SSETT
Advanced Systems & Supportability Engineering Technology and Tools

Systems Engineers provide a Key Contribution and Role in System Integration and Test

National Defense Industrial Association (NDIA)
9th Annual Systems Engineering Conference
October 23-26/2006

Test & Evaluation Track, Tuesday September 24

William Lyders, ASSETT Inc

SSETT
Advanced Systems & Supportability Engineering Technology and Tools

Agenda

- The Systems Engineering Process Blends with the Test & Evaluation Process over the System Life Cycle
- System Integration Planning and Execution requires both SE and T&E Collaboration
- The Use of COTS challenges SE and T&E and requires planning for Technology Refresh
- Field and Production Testing Offer Different Challenges
- T&E Lessons Learned at ASSETT
- Summary and Conclusions
- Q&A

SSETT
Advanced Systems & Supportability Engineering Technology and Tools

The SE and T&E Message

Successful Test & Evaluation (T&E) starts at the beginning of the Systems Engineering Process with the SE discipline generating Use Cases and Testable requirements …

Determine whether the program will use traditional Requirements Based Contracting or Performance Based Contracting…Use Cases -> Requirements

…it gains momentum with the collaboration of SE and T&E transitioning into System T&E integration planning…

…and peaks with the T&E discipline during Acceptance and Certification testing…

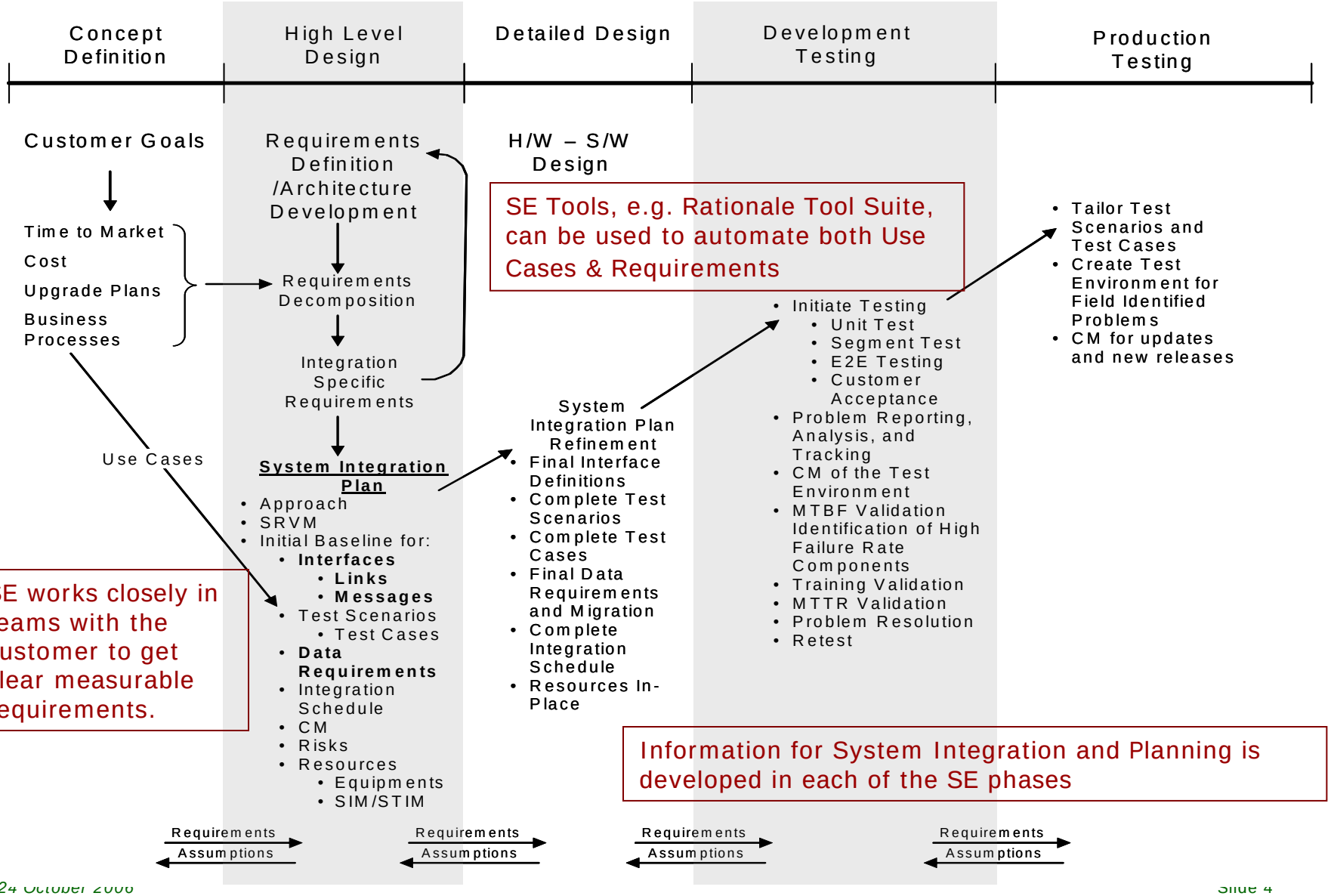
Acceptance criteria should be defined early in a project…validation of Use cases or Requirements

