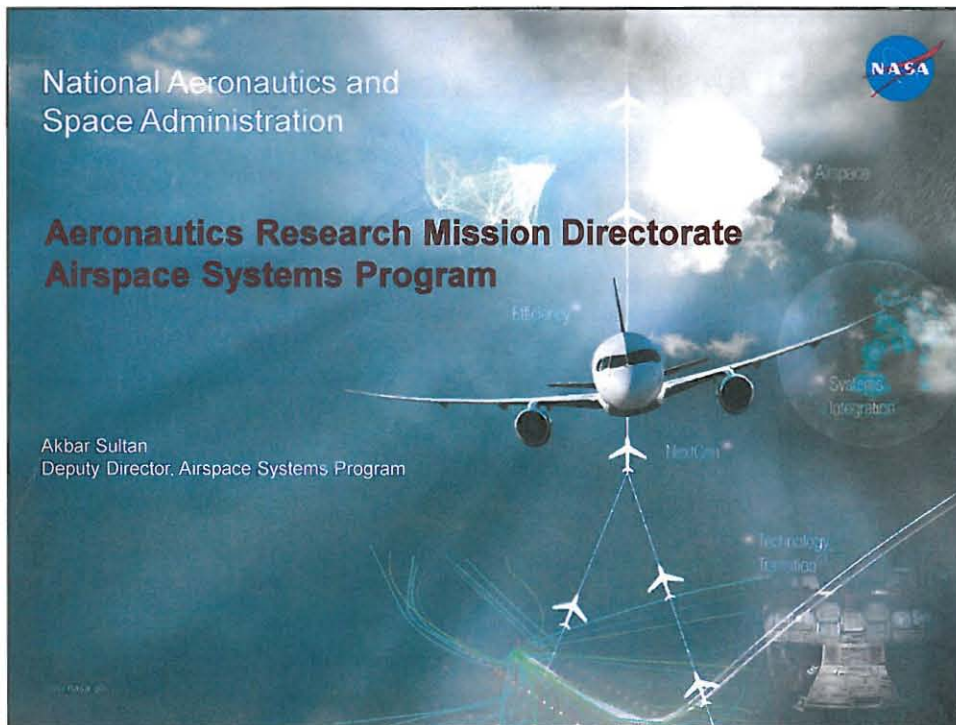




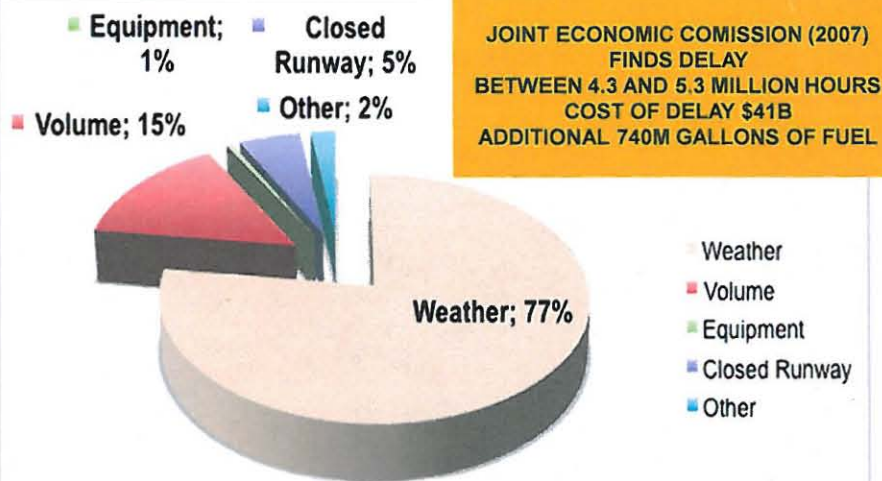
Setting the context....

ARMD Global ATM and
US FACET
Video

National Airspace System Delays



Period: September'08 – August'09 (Source FAA), Roughly 25% aircraft get delayed



Weather is a big delay contributor – Can't change it but we can optimize around it

