INCOSE

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

How are We Doing?

Realizing the Systems Engineering Vision 2035

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INCOSE International Symposium 2025 | Ottawa, Canada

Topics

- Bottom Line Up Front (BLUF)
- FuSE Timeline 2018-2025
- Project Context: Systems Engineering Vision 2035 (SEV2035) Context and Realization
- Project Context: INCOSE Strategic Plan – SEV2035 Realization
- FuSE Vision and Roadmaps Project Charter
- FuSE Roadmapping Approach
- V&R Project Timeline to IW2026
- FuSE Project Portfolio
- The State of the Systems Engineering Discipline: A Longitudinal Analysis of INCOSE International Symposium Contributions (2012–2025)
- Meeting SEV2035 Goals for 2025
- BLUF REDUX

Bottom Line Up Front (BLUF)

Refining the Vision – Findings

- We need to place significant attention of the system definition and realization processes and practices, as these will change with respect to their application, methods, timing, and support from modeling/analytics
- Emerging technologies critically dependent on computing, software, and algorithms
- Machine learning (ML) and AI, in combination with complement physics-based/analytic models, can significantly accelerate system definition from 2 to 3 orders of magnitude or more, but come with challenges, especially for V&V

Vision Refinement and Roadmaps (V&R)

- Roadmap realization categories are interdependent (Competencies, Research, Tools & Environment, Practices, Applications)
- Causal loop models of interdependencies underlying V&R models
- Host V&R models in INCOSE SE Laboratory
- V&R Releases on Public INCOSE Web for Review and Feedback

V&R Project Timeline

- Quarterly Status Updates to BoD
- V&R Release 1 December 2025
- Rollout IW2026

FuSE Timeline 2018 - 2025

FuSE begins
IW 2018

INCOSE published
SE Vision 2035
IW 2022

Collaboration
with SERC

AAAS SE&AI 2021

SEV2035
Roadmap
Goals 2025

SEV2035
Roadmap
Goals 2030

SEV2035
Roadmap
Goals
2035

INSIGHT 2019-2025

Complexity &
Elegance 9/25

Digital
Engineering 10/25

2018 AIAA
Space Forum

SERC SE4AI/AI4SE
Workshops 2018-2025

NAFEMS WC 2019

IEEE SMC Conferences 2018, 2019, 2021, 2023

Project Context: Systems Engineering Vision 2035 Context & Realization

SEV2035 Global Context for Systems Engineering

- **Human and Societal Needs Drive Systems Solutions**
  - United Nations sustainability goals serve as a proxy for human needs
- **Global Megatrends Shape the Systems of the Future**
  - Sustainability, Interdependent World, Digital Transformation, Industry 4.0 / Society 5.0, Smart Systems, Complexity Growth
- **Systems Address a Wide Variety of Domains**
  - Energy, Financial, Transportation, Defense, Healthcare, Education, Exploration, Agricultural, Biomedical, Information, Manufacturing, Telecommunications, Urban, Supply Chain Logistics
- **Technology Trends / Advances Shape the Nature of Systems**
  - Advances in Materials and Manufacturing; Advanced Modeling and Simulation; Autonomy and AI; Big Data and Analytics; Bio/Life Science and Nano Technologies; Communications Technologies; Edge Computing; Geospatial Technologie; Power Generation, Storage, and Conversion; Quantum Information Science
- **Growing Stakeholder Expectations**
  - Simple, Timely, Safe, Secure, Stable and Predictable, Smart, Sustainable, Maintainable, Scalable, Affordable
- **The Enterprise Environment**
  - Globalization and Diversity; Sustainability Ethics; Systems Thinking; Anticipation of Technology; Supply Chain Integration; Enterprise Intelligence; Decision Making, and Learning; Automation and Digital Transformation

Many variables, non-deterministic, interdependent and dynamic!!

Emerging Challenges

The future environment is becoming:

- More dynamic and nondeterministic
- Increasingly evolutionary, with an accelerating rate of change
- Resource constrained driving a need for sustainability
- Highly interactive among individuals, communities, organizations, and systems

V&V is more difficult to perform in any adequate manner when the system and ecosystem are non-deterministic/evolutionary

There are growing expectations for SE solutions:

- Increased level of functionality providing more comprehensive solutions
- Higher order of intelligence and adaptability augmenting human performance
- Greater level of connectivity and interoperability across and between systems
- Trust, safety, and cybersecurity of digital representations
- Increased inclusivity, growing the scale and scope of solutions

Emerging technologies provide opportunities to enhance the practice of SE:

- Machine Learning
- Autonomous Physical Systems
- 3D Printing, Genomics
- Quantum and Nano Technology
- Biomimicry
- Complexity Science
- Systems Sciences
- Data Science (Big Data)
- Smart Everything
- Connected Everything (IoT)
- Artificial Intelligence
- Cybersecurity

All Dependent on Computing, Software, and Algorithms

Context: SEV2035 Systems Engineering Challenges

To Address Gaps Between Current and Future State

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 & Environments

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

Research

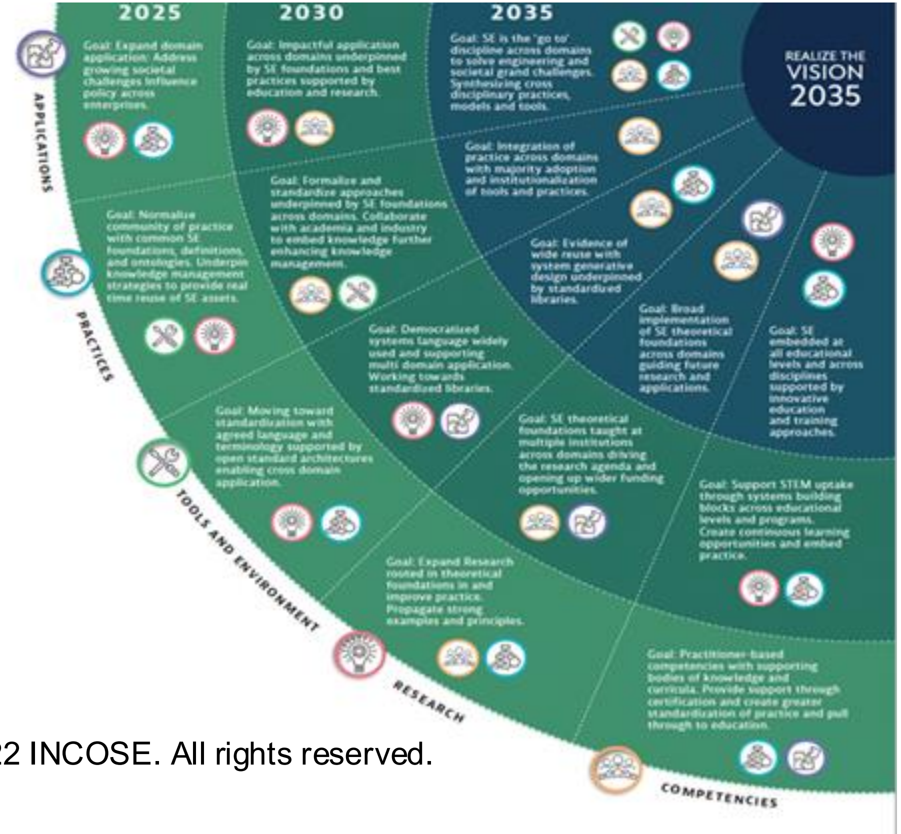
8. Systems engineering practices are based on accepted theoretical foundations and taught as part of the systems engineering curriculum.

Competencies

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

Systems Engineering Vision 2035 Top-Level Roadmap

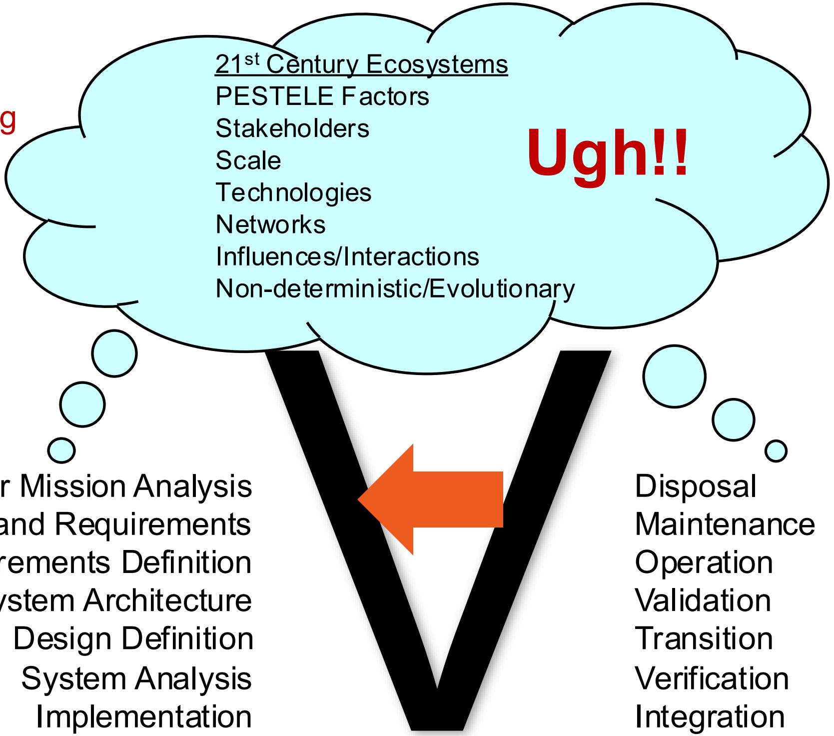
SEV2035 Category Goals are Interdependent Across Categories