But it doesn't end there…

…it continues with the SE discipline as an on-going force as Technical Evaluations and Operational Evaluations of the system continue in the life cycle phase of Production Testing

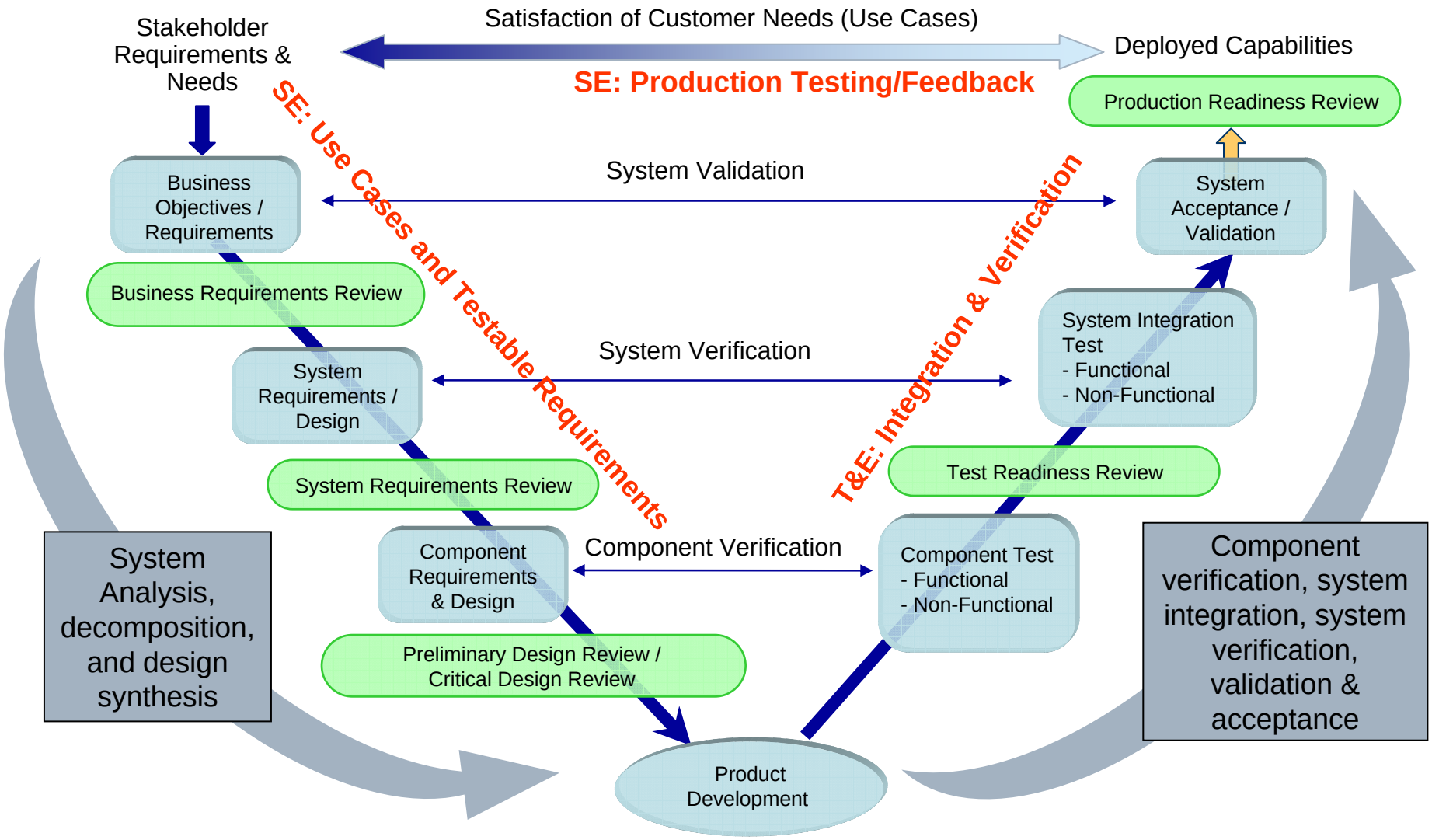
SSETT
Advanced Systems & Supportability Engineering Technology and Tools

