailed plan and the right budget, we can achieve anything.

7.11. I really understand the team and the challenges they are working to overcome

7.12. I like to spread responsibility among the team

7.13. My team always seems very engaged and enthusiastic

7.14. Although we start with a plan, we tend to challenge and refine it as we move forward.

7.15. Our contracted responsibilities are well understood by me and the team

7.16. I share leadership of complex and challenging projects

7.17. Most of my work uses spreadsheets, databases and Gantt Charts.

7.18. I am always modifying my approach and the way I lead.

7.19. My role is setting the goals and deliverables for the team, its down to them how they achieve the goals. They are the experts.

7.20. If people are accountable for their commitments, they become self-managing.

7.21. The more the team communicates, the better the solutions become.

7.22. Sometimes we go outside the team for advice or a second opinion.

7.23. Despite things not always going our way, we always find a good way forward.

7.24. Through regular communication, I can see the flow of the work and sense when individuals are hitting obstacles or drifting off topic.

7.25. The team may not always agree with my plans and methods, but they respect my authority.

7.26. I protect the team from external distractions while they get on with delivering the work.

7.27. I know what work will fit best with each team member

7.28. I know my where my skills lie and will give others responsibility to allow their strengths to compliment my own.

8. When things start going wrong in a team I am leading, I normally... (please choose one option which reflects your most common response)

Correlation analysis for Survey 1 with heat map (blue = strong correlation):

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22	Column 23	Column 24	Column 25	Column 26	Column 27	Column 28
Column 1	1																											
Column 2	0.219974	1																										
Column 3	0.115718	0.080306	1																									
Column 4	0.117422	0.25508	0.544462	1																								
Column 5	0.05671	0.151568	0.415712	0.44858	1																							
Column 6	0.115005	0.129439	0.421918	0.282022	0.388704	1																						
Column 7	0.162816	0.2832	0.380994	0.29769	0.321265	0.4515	1																					
Column 8	-0.04601	0.211912	0.337324	0.367382	0.20158	0.301258	0.37971	1																				
Column 9	0.064884	0.320073	0.25287	0.273592	0.193145	0.272669	0.264816	0.138169	1																			
Column 10	0.100803	0.231732	0.130336	-0.05062	0.054939	0.117484	0.138169	0.273678	0.155013	1																		
Column 11	-0.345118	0.265169	0.132534	0.239244	0.076394	0.082437	0.246296	0.113665	0.155013	0.260371	1																	
Column 12	0.166757	0.185896	-0.00136	0.153826	0.032209	0.120586	0.134278	0.098203	0.119165	0.1694	0.349755	1																
Column 13	0.10331	0.252388	0.292177	0.441715	0.319082	0.252162	0.245503	0.35984	0.232634	0.018622	0.29062	0.260687	1															
Column 14	0.048712	0.082495	0.177179	0.219792	0.088833	0.137337	0.106892	0.240057	0.125704	-0.06956	0.058062	0.129279	0.238789	1														
Column 15	0.213243	0.173674	0.216413	0.184317	0.307935	0.31058	0.159894	0.244609	0.060889	0.2703	0.104242	0.144104	0.23935		1													
Column 16	0.286462	0.155514	0.030497	0.162736	0.069453	0.129918	0.008998	0.052377	0.006246	0.157542	0.253129	0.187862	0.123139	0.137979	0.056108	1												
Column 17	-0.099286	-0.00192	-0.04053	0.053564	0.029155	0.052208	0.007049	0.111765	0.073119	0.050057	0.166312	0.143923	0.256813	0.249894			1											
Column 18	0.185779	0.136158	-0.01026	0.039476	0.02419	-0.07712	0.110911	-0.01664	0.09087	0.234812	0.189172	0.15227	-0.00342	0.134153	0.124469	0.268793	0.135432	1										
Column 19	0.095047	0.078212	0.117035	0.10729	-0.03897	-0.00772	0.073283	0.154058	0.111752	0.219718	0.176942	0.223958	0.126369	0.032084	0.134695	0.176105	0.055289	0.17771	0.160279	1								
Column 20	-0.00378	0.079641	0.107592	0.150985	0.109977	0.090172	0.12491	0.143011	0.12575	0.226917	0.089221	0.262591	0.186883	0.153128	0.144254	0.145683	0.090787	0.172961	0.207615	0.322188	1							
Column 21	0.158297	0.200183	0.03131	0.092142	0.127985	0.037164	0.204	0.129838	0.156928	0.132011	0.275877	0.205726	0.111584	0.153128	0.206362	0.180599	0.081102	0.090787	0.152112	0.20656	1							
Column 22	0.200183	0.180872	0.217474	0.271559	0.165977	0.117984	0.124705	0.243057	0.158843	0.054773	0.261663	0.216955	0.180599	0.184512	0.064069	0.031983	0.163684	0.282356	0.222714	1								
Column 23	0.146636	0.287317	0.180661	0.244894	0.227859	0.172324	0.358896	0.255755	0.345517	0.113316	0.213047	0.135027	0.243485	0.116489	0.061086	0.143592	0.081034	0.100699	0.11328	0.303299	1							
Column 24	0.119836	0.173766	0.03778	0.183599	0.17905	0.135922	0.218274	0.223788	0.148015	0.130414	0.1561	0.195677	0.199639	0.087373	0.150317	0.083258	0.011898	0.145177	0.129663	0.145346	0.265203	1						
Column 25	-0.00138	0.201553	0.100354	0.327628	0.135511	0.195299	0.186764	0.211847	0.133219	0.24124	0.231404	0.092898	0.307394	0.129985	0.161712	1.68E-17	0.093245	0.099989	0.090392	0.145346	0.225884	0.294599	0.148105	1				
Column 26	0.137863	0.152893	0.089403	0.076849	0.034807	0.092969	0.125709	0.094211	0.054309	0.181197	0.123725	0.206752	0.073954	0.212912	0.093734	0.050917	0.073373	0.2752	0.16907	0.114679	0.231083	0.27795	0.230902	0.233709	1			
Column 27	0.152893	0.289776	0.342456	0.183154	0.214885	0.33142	0.344497	0.296997	0.319557	0.376671	0.172148	0.187354	0.138652	0.260796	0.039762	0.201071	0.173814	0.244118	0.221096	0.254673	0.27795	0.233709	0.259758	1				
Column 28	0.237288	0.218856	0.03402	0.147241	0.060195	-0.0043	0.125836	0.103043	0.135114	0.191224	0.227914	0.364604	0.135771	0.100603	0.318632	0.102705	0.29508	0.266049	0.222652	0.305441	0.252813	0.223661	0.198949	0.333716	0.259758	0.306751	1	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.807
Bartlett's Test of Sphericity	Approx. Chi-Square	1477.282
	df	378
	Sig.	<.001

