Air Traffic Management Research at NASA Ames

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NASA Aeronautics Programs

**Fundamental Aeronautics Program**

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to enable revolutionary changes for vehicles that fly in all speed regimes.

**Integrated Systems Research Program**

Conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment.

**Aviation Safety Program**

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to improve the intrinsic safety attributes of current and future aircraft.

**Airspace Systems Program**

Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS.

**Aeronautics Test Program**

Preserve and promote the testing capabilities of one of the United States’ largest, most versatile and comprehensive set of flight and ground-based research facilities.
Airspace Systems Research @ Ames

Air Traffic Management

Boeing 747 Simulator

Vertical Motion Simulator

Future Flight Central
What do we do?

• Our research business is air-traffic-management and flight simulation
  – We have already made your flying experience better
  – We are trying to safely and effectively automate tomorrow’s air traffic control system (“NextGen”)
  – Our flight simulation capabilities and experience are unrivaled
Research Challenges for NextGen

Why is it difficult?

• System must accommodate aircraft with:
  – Widely varying performance capabilities
  – Different flight phase (descending, climbing, cruising) in the same airspace
  – Many levels of equipage

• Operators have widely varying/competitive mission objectives
  – Hub and spoke operations and point-to-point operations are different

• Transition from current state to desired end state

• Assuring a collision risk of less than 1 in ~100 million flight hours

• Impracticality of validating ~10 million lines of software code to assure safety of automated system
  – Design of fail-safe architecture

• Testing and validation to discover the “unknown unknowns”
What are the research focus areas?

• **Concepts and Technology Development**
  – Traffic Flow Management
  – Dynamic Airspace Configuration
  – Safe & Efficient (Airport) Surface Operations
  – Super Density Operations
  – Separation Assurance

• **Systems Analysis, Integration and Evaluation**
  – System Portfolio Analysis
  – Interoperability Research
  – Integration, Evaluation & Transition
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Traffic Flow Management

Investigate modeling, simulation and optimization techniques to manage air traffic flows subject to airspace and airport capacity constraints while accommodating user preferences with increased traffic demand in the presence of uncertainty.
Spot and Runway Departure Advisor (SARDA)

**Problem** - Surface traffic suffers from excessive taxi delay and fuel spending due to lack of planning and coordination among stakeholders.

**Technical Progress in FY12**
- Enhanced scheduler for optimal runway sequence, spot release, and gate push back
- Flight info and Tower controller advisories displayed on the Electronic Flight Strips (EFS)
- Added realism by using the air traffic control tower simulator

**Impact**
- The human-in-the-loop simulation showed promising results:
  - Up to 60% reduction in taxi delay
  - Up to 34% reduction in fuel consumption
  - No increase in controller workload
- Demonstrated a potential as a near-term decision support tool for ATC and airlines

**Next Steps**
- Build a partnership with airline industry and the FAA
- Develop and test the SARDA tool for field evaluation
Current Day Conflict Alert
Dead Reckoning

false alert, a.k.a. nuisance alert
Terminal Tactical Separation Assured Flight Environment

Use flight intent information to avoid false alerts
Current Day Conflict Alert
Dead Reckoning

Missed alert, not safe!
Terminal Tactical Separation Assured Flight Environment

Use flight intent information to avoid missed alerts
Efficient Descent Advisor (EDA)

Computes trajectory-based advisories for ARTCC controllers that:

- Enable continuous descents at near-idle thrust
- Conform to Traffic Management Advisor (TMA) arrival schedules for maximum throughput
- Avoid traffic and airspace conflicts along the arrival path
- Allow clearance delivery by voice or data link
- Leverage existing flight deck automation for precision guidance and control
Potential Benefits: Noise Reduction from Tailored Arrivals SFO
Dynamic Weather Routes

- Flight Plan Route
- Direct-To Fix
- Dynamic Weather Route
- auxiliary waypoint
- nearby named waypoint
AAL1821 MIA/LAS
6.8 min savings
Potential Flying Time Savings

Dynamic Weather Routes - PBD Waypoints - Resolve Weather - ZFW 2010/05/14 1400 - 1630 UTC

