34th Annual INCOSE international symposium
hybrid event
Dublin, Ireland
July 2 - 6, 2024

Sustainability Mindshift: Incorporating the Systems Perspective

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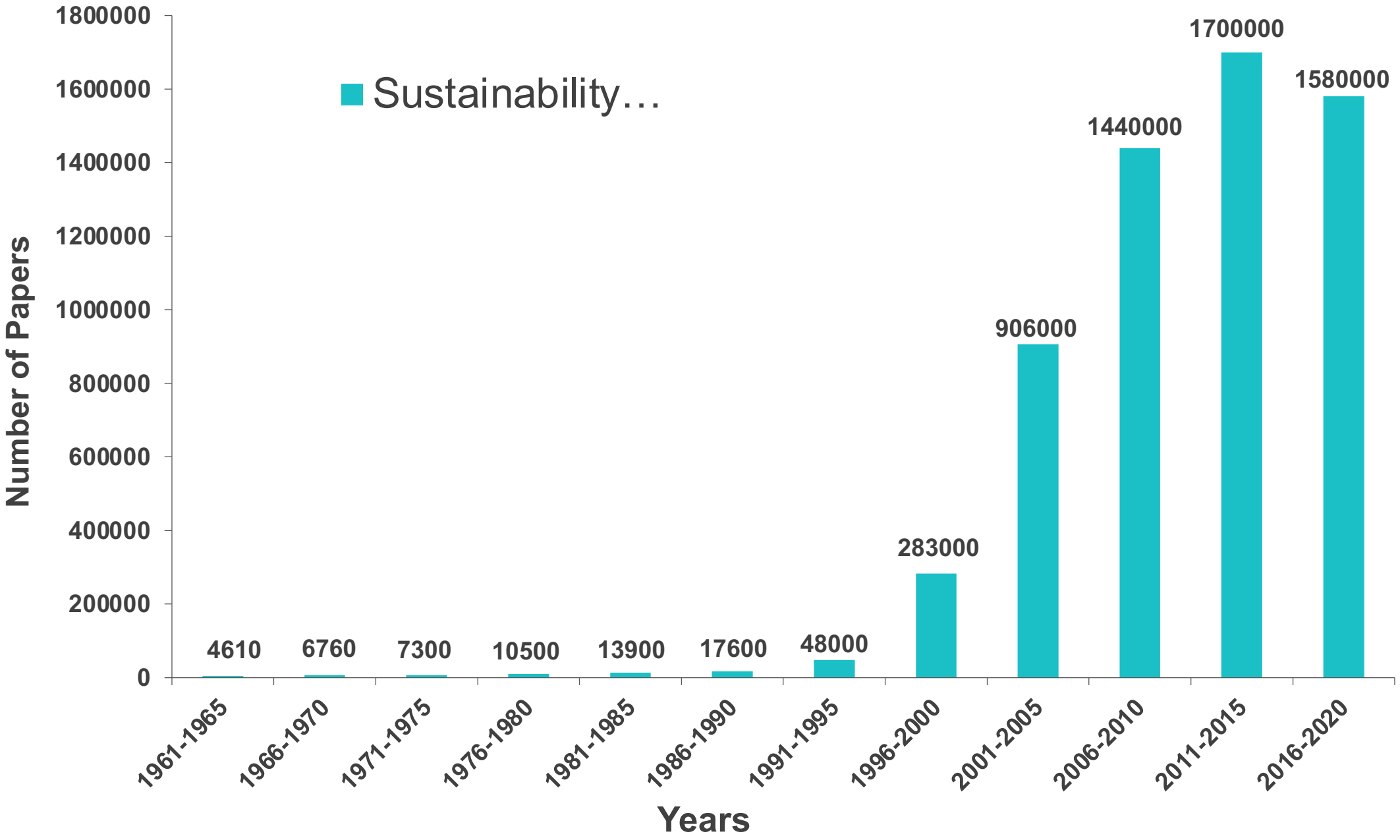
Topics

- Background: Concepts Of Sustainability and ‘Mindshift’
- Three Mindshift Challenges
  - Sustainability as a “byproduct” of an underlying system
  - Sustainability through the lenses of Systems Theory
  - Enhancing sustainability through system pathologies
- Concluding Notes

