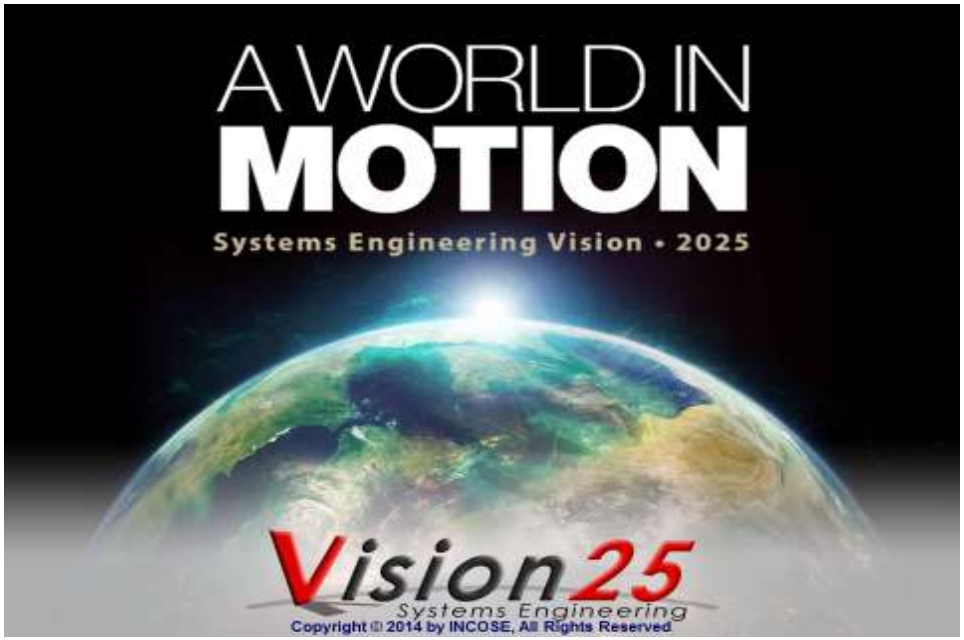


Shaping Systems Engineering and INCOSE for the Future

Garry Roedler, ESEP

INCOSE President-Elect,

INCOSE Fellow and Founder Recipient,

IEEE-CS Golden Core,

Lockheed Martin Fellow,

Engineering Outreach Program Manager

INCOSE Socorro Systems Summit
28 October 2016

Agenda

- Our Current Situation
- Overview of SE Vision 2025
- How the Vision is Shaping the Future of INCOSE
- Looking at the Systems Summit

Our Current Situation

Current Situation: Practices and Challenges

1. Mission complexity is growing faster than our ability to manage it . . . increasing mission risk from inadequate specifications and incomplete verification.

2. System design emerges from pieces, rather than from architecture . . . resulting in systems that are brittle, difficult to test, and complex and expensive to operate.

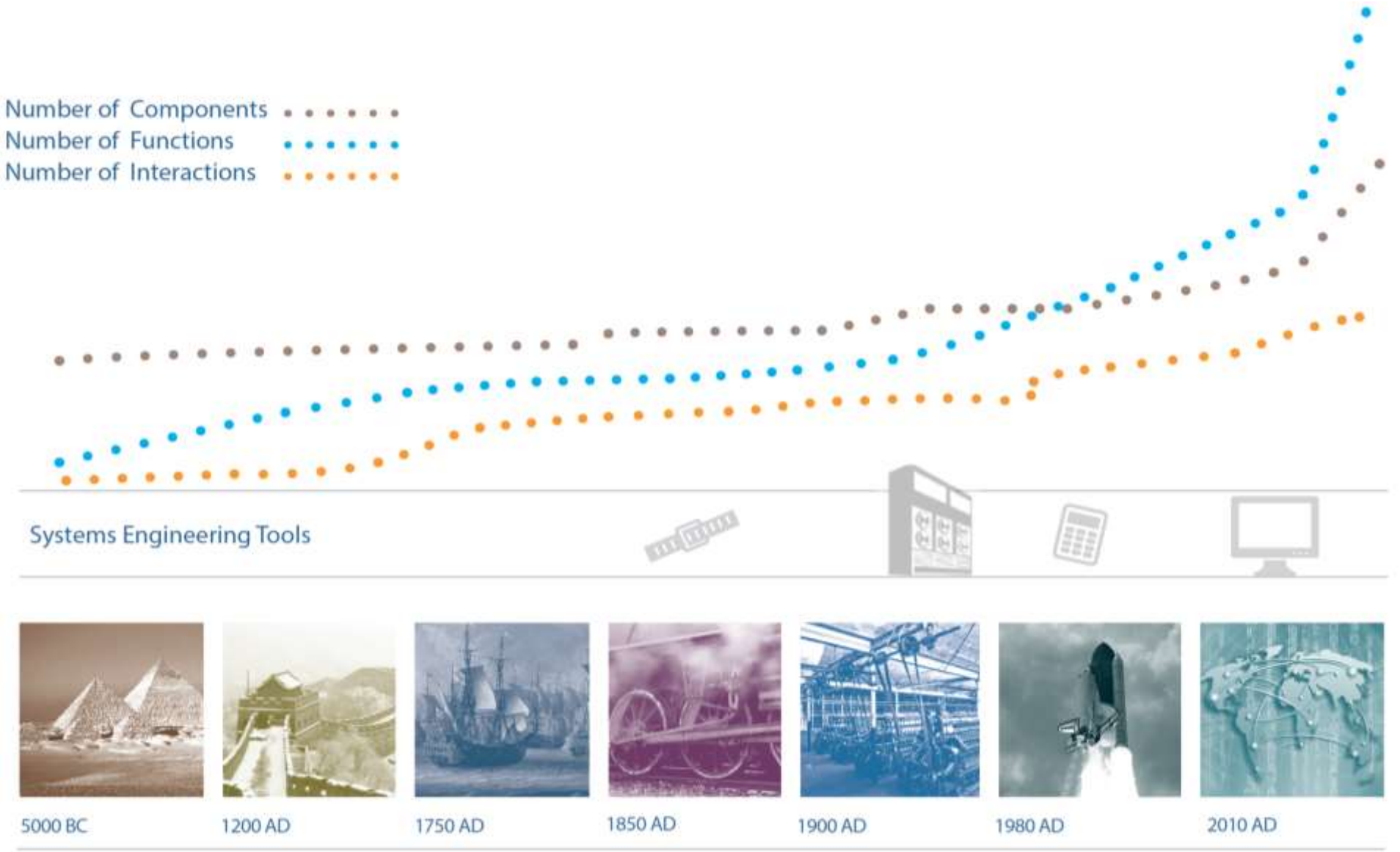
3. Knowledge and investment are lost at project life cycle phase boundaries . . . increasing development cost and risk of late discovery of design problems

4. Knowledge and investment are lost between projects . . . increasing cost and risk: dampening the potential for true product lines.

5. Technical and programmatic sides of projects are poorly coupled . . . hampering effective project risk-based decision making.

6. Most major disasters such as Challenger and Columbia have resulted from failure to recognize and deal with risks. The Columbia Accident Investigation Board determined that the preferred approach is an "independent technical authority".

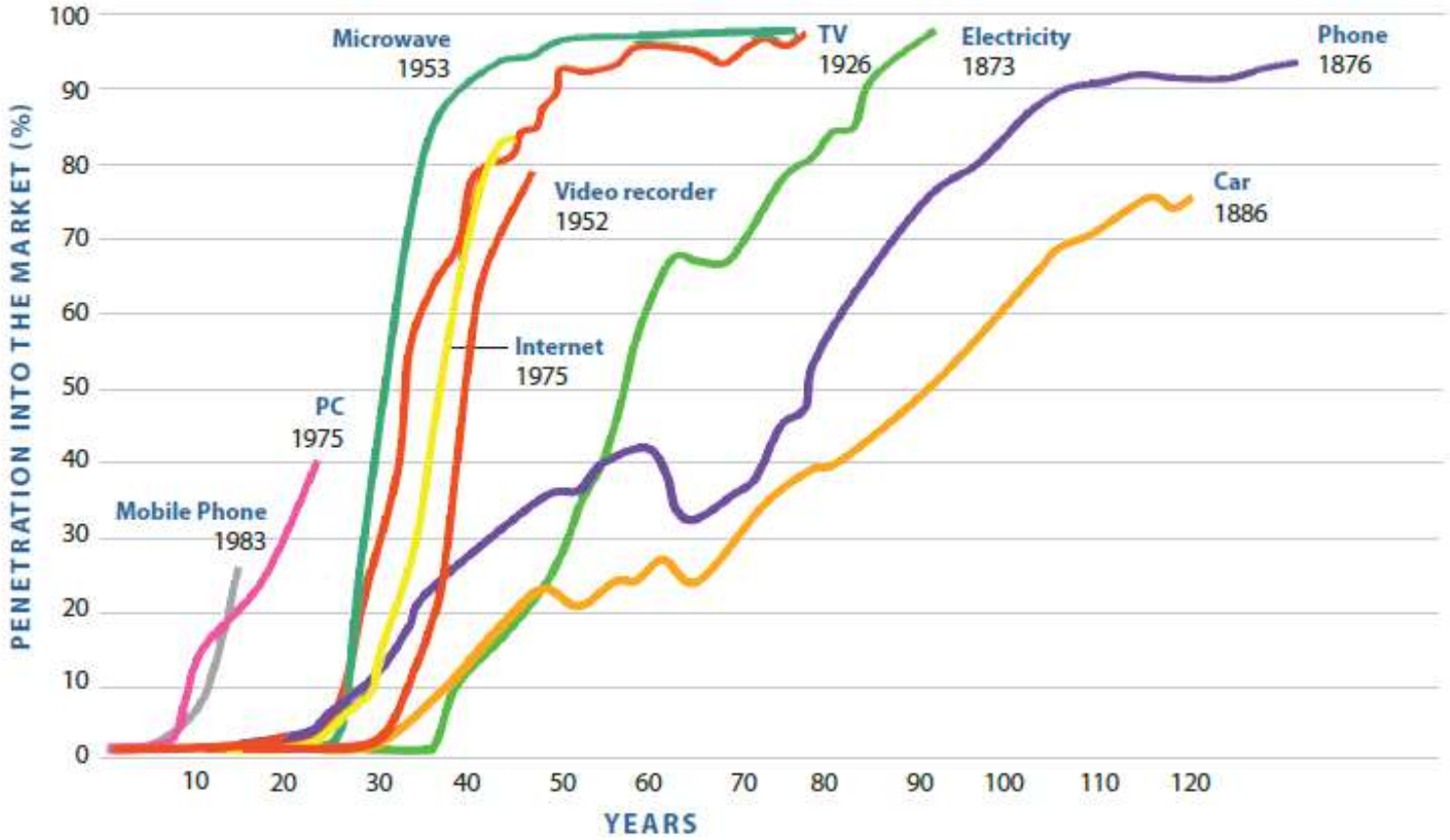
Current Situation: Increasing Complexity of Systems



