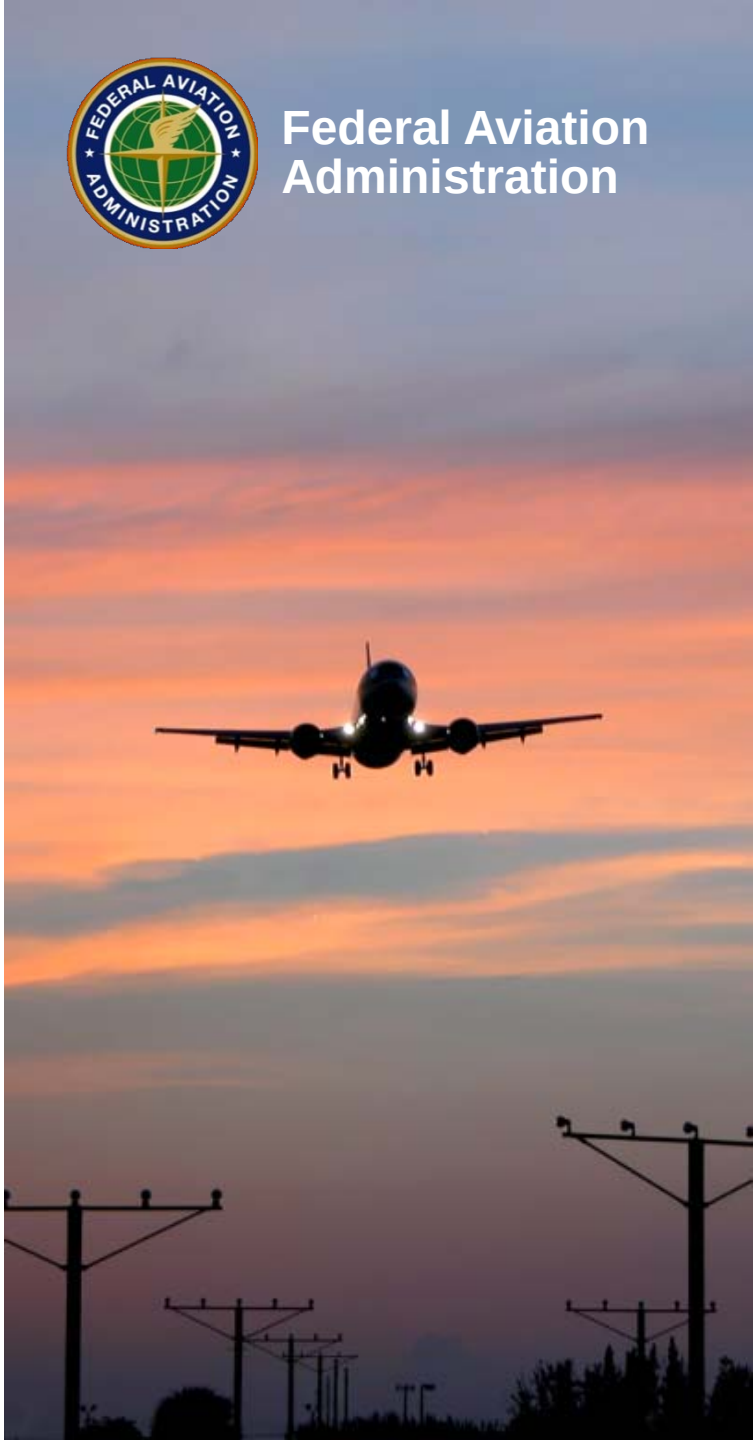
Evolving T&E in the FAA



Presented to: INCOSE: Enchantment Chapter
April 9, 2014

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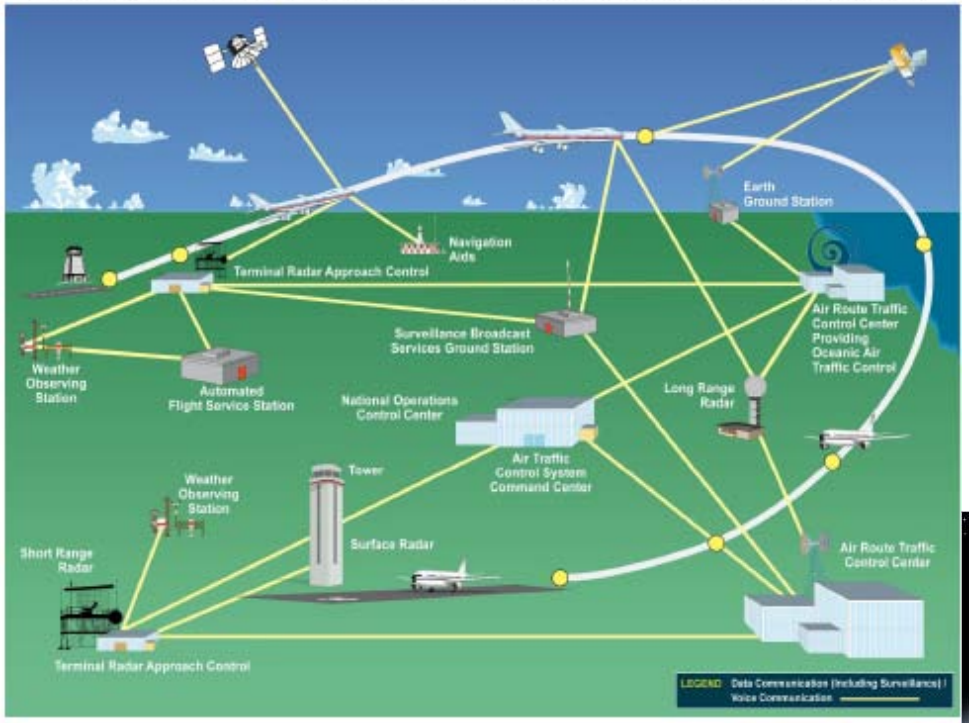
Topics

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

National Airspace System Near-Term (2011) As-Is Enterprise-Level Architecture High Level Concept Graphic (OV-1)



Current NAS

Future NAS

NextGen 2025 OV-1

Net Centric Operations

SOA CORE SERVICES					SUPPORT SERVICES		ENTERPRISE GOVERNANCE		ADMINISTRATIVE SERVICES		
Messaging Services	Interface Management	Security Service	Enterprise Services Mgt	Collaboration Services	Data Flow Management	Data Access	Strategic Governance	Run-time Management	Data/Network Support Services	Services Provisioning Management	Training Support

