



Governance of Complex Systems

This is a report of a roundtable held on 3 December 2024 where a diverse group of leaders from around the world came together to discuss the governance of complex systems. This report contains the themes that came up during the discussions and we welcome your views, feedback, and suggestions.

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Executive summary

The Safer Complex Systems (SCS) programme was launched in 2019 through Engineering X, a collaboration between the Royal Academy of Engineering and Lloyds Register Foundation. This initiative focuses on the long-term impact of enhancing the safety and resilience of critical infrastructure systems, which are becoming increasingly complex and interconnected, and whose failures can have a significant impact on both the environment and people's lives.

A roundtable, held on 3 December 2024, was a key event within the Governance workstream. The event brought together 27 diverse leaders from nine countries to create a space to share perspectives and build a dialogue towards improved governance in complex systems. The event focused on the findings from [four research projects](#) and some [emerging principles](#) which aim to strengthen governance practices and foster agility in decision-making. The work was further grounded in the insights from [18 case studies](#) which examined governance in different topical and complex environments.

The principles were central to the roundtable discussions and were shared for resonance and further development by participants. They are designed to support leaders in their efforts to promote safer, more resilient systems. The six key principles discussed were:

Participants focused on identifying leverage points for improved governance processes and mechanisms to deal with complexity. As critical issues emerge within complex systems, the programme identified that governance gaps can pose risks to systems resilience and safety. These could be current governance frameworks, including procedures, policies, regulations, and oversight mechanisms, that have traditionally supported performance and safety.

This roundtable report identifies the six key principles above but recognises that they are emergent ideas at this stage. The aim now is to explore them further with others. We see a gap in the governance of complex systems for more organisations to play a role as system conveners. We want to help play this role and codesign creative solutions with others and invite you to participate in this.

- 1. Development of a systems mindset:** encouraging systems thinking as a core competency for better system stewardship.
- 2. Building internal capabilities:** integrating systems thinking into organisational strategies and leadership.
- 3. Strengthening governance mechanisms:** enhancing accountability and enforcement while incorporating informal governance practices.
- 4. Monitoring and adaptation:** implementing effective monitoring to address emergent issues and support adaptive governance.
- 5. Fostering inclusion:** promoting diversity and inclusion to ensure diverse perspectives are considered, enhancing system ownership.
- 6. Re-evaluating failure:** viewing failure as an opportunity for collective learning and promoting shared responsibility.

