

# Performance-Based Navigation

## Active Increments

### Portfolio Overview

Improvements in aircraft navigation performance provide an opportunity to increase efficiency and flexibility. The Performance-Based Navigation (PBN) portfolio addresses ways to leverage emerging technologies, such as RNAV and RNP, to improve access and flexibility for point-to-point operations.

The PBN portfolio reflects the intention to safely permit and enhance the flexibility of point-to-point operations, while allowing for the development and use of more efficient routes, procedures, and approaches that are free from the constraints of ground-based navigational aids (NAVAIDS).

Anticipated benefits include efficiency and predictability through the proliferation of PBN operations.

Note: The dates and timelines included in the NAS Segment Implementation Plan (NSIP) are for planning purposes only. All capability schedules are tentative until their supporting programs are officially baselined.

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 External Commitment     Primary Benefit     Secondary Benefit     Operationally Available     Complete 

 Access & Equity     Capacity     Flexibility     Efficiency     Environment     Predictability     Safety    **C** Charlie    **D** Delta    **E** Echo    **F** Foxtrot

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# Performance-Based Navigation

## Portfolio Content Summary Statistics

Segment	Total by Segment	Increment Status				
		Planned	Concept Exploration & Maturation	Development	Initial Operational Availability	Completed
*Alpha (2010 - 2015)	8	0	0	0	0	8
*Bravo (2016 - 2020)	3	0	0	0	0	3
Charlie (2021 - 2025)	4	0	1	1	0	2
Delta (2026 - 2030)	1	0	1	0	0	0
Echo (2031 - 2035)	1	0	0	1	0	0
Foxtrot (2036 - 2040)	0	0	0	0	0	0
<b>TOTAL</b>	<b>17</b>	<b>0</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>13</b>

Segment	% by Segment	% by Segment/Increment Status				
*Alpha (2010 - 2015)	47 %	0 %	0 %	0 %	0 %	100 %
*Bravo (2016 - 2020)	18 %	0 %	0 %	0 %	0 %	100 %
Charlie (2021 - 2025)	24 %	0 %	25 %	25 %	0 %	50 %
Delta (2026 - 2030)	6 %	0 %	100 %	0 %	0 %	0 %
Echo (2031 - 2035)	6 %	0 %	0 %	100 %	0 %	0 %
Foxtrot (2036 - 2040)	0 %	0 %	0 %	0 %	0 %	0 %
<b>TOTAL</b>	<b>100%</b>	<b>0 %</b>	<b>12 %</b>	<b>12 %</b>	<b>0 %</b>	<b>76 %</b>

\* Please see Appendix A and B for information about Alpha and Bravo Increments, respectively.

# Performance-Based Navigation

## Operational Improvements/Current Operations & Increments

## Benefits

### OI: [107120] Resilient PBN Operations (2021 - 2035)

**C** [107120-01] Resilient En Route PBN Operations for DME-Equipped Aircraft (2021 - 2030)



**E** [107120-03] Resilient PBN Operations In the Terminal Environment (2031 - 2035)



### OI: [108215] Increase Capacity and Efficiency Using Streamlined PBN Services (2021 - 2030)

**C** [108215-01] PBN Airways (2021 - 2025)



**C** [108215-02] Established-on-RNP Independent Duals and Triples with TF Procedures (2021 - 2025)



**C** [108215-05] Multiple Airport Route Separation (2023 - 2030)



### OI: [108216] Urban Air Mobility Airspace Access (2029 - 2035)

**D** [108216-01] Initial UAM Airspace Corridors (2029 - 2033)



External Commitment   Primary Benefit   Secondary Benefit   Operationally Available   Complete

Access & Equity   Capacity   Flexibility   Efficiency   Environment   Predictability   Safety   **C** Charlie   **D** Delta   **E** Echo   **F** Foxtrot



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2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040		
<b>OI: [107120] Resilient PBN Operations (2021 - 2035)</b>																					
<b>c</b> [107120-01] Resilient En Route PBN Operations for DME-Equipped Aircraft (2021 - 2030)																					
										<b>E</b> [107120-03] Resilient PBN Operations In the Terminal Environment (2031 - 2035)											
<b>OI: [108215] Increase Capacity and Efficiency Using Streamlined PBN Services (2021 - 2030)</b>																					
<b>c</b> [108215-01] PBN Airways (2021 - 2025) ✓																					
<b>c</b> [108215-02] Established-on-RNP Independent Duals and Triples with TF Procedures (2021 - 2025) 🚀✓																					
										<b>OI: [108216] Urban Air Mobility Airspace Access (2029 - 2035)</b>											
										<b>D</b> [108216-01] Initial UAM Airspace Corridors (2029 - 2033)											
<b>c</b> [108215-05] Multiple Airport Route Separation (2023 - 2030) 🚀																					

OI
Planned
CO
Concept Exploration & Maturation
COE/CBTE
Development
Initial Operation Available ✓
Complete ✓
C Charlie
 D Delta
 E Echo
 F Foxtrot
 🚀 External Commitment

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# Performance-Based Navigation

## OI: [107120] Resilient PBN Operations (2021 - 2035)

The ability to conduct PBN operations in the event of Global Navigation Satellite Service (GNSS) outages will be assured through the use of multiple mitigation strategies. These strategies will enable aircraft to continue to navigate using PBN en route and at our most economically important locations. The ability to assure that PBN operations will continue during GNSS outages or interference events will result in a more resilient NAS. If GNSS services become temporarily unavailable, appropriately equipped users can continue PBN operations. Without the ability to perform resilient PBN operations, lesser equipped users will navigate out of the outage area using conventional means or land at an airport within the outage area.

### OI Benefit

Access and Equity (P): Provide appropriately equipped users the ability to use PBN routes in the event of GNSS outage.

Efficiency (S): Provide users access to more efficient PBN routes during GNSS outages.

### Increments

**Charlie**  
(2021 - 2025)

1

**Echo**  
(2031 - 2035)

1

**C** [107120-01] Resilient En Route PBN Operations for DME-Equipped Aircraft (2021 - 2030) (Development)

**E** [107120-03] Resilient PBN Operations In the Terminal Environment (2031 - 2035) (Development)

 External Commitment  Primary Benefit  Secondary Benefit  Operationally Available  Complete   Access & Equity  Capacity  Flexibility  Efficiency  Environment  Predictability  Safety **C** Charlie **D** Delta **E** Echo **F** Foxtrot



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# Performance-Based Navigation

## Increments/Enabling Activities

**C** [107120-01] Resilient En Route PBN Operations for DME-Equipped Aircraft (2021 - 2030)

### Increment Overview

Appropriately equipped aircraft will be able to continue PBN operations in the en route environment during both wider space-based and localized GNSS interference events. The provision of DME coverage without gaps in Class A airspace will provide a resilient position and navigation service for the continuation of PBN navigation in en route airspace.

### Increment Status

Development

### Success Criteria

2027 : Complete Segment 1 - En Route Coverage

### Implementation Approach

The NextGen DME program will rely on existing and additional DMEs to fill coverage gaps and add the required redundancy, while some existing DMEs will be targeted for discontinuance as part of the program. The first segment is to provide En Route airspace coverage by the year 2021, and the second and third segments call for coverage of the terminal airspace and are covered in another increment.

#### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

Access and Equity (P): DME/DME equipped aircraft will continue PBN operations during a GNSS service disruptions where coverage is provided.

Efficiency (S): Provide users access to more efficient PBN routes during GNSS outages.

### System Interactions

LP/HP DME (P): This increment will be completed by installing DME facilities in line with the PBN Strategy.

DME Avionics (A): Aircraft need DME Avionics as a backup to navigate PBN procedures during a GPS outage.

#### Primary Systems

LP/HP DME: Distance Measuring Equipment : Low Power/High Power

#### Avionics Systems

DME Avionics: Distance Measuring Equipment Avionics

External Commitment   Primary Benefit   Secondary Benefit   Operationally Available   Complete

Access & Equity   Capacity   Flexibility   Efficiency   Environment   Predictability   Safety   **C** Charlie   **D** Delta   **E** Echo   **F** Foxtrot



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# Performance-Based Navigation

## Increments/Enabling Activities

**E** [107120-03] Resilient PBN Operations In the Terminal Environment (2031 - 2035)

### Increment Overview

Appropriately equipped aircraft will be able to continue PBN operations in the terminal environment during both wider space-based and localized GNSS interference events. The provision of DME coverage without gaps at economically important airports in the CONUS will provide a resilient position and navigation service for the continuation of PBN navigation in terminal airspace.

### Increment Status

Development

### Success Criteria

2029 : Complete Segment 2 - NSG 1 (15 Airports) and select NSG-2 (11 Airports) Coverage

2035 : Complete Segment 3 - NSG-2 (36 Airports) Coverage

### Implementation Approach

The NextGen DME program will rely on existing and additional DMEs to fill coverage gaps and add the required redundancy, while some existing DMEs will be targeted for discontinuance as part of the program. The first segment is to provide En Route airspace coverage and is covered in another increment. The second segment calls for coverage of the terminal airspace by 2025 at 15 NSG-1 airports and 11 NSG-2 airports and the third segment will provide terminal coverage at 36 additional NSG-2 airports at economically important airports.

### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

Access and Equity (P): DME/DME equipped aircraft will continue PBN operations during a GNSS service disruptions where coverage is provided.

Efficiency (S): Provide users access to more efficient PBN routes during GNSS outages.

### System Interactions

LP/HP (Low Power/High Power) DME (P): This increment will be completed by installing DME facilities in line with the PBN Strategy.

DME Avionics (A): Aircraft need DME Avionics as a backup to navigate PBN procedures during a GPS outage.

### Primary Systems

LP/HP DME: Distance Measuring Equipment : Low Power/High Power

### Avionics Systems

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
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# Performance-Based Navigation

## OI: [108215] Increase Capacity and Efficiency Using Streamlined PBN Services (2021 - 2030)

Leveraging lessons learned regarding community outreach, airspace efficiencies will be gained through the development and implementation of additional and advanced PBN services which provide more efficient aircraft trajectories and increase airspace capacity. PBN procedures will also be redesigned to streamline services in order to enable more optimal descents with time-based terminal sequencing and spacing tools.

The expansion of RNAV and RNP capabilities will enable additional locations to have the flexibility of point-to-point operations and allow for the development of routes, procedures, and approaches that are more efficient and free from the constraints and inefficiencies of the ground-based NAVAIDS. This will expand the benefits of RNAV and RNP to additional locations by providing safe and efficient procedures and airspace that address the complexities of the terminal operation through repeatable and predictable navigation. Where structure is needed, additional Q and T will be developed to replace jet routes and victor airway routes.

Additional advanced RNP procedures will be developed and implemented. As additional aircraft equip with advanced navigation capabilities, the implementation of RNAV and RNP routes at additional sites will be warranted.

In the metroplex environment, existing PBN procedures will be adjusted in order to increase the ability to perform more optimal routes with the aid of time-based sequencing and spacing tools.

### OI Benefit

Efficiency (P): Efficiency is improved through airspace design that allow for route placement in locations where they are needed rather than over ground-based NAVAIDS, allowing for more efficient routings and increased ability to accommodate optimal descent and ascents.

Access and Equity (P): Improved as PBN procedures allow access without the need for additional ground infrastructure.

Capacity (P): Additional routes and fewer conflicts between arrival and departure paths will increase airspace capacity.

