Airspace Systems Program

- NextGen Concepts and Technology Development (CTD) Project

- NextGen Systems Analysis, Integration, and Evaluation (SAIE) Project

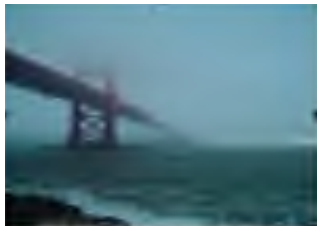
Air Transportation Needs, Research and Transition

Needs

- On-time arrival/departure (schedule integrity)
- Reduce operator costs (fuel)
- Increase system productivity (aircraft/ operator)
- Minimize impact on environment
- Design for scalability
- Safety
- Predictability

Challenges

- Weather uncertainty
- Human workload limits capacity, throughput, and precision delivery
- Interactions: arrivals, departures, and surface; and metroplex
- Prediction uncertainty (trajectory, aircraft count, aircraft location)
- Mixed equipage
- Trade-off between environment and capacity/throughput



Research Threads

- Conflict detection and resolution and analysis
- Functional allocation
- Safety assessment
- Arrival operations (integrated scheduling, sequencing, and merging and spacing)
- Integrated arrival/ departure operations
- Surface operations optimization
- Modeling, simulation and optimization techniques to minimize total delay
- Decision-making under uncertainty (weather integration)
- Capacity management
- Trajectory requirements
- Trajectory uncertainty prediction
- Trajectory interoperability
- Trajectory validation
- System level impact assessment
- Interactions between key research focus area

Research Focus Area

NextGen Concepts and Technology Development Project

- Separation Assurance
- Super Density Operations
- Traffic Flow Management
- Dynamic Airspace Configuration
- Safe and Efficient Surface Operations

NextGen Systems Analysis, Integration, and Evaluation Project

- Integration, Evaluation, and Transition
- Interoperability Research
- System and Portfolio Analysis

Domain and operations are complex and require sustained R&D to address challenges. NASA has the skills and experience to change the airspace system.

Airspace System Program (ASP) Objectives and Projects

Perform research to enable new aircraft system capabilities and air traffic technology to increase the capacity and mobility of the nation's air transportation system.
Integrate these capabilities to maximize operational throughput, predictability, efficiency, flexibility, and access into the airspace system while maintaining safety and environmental protection.

Projects

- **NextGen Concept and Technology Development (CTD) Project:**

  Develop gate-to-gate concepts and technologies for NextGen to enable significant increases in capacity and efficiency

- **NextGen Systems Analysis, Integration, Evaluation (SAIE) Project:**

  Facilitates R&D maturation of integrated concepts and technologies through evaluation in relevant environments, enabling transition to stakeholders

SAIE and CTD work together to cover foundational research to integrated capabilities

NextGen Concepts and Technology Development Project

Develop gate-to-gate concepts and technologies towards NextGen to enable significant increases in capacity and efficiency

Research Focus Area: Separation Assurance (SA)

Problem

- Human controller workload and uncertainty limits airspace efficiency and capacity
- Sector-based solutions and mixed equipage

Research Being Pursued

- Automation and operating concepts for separation, metering, and weather avoidance in en route and transition airspace (airborne and ground-based)
- Concepts/algorithms for higher levels of separation assurance automation
- Efficient trajectories into capacity constrained airspace
- Separation assurance and collision avoidance algorithm compatibility

Partners: FAA, Lockheed Martin, Boeing, NRAs (MIT, Purdue, SJSU, Stanford, California State University-Long Beach, SAIC, LMI, and others)