System Integration Planning and Execution includes many SE and T&E Activities



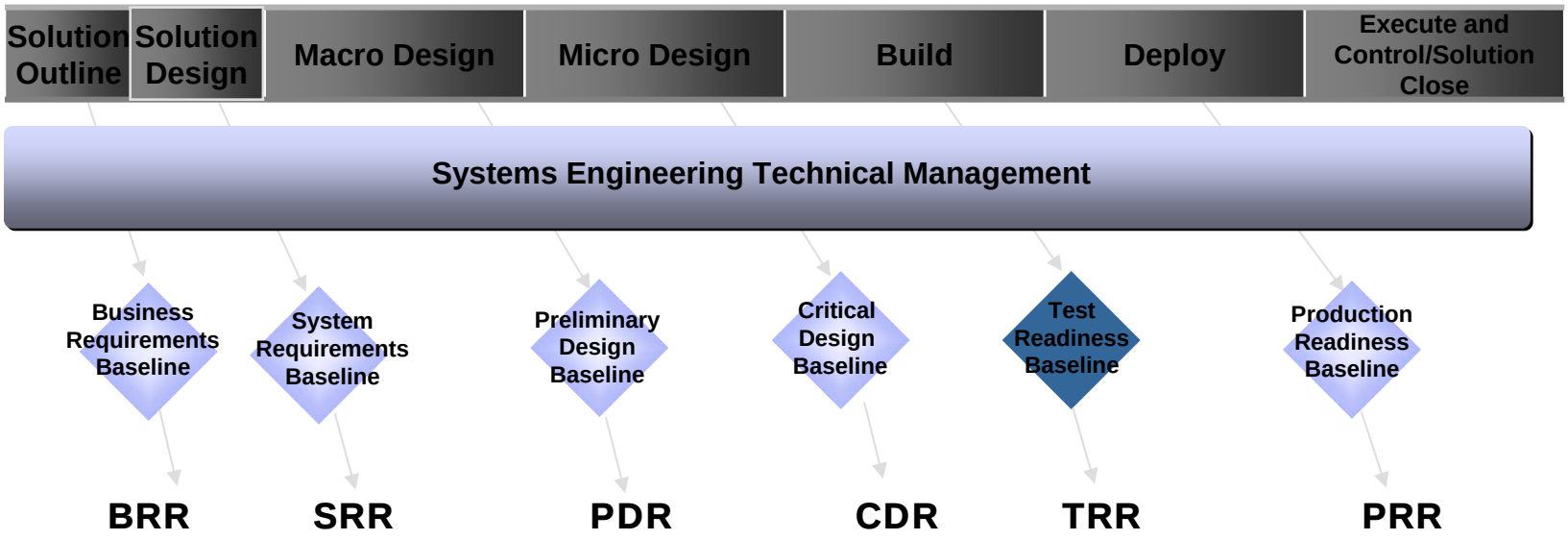
SSETT
Advanced Systems & Supportability Engineering Technology and Tools

SE Vee Process blends into the T&E Integration (Verification and Validation)



