Testing for Capabilities: The Importance of Mission Accomplishment in T&E

10th Annual V&V Summit

Kevin Knudsen
Boeing Test & Evaluation, Enterprise Systems Test

Increasing Complexity Challenges to V&V

- Systems and systems of systems (S/SOS) are complex, and the complexity increases exponentially.

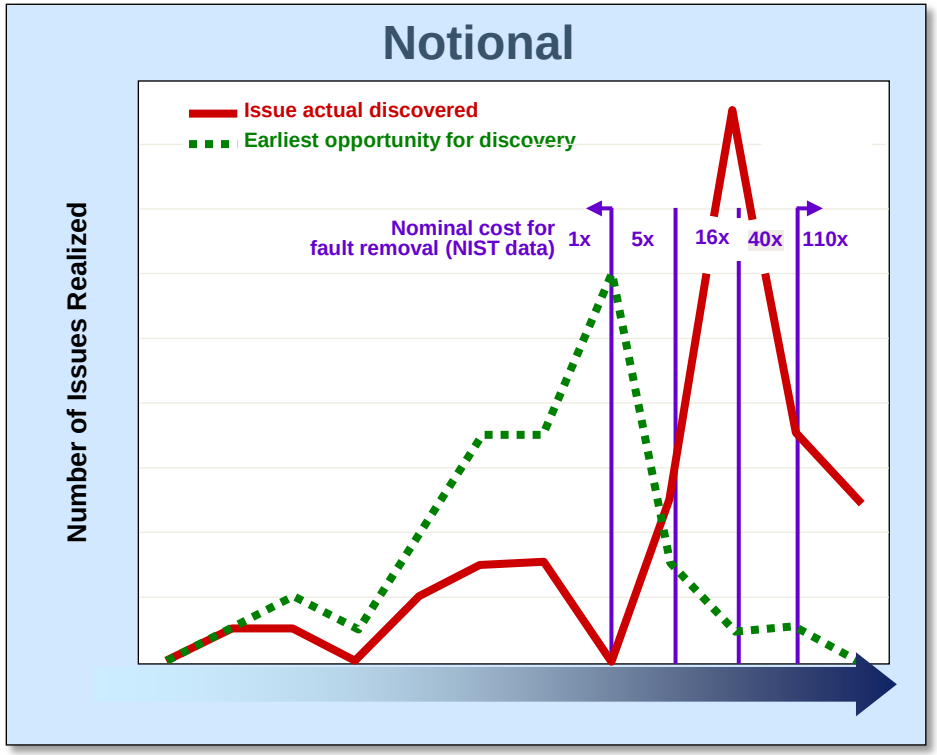
  How do we
  - Ensure that S/SOS are interoperable?
  - Know when an S/SOS meets the end user needs under all actual operational conditions?
- The inherent emergent behaviors (beneficial, neutral, and harmful) arising from systems of systems are difficult to understand, predict, and manage.

  How do we
  - Monitor, manage, and respond to emergent behavior and exploit emergent and unintended effects?
  - Detect and then correct critical anomalies?

Industry must revisit approach to V&V of complex systems/systems of systems.