3

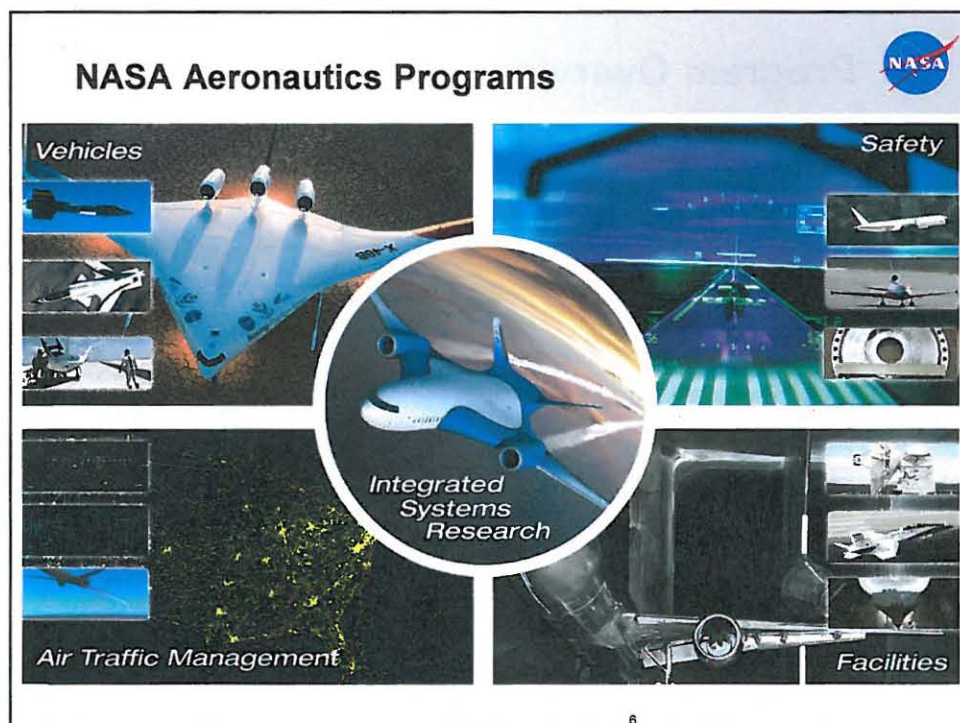
ASP International Collaboration: Objectives and Approach

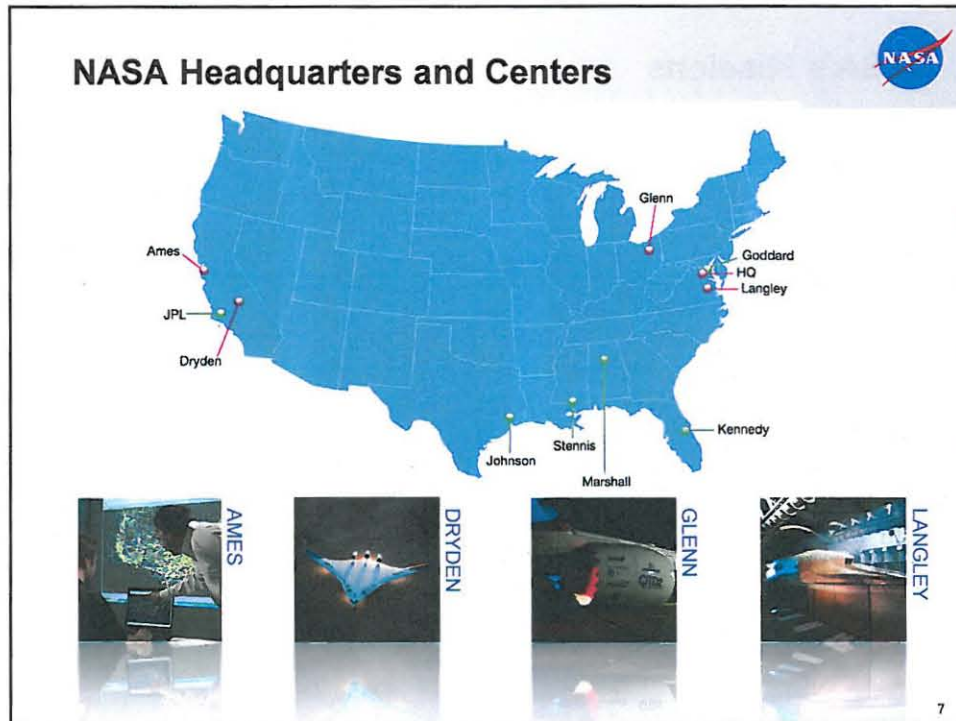


*Explore pre-competitive R&D collaborations with foreign entities
with unique interests and capabilities*

- Strategic program objectives
 - Define rationale under which to collaborate
 - Join strengths
 - Trade strengths
 - Enable access to test beds, unique facilities, carriers, system performance data
 - Identify broad high value topic areas (i.e., ADS-B enabled TBO, weather integration, etc.)
 - Define valued-added interactions
- Strategic approach
 - Define meaningful activity based collaboration and not just interaction available at existing, conventional venues (i.e., conferences)
 - In-depth technical discussions with expected clear outcomes and goals
 - Ensure researchers and project leads participation
 - Require definition of mutual, bilateral gains/objectives (i.e., tangible benefits, products)
 - Identify baseline activities for complimentary collaboration
 - Researchers develop detailed proposal plans for collaborative subtopics
 - Engage OIIR facilitation critical for strategic agency-to-agency discussion
- WebEx in lieu of in-person meetings to facilitate frequent/detailed discussion
 - Eliminate geographic separation as obstacle to progress
- Face-to-Face meetings for down-selection and formal agreement drafts

4





Program Overview

Enable NextGen from Gate-to-Gate and Reduce the Total Cost of air transportation operations

Increase Maturation and Implementation of ASP technologies to accelerate NextGen

- **Concepts and Technology Development (CTD) Project:**
Develop gate-to-gate concepts and technologies for NextGen to enable significant increases in capacity and efficiency
- **Systems Analysis, Integration and Evaluation (SAIE) Project:**
Facilitates R&D maturation of integrated concepts and technologies through evaluation in relevant environments, enabling transition to stakeholders



