Achieving the Systems Engineering Vision 2025

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INCOSE Vision: A better world through a systems approach

INCOSE Mission: To address complex societal and technical challenges by enabling, promoting, and advancing Systems Engineering and systems approaches
Agenda

- Our Current Situation
- Overview of SE Vision 2025
- Model Based Engineering
- The Path Forward
Our Current Situation
Increasing Complexity of Systems

Number of Components
Number of Functions
Number of Interactions

Systems Engineering Tools

5000 BC  1200 AD  1750 AD  1850 AD  1900 AD  1980 AD  2010 AD
Growing Levels of System Complexity

- **Early systems** – single domain/technology
- **Current and future systems**
  - Multi-disciplinary
  - Socio-technical
  - Connected
  - Evolve rapidly
- **Explosion in scale and diversity of system functions & expectations**
IoT explosion in connectivity

- Connected devices with self-knowledge
- Exponential growth
- Fantastic opportunities
- Unknown & emerging threats
- Huge complexity and scale
- Systems Engineering MUST play part
Overview of SE Vision 2025
Systems Engineering Vision 2025

- “Inspiring and guiding the direction of systems engineering across diverse stakeholder communities”
- Basis for conversations on the future of systems and systems engineering
- Major influence on INCOSE’s strategy and plans
Today’s Global Challenges

- Food and Shelter
- Clean water
- Health environment
- Access to healthcare
- Transportation and mobility
- Economic security & equity
- Security and safety
- Access to info, communications, education
Global Trends

- Changes to
  - Socio-economic conditions
  - Physical environment
- New demands on systems
- Impacted by technology and system developments
- Globalisation amplifies changes
- How can systems positively contribute to social condition and natural environment
Systems Engineering Imperatives

- Expanding the APPLICATION of systems engineering across industry domains.

- Embracing and learning from the diversity of systems engineering APPROACHES.

- Applying systems engineering to help shape policy related to SOCIAL AND NATURAL SYSTEMS.

- Expanding the THEORETICAL foundation for systems engineering.

- Advancing the TOOLS and METHODS to address complexity.

- Enhancing EDUCATION and TRAINING to grow a SYSTEMS ENGINEERING WORKFORCE that meets the increasing demand.
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- Systems Engineering already practiced in multiple domains
  - Adapting approaches
  - Recognise diverse settings and practice
  - Learning between domains

- INCOSE Application Domain WG
  - Biomedical & Healthcare
  - Transportation
  - Automotive
  - Power & Energy
  - Oil & Gas
  - Critical Infrastructure
  - ... others to follow
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- System types
- Business models
- Lifecycle models
- Software Development
- Products to Services

- INCOSE
  - Application Domain WG
  - Process Enabler WG
Systems Engineering Imperatives

- Consistent with INCOSE Vision & Mission
- Perspectives:
  - UN Sustainability Model: Social, Environmental, Economic
  - PESTLE: Political, Economic, Social, Technology, Legal, Environmental
- Often applied as Systems Thinking

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- SE is getting harder!
- Craft skills no longer sufficient
- Must underpin with theory
- INCOSE initiated work in this area, initially US but this is a global conversation:
  - US SE Research Center
  - US National Science Foundation
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Practitioners in Transition: Systems Engineers and Systems Engineering

Important Characteristics of Effective Systems Engineers

1. **Paradoxical Mindset**
   - Big Picture Thinking and Attention to Detail
   - Strategic and Tactical
   - Analytic and Synthetic
   - Courageous and Humble
   - Methodical and Creative

2. **Effective Communication**
   - Modes (oral and written; good speakers and listeners)
   - Audience (bridge between problem domain and solution domain)
   - Content (social, managerial, technical)
   - Purpose (understanding needs, negotiation, information brokering, technical arbitration, driving consensus)

3. **Flexible Comfort Zone**
   - Open Minded
   - Rational Risk Taking
   - Multidisciplinary
   - Enjoys Challenges

4. **Smart Leadership**
   - Quick Learning and Abstraction
   - Knowing when to stop
   - Focused on ‘Vision’ for System
   - Ability to Connect the Dots
   - Patience

5. **Self Starter**
   - Curiosity
   - Passionate and Motivated
   - Eager to Learn

**SYSTEMS ENGINEERING IS BROADLY APPLICABLE**

- Systems thinking is used by many.
- Systems engineering is understood and embraced by all engineers.
- Systems engineering is a career for a few.
Advancing our Competency

- Systems engineer is the linchpin
- Must lead/influence decision-making
- Balance hard & soft skills
- “T-shaped” individual

- Competency is key
  - Specialist SE skills
  - Wider general understanding
  - Leadership and soft skills
SE in the future will be

- Relevant to a broad range of application domains
- Applied more widely to support policy decisions
- Comprehensively integrating stakeholder demands
- Support collaboration across organizational, regional and discipline boundaries
- Education stresses systems thinking and analysis
- Practiced by a growing cadre of professionals with technical acumen and mastery of tools and methods
- Supported by more encompassing foundation of theory and sophisticated model-based methods and tools allowing understanding of increasingly complex systems and decisions in the face of uncertainty
Model Based Engineering
Models at the heart of everything

Technical Processes

“Non-traditional domains”

Model-Based SE

SE Management

Soft Systems

Systems Science

SE Leadership

Systems Thinking

Photo © Hans Hillewaert

David Long: Building for Tomorrow: Towards 21st Century Systems Engineering
Model-Based Engineering (MBE): An approach to engineering that *uses models as an integral part of the technical baseline* that includes the requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition life cycle.

Model-based systems engineering (MBSE) is the *formalized application of modeling* to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.
Today: Standalone models related through documents

Future: Shared system model with multiple views, and connected to discipline models
Model Based Engineering

MBE Enhances Affordability, Shortens Delivery and Reduces Risk Across the Acquisition Life Cycle

NDIA Model-Based Engineering Final Report, February 2011
Future State: Digital Thread (DT)/System Model (SM) Concept

Digital Thread/System Model

Information Management System for Engineering (and Acquisition)
Where are we on this journey?

- “Transition to MBE started many years ago with introduction of Computer Aided Design tools”
- “Usage of models that depict systems physical behaviour using mathematical equations is quite mature”
- “We are seeing people adopting more MBSE techniques and this is not because of any fad, but because it is necessary”
- “MBE ... is putting engineering back into SE which had become too process oriented and based on SME input”
- “MBSE mostly limited to up-front SE but little follow through to the rest of the system life cycle”
- “There are real barriers in terms of the IT infrastructure and the expense of the software required”
Key Progress and indicators

- “Over five years ago, the argument was whether we should model or not. This argument has now been won. The challenge now is how do we model effectively and efficiently?”
- “The increasing use of ontologies, frameworks and processes that are enabled by MBSE in industry.”
- “The progress in the MBE is evident if one looks at the specialized and validated tools in many area”
Blockers we still face

- Cultural and General Resistance to change
  - “Cultural resistance”
- Investment
  - “Required investment and effort to actually change the way of working”
- MBSE learning curve
  - “Training and where necessary education of current workforce”
- Availability of skills
  - “Lack of sufficiently educated staff”
  - “Model outputs (e.g. SysML) are unreadable to non-specialists”
- Lack of perceived value
  - “Up-front investment needed where benefits are seen as medium-term”
The Path Forward
The Path Forward

- Forseen by INCOSE SE Vision
- Marathon not sprint
- Grows the “pull” for MBE as well as the capability “push”
- Must be done in collaboration with industry, government and academia leads
- Informs INCOSE priorities and plans
Thank-you

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