Opportunity for Improvement on Developmental Programs

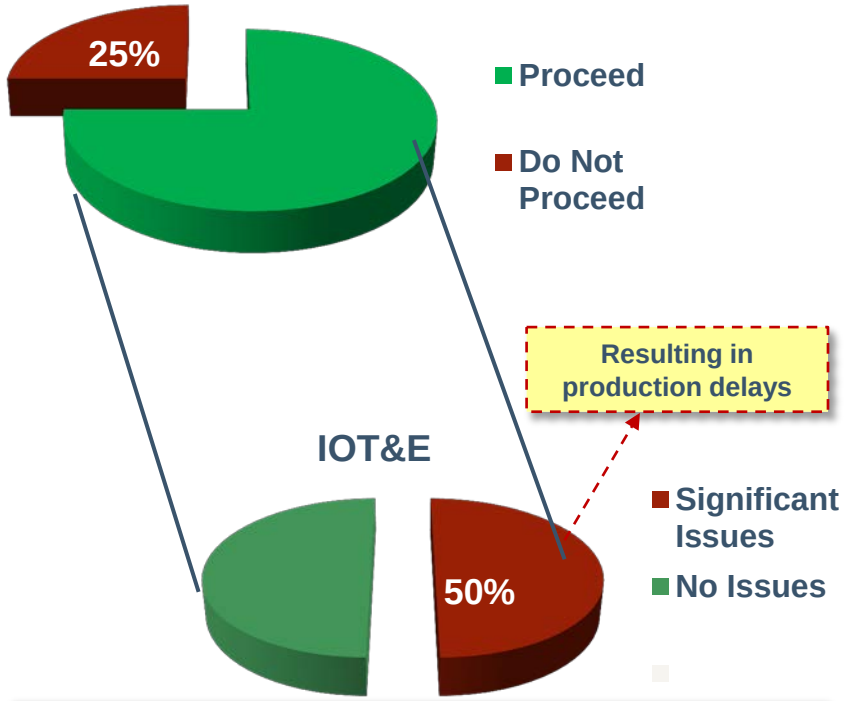
The Cost



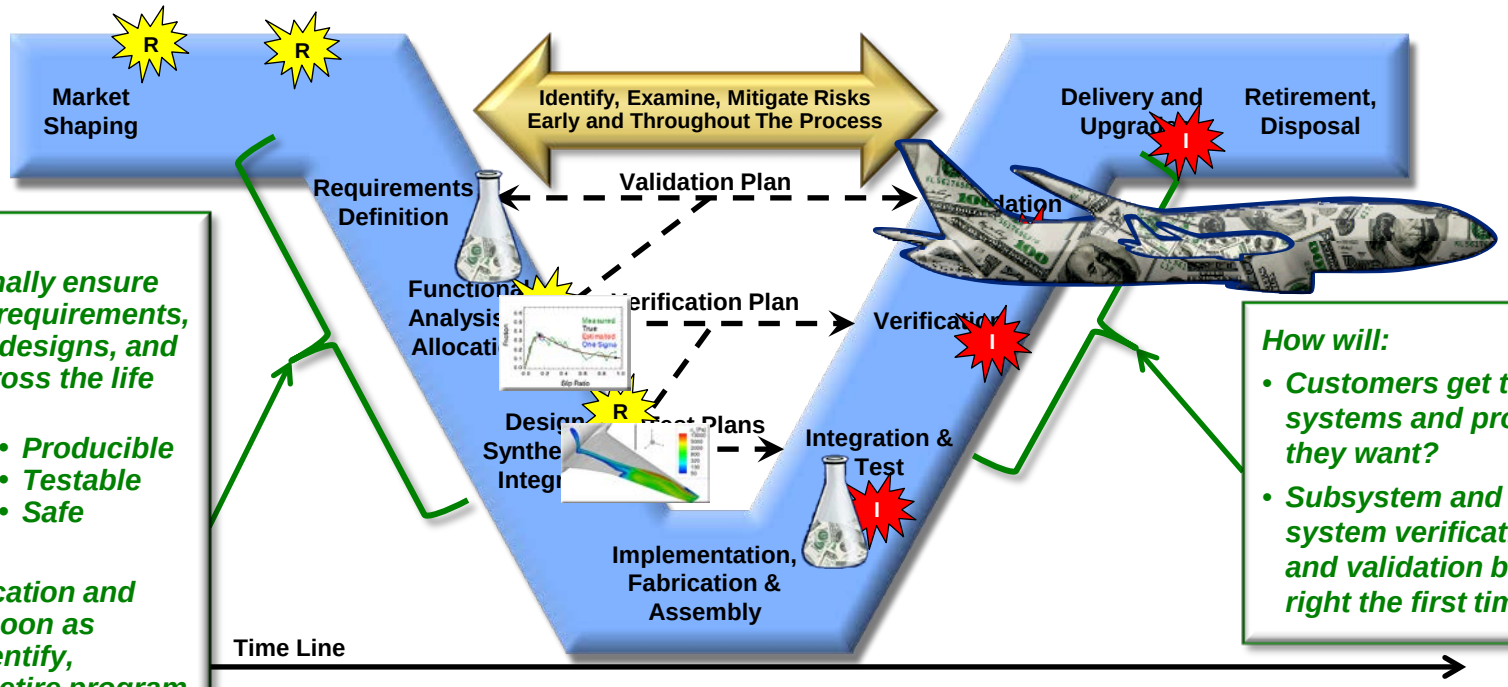
Late discoveries are considerably more costly!