SE Process – Baselines & Reviews

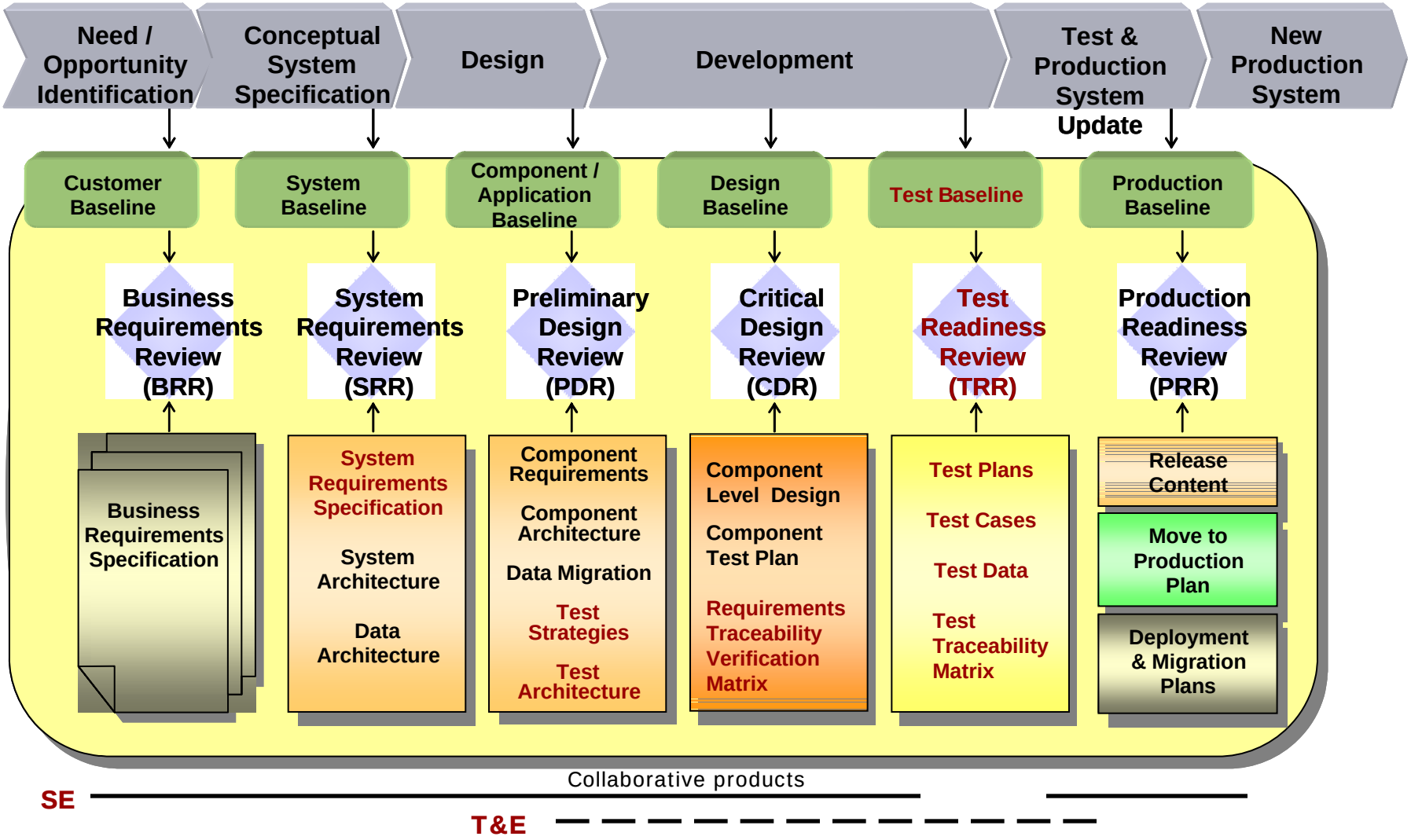
Systems Engineering is: A rigorous discipline for successful system development and integration. It elaborates business needs derived from Use Cases into traceable and testable requirements, establishes system baselines, and integrates and delivers the full system solution.



Many an SE will move into T&E roles for continuity of understanding the system and understanding the customer requirements.

SSETT
Advanced Systems & Supportability Engineering Technology and Tools

SE and T&E Products Build on Each Other



SSETT
Advanced Systems & Supportability Engineering Technology and Tools

Responsibilities of SE and T&E to each Other

Responsibilities of Systems Engineering regarding T&E

- Recommend best practices in system engineering, assist in system & test architecture, design, and development
- Monitor technical baseline along the project life cycle
- Work with Test team to support test case definitions, test planning and coordination, end to end testing
- Work with Test team for system, performance, and user acceptance testing activities.
- Coordinate defect resolution with Chief Architect, Delivery Manager, and Test Manager

Responsibilities of Test & Evaluation regarding SE

- Influence prioritization and testability of requirements
- Verify requirements implementation at many levels
- Independent review of risks and input of T&E issues
- Collaborate on Integration planning
- Execute tests – feedback to systems engineering
- Provides an independent verification and validation of system
- Supports SE with recommendations for next acquisition phase

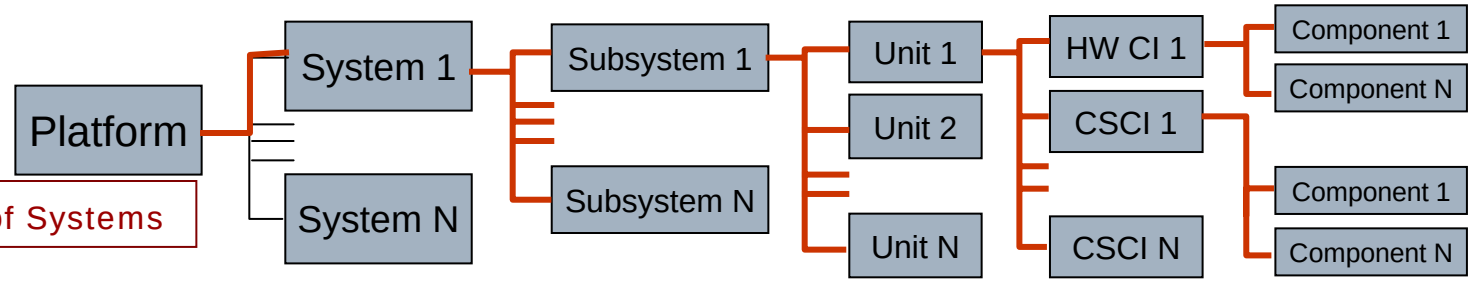
This makes the SE a better designer as they know which requirements and capabilities really do work or how hard it was to get them to work – as they return to proposal & system definition phases on new systems.