Safety (S): Increasing navigation accuracy will result in repeatable and predictable navigation performance which will increase safety.

### Increments

Charlie  
(2021 - 2025)

3

**C** [108215-01] PBN Airways (2021 - 2025)  (Complete)

**C** [108215-02] Established-on-RNP Independent Duals and Triples with TF Procedures (2021 - 2025)  (Complete)

**C** [108215-03] Multi-Altitude Procedures (2021 - 2025)  (Complete)

 External Commitment  Primary Benefit  Secondary Benefit  Operationally Available  Complete   
 Access & Equity  Capacity  Flexibility  Efficiency  Environment  Predictability  Safety **C** Charlie **D** Delta **E** Echo **F** Foxtrot



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# Performance-Based Navigation

## Increments/Enabling Activities

**C** [108215-01] PBN Airways (2021 - 2025)

### Increment Overview

In airspace where structure is needed due to complexity and demand, more direct T and Q PBN routes will be added to replace Low Altitude Victor airways and high altitude Jet routes. These routes will provide more efficient aircraft trajectories that increase airspace capacity.

### Increment Status

Complete

### Success Criteria

- ✓ 2021 : Create an initial PBN Airways Plan for removal of J routes and V routes and conversion of J routes to Q routes and V routes to T routes where appropriate.
- ✓ 2022 : Complete initial conversion or removal of 52 V routes
- ✓ 2022 : Complete initial conversion or removal of 40 J routes

### Implementation Approach

Implemented through the removal of legacy routes (V and J) and replacement with T and Q routes as needed.

#### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

Access and Equity (P): Access is improved as PBN procedures allow access without the need for additional ground infrastructure.

Efficiency (P): Efficiency is improved through designs that allow for route placement in locations where they are needed rather than over ground-based NAVAIDS, allowing for more efficient routings.

### System Interactions

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
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# Performance-Based Navigation

ERAM (S): ERAM provides the controllers with air traffic control displays that are essential to maintaining aircraft separation. As the volume of air traffic increases in densely populated areas, controllers may require improved automation tools to manage their airspace.

GPS (T): GNSS provides precise Positioning, Navigation, and Timing (PNT) information to suitably equipped aircraft and is the principal enabler of two-dimensional PBN.

LP/HP DME (T): DME infrastructure is necessary to support continued PBN operations in the event of GNSS service disruptions.

DME Avionics (A): DME Avionics are a component for RNAV 2 resiliency in the case of GPS failure. DME Avionics can be a component in a certified RNAV system to fly Q routes.

FMS (A): FMS integrates the components of a certified RNAV system.

GNSS/GPS Avionics (A): Aircraft need GNSS/GPS Avionics in order to fly PBN T routes.

## Secondary Systems

● ERAM: En Route Automation Modernization

## Tertiary Systems

● LP/HP DME: Distance Measuring Equipment : Low Power/High Power

● GPS: Global Positioning System

## Avionics Systems

● DME Avionics: Distance Measuring Equipment Avionics

● GNSS/GPS Avionics: Global Navigation Satellite System/Global Positioning System Avionics

● SBAS (WAAS) Avionics: Satellite Based Augmentation System/Wide Area Augmentation System Avionics

● FMS: Flight Management System

External Commitment Primary Benefit Secondary Benefit Operationally Available Complete ✓  
Access & Equity Capacity Flexibility Efficiency Environment Predictability Safety C Charlie D Delta E Echo F Foxtrot



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# Performance-Based Navigation

## Increments/Enabling Activities

**C** [108215-02] Established-on-RNP Independent Duals and Triples with TF Procedures (2021 - 2025)

### Increment Overview

This increment includes development of Established-on-RNP for independent dual and triple approaches with Track-to-Fix procedures. RNP-established will allow suitably equipped RNP-capable aircraft to turn onto final to parallel runways using an RNP track-to-fix path without requiring 1000 feet of vertical or 3 nautical mile lateral separation. This would allow shorter downwind legs for the suitably equipped aircraft.

### Increment Status

Complete

### Success Criteria

✔ 2018 : Establish a new National Standard for Duals and Triples (DCP to paragraph 5-9-7 of 7110.65) that can be applied to TF procedures. This will satisfy a NAC/NIWG Commitment.

### Implementation Approach

Research leads to the creation of NAS-wide Document Change Proposals (DCPs). Implemented through the development of procedures and flight inspection.

#### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

Efficiency (P): Improvements in flight efficiency result from the ability to have consistent curved path approaches operating simultaneously to the same runway.

### System Interactions

TBFM (S): Metering needs to account for RNAV capable aircraft to the runway.

STARS (S): STARS provides controller displays and aids to monitor the Established on RNP (EoR) operations.

FMS (A): FMS must meet RNAV requirements.

#### Secondary Systems

- TBFM: Time Based Flow Management
- STARS: Standard Terminal Automation Replacement System

#### Avionics Systems

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- C** Charlie
- D** Delta
- E** Echo
- F** Foxtrot



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# Performance-Based Navigation

## Increments/Enabling Activities

**C** [108215-05] Multiple Airport Route Separation (2023 - 2030)

### Increment Overview

This increment increases the capacity and total throughput of a geographical area by extending the concept of monitored procedural separation used in Established on RNP (EoR) to multiple airports in close proximity. EoR is approved to separate aircraft on adjacent instrument approach flight procedure paths to parallel runways at one airport for simultaneous operations. MARS will allow controllers to use procedural separation between suitably equipped and capable aircraft on parallel RNP/RNAV routes without requiring 1000 feet of vertical or 3 nautical mile lateral separation between aircraft established on PBN procedures to or from adjacent airports. This would remove conflicts between routes to adjacent airports and, in some cases, allow for shorter routes. The capability may also be approved for departure interactions.

### Increment Status

Concept Exploration & Maturation

### Success Criteria

- 2019 : Complete Concept Exploration for Multiple Airport Route Separation (MARS). This will satisfy a NAC NEC Commitment.
- 2024 : Establish a new National Standard for MARS (DCP to JO 7110. 65) or a site specific waiver to the current National Standard.
- 2025 : Begin MARS operations at key site.

### Implementation Approach

Research leads to the creation of NAS-wide Document Change Proposals (DCPs) or a site specific waiver expanding the application of the current 7110. 65 to adjacent airports. Implemented through the development of procedures and flight inspection.

#### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

Capacity (P): Provide access to runways that could otherwise not be used due to nearby airport airspace use.

Efficiency (S): Improvements in flight efficiency result from the removal of constraints and route conflicts between adjacent airports in major metropolitan areas.

### System Interactions

STARS (S): STARS provides controller displays and aids to monitor the operations.

TBFM (S): Metering needs to account for RNP capable aircraft to the runway.

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
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# Performance-Based Navigation

## Secondary Systems

- STARS: Standard Terminal Automation Replacement System
- TBFM: Time Based Flow Management

## Avionics Systems

- FMS: Flight Management System

 External Commitment    Primary Benefit    Secondary Benefit    Operationally Available    Complete 

 Access & Equity    Capacity    Flexibility    Efficiency    Environment    Predictability    Safety   **C** Charlie   **D** Delta   **E** Echo   **F** Foxtrot



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# Performance-Based Navigation

## OI: [108216] Urban Air Mobility Airspace Access (2029 - 2035)

Urban Air Mobility (UAM) access to airspace is determined based on the performance level of the UAM operator’s vehicle and supporting services, and the rules which govern their operations in UAM corridors. UAM corridors are the primary mechanism of separation between UAM and air traffic controlled operations. Airspace management provides the availability status for UAM airspace corridors based on operational conditions, including competing aircraft flows into airports. In airspace corridors, requirements are established for UAM operators to make their position location available to other airspace users who are able to receive near real-time traffic and airspace status updates. The performance and participation requirements for UAM vehicles and operators may vary between UAM corridors and may change in order to optimize the capacity utilization of the airspace. Structure within corridors (e.g., “tracks”) may be implemented to support increased capacity needs in busy operational environments.

### OI Benefit

Safety (P): UAM airspace corridors provide a mechanism for segregating UAM from air traffic control operations so that they do not pose a safety risk to aircraft operations.

Access and Equity (P): UAM operators receive airspace access through airspace management practices that determine the availability status for UAM airspace corridors based on operational conditions, including competing aircraft flows into airports.

Capacity (S): The performance and participation requirements for UAM vehicles and operators are tailored to optimize the capacity utilization of the airspace.

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### Increments

Delta  
(2026 - 2030)

1

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## D [108216-01] Initial UAM Airspace Corridors (2029 - 2033) (Concept Exploration & Maturation)

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External Commitment   Primary Benefit   Secondary Benefit   Operationally Available   Complete

Access & Equity   Capacity   Flexibility   Efficiency   Environment   Predictability   Safety   Charlie   Delta   Echo   Foxtrot



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# Performance-Based Navigation

## Increments/Enabling Activities

**D** [108216-01] Initial UAM Airspace Corridors (2029 - 2033)

### Increment Overview

In certain geographical areas where the demand for UAM operations exceeds the available service levels afforded by current rules, regulations, and airspace availability, UAM corridors will be created to handle increased demand for service. Initial UAM airspace corridors will become available in cooperative areas that segment UAM cooperative operations from controlled air traffic. These initial corridors will be simple in design with unidirectional traffic or comprised of a single track in each direction. New procedures and flight rules will establish the performance requirements for aircraft within the corridor. Users will develop cooperative operating practice which will detail the agreed upon methods for planning and managing their operations. These practices will be reviewed and approved by the FAA. It is envisioned that aircraft operations within the corridor will be strategically de-conflicted pre-departure with users responsible for maintaining separation while in-flight.

### Increment Status

Concept Exploration & Maturation

### Success Criteria

To Be Defined

### Implementation Approach

#### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

Safety (P): UAM airspace corridors provide a mechanism for segregating UAM from air traffic control operations so that they do not pose a safety risk to aircraft operations.

Access and Equity (P): UAM operators receive airspace access through airspace management practices that determine the availability status for UAM airspace corridors based on operational conditions, including competing aircraft flows into airports.

Capacity (S): The performance and participation requirements for UAM vehicles and operators are tailored to optimize the capacity utilization of the airspace.

