Evolving T&E in the FAA

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Topics

• National Airspace System (NAS) Operational Views and evolving challenges
• Where do we to focus?
• Improving T&E: People, Process, Tools
• Optimizing the Approach
Current NAS

Future NAS

Evolving T&E in the FAA - 2014
FAA Challenges: Changes and Gaps

• **Next Generation Air Transportation System**
  – System-of-systems architecture
  – New Operational Concepts
  – More stakeholders engage with the National Airspace System

• **Cultural and organizational stovepipes inhibiting advancement and integration**

• **Test capabilities and infrastructures based on old legacy systems and programs**
  – Independent systems providing FAA services
  – Labs, simulators and models focused on independent systems
THE STAN SHIH SMILE CURVE

VALUE ADDED

HIGHER

CONCEPT/R&D
BRANDING
DESIGN
MANUFACTURING
DISTRIBUTION
MARKETING
SALES/AFTER SERVICE

PRODUCTION CHAIN

TIME

LOWER

Under this model manufacturing is the lowest value input
Relative Cost to Fix

* Boehm 1981
Cost Avoidance Data for V&V

Where faults are introduced
Where faults are found
The estimated nominal cost for fault removal

Sources:
B.W. Boehm, Software Engineering Economics, Prentice Hall
Federal Aviation Administration

T&E for Event Driven Programs - ITEA 2012

Decision Support
- Operational mission
- Operational concepts
- Available technologies
- Solution sets
- Requirements
- Design
- System performance
- Implementation plans
- Criteria for deployment

FAA Lifecycle V&V

In-process V&V

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SE Work Products:
- CONOPS
- Functional Analysis
- Alternative Analysis
- PRD (P,I,F)
- EA
- Specs & Interface Requirements
- Design (PDR, CDR, Docs)

*Work Products to be verified & validated and serve as V&V criteria. V&V criteria are previous work products and applicable standards.

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<tr>
<td>Mission Analysis</td>
<td>Investment Analysis</td>
<td>Solution Implementation</td>
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FAA T&E Area of Focus

People:
Fostering culture change, establish organizational V&V roles, promoting capability focus/roles, training, credentialing, technical interchanges

Process:
Standardized V&V/T&E processes with:
• Quality oversight
• More rigor in policies

Tools:
Enhanced lab with system-of-systems evaluation capabilities
People: Concept Behind Quality V&V

Verification
Build the system right

V&V
Build an effective system efficiently

Validation
Build the right system
Improving the Quality of Test

- Verification and Validation (V&V) approach with a focus on quality Test and Evaluation (T&E)

- Adopted V&V goals defined in CMMI
  
  Verification: *Build the system right*
  
  - Ensures work products and products meet specified requirements

  Validation: *Build the right system*
  
  - Demonstrates that products and product components will fulfill their intended purpose when placed in the intended environment

  V&V: *Build an effective system efficiently*
  
  - Focuses on problem prevention, detection, and resolution as early in the lifecycle as possible
  - Provide basis for T&E quality standard practices

Based on the same CMMI® model used for GAO audits
Implementing V&V in the FAA

• **Need to establish**
  – V&V advocate at executive and decision levels (e.g. ASAG, AEB, JRC, ISD)
  – V&V Organization (facilitator/custodian)
  – Budget for V&V

• **Consistently factor V&V into:**
  – Decision Making
  – Planning and PM
  – Research and Engineering
  – Contracting
  – Design & Development
  – Testing and Reporting
V&V Concepts: Systems Thinking

- Challenge concepts - drives programs to a comprehensive understanding of the product
- Fully considers interaction between all elements and environments

Systems Thinking provides a means to identify all interactions and supports cause and effect analysis to mitigate undesirable emergent behavior
Process: Methodical V&V Approach

• Encourages a methodical approach – premised on the Deming “PDCA” Cycle for quality management:
  – **Plan**: Identifying and analyzing the problem.
  – **Do**: Developing and testing a potential solution.
  – **Check**: Measuring how effective the test solution was, and analyzing whether it could be improved in any way.
  – **Act**: Implementing the improved solution fully.