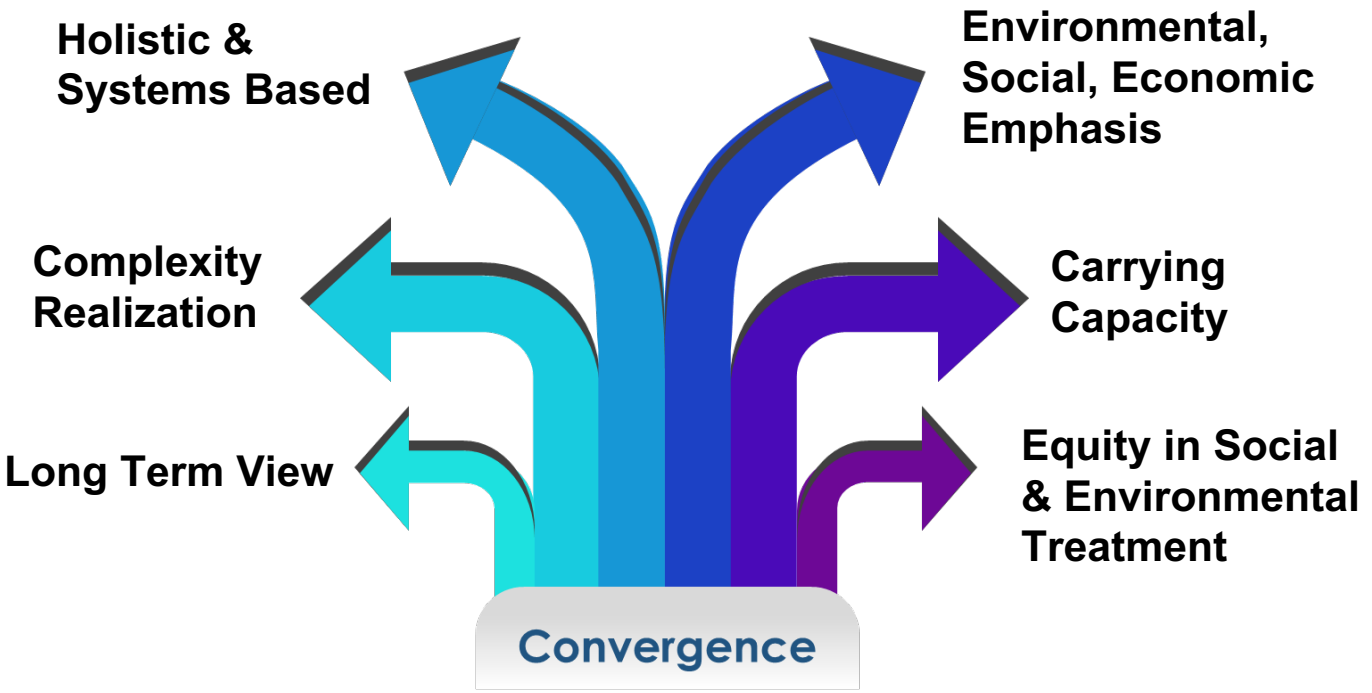
Sustainability


Sustainability…
Number of Papers
Years
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
4610
6760
7300
10500
13900
17600
48000
283000
906000
1440000
1700000
1580000
1961-1965
1966-1970
1971-1975
1976-1980
1981-1985
1986-1990
1991-1995
1996-2000
2001-2005
2006-2010
2011-2015
2016-2020

What is Sustainability?

Sustainability: "meeting the needs of the present without compromising the ability of future generations to meet their own needs." (United Nations, 1987)

- Multitude of perspectives, definitions, and themes – 500 definitions as of 2012
- Fragmented viewpoints
- Strong concept, but needs more rigorous technical formulation
- Some general convergence across the literature



Keating, C. B., Katina, P. F., Bradley, J. M., Hodge, R., & Pyne, J. C. (2023, July). Sustainability: A Complex System Governance Perspective. In *INCOSE International Symposium* (Vol. 33, No. 1, pp. 1117-1131).

Sustainability: Frequently suggested as goal(s) or aims.

NO POVERTY — 7 Targets, 13 Indicators, 1417 Actions

ZERO HUNGER — 8 Targets, 14 Indicators, 1359 Actions

GOOD HEALTH AND WELL-BEING — 13 Targets, 28 Indicators, 1278 Actions

QUALITY EDUCATION — 10 Targets, 12 Indicators, 1798 Actions

GENDER EQUALITY — 7 Targets, 14 Indicators, 1625 Actions

CLEAN WATER AND SANITATION — 8 Targets, 11 Indicators, 1803 Actions

AFFORDABLE AND CLEAN ENERGY — 5 Targets, 11 Indicators, 1033 Actions

DECENT WORK AND ECONOMIC GROWTH — 12 Targets, 13 Indicators, 1893 Actions

INDUSTRY, INNOVATION AND INFRASTRUCTURE — 8 Targets, 12 Indicators, 1028 Actions

REDUCED INEQUALITIES — 10 Targets, 14 Indicators, 972 Actions

SUSTAINABLE CITIES AND COMMUNITIES — 10 Targets, 15 Indicators, 1220 Actions

RESPONSIBLE CONSUMPTION AND PRODUCTION — 11 Targets, 13 Indicators, 1572 Actions

CLIMATE ACTION — 5 Targets, 8 Indicators, 2096 Actions

LIFE BELOW WATER — 10 Targets, 10 Indicators, 2838 Actions

LIFE ON LAND — 12 Targets, 14 Indicators, 1296 Actions

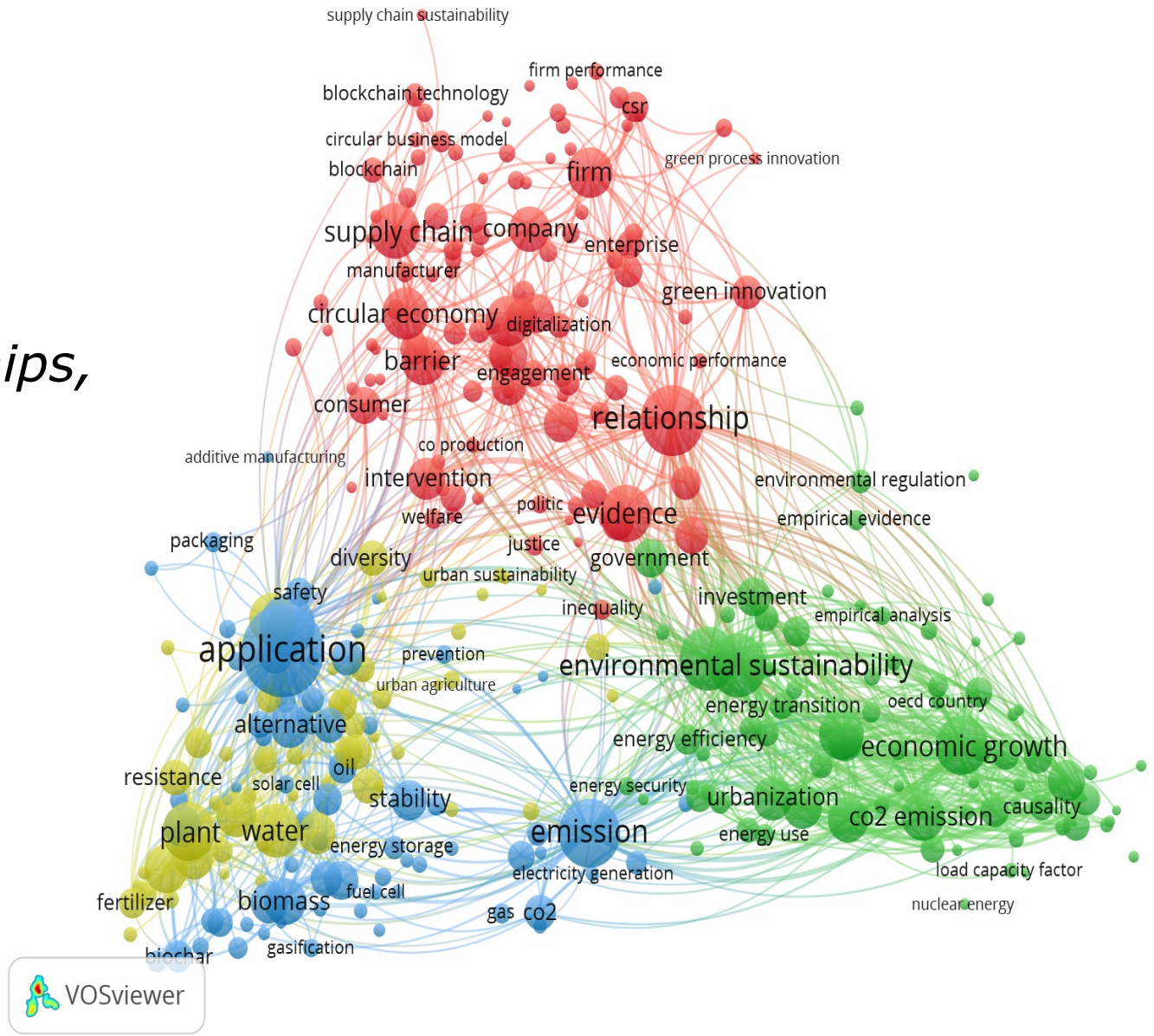
PEACE, JUSTICE AND STRONG INSTITUTIONS — 12 Targets, 24 Indicators, 1029 Actions