Context: SEV2035 Systems Engineering Challenges

Realizing systems that are *fit for purpose* and *do no (unintended) harm* in the 21st Century

Kevin Forsberg and Hal Mooz innovated the systems engineering *Vee* as a relationship model, NOT a temporal model



The nature of 21st Century ecosystems pose significant challenges in the engineering of systems across the ensemble of technical processes, especially V&V

Business or Mission Analysis
Stakeholder Needs and Requirements
System Requirements Definition
System Architecture
Design Definition
System Analysis
Implementation

Disposal
Maintenance
Operation
Validation
Transition
Verification
Integration

Context: SEV2035 Recommendations (1 OF 5)

Systems Engineering Contributions to Solving Societal Challenges

CHANGES NEEDED

- Foundational Systems Engineering competencies are integrated into college and pre-college curricula.
- Digital engineering methods and tools enable integrated analysis of both technical and non-technical elements.
- Systems engineering application is promoted for a broad set of domains and non-technical/socio-technical needs.
- Systems engineering serves as an integrator for many engineering and global challenges (such as, sustainability).
- Systems engineering is included on agendas for industry and government leadership.

Demonstrate the Value of Systems Engineering

CHANGES NEEDED

- Systems Engineering Core Competencies are part of individual, team, and enterprise learning.
- Digital Engineering transformation integrates systems engineering practices and systems thinking across all disciplines.
- Systems engineering is effective across domains, life cycle models, delivery approaches, and solution portfolios.
- Strong systems engineering Communities of Practice form within application domains.
- Systems engineering demonstrates utility for solutions of any complexity [and integrates both horizontally and vertically].

Context: SEV2035 Recommendations (2 OF 5)

Addressing Dynamic Change and Uncertainty

CHANGES NEEDED

- Data standards are developed and adopted enabling effective data interconnection and exchange.
- Methods and tools for dealing with product variation and variability are widely adopted.
- Knowledge Management and incremental learning are integrated with systems engineering practices.
- Systems engineering incorporates dynamic feedback into solutions across the life cycle (such as Agile practices).
- Increasing technology assistance for human tasking is incorporated including automated workflows.

MBSE– Digital Transformation

CHANGES NEEDED

- Use and management of models, architecture, and digital thread mature, including digital twins.
- Immersive visualization with modeling and simulation is incorporated.
- Trusted digital environments with broad span are established.
- Trusted data is managed as an essential asset.
- Effective semantic integration of digital assets is applied, including knowledge representation.
- MBSE is supported by AI/ML to aid development of solutions.

Context: SEV2035 Recommendations (3 OF 5)

Analytic Framework for Enhanced System Understanding

CHANGES NEEDED

- Advanced data science, AI/ ML, augmentation, and visualization are integrated to support analyses for improved understanding of system behavior.
- Standards and regulations are integrated in the framework.
- Capability to analyze a broader set of elements across the life cycle (such as, sustainability and social acceptability) is developed.
- Effective synthesis capabilities are matured, including for systems of systems.
- Knowledge is increased of natural systems and how they embody and deal with complexity.

Systems Engineering Adoption of Reuse Practices

CHANGES NEEDED

- Commonality of practice across a range of systems engineering use cases is understood and applied.
- Patterns and unified models that account for variations are established.
- Effective reuse practices evolve and become widely applied across domains (Product Line Engineering and Composable Design).

Context: SEV2035 Recommendations (4 OF 5)

Systems Engineering Tools for Digital Environment

CHANGES NEEDED

- Focus shifts to data/ information rather than tools.
- Consistent artifacts for communication are established.
- Modeling language and data interchange standards are developed and used that facilitate information sharing.
- Effective distributed information sharing/interchange is common.
- Speed and capacity for analyzing alternatives and impacts increases (orders of magnitude).

Foundations and Research

CHANGES NEEDED

- New principles, phenomena, concepts, heuristics, and technologies are integrated with existing knowledge.
- Research to define and validate the systems engineering Theoretical Foundations is launched.
- Research on systems engineering practices, tools, and applications that address dynamic change and uncertainty is facilitated.
- Industry, government, and associations team with academia to further systems engineering research and incorporate systems engineering foundations into the curriculum.
- Systems engineering research encourages cross-disciplinary engagement to move towards integrated approaches.

Context: SEV2035 Recommendations (5 OF 5)

Advancement of Education

CHANGES NEEDED

- Enhance workforce via lifelong education/training.
- Engineering continuing education and pre-college education integrates select systems engineering concepts and systems thinking into their curricula.
- Systems Engineering community and accreditation bodies team to add systems engineering and system concepts into all engineering accreditation criteria.
- Non-technical requirements are added to the curricula, such as human dynamics and sustainability.
- Challenge-based, hands-on education, and training of integrated methods and approaches evolves.

Ideal Future State:
Measures of Progress in Realizing the SE Vision 2035

Refer to:

Michael Griffin 2010 **"How do we fix system engineering?"**
https://www.youtube.com/watch?v=8l4J38D7VaE&t=51s
Complexity of systems and 4 attributes of elegant design: 1) functionality, 2) resilience (nee robustness), 3) resources efficiency, and 4) minimizing unintended consequences

Stephen Welby DASD-SE IS2013 Plenary **21st Century (Systems) Engineering**
https://www.youtube.com/watch?v=ZjRXfCmbOpU
Putting engineering back into systems engineering!
Systems Engineering focuses on the creative application of scientific and engineering principles:
- To design, develop, construct, and operate complex systems
- To forecast their behavior and interaction under specific operating conditions and
- To deliver their intended function while addressing economic efficiency, environmental stewardship, and safety of life and property.

The key gaps in our current engineering practice, as I see them, are threefold:
- Dealing with Complexity at Scale
- Quantifying Risk, and
- Predicting the Impact of Engineering Decisions in the Product Context

SE Vision 2020 (2014) based on math, science, and humanistic foundations (Schindel 2020)

FROM:

Systems engineering practice is only weakly connected to the underlying theoretical foundation, and educational programs focus on practice with
little emphasis on underlying theory."

TO:

The theoretical foundation of systems engineering encompasses not only mathematics, physical sciences, and systems science, but also human and social sciences. This foundational theory is taught as a normal part of systems engineering curricula, and it directly supports systems engineering methods and standards. Understanding the foundation enables the systems engineer to evaluate and select from an expanded and robusttoolkit, the right tool for the job."

Transition perception of systems engineering as being process centric to its roots as being engineering of systems centric

From: Friedenthal, Beihoff, Kemp, Oster, Paredis, Stoewer, Wade, "A World in Motion: INCOSE Vision 2025", INCOSE, 2014.

Project Context: INCOSE Strategic Plan

INCOSE Strategic Plan v1.0 → FuSE

Input to FuSE Roadmap System 3 Enterprise (Business Level)

- Vision: To unite and advance the global systems community
- Mission: INCOSE fosters systems engineering knowledge exchange, application, education, and research. We are dedicated to being the world’s trusted authority and forum for the practice, science, and art of systems engineering.
- Objective O.1: Advance systems engineering as the world’s trusted authority
  - Key Results KR.1.1. Satisfaction of / progress against future of systems engineering roadmap
- Strategies
  - S.1.1.Create the future of systems engineering and mature its foundation by aligning roadmaps, initiatives, and strategic partnerships

FuSE Vision and Roadmaps Project Charter

FuSE Vision and Roadmaps (V&R) Project Charter (1 of 2)

Scope and Timeline to IW2026

- Chair: S.J. (Bas) van der Leeuw
- Co-Chairs: David Endler, Garry Roedler, et al.
- **Purpose[Context:** Systems Engineering Vision 2035: Engineering Solutions for a Better World (2021), Systems Engineering Principles (2022), 3DSE Synthesis Report Vision and Roadmaps (22 December 2023), INCOSE Strategic Plan v1.0 (17 June 2024)]

  The Systems Engineering (SE) Vision and Roadmaps (V&R) stream periodically statuses, refines, evolves, and complements the SE Vision 2035. Furthermore, we create an integrated set of roadmaps across the four interrelated Future of Systems Engineering (FuSE) streams (V&R, Foundations, Methodologies, and Application Extensions) that span the five categories in the Vision (Competencies, Roadmaps, Tools & Environment, Practices, and Applications). The concurrently executed streams guide and influence each other. The FUSE roadmaps feed the INCOSE Strategic Roadmaps
- **Outcomes (Products/Services):** The V&R team generates periodic updates to the Vision and provides detailed roadmaps for presentation at INCOSE events, which are also be fed to the INCOSE Strategic Plan updates. This work began at the INCOSE 2023 International Workshop and continues through 2035 with special emphasis to the overall Vision Roadmap goals in 2025, 2030, and 2035.

The output is a “living,” updated, interactive model to provide a service to stakeholders

FuSE Vision and Roadmaps (V&R) Project Charter (2 of 2)

Scope and Timeline to IW2026

- **Fit for future: Mapping prioritized topics to recommendations:**
  - Harmonize the activities across the FuSE streams
  - Promote the SE Vision 2035 and Its Extensions
  - Gather stakeholder feedback on the Vision document
  - Determine the priority of roadmap topics including research topics for both academia and research centers.
- **Roadmaps:**
  - A causal relationship model across the SE Vision 2035 categories
  - Detailed roadmaps for each of the categories
  - A breakdown into actionable steps

FuSE Roadmapping Approach

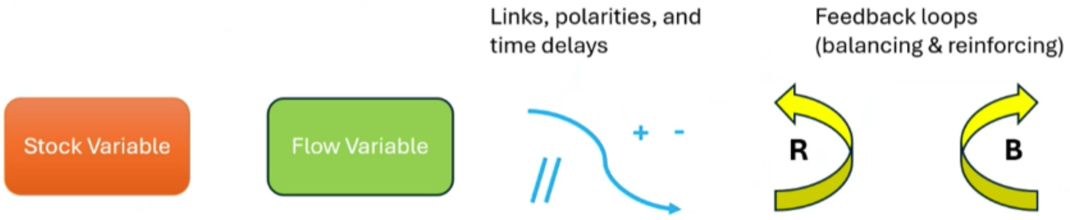
Causal Loops

- Basic Concept
- UN Sustainable Development Goals
- SEV2035 Top-Level Roadmap Category Interdependencies

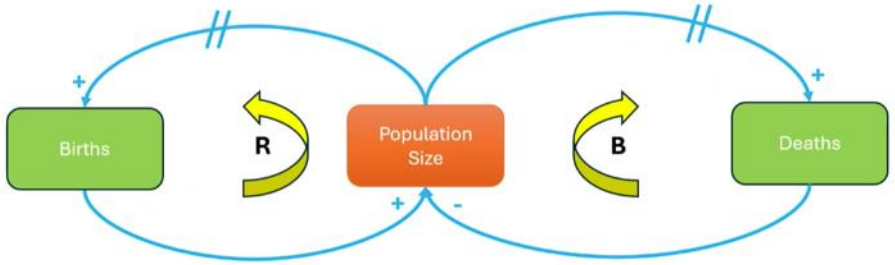
System Causal Loop Key Concepts

For reference

Key Concepts



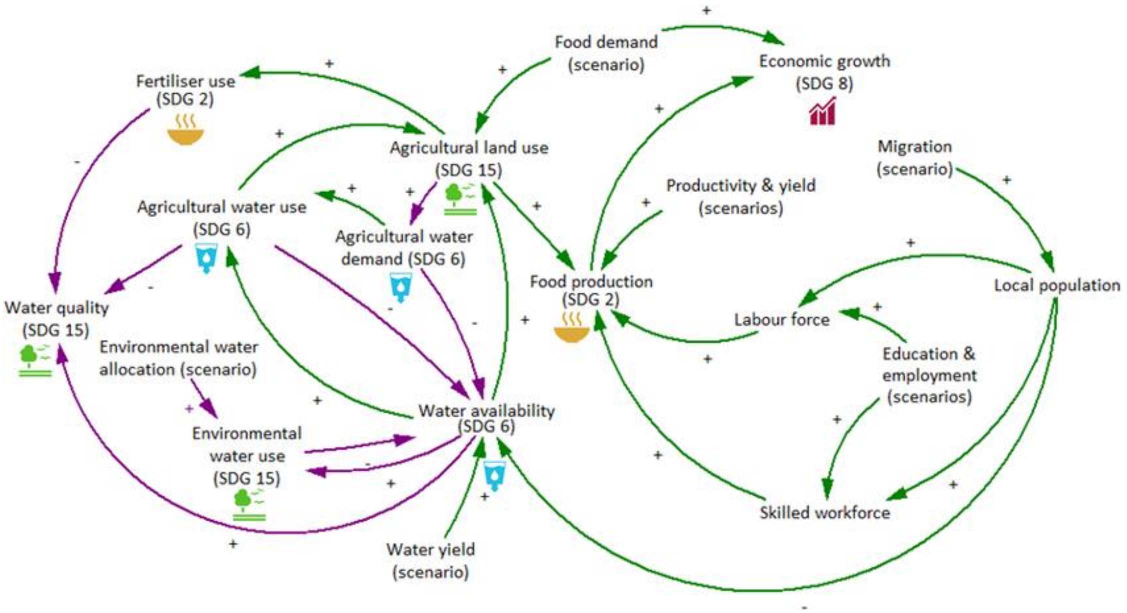
Example



UN Sustainability Goals Causal Loop Model

Earth's Future Wiley and American Geophysical Union Online ISSN: 2328-4277

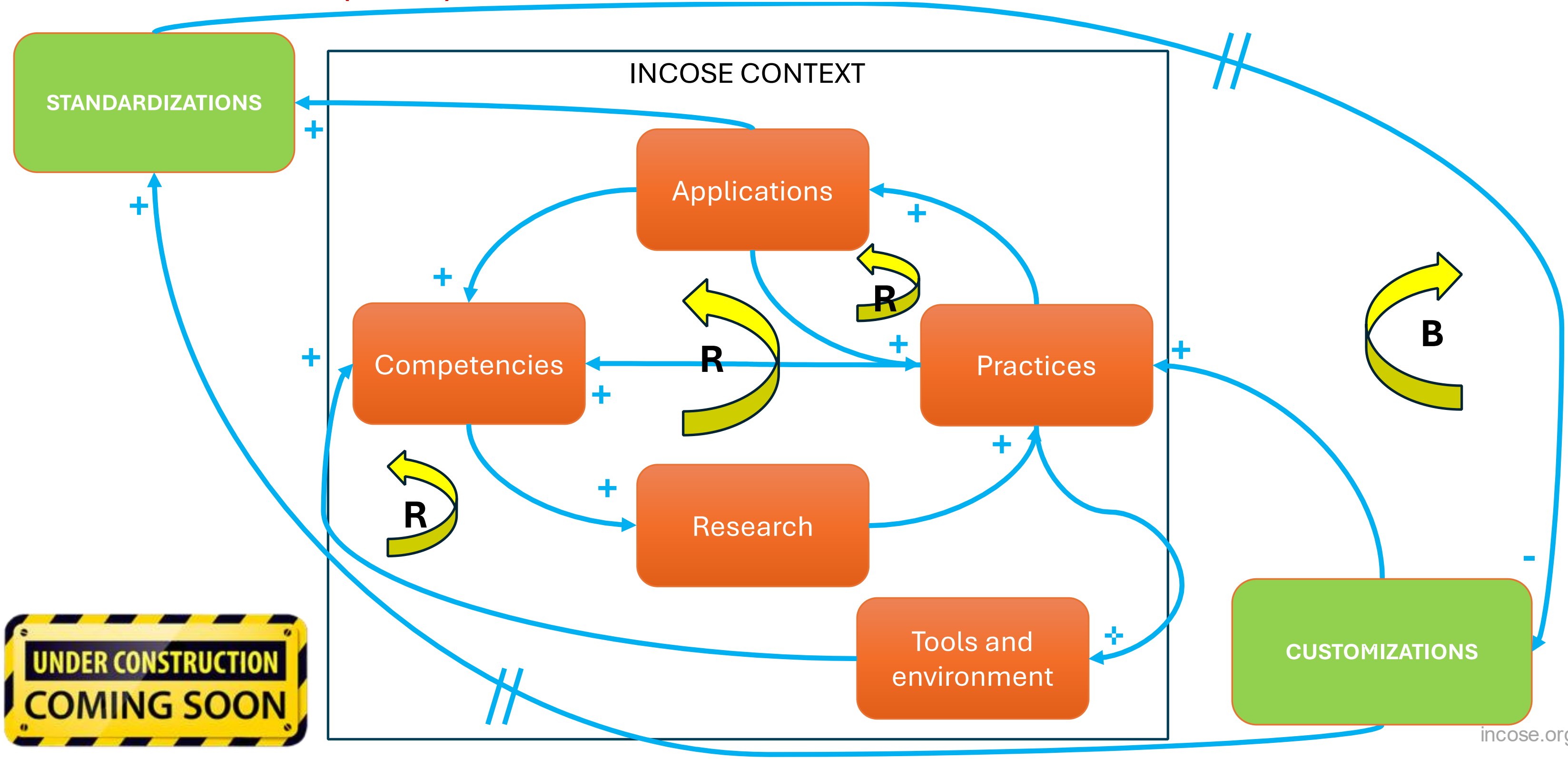
https://www.researchgate.net/figure/Causal-loop-diagram-capturing-the-interactions-trade-offs-and-synergies-between_fig4_376613782



Causal loop diagram capturing the interactions, trade-offs, and synergies between agriculture (SDG 2), water availability (SDG 6), economic growth (SDG 8), and life on land (SDG 15). Positive feedback linkage are shown as a positive sign (+), whereas negative feedback linkages are shown with a negative sign (−). The purple arrows indicate the enviro-biophysical linkages. The green arrows indicate the socio-economic linkages. The SDG icons are courtesy of the UN SDG communications material.

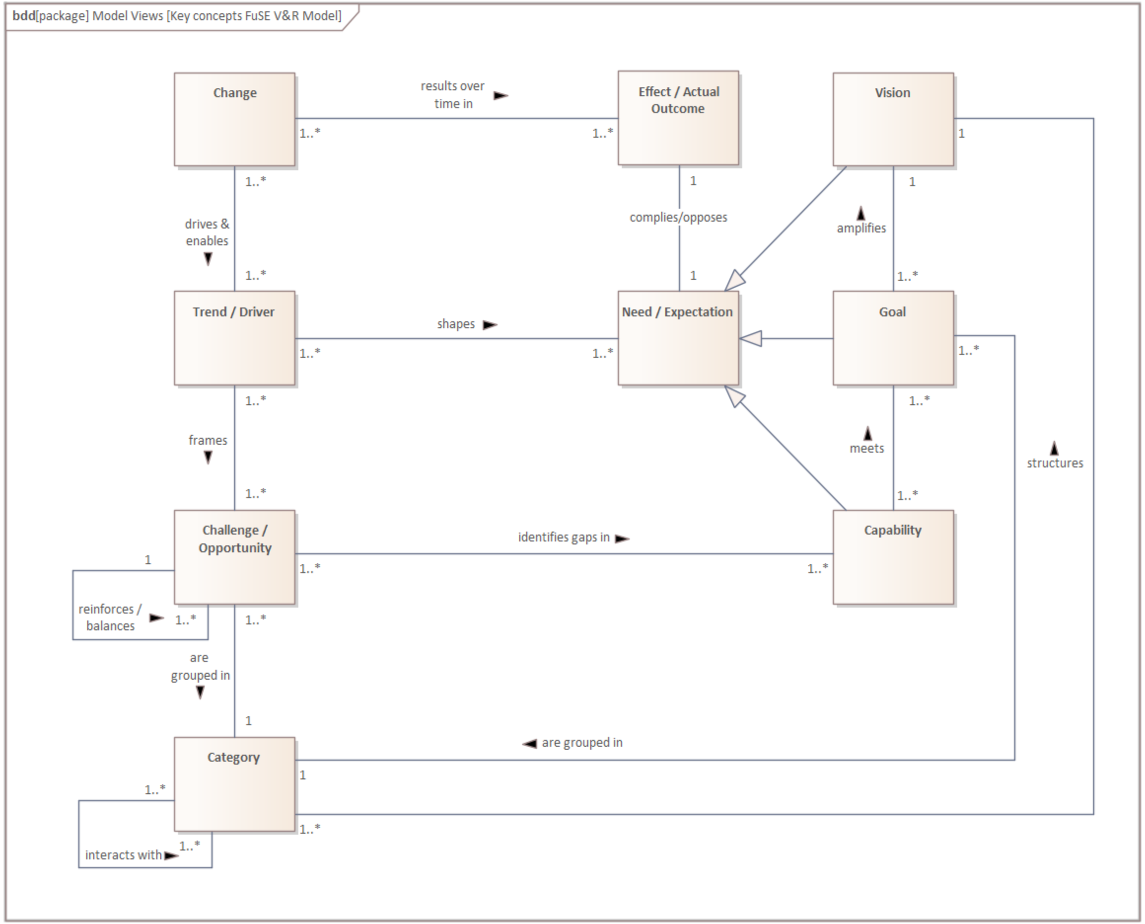
SE Vision 2035 Top-Level Categories Interdependence Customization vs Standardization Example

To be refined (TBR)



SE Vision 2035 Top-Level Categories Interdependence

SysML Diagram View

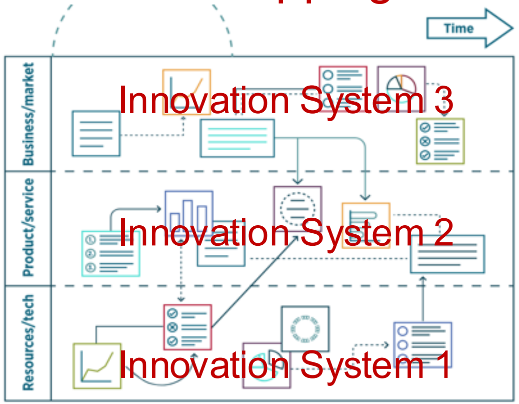


Roadmap Framework

- IfM Engage (university of Cambridge)

Cambridge University Roadmap Framework

https://engage.ifm.eng.cam.ac.uk/roadmapping/



The Global Context (Model) for Systems Engineering

1. Clarify/model context
2. Recruit assets who commit to tasks
3. Design the roadmap template
4. Design the roadmapping process
5. Identify key stakeholders
6. Implement the roadmapping process
7. Validate and use the roadmap
8. Reflect and learn from the process

a. Data collection (open source)
b. Analysis (identify dominant, key driver variables rather than try to model the world)
c. Reviews and feedback
d. Iterations

Recommendations driven by INCOSE Strategic Plan

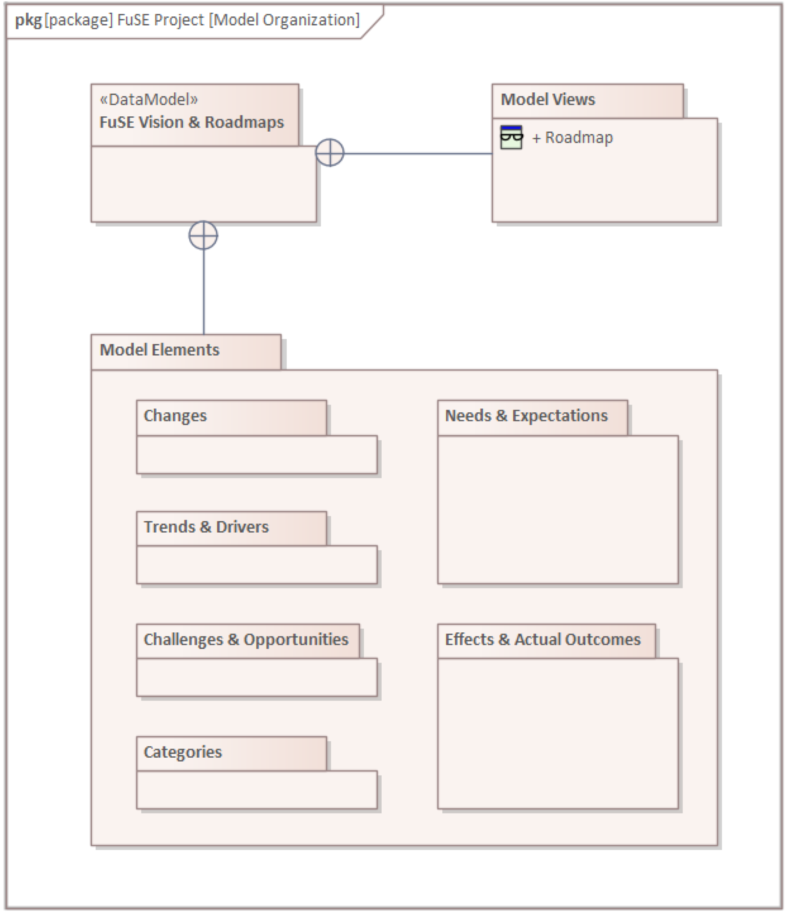
Align roadmaps
Priorities
Projects
Initiatives
Strategic partnerships

SE Model Organization

SysML Diagram View

Examples:

- Global socio-economic changes
- Global and enterprise trends, domain specific drivers, and technology advances
- Societal challenges, grand engineering challenges, and SE challenges
- Applications, practices, tools & environment, research, and competencies



V&R Roadmap Template

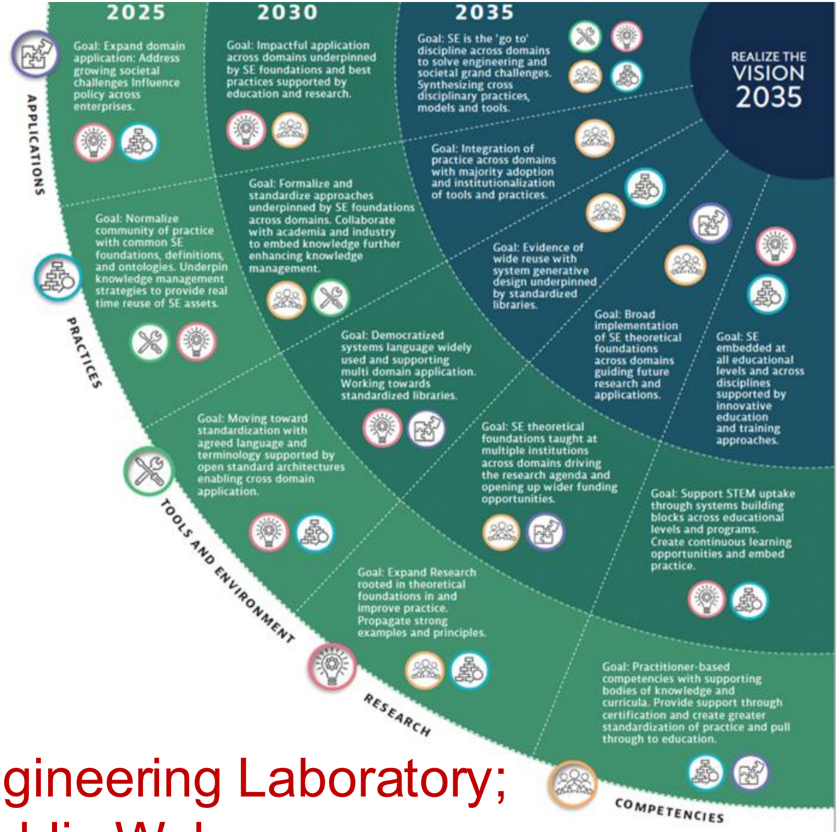
SysML Diagram View

High Level

- Categories to structure Roadmap
- Goals per Category

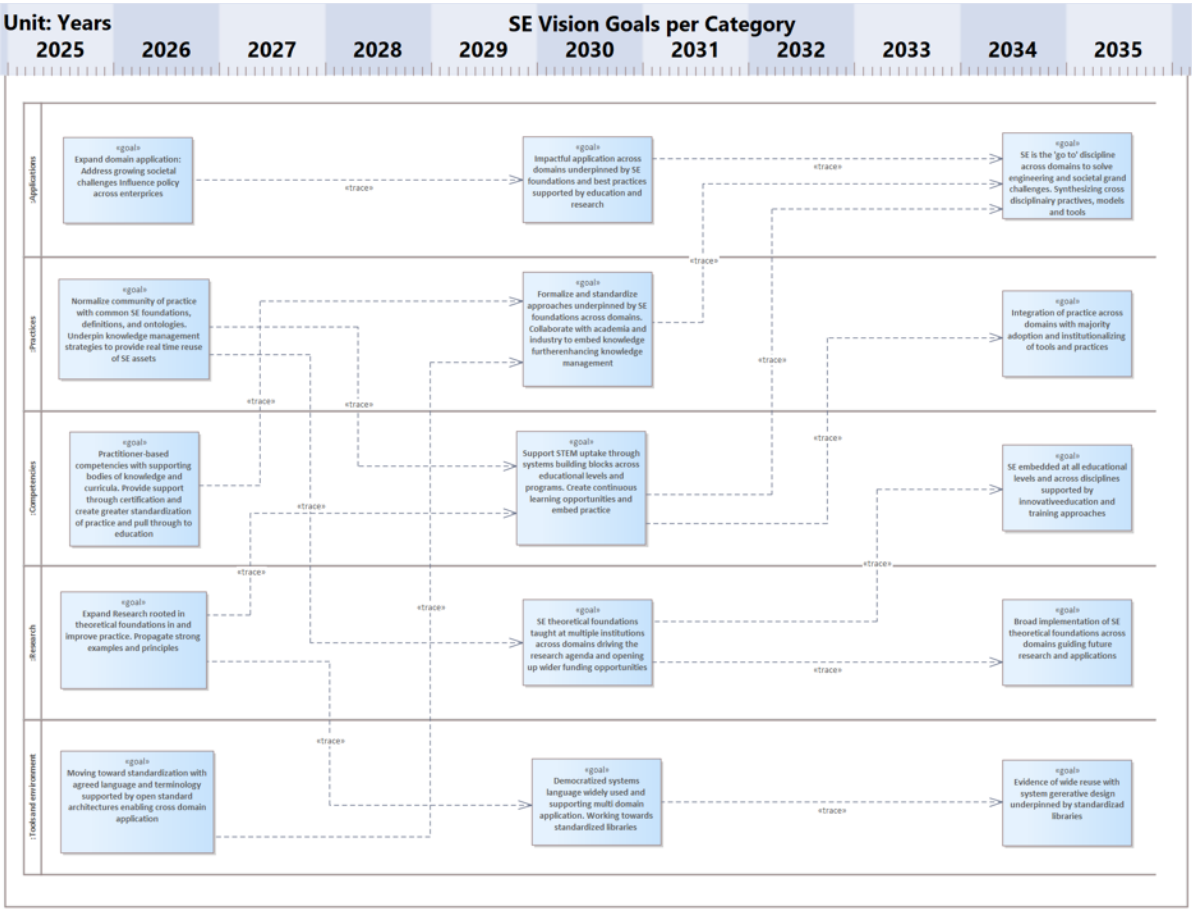
Lower Level

- Show balancing/reinforcing loops over Categories
- Show positive/negative links between Categories
- Show Capabilities per Sector/Chapter/WG



Host model in INCOSE Systems Engineering Laboratory;
Releases accessible on INCOSE Public Web
Solicit systems community review and feedback

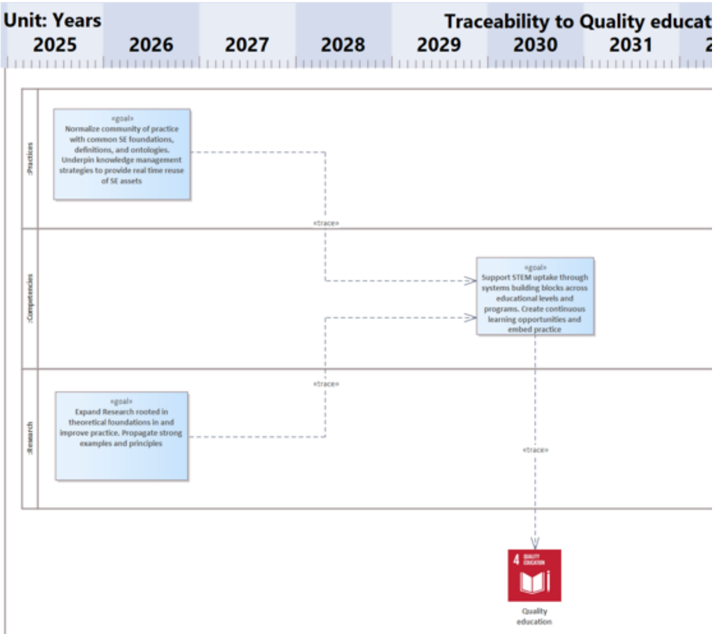
Roadmap Mockup in SysML



Roadmap Curated Mockup

Apply 7 +/- 2 rule:

- Create separate diagrams for each Sustainable Development Goal (SDG) or Grand Engineering Challenge (GEC)
- Create separate diagrams for each feedback loop
- Create separate diagrams per domain / story
- Visualize SysML blocks with SDG, GEC, and SE Vision 2035 category icons in SEV 2035 (pages 2, 13, 61)



V&R Modeling Activities

To be refined (TBR)

- Consolidate on modeling framework
- Integrate FuSE project roadmaps (Systems Security, Agile Systems, Decision Analysis Data Model to date) and systems community roadmaps (SERC/AIRC, SEI/CMU software engineering, IEEE technology to date)
- Collect/poll statements from different domains
- Connect statements to validate stories per domain [Reinforcing (R) / Balancing (B) causal loops]
- Trace stories to drivers, challenges, needs, and (recommended) changes
- Monitor effects, and outcomes per implemented change

V&R Project Timeline to IW2026

V&R Project Timeline

Version 1 Target is IW2026

Jul IS25	Aug	Sep	Oct	Nov	Dec	Jan	Feb IW26
Clarify/Model Context							
Scale V&R Team (Sectors, Chapters, WGs)							
Design Roadmap Template & Process							
Identify Stakeholders							
		Iteration 1	Review 1				
				Iteration 2	Review 2		
						Prepare IW2026	
			4Q25 BOD Brief(TBR)			1Q26 BOD Brief (TBR)	Rollout IW26

FuSE Project Portfolio

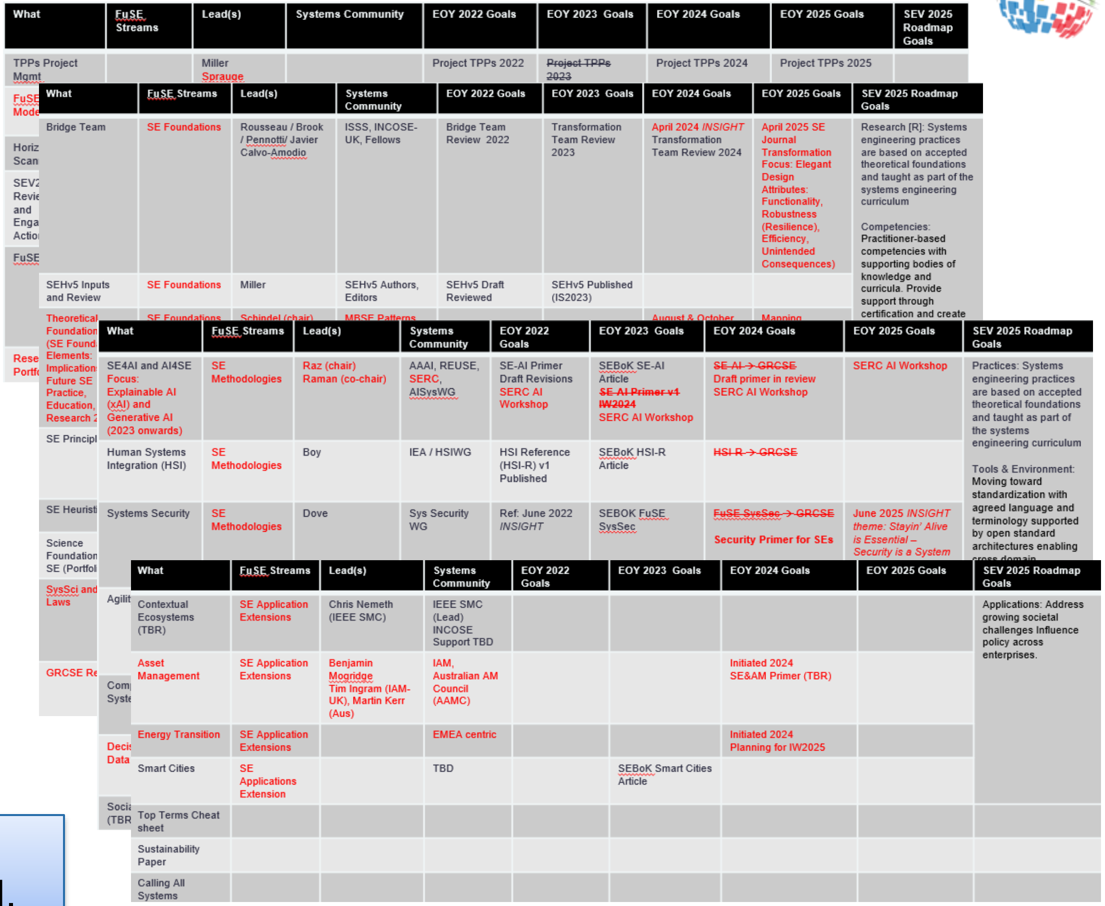
FuSE Project Streams

- Vision and Roadmaps (Lead S.J. (Bas) van der Leeuw)
- Foundations (Lead Oli de Weck with support from Joshua Sutherland) loosely coupled with
  - System Sciences Working Group (Chair Javier Calvo-Amodio) now including the “Bridge Team” focused on Elegant SE (Ref. Michael Griffin, “How do we fix system engineering:?” Prague, 2010)
  - Complex Systems working Group (Chair Dean Beale)
  - MBSE Patterns Working Group (Chair William D. (Bill) Schindel)
- Methodologies (Lead TBD) loosely coupled with
  - Loss-Driven SE Project (Chair John Brtis)
  - AI Systems Working Group (Chair Ali K. Raz) with support from Systems Engineering Research Center (SERC) https://sercuarc.org/event/ai4se-se4ai-workshop-2025/
  - Agile Systems and SE Working Group (Chair Rick Dove)
  - Decision Analysis Working Group (Chair Frank J. Salvatore)
  - Human Systems Integration (Chair Grace A. Kennedy)
  - Systems Security Engineering Working Group (Chair Rick Dove)
- Application Extensions (Lead Tom Strandberg)
  - Energy Transition (Swedish and Dutch Chapters)
  - Asset Management (UK)

FuSE Projects

- 28 projects tracked in FuSE
- Dashboard 11 projects being worked by Technical Operations working groups or initiatives
- 9 projects being worked with FuSE specific project teams (Bridge Team, Horizons Scanning, Heuristics Team, etc.)
- 2 projects completed or terminated
- 4 projects newly forming / pending start
- 2 projects overlap other existing Service Organizations (Academic Matters, Services)

Many publications, INSIGHT articles, SEBoK articles and inputs to SE Handbook produced.



What	FuSE Streams	Lead(s)	Systems Community	EOY 2022 Goals	EOY 2023 Goals	EOY 2024 Goals	EOY 2025 Goals	SEV 2025 Roadmap Goals
TPPs Project Mgmt		Miller Sprague		Project TPPs 2022	~~Project TPPs 2023~~	Project TPPs 2024	Project TPPs 2025	
FuSE Mode…								
Horiz… Scan…								
SEV2… Revie… and Enga… Actio…								
FuSE…								
Rese… Portf…								

What	FuSE Streams	Lead(s)	Systems Community	EOY 2022 Goals	EOY 2023 Goals	EOY 2024 Goals	EOY 2025 Goals	SEV 2025 Roadmap Goals
Bridge Team	SE Foundations	Rousseau / Brook / Pennotti/ Javier Calvo-Amodio	ISSS, INCOSE-UK, Fellows	Bridge Team Review 2022	Transformation Team Review 2023	April 2024 *INSIGHT* Transformation Team Review 2024	April 2025 SE Journal Transformation Focus: Elegant Design Attributes: Functionality, Robustness (Resilience), Efficiency, Unintended Consequences)	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…
SEHv5 Inputs and Review	SE Foundations	Miller	SEHv5 Authors, Editors	SEHv5 Draft Reviewed	SEHv5 Published (IS2023)			
Theoretical Foundation (SE Found… Elements: Implication… Future SE Practice, Education, Research…	SE Foundations	Schindel (chair)	MBSE Patterns			August & October	Mapping	
SE Principl…								
SE Heuristi…								
Science Foundation… SE (Portfol…								
SysSci and Laws								
GRCSE Re…								

What	FuSE Streams	Lead(s)	Systems Community	EOY 2022 Goals	EOY 2023 Goals	EOY 2024 Goals	EOY 2025 Goals	SEV 2025 Roadmap Goals
SE4AI and AI4SE Focus: Explainable AI (xAI) and Generative AI (2023 onwards)	SE Methodologies	Raz (chair) Raman (co-chair)	AAAI, REUSE, SERC, AISysWG	SE-AI Primer Draft Revisions SERC AI Workshop	SEBoK SE-AI Article ~~SE AI Primer v1 IW2024~~ SERC AI Workshop	~~SE AI → GRCSE~~ Draft primer in review SERC AI Workshop	SERC AI Workshop	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…
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	Ref: June 2022 *INSIGHT*	SEBOK FuSE SysSec	~~FuSE SysSec → GRCSE~~ Security Primer for SEs	June 2025 *INSIGHT theme: Stayin' Alive is Essential – Security is a System*	
Agilit…								
Comp… Syste…								
Decis… Data…								
Soci… (TBR…								

What	FuSE Streams	Lead(s)	Systems Community	EOY 2022 Goals	EOY 2023 Goals	EOY 2024 Goals	EOY 2025 Goals	SEV 2025 Roadmap Goals
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.
Asset Management	SE Application Extensions	Benjamin Mogridge Tim Ingram (IAM-UK), Martin Kerr (Aus)	IAM, Australian AM Council (AAMC)			Initiated 2024 SE&AM Primer (TBR)		
Energy Transition	SE Application Extensions		EMEA centric			Initiated 2024 Planning for IW2025		
Smart Cities	SE Applications Extension		TBD		SEBoK Smart Cities Article			
Top Terms Cheat sheet								
Sustainability Paper								
Calling All Systems								

Featured FuSE Projects

- Security Engineering (Systems Security Engineering Working Group, Chair Rick Dove)
- System Agility (Agile Systems and Systems Engineering Working Group, Chair Rick Dove)
- Decision Analysis Data Model (DADM) (Decision Analysis Working Group, Chair Frank Salvatore)
- Loss-Driven Systems Engineering (LDSE Project, Chair John Brtis)
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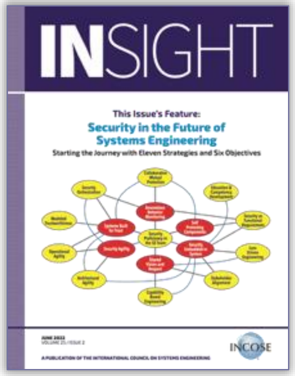
Security Engineering Roadmap (1 of 4)

Synergistic linkage of eleven strategic foundation concepts to six objectives



Security in the Future of Systems Engineering (FuSE)

Security Engineering Roadmap (2 of 4)

Concept	General Problems to Address	General Needs to Fill	General Barriers to Overcome
Security Proficiency in the Systems Engineering Team	Insufficient knowledge of system security engineering at the systems engineering level; communication across knowledge and expertise boundaries.	System security and its evolution effectively enabled by systems engineering activity.	Disrespect between systems engineering and security people; perception of security as non-functional requirement; finding high level security expertise (architecture/strategy/empathy).
Education and Competency Development	Inadequate security education integration with engineering education, creating a skills gap.	Education at all levels focused on security of cyber-physical systems.	Perception of insufficient scientific/technical rigor for inclusion in engineering programs; engineering faculty have a security knowledge gap.
Stakeholder Alignment	Misalignment of security vision among stakeholders. Inconsistent appreciation for security among stakeholders.	Common security vision and knowledge among all stakeholders.	Stakeholder willingness to engage in collaborative convergence.

Security Engineering Roadmap (3 of 4)

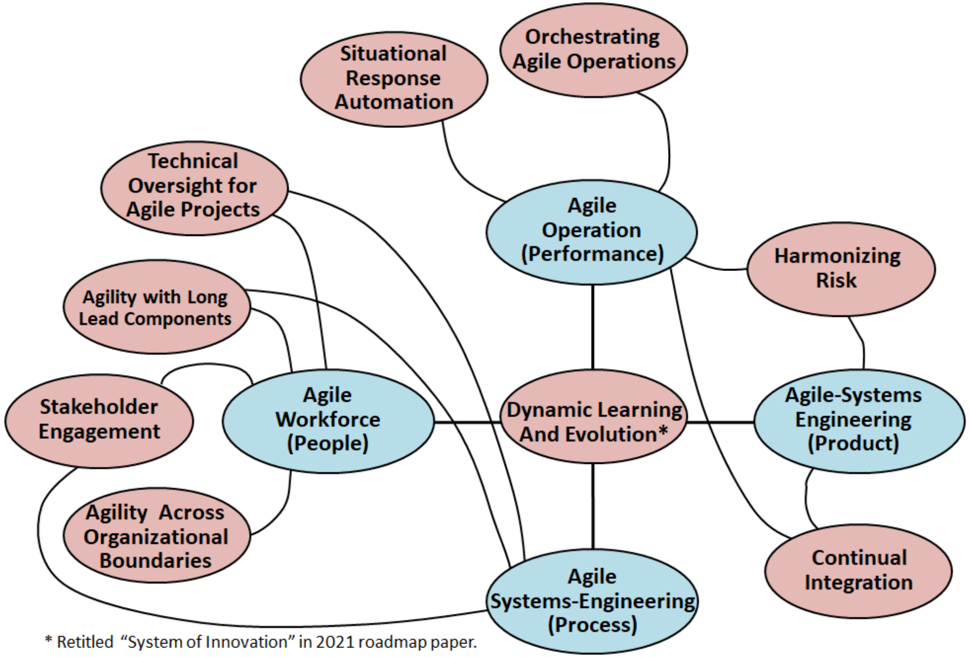
Concept	General Problems to Address	General Needs to Fill	General Barriers to Overcome
Loss-Driven Engineering	**Traditional vulnerability assessments and risk/consequence models for security, safety, and related 'ilities occur too late in the systems engineering process.**	**Standard metrics and abstractions relevant to all system lifecycle phases.**	**Cross domain vocabulary/taxonomy differences; insufficient respect for potential leverage; solution-rather than problem-dominant security thinking.**
Architectural Agility	Enabling effective response to innovative threats and attacks.	Readily composable and re-composable security with feature variants.	Comfort with and acceptance of a dynamic security profile.
Operational Agility	Timeliness of detection, response, and recovery.	Ability for cyber-relevant response to attack and potential threat; resilience in security system.	Comfort with and acceptance of a dynamic response and recovery capability.
Capability-Based Security Engineering	Security strategies based on available solutions rather than desired results.	Top-down approach to security starting with desired results/value.	Difference between capability and features; solution-dominant thinking; trust that the outcome will be satisfactory.

Security Engineering Roadmap (4 of 4)

Concept	General Problems to Address	General Needs to Fill	General Barriers to Overcome
Security as a Functional Requirement	As a non-functional requirement, systems security does not get prime systems engineering attention.	Systems engineering responsibility for the security of systems.	Cultural inertia that prioritizes system purpose over viability.
Modeled Trustworthiness	Systems Security has moved away from its traditional focus on trust to a more singular focus on risk.	Reinvigorate formal modeling of system trust as a core aspect of system security engineering; address issues of scale with model-based tools and automation.	Entrenched risk-based practices and education; simplicity of communicating and comparing risk metrics; perception of security as a non-functional requirement.
Security Orchestration	Disparate security solutions operate independently with little to no coordination.	Tightly coupled coordinated system defense in cyber-relevant time.	Independent stovepipe solution tools; multiple disparate stakeholders; hesitation to explore interdependencies.
Collaborative Mutual Protection	Insufficient detection capability for innovative attack methods with dedicated purpose security components.	Augmented detection and mitigation of known and unknown attacks with components collaborating for mutual protection.	Trust in the security of the approach; trust in the emergent result.

System Agility Roadmap (1 of 4)

Synergistic linkage among nine strategic foundation concepts and four objectives



* Retitled "System of Innovation" in 2021 roadmap paper.

System Agility Roadmap (2 of 4)

Synergistic linkage among nine strategic foundation concepts and four objectives

Concept	General Problems to Address	General Needs to Fill	General Barriers to Overcome
Dynamic Learning and Evolution	Insufficient learning and knowledge management processes; barriers to learned-knowledge application.	Situational awareness and learning embedded in lifecycle processes; timely/affordable learning-application; knowledge management.	Unclear what to do or where to do it beyond learning ceremonies and contract obligation satisfaction.
Technical Oversight	Traditional technical oversight methods are counterproductive in agile programs.	An interactive approach that reveals relevant knowledge for guidance and decision making.	Oversight traditions; standard contract wording; disrespect for oversight.
Stakeholder Engagement	Timeliness and depth of stakeholder collaborative engagement.	Discovery of true requirements and integration conflicts.	Time involved; travel cost; inconvenient scheduling; lack of motivation.
Agility Across Organizational Boundaries	Incompatible siloed cultures and languages.	Common language; less handoffs; product-based teams; common metrics.	Functional organizational silos.

System Agility Roadmap (3 of 4)

Synergistic linkage among nine strategic foundation concepts and four objectives

Concept	General Problems to Address	General Needs to Fill	General Barriers to Overcome
Agility with Long Lead Components and Dependencies	Components and external dependencies with long lead times complicate schedule coordination and disrupt technical performance.	Scheduling and acquisition techniques that better align with agile-SE principles.	[False] justification that long-lead items prohibit the use of agile-SE.
Continual Integration	Late discovery of integration and requirements issues.	Minimize risk and rework with fast learning; maximize stakeholder engagement.	Development effort and expense; technologies for integrating/testing software before hardware is ready.
Orchestrating Agile Operations	Coherence among loosely coupled multi-actor outcomes.	Dynamic operational coordination in real-time.	Ability to encode self-learning; adaptive logic as decision-support for people and for autonomous decision making.

System Agility Roadmap (4 of 4)

Synergistic linkage among nine strategic foundation concepts and four objectives

Concept	General Problems to Address	General Needs to Fill	General Barriers to Overcome
Situational Response Automation	Decision and action too slow.	Continual dynamic adaptation within cyber-relevant time.	Complicatedness of encoding autonomous governance and adjudication logic and rules; situational awareness that provides necessary inputs.
Harmonizing Risk in Agile Operations	Agility focus is principally loss avoidance	Expand awareness and operational realization of both the negative side of risk (loss) and the positive side of risk (opportunity, seek gain, optimize).	Silo-thinking and predominance of looking at risk only in terms of loss.

Decision Analysis Data Model (DADM) Roadmap (1 of 3)

Realize the SE Vision 2035 objectives for analytical frameworks, data-centricity, model re-use

1 Develop a reusable Decision Analysis Data Model to support SE Vision 2035

2 Integrate Decision Management Life Cycle Process in MBSE

3 Enhance Data Driven Decision Making with Models

The DADM is an INCOSE product that is **available on SE Lab** for INCOSE members to use

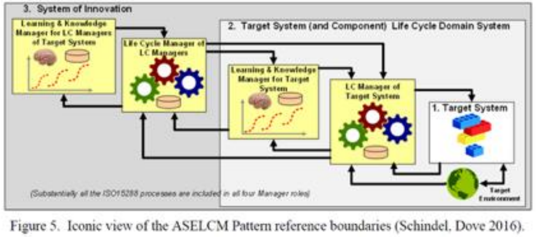
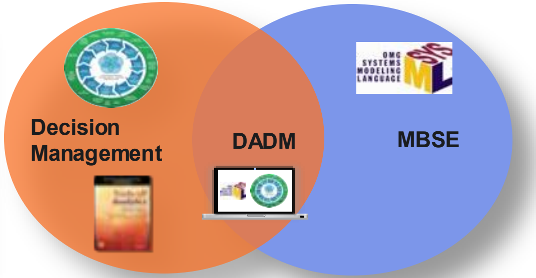


Figure 5. Iconic view of the ASELCM Pattern reference boundaries (Schindel, Dove 2016).

The DADM is a data model validated against a **Decision Analysis Process Model** flexible to multiple domains and lifecycle stages

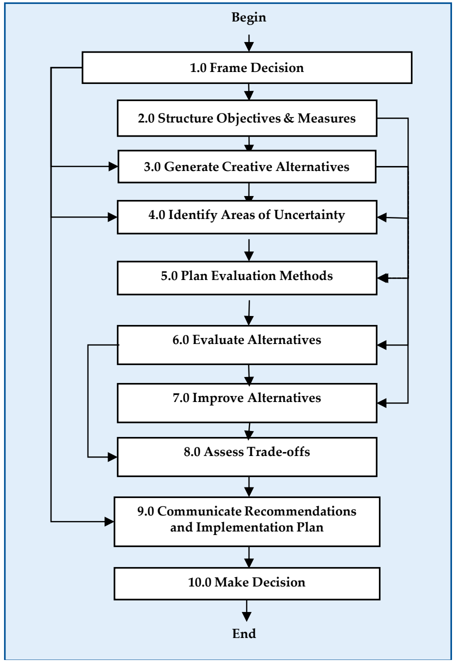


The DADM enhances pre-existing SE literature by **incorporating system modeling and data architecture practices** into decision analysis.

Decision Analysis Data Model (DADM) Roadmap (2 of 3)

Realize the SE Vision 2035 objectives for analytical frameworks, data-centricity, model re-use

Process Model



Value-Added Data Artifacts

Stakeholders, Stakeholder Need, Decision Context, Scenarios, Use Cases, Vision, Issues, Decision Hierarchy, Influence Diagram, Uncertainty, Decision Frame

Values, Decision Objectives, Value Measures ((Performance, Cost, and Schedule), Value Hierarchy, Requirements

Context, Value Hierarchy, Qualitative Value Space, Options, Potential Alternatives

Decision Frame, Value Hierarchy, Scenarios, Use Cases, Uncertainties (Stakeholder, Performance, Cost, Schedule, Other, Courses of Action, Previous)

Previous Systems Analysis Plan, Value Hierarchy, Courses of Action, Data, Models, Simulations, Assessment Flow Diagram

Assessment Flow Diagram, Quantitative Value Model, Alternative Values, Deterministic Analysis, and Probabilistic Analysis

Risk Treatments, Opportunity Treatments, Revised Courses of Action, Reevaluate Alternatives

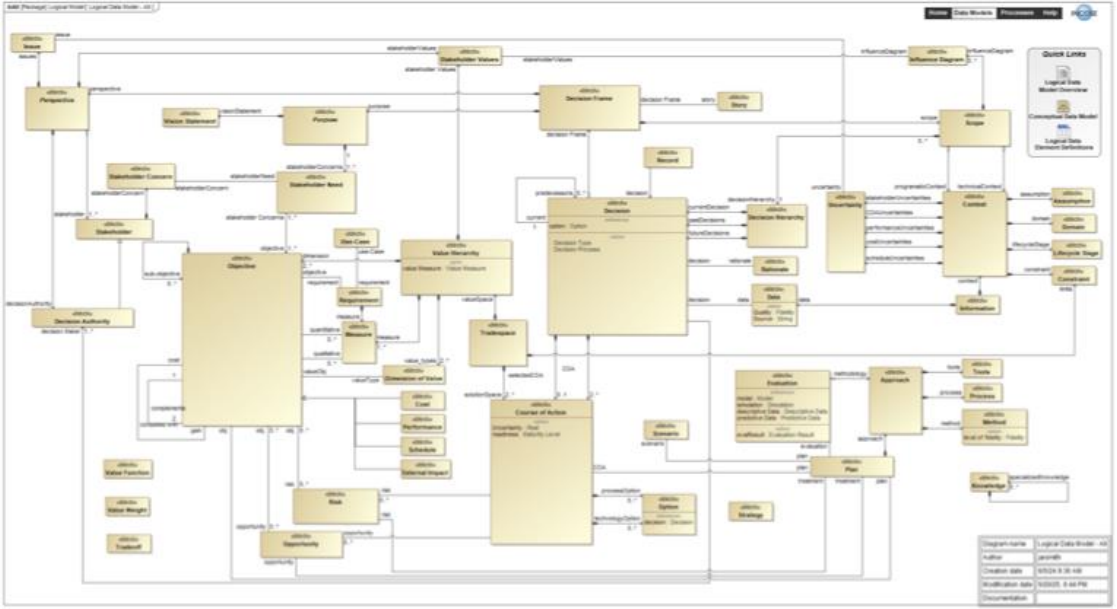
Value Hierarchy, Courses of Action, Tradespace Analysis (Deterministic, Probabilistic), Trade-offs

Decision Frame, Value Hierarchy, Courses of Action, Requirements, Decision Story, Recommendation, Risks, Implementation Plan

Decision Hierarchy, Value Hierarchy, Tradespace, Course of Action, Rationale, Implementation Plan, Decision Record

Decision Analysis Data Model (DADM) Roadmap (3 of 3)

Realize the SE Vision 2035 objectives for analytical frameworks, data-centricity, model re-use



- Explicitly define the data needed for a quality decision
- This definition enables consistency across decisions
- This consistency enables the reuse of past decisions in future decisions
- This chain of decisions enables real analytics for decision quality and program outcomes for an organization

The logical data model represents a comprehensive Decision Analysis process and data definition that supports decision management in the system life cycle.

Loss-Driven Systems Engineering (LDSE) Project

Purpose:

Eliminate the silos and achieve unification of the loss-driven quality characteristics such as security, safety, resilience, operational risk, environmental protection, availability, etc.

– Reducing engineering effort by eliminating redundant efforts among the quality characteristics

– Ensuring effective solutions that address the interests of multiple loss-driven quality characteristics

– Eliminating conflicts among the loss-driven solutions

– Reducing the load of data generated by multiple quality characteristics to a minimal, non-redundant set

– Achieving mutual learning among the loss-driven quality characteristics

Outcomes (Products/Services)

Generate periodic white papers for presentation at INCOSE events, which will also be reflected in SEBOK updates. The work will span, two to three years, culminating in a primer, a handbook, revised SEBOK articles on LDSE, the creation of a new loss-driven enabling domain, and the creation of new LDSE content for the next revision of the Systems Engineering Handbook.

The State of the Systems Engineering Discipline: A Longitudinal Analysis of INCOSE International Symposium Contributions (2012–2025

First-of-its-kind meta-analysis of data structured and maintained by INCOSE International Symposia submission database providing unprecedented insights into systems engineering evolution.

Two key findings of concern show:

1. Reduction in foundation papers & presentations over time in favor of MBSE applications
2. Few contributions validating methodologies.

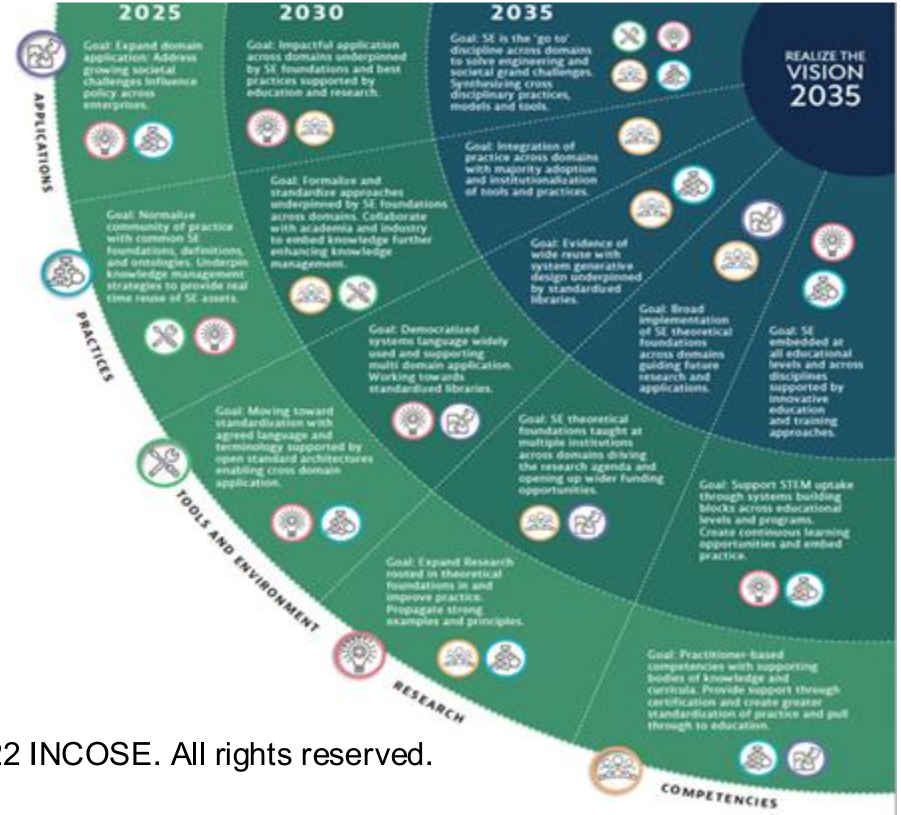
Results corroborate observations of FuSE Foundations stream lead Oli de Weck (IW2023 FusE Keynote):

- We are in a transition phase between practice (with plenty of heuristics and data) and the beginnings of a deeper theory
- What are the laws that can accurately predict the behavior of complex systems under a set of given assumptions ?
- In order for any “laws” to be accepted as true, there needs to be a set of experiments and data to validate (or falsify) them.

Meeting SEV2035 Goals for 2025

Systems Engineering Vision 2035 Top-Level Roadmap

SEV2035 Category Goals are Interdependent Across Categories



SEV2035 Roadmap 2025 Goals and Targets

To be refined (TBR)

	2025 Goals	Targets (To be Refined)
Applications	Expand domain application: Address growing societal challenges Influence policy across enterprises.	Establish energy transition initiative (NL, SE. AU, US-OH chapters) (?) Gaps?
Practices	Normalize community of practice with common SE foundations, definitions, and ontologies. Underpin knowledge management strategies to provide real time reuse of SE assets.	INCOSE SE Handbook 5e (?) Baseline Agile Systems, Systems Security, AI, Human Systems Integration, Complex Systems WGs products Gaps?
Tools & Environment	Moving toward standardization with agreed language and terminology supported by open standard architectures enabling cross domain Application	TBD re MBSE and Digital Engineering (DE) Gaps?
Research	Expand Research rooted in theoretical foundations in and improve practice. Propagate strong examples and principles.	Baseline current theoretical foundations: SE Principles, MBSE Patterns and Systems Science WG products. Gaps? Establish research topic portfolio from identified gaps.
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	Competency framework as baseline. Gaps? Initiate GRCSE (Professional Master's degree) revision

BLUF Redux

Refining the Vision – Findings

- We need to place significant attention of the system definition and realization processes and practices, as these will change with respect to their application, methods, timing, and support from modeling/analytics
- Emerging technologies critically dependent on computing, software, and algorithms
- Machine learning (ML) and AI, in combination with complement physics-based/analytic models, can significantly accelerate system definition from 2 to 3 orders of magnitude or more, but come with challenges, especially for V&V,

Vision Refinement and Roadmaps (V&R)

- Roadmap realization categories are interdependent (Competencies, Research, Tools & Environment, Practices, Applications)
- Causal loop models of interdependencies underlying V&R models
- Host V&R models in INCOSE SE Laboratory
- V&R Releases on Public INCOSE Web for Review and Feedback

V&R Project Timeline

- Quarterly Status Updates to BoD
- V&R Release 1 December 2025
- Rollout IW2026