### System Interactions

To be determined

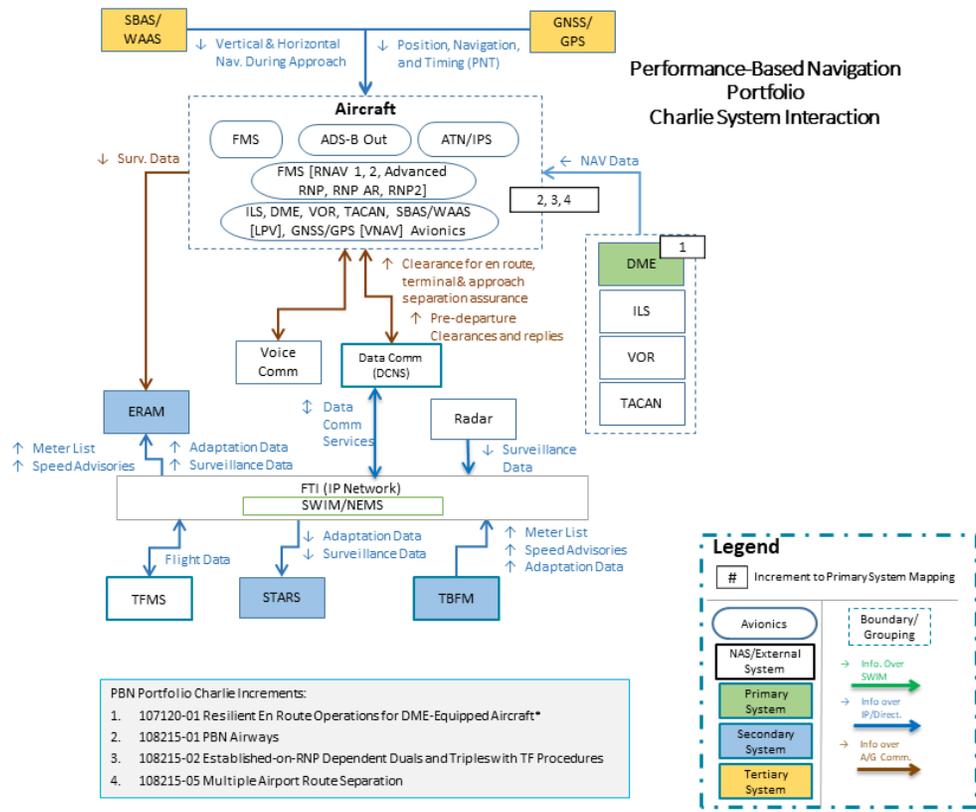
- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- Charlie
- Delta
- Echo
- Foxtrot



# Performance-Based Navigation

## Systems Interactions

PBN capabilities are enabled through a combination of legacy and new NAS services to include but are not limited to communications, navigation, surveillance, and automation. This figure depicts the primary enabling services and infrastructure necessary to enable PBN operations. A number of emerging capabilities and new technologies will be implemented to enable PBN capabilities. The functional connections among these programs are captured in the NAS Infrastructure section of this document and the Airspace and Procedures Roadmaps of the NAS EA. 222



# Performance-Based Navigation

Increment	DME Avionics	ERAM	FMS	GNSS/GPS Avionics	GPS	LP/HP DME	SBAS (WAAS) Avionics	STARS	TBFM
<b>c</b> [107120-01] Resilient En Route PBN Operations for DME-Equipped Aircraft	A					P			
<b>c</b> [108215-01] PBN Airways	A	S	A	A	T	T	A		
<b>c</b> [108215-02] Established-on-RNP Independent Duals and Triples with TF Procedures			A					S	S
<b>c</b> [108215-05] Multiple Airport Route Separation			A					S	S

Operationally Available

Complete

In Service System

Planned System

**P** Primary Systems

**S** Secondary Systems

**T** Tertiary Systems

**A** Avionics Systems

**c** Charlie

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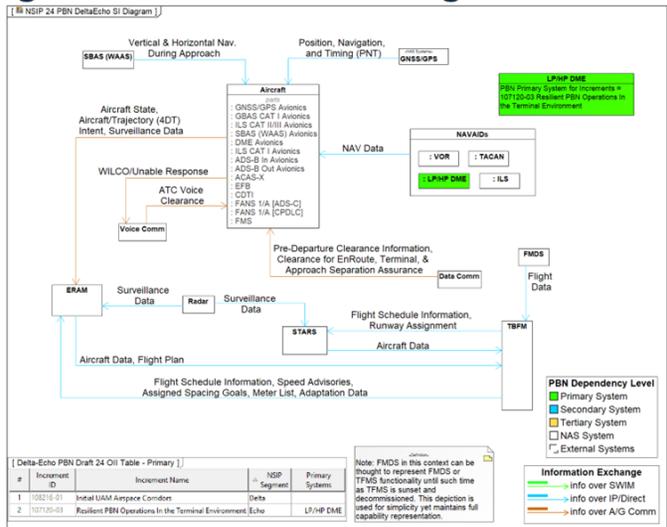


# Performance-Based Navigation

## Systems Interactions

PBN capabilities are enabled through a combination of legacy and new NAS services to include but are not limited to communications, navigation, surveillance, and automation. This figure depicts the primary enabling services and infrastructure necessary to enable PBN operations. A number of emerging capabilities and new technologies will be implemented to enable PBN capabilities. The functional connections among these programs are captured in the NAS Infrastructure section of this document and the Airspace and Procedures Roadmaps of the NAS EA. 222

### PBN SI Diagram – Delta & Echo Segments



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Increment

**D** [108216-01] Initial UAM Airspace Corridors

 Operationally Available

**P** Primary Systems

 Complete

**S** Secondary Systems

 In Service System

**T** Tertiary Systems

 Planned System

**A** Avionics Systems

**D** Delta

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NextGEN

# Performance-Based Navigation

## Stakeholders

Specific roles and responsibilities for the implementation of all increments are outlined in the RASCI (Responsible, Accountable, Supporting, Consulted, and Informed) matrix that follows below. All stakeholder organizations involved in the delivery of capabilities are listed across the top. Portfolio capabilities are listed on the left side of the table, organized by OI and increment. AAJV-1 is accountable and responsible, and AIR-100 and AFS-400 have responsibility, for the following increments: RNP and RNP AR Approaches, RNAV SIDs and STARs at Single Sites, Advanced and Efficient RNP, Metroplex, Large-Scale Redesign of Airspace, and Transition to PBN Routing. The design, implementation, and air traffic aspects of these capabilities will rely on support from AJT-2, ARP, AJM-32, and AEE and consultation with offices within ANG-C7, AJT-2, and ARP. ANG-C5 will provide F&E resource management and program management support for Metroplex and Advanced and Efficient RNP and is responsible for delivering the safety case for the latter. AJM-1 is accountable and responsible for implementing PBN Route Eligibility Check, in consultation with AOV and AFS-400. AJT supporting the implementation through automation development. ANG-C7 is consulted on all increments in this portfolio. APO provides support by developing policies for incentivizing operators for the increments RNP Approaches, RNAVSIDs/STARs, Metroplex, and PBN Route Eligibility Check. For the increment RNAV (GPS) Approaches, AJM-32 is accountable and responsible, AJV-3, AIR-130, and AFS-400 have responsible roles, and ARP, AEE, and APO provide support.

- A** Accountable for the completion of NextGen capability. The highest level within the RASCI matrix, this office is charged by the FAA to deliver a particular capability. Typically, this designation is provided via an Acquisition Program Baseline. To foster a clear line of accountability, two different offices can never be Accountable for the same increment, and Accountability can never be delegated to another office.
- R** Responsible for the successful completion of NextGen capability or a critical component of the capability. This office is responsible to the Accountable office. The Responsible office is responsible for initiating an actual change to the NAS such as automation changes, and is often also designated as the Accountable office for that increment. However, there are examples in the NSIP where one office is Accountable for an increment while another office (or offices) is actually making a change in the NAS on behalf of the Accountable office.
- A/R** Accountable for the completion of NextGen capability as well as Responsible for its implementation.
- S** Supports the Responsible office in the implementation of NextGen capability. Typically, this support is in the form of subject matter expertise, procedural guidance, or training activities.
- C** Consulted for input during the implementation of NextGen capability. Provides input on a specific aspect in the development and implementation of a capability, such as safety analysis or approval. Input may or may not be used as determined by the Responsible and Accountable offices.
- I** Informed about the progress of implementation.

 Operationally Available

 Complete

 External Commitment

 Charlie

 Delta

 Echo

 Foxtrot



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# Performance-Based Navigation

RASCI Matrix	ANG			AOV	APO	AJT		AJW	AJM			AJI				AFS		AAE	ARP	AIR	AJV
	C	C5	C7	001	001	2	0	1	322	32	3	0	1	2	3	001	400	001	001	001	0
<ul style="list-style-type: none"> <li><b>C</b> [107120-01] Resilient En Route PBN Operations for DME-Equipped Aircraft (2021 - 2030)</li> </ul>			C	C			S	C	A/R			S			S						
<ul style="list-style-type: none"> <li><b>C</b> [108215-01] PBN Airways (2021 - 2025)</li> </ul>			C																		A/R
<ul style="list-style-type: none"> <li><b>C</b> [108215-02] Established-on-RNP Independent Duals and Triples with TF Procedures (2021 - 2025) </li> </ul>		A/R	C			S						S	S		R	S	S	S	I		
<ul style="list-style-type: none"> <li><b>C</b> [108215-05] Multiple Airport Route Separation (2023 - 2030) </li> </ul>		A/R	C			S						S	S		R	S	S	S	I		
<ul style="list-style-type: none"> <li><b>D</b> [108216-01] Initial UAM Airspace Corridors (2029 - 2033)</li> </ul>																					
<ul style="list-style-type: none"> <li><b>E</b> [107120-03] Resilient PBN Operations In the Terminal Environment (2031 - 2035)</li> </ul>			C	C			S	C	A/R			S			S						

Operationally Available

Complete

External Commitment

**C** Charlie

**D** Delta

**E** Echo

**F** Foxtrot

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# Performance-Based Navigation

## Appendix A

### Alpha Increments

#### Portfolio Overview

Improvements in aircraft navigation performance provide an opportunity to increase efficiency and flexibility. The Performance-Based Navigation (PBN) portfolio addresses ways to leverage emerging technologies, such as RNAV and RNP, to improve access and flexibility for point-to-point operations.

The PBN portfolio reflects the intention to safely permit and enhance the flexibility of point-to-point operations, while allowing for the development and use of more efficient routes, procedures, and approaches that are free from the constraints of ground-based navigational aids (NAVAIDS).

Anticipated benefits include efficiency and predictability through the proliferation of PBN operations.

Note: The dates and timelines included in the NAS Segment Implementation Plan (NSIP) are for planning purposes only. All capability schedules are tentative until their supporting programs are officially baselined.

#### Portfolio Content Summary Statistics

Segment	Total by Segment	Increment Status				
		Planned	Concept Exploration & Maturation	Development	Initial Operational Availability	Completed
*Alpha (2010 - 2015)	8	0	0	0	0	8
<b>TOTAL</b>	<b>8</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>8</b>
Segment	% by Segment	% by Segment/Increment Status				
*Alpha (2010 - 2015)	100%	0 %	0 %	0 %	0 %	100 %
<b>TOTAL</b>	<b>100%</b>	<b>0 %</b>	<b>0 %</b>	<b>0 %</b>	<b>0 %</b>	<b>100 %</b>

External Commitment    
 Primary Benefit    
 Secondary Benefit    
 Operationally Available    
 Complete

Access & Equity    
 Capacity    
 Flexibility    
 Efficiency    
 Environment    
 Predictability    
 Safety    
 Alpha

# Performance-Based Navigation

## Operational Improvements/Current Operations & Increments

## Benefits

### CO: [107103] RNAV SIDs, STARs, and Approaches (2010 - 2016)

- A [107103-12] RNP Authorization Required (AR) Approaches (2010 - 2016) ✓
- A [107103-13] RNAV SIDs and STARs at Single Sites (2010 - 2016) ✓


### OI: [108209] Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP) (2010 - 2021)

- A [108209-12] Metroplex PBN Procedures (2014 - 2020) ✓
- A [108209-13] Large-Scale Redesign of Airspace Leveraging PBN (2010 - 2016) ✓
- A [108209-14] Transition to PBN Routing for Cruise Operations (2014 - 2021) ✓
- A [108209-18] PBN Route Eligibility Check (2012 - 2012) ✓
- A [108209-19] RNAV (GPS) Approaches (2010 - 2016) ✓
- A [108209-21] Equivalent Lateral Spacing Operation Standard (ELSO) (2015 - 2018) ✓


