International Council on Systems Engineering
A better world through a systems approach

Complexity in the Context of Systems Engineering

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Presentation Roadmap

Why Study Complexity in Systems Engineering?

Objective of the Paper

Methodology Overview

Defining Complexity (Across Sources)

Synthesized Definition of Complexity

Elements That Drive Complexity

Tools & Methods to Address Complexity

Timeline of Evolving Definitions

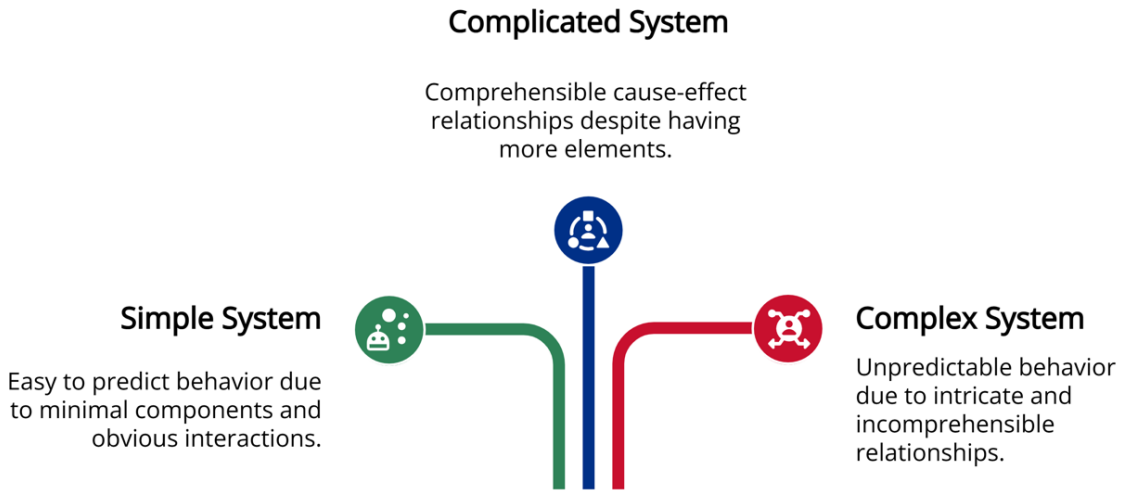
Conclusion

Why Study Complexity in Systems Engineering?

The complexity of systems continues to increase rapidly

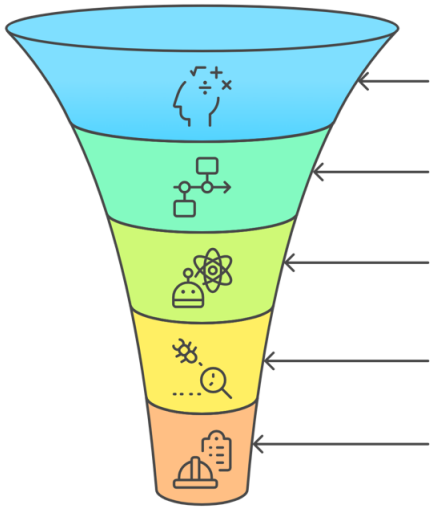
- Technological advancements
- Increasing connectivity
- Complex interactions

Understand complexities to develop effective management and engineering strategies



Objective of the Paper

Analyse how complexity is discussed in systems engineering literature



Define Complexity

Trace Evolution of Complexity Understanding

Discriminate between Complex and Complicated Systems

Identify Elements that make a System Complex

List Tools to Handle Complexity

Methodology Overview

Finding the papers

Steps	SE Journal	Symposium
Initial Articles Processed with NLP (1998 to 2019)	621	3689
1st Topic Allocation to “Complexity”	36	161
2nd Topic Allocation to “Complexity” (25%)	9	47
Manual Title and Abstract Review	33	45
New Papers from Manual Review (2000 to 2024)	16	27
Total Papers Remaining for Analysis	49	72
Total Articles Processed	766	4069

Oosthuizen, R. and Pretorius, L., 2021. Analysis of INCOSE Systems Engineering journal and international symposium research topics. *Systems Engineering*, *24*(4), pp.203-220.