1. Context

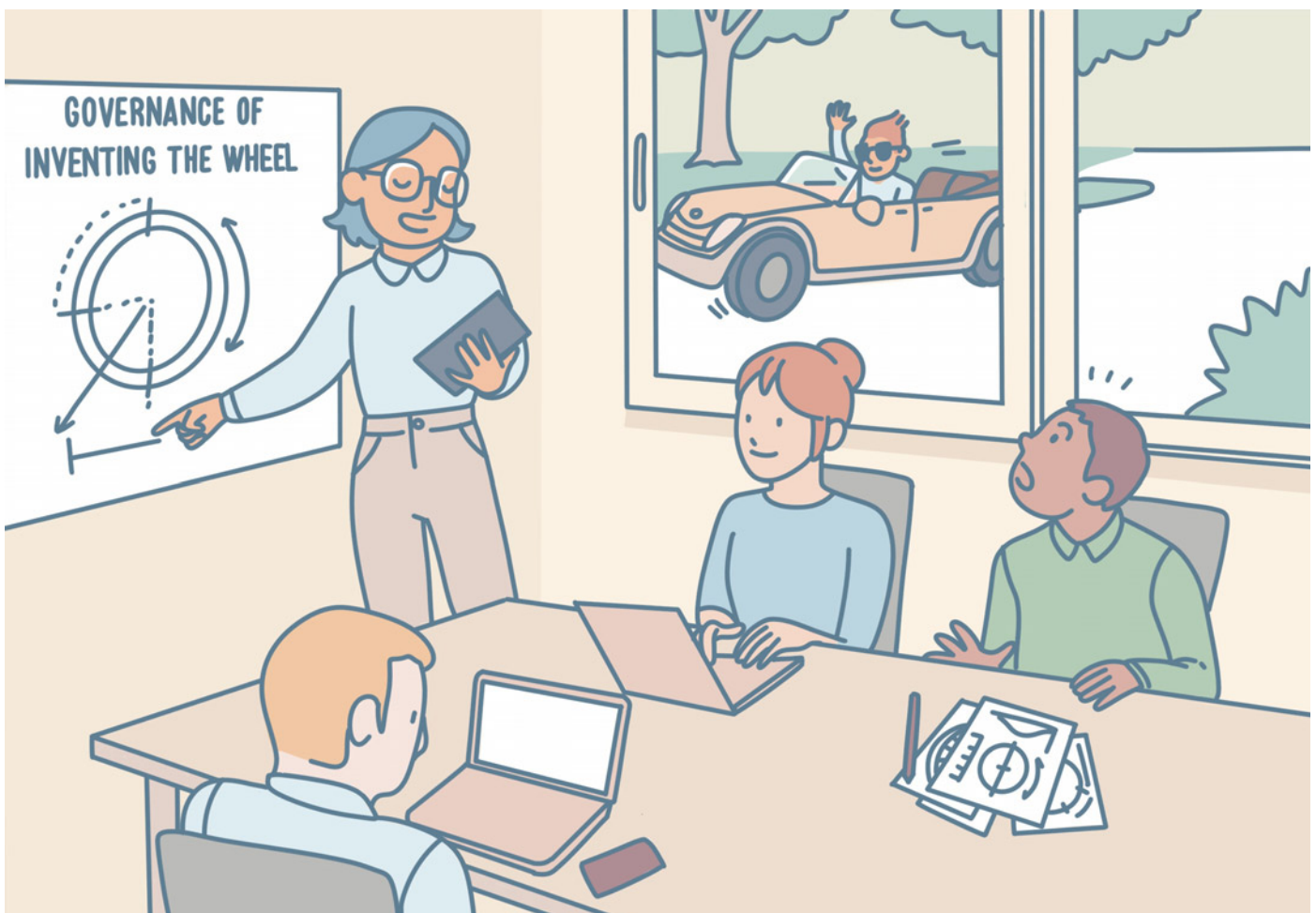
The Safer Complex Systems programme was launched in 2019 through Engineering X, a collaboration between the Royal Academy of Engineering and Lloyds Register Foundation. This initiative focuses on the long-term impact of enhancing the safety and resilience of critical infrastructure systems, which are becoming increasingly complex and interconnected.

The programme's [strategy](#) emphasises four key areas: **Govern**, **Advocate**, **Educate**, and **Convene**. These key activities work together to better equip stakeholders to navigate complex systems and increase their ability to cope with uncertainty. This is achieved through supporting innovative collaborations, developing educational resources and fostering a diverse global community to leverage systems thinking for safer outcomes.

The programme held a roundtable on 3 December 2024, which sought to identify leverage points for change in the governance of complex systems to improve safety outcomes across systems. The first topic of discussion was to review the findings from four research projects ([Govern reports](#)) previously

commissioned by the Engineering X programme. The projects had varied research aims and produced a range of insights that could be applied to the governance of complex systems.

Two of the reports focused on complex topics in Africa and Asia and highlighted a lack of coordination and collaboration between diverse sets of actors in sociotechnical systems. This can often result in crucial information not being shared in governance practices which makes the risk of unsafe consequences more likely. They also identified the importance of acknowledging informal governance, inequalities, and power dynamics while designing safety measures and access to services.



The remaining two reports were based on macro trends and highlighted the importance of balancing principles-based and rules-based practices. They also emphasised the need to challenge reductionist frameworks, where the approach is to break systems into smaller, discrete parts, which often underpin laws and regulations. Instead, they proposed developing regulatory and management systems and mindsets ready to anticipate and adapt, enabling more dynamic and responsive governance.