External Commitment	Primary Benefit	Secondary Benefit	Operationally Available	Complete ✓			
Access & Equity	Capacity	Flexibility	Efficiency	Environment	Predictability	Safety	Alpha



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# Performance-Based Navigation

2010	2011	2012	2013	2014	2015
<b>CO: [107103] RNAV SIDs, STARs, and Approaches (2010 - 2016)</b>					
[A] [107103-12] RNP Authorization Required (AR) Approaches (2010 - 2016) ✓					
[A] [107103-13] RNAV SIDs and STARs at Single Sites (2010 - 2016) ✓					
<b>OI: [108209] Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP) (2010 - 2021)</b>					
[A] [108209-12] Metroplex PBN Procedures (2014 - 2020) ✓					
[A] [108209-13] Large-Scale Redesign of Airspace Leveraging PBN (2010 - 2016) ✓					
[A] [108209-14] Transition to PBN Routing for Cruise Operations (2014 - 2021) ✓					
[A] [108209-18] PBN Route Eligibility Check (2012 - 2012) ✓					
[A] [108209-19] RNAV (GPS) Approaches (2010 - 2016) ✓					
[A] [108209-21] Equivalent Lateral Spacing Operation Standard (ELSO) (2015 - 2018) ✓					

■ Planned    
 ■ Concept Exploration & Maturation    
 ■ Development    
 ■ COE/CBTE    
 ■ Initial Operation Available ✓    
 ■ Complete ✓

■ OI

■ CO

■ Alpha

⬆️ External Commitment

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# Performance-Based Navigation

## CO: [107103] RNAV SIDs, STARs, and Approaches (2010 - 2016)

PBN is the framework for defining navigation performance along a route, during a procedure, or in an airspace. Progressive stages of PBN capabilities include the safe implementation of more closely spaced paths for departure, arrival, and approach that allow for improved operations and efficiency. Complementary efforts to new capabilities include NAS right-sizing activities that allow for the removal of non-beneficial procedures and infrastructure currently in place.

### CO Benefit

Access and Equity (P): Access is improved as PBN procedures allow access without the need for additional ground infrastructure.

Capacity (S): Capacity is increased by increasing the available route options into and out of airports.

Efficiency (P): PBN routing provides for more direct access to airports, optimized arrival and departure vertical profiles and reductions in lateral track distances allows for improved flight efficiency.

Predictability (S): Increased predictability of repeatable flight paths.

Environment (S): Improved descent profiles result in decreased emissions and fuel burn.

### Increments

Alpha  
(2010 - 2015)

2

A [107103-12] RNP Authorization Required (AR) Approaches (2010 - 2016)  (Complete)

A [107103-13] RNAV SIDs and STARs at Single Sites (2010 - 2016)  (Complete)

-  External Commitment
-  Primary Benefit
-  Secondary Benefit
-  Operationally Available
-  Complete 
-  Access & Equity
-  Capacity
-  Flexibility
-  Efficiency
-  Environment
-  Predictability
-  Safety
-  Alpha



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# Performance-Based Navigation

## Increments/Enabling Activities

**A** [107103-12] RNP Authorization Required (AR) Approaches (2010 - 2016)

### Increment Overview

RNP Authorization Required (AR) approaches are performance-based navigation operations that are implemented to meet the needs of the airspace users and airports in terms of efficiency, safety, and access. A key feature of RNP AR approaches is the ability to use curved path segments known as radius-to-fix (RF) inside the final approach segment. RNP AR is an optional capability that involves avionics and FAA AVS Headquarters aircraft and flight crew approvals.

Safety analysis will be conducted to help determine the feasible route spacing for these approaches based on equipage.

### Increment Status

Complete

### Success Criteria

- 2011 : Initially operationally available for all Operational Evolution Partnership (OEP) and non-OEP airports. Continue to implement as outlined in H.R. 658 Sec. 213.
- 2012 : Certify, Publish, and Implement 25% of the required procedures at the selected OEP airports as outlined in H.R. 658 Section 213 a.
- 2013 : Certify, Publish, and Implement 25% of the required procedures at the selected non-OEP airports as outlined in H.R. 658 Section 213 b.
- 2013 : Certify, Publish, and Implement 50% of the required procedures at the selected OEP airports as outlined in H.R. 658 Section 213 a.
- 2014 : Certify, Publish, and Implement 50% of the required procedures at the selected non-OEP airports as outlined in H.R. 658 Section 213 b.
- 2014 : Certify, Publish, and Implement 75% of the required procedures at the selected OEP airports as outlined in H.R. 658 Section 213 a.
- 2015 : Certify, Publish, and Implement 100% of the required procedures at the selected OEP airports as outlined in H.R. 658 Section 213 a.
- 2015 : Certify, Publish, and Implement 75% of the required procedures at the selected non-OEP airports as outlined in H.R. 658 Section 213 b.
- 2016 : Certify, Publish, and Implement 100% of the required procedures at the selected non-OEP airports as outlined in H.R. 658 Section 213 b.

### Implementation Approach

Implemented through the development of procedures and flight inspection.

 External Commitment	 Primary Benefit	 Secondary Benefit	 Operationally Available	 Complete 			
 Access & Equity	 Capacity	 Flexibility	 Efficiency	 Environment	 Predictability	 Safety	 Alpha

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# Performance-Based Navigation

Access and Equity (P): Access is improved as PBN procedures allow access without the need for additional ground infrastructure.

Efficiency (P): Efficiency is improved through designs that allow for route placement in locations where they are needed rather than over ground-based NAVAIDS, allowing for more efficient routes.

Environment (S): Environment is improved through reductions in emissions and fuel burn

## System Interactions

ERAM (S): ERAM provides the controllers with air traffic control displays that are essential to maintaining aircraft separation

STARS (S): STARS provides the controllers with air traffic control displays that are essential to maintaining aircraft separation

TBFM (S): TBFM is designed to improve the flow of aircraft within congested airspace

GNSS/GPS (T): GNSS provides precise Positioning, Navigation, and Timing (PNT) information to suitably equipped aircraft and is the principal enabler of two-dimensional PBN

SBAS/WAAS (T): WAAS provides aircraft guidance during approach procedure. The FAA's Satellite-Based Augmentation System (SBAS), WAAS, is used to improve the accuracy, integrity, and availability of basic GPS services to enable vertically guided LPV approach or horizontally guided LP approach operations. WAAS users also experience higher availability of service and therefore do not typically need IRUs, which provide a lower-cost avionics solution

Avionics: SBAS/WAAS, GNSS/GPS, FMS (RNP AR)

## Secondary Systems

- TBFM: Time Based Flow Management
- STARS: Standard Terminal Automation Replacement System
- ERAM: En Route Automation Modernization

## Tertiary Systems

- SBAS (WAAS): Satellite Based Augmentation System (Wide-Area Augmentation System)
- GPS: Global Positioning System

## Avionics Systems

- FMS: Flight Management System
- SBAS (WAAS) Avionics: Satellite Based Augmentation System/Wide Area Augmentation System Avionics
- GNSS/GPS Avionics: Global Navigation Satellite System/Global Positioning System Avionics

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- Alpha



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# Performance-Based Navigation

## Increments/Enabling Activities

**A** [107103-13] RNAV SIDs and STARs at Single Sites (2010 - 2016)

### Increment Overview

This increment covers PBN procedure improvements initiated and developed outside of the Metroplex and Large-Scale Redesign of Airspace Leveraging PBN increments. These RNAV procedures address location-specific requirements and seek to add efficiency and optimize existing initial capability PBN procedures.

### Increment Status

Complete

### Success Criteria

- ✓ 2011 : Initially operationally available for Operational Evolution Partnership (OEP) airports. Continue to implement as outlined in H.R. 658 Sec. 213 a.
- ✓ 2013 : Certify, publish, and implement 33% of the required procedures at OEP airports as outlined in H..R. 658 Section 213 a.
- ✓ 2014 : Certify, publish, and implement 66% of the required procedures at OEP airports as outlined in H..R. 658 Section 213 a.
- ✓ 2014 : Complete Las Vegas Basin assessment. This will satisfy a NAC/NIWG Commitment.
- ✓ 2015 : Certify, publish, and implement 100% of the required procedures at OEP airports as outlined in H..R. 658 Section 213 a.
- ✓ 2016 : Continue annual National Airspace and Procedures Team (NAPT) production plans to satisfy the goals outlined in H.R. 658 Sec. 213 b by completing procedures for the non-OEP airports.

### Implementation Approach

Implemented through the development of procedures and flight inspection.

#### Benefits

- Access & Equity Capacity Flexibility Efficiency Environment Predictability Safety

Access and Equity (P): Access is improved as PBN procedures allow access without the need for additional ground infrastructure

Capacity (S): Reduced Air Traffic Control (ATC) task complexity and pilot/controller communications due to reduced radar vectoring<

Efficiency (P): Optimization of arrival and departure vertical profiles and reductions in lateral track distances allows for improved flight efficiency

Environment (S): Environmental improvements through reductions in emissions and fuel burn

Predictability (P): Repeatable flight paths allow for increased predictability

- External Commitment Primary Benefit Secondary Benefit Operationally Available Complete Alpha
- Access & Equity Capacity Flexibility Efficiency Environment Predictability Safety



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# Performance-Based Navigation

STARS (S): STARS provides the controllers with air traffic control displays that are essential to maintaining aircraft separation

TBFM (S): TBFM is designed to improve the flow of aircraft within congested airspace

LP DME (T): DME is a legacy system that provides positioning service suitable for some PBN operations. Aircraft equipped with suitable RNAV avionics can use multiple DMEs to calculate their positions. Most air carrier, regional, and business aircraft are equipped with scanning DME avionics, allowing DME/DME RNAV as a suitable positioning source for RNAV operations

GNSS/GPS (T): GNSS provides precise Positioning, Navigation, and Timing (PNT) information to suitably equipped aircraft and is the principal enabler of two-dimensional PBN

SBAS/WAAS (T): WAAS provides aircraft guidance during approach procedure. The FAA's Satellite-Based Augmentation System (SBAS), WAAS, is used to improve the accuracy, integrity, and availability of basic GPS services to enable vertically guided LPV approach or horizontally guided LP approach operations. WAAS users also experience higher availability of service and therefore do not typically need IRUs, which provide a lower-cost avionics solution

Avionics: DME, GNSS/GPS, SBAS/WAAS

## Secondary Systems

- ERAM: En Route Automation Modernization
- TBFM: Time Based Flow Management
- STARS: Standard Terminal Automation Replacement System

## Tertiary Systems

- SBAS (WAAS): Satellite Based Augmentation System (Wide-Area Augmentation System)
- GPS: Global Positioning System
- LP/HP DME: Distance Measuring Equipment : Low Power/High Power

## Avionics Systems

- SBAS (WAAS) Avionics: Satellite Based Augmentation System/Wide Area Augmentation System Avionics
- GNSS/GPS Avionics: Global Navigation Satellite System/Global Positioning System Avionics
- DME Avionics: Distance Measuring Equipment Avionics

- 📍 External Commitment
- 🌐 Access & Equity
- 👤 Capacity
- 🕒 Flexibility
- 👤 Primary Benefit
- ✈️ Efficiency
- 🌱 Environment
- 📅 Predictability
- 🛡️ Safety
- 📌 Alpha
- ✅ Operationally Available
- 🟢 Complete



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# Performance-Based Navigation

## OI: [108209] Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP) (2010 - 2021)

Both RNAV and RNP will enable more efficient aircraft trajectories. RNAV and RNP, combined with airspace changes, increase airspace efficiency and capacity. Further efficiencies will be gained through the development and implementation of advanced criteria.

