Agenda

- Background
- Concept of Operations
- Independent Assessment
- Stakeholder Review
- Operational Improvement Roadmaps
- Additional Questions
NGATS CONOPS Purpose

- Common view of how the NGATS will operate in the 2025 timeframe,
- Highlight key differences from today’s operations,
- Identify key research and policy issues that need to be resolved in achieving national goals for air transportation

... baseline to initiate a dialog with the stakeholder community in order to prioritize and synchronize investments
Background

- **Scope: Block to Block**
  - Air Navigation Service Provider (ANSP) and Flight Operator focus

- **Next Version completes the NGATS story with:**
  - Airports, Security, Safety, Weather and Environment

- **Developed jointly by NGATS Institute and Federal members of IPTS**

- **Single set of concepts - range of advanced operations**
  - Selected for ability to meet the goals in the national plan
  - Selected “most transformational”
  - Concept refinement and evolution through:
    - Stakeholder review, research results, and policy decisions
CONOPS “To-Do” Items

• Synchronize CONOPS with other JPDO products
  – Enterprise Architecture
  – NGATS Business Case
  – Operational Improvement Roadmaps
• Complete the Story
• Add “flight threads” and ANSP Mission Support
• Address Independent Review Comments
  – Discussed later
Key Transformational Elements for ATM Operations

Minimize Weather Impact
Advanced Aircraft Capabilities
Separation Management

Collaboration between NAS Users & ANSP
Performance-Based Operations & Services

Efficient Surface Operations
Dynamic Airspace Allocation

Network-Centric Information Sharing
Air-Ground Data Communications

Enablers

Information Services Transformation
Improved Aeronautical Information Services
Improved Wx Products
Improved Navigation Services
Improved Surveillance Services
Flow Strategy & Trajectory Impact Analysis
Intelligent Decision Support
Flight Planning Services
Infrastructure Management

Advanced ANSP Capabilities
Key Transformational Elements for ATM Operations

- Minimize Weather Impact
- Collaboration between NAS Users & ANSP
- Efficient Surface Operations
- Dynamic Airspace Allocation
- Advanced Aircraft Capabilities
- Separation Management
- Trajectory-based Operations
- Performance-based Operations & Services

• User-driven: assets allocated to best performance
• Performance-based services provide benefits to more capable aircraft
• Improved negotiation
• Separation standards based on aircraft performance, capabilities, geometry, and environment
• Capacity maintained during low demand
• Exchange and execute 4DTs
• A large percentage of aircraft flying in trajectory-based ops airspace can meet demand
• Some aircraft have delegated separation capability

- Different aircraft capability and performance accommodated
- Wake vortex separation
- Separation boundaries independent of airspace
- Trajectory-specific adjustments for a large percentage of aircraft flying in trajectory-based ops airspace can meet needs (temporal, geographic, performance)
- Wake vortex separation
- Separation capability
- Wake vortex separation
- Trajectory-specific adjustments for a large percentage of aircraft flying in trajectory-based ops airspace can meet needs (temporal, geographic, performance)
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- Wake vortex separation
- Trajectory-specific adjustments for a large percentage of aircraft flying in trajectory-based ops airspace can meet needs (temporal, geographic, performance)
Air Navigation Service Operations

• Major Themes
  – Performance Based Services/Trajectory Based Operations are key mechanisms
    • Enables reduced complexity in increased capacity
    • Enables scaling of NAS to predicted demand
  – ANSP and flight crew become more strategic
    • ANSP manage flows and trajectories
    • decision support tools to provide context-sensitive ATM information
    • automation performs routine tasks
      – Systems monitor separation in most trajectory based operations
  – Flexible Airspace/Operations
    • low demand – low requirements
    • high demand – high requirements
  – Higher performance used to manage capacity when needed
Four Dimensional Trajectory (4DT)

- **4DT Agreement**: Represents an agreed-to trajectory between the Operator and the ANSP
- **4DT Proposal**: Represents a potential change suggested by the Operator or the ANSP
Examples of 4DTs
Trajectory Based Operations

• Major Themes
  – 4 dimensional trajectories (4DT)
    • Used for information exchange, planning, analysis, agreements
  – Controlled Time of Arrive (CTA)
  – Flexible volumes
    • Flexibility to maneuver within volume
    • Used to predict demand
    • Limit impact of self separating a/c in dense airspace

– Airspace & A/C Trajectory Management
  • Capacity Management (CM)
  • Flow Contingency Management (FCM)
  • Tactical Trajectory Management (TTM)
  • Tactical Separation Management (TSM)
Trajectory Based Operations, cont.

