Abstract
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Air Traffic Management Research at NASA Ames Research Center

Since the late 1980’s, NASA Ames researchers have been investigating ways to improve the air transportation system through the development of decision support automation. These software advances, such as the Center-TRACON Automation System (CTAS) have been developed with teams of engineers, software developers, human factors experts, and air traffic controllers; some NASA Ames decision support tools are currently operational in Federal Aviation Administration (FAA) facilities and some are in use by the airlines. These tools have provided air traffic controllers and traffic managers the capabilities to help reduce overall delays and holding, and provide significant cost savings to the airlines as well as more manageable workload levels for air traffic service providers. NASA is continuing to collaborate with the FAA, as well as other government agencies, to plan and develop the next generation of decision support tools that will support anticipated changes in the air transportation system, including a projected increase to three times today’s air traffic levels by 2025. The presentation will review some of NASA Ames’ recent achievements in air traffic management research, and discuss future tool developments and concepts currently under consideration.
Air Traffic Management Research at NASA Ames Research Center

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Outline

• NASA’s Missions and Aeronautics Research
• Today’s Air Traffic Control System
• Development of Decision-Support Tools
• The Center–TRACON Automation System (CTAS)
• The Traffic Management Advisor (TMA)
• The Multi–Center Traffic Management Advisor (McTMA)
• The Surface Management System (SMS)
• Future Directions: The Joint Planning and Development Office
Current Airspace Systems Projects

**4 Mission Directorates**

- Exploration Systems
- Science
- Space Flight
- Aeronautics Research

**NASA's Mission:**

*To understand and protect our home planet.*
*To explore the universe and search for life.*
*To inspire the next generation of explorers... as only NASA can.*

**Aeronautics Research Mission Directorate Objective:**

*Increase Mobility:* "Enable more people and goods to travel faster and farther, with fewer delays."

**Airspace Systems Program Goal:**

Enable major increases in the capacity and mobility of the air transportation system through development of revolutionary concepts for operations and vehicle systems.

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**Current Airspace Systems Projects**

**NExTNAS Elements**

- **VAMS**
  - 2002-2006
  - Explore advanced concepts & model/simulate the NAS
- **EFPM, SAU, HMP, EAS**
- **SATS**
  - 2001-2005
  - Improve public mobility & community access with small aircraft/airports

**2004-2009**

- Improve public mobility and community access with small aircraft/airports
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Current Airspace Systems Projects

NEXTNAS Elements

2004-2009

VAMS

2002-2006

EFPM, SAU, HMP, EAS

Technologies to enable future operational concepts for a more flexible & efficient NAS

SATS

2001-2005

Improve public mobility & community access with small aircraft/airports

Explore advanced concepts & model/simulate the NAS
Today’s Air Traffic Operational Concept Baseline

Route of flight includes transition through 35 sectors:
- 6 surface/terminal area sectors (departure)
- 23 en route area sectors
- 6 terminal/surface area sectors (arrival)
Current Daily En-Route Operations

A DAY IN THE LIFE OF
AIR TRAFFIC OVER
THE CONTINENTAL U.S.

ANIMATION CREATED USING
FUTURE ATM CONCEPTS
EVALUATION TOOL
(FACET)

FOR
AVIATION SYSTEMS DIVISION
(AF)
NASA AMES RESEARCH CENTER

Current Air Transportation System Status

- Data indicates that the system breaks down with air carrier operations greater than 14 million per year
  - Major carriers will continue to use high density airports (cost/convenience)
  - Emerging carriers will support high density point-to-point routes (increased use of air taxis and smaller airports)

Reference: FAA Aerospace Forecasts
March 2003

Air Carrier Operations
Regional Operations
Current Air Transportation System Status (2)

• Demand:
  - In 2004, 17 of the nation's 35 busiest airports exceeded their pre-Sept. 11 levels
  - By the end of 2005, it is expected that flight operations at 23 of the nation's 35 busiest airports will exceed their pre-Sept. 11 levels

• Runway Capacity:
  - It takes approximately 10 years to build new runways
  - Approximately half of the nation's 25 busiest airports cannot add runway capacity (due to geography)

Capacity Solution Space

• Increased utilization of airports
  - Improve flow in and around airports
  - Increase use of under-utilized airports
  - Build new airports

• Increase utilization of airspace
  - Density
  - Availability
  - Structure

• Improve coordination and optimization
Center-TRACON Automation System (CTAS)

- Developed from algorithms for flight management systems (FMS)
- Set of computer tools which assist in the efficient planning and control of air traffic
- Utilizes:
  - Expert rules
  - Highly-accurate, 4-D trajectory prediction
- Adaptable to user preferences/ constraints
- Network of workstations interfaced with current FAA Air Traffic systems (HOST and ARTS)

CTAS Tool Development: Technical Approach
Facility Interoperability: Aviation Systems Division

CTAS Laboratories
ATC Pseudo Aircraft

Future Flight Central
Pseudo AOC Surface Tools

Vertical Motion Simulator
ICAB Field Based Laboratories

Field Test Sites

CTAS Concept (1)

TMA Traffic Management Advisor

pFAST Passive Final Approach Spacing Tool

DA Descent Advisor

Center TRACON
**CTAS Concept (3)**

**Air Traffic Control System Command Center**

- **TMA**
- **TRACON**
- **SMS**
- **pFAST**
- **aFAST**
- **EDP**
- **E/DA**
- **Airlines**
- **CAP**
- **SWEPT**

**Traffic Management Advisor (TMA)**

The Problem:
- Heavy traffic flows to a single major terminal area/airport leading to delays
- Inefficient miles-in-trail spacing methods
- Inefficient time-based metering system
The TMA Solution

- Decision-support tool used by traffic management coordinators and enroute air traffic controllers.
- Develops a safe and efficient arrival schedule that meets, but does not exceed, the specified capacity of the airport, and minimizes delays.