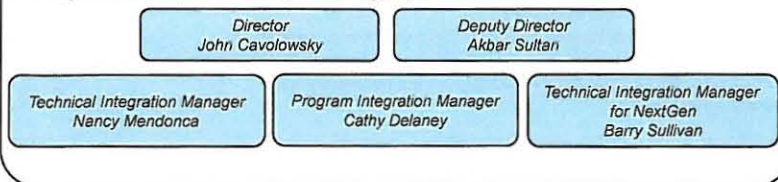
CTD and SAIE will deliver on collaborative work plans to accelerate products and impacts for NextGen

8

ASP Organizational Chart



Program Office, NASA HQ, Washington, DC



NextGen Concepts & Technology Development Project - ARC (Host)



NextGen Systems Analysis, Integration & Evaluation Project - ARC (Host)



9

ASP Technical Challenges



TC 1: Develop Tactical Automation technologies for complex operational choke points including surface, arrival/departure, and dense terminal operations.

Target Technologies/Demonstrations: ATD-1, SARDA, PDRC, TRCM, F-IM, Metroplex

TC 2: Establish the basis for air/ground functional allocation for separation assurance including safe, graceful degradation of performance in response to off-nominal conditions.

Target Technologies/Demonstrations: F/A Mixed Equipage; Uncertainties; Off-Nominals

TC 3: Develop Strategic Automation technologies that integrate probabilistic weather information and flow management capabilities.

Target Technologies/Demonstrations: Stratus, DWR, TASAR, TFM with weather

TC 4: Conduct seamless integration of automation applications in a resilient, end-to-end Trajectory-Based Operations system.

Target Technologies/Demonstrations: SMART-NAS

TC 5: For the highest levels of NextGen performance and beyond, develop concepts, technologies, and system-wide evaluation and validation approaches.

Target Technologies/Demonstrations: Networked ATM F/A to reduce total cost, SPO

10

NASA Offers Gate To Gate NextGen Concepts and Technologies



- **Strategic/Enroute**
 - Corridors-in-the-sky, Airspace Reconfigurations, Generic Airspace
 - Smart TFM and Collaborative Decision Making which reduces impact of convective weather and ceiling/visibility
 - Oceanic In-Trail Climbs delegated to aircraft flight-decks in non-radar airspace for optimal performance, favorable winds, and turbulence avoidance
 - Continuous Descent Approaches in a congested environment while maintaining throughput
- **Terminal**
 - Aircraft based runway/taxiway Collision Avoidance for Airport Traffic (CAAT)
 - Non-stop taxi via data-linked 4-Dimensional (4D) taxi information, resulting in reduced noise, emissions and fuel consumption.
 - Wake vortex behavior and prediction for in-trail and parallel operations
 - Integration of runway and surface operations
 - Comprehensive management of operations in a metroplex area with interdependent, closely situated congested airports
 - System-level engineering and evaluations, and human-system integration concepts
- **Challenges**
 - Functional Allocation (Human/Machine and Airborne/Ground based)
 - Accommodation of Advanced Vehicles in NextGen NAS (Advanced Rotorcraft, UAS, BWB, CESTOL, Supersonic)
 - Integration and Translation of Probabilistic Weather Information



Environmentally Responsible Operations: Reduced time/distance flown and increased capacity/efficient operations lead to reduced fuel consumption/emissions

Program Highlights



ACCELERATE NextGen by making an impact with it's stakeholders:

Efficient Descent Advisor (EDA) – Transferred to FAA 3D-PAM in Nov. 30, 2011. FAA working to define requirements for initial EDA deployment under GIM-S

- Benefits: Increased fuel efficient arrival profiles that are closer to optimal profile descents: potential for \$300M/yr fuel savings.

ATM Technology Demonstration (ATD) #1 – Demonstrate user operational benefits through the integration of ADS-B enabled Flight Deck Merging and Spacing and Terminal Area Precision Scheduling and Controller-Managed Spacing

- Benefits: Increased throughput and efficiency; benefit potential, 2020 - \$500M/yr

Dynamic Weather Routing – Delivering weather avoidance and time savings trajectories for better weather routes for aircraft in-flight

- Benefits: Increased fuel efficiency and reduced delays under severe weather conditions.

SFO Status - Ground Delay Program (GDP) Selection model for SFO airport to investigate reducing current ground delay policy leading to excessive unrecoverable delays

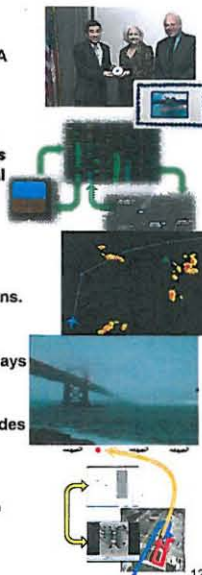
- Benefits: Reduced delays (2011: ~55,000 minutes)

In-Trail Procedures (ITP) - Enabling aircraft to achieve ADS-B enabled efficient altitudes and speeds by flight deck in-trail climb and descent in the oceanic environment

- Benefits: Increased fuel efficiency (\$200K/aircraft annually)