Strategic
- Airspace Organization and Management
- Airport Operations
- Fleet and Schedule Planning
- Demand and Environmental Performance Balancing

Tactical
- Fleet and Schedule Planning
- Demand and Environmental Performance Balancing
- User Requested Profile
- Agreement
- Clearance
- Conformance Monitoring
- ANSP Service Delivery
- Projected Profiles/Planned Profiles

Separation Mgmt
- Tactical Separation Management
- Weather, Aggregate Flow, Airport Configuration/Infrastructure

ANSP Service Delivery

Conformance Monitoring

Clearance

User Requested Profile

Agreement

Projected Profiles/Planned Profiles

Weather, Aggregate Flow, Airport Configuration/Infrastructure
Interactive Airspace and Trajectory Management Process

Capacity Manager
- Design Airspace
- Assign Airspace

Flow Contingency Manager
- Identify Congestion
- Identify Demand/Capacity Imbalances
- Identify High Complexity
- Identify Constrained Airspace

Tactical Trajectory Manager
- Manage Trajectories w/in Flows
- Negotiate Trajectories
- Assign Routes, Runways
- Assign Sequencing, Spacing

Tactical Separation Manager
- Ensure Safe Separation

Years in advance to day-of-flight
- Days in advance to day-of-flight
- Several minutes (e.g., 20 mins) to 1 hour ahead
- Few minutes (e.g., 5 mins) look-ahead
Collaborative Traffic Flow Management

ANSP
- Predicted NAS performance
- Allocate Airspace & other assets, manage flows as needed
- NAS performance objectives
- Asset & Flow Strategies

Common flow strategy and trajectory impact analysis service

Iterate over time as conditions or objectives change

Capacity Management and Flow Management Plans & Strategies

Aircraft Operators
- Flight Plans with 4DTs
- 4DT impacts & constraint information
- Flight operator objectives, constraints, & preferred solutions
- Asset & Flow Strategies
Integrated Airspace Operations

• Classic Airspace
  - Just like today

• Trajectory Based Airspace
  - En Route
    • ANSP Flow Airspace
    • Flow Corridors
    • Autonomous Operations
  - Super Density Terminal
  - Flexible Terminal

• Tower and Surface
  - Staffed Virtual Towers
  - Automated Virtual Towers
Integrated Airspace Operations

Examples

- Near-Space Airspace
  - Autonomous Operations
    - Basic ANSP-managed operations
    - Constrained Airspace (e.g. weather, military ops, security, etc.)
    - Super-Density Transition Operations
  - Charted Super-Density Airspace
  - Flexible Terminal Operations
  - Classic Terminal Operations
  - Non-Managed Airspace

- Classic En Route Airspace
  - Classic Flow Operations
  - Classic Airspace

- Moving Constrained Airspace
  - ANSP Flow Operations
  - Trajectory-Based Airspace
  - Classic Airspace

- Super-Density Airspace
  - Flow Corridor Operations
  - Autonomous Operations
  - Trajectory-Based Airspace
  - ANSP Flow Operations

Next Generation Air Transportation System
Joint Planning and Development Office
# En Route - TBO

<table>
<thead>
<tr>
<th>Operation</th>
<th>Benefit</th>
<th>ANSP Capability</th>
<th>Aircraft Capability</th>
<th>Provision of Tactical Separation</th>
</tr>
</thead>
<tbody>
<tr>
<td>En-Route Trajectory-Based Operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ANSP flow operations</td>
<td>High traffic density</td>
<td>4DT exchange, including updates for TSM, TTM</td>
<td>Exchange &amp; execute 4DT, CTA, RNP, some aircraft have delegated separation capability</td>
<td>ANSP, may be automated and may be delegated by exception</td>
</tr>
<tr>
<td>• Flow corridors</td>
<td>Very high traffic density, Preferred routing ANSP productivity</td>
<td>4DT exchange, with reduced requirement for updates, TTM</td>
<td>Exchange &amp; execute 4DT, CTA, RNP, delegated separation capability</td>
<td>Procedural separation of corridor from other airspace, aircraft within corridor separate themselves</td>
</tr>
<tr>
<td>• Basic ANSP-managed operations</td>
<td>Accommodate wider range of aircraft capabilities</td>
<td>4DT exchange, TTM, TSM</td>
<td>Exchange &amp; execute basic 4DT</td>
<td>ANSP, supported by automation and may be delegated by exception</td>
</tr>
<tr>
<td>• Autonomous Operations</td>
<td>Preferred routing ANSP productivity</td>
<td>Reduced 4DT exchange</td>
<td>Exchange &amp; execute 4DT, CTA, RNP, full self-separation</td>
<td>Aircraft</td>
</tr>
</tbody>
</table>
# Classic Airspace