The Impact

DT&E Assessments recommending to proceed to IOT&E (2012 DT&E Annual Report)



Only 41% (5 of 12) programs made it to —and through—a successful IOT&E



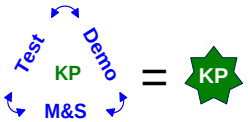
Hypothesis:

- *Cross functionally ensure the concepts, requirements, architectures, designs, and operations across the life cycle are:*
  - *Affordable*
  - *Feasible*
  - *Suitable*
  - *Valid*
  - *Producible*
  - *Testable*
  - *Safe*
- *Perform verification and validation as soon as possible to identify, mitigate, and retire program risks early*
- *Keep the Mission as the North star*

How will:

- *Customers get the systems and products they want?*
- *Subsystem and system verification and validation be done right the first time?*

- **Early T&E engagement in the development phase.**
- **No single organization can afford to own and control all the "right" assets and capabilities.**



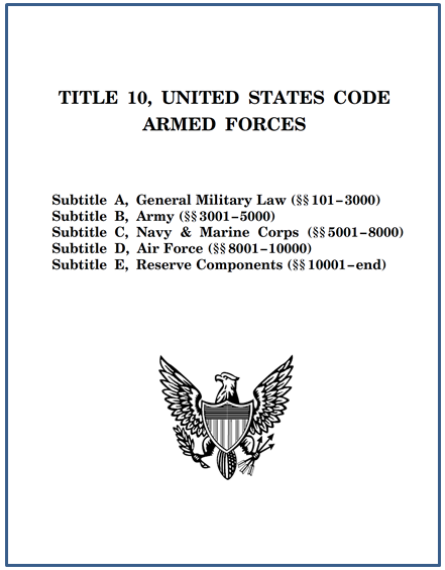
KP = Knowledge Point

I = Issue Impacting Execution

R = Risk

Shift Left To Retire Risk Early While Focusing on the Mission

Chief Developmental Tester Project


TITLE 10, UNITED STATES CODE
ARMED FORCES

Subtitle A, General Military Law (§§ 101–3000)
Subtitle B, Army (§§ 3001–5000)
Subtitle C, Navy & Marine Corps (§§ 5001–8000)
Subtitle D, Air Force (§§ 8001–10000)
Subtitle E, Reserve Components (§§ 10001–end)

Title 10, Section 139b

The Secretary of Defense shall require that each major defense acquisition program be supported by—

"(A) a **chief developmental tester**; and

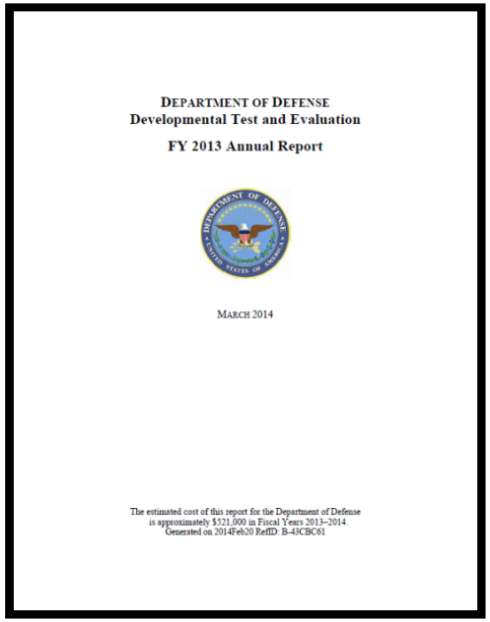
"(B) a governmental test agency, serving as **lead developmental test and evaluation organization** for the program.

Goal: **Propose a model for industry interaction throughout the phases of a development program with an emphasis on "Shift Left".**

CDT Project team

Joe Manas (Lead)	**– Raytheon**	**Brendan Rhatigan**	**– Lockheed Martin**
Sandi Gianotas	**– Boeing (BTE)**	**Steve Scukanec**	**– Northrop Grumman**
Tom Simms	**– DASD(DT&E)**	**Paul Alfieri**	**– DAU**
Joe Wascavage	**– NAVAIR**		

DASD (DT&E) Initiatives



DT&E FY 2013 Annual Report

"Shift Left" (started in 2012)

- Find and Fix Problems **EARLY!**
- Three focus areas:
  - Earlier Mission Context
  - Earlier Interoperability Testing
  - Earlier Cybersecurity Testing
- Currently, the initiative is also focusing on:
  - System performance
  - Reliability

