Aviation Systems Division: Challenges and Opportunities

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The Aviation Systems Division

Outline

- National Airspace System
- Operational Challenges
- Research and development areas and NASA products
- Simulation Facilities
- Summary

Operational Challenges of the Future NAS

- The air transportation system of the future will be characterized by:
  - higher demand of commercial air traffic
  - a complex mixture of flying vehicles, including unmanned aircraft systems (UAS)
  - increased requirements for safety
  - requirement to reduce environmental impact
- The operators of the system will be increasingly relying on technology advances and all levels of automation assistance to make the overall system run more efficiently without compromising safety.
- What are the right roles and responsibilities of humans and automation in a future air transportation system?

Our Core Abilities

- Air Traffic Management (ATM) research
  - *Airspace domains* - en route, terminal area, airport surface, regional, nation-wide, new concepts
  - *Engineering skills* - airspace operations and procedures, optimization, scheduling, trajectory prediction and analysis, data mining, learning algorithms, human factors and automation, software development, computer and systems engineering
- Flight simulation
  - Operate world-class, high fidelity flight simulators
  - Develop flight simulation scenarios, math models, etc.

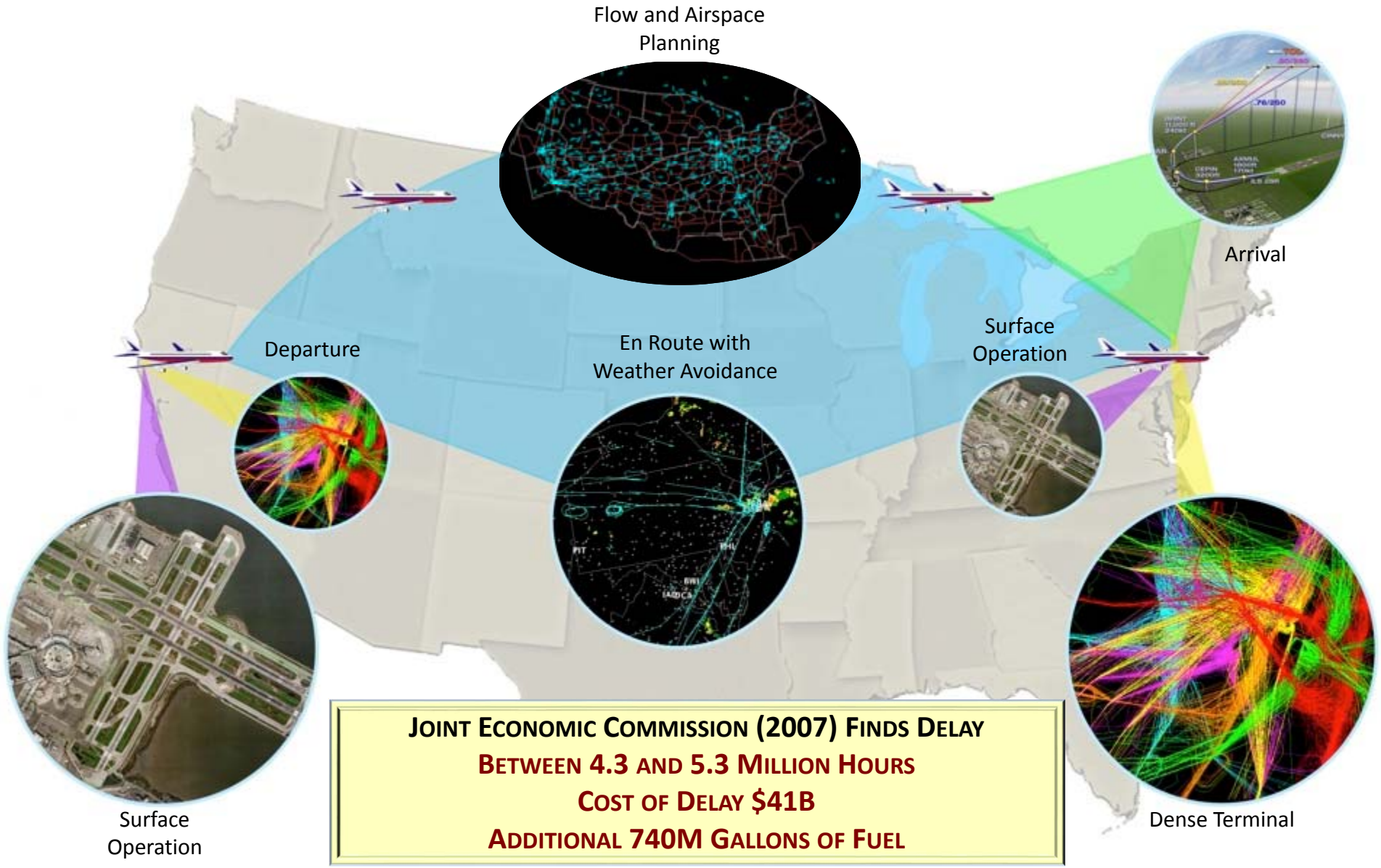
ATM Research General Approach

- Develop and test decision support automation in all airspace domains, from laboratory to operational testing
- Analyze and evaluate the air transportation system through fast-time to real-time modeling and simulation
- Integrate systems, data, and concepts to improve the efficiency and capacity of the air transportation system

Air Transportation System Needs

- Operators
  - On-time performance, predictability, fuel efficiency, growth, and cost
- Service Providers
  - System performance, productivity, capacity, scalability and cost
- National and community needs
  - Competitiveness, safety, and environmental impact
- Passengers
  - On time performance, mobility, and affordability