RNAV and RNP will permit the flexibility of point-to-point operations and allow for the development of routes, procedures, and approaches that are more efficient and free from the constraints and inefficiencies of the ground-based NAVAIDS. This capability can also be combined with an Instrument Landing System (ILS), to improve the transition onto an ILS final approach and to provide a guided missed approach. Consequently, RNAV and RNP will enable safe and efficient procedures and airspace that address the complexities of the terminal operation through repeatable and predictable navigation. These will include the ability to implement curved path procedures that can address terrain, and noise-sensitive and/or special-use airspace. Terminal and en route procedures will be designed for more efficient spacing and will address complex operations.

### OI Benefit

Efficiency (P): Efficiency is improved through airspace design that allow for route placement in locations where they are needed rather than over ground-based NAVAIDS, allowing for more efficient routings and increased ability to accommodate optimal descent and ascents.

Access and Equity (P): Improved as PBN procedures allow access without the need for additional ground infrastructure.

Capacity (P): Additional routes and fewer conflicts between arrival and departure paths will increase airspace capacity.

Safety (S): Increasing navigation accuracy will result in repeatable and predictable navigation performance which will increase safety.

### Increments

Alpha  
(2010 - 2015)

6

- A [108209-12] Metroplex PBN Procedures (2014 - 2020) (Complete)
- A [108209-13] Large-Scale Redesign of Airspace Leveraging PBN (2010 - 2016) (Complete)
- A [108209-14] Transition to PBN Routing for Cruise Operations (2014 - 2021) (Complete)
- A [108209-18] PBN Route Eligibility Check (2012 - 2012) (Complete)
- A [108209-19] RNAV (GPS) Approaches (2010 - 2016) (Complete)
- A [108209-21] Equivalent Lateral Spacing Operation Standard (ELSO) (2015 - 2018) (Complete)

External Commitment Primary Benefit Secondary Benefit Operationally Available Complete

Access & Equity Capacity Flexibility Efficiency Environment Predictability Safety Alpha



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# Performance-Based Navigation

## Increments/Enabling Activities

**A** [108209-12] Metroplex PBN Procedures (2014 - 2020)

### Increment Overview

This increment provides expected improvements from the Metroplex to include efficient descents, diverging departure paths, and decoupling of operations among airports within the metroplex airspace. The Metroplex project is a systematic approach to implementing PBN procedures and associated airspace changes in major metropolitan areas. The project focuses on the airspace surrounding a metropolitan or geographical area with multiple airports, including all types of operations, as well as connectivity with other metroplexes. Metroplex projects make use of existing aircraft equipment and utilize existing ground-based NAVAIDS as well as newer GPS-enabled technologies.

The timeline and focused scope of this initiative binds the airspace and procedures solutions to those that can be achieved without requiring an Environmental Impact Statement (e.g., requiring only an environmental assessment or categorical exclusion) and within current infrastructure and operating criteria. The metroplexes addressed under this activity have been defined in the RTCA Task Force 5 Final Report and have been prioritized using criteria and considerations developed with industry consensus.

### Increment Status

Complete

### Success Criteria

- ✓ 2014 : Complete Houston Metroplex implementation activities
- ✓ 2015 : Complete North Texas Metroplex implementation activities.
- ✓ 2015 : Complete Northern California Metroplex implementation activities. This will satisfy a NAC/NIWG Commitment.
- ✓ 2015 : Complete Washington DC Metroplex implementation activities.
- ✓ 2016 : Complete Atlanta Metroplex implementation activities. This will satisfy a NAC/NIWG Commitment.
- ✓ 2017 : Complete Charlotte Metroplex implementation activities. This will satisfy a NAC/NIWG Commitment.

### Implementation Approach

Implementation of Metroplex includes designing/ publishing procedures, conducting environmental assessment or CatEx planning by all impacted facilities and users, flight inspection of procedures, system adaptation, workforce training, and Industry participation/collaboration/training. Procedures may be implemented in one publication cycle or in multiple cycles.

### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- Alpha



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# Performance-Based Navigation

Access and Equity (P): Improved access to en route structure through additional PBN procedures.

Capacity (S): Reductions in lateral track distances.

Efficiency (P): Efficiency is improved through designs that allow for route placement in locations where they are needed rather than over ground-based NAVAIDS, allowing for more efficient routes.

## System Interactions

ERAM (S): ERAM provides the controllers with air traffic control displays that are essential to maintaining aircraft separation

STARS (S): STARS provides the controllers with air traffic control displays that are essential to maintaining aircraft separation

TBFM (S): TBFM is designed to improve the flow of aircraft within congested airspace. TBFM is a metering tool used for adjusting capacity/ demand imbalances at select airports and arrival fixes. It establishes a schedule with an assumed runway assignment and runway sequence for each arriving flight. It facilitates spacing/metering of aircraft that are assigned RNAV/PBN OPD arrivals

LP DME (T): DME is a legacy system that provides positioning service suitable for some PBN operations. Aircraft equipped with suitable RNAV avionics can use multiple DMEs to calculate their positions. Most air carrier, regional, and business aircraft are equipped with scanning DME avionics, allowing DME/DME RNAV as a suitable positioning source for RNAV operations

GNSS/GPS (T): GNSS provides precise Positioning, Navigation, and Timing (PNT) information to suitably equipped aircraft and is the principal enabler of RNAV/PBN/RNP procedures

SBAS/WAAS (T): WAAS provides aircraft guidance during approach procedure. The FAA's Satellite-Based Augmentation System (SBAS), WAAS, is used to improve the accuracy, integrity, and availability of basic GPS services to enable vertically guided LPV approach or horizontally guided LP approach operations. WAAS users also experience higher availability of service and therefore do not typically need IRUs, which provide a lower-cost avionics solution

DME (A) GNSS/GPS (A) SBAS/WAAS (A)

## Secondary Systems

- ERAM: En Route Automation Modernization
- TBFM: Time Based Flow Management
- STARS: Standard Terminal Automation Replacement System

## Tertiary Systems

- GPS: Global Positioning System
- LP/HP DME: Distance Measuring Equipment : Low Power/High Power
- SBAS (WAAS): Satellite Based Augmentation System (Wide-Area Augmentation System)

## Avionics Systems

- GNSS/GPS Avionics: Global Navigation Satellite System/Global Positioning System Avionics

External Commitment Primary Benefit Secondary Benefit Operationally Available Complete ✓  
Access & Equity Capacity Flexibility Efficiency Environment Predictability Safety Alpha



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# Performance-Based Navigation

## Increments/Enabling Activities

**A** [108209-13] Large-Scale Redesign of Airspace Leveraging PBN (2010 - 2016)

### Increment Overview

Airspace and procedures solutions that do not fit within the environmental and criteria boundaries of an OAPM project become candidates for other Integrated Airspace and Procedures efforts. Also included in this increment are the legacy Airspace Management Program projects. These include projects started prior to the formation of the National Operational Airspace Council in August 2009. These are the NY/NJ/PHL Metropolitan Area Airspace Redesign, Chicago Airspace Project, Houston Area Air Traffic System (HAATS), and the Las Vegas Optimization Project. Although these are considered legacy projects, many of the efficiencies and benefit gains will come from optimized PBN procedures.

### Increment Status

Complete

### Success Criteria

- ✓ 2010 : Completion of Stage 2A and completion of airspace designs for remaining stages.
- ✓ 2010 : Full implementation of HAATS.
- ✓ 2013 : Chicago Airspace Project - Implementation of Stage 3, coincident with runway 10C/28C completion under OHare Modernization Plan.
- ✓ 2014 : Successful Completion of RTCA TF5 4/21a32b-AP1 through 3. AP 2are complete.

### Implementation Approach

Implementation led by regions/facilities.

#### Benefits

 Access & Equity  Capacity  Flexibility  Efficiency  Environment  Predictability  Safety

Access and Equity (S): Access is improved as PBN procedures allow access without the need for additional ground infrastructure.

Environment (S): Environment is improved through reductions in emissions and fuel burn.

Safety (P): RNAV approach procedures allow aircraft to fly precise paths, increasing navigation accuracy and flight safety

### System Interactions

 External Commitment  Primary Benefit  Secondary Benefit  Operationally Available  Complete   Access & Equity  Capacity  Flexibility  Efficiency  Environment  Predictability  Safety  Alpha



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# Performance-Based Navigation

ERAM (S): ERAM provides the controllers with air traffic control displays that are essential to maintaining aircraft separation

STARS (S): STARS provides the controllers with air traffic control displays that are essential to maintaining aircraft separation

TBFM (S): TBFM is designed to improve the flow of aircraft within congested airspace

LP DME (T): DME is a legacy system that provides positioning service suitable for some PBN operations. Aircraft equipped with suitable RNAV avionics can use multiple DMEs to calculate their positions. Most air carrier, regional, and business aircraft are equipped with scanning DME avionics, allowing DME/DME RNAV as a suitable positioning source for RNAV operations

GNSS/GPS (T): GNSS provides precise Positioning, Navigation, and Timing (PNT) information to suitably equipped aircraft and is the principal enabler of two-dimensional PBN

SBAS/WAAS (T): WAAS provides aircraft guidance during approach procedure. The FAA's Satellite-Based Augmentation System (SBAS), WAAS, is used to improve the accuracy, integrity, and availability of basic GPS services to enable vertically guided LPV approach or horizontally guided LP approach operations. WAAS users also experience higher availability of service and therefore do not typically need IRUs, which provide a lower-cost avionics solution

DME (A)

GNSS/GPS (A)

SBAS/WAAS (A)

## Secondary Systems

- TBFM: Time Based Flow Management
- ERAM: En Route Automation Modernization
- STARS: Standard Terminal Automation Replacement System

## Tertiary Systems

- SBAS (WAAS): Satellite Based Augmentation System (Wide-Area Augmentation System)
- LP/HP DME: Distance Measuring Equipment : Low Power/High Power
- GPS: Global Positioning System

## Avionics Systems

- DME Avionics: Distance Measuring Equipment Avionics
- SBAS (WAAS) Avionics: Satellite Based Augmentation System/Wide Area Augmentation System Avionics
- GNSS/GPS Avionics: Global Navigation Satellite System/Global Positioning System Avionics

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- Alpha



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# Performance-Based Navigation

## Increments/Enabling Activities

**A** [108209-14] Transition to PBN Routing for Cruise Operations (2014 - 2021)

### Increment Overview

This increment provides PBN Q- (high) and T- (low) routes to replace the VHF Omni-directional Range (VOR)-based Jet and Victor airways. Additionally, point-to-point navigation will be utilized where feasible to provide flexibility for the operator as the primary method of navigation in regions where PBN ATS route utilization is not required, as determined by ATC needs. The determination of requirements for the end-state PBN route structure will be data driven, and based on factors such as traffic demand, airspace constraints, ATC task complexity, and potential operational efficiency gains in high traffic volume corridors. Other key focus areas include Q/T-route development connecting the terminal improvements in the metroplex environment and resolution of en route choke points. A small subset of conventional low-altitude ATS routes will likely be retained where unique navigational constraints exist.

