BT&E Enterprise Integration and System of Systems Test for V&V

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Three Parts

- Big Picture: Consolidate
- Study SOS Effort Systems Engineering (SE)/T&E Integration and V&V through LVC-Test
- Extend to NextGen

Part 1: An All Too Familiar Story…

The outcome can be determined before the program begins:

- **Program schedule will stretch out**
- **Costs will dramatically increase**
- **Product content will be compromised**

In other words, the program will be late, over budget, and the weapon system will fall short of the warfighters' requirements or expectations…

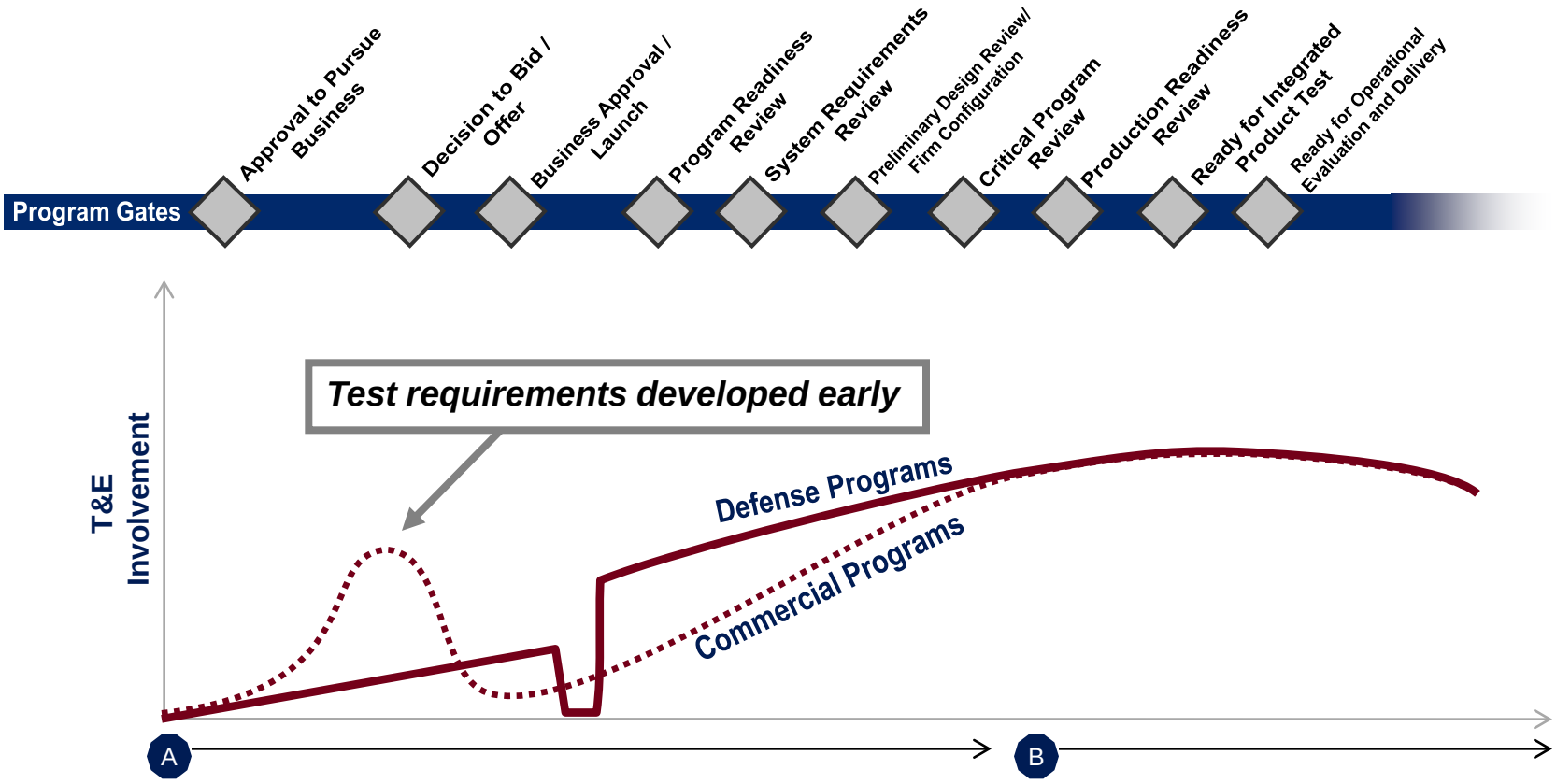
...despite DOD's and the contractor's best efforts to the contrary.

Why???

- The problem is “structural.”
- Business Results = Resources + Behaviors
- The structure of the business system drives the behavior of the system.
- Structure includes:
  - Processes/Procedures
  - Policy
  - Culture
  - Incentives

If we want better results, we must change the structure of the system!

Test Requirements and Program Life Cycles



Test requirements development effort and influence varies between commercial and military programs.