Gate-to-Gate Concepts and Technology



JOINT ECONOMIC COMMISSION (2007) FINDS DELAY
BETWEEN 4.3 AND 5.3 MILLION HOURS
COST OF DELAY $41B
ADDITIONAL 740M GALLONS OF FUEL

Some Barriers to Today's System

- Human workload
- Limited automation
- Lack of up-to-date information

Major Research and Development Areas

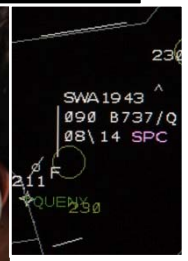
- Integrated Arrival Operations
- Integrated Arrival/Departure/Surface Operations
- Weather Integrated Decision Making
- Unmanned Vehicles and Traffic Management
- SmartNAS
- Large-scale simulation capability: Shadow Mode Assessment for Realistic Technologies for the National Airspace

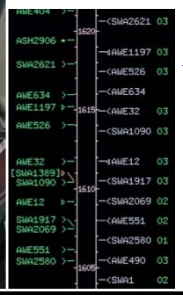
Research and development areas address major NAS operational needs

ATM Technology Demonstration #1 (ATD-1)
Integrated Arrival Solution

FIM Flight Deck Interval Management for Arrival Operations

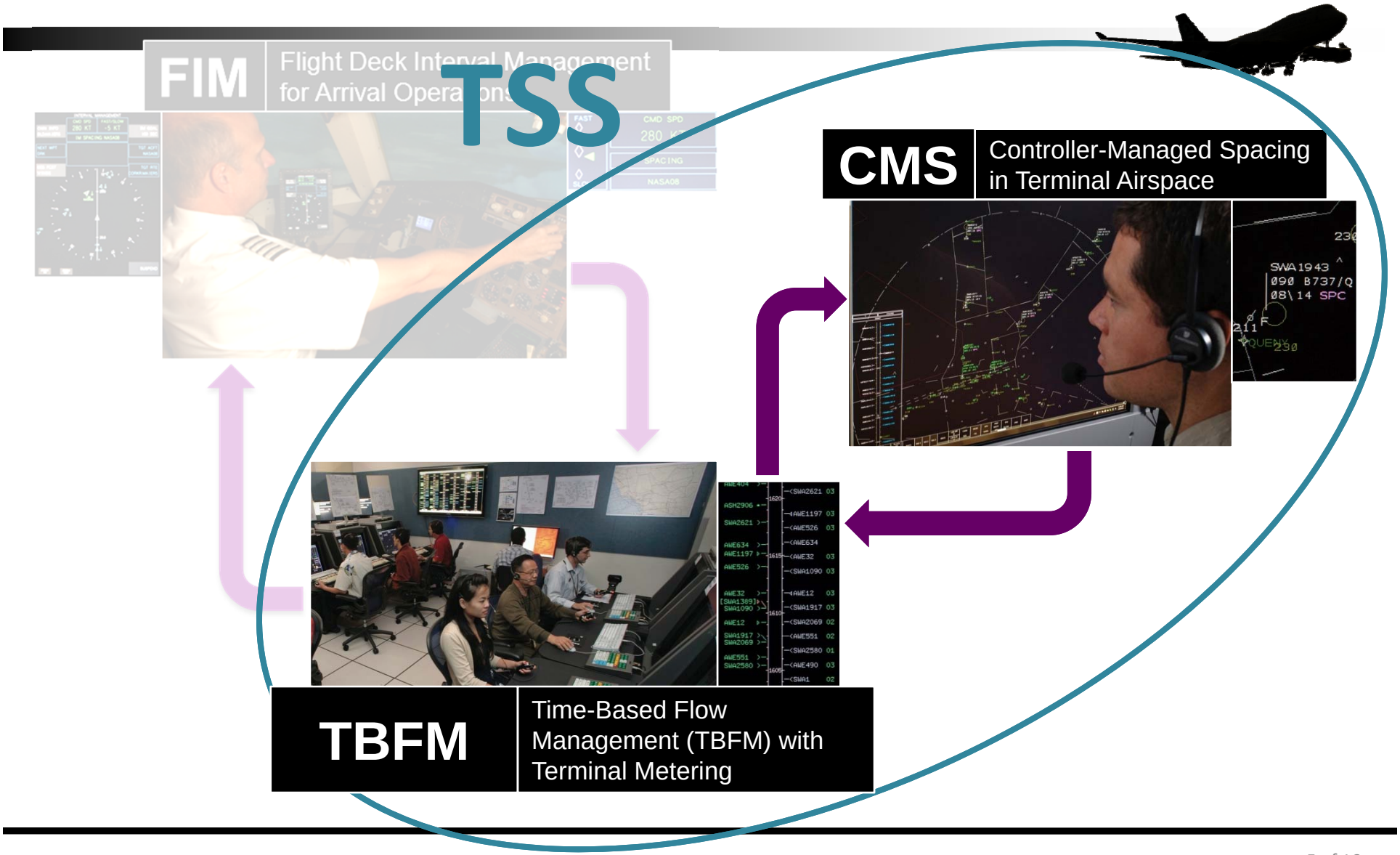
CMS Controller-Managed Spacing in Terminal Airspace