Developmental Evaluation Framework

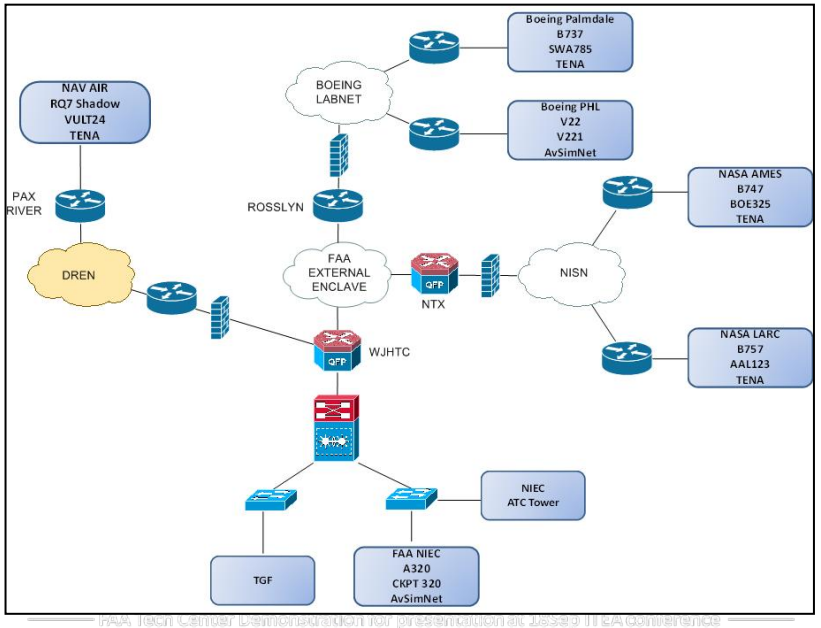
- Provides the roadmap to obtain developmental data.
- Knowledge gained from testing provides information for technical, programmatic, and acquisition decisions.
- Aids programs in determining how to structure a test program.
  - Shows correlation/mapping test events, resources, and decisions.

Early DT&E activities inform technical, programmatic, and acquisition decisions.

FAA ITEA Test Event Overview

23 Aug '12

- Demonstrated a distributed test capability involving multiple agencies and industry.
- Capability was envisioned to verify and validate a complex system of systems, such as NextGen.
- Networking existing simulation facilities was less expensive than replicating dedicated capabilities.
- Six facilities, from four separate government and industry organizations, participated in this event, along with the FAA's simulated air traffic control tower.



FAA Tech Center Demonstration for presentation at 2009 ITEA Conference

Source: FAA Test Team

CONOPS and organizational issues need to be addressed early and continuously.

Global Systems Integration Lab (GSIL)/Distributed Test Highlights

11-Nov-2014 – IAE simulation involving Madrid-Bangalore-Brisbane-Chantilly-Embry Riddle (FTB) – Mosaic ATM-Palmdale. Successfully executed Airbridge Scenario and uploaded flight plans and data updates using FIXM.*