Recommendation #1 : Realign the Incentives

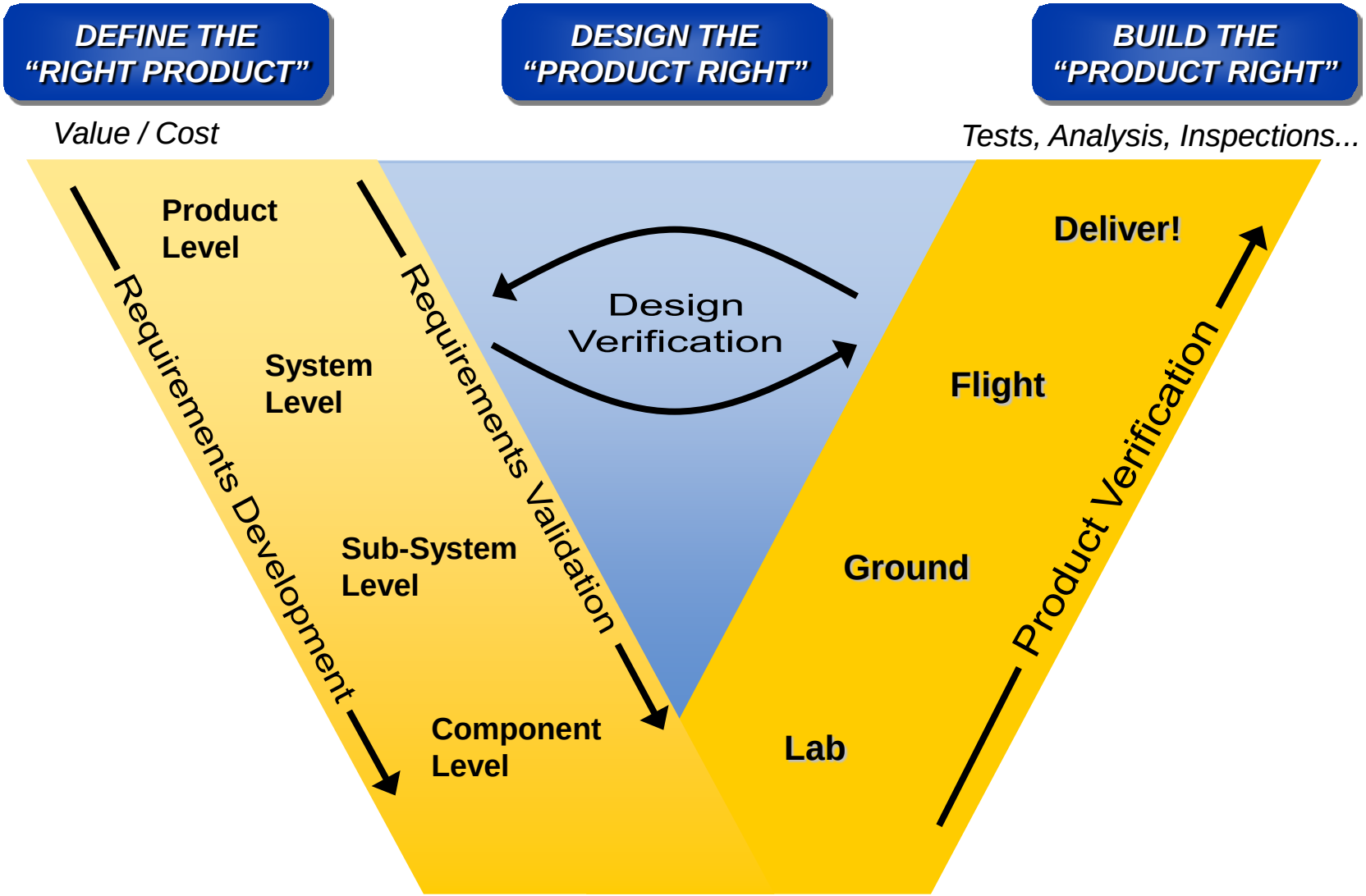
- People respond to incentives.
- Contractors are not incentivized to develop detailed test requirements early in the program.
- The lack of detailed test requirements drives risk downstream into the test phase of programs, resulting in delays, rework, and changing requirements.
- T&E leaders should advocate for funding to develop detailed test requirements prior to proposal submittal.
- Higher fidelity test requirements will give program managers a more realistic assessment of T&E cost and schedule.

Test Requirements: The Importance of Getting it Right the First Time

"Late is ugly until you launch. Wrong is ugly forever!"

- Dr. Michael Griffin, former NASA Administrator

Test Validation and Verification in the Product Life Cycle



Recommendation #2: Reinvigorate Systems Engineering

- T&E engineers must work more closely with systems engineers to develop and validate test requirements.

- Early collaboration between SE and T&E can lead to tighter integration of program schedules and improve “critical path” and Earned Value Management, thereby improving the probability of program completion on time and on budget.

Changing the T&E Culture

- We must think of ourselves as more than just evaluators.
- We should think of ourselves as program partners who are invested in the outcome—a weapon system delivered on time, on budget, and meeting our warfighters' expectations.
- Effecting the cultural shift will require courage, tenacity, and a tolerance for failure. Moreover, it will require sponsorship (persistent and consistent messaging through words and actions) at the highest levels of DOD T&E.

Recommendation #3: Redefine our Relationship with the Acquisition Community

- The DOD T&E Community must make it clear to our program partners that we are invested in the outcome. We should learn to collaborate like business partners.
- It starts with the leadership at the top, but the cultural shift must permeate every layer of the DOD T&E community.
- Effecting the cultural shift will take vision and courage. Leaders must stay on message and never waver.

Recommendation #4: Consolidate DOD T&E

- Every acquisition program acts like its own empire. Program managers rarely look beyond the needs of their own program.
- Programs often procure (sometimes at considerable expense) test assets that already exist in other parts of the DOD infrastructure.
- There is significant duplication of test infrastructure, leading to underutilization of DOD T&E capabilities and inefficient use of limited acquisition funding.
- The Test Resources Management Center (TRMC) is a step in the right direction…

BT&E - Boeing's Experience with a Consolidated Test Organization

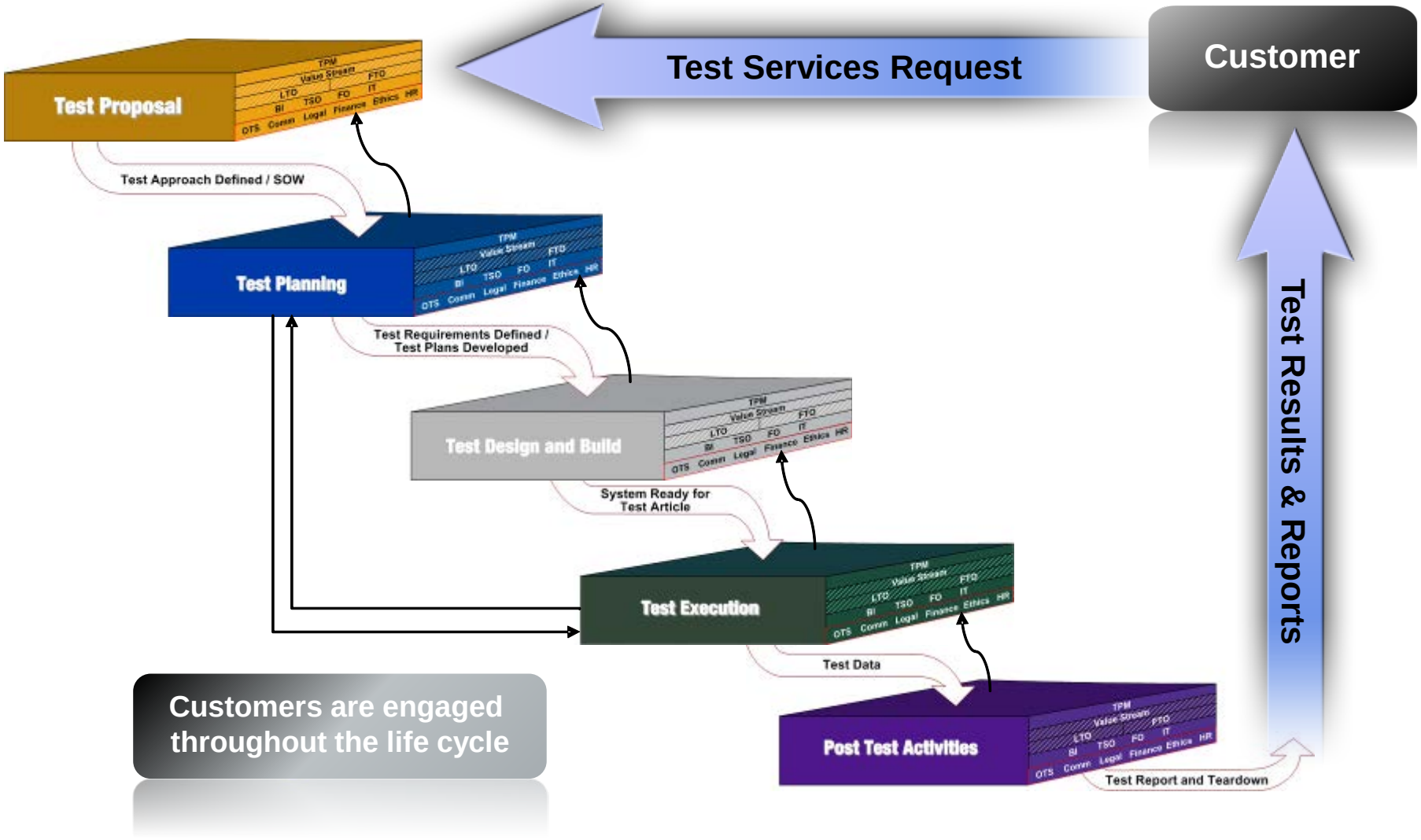
Strategic Focus:

- Execute our commitments while integrating Test & Evaluation across the enterprise to dramatically improve the cost effectiveness of BT&E operations and yield improved competitiveness of Boeing's products and services.

Strategic Objectives:

- Execute on our commitments.
- Institute operational excellence through functional discipline.
- Integrate Test & Evaluation operations across the enterprise.
- Dramatically improve our competitiveness.
- Engaged, diverse, and highly capable workforce.

BT&E Product Test Life Cycle - Top Level Test & Evaluation Process



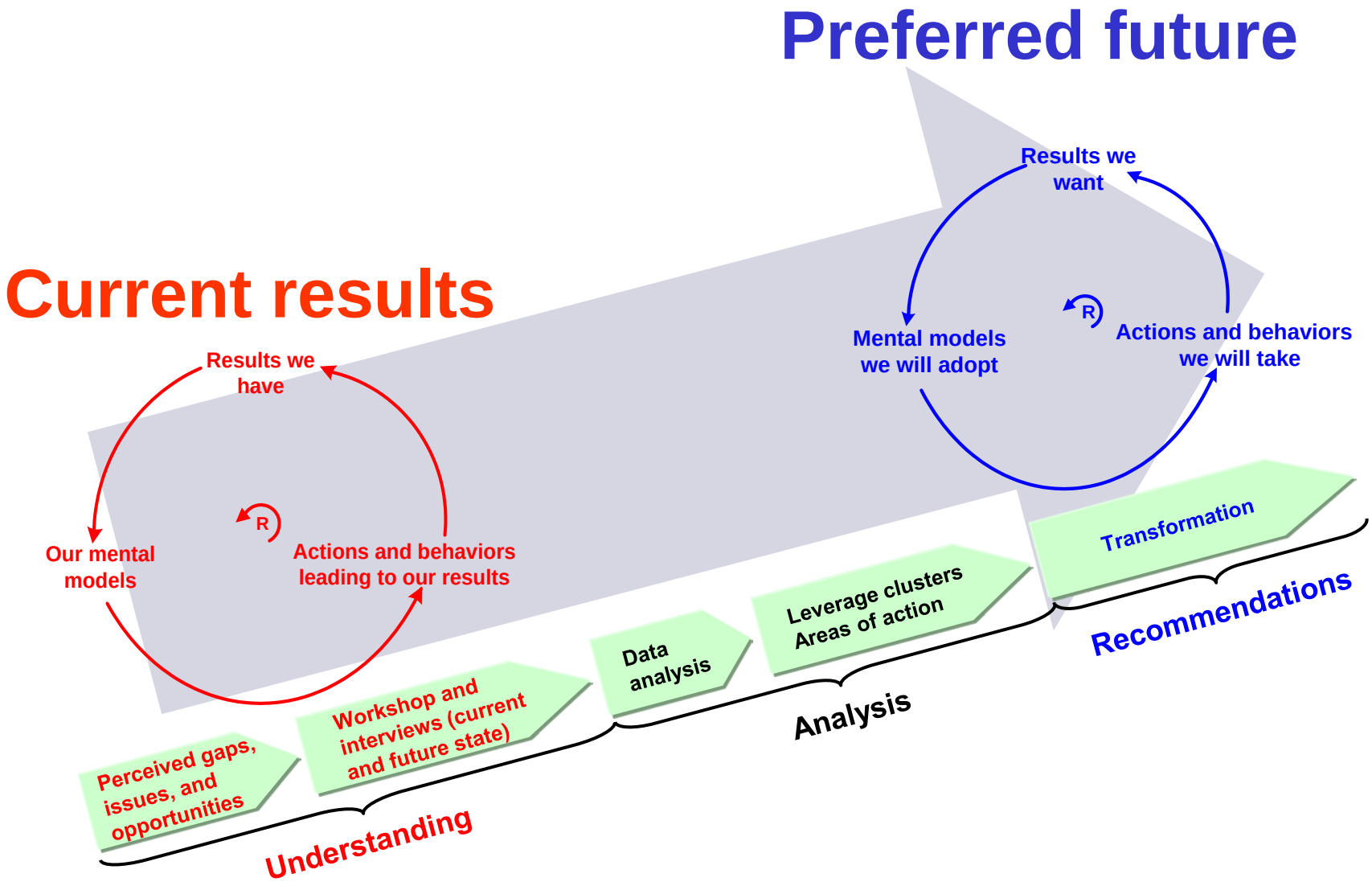
BT&E – The Results

- Saved hundreds of millions ($M) in operations and facilities costs (2009 to Sept 2011).

- Achieved record levels of productivity:
  - Completed two major aircraft development programs simultaneously over the last 18 months, logging over 8,000 flight hours, 5,000 ground test hours with as many as 15 wide-body aircraft in the test fleet, all while supporting P-8A, AEW&C, F-15, F-18, CH-47, AH-6, AH-64, A-160, BTCM, and GMD and space systems T&E programs.
  - Flew 7,500 test and test support flights in 2010 and over 5,000 flights to date in 2011.