Methodology Overview

Processing and analysing the papers

Large Language Model (ChatGPT-4o) used to process extensive bibliometric data

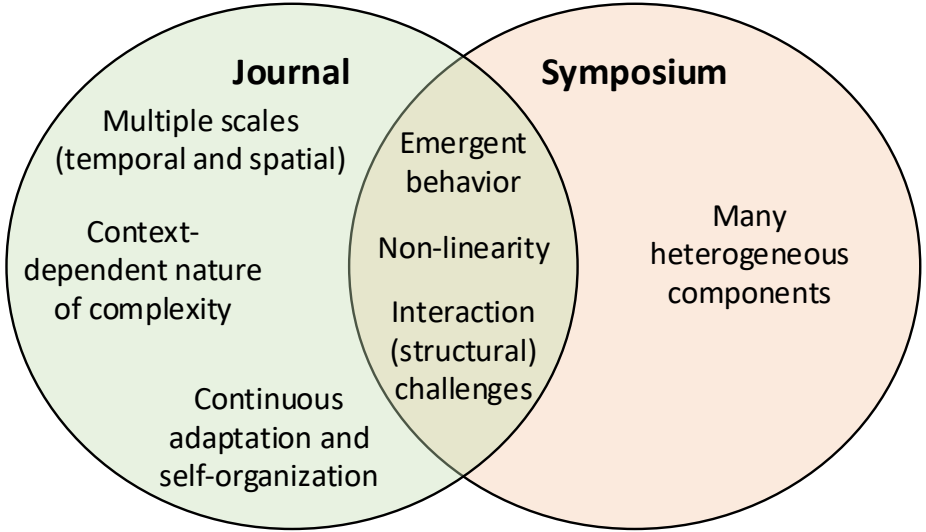
All papers were summarised and queried using a set of prompts

Generated output was manually cleaned up and saved to a document for processing

Limitations (hallucinations and context misinterpretations) are addressed with expert human oversight to validate outputs and ensure academic rigour

Defining Complexity (Across Sources)

SE Journal vs INCOSE Symposium Proceedings



Comprehensive and fluid understanding of complexity

Practice-based report on practitioner experiences in understanding, predicting and managing systems

Synthesized Definition of Complexity

Synthesized from the complete dataset

"… the degree of difficulty in accurately ***predicting*** the future behavior of a system due to the ***interconnected, interdependent***, and adaptive nature of its components. ***Emergent behavior***, ***non-linear interactions***, ***self-organization***, and continuous ***adaptation*** in response to internal and external changes characterize complex systems. These systems operate on ***multiple scales*** and involve ***diverse elements*** that interact unpredictably, often leading to behaviors that cannot be predicted solely by analyzing individual components. Managing complexity requires holistic approaches that account for these dynamic and evolving interactions."

CSWG. 2021. "A Complexity Primer for Systems Engineers." https://doi.org/INCOSE-TP-2021-007-01.