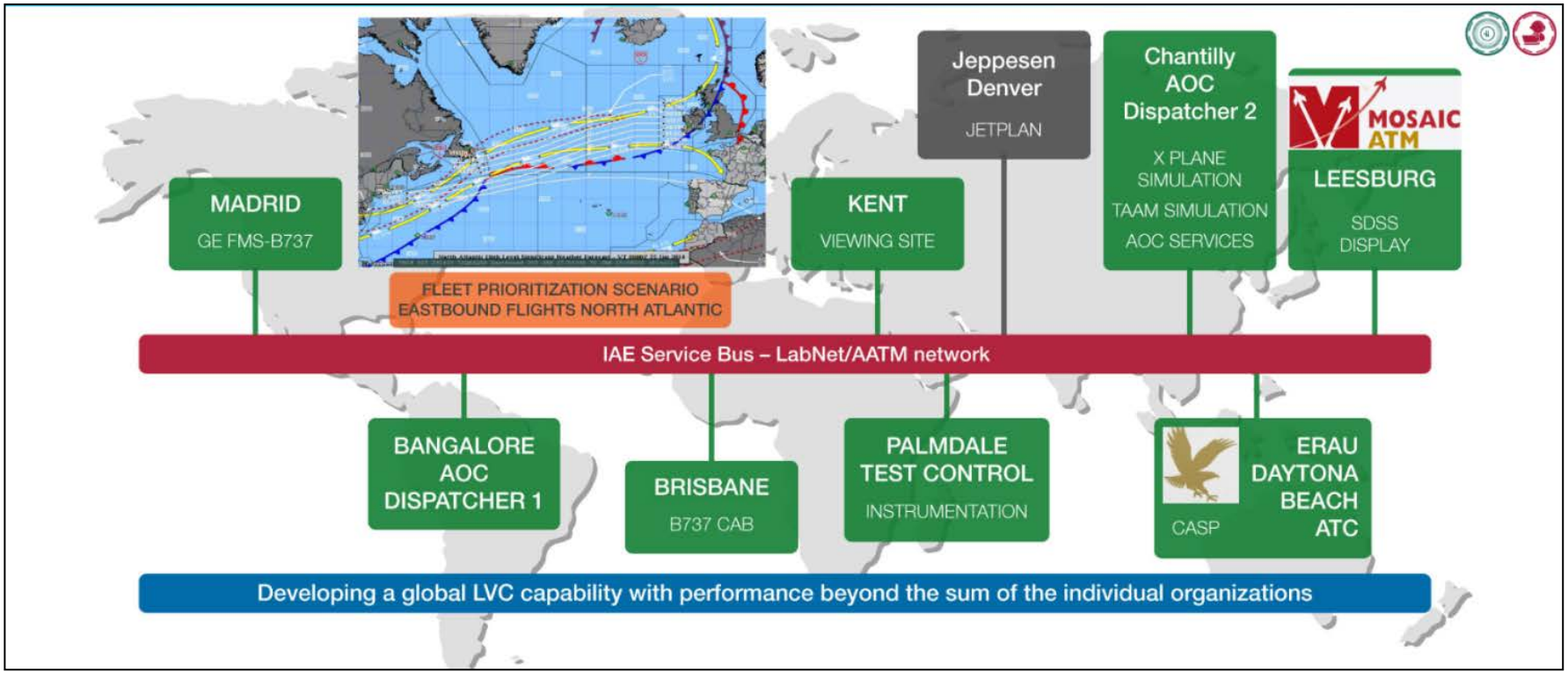
27-Mar-2014 – GSIL Phase 0 simulation involving Palmdale ITR/IASL/ASIC/BR&T-Australia/BR&T-Madrid. Successfully verified connectivity across three continents.*

4-Dec-2013 - 3rd FAA Tech Center/Boeing simulation involving Palmdale ITR/IASL/ASIC. Successfully verified connectivity via Labnet.*

23-Aug-2012 – 1st FAA Tech Center/NASA/DOD/ Boeing simulation event involving Philly-V22 Cab & Palmdale-ITR – video shown at ITEA conference.

It is not just "T&E" in the early phase but the commitment of a T&E person with the "integrator" mindset.

GSIL



Promoting a project that enables Boeing organizations to work together across geographic, technical, and organizational boundaries

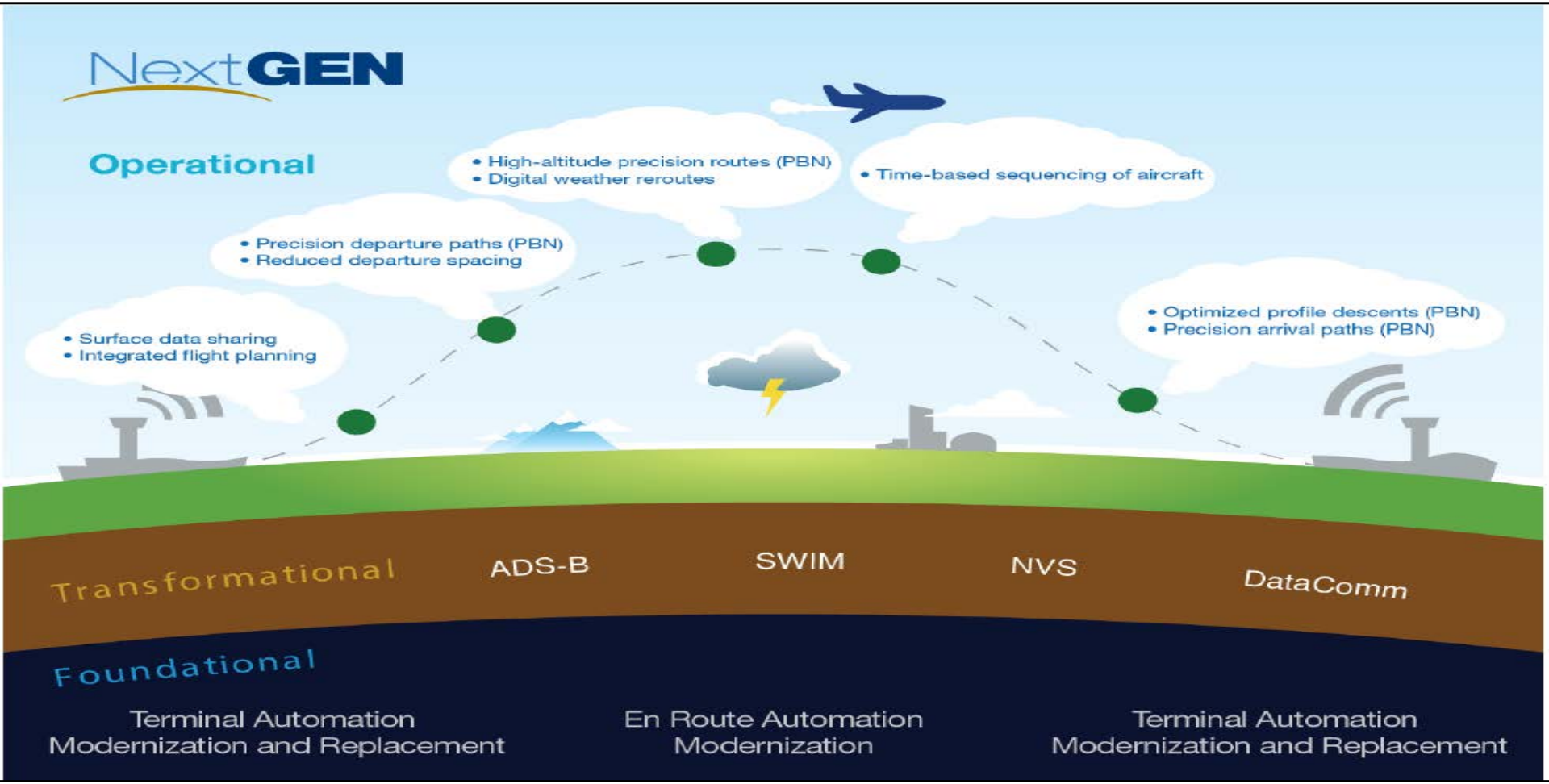
<u>Researchers – "Owned" the technology</u>
- Researchers developed the systems and applications.

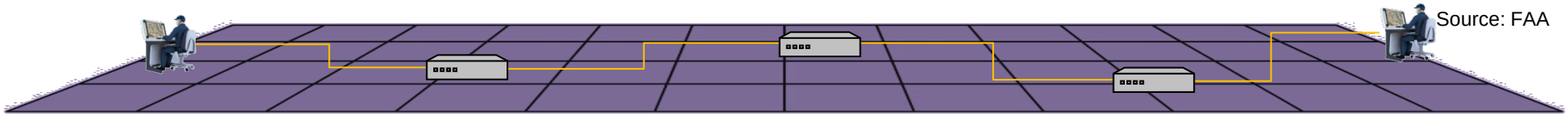
<u>T&E – "Owned" the events</u>
- T&E integrated across organizational boundaries to ensure readiness of participants and test systems.

Acronyms:
AOC – Airline Operations Center
AATM – Advanced Air Traffic Management
CASP – Common Air Surveillance Picture
FMS – Flight Management System
GSIL – Global Systems Integration Lab
SDSS – Surface Decision Support System
TAAM – Total Airspace & Airport Modeler

T&E is team recognized as the independent source for coordination and schedule development.

How Do You V&V a Complex System of Systems?





Source: FAA

Test Infrastructure Layer

Elements include tools, processes, procedures, training, and staff with expertise in distributed test, network integration, and security across all stages of the SOS.

Summary

- **Foster a V&V best practices and corporate V&V philosophy –**
  Boeing has an enterprise T&E organization that cuts across the commercial and defense boundaries to ensure best practices and shared lessons learned.

- **Explore new and practical ways to apply V&V to better support acquisitions and decision making –**
  - *Test Before Design/Test For Learning*
  - *Set-Based Concurrent Engineering*
  - *Early Integration*
  - *Shift Left*
  - *Knowledge Point Capture - KNOT*
  - *Risk Reduction*
  - *Chief Test Architect*

- **Highlight "real world" ways to incorporate V&V into organizational operations –**
  - *IAE: Successfully executed Airbridge Scenario and uploaded flight plans and data objects using FIXM.*
  - *ITEA FAA Project: Six facilities, from four separate government and industry organizations, coordinated to demonstrate that LVC model will work for complex SOS verification.*

Shift Left to Retire Risk Early While Focusing on the Mission