SSETT
Advanced Systems & Supportability Engineering Technology and Tools

Levels of Systems Integration Planning

Integration Planning

NCO => System of Systems

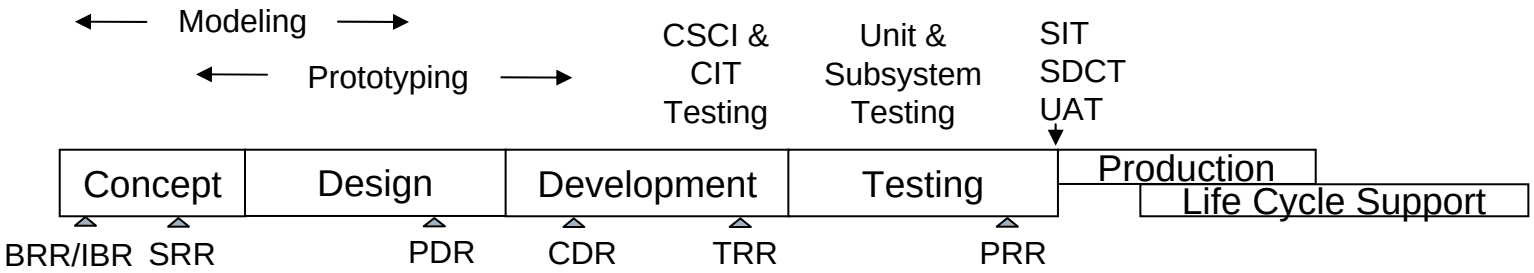


- Levels of Planning
  - Platform
  - System
  - Subsystem
  - Unit/Program
  - Configuration Item
  - Component

System Test Strategy
- Acceptance Criteria for each system is identified.
- Test Strategy for each system is established.

- The System Integration Planning Must Address All Levels of Test and Leverage the Coverage at Each Level to Eliminate Duplication
  - Results in Multiple Test Plans
- Planning for Regression Testing (Automatic & Manual)

System Integration Planning – Key: Master Test Plan



Test Planning and Execution Is Initiated in the Design Cycle to Reduce Risk and Validate Requirements Early

- Test Phases
  - Modeling
  - Prototyping
  - CSCI Testing
  - Configuration Item Testing
    - Software Integration and Test (SWIT)
    - Hardware Integration and Test
  - Unit Test
  - Subsystem Test
  - System Integration and Test (SIT)
  - System Design Certification Testing (SDCT)
  - User Acceptance Testing (UAT)

Systems Engineer provides traceability to Test Manager.

Test Manager completes Verification Matrix.

(Key Outputs of Systems Engineering)
- Requirements Traceability and Verification Matrix (RTVM)
- Test Plan, Test Cases, Test Scripts in Micro Design,
- Weekly Defect Report

SSETT
Advanced Systems & Supportability Engineering Technology and Tools

Requirements Verification Matrix

Requirements Verification Matrix

Project: ***Enter name of project here***

Customer Business Requirements / System Requirements / Component Requirements	Requirements	CI Level	Unit Level	System Level	SDCT	Customer Acceptance	Production
R1	Customer business requirement with multiple system requirements			T	T	D	D
R1 S1.1	System requirement with multiple component requirements	T					
R1 S1.1 C1.1.1	Component requirement	T					
R1 S1.1 C1.1.2	Component requirement		T				
R1 S1.2	System requirement with multiple component requirements	A					
R1 S1.2 C1.2.1	Component requirement	A					
R1 S1.2 C1.2.2	Component requirement	A					
R1 S1.2 C1.2.3	Component requirement		T				
R2	Customer business requirement with multiple system requirements						
R2 S2.1	System requirement with one component requirement	I					
R2 S2.1 C2.1.1	Component requirement		T				
R2 S2.2	System requirement with one component requirement	I					
R2 S2.2 C2.2.1	Component requirement		T				
R3	Customer business requirement with one system requirement						
R3 S3.1	System requirement with no component requirements		T				
R4	Customer business requirement with one system requirement						
R4 S4.1	System requirement with no component requirements						

Systems Engineering Responsibility | T&E Responsibility (SE Collaboration)

T = Test
D = Demonstrate
A = Analyze
I = Inspect

- Complete Traceability Matrix
  - Enumerated System Requirements trace back to enumerated Business Requirements.
- Complete Verification Matrix
  - Verification Strategy is determined for each System Requirement.