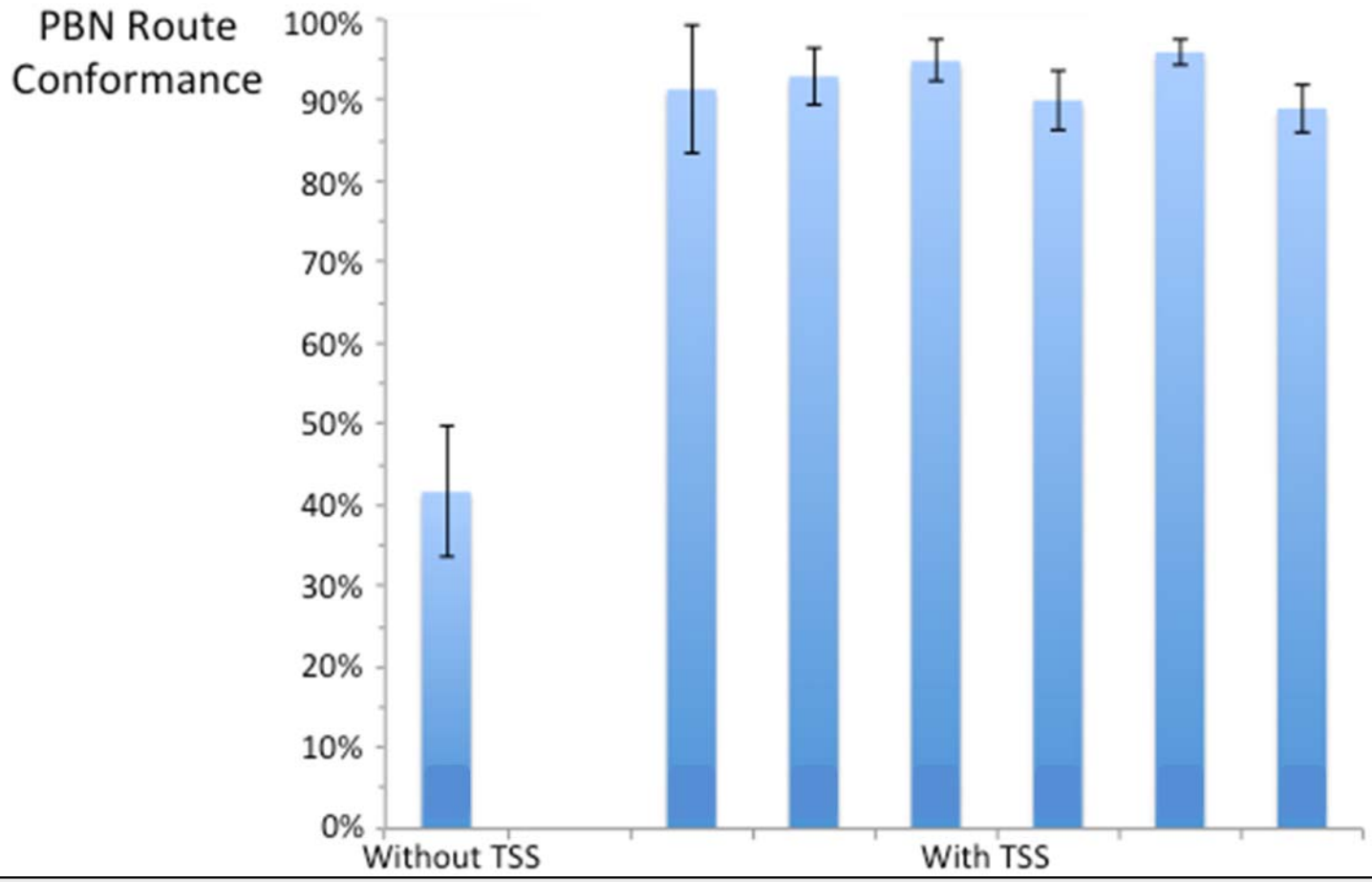


TBFM Time-Based Flow Management (TBFM) with Terminal Metering

Terminal Sequencing and Spacing (TSS)



Results

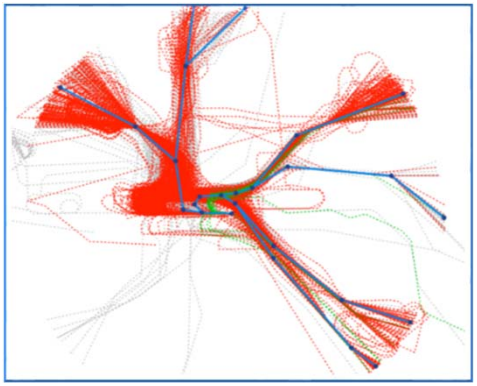


Robinson, J., Thipphavong, J., Johnson, W., "Enabling Performance-Based Navigation Arrivals: Development and Simulation Testing of the Terminal Sequencing and Spacing System," 11th USA/Europe ATM R&D Seminar, Portugal, 23–26 June 2015.

Integrated Arrival/Departure/Surface Operations

Simultaneously increase arrivals, departures, and surface operations efficiency while increasing overall throughput