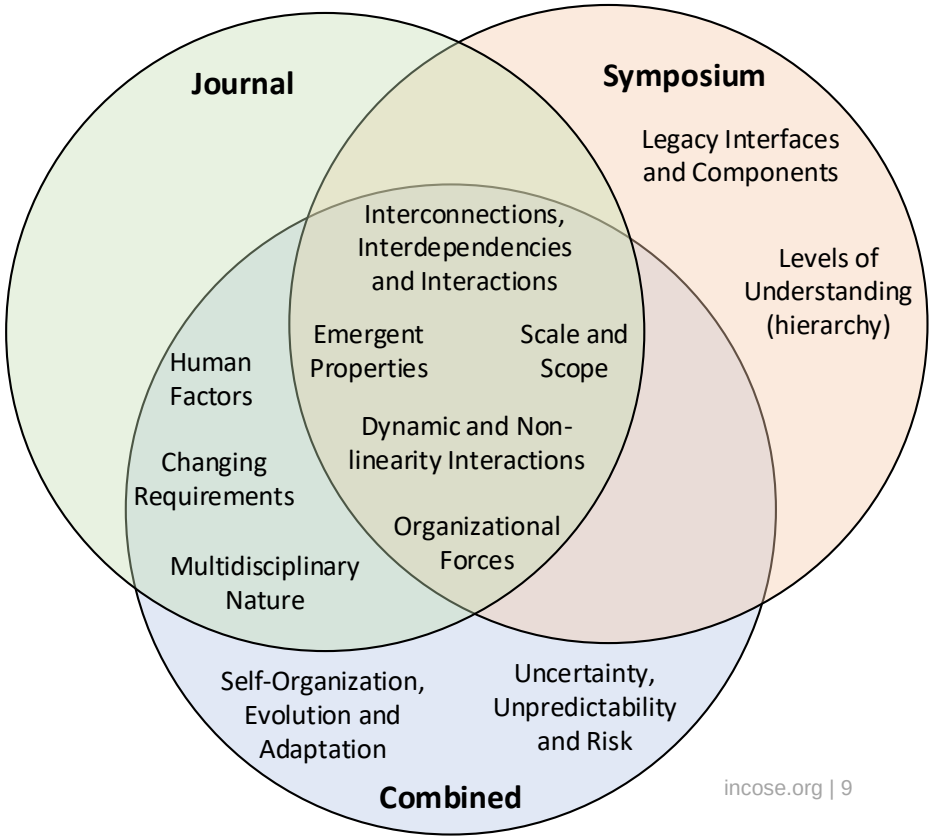
Elements That Drive Complexity

Processing data sets from SE Journal, INCOSE Symposium and the full combined set

Journals: Lasting theoretical contributions

Conferences: Immediate exchange of ideas and practical insights

Combined: Universally important, bridging theory and practice



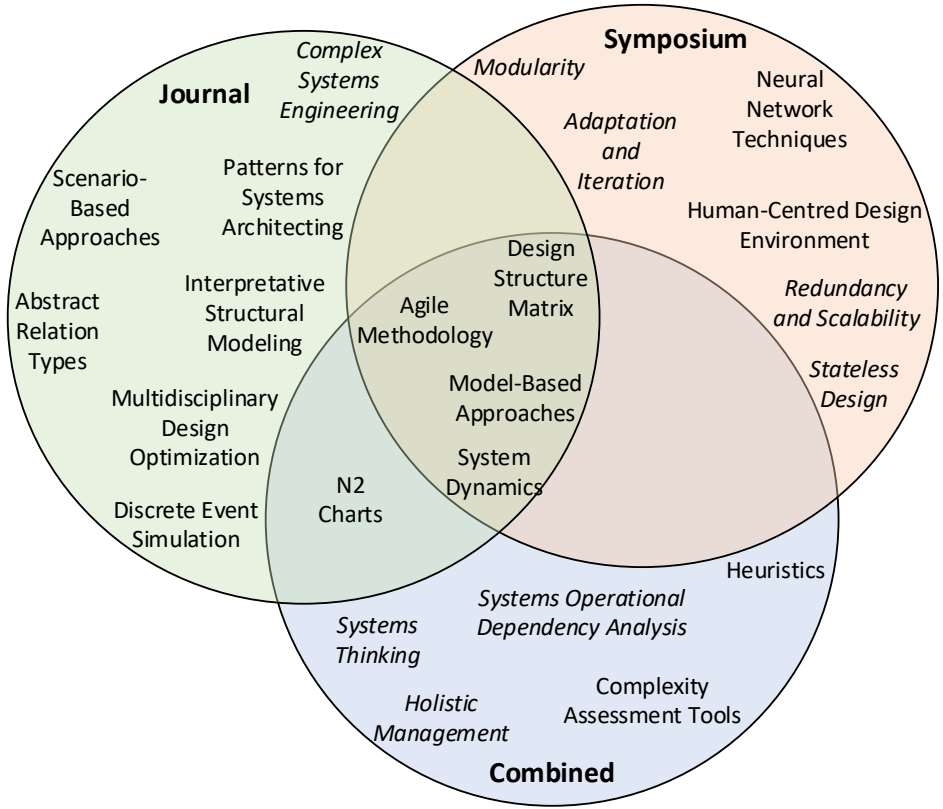
Tools & Methods to Address Complexity

Processing data sets from SE Journal, INCOSE Symposium and the full combined set

Journals: Theoretical conceptual development for robust methods

Conferences: Practical applications and real-world challenges