• Integrates T&E & SE to foster methodical checks and balances
  – Promotes quality
  – Essential to continually maturing products
  – Attain greater understanding
V&V Lifecycle Goal

Identify and resolve issues as early in the lifecycle as possible

Defect Detection Conceptual Model

- Ideal
- Realistic Goal
- Currently

Cost to fix defects increases $$$

Number of Detected Defects

- Req.'s/Concepts
- Design
- Code
- Development Test
- Operational Test
- Release
- In-Service
V&V Across the FAA Acquisition Lifecycle

Research and analysis provides critical inputs to the acquisition management process and the acquisition management process can identify potential research projects.

CRDRD - Concept and Requirements Definition Readiness Decision
IARD - Investment Analysis Readiness Decision
IID - Initial Investment Decision
FID - Final Investment Decision
ISD - In-Service Decision
The effectives of V&V is maximized when integrated into a structured knowledge-based (event driven) programmatic approach.
Keys to Knowledge-based Approach

• **Understand** the differences between Event and Schedule Driven Acquisition practices
• **Be Aware** when a program drifts to schedule driven and encourage event driven strategies
• **Promote** practices for knowledge and criteria based decision making and milestones
Government Policies

• Promote Event Driven Programs
• Recognizes the Benefits of Event Driven - Knowledge Based Practices

Yet many programs inevitably drift into a schedule driven strategy that is contrary to quality T&E practices.
Pitfalls of Time Based Decisions

• The program is at risk of advancing without full knowledge
• The program may be essentially guessing or hedging that the product is ready
When Event Driven Drifts to Schedule Driven

• When an Event Driven structured program adopts Schedule Driven tactics:
  – Many programs tend to perpetuate the one thing that they set out to avoid:

Schedule Slips
  – Eventual cost overruns
  – Reduced deployed capability
Schedule Driven Mistakes

“I never guess. It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts.”

Sir Arthur Conan Doyle
When is Schedule Driven the right approach?

When circumstances call for it…

• Expectations are set
  – E.g. Deployed product may be immature

• Risk mitigations are in place

• Time is of the essence

• Final delivery date is the overriding constraint

… Plan on consuming whatever resources are required to ensure delivery on the established milestone…
Tools: Holistic Evaluation Capabilities

Goal:
Enable FAA Leadership, Engineers and other key personnel to understand the complex and emergent behavior of FAA systems throughout the acquisition life cycle in order to make informed decisions on the construction and delivery of FAA systems.

Need:
Develop a Live, Virtual, and Constructive Integrated M&S environment and technical toolset that will assist with making informed decisions throughout the lifecycle, from early concept analysis, through design, developmental test and evaluation, integration, operational test and evaluation, and in-service operations..
System-of-Systems V&V Capability: NextGen Synthetic Environment

In combination, these components form the capability:
- Live: Real People in Real Environments
- Virtual: Real People in Synthetic Environments (Flight Simulators)
- Constructive: Synthetic People in Synthetic Environments

Entity based verses Aggregated model based.
Things to Consider

• Leverage existing FAA investments

• Use intelligent agent technology to model air traffic controllers, pilots, and command center decisions

• Model communications using simulated voice and data

• Basic design:
  – Open architecture, non-proprietary
  – Low-cost alternatives
  – Real-time and Fast-time synthetic environment
  – Entire NAS network
  – Variable fidelity, with capability to represent real-world dynamics
Architecture Major Components

An end-to-end System of Systems integration and test environment supporting the full breadth and depth of the NAS

- Test **entire** NAS as a system-of-systems
- Influence research, **development** and **test**
- Evaluation in realistic/intended environment
SEAMLESS V&V

SAFETY
EFFICIENCY
SECURITY
EFFECTIVENESS

Common Org. View
Best Practices & Continuous Improvement
Smooth Transition Between Lifecycle Phases
Common Tools & Methods
Standard Processes & Criteria
Quality Culture
Summary