The purpose of the roundtable was therefore twofold:

- (1) To identify opportunities to maximise the impact of the individual research insights.**
- (2) To review emerging themes across all four pieces of research and assess how they might be operationalised in practice.**

The roundtable brought together (virtually) 27 participants from nine different countries across four continents bringing together diverse perspectives. The participants included a mixture of researchers and practitioners from various industries and disciplines working in governance roles.

The working session was broken into two halves. The first half of the session focused on the existing research findings and used an ecosystem map to frame the discussion. The second half focused on the emerging principles and asked for participants feedback and future impact suggestions.



2. Maximising the impact of research insights

In the session, participants were asked to share their ideas for impact based on the individual research projects. The participants were split into four breakout groups and each asked to place their ideas on an ecosystem map.¹ This resulted in over 60 suggestions for impact across the four research projects which were grouped into themes which are discussed below.

Participants identified a range of impact opportunities across the three system levels (Figure 1).

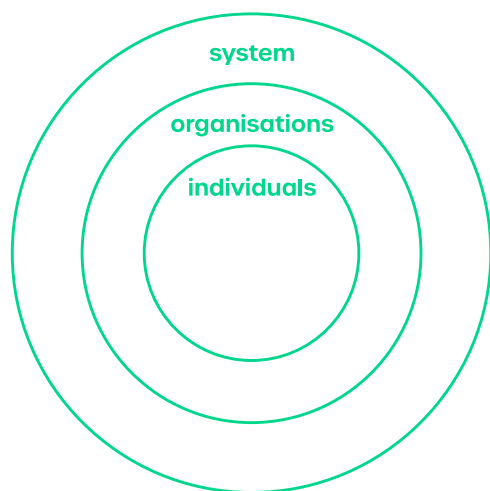


Figure 1. Tool: Ecosystem Map

The **Regulation-fit-for-complexity** discussion touched on different theories of change for shifting mindsets towards more systemic ways of thinking. Discussions also referred to emerging trends in regulation including regulatory stewardship and smart regulation (see **Info box 1: Regulation**). Tangible activities such as workshops, training, and examples were cited as pathways to share the insights more widely.

Info box 1: Regulation

Regulatory research and practice have advanced considerably over the last thirty years. From a dispersed, siloed discipline, efforts have been made to draw researchers and practitioners together to share learning and adapt approaches. This has led to new approaches such as problem focused regulation (Sparrow, 2008), behavioural insights informed regulation (Thaler and Sunstein, 2008) and the creation of an Institute of Regulation (Institute of Regulation, 2025). From an academic perspective, work has evolved alongside these changes and continues to contribute valuable insight (van der Heijden, 2022).

‘In the real world, the advice “do more of this...” usually doesn’t work – there is usually a connected “less of something else” or additional risk by following any (even very “wise”) recommended changes.’

Roundtable participant

While the research resonated with participants, they also highlighted that efforts to shift mindsets are not easy and often come with trade-offs in other areas (see **Info box 2: Systems thinking**).

Info box 2: Systems thinking

The work of Donella Meadows suggests that shifting paradigms and mental models is a deep leverage point. This means that it has the potential to drive large scale change in systems but is also more difficult to change than more shallow leverage points (Meadows, 1997).

1. The model is based on Urie Bronfenbrenner’s bio-sociological model of human development and adapted based on the findings from the Engineering X report: Learning from failures in complex systems: Embracing rules and principles in practice for effective governance.

The [Governance of safer electricity systems in Kenya](#) report triggered discussions about how governments and organisations might better support women in technical roles through adapting hours, materials, and safety procedures.

‘Companies and governments need to better adapt and regulate the ‘technical task roles’ to make it [of] interest and safe for women to get involved.’

