FuSE
Future of Systems Engineering

INCOSE | FuSE

Shaping the Future of Systems Engineering Together

IEEE Systems Council TC SE Methodology 10 October 2023

William Miller

The future is complex.

We need a fit for purpose systems approach to solve the challenges.

https://www.incose.org/about-systems-engineering/se-vision-2035

SE Vision 2035 Background & Milestones

- SE Vision **2025** rollout at the INCOSE IS on July 3, 2014
- INCOSE BoD requested vision update in July 2019
- SE Vision **2035**
  - Core Team kickoff on January 26-27, 2020
  - Preliminary Review conducted Feb-March, 2021
  - Final Review conducted Sept-Oct, 2021
  - Rollout at INCOSE IW, January 2022

- Print copy
- Downloadable PDF
- Web version and briefing charts
  - www.incose.org/sevision

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The Global Context for Systems Engineering

United Nations Sustainable Development Goals

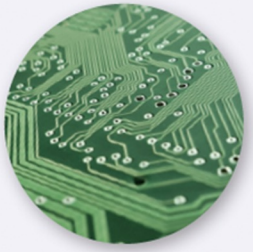
All of these Goals require comprehensive System Solutions!

Global Megatrends

MEGATRENDS expected to influence systems engineering through 2035.

1. Sustainability

2. Interdependent World



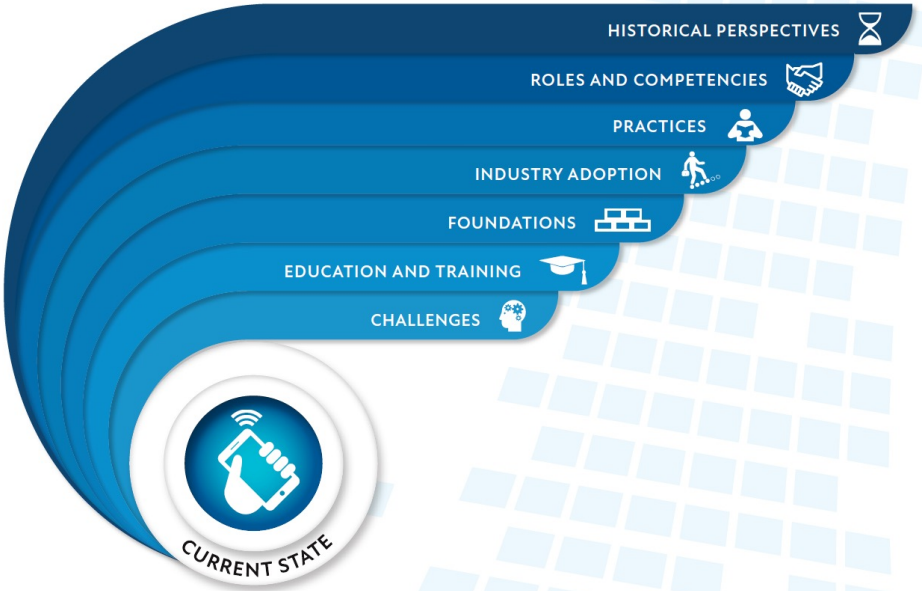
3. Digital Transformation

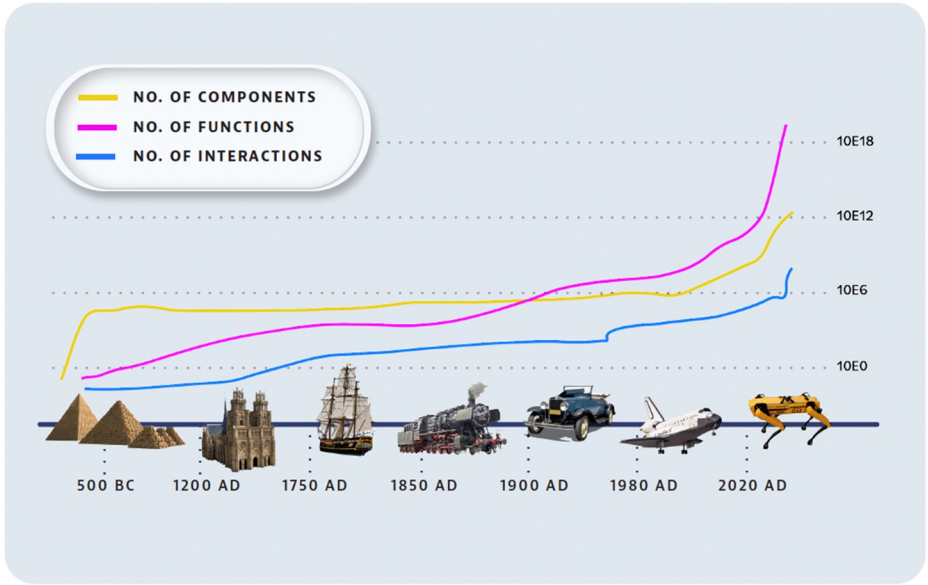
4. Industry 4.0/ Society 5.0

5. Smart Systems

6. Complexity Growth

The Current State of Systems Engineering



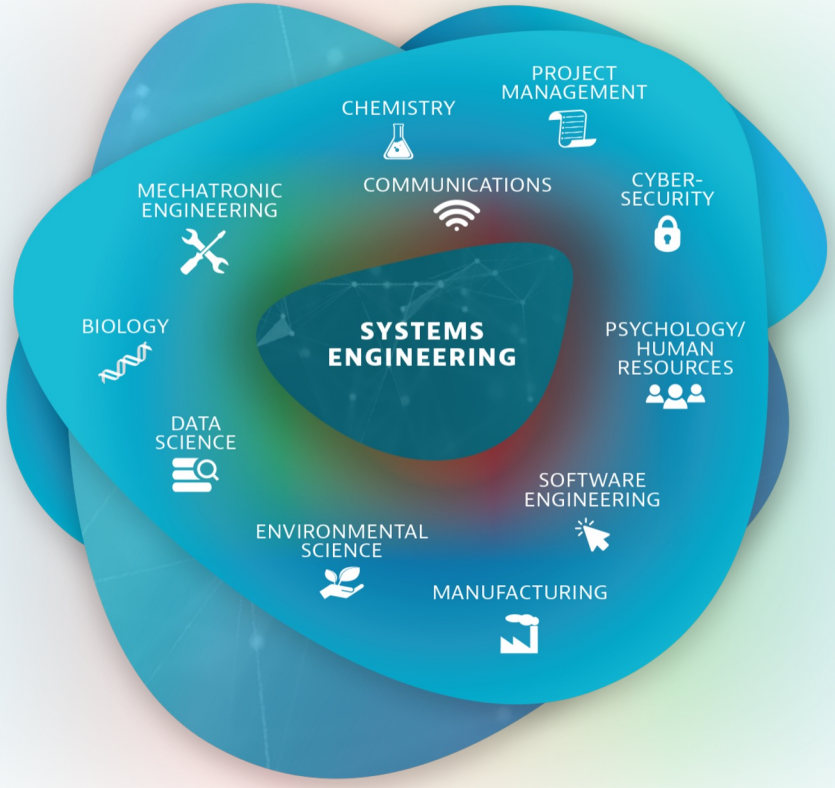


History of Systems Engineering, ever growing complexity

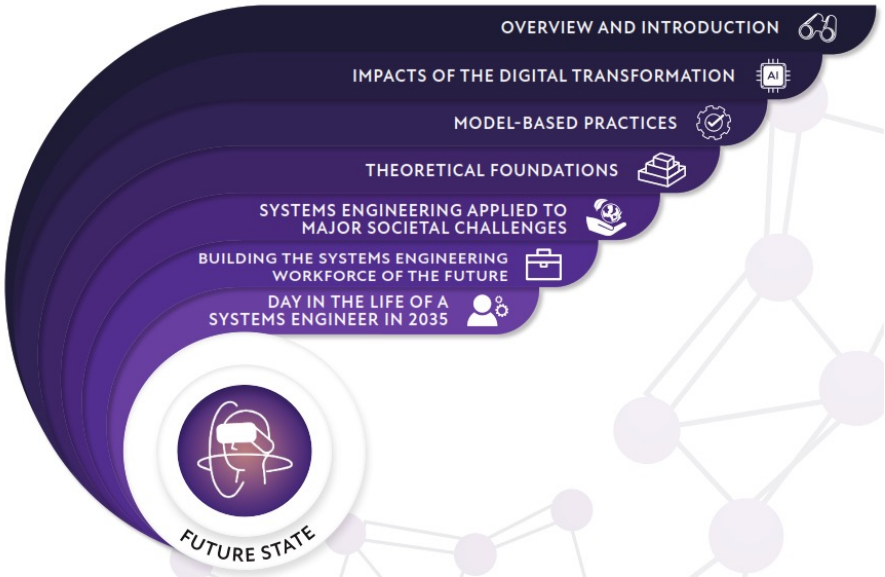
Systems Engineering is Adopted by an Increasing Variety of Industries