<table>
<thead>
<tr>
<th>Operation</th>
<th>Benefit</th>
<th>ANSP Capability</th>
<th>Aircraft Capability</th>
<th>Provision of Tactical Separation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Classic Airspace Operations</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>• Classic Operations</td>
<td>Accommodate all aircraft capabilities, preferred routing sometimes available for more capable aircraft</td>
<td>TTM, TSM</td>
<td>RNAV (most aircraft), some aircraft more capable</td>
<td>ANSP and may be delegated for some aircraft</td>
</tr>
<tr>
<td>• CDA, Other RNP trajectories (equipped aircraft only)</td>
<td>Reduced environmental impact, high throughput</td>
<td>4DT exchange, TTM, TSM</td>
<td>Exchange &amp; execute 4DT, CTA, RNP</td>
<td>ANSP and may be delegated for some aircraft</td>
</tr>
</tbody>
</table>
## Super Density Terminal

<table>
<thead>
<tr>
<th>Operation</th>
<th>Benefit</th>
<th>ANSP Capability</th>
<th>Aircraft Capability</th>
<th>Provision of Tactical Separation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Super Density Terminal Operations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Merging &amp; spacing</td>
<td>Arrival throughput match to runway capacity ANSP productivity</td>
<td>4DT exchange, TTM, TSM</td>
<td>Exchange &amp; execute 4DT, CTA, RNP, airborne spacing</td>
<td>ANSP, supported by automation and may be delegated for some aircraft</td>
</tr>
<tr>
<td>• CSPA, paired approaches</td>
<td>Closely spaced runways maintain VMC capacity in all visibility conditions</td>
<td>4DT exchange to establish aircraft on approach, TTM, TSM</td>
<td>Exchange &amp; execute 4DT, CTA, RNP, parallel runway procedures</td>
<td>ANSP, except between aircraft conducting approach</td>
</tr>
<tr>
<td>• CDA, Other RNP trajectories</td>
<td>Reduced environmental impact, high throughput</td>
<td>4DT exchange, TTM, TSM</td>
<td>Exchange &amp; execute 4DT, CTA, RNP</td>
<td>ANSP and may be delegated for some aircraft</td>
</tr>
</tbody>
</table>
Super Density Terminal Operations

- Procedures and reduced separation standards increase throughput
- Reduced impact on surrounding traffic flows
- Increase access to aircraft that can receive dynamic airspace boundary updates

Procedures include:
- Merging and spacing
- Parallel runway operations
- Low-visibility approach and departures
- Multiple aircraft on runways
- Wake vortex spacing
- Dynamic 4D routes
# Flexible Terminal Operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Benefit</th>
<th>ANSP Capability</th>
<th>Aircraft Capability</th>
<th>Provision of Tactical Separation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible Terminal Operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Basic arrival procedures</td>
<td>Accommodate all aircraft capabilities</td>
<td>TTM, TSM</td>
<td>Precision Approach to Cat 1, voice communications</td>
<td>ANSP and may be delegated for some aircraft</td>
</tr>
<tr>
<td>• Merging &amp; Spacing (equipped</td>
<td>Arrival throughput match to runway capacity</td>
<td>4DT exchange, TTM, TSM</td>
<td>Exchange &amp; execute 4DT, CTA, RNP, airborne spacing</td>
<td>ANSP and may be delegated for some aircraft</td>
</tr>
<tr>
<td>aircraft only)</td>
<td>ANSP productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• CDA, Other RNP trajectories</td>
<td>Reduced environmental impact, high throughput</td>
<td>4DT exchange, TTM, TSM</td>
<td>Exchange &amp; execute 4DT, CTA, RNP</td>
<td>ANSP and may be delegated for some aircraft</td>
</tr>
<tr>
<td>(equipped aircraft only)</td>
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</tbody>
</table>
Tower and Surface