Major Research Threads

	Trajectory based operations: enabled by conflict detection and resolution	Human/Machine Air/Ground Functional Allocations	Safety Assessment for CD&R Automation
Strategic	Integration of Tactical and Strategic CD&R (traffic, Wx, metering)	Final Report with functional allocation recommendations	Validate and generate guidance related to safety assurance methods for higher automation
Strategic	Ground / Airborne Conflict Resolution Algorithm Development & Performance Assessment (traffic, Wx, metering)	Mixed Operational Off-Nominal	
Strategic	Conflict Detection Algorithm Development & Performance Assessment	Homogenous Off-Nominal	Analysis of Existing Algorithms
Tactical	Ground / Airborne Conflict Resolution Algorithm Development & Performance Assessment (traffic, Wx, metering)	Mixed Operations Air/ Ground Combination	Developing Safety Methods Applicable for Higher Levels of Automation
Tactical	Ground / Airborne Conflict Detection Algorithm Development & Performance Assessment	Homogeneous Operations Air and Ground Automation	
	Conflict detection and resolution	Functional allocation	Safety assessment

Increase productivity, safety, and scalability

Research Focus Area: Super Density Operations (SDO)

Problem

- Human control of spacing, merging, and separation assurance limits the capacity of the terminal airspace
- Mixed equipage must be safely managed
- Interactions between arrivals and departures

Research Being Pursued

- Algorithms that simultaneously solve/optimize the sequencing, merging, de-confliction and spacing
- Regional resource utilization or metroplex operations
- Closely spaced parallel runways

Partners: FAA, UPS, MITRE, ACSS, NRAs (MIT, Purdue, Metron, GA Tech, SJSU, Mosaic ATM)

Major Research Threads

Efficient Arrival Operations	Efficient Arrival/ Departure/Surface Operations	Separation Based on Wake Prediction
Metroplex Operations: Multiple Airports	Arrival/Departure Surface Scheduling and Execution	Dynamic Separation Guidance Based on Advanced Wake Models
Multiple Runways Crossing Runways Parallel Runways (Integrated Scheduling & Merging & Spacing)	Runway Configuration Management & Combined Arrival/ Departure Scheduling	Validation of Models and application for operations
	Departure Scheduling	Probabilistic Wake Models for Location and Strength
Single Runway Scheduling, Merging & Spacing	Terminal Conflict Alert and Compression Monitoring	Deterministic Wake Models for Location and Strength
Aircraft Energy Navigation to support efficient approaches	Arrival Scheduling	Validation of Wake Sensors
Arrival Operations	**Arrival/Departure Operations**	**Wake Modeling & Applications**

On-time arrival/departure, reduce costs, impact on environment, safety and scalability

Research Focus Area: Traffic Flow Management (TFM)

Problem

- Planning involves multiple time scales (local, regional, and national)
- Multiple decision with different goals (pilots, dispatchers, Air Traffic Service Providers (ATSP) flow managers)
- Decision making under uncertainty (e.g., weather)

Research Being Pursued

- Optimization methods for advanced flow management
- Probabilistic methods to address system uncertainties
- Weather Translation
- Collaborative Traffic Flow Management

Partners: Mosaic, U.C. Berkeley, GA Tech, Virginia Tech, Univ. Maryland, MIT-LL, Engility Corp, and Washington State University

Major Research Threads

Optimization	Weather Integration	Collaborative Decision Making
Develop TFM Models to Optimize NAS Performance	Develop Algorithms & TFM Strategies to Minimize Impact of Weather and to Environment	Increase Efficiency Through User Collaboration
Validate Models	Develop TFM Strategies to Optimize NAS Performance & Environmental Concerns Under Convective & Non-Convective Weather	Validation of Concepts and Technologies for Operational Improvements
Develop Integrated Impact Assessment Models		
Develop Stochastic Models at Regional & NAS Levels	Non Convective Weather Models Identify impacted Airspace/Airports	Technology Development & Assessment for Collaboration
Develop Deterministic Strategic Models at Regional & NAS Level		
Develop Capacity and Demand Estimation Models	Convective Weather Models Use Identify Impacted Airspace/Airports	Concepts for Collaboration Among Users

Demand/capacity imbalance with demand management

Research Focus Area: Dynamic Airspace Configuration (DAC)

Problem

- Limited degrees of freedom for airspace changes (e.g., combine two adjoining sectors) and controller interchangeability
- Substantial time to modify airspace (years) and train controllers (months)

