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**

- **Conflict Detection**
  - Algorithm Development & Performance Assessment
  - Integration of Tactical and Strategic CD&R (traffic, Wx, metering)

- **Conflict Resolution**
  - Algorithm Development & Performance Assessment
  - Mixed Operations Air/ Ground Combination

- **Trajectory based operations**
  - enabled by conflict detection and resolution

- **Human/Machine Air/ Ground Functional Allocations**
  - Final Report with functional allocation recommendations
  - Mixed Operational Off-Nominal
  - Homogenous Off-Nominal

- **Safety Assessment for CD&R Automation**
  - Validate and generate guidance related to safety assurance methods for higher automation
  - Analysis of Existing Algorithms
  - Developing Safety Methods Applicable for Higher Levels of Automation

**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**
- **Multiple Runways**
- **Crossing Runways**
- **Parallel Runways (Integrated Scheduling & Merging & Spacing)**
- **Single Runway Scheduling, Merging & Spacing**
- **Aircraft Energy Navigation to support efficient approaches**
- **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
**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)

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### Major Research Threads

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<th>Capacity Management</th>
<th>Generic Airspace Operations</th>
<th>Corridors-in-the-Sky Design to Increase Efficiency</th>
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<tr>
<td>Address Demand/ Capacity Imbalance by Capacity Management</td>
<td>Develop Requirements for Technologies &amp; Procedures to Support Generic Airspace Operations</td>
<td>Develop Requirements for Technologies &amp; Procedures to Support Corridors-in-the-Sky</td>
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<tr>
<td>Validate Algorithm</td>
<td>Conduct Generic Airspace Operations Benefits Analysis</td>
<td>Conduct Corridors-in-the-Sky Benefits &amp; Feasibility Analysis</td>
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<tr>
<td>Examine the Feasibility and Benefits of Airspace Boundary Adjustments</td>
<td>Conduct Studies To Identify Scope and Limits of Generic Airspace Operations</td>
<td>Develop Algorithms to Identify Corridors-in-the-Sky</td>
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<tr>
<td>Develop Concepts for Airspace Capacity Management</td>
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**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)

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### Major Research Threads

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<th>Research Focus</th>
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<td>Improve Efficiency by Optimizing Surface Movement</td>
<td>Improvement in surface movement efficiency</td>
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<tr>
<td>Reduce Uncertainty &amp; Improve Taxi Conformance By Better Trajectory Prediction</td>
<td>Enhanced taxi conformance</td>
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<tr>
<td>Improve Safety by Surface Traffic Conflict Detection &amp; Resolution (CD&amp;R)</td>
<td>Safety enhancement in surface traffic operations</td>
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**Problem**

- Surface operations become inefficient under high density operations
- Static procedures limit flexibility, efficiency, and cause imbalance in runway loads
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**Research Being Pursued**

- Concepts, algorithms, experiments, and analysis for surface traffic optimization
- Algorithms, analysis, and experiments for surface trajectory prediction and taxi conformance monitoring
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**Partners:** FAA, NRAs (Mosaic ATM, Metron, Georgia Tech)
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

- **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.
  - 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)

- **Integrated Arrival/Departure/Surface:** 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

- **Flow-Based Trajectory Management:** Identifying the feasibility and benefits of a multi-sector planner position and associated planning tools.

- **Dynamic Airspace Configuration:** 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