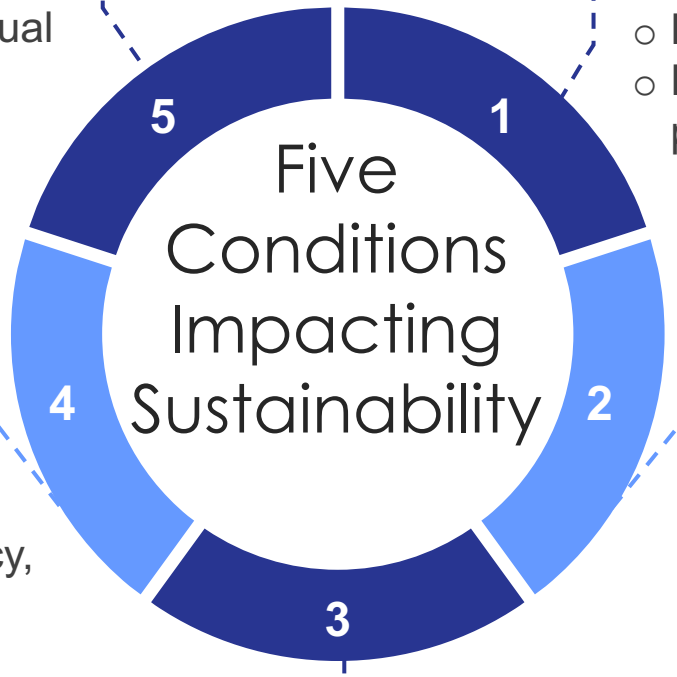
PARTNERSHIPS FOR THE GOALS — 19 Targets, 24 Indicators, 2167 Actions

Numerical targets, indicators, and actions accessed 11/23/23 from UN website https://sdgs.un.org/goals

A Bibliometric Literature View of Sustainability

- 330 items (with at least 20 interconnections following superfluous items removal)
- Four broad clusters (*relationships, environmental sustainability, application, and emissions*)
- Diversity in literature across multiple sectors
- Significant fragmentation
- Lack of a unified body of knowledge





Contextual Influences

- Understanding influence of specific circumstances, factors, and trends
- Enabling as well as disabling contextual considerations

Complexity Increasing Exponentially

- Large number of entities/variables
- Rich interconnections among entities/variables
- Dynamically changing over time
- Emergence – unpredictable structure, behavior, performance patterns through operation

Holistic Satisficing Solutions

- Emphasis on finding 'workable' approaches instead of best approaches
- Consideration of technology, social, human, organizational, managerial, policy, and political influences

Ambiguous/Incomplete Understanding

- Cause-effect understanding breakdown
- Shifting enterprise landscape
- Traditional formulations questionable relevance

Uncertainty as a Reality

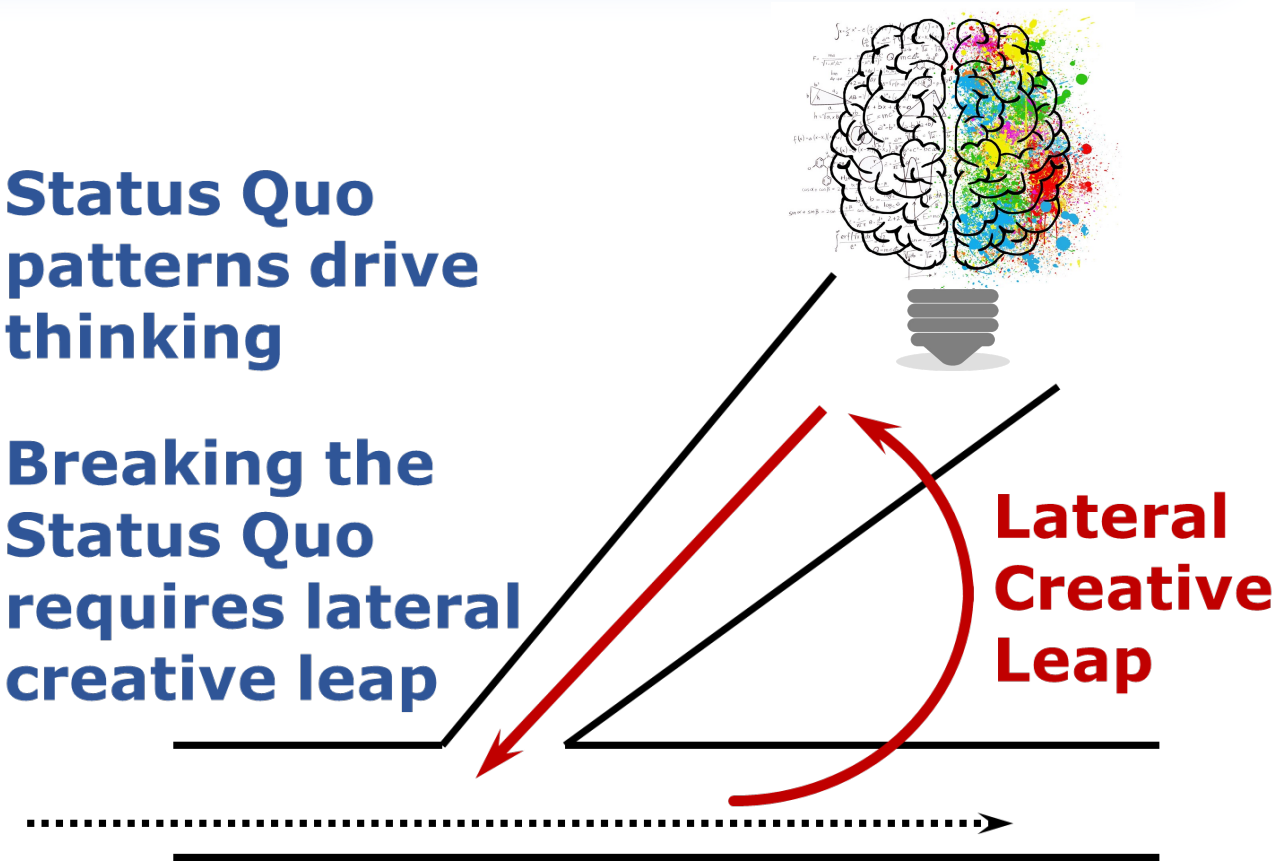
- Reductionist formulations lack veracity
- Incomplete, fallible, and errors in knowledge and understanding
- Shifting knowledge over time