### Increment Status

Complete

### Success Criteria

- ✓ 2015 : Complete FAA Internal draft of PBN Route Structure Concept of Operation (PBN RS CONOPS)
- ✓ 2016 : Design a regional network of high altitude PBN routes on the eastern seaboard in airspace meeting criteria for establishment of route structure outlined in the PBN RS CONOPs
- ✓ 2018 : Implement Southeastern Seaboard high altitude PBN routes (including SID/STAR connectivity).
- ✓ 2018 : Complete design for high altitude airspace throughput for PBN Q and Y routes from Northeast Corridor to San Juan
- ✓ 2023 : Implement Northeastern Seaboard high altitude PBN routes (including SID/STAR connectivity) in ZBW, ZNY and ZDC airspace. This will satisfy a NAC NEC commitment

### Implementation Approach

Implemented through the removal of legacy routes and replacement with structure where needed.

#### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

Access and Equity (P): Access is improved as PBN procedures allow access without the need for additional ground infrastructure.

Efficiency (P): Efficiency is improved through designs that allow for route placement in locations where they are needed rather than over ground-based NAVAIDS, allowing for more efficient routings.

### System Interactions

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Alpha
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety



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# Performance-Based Navigation

ERAM (S): ERAM provides the controllers with air traffic control displays that are essential to maintaining aircraft separation. As the volume of air traffic increases in densely populated areas, controllers may require improved automation tools to manage their airspace.

GPS (T): GNSS provides precise Positioning, Navigation, and Timing (PNT) information to suitably equipped aircraft and is the principal enabler of two-dimensional PBN.

SBAS (WAAS) (T): WAAS provides aircraft guidance during approach procedure. WAAS is used to improve the accuracy, integrity, and availability of basic GPS services to enable vertically guided LPV approach or horizontally guided LP approach operations. WAAS users also experience higher availability of service and therefore do not typically need IRUs, which provide a lower-cost avionics solution.

FMS (A): FMS must meet RNAV 2 or RNP 2 requirements.

GNSS/GPS Avionics (A), SBAS (WAAS) (A) Avionics

## Secondary Systems

● ERAM: En Route Automation Modernization

## Tertiary Systems

● GPS: Global Positioning System

● SBAS (WAAS): Satellite Based Augmentation System (Wide-Area Augmentation System)

## Avionics Systems

● SBAS (WAAS) Avionics: Satellite Based Augmentation System/Wide Area Augmentation System Avionics

● FMS: Flight Management System

● GNSS/GPS Avionics: Global Navigation Satellite System/Global Positioning System Avionics

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- Alpha



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# Performance-Based Navigation

## Increments/Enabling Activities

**A** [108209-18] PBN Route Eligibility Check (2012 - 2012)

### Increment Overview

This increment will enhance the controller's ability to assign the clearance to the pilot. The En Route Automation will check the eligibility of aircraft to operate on performance-restricted routes. Performance-restricted routes are identified in system adaptation using associated attributes that characterize the required performance. A filed flight plan or amendment with ineligible routes will be rejected, the ineligible portion replaced with an alternative route, or indication provided to the controller that the flight is ineligible for a portion of its flight.

### Increment Status

Complete

### Success Criteria

✔ 2013 : Operational capability at ZSE and ZLC.

### Implementation Approach

The PBN Route Eligibility capability is provided by ERAM via its Release 3 baseline.

#### Benefits

Access & Equity Capacity Flexibility Efficiency Environment Predictability Safety

Capacity (S): Appropriately equipped aircraft have access to performance restricted routes, without creating additional workload for controllers, which will allow for increased capacity

Efficiency (P): Efficiency is improved through controller knowledge on avionics available per flight

### System Interactions

ERAM (S): ERAM provides the controllers with air traffic control displays that are essential to maintaining aircraft separation

#### Secondary Systems

ERAM: En Route Automation Modernization

External Commitment Primary Benefit Secondary Benefit Operationally Available Complete   
 Access & Equity Capacity Flexibility Efficiency Environment Predictability Safety Alpha



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# Performance-Based Navigation

## Increments/Enabling Activities

**A** [108209-19] RNAV (GPS) Approaches (2010 - 2016)

### Increment Overview

Area Navigation (RNAV) approach procedures allow aircraft to fly precise paths, with and without vertical guidance, providing airports with significant increases in access benefits, especially for runway ends not equipped with Instrument Landing System (ILS), and in flexibility, by providing an alternative instrument approach at airports with ILS. All RNAV (GPS) approach procedures require the aircraft to be equipped with suitable RNAV avionics with global positioning system (GPS) or the Wide Area Augmentation System (WAAS). RNAV (GPS) approaches include minima for lateral navigation (LNAV), lateral navigation with vertical navigation (LNAV/VNAV), localizer performance (LP), and localizer performance with vertical guidance (LPV). WAAS equipment is required to fly the LPV and LP minima. LP minima are published at runways where obstacles prohibit publishing an LPA minimum. RNAV (GPS) procedures can also include RF turns outside of the final approach segment. Implementation of RNAV (GPS) procedures with LPV or LP will continue until all qualified runway ends are served.

### Increment Status

Complete

### Success Criteria

- ✓ 2010 : Work with the aviation community to prioritize the schedule of runway ends slated to receive LPV procedures. This will satisfy RTCA TF5 22-AP2.
- ✓ 2011 : Operationally available LP approach at one airport. This will satisfy RTCA TF5 22-AP4.
- ✓ 2011 : Produce 496 WAAS LPV & LP procedures in FY11. This will satisfy RTCA TF5 22-AP1.
- ✓ 2012 : Complete a study to re-evaluate the airport infrastructure requirements for LPV approaches with minima down to 200 feet. This will satisfy RTCA TF5 22-AP3.
- ✓ 2012 : Produce 542 WAAS LPV & LP procedures in FY12. This will satisfy RTCA TF5 22-AP1.
- ✓ 2013 : Produce 483 WAAS LPV & LP procedures in FY13. This will satisfy RTCA TF5 22-AP1.
- ✓ 2014 : Produce 212 WAAS LPV & LP procedures in FY14. This will satisfy RTCA TF5 22-AP1.
- ✓ 2015 : Produce 100 WAAS LPV & LP procedures in FY15. This will satisfy RTCA TF5 22-AP1.
- ✓ 2016 : Produce approximately 100 WAAS LPV & LP procedures in FY16. This will satisfy RTCA TF5 22-AP1.

### Implementation Approach

Implemented through the development of procedures and flight inspection.

#### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

Access and Equity (P): Access is improved as PBN procedures allow access without the need for additional ground infrastructure

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- Alpha



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# Performance-Based Navigation

ERAM (S): ERAM provides the controllers with air traffic control displays that are essential to maintaining aircraft separation

STARS (S): STARS provides the controllers with air traffic control displays that are essential to maintaining aircraft separation. As the volume of air traffic increases in densely populated areas, controllers may require adaptation changes to existing systems to accommodate RNAV (GPS) approaches

TBFM (S): TBFM is designed to improve the flow of aircraft within congested airspace

LP DME (T): DME is a legacy system that provides positioning service suitable for some PBN operations. Aircraft equipped with suitable RNAV avionics can use multiple DMEs to calculate their positions. Most air carrier, regional, and business aircraft are equipped with scanning DME avionics, allowing DME/DME RNAV as a suitable positioning source for RNAV operations

GNSS/GPS (T): GNSS provides precise Positioning, Navigation, and Timing (PNT) information to suitably equipped aircraft and is the principal enabler of two-dimensional PBN

SBAS/WAAS (T): WAAS provides aircraft guidance during approach procedure. WAAS is used to improve the accuracy, integrity, and availability of basic GPS services to enable vertically guided LPV approach or horizontally guided LP approach operations. WAAS users also experience higher availability of service and therefore do not typically need IRUs, which provide a lower-cost avionics solution

DME (A)

GNSS/GPS (A)

SBAS/WAAS (A)

## Secondary Systems

- STARS: Standard Terminal Automation Replacement System
- TBFM: Time Based Flow Management
- ERAM: En Route Automation Modernization

## Tertiary Systems

- LP/HP DME: Distance Measuring Equipment : Low Power/High Power
- SBAS (WAAS): Satellite Based Augmentation System (Wide-Area Augmentation System)
- GPS: Global Positioning System

## Avionics Systems

- GNSS/GPS Avionics: Global Navigation Satellite System/Global Positioning System Avionics
- DME Avionics: Distance Measuring Equipment Avionics

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- Alpha



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# Performance-Based Navigation

## Increments/Enabling Activities

**A** [108209-21] Equivalent Lateral Spacing Operation Standard (ELSO) (2015 - 2018)

### Increment Overview

This increment increases departure efficiency, increases throughput and reduces departure delays by capitalizing on improved navigational precision of PBN operations and more design options when developing departure procedures. ELSO enables reduced-divergence departure operations of 5 to 10 degrees instead of the current requirement for 15 degrees, and better accommodates airspace and environmental constraints.

### Increment Status

Complete

### Success Criteria

- ✓ 2014 : Implement ELSO capability at one location in NAS. This will achieve Initial Operational Availability.
- ✓ 2015 : Establish ELSO National Standard. This will satisfy a NAC/NIWG Commitment.
- ✓ 2016 : After publication of ATC rule changes implement at two additional locations as part of Metroplex or RNAV SID development activities

### Implementation Approach

Research leads to the creation of a Document Change Proposal (DCP) to the 7110.65. Implemented through the development of procedures and flight inspection.

### Benefits

- Access & Equity Capacity Flexibility Efficiency Environment Predictability Safety

Capacity (P): ELSO provides for additional departure capacity by providing additional departure heading options for ATC and operators.

Efficiency (P): ELSO provides flight efficiency by providing additional departure heading options for ATC and operators

### System Interactions

External Commitment   Primary Benefit   Secondary Benefit   Operationally Available   Complete ✓

Access & Equity   Capacity   Flexibility   Efficiency   Environment   Predictability   Safety   **A** Alpha

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# Performance-Based Navigation

STARS (S): STARS provides the controllers with air traffic control displays that are essential to maintaining aircraft separation.