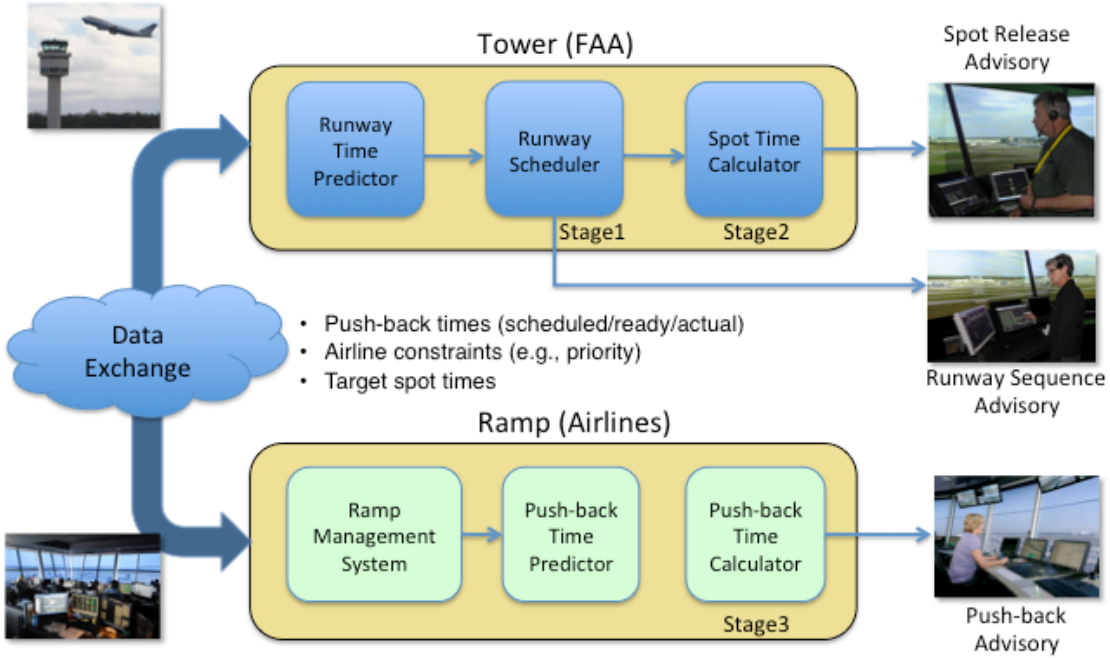
'I saved 10 minutes at the hotel with speedy checkout, 10 minutes at the car rental with instant check in. Now I'm spending 6 hours on the runway."