• Increased traffic levels at many airports
  – Increased use of smaller airports
  – More operations for non-fixed-wing aircraft
  – More integrated ATM operations and air service planning

• Improved surface traffic management and safety
  – Automation integrates departures and arrivals to increase throughput
  – Aircraft capabilities improve surface movement guidance
  – CTAs used to improve efficiency where needed

• Virtual towers
  – Provide increased service at reduced cost
  – Eliminate requirement for visual monitoring of airports
    • Enable continued operation at low- or zero- visibility
  – Staffed virtual towers provide “full service” operations
  – Automated virtual towers provide sequencing guidance
Flight Operations

• Introduction
  – How operators use capabilities to achieve objectives
  – Less driven by regulation – more capability based

• Operators
  – Scheduled Operators
  – On-Demand Operators
  – Personal Aircraft Operators
  – State Aircraft Operators
NGATS Principles for Operators

- Accommodates a range of operator goals and business models
- Resources are managed to maximize utility to operators
- Restrictions are imposed only for reasons of projected congestion, security or safety.
- Broad, active participation in the C-TFM process
- Access to airspace and aerodromes is capability driven
- C-TFM - a transparent policy, known by all operators and stakeholders, provides the resolution to prioritize access to NGATS resources
- National objectives for the NGATS are considered in addressing access to NAS resources
Flight Operators

- For many aircraft, role of the flight crew evolves to:
  - Supervisory override, aircraft system manager, C-TFM participant

- IFR Operations:
  - The 4DT basis for operation
  - If the Operator intends to leave the flexibility zone, or cannot comply with the 4DT agreement, a new 4DT agreement needs to be made
  - Special accommodations to enable transit through trajectory-based airspace

- VFR flight operations are
  - Generally unrestricted, except when ANSP workload or other factors prohibit VFR access to certain airspace
  - VFR flights granted access to trajectory-based airspace, workload permitting
  - Electronic VFR operations are conducted like VFR flights, but with relaxed cloud clearance and visibility requirements
Operator Capabilities

- Most interactions between operator and ANSP are data communications.
  - service levels received depend on the sophistication of the systems that operators invest in.

- Service difference driven by:
  - ability to receive and request 4DT changes
  - ability to receive changes to airspace changes

- Aircraft/Airframe Capabilities
  - Area Nav
  - Air-to-ground Data Communications
  - Air-to-ground and air-to-air suveillance
Flight Management

• C-TFM
  – Revolutionized with machine-to-machine “negotiation” replacing the labor-intensive, telephone based process
  – Operator and ANSP automation fully inteegrated
    • Operators share information with ANSP via network enabled operations and common data
    • FOC provides ANSP with options and preferences for flights

• Collaborative Airspace Management
  – Dynamic Airspace status decreases reserved airspace
    • Lack of equipage for status reduces flexiblity
  – Operators participate in the definition and selection of capacity and flow strategies
  – Segregated airspace managed collaboratively
UAS, Vertical Flight, and Space Operations

- Unmanned Aircraft Systems (UAS)
  - Includes remotely operated and “autonomous” operations
  - UAS interoperate among crewed aircraft when
    - Can comply with 4DT trajectory management requirements
    - Cab “sense and avoid”, so other aircraft are not burdened with separation responsibility

- Vertical Flight Operations
  - Vertical flight capabilities incorporated into terminal departure and arrival trajectory planning

- Space operations have less impact on ATM operations
  - More precise geographic and time restrictions
  - More accurate allocation of airspace to match operations
  - Updates reduce disruption to affected traffic
What does this mean?

- Reliever to Reliever
  - Demand will dictate performance
- Small Airport to Reliever
  - Demand will dictate performance
- Small Airport to Small Airport
  - Automated Virtual Towers
Independent Assessment

• Recommendation of REDAC Subcommittee
• Members
  – Don Bateman, Honeywell
  – Dallas Denery, UCSC
  – R. John Hansman, MIT
  – Bob Peake, AirServices Australia
  – Dave Shaffer
  – Al Spain, JetBlue (ret)
• Charter
  – Assess Conops
  – Recommendations for improvement and risk reduction
General Observations

• Integration appears to be a challenge
  – Need JPDO to take system integration leadership
  – Buy-in from SPC members not sufficient

• Consensus approach will not get closure
  – Runs the same risk as Free Flight Task Force 3
  – Can’t keep everyone happy