Precision Departure Release Capability - Integrate aircraft OFF time predictions to Traffic Management Advisor to fit departing aircraft in an overhead stream

- Benefits: Reduced delays. 8700/month lost overhead slot opportunities, PDRC may reclaim up to 80%



Program Highlights



INNOVATE in emerging new capabilities:

Spot and Runway Departure Advisor (SARDA) – Integration of SARDA with airline collaboration in push back management to maximize the efficiency of surface operations

- Benefits: Reduced fuel/noise/emissions/delays



Compression monitoring and terminal conflict alert – Three-segment deceleration model for compression monitoring consistently has the best probability of detection

- Benefits: Increased capacity and safety



Separation Assurance Functional Allocation – 2nd the series of culminating simulations

- Benefits: Key enabler for NextGen automation implementation, increased capacity/efficiency/safety



LEAD the research community:

Shadow mode NextGen – SMART NAS

- Benefits: Full domain modeling and simulation of future automation and benefits analysis

Single Pilot Operations

- Benefits: Reduced user costs

Ground Based Surface CD&R

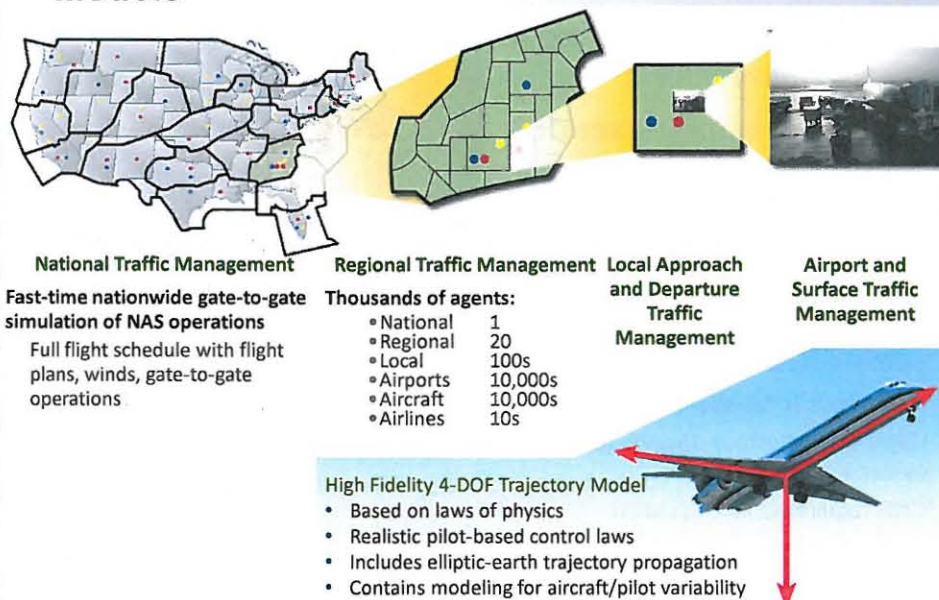
- Benefits: Increased safety and throughput

Strategic international partnerships

- Benefits: Influence concepts, set research direction, and attack broader solution space

13

Airspace Concept Evaluation System (ACES) Models



14

Future ATM Concepts Evaluation Tool (FACET)

FACET models the National Airspace System, for both research and operational use



Key FACET capabilities used by FAA traffic flow managers and airline dispatchers

- 500 traffic flow managers at 100 FAA operational sites
- 4,700 dispatchers at 600 air carriers via Flight Explorer

Air Traffic Operations Lab (ATOL)

Multi-fidelity, part-task, air traffic simulation environment

Exploration of inter-aircraft, aircraft / airspace, and air / ground interactions in a NextGen environment

- Concept-level operations research
- Technology / concept / procedures performance assessment
- Flight deck automation development
- Flight deck interface development and evaluation
- CNS requirements evaluation



- Over 500 airplane simulations
- Twelve human-in-the-loop stations; remainder flown by pilot model
- Eight air traffic control stations
- May be connected to external simulations and facilities through AviationSimNet

Airspace Facilities



AIRSPACE OPERATIONS LAB: Investigates human operator requirements for NextGen



**CREW-VEHICLE SYSTEMS
RESEARCH FACILITY:**
Full mission simulation
capability in 747-400 and
advanced concepts flight
cabs and air traffic control



FUTURE FLIGHT CENTRAL: 360° full-scale tower simulator for airport surface research



ATM SIM LAB:
Multi-facility air traffic
simulation capability for
advanced NextGen
research



NTX
North Texas Research Station
NASA / FAA
NORTH TEXAS RESEARCH STATION: Lab with established data networks to FAA air traffic facilities, air carriers, and other national research labs