Research Being Pursued

- Structure of the airspace (e.g., corridors-in-the-sky)
- Algorithms for airspace configurations - benefits and feasibility considerations
- Generic airspace

Partners: FAA, NRAs (Metron, Mosaic ATM, CSSI)

Major Research Threads

Capacity Management	Generic Airspace Operations	Corridors-in-the-sky
Address Demand/ Capacity Imbalance by Capacity Management	Generic Airspace Operations (interchangeable)	Corridors-in-the-Sky Design to Increase Efficiency
Validate Algorithm	Develop Requirements for Technologies & Procedures to Support Generic Airspace Operations	Develop Requirements for Technologies & Procedures to Support Corridors-in-the-Sky
Examine the Feasibility and Benefits of Airspace Boundary Adjustments	Conduct Generic Airspace Operations Benefits Analysis	Conduct Corridors-in-the-Sky Benefits & Feasibility Analysis
Develop Algorithms to Change Airspace Boundaries & Capacity	Conduct Studies To Identify Scope and Limits of Generic Airspace Operations	Develop Algorithms to Identify Corridors-in-the-Sky
Develop Concepts for Airspace Capacity Management	Develop Generic Airspace Operation Concepts	Develop Corridors-in-the-Sky Concepts

Demand/capacity imbalance addressed by resources and capacity management

Research Focus Area:
Safe and Efficient Surface Operations (SESO)

Problem

- Surface operations become inefficient under high density operations
- Static procedures limit flexibility, efficiency, and cause imbalance in runway loads
- Human workload may limit accommodation of expected future surface capacity growth

Research Being Pursued

- Concepts, algorithms, experiments, and analysis for surface traffic optimization
- Algorithms, analysis, and experiments for surface trajectory prediction and taxi conformance monitoring
- Concepts, algorithms, analysis and experiments for aircraft- and ground-based surface/low altitude conflict detection and resolution

Partners: FAA, NRAs (Mosaic ATM, Metron, Georgia Tech)

Major Research Threads

Surface operations optimization	Taxi operations conformance	Surface CD&R
Improve Efficiency by Optimizing Surface Movement	Reduce Uncertainty & Improve Taxi Conformance By Better Trajectory Prediction	Improve Safety by Surface Traffic Conflict Detection & Resolution (CD&R)
Integrated Arrival/ Departure/Surface Operations	Analyze Benefits for Accurate Trajectory Prediction and Taxi Conformance Monitoring	Validate Algorithm for Operational Use
Validate the Surface Movement Algorithms for Operational Use	Develop and Validate Algorithms for Trajectory Predictions & Conformance Monitoring	Develop Integrated CD&R Solutions between Ground & Cockpit
Examine the Benefits & Feasibility of the Surface Movement Algorithms	Develop Concept & Requirements for Modeling Surface Trajectories	Analyze Performance of the Surface Traffic CD&R Algorithms
Develop Surface Movement Algorithms for Surface Movement Optimization	Characterize Surface Trajectories and Quantify Uncertainties	Develop Concepts & Algorithms to Detect Surface Traffic CD&R

NextGen Systems Analysis, Integration, and Evaluation

Develop integrated solutions and transition technologies to stakeholders

Research Focus Area
Integration, Evaluation, & Transition (IET)

