Model Driven Systems Engineering: Linking the “Vee”

Tim Tritsch – Vitech Corporation
Janice Magill - NAVAIR
James Newbury – NAVAIR

NDIA Systems Engineering Conference
24 October 2006

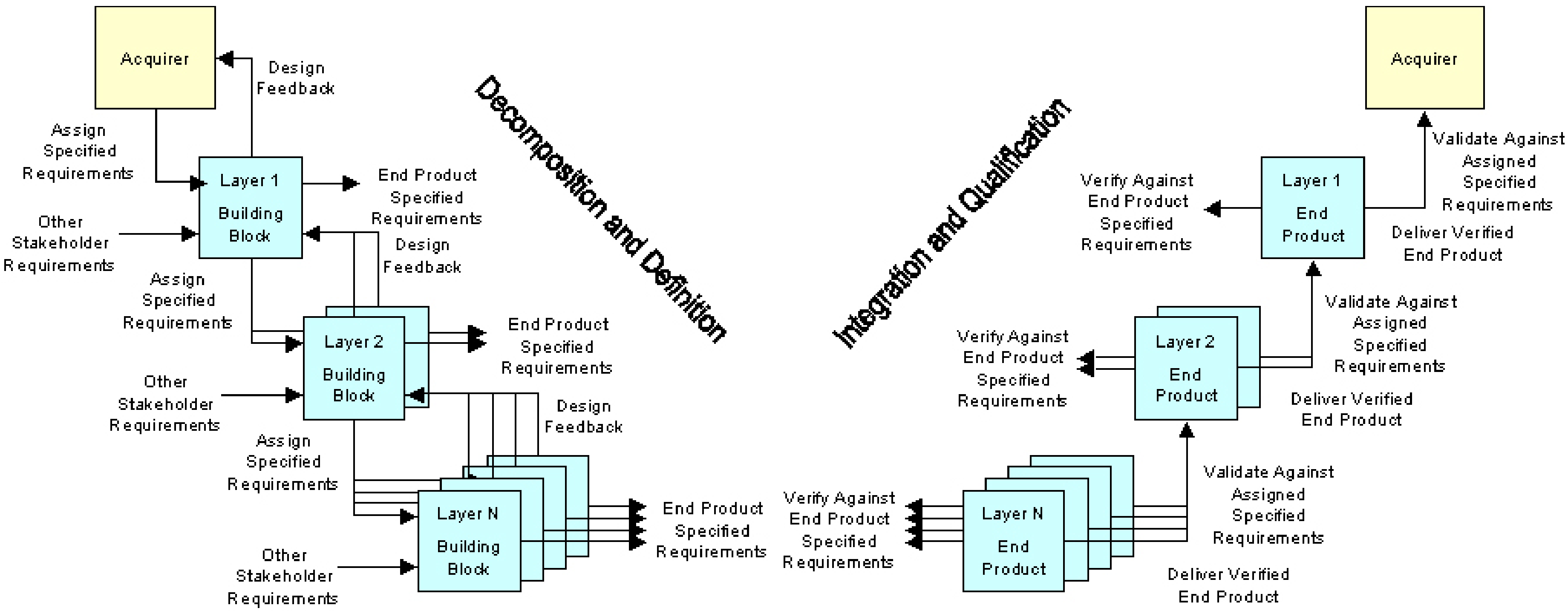
Topics

- The “Vee” chart – Review
- Model Driven Systems Engineering – Overview
- The Advanced Arresting Gear Program
- AAG System Model Development
- AAG Test Program
- Description of Verification Method Structure
- Relating Requirements to Verification Methods
- Summary and Conclusions

Forsberg and Mooz "Vee"

- Provides basic map of a system development cycle
- Implies each phase of design definition has associated integration and qualification activities
- Principles adopted in DoD acquisition guidelines and many ACAT programs
  - ANSI/EIA- 632 (Processes for Engineering a System)
  - Defense acquisition's *Integrated Defense Acquisition, Technology and Logistics Life Cycle Management Framework*

Requirements Development and Qualification



Has been extended to include phased development strategies.