Mindshift

What is a Mindshift?

Mindshift: A lateral creative leap that changes assumptions, beliefs, and ways of thinking about something.

- Reorganizes thinking by challenging dominant conversations and logic
- Offers alternative perspective and reframing concerning a topical focus area
- Sets foundations for different developmental paths to move forward
- Offers ‘equifinality’ in pursuit of desirable intents
- Respects Einstein's “We can’t solve our problems at the same level of thinking that created them”

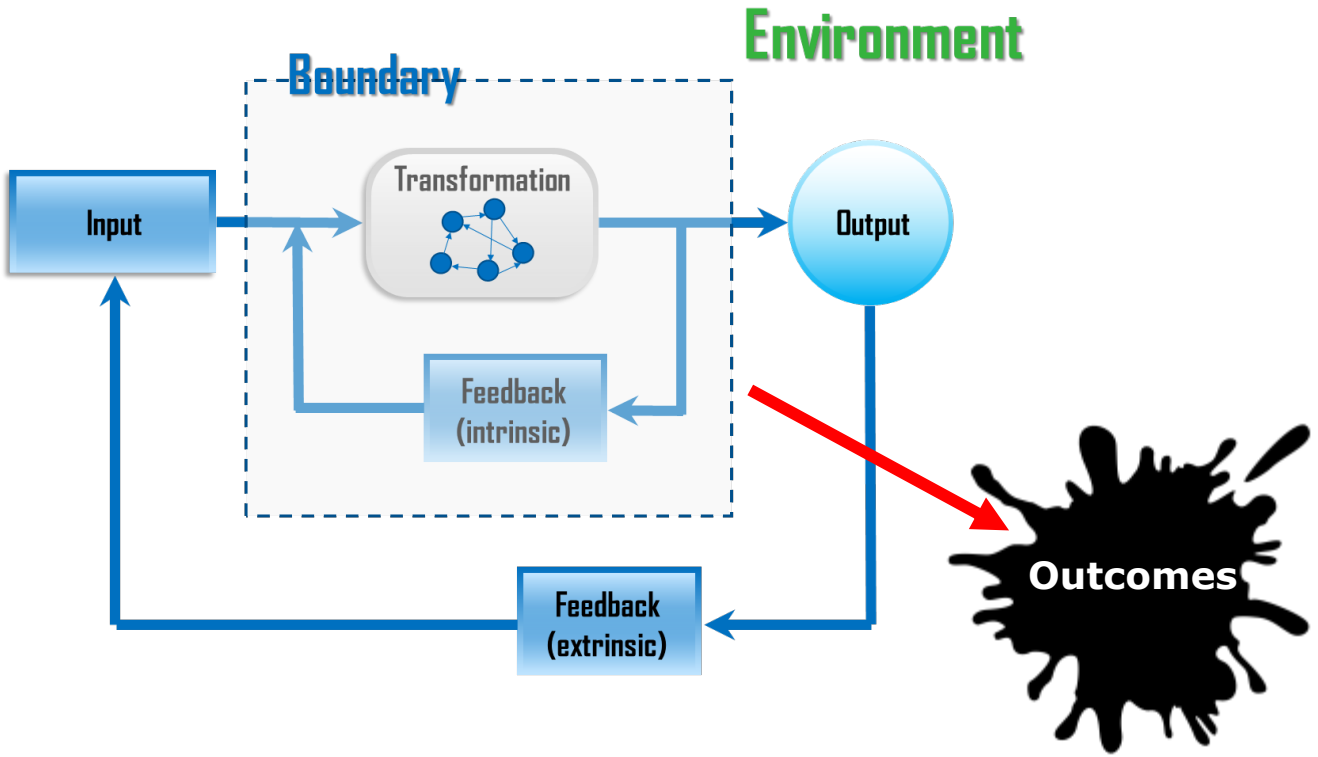


Lateral Thinking based on work of De Bono, E. (1990). *Lateral thinking: A textbook of creativity*. Penguin UK

First ‘Mindshift’ Challenge – *Sustainability as a Systems Engineered Byproduct*

Sustainability – A Systems Engineered Byproduct

Engineered systems produce outputs and outcomes. Sustainability can be viewed as an outcome.