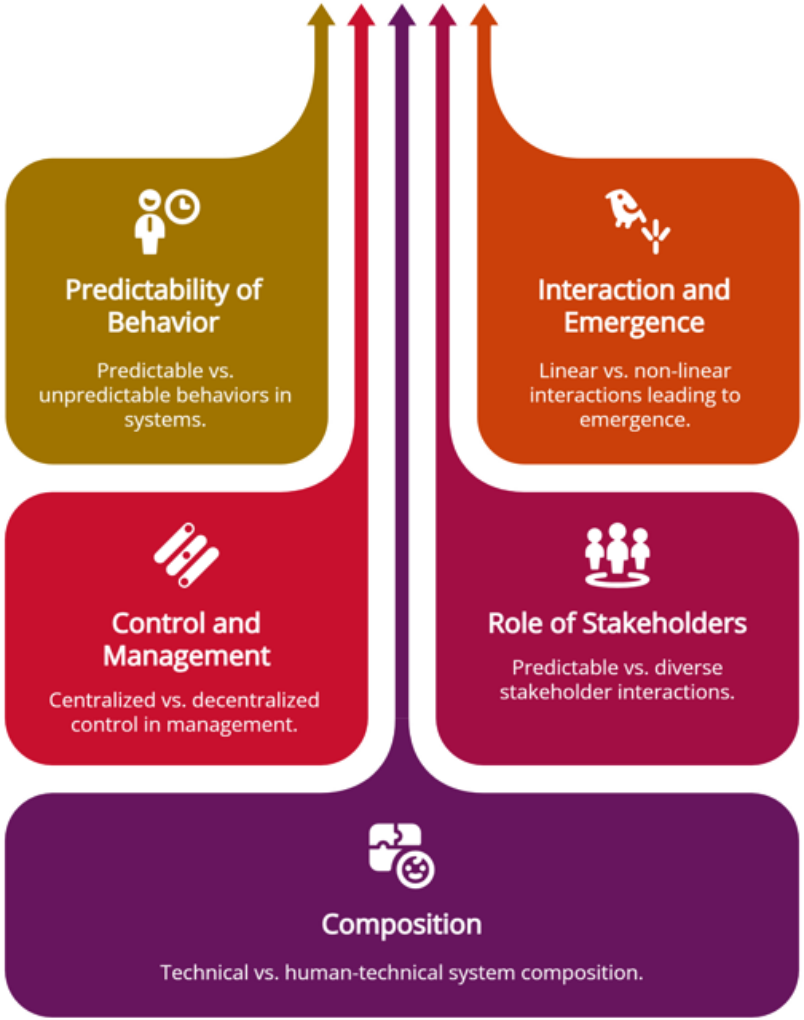
Combined: Tools that bridge the gap between theory and practice for broad applicability



Complicated vs Complex Systems

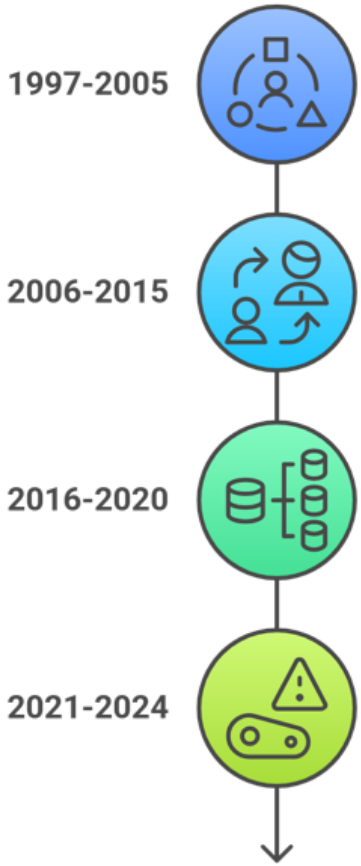
Complicated: Many components with well-defined interactions making them predictable, decomposable, stable, and manageable through reductionist approaches and centralized control

Complex: Dynamic, unpredictable, and exhibit emergent properties that are non-linear, adaptable, and self-organizing, requiring holistic, adaptive management involving multiple stakeholders and perspectives