Finally, during the Test Execution Phase, the Systems Engineer supports the T&E team with FFR - problem find (identification), problem fix, and problem resolution

Up to this point we have been discussing the Traditional Approach for Development….

What do you believe would happen if commercial products were incorporated in your system?.....

We will now briefly discuss the impacts to Systems engineering and T&E efforts

SSETT
Advanced Systems & Supportability Engineering Technology and Tools

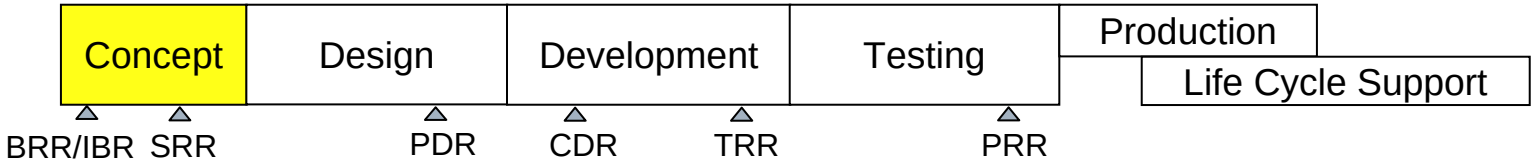
The Use of COTS Impacts the SE and T&E Planning Process

- Advantages
  - Time to Market
    - Vendor Testing
    - Product Availability
    - Reduced Risk
    - Level of Integration
- Disadvantages
  - System Compliance Testing
  - Configuration Control
    - Short Product Life Cycle
    - Upgrades
    - Standards Compliance
- Built In Test (BIT) Test Coverage

Systems Engineering and T&E have different challenges with COTS – some are advantages and some disadvantages

Products come quicker … but more test cycles (regression testing) may be required as product upgrades occur

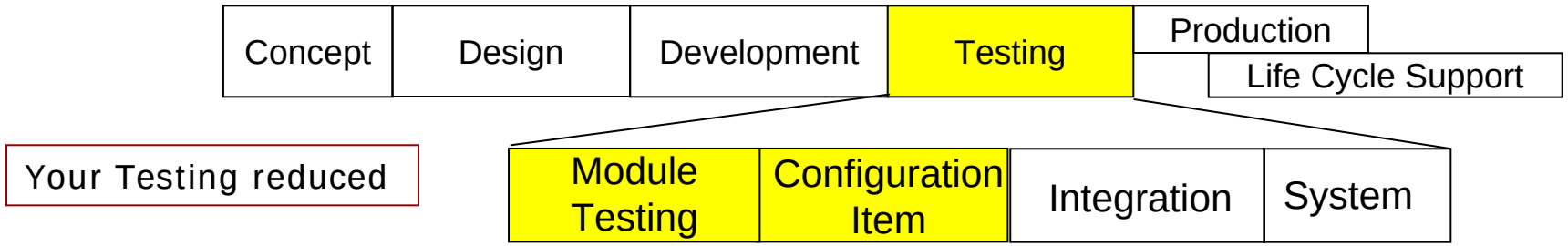
Impact of COTS on T&E Planning - Requirements



- Successful Test and Integration of COTS Technologies Starts with the Concept Phase – SE: new challenges defining Requirements
  - Physical – Write Requirements that Will Allow COTS to Meet the Environmental Conditions
    - Adapt the System to COTS not COTS to the System
  - Functional – Perform Functional Decomposition and Generate Derived Requirements to Align Required Capabilities with the Capabilities of Widely Available COTS Products
    - Target COTS Products/Capabilities During the Functional Decomposition Process
  - Operational – Leverage the Widely Used Commercial Graphical User Interface to Simplify/Reduce Training Requirements
    - e.g. Interactive Maintenance
  - Make Standards a Part of the System Requirements
    - Require Compliance