TBFM (S): TBFM is designed to improve the flow of aircraft within congested airspace

LP DME (T): DME is a legacy system that provides positioning service suitable for some PBN operations. Aircraft equipped with suitable RNAV avionics can use multiple DMEs to calculate their positions. Most air carrier, regional, and business aircraft are equipped with scanning DME avionics, allowing DME/DME RNAV as a suitable positioning source for RNAV operations

GNSS/GPS (T): GNSS provides precise Positioning, Navigation, and Timing (PNT) information to suitably equipped aircraft and is the principal enabler of two-dimensional PBN

DME, GNSS/GPS (A)

## Secondary Systems

- STARS: Standard Terminal Automation Replacement System
- TBFM: Time Based Flow Management

## Tertiary Systems

- GPS: Global Positioning System
- LP/HP DME: Distance Measuring Equipment : Low Power/High Power

## Avionics Systems

- GNSS/GPS Avionics: Global Navigation Satellite System/Global Positioning System Avionics
- DME Avionics: Distance Measuring Equipment Avionics

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- Alpha



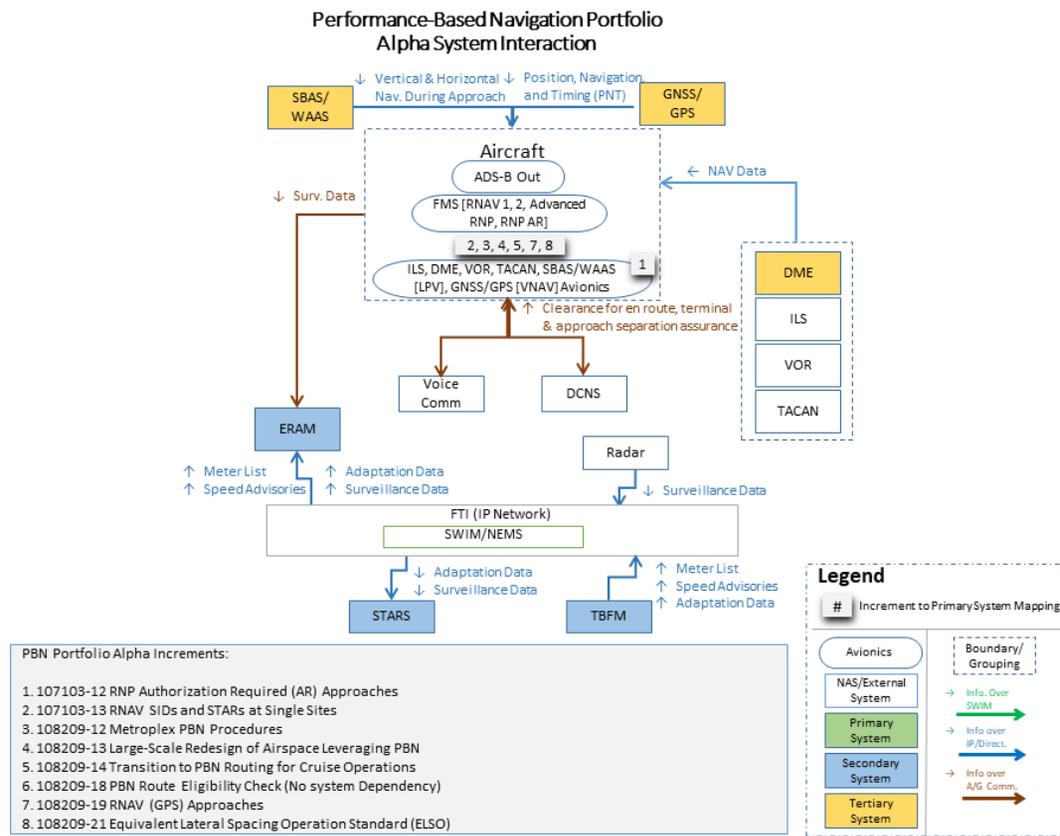
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# Performance-Based Navigation

## Systems Interactions

PBN capabilities are enabled through a combination of legacy and new NAS services to include but are not limited to communications, navigation, surveillance, and automation. This figure depicts the primary enabling services and infrastructure necessary to enable PBN operations. A number of emerging capabilities and new technologies will be implemented to enable PBN capabilities. The functional connections among these programs are captured in the NAS Infrastructure section of this document and the Airspace and Procedures Roadmaps of the NAS EA. 222



# Performance-Based Navigation

Increment	DME Avionics	ERAM	FMS	GNSS/GPS Avionics	GPS	LP/HP DME	SBAS (WAAS)	SBAS (WAAS) Avionics	STARS	TBFM
<b>A</b> [107103-12] RNP Authorization Required (AR) Approaches		S	A	A	T		T	A	S	S
<b>A</b> [107103-13] RNAV SIDs and STARs at Single Sites	A	S		A	T	T	T	A	S	S
<b>A</b> [108209-12] Metroplex PBN Procedures	A	S		A	T	T	T	A	S	S
<b>A</b> [108209-13] Large-Scale Redesign of Airspace Leveraging PBN	A	S		A	T	T	T	A	S	S
<b>A</b> [108209-14] Transition to PBN Routing for Cruise Operations		S	A	A	T		T	A		
<b>A</b> [108209-18] PBN Route Eligibility Check		S								
<b>A</b> [108209-19] RNAV (GPS) Approaches	A	S		A	T	T	T	A	S	S
<b>A</b> [108209-21] Equivalent Lateral Spacing Operation Standard (ELSO)	A			A	T	T			S	S

Operationally Available

**P** Primary Systems

Complete

**S** Secondary Systems

In Service System

**T** Tertiary Systems

Planned System

**A** Avionics Systems

**A** Alpha

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# Performance-Based Navigation

## Stakeholders

Specific roles and responsibilities for the implementation of all increments are outlined in the RASCI (Responsible, Accountable, Supporting, Consulted, and Informed) matrix that follows below. All stakeholder organizations involved in the delivery of capabilities are listed across the top. Portfolio capabilities are listed on the left side of the table, organized by OI and increment. AAJV-1 is accountable and responsible, and AIR-100 and AFS-400 have responsibility, for the following increments: RNP and RNP AR Approaches, RNAV SIDs and STARs at Single Sites, Advanced and Efficient RNP, Metroplex, Large-Scale Redesign of Airspace, and Transition to PBN Routing. The design, implementation, and air traffic aspects of these capabilities will rely on support from AJT-2, ARP, AJM-32, and AEE and consultation with offices within ANG-C7, AJT-2, and ARP. ANG-C5 will provide F&E resource management and program management support for Metroplex and Advanced and Efficient RNP and is responsible for delivering the safety case for the latter. AJM-1 is accountable and responsible for implementing PBN Route Eligibility Check, in consultation with AOV and AFS-400. AJT supporting the implementation through automation development. ANG-C7 is consulted on all increments in this portfolio. APO provides support by developing policies for incentivizing operators for the increments RNP Approaches, RNAV SIDs/STARs, Metroplex, and PBN Route Eligibility Check. For the increment RNAV (GPS) Approaches, AJM-32 is accountable and responsible, AJV-3, AIR-130, and AFS-400 have responsible roles, and ARP, AEE, and APO provide support.

- A** Accountable for the completion of NextGen capability. The highest level within the RASCI matrix, this office is charged by the FAA to deliver a particular capability. Typically, this designation is provided via an Acquisition Program Baseline. To foster a clear line of accountability, two different offices can never be Accountable for the same increment, and Accountability can never be delegated to another office.
- R** Responsible for the successful completion of NextGen capability or a critical component of the capability. This office is responsible to the Accountable office. The Responsible office is responsible for initiating an actual change to the NAS such as automation changes, and is often also designated as the Accountable office for that increment. However, there are examples in the NSIP where one office is Accountable for an increment while another office (or offices) is actually making a change in the NAS on behalf of the Accountable office.
- A/R** Accountable for the completion of NextGen capability as well as Responsible for its implementation.
- S** Supports the Responsible office in the implementation of NextGen capability. Typically, this support is in the form of subject matter expertise, procedural guidance, or training activities.
- C** Consulted for input during the implementation of NextGen capability. Provides input on a specific aspect in the development and implementation of a capability, such as safety analysis or approval. Input may or may not be used as determined by the Responsible and Accountable offices.
- I** Informed about the progress of implementation.

 Operationally Available

 Complete

 External Commitment

**A** Alpha



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# Performance-Based Navigation

RASCI Matrix	ANG			AOV	APO	AJT		AJW	AJM			AJI			AFS		AAE	ARP	AIR	AJV	
	C	C5	C7	001	001	2	0	1	322	32	3	0	1	2	3	001	400	001	001	001	0
<ul style="list-style-type: none"> <li><b>A</b> [107103-12] RNP Authorization Required (AR) Approaches (2010 - 2016)</li> </ul>					S	S				S			S	S	S	R		S	S	R	
<ul style="list-style-type: none"> <li><b>A</b> [107103-13] RNAV SIDs and STARs at Single Sites (2010 - 2016)</li> </ul>					S	S				S			S	S	S	R		S	S	R	
<ul style="list-style-type: none"> <li><b>A</b> [108209-12] Metroplex PBN Procedures (2014 - 2020)</li> </ul>	R	R			S	S				S			S	S	S	R		S	S	R	
<ul style="list-style-type: none"> <li><b>A</b> [108209-13] Large-Scale Redesign of Airspace Leveraging PBN (2010 - 2016)</li> </ul>						S				S			S	S	S	R		S	S	R	
<ul style="list-style-type: none"> <li><b>A</b> [108209-14] Transition to PBN Routing for Cruise Operations (2014 - 2021)</li> </ul>			C			S										R		S	S	R	
<ul style="list-style-type: none"> <li><b>A</b> [108209-18] PBN Route Eligibility Check (2012 - 2012)</li> </ul>				C	S	S										C					
<ul style="list-style-type: none"> <li><b>A</b> [108209-19] RNAV (GPS) Approaches (2010 - 2016)</li> </ul>					S					A/R			S	S	S	R		S	S	R	
<ul style="list-style-type: none"> <li><b>A</b> [108209-21] Equivalent Lateral Spacing Operation Standard (ELSO) (2015 - 2018)</li> </ul>			C																		

Operationally Available

Complete

External Commitment

**A** Alpha

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# Performance-Based Navigation

## Appendix B

### Bravo Increments

#### Portfolio Overview

Improvements in aircraft navigation performance provide an opportunity to increase efficiency and flexibility. The Performance-Based Navigation (PBN) portfolio addresses ways to leverage emerging technologies, such as RNAV and RNP, to improve access and flexibility for point-to-point operations.

The PBN portfolio reflects the intention to safely permit and enhance the flexibility of point-to-point operations, while allowing for the development and use of more efficient routes, procedures, and approaches that are free from the constraints of ground-based navigational aids (NAVAIDS).

Anticipated benefits include efficiency and predictability through the proliferation of PBN operations.

Note: The dates and timelines included in the NAS Segment Implementation Plan (NSIP) are for planning purposes only. All capability schedules are tentative until their supporting programs are officially baselined.

#### Portfolio Content Summary Statistics

Segment	Total by Segment	Increment Status				
		Planned	Concept Exploration & Maturation	Development	Initial Operational Availability	Completed
*Bravo (2016 - 2020)	3	0	0	0	0	3
<b>TOTAL</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>
Segment	% by Segment	% by Segment/Increment Status				
*Bravo (2016 - 2020)	100%	0 %	0 %	0 %	0 %	100 %
<b>TOTAL</b>	<b>100%</b>	<b>0 %</b>	<b>0 %</b>	<b>0 %</b>	<b>0 %</b>	<b>100 %</b>

 External Commitment    
  Primary Benefit    
  Secondary Benefit    
  Operationally Available    
  Complete 

 Access & Equity    
  Capacity    
  Flexibility    
  Efficiency    
  Environment    
  Predictability    
  Safety    
  Bravo



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# Performance-Based Navigation

## Operational Improvements/Current Operations & Increments

## Benefits

### OI: [108209] Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP) (2010 - 2021)

- B** [108209-20] Advanced and Efficient RNP (2013 - 2020)
- B** [108209-22] Expansion of Metroplex PBN Procedures (2017 - 2021)
- B** [108209-23] Established-on-RNP Independent Duals and Triples with RF Procedures (2017 - 2020)



- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- Bravo



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# Performance-Based Navigation

2016	2017	2018	2019	2020
<b>OI: [108209] Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP) (2010 - 2021)</b>				
<b>B [108209-20] Advanced and Efficient RNP (2013 - 2020) 🚀✅</b>				
<b>B [108209-22] Expansion of Metroplex PBN Procedures (2017 - 2021) 🚀✅</b>				
<b>B [108209-23] Established-on-RNP Independent Duals and Triples with RF Procedures (2017 - 2020) 🚀✅</b>				

Planned  
OI

Concept Exploration & Maturation  
CO

Development  
COE/CBTE

Initial Operation Available 🚀  
Bravo

Complete ✅  
External Commitment

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# Performance-Based Navigation

## OI: [108209] Increase Capacity and Efficiency Using Area Navigation (RNAV) and Required Navigation Performance (RNP) (2010 - 2021)

Both RNAV and RNP will enable more efficient aircraft trajectories. RNAV and RNP, combined with airspace changes, increase airspace efficiency and capacity. Further efficiencies will be gained through the development and implementation of advanced criteria.