Timeline of Evolving Definitions

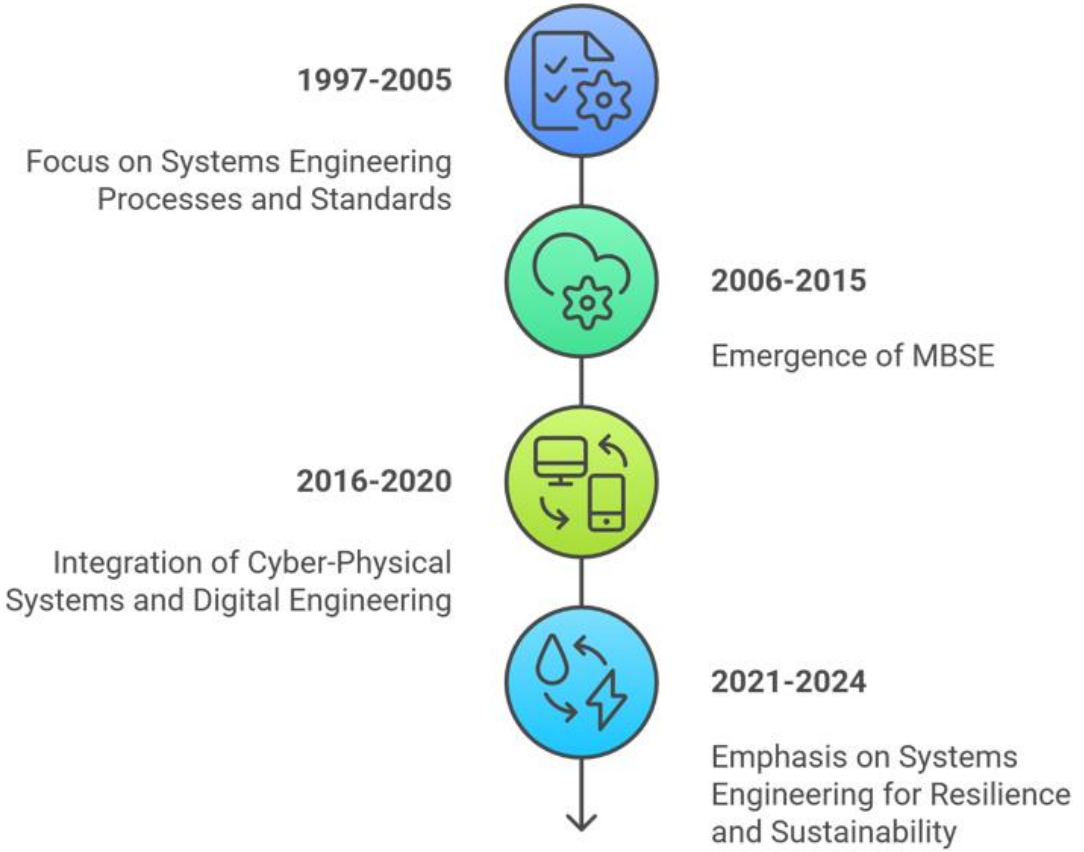
Period	Journal	Conference
1997 – 2005	11	14
2006 – 2015	15	15
2016 – 2020	13	26
2021 – 2024	10	17



Timeline of Evolving Tools

Paradigm shift from structure and process to adaptability and anticipation

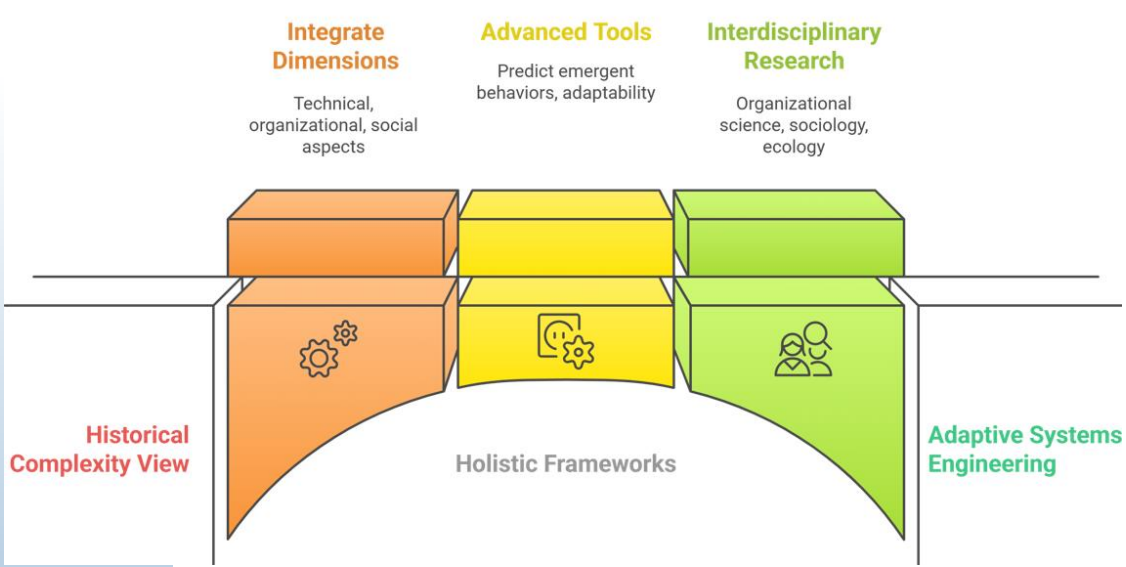
Tool implementation lags understanding



Conclusion

Complexity is multiscale and context-dependent

Need for new tools and mindsets



Clear shift from reductionist SE approaches to holistic, adaptive strategies

Context sensitivity, stakeholder diversity, and multidisciplinary perspectives are essential

Future research should include sociological, ecological, and organizational science insights

Q&A

Insert subtitle.

Optional: contact info or reference slide