SSETT
Advanced Systems & Supportability Engineering Technology and Tools

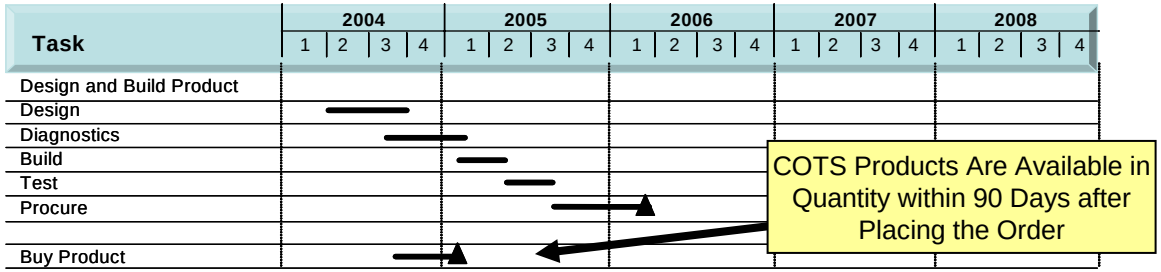
Impact of COTS on T&E Planning- Advantage: Vendor Testing



- Vendor Testing
  - Vendor Supplied Products Are Tested through Configuration Item Testing Prior to Delivery
    - Eliminates the Need for the System Integrator to Establish the Test Environment and Test Process for these Levels of Testing
  - Systems Integrator Must Validate Vendor Test Process
    - Review of Vendor Test Procedures
    - Witness Testing at the Vendors Site
    - Incoming Inspection and Validation

SSETT
Advanced Systems & Supportability Engineering Technology and Tools

Impact of COTS on T&E Planning – Advantage Product Availability

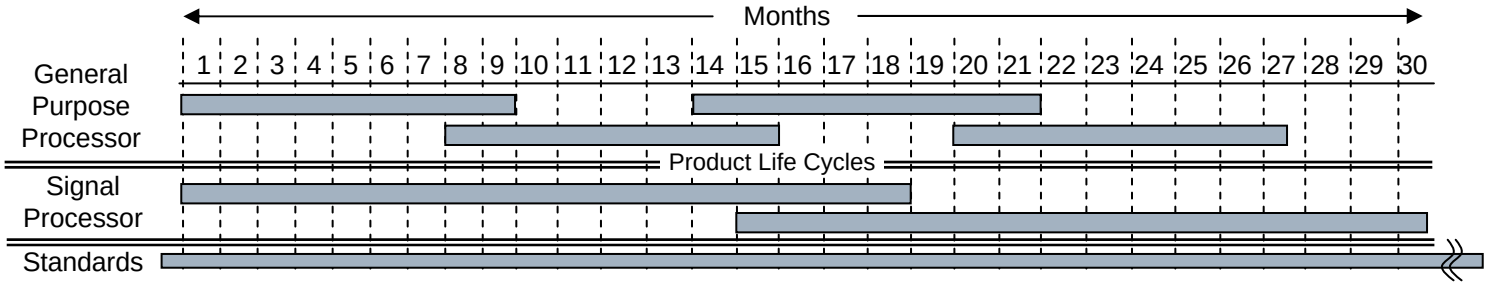


Products available earlier – testing earlier

- Product Availability
  - COTS Products Available 12-21 Months Before a Product Can Be Designed, Built, Tested and Ready for Production
    - COTS Products Generally Available within 90 Days of Placing the Order
    - Design and Build of a Product (Hardware or Software) Requires Approximately 24 Months
  - Testing Can Begin When Products Are Available
    - Functional Definition and therefore the Development of Application Code Must Support the Delivery of COTS Products into Test

SSETT
Advanced Systems & Supportability Engineering Technology and Tools

Impact of COTS on T&E Planning – Disadvantage: Shorter Product Life Cycle



Products need to be replaced earlier – more testing

- System Life Cycles Are Significantly Longer than the Life Cycle of Electronics
  - Driven By the Rapid Evolution of Technologies
- Open Standards Are the Key to Ensuring a "Plug and Play" Environment
- Establish a Plan for Upgrading Technology Over the System Life Cycle
  - Frequency of Refreshment
    - During the Development Cycle
    - During Production and Life Cycle Support
  - Ensure System Partitioning Facilitates Technology Refreshment
  - Product upgrades will necessitate regression testing