Current Situation: Increasing Rate of Technology Adoption

NEW TECHNOLOGIES CHANGE OUR DAILY LIFE AT AN EVER INCREASING RATE

Source: Forbes magazine



"With technology infusion rates increasing, the pressure of time to market will also increase, yet customers will be expecting improved product functionality, aesthetics, operability, and overall value. "

Recent technology adoption example

- Autonomy / AI
  - Embedding into many of our systems
  - Driverless cars
    - Uber - Pittsburgh
    - Google – Palo Alto
  - Deliveries
    - Amazon
    - Budweiser - Otto
  - Hotels (CNN)
  - Google DeepMind
  - DoD
    - Autonomous Learning Systems
    - Human-machine Collaborative Decision Making
    - Assisted Human Operations
    - Advanced Manned-Unmanned System Operations

“This Bud’s For Who?” (10/20/16)

USA TODAY
WEDNESDAY, OCTOBER 26, 2016

The “self-driven” part of the truck’s slogan is all about the driver-less nature of the truck transporting this recent shipment of beer to Colorado Springs.

Self-driving semi makes first trip — a beer run

Uber-owned Otto, Anheuser-Busch partner for successful 120-mile tech test in Colorado

Marco della Cava
USA TODAY

SAN FRANCISCO *If you're sipping a Budweiser somewhere in Colorado Springs, you just might have a robot to thank for that thirst-quenching brew.*

Last week, self-driving truck start-up Otto teamed with Anheuser-Busch to successfully deliver a semi-tractor full of beer from Fort Collins, through Denver and on to the southern Colorado city in the shadow of Pikes

on the road longer without cutting into their carefully monitored driving time.

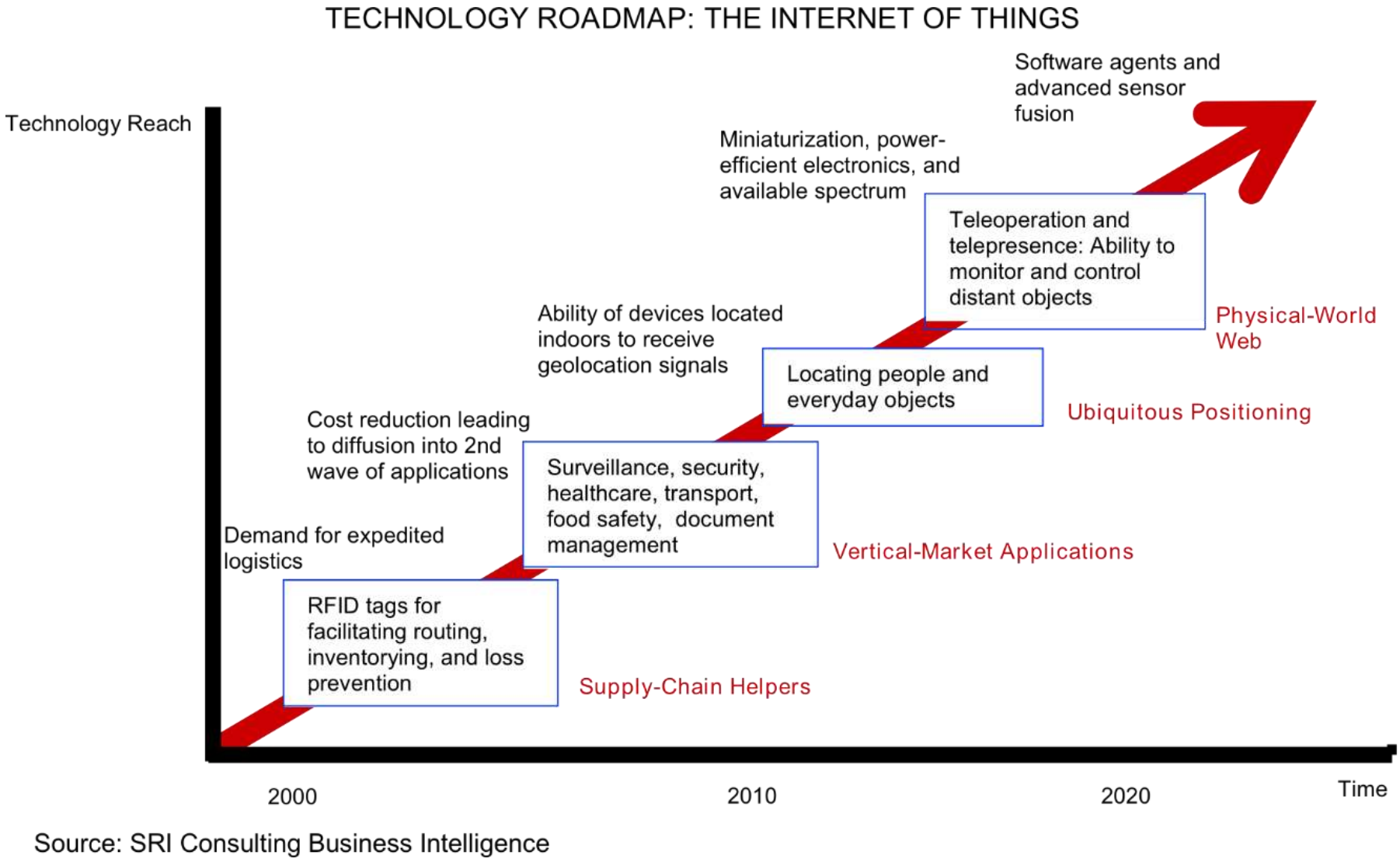
Otto's — and Uber's — interest in cornering the trucking market doesn't need much explanation. In 2015, trucking brought in $726 billion in revenue and accounted for 81% of all freight transport, according to the American Trucking Associations.

Trucking industry advocates remain concerned about both the technology's ability to decipher every road emergency and the danger of having a driver resting or even sleeping while a truck is

Video

Source: USA Today, 26 October 2016

From Stand-Alone to Interconnected to IoT



Source: SRI Consulting Business Intelligence

Quiz Time: True or False?