• Integrated Plan goal need updating

• Products generally too complex
  – Products need consolidation
  – Abstraction of key issues

• Rationale and assumptions need to be explicit
Stakeholder Review

• Dates
  – August 24, 2006 through September 14, 2006

• Individual & Specific Comments
  – Web based comment form
    • http://techhanger.jpdo.aero
    • Register and comment

• Strategic view points from JPDO Board Members
  – Collective views on direction and implementation
  – If the view points don’t fit Web form
    • Contact Ed Waggoner or Jay Merkle
      – Phone: 202 220 3487
      – Email: Edgar.g.waggoner@nasa.gov or jay.merkle@faa.gov
NGATS Operational Improvement Roadmap

- NGATS Operational Improvement Roadmaps
  - Describe how the air transportation system will transform from the current system to the NGATS Concept described in the 2025 timeframe
  - Your input is essential

- NGATS OIs are on the web for stakeholder review
  - [http://techhanger.jpdo.aero](http://techhanger.jpdo.aero)
NGATS CNS/ATM Evolution

ATM Research

**FY05 & Earlier**
- 4DT & “Flight Object”
- Space Based NAV
- RNP/RNAV
- ADS-B/CDTI
- Decision Support Tools

**FY06 – FY11**
- 4DT Management
- RTSP & Levels of Service
- Equivalent Visual Ops (CDTI)
- Roles of Pilots & Controllers

**FY12 – FY17**
- Super Density Operations
- 4DT on Surface
- Right Sizing of Facilities

**FY18 & Later**
- Research for Beyond NGATS

---

### Establish NGATS Infrastructure

<table>
<thead>
<tr>
<th>Segments: 0,1,&amp;2</th>
<th>Develop: 06-11</th>
<th>Implement: 08-13</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Deploy critical infrastructure for NGATS operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ADS-B, DL, RNP, NEO</td>
<td></td>
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<tr>
<td>• Policy: Establish aircraft equipage rules</td>
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<tr>
<td>• NAS wide (ADS-B “OUT”, NAV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Airspace/Route access based on RTSP (CDTI, DL, Lower RNP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Commercial fleet equips for NGATS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Capacity benefits realized by those equipped and the system</td>
<td></td>
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</tr>
</tbody>
</table>

### Primary NGATS Operations

<table>
<thead>
<tr>
<th>Segments: 3,4,&amp;5</th>
<th>Develop: 12-17</th>
<th>Implement: 14-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Equipage of all aircraft completed for NGATS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Airspace/Route access and Level of Service based on RTSP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Most of NGATS capacity gains realized</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 4DT Management (Runway-to-Runway)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• VMC rates achieved in IMC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Delegation to flight deck for self-separation, merging, and passing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NGATS Super Density Operations

<table>
<thead>
<tr>
<th>Segments: 6 &amp; 7</th>
<th>Develop: 18-21</th>
<th>Implement: 20-23</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Airports network expanded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Capacities of congested airports further increased</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 4DT Management (Gate-to-Gate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Reduced Runway Lateral Spacing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Complete reduction of facilities and NAV &amp; surveillance infrastructure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Transition to NGATS

Enhanced System Operations to Meet NGATS Goals (Operations $)

Foundational Research, Applications Research, and Systems Engineering / Demonstrations
<table>
<thead>
<tr>
<th>Segment Operational by</th>
<th>Operational Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2012</td>
<td>● RNAV is available for all general aviation aircraft</td>
</tr>
<tr>
<td>2 2014</td>
<td>● RNP routes are available to/from all runways at OEP airports</td>
</tr>
</tbody>
</table>
| 3 2016 | ● CAT I/II approaches are available at all runway ends throughout the NAS without ground augmentation  
        ● Area navigation routes with lower RNP are available NAS-wide |
| 5 2020 | ● RNP routes are available to/from all runways at top 100 airports  
        ● CAT III approaches are available where needed, with augmentation |
| 6 2022 | ● RNP routes are available to/from all desired airports |
## Airspace Access and Management