- Supported over 600 contract proposals.

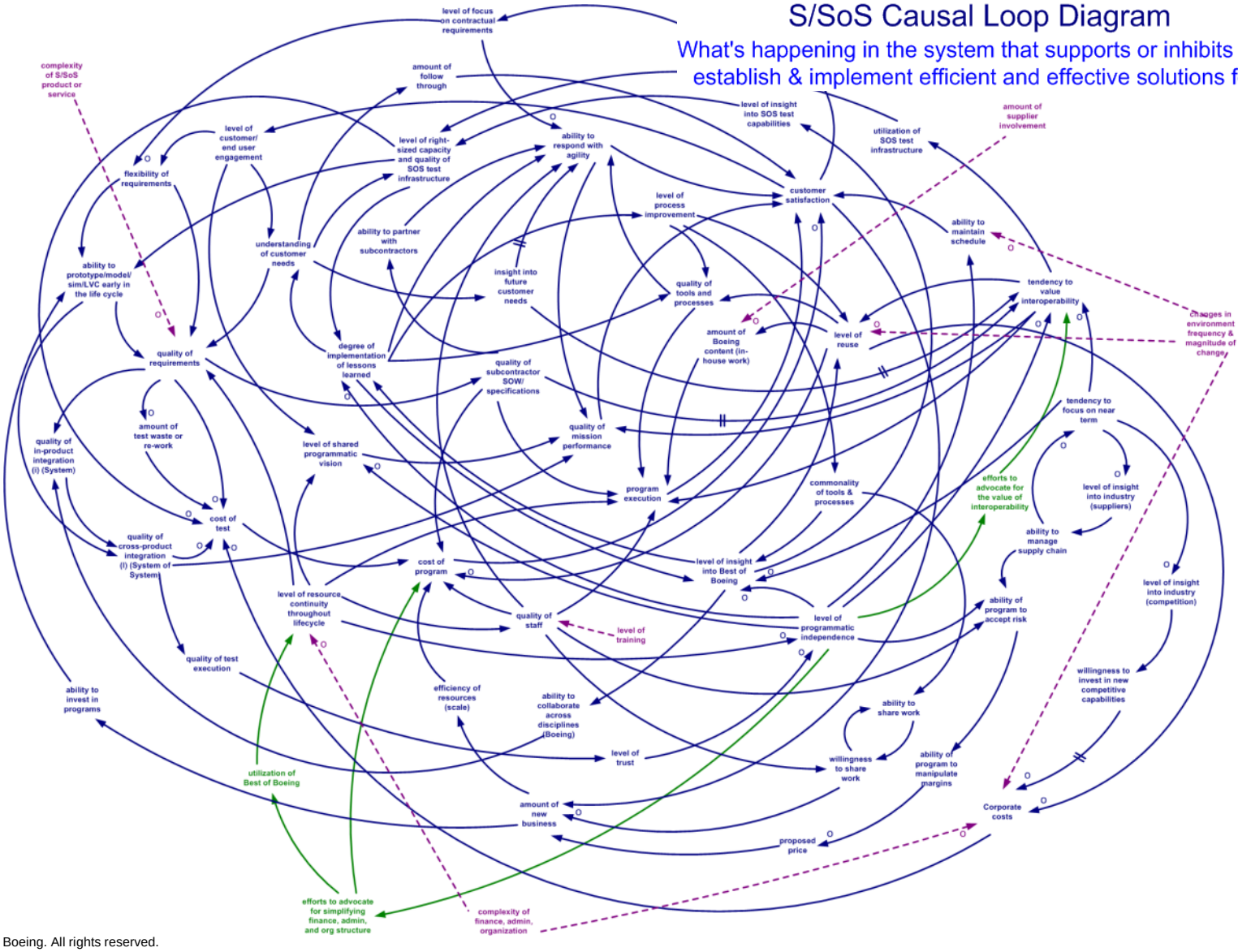
Transformation Cycle



Workshop

Day 1: Systems Thinking
Day 2: Systems Thinking and Applying Causal Loop Diagram
Day 3: Current State and Desired Future State
Day 4: Refining the Future State
Day 5: Implementation in Support of Accelerating Change

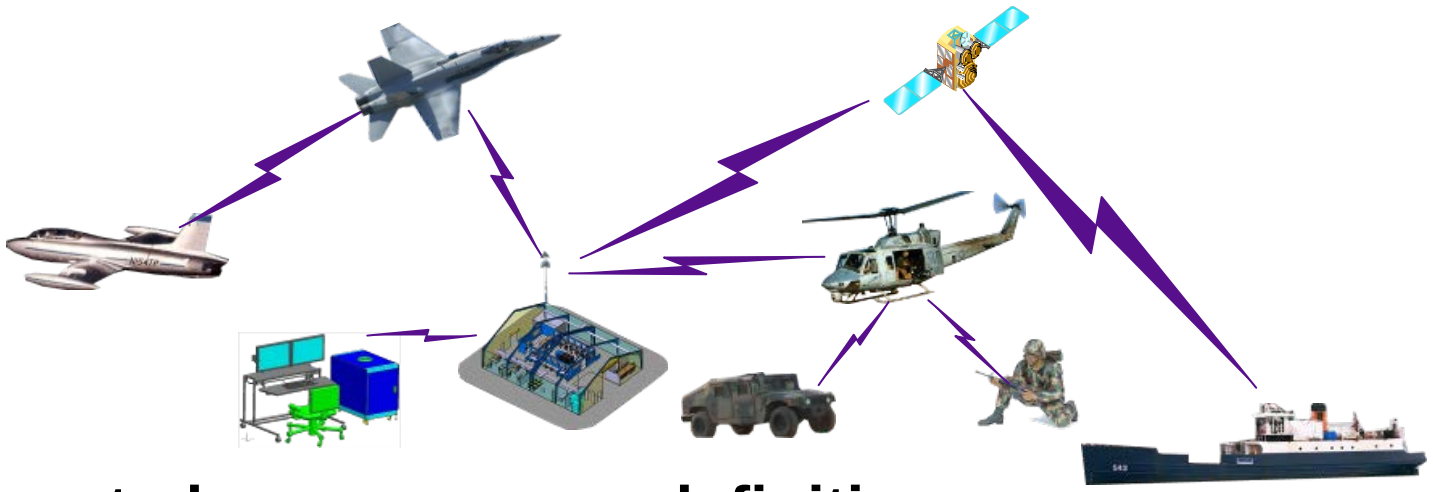
Better Understanding of the Current State



What Is a System of Systems?