Practices, Foundations, Education, and Training

Systems Engineering is Transdisciplinary

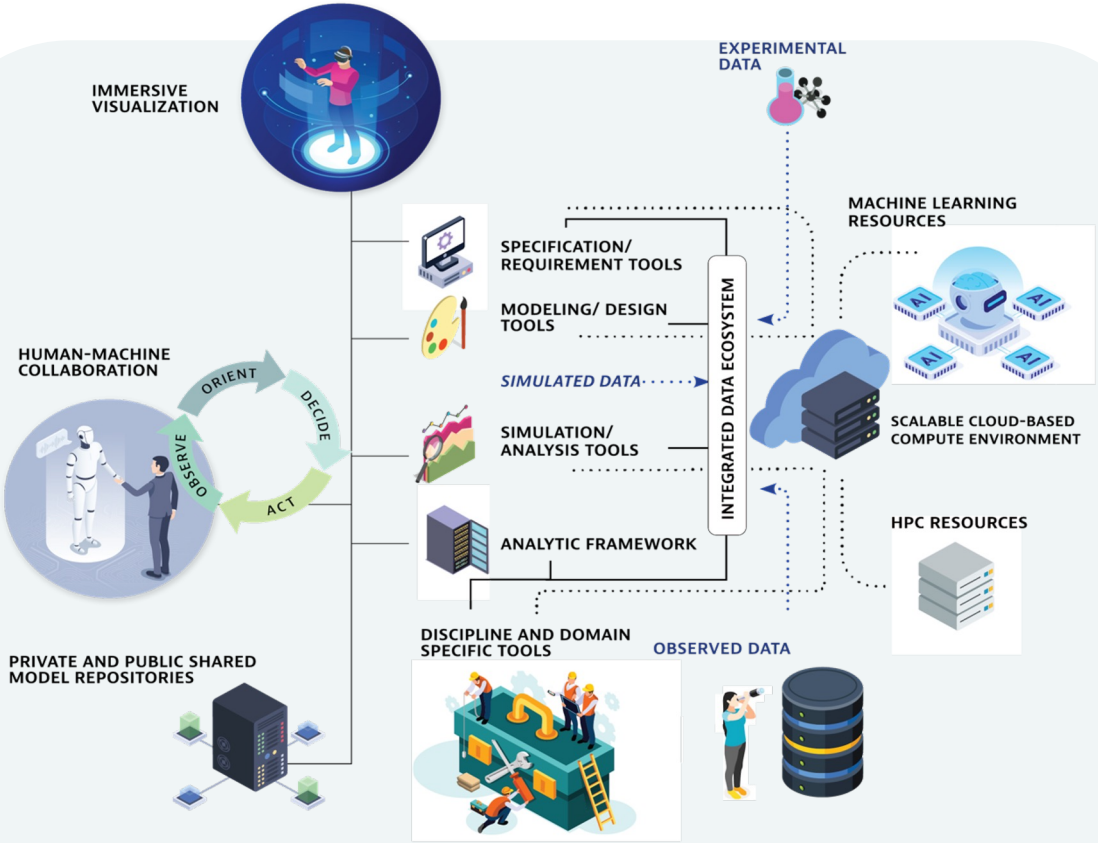


The Future State of Systems Engineering

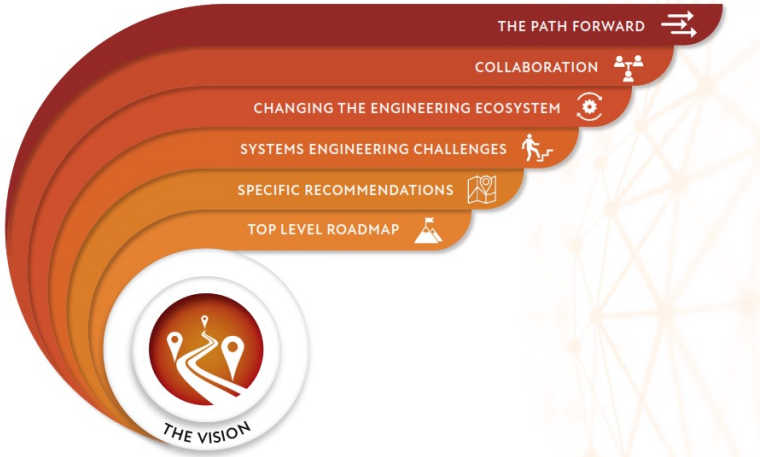


- Future of SE is Model-Based
- AI has changed SE application as well as Systems themselves
- Data Science makes sense of large data sets and supports integration of tools
- Human-System Integration essential to design smart systems
- A theoretical foundation for SE is established
- SE and Systems Thinking life-long education provided to engr & mgmt
- SE adopted by SMEs that adapt SE to market needs

Digital Transformation Impact to Systems Engineering



Realizing the Vision of Systems Engineering



Applications

1. Systems engineering contributes innovative solutions to major societal challenges.

2. Systems engineering demonstrates value for projects and enterprises of all scales, and applies across an increasing number of domains.

Practices

3. Systems engineering anticipates and effectively responds to an increasingly dynamic and uncertain environment.

4. Model-based systems engineering, integrated with simulation, multi-disciplinary analysis, and immersive visualization environments is standard practice.

5. Systems engineering provides the analytic framework to define, realize, and sustain increasingly complex systems.

6. Systems engineering has widely adopted reuse practices such as product-line engineering, patterns, and composable design practices.

Tools and Environment

7. Systems engineering tools and environments enable seamless, trusted collaboration and interactions as part of the digital ecosystem.

Research

8. Systems engineering practices are based on accepted theoretical foundations and taught as part of the systems engineering curriculum.

Competencies

9. Systems engineering education is part of the standard engineering curriculum, and is supported by a continuous learning environment.

Systems Engineering Challenges
(To Address Gaps Between Current and Future State)