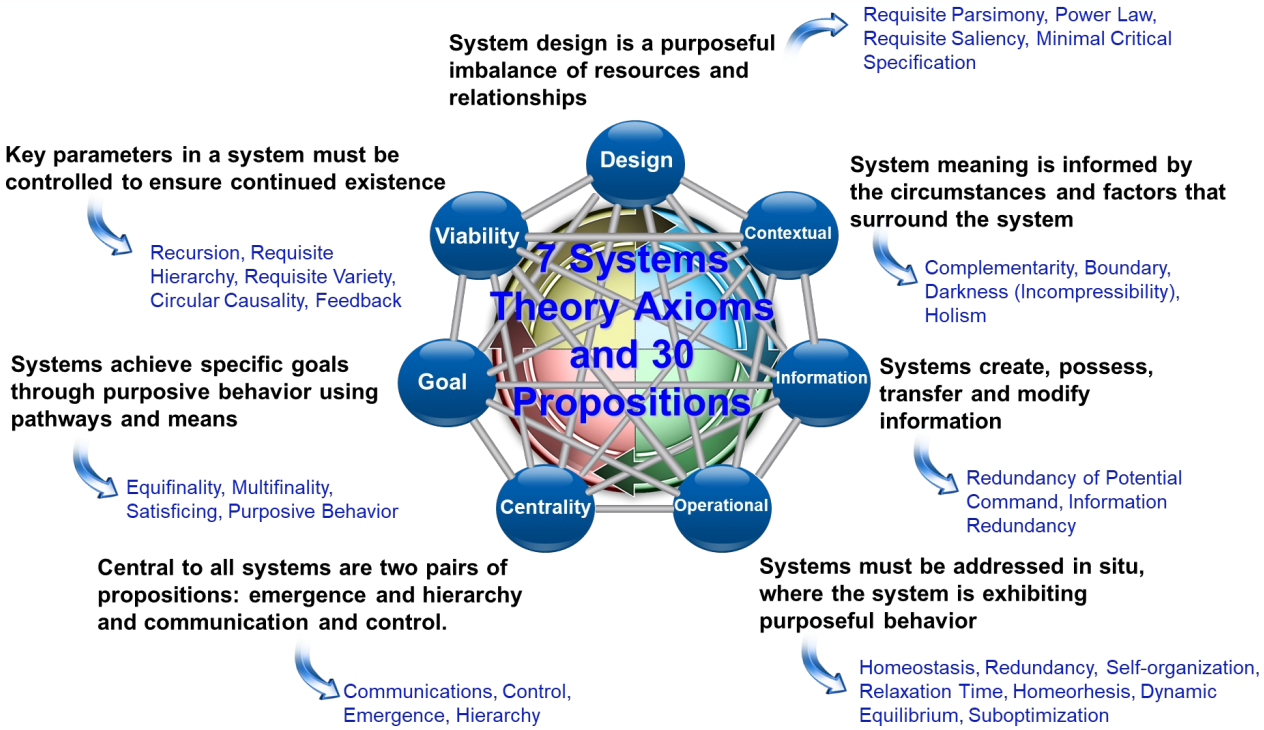
- Outputs/outcomes are the products/byproducts of an underlying system
- System **outputs** are directly intentional and measurable, verifiable, objective, directly traceable to the underlying system, predictable, and short in timeframe to experience
- System **outcomes** can be intentional or unintentional – difficult to measure or verify, subjective, not directly traceable to the underlying system, not necessarily predictable, and can be long in timeframe to experience
- Achievement of sustainability is an outcome/byproduct of the underlying system and is subject to complex and dynamic changes/forces beyond the system

Second ‘Mindshift’ Challenge – *Systems Theory Foundations*

Systems Theory

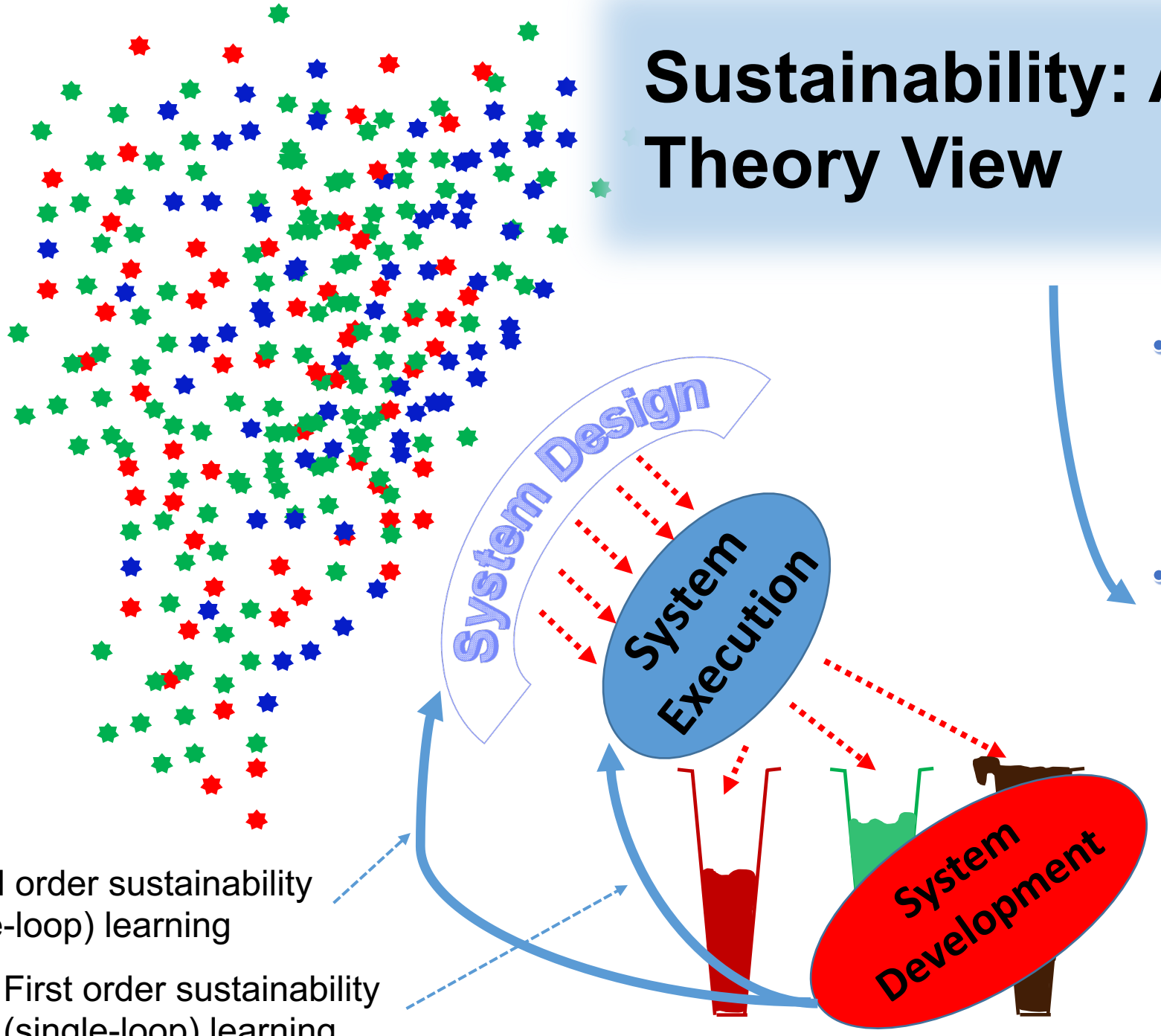
"A set of axioms (taken for granted truths about systems) and propositions (principles, concepts, and laws serving to explain system phenomena)" (Keating, et al., 2020, p. 1020)