Problem

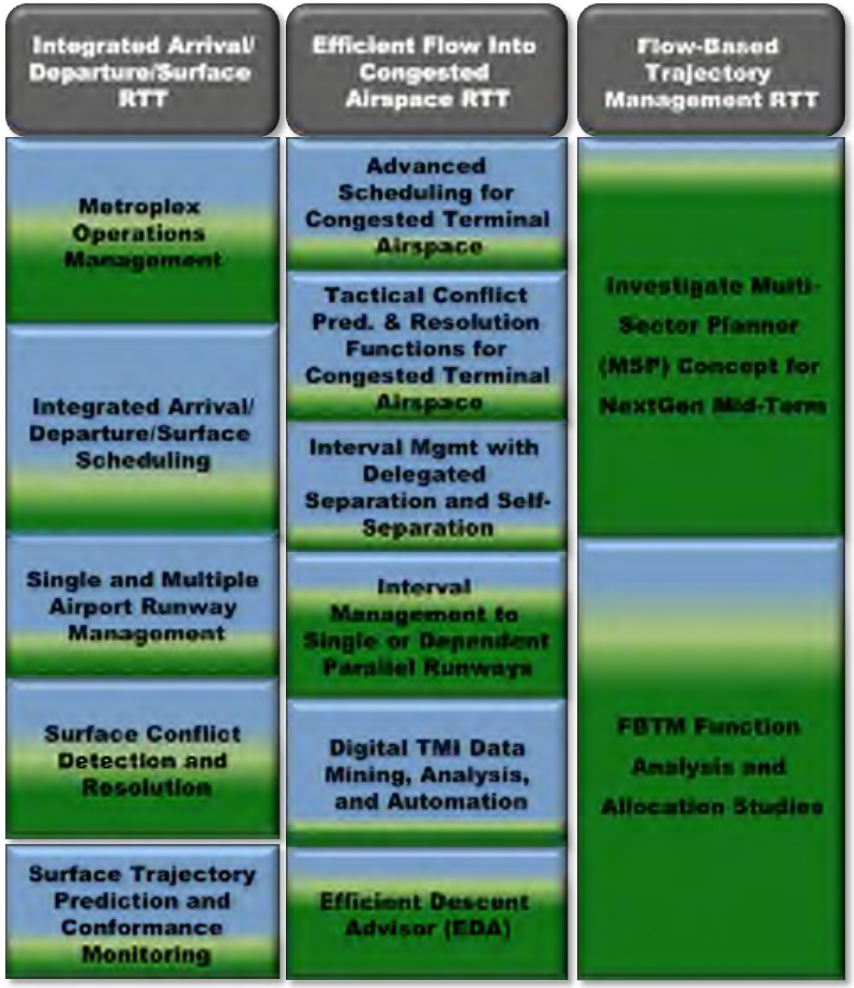
- Maturing foundational research requires additional efforts and integration of operational skill mixes to be teamed with researchers ("idea to implementation")
- Transition of research concepts and technologies is more complex than handing a finished research product to a stakeholder

Research Threads

- Flow-Based Trajectory Management (FBTM) Research Transition Team (RTT)
- Efficient Flow Into Congested Airspace (EFICA) RTT
- Integrated Arrival/Departure/Surface (IADS) RTT

Research Being Pursued

- Multi-Sector Planner (MSP) requirements analysis – supports FBTM RTT
- Efficient Descent Advisor (EDA) simulations – supports EFICA RTT
- Interval Management – supports EFICA RTT
- Precision Departure Release Control (PDRC) – supports IADS RTT
- Airport surface optimization – supports IADS RTT



Research Focus Area
Interoperability Research (IR)