Roundtable participant

The research also led to discussions about how to include considerations for the safety of future generations.² These issues highlighted how storytelling and the power of narratives enabled sharing these sorts of insights in an accessible way (**Info box 3: Systemic storytelling**). Personal testimonies and government apprenticeships for technical roles were also discussed in this group.

Info box 3: Systemic storytelling

Systemic storytelling can be a powerful method to convey complex information in an intuitive way. Storytelling can help share different perspectives and quite naturally zoom in and out to different levels of complexity. A strong example of this comes from the journalist and author Peter Apps (2022) who wrote the book *Show me the bodies* about the Grenfell Tower fire. Apps tells the harrowing story of the night of the fire in parallel to an analysis of the systemic failures which contributed to the fire. This method provides an intuitive way to educate the reader about the systemic failures which contributed to the fire and the real-world impact they had.

The [Learning from failures in complex systems](#) report led to conversations between organisations about policies for shared risk in specific industries. The role of emotions and how feelings of agency can impact behaviour in different ways also emerged (see **Info box 4: Systems thinking and emotions**). Linked to this, the discussion focused on helping individuals learn the skills of learning and the emotions tied

to those. Unlearning was also a topic of conversation and the role it plays in shifting perspectives on failure.

‘Promote and advocate for unlearning: challenge ourselves to think about what we need to do differently and be conscious about it (make part of the mindset work).’

Roundtable participant

Actual pathways such as guidance, case studies, and system convening also emerged.

Info box 4: Systems thinking and emotions

The fields of systems thinking and psychology are increasingly coming together to learn from one and other. The work of Lisa Feldman Barrett suggests that emotions are constructed and influenced by our cultures and experiences. This has implications for systems thinking which is explored further during a keynote speech at the 2024 Systemic Design Conference (RSD13).

The final report, [Diversifying governance of fire risk and safety in informal settlements](#), identified several different topics. At the individual level there were questions asked about how different groups perceive risk – to the extent that not all individuals ‘lose’ from residential fires. This brought up the question of different perceptions of ‘failure’ in systems.

‘Whose voices count when we think about safety design?’

Roundtable participant

At an organisational level, the power of coproducing knowledge was championed to counter traditional power dynamics in systems (see **Info box 5: Coproduction of knowledge**). Finally, discussion focused on ways to create hope for positive change at all three systemic levels.

2. A great example of considering future generations comes from The Well-being of Future Generations Act (Wales) 2015, part of Wales’ commitment to the well-being of future generations which takes inspiration from indigenous wisdom and the Seventh Generation Principle.

Info box 5: Coproduction of knowledge

Whilst different definitions exist for coproduction, the general process involves people from diverse backgrounds and traditionally separate knowledge domains coming together to learn and coproduce new knowledge (Jasanoff, 2004; Redman et al., 2021). The objective is to create a more inclusive and relevant knowledge base that can be used to inform policy and practice.

