Abstract

- Systems engineering is foundational in architecting, designing and deploying complex systems. The enterprise is a complex system. People, processes, infrastructure, hardware, software, data, etc. make up this complex ecosystem. The presentation will explore the importance of systems engineering and technology in delivering an integrated digital enterprise. Examples will be provided not only on the importance systems engineering has on architecting complex systems for our warfighter but also on architecting the enterprise to transform the way we design, develop, test, deploy and sustain mission critical systems.

A Systems Engineering Perspective on the Digital Enterprise

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Chris Orlowski Bio

- Education
  - The George Washington University, PhD Systems Engineering
  - Virginia Tech, B.S. Aerospace/Ocean Engineering; M.S. Systems Engineering
  - University of Virginia, Darden Business School – Executive Program
- Director, Integrated Digital Product Development and Services (*Enterprise Services*)
  - Digital strategy for engineering, manufacturing, and logistics
- Prior Roles:
  - Director, Programs (*Corporate Office*, *Information Systems; Technology Services*)
  - Corporate Director, Engineering & Technology (*Corporate Office*)
  - Department Head, Systems Engineering (*Newport News Shipbuilding*)
  - Program Manager – C4ISR - Domestic & International (*Electronic Systems*)
  - Naval Architect – PEO CV Technical Directorate
- Industry: Corporate Advisory Board, INCOSE

To Meet Current and Future Challenges…

Increased system complexity

Affordability as a key requirement

Demand for talent and resources

Need for adaptable & resilient systems

Urgent mission needs for rapid fielding

Reinvent the customer experience

…we must partner and set direction collectively

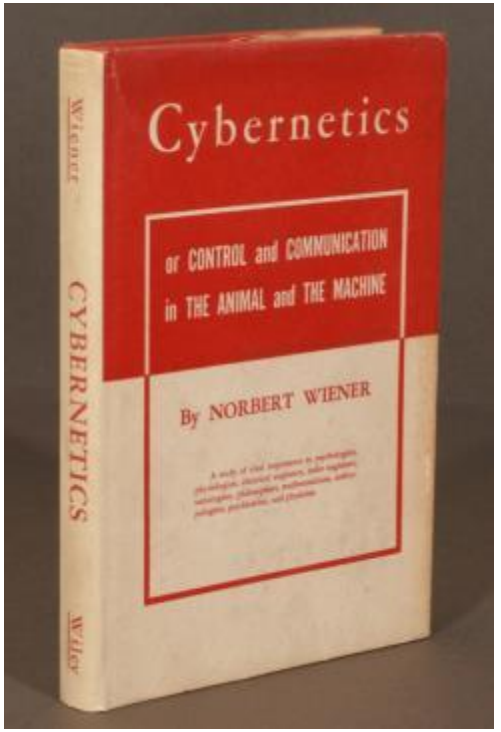
Increased Complexity in Today's Systems

- **Changing environment** and emerging threats
- "Do More With Less" - **affordability**
- More emphasis on multi-mission capability, **adaptability and resiliency**
- Results in **increased complexity** in functional architecture and resulting physical solution
- Complex interfaces with numerous components
- Electronics footprint continues to increase
- Exponential growth in software (automation)

Leveraging systems engineering to deliver mission success

Systems Engineering & Cybernetics

- Systems engineering emerged to address complexity and change
- Systems engineering roots can be traced to cybernetics
- Norbert Wiener authored Cybernetics in 1947 [1]
- Central to cybernetics theory is the concept of **feedback and control**
- Technical management activities required to measure and control performance are critical to ensuring systems engineering effectiveness [2]

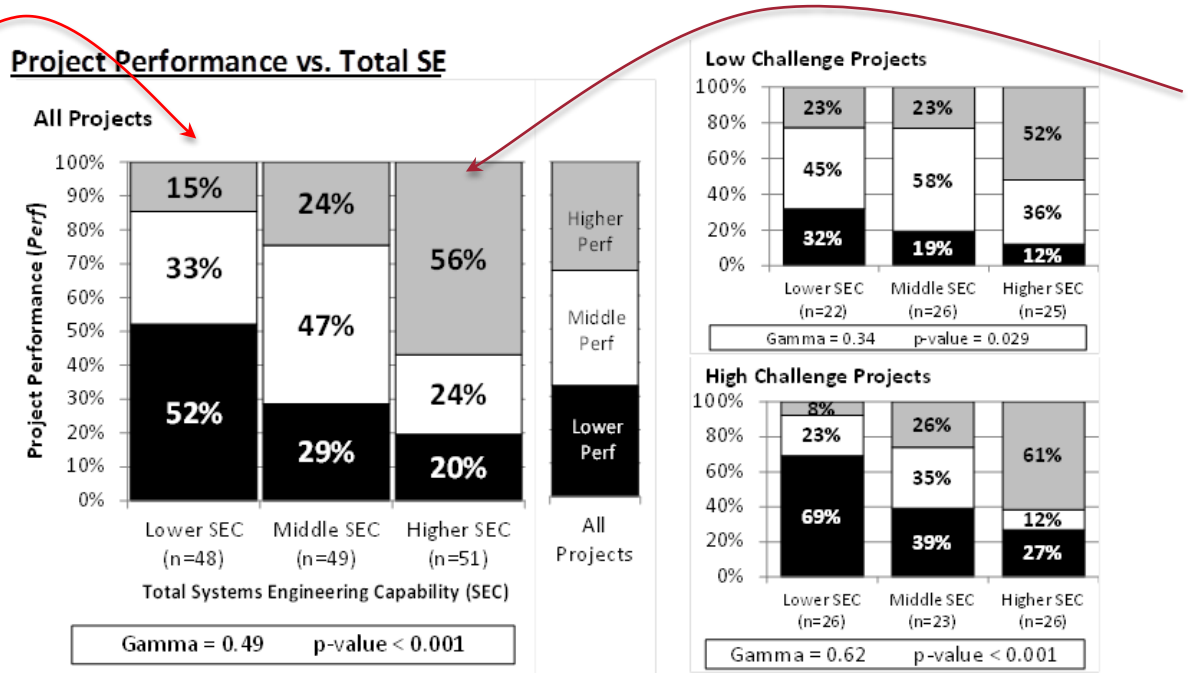


Cybernetics is defined by Webster's dictionary as "the science of communication and control theory that is concerned especially with the comparative study of automatic control systems (as the nervous system and brain and mechanical-electrical communication systems)" [3]

Systems Engineering Effectiveness [4]

- SEI & NDIA surveyed 148 development projects and found clear and significant relationships between systems engineering best practices and performance on those projects
- Projects that contained high level of systems engineering best practices performed much better than projects with low SE capability

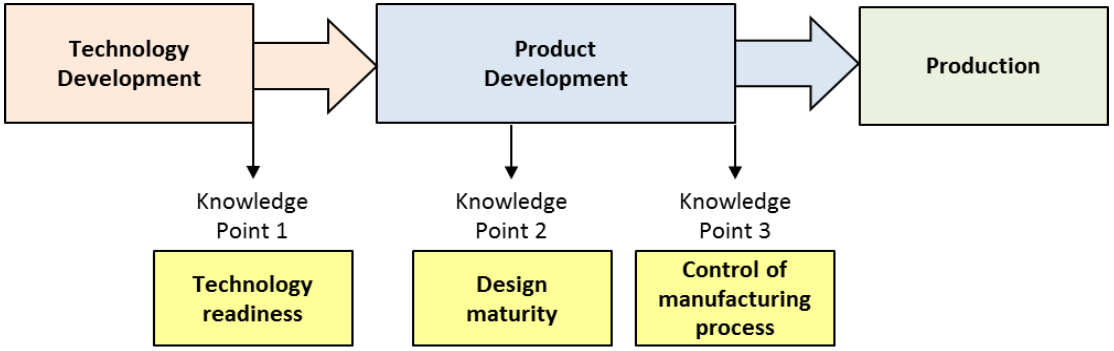
For the projects that did the least SE, only 15% delivered the best project performance.



For the projects that did the most SE, 56% delivered the best project performance

Systems Engineering Leading Indicators

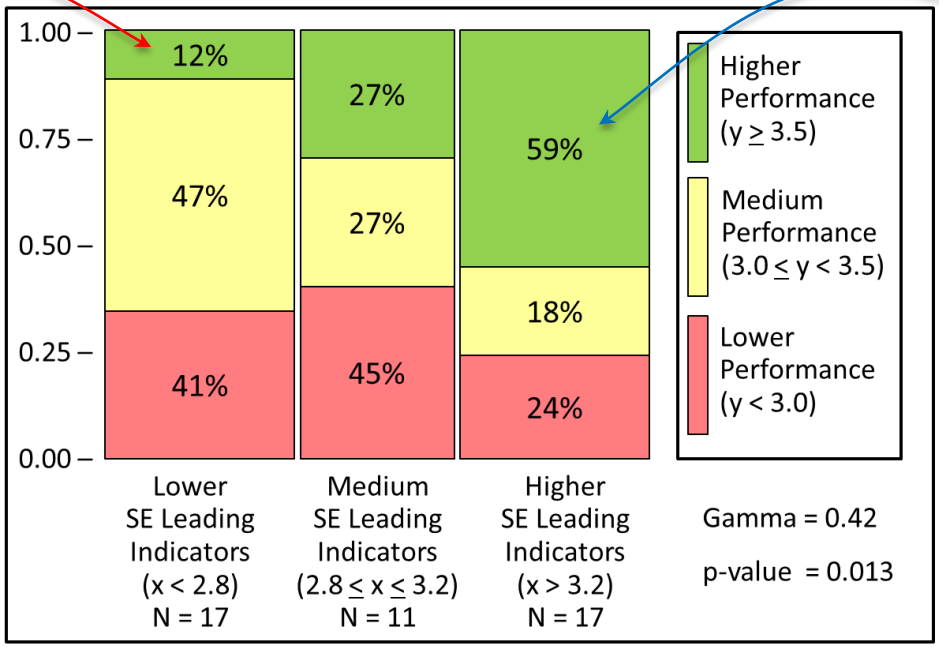
KP	Knowledge-Based Practice [5]	Systems Engineering Leading Indicator [6]
	Demonstrate all critical technologies in a relevant environment	Technology Maturity Trends
1	Demonstrate all critical technologies in an operational environment	Technology Maturity Trends
1	Complete SRR and SFR before development start	Requirements Trends
1	Complete preliminary design review before development start	Technical Measurement Trends
2	Constrain development phase to 6 years or less	Schedule Pressure
2	Release at least 90 percent of drawings	Work Product Approval Trends
2	Test a system-level integrated prototype	Requirements Verification Trends
2	Establish a reliability growth curve	Technical Measurement Trends (ex. Reliability)
2	Identify key product characteristics	System Definition Change Backlog Trends
2	Identify critical manufacturing processes	Facility and Equipment Availability Trends
2	Conduct producibility assess. to identify mfg. risks for key technologies	System Affordability Trends
2	Complete failure modes and effects analysis	Defect/Error Trends
3	Demonstrate manufacturing process capabilities are in control	Process Compliance Trends
3	Demonstrate critical processes on a pilot production line	Defect/Error Trends
3	Test a production-representative prototype in its intended environment	Requirements Validation Trends



Cycle for Providing Users a Product with Better Capabilities [5]

SE Measurement as a Leading Indicator

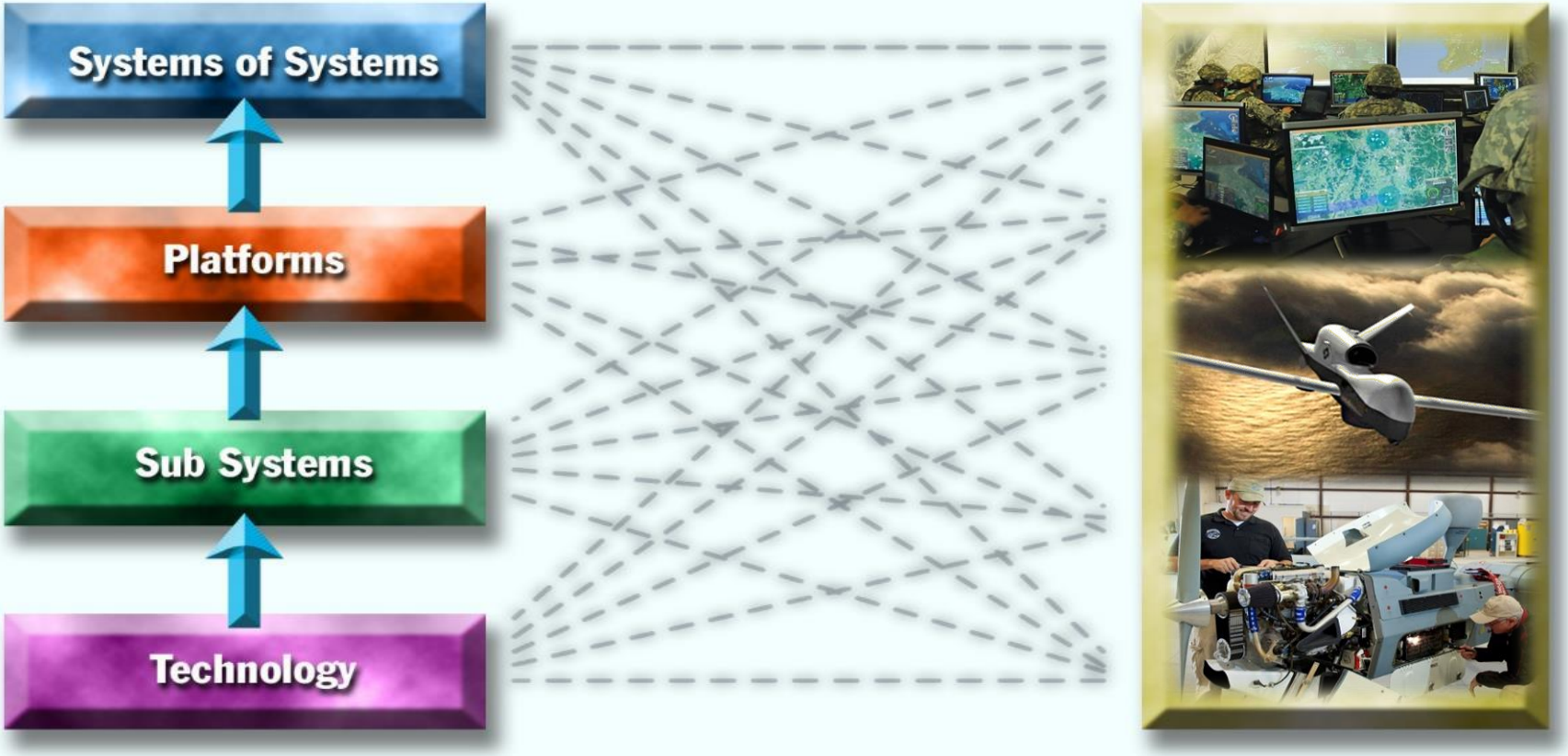
For the projects that did the least SE Measurement, only 12% delivered the best project performance.



For the projects that did the most SE Measurement, 59% delivered the best project performance

- The above mosaic format was adapted from the SEI SE Effectiveness Study in order to summarize the results of the research [4]
- Surveyed 45 projects and found clear and significant relationships between systems engineering measurement and performance on those projects
- Projects that contained high level of systems engineering measurement (i.e. SE leading indicators) performed much better than projects with low SE measurement capability

Highly Complex and Challenging Programs
Demand Systems Engineering



Engineering mission critical systems

Developing the Integrated Digital Enterprise

Also Demands Systems Engineering

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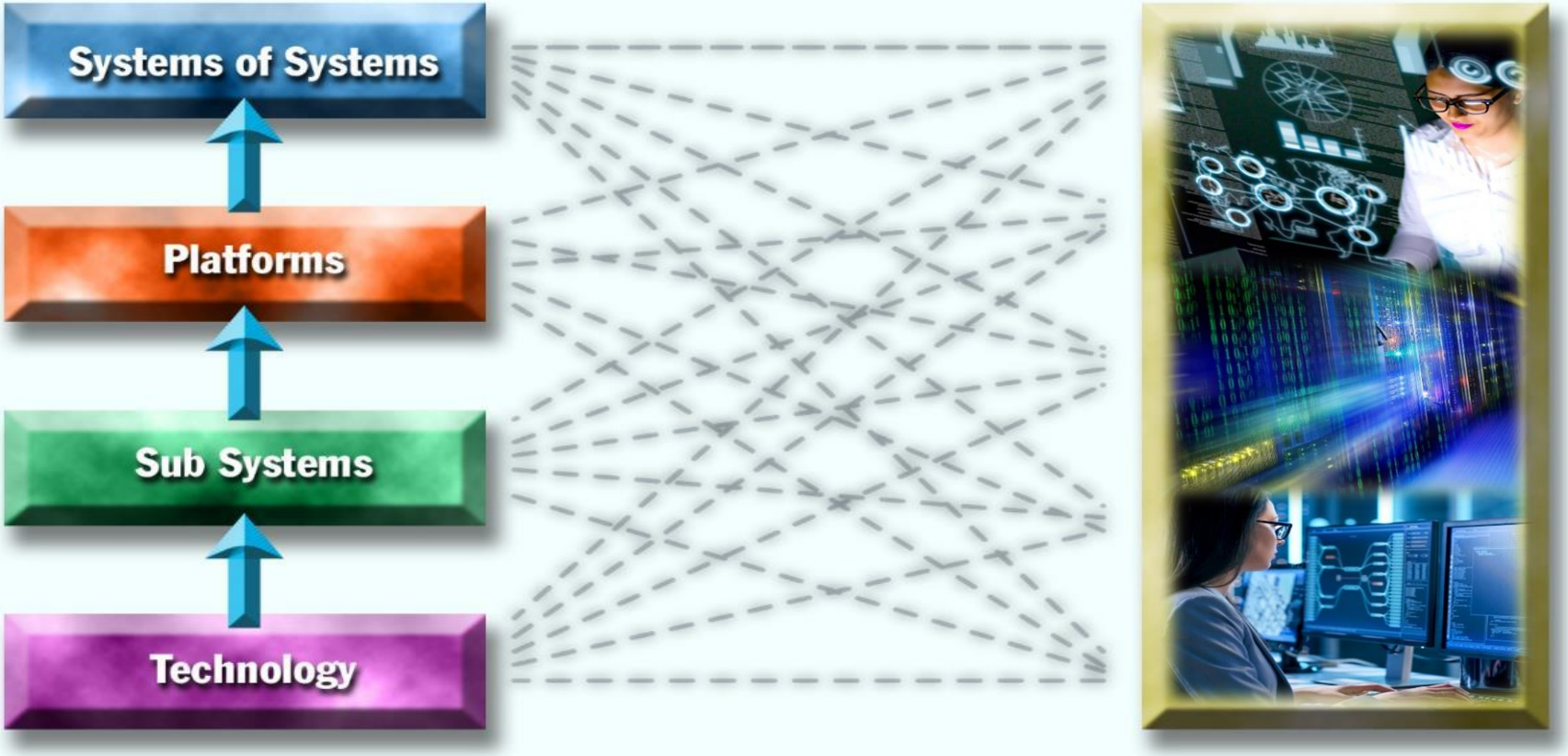

Focused on the speed of delivery through digital transformation

Digital Transformation of the Product Life Cycle

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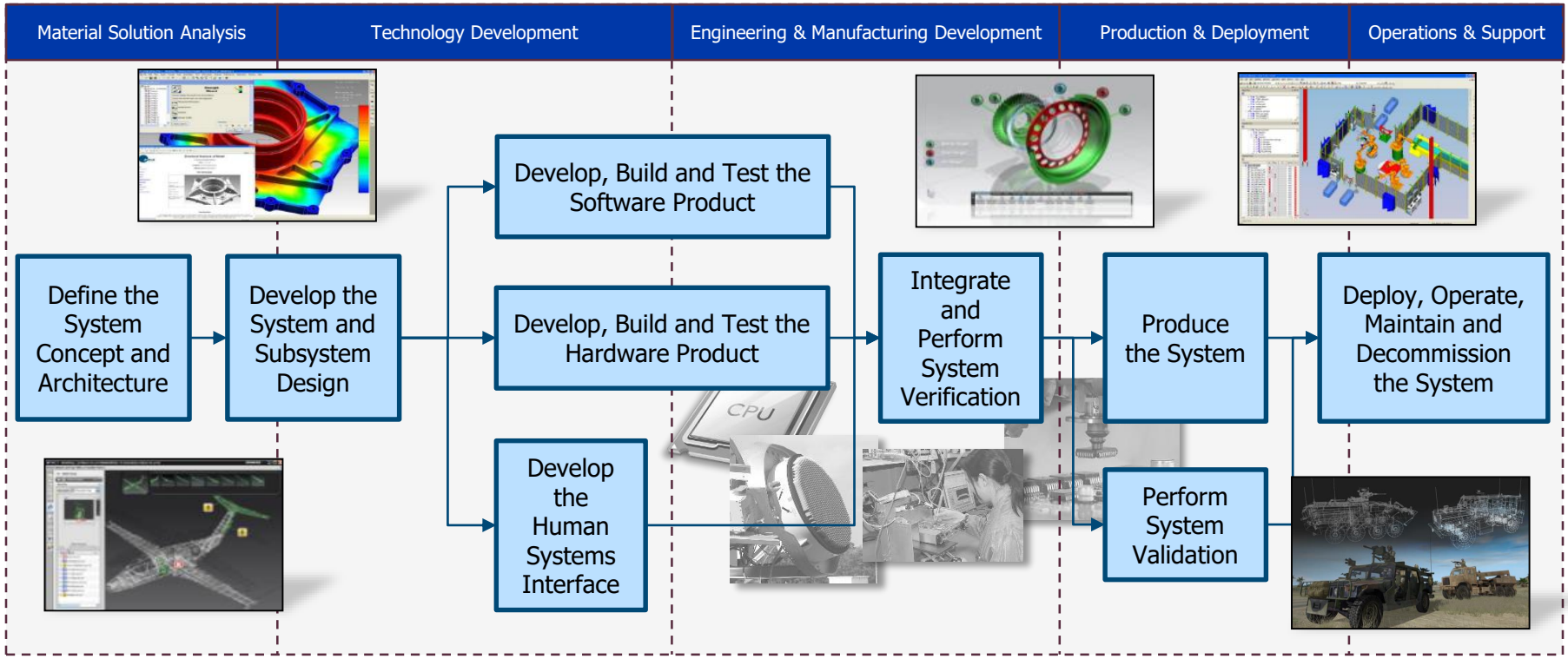

Digitally represent the system of interest throughout the life cycle

A Digital “Burble” Sets the Journey in Motion

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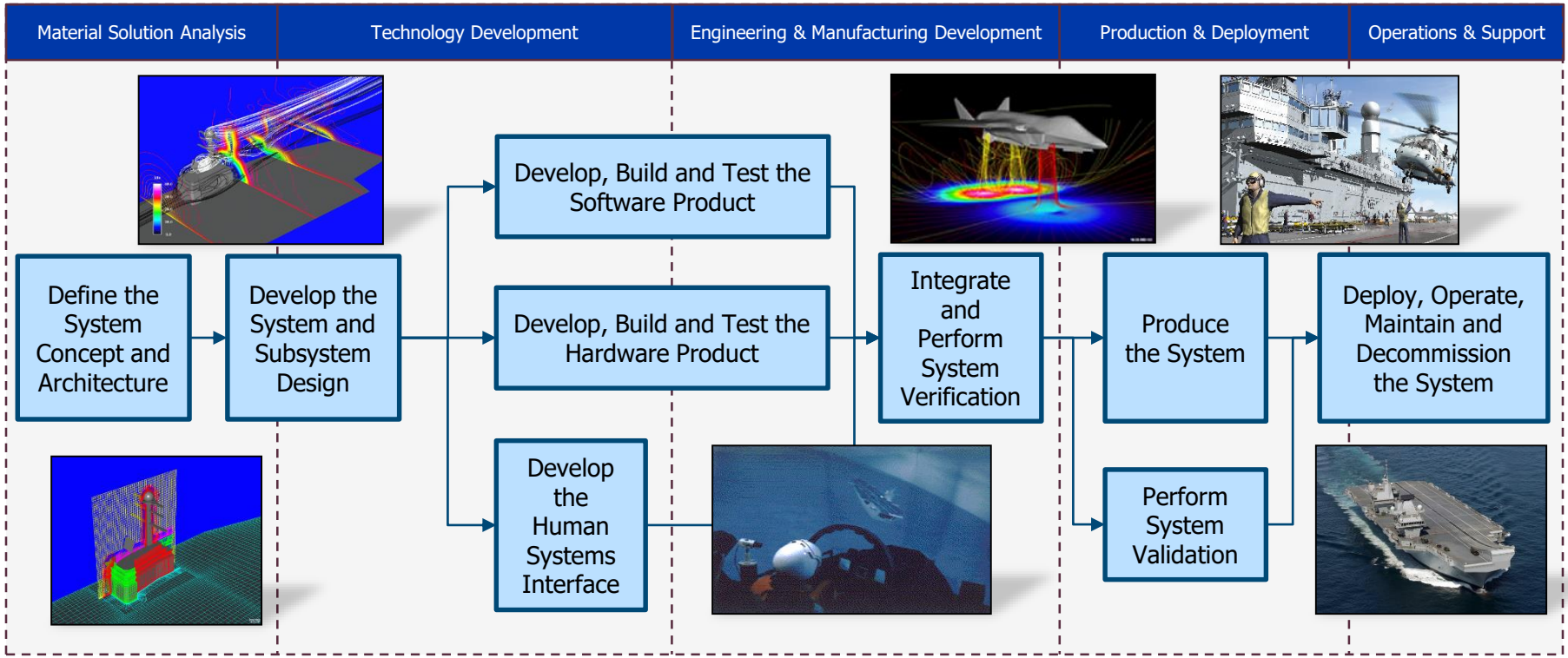

Design and development of HMS Queen Elizabeth Class

Emphasis on the Model Based Enterprise

Engineering

Manufacturing

Sustainment

Advance and accelerate the development and deployment of warfighting capability

Model Based Needs Overlap

Model Based Sustainment

Model Based Manufacturing

Model Based Engineering

Requires intelligent connected digital models and data interoperability

Technology Enablers for Digital Transformation

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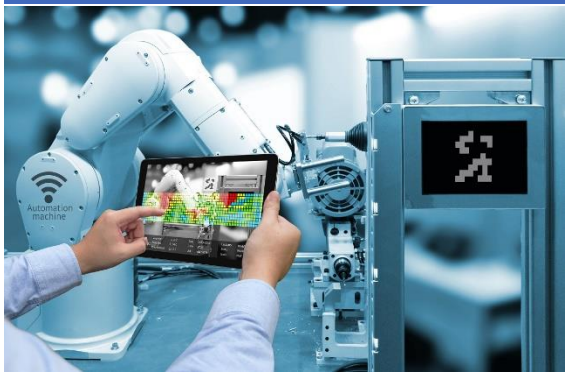
Advanced Computing

Big Data Analytics

Artificial Intelligence

Augmented Reality

Robotics



Machine Learning

Mission Value through Program Excellence

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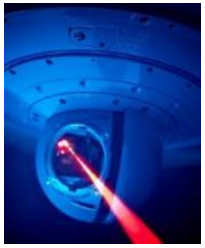






Summary – Enable the Integrated Digital Enterprise

- **"*Global Product Data Interoperability Summit*"**
- **Partner to support the Model Based Enterprise**
- **Share experiences and best practices**
- **Celebrate and showcase - delivering program value**
- **Identify barriers and explore**
- **Set new direction**

The Journey Continues….