Starting point:

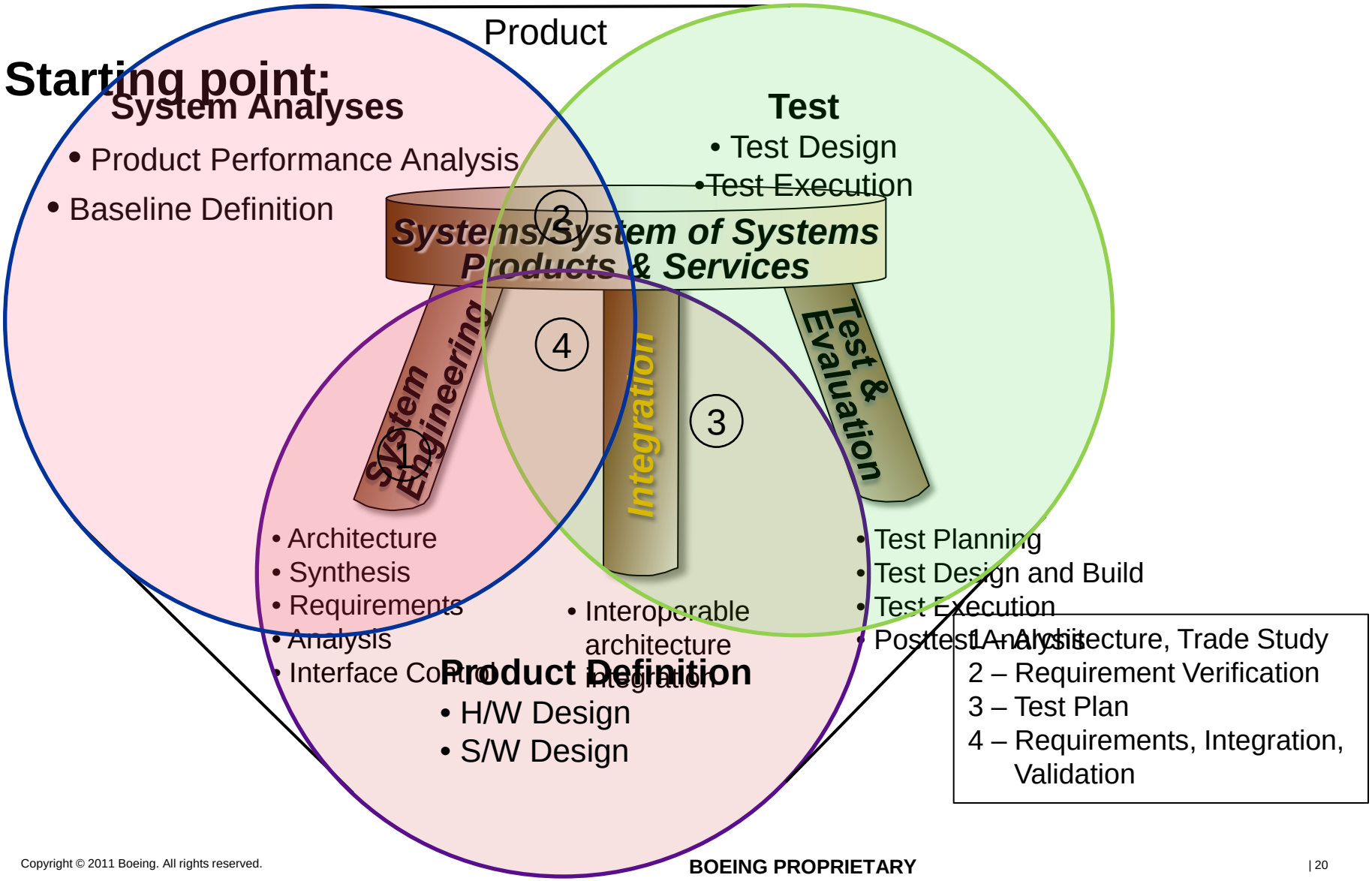
A system of systems (SOS) is a collection of independent systems that provide more functionality and performance than the sum of the constituent systems.



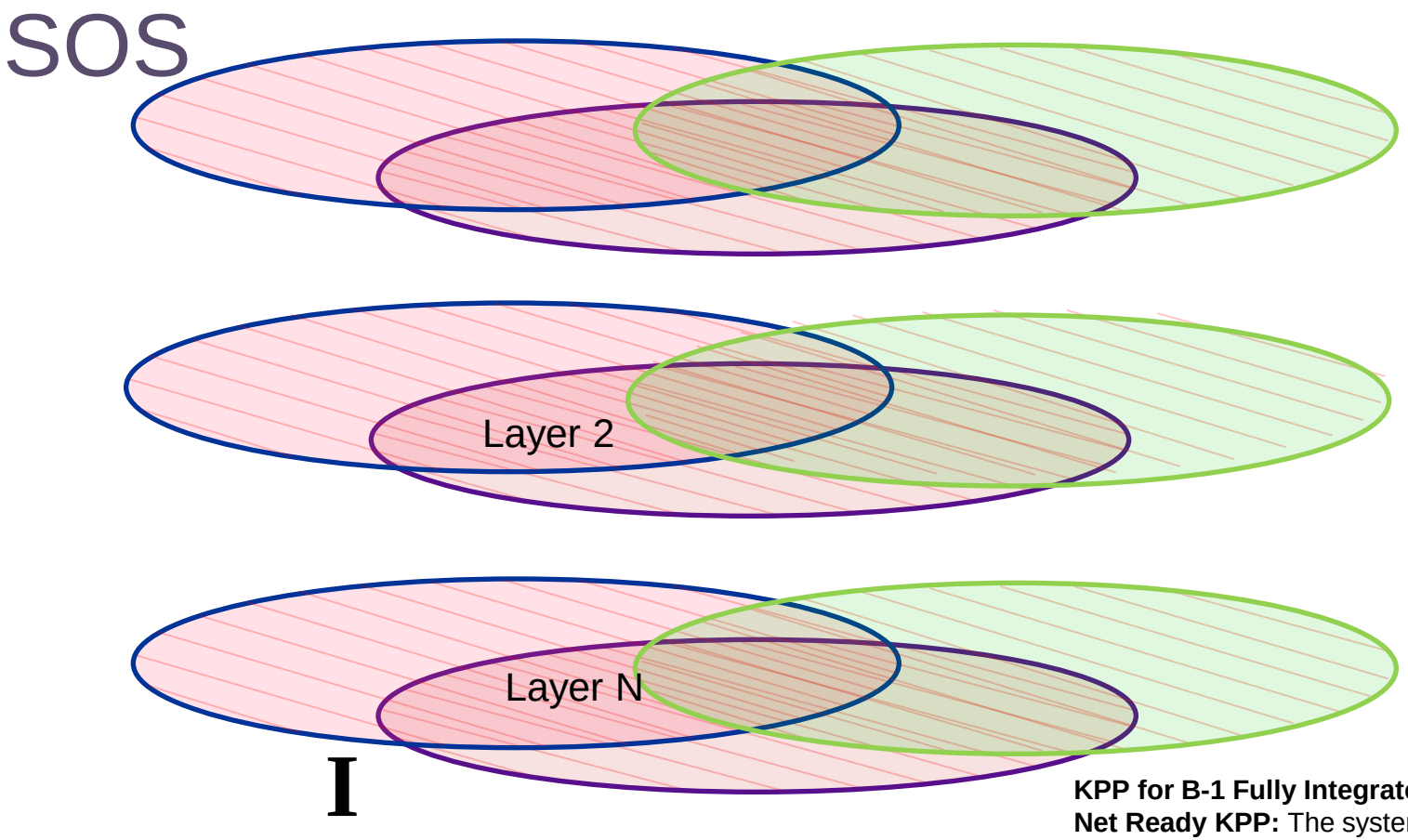
Collaborated on a common definition:

A system of systems is a set of interoperable, independent systems that, when integrated, provides capabilities and performance beyond the sum of the individual systems.

Who Does What?



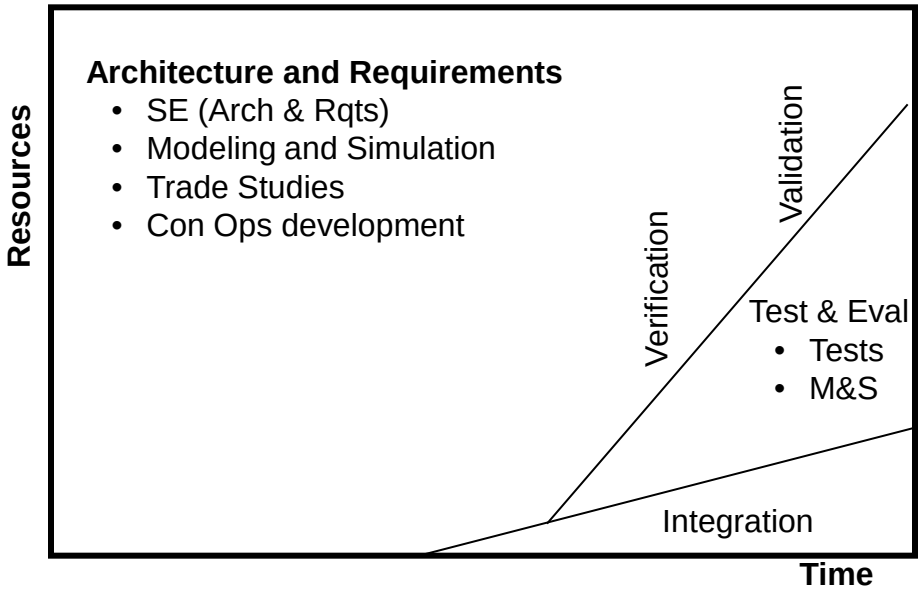
Developed An Improved CONOPs



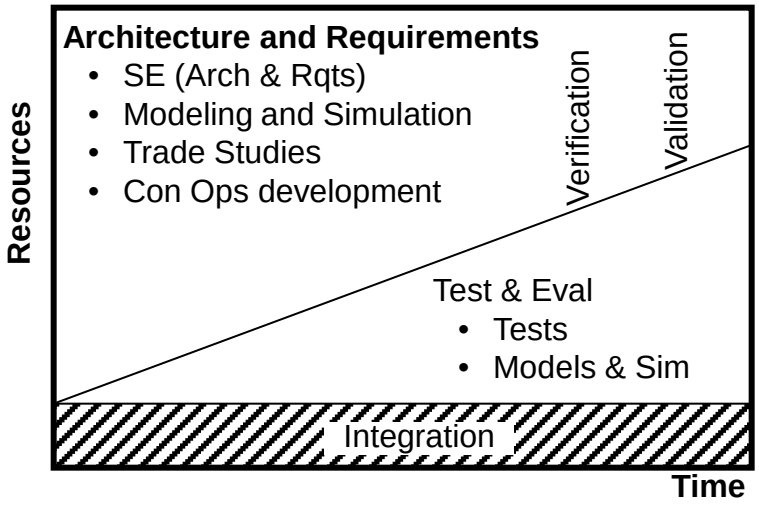
KPP for B-1 Fully Integrated Data Link (FIDL)
Net Ready KPP: The system must support Net-Centric military operations by being able to enter and be managed in the network; exchanging data in a secure manner to enhance mission effectiveness; and not significantly increasing the workload of operators, system administrators, or maintainers.
Chairman Joint Chiefs of Staff Instruction 6212.01D

Developed a Temporal View

Current State



Future State



Study ~~Recommendations~~ Actions

1. **Charter BT&E and SE to collaborate and team to improve integration alignment for Systems Engineering, Integration, and Test (SEIT).**
   a. Define RAA and establish integration discipline.
2. **Ensure BT&E is fully engaged in Project X and Engineering Excellence.**
3. **Assign an SOS T&E SME to an early life cycle program to:**
   a. Partner with TPM for discovery/mitigation of NR-KPP program risks.
   b. Ensure early involvement per Enterprise Product Test Life Cycle PRO & BPGs:
      - PRO-5139: Test and Evaluation Engineering
      - SSPI EP-891: Perform Test Proposal Method
      - SSPI EP-888: Perform Test Planning Method
      - SSPI EP-892: Perform Test Design and Build Method
4. **Establish a capability/organization accountable for S/SOS T&E execution and Operational Excellence across Lab Test (LT)/Flight Test (FT) value streams.**
   a. Develop and implement a multi-year, program requirement-/Enterprise technology roadmap-aligned innovation and infrastructure plan for live, virtual, constructive (LVC) experimentation, demonstration, and test.
   b. Implement Operational Excellence across both LT and FT Value Streams (VS).

Implementation in Progress

Study Action 1: Implement Integration Improvements

Rick Baily
BDS Enterprise Engineering

- Christi Gau-Pagnanelli
- John Goepp

Mike Delaney
BCA Enterprise Engineering

- Paul Lambertson
- Dave Presuhn

Mark Burgess
EO&T Enterprise Engineering

- Marc Nance

Sandra Gianotas
Test Programs Management

- Rudy Duran

- **Reviewing/analyzing BT&E S/SOS Study data**
- **Reviewing/analyzing source data from BDS Mission Assurance Summary of Technical Independent Reviews (December 2010 and 4-year Cumulative)**
- **Planning a joint BT&E/SE Leaders of Change Workshop`**
  - Intended Deliverables:
    1. Requirements/V&V concurrence checklist between BT&E and SE.
    2. Identify the uniqueness of SOS versus Systems from an integration standpoint, with respect to areas of improvement
    3. Checklists with relevant artifacts to align/integrate T&E into the ESGP, throughout the Product Life Cycle.
    4. Proposed language for including T&E into the Systems Engineering Master Plan (SEMP) or Program Execution Plan (PEP) development process.
    5. Integrated plan to improve alignment of the SE and T&E processes, tools, and training.

BT&E S/SOS Test Event

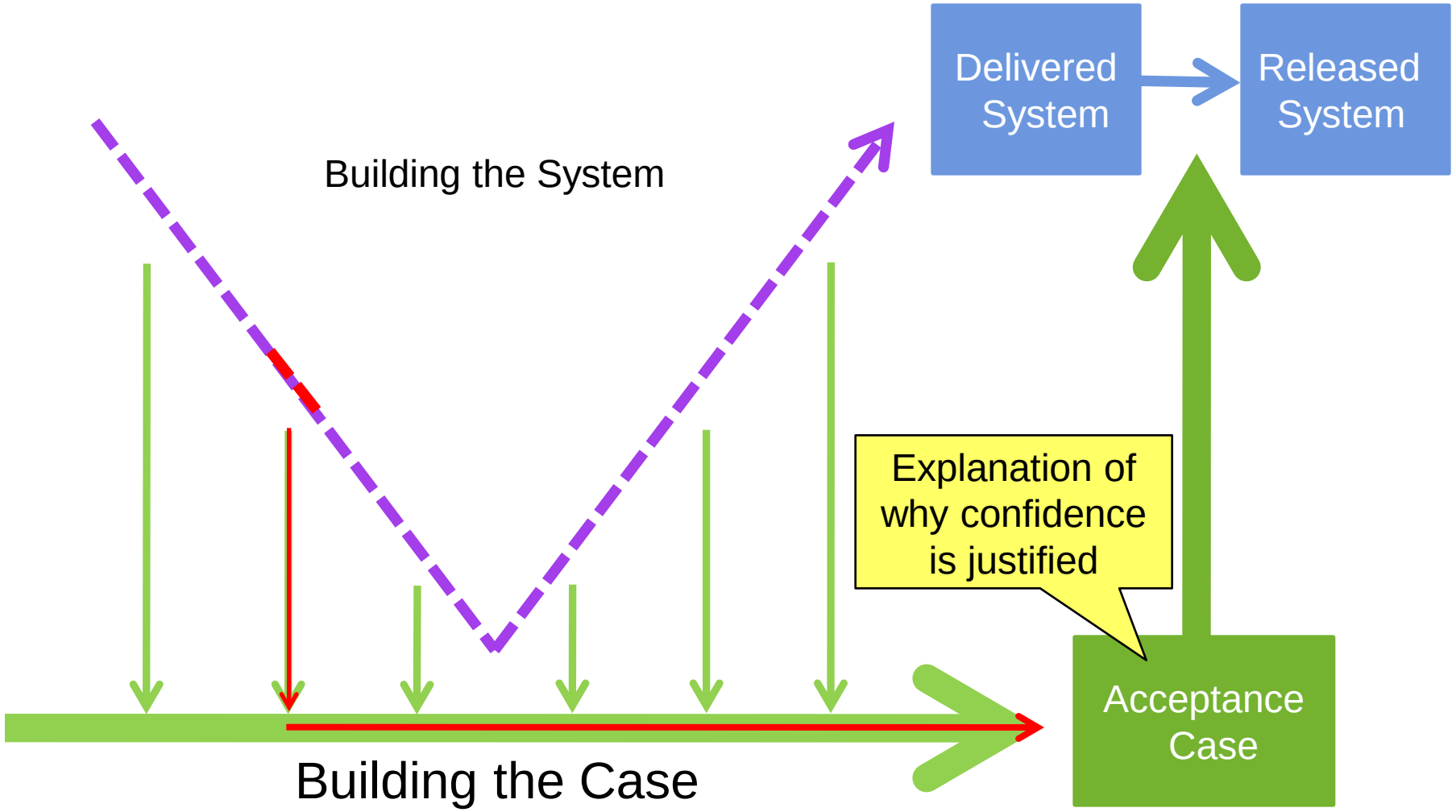
- This test event, conducted no later than 14 Dec 2011, will be a distributed S/SOS test controlled at the Palmdale ITR, using live, virtual, and constructive assets (Palmdale) combined with virtual and constructive assets (St. Louis & Huntington Beach).
- The event will be centered around a simulated engagement of enemy combatants by ground and air components.
  - This integrated SOS will facilitate successful exchange of situational awareness (SA)/situational understanding (SU) using the global information grid (GIG) from subscribed and participating facilities down to the platform to include the capability to execute Call for Fire (CFF).
- Throughout the planning, preparation, and execution of the test event, multiple Operational Excellence (OE) elements will be exercised and evaluated.
  - The team will gather data to implement S/SOS T&E OE across BT&E by testing and demonstrating the usability of BT&E products and processes to include people, processes and tools, culture, training, and infrastructure and innovation.

Objectives: Evaluate System Under Test, Operational Excellence Tools

Important SOS V&V Considerations

- **Continuous SOS evolution implies**
  - Continuous V&V and/or
  - V&V focused on robustness against unanticipated changes/usage
- **V&V traditionally emphasizes test results as the best evidence**
  - When tests are successful, what is learned about untested cases?
  - SOS V&V will heavily depend on analysis, modeling, and simulation
    - Need to validate the analyses, models, and simulations
- **Early life cycle is not just about making requirements/design testable**
  - Need to gather information showing that hazards to SOS operation have been recognized and dealt with appropriately
  - Need to ensure that requirements and design do not introduce hazards

Building Justified Confidence



NextGen 2025 OV-1

NextGen ATM In All Flight Phases → Benefits & Effects

PUSH BACK, TAXI, DEPART

- ADS-B, Traffic Information Services-Broadcast (TIS-B), Flight Information Services-Broadcast (FIS-B)
- Area Navigation (RNAV) and Required Navigation Performance (RNP)
- Data Comm