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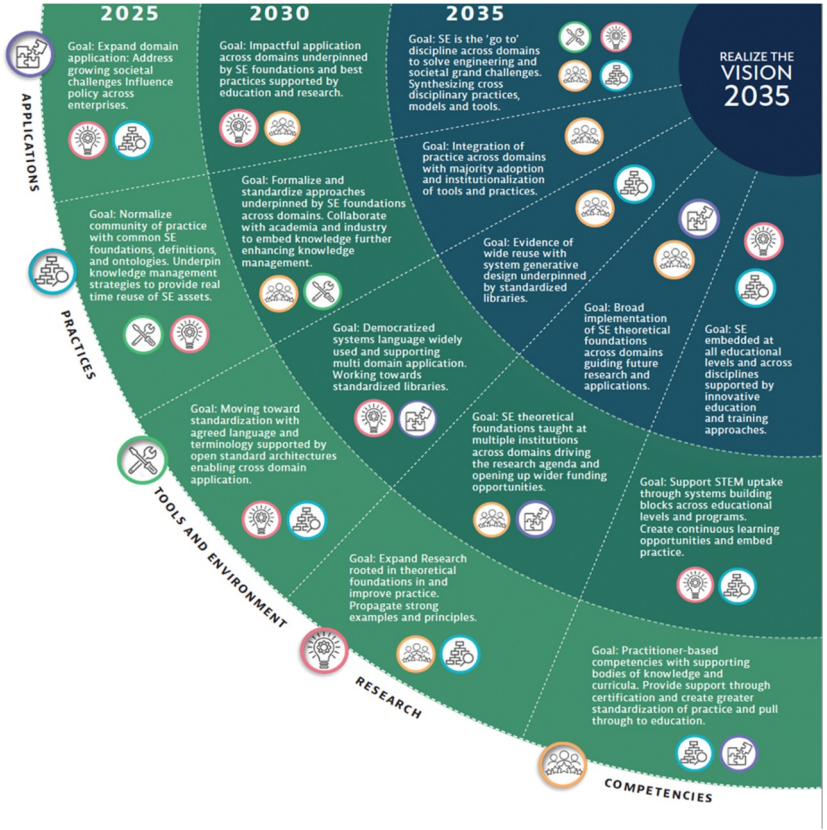
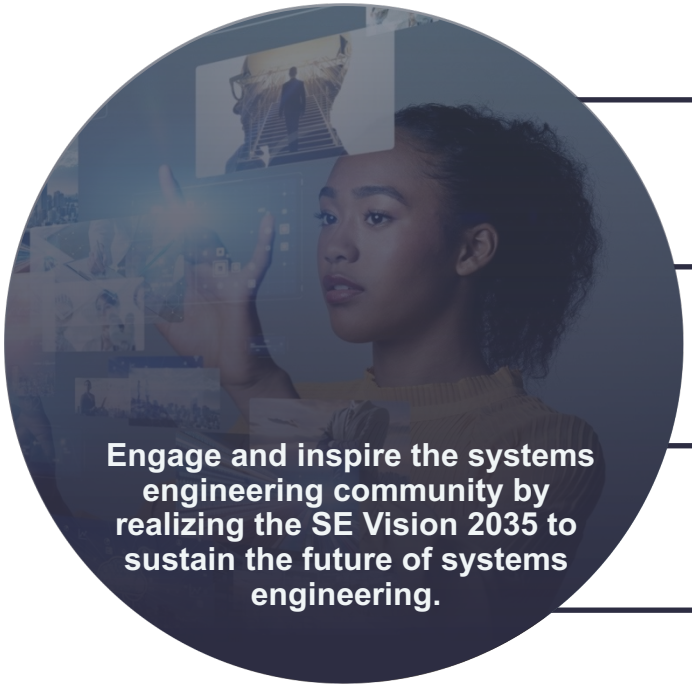
System Engineering Vision 2035 Roadmaps



- SE Vision 2035 includes a top-level roadmap
  - Integrated view across the categories of challenges
  - Shows interrelationships
- Work has been started on lower level roadmaps for each challenge
  - These will be further developed and matured as part of the FuSE initiative

FuSE Inspires the Global Community to Realize the SE Vision



FuSE refines and evolves the SE Vision 2035 across competencies, research, tools & environment, practices, and applications.