Problem

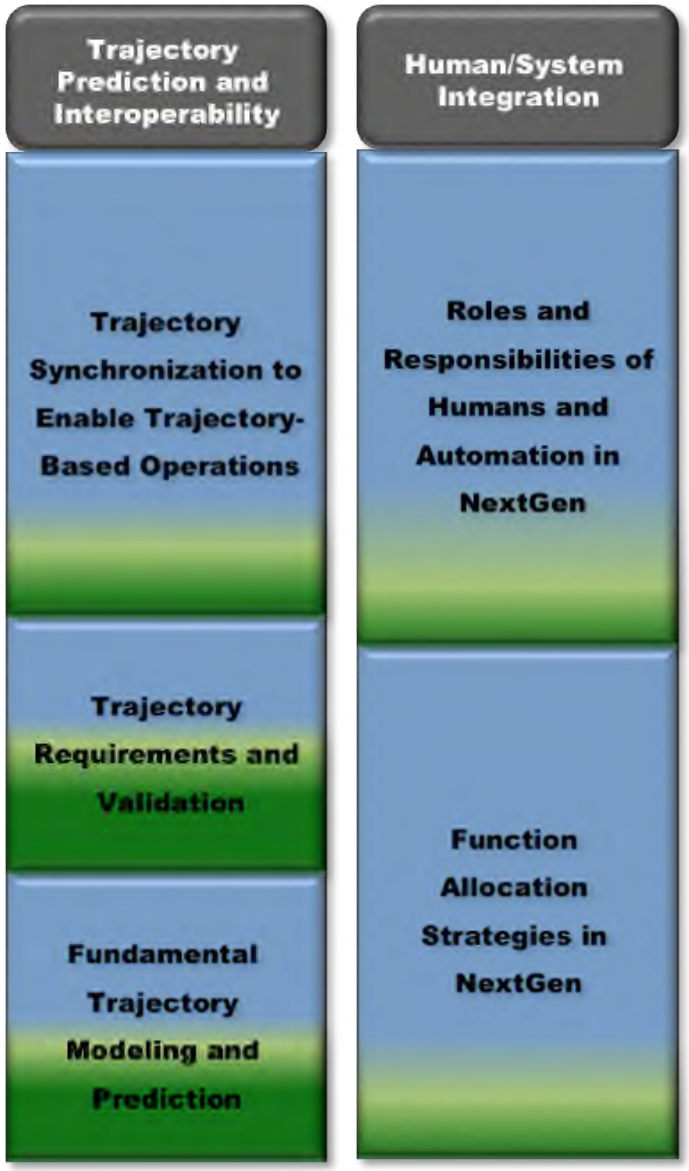
- Disparate flight and ground computers running trajectories created by various global stakeholders could create incompatible trajectory information
- Optimum allocation of roles between automation and humans unknown
- Optimum allocation of roles between air and ground automation unknown

Research Threads

- Trajectory Prediction and Interoperability (TPI)
- Human/System Integration (HSI)

Research Being Pursued

- TP Requirements/Uncertainty/Validation
- New Trajectory Modeling and Prediction Capabilities
- Interoperability Across Multiple Systems
- Human/Automation Function Allocation in NextGen
  - Current focus: Tool Development, Tower Controllers (continuation of previous Airportal-funded research)



Research Focus Area
System and Portfolio Analysis (SPA)

Problem

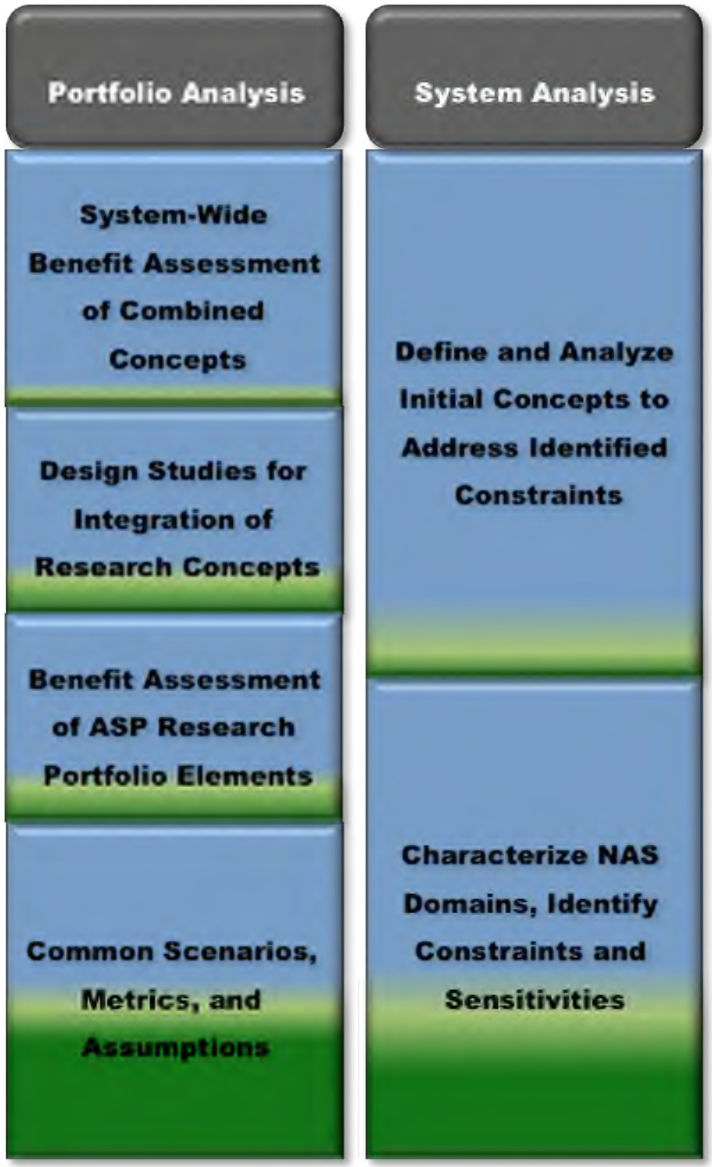
- Research is conducted on independent concepts and technologies in ASP portfolio and also needs to be analyzed with multiple concepts or at the system level for full benefits assessment
- The NAS is large and complex and the state-of-the-art knowledge must keep up as changes with new operations, operators, or operator behaviors continue to occur