- All systems are subject to the axioms and propositions of Systems Theory
- Axioms and propositions serve to define, explain, and predict behavior and performance of systems
- Violations of system propositions have consequences that can degrade performance, influence sustainability, and produce failures



Keating, C. B., Katina, P. F., Hodge, R., & Bradley, J. M. (2020, July). Systems Theory: Bridging the Gap Between Science and Practice for Systems Engineering. In *INCOSE International Symposium,* Vol. 30, No. 1, pp. 1017-1031.

Sustainability: A Systems Theory View



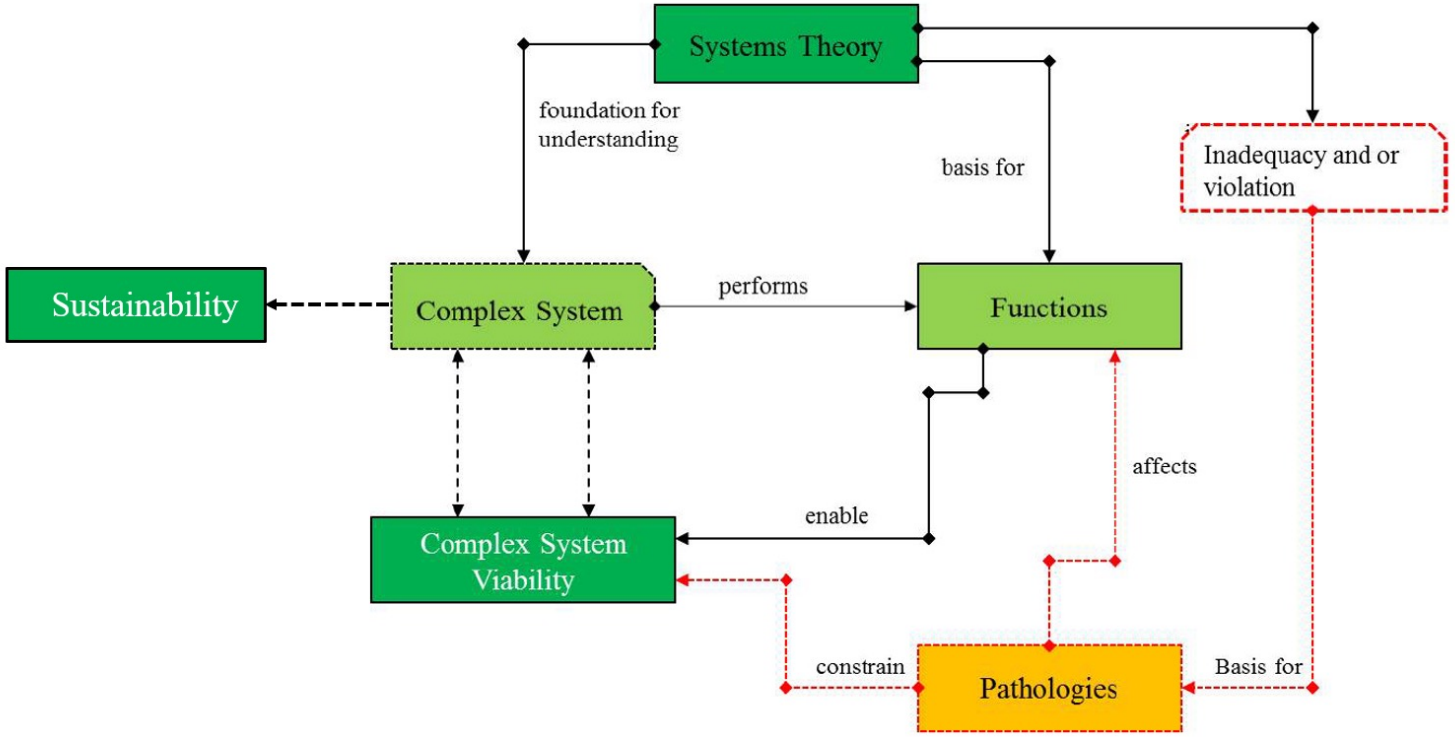
- Constant Shifts – external perturbations & internal flux
- Sustainability as byproduct requires constant adjustment of design & execution through system development

Third ‘Mindshift’ Challenge – *Addressing Pathologies in Sustainability*

System Pathologies Theory

System Pathology – "A circumstance, condition, factor, or pattern that acts to limit system performance, or lessen system viability, such that the likelihood of a system achieving performance expectations is reduced." (Keating & Katina, 2012, p. 253)

- All systems have pathologies in design, execution, or development
- Pathologies experienced as violations of systems propositions
- Pathologies will influence sustainability outcomes for a system
- Elimination or mitigation of pathologies is essential to the continuous achievement of sustainability



Keating, C.B. and Katina, P.F. (2012) 'Prevalence of pathologies in systems of systems', *Int. J. System of Systems Engineering*, Vol. 3, Nos. 3/4, pp.243–267.

From Katina, P.F. (2015). 'Emerging systems theory-based pathologies for governance of complex systems', *Int. J. System of Systems Engineering*, Vol. 6, Nos. 1/2, pp.144–159.