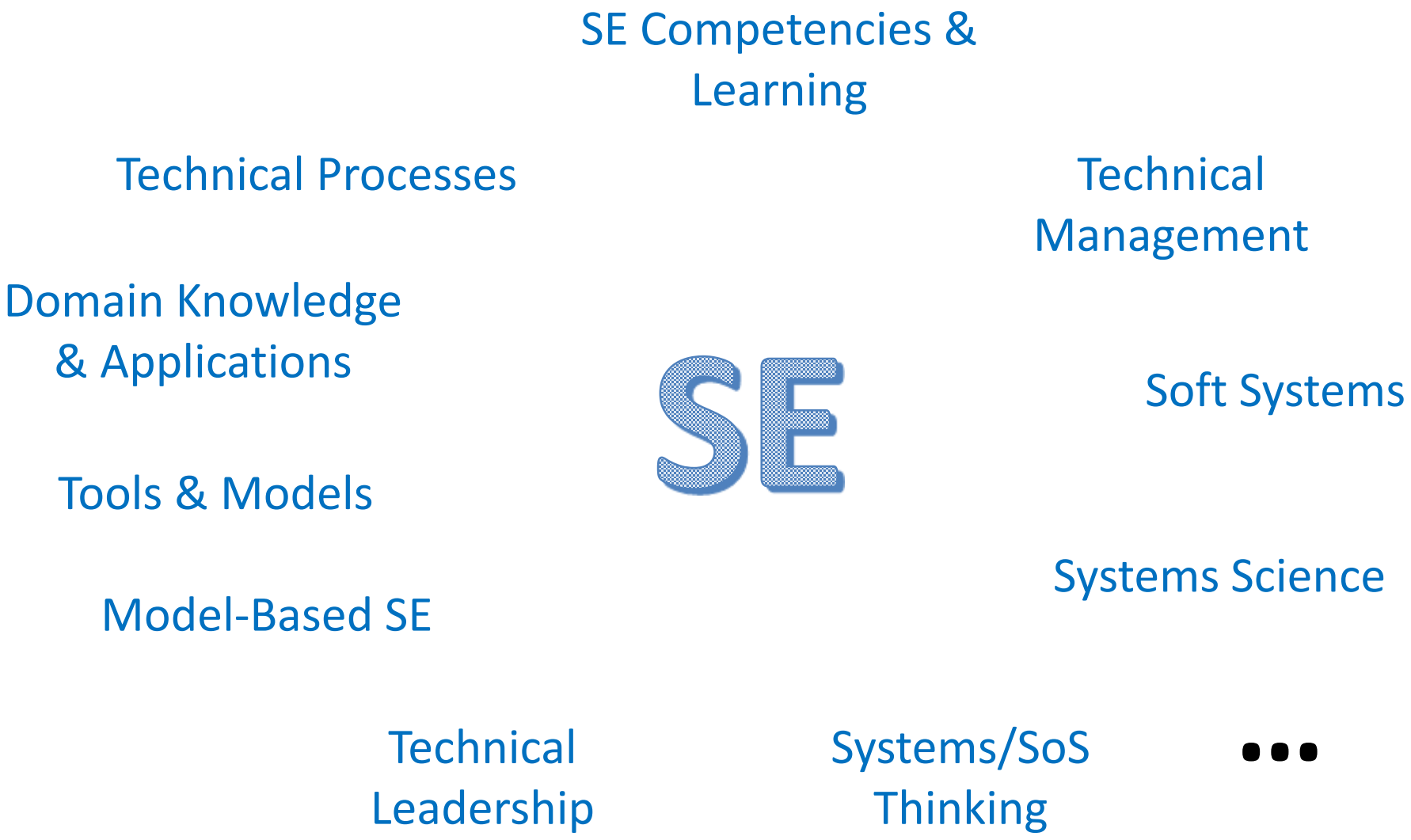
SE ≠

Processes and Methods

SE ≠

Tools and Models

Many Elements of SE: Enabling Achievement of System Solutions



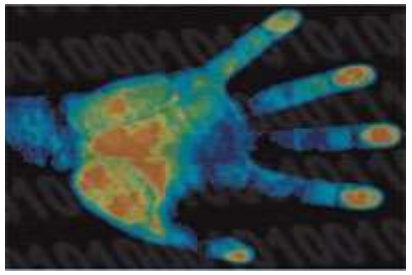
Revisiting the Autonomy example

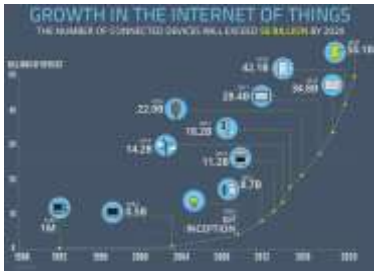
What are some of the things that will change or are changing in SE from this? What challenges?

- Driverless cars
  - Uber - Pittsburgh
  - Google – Palo Alto
- Deliveries
  - Amazon
  - Budweiser - Otto
- Hotels (CNN)
- Google DeepMind
- DoD
  - Autonomous Learning Systems
  - Human-machine Collaborative Decision Making
  - Assisted Human Operations
  - Advanced Manned-Unmanned System Operations

Evolution is Needed

- Evolve our systems





- Evolve our systems engineering approaches (processes, methods, tools, perspectives, …)

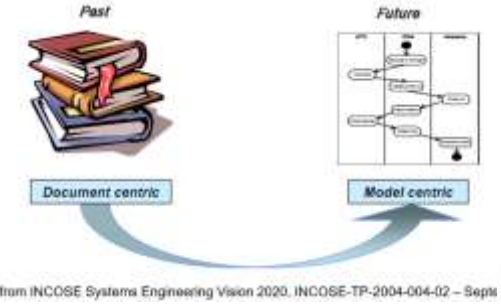
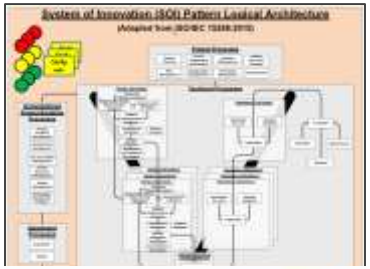


Figure from INCOSE Systems Engineering Vision 2020, INCOSE-TP-2004-004-02 – Septe

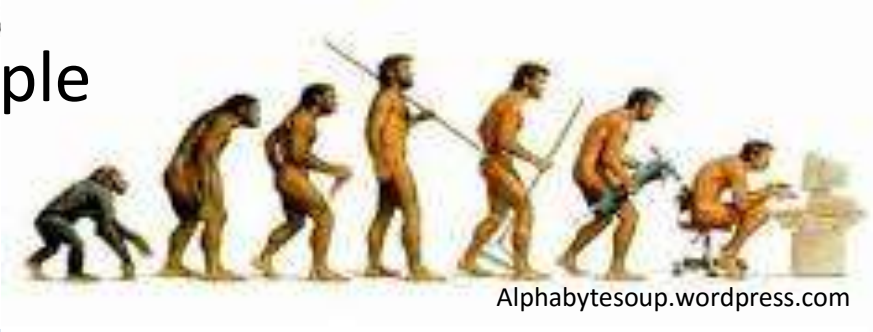


Deterministic
Linear
Predictable

→

Non-deterministic
Evolutionary
Stochastic

- Evolve our people



Alphabytesoup.wordpress.com

We need to be leaders in enabling this evolution

Definition Time

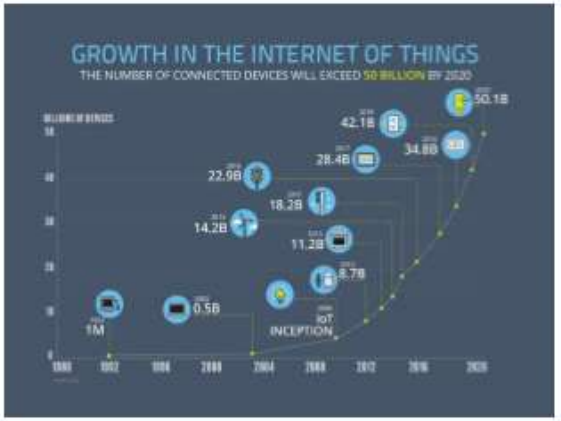
Insanity: doing the same thing over and over again and *expecting different results*.

Albert Einstein

Motivation for Transformation

"When the rate of external change exceeds the rate of internal change, the end of your business is in sight."

Jack Welch



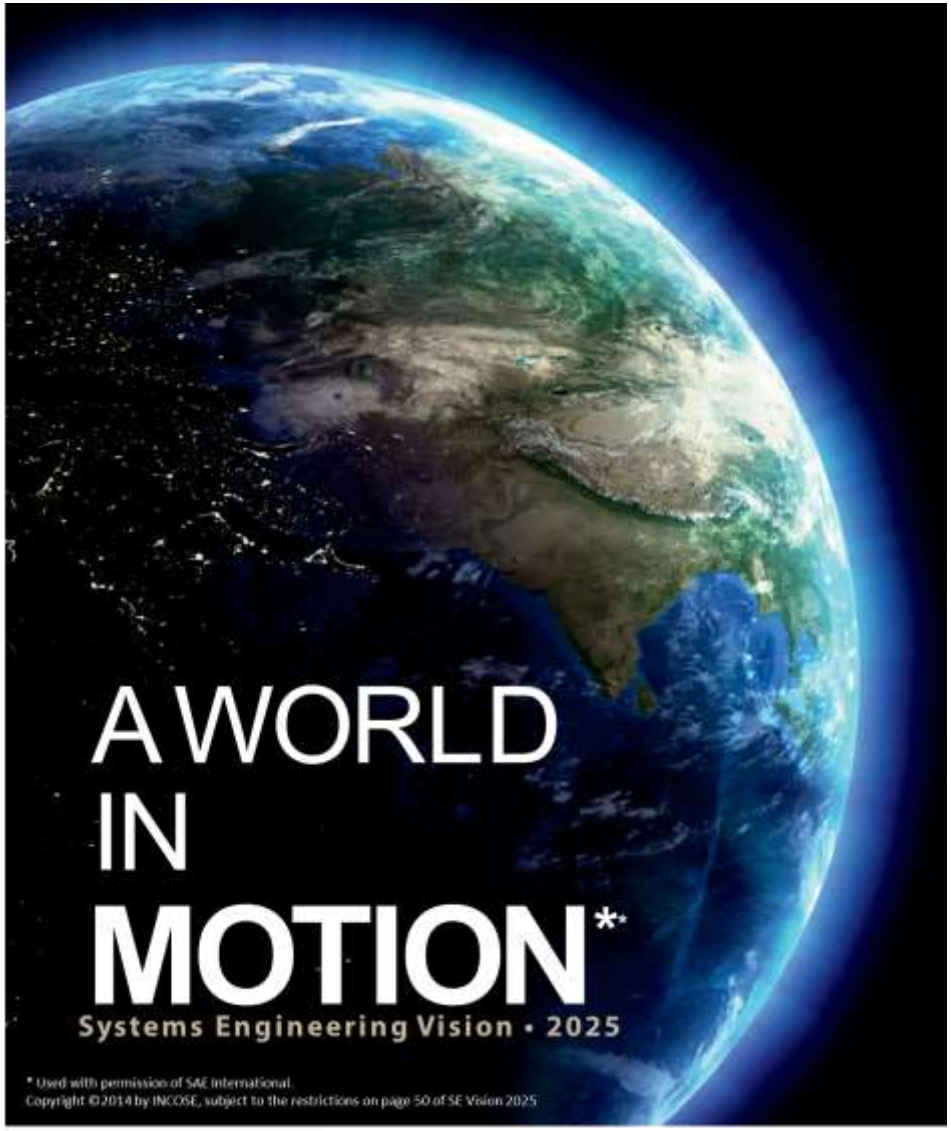
"It is not necessary to change. Survival is not mandatory."

W. Edwards Deming

With Permission from Troy Peterson

Overview of SE Vision 2025

Systems Engineering Vision 2025



- Published June 2014
- "Inspiring and guiding the direction of systems engineering across diverse stakeholder communities"
- Freely available from the INCOSE website
  - Hardcopies available for purchase

Vision Objectives

The purpose of the Vision 2025 is to *inspire and guide* the direction of systems engineering across diverse stakeholder communities, which include:

- Engineering Executives
- Policy Makers
- Academics & Researchers
- Practitioners
- Tool Vendors

This vision will continue to evolve based on stakeholder inputs and on-going collaborations with professional societies.