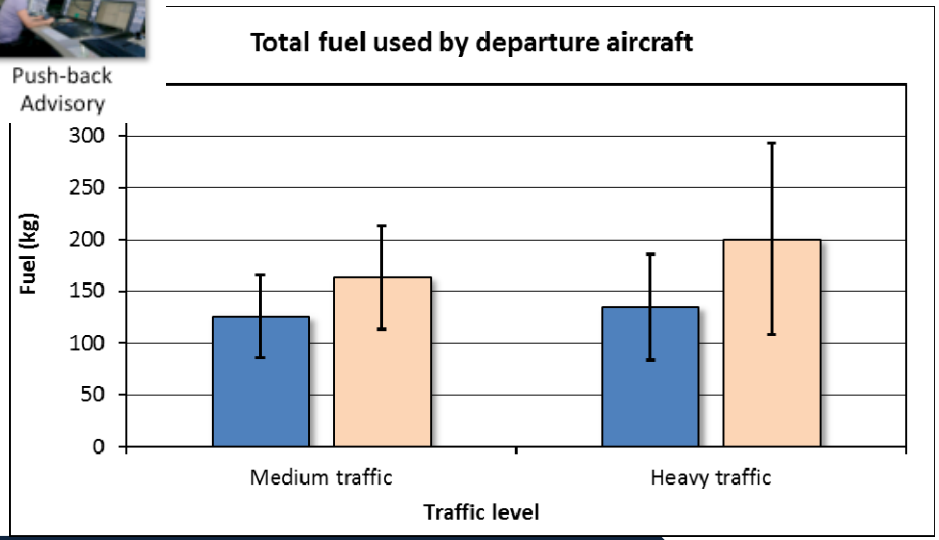


Simultaneously increase throughput and individual aircraft efficiency

Surface Operations: Spot and Runway Departure Advisor

Increase surface operations efficiency



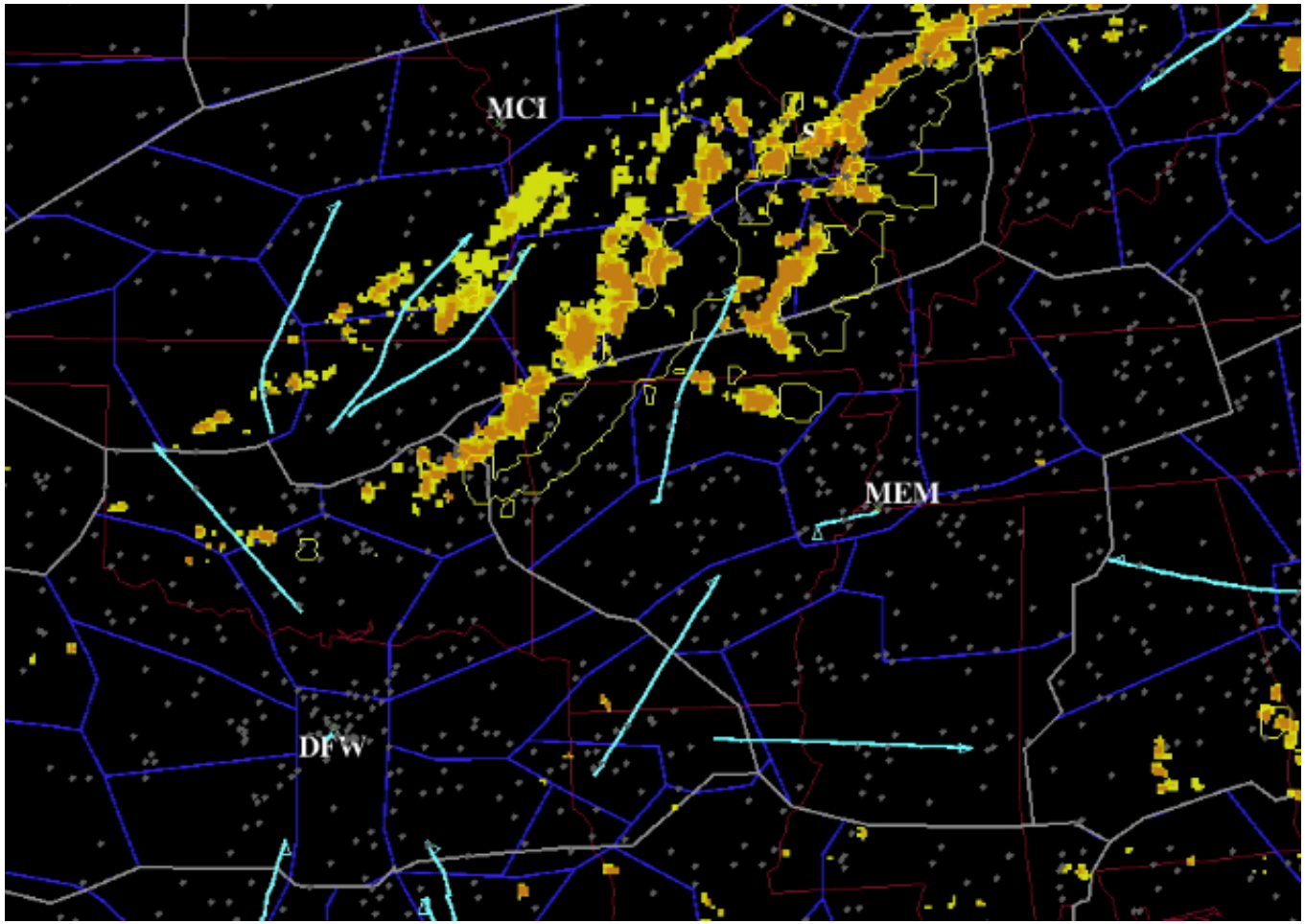


Separate User and FAA Decision Support Tools – offer direct benefit to users

Backup

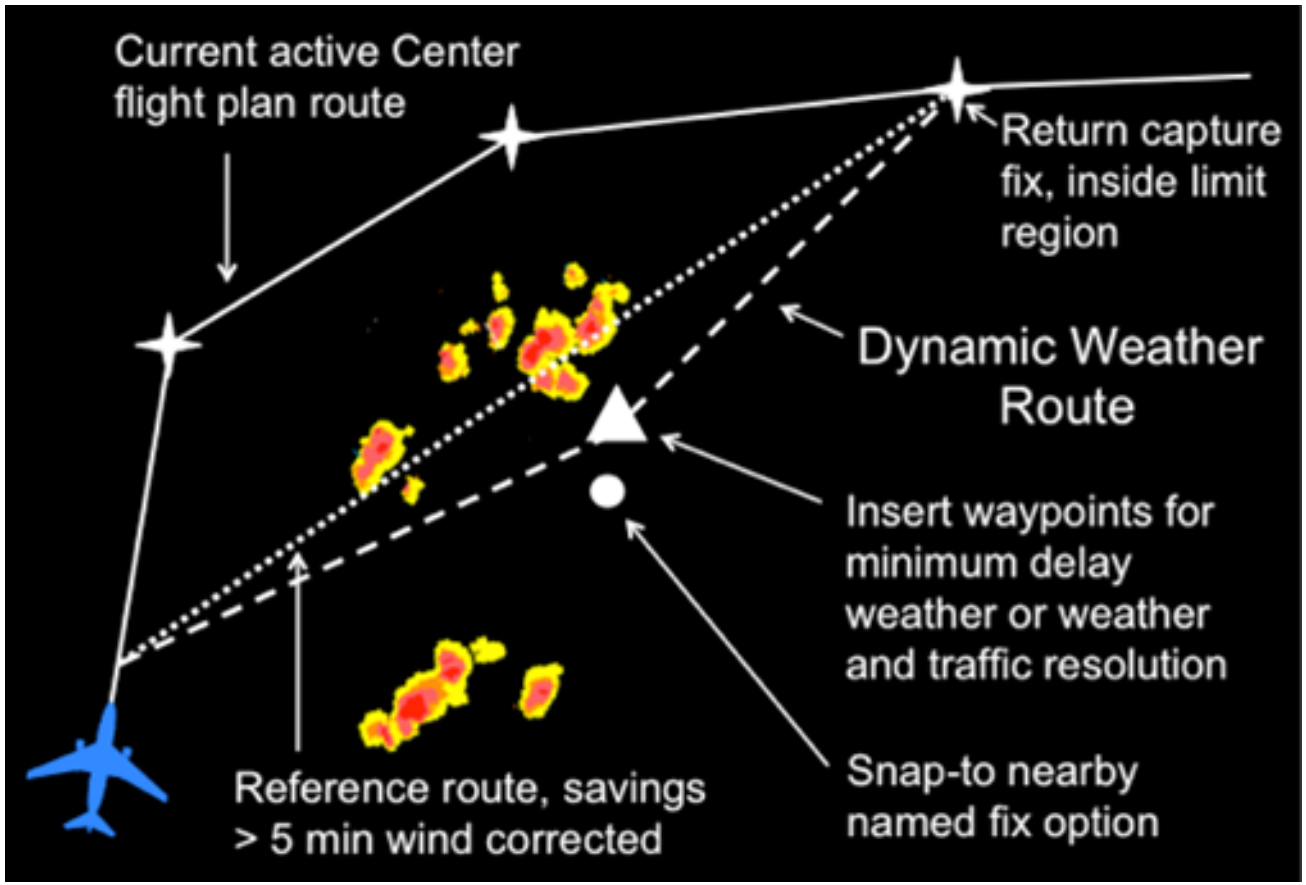
Weather Integrated Decision Making

Reduce weather-induced delays by integrating probabilistic weather information



Dynamic Weather Routes

Develop dispatcher decision support tool that will provide dynamic, efficient routing for airborne aircraft and flows to avoid severe weather at regional level