Flow and Airspace Management

Surface

Departure

En Route

Arrival

Surface



Technical Challenge

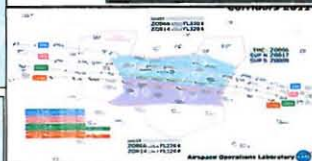
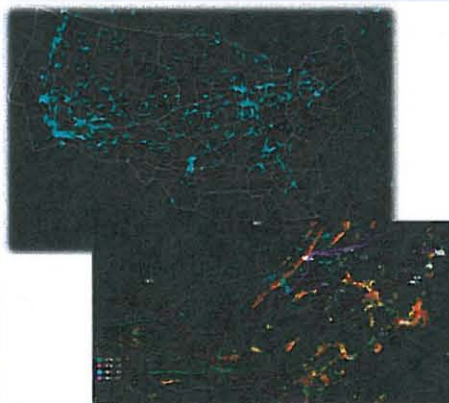
- Balancing Demand and Capacity
- Minimize impact of weather and to environment
- Maximize National Airspace System (NAS) performance

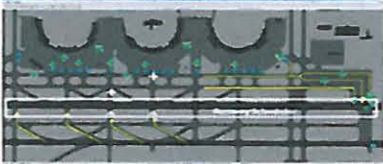
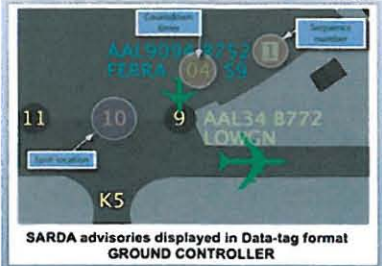
NASA Technology

- Capacity management/airspace configurations
- Strategic and tactical flow management algorithms
- Weather integrated flow models
- Collaborative decision making
- Integrated airspace and flow management (capacity and demand management) models
- Integrated weather, regional, strategic flow models, airspace configuration models to maximize NAS performance and minimize environmental impact

Potential Benefit

- Reduced delays, increased fuel efficiency, reduced emissions

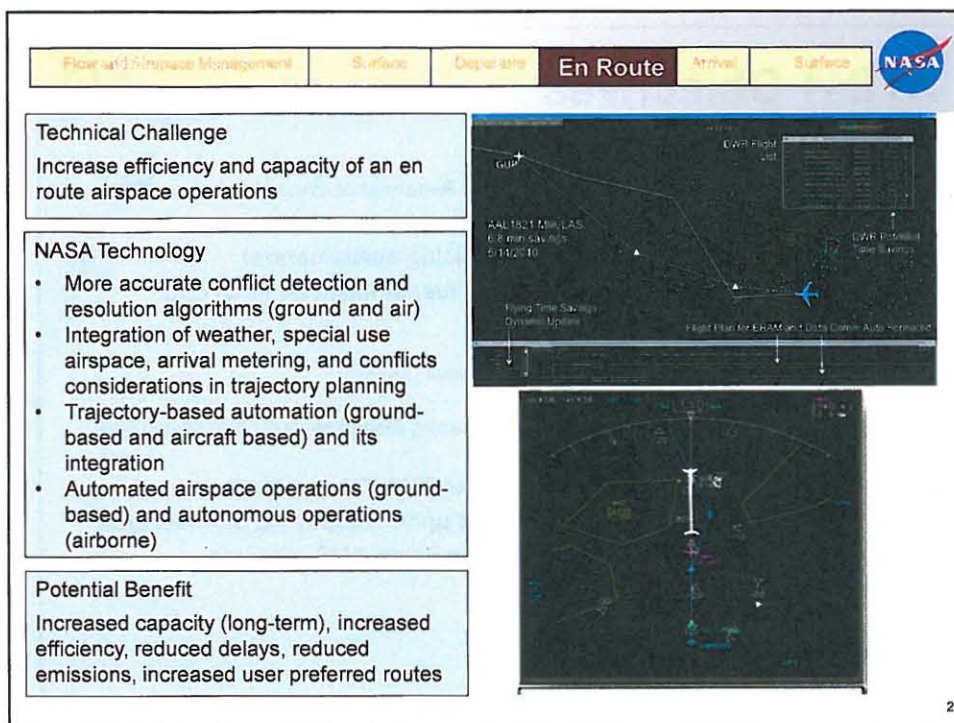


Flow and Airspace Management	Surface	Departure	En Route	Arrival	Surface
					
Technical Challenge Increasing efficiency of surface operations					
NASA Technology - Spot and Runway Departure Advisory - Taxiway Conformance for movement - Conflict/collision detection and resolution for surface operations - Runway Configuration Management - Combined Arrival/Departure Runway Scheduling					
Potential Benefit Reduced delays, reduced stop-and-go's, reduced fuel consumption, increased throughput, and increased conflict avoidance					
 					