Model Driven Systems Engineering

- Complete System Definition Capture in System Model
  - Concept of Operations
  - System requirements
  - System behavior
  - System structure
  - Component interaction (I/O)
  - Verification, Validation, and Qualification tasks and methods
  - Relevant relationships between all the above
- Consistency in documentation
- Multiple views of the System (Textural and/or Graphical)

Advanced Arresting Gear Environment

Challenges of an Aircraft Carrier

- A typical airport has a runway over a mile, an aircraft carrier has less than 800 feet.
- On a carrier, the runway moves with the waves.
- On a carrier, the hot, wet, salty environment is destined to corrode any equipment.
- On a carrier, there are stringent equipment requirements
  - Space limitations
  - Rigorous shock and vibration standards
  - Strict electromagnetic interference and compatibility requirements
- On a carrier, equipment is repaired and maintained by 19 year olds working 12 hour shifts.

Advance Arresting Gear

- Naval Air System Command (NAVAIR) and General Atomics (GA) have taken the challenge to develop a new arresting system that will take aircraft carriers into the 21^{st} century
- The AAG program
  - Has completed a technology demonstration phase
  - Was designated ACAT II at MS B in October 2004
  - Is currently in System Development and Demonstration
  - Has Low Rate Initial Production slated for October 2009
- The team is jointly applying a Model Based Approach to manage the Advance Arresting Gear system definition.

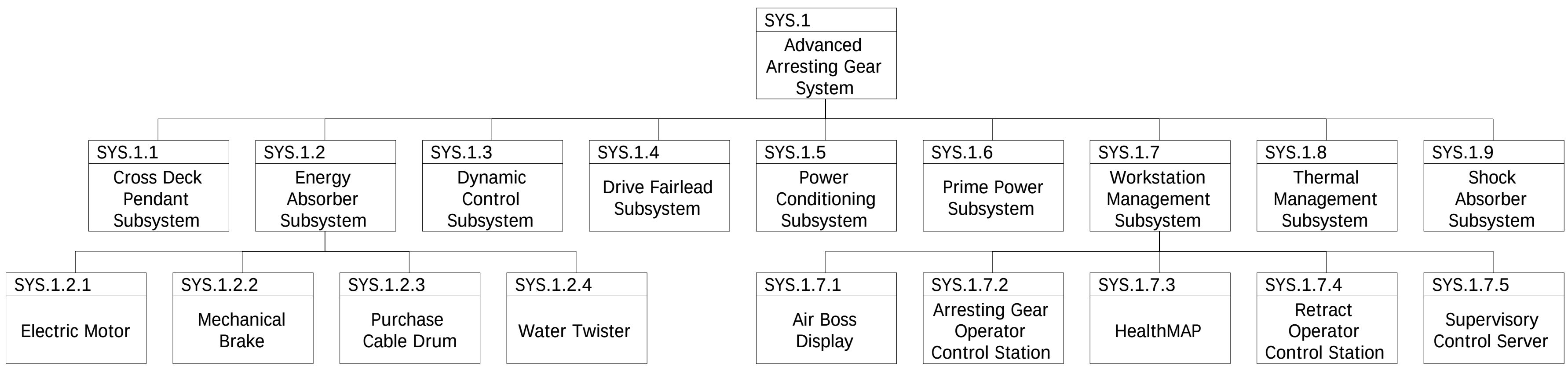
AAG System Model Development

- NAVAIR –
  - Stakeholder Requirements identified, collected, and defined to develop Operational Capability Document (OCD)
  - Chose CORE™ as the CASE tool to manage system technical requirements and produce System Specification part of Request for Proposal (RFP)
    - Performance Requirements
    - Constraints
    - External System Interfaces
    - Verification Methods for all requirements
  - Model Provided as GFI
    - Traceability to OCD
    - System Functional and Physical Architecture
    - Data Item Flow from External Systems
  - Modified in transition to Capability Design Description (CDD)

AAG System Model Development (cont.)