SSETT
Advanced Systems & Supportability Engineering Technology and Tools

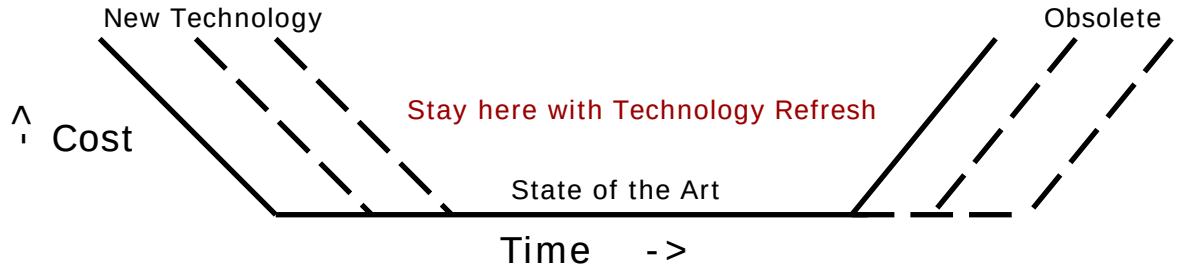
Technology Refresh Objectives

Upgrading Technology: SE Oversees

- Obsolescence Avoidance
  - Replace Obsolete Hardware and Software System Elements With Currently Supported Vendor Products
    - In Some Cases Will Require Limited Redesign
  - Avoid Product End-of-life Issues
- Maintain Infrastructure Currency
  - Ensure Compliance With Current Industry State of the Practice
  - Gradual Migration With Industry Trends and Mainstream Standards and Products
- Reduce System Total Life Cycle Cost
  - Avoid Large Investments in Spare Parts Inventories
  - Leverage Emerging Technologies and Products to Lower Costs
- Support Cost Effective Technology Insertion
  - Anticipate Requirements Pull and Technology Push
  - Plan TR and TI Evolution Together

Technology Refresh – Strategy & Planning

- Technology Refreshment Should be an Integral Part of a COTS-based Systems Design Strategy
  - Exploits Exponentially-improving Technology
  - Facilitates Introduction of Advanced System Capabilities
  - Allows for Cost-Effective Post-Deployment Support
  - Reduces Total Life-Cycle Cost
- Effective Planning for Technology Refreshment Based on
  - Implementation-independent Design
  - Comprehensive Technology Strategy
  - Updated Fleet Support Strategy



SSETT
Advanced Systems & Supportability Engineering Technology and Tools

Research & Production Testing – Different Challenges

- **Full Production Testing**
  - Full SE process
  - All levels of T&E testing
  - Formal documentation
  - Production Quality system and products for production platforms
- **Research Testing (e.g. SBIR & ABP programs)**
  - Streamlined SE process
  - Mix of experimental technology and/or commercial test equipment integration
  - High level design and test documentation
  - Breadboard and prototype system and products
  - Usually involves Field testing of prototype to collect data for later production design






Some T&E Lessons Learned at ASSETT

- Get testable requirements and acceptance criteria defined early and agreed upon with the Customer
- Create a Test Strategy and Master Test Plan
  - It should be a much shorter but do so for research also
  - Get buy in by all parties involved
- Prepare Test Plans for each of the different levels of integration and conduct peer reviews and customer reviews as necessary – don't want surprises at acceptance
- Create a SRVM and get it reviewed/approved
- Design as many auto regression tests as possible to simplify testing for upgrades and product release certifications
- Fully dry run all test procedures – do exactly as plan to do in formal testing – whether it be research or production
- Hold regular test progress/results meetings internally
- Document all test findings and share them with both Customer and own teams

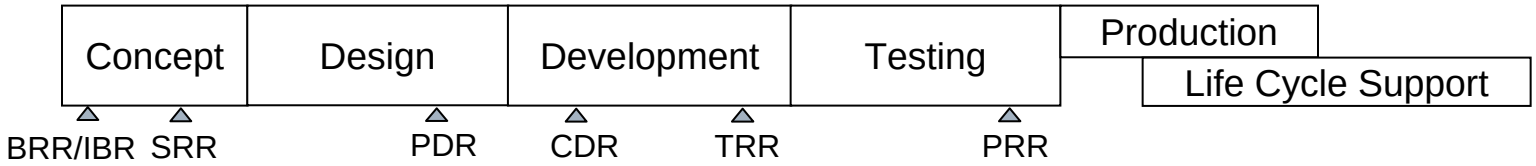
SSETT
Advanced Systems & Supportability Engineering Technology and Tools

Summary & Conclusions

Systems Engineering provides a structured approach to managing the technical solution over the full life cycle from concept to deployment to retirement…

…Test and Evaluation complements this approach with support for defining requirements and integration planning…and conducting many levels of integration tests with systems engineering support to achieve customer acceptance of a system…

…later production testing on platforms provides feedback for new requirements.



- Concept: Solution Feasibility
  - Initial Requirements Defined
- Design: Functional/Physical/Data Architectures
  - Requirements Finalized
- Development: Detailed Design/Implementation
- Testing: Verification and Validation
  - Validate Implementation Against Requirements
- Production: Manufacturing/Assembly
  - Build to Print
  - Test
- Life Cycle Support: Deployment to Retirement

Q&A