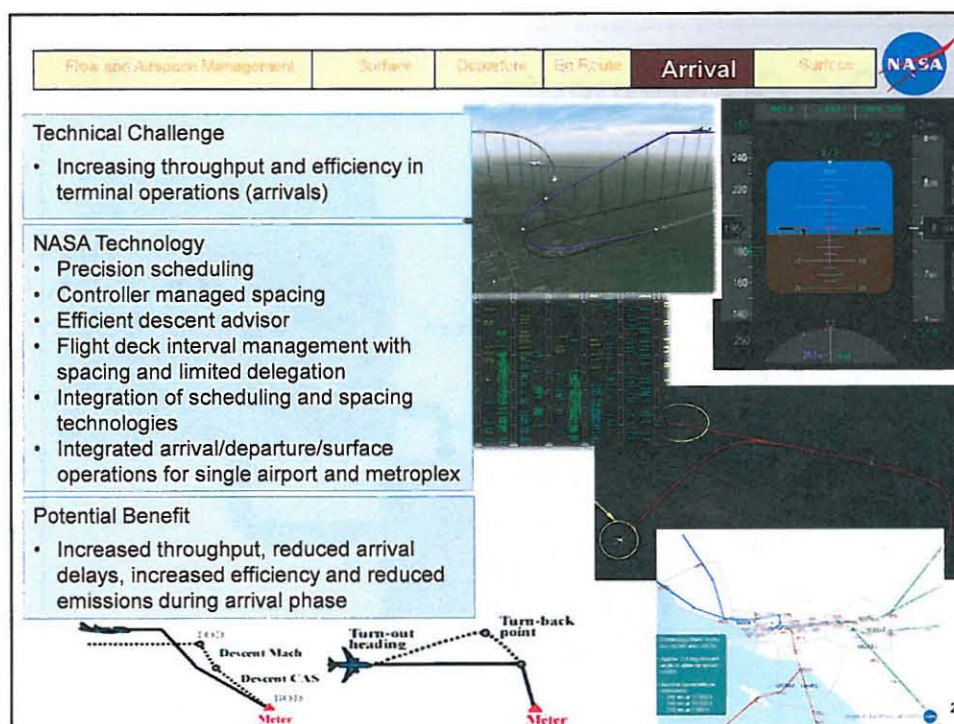
19

Flow and Airspace Management	Surface	Departure	En Route	Arrival	Surface
					
Technical Challenge Increasing throughput and efficiency in terminal operations (departures)					
NASA Technology - Increased departure path efficiency - Departure scheduling - Interval management for departures - Integrated departure, arrival, and surface operations					
Potential Benefit Increased throughput, reduced departure delays, increased efficiency and reduced emissions during departure phase					
  					

20



21



22

ATD-1 Objectives



- Demonstrate increased more consistent use of Performance-Based Navigation (PBN)
 - RNAV/RNP arrival procedures from cruise to touchdown
 - Optimized Profile Descents (OPD) using speed control
 - Simultaneous high throughput and fuel-efficient terminal ops
- Demonstrate ADS-B In Spacing Application
 - Langley ADS-B In merging and spacing algorithm (ASTAR)
- Accelerate transfer of NASA scheduling and spacing technologies for inclusion in late mid-term NAS
 - Terminal metering based upon Ames TMA-TM research
 - Airborne spacing application based upon Langley ASTAR research
 - Controller spacing tools based upon Ames CMS research

ATD-1 Components



Flight Deck Interval Management (FIM) to Runway Threshold

Controller Managed Spacing (CMS) in Terminal Airspace

Integrated Arrival Solution

Traffic Management Advisor with Terminal Metering (TMA-TM)

24

Specific ASP Research - Continuous Descent Approaches



Develop & demonstrate novel operation concepts to safely increase throughput while reducing environmental impact

Today:

Continuous Descent Approaches (CDA's) only flown at off-peak hours or in low-congestion airspace



San Francisco trials indicate fuel savings of up to 3000 pounds (10,000 lb CO₂ reduction) per flight for large aircraft during peak traffic conditions

Tailored Arrivals & Enroute Descent Advisor (EDA)

- EDA combines scheduling with CDA to generate green solutions that maximize runway throughput and avoid conflicts
- Tailored Arrivals optimize CDA's to individual aircraft performance capability

UPS claims Merging and Spacing operations with Continuous Descent Arrivals (CDAs) will enable savings of 1 million gallons of fuel per year

Airborne Merging and Spacing

- Merging and spacing will be delegated to the flight deck instead of current ground-based process
- Will enhance EDA through closer spacing and eliminating missed slots

Development Partners:

FAA, Boeing, United Airlines, US Air, UPS

Early Adopters of Tailored Arrivals:

United Airlines, Qantas, Air New Zealand, Japan Airlines

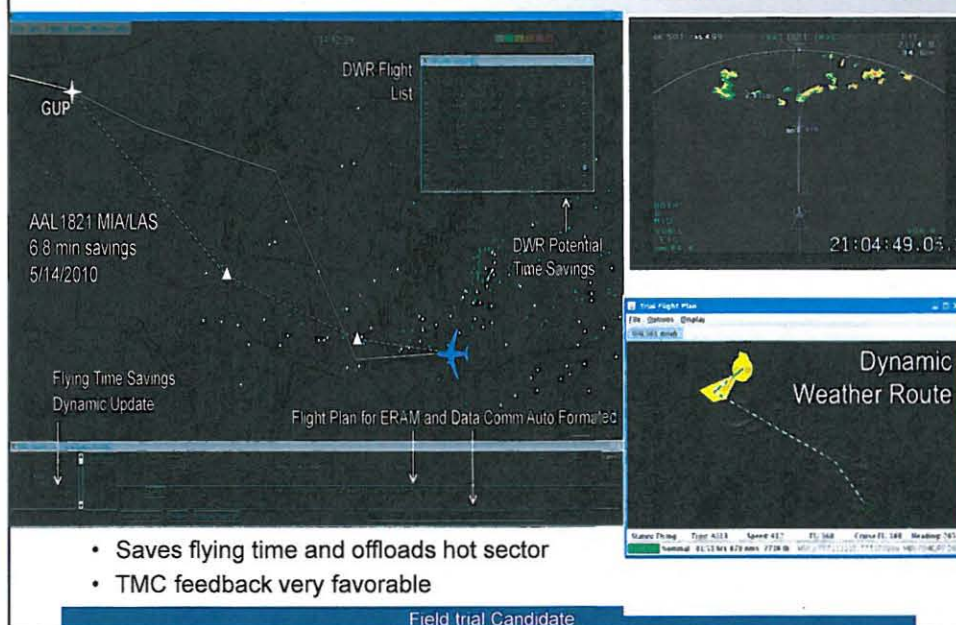
Energy navigation concept (eNAV)