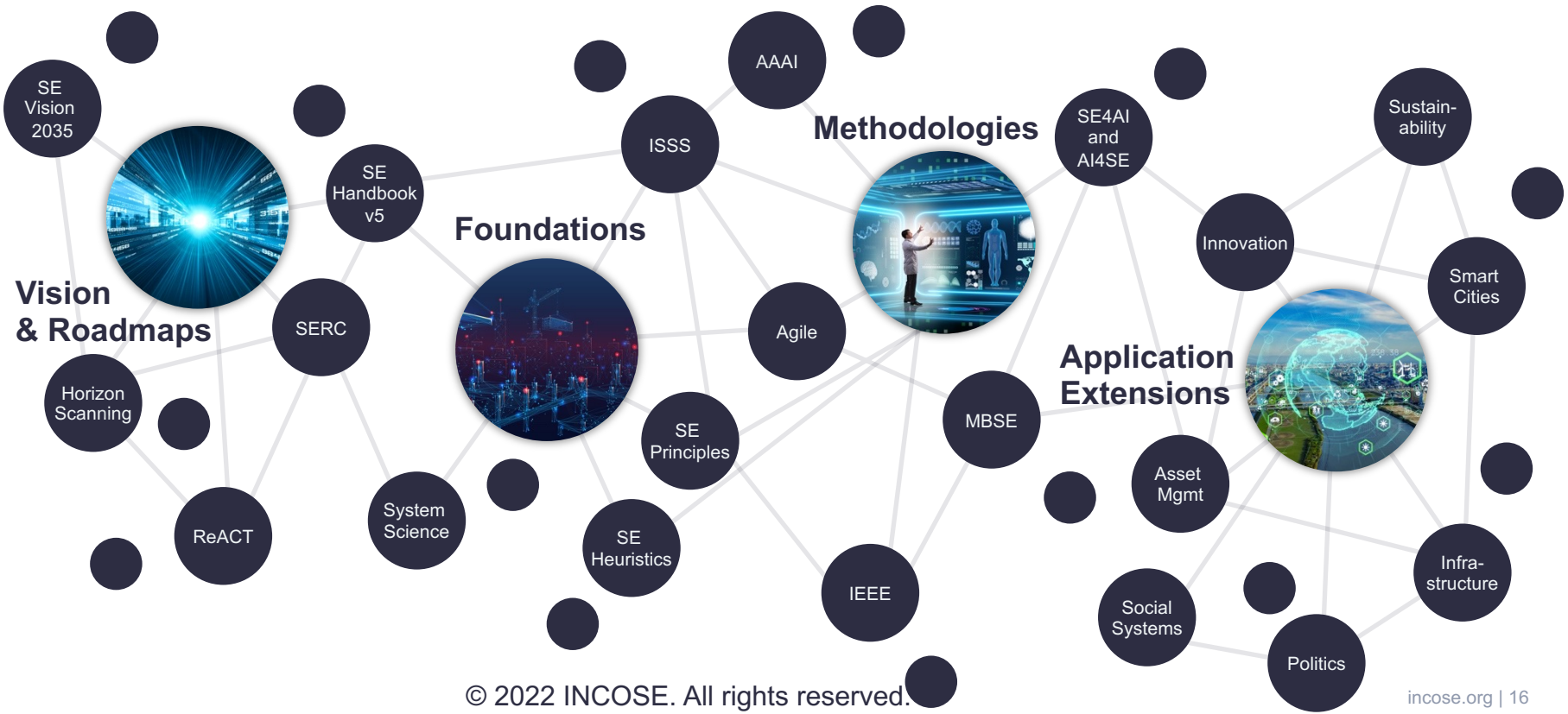
FuSE identifies critical gaps towards the vision realization and initiates & supports relevant actions

FuSE fosters involvement and collaboration within and outside of INCOSE.

FuSE educates, shares success, and expands.

Shaping the Future of SE is a community effort.

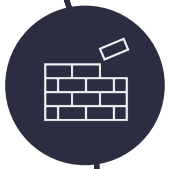
FuSE orchestrates and enables enthusiasts (within and outside of INCOSE) to contribute to the realization of the SE Vision



The FuSE Intiative is Organized in 4 Streams

Vision & Roadmaps

The Systems Engineering Vision and Roadmaps stream continuously refines, evolves, and complements the SE Vision 2035. Furthermore, we create an integrated set of roadmaps across the four interrelated FuSE streams. The concurrently executed streams will guide and influence each other.



Foundations

In order to yield predictable results Systems Engineering methods and tools need to be built on foundational principles that are provably true and based on laws and axioms that can be tested for falsifiability similar to those in other well-established disciplines of science and engineering like Chemical Engineering, Electrical Engineering or Biological Engineering. This stream will formulate a set of candidates underlying Laws of Systemics, the science at the foundation of Systems Engineering.

Methodologies

The SE Methodologies stream guides the advancement of practices, methods, and tools for the effective engineering of systems to be fit for purpose in the presence of varying scale, interrelatedness, complexity, non-determinism, and emerging technology innovations such as AI and agility.

Application Extensions

The SE Application Extensions stream integrates social sciences, soft systems, as well as initiatives such as Smart Cities to address grand challenges to meet human and societal needs as stated in the United Nations Sustainable Development Goals.