<table>
<thead>
<tr>
<th>Segment Operational By</th>
<th>Operational Improvement</th>
</tr>
</thead>
</table>
| 1 2012                 | • RTSP serves as the basis for airspace and route access and level of service  
                        | • General aviation corridors are established in Class B airspace to ensure efficient and safe movement of aircraft |
| 2 2014                 | • Systems and airspace policies are in place that increase civilian access to SUA and flow restricted airspace |
| 4 2018                 | • Arrival/departure terminal airspace boundaries in large metro-area are dynamically configured to meet flow requirements |
| 5 2020                 | • Air-ground data communication (addressable and broadcast) is used to support improved access to SUA and flow restricted airspace  
                        | • Airspace is dynamically configured to meet flow requirements |
# 4D Trajectory Management

<table>
<thead>
<tr>
<th>Segment Operational By</th>
<th>Operational Improvement</th>
</tr>
</thead>
</table>
| 1 2012                 | - Flight planning is based on 4D trajectories for **commercial** aircraft that fly in high altitude airspace  
- Trajectories are available with variable separation to accommodate special classes of aircraft (e.g., UAS, A380) |
| 2 2014                 | - Flight planning is based on 4D trajectories for **all aircraft** that fly in high altitude airspace |
| 3 2016                 | - All aircraft in **high altitude airspace** are **managed** by 4D trajectories, with trajectories exchanged via data communications |
| 4 2018                 | - Management by 4D trajectories is expanded to **additional airspace**, with trajectories exchanged via data communications |
| 5 2020                 | - All aircraft departing from or arriving at OEP airports file 4D **runway-to-runway** trajectories  
- Trajectory management is enhanced by auto negotiation with properly equipped aircraft |
| 6 2022                 | - All aircraft departing from or arriving at OEP airports will file 4D **gate-to-gate** trajectories |
### Reduced Separation between Aircraft

<table>
<thead>
<tr>
<th>Segment Operational By</th>
<th>Operational Improvement</th>
</tr>
</thead>
</table>
| 1 2012                 | • 3-mile and 5-mile separation procedures are applied to **new airspace** based on RSP  
                        | • RSP standards are established for surface operations (control off glass) |
| 2 2014                 | • Oceanic longitudinal and lateral spacing is reduced to **15 X 15 nm** by use of RNP, ADS and data communications |
| 3 2016                 | • Lateral separation requirements are reduced for **converging and parallel runway operations** based on use of RTSP, CDTI and ADS-B |
| 4 2018                 | • Procedures based on RTSP for **less than 3 mile** separation are implemented  
                        | • Longitudinal arrival and departure spacing are dynamically adjusted at OEP airports, based on ground-based **wake vortex detection and prediction** |
| 5 2020                 | • 5 mile separation procedures are used in some **oceanic airspace** via enhanced CNS and CDTI (lower RTSP)  
                        | • Multiple runway occupancy procedures for single runway **arrivals** are available at all OEP airports |
| 6 2022                 | • Reduced arrival spacing (**with altitude offset**) is allowed for very closely spaced parallel runways at OEP airports  
                        | • Multiple runway occupancy procedures for single runway **departures** are available at all OEP airports |
| 7 2024                 | • Reduced arrival spacing (**co-altitude**) is allowed for very closely spaced parallel runways at appropriate OEP airports |
### Flight Deck Situational Awareness and Delegation

<table>
<thead>
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| 1 2012                 | - Oceanic pair-wise maneuvers (in-trail climbs, descents and passing maneuvers) are enabled through the use of ADS-B, CDTI and satellite-based communications  
- Increased use of visual approaches is supported by ADS-B and CDTI-aided visual separation (CAVS)  
- Self-spacing at near VFR levels on single runway approaches is enabled by CDTI, ADS-B  
- Departures rates in reduced visibility/ceilings are increased by use of ADS-B and CAVS |
| 2 2014                 | - Self spacing, merging and passing in *en route* airspace is allowed under certain conditions in certain airspace via CDTI, ADS-B |
| 3 2016                 | - Aircraft and ground vehicle movement on the airport surface in *low visibility* conditions is guided by moving map displays, CDTI, and ADS-B at OEP airports. |
| 5 2020                 | - Aircraft-to-aircraft separation is delegated to the flight deck in some *oceanic airspace* via CDTI and improved CNS and oceanic automation  
- High density *en route corridors (tubes)* are in use and are characterized by parallel tracks and delegation of separation responsibility to the flight deck via CDTI and ADS-B  
- Self-spacing with CDTI/ADS-B coupled with sequencing automation is in use at *non-towered* airports  
- Aircraft and ground vehicle movement on the airport surface in *zero/zero* visibility conditions is guided by moving map displays, CDTI, and ADS-B at OEP airports. |
| 6 2022                 | - Aircraft and ground vehicle movement on the airport surface in *low visibility* conditions is guided by moving map displays, CDTI, and ADS-B at *all desired* airports |
| 7 2024                 | - Aircraft and ground vehicle movement on the airport surface in *zero/zero* visibility conditions is guided by moving map displays, CDTI, and ADS-B at *all desired* airports |
## ATM Decision Support