Research Threads

- Portfolio Analysis
- System Analysis

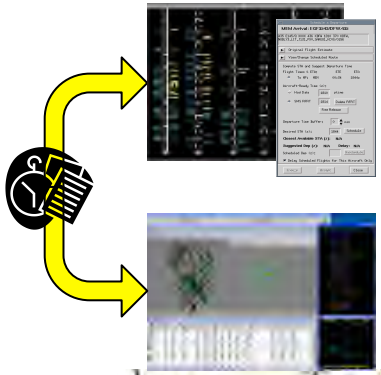
Research Being Pursued

- Benefits Assessment of maturing R&D technologies
- Portfolio Analysis
- Integration Design Studies
- System Level Assessments
- Domain Characterization and Constraint Analysis



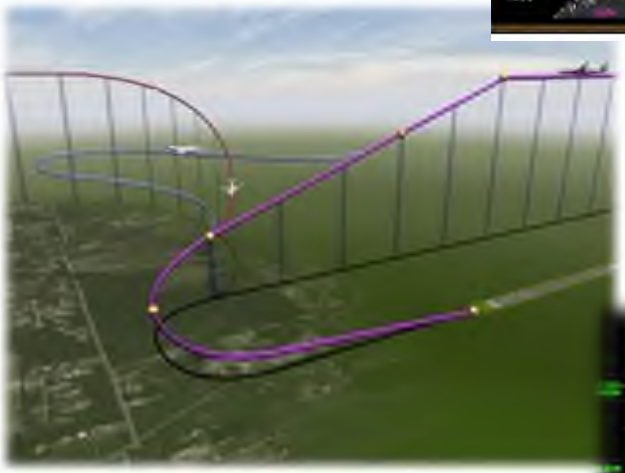
Research Transition Teams

- **<u>Efficient Flow into Congested Airspace</u>:** Joint collaboration with industry partners for near-term efficient and reduced environmental impact of arrival operations under constrained airspace conditions.
  - TFM (digital Traffic Management Initiatives) analysis
  - Time-based flow management
  - Merging and spacing (work with ATO-P and SBS office)
  - Efficient Descent Advisor (Human in the Loop simulations and Flight Trial data collection)
- **<u>Integrated Arrival/Departure/Surface:</u>** Develop system-level concepts to efficiently manage NextGen arrival/departure/surface operations for the mid-term.
  - Precision Departure Release Capability
  - Tactical Runway Configuration Management
  - NASA's NTX testbed coordination with FAA testbed
- **<u>Flow-Based Trajectory Management:</u>** Identifying the feasibility and benefits of a multi-sector planner position and associated planning tools.
- **<u>Dynamic Airspace Configuration:</u>** Develop far-term concept for efficient partitioning of airspace and allocation of resources to meet NextGen capacity needs.



Notional Integration of Technologies

Flight Deck Precision Spacing



Efficient Arrival Procedures

Controller Spacing Tools

Advanced Scheduling Methods