Future of Systems Engineering Projects Dashboard

What	FuSE Streams	Lead(s)	Systems Community	EOY 2022 Goals	EOY 2023 Goals	EOY 2024 Goals	SEV 2025 Roadmap Goals
TPPs Project Mgmt		Miller		Project TPPs 2022	Project TPPs 2023	Project TPPs2024	Project TPPs 2025
Horizons Scanning		McDermott	TBD Survey Participants	~~Horizon Scan 2022 (Missed)~~	Horizon Scan 2023	Horizon Scan 2024	Horizon Scan 2025
SEV2035 Review/Roll-out and Engagement Action (REAct) Team	SE Vision & Roadmaps	Schreinemakers	External Reviewers SEV2035 Leads	TBD	TBD	TBD	SEV Goals for 2025
FuSE Roadmap	SE Vision & Roadmaps	Miller	TBD, FuSE Core Team	~~FuSE Roadmap 2022~~ (Missed)	FuSE Roadmap 2023	FuSE Roadmap 2024	FuSE Roadmap 2025
Bridge Team	SE Foundations	Rousseau / Brook / Pennotti	ISSS, INCOSE-UK, Fellows	Bridge Team Review 2022	Transformation Team Review 2023	Transformation Team Review 2024 April 2024 *INSIGHT*	Research [R]: Systems engineering practices are based on accepted theoretical foundations and taught as part of the systems engineering curriculum Competencies: Practitioner-based competencies with supporting bodies of knowledge and curricula. Provide support through certification and create greater standardization of practice and pull through to education
SEHv5 Inputs and Review	SE Foundations	Miller	SEHv5 Authors, Editors	SEHv5 Draft Reviewed	SEHv5 Published (IS2023) Does not support 2025 Goals?		
SE Principles	SE Foundations	Watson	NASA, AIAA, IEEE-SC, IEEE-SMC, ISSS, NDIA, INCOSE SEPAT	SE Principles V1 Published SEBoK Principles Article SE Principles V12 Published		SE Principles → GRCSE	
SE Heuristics	SE Foundations	McKinney / Brook	INCOSE Fellows, INCOSE-UK	SE Heuristics V1 Published	SEBoK Heuristics Article	SE Heuristics → GRCSE	
Science Foundations for SE (Portfolio)	SE Foundations	Javier Calvo-Amodio	ISSS, SysSciWG		SEBoK SF4SE Article	SF4SE → GRCSE	
SE4AI and AI4SE	SE Methodologies	Brown (chair) Co-chairs: McDermott, Raz	AAAI, REUSE, AISysWG	SE-AI Primer Draft Revisions	SEBoK SE-AI Article	SE-AI → GRCSE SE-AI Primer v1 Published	Practices: Systems engineering practices are based on accepted theoretical foundations and taught as part of the systems engineering curriculum Tools & Environment: Moving toward standardization with agreed language and terminology supported by open standard architectures enabling cross domain application.
Human Systems Integration (HSI)	SE Methodologies	Boy	IEA / HSIWG	HSI Reference (HSI-R) v1 Published	SEBoK HSI-R Article	HSI-R → GRCSE	
Systems Security	SE Methodologies	Dove	Sys Security WG	June 2022 *INSIGHT*	SEBOK FuSE SysSec	FuSE SysSec → GRCSE	
Agility	SE Methodologies	Dove Larri Rosser (support)	Agile Sys & SE WG		SEBoK SE Agility Article June 2023 *INSIGHT*	SE Agility → GRCSE	
Complex Systems	SE Methodologies	Watson	Complex Sys WG	Primer Rev 1 (2021)	SEBoK Complexity Article	Complexity → GRCSE	
Social Systems. (TBR)	SE Methodologies	Palmer	Social Systems WG				
Contextual Ecosystems (TBR)	SE Application Extensions	Chris Nemeth (IEEE SMC)	IEEE SMC (Lead) INCOSE Support TBD				Applications: Address growing societal challenges Influence policy across enterprises.
Smart Cities	SE Applications Extension		TBD		SEBoK Smart Cities Article		

Overview of FuSE Streams and Achievements

Vision & Roadmaps

The SE Vision and Roadmaps stream **continuously refines, evolves, and complements the SE Vision 2035**.