Total Flights: 43
Total Savings: 352 min
Avg Savings: 8 min/flight
Advanced Airspace Concept

- **TCAS** (Avoid collisions) [e.g., TSAFE]
- **Tactical System** (Maintain legal sep’n) [e.g., Autoresolver]
- **Strategic System** (Maintain legal separation) [e.g., Autoresolver]

Time to Loss of Separation, minutes:

- TCAS: 0 minutes
- Tactical System: 4 minutes
- Strategic System: 10 minutes

Graph showing the time to loss of separation for different systems.
System-wide Performance & Analysis: ACES Models

**National Traffic Management**
- Fast-time nationwide gate-to-gate simulation of NAS operations
  - Full flight schedule with flight plans, winds, gate-to-gate operations

**Regional Traffic Management**
- Thousands of agents:
  - National: 1
  - Regional: 20
  - Local: 100s
  - Airports: 100s
  - Aircraft: 10,000s
  - Airlines: 10s

**Local Approach and Departure Traffic Management**

**Airport and Surface Traffic Management**

**High Fidelity 4-DOF Trajectory Model**
- Based on laws of physics
- Realistic pilot-based control laws
- Includes elliptic-Earth trajectory propagation
- Contains modeling for aircraft/pilot variability
Taking the research to the real world...
ATM Technology Demonstration 1:
Maintaining efficient operations during higher densities

- Flight Deck Interval Management (FIM) for Arrival Operations
- Controller Managed Spacing (CMS) in Terminal Airspace
- Integrated Arrival Solution
- Traffic Management Advisor with Terminal Metering (TMA-TM)
Operational Context

NOTE: Nominal spacing precision is indicated in parentheses.

Increasing level of automation, accuracy, maturity...

Terminal TBO
Reduced excess separation
CDAs during high demand

Terminal vectoring
Excess separation
CDAs during low demand

En Route
Metering (~60 sec)

Ground-based Spacing Aids
(~15 sec)

Flight Deck-based Spacing Aids
(~5 sec)

Terminal Metering
(~30 sec)

Independent Scheduling

Integrated Scheduling and Spacing
ATD-1 Objectives

• **Demonstrate increased, more consistent use of Performance-Based Navigation**
  – Precision arrival procedures from cruise to touchdown
  – Optimized Profile Descents using speed control
  – Simultaneous high throughput and fuel-efficient terminal operations

• **Demonstrate ADS-B In for arrival flow management**
  – ADS-B In receives surveillance information for nearby aircraft

• **Accelerate transfer of NASA scheduling and spacing technologies for inclusion in NextGen**
  – Scheduling based upon Ames’ Traffic Management Advisor (TMA)
  – Airborne spacing application based upon Langley’s ASTAR
  – Controller tools based upon Ames’ Controller Managed Spacing (CMS)
Terminal Metering

• Precision route structure to runways
  – Mostly RNAV OPD arrivals
  – Primarily speed control past top-of-descent

• TMA scheduler
  – Models terminal merges that affect traffic flow
  – Compatible with Interval Management and RTA operations

• Controller decision support
  – Timelines to meter points
  – TMA information displayed to en route and terminal controllers
Controller-Managed Spacing

Three Successively More Advanced Toolsets

"Schedule"

Early/Late Indicator

"Slot Marker"

Early/Late Indicator + Slot Marker

"Speed Advisory"

Slot Marker + Speed Advisory
Flight Deck Interval Management

- Computes lead and ownship times of arrival at runway
- Calculates speed guidance to achieve desired spacing over remainder of route
- Commands speed, if necessary, to prevent spacing errors

- Assigned spacing interval: 90 sec
- 15 seconds early
  → Slow down 5 knots

Lead ETA = 14:22:15
Ownship ETA = 14:23:30
Summary

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  – Our flight and air traffic simulation capabilities and experience are unrivaled
Backup Slides
We have already made your flying experience better: Nationwide Deployment
Solve aircraft-to-aircraft conflicts, arrival metering and weather avoidance in integrated fashion
Major AAC Research

• Handle trajectory prediction errors in robust and efficient fashion
• Assure seamless integration of strategic and tactical systems
• Prove feasibility of future arrival management concepts