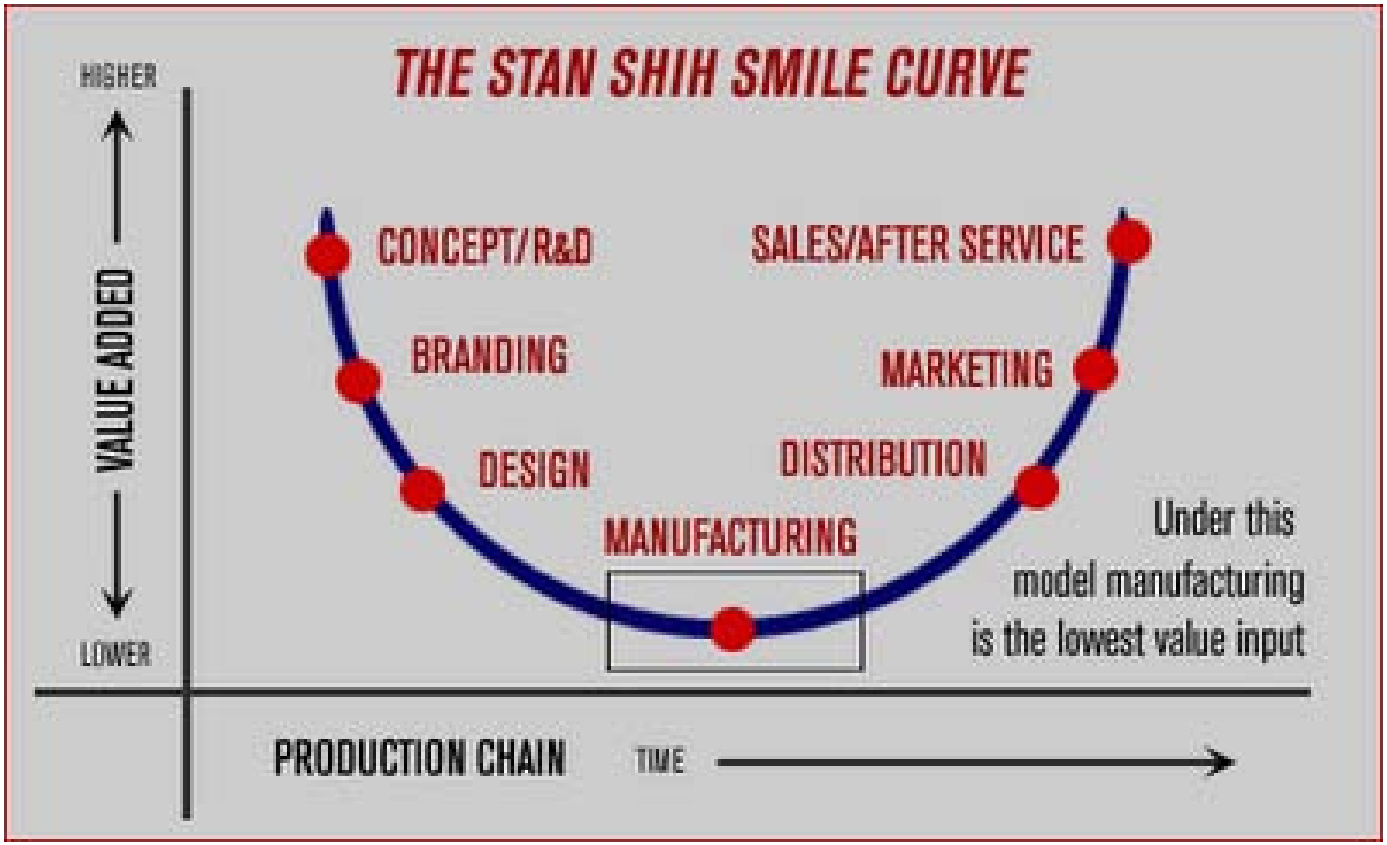
ENTERPRISE WIDE OPERATIONS (NATIONAL)									
System & Services Analysis	System & Services Management	Safety Management Service	Trajectory Management	Flow Contingency Management	Capacity Management	Flight & State Data Management	Weather Information Management	Aeronautical Information Management	Surveillance Information Management

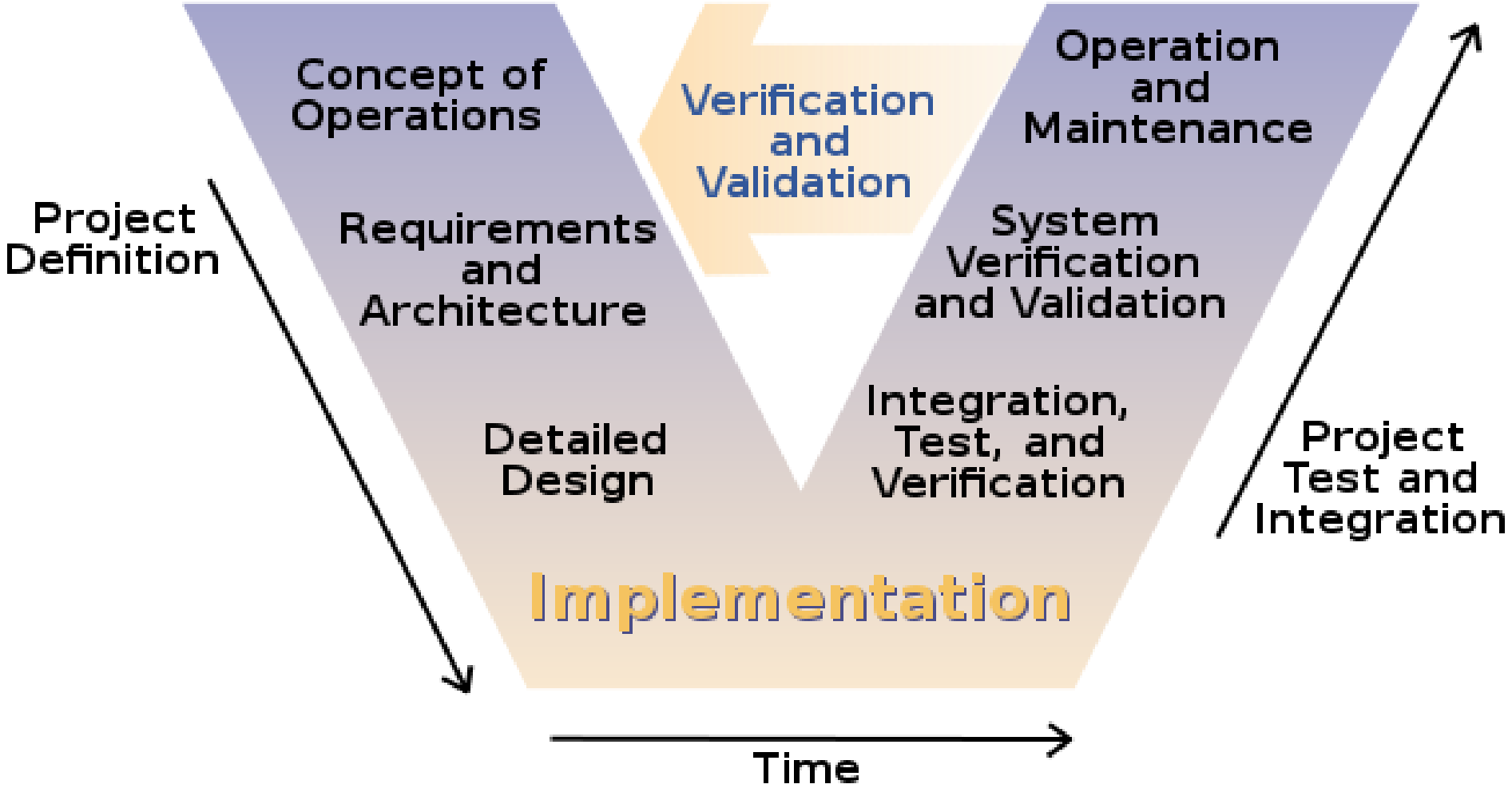
FAA Challenges: Changes and Gaps

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

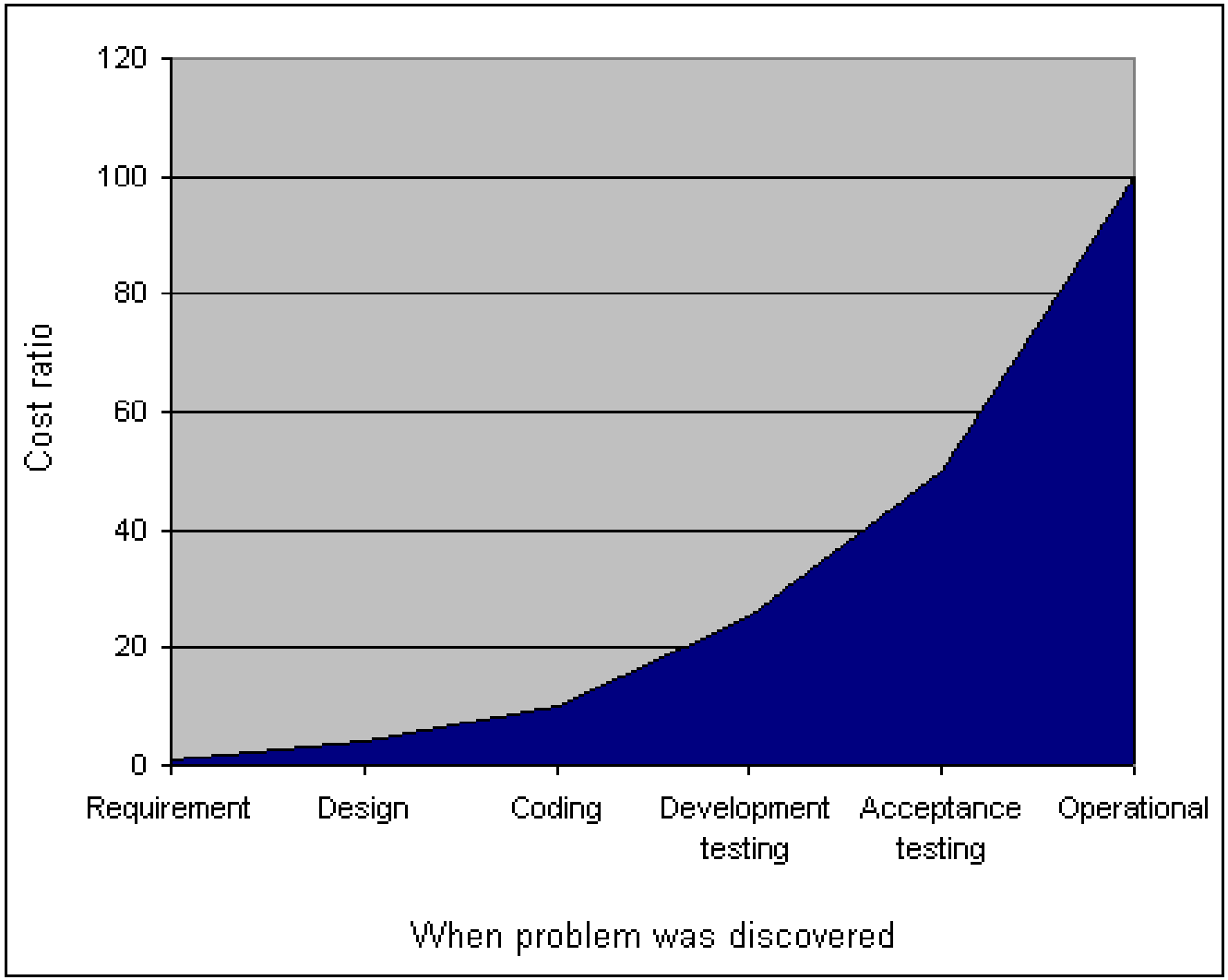
- **Cultural and organizational stovepipes inhibiting advancement and integration**