Communalities

	Initial	Extraction
V1	.254	.360
V2	.269	.293
V3	.500	.595
V4	.521	.685
V5	.384	.443
V6	.400	.455
V7	.417	.469
V8	.372	.403
V9	.309	.289
V10	.315	.588
V11	.413	.551
V12	.341	.304
V13	.401	.433
V14	.214	.195
V15	.305	.357
V16	.315	.469
V17	.131	.134

V18	.262	.419
V19	.265	.393
V20	.279	.309
V21	.237	.223
V22	.260	.366
V23	.327	.413
V24	.287	.343
V25	.317	.281
V26	.286	.233
V27	.391	.391
V28	.405	.463

Extraction Method: Principal Axis Factoring.

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.750	20.535	20.535	5.165	18.447	18.447	2.741	9.788	9.788
2	2.455	8.767	29.302	1.914	6.835	25.282	1.741	6.219	16.007
3	1.413	5.046	34.348	.823	2.939	28.221	1.427	5.095	21.102
4	1.352	4.828	39.176	.747	2.667	30.887	1.342	4.792	25.894
5	1.273	4.546	43.722	.638	2.280	33.168	.975	3.481	29.374
6	1.216	4.344	48.067	.617	2.203	35.371	.925	3.303	32.677
7	1.109	3.962	52.029	.498	1.780	37.151	.868	3.100	35.777
8	1.054	3.763	55.792	.454	1.621	38.772	.839	2.995	38.772
9	.999	3.567	59.359						
10	.975	3.481	62.840						
11	.871	3.111	65.951						
12	.842	3.006	68.957						
13	.804	2.871	71.828						
14	.773	2.761	74.589						
15	.736	2.629	77.218						
16	.709	2.531	79.750						
17	.698	2.493	82.243						
18	.603	2.153	84.396						
19	.571	2.040	86.437						
20	.552	1.973	88.410						
21	.522	1.863	90.273						
22	.505	1.802	92.075						
23	.460	1.644	93.719						
24	.409	1.462	95.181						
25	.394	1.406	96.587						
26	.353	1.261	97.848						
27	.318	1.136	98.984						
28	.284	1.016	100.000						

Extraction Method: Principal Axis Factoring.