Results so far:
- Collection of feedback & white spots in the SE Vision 2035 (roadmap and challenges)

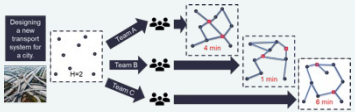
What is coming up:
- Processing of results generated so far
- Formulate a process to process and refine complements to the SE Vision 2035

Foundations

The SE Foundations stream has its basis in both theory and industrial practice.
First goal is to assess the **adequacy of the foundations and identify gaps to determine future directions.**

Results so far:
- Facilitation of complexity experiments
- Survey on key areas to work on
- The Pursuit of Elegant Solutions to Complex Problems
- AI Primer: SE4AI and AI4SE

What is coming up:
- Publication of results from complexity experiment
- Paper on literature review of complexity
- Expansion of experiments

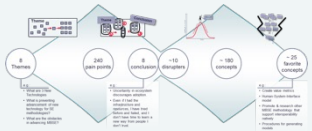


Methodologies

The SE Methodologies stream guides the **advancement of practices, methods, and tools** for engineering systems to be fit for purpose.

Results so far:
- Elaboration and prioritization of methodology gaps
- Identification and prioritization of disrupters

What is coming up:
- Address the identified disrupters
- Shift from “talking” towards creating products and update practices

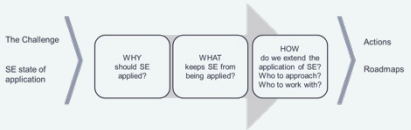


Application Extensions

The SE Application Extensions stream **integrates social sciences and soft systems into systems engineering practice to address grand challenges**.

Results so far:
Discussion on Systems Engineering contribution to the fields of:
- Smart Cities
- Innovation
- Grand Challenges
- Asset Management
- Climate Change

What is coming up:
- Collaboration proposal with IAM and AMC
- Establishment of a Sustainability Working group based on working session at EMEA (Climate Change)



IAM: Institute of Asset Management
AMC: Australian Asset Management Council)

The FuSE Journey – a few highlights so far…

The FuSE journey begins at IW 2018

INCOSE published the SE Vision 2035

Introducing the new FuSE PMO organization at IW 2023

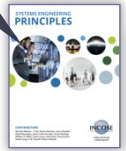
Impact of FuSE: Complexity Primer, Principles, Heuristics, Systems Science and Systems Thinking, Human Systems Integration, Agile Systems Engineering Life Cycle Model, Artificial Intelligence in Systems Engineering, …

15 Principles plus 20 sub-principles: Descriptions, Evidence, Implications. The real system is the perfect representation of the system.

Interdependencies between algorithms and human users in development of human-centric complex systems

“Rules of thumb” to reduce cognitive load

SE Handbook V5



First FuSE related products and articles are published

FuSE related products and articles are published

Imperative for Explainable AI (Why do neural networks look the way they look?) Putting Guardrails on AI

Introducing the Archimedes Initiative that aims to accelerate innovation in systems engineering (SE) research.

The next big things – what FuSE is working on…

- 1st law of complexity: Results from the experiments during the International Symposium and EMNEA SE Conference
- The Pursuit of Elegant Solutions to Complex Problems
- AI Primer Addressing SE4AI and AI4SE

- How SE supports Smart Cities, Innovation, Grand Challenges, Asset Management, PESTEL factors
- Working Group Sustainability created

Vision & Roadmaps

Updates the SE Vision and provide FuSE results to the systems community

- Identification of gaps in the Vision Roadmap
- Implementing regular horizon scanning to keep the vision updated

Foundations

Validate Systems Engineering principles and heuristics by experiments

Methodologies

Validate processes, methods & tools to be fit for purpose

Identification of the key disrupters in particular:

- People (Organizational) Change Management
- Get rid of the “Clutter”

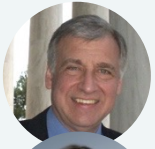
Application Extensions

Communicate the value of SE and introduction SE to new domains.

Let's connect.

Find us on
www.incose.org/fuse

Or write us at
fuse@incose.net



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