Questions?

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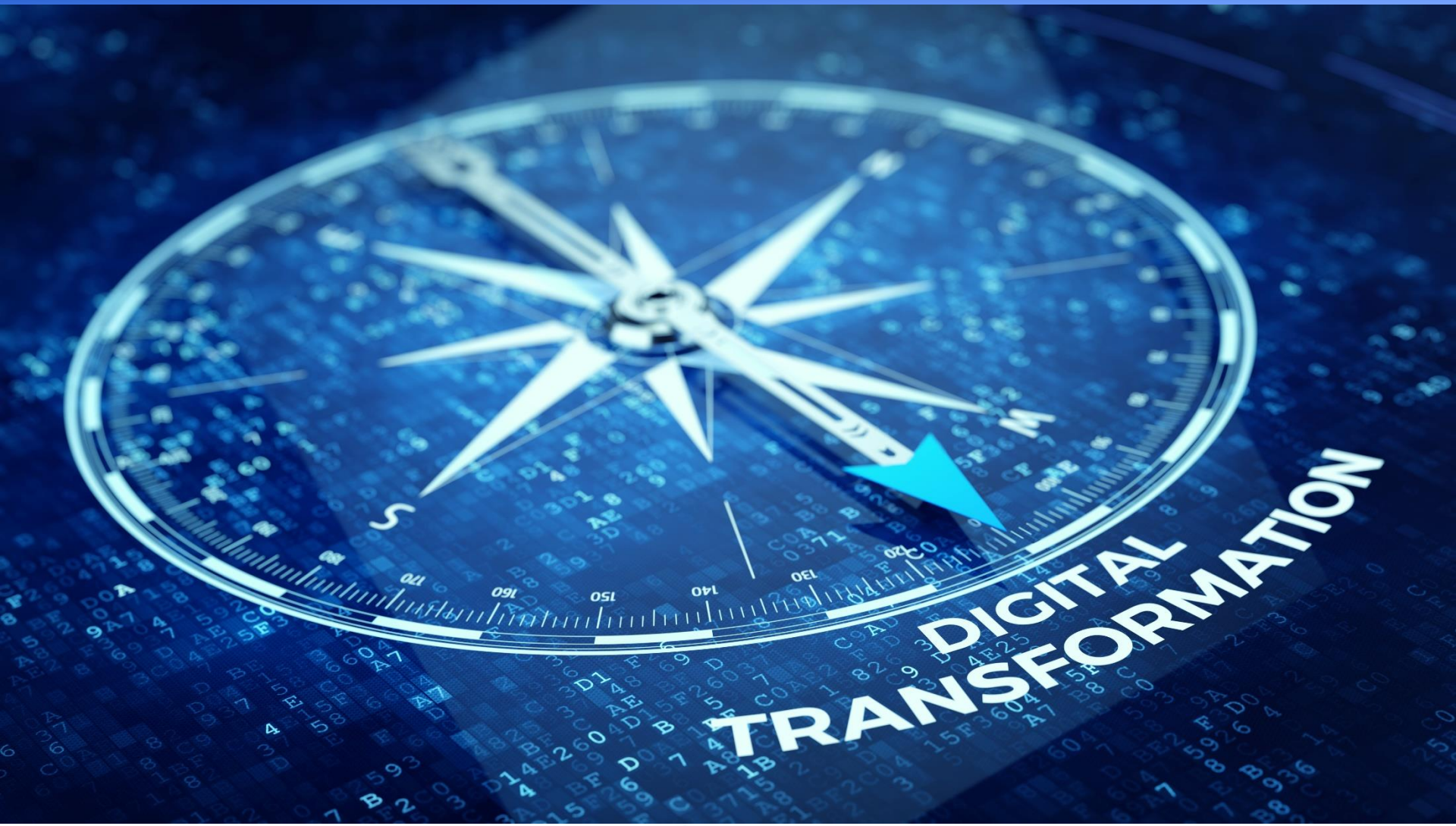

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