UAS Integration in the NAS Project

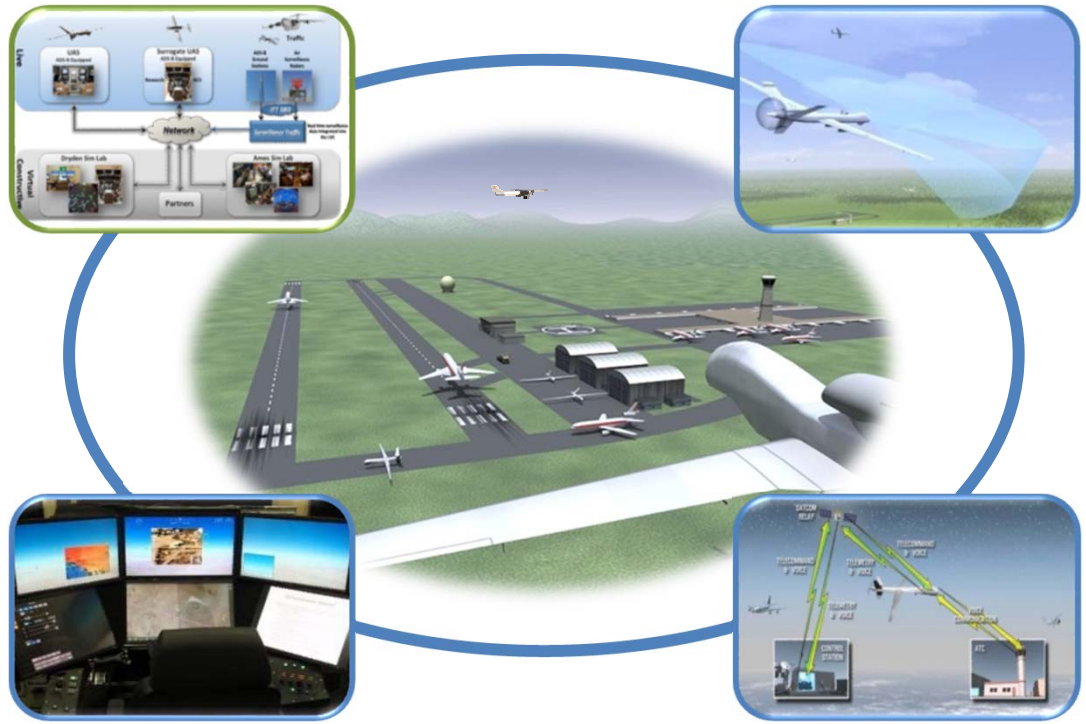
Goal: Provide research findings to reduce technical barriers associated with integrating Unmanned Aircraft Systems into the National Airspace System utilizing integrated system level tests in a relevant environment

Research Theme 1: UAS Integration - Airspace integration procedures and performance standards to enable UAS integration in the air transportation system

Research Theme 2: Test Infrastructure - Test infrastructure to enable development and validation of airspace integration procedures and performance standards

