V&V Needs for NextGen of 2025 and Beyond

A JPDO Perspective

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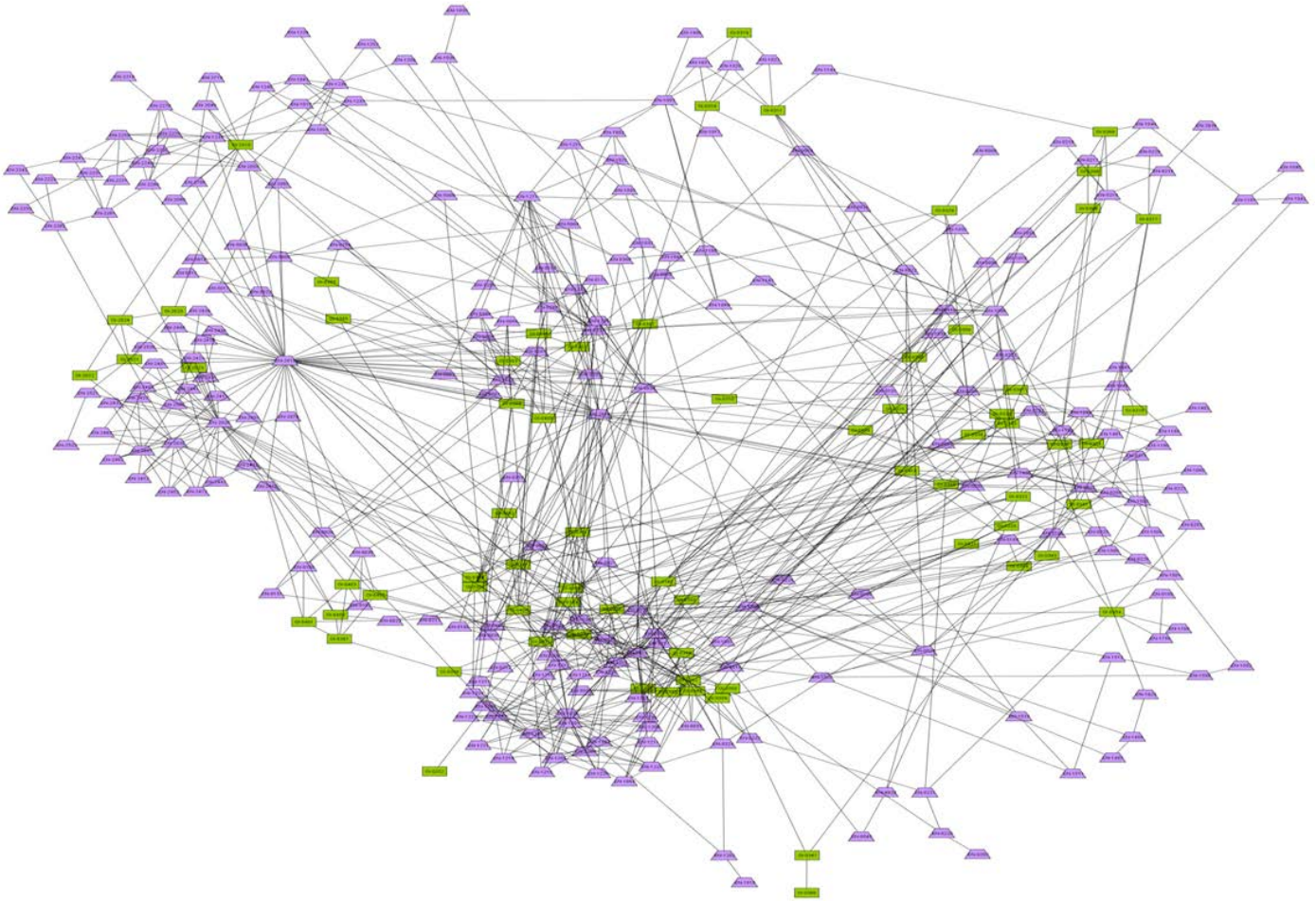
Where We've Been, Where We're Going

From...	To...
Ground-Based Navigation and Surveillance	Satellite-Based Navigation and Surveillance
Voice Radio Control	Digital Data Exchange
Disconnected Information Systems	Net-Centric Information Access
Human-Centric Air Traffic Control	Automation Assisted Air Traffic Management
Fragmented Weather Forecasting	Probabilistic Weather Decision Tools
Visibility Limited Airfield Operations	Equivalent Visual Operations
Forensic Safety System	Prognostic Safety System
Inefficient Security Screening	Integrated Security Risk Management
Current Aircraft Environmental Footprint	Reduced Aircraft Environmental Footprint

NextGen

- NextGen is not a single piece of equipment or a program or a system that will instantaneously transform aviation
- Parts of NextGen are already being turned on
- NextGen is a continuous roll-out of improvements, ultimately leading to Trajectory-Based Operations

Death Star



JPDO's Focus

- Define the optimal NextGen 2025 given current data/conditions and risk analysis
  - Prioritize required research and policy analysis to achieve that definition
- Champion the NextGen vision
  - Frame the debate and facilitate decision making to achieve advanced NextGen Capabilities beyond 2025
- Accelerate Net-Enabled Aviation System Operations to achieve greater data sharing efficiencies

JPDO is an Interagency Organization

Next Generation Air Transportation System
Joint Planning and Development Office

Risk Analysis Strategy: JPDO has seeded the process for reviews with the Partner Agencies

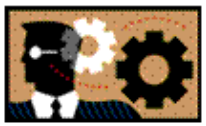
Risks to Successful Realization of NextGen are Identified

Risk Register

JPDO Issue Log

172 Detailed Risks

SMEs Evaluate 'High' Risks from Risk Register



Key NextGen Risks and Issues are Documented

Category	Key Risks and Issues
NextGen priorities	1
Environmental reviews	1
Barriers to airport capacity enhancements	2
Development of higher levels of automation	6
Transition to higher levels of automation	4
Implementation	1
Aircraft equipage implementation policy	1
Total Key Risks and Issues[1]	**16**

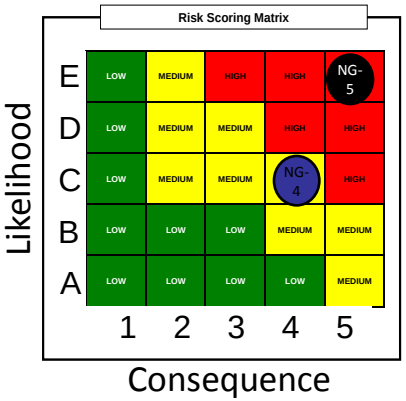
Reviewed and Modified by the Partner Agencies

JPDO Risk Management Board

[1]*Includes only key risks and issues identified by JPDO; Discussions were also held with NASA, leading to the issues identified in the right-hand column on the next slide*

Next Generation Air Transportation System
Joint Planning and Development Office

Verification and Validation (V&V) of Complex Systems



Risk

- Category
  - Development of higher levels of automation
- Risk Statement
  - If the state of practices for V&V are insufficient for the technologies that NextGen expects to deploy, then performance of NextGen capabilities may be less than planned, resulting in limited benefits for NextGen
- Scoring
  - Likelihood: C. Likely (mid-term) – E. Nearly Certain (far-term)
  - Consequence: 4 – 5
- JPDO Next Steps
  - Inquire about the status of research and development activities relating to validation and verification methods for complex systems
- Partner Agency Mitigation
  - To be proposed by the partner agency

What Does This All Mean?

- For NextGen, V&V is critical in the areas of
  - Advanced Data Communications
  - ATS-Specific Data Link
  - Advanced uses of RNP with Authorization Required
  - ADS-B In
  - Trajectory Based Operations
  - And there are probably more…

What's Different?

- NextGen is a system of systems - more complex than current NAS
  - More software
  - More interaction of different system components
  - Cuts across domains, systems, and organizations
    - Safety/security/efficient NAS operation no longer separate
    - Functions are more distributed across components, agents, systems, and locations
    - New air-ground/ ANSP-operator interactions
    - New roles and responsibilities
    - All this means that systems belonging to different organizations will have to interact in a net-centric environment

What's Different? (cont)

- System architecture not inherently as resilient as today's NAS
  - Comm - Nav – Surv no longer "independent"
  - Controller's provide resilience – they are able to deal with most failures
- Transition involves many more steps, which often occur more frequently than changes in the past
- Environment in which 2025 functions will be used is still uncertain
  - Business models/types of aircraft/environmental concerns/ATM system evolution/security needs …
  - Need for a flexible, adaptable system of system

Again, What Does This All Mean?

- Do we really have the right V&V methods available to meet the NextGen challenges

Implication for V&V

- For 2025, we need to consider many new concepts and infrastructure elements and also validate complete System of Systems
  - Methods/tools for early life cycle are limited
  - For the development and implementation phases, Industry has V&V toolkit that works well for individual systems
  - Methods lacking for integrating many components into a complex environment

Implication for V&V (cont)

- NextGen will introduce operational improvements that use many infrastructure systems
  - Human roles and how the infrastructure will be used change
  - Existing procedures like RVSM and RNP need to be evaluated in the new environment

Implication for V&V (cont)

- Validating resilience
  - *"Resilience is the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations even after a major mishap or in the presence of continuous stress."*

    – Erik Hollnagel
  - How do we measure this?
  - How do we validate it?
- Validation must take uncertainty of the future environment into account
  - How do we validate flexibility to adapt to future changes?
  - Are there architectural guidelines for complex system of systems that change over time?

Implication for V&V (cont)

- In some cases failure scenarios are more challenging and the safety bar is higher, which makes V&V more difficult
- Complexity of interactions means traditional safety analysis assumptions of independent events are no longer valid
- Must be able to validate that a function continues to behave correctly as NextGen evolves
- Must be able to deal with emergent behavior of new functions

Building the RIGHT System?

- Validation needs to address human factors issues in addition to traditional safety assessment
  - View of the world is uncertain (and often not coherent)
  - Human in the loop simulations are necessary, but difficult because of this uncertainty
  - Methodology that combines system engineering analysis with HITL simulations is needed
    - Can we simulate a system of systems to make a judgment of whether it will meet the “needs” (i.e. fitness for purpose)?
- Need to keep multiple stakeholders involved
- Experience has shown new functions are rarely used as envisioned

Questions?