Scree Plot
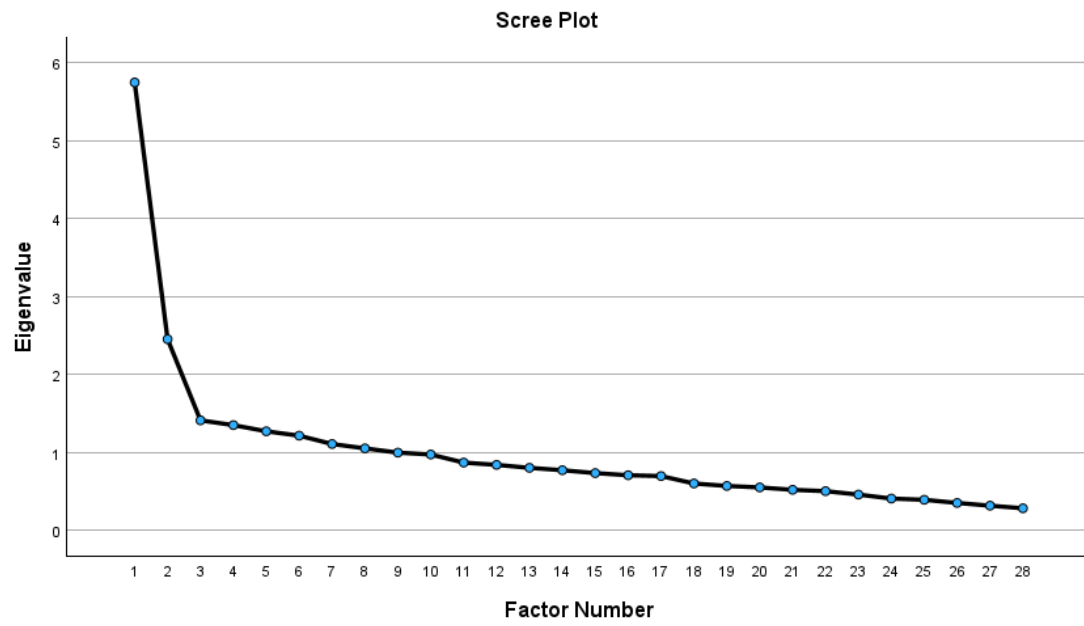
Factor Matrix[a]

	Factor							
	1	2	3	4	5	6	7	8
V1								
V2	.463							
V3	.453	-.526						
V4	.612							
V5	.424							
V6	.427	-.411						
V7	.558							
V8	.485							
V9	.454							
V10					-.459			
V11	.523							
V12								
V13	.524							
V14								
V15	.444							
V16								
V17								
V18								
V19								
V20								
V21								
V22	.416							
V23	.517							
V24								
V25	.425							
V26								
V27	.582							
V28	.455	.428						

Extraction Method: Principal Axis Factoring.

a. 8 factors extracted. 22 iterations required.

Rotated Factor Matrix[a]

	Factor
	1	2	3	4	5	6	7	8
V1			.551					
V2								
V3	.727							
V4	.580							
V5	.576							
V6	.636							
V7	.553							
V8	.428							
V9								
V10					.694			
V11			.647					
V12								
V13								
V14								
V15								
V16								.456
V17								
V18							.535	
V19				.599				
V20				.485				
V21								
V22						.524		
V23		.523						
V24		.531						
V25								
V26								
V27								
V28								

Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 10 iterations.

Matrix from parallel analysis

Principal Components

Specifications for this Run:

Ncases   223

Nvars   28

Ndatsets 100

Percent   95

Random Data Eigenvalues

     Root   Means   Prcntyle

1.000000	1.723570	1.825871
2.000000	1.611136	1.683180
3.000000	1.530681	1.591384
4.000000	1.461172	1.515998
5.000000	1.402308	1.447549
6.000000	1.342259	1.385289
7.000000	1.289750	1.333225
8.000000	1.242079	1.282233
9.000000	1.192998	1.225999
10.000000	1.147783	1.188947
11.000000	1.102753	1.136472
12.000000	1.061648	1.092710
13.000000	1.018841	1.055570
14.000000	.984082	1.024309
15.000000	.946170	.978996
16.000000	.905467	.939745
17.000000	.868069	.900902
18.000000	.832964	.864443
19.000000	.796418	.827656
20.000000	.758469	.787094
21.000000	.724445	.751289
22.000000	.690245	.722121
23.000000	.654294	.687092
24.000000	.619476	.650651
25.000000	.584926	.620031
26.000000	.546904	.577249
27.000000	.506157	.536655
28.000000	.454935	.500078

Survey 2:

The survey content is as follows:

Leadership self assessment

0% complete

Page 1: Page 1

Hello, welcome to the Complexity Leadership self-assessment survey. This survey is not anonymous but the data from it will not be shared with any personal details of the participants. Your name and email are needed so that you can recieve the results which are not generated automatically and will take some time to compile.

The survey is interested in what you do rather than what you believe. Please respond based on your normal activities.

The survey should take around 10-15 minutes to complete.

Please insert your name.

What is the email address you would like the results sent to?

Please enter a valid email address.

Next >

Leadership self assessment

16% complete

Page 2: Questions Page 1/5 - Direction

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these activity statements

Please don't select more than 1 answer(s) per row.

	This is an important part of what I do	I do this from time to time	I might do this occasionally	I rarely do this	I never do this
Broadcast a vision of the future which is accepted and used by the business	☐	☐	☐	☐	☐
Create the context for high-level priority setting and strategizing	☐	☐	☐	☐	☐
Set strategic goals which will contribute to achieving the organizational vision	☐	☐	☐	☐	☐
Deliver strategic direction	☐	☐	☐	☐	☐
Monitor the global business environment and adjust strategies for success	☐	☐	☐	☐	☐

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these behaviour statements

Please don't select more than 1 answer(s) per row.