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| 2 2014                 | - Departure Management incorporates surface traffic information reduces the time to develop and execute Traffic Management Initiatives (TMIs) and increases the predictability of departure times  
- Probabilistic weather information is incorporated into 4D trajectory flight planning decision support tools |
| 3 2016                 | - Timely and accurate weather information is available to all automated decision support tools  
- Arrival scheduling and sequencing tools are used to flow aircraft from en route airspace to individual arrival runways at all OEP airports  
- A Surface Management System is available at all OEP airports that uses automation, ADS-B, CDTI/aircraft moving map displays, and **data linked taxi instruction prior to pushback**  
- RTSP-based TMI allow “multiple TMI what-if analysis” and are incorporated into TFM automation |
| 4 2018                 | - Time-based and metered RNP routes are assigned by Decision Support Tools (DSTs) for aircraft arriving/departing at all OEP airports  
- A Surface Management System is available at all OEP airports that is used to generate **data linked taxi instructions prior to final approach**  
- Flight Operations Center (FOC) automation and net-centric data-sharing mechanisms are implemented with service providers to allow flight planning feedback and negotiation mechanism |
| 5 2020                 | - Integrated Arrival/Surface/Departure Manager improves decision making and flow management  
- Time-based surface traffic management is used at all OEP airports |
| 6 2022                 | - Time-based and metered RNP routes are assigned by DSTs for aircraft arriving/departing at the **top 100** airports |
## Improved Weather Data and Dissemination

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| 2012                   | ● Improved and automated upper-air wind and weather observations allow more accurate flight planning  
                          ● In-flight icing and turbulence forecasts are improved due to additional data from aircraft-based weather sensors  
                          ● New transoceanic weather products (e.g., convection, volcanic ash, in-flight icing, clear air turbulence, and convection-induced turbulence) are available  
                          ● Improved airport weather sensors support improved airport operations |
| 2014                   | ● A single national weather virtual database ensures a common aviation weather picture. This common picture enables improved NGATS decision making and leads to improved recovery from disruption  
                          ● Digital weather information are broadcast to the flight deck via UAT FIS-B |
| 2016                   | ● Robust network-centric disseminates weather information to users  
                          ● Enhanced Echo Top mosaic and forecast are available that facilitate over-the-top routing  
                          ● Improved weather forecasts are provided to minimize the predicted volume of airspace impacted by weather |
| 2018                   | ● Runway reconfiguration forecasts are improved through new sensors and improved forecast products  
                          ● Advisories, in-flight weather information, and alerts are immediately available to all system users (controller, pilots, airline operation centers, and airport operations managers) via net-centric architecture |
| 2020                   | ● A depiction of hazardous weather impacting the NAS is available to all users  
                          ● **Hazardous weather** information and alerts (particularly wind shear and microbursts) are provided to pilots and controllers by an Automatic Hazardous Weather Alert Notification System using voice circuits, ground based transceivers, and air-ground data communication |
## Reduced Cost to Deliver ATM Services

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| 1 2012                 | ● A decision is made regarding backup systems for surveillance and navigation  
                          ● NDB ground-based navigation aids are shut down |
| 2 2014                 | ● NAS-wide transition to ADS-B for air/ground surveillance is completed |
| 3 2016                 | ● VOR/DME ground-based navigation network is reduced to minimize sustainment costs and to reduce reliance on terrestrial-based systems |
| 4 2018                 | ● Arrival/departure terminal airspace boundaries and sectors in large metro-area are dynamically configured to increase resource efficiency and balance capacity with demand |
| 5 2020                 | ● En route airspace is dynamically reconfigured during the day within a facility to increase resource efficiency and balance capacity with demand  
                          ● Tower functions at all but high capacity airports are remoted (virtual towers)  
                          ● Terminal facilities are combined and reduced to 30-55 facilities |
| 7 2024                 | ● En route and terminal facilities are combined and reduced to 15 ground service delivery facilities  
                          ● ILS is shut down at all but CAT III approach locations |
Additional Questions?