• Culture and a common organizational view and philosophy are the first hurdles on overcoming these enterprise problems

• Standardized best practices and continuous improvement is the road map for quality T&E in the FAA
  – V&V applied at critical points to get the most value added
  – Quality practices that efficiently move capabilities through the lifecycle

• Test beds and tools that can address the enterprise level challenges holistically need to be planned for and instituted

Seamless V&V is our goal – Complex/net centric systems are our challenge
Back-Up Slides
FAA V&V White Paper Findings

- Identified the need for:
  - Quality standards and policies for V&V
  - Formal processes to manage T&E and V&V
  - Independence
  - Organizational structure that ensures continued quality practices
  - Accountable authorities at key decision points
  - Lifecycle focus V&V
  - Advanced V&V methods, capabilities, and automated tools

**Key elements:**
- **Accountability** - substantiate commitments
- **Accreditation/Sufficiency** - assure quality/efficiency
- **Approval** - checks and balances
V&V to Address Common Pitfalls

- Poorly documented operational concepts
- Immature or misunderstood operational concepts
- Defective or incomplete requirements
- Poor operational requirements or design
- Ineffective test environments
- Overly redundant testing
- Poorly managed system baseline
- Systems/services that are operationally unacceptable or do not integrate well into the operational environment
Applying V&V to Work Products

Needs → Validate* → V&V Results → Program Decision & Risk Mitigation

Previous
Work Product
Product Component
Product

Current
Work Product
Product Component
Product

Future
Work Product
Product Component
Product

Requirements

Verify*

Standards**

* Performed in accordance with standardized processes.
** Standards the Work Product must adhere to (e.g., FAA Policy and Guidance, orders, regulations, Mil-Stds, EA, local codes, ...)
Contrasting Characteristics

Schedule-driven projects are performed and managed under the overriding constraint of time. Time becomes the key condition for making project management decisions.

Event-driven projects use success criteria to assess technical progress. These criteria are intermediate targets on the path to meeting desired capabilities.
The fundamental purpose of T&E is to provide knowledge to assist in managing the risks involved in developing, producing, operating, and sustaining systems and capabilities. **DAU**

Who usually wins?

The Integrated Master Schedule is a time-based schedule containing the networked, detailed tasks necessary to ensure successful program/contract execution. **DAU**
Current FAA Mission/Responsibilities

FAA ANG National Policy: N 1100.340 (08/24/2012)

**Assistant Administrator:**
(13) Ensures that NextGen and NextGen enabling programs (equipment, hardware, software, services, capabilities) receive test, evaluation, verification, and validation services throughout their lifecycle.

**Director, William J. Hughes Technical Center:**
(11) Tests, evaluates, verifies, validates, and monitors performance of NAS components, services, and procedures in support of NextGen through the solution implementation phase of the acquisition lifecycle and other lifecycle phases.
LVCE Phased Approach
Phase I Action Plan

Design and Prototype Agent-based Framework
- Infrastructure
- Data model
- Scenario Design
- Agents
- Database

Research Simulation Systems
- Research available simulation systems
- Establish simulation requirements
- Choose a sim to get us going with demo (TGF)
- Research accessibility to simulation systems
- Compare available sim systems to requirements

Data Research and Acquisition
- Determine where NAS data is stored
- Determine what data the simulation components need
- Find path to get all of the NAS data, even though simulations only need pieces of data because we need it all for (routes, airports, fixes, runways, centers, TRACON, tower, etc)

Research and Prototype Visualization
- Determine best products to produce visualization
- Develop in house mapping to avoid the web
- Combine simulation, data, and visualization in a common framework
- Research web based visualization to simplify installations
- Render sim planes on map

Data Logging
- Research and profile data logging

Prepare Engineering Report Documenting Initial Analysis

Test Sim, agents, hardware, logging, visualization for:
- 7K Simultaneous Aircraft; 50K Daily
- All NAS objects: Waypoints, routes, airports