- General Atomics –
  - Required to use “A CASE tool”, chose CORE™ to take full advantage of GFI system model
  - Developed physical and functional representation at the subsystem and component level
    - Derive Performance Requirements
    - Derive Design Constraints
    - Define Internal Interface Requirements
    - Define Internal Data flow
    - Flow Down of System Constraints (i.e. reliability, maintainability, and human factors)

AAG Physical Hierarchy



AAG System Model Development (cont.)

- System Model used by General Atomics to
  - Ensure flow down and traceability to procurement specification
  - Enabled traceability to trade studies and design analysis
    - Functional Baseline for Initial FMECA
  - Produced:
    - System Specification
    - Subsystem Specifications
    - Components Specifications
    - Software Requirements Specifications
    - Test and Evaluation Plans

AAG Test Program

- The AAG program has applied a cohesive integration and test strategy to verify the engineering development of the system.
  - Component, subscale, and prototype level to verify concepts, validate the developmental arrestment model, and reduce risks
  - Integration and reliability testing will reduce risk through integration of major components
  - Environmental tests to ensure the system is qualified for the intended operational environment
  - System level tests at Jet Car Test Site and Remote Aircraft Landing Site

AAG Test Documentation

- For the AAG program,
  - The overall test strategy is captured Test and Evaluation Master Plan (TEMP)
  - The developmental test framework is captured in the Test Evaluation Plans (TEP) in accordance with test strategy
  - Detailed procedures are captured in the individual test directives
  - Developmental tests will be documented in a series of test reports

Associating Requirements to Verification Methods

REQUIREMENT IDENTIFICATION
(Function, Performance Index, Constraint)

VERIFICATION METHOD SELECTION

ANALYSIS

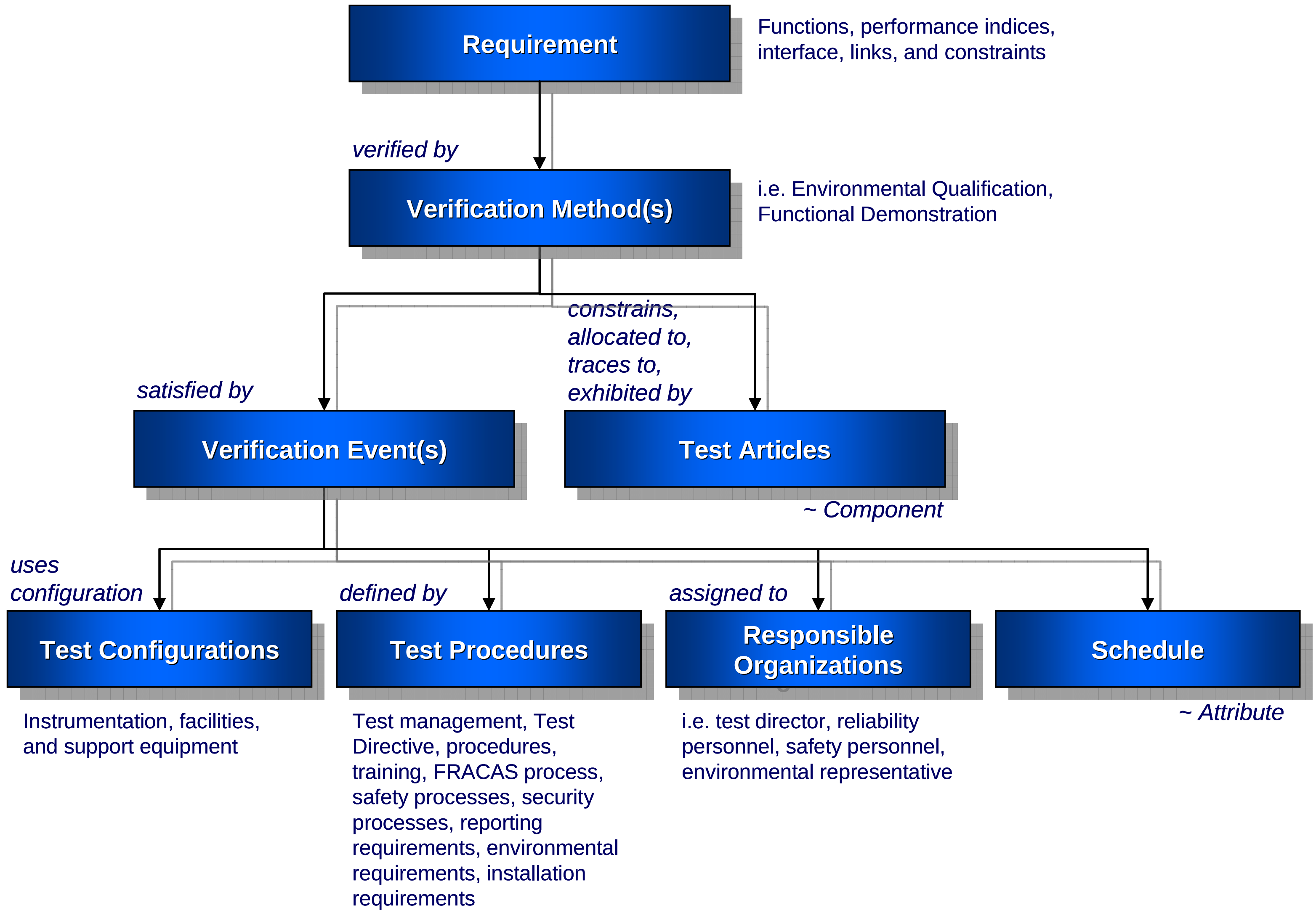
- TD Qualification Analysis
  - System Simulation
  - Engineering Analysis
  - Reliability Analysis
- SDD Qualification Analysis
  - System Simulation
  - Engineering Analysis
  - Reliability Analysis

INSPECTION, DEMONSTRATION, & TEST

- SDD Inspection Test
- SDD Controls / HealthMAP Software
  - Software Unit Test
  - Software Integrated Test
- SDD Prototype Subsystem & Component Tests
- SDD Integration & Extended Reliability Tests
- SDD Fairlead Tests & JCTS Commissioning
- SDD JCTS Functional & Performance Demonstration Tests
- SDD RALS Functional & Performance Demonstration Tests
- SDD Maintainability Tests
- Environmental Qualification Tests
  - Humidity, Salt Fog, Shock, Vibration, Rain UE, Rain CE, Solar Radiation, Icing, Fluid Contamination, Sand & Dust, EMI, Extreme Temperatures
- Preparation For Delivery / Shipment

Model Based Approach Developed the Test Plans and Specification Qualification Section

Map of Elements for Test Planning



Lessons Learned

- Aggressive development schedule reduced adherence to :
  - "Bottom to top" test plan development, Integration test plans completed before component requirements (and verification plans) fully developed
  - Program leveraged integrated tests for the verification of a majority of the component requirements
- Through the process of assigning requirements to verification methods, *the need for a substantial integrated test was clear*
  - Many requirements of component tests not achievable at component level due to design parameters beyond test fixture capability
  - Integration test phase expanded to include additional major components of the system for risk reduction

Conclusions

- The model-based approach increases confidence that the system design solution is on track to meet requirements
- *Discipline* of the model-based approach ensures that performance capability and reliability are designed into the system early
- Development of the TEPs provided the program and stakeholders early visibility of the derived requirements, the planned verification, and the resources required
- Managers, design engineers, systems engineers, test engineers, logistics, etc. all contributed to the same product baseline
- Early identification of verification requirements provided better scheduling and resource budgeting