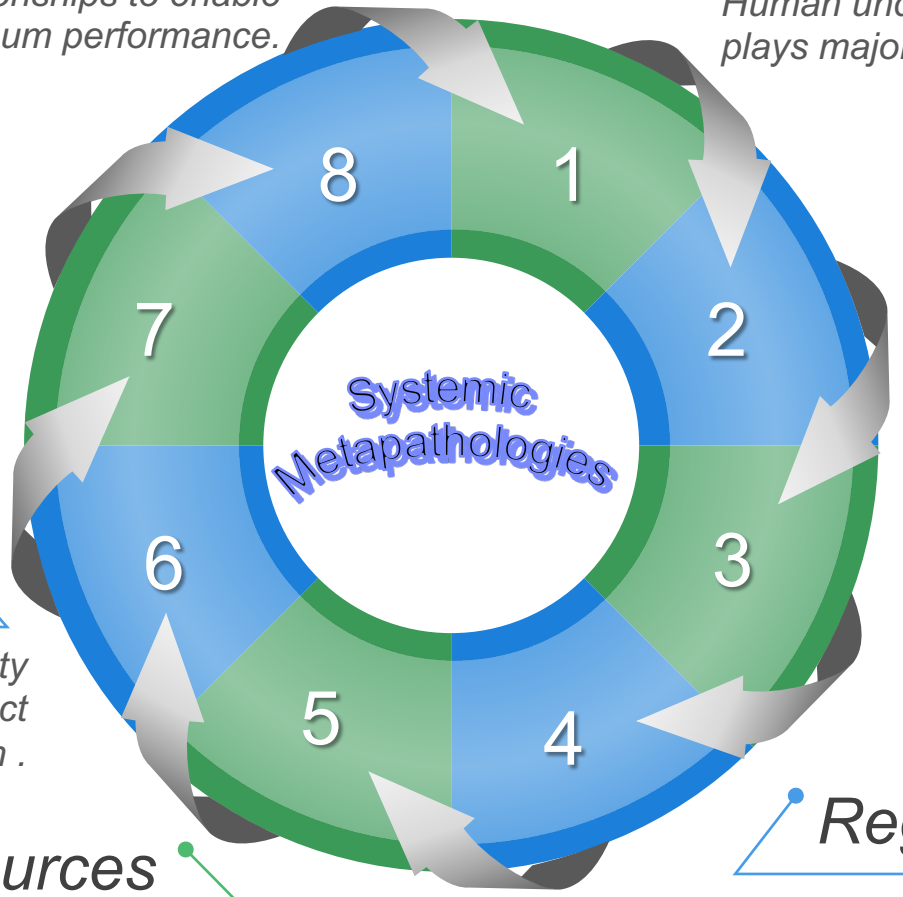
Organizing 83 Pathologies From Systems Theory

Structure

Organized in certain patterns and relationships to enable achieving maximum performance.

Understanding

Human understanding of complex systems; capacity plays major role



Dynamic

Complex systems continuously interact with subsystems, other systems, and environment to produce performance

Process

Processes that ensure system development, stability, and viability

Goal

Complex systems have goals, achieved through effective use of systems concepts

Information

Performance is related to related to the ability to create, transmit, receive, and extract meaning from information .

Regulatory

A certain level of control is required to guide complex system development and enabling growth, stability, and continued viability

Resources

Need for resources in enabling system development and impact of resource utilization on system productivity

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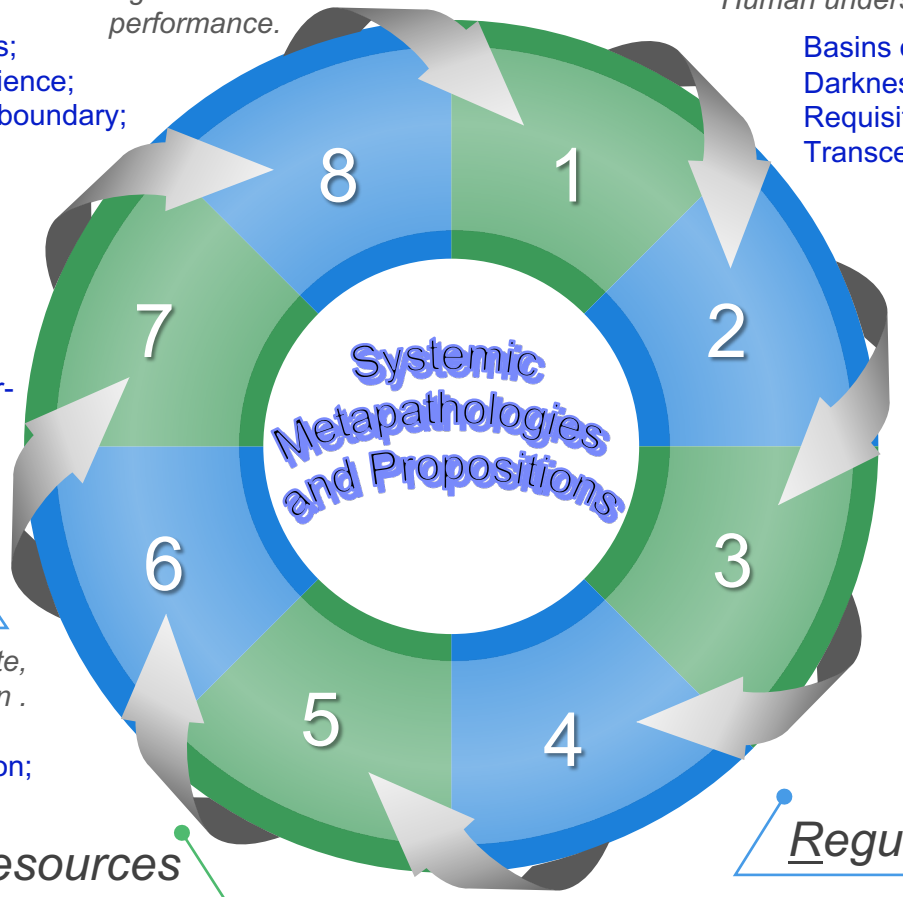
Organizing 83 Pathologies From Systems Theory



Structure

Organized in certain patterns and relationships to enable achieving maximum performance.