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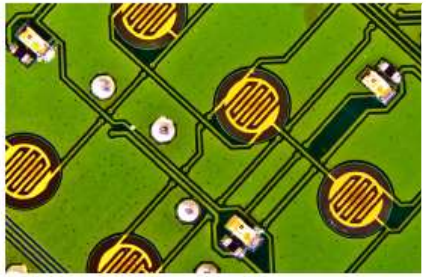
Align SE initiatives, including SE research, SE standards, methods, tools, and curriculum

Promote SE research and organizational investment

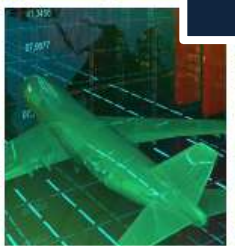
Identify SE capabilities to support future challenges and needs

Broaden the base of practitioners across industry domains





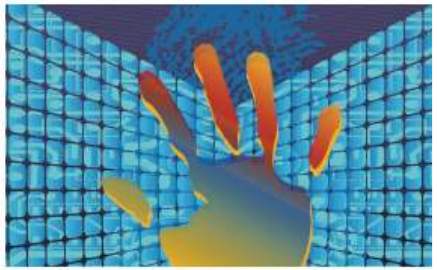
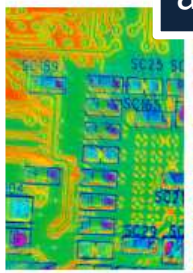
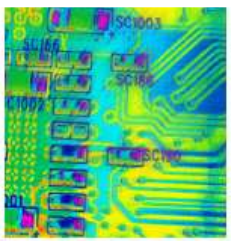










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Systems Engineering Imperatives

- 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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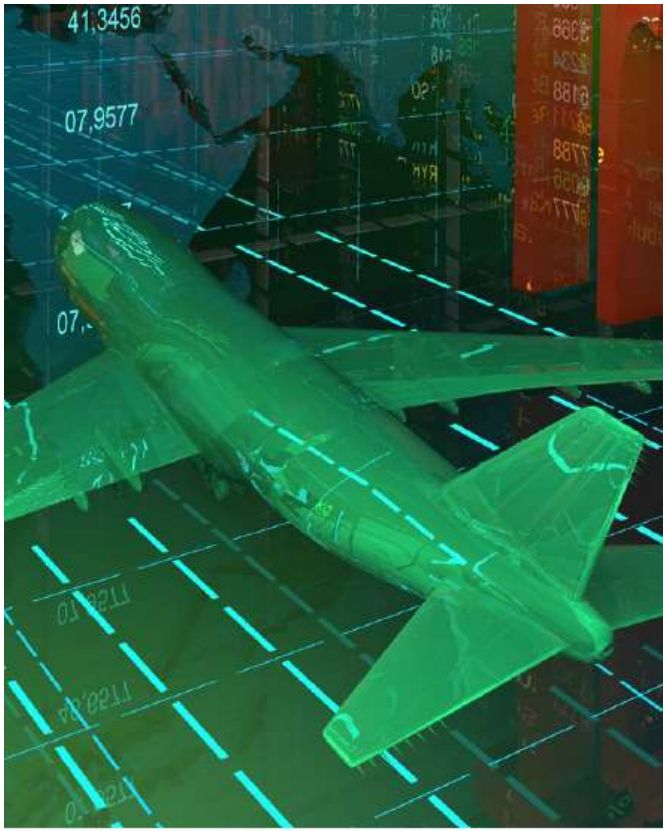
Transforming Practices

- Collaborative Engineering
- Complex System Understanding
- System of Systems Engineering
- System Architecting for multiple viewpoints
- Composable Design
- Design for Resilience
- Design for Security – system integrity
- Decision Support
- Virtual Engineering and MBSE – part of the digital revolution
- Change of process implementation to address technology & application
- Tailoring and scaling practices for value



Source: SE Vision 2025.

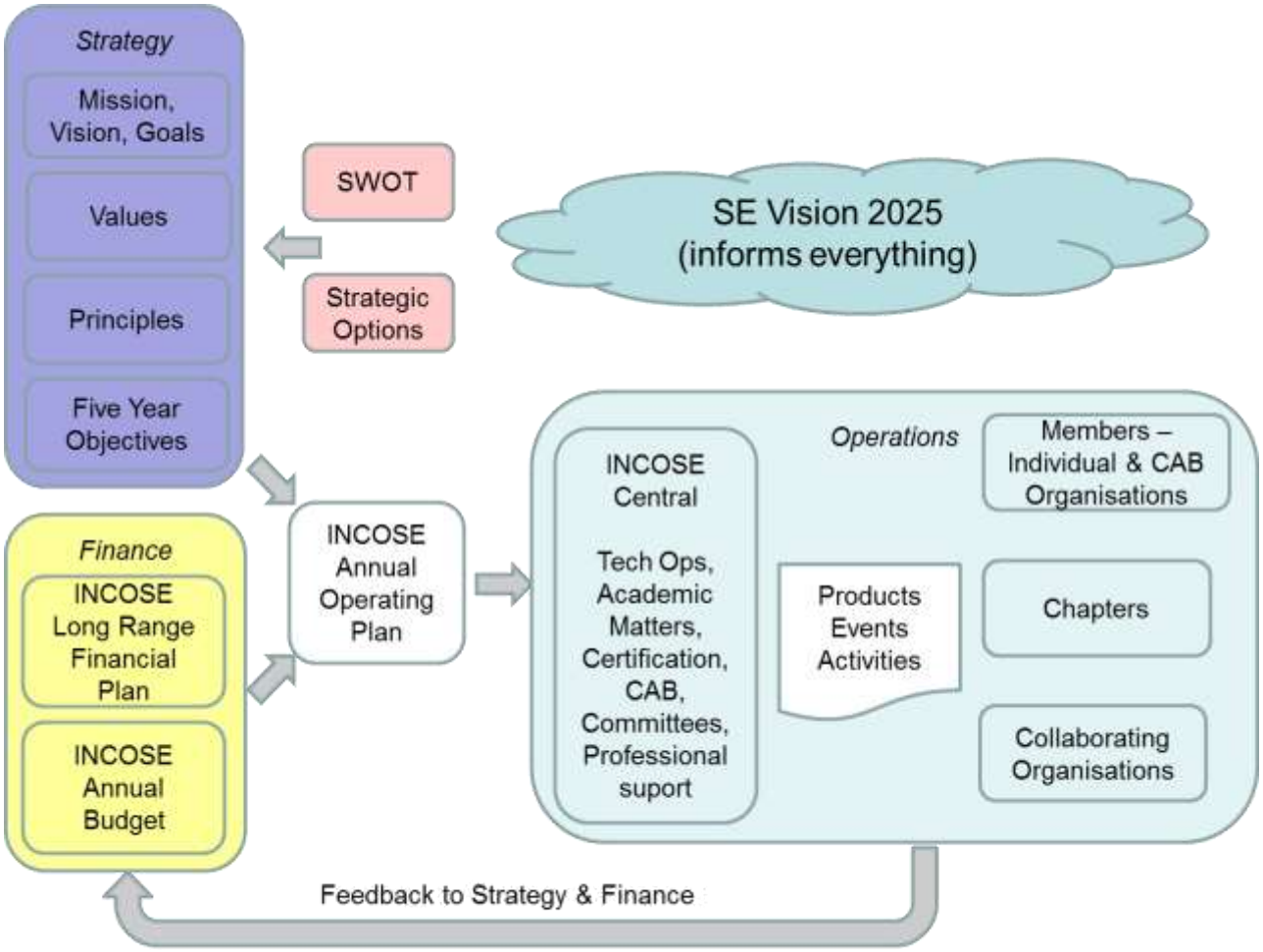
How the Vision is Shaping the Future of INCOSE

INCOSE Actions to achieve the vision

INCOSE Strategy Context

- SE Vision 2025
- Clear strategy
- Careful finance
- Effective operations

- Purpose:
  - What: Strategic objectives
  - How: Values & principles



Embracing Vision 2025 from the Top

- Many of the INCOSE Strategic Objectives have been developed with the SE Vision in mind
  - Growth, Competency, Education, Alliances, and Transformation
- The other strategic objectives serve as enablers
  - Impactful Products and Impactful Events
- Chapter and Domain versions of the Vision are being developed (e.g., Dutch Chapter and Automotive)
- Greater focus on establishing domain WGs

Our Objectives

Growth: Double membership; expand presence in other domains

Competency: Help raise SE competency

Alliances: Amplify our efforts through outreach

Impactful Products: Create and broker impactful products

Forums: Produce and support world-leading forums

Education: Raise the quality of engineering education

Transformation: Accelerate transition of SE to model-based

Progress is being made!
We all need to be the advocates…

Our Objectives: Growth

Growth: Double membership; ***expand presence in other domains***	***Competency***: Help raise SE competency	***Alliances***: Amplify our efforts through outreach
Impactful Products: Create and broker impactful products	***Forums***: Produce and support world-leading forums	***Education***: Raise the quality of engineering education
Transformation: Accelerate transition of SE to model-based		

- Growth Strategy has strong focus on broadening the practitioner base (one of the Visions objectives)
  - Industry Outreach efforts
  - Integration of WGs/Chapters
  - Formation of PM-SE Integration WG
  - Other alliances being discussed

Imperative Addressed: Expanding the APPLICATION of SE across industry domains

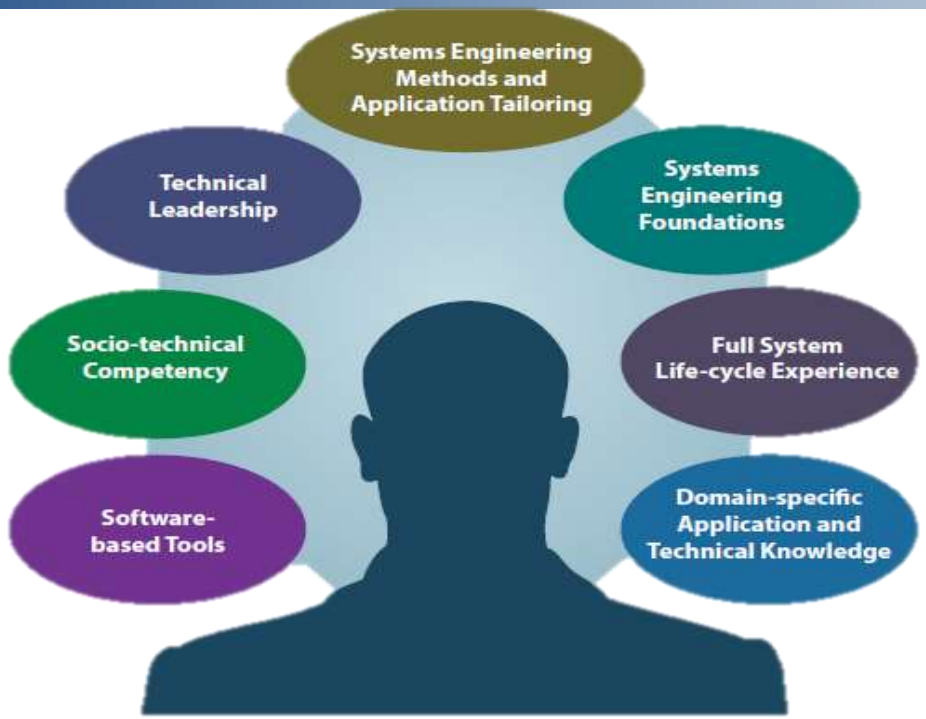
Our Objectives: Competency

Growth: Double membership; expand presence in other domains	***Competency***: Help raise SE competency	***Alliances***: Amplify our efforts through outreach
Impactful Products: Create and broker impactful products	***Forums***: Produce and support world-leading forums	***Education***: Raise the quality of engineering education
Transformation: Accelerate transition of SE to model-based		