RNAV and RNP will permit the flexibility of point-to-point operations and allow for the development of routes, procedures, and approaches that are more efficient and free from the constraints and inefficiencies of the ground-based NAVAIDS. This capability can also be combined with an Instrument Landing System (ILS), to improve the transition onto an ILS final approach and to provide a guided missed approach. Consequently, RNAV and RNP will enable safe and efficient procedures and airspace that address the complexities of the terminal operation through repeatable and predictable navigation. These will include the ability to implement curved path procedures that can address terrain, and noise-sensitive and/or special-use airspace. Terminal and en route procedures will be designed for more efficient spacing and will address complex operations.

### OI Benefit

Efficiency (P): Efficiency is improved through airspace design that allow for route placement in locations where they are needed rather than over ground-based NAVAIDS, allowing for more efficient routings and increased ability to accommodate optimal descent and ascents.

Access and Equity (P): Improved as PBN procedures allow access without the need for additional ground infrastructure.

Capacity (P): Additional routes and fewer conflicts between arrival and departure paths will increase airspace capacity.

Safety (S): Increasing navigation accuracy will result in repeatable and predictable navigation performance which will increase safety.

### Increments

Bravo  
(2016 - 2020)

3

- B** [108209-20] Advanced and Efficient RNP (2013 - 2020)  (Complete)
- B** [108209-22] Expansion of Metroplex PBN Procedures (2017 - 2021)  (Complete)
- B** [108209-23] Established-on-RNP Independent Duals and Triples with RF Procedures (2017 - 2020)  (Complete)

Legend:  External Commitment,  Primary Benefit,  Secondary Benefit,  Operationally Available,  Complete 

Icons:  Access & Equity,  Capacity,  Flexibility,  Efficiency,  Environment,  Predictability,  Safety, **B** Bravo

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# Performance-Based Navigation

## Increments/Enabling Activities

**B** [108209-20] Advanced and Efficient RNP (2013 - 2020)

### Increment Overview

This increment includes development of Established-on-RNP for simultaneous and dependent parallel approaches and concurrent RNP operations at airports in close proximity, and other advanced PBN criteria. RNP-established will allow suitably equipped RNP-capable aircraft to turn onto final to a parallel runway using an RNP curved path without the necessity of 3NM of later separation or 1000 feet of vertical separation once the aircraft is established on the PBN approach. This would allow shorter downwind legs for the suitably equipped aircraft.

### Increment Status

Complete

### Success Criteria

- ✓ 2013 : Completion of Greener Skies SEA/BFI Phase 2.
- ✓ 2013 : Implementation at SEA/BFI (Phase 1 Completed).
- ✓ 2015 : Begin EoR Widely Spaced Operations at Denver. This will achieve Initial Operational Availability and satisfy a NAC/NIWG Commitment.
- ✓ 2015 : Complete the EoR Track-to-Fix of fly-by approach safety analysis. This will satisfy a NAC/NIWG Commitment.
- ✓ 2015 : Begin Dependent EoR operations at SEA
- ✓ 2016 : Develop EoR Widely Spaced Operation National Standard. This will satisfy a NAC/NIWG Commitment.

### Implementation Approach

Research leads to the creation of NAS-wide Document Change Proposals (DCPs). Implemented through the development of procedures and flight inspection.

#### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

Efficiency (P): Improvements in flight efficiency result from the ability to have curved path approaches operating simultaneously to the same runway.

### System Interactions

External Commitment  
 Primary Benefit  
 Secondary Benefit  
 Operationally Available  
 Complete  
 Bravo

Access & Equity  
 Capacity  
 Flexibility  
 Efficiency  
 Environment  
 Predictability  
 Safety

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# Performance-Based Navigation

ERAM (S): ERAM provides the controllers with air traffic control displays that are essential to maintaining aircraft separation. As the volume of air traffic increases in densely populated areas, controllers may require improved automation tools to manage their airspace.

STARS (S): STARS provides the controllers with air traffic control displays that are essential to maintaining aircraft separation. As the volume of air traffic increases in densely populated areas, controllers may require adaptation changes to existing systems to accommodate RNAV and RNP (GPS) approaches.

TBFM (S): TBFM is designed to improve the flow of aircraft within congested airspace. As the volume of air traffic increases in densely populated areas, controllers may require improved automation tools to manage their airspace.

GPS (T): GNSS provides precise Positioning, Navigation, and Timing (PNT) information to suitably equipped aircraft and is the principal enabler of two-dimensional PBN.

SBAS (WAAS) (T): WAAS provides aircraft guidance during approach procedure. WAAS is used to improve the accuracy, integrity, and availability of basic GPS services to enable vertically guided LPV approach or horizontally guided LP approach operations. WAAS users also experience higher availability of service and therefore do not typically need IRUs, which provide a lower-cost avionics solution.

GNSS/GPS Avionics (A): Aircraft use GNSS/GPS Avionics to navigate specific PBN procedures within the avionics' performance range.

SBAS (WAAS) Avionics (A): Aircraft use SBAS (WAAS) Avionics to navigate specific PBN procedures within the avionics' performance range.

FMS (A): FMS must meet RNAV or RNP requirements.

## Secondary Systems

- STARS: Standard Terminal Automation Replacement System
- ERAM: En Route Automation Modernization
- TBFM: Time Based Flow Management

## Tertiary Systems

- SBAS (WAAS): Satellite Based Augmentation System (Wide-Area Augmentation System)
- GPS: Global Positioning System

## Avionics Systems

- FMS: Flight Management System
- GNSS/GPS Avionics: Global Navigation Satellite System/Global Positioning System Avionics

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety
- Bravo



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# Performance-Based Navigation

## Increments/Enabling Activities

**B** [108209-22] Expansion of Metroplex PBN Procedures (2017 - 2021)

### Increment Overview

This increment provides expected improvements to additional Metroplex locations to include efficient descents, diverging departure paths, and decoupling of operations among airports within the metroplex airspace. The Metroplex project is a systematic approach to implementing PBN procedures and associated airspace changes in major metropolitan areas. By providing Metroplex benefits to additional locations, the efficiency and capacity improvements afforded through more direct routes and optimized airspace will be gained at additional locations. Metroplex projects make use of existing aircraft equipage and utilize existing ground-based NAVAIDS as well as newer GPS-enabled technologies.

The timeline and focused scope of this initiative binds the airspace and procedures solutions to those that can be achieved without requiring an Environmental Impact Statement (e.g., requiring only an environmental assessment or categorical exclusion) and within current infrastructure and operating criteria. The metroplexes addressed under this activity will be prioritized using criteria and considerations developed with industry consensus through the RTCA NextGen Advisory Committee.

### Increment Status

Complete

### Success Criteria

- ✓ 2017 : Complete Southern California Metroplex implementation activities.
- ✓ 2017 : Start Las Vegas Design Phase. This will satisfy a NAC/NIWG Commitment.
- ✓ 2018 : Complete Cleveland/Detroit Metroplex implementation activities. This will satisfy a NAC/NIWG Commitment.
- ✓ 2020 : Complete Denver Metroplex implementation activities. This will satisfy a NAC/NIWG Commitment.
- ✓ 2021 : Complete Las Vegas Metroplex implementation activities. This will satisfy a NAC/NIWG Commitment.
- ✓ 2021 : Complete South/Central Florida Metroplex implementation activities. This will satisfy a NAC/NIWG Commitment.

### Implementation Approach

Implementation of Metroplex includes designing/ publishing procedures, conducting environmental assessment or CatEx planning by all impacted facilities and users, flight inspection of procedures, system adaptation, workforce training, and Industry participation/collaboration/training. Procedures may be implemented in one publication cycle or in multiple cycles.

#### Benefits

Access & Equity Capacity Flexibility Efficiency Environment Predictability Safety

External Commitment Primary Benefit Secondary Benefit Operationally Available Complete Bravo

Access & Equity Capacity Flexibility Efficiency Environment Predictability Safety Bravo



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# Performance-Based Navigation

Access and Equity (P): Improved as PBN procedures allow access without the need for additional ground infrastructure. Improved connectivity to en route structure through additional PBN procedures in terminal airspace.

Capacity (S): Reductions in lateral track distances.

Efficiency (P): Efficiency is improved through designs that allow for route placement in locations where they are needed rather than over ground-based NAVAIDS, allowing for more efficient routes.

## System Interactions

ERAM (S): ERAM provides the controllers with air traffic control displays that are essential to maintaining aircraft separation.

STARS (S): STARS provides the controllers with air traffic control displays that are essential to maintaining aircraft separation.

TBFM (S): TBFM is designed to improve the flow of aircraft within congested airspace. TBFM is a metering tool used for adjusting capacity/ demand imbalances at select airports and arrival fixes. It establishes a schedule with an assumed runway assignment and runway sequence for each arriving flight. It facilitates spacing/metering of aircraft that are assigned RNAV/PBN OPD arrivals. TBFM functionality is essential for efficient use of Metroplex procedures.

LP/HP DME (T): DME is a legacy system that provides positioning service suitable for some PBN operations. Aircraft equipped with suitable RNAV avionics can use multiple DMEs to calculate their positions. Most air carrier, regional, and business aircraft are equipped with scanning DME avionics, allowing DME/DME RNAV as a suitable positioning source for RNAV operations.

GPS (T): GNSS provides precise Positioning, Navigation, and Timing (PNT) information to suitably equipped aircraft and is the principal enabler of RNAV/PBN/RNP procedures.

SBAS (WAAS) (T): WAAS provides aircraft guidance during approach procedure. The FAA's Satellite-Based Augmentation System (SBAS), WAAS, is used to improve the accuracy, integrity, and availability of basic GPS services to enable vertically guided Localizer Performance with Vertical guidance (LPV) approach or horizontally guided Localizer Performance (LP) approach operations. WAAS users also experience higher availability of service and therefore do not typically need Inertial Reference Units (IRUs), which provide a lower- cost avionics solution.

DME Avionics (A): Aircraft need DME Avionics as a backup to navigate PBN procedures during a GPS outage.

GNSS/GPS Avionics (A): Aircraft use GNSS/GPS Avionics to navigate specific PBN procedures within the avionics' performance range.

SBAS (WAAS) Avionics (A): Aircraft use SBAS (WAAS) Avionics to navigate specific PBN procedures within the avionics' performance range.

External Commitment   Primary Benefit   Secondary Benefit   Operationally Available   Complete   Access & Equity   Capacity   Flexibility   Efficiency   Environment   Predictability   Safety   Bravo



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# Performance-Based Navigation

## Secondary Systems

- ERAM: En Route Automation Modernization
- STARS: Standard Terminal Automation Replacement System
- TBFM: Time Based Flow Management

## Tertiary Systems

- SBAS (WAAS): Satellite Based Augmentation System (Wide-Area Augmentation System)
- LP/HP DME: Distance Measuring Equipment : Low Power/High Power
- GPS: Global Positioning System

## Avionics Systems

- SBAS (WAAS) Avionