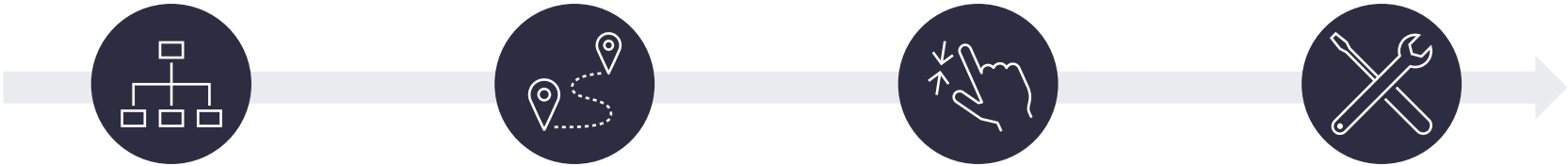
The Future of Systems Engineering: Realizing the Systems Engineering Vision 2035.

A Systems Community Initiative

FuSE Mini-Event: Introduction and Update, 29 March 2023

William D. Miller
Future of Systems Engineering Lead

First FuSE Mini-Event Series



MAR 29, 2023

Future of Systems Engineering (FuSE) Introduction and Update And FuSE Foundations Overview

APR 06, 2023

Future of Systems Engineering (FuSE) Vision & Roadmaps

APR 13, 2023

FuSE Application Extensions – SE and Asset Management

APR 20, 2023

FuSE Methodologies Virtual Workshop

Visit https://www.incose.org/about-systems-engineering/fuse
or https://www.incose.org/events-and-news for details and registration information

FuSE Mini-Event: Introduction and Update
29 March 2023

- Future of Systems Engineering (FuSE) Initiative Introduction and Update – William Miller
- FuSE Foundations Stream Overview and Update – Joshua Sutherland
- Q&A

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Systems Engineering Vision 2035

Executive Summary

- The Global Context for Systems Engineering
- The Current State of Systems Engineering
- The Future State of Systems Engineering
- Realizing the Vision

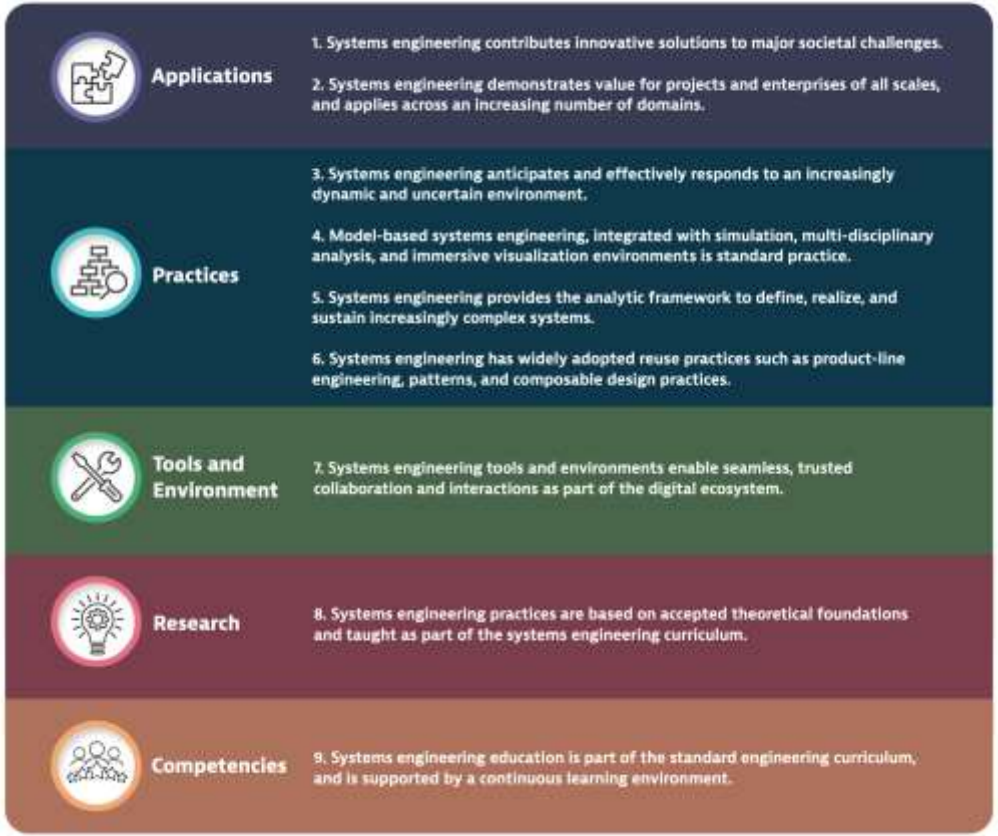
5 Categories:

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

Understanding Socio-Technical Complex Systems with Human Systems Integration Methods Applied to Major Societal Challenges

- The future of systems engineering is **model-based**, leveraging next generation modeling, simulation, and visualization environments powered by the global digital transformation, to specify, analyze, design, and verify systems. High fidelity models, advanced visualization, and highly integrated, multi-disciplinary simulations will allow systems engineers to evaluate and assess an order of magnitude more alternative designs more quickly and thoroughly than can be done on a single design today.
- **Artificial Intelligence**, powered by large data sets and expert domain knowledge will drive major changes in systems engineering methods and tools, and within systems themselves, as algorithms are developed to assist the systems engineer be more efficient and effective to deliver solutions.
- **Data science** techniques will be infused into the systems engineering practice to help make sense of large-scale data sets and assess complex systems. Further, the rapidly expanding set of data science tools will be an important part of an integrated analytic framework for systems engineering.
- **Human-systems integration** practices will become essential to design smart systems that can effectively interact with humans, and account for increasing levels of systems complexity and autonomy.
- The **theoretical foundations** for systems engineering will be based on established science and mathematics that characterize systems phenomena and stakeholder value, and provide the basis for systems education and evolving methods and tools.
- Ongoing **education and training** of systems engineers and the infusion of systems thinking across a broad range of the engineering and management workforce will meet the demands for a growing number of systems engineers with the necessary technical and leadership competencies.
- **Systems engineering will be embraced by a greater number and broader range of small and medium enterprises and will be continually adapted to manage systems complexity while also driving incremental market value.**

Systems Engineering Challenges



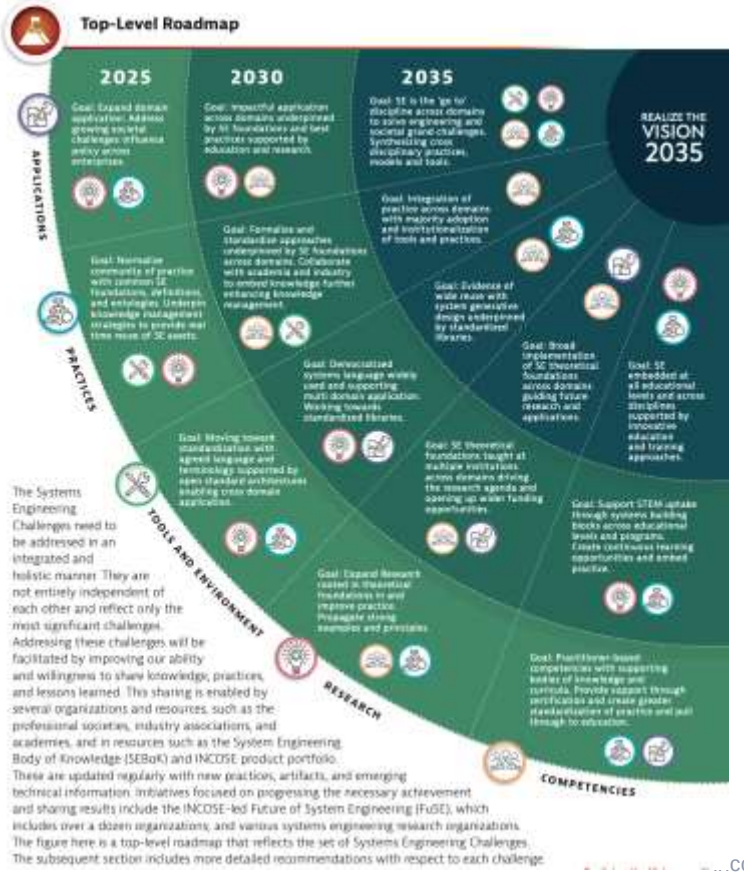
Realizing the Vision: Top-Level Roadmap

The figure here is a top-level roadmap that reflects the set of Systems Engineering Challenges.

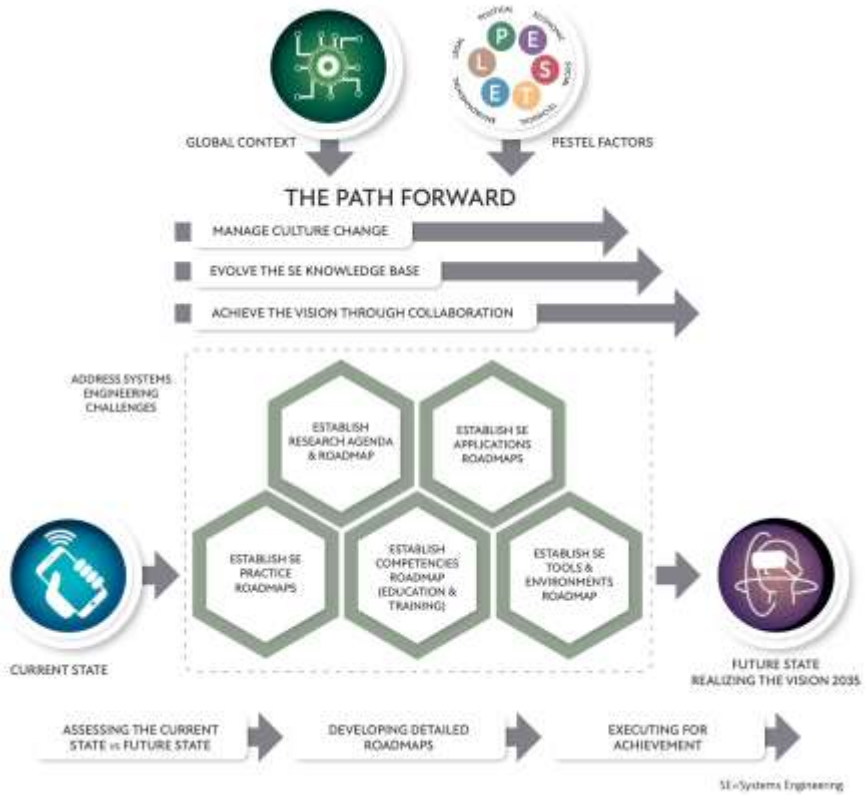
The Systems Engineering Challenges need to be addressed in an integrated and holistic manner. They are not entirely independent of each other and reflect only the most significant challenges.

Addressing these challenges will be facilitated by improving our ability and willingness to share knowledge, practices, and lessons learned. This sharing is enabled by several organizations and resources, such as the professional societies, industry associations, and academies, and in resources such as the System Engineering Body of Knowledge (SEBoK) and INCOSE product portfolio.

These are updated regularly with new practices, artifacts, and emerging technical information. Initiatives focused on progressing the necessary achievement and sharing results include the INCOSE-facilitated Future of System Engineering (FuSE), which includes over a dozen organizations; and various systems engineering research organizations.



Realizing the Vision: The Path Forward



"When the rate of change inside an institution becomes slower than the rate of change outside, the end is in sight. The only question is when."

Jack Welch, General Electric Chairman and CEO (1981-2001)

"Our situation is not comparable to anything in the past. It is impossible, therefore, to apply methods and measures which at an earlier age might have been sufficient. We must revolutionize our thinking, revolutionize our actions …."

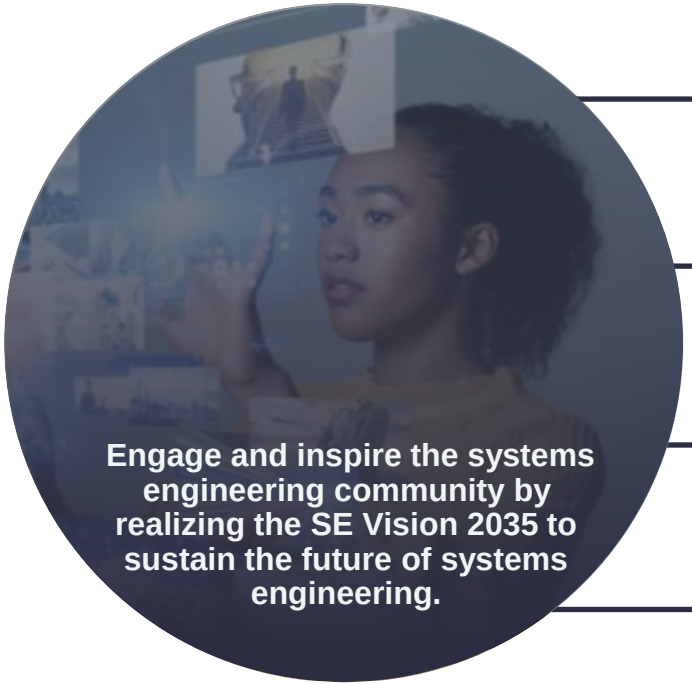
Albert Einstein (1948) in "A Message to Intellectuals"

"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind."

William Thomson, Lord Kelvin (1824-1907)

Program Overview

FuSE Program Mission Statement



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.

FuSE Program Charter

Vision Statement

Inspire the global community to realize the Vision of SE

Mission

Engage and inspire the systems community for sustaining the future of systems engineering in realizing the SE Vision 2035

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

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

FuSE **fosters involvement and collaboration** within and outside of INCOSE.

FuSE **educates, shares success, and expands**.

Success Factors

Inclusive: From an exclusive club to inclusive initiative

Attractive: Engage members and non-members

Implementation: The degree to which the road map is realized

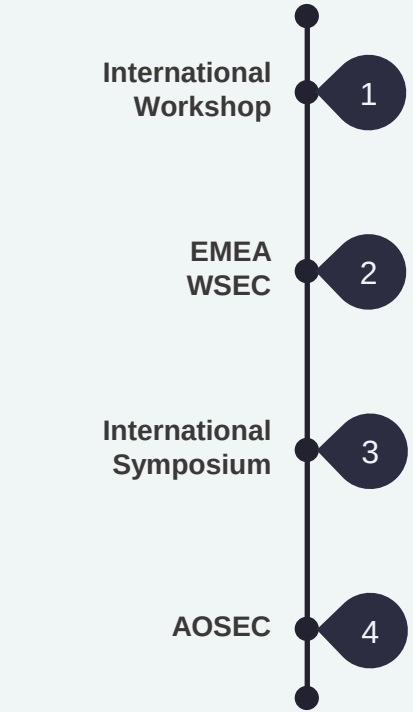
Fresh: Relevant and updated road map and context

Close to application: Involvement of companies and domains

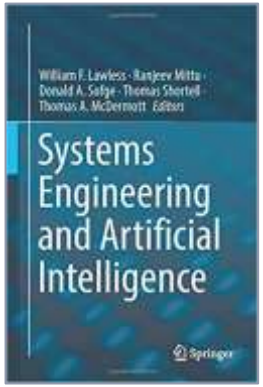
Global promotion: Attractive global digital marketing

Passion: To get the working group proud to be part of it

2023 Milestones



FuSE Journey Beginning IW 2018



The Systems Community Initiative Facilitated by INCOSE

Engagement with INCOSE Working Groups, Initiatives, and Periodicals

SEBoK

INSIGHT Practitioners' Magazine

Systems Engineering Journal

Systems Engineering Vision 2035

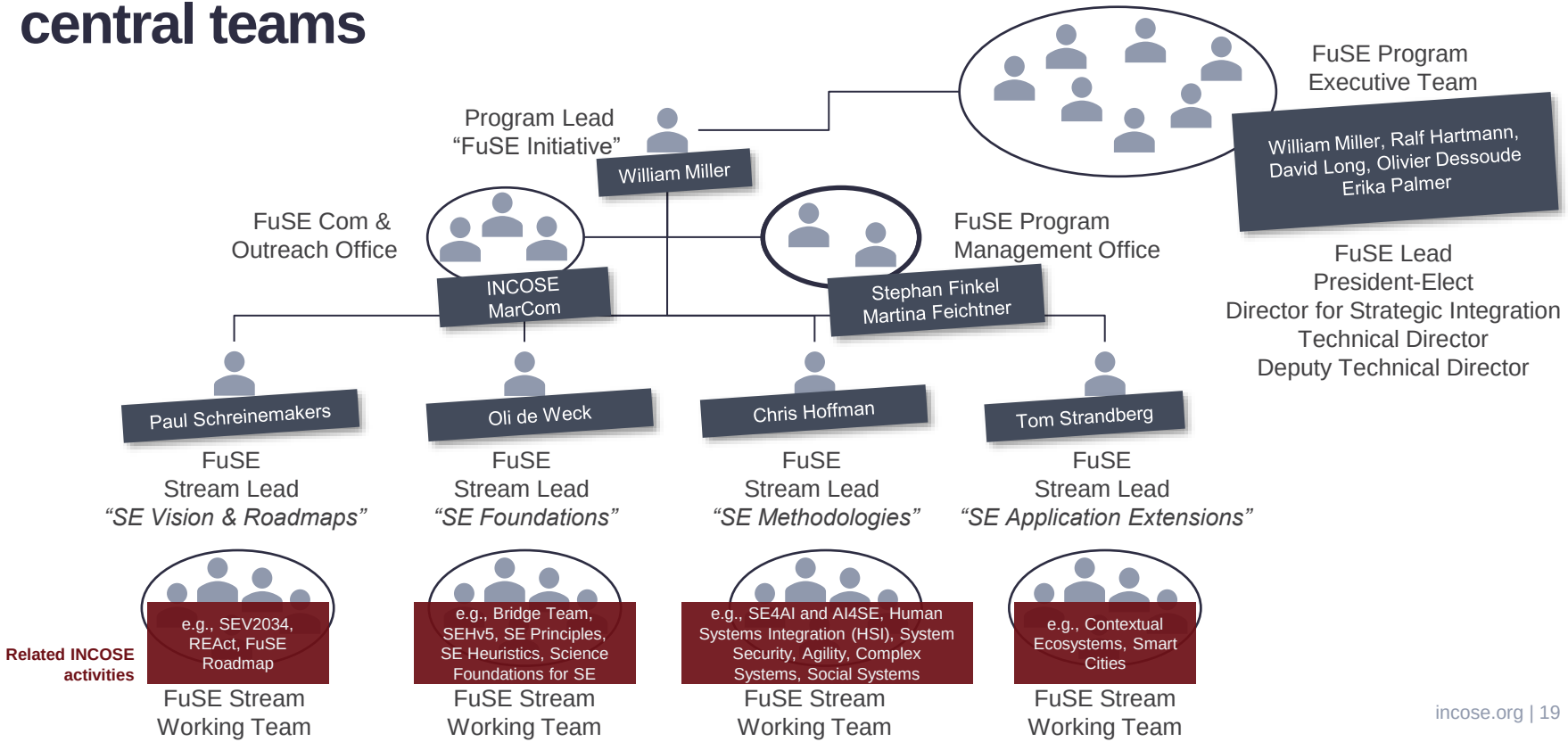
SE Principles Action Team

Current and potential FuSE intra INCOSE engagements

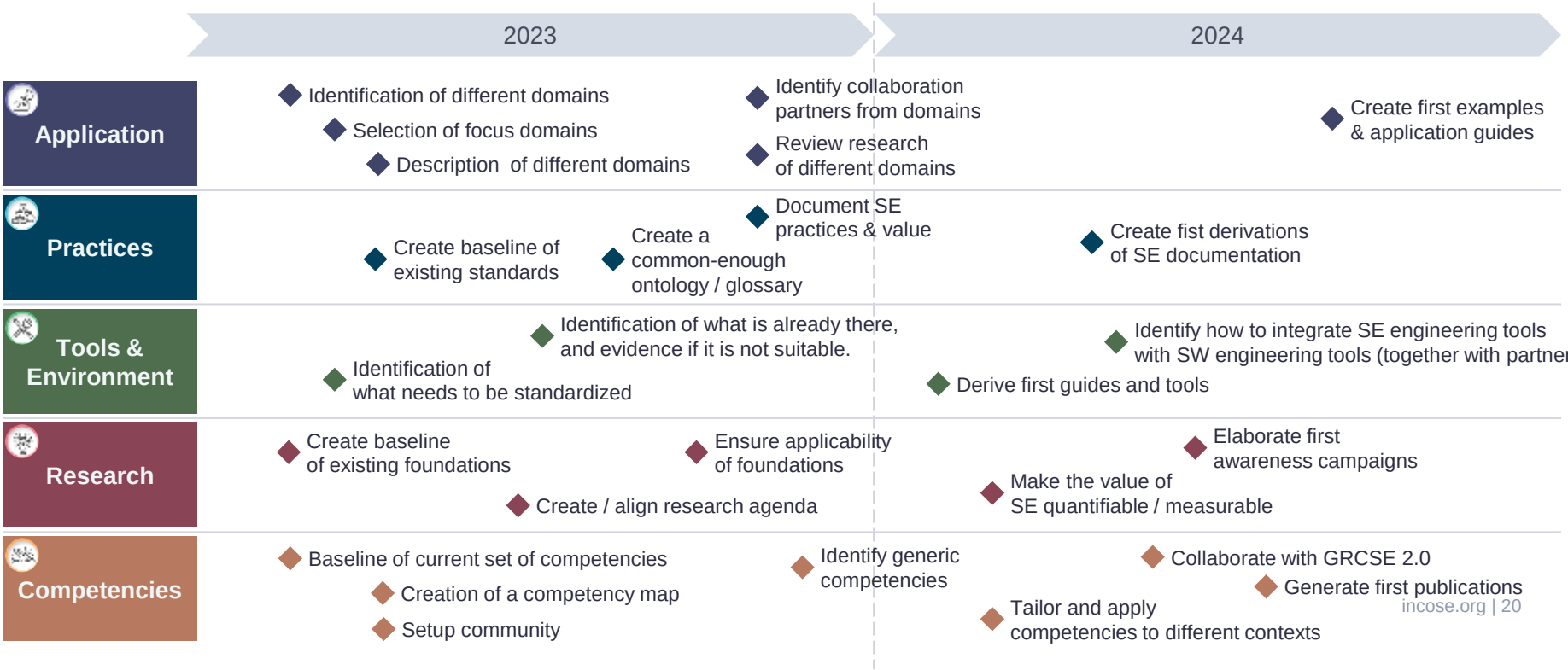
Future of Systems Engineering Projects Dashboard

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	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	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	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 Primer v1 Published	SE-AI → GRCSE	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	Ref: June 2022 *INSIGHT*	SEBOK FuSE SysSec	FuSE SysSec → GRCSE	
Agility	SE Methodologies	Dove Larri Rosser (support)	Agile Sys & SE WG		SEBoK SE Agility Article	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		

The FuSE program is organized in 4 streams with additional central teams



Sequence of SE Vision 2035 elements for 2025 goals




FuSE
Future of Systems Engineering
IW 2023

Keynote:
The First Law of Systems Science: Conservation of Complexity

Prof. Olivier de Weck, INCOSE Fellow
Massachusetts Institute of Technology

deweck@mit.edu

FuSE at IW 2023 overview

	SAT	SUN	MON	TUE
08:00		FuSE Stream Working Sessions 4 rooms (in person only)	FuSE Stream Working Sessions 4 rooms (in person only)	
08:30				Wrap-up FuSE (for participants)
09:00				
09:30	Break			
10:00	FuSE Kick-off	Break		
10:30				
11:00				Wrap-up FuSE
11:30				
12:00	Lunch			
12:30				
13:00				
13:30				
14:00	FuSE Stream Working Session 4 rooms (in person only)			
14:30		B		
15:00	Break			
15:30	FuSE Steam Working Session 4 rooms (in person only)			
16:00				
16:30				

Rooms for FuSE Stream Sessions:

Vision & Roadmaps Stream: Ballroom

Foundations Stream: Salon A

Methodologies Stream: Salon D

Application Extensions Stream: Salon C

The FuSE Setup at IW was well received.

Systems Engineering Vision & Roadmaps Stream

Paul Schreinemakers
Stream Lead “SE Vision & Roadmaps”

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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.