- **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
HIGHER
VALUE ADDED
LOWER
CONCEPT/R&D
SALES/AFTER SERVICE
BRANDING
MARKETING
DESIGN
DISTRIBUTION
MANUFACTURING
Under this model manufacturing is the lowest value input
PRODUCTION CHAIN
TIME

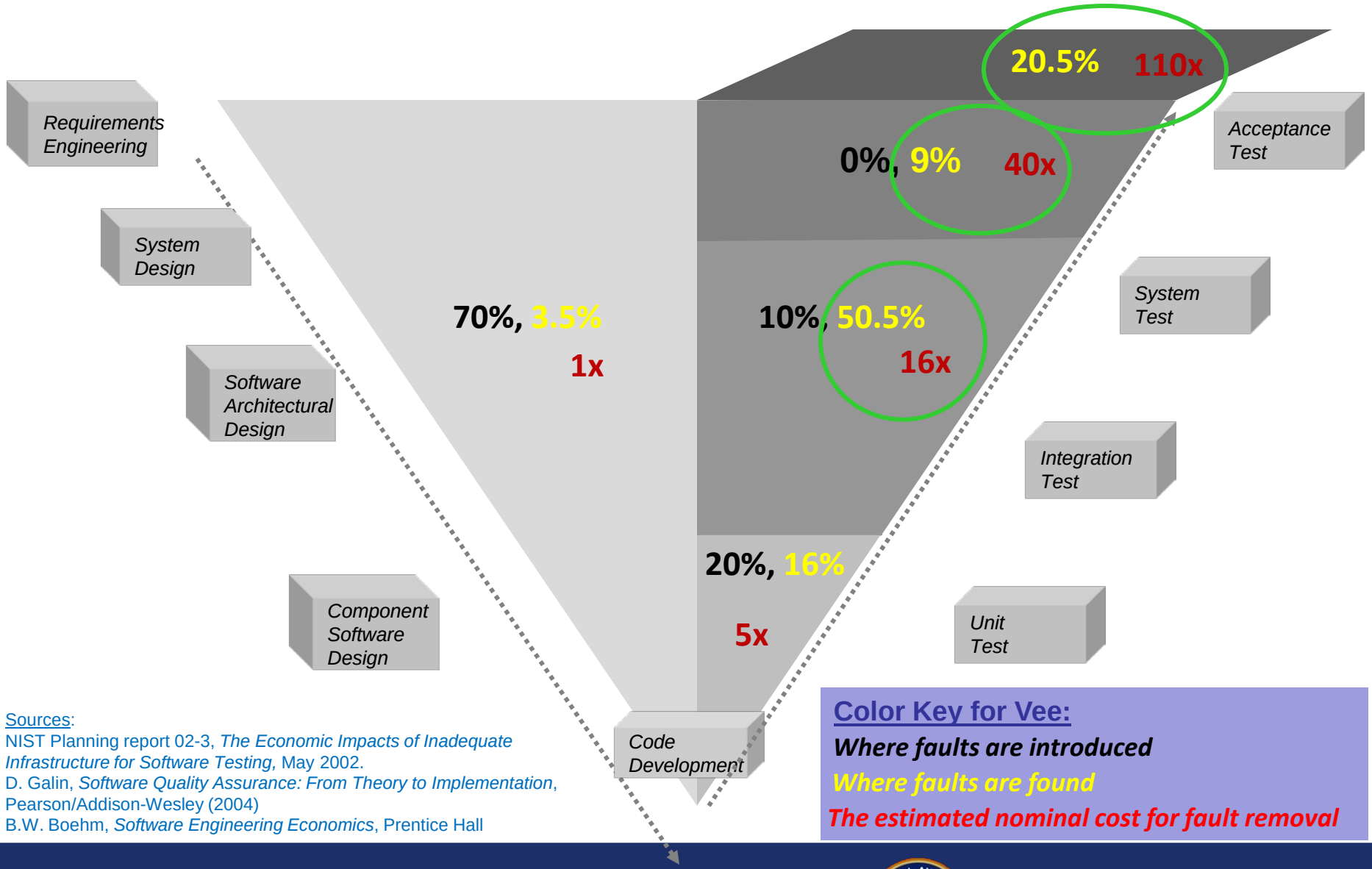

Concept of Operations
Requirements and Architecture
Detailed Design
Implementation
Integration, Test, and Verification
System Verification and Validation
Operation and Maintenance
Verification and Validation
Project Definition
Project Test and Integration
Time

Relative Cost to Fix



*** Boehm 1981**

Cost Avoidance Data for V&V



Sources:
NIST Planning report 02-3, *The Economic Impacts of Inadequate Infrastructure for Software Testing,* May 2002.
D. Galin, *Software Quality Assurance: From Theory to Implementation*, Pearson/Addison-Wesley (2004)
B.W. Boehm, *Software Engineering Economics*, Prentice Hall

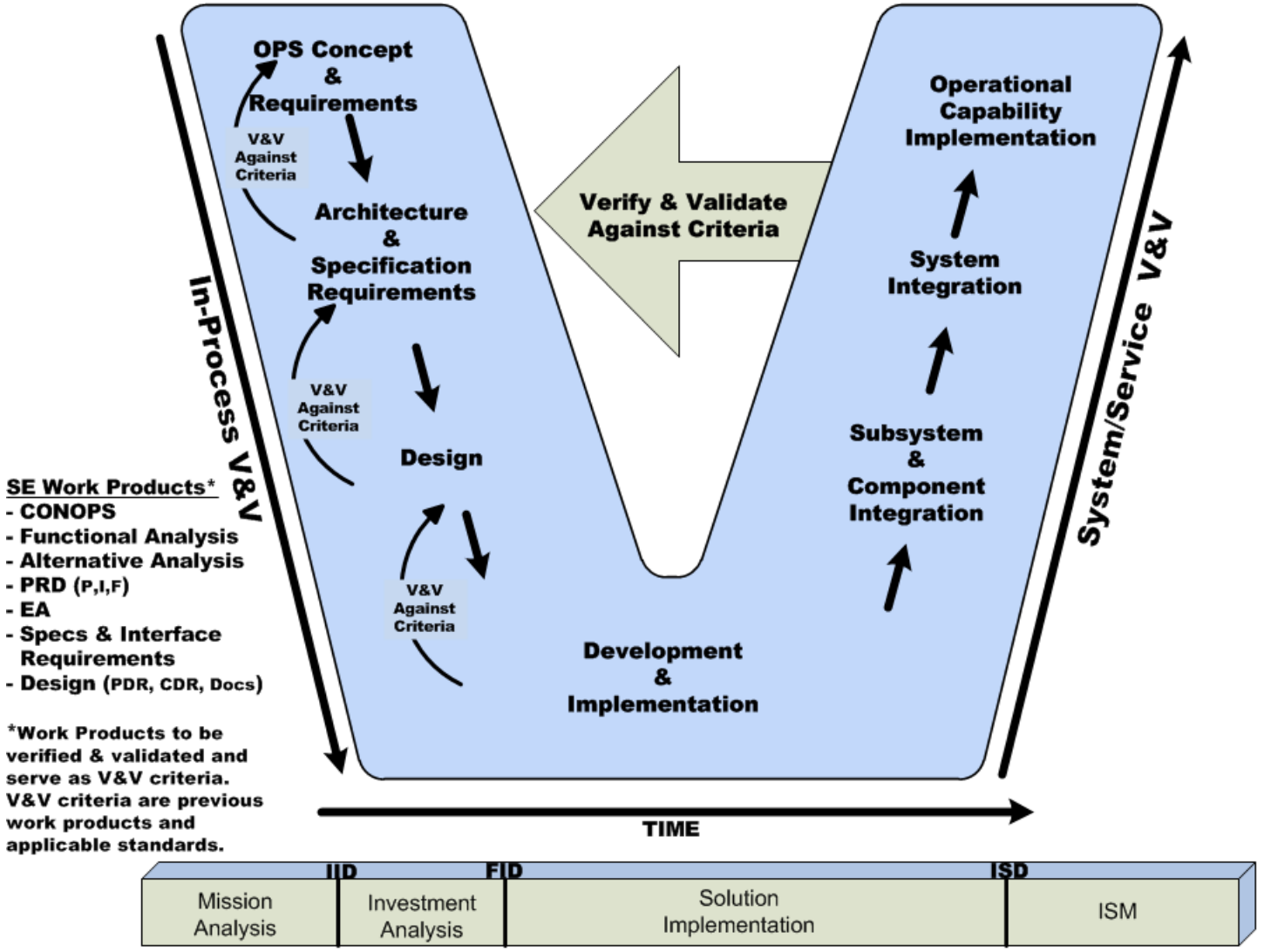
Color Key for Vee:

Where faults are introduced

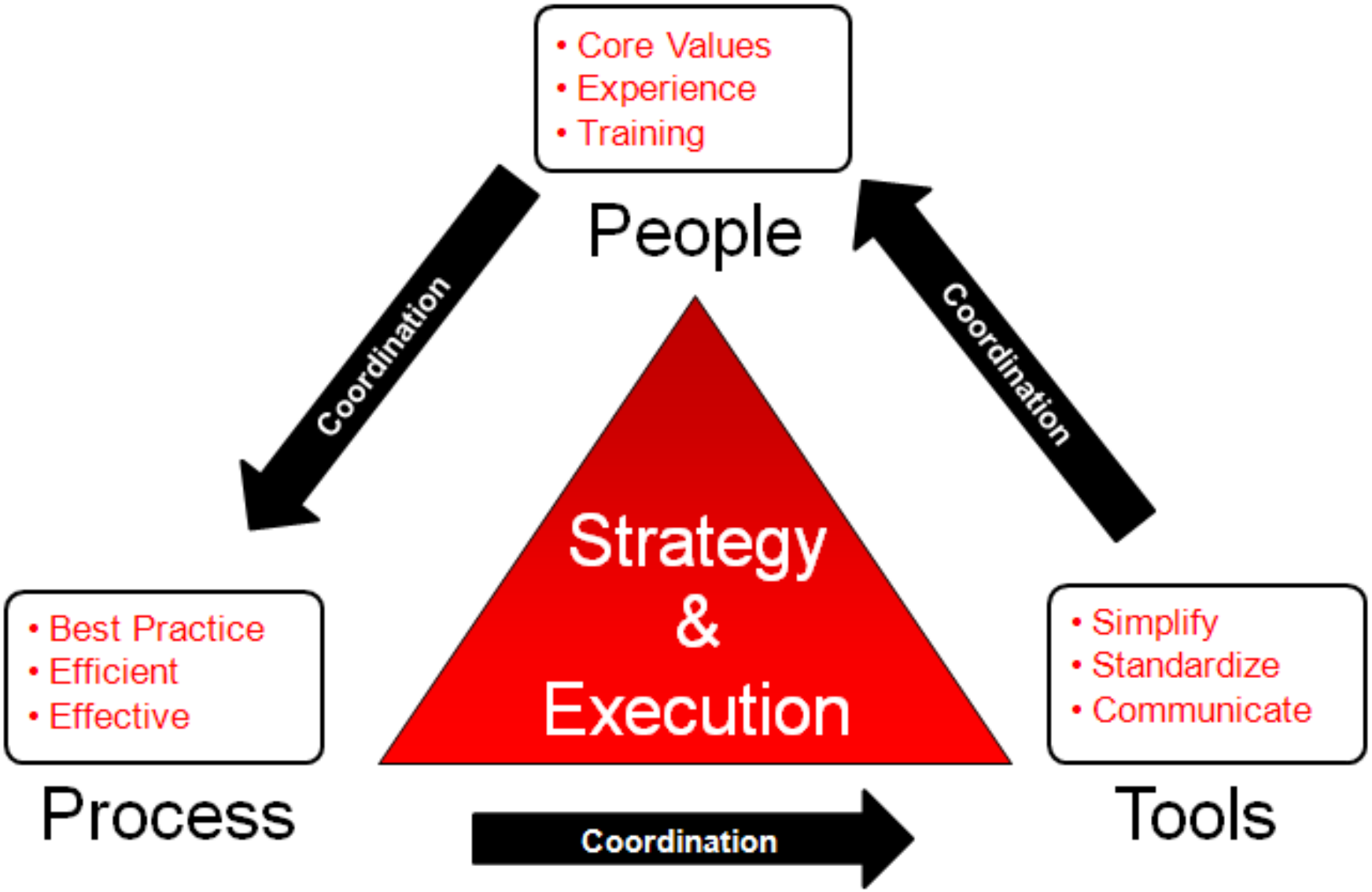
Where faults are found

The estimated nominal cost for fault removal

FAA Lifecycle V&V



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


• Core Values
• Experience
• Training
People
Coordination
Coordination
Strategy
&
Execution
• Best Practice
• Efficient
• Effective
Process
Coordination
• Simplify
• Standardize
• Communicate
Tools

FAA T&E Area of Focus

People:

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

Process:

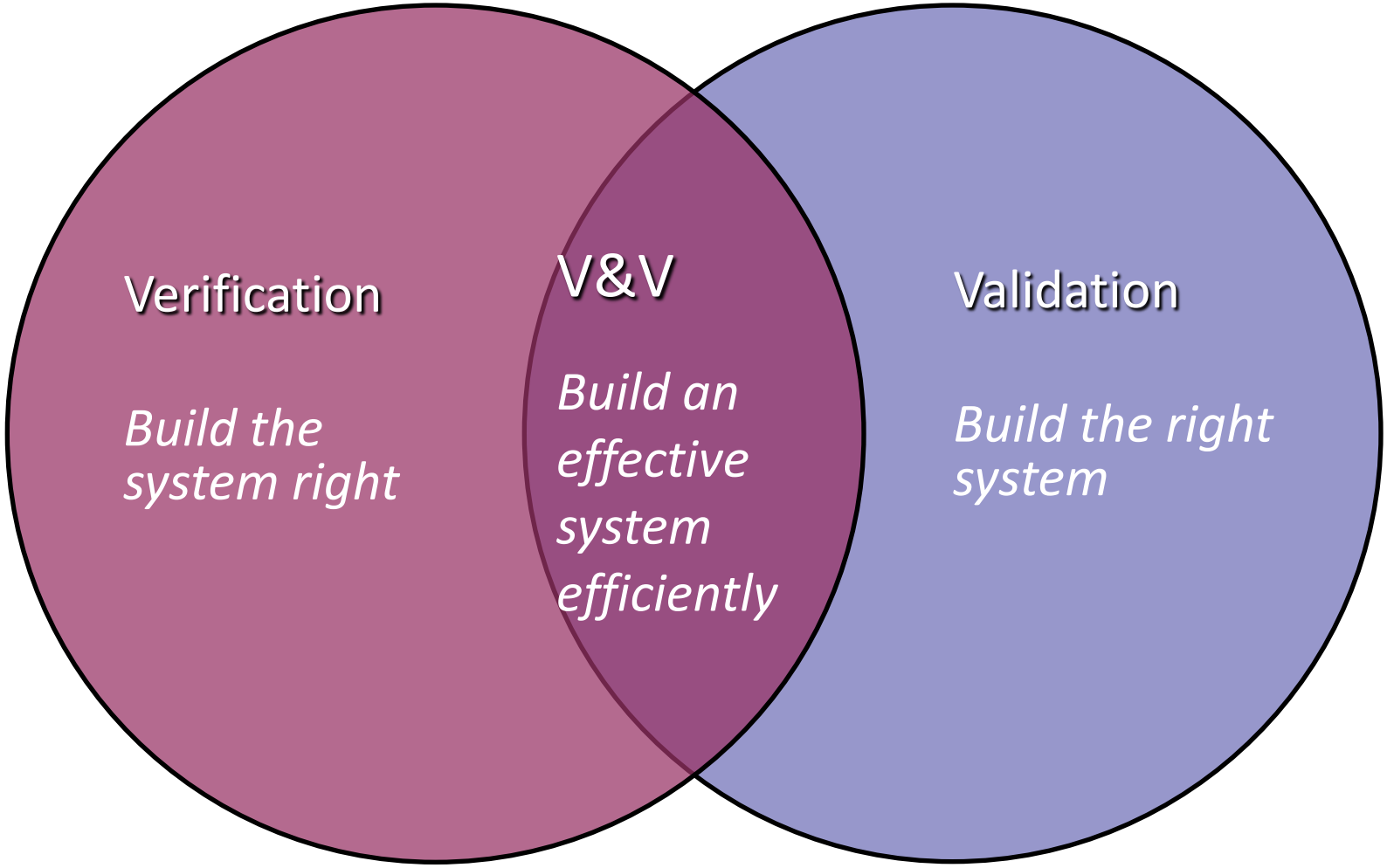
Standardized V&V/T&E processes with:

- Quality oversight
- More rigor in policies

Tools:

Enhanced lab with system-of-systems evaluation capabilities

People: Concept Behind Quality V&V



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

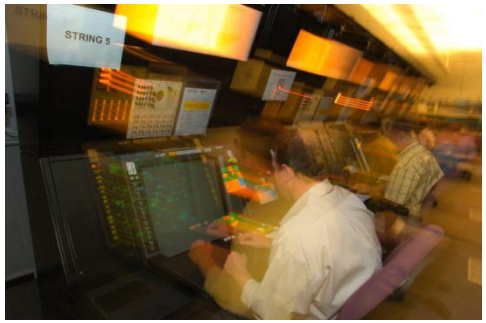
V&V: ***Build an effective system efficiently***

- 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

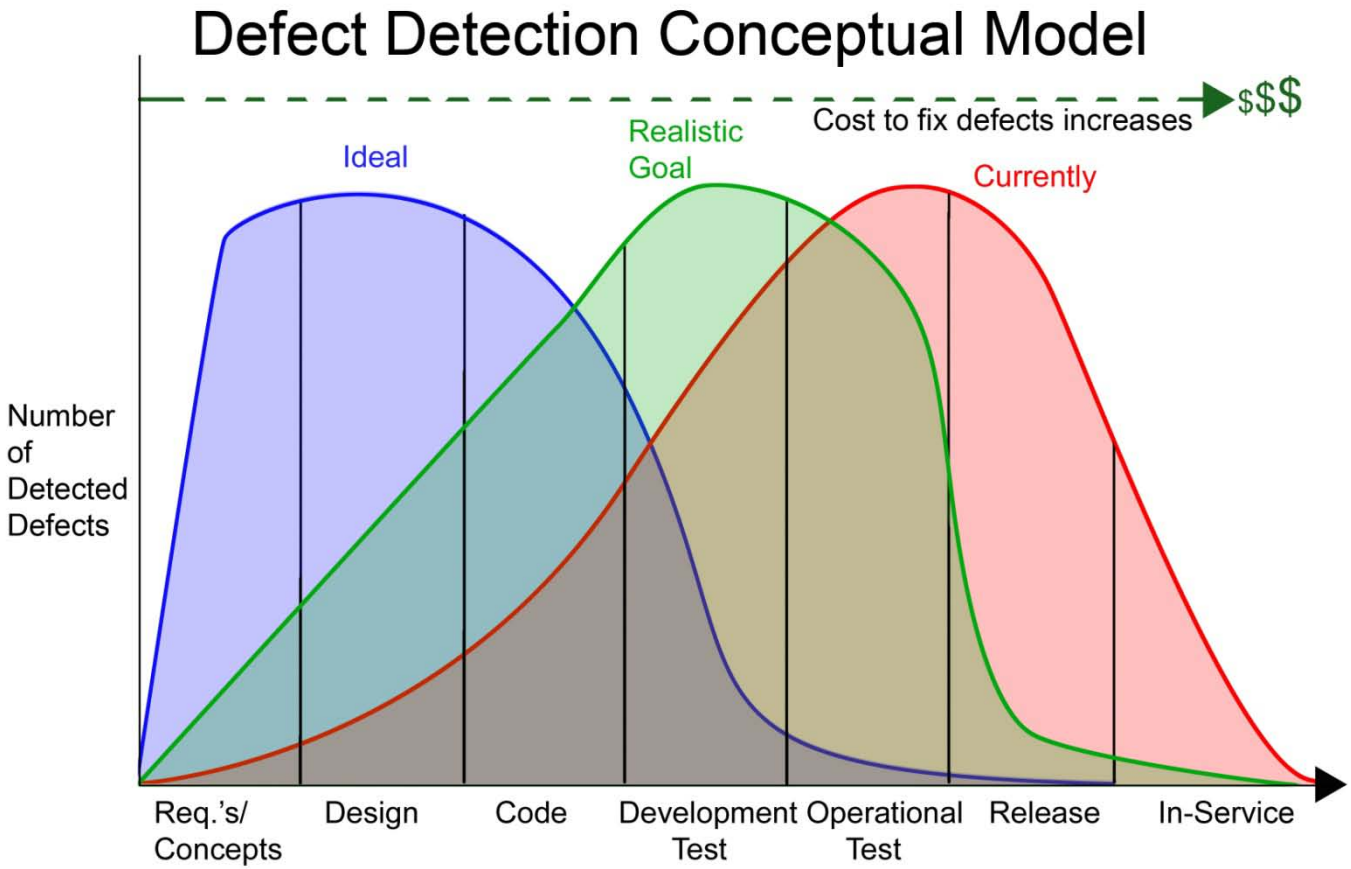
Process: Methodical V&V Approach

- **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.

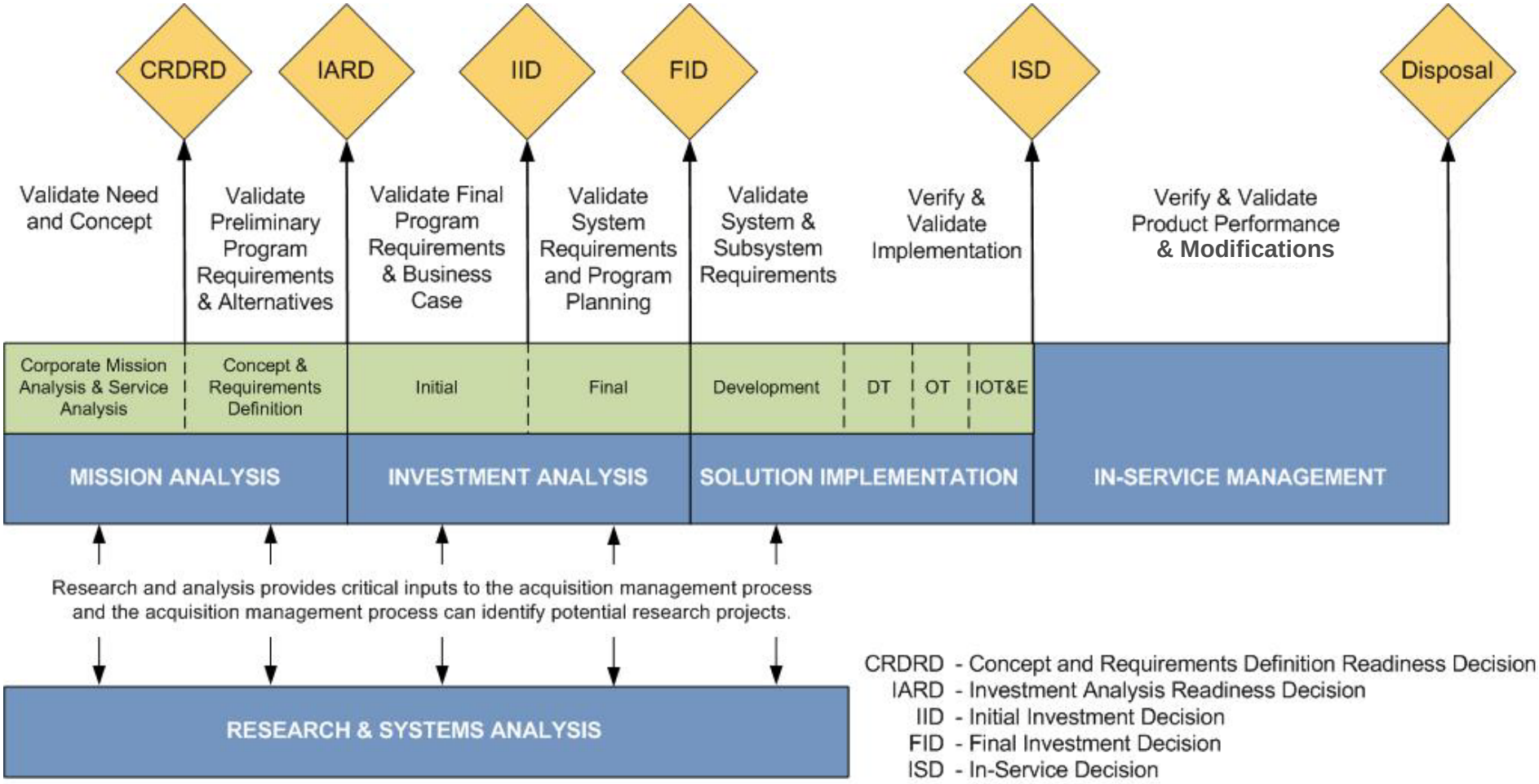
- **Integrates T&E & SE to foster methodical checks and balances**
  - Promotes quality
  - Essential to continually maturing products
  - Attain greater understanding

V&V Lifecycle Goal

Identify and resolve issues as early in the lifecycle as possible



V&V Across the FAA Acquisition Lifecycle



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

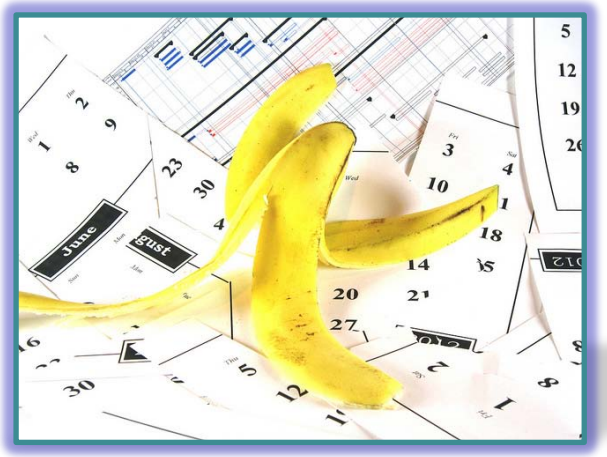
- **The program is at risk of advancing without full knowledge**
- **The program may be essentially guessing or hedging that the product is ready**

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

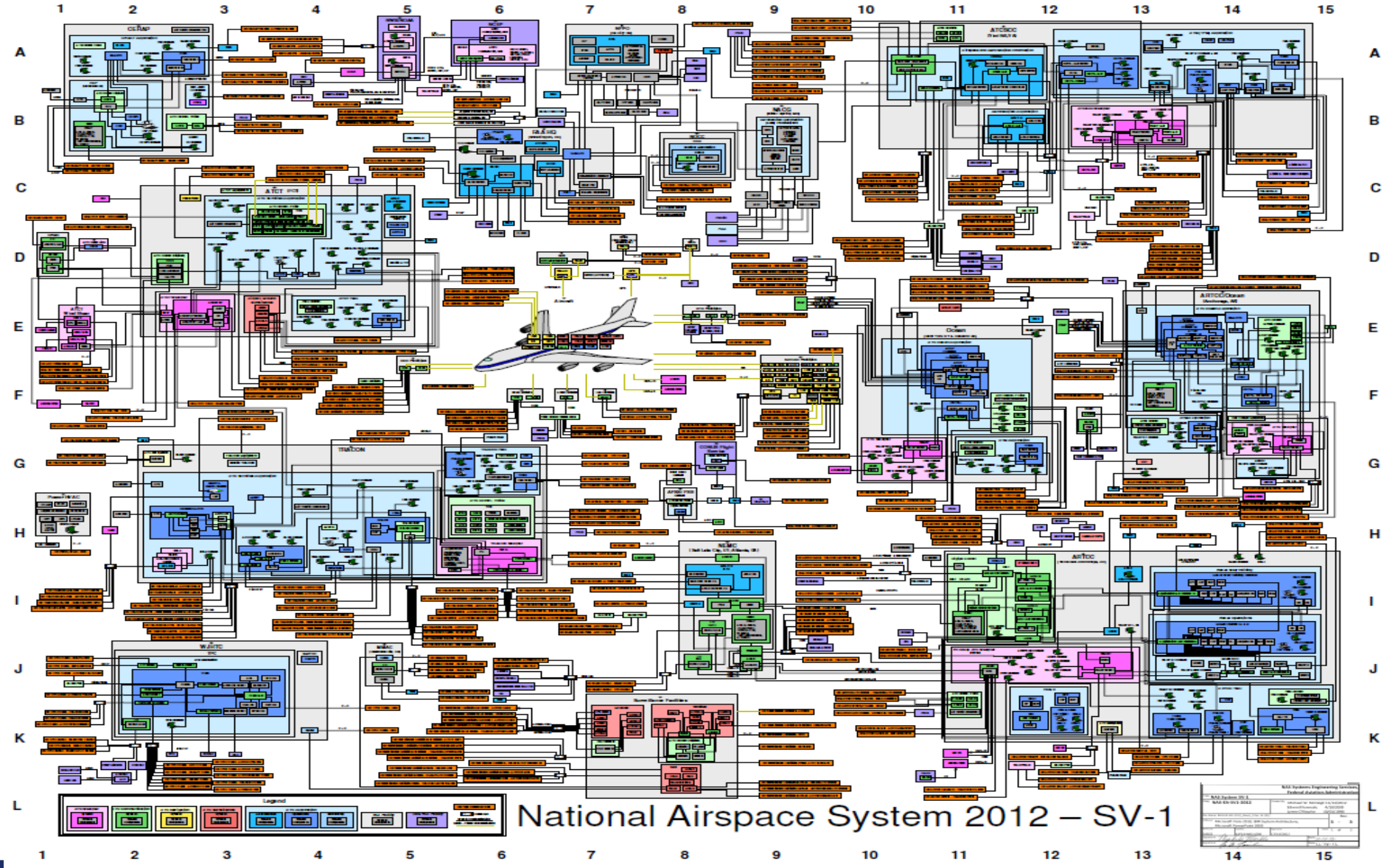
Goal:

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..

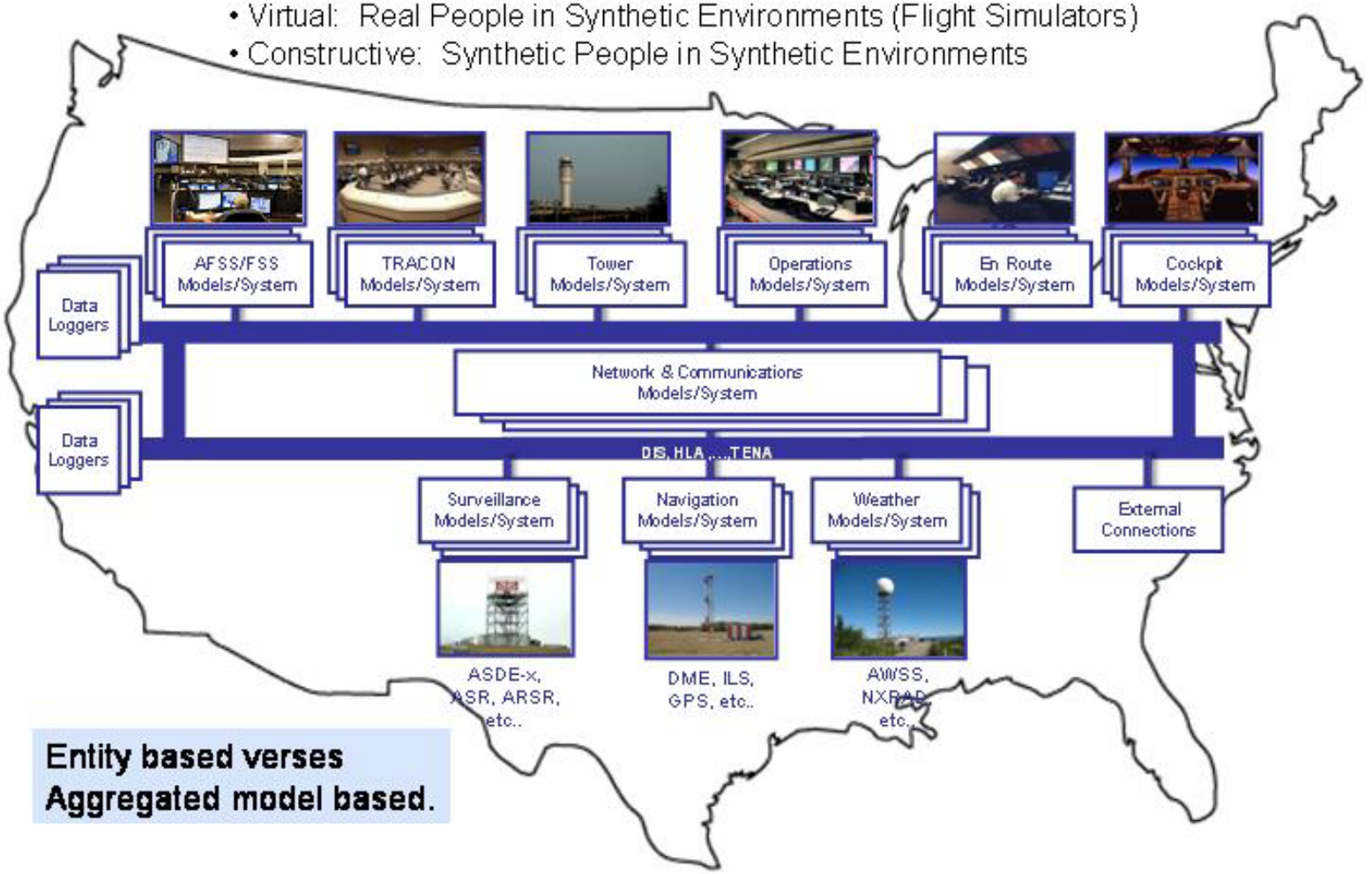
“Simplified” NAS SV-1



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

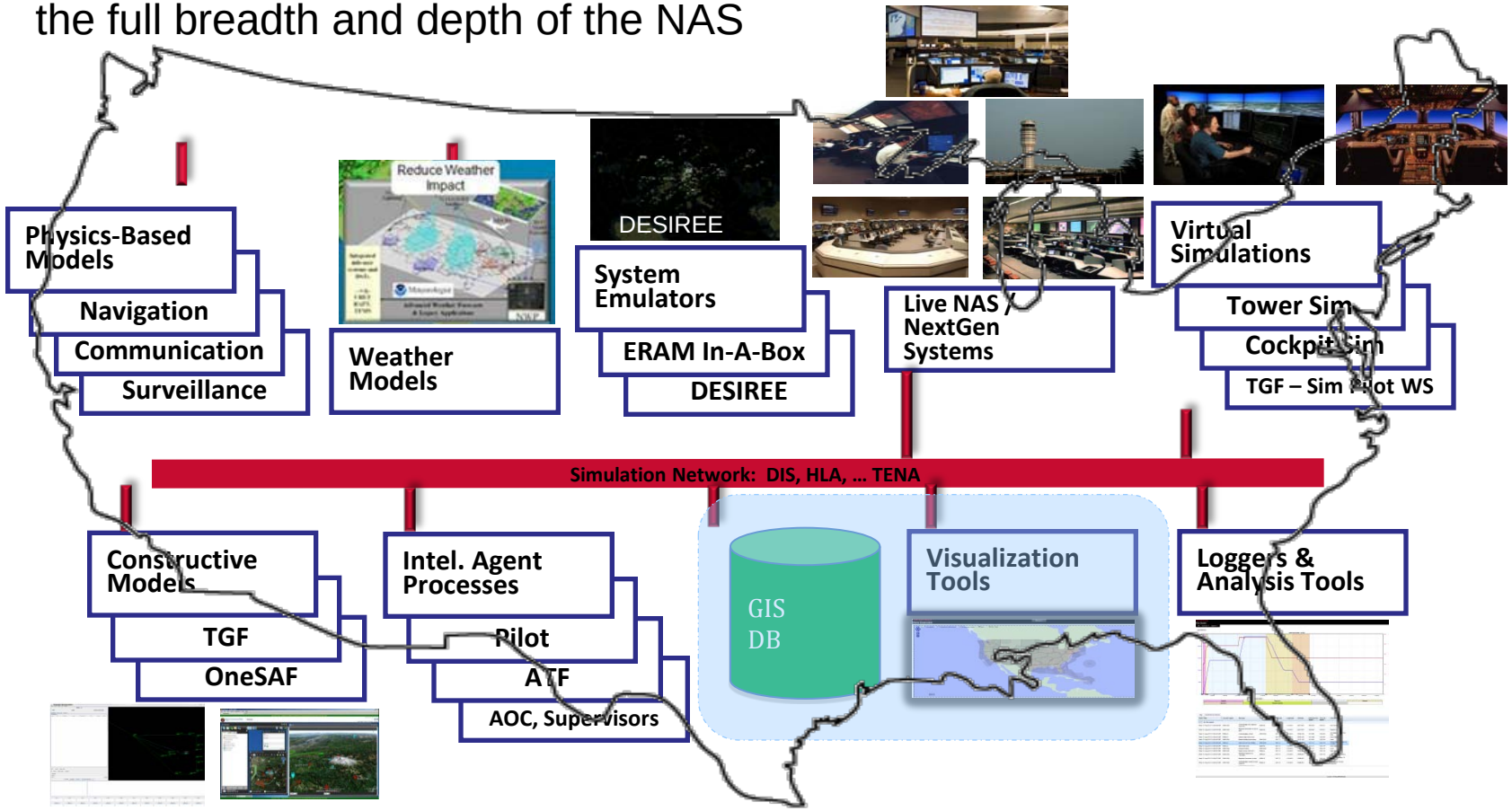


Things to Consider

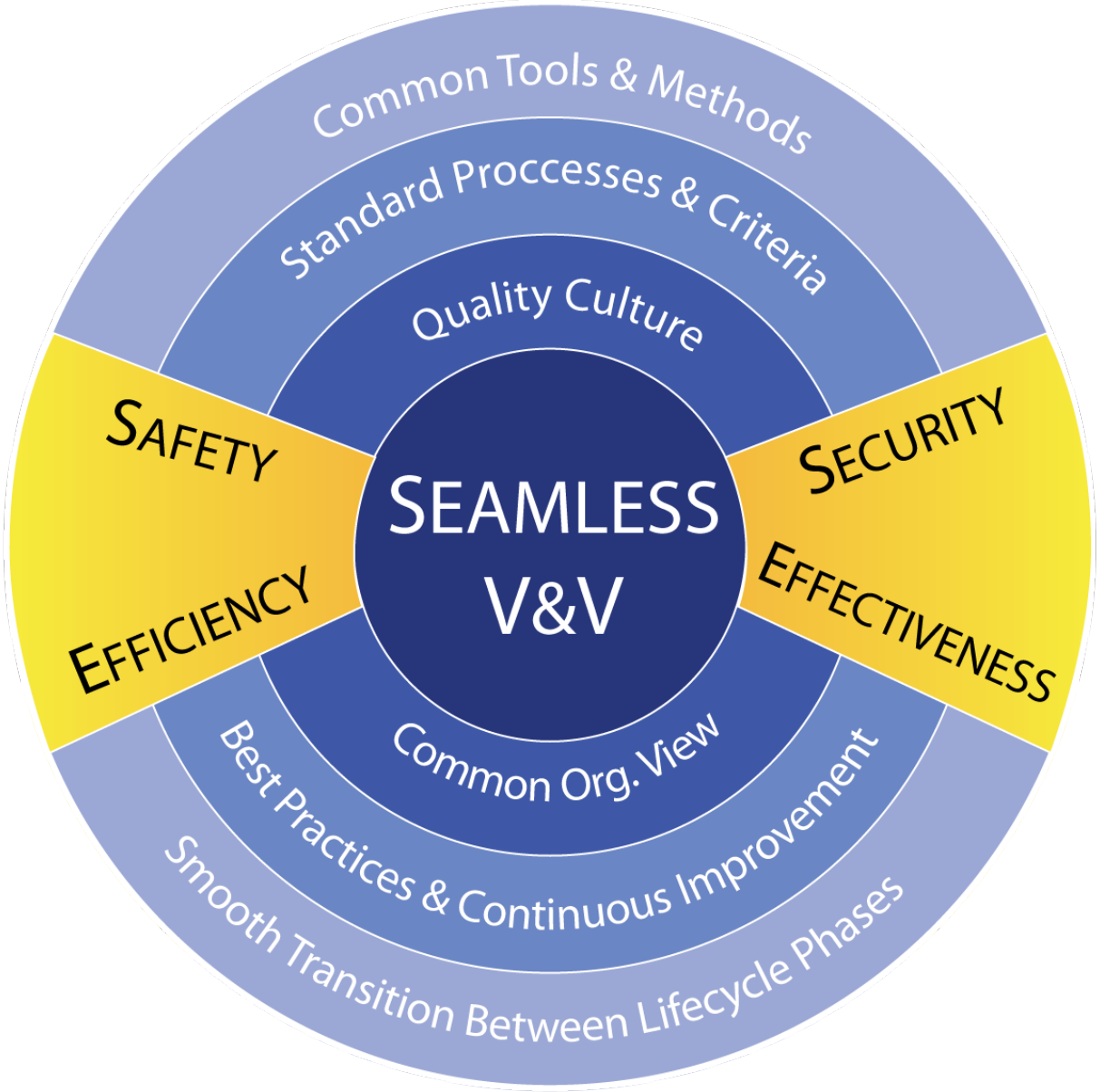
- **Leverage existing FAA investments**
- **Use intelligent agent technology to model air traffic controllers, pilots, and command center decisions**
- **Model communications using simulated voice and data**
- **Basic design:**
  - Open architecture, non-proprietary
  - Low-cost alternatives
  - Real-time 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**