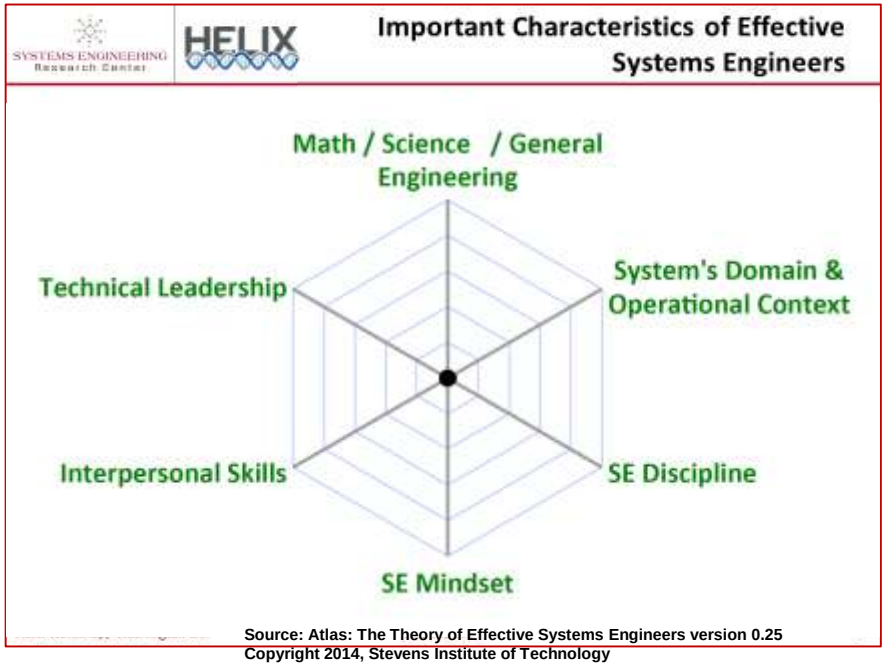
- Comprehensive Professional Development (PD) capability being developed
  - Competency Framework
  - Professional Development Portal
  - Collaboration with SERC on Helix
  - Integration of Helix into the PD Portal
  - Professional Training Initiative & Training WG
  - Certification
  - Leadership Institute
- Formed a PD Steering Group

Imperative Addressed: Enhancing EDUCATION and TRAINING to grow a SE WORKFORCE that meets the increasing demand

INCOSE Focus on Professional Development and Competency



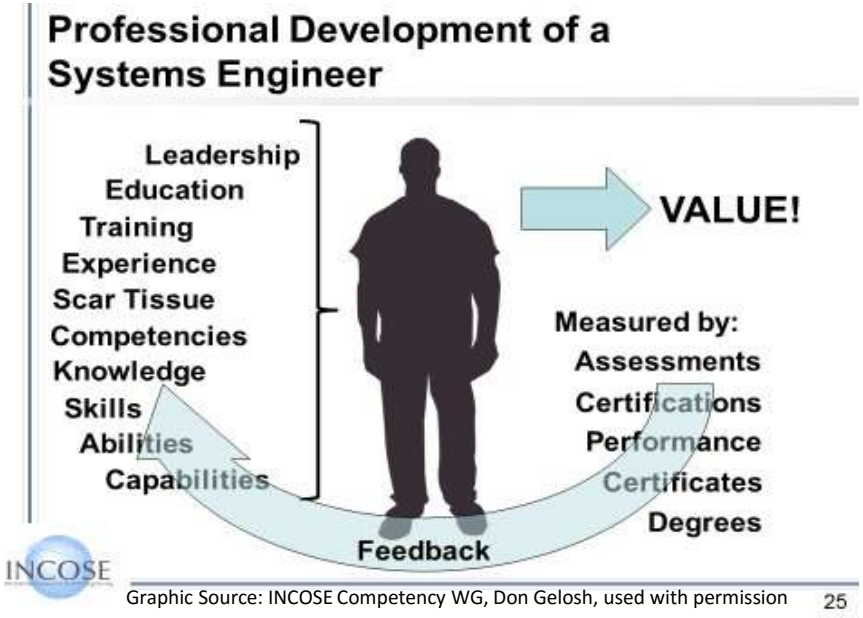
- SE Vision 2025 is a context for the Competency Framework and Professional Development ConOps
- Helix project has identified important characteristics for Effective Systems Engineers



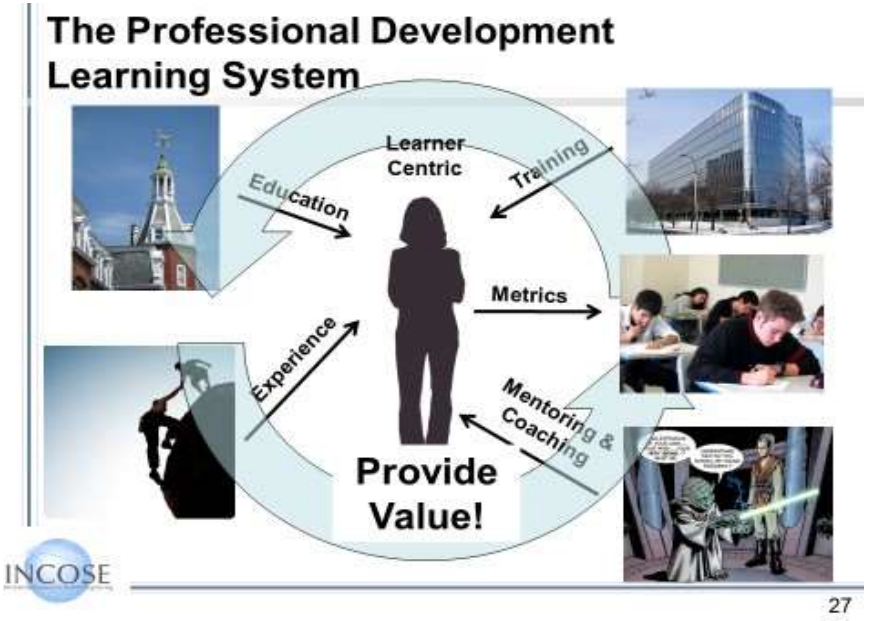
Knowledge | Experience | Communi-cation and Mentoring

Adapted from Alan Harding, 2014

INCOSE Focus on Professional Development and Competency



Graphic Source: INCOSE Competency WG, Don Gelosh, used with permission



INCOSE ASEP | INCOSE CSEP | INCOSE ESEP

GRCSE® BKCASE

Graduate Reference Curriculum for Systems Engineering

Includes:

- Understand the characteristics of Systems Engineers
- Evolving the existing INCOSE SE Competency Framework
- Ensure the right enablers are in place
- Take a holistic approach to Professional Development
- Work collaboratively with others to get wide community consensus

Our Objectives: Alliances

Growth: Double membership; expand presence in other domains

Competency: Help raise SE competency

Alliances: Amplify our efforts through outreach

Impactful Products: Create and broker impactful products

Forums: Produce and support world-leading forums

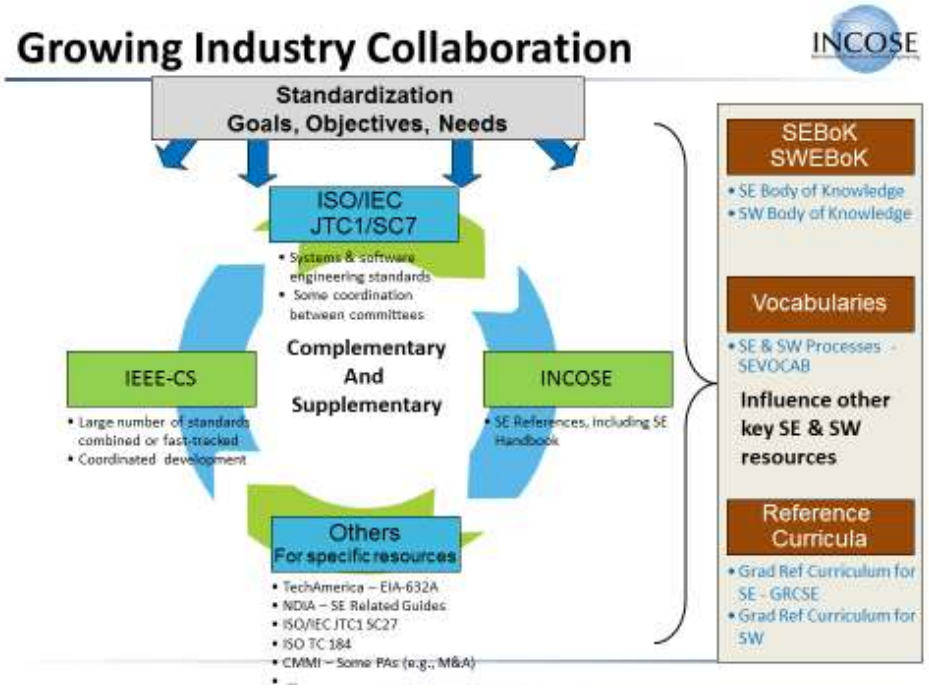
Education: Raise the quality of engineering education