The IW 2023 goal is to frame the structural relationships and value models for the roadmaps’ creation.

	SAT	SUN	MON	TUE
08:00		1. How we keep collecting feedback 2. Elaborate on roadmap items to address in each stream 3. Elaborate on projection of the challenges on each stream 4. Set up an Inventory	Which WG's and external organizations are to be involved in the efforts identified	
08:30				Wrap-up FuSE (for participants)
09:00				
09:30	Break			
10:00	FuSE Kick-off	Break		
10:30				
11:00				Wrap-up FuSE
11:30				
12:00	Lunch			
12:30				
13:00				
13:30				
14:00	Introduction, Activities for 2023, Prioritization of roadmap topics to be addressed			
14:30		Break		
15:00	Break			
15:30	Introduction, Activities for 2023, Prioritization of roadmap topics to be addressed			
16:00				
16:30				

Key Insights Vision & Roadmaps Stream

Topics

- Get familiar with SE Vision 2035, roadmaps, and actions to be done.
- Generate first insights on what is needed to realize the SE Vision 2035
- Identify missing elements of the SE Vision 2035
- Collect means to keep the SE Vision a living document

Key Insights

- The goals stated in the SE Vision 2035 needs to be made measurable.
- It is crucial to involve a young and diverse community (within and outside) of INCOSE to realize the SE Vision 2035.
- Specific measures to do the above were conceptualized at IW

Systems Engineering Foundations Stream

Oli de Weck
Stream Lead “SE Foundations”

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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.

The IW 2023 goal is to assess the foundational value of the “Conservation of System Complexity,” which parallels the Conservation of Energy in the First Law of Thermodynamics and the Conservation of Mass in continuum mechanics.

	SAT	SUN	MON	TUE
08:00		FuSE Interactive working session on technical complexity	FuSE Working Sessions on organizational complexity	
08:30				Wrap-up FuSE (for participants)
09:00				
09:30	Break			
10:00	FuSE Kick-off	Break		
10:30				
11:00				Wrap-up FuSE
11:30				
12:00	Lunch			
12:30				
13:00				
13:30				
14:00	FuSE Interactive working session Conduct complexity experiment Frame SE Foundations			
14:30		Break		
15:00	Break			
15:30	FuSE Interactive working session Conduct complexity experiment Frame SE Foundations			
16:00				
16:30				

Key Insights Foundations Stream

Topics

- Introduced proposed **1st law** "Conservation of Complexity"
- Ran experiment on complexity designing a transport system to **test our hypotheses**, i.e. effort increases with complexity, etc.
- Shared case study on "technical complexity" usin **Jet Engine** evolution, did group breakout work to **understand complexity drivers**
- Shared case study on "organizational complexity using **SLS and Space X Falcon 9**, did group breakout work to **understand complexity drive**
- **System Science WG** shared state of their work

Key Insights

- Generated data via the complexity **experiment**, need to post process data and **verify or falsify** our initial assumptions
- Experiment was fun and mimics SE reality, but needs refinement to be even more realistic
- Group breakout on technical complexity did confirm our basic direction, but also revealed additional drivers we need to considered
- Involvement of SSWG highlighted what is already existing and benefits of joining forces
- Group breakout on org complexity illustrated need for more discussion and alignment on how to model org complexity

Systems Engineering Methodologies Stream

Chris Hoffman
Stream Lead “SE Methodologies”

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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.

The IW 2023 goal is to assess the adequacy of current INCOSE technical products and ongoing FuSE projects in this stream and identify gaps.

	SAT	SUN	MON	TUE
08:00		Elaborate disruptors: 1. Scale & Interrelatedness 2. Complexity, Chaotic, Complicated, Clear 3. A.I. for SE, other technologies 4. TBD by participants	Clarify problems / opportunities: 1. Digital ecosystem 2. Software as the capability driver 3. Continuous iterative model development 4. Evolution in learning systems	
08:30				Wrap-up FuSE (for participants)
09:00				
09:30	Break			
10:00	FuSE Kick-off	Break		
10:30				
11:00				Wrap-up FuSE
11:30				
12:00	Lunch			
12:30				
13:00				
13:30				
14:00	Introduction, Activities for 2023, Initial feedback, Opt-in participation			
14:30		Break		
15:00	Break			
15:30	Introduction, Activities for 2023, Initial feedback, Opt-in participation			
16:00				
16:30				

Key Insights Methodologies Stream

Topics

Introduced the stream´s purpose, content and goals.

Major disrupters and obstacles for advancing systems engineering methodologies were captured.

Selected disrupters were clarified with solution proposals generated.

A needs gathering form for solution proposals was shared @ www.incose.org/needs

Key Insights

Disrupters were multi-dimensional and included:

- Lack of training
- Past failures leading to low trust of new items
- Limited resources
- Impeded development of practical SE methods
- Lack of support to change (stagnated culture)

Solution proposals were generated and initially screened. Work remains to form and select the highest potential solutions to focus upon.

