Aviation Systems Division: Challenges and Opportunities

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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

Flow and Airspace Planning

En Route with Weather Avoidance

Surface Operation

Dense Terminal

Departure

Arrival

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
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)
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.”
Surface Operations: Spot and Runway Departure Advisor

Increase surface operations efficiency

- Tower (FAA)
  - Runway Time Predictor
  - Runway Scheduler
  - Spot Time Calculator
  - Stage 1
  - Stage 2

- Ramp (Airlines)
  - Ramp Management System
  - Push-back Time Predictor
  - Push-back Time Calculator
  - Stage 3

Data Exchange

- Spot Release Advisory
  - Runway Sequence Advisory

- Push-back Advisory

Total fuel used by departure aircraft

- Medium traffic
- Heavy traffic

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

Successful American Airlines Operational Trials
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.
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

**NOTIONAL SCENARIO**

- Agricultural Application
- Rail Surveillance
- Search & Rescue
- Cargo Delivery
- Low Altitude Radar
- Pictures
- UAV Following Car

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

- 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
Our Simulation Facilities
Future Flight Central (FFC)
Crew Vehicle Systems Research Facility (CVSRF)
Distribution Simulation Lab

(DSRL)
Summary

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- National Airspace System is complex
- Many operational challenges
- NASA conducts research to address many 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)
- SMART NAS Test-bed
- Network-enabled ATM
- Verification and Validation
- Data Mining and Prognostics
- 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
Real-time Wx and wind

Wx and wind Prediction

Airspace Constraints

Other low-altitude operations

3-D Maps:
Terrain, human-made structures

Constraints based on community needs about noise, sensitive areas, privacy issues, etc.

Transition between UTM and ATM airspace

Low altitude CNS options such as:
• Low altitude radar
• Surveillance coverage (satellite/ADS-B, cell)
• Navigation
• Communication

Autonomicity:
• Self Configuration
• Self Optimization
• Self Protection
• Self Healing
• Operational data recording

• Authentication
• Airspace design and geo fence definition
• Weather integration
• Constraint management
• Sequencing and spacing
• Trajectory changes
• Separation management
• Transit points/coordination with NAS
• Geofencing design and adjustments
• Contingency management

Range of UAVs from disposable to autonomous

UTM – One Design Option

Multiple customers
With diverse mission needs/profiles

UAS 1

UAS 2

UAS 3

UAS n