- Optimized fuel burn, noise, and emissions reduction by commanding pilots when to deploy flaps, gear, engine power settings, etc.

25

Dynamic Weather Routes

AS.3.5.19/FY11Q4 "Near-Term TBO with Data Comm Simulation and Analysis"



SFO GDP Parameters Selection Model (GPSM)



Objective: Evaluation of GPSM's recommendations for SFO GDPs by traffic managers in a real-time environment:

- Familiarity for users
- Assess robustness
- Identify potential enhancements
- Assess potential benefits

Approach:

- Shadow-mode position to evaluate GPSM's recommendations while observing actual decision making (June 1- October 15)
- Actual decisions are compared with GPSM recommendations

Results

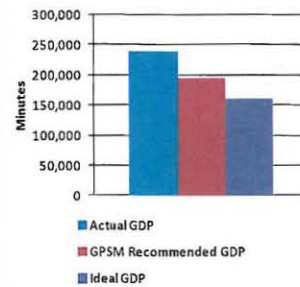
- Recommendations result in less unnecessary delay

Lessons Learned

- Expect the unexpected: weather type
- Meteorologist-in-the-loop
- Shadow mode is very important step



Actual vs. GPSM-Recommended
SFO GDP Delay + Holding
Jun 1 - Sep 14, 2011, 44 GDPs



Next Steps

- End-of-season review on November 9
- ATCSCC to integrate GPSM in operational decision making in 2012
- ATCSCC to initiate training, procedures, software enhancement during winter

GPSM recommendations would have reduced overall delay by ~20% this season, a 57% reduction in unnecessary delay.

27

Surface Technology Enhancements

AP.2.S.12 Augment Surface Optimization and Environmental Algorithms

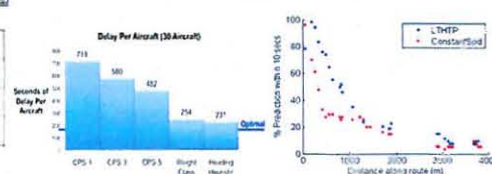
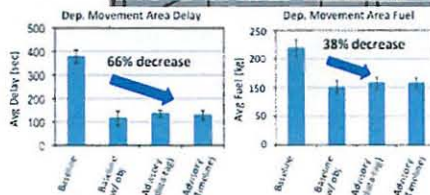


Objective: Enhance surface operations capabilities beyond spot scheduling

Initial surface scheduling capabilities are ready and further enhancements will increase gate-to-runway conformance

Enhancements:

- Efficient runway assignment scheduling algorithm
- Fast-time capability to conduct trade-offs
- Electronic flight strips
- Hybrid closed loop and human-in-the-loop simulation capability
- Adapt Spot and Runway Departure Advisor to multiple airports



28

Surface Operations Aircraft Technologies

AP.2.S.10 : Develop Interim Aircraft-Based CD&R Algorithms, AP.2.S.11: Pilot 4D Taxi Clearance



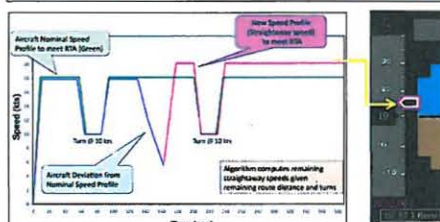
Objectives 1: Evaluate aircraft-based CD&R algorithms via fast-time simulations

- Effect of position accuracy
- Levels of CD&R equipage
- Directive alerting

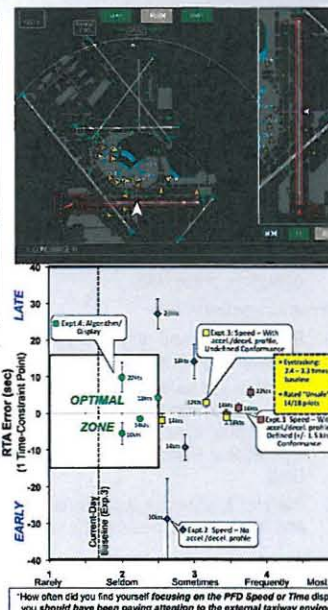
Objective 2: Develop flight deck capability to maintain and monitor trajectory conformance during surface operations

Status/Next Steps:

- Complete data analysis underway of NASA algorithm
- Data collection for SURF IA algorithm to occur 1QFY12
- Integrate CD&R and conformance monitoring capabilities



Error-nulling algorithm (to be patented) determines speed profile (shown on PFD) needed to meet RTA based on remaining time, distance, route geometry, acceleration and deceleration requirements



Flight Deck Merging and Spacing/Interval Management

AS.3.6.09: "Evaluation of IM to a Single Airport Dependent Parallel Runways"

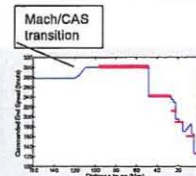


Objective

- Use flight deck Interval Management algorithm and procedures for precise delivery of aircraft to threshold of dependent parallel runways

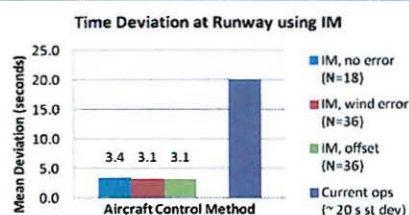
Approach

- Ground/Air concept development
- ASTAR algorithm supports both time-based and relative spacing operations
- Conducted batch studies and HITL



IM	
Error Source	Mean (#)
No Error	9.72
Wind Error	16.11
Offset Error	13.14

Number of speed changes during arrival



Results

- Aircraft arrival accuracy during HITL
 - 3 ± 4 sec @ runway threshold by flight crew
 - Very robust during error conditions (no further ATC action is required)
 - Data from current day operations show up to 20 seconds deviation
- Speed changed more often than desired
 - Forecast wind error plus wind shear caused highest number of changes
 - Published arrival had five speeds (shown as red lines in graph)

Partners: FAA SBS Office (concept, data link), FAA ATO (experiment design)

Efficiency and throughput for arrival operations

NASA UAS Access to the NAS Focus



- Separation Assurance
 - Provide an assessment of how NextGen separation assurance systems with different functional allocations perform for UAS in mixed operations with manned aircraft
 - Assess the applicability to UAS and the performance of NASA NextGen separation assurance systems in flight tests with realistic latencies and trajectory uncertainty
- Human Systems Integration
 - Develop a research test-bed and database to provide data and proof of concept for GCS operations in the NAS
 - Coordinate with standards organizations to develop human factors guidelines for GCS operation in the NAS
- Communications
 - Develop data and rationale to obtain appropriate frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS
 - Develop and validate candidate UAS secure safety critical command & control (C2) system/subsystem test equipment which complies with UAS international/national frequency regulations, ICAO Standards and Recommended Practices, and FAA/RTCA Minimum Operational Performance Standards/Minimum Aviation System Performance Standards for UAS
 - Perform analysis to support recommendations for integration of safety critical C2 systems and ATC communications to ensure safe and efficient operation of UAS in the NAS

31

NASA UAS Access to the NAS Focus (continued)



- Certification
 - Define a UAS classification scheme and approach to determining airworthiness requirements (FAR xx.1309) applicable to all UAS digital avionics
 - Provide hazard and risk-related data to support development of type design criteria and best development practices
- Integrated Tests and Evaluation
 - Integrate and test mature concepts from the technical elements to demonstrate and test viability
 - Evaluate the performance of the research in a relevant environment (full mission human-in-the-loop simulations and flight tests)

32

NASA/FAA Research Transition Teams



Goal

- Ensure that R&D needed for NextGen implementation is identified, conducted, and effectively transitioned to the implementing agency

Objectives

- Provide a structured forum for researchers and implementers to collaborate on a continual basis
- Ensure that planned research results can be fully utilized and will be sufficient to enable implementation of NextGen Operational Improvements

Efficient Flow into Congested Airspace: Joint collaboration with industry partners for near-term efficient and reduced environmental impact of arrival operations under constrained airspace conditions

- **Deliverable:** Efficient Descent Advisor technology transition to FAA, Nov 2011; Agency High Priority Performance Goal

Integrated Arrivals/Departures/Surface Management: Develop system level concept to accelerate NextGen arrival/departure and surface operations for the mid-term

- **Deliverable:** Precision Departure Release Capability shadow evaluation in late May 2011 with first round of operational evaluations in June/July 2011

Flow Based Trajectory Management: Evaluate System-Operations to determine roles & responsibilities for efficient flow of traffic for the mid-term

- **Deliverable:** Multi-Sector Planning capability collaboratively developed with and transitioned to the FAA, July 2011

Dynamic Airspace Configuration: Develop far-term concept for efficient partitioning of airspace and allocation of resources to meet NextGen capacity needs

- **Deliverable:** Assessment tools for proposed airspace redesign for Cleveland Center, Sep 2011



33

Partnership Examples



34

Summary



- **Challenge can not be met without a partnership** of researchers, implementers, users, operators, and many others
- Explore collaboration to reduce fuel, noise, and emissions while increasing efficiency
 - CAAS, CoE, Singapore Airlines, SilkAir, Changi Airport
 - Optimized surface automation
 - Optimized dense terminal operations (CDA, metering)
 - Integrated Arrival/Departure/Surface operations
 - Traffic Flow Management and adverse weather