Systems Engineering Application Extensions Stream

Tom Strandberg
Stream Lead “SE Application Extensions”

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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.

The IW 2023 goal is to frame the value model to justify systems engineering’s role at the policy table for these grand challenges.

	SAT	SUN	MON	TUE
08:00		1. How SE supports sustainable cities 2. How SE supports innovation	1. SE to improve public spending (joint effort – physical – asset management) 2. Integrate soft systems, social systems and other initiatives for grand challenges	
08:30				Wrap-up FuSE (for participants)
09:00				
09:30	Break			
10:00	FuSE Kick-off	Break		
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15:00	Break			
15:30	Introduction, Activities for 2023, Initial feedback			
16:00				
16:30				

Key Insights SE Application Extensions

Topics

Validating the stream´s **purpose**, content and goals

Topics for extending SE applications proposed validated fit for purpose:

- Smart Cities
- Innovation
- SE and Asset Management
- Grand Challenges

Key Insights

SE Application Extensions stream **purpose and topics** have been **validated. MoE, risks and activities** have been **proposed** by the participants.

Smart Cities – good foundation exists for reaching out to internal & external groups. Next step is the validation by application together with mayors or alike.

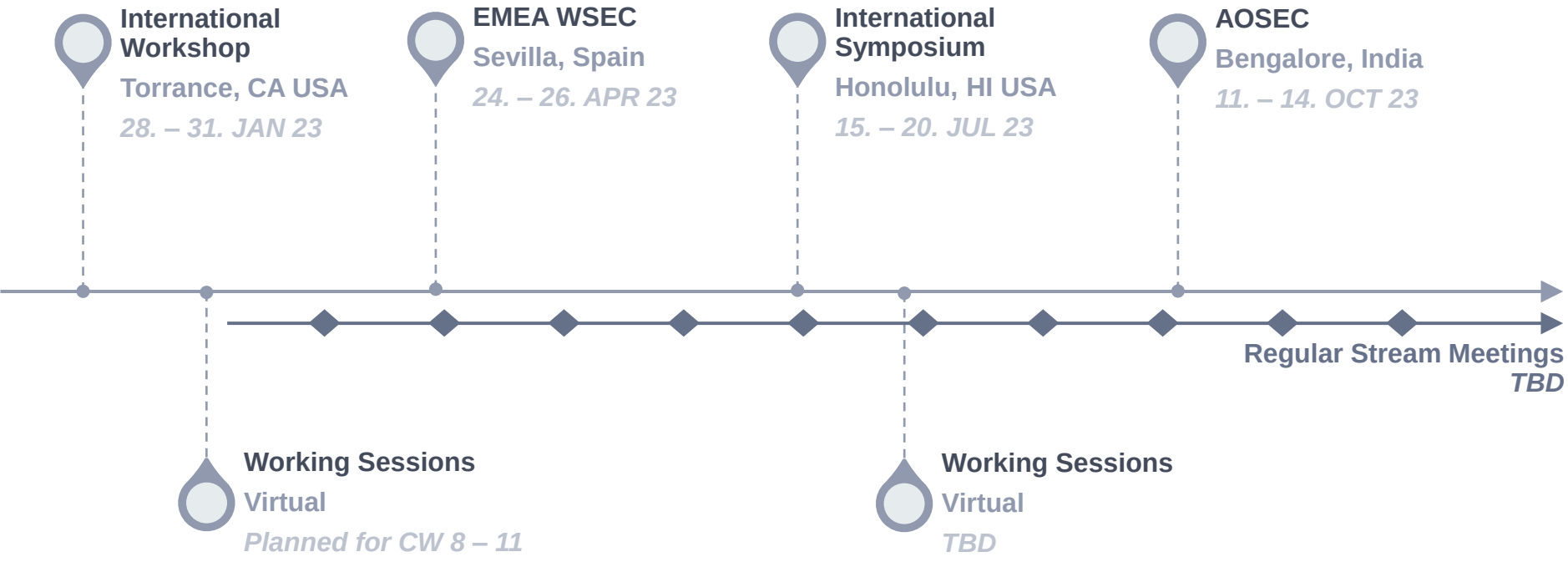
Innovation – an innovation framework based on systems thinking identified to be a useful means to engage with new target groups. Good potential for collaboration between WGs.

Asset Management – Value and interest to cooperate with the Institute of Asset Management in order to align the forces. Identify the respective WGs within INCOSE.

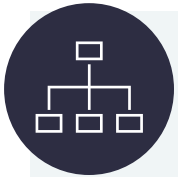
Grand Challenges – Quite some Value Propositions identified that INCOSE could provide – Proposed next step set up a cross-WG initiative and to seek collaboration with complementary organizations with a joint message to target groups.

FuSE Targeted Events in 2023

Where to engage



First FuSE Mini-Event Series



Future of Systems Engineering (FuSE) Introduction and Update & Foundations

MAR 29, 2023

Introduction to the Future of Systems Engineering (FuSE) to realize the Systems Engineering Vision 2035. FuSE started at IW2018 and has a dozen ongoing projects including participation by INCOSE working groups and engagement in the broader systems community. We announced the next phase of FuSE at IW2023 with the establishment of a program management office (PMO) and the clustering of projects into four streams: SE Vision & Roadmaps, Foundations, Methodologies, and Application Extensions.