Transformation: Accelerate transition of SE to model-based

- Collaboration rather than competition
- MOUs with other industry associations
- Strategic Analysis to determine alliances needed to enable objectives
- Other Industry Associations that touch systems, not just SE

Imperative Addressed: Expanding the APPLICATION of SE across industry domains; Enables other imperatives through collaborative projects

INCOSE Outreach – Greater Collaboration with industry on targeted objectives



- Work closely with Outreach Director, Tech Ops, CAB, Sectors/Chapters to build/refine an effective outreach strategy and set of alliances
- Focus needs to be on mutual value and clear objectives to be effective
- Outreach includes:
  - Industry domains beyond Aerospace & Defense
  - Enterprises beyond the large corporations
  - Industry Associations that touch systems
  - Investment opportunities for research, international development, STEM/Competency

Our Objectives: Impactful Products and Forums

Growth: Double membership; expand presence in other domains

Competency: Help raise SE competency

Alliances: Amplify our efforts through outreach

Impactful Products: Create and broker impactful products

Forums: Produce and support world-leading forums

Education: Raise the quality of engineering education

Transformation: Accelerate transition of SE to model-based

- Strong product and event focus to build value
- Treasure Hunt
  - 100 products/40 WGs; 49 products/31 chapters
- Anthologies of existing work
- Easier Access
- More local forums, collaborative events, and focused high-impact events

Imperative Addressed: Enablers for many of the imperatives

Our Objectives: Education

Growth: Double membership; expand presence in other domains	***Competency***: Help raise SE competency	***Alliances***: Amplify our efforts through outreach
Impactful Products: Create and broker impactful products	***Forums***: Produce and support world-leading forums	***Education***: Raise the quality of engineering education

GRCSE®

Graduate Reference Curriculum for Systems Engineering

- Strong focus on engineering education needs
- Academic Council - Now 26 universities
- Development and maintenance of Graduate Reference Curriculum for SE (GRCSE)
- Conduct of periodic Academic Forums
- Support to SE Educational Research
- Capstone Marketplace

Imperative Addressed: Enhancing EDUCATION and TRAINING to grow a SYSTEMS ENGINEERING WORKFORCE that meets the increasing demand

Our Objectives: Transformation

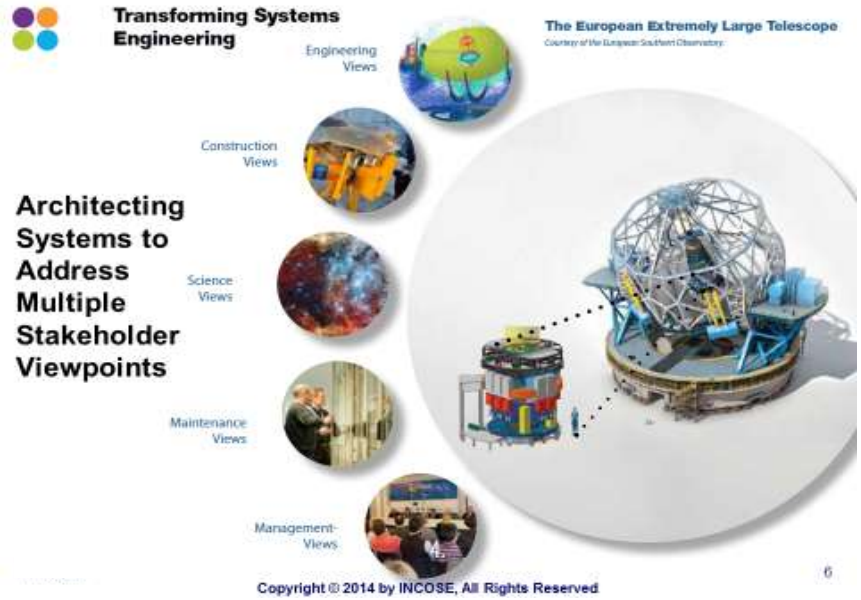
Growth: Double membership; expand presence in other domains	***Competency***: Help raise SE competency	***Alliances***: Amplify our efforts through outreach
Impactful Products: Create and broker impactful products	***Forums***: Produce and support world-leading forums	***Education***: Raise the quality of engineering education

Transformation: Accelerate transition of SE to model-based

- MBSE has been a focus of INCOSE for several years
- Now integrated into mainstream of INCOSE
  - Significant traction across WGs – all functions
- Making progress on path forward
  - Strategy and Plan for Transformation
  - Business Case / ROI briefing – Storylines, Case studies, and principles

Imperative Addressed: Advancing the TOOLS and METHODS to address complexity

INCOSE Focus on Evolving the Discipline

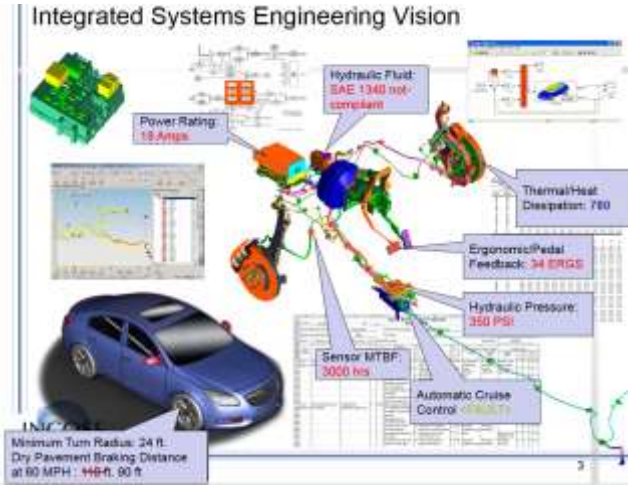


- Systems Engineering needs to evolve practices to address:
  - Faster pace of change
  - Increasing complexity
  - Affordable solutions
  - Agile, adaptable, and resilient solutions
  - Challenges of tomorrow
- Move SE to a cohesive discipline

- Projects are in place with emphasis on transforming our SE practices
  - Model Based SE / Digital Systems Models
  - ***System of Systems / Complex Systems***
  - ***Agile Systems & Systems Engineering***
  - Product Line Engineering
  - Composable Architectures and Designs
  - Resilient and Adaptable Systems
  - Affordability of solutions
  - …

SE Transformation Strategic Direction

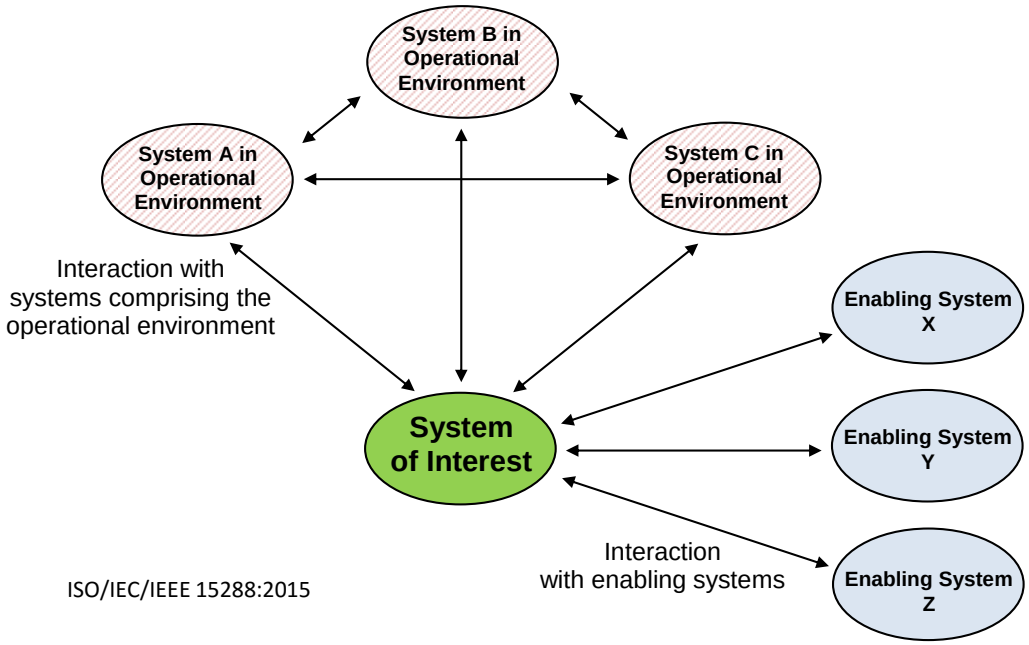
- Advance and mature the MBSE Practice
- Mainstream Model Based Systems Engineering
- Evolve to a cohesive MBSE language, applicable to multiple domains
- Promote and advance the role of MBSE in global Model Based Engineering (MBE)
- Connect to other MBE cross domain standards like Building Information Modeling (BIM)
- Get authoritative information on MBSE out to practitioners and the broader community
- Infuse MBSE into SEBoK
- Align with SE Vision 2025 (see page 38-39)



Other Needs & Trends Highlighted in the Vision

- Advancing SE Research
- Social & Natural Systems
- Growing Need for System-of-Systems Perspective – includes:
  - Mission Analysis, Capability Engineering, Portfolio Management
- System Security Engineering needs to be *designed in* – all levels – includes:
  - Cybersecurity, System/SW Assurance, Anti-tamper, …
- Scalable, adaptable, resilient systems and systems engineering
- Affordable solutions – whole life cycle considered
- Open Systems Architecture/Approaches
  - Challenges are both technical and business related
- Theoretical Foundations

Example: SoS Impact on SE Practices



ISO/IEC/IEEE 15288:2015

ISO/IEC JTC1/SC7 SoSE Study Group Report

> "A SoS is an integration of a finite number of constituent systems which are independent and operable, and which are networked together for a period of time to achieve a certain higher goal."
>
> — *Jamshidi, 2009*

Moving Forward

- Needs to leverage INCOSE strengths
  - Our ability to look at our organization from a holistic system view
  - Our energetic, talented, and passionate membership
  - Our ability to embrace diversity
    - Domains
    - Cultures
    - Perspectives
    - Nationalities
- Need to work as a united set of stakeholders
  - Build on strengths and continue to evolve

Focus on our membership, our discipline, and our leadership role

LOOKING AT THE SYSTEMS SUMMIT

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.

