MAKING SENSE OF COMPLEX SYSTEMS: PRACTICAL PRINCIPLES AND FRAMEWORKS

Dr Ryan Young
Prof Katherine Daniell
Flynn Shaw

Australian
National
University

Final Project Report

Research undertaken with the support of the Defence Science and Technology Group of the Department of Defence.

Executive Summary

Many real world systems are irreducibly complex. The sciences and arts of complexity have shown we need to think differently to analyse and act differently in them.

Humans have been inherently grappling with this complexity with partial knowledge for millennia. We have many instinctive and practiced ways of dealing with complexity. Knowledges of these systems and methods for navigating them are shaped by culture, context and learning.

Multiple perspectives are required to understand more about any complex system. However, irreducibly complex systems are unable to be completely solved or understood. We can only expect to find multiple partial descriptions and experiences of them.

Effectively navigating complexity therefore requires an ability to manage multiple, often 'incommensurate' knowledges and to structure collective processes of exploration and creation of potential future directions for action.

As per the original objectives, this research project has delivered new frameworks and principles to help teams analyse and make sense of the complexity inherent in the modern environment.

The project took a desk-based research, case study analysis and participatory workshop design and testing approach to develop and test:

1. **A four-stage analytic and principles for staging processes of complexity analysis and future action decision-support.** This has included a mapping of types of complexity method use at each stage and principles to get the most out of these stages.

2. **A meta-methodology** for bringing together incommensurate knowledges which includes:

   a) **A two-level interactive knowledges framework that** provides a structure for thinking through knowledge systems in a cybernetic and connected manner, considering their different internal elements and external dynamics when brought together.

   b) **16 principles for participatory process design** coupled to questions to action them, derived from cybernetics and transdisciplinary case studies.

A combination of these frameworks, methods and principles were successfully applied in a one-day workshop on 3 March 2023 to support DSTG and partners to Navigate complexity around Australia's Engagement in the South-West Pacific.

Future research could further test, explore, expand and hone the contributions for other contexts and issues of strategic interest to DSTG and other organisations.

Table of Contents

Introducing genuine complexity

Many real world systems are irreducibly complex. The science of complexity has shown we need to think differently to analyse them.

Some systems are irreducibly complex.

Things in, or parts of, these systems are **mutually dependent.** We cannot say which comes first or what causes what.

Moreover, **causation and influence occur across different scales and levels**. Small things, like molecules, can directly influence much larger things, like ecosystems. And large things, like nations, can directly influence small things, like individual people.

Causation, influence and relationships within these systems cannot be easily, if ever, mapped and understood.

This all means that they can **never be solved, only partially understood.**

Complex systems behave differently to how we expect.

They have **emergent** properties, so can behave in ways that cannot be observed in their constituent parts.

They are often **non-linear**. Small inputs or shocks sometimes lead to radical changes, yet at other times large inputs or shocks lead to no change at all.

Their structures or order often arise from **self-organisation**. There is no direction or plan, but order emerges spontaneously from local interactions within the system.

They also exhibit **universality**. Similar structures or patterns of behaviour occur across different spatial and time scales.

Therefore, we need to analyse many systems differently.

Human skills are invaluable

Humans have been inherently grappling with complex systems with partial knowledge for millennia. We have many instinctive and practiced ways of dealing with complexity.

Integrating differing perspectives, considering cultural and location specific contexts, and teasing out consequences, intended or unintended, *come naturally to humans as we tell stories, swap insights and wonder about the world.*

These human skills are fallible and prone to a range of explicit and implicit biases. This means that many researchers, analysts and organisations are increasingly relying on big data, data analytics and AI based approaches to try to solve current and future analytic challenges.

However, we are realising that these *digital approaches do not eliminate bias, but more often perpetuate it*. And the irreducible complexity of many important real world systems is not amenable to digital analysis.

We should therefore look to tap into a variety of instinctive human skills to help make sense of complexity. These can be *both efficient and analytically powerful*. However, this needs to be done well to acknowledge, organise and minimise biases and therefore get the most out of these approaches. Poor analytic structure, process and habits usually lead to poor decisions.

Our research was focused around two parts to the challenge of using human skills well: the **analytic processes** themselves; and the **human dynamics** we want to harness (otherwise they get in the way).

These two parts form the basis of the report, followed by a summary of the capstone workshop that applied the research in a practical activity to inform government thinking.

The section focussed on analytic processes builds a framework for choosing analytic methods to use for making sense of complexity. This is motivated by established features of complex systems that require us to think differently when dealing with complexity.

Alongside the analytic methods, we often need to harness human dynamics, such as differing perspectives and incommensurate knowledges, for richer analysis of complexity. However, the same dynamics often get in the way or make work difficult.

The second section synthesises a framework and a set of principles for using these human dynamics and skills to get high quality research and analytic outcomes. These are drawn from a range of trans-disciplinary, cybernetic case studies.

ANALYTIC PROCESSES FOR MAKING SENSE OF COMPLEXITY

Analysing complexity requires a different approach

Irreducibly complex systems are unable to be completely solved or understood. We can only expect to find partial descriptions of them.

Modern analytic practices are largely focused around breaking problems and systems down into smaller constituent parts; then analysing the smaller part before moving back up to the whole.

However, this does not work for complex systems. The whole system often has properties that depend on the system, not on the parts.

To analyse complexity, we therefore need to focus more on ***building an understanding, rather than breaking the system down.*** This requires a more holistic, but less detailed, view.

Bringing different sources of information and ways of seeing a system together is essential to making sense of complexity. In other words, ***we need to synthesise information rather than just analyse.***

To do this well, we need to ***draw in disparate perspectives.*** No one way of viewing a complex systems is complete, and highly varied perspectives often provide greater insights.

For many, methods for making sense of complexity are uncomfortable. We can almost never reach a final answer as we can only achieve a partial understanding of a system. However, this discomfort can be harnessed to provide better analysis and thinking.

We can never reach a final answer, so we should ***iterate our analysis and keep testing*** our thinking. All analysis can be improved and an iterative approach is important to making sense of complexity.

It is also important to ***explore inconsistencies, rather than just eliminating them.*** In a complex system, inconsistent information tells us something important. It often doesn't mean that one source is wrong.

With this principles in mind, our research has been synthesised into a process based framework that can be followed to improve understanding and analysis of complex systems.

Complex system analytic process

A useful way to structure thinking through complexity is to follow a staged approach. In practice, any work is likely to require iterative testing, but these stages cover the activities required to achieve good decisions.

Analytic process

Scope

The purpose of analysis and boundaries around relevant system

Seeking to understand a particular complex system writ large will almost invariably lead to an indefinitely expanding task. We need therefore to narrow our analysis and put clear boundaries around it, otherwise, it will never be achievable.

Explore

Try to understand key system features and identify expected behaviours

Due to the many challenges involved in understanding complex systems and especially since they aren't easily solvable, it is important to take time to try to understand how the system functions in practice and make sense of its properties.

Build

Capture insights in a coherent structure for communication, prediction, further insight

Initial outputs are likely to be a series of observations of system behaviour under certain conditions. It is important to build a reasonably coherent description, or descriptions, of the system as a whole.

Apply

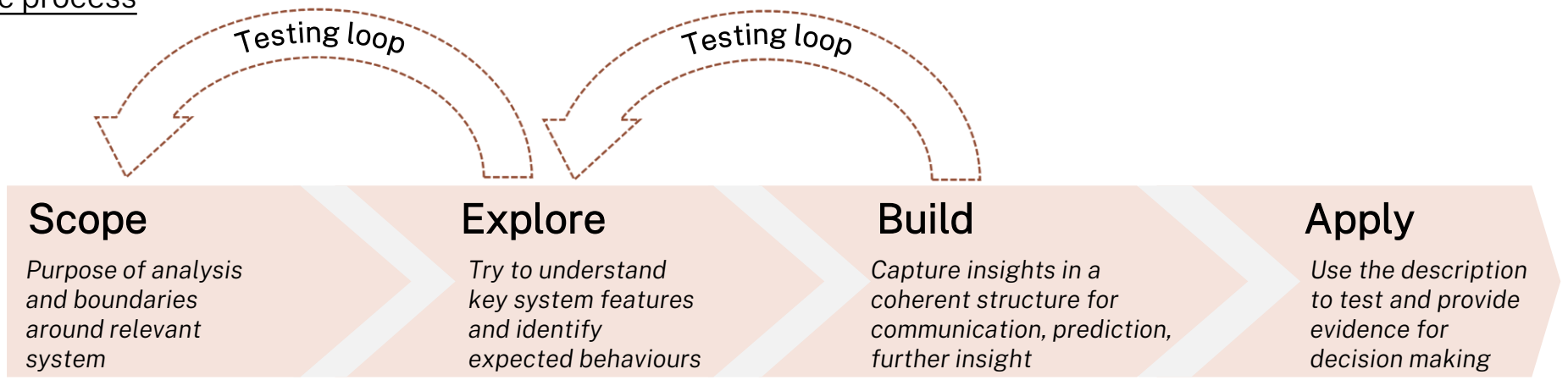
Use the description to test and provide evidence for decision making

The whole process, including building the understanding of the system, will typically be designed to feed into some decision or action. A key principle is that all the prior work should be designed to ensure that it has the right effect and is useful at this stage.

Methods for complex system analysis

There are a wide range of different analytic methods that can be used at different stages of the process. Some are listed here, with more available on request[1].

Analytic process



Techniques

Scope	Explore	Build	Apply
1. Question definition 2. Empirical conceptual analysis	1. System mapping 2. Key factors or nodes 3. "In the life of…" 4. Break the system 5. Random selection	1. Scenario 2. Metaphor 3. Key principles 4. Game / simulation 5. Formal model	1. Stress-test 2. Creative problem solving 3. Any other policy / planning process

A few principles for maximising the value of analysis

Encourage the idiosyncratic or unexpected. Safe inputs lead to outputs without insight.

Take time in the build phase. The first prototype is almost always flawed or incomplete.

Multiple iterations of analysis can build more insight than one comprehensive attempt.

HARNESSING HUMAN DYNAMICS

Harnessing different knowledge systems

Multiple perspectives matter in understanding complexity[2] but their interaction is fraught with potential for complexity, uncertainty and ambiguity. We have developed a meta-methodology to navigate these challenges.

Analytic approaches to complexity always depend on bringing multiple perspectives to bear. However, different human perspectives are often built on different knowledge systems – different observations, values and frames – that are mutually incomprehensible or 'incommensurate'.

The challenge of incommensurate knowledges has long been studied in some disciplines including philosophy and operational research (OR). Yet, like other parts of complex systems-related theory, there is a need for greater awareness and more easily actionable approaches that can be applied in daily work. We have synthesised an actionable analytic framework and a set of principles as the basis of a ***meta-methodology for the design of participatory processes*** intended to support collective navigation of complexity.

The framework was based on an analysis of multiple literatures investigating knowledges from different disciplinary and cultural standpoints. It illuminated a number of ***patterns of processes and dynamics within and between knowledges***.

These patterns differed across two levels. We identified ***'intra' knowledge system processes*** common within different systems, as well as the ***'inter' knowledge system dynamics*** *that arise* when different or incommensurate knowledges are brought together.

These patterns can be translated into action via a series of principles that are a guide to what matters in putting a successful human processes together. These were honed through a comparative case study approach that looked at successes and failure amongst historical and contemporary cybernetics and transdisciplinary groups around the world.

The principles included some that are regularly discussed in OR and related literatures, such as *the importance of vision or purpose, attention to context and culture, the need for perspective plurality, trust building, collective modelling, boundary spanning and reflexive praxis*.

However, other principles are less discussed in OR even if greater amounts of investigation occur in specific disciplines or communities. These include *the importance of a common group 'politic', productive discomfort, radicalism, serendipitous encounters, having a license to dream and shared space/social islands, and envisaging endings*.

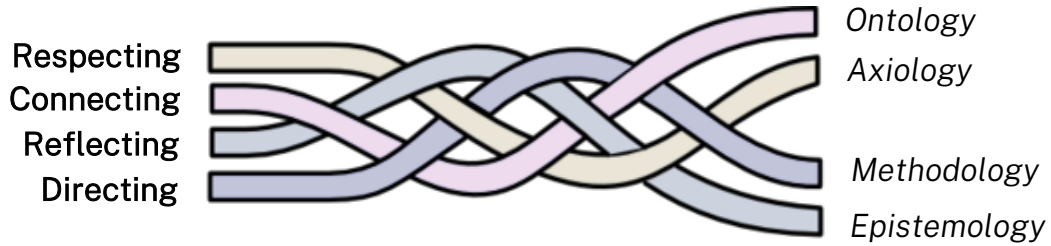
To enable the simple translation of the principles into daily action, **all sixteen principles have been translated into simple questions** to ask for any human-centred process to think through complexity.

Meta-methodology

Knowledge dynamics framework[3]

There are distinct internal and external dynamics when multiple knowledges interact. These can be brought together in a cybernetic and connected manner. This framework centres an Australian Indigenous concept of knowledge processes (Yunkaporta and Shillingsworth, 2020[4]) and their translation to Western philosophical terms.

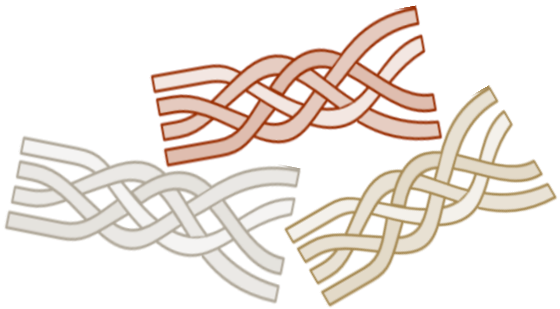
Level 1: *Intra-knowledge process elements*



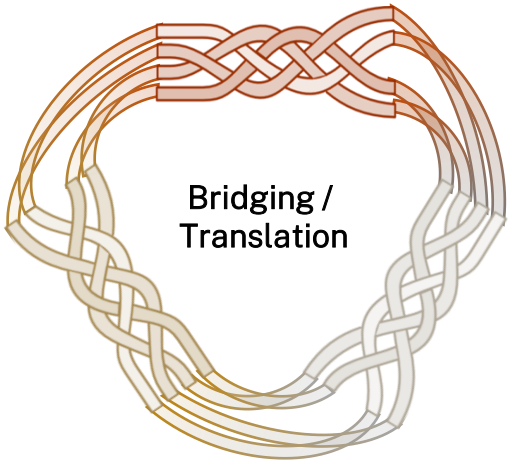
Cybernetic Mechanisms

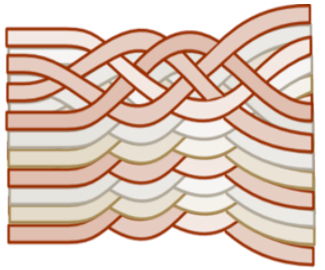
Feedback *Learning* *Communication* *Self-organisation* *Control* *Relationality* *Plurality composition*

Level 2: *Inter-knowledge process dynamics*



Fragmentation





Integration

Cybernetics & Transdisciplinary Case Studies

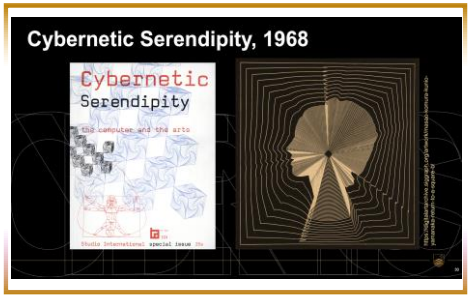
Cybernetics is a field of study and practice in navigating complexity, known for encouraging ongoing conversations between different disciplines and knowledges. Cybernetics carries common origins and similarities to transdisciplinary work and hence provided useful inspiration for deriving a set of principles for participatory design.

The comparative case study research of this project[3] focussed on transdisciplinary and cybernetics-focussed groups and initiatives from around the world since the end of WWII. These covered a range of community types including different configurations of academic disciplines, those that focussed more heavily on design and the arts, Indigenous-driven practice, groups merging research and politics, and education-focussed endeavours.

The Macy Conferences

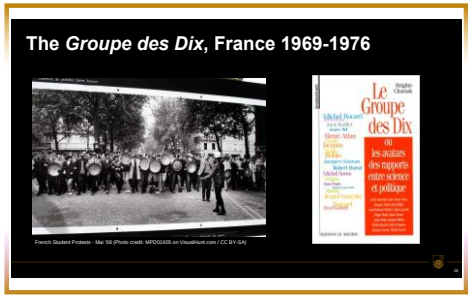
The Ratio Club

Hochschule für Gestaltung

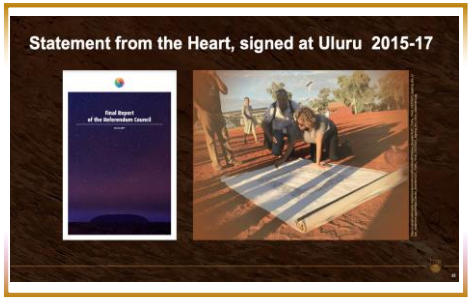


Cybernetic Serendipity

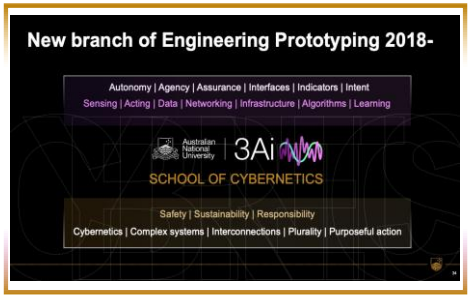
The Club of Rome



Le Groupe des Dix



Statement from the Heart



Applied Cybernetics Master's

Meta-methodology

Principles for process design[3]

Actively considering these sixteen principles, via the example questions, provides a strong basis for productive human dynamics in group settings in grappling with, navigating, and ultimately transforming, complex systems.

Purpose

Vision - What is our problematique and how do we frame it to encourage participants to engage?

Common politic - What is the common politic of the group we want to create and why?

Appreciation of context - How are we going to demonstrate an appreciation of the diversity of knowledge contexts present?

Attention to culture - What type of culture do we aim to create in the group? What should be the ground rules for interactions and how can these be fostered?

Perspective

Building trust - How can trust be quickly build/maintained for the duration of the proposed process?

Perspective plurality - How do we want to think about (and potentially classify) perspective plurality in this process? Who ought to be invited and how do we engage them through the process phases (and why)?

Collective modelling - What types of collective modelling and languages are we seeking to use in the process and why?

Radicalism - What is the status quo we're looking to disrupt and why? Whose views that are usually excluded will be included?

Creativity

Productive discomfort - How can we hold participants in a state of productive discomfort, with things not to comfortable and not too full of unproductive conflict?

Serendipitous encounters - What kinds of serendipitous encounters are we hoping to create, and how might we encourage these through our design?

Embodied experiences - How do we incorporate embodied experiences in the process?

Licence to dream - How (and when) are we going to signal a space and time for dreaming and imagination?

Reflection

Reflexive praxis - How will we support reflective practice for participants (and convenors) of this process?

Shared space/social islands - What is the shared space we will inhabit and how do we make it feel sufficiently safe for different participants?

Boundary spanning - How do we define the core group in this setting and then what boundary spanning might be helpful for an effective process and future action?

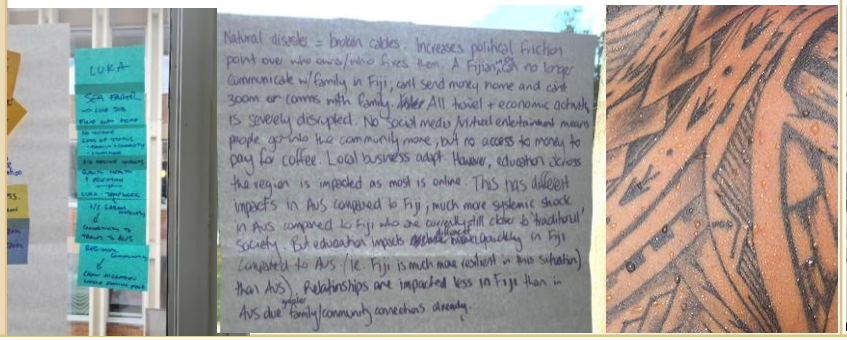
Envisioning endings - How do we want to end this group engagement? Should it transform into anything?

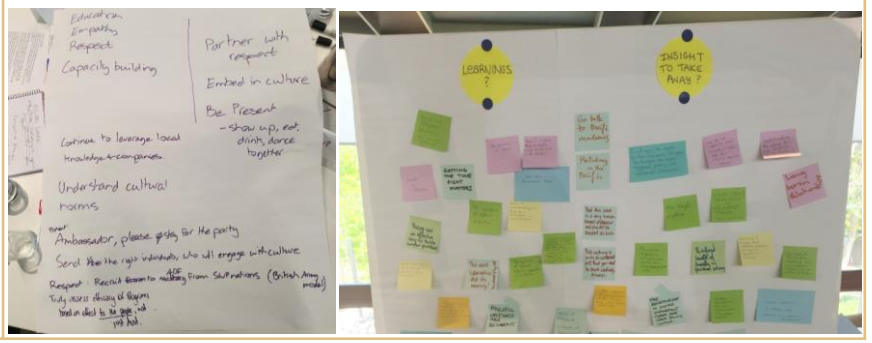
TRANSLATING ANALYTICS AND PRINCIPLES INTO PRACTICE

Navigating complexity: Australia's Engagement in the South-West Pacific

To support the Australian Government including Defence to engage in Oceania, a one-day workshop was developed drawing on both complexity analytics/process phases and participatory design principles. The workshop participants were taken through a carefully and sensitively orchestrated process, as shown through the diagram below, aimed at bridging/translating Pacific Islander and Australian Government perspectives and encouraging follow-up action.

	INTERPERSONAL Focused on Emotions & Relationships	TECHNICAL Focused on Knowledge & Skills
FACILITATE Remove Barriers	**1. SCOPING** ***Respecting*** / Cultivate Psychological Safety	**2. EXPLORING** ***Reflecting*** / Develop Shared Mental Models
MOTIVATE Funnel Energy	**3. BUILDING** ***Connecting*** / Build an Engaging Vision	**4. APPLYING** ***Directing*** / Empower Agile Execution





Workshop process design representation based on Edmondson and Harvey 2017[5], Young et al., 2022[1] and Yunkaporta & Shillingsworth, 2020[4]

Conclusions

As per the original objectives, this research project has delivered new frameworks and principles to help groups analyse and make sense of the complexity inherent in the modern environment. These were drawn from research and case studies and initial indications show they have significant practical promise.

The final workshop provided a successful and practical demonstration of the frameworks and principles identified through this research project. Importantly, *it showed how the two parts to the research can be integrated and complement each other.*

As such, this project has been a successful proof of concept. The developed frameworks, principles and methods seem to provide the basis for rigorous and practical approaches to analysing complexity, strategic risk, operations research and communication.

Further research with a *broader scope and longer timeframe would add depth and nuance* to what has been produced. Specifically, this could enable the exploration of further methods and principles that haven't been identified or synthesised yet, and additional knowledge could be bought together on trade-offs and consequences of the use of specific methods, principles and process designs.

Further research and practical testing of the combined methods and principles developed through this research could identify the potential transferability and adaptation across a wide range of topics and contexts.

We hypothesise that the frameworks, principles and methods are also likely to be useful for designing longer term projects and programs, educational design, adapting organisational structures and workflows and even constructing research projects . However, this will require further explicit exploration, testing, and potential extension/iteration of principles.

The style and communication approaches in the frameworks could also be tested with more target audiences for resonance or impact. This may, or may not, be a limitation on the adoption of frameworks like these in a broader range of areas.

Through the research project, there has been sufficient material gathered to form the basis of various sorts of education offerings on complex systems, multiple knowledges and frameworks for thinking them through. This is a future opportunity for any organisation interested.

APPENDICES

Footnotes

[1] Young, R. et al (2022) *Understanding complexity across scales and levels*, A literature review prepared for DSTG, September 2022. Available on request.

[2] Perspective plurality is one of the key skills required for managing complexity, as outlined in Gould, M., Daniell, K.A., Bell, G., Meares, A. (2022) *Re/defining Leadership in the 21st century: the view from cybernetics*, A white paper developed by the ANU School of Cybernetics powered by the Menzies Foundation, Australian National University & Menzies Foundation, Canberra, Australia.

[3] The two-level interactive framework and cybernetics case study analysis work to derive the set of principles for participatory process design was was developed through the following piece of research: School of Cybernetics (2022) "*Understanding Complexity and Transdisciplinary Praxis",* A literature review for the DSTG-ANU project, September 2022, The Australian National University, Canberra (internal project deliverable).

[4] Yunkaporta, T. and Shillingsworth, D. (2020) '*Relationally Responsive Standpoint*', Journal of Indigenous Research, 8(2020, Article 4), pp. 1–14. Available at: https://doi.org/10.26077/KY71-QT27.

[5] Edmonson, A., Harvey, J.-F. (2017) *Extreme Teaming: Lessons in Complex, Cross-Sector Leadership*, Emerald Publishing Limited, Bingley, UK.

Project contributors and acknowledgements

- **Summary report authors:**
  Ryan Young, Katherine A. Daniell, Flynn Shaw

- **ANU Futures Hub team:**
  Ryan Young, Rohan Hosking, Adegboyega Adeniran, Daniel Kilov, Abbey Morris

- **ANU School of Cybernetics team:**
  Katherine Daniell, Flynn Shaw, Matthew Holt, Mina Henein, Andrew Meares, Julian Vido, Genevieve Bell + students cohort of the 2022 ANU Master of Applied Cybernetics

- **DSTG team:**
  Ivan Garanovich, Alexei Filinkov, David Matthews, Daniel Bilusich

- The project team would like to thank all participants and contributors to the final workshop, including Danny Bettay for the loan of Pacific artefacts.

- This research project was undertaken with the support of the Defence Science and Technology Group of the Department of Defence. It is a summary of the work completed under the project “Understanding complexity and transdisciplinary praxis: strategies for bringing together knowledge, resolving problems, and identifying insights across different scales and levels” for the Defence Science and Technology Group under their Philosophy of Operations Research call for collaboration 2021.

- **Suggested citation:** Young, R., Daniell, K.A., Shaw, F. (2023) Making sense of complex systems: practical principles and frameworks. Project report to DSTG. National Security College Futures Hub and School of Cybernetics, The Australian National University, Canberra.