Integrated Test & Evaluation

Separation Assurance Performance Standards



Human Systems Integration

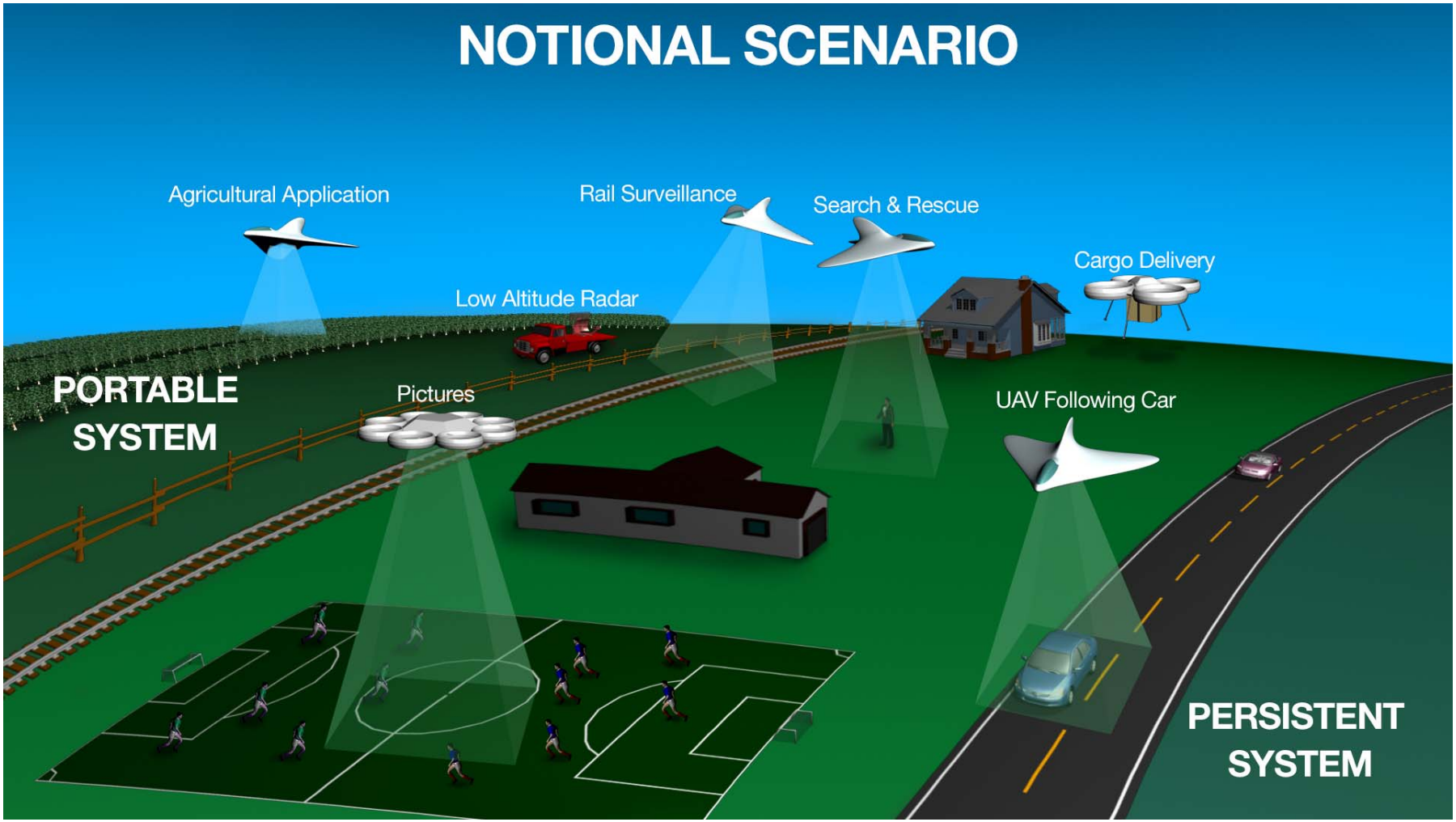
System Performance Standards

Unmanned Aerial Systems Traffic Management (UTM)

- Many civilian applications of Unmanned Aerial System (UAS) are being considered
  - Humanitarian
  - Goods delivery
  - Agricultural services
  - Strategic assets surveillance (e.g., pipelines)
- Many UAS will operate at lower altitude (Class G, 2000 Feet)
  - Other low-altitude uses such as personal vehicles are emerging
- No infrastructure to safely support these operations is available
- Global interest (e.g., Australia, Japan, France, United Kingdom, Europe)
- Lesson from History: Air Traffic Management started after mid-air collision over Grand Canyon in 1956
- Need to have a system for civilian low-altitude airspace and UAS operations

UTM will enable low-altitude airspace operations

UTM Supported Applications



Heterogeneous vehicles and missions

UTM Design Functionality

- UAS operations will be safer if a UTM system is available to support the functions associated with
  - Airspace management and geo-fencing (reduce risk of accidents, impact to other operations, and community concerns)
  - Weather and severe wind integration (avoid severe weather areas based on prediction)
  - Predict and manage congestion (mission safety)
  - Terrain and man-made objects database and avoidance
  - Maintain safe separation (mission safety and assurance of other assets)
  - Allow only authenticated operations (avoid unauthorized airspace use)

- Analogy: Self driving or person driving a car does not eliminate roads, traffic lights, and rules
- Missing: Infrastructure to support operations at lower altitudes

Examining New Concepts, Algorithms, and Technologies: SMART NAS

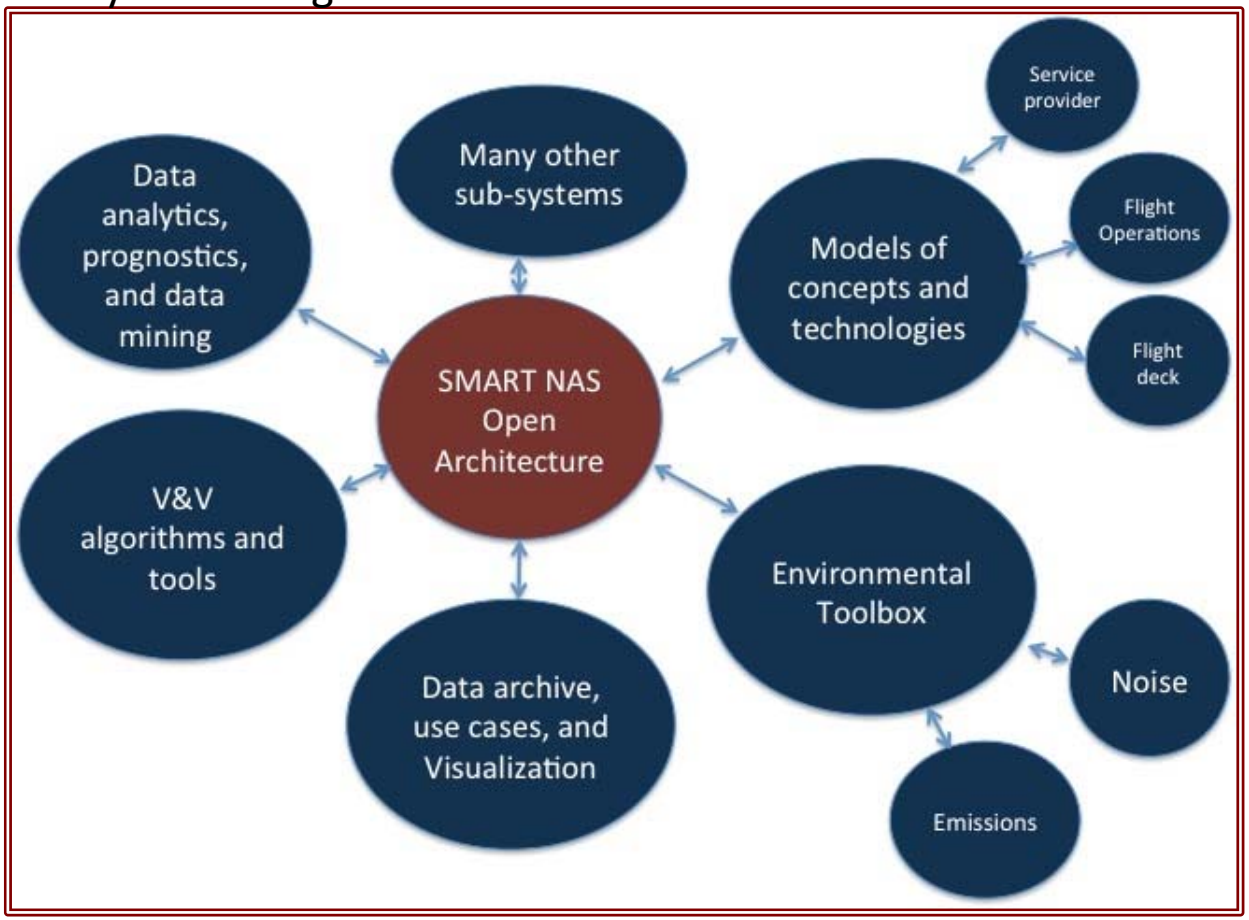
- Shadow Mode Assessment using Realistic Technologies for the National Airspace System (SMART NAS)
- Motivation
  - General agreement that National Airspace System needs to transform faster
  - NAS is a complex system with high safety requirements
  - Such incremental upgrade approach is rather slow and does not consider integrated operations efficiently
- Project goals
  - Explore and Develop Concepts, Technologies and a Test Bed for Safe, Global, Gate-to-Gate Trajectory Based Operations in the 2025-2035 time horizon