Includes learning
Collaborative Work Practices

Systems of Systems evolutionary integrity

Fail-fast rapid innovation concepts

Agile security adaptable to adversary attack evolution

Agile hardware-development infrastructure and ConOps

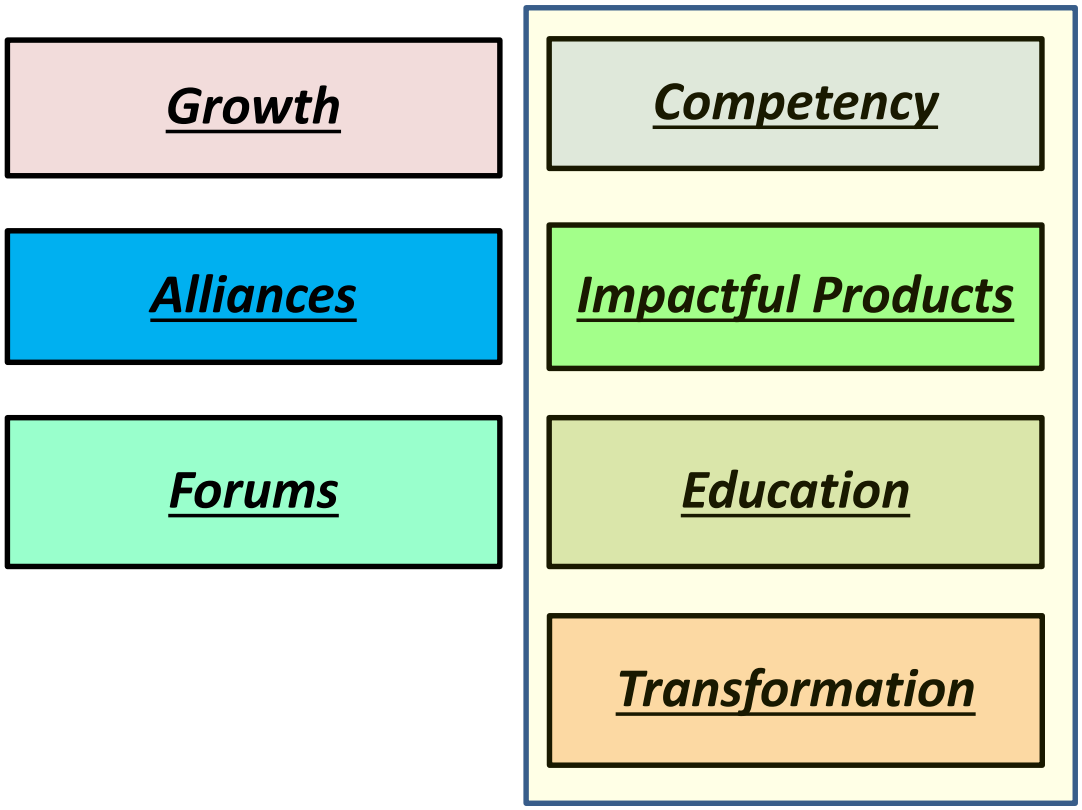
Systems engineering as multidiscipline enabler, art, and science

Systems engineering cultural transformation

High performance teaming

Organizational teaming for Joint project pursuit

INCOSE Objectives



Systems of Systems evolutionary integrity

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Systems engineering cultural transformation

High performance teaming

Organizational teaming for Joint project pursuit

Summary

- Our environment and technologies continue to change at a faster pace
- Most systems are part of a SoS and need to interact with them
- We need to evolve our practices, tools, perspectives, etc. to enable meeting the system needs of tomorrow
- SE Vision 2025 is an important and very insightful product
- It provides a communication tool for working with others
- We are committed to using it to help guide our strategic decisions
- We have already shaped used the Vision to help shape our strategic objectives and the resulting actions
- We also are seeing positive impact from it throughout the INCOSE organization
- ***Finally, this Systems Summit is addressing many items that should help focus our evolution – looking forward to the results***

Questions?

SE Vision 2025 Copyright (for extracts from the Vision)

BACK-UP CHARTS

Session Descriptions for the Systems Summit - 1

- **Systems engineering cultural transformation**—A systems engineering culture is an umbrella of shared values and behaviors that transcends the individual cultures of teams, departments, and disciplines—rooted in the appreciation of overarching system concepts and system relationships. What impedes a compelling draw toward the recognition and realization of value here? What is required for an effective transformation?
- **Systems engineering as multidiscipline enabler, art, and science**—Systems engineering has migrated to an engineering procedure and project management based discipline. How can we raise awareness and understanding to a systems level?
- **High performance teaming**—A high-performance team is a group of people committed to a common purpose, showing high levels of collaboration and innovation. Why isn't this a compelling behavior that sucks all of us in naturally? What stands in the way? What requirements are needed to enable and facilitate a natural attraction to high performance teaming?
- **Systems of Systems evolutionary integrity**—Systems-of-systems evolve as individual systems change. What are the requirements for maintaining SoS integrity with asynchronous and self-serving system evolution?

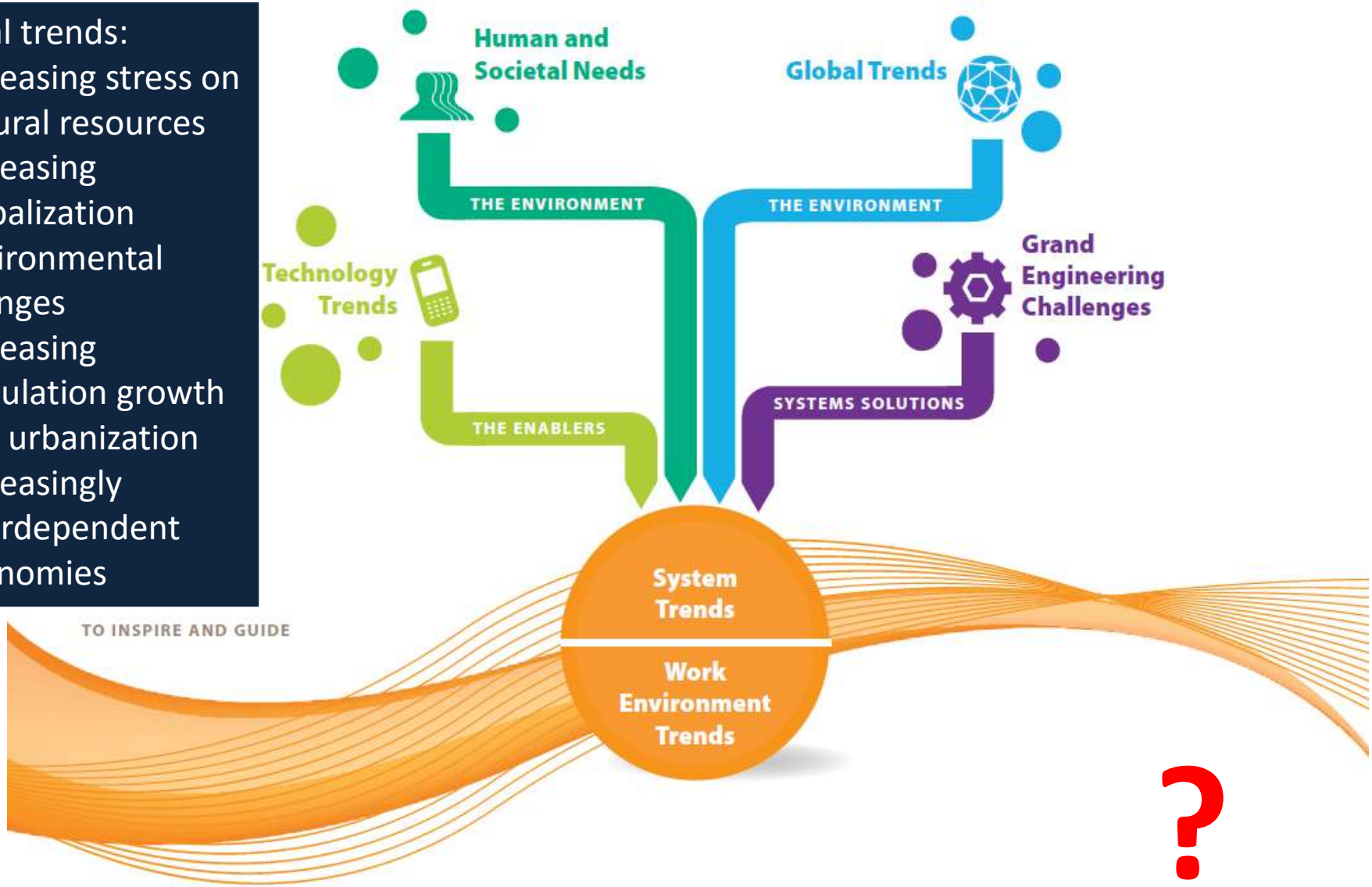
Session Descriptions for the Systems Summit - 2

- **Fail-fast rapid innovation concepts**—How do we enable and facilitate innovative experimentation, driven by a focus on fast discovery of insufficiency or inadequacy? What is the compelling value proposition for budgeting and scheduling innovation experimentation? How can experimentation be managed for fail-fast discovery, and appreciated for value?
- **Agile security adaptable to adversary attack evolution**—What are the requirements for system and security strategy that will enable response with at least the agility of the adversary? What are implications for architecture, design, and ConOps?
- **Agile hardware-development infrastructure and ConOps**—How can hardware development infrastructures enable and facilitate asynchronous unit testing and safe, rapid design change? Software uses an infrastructure of object-oriented development platforms and loosely-coupled web-page linkage. What are infrastructure requirements for equivalent hardware capability?
- **Organizational teaming for Joint project pursuit**—What impedes discovery and appreciation of opportunities for working together among organizations, what is required to break down these impediments, and what can be done about them?