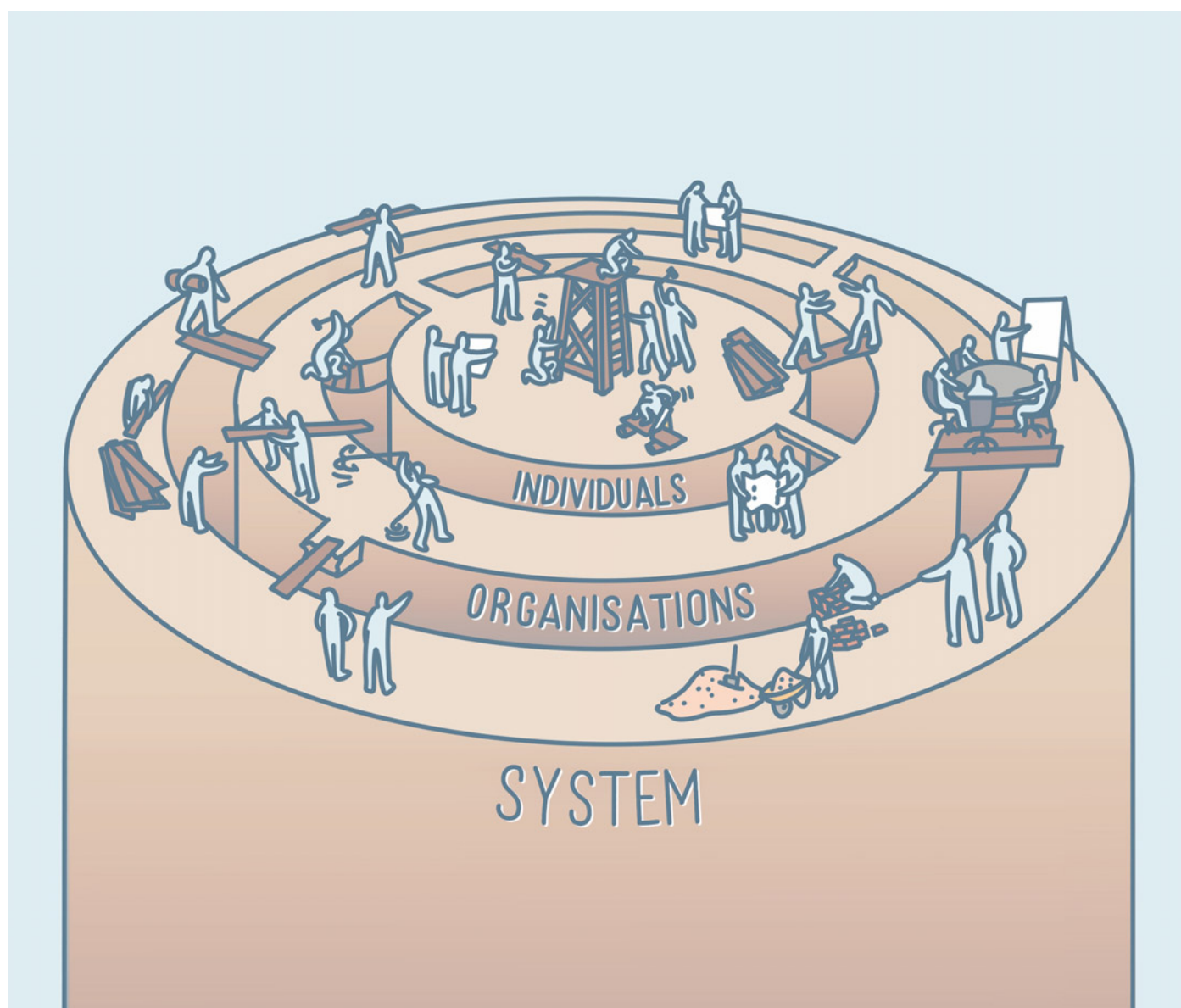
Overall, the rich discussions, ideas, and debates brought new and diverse perspectives to the research findings. One interesting thread from all four conversations was the role of **systems convening** in amplifying the impact of the research. Participants saw the organisational

level as 'bridging the gap' between the individual and system level boundaries to deliver impact.

"... bringing people together to build relationships across boundaries has the power to shift situations that would otherwise remain stuck."

(TACSI, 2024, p1)

System convening is the idea that learning and knowledge sharing happens within networks, rather than top-down hierarchies. The idea built on the concept of 'communities of practice' and was initially used to identify individuals as system conveners (Wenger-Trayner, 2021). The term has since broadened in application and is often used in an organisational context where organisations, as conveners, might bring together governments, NGOs, and businesses to drive systemic change.



3. Emerging principles

The primary goal of the roundtable was to enable the coproduction of knowledge and create new systemic connections and insight. This report aims to capture the dialogue and debate that emerged, serving as an entry point for further discussions. It is hoped that, through refinement, these principles will form the foundation of a broader movement to collectively learn and improve safety outcomes across various environments.

There were six cross-cutting principles that emerged from the four [Govern research projects](#) and were shared with the participants ahead of the roundtable for reflection. Participants were asked to share their feedback in interactive breakout sessions.

