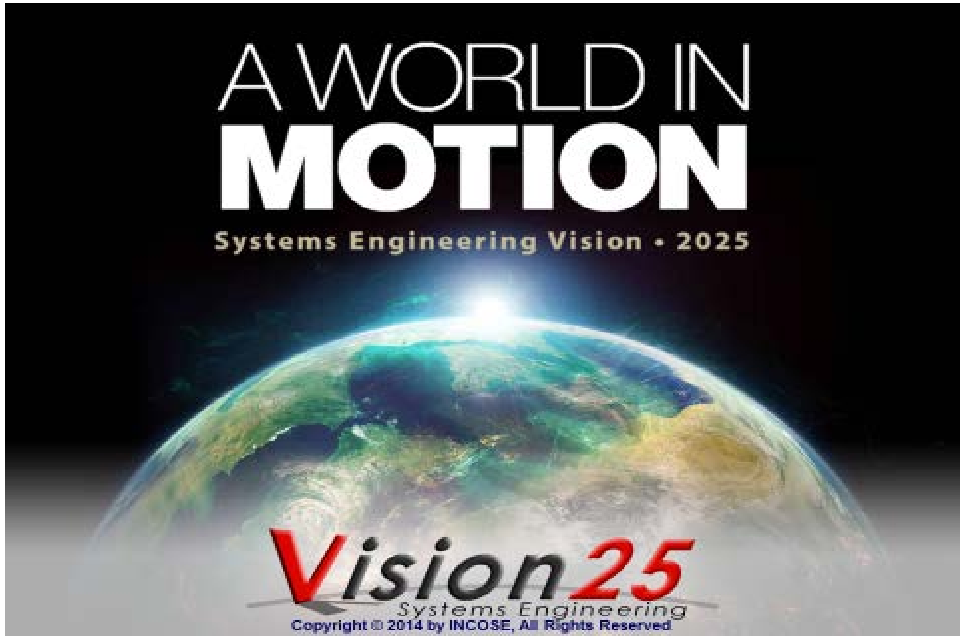
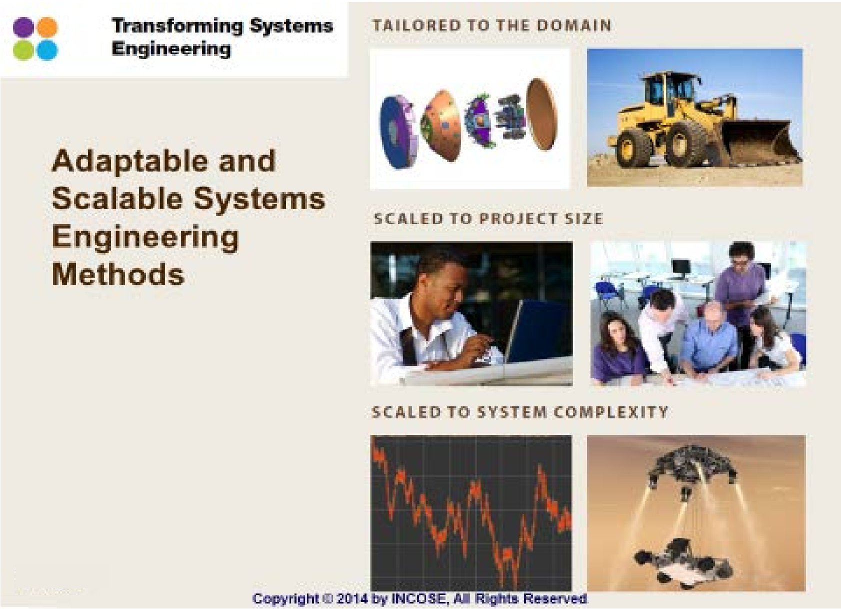


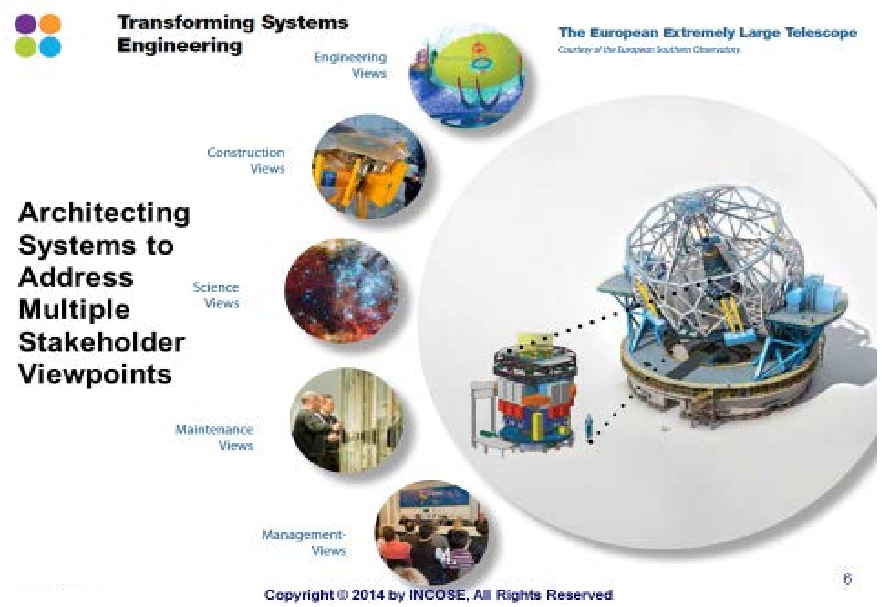
SE of the Future: Shaping the Future of Systems Engineering

Garry Roedler, ESEP
INCOSE President,
INCOSE Fellow and Founder Recipient,
IEEE-CS Golden Core,
Lockheed Martin Senior Fellow,
Engineering Outreach Program Manager

NDIA SE Division Meeting
28 February 2018

INCOSE Focus on Evolving the Discipline

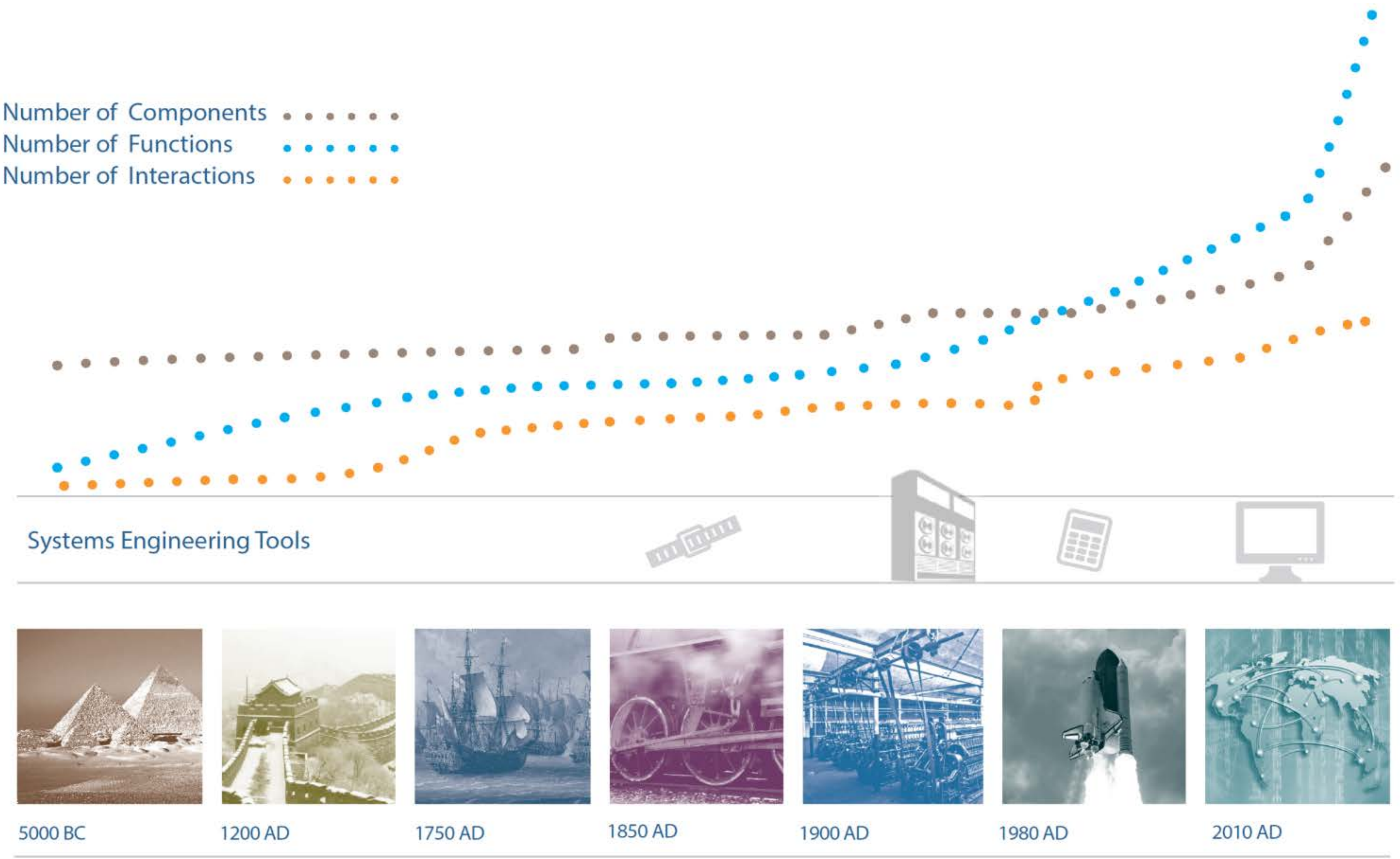




- Systems Engineering needs to evolve practices to address:
  - Faster pace of change
  - Increasing complexity
  - Affordable solutions
  - Agile, adaptable, and resilient solutions
  - Challenges of tomorrow
- Move SE to a cohesive discipline

- Need to place emphasis on transforming our SE practices
  - Model Based Systems Engineering / Digital Systems Models
  - System of Systems / Complex Systems
  - Agile Systems Engineering
  - Product Line Engineering
  - Composable Architectures and Designs
  - Resilient and Adaptable Systems
  - …

Trend: Increasing Complexity of Systems



Trend: Increasing Rate of Technology Adoption

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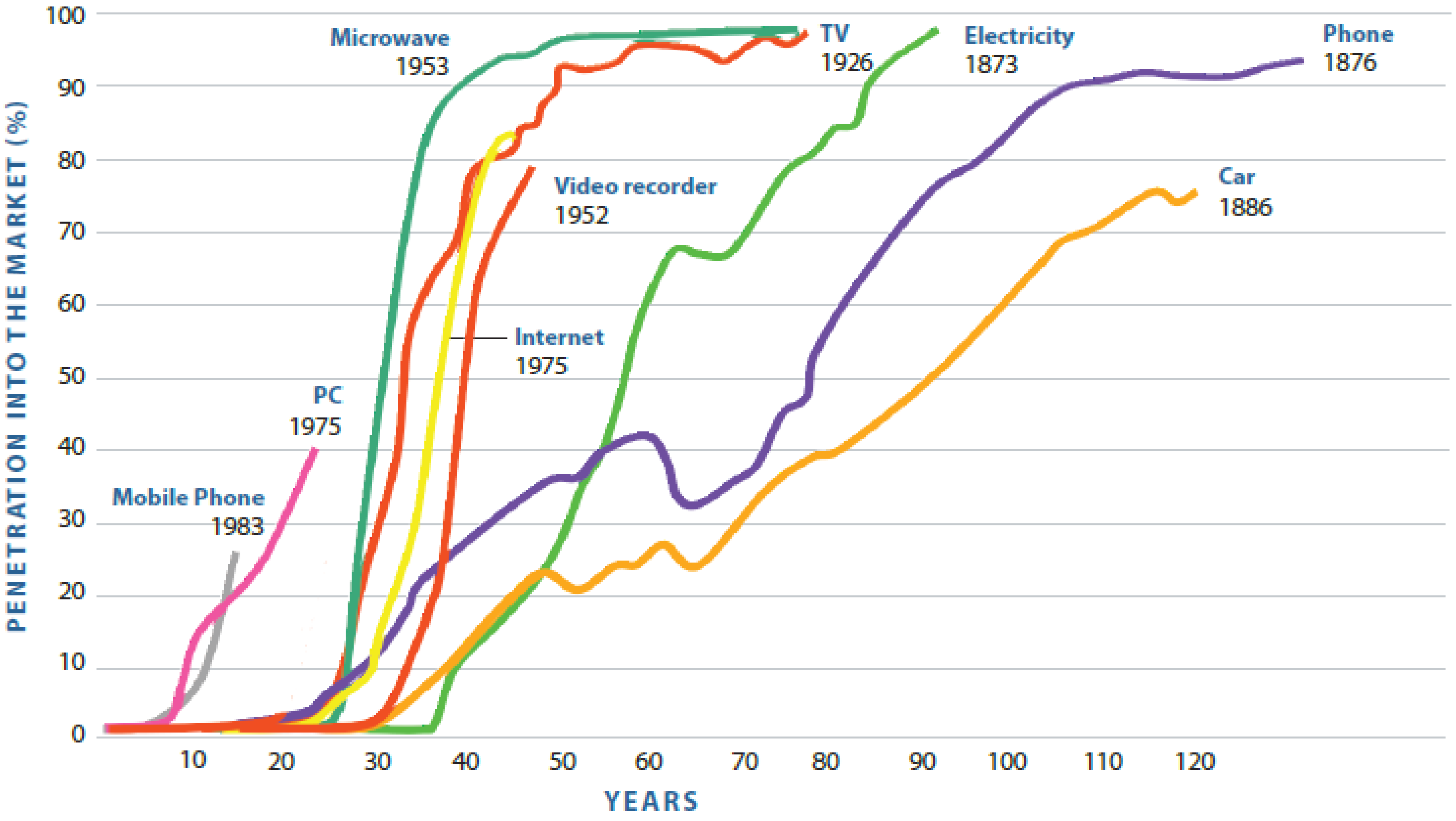
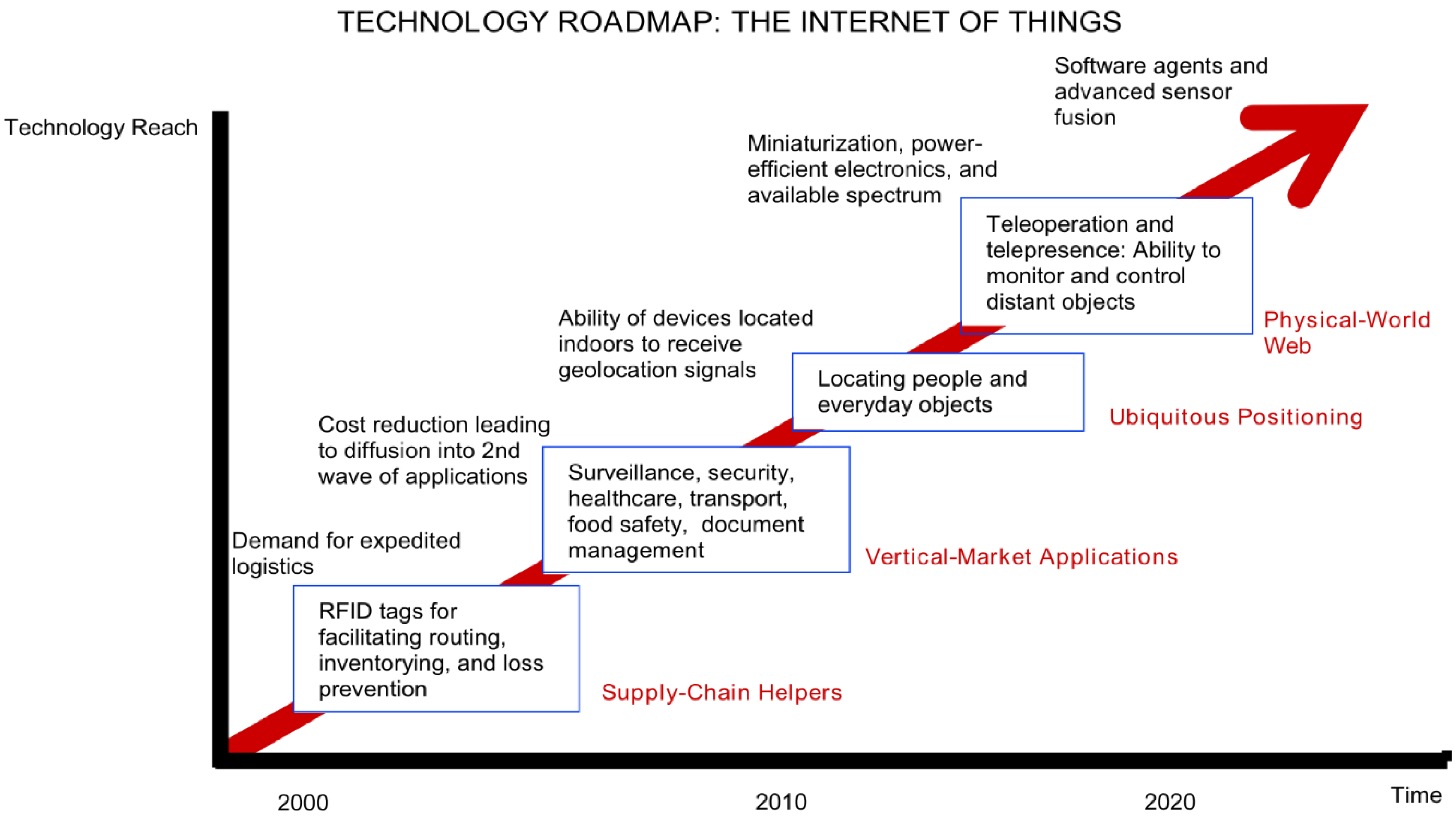
NEW TECHNOLOGIES CHANGE OUR DAILY LIFE AT AN EVER INCREASING RATE

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. "

Trend: From Stand-Alone to Interconnected to IoT



Source: SRI Consulting Business Intelligence

What Does SE Look Like in This Environment? (1)

Dynamic, non-deterministic, evolutionary

- Emergent Behavior is common
- Capabilities continue to evolve
- Learns and adapts to new needs

Cybersecurity and assurance need to be integral, not "bolt-on"

- Integrity, Availability, and Confidentiality (resistance to access)

New approaches to V&V

- Current methods are inadequate for testing systems that learn and adapt
- Behavior changes as data and models are changed by system
- V&V needed throughout life cycle – especially when state changes

What Does SE Look Like in This Environment? (2)

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Ongoing modeling and simulation challenges	• Robust modeling and simulation capabilities are needed, but … • How is M&S kept current and controlled when system learns and adapts?
Ongoing operational changes	• Less human dependent, changing Rules of Engagement and Concept of Operations • Changes to training and mission/business parameters
Changes required for a literate workforce	• Much greater man-machine interface, and machine may have the leading role • Need for skilled personnel at all lifecycle phases • Adaptable workforce, as roles will change more quickly - get past culture change issues

What Does SE Look Like in This Environment? (3)

Technology will continue to influence

- But at potential faster rates …
- "Tech watch" programs are necessary, but not sufficient

Governance may present issues

- Different "ownership" of the interacting systems (System of Systems issue)
- Control of the learning and changing system
- Management of the changing operational areas
- Preventing unintended use or consequences

Impacts from Technology Advances

- V&V methods/techniques – Building trust
- Managing models as technologies improve the system? E.g., Self-Adaptive changes
- Managing an evolving architecture – both from rapidly changing SW and self-adaptation
- Need for fast, robust data analysis
- Increased cyber threat – need for greater emphasis

Systems Engineering of the Future
Systems of Systems Challenges

Deterministic	→	Non-deterministic
Linear		Evolutionary
Predictable		Stochastic

Context: The scale of complicated and complex systems & services continues to increase exponentially with intricate and often hidden interfaces & interrelationships, and operating in a dynamic and non-deterministic world.

NIST 2016

Cyber-physical, complex adaptive, socio-technical systems:
Flows & conversions of energy, materials, signals/information
Transforming materials → objects → goods & services
Mo
App

“When the rate of external change exceeds the rate of internal change, the end of your business is in sight.”
[Jack Welch]

Systems Engineering of the Future
A New Collaborative Initiative

- Imperative to address current and future systems challenges – “Adapt or be irrelevant”
- Intended Outcome – Evolving systems engineering that enables us to leverage the new technologies that drive us fully into a dynamic, nondeterministic, and evolutionary environment
- Draft Framework:
  - Define problem statement
  - Define the challenges that are driving change
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  - Initiate actions, projects, research, benchmarking, training/education, and communications – short term, mid-term, and long-term

Systems Engineering of the Future

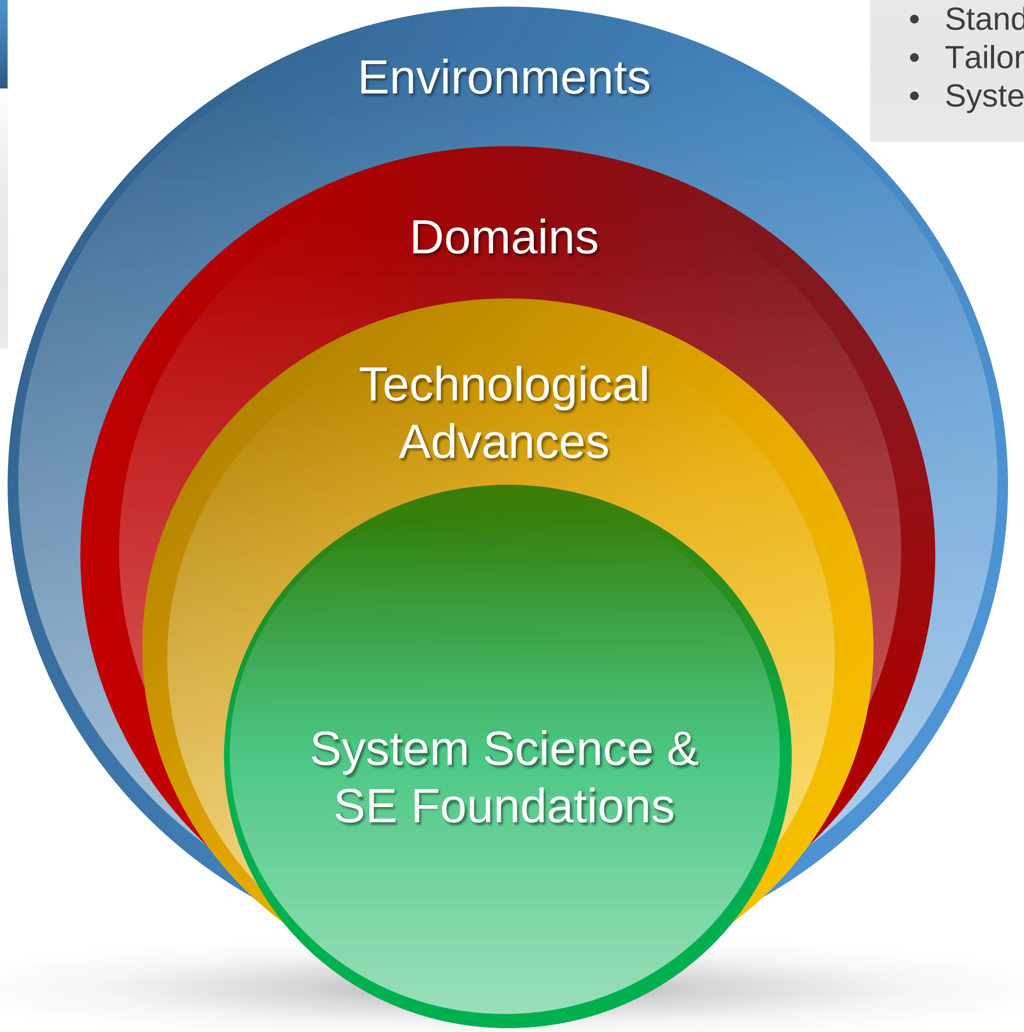
A Systems World Perspective of Context

Environments

- Ecosystems– Natural & Artificial/Manmade
- Economical Environment
- Political Environment
- Health Environment

Domains

- Defense
- Space
- Healthcare
- Games – serious games
- Transportation
- Communications
- Information
- Consumer Electronics
- Public Policy
- Biomedical
- Housing



System Science & SE Foundations

- Processes, Methods & Guidelines
- Models & Tools
- Standards
- Tailoring Guidance
- System Research & Theories

INCOSE

Technological Advances

- Artificial Intelligence (AI)
- Autonomy
- Big Data
- Internet of Things (IoT) / Smart Things
- Smart X (eg Smart Cities)
- Cloud Computing
- Ubiquitous Access to Information
- Power/Energy
- Augmented Virtual Reality
- Simulation/Stimulation
- Sustainment/Elegant Systems
- 3D Printing
- Cyber-Physical Systems
- Ability to find Unique (Old) via eBay, Amazon, etc

How You Can Get Involved

- Core Team
  - Meets weekly
  - Requires representation of an major group
  - Requires significant level of commitment
- Broader SE Team
  - Meets Monthly
  - Expected to be more than an interested party
  - Review and input
  - May be requested to lead actions
- Need an NDIA SED Liaison/Representative
- Initiative Lead and Primary POC
  - Bill Miller (wdmiller220@gmail.com)

Plan to be with us in Washington DC for IS2018!

July 7 – 12, 2018

Grand Hyatt Washington

1000 H Street NW, Washington, DC 20001

Back-up Charts

Example: Recent technology adoption with increasing complexity

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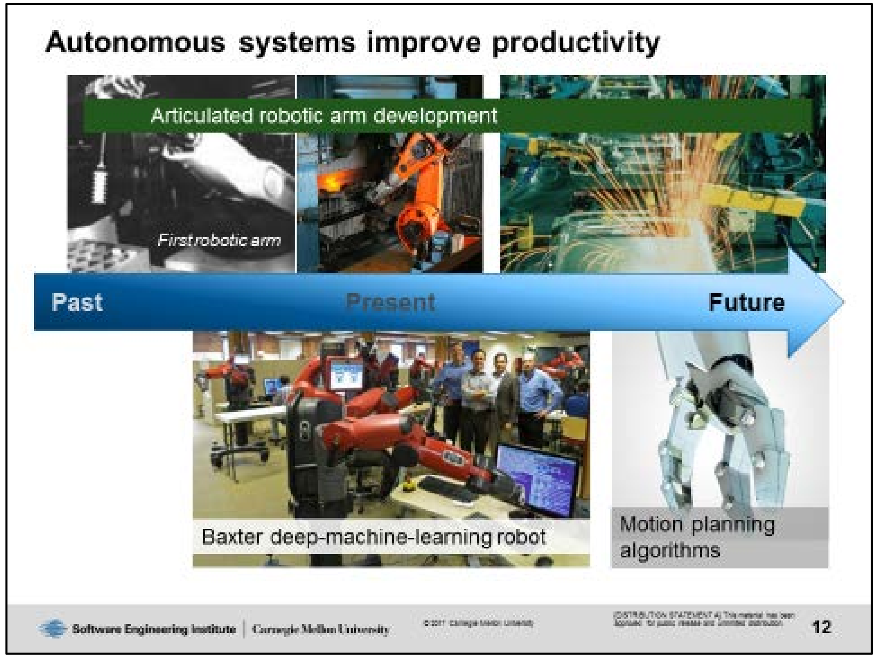
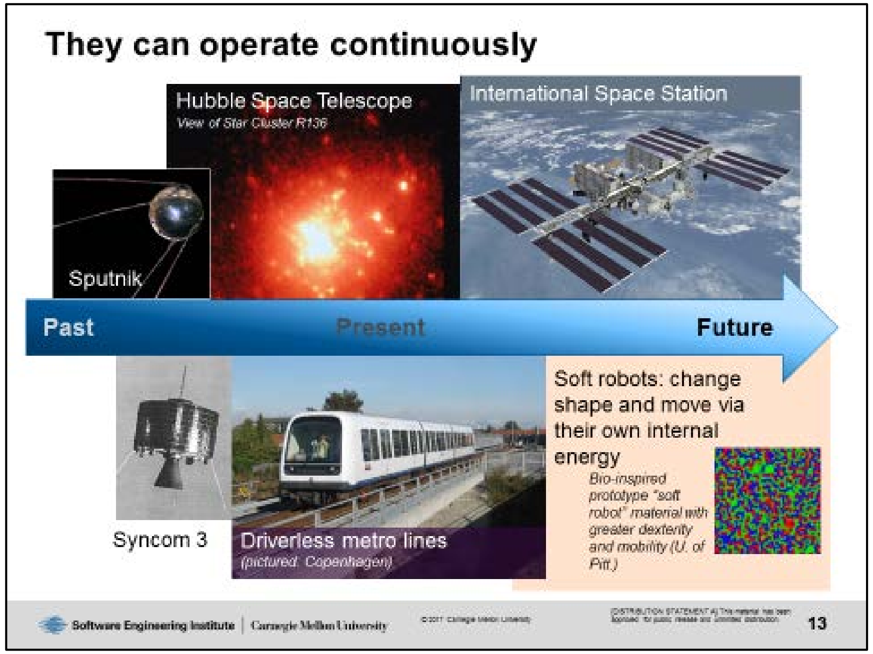
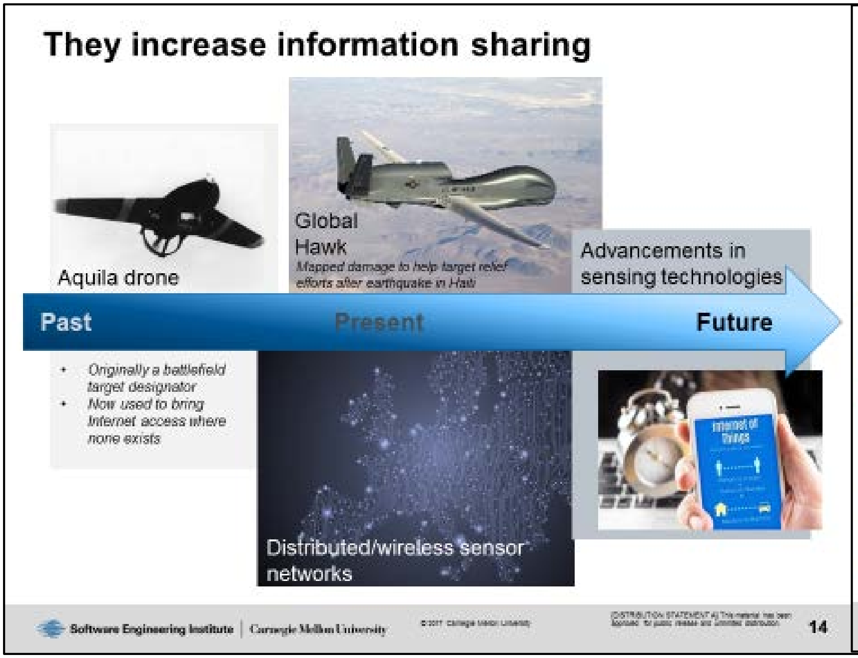
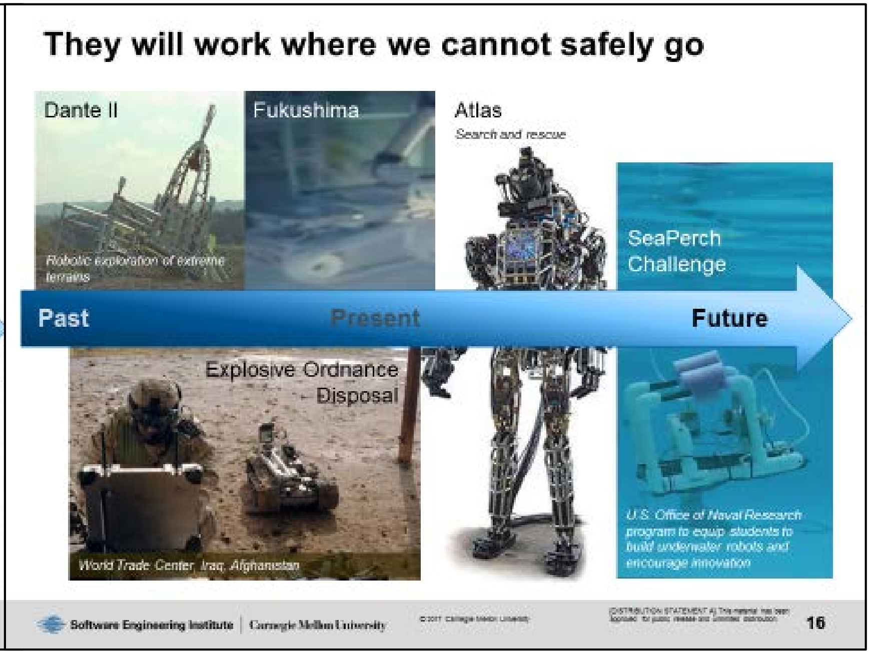
- Autonomy / AI
  - Embedding into many of our systems
  - Driverless cars
    - Uber - Pittsburgh
    - Google – Palo Alto
  - Deliveries
    - Amazon
    - Budweiser – Otto - Video
  - Hotels (CNN)
  - Google DeepMind
  - Advanced Robotics (Sophia)
  - DoD
    - Autonomous Learning Systems
    - Human-machine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

Effects of Autonomy









Source: Paul Nielsen, "Systems Engineering and Autonomy: Opportunities and Challenges", Keynote Presentation at INCOSE Symposium, July 2017 – used with permission

Effects of Autonomy - 2

Source: Paul Nielsen, "Systems Engineering and Autonomy: Opportunities and Challenges", Keynote Presentation at INCOSE Symposium, July 2017 – used with permission

- However, autonomy creates other issues
  - Emergent behavior
  - Continuous change
  - Human/machine interfaces
  - How to do V&V
  - Trust
  - Attack vulnerabilities
  - Unemployment
  - Unintended changes to other businesses
  - Ethics
  - Issues from new interfaces
  - Information overload

Are we ready to deal with these new issues?

Example Issue: V&V - Trust

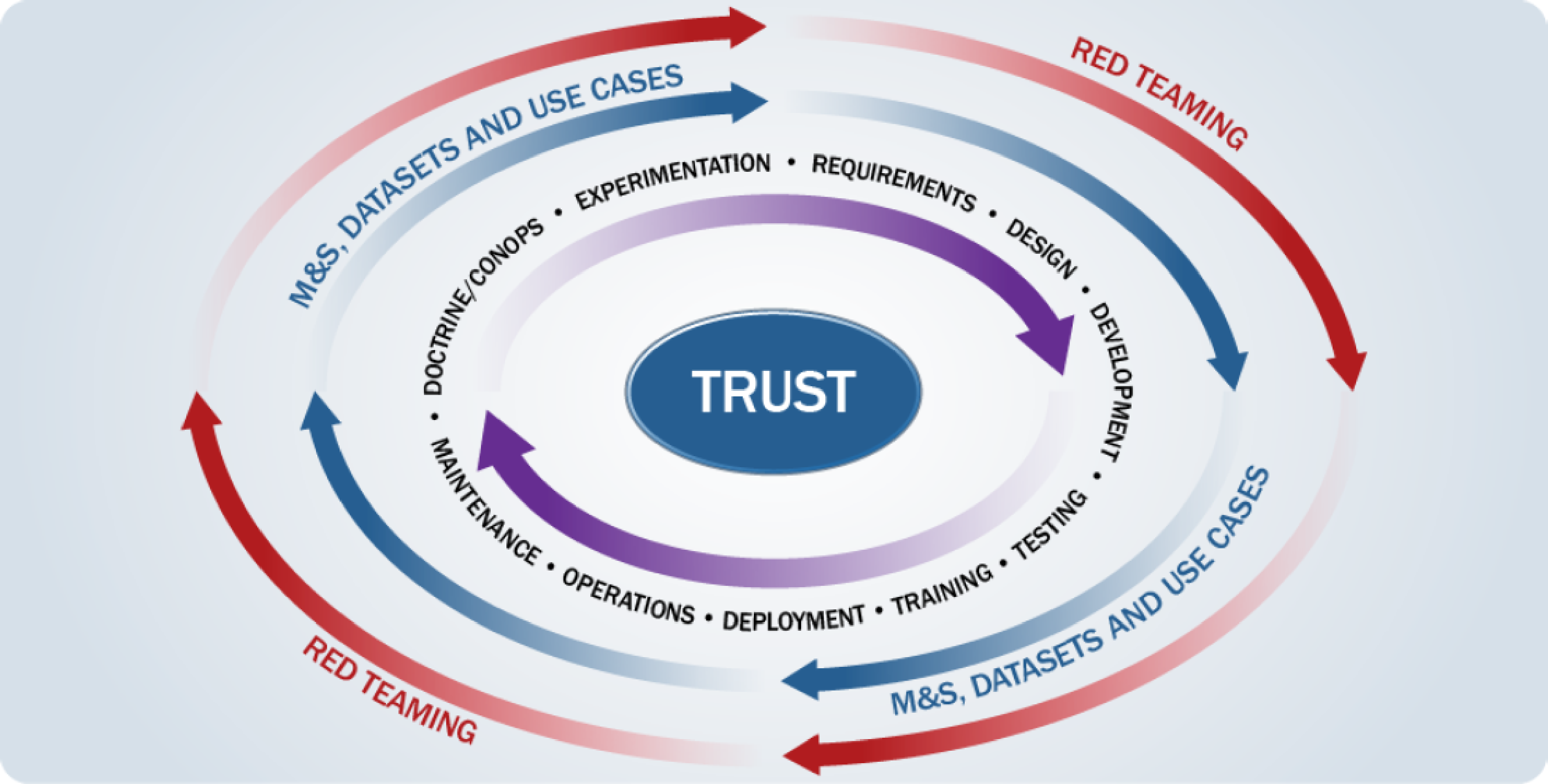
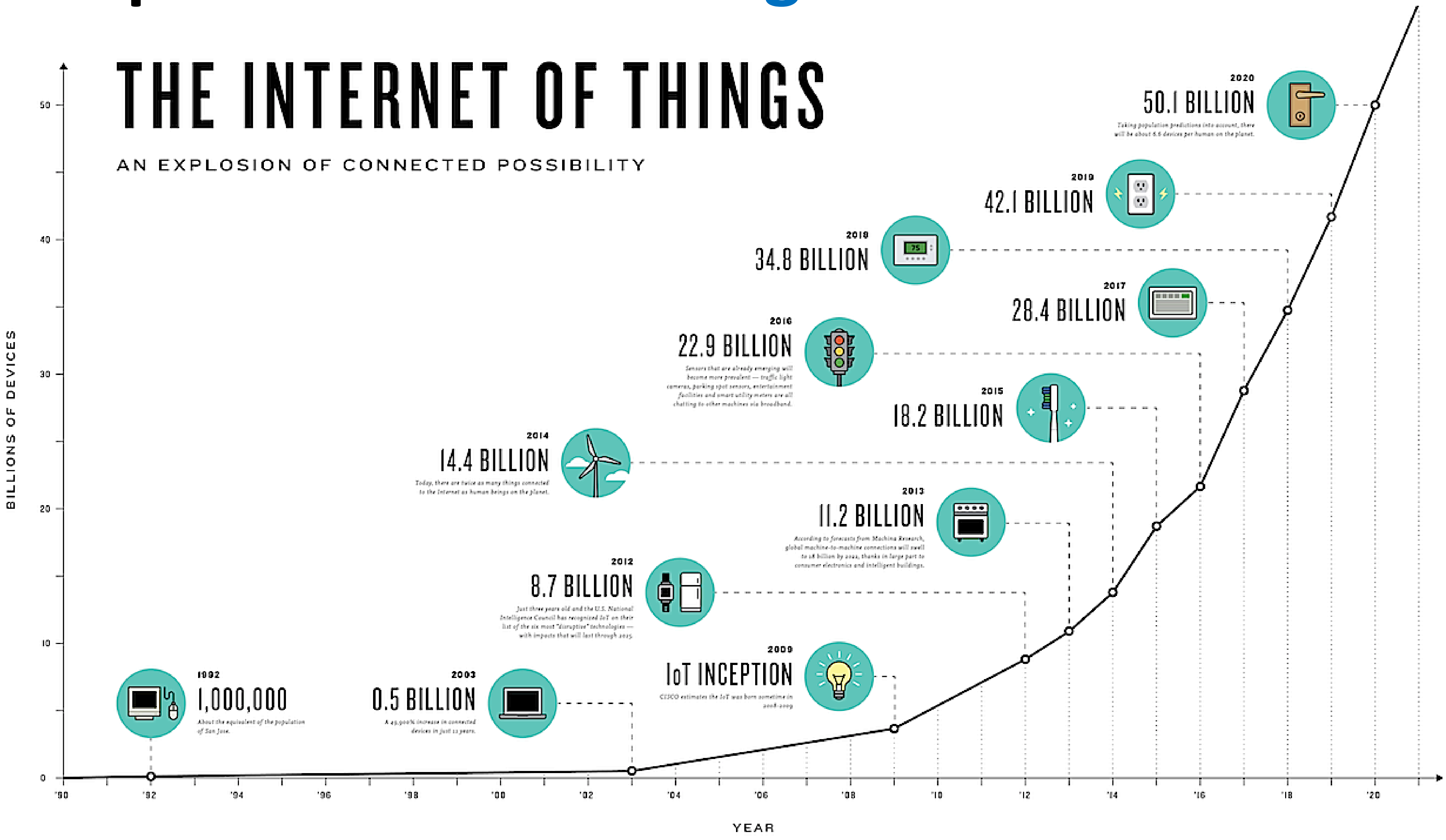


Figure 7 The lifecycle of the systems needs to establish an appropriate calibration of trust in autonomous systems.

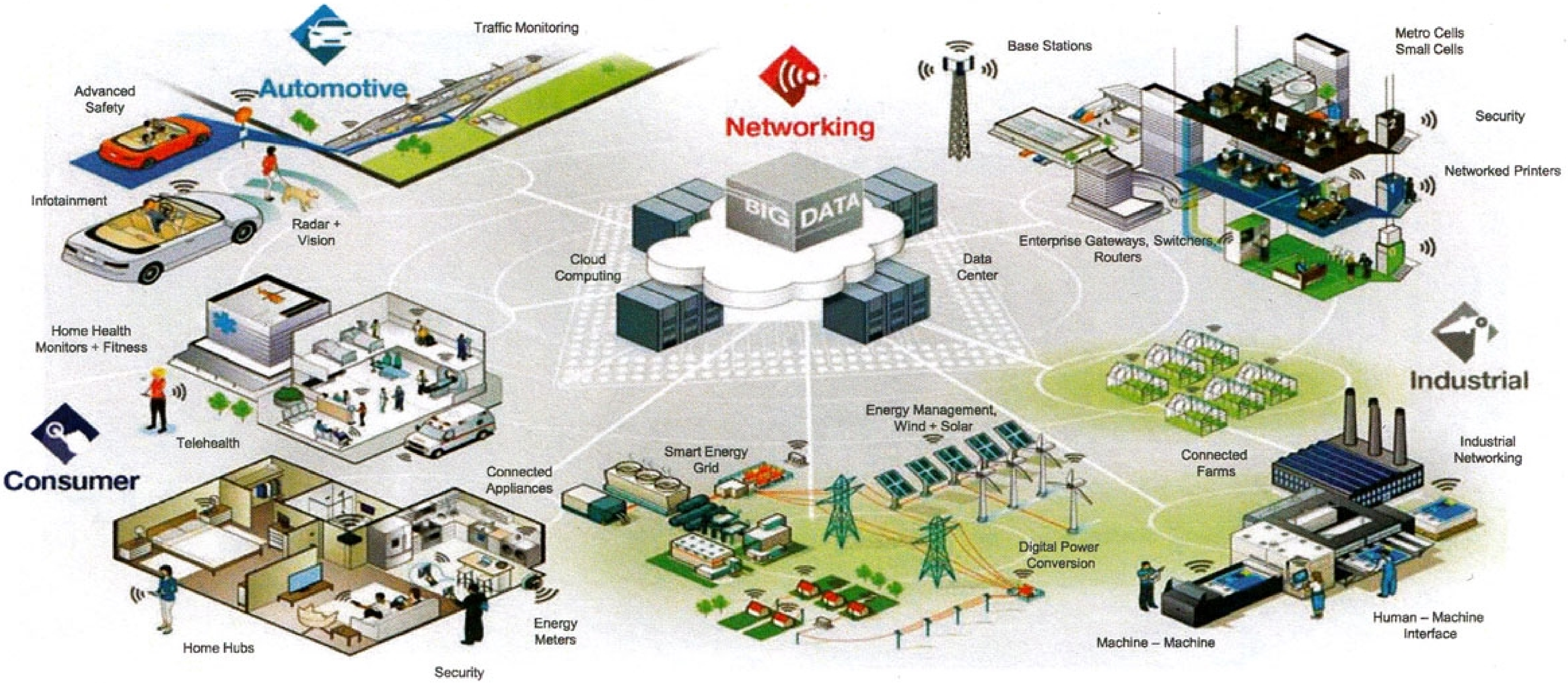
- Current problem: Impossible to test all scenarios; what is good enough?
- Future problem: Human acceptance and adoption
- Requires changing how we verify and validate to build the trust in the system

Source: Defense Science Board Summer Study on Autonomy, June 2016

Example: Internet of Things

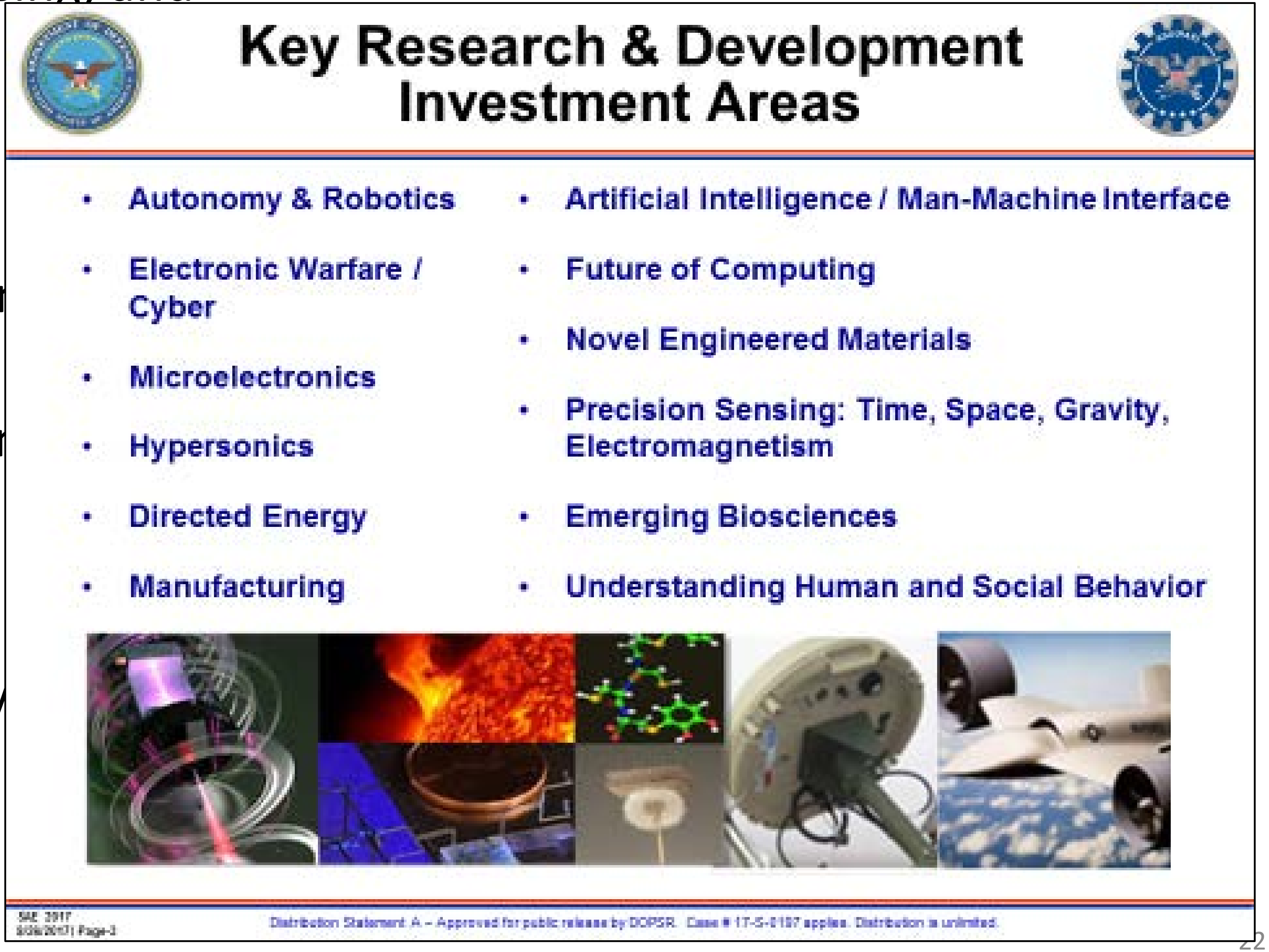


Example: Systems of Systems Connectedness



Other technology trends in systems

- Brain-Machine Interface Systems
- Intelligent Systems, Intelligent Sensing, and Intelligent Learning in Systems
- Digital Engineering / Digital Twins
- Cognitive Computing
- Applied Artificial Intelligence - Cogr and Human Augmentation
- Interactive and Wearable Computir
- Cyber physical systems
- Biometrics, Bio-mechatronics, and
- Augmented Reality / Virtual Reality
- Big Data and Data Analytics
- Cyber Resilient Systems
- …



Source: Kristen Baldwin, “Systems Engineering Opportunities”, SAE 2017 AeroTech Congress & Exhibition, 26 Sep 2017 – used with permission.

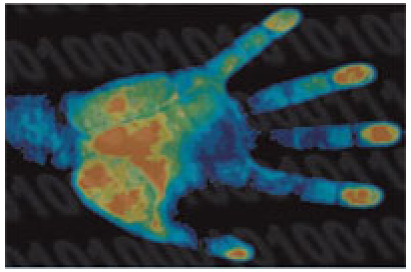
Transforming Practices

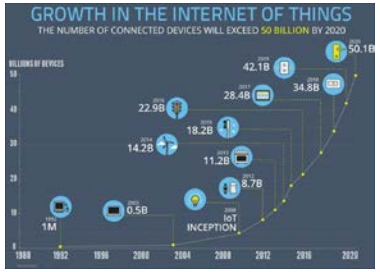
- Collaborative Engineering
- Complex System Understanding
- System of Systems Engineering
- System Architecting for multiple viewpoints
- Composable Design
- Design for Resilience
- Design for Security – system integrity
- Decision Support
- Virtual Engineering and MBSE – part of the digital revolution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

Source: SE Vision 2025.

Evolution is Needed

- Evolve our systems





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

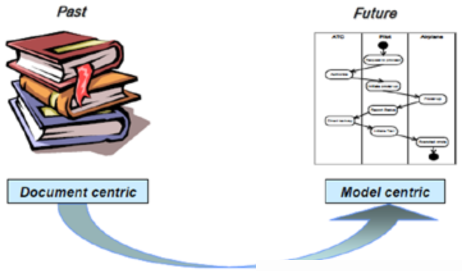
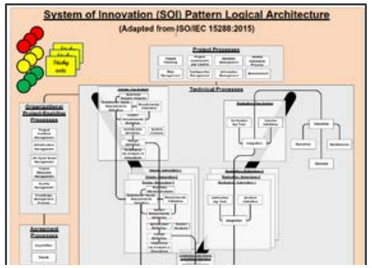


Figure from INCOSE Systems Engineering Vision 202



Deterministic	→	Non-deterministic
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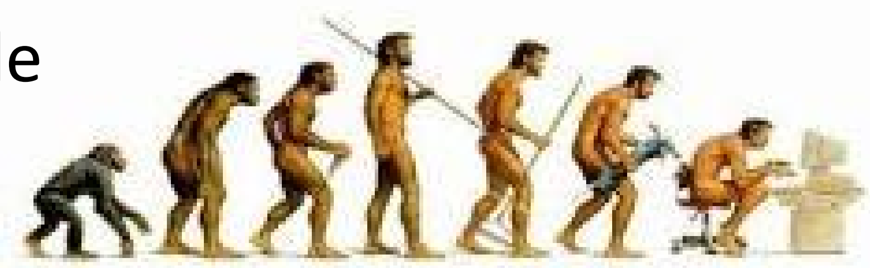
- Evolve our people



Alphabytesoup.wordpress.com

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