SMART NAS (continued)

- Objectives
  - Develop approach to faster validation of concepts, technologies and their integration, and future autonomy architectures
  - Reduce the time to validate concepts, technologies and their interactions
  - Provide plug-and-play capability that is modular and based on open architecture principles to compare alternative approaches
  - Provide live, virtual, and constructive distributed environment
- SMART NAS capability is a community resource to reach a transformed future system

SMART NAS (continued)

- SMART NAS will allow examination of design alternatives, “auto” architectures, variety of roles of human-machine interface
- Open architecture based capability - Opportunity to redesign the airspace operations system using SMART NAS



Examine future concepts, algorithms, architectures by live, virtual and constructive capability

Our Simulation Facilities

Air Traffic Control Simulation Facilities

Future Flight Central (FFC)

Crew Vehicle Systems Research Facility

(CVSRF)

Distribution Simulation Lab

(DSRL)

SIMULATED UNMANNED AIRCRAFT

SIMULATED MANNED AIRCRAFT

DSRL

ATC SIMULATION

LIVE AIRCRAFT

Summary

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- National Airspace System is complex
- Many operational challenges
- NASA conducts research to address many of the of these challenges, using analysis and simulation techniques

Back-up Slides

Metrics

- Scalability to accommodate future demand and vehicles
- Better on-time performance
- Better predictability of operations
- Increased system productivity
- Increased fuel efficiency
- Reduced environmental impact
- Maintain high throughput and capacity under all weather conditions
- Reduce total costs of operations

SMART NAS for Safe Trajectory Based Operations (TBO) Project

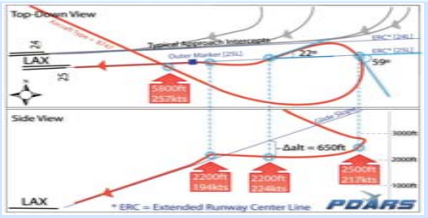
Project Goals:

Explore and Develop Concepts, Technologies and a Test Bed for Safe, Global, Gate-to-Gate Trajectory Based Operations in the 2025-2035 time horizon

Project Research Themes:

Trajectory Based Operations (TBO)

Network-enabled ATM

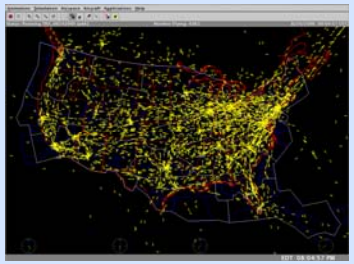


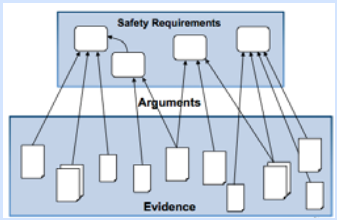
Data Mining and Prognostics

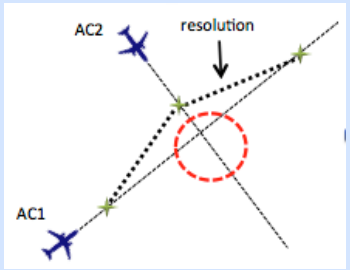
SMART NAS Test-bed

Verification and Validation

Function Allocation of Separation Assurance







NASA Aeronautics Six Strategic Thrusts

Safe, Efficient Growth in Global Operations
- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

Innovation in Commercial Supersonic Aircraft
- Achieve a low-boom standard

Ultra-Efficient Commercial Transports
- Pioneer technologies for big leaps in efficiency and environmental performance

Transition to Low-Carbon Propulsion
- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

Real-Time System-Wide Safety Assurance
- Achieve proactive safety management of the integrated aviation system

Assured Autonomy for Aviation Transformation
- Develop high impact aviation autonomy applications

UTM – One Design Option