Flatness; Hierarchy; Internal elaboration; Morphogenesis; Omnivory; Organizational closure; Recursiveness; Resilience; Robustness; Separability; Genesis of structure; System boundary; System Context

Understanding

Human understanding of complex systems; capacity plays major role

Basins of stability; Circular Causality; Complementarity; Darkness; Eudemony; Holism; Incompleteness; Reification; Requisite Parsimony; Requisite Saliency; Synchronicity; Transcendence; Ultra-stability; Undifferentiated coding

Dynamic

Complex systems continuously interact with subsystems, other systems, and environment to produce performance

Adaptation; Dynamic equilibrium; Emergence; Environmental-modification; High-flux; Morphostasis; Over-specialization; Polystability; Punctuated equilibrium; Relaxation time; Safe environment; Self-organization; Steady state; System environment; Red queen;

Process

Processes that ensure system development, stability, and viability

Consequent production; Diminishing returns; Events of low probability; Maximum power; Sociotechnicality; Suboptimization

Goal

Complex systems have goals, achieved through effective use of systems concepts

Equifinality; Multifinality; Purposive behaviorism; Satisficing; Unity; Viability

Information

Performance is related to related to the ability to create, transmit, receive, and extract meaning from information .

Channel capacity; Communication; Equivocation; Information Redundancy

Resources

Need for resources in enabling system development and impact of resource utilization on system productivity

Buffering; Pareto optimality; Patchiness; Redundancy of resources

Regulatory

A certain level of control is required to guide complex system development and enabling growth, stability, and continued viability

Autonomy; Balance of tensions; Control; Cybernetic stability; Dialecticism; Feedback; Frame of reference; Homeorhesis; Homeostasis; Iteration; Least effort; Mimimal critical specification; Pareto; Redundancy of potential command; Requisite hierarchy; Requisite knowledge; Requisite variety; Subsidiarity; First cybernetic control; Second cybernetic control; Third cybernetic control

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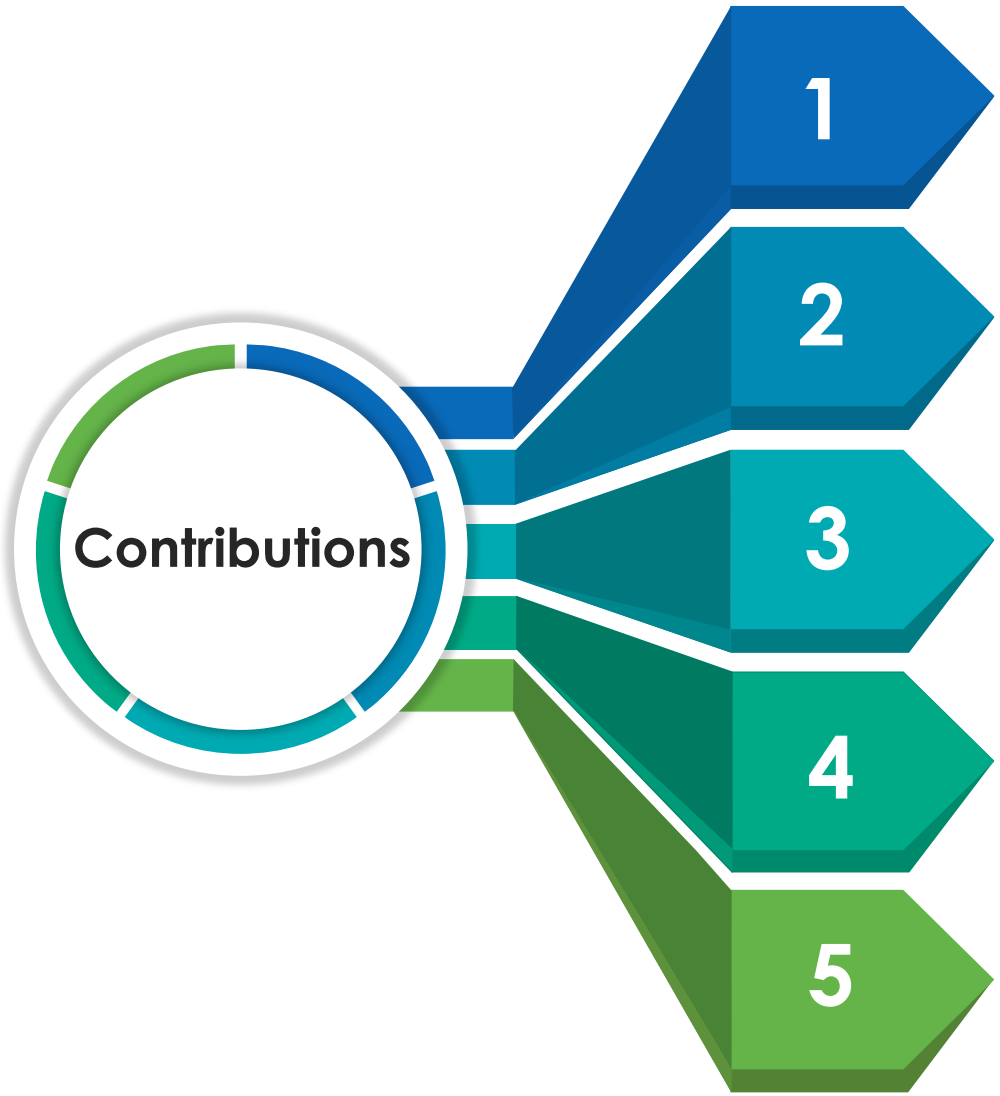
Conclusion

Mindshift Contributions to Sustainability



» New and Novel Perspective of Sustainability

- Sustainability as a ‘systems engineered byproduct’/outcome
- Movement from sustainability as an aim, goal, or state

» Continuous Design, Execution, and Development

- System responsible for sustainability outcomes/byproducts is subject to continuous design, execution, and development.

» Systems Theory Offers Rigorous Grounding

- Anchoring in Systems Theory provides a solid theoretical foundation.

» System Pathologies offer Different Perspective

- System pathologies can identify potential failure modes in the design, execution, or development of systems that produce sustainability

» Enhanced Role for Systems Engineering

- Incorporation of SE in a more active role for sustainability to better align with the emphasis of INCOSE SE Vision 2035.