We will highlight the outcomes of the stream workshops at IW2023 and our program plan moving forward. We will have virtual mini-events for each of the streams in April, followed by workshops at EMEA WSEC and AOSEC, and invited content sessions at IS2023. We are also partnering with the broader systems community. We welcome the proactive engagement of individuals, working groups, and initiatives to realize the SE Vision 2035.

Future of Systems Engineering (FuSE) Vision & Roadmaps

APR 06, 2023

The Future of Systems Engineering (FuSE) SE Vision & Roadmaps stream is maintaining the online version of the SE Vision 2035 and populating it with valuable add-on information and white papers. Maintaining and synchronizing the SE Vision's implementation roadmap as well as those of all four FuSE Stream's has our focus.

To prepare for this session, please read chapter 4 (Realizing the Vision) of the SE Vision 2035. (www.incose.org/sevision)

After a short introduction of the Vision & Roadmaps stream an overview of the results from the IW2023 activities is presented. This is followed by interactive involvement of all participants, collecting their additions to the Systems Engineering Challenges and the Roadmap as defined in the SE Vision 2035. The information gathered will be evaluated afterwards for implementation in the near future FuSE activities.

FuSE Application Extensions – SE and Asset Management

APR 13, 2023

The Future of Systems Engineering (FuSE) SE Application Extensions stream is focusing on stimulating and supporting initiatives that broadens the application of systems engineering in non-traditional domains including socio-technical systems. As a means different cross-cutting topics where SE can bring value to new applications were discussed at the International Workshop 2023.

This online session will focus on physical Asset Management (AM), a topic that brings a systems and life cycle approach to in particular the infrastructure domain. The topic will be introduced by Ben Mogridge, AM expert and member of INCOSE as well as representative from organizations focusing on AM. This is followed by interactive involvement of all participants elaborating on the findings from the workshop at IW2023. The information gathered will contribute to the establishment of a joint initiative to reach out to new target groups.

FuSE Methodologies Virtual Workshop

APR 20, 2023

Following previous FuSE sessions at IW2023, how might we evolve System Engineering Methodologies to engineer solutions for a better world? After a brief introduction on FuSE and a summary from IW2023, participants will leverage the SE Vision 2035 publication, the FuSE IW2023 session outputs, and their own wisdom to elaborate on methodology gaps, share work-in-progress to close those gaps, and then propose go-ahead ideas to realize SE Vision 2035 (www.incose.org/sevision). This workshop will require active engagement in a Miro board. No prior training or Miro account is necessary, but participants are encouraged to complete a few Miro tutorials (https://miro.com/app/dashboard/#/lc/getting-started/) ahead of the event to increase their focus on the content and not the Miro tool during the workshop.

Visit https://www.incose.org/about-systems-engineering/fuse or https://www.incose.org/events-and-news for details and registration information

EMEA details

FuSE is going to be part of EMEA WSEC in Sevilla.

Planned content

- Presentation of FuSE including focus topic
- 4x2h working session for each FuSE stream

Systems Council Technical Committee on Systems Engineering Methods

Tuesday, 11 April 2023
11 AM ET/3 PM UTC
Space is limited to the first 100 registrants

IEEE SMC 2023
Maui, Hawaii
October 1-4, 2023

Home Organization Contributing Partners and Exhibitors **Program** Registration Local-Info FAQ

Joint SMCS- INCOSE Panel: Seeing and Building the Future of SE

After Joint FuSE panels at Bari, IT and Toronto CA IEEE Systems, Man, and Cybernetics Society conferences, this third in a series with the International Council on Systems Engineering (INCOSE) will build on the evolving relationship between SMCS and INCOSE by inviting respective insights on the future of systems engineering from both development and research points of view.

Both SMCS and INCOSE value quality in the professional practice of system engineering (SE), which continues to evolve in response to technical opportunities and political, economic, social, technological, environmental, and legal (PESTEL) factors. Anticipating what SE will and should be in the future has significant implications for research, education, training, certification, and resources. What challenges can be expected? Are our members ready to engage them?

The panel will:

- Describe how INCOSE plans for the future
- Identify development needs that INCOSE can inform, and potential needs
- Identify new SE challenges and opportunities from the SMCS perspective
- Suggest opportunities for joint collaboration

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www.incose.org/fuse

Return to INCOSE Home

FUTURE OF SYSTEMS ENGINEERING (FUSE)

Vision: Inspire the global community to realize the SE Vision

Home / About Systems Engineering / Future of Systems Engineering - FuSE

The FuSE Program is organized in 4 streams.

Vision & Roadmaps

Foundations

Methodologies

Application Extensions

Let's connect.

Or find us on
www.incose.org/fuse

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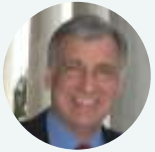

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