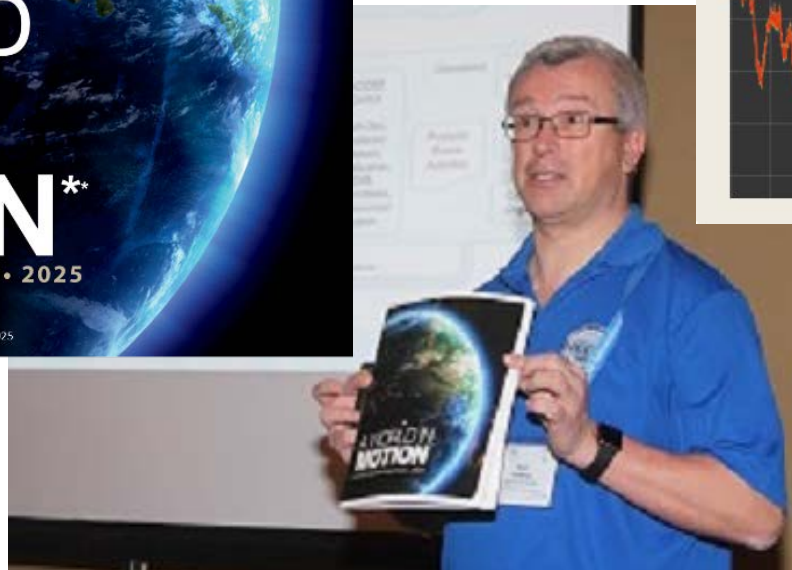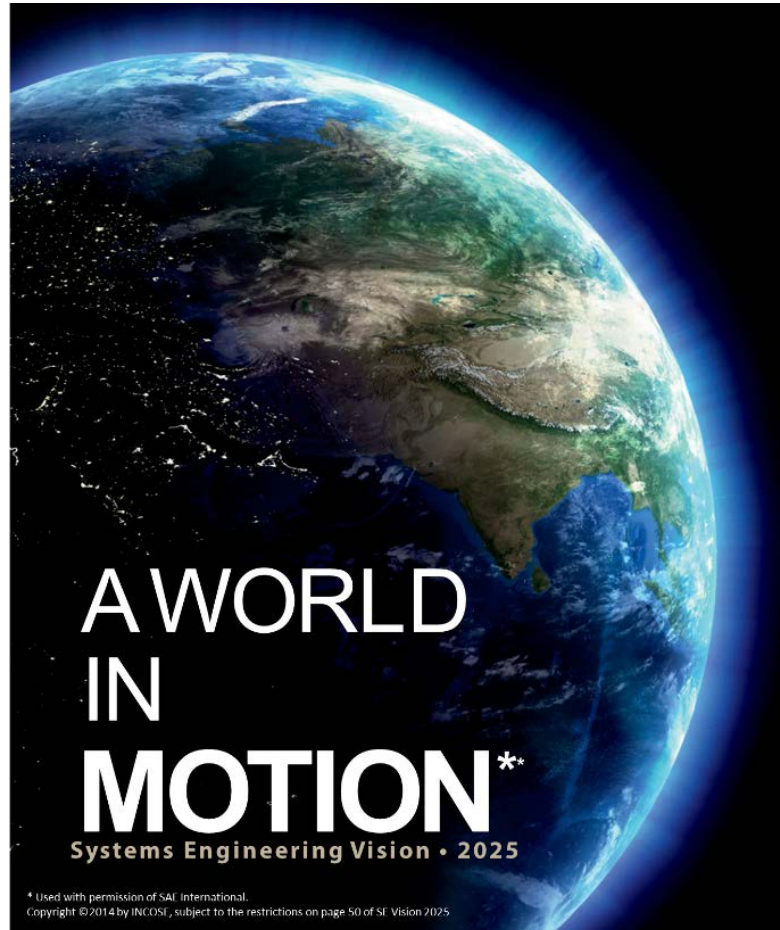**GLRC 2018**

INCOSE

2018 Annual INCOSE
Great Lakes Regional Conference
SYSTEMS AT THE CROSSROADS
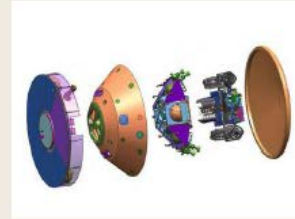17 - 20 October 2018 | Indianapolis, Indiana

Mike Celentano
INCOSE Technical Director
Roche Principal Systems Engineer

The Future of INCOSE

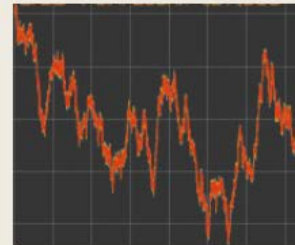www.incose.org/glrc2018

The SE Vision 2025

TAILORED TO THE DOMAIN

SCALED TO PROJECT SIZE

SCALED TO SYSTEM COMPLEXITY

A WORLD IN MOTION*
Systems Engineering Vision • 2025

* Used with permission of SAE International.
Copyright ©2014 by INCOSE, subject to the restrictions on page 50 of SE Vision 2025

THE PATH FORWARD

EVOLVING THE VISION THROUGH COLLABORATION

Establish Grand Challenges

Establish Research Roadmap

Establish Standards Roadmap

Establish Education and Training Roadmap

Evolve the SEBoK to encompass new application domains

Engage industry, government, and academic leaders

ASSESSING THE CURRENT STATE

DEVELOPING DETAILED ROADMAPS

EXECUTING FOR ACHIEVEMENT

A View to the Future

- Continue to Address SE Vision 2025
- SE of the Future initiative
- Future Direction of SE Research (and SoSE Research)
- SE for Policy and Governance
- Effective Integration with Other Disciplines
- Evolving Practices and Standards (non-exhaustive list)
  - *Follow the lead of the SE Vision*
  - *System of Systems Engineering (SoSE)*
  - *Complex Systems*
  - *SE Transformation (including DEIX)*
  - *Agile Systems and SE*
  - *…*
- What else?

The Future of SE …
Informed by the Past

Hubble
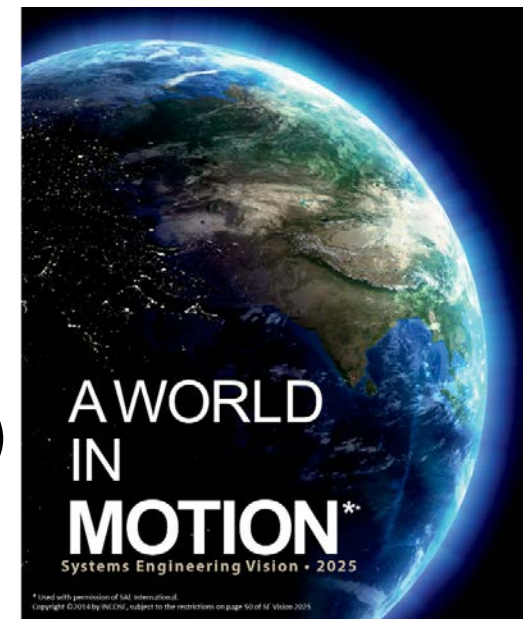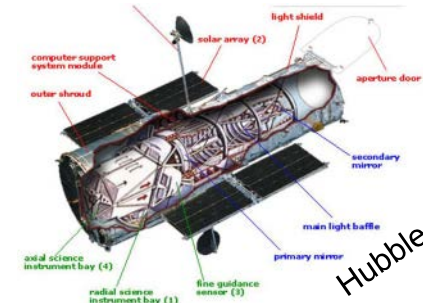
Tech from the 90's

Practical Laptops

DVD

Digital Camera

Interviewed 2 Matriarchs & 4 Patriarchs of SE

- How far SE has come in ~ 25 years
- What has changed since then
- What are still core principles today
- How good we were at predicting our future

Smart Phone

These insights should help inform our future.

Furbie

The Future of SE ...

Relevant Presentations from INCOSE "Rock Stars" …

Papers presented at the annual symposium of INCOSE, Chattanooga, TN, Oct 20–23, 1991.

Grady, Jeffery O. (General Dynamics). "Local Systems Engineering Education Program Ignition and Sustenance".

Forsberg, Kevin (CSM). "The Relationship of Systems Engineering to the Project Cycle".

Shishko, Robert (JPL/NASA). "Fundamentals of Systems Engineering at NASA".

Rhodes, Donna (IBM Federal Systems). "The Infrastructure for a Systems Engineering Evolution".

Sheard, Sarah (Hughes Aircraft Corp). "Capturing the Systems Engineering Process".

Bahill, A. Terry (U of Arizona). "30 Years of Systems Engineering at the University of Arizona".

Paper presented at the annual symposium of INCOSE, Seattle, WA, July 20–22, 1992.

The Future of SE … Informed by the Past

Chattanooga Conference [1991]

- My paper focused on an education program for my Systems Development department members
  - GD corporate policy to encourage hiring of recent college graduates
  - I was a hiring manager with a preference for hiring people with experience
  - Concluded I would respect policy by ensuring competence of new hires out of college through a Systems Engineering Institute training program
  - Prepared written practices for all department work on programs that were used as texts for classes
  - Developed one hour sessions that my Chiefs and I could present during lunch hour at no cost to the company
- To this day there are probably not enough companies providing in-house training in accordance with their preferred system development process
- University education continues to be a problem especially where universities tend toward distance learning that results too often in simple sale of credits
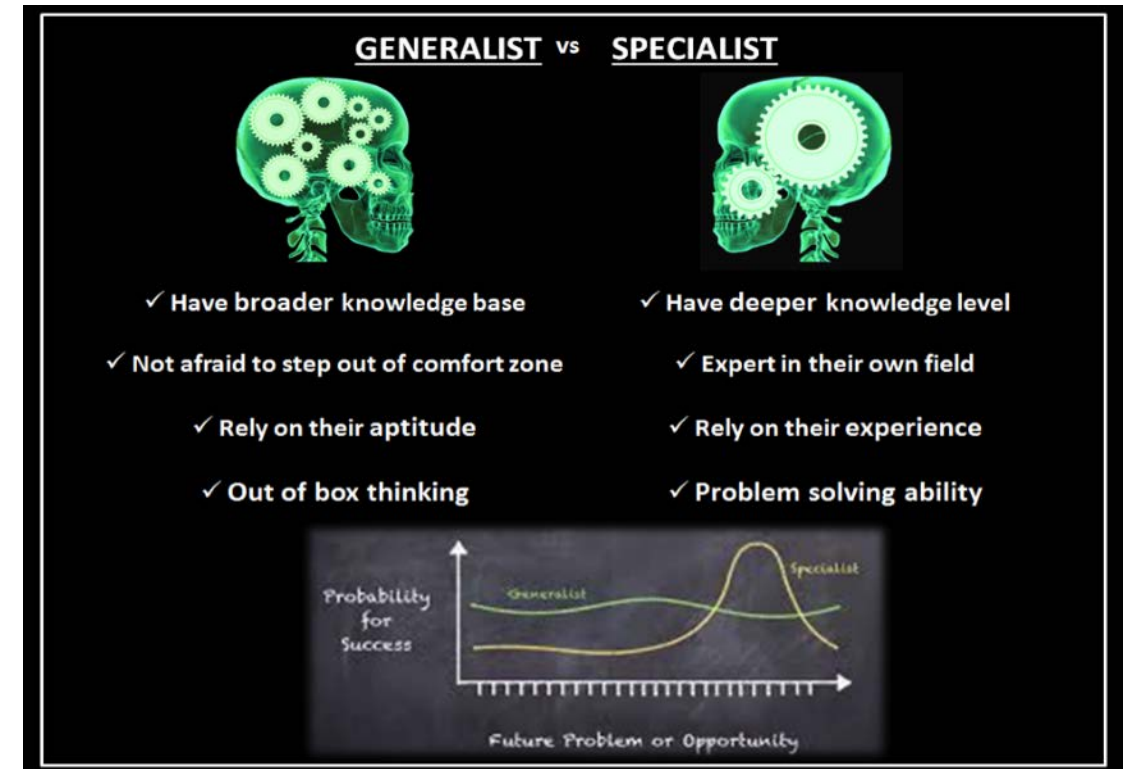
The Future of SE …

Our Span of Interest In Modeling Is Too Small

- We focus our interest in model based systems engineering too tightly on the technical problem to be solved on a program
- The reality is that every enterprise dealing with systems development is simultaneously dealing with three inter-active systems
  - The Product System to be delivered
  - The Program System that creates the product system
  - The Enterprise System embracing multiple programs and a functional department structure
- We need to master the aggregate of the three systems if we hope to master model based system engineering

The Future of SE

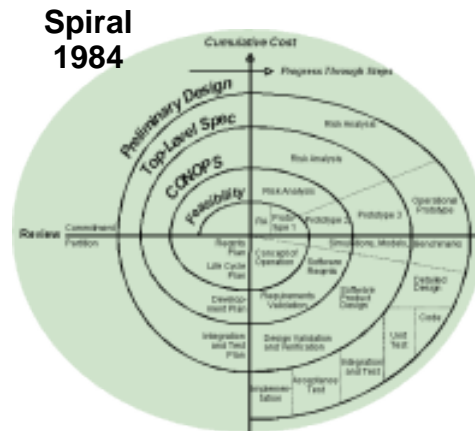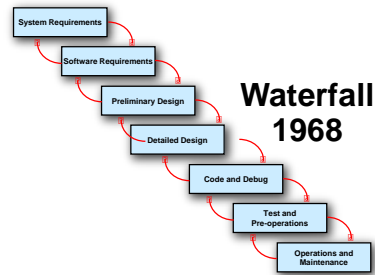## What I have Learned To Be the Biggest Problems In Our Profession

- We populate development programs with two kinds of people
  - Specialists master a deep but narrow field of knowledge with a specialized vocabulary
  - System Engineers are a mile wide and an inch deep who focus on the domain and product boundaries and effective cross functional communication
- Management mastered by few
- Modeling scope too small to encourage MBSE success
- Our ignorance of how the human mind works – the most difficult system problem of all time

http://www.jiteshpant.com/generalists-or-specialists-who-are-more-successful/

The Future of SE ... Informed by the Past

Project (Program) Cycle Development History and Strategy

Waterfall 1968

Spiral 1984

INCOSE Symposium 1991

Vee 1990

Incremental 1992

Evolutionary 1992
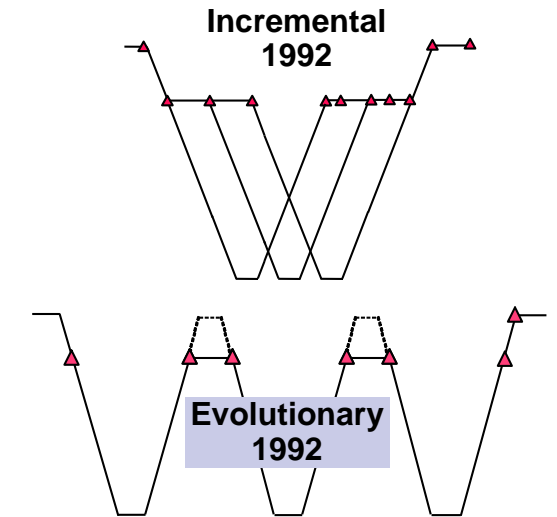
AGILE Software Best Practices 1998

Extreme Programming 2000

Vee Views 2014
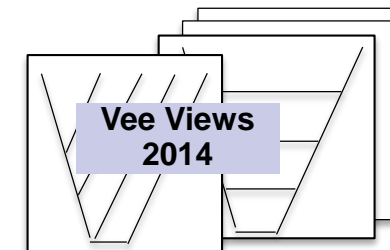
The Future of SE …

The Four Views, D Scheithauer & K Forsberg, 2014

1 — The Basic V
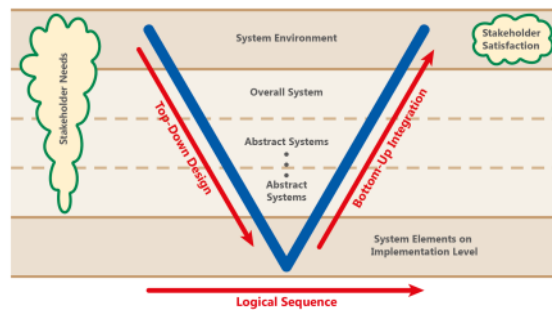
4 — The Dynamic V
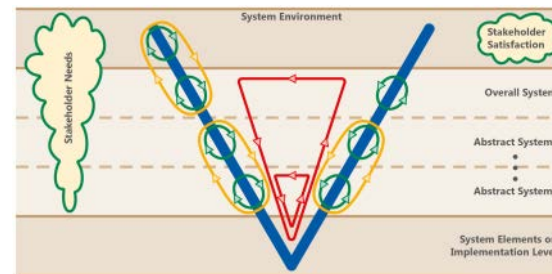
2 — The Development V
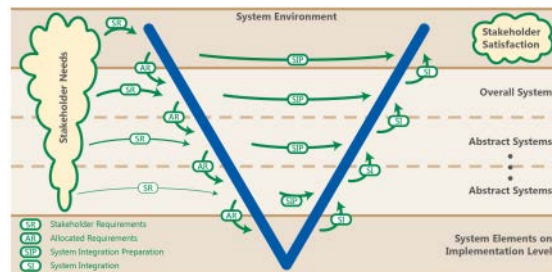
3 — The Assurance V

The Future of SE?

Who did the physical interface analysis?

The Future of SE

Success

"We tend to seek easy, single-factor explanations of success. For most important things, though, success actually requires avoiding many separate possible causes of failure."

Guns, Germs, and Steel,
The Fates of Human Societies
- Jared Diamond
Norton Press 1999

The Future of SE … Informed by the Past
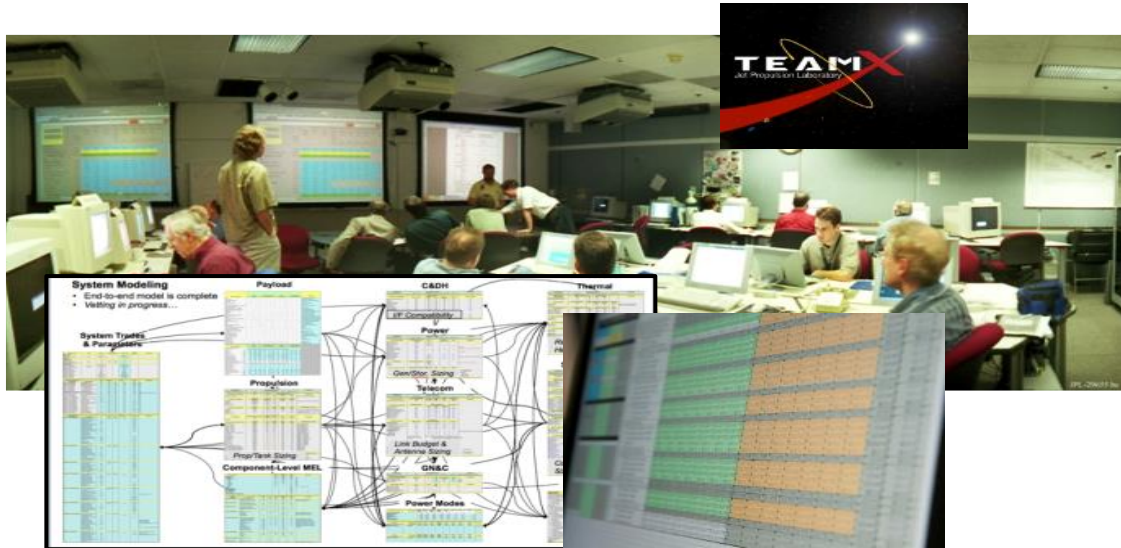
20 years ago

- "Faster, Better, Cheaper"
- Forefront of concurrent engineering
- Linked subsystem models

In the last few years

- Developed new capabilities for early mission concept formulation
- New services for Team X
    - Team X Lite
    - Red Team type reviews
    - Science Traceability Matrix
- New Teams
    - A-Team (Mission Architecture)
    - Team Xc (CubeSat)
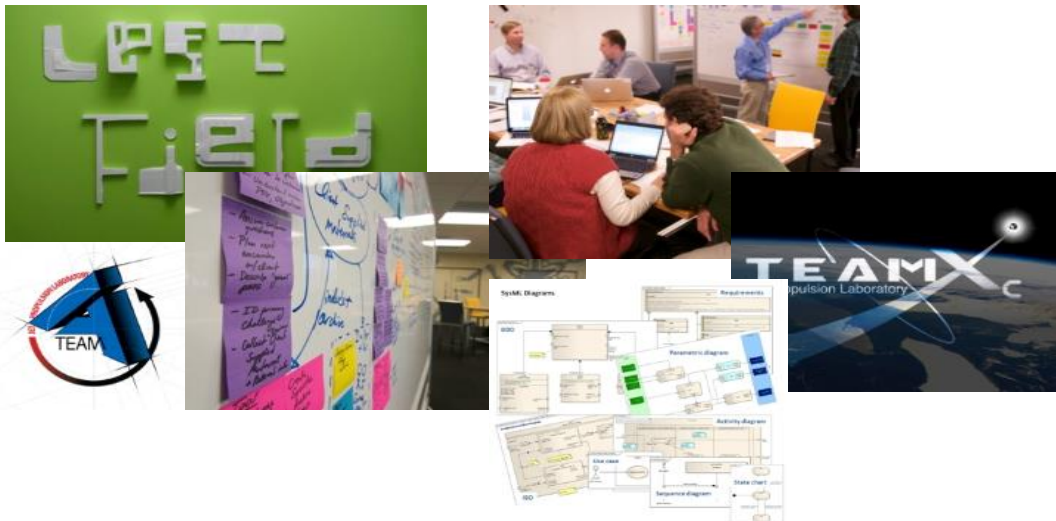
The Future of SE

JPL's Evolving Concurrent Engineering Capability

Power Beaming
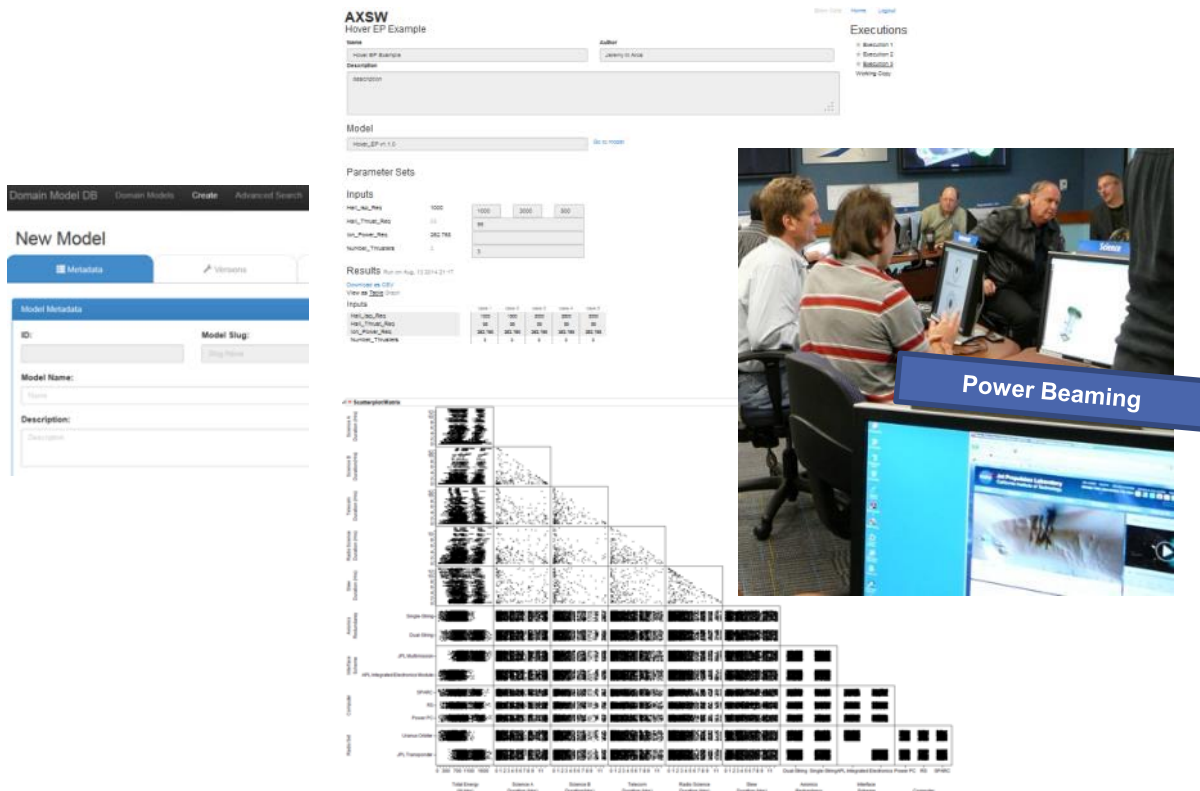
- Powerful analysis capability to infuse new models
- Common database, providing a Single Source of Truth
- Common infrastructure for concept formulation teams
- Access to prior study results, enabling re-use

The Future of SE

JPL's Evolving Concurrent Engineering Infrastructure

Study Management — **Stand-alone Databases** — **Model Repository** — **Model Construction & Execution Environment** — **Execution Engine**

Concept Maturity Level

Robert Shishko, Jet Propulsion Laboratory & CIT, 2015
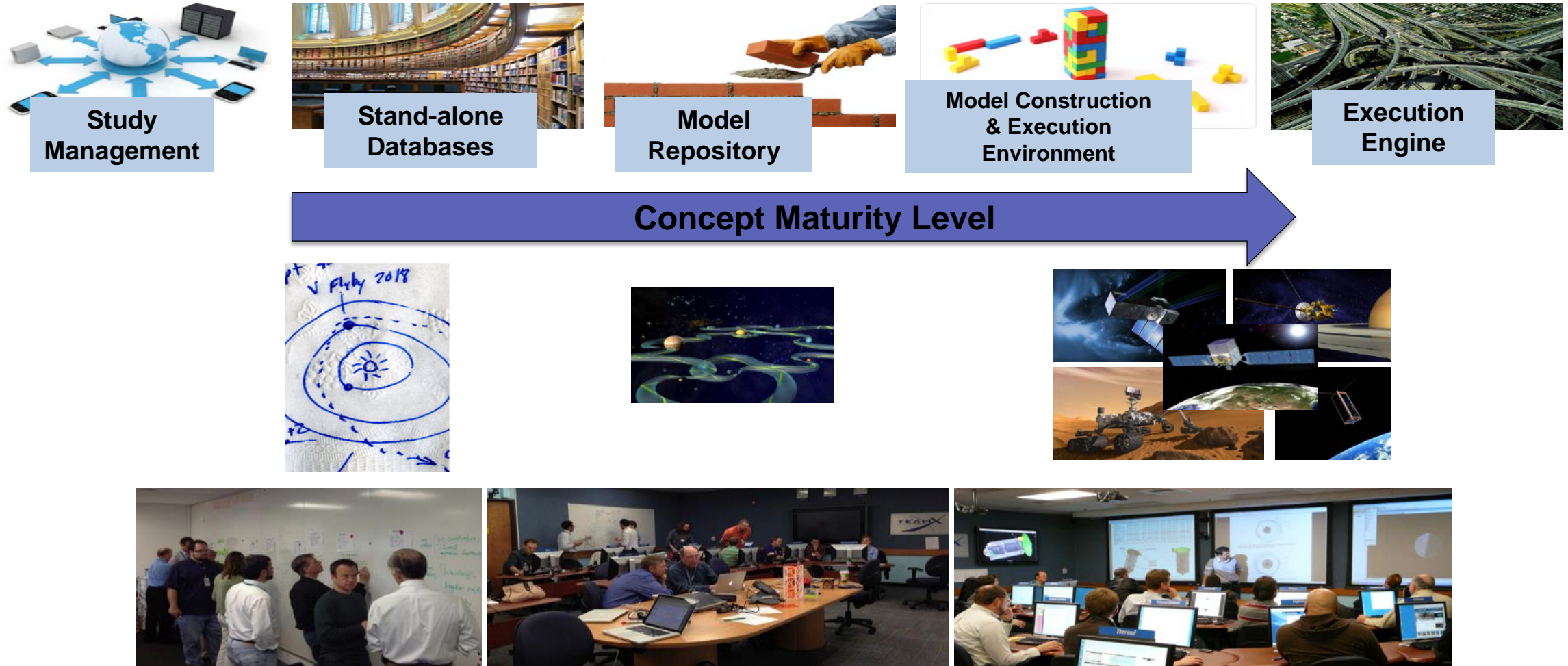
The Future of SE … Informed by the Past

Paradigm Shift ➤ *NCOSE* ➤ 1993

NATIONAL COUNCIL ON SYSTEMS ENGINEERING

Collaboration will benefit industry as a whole
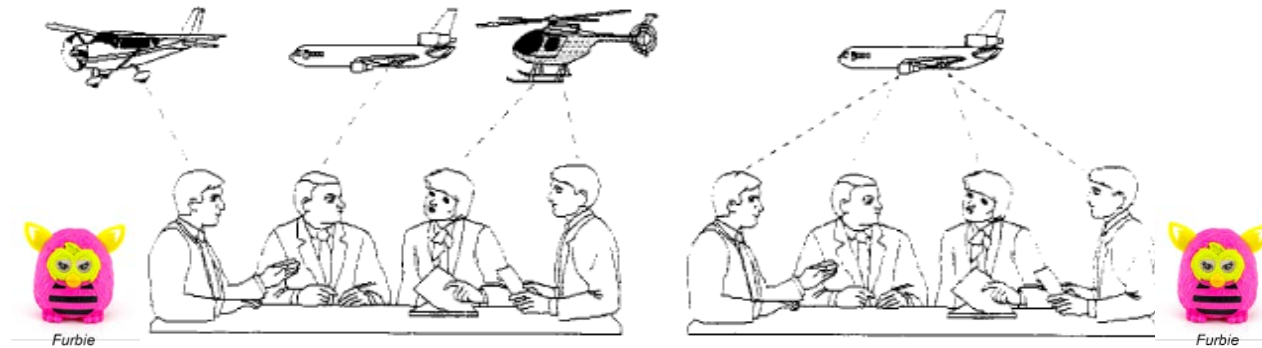
	COOPERATION	COLLABORATION
TEAM BUILDING	• Available Resources	• Scientific Approach
LEADERSHIP	• Distributed	• Shared
MEANS TO CONVERGENCE	• Communication	• Formal Methods
METHODS and TOOLS	• Compatible	• Seamless
REWARD FOCUS	• Team Success	• Successful Teamwork

The Future of SE … Informed by the Past

Environments

1993

increasing sophistication of methods and tools will provide higher levels of

integration, resulting in seamless engineering with process enactment and information management

Example Enabling Technologies

- Collaboration Technologies
- Computer Aided Systems Engineering (CASE)
- Computer Based Training
- Design Analysis Tools
- Electronic/Video Conferencing
- Information Engineering Techniques
- Information Technology
- Prototyping Tools
- Process Enactment Technologies
- Reverse Engineering Tools
- Simulation Tools

2003

modeling and simulation and **seamless** "cradle to grave" databanks in interactive environment

boundaries between hardware, software and humans will gradually become transparent

Donna Rhodes, MIT, 2015

The Future of SE … Informed by the Past

Education

our environments will foster technical vitality and innovation, using state-of-the-art techniques and technologies to deliver **on-demand JIT training**

- **convergence in curricula** and shared knowledge assets, while **allowing flexibility to retain unique value** of a given university
- **distance education, on-demand/just-in-time** training, and extensive **use of simulation** technologies
- **capstone projects** with significant complexity

The Future of SE

- Collaboration paradigm achieved to a degree, hindered by IP and competitive concerns

- Achieved predictions for competency models, certification and education

- Moved beyond mechanistic strategies, but still too much 'checklist' engineering

- Measurement has matured but still evolving

- "Instances" of impressive model-based environments

- Model-based engineering has evolved, but many culture/resource barriers to fully implementation

ONCE YOU'VE MASTERED THIS SIMPLE TECHNIQUE, WE'LL MOVE ON TO SOMETHING MORE CHALLENGING, LIKE CHANGING YOUR CORPORATE CULTURE.

https://www.torbenrick.eu/blog/culture/changing-organizational-culture-is-daunting/

SE Trends Reflected by Sheard Papers 1990-2015

What is Process? Why is it important?

Early Systems Engineering tools

1990

IPTs

1995

Quagmire of Standards & Models

What is SE?
(12 Roles)

SE for SW and HW systems

Maturing Processes, Assessments

2000

SE Implementations:
Discovery, Program SE

Hard
Numbers

SoS

Multiple models,
Management
Commitment

2005

Resilience

Fads (Silver Bullets)

2010

Change

Complexity Theory

Complex Systems

SW
Sustainment

2015

Sarah Sheard, Software Engineering Institute, 2015

The Future of SE

Past & Present –> Future

- Process defined, will be a commodity
  - Change process, IPTs, Fads, Value of SE
- What is SE? Known, defining more parts, aspects
- Newer topics, big in the future
  - <u>Systems of Systems: Everything</u>
  - Software-dominant systems
    - More integration with SW
    - Education
    - Cybersecurity
  - Modeling and simulation; formal methods
  - Sustainment
- "Keeper of the holy flame": Always

https://www.sics.se/projects/systems-of-systems-agenda

The Future of SE … Informed by the Past

Engineering "plus"

Image via Amador Ledger Dispatch

Direct-Dialing for long distance began replacing operators in the 60s

- In the 1960s, the engineering department believed that systems engineering was engineering and mathematics plus the ologies: Psychology, Sociology, Anthropology and Philosophy.

- The undergraduate students took a degree in Engineering Mathematics

The Future of SE … Informed by the Past

Quotes from the UofA Catalogue [1959-1961]

- *Systems Engineering, as defined by the College of Engineering, refers to that particular class of technological systems in which the measures of effectiveness are necessarily and directly involved with the structure of human values.*

- *While nearly all engineering work is a consequence of socio-cultural need or desire, the measure of effectiveness may or may not be directly involved with human value scales.*

- *The problem becomes systems engineering only when this involvement is direct.*

- *In this context, systems engineering requires all of the tools of analysis and design required in all fields of engineering.*

- *In addition, organized study is required in the structure of human values and its reduction to quantitative and systematic criteria.*

To a man with a hammer, everything looks like a nail.

"Problem stating is more important than problem solving."

The Future of Systems Engineering

Summary of Predictions Based on the Past

➢ *Improved understanding of, and communication with, the Human Mind*

➢ *Single point of failure is a thing of the past*

➢ *Concurrent Engineering & Science evolves even more*

➢ *Barriers to SE, like IP & business culture, are broken down*

➢ *Everything is part of an SoS*

➢ *Problem stating (in terms of human values) is more important than problem solving*

It's Up To Us To Make It Happen

www.incose.org/glrc2018