Global Context of SE

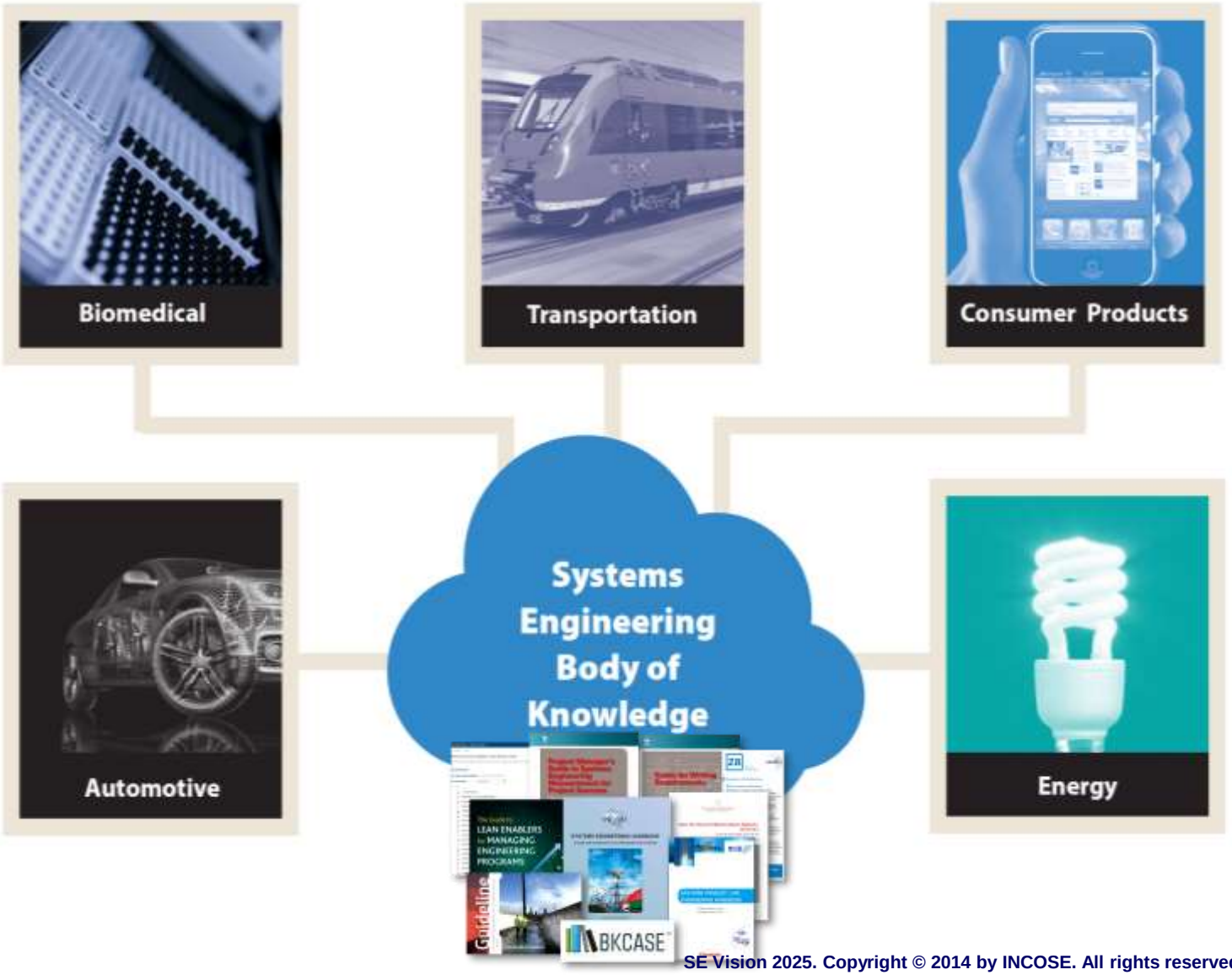
Global trends:

- Increasing stress on natural resources
- Increasing globalization
- Environmental changes
- Increasing population growth and urbanization
- Increasingly interdependent economies



Application of Systems Engineering - Systems Engineering Across Industry Domains

SHARING OF PRACTICES AND KNOWLEDGE ACROSS DOMAINS (AND ADDING VALUE TO EACH DOMAIN)

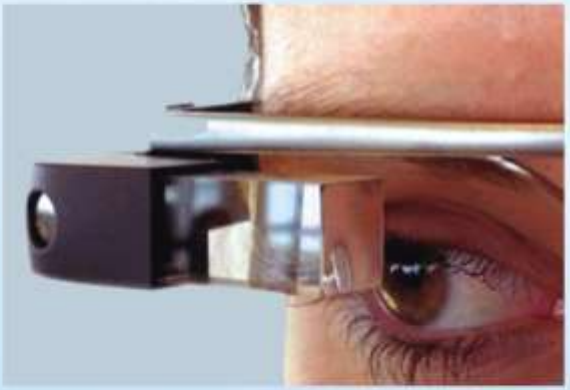


Transforming Systems Engineering – Leveraging Technology for SE Tools

Cloud-based high performance computing supports high fidelity system simulations

Advanced search query, and analytical methods support reasoning about systems

Immersive technologies support data visualization



Net-enabled tools support collaboration

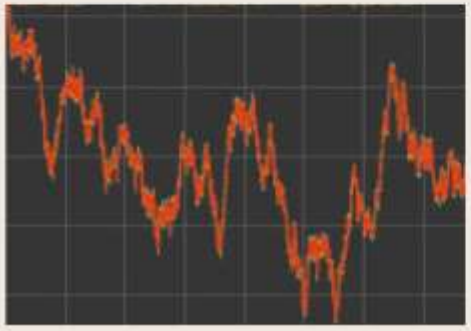
Transforming Systems Engineering – Tailoring and Scaling Practices for Best Value

Value Driven Practices for Developing Systems in 2025 and Beyond

TAILORED TO THE DOMAIN

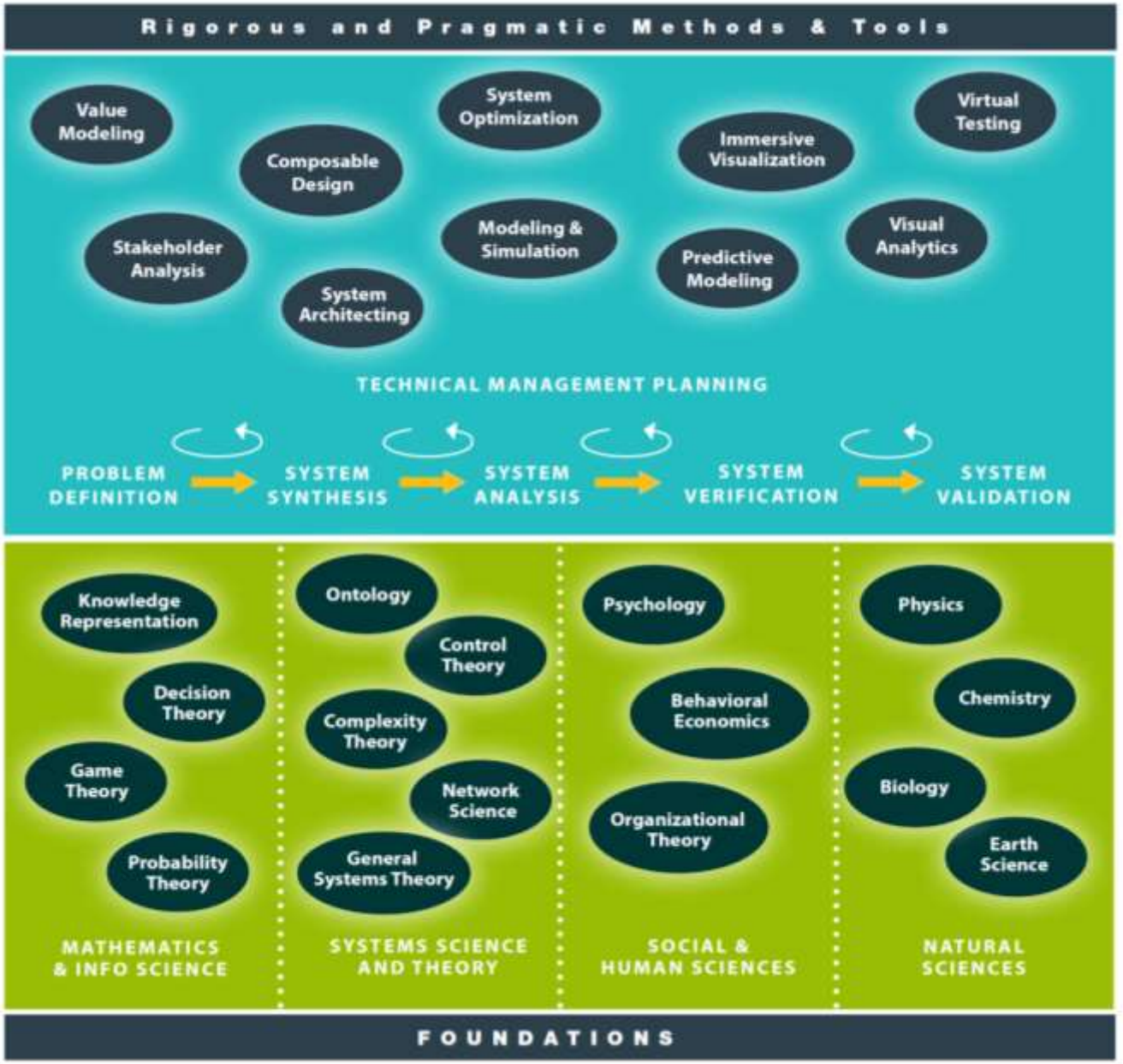
SCALED TO PROJECT SIZE

SCALED TO SYSTEM COMPLEXITY



Systems Engineering Foundations

SHORING UP THE THEORETICAL FOUNDATION OF SYSTEMS ENGINEERING



Essential Systems Engineering Competencies