- Provides traffic flow visualization capability for traffic flow management.
- Advises enroute sector controllers of the optimized schedule.
- Increases airport capacity, reduces arrival delays, and reduces controller workload.

Current TMA Operational Deployment
Multi-Center TMA (McTMA)

The Problem:
- Multiple facilities involved in traffic management
- Intersecting, interdependent traffic streams
- No-notice holding and reactive traffic management measures

Conventional Metering Horizon
McTMA Solutions

- Extendable, flexible system architecture to link traffic predictions and schedules between facilities
- Distributed scheduler to provide robust scheduling for the entire system while preserving facility independence to address local traffic problems
- Enables inter-facility collaboration to manage arrival traffic
- Provides a generic scheduling solution for the NAS
McTMA Accomplishments

- Developed new capabilities tested both in simulation and in the field
- Field evaluation at four ARTCCs, Philadelphia TRACON, and the Air Traffic Control System Command Center (November 2004)
- Demonstrated favorable performance of the new algorithms
- Working with the FAA to merge McTMA functionality into its existing operational baseline
- Anticipated rollout of new McTMA system to key test-sites in 2006
- Eventual deployment of "new" TMA (with McTMA functionality) to all current Single-Center TMA sites

Surface Management System (SMS)

The Problem:
- Ground operations bottleneck
- Different user groups impact the surface operation
- Departure planning on the surface is reactive and very manual
- Runway capacity is a limitation for many airports
SMS Solution

SMS is a decision aid to Tower controllers and airline surface operators to effectively manage ground congestion at ramps, taxiways and runways.

ETMS

Surface Surveillance

SMS

Displays for Traffic Managers and Airline Ramp Coordinators

SMS Accomplishments

• The SMS project has worked closely with FedEx and Northwest Airlines at Memphis Airport to develop and test concepts and functionality.
• Operational demonstrations at Memphis Tower, TRACON, and Center and integration of SMS with the FAA's SafeFlight 21 Program and UPS operations at Louisville Airport were completed.
• Information provided enables Tower and Airline operators to reduce taxi delays, reduce fuel costs, and improve predictability of take-off times
• Estimated annual benefits to the airlines of $315M/year NAS-wide
Future Directions

• NASA, together with the FAA, is leading the Joint Planning and Development Office (JPDO) to define the next generation of the Air Transportation System
• Other agencies/departments involved: DHS, DOC, DOT, DOD, OSTP
• As part of the output of the JPDO National Plan, NASA will be working to address much of the ATM research work needed to achieve the goals in the National Plan
• Major goals:
  • Retain US Leadership in Global Aviation
  • Expand Capacity
  • Ensure Safety
  • Protect the Environment
  • Ensure Our National Defense
  • Secure the Nation
• The plan addresses not only air traffic management, but airport infrastructure, security, aircraft equipage, environmental impact, weather, and international operations

Future Directions (2)

• Virtual Airspace Modeling and Simulation Project
  - To define and assess future concepts for airspace operations
  - Goal to provide a revolutionary improvement in system capacity, while maintaining affordability and safety

• En-route Environment: Advanced Airspace Concept (H. Erzberger)
  - Addresses bottleneck created by human controller workload (limitations in sector size reductions)
  - Separation assurance no longer the responsibility of the air traffic controller for equipped aircraft
  - Utilizes Controller/Computer-Pilot Datalink
  - Requires an automated separation monitoring and conflict avoidance system
Flight from SFO to IAD

Route of flight includes transition through 35 sectors:
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ANIMATION CREATED USING FUTURE ATM CONCEPTS EVALUATION TOOL (FACET) FOR AVIATION SYSTEMS DIVISION (AF) NASA AMES RESEARCH CENTER

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TOTAL U.S. ATM SYSTEM DELAY (Thousands of Flights with Delay>15 min.)

Operations (Millions)

Reference: FAA Aerospace Forecasts March 2003
Air Carrier Operations Regional Operations
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CTAS Tool Development: Technical Approach

- Concept Definition
- Initial Software
- On-site Controllers
- Airlines
- System Development Team
- Adaptation for Target Site
- Assessment Team/Cadre
- Preparation for Operational Test
- Operational Test

Human Factors
- Analysis
- Shadowing
- Real-time Simulation
- Fast-time Simulation

Controller and Pilot Involvement

Development Progress
CTAS Concept (2)

CTAS Concept (3)
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**Current TMA Operational Deployment**

[Map showing operational and planned TMA sites across the United States.]
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ZFW Airspace Outline
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ETMS

Surface Surveillance

Displays for Traffic Managers and Airline Ramp Coordinators

• Pushback Times, Flight Plans, EDCTI, Airborne Surveillance, Parking Gates

SMS

SMS display depicting arrival and departure demand, delays, and queues

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