CLIMB, CRUISE

- ADS-B In and Out, with associated displays like Cockpit Display of Traffic Information
- Data Comm, including integration with the Flight Management System
- Future Air Navigation System in oceanic airspace
- RNAV and RNP

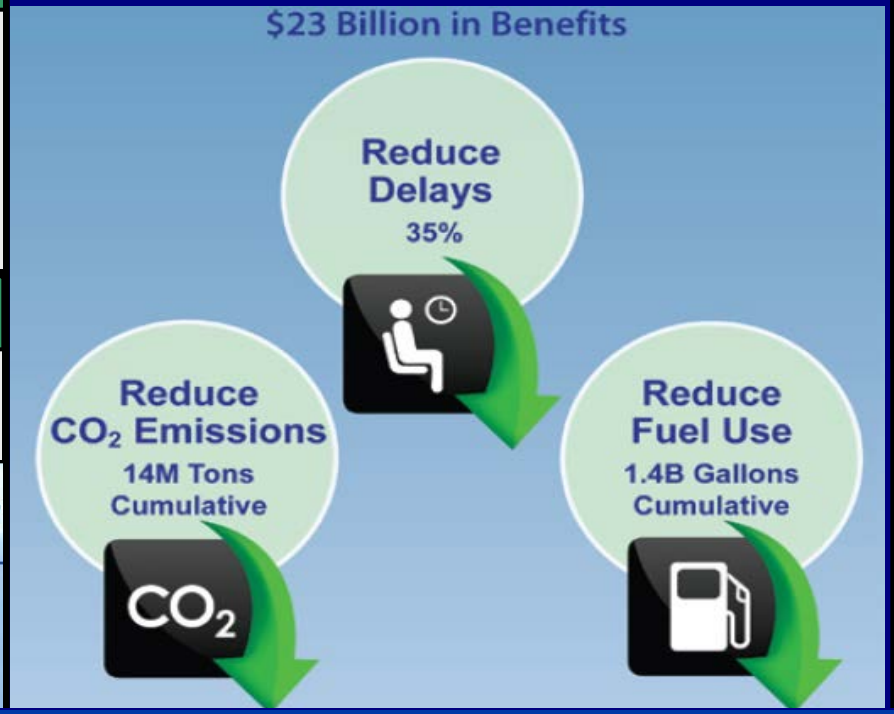
DESCEND, APPROACH

- ADS-B In and Out
- Data Comm
- GBAS avionics
- RNAV and RNP
- Vertical Navigation

LAND, TAXI, ARRIVE

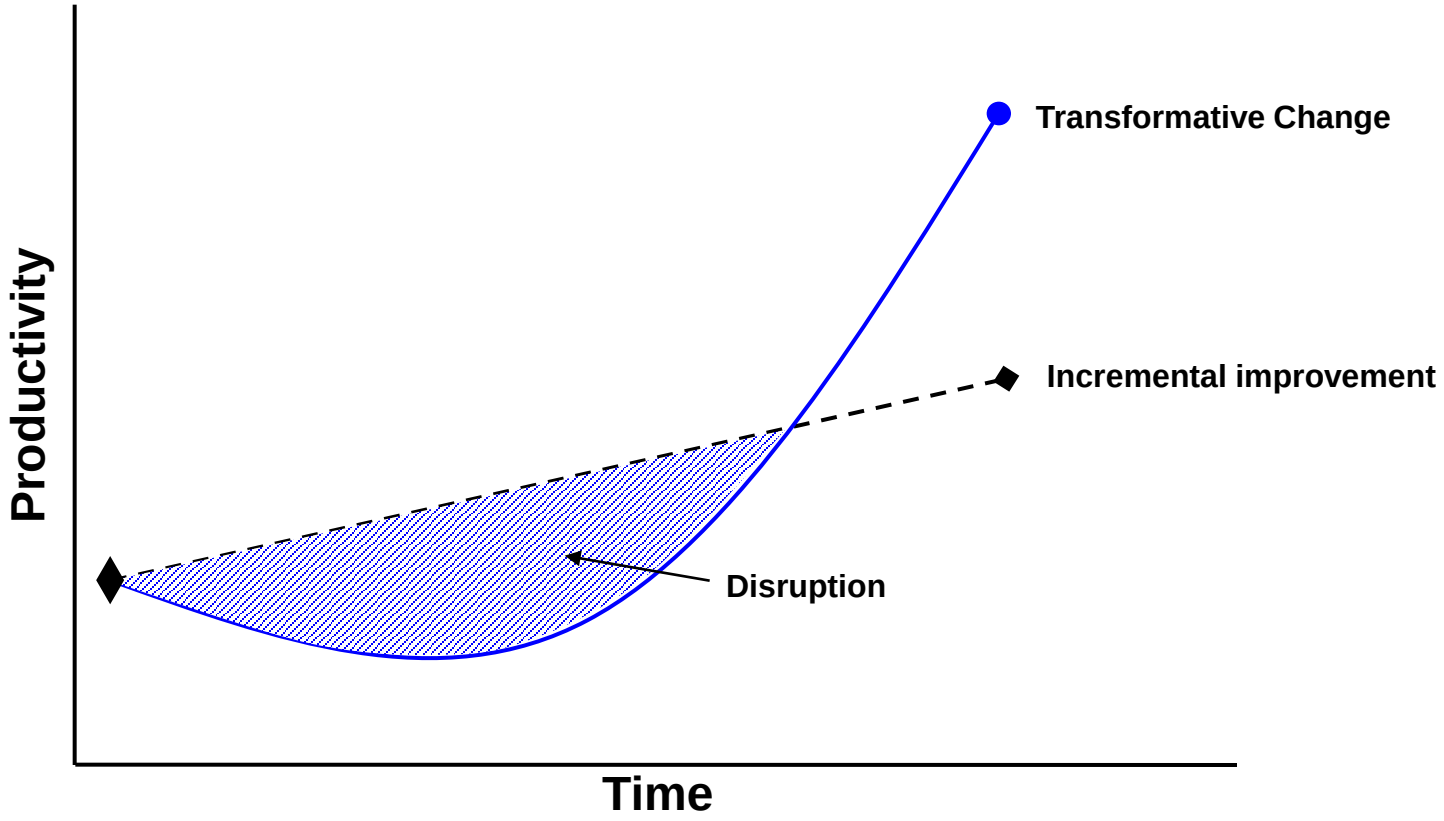
- ADS-B, TIS-B
- Data Comm

2018 PROJECTED BENEFITS



Benefits Via Proven Technology Provide Safely Increased Capacity …Affecting How Boeing Products Are Used

A Final Thought……



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