As the results came in, several key principles began to surface, suggesting promising directions for improving the governance of complex systems, venturing into new territory by fostering dialogue around these emerging principles. Some principles, *Foster meaningful inclusion* (3.5) and *Development of a systems mindset* (3.1) received a lot of focus and support from participants. Others, such as *Enhance monitoring and adaption* (3.4) divided participants and drew less focus.

3.1 Development of a systems mindset as a key skill that could lead to better systems stewardship

Systems thinking has been mentioned as one of the crucial skills of our century. It should be promoted and encouraged both in formal education and in organisational training spaces. As decision-makers and teams develop this skill within their learning and working environments, improved systems stewardship could also emerge as a result.



"This very much resonates: the mindset of collaboration, questioning, critical inquiry (and more) are so important, but 'schooling' systems are constraining these skills."

Language was a topic raised in multiple breakouts and the power of language to make connections and break down silos. It was also suggested that systems thinking language can

be quite divisive and more effort was needed to simplify the language used and put it in context. Participants also asked *who* might benefit from developing a systems mindset: does the principle imply everyone might? The suggestion was that efforts might be better spent helping individuals and communities understand systems rather than the traditional focus on decision-makers and organisations. One participant also highlighted that systems thinking is seen by some as a *mindset* and attitude rather than a skill and recognised that multiple perspectives on this point exist. *Learning systems* to support the development of a systems thinking mindset were also discussed in multiple conversations as well as how to create informal learning spaces to support this. Often the focus was felt to be too much towards organisations and formal learning vs informal, network driven programmes. Some important *barriers* to a systems thinking mindset were raised which included the incentives to invest, a reluctance to work in a transdisciplinary way and a need for "more action and less talk."

3.2 Build internal capabilities to embed systems approaches in strategy development

Systems approaches are a valuable toolkit that allow organisations to think holistically about the ways they approach problems and create solutions. Applying these might need an internal upskilling strategy with selected individuals that can become organisational systems champions.



"Agree in principle but don't believe there is an actual toolkit available which is applicable to non-systems experts. Toolkit development is needed to democratise relevant methodologies, concepts, etc."

A range of systems thinking capability development methods emerged from all four discussions. One group felt that there was a lack of a *toolkit* which was accessible for 'non-systems experts' which would increase capability development at scale. Another group saw capability development through the lens of *competence standards* that might help provide a structured approach to learning and development. A third group highlighted the role of networks such as the *Systems Innovation* (SI) network in attracting volunteers to cocreate methods and amplify impact through the network (SI Network, 2025). The final group felt that the phrase "...in *strategy* development" was unhelpful as it might reinforce existing narratives around systems thinking being for senior decision-makers only. Conversations also turned to a lack of incentives for organisations to invest in building systems thinking capability and how it might be connected to tangible, organisational challenges.

3.3 Strengthen and improve enforcement and accountability in formal governance mechanisms and integrate and acknowledge informal governance practices

Enforcing accountability in complex, multi-actor systems is a significant challenge for governments. Strengthening formal governance is essential: improving policies, codes, and regulations is critical, as many existing frameworks are not fit for purpose. A balance must also be struck between formal regulation and informal governance systems, which often provide valuable insights.



"I think we need to discuss more how we can build accountability in complex systems beyond the question of regulation. What do we do where regulation is weak, or enforcement is challenged by resources? How could formal and informal mechanisms work together..."

Regulation was a heated discussion topic in one group and how formal and informal mechanisms may work together. Some felt regulation was, and

could be an adaptive form of governance, whereas others felt it was a blunt tool, not fit for complex environments. While efforts to test and learn in regulation were recognised (HSE, 2025; NESTA, 2025) it was felt they were the exception rather than the rule. Others also suggested that the way the principle was *framed* reinforced an existing extractive paradigm. The suggestion was to reframe the principle as:

"What would governance look like if it was fit for purpose for everyone?"

Other groups suggested this principle was "more a *challenge* than a principle" and were still unclear how to achieve accountability in complex systems. Adding some examples to the principle or a mechanism for the sharing of good practice was suggested would help build out the principle.

3.4 Enhance monitoring and adaptation for emergent issues

Effectively addressing emerging issues and monitoring complex systems is crucial for adaptive governance. Technology and data processing can be helpful in this aim, for example in the use of comprehensive monitoring tools, such as whole system scanners, to quickly identify and manage new challenges.



"Just never forget the real outcomes – important to move away from proxies."

Some reservation was shown towards this principle, participants highlighted the *unintended consequences* of measurement efforts in different contexts. It was acknowledged that such measurement efforts often came with expensive tools, lack of clear incentives for actually using them, and data and privacy considerations. The question of what to monitor and how to avoid becoming "*buried in data*" emerged from a few different discussions. Concerns were also raised about any future regulatory *skills and infrastructure* required if monitoring efforts spanned public sector boundaries. One group suggested there were monitoring elements to Safety, Health, Environment and Quality (SHEQ) management which was an example of good practice in this field.

3.5 Foster meaningful inclusion

Diversity and inclusion are crucial to incorporate different viewpoints. This can ensure well-rounded solutions and improve ownership. Following that, we recommend value inclusion over participation, address power dynamics, consider political influence, enhance communication, and use technology wisely.



“So pleased to see the idea of ‘meaningful’ being picked up – It’s critical to not perpetuate power imbalances that result in extraction or where participation becomes a tick box.”

The power of *meaningful* diversity and inclusion to foster innovation emerged as a common theme across all breakout groups. Moving from a tick box activity to something which is embedded throughout organisations. One group suggested this was the most important principle in determining desired outcomes and it should be an intensely democratic process. They also suggested that there needs to be more ways of giving a voice to the voiceless, including giving a *voice to nature*. Another group highlighted the importance of recognising the identity and values of different groups being a “very deep trigger for change” and an area where understanding between diverse groups can be created. Similarly, *interdisciplinarity* was suggested as an additional consideration.

“How to make engineering spaces more open to disciplines that encourage thinking differently and collaboration.”

One *barrier to meaningful inclusion* was highlighted as the difficulty in finding studies and research into how to foster inclusion that included examples.

3.6 Re-evaluate approaches to failure, integrate learning mechanisms, and promote collective ownership

Organisations must cultivate environments where failure is recognised as a valuable learning opportunity, feedback mechanisms are embedded, and individuals are empowered to take ownership of outcomes.



“Resonates! But how to define the failure, who defines, what counts (e.g. is it the loss of one home or five? Or no lives lost but 50 homes lost is a success? What about near misses that leave a lasting impact, perhaps trauma, but perhaps change in interaction with a hazard in the home?)”

This principle was highlighted as critically important by most groups and yet identified as notoriously difficult to implement in practice. Near miss data and weak signals were said to play a key role in maintaining *safety outcomes* and preventing critical accidents. Deciding when failure is and is not acceptable was however a more difficult topic and *safe-to-fail learning* was tough to enact beyond the organisational level. In a broader system, it was suggested that donors, funders, and clients might not support learning from failure in the same way. A *blame culture* was still felt to be prevalent in many industries and that it would prevent learning at a larger scale than organisational.

3.7 Additional suggestions

In addition to the six emerging principles, space was left free for participants to add their own perspectives on what principles were missing. This resulted in several suggestions which have been captured below in narrative format.

A popular addition to the principles was identifying *education* as a leverage point for change. Systems thinking and critical thinking were suggested to be less encouraged at school in every subject. Alongside this, *unlearning* was also put forward as a potential antidote to linear thinking within the education system. Combined, they might form the powerful basis for an education principle.