Common Tools & Methods
Standard Proccesses & Criteria
Quality Culture
SAFETY
SECURITY
SEAMLESS
V&V
EFFICIENCY
EFFECTIVENESS
Common Org. View
Best Practices & Continuous Improvement
Smooth Transition Between Lifecycle Phases

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 though 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

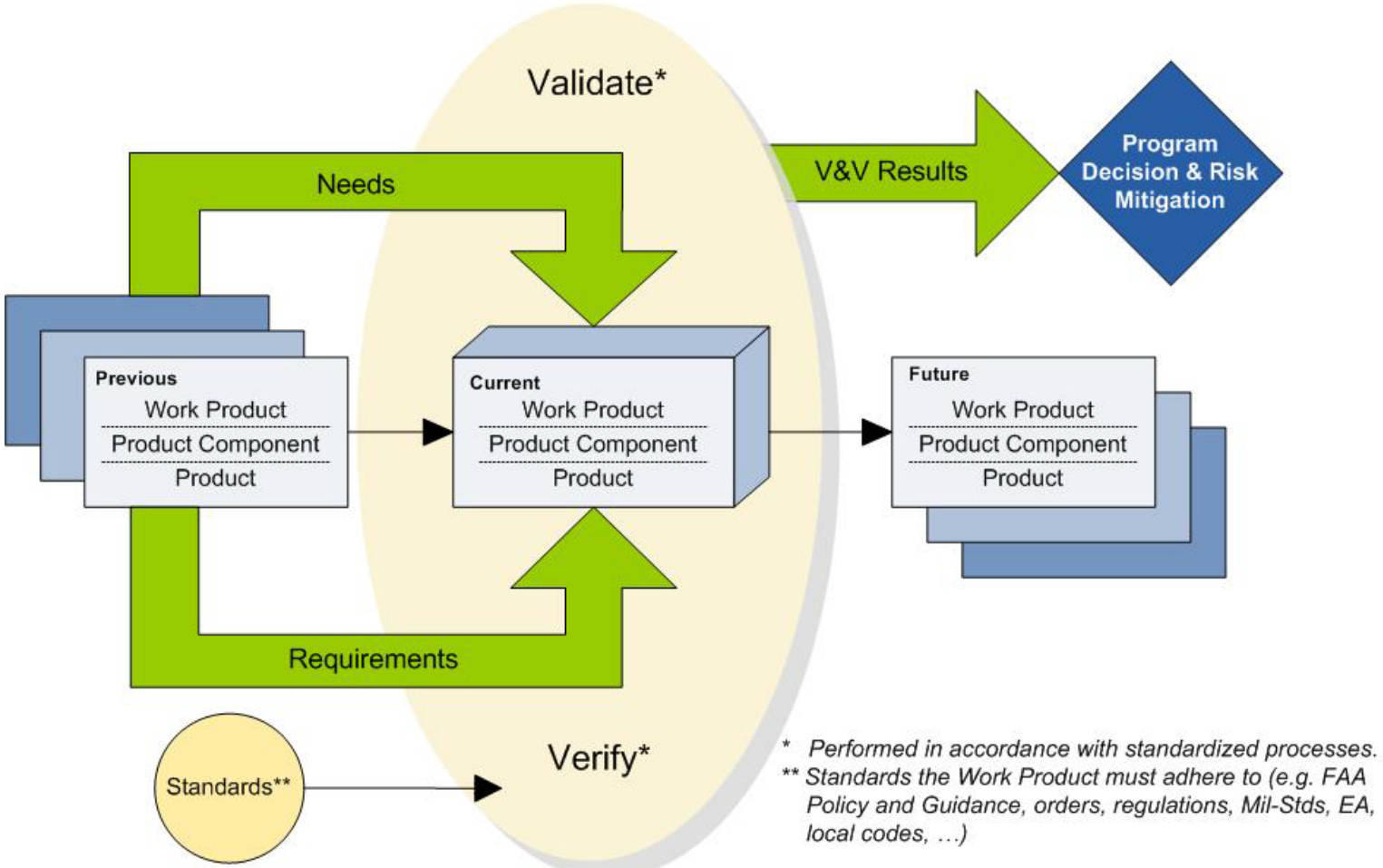
- **Identified the need for:**
  - Quality standards and policies for V&V
  - Formal processes to manage T&E and V&V
  - Independence
  - Organizational structure that ensures continued quality practices
  - Accountable authorities at key decision points
  - Lifecycle focus V&V
  - Advanced V&V methods,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



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.

T&E vs. Schedule

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)

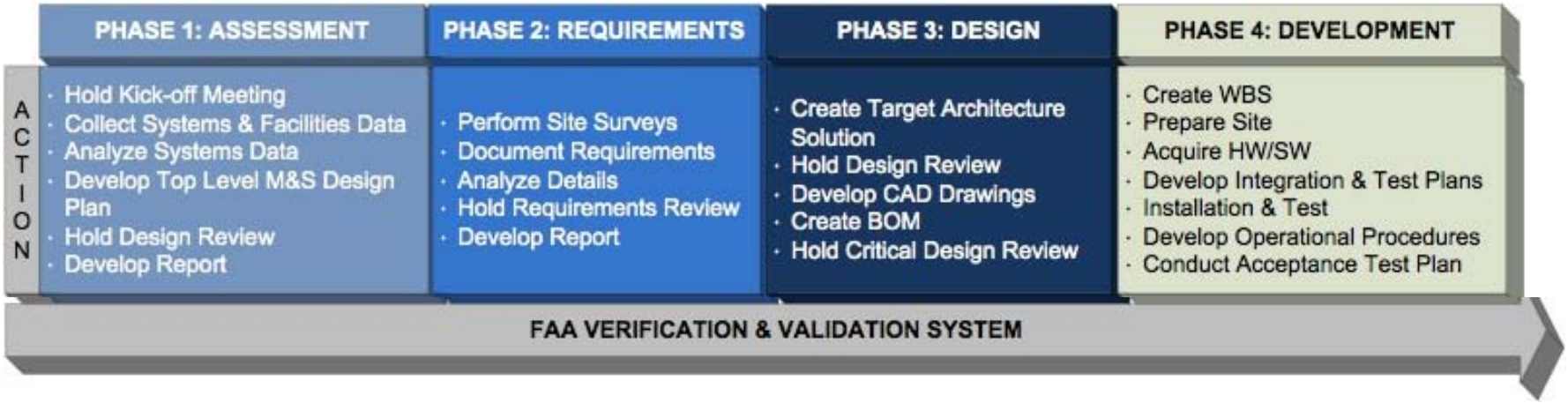
Assistant Administrator:

(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
- White Cell Control
- Prepare Engineering Report Documenting Initial Analysis
- Test Sim, agents, hardware, logging, visualization for:
  - 7K Simultaneous Aircraft; 50K Daily
  - All NAS objects: Waypoints, routes, airports