	Strongly Agree	Agree	Somewhat agree	Don't agree	Doesn't apply to me
When delivering my vision, I contrast our current state with my vision for the future	☐	☐	☐	☐	☐
I make sure that the actions of my team and I are in line with my stated vision and strategy	☐	☐	☐	☐	☐
I make sure our strategies evolve gradually over time	☐	☐	☐	☐	☐

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Leadership self assessment

Page 3: Questions Page 2/5 - Strategic Administration

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these activity statements

Please don't select more than 1 answer(s) per row.

	This is an important part of what I do	I do this from time to time	I might do this occasionally	I rarely do this	I never do this
Create or contribute to policies and processes for the wider business	☐	☐	☐	☐	☐
Understand legislation and standards which affect the business	☐	☐	☐	☐	☐
Understand legal commitments made by the business	☐	☐	☐	☐	☐
Ensure our procedures are clearly written	☐	☐	☐	☐	☐
Regularly use business administration tools	☐	☐	☐	☐	☐
Engage with stakeholders when formulating or changing a procedure	☐	☐	☐	☐	☐

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these behaviour statements

Please don't select more than 1 answer(s) per row.

	Strongly Agree	Agree	Somewhat agree	Don't agree	Doesn't apply to me
I ensure that our general processes are usable and accessible by everyone	☐	☐	☐	☐	☐
I am seen as someone who can create processes and policies which balance the needs of all stakeholders	☐	☐	☐	☐	☐

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Next ›

Leadership self assessment

Page 4: Questions Page 3/5 - Adaptive leadership

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these activity statements

Please don't select more than 1 answer(s) per row.

	This is an important part of what I do	I do this from time to time	I might do this occasionally	I rarely do this	I never do this
Reacting positively to unplanned events which cannot be solved with normal processes	☐	☐	☐	☐	☐
Bring together a team of experts to solve unexpected problems	☐	☐	☐	☐	☐
Use analytical methods to get to the root cause of problems	☐	☐	☐	☐	☐

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these behaviour statements

Please don't select more than 1 answer(s) per row.

	Strongly Agree	Agree	Somewhat agree	Don't agree	Doesn't apply to me
I can make decisions even when there is no clear path to success	☐	☐	☐	☐	☐
When something derails our plans, I act quickly to formulate a recovery plan	☐	☐	☐	☐	☐
I am confident that I will find or facilitate novel solutions to unusual challenges	☐	☐	☐	☐	☐
In the face of an unexpected challenge, I will work hard to minimize disruption and get back on track	☐	☐	☐	☐	☐
People know they can trust me to deal with challenges, even if they are outside my previous experience	☐	☐	☐	☐	☐
When looking to resolve an significant emergent challenge, I know I can pull a team together to get things done.	☐	☐	☐	☐	☐
When solving an urgent problem I'm always careful to identify and engage with the stakeholders	☐	☐	☐	☐	☐
I seek out diverse ways of thinking when faced with a new challenge	☐	☐	☐	☐	☐

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Leadership self assessment

66% complete

Page 5: Questions Page 4/5 - Enabling leadership

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these activity statements

Please don't select more than 1 answer(s) per row.

	This is an important part of what I do	I do this from time to time	I might do this occasionally	I rarely do this	I never do this
Creating the optimal evironment for the success of the team	☐	☐	☐	☐	☐
Determine and deploy the best structure for a team	☐	☐	☐	☐	☐
Present the wider priorities of the business to my team	☐	☐	☐	☐	☐
Take time to listen to the team in one-to-one sessions	☐	☐	☐	☐	☐
Balance the needs of the plan with the realities the team are facing	☐	☐	☐	☐	☐
Take time to understand my team as people	☐	☐	☐	☐	☐
Monitoring the performance of individuals within a team	☐	☐	☐	☐	☐
Monitoring the behaviour of my team members	☐	☐	☐	☐	☐

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these behaviour statements

Please don't select more than 1 answer(s) per row.

	Strongly Agree	Agree	Somewhat agree	Don't agree	Doesn't apply to me
I spend time ensuring my team collaborates	☐	☐	☐	☐	☐
I have delegated some of my responsibilities to other team members	☐	☐	☐	☐	☐
I encourage and support innovative thinking	☐	☐	☐	☐	☐
My team feel engaged and are pro-active and enthusiastic	☐	☐	☐	☐	☐
While processes are important, sometimes we need to be pragmatic in order to respond in an agile way.	☐	☐	☐	☐	☐
I care about my team's well-being	☐	☐	☐	☐	☐
I feel trusted by my team	☐	☐	☐	☐	☐
I feel like I am an experienced and successful hands-on leader	☐	☐	☐	☐	☐
I would describe my soft skills as a particular strength	☐	☐	☐	☐	☐
When I see performance issues, I take steps to address them	☐	☐	☐	☐	☐
When I see poor behaviour, I take steps to address it	☐	☐	☐	☐	☐
While I strive to deliver my projects, I do understand the wider picture within the wider organization	☐	☐	☐	☐	☐

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Leadership self assessment

83% complete

Page 6: Questions Page 5/5 - Tactical Administration

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these activity statements

Please don't select more than 1 answer(s) per row.

	This is an important part of what I do	I do this from time to time	I might do this occasionally	I rarely do this	I never do this
Generate plans for delivering projects or activities	☐	☐	☐	☐	☐
Negotiate to gather the resources needed to achieve delivery	☐	☐	☐	☐	☐
Report progress against a plan	☐	☐	☐	☐	☐
Measure costs for a project or activity	☐	☐	☐	☐	☐
Analyse the plan to determine the critical path	☐	☐	☐	☐	☐
Set the sequence of tasks to be executed by the team	☐	☐	☐	☐	☐
Meet regularly with the project delivery team to discuss progress and challenges	☐	☐	☐	☐	☐
Plan and administrate important projects	☐	☐	☐	☐	☐

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these behaviour statements

Please don't select more than 1 answer(s) per row.

	Strongly Agree	Agree	Somewhat agree	Don't agree	Doesn't apply to me
I am responsible for bringing new people into the team as required	☐	☐	☐	☐	☐
I set the priorities for individuals in order to achieve the planned work	☐	☐	☐	☐	☐
When requirements change, I conduct an impact analysis	☐	☐	☐	☐	☐
My plans are updated to respond to real events	☐	☐	☐	☐	☐
I understand that my plan will never completely reflect reality	☐	☐	☐	☐	☐
When I plan, I work with input from the stakeholders	☐	☐	☐	☐	☐
I am trusted to manage large or important projects	☐	☐	☐	☐	☐
The team knows I can be trusted to balance the needs of the customer with their ability to deliver	☐	☐	☐	☐	☐

‹ Previous   Finish ✔

Survey 3:

The survey content is as follows:

Page 1: Page 1

Hello, welcome to the Complexity Leadership Environment survey. This survey is not anonymous but the data from it will not be shared with any personal details of the participants. Your name and email are needed so that you can recieve the results which are not generated automatically and will take some time to compile.

The survey is interested in the leadership you experience rather than your personal leadership. Please respond based on the leadership you recieve and which affects your work or working environment.

The survey should take around 10-15 minutes to complete.

Please insert your name.

What is the email address you would like the results sent to?

Please enter a valid email address.

Leadership environment survey

Page 2: Questions Page 1/5 - Direction

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these balance statements

Please don't select more than 1 answer(s) per row.

	Too often	A bit too often	The right amount	Not quite often enough	Not often enough
Our company vision is changed or updated…	☐	☐	☐	☐	☐
We have meetings where the direction of the business is presented…	☐	☐	☐	☐	☐

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these success statements

Please don't select more than 1 answer(s) per row.

	Strongly Agree	Agree	Somewhat agree	Don't agree	Doesn't apply to me
The company vision is inspiring	☐	☐	☐	☐	☐
The company vision is clear	☐	☐	☐	☐	☐
The company vision allows me to set priorities	☐	☐	☐	☐	☐
We have a clear set of strategic goals	☐	☐	☐	☐	☐
I believe in the vision of the Senior Management Team	☐	☐	☐	☐	☐
I see actions and behaviours which match the company vision and values	☐	☐	☐	☐	☐
I have confidence that the company vision will remain largely stable in the medium to long term	☐	☐	☐	☐	☐

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Leadership environment survey

33% complete

Page 3: Questions Page 2/5 - Strategic Administration

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these balance statements

Please don't select more than 1 answer(s) per row.

	Too often	A bit too often	The right amount	Not quite often enough	Not often enough
Our business processes are updated…	☐	☐	☐	☐	☐
Our business tools are updated or changed…	☐	☐	☐	☐	☐

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these success statements

Please don't select more than 1 answer(s) per row.

	Strongly Agree	Agree	Somewhat agree	Don't agree	Doesn't apply to me
We have common processes across the business	☐	☐	☐	☐	☐
Our business tools work well	☐	☐	☐	☐	☐
We are all trained in the business processes	☐	☐	☐	☐	☐
Our business processes apply equally to all	☐	☐	☐	☐	☐
Our procedures are clear and easy to use	☐	☐	☐	☐	☐
Our procedures are accessible	☐	☐	☐	☐	☐
When processes that affect me are changed, I am consulted	☐	☐	☐	☐	☐
Our business processes are mostly stable	☐	☐	☐	☐	☐
Our business processes are agile not bureaucratic	☐	☐	☐	☐	☐

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Leadership environment survey

Page 4: Questions Page 3/5 - Adaptive leadership

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to this balance statement

Please don't select more than 1 answer(s) per row.

	Too often	A bit too often	The right amount	Not quite often enough	Not often enough
When something unplanned arises, a response team is assembled to deal with it…	☐	☐	☐	☐	☐

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these success statements

Please don't select more than 1 answer(s) per row.

	Strongly Agree	Agree	Somewhat agree	Don't agree	Doesn't apply to me
When we respond to unexpected events, I see decisive leadership	☐	☐	☐	☐	☐
When things get derailled, we recover quickly and move on	☐	☐	☐	☐	☐
We are innovative in the way we respond to challenges	☐	☐	☐	☐	☐
I am confident that we will always deal with the unxpected in an agile and effective manner	☐	☐	☐	☐	☐
We have a great team who will rise to a challenge collaboratively	☐	☐	☐	☐	☐
When solving problems, we use people's knowledge effectively	☐	☐	☐	☐	☐
When evaluating solutions, we engage with and listen to stakeholders	☐	☐	☐	☐	☐
We have a range of tools and techniques which can be useful when searching for the root cause of a problem	☐	☐	☐	☐	☐
We are flexible and open-minded in our approach to finding solutions	☐	☐	☐	☐	☐

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Leadership environment survey

Page 5: Questions Page 4/5 - Enabling leadership

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these balance statements

Please don't select more than 1 answer(s) per row.

	Too often	A bit too often	The right amount	Not quite often enough	Not often enough
I meet with my line-manager for a one-to-one...	☐	☐	☐	☐	☐
As a team, we discuss progress and challenges...	☐	☐	☐	☐	☐

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these success statements

Please don't select more than 1 answer(s) per row.

	Strongly Agree	Agree	Somewhat agree	Don't agree	Doesn't apply to me
The team is strongly collaborative	☐	☐	☐	☐	☐
Responsibility is shared within the team in an effective way	☐	☐	☐	☐	☐
We have freedom to innovate	☐	☐	☐	☐	☐
I feel engaged	☐	☐	☐	☐	☐
I feel recognized	☐	☐	☐	☐	☐
We achieve a pragmatic balance between the planned commitments and the challenges of reality	☐	☐	☐	☐	☐
My line manager understands me as a person	☐	☐	☐	☐	☐
I trust my line manager	☐	☐	☐	☐	☐
I see managers who influence my work as competent and professional	☐	☐	☐	☐	☐
Performance issues are dealt with quickly and effectively	☐	☐	☐	☐	☐
Behaviour issues are dealt with quickly and effectively	☐	☐	☐	☐	☐
My line manager balances our immediate commitments with the needs of the wider business	☐	☐	☐	☐	☐

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Leadership environment survey

Page 6: Questions Page 5/5 - Tactical Administration

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these balance statements

Please don't select more than 1 answer(s) per row.

	Too often	A bit too often	The right amount	Not quite often enough	Not often enough
The time we spend planning what we do is…	☐	☐	☐	☐	☐
We adjust our plans to reflect reality…	☐	☐	☐	☐	☐

This part of the survey uses a table of questions, view as separate questions instead?

Please respond to these success statements

Please don't select more than 1 answer(s) per row.

	Strongly Agree	Agree	Somewhat agree	Don't agree	Doesn't apply to me
We plan our projects well	☐	☐	☐	☐	☐
We have the resource we need for delivery	☐	☐	☐	☐	☐
We always have a clear understanding of our progress	☐	☐	☐	☐	☐
Costs are always accurately accounted for	☐	☐	☐	☐	☐
The time spend on individual tasks is accurately recorded	☐	☐	☐	☐	☐
I always have a clear set of priorities	☐	☐	☐	☐	☐
When there is a change in requirement, we always do an impact assessment	☐	☐	☐	☐	☐
Our plans will be adjusted as events unfold	☐	☐	☐	☐	☐
The planners collabrate with the delivery team	☐	☐	☐	☐	☐
Plans take the views of stakeholders into account	☐	☐	☐	☐	☐
I believe in our ability to plan and measure progress	☐	☐	☐	☐	☐
There is mutual trust between the planners and the delivery team	☐	☐	☐	☐	☐

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Data analysis of the combined results of Survey 2 and 3 is as follows:

As can be seen (blue is high correlation on the heat map), the high correlation areas are at the boundary of the diagonal and correlate to questions pertaining to the same leadership mode:

This was the area containing the highest correlation value.

	Column 95	Column 96	Column 97	Column 98	Column 99	Column 100	Column 101	Column 102	Column 103	Column 104	Column 105	
Column 95												
Column 96	0.147106237	X										
Column 97	-0.063797305	0.584795349	X									
Column 98	0	0.403088547	0	X								
Column 99	0.25068213	0.435385392	0.081296958	0.6172134	X							
Column 100	0.134422061	0.367883604	-0.010568115	0.403677428	0.809754132	X						
Column 101	0.086856871	0.553128569	0.404292801	-0.072332767	0.156256635	0.170116526	X					
Column 102	0.097088771	0.22483205	0	0.418330013	0.645497224	0.627232854	-0.121035869	X				
Column 103	0.241189783	0.373157208	0.024274726	0.41210584	0.635893117	0.626166722	0.041473051	0.886609243	X			
Column 104	-0.173409654	0.345537952	0.141247085	0.513839092	0.555009652	0.555138089	0.241318791	0.62097913	0.595372197	X		
Column 105	0	0.22483205	0.314861765	0.298807152	0.25819889	-0.048248681	-0.060517934	0.25	0.246280345	0.429908628	X	
Column 106	-0.028629917	0.416738799	0.458932764	0.231612424	0.312712513	0.11991969	0.132568542	0.290671285	0.309171218	0.503068009	0.872013855	X
Column 107	0.200720111	0.36561665	0.079383082	0.554468443	0.598894368	0.574163361	0.283795217	0.463901583	0.509156904	0.525083259	0.115975396	

Coding and thematic analysis

The following shows the themes and their associated codes divided by AR session.

Theme	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6
	good businesses	capability building				
The drive for success	leading right	engineering capability	continuous improvement			
	proper software lead	good video meeting capability	process improvement			
	formal leadership	teams capability	exploring solutions			
	leadership ability	continuous improvement	perfect design solution			
		improving employee	preliminary solution draft solution			
		process improvement				

Theme	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6
	balance changes	big step changes				
	changing organization	change initiatives	change sake			
	dynamic change	change process	changing anything	business culture	causing problems	
Transformation	gonna change	significant change	uncontrolled change	business decision	engaging cause	
	team changes	continuous improvement	problem statement definition	business priority	interesting cause	
	transient change	continuous improvement			change management	
		improvement stuff			nonsense changes	
		improving employee			fast growth mode	
		process improvement			survival mode	
					peer-to-peer knowledge share	
					peer-to-peer sharing	

Theme	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7
		line manager					
		management engineer					
		program manager					
		project manager role					
		risk management process					
		bureaucracy level	administrative costs				
		good recording function	calculating cost				
	administrative leadership	accounts department	cost benefit				
	program managers	apparent accounts	cost benefit analysis	cost creeps	internal audits		business administration
Administration and financial control	project managers	different cost	cost efficiency	administrative leadership framework	third party audit		strategic administration
	store manager deals	expense costs	gonna cost	project delivery team	strategic administration		tactical administration
	program excellence	extra travel costs	hidden costs	project management	tactical administration		
	program managers	gonna cost	simple cost analysis	project review	wide administration		
		total cost	support functions	exchange rate risks			
		finance director		risk budget			
		finance director		specific risk			
		finance person					
		finance team					
		administrative leadership function					
		budgetary performance side					

Theme	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7
New thinking		functional negotiation training	generating ideas	complex systems	emotional content		
		niche functions	pattern generation	complexity leadership			
		support type functions	generating ideas	deterministic elements			
			good ideas	stable elements			
			great idea	unstable elements			
			ideas guy	paradox example			
			revolutionary ideas	administrative leadership framework			
			innovative mode	idealised model			
			innovative nature	interesting model			
			innovative thinking	simplistic model			
			innovative thoughts				
			constructive innovation	science project			
			engineering innovation				
			product innovation				
			supporting innovation				
			technology innovation				
			supporting innovation				
			good thinking time				

Theme	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7
						strategic administration	line manager
		clear policy		micromanaged team meetings		tactical administration	line managers interaction
		good policies	supporting innovation	difficult leadership	enabling leadership	wide administration	management level
		administrative leadership function	team leaders	direct labour	conveying ideas	adaptive leadership	managing person
		leadership skills	generating ideas	directing mode	different ideas	broad brush leadership profile	operations manager
Leadership		leadership style	pattern generation	complex systems	administrative leadership	current leadership model	opportunity management
		line manager	different leadership types	complexity leadership	enabling leadership	different leadership modes	product manager
		management engineer	different mode	detail level	half dozen leadership theories	enabling leadership	software manager
		program manager	innovative mode	detailed plans	leadership failure	enough leadership	business administration
		project manager role	insightful mode	level expectation	leadership theory	leadership environment	strategic administration
		risk management process	support functions	good manager		leadership team	tactical administration
		company values	support groups	managing paradox		leadership type	support departments
						senior leadership	support network
							supporting bids

Theme	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7
		assessing people	action people				different people
		giving people	bringing people				enabling people
		lovely people	certain people	clever people	bad person	enough resource	good people
The talent pool / people / skills		mixed people	disrupted people	different skills	problematic person	right resource	fully resource
		moving people	limited people	real skill			resource diverter
		often people	maybe people	skill set			right resource
		people people	people people				throwing resource
		right people	right people				
		stopping people					
		talented people					
		performance review					
		personal development					
		personal observation					
		personal perspective					
		personal thought					
		personality side					
		additional skills					
		conversation skills					
		leadership skills					
		negotiation skills					
		skill set					

11. APPENDIX B

This chapter contains consent forms and ethical approval.

College of Engineering, Design and Physical Sciences Research Ethics Committee
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

www.brunel.ac.uk

14 December 2021

LETTER OF APPROVAL

APPROVAL HAS BEEN GRANTED FOR THIS STUDY TO BE CARRIED OUT BETWEEN 31/01/2022 AND 23/12/2023

Applicant (s): Mr Chris Biggadike

Project Title: Complexity Leadership - Action research in Ultra Electronics

Reference: 31672-LR-Dec/2021- 36672-2

Dear Mr Chris Biggadike

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- **The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.**
- In addition to the above, please ensure that you monitor and adhere to all up-to-date local and national Government health advice for the duration of your project.

Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor (where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee.
- Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.
- The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the study.
- You may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.

Professor Simon Taylor

Chair of the College of Engineering, Design and Physical Sciences Research Ethics Committee

Brunel University London

Invitation to participate – Complexity Leadership Action Research

You are invited to participate in a programme of Complexity Leadership Action Research which is being run within the Ultra Electronics Group.

Purpose of study

Ultra recognizes that the Complexity Leadership approach has the potential to significantly enrich the leadership practice within Ultra. Quality of leadership is fundamental to the success of the business. This research is designed to develop a robust framework for Complexity Leadership for general deployment within Ultra. It is also intended to measure the perceived benefits of such a framework.

Why have I been invited to participate?

Anyone who's primary role involves the leadership of complex tasks within Ultra is eligible to participate, but places are limited. The participant mix will be chosen to achieve a wide spread of demographic from across the business.

Volunteers should be open to new ideas and methods and be prepared to take the time needed to participate.

Do I have to take part?

Participation is purely voluntary and, as places are limited, not all volunteers will be accepted onto the scheme. The goal of selection is to achieve a varied demographic for the volunteer group. Beyond this goal, volunteers will be selected at random to achieve a manageable group size (even a small group will generate a large amount of data).

All leaders within the business should receive some training in the ideas of Complexity Leadership so not taking part does not mean missing out.

What will happen if I take part?

Volunteers will be trained in the ideas of Complexity Leadership, then form a small group who meet periodically to discuss the application of the methods, have access to additional training material and collectively influence the way the Complexity Leadership Approach is applied within Ultra.

Volunteers will also be exposed to some of the more detailed ideas within the Complexity Leadership approach which go beyond those taught in the standard presentation. These ideas include:

- Distributed Leadership
- Managing paradox
- Cognitive diversity

Action Research (the research methodology) is a light-touch participatory method for gathering data and improving understanding without disrupting ongoing working practices.

What are the possible benefits of taking part?

Complexity Leadership is a method for understanding the leadership mechanisms behind the successful leadership of complex activities within the business. Any long-term activity which involves multiple stakeholders and contains unknowns can be considered complex. Complexity Leadership applies to much of what is considered normal practice within Ultra and leading such activities successfully is critical to our competitive advantage.

What are the possible risks of taking part?

This research is sponsored by Ultra with ethical oversight by Brunel University London. It is designed to have a minimal disruptive impact and should be a positive experience. There are no identified risks to participating but you are free to leave the programme at any time. You can also ask for any recorded interviews you participate in to be deleted without inclusion in the study. Your comments within group discussions are public (to the group) but records of your contribution can also be deleted from the research on request.

How much time will it take?

The programme of activities is planned to span around 2 calendar years (Jan 2022 to Dec 2023) and is designed to be incorporated into other transformation activities which you may already be a part of. You should expect a quarterly group discussion (on Teams) lasting an hour plus the possibility of a one-to-one interview lasting 30 minutes.

In addition to this, you will be able to ask questions and seek advice on Complexity Leadership (by email) during that period.

The activities are designed to require minimal interaction and the primarily task is the application of taught leadership in your normal leadership duties.

What do I get from it?

Although all leaders within the business will receive some training on Complexity Leadership, the volunteers for this Action Research will receive a more detailed understanding of the approach through additional training material and group discussions.

Ethical Considerations

While your application to participate will contain your name, business unit and other similar personal details, any personal data will be stripped from all reports generated by this research. All interviews will be considered confidential.

Recordings, where used, will be used to generate transcripts for thematic analysis.

You can withdraw your participation at any time during the process.

Any data you have provided can be removed from the research at any time (and will always be treated confidentially and made anonymous before publication).

No promise of promotion or other benefits (direct or indirect) is associated to participating in this activity.

The performance of individuals is not being measured or reported as part of this research.

Personal data gathered for the purpose of this research will be destroyed as soon as its use has expired, in line with the rules of the General Data Protection Act.

Data will be stored on an Ultra company server and backed-up on a personal computer owned by the researcher.

What will happen to the results of the research study?

As a volunteer, you will have access to the results of the study, once they are compiled. The results will be published in two forms:

1. Within Ultra with business sensitive elements included but with personal details of participants anonymized
2. Externally as an academic paper with no company sensitive elements or volunteer personal details included.

Who has reviewed the study?

The study has been approved by the Chief Human Resources Officer at Ultra and by the Research Ethics Committee at Brunel University London.

Contact for further information and complaints

Professor Simon Taylor - simon.taylor@brunel.ac.uk (Chair of CEDPS Research Ethics Committee)

Researcher Name: Chris Biggadike – chris.biggadike@ultra-pcs.com

Chief Human Resources Officer - Steve.Izquierdo@ultra-electronics.com