From a systems thinking perspective, participants suggested there was room for more foundations in *resilience* and *trade-offs*. Looking at the systems thinking literature, this might suggest incorporating more thinking from Organisational Cybernetics (Beer, 1984), Socio-Technical Systems (Emery and Trist, 1960), and System Dynamics (Meadows, 2008). The first two are well suited to problems of viability or resilience, and the latter for identifying interconnections and trade-offs.

More traditional approaches to governance were also put forward including how *enforcement*

might be further explored and linked to accountability. Alongside this there were suggestions of creating an *ISO standard* for governance of complex systems. This could help establish common methodologies for handling uncertainty, interdependencies, and systemic risks. On the other hand, however, governance of complex systems is highly context-dependent, and rigid standards may fail to accommodate emerging risks, innovation, and complexity. One option could be to consider a Guidance Standard such as ISO 31000 for Risk Management. Likewise, there were calls for more evidence of good practice of governance methods which apply systems thinking.

“How to go beyond saying systems thinking is good and move towards why it would be useful for people and organisations, what they can actually do, and how it can benefit them.”

Along similar lines, there were suggestions that more of a focus on incentives and behaviour change might be beneficial as emerging principles.

“I was surprised that incentives and measures were not included, a thing that can drive behaviour (either way). More corporate psychology input?”

The remaining suggestions had their roots in emancipatory considerations. The first was a suggestion to include a principle about *navigating power imbalances* and that power imbalances might actually hinder progress towards many of the principles discussed.

“Limiting the ability of multinationals to evade responsibility with legal structures that seek to limit liability.”

There was also a suggestion that *future generations* were underrepresented in the principles, and participants asked for further consideration in some capacity, such as the emphasis placed on well-being in the Well-being of Future Generations (Wales) Act 2015 mentioned earlier. Finally, a more explicit focus was suggested about *lived experiences* and how they can build shared understanding in complex environments.

“A shared understanding grows from co-reflected lived experiences.”

These last three may benefit from closer analysis through the lens of Critical Systems Heuristics (Ulrich and Reynolds, 2010) and Boundary Critique (Midgley, 2003), both are systems thinking approaches well suited to problems of emancipation (See **Info box 6: Boundary Critique**).

Info box 6: Boundary Critique & Critical Systems Heuristics

Boundary Critique (BC) recognises the intertwined nature of boundary judgments and value judgements. Drawing boundaries is heavily influenced by values and determines who and what is impacted by any intervention. BC advocates for including all those involved in and impacted by any systemic intervention to minimise issues of power imbalance and marginalisation. (Midgley, 2023). In practice this can be difficult to feasibly achieve, so Ulrich developed 12 questions as part of Critical Systems Heuristics to support such decisions.

4. Next Steps

The roundtable was an opportunity to bring stakeholders together to reflect on governance and various mechanisms that are challenging but vital levers for enabling better and safer systems. The development and testing of emerging principles have been a step forward in looking for actionable ideas that decision-makers can take forward in their work.

We would like to use this as a continuous step and opportunity to collaborate with others on emerging impact pathways and look forward to exploring these ideas further. Recognising a gap in the governance of complex systems, we believe there is a need for more organisations to take on the role of system conveners. We are committed to playing an active role in this process, working alongside others to codesign innovative solutions. By exploring best practices and partnering with organisations addressing related challenges such as governance of complex systems, adaptive governance, building through collective action, and meaningful inclusion, we aim to drive impactful change and contribute to the development of more resilient and effective governance practices.

We look to compliment these and develop other ways forward in the coming years of the SCS programme. A huge thank you to the participants who gave up their time to collaborate and share their wisdom about the governance of complex systems.

As a next step we want to hear from you.

- **We would love to know what you think about the principles.**
- **Do they resonate with you?**
- **What might be missing?**

Do you have any experiences that could serve as an example of innovative approaches to improve safety in complex systems?

They are emergent ideas at this stage, and we aim to explore them further with others. We see a gap in the governance of complex systems for more organisations to play a role as system conveners. We want to help play this role and codesign creative solutions with others. We want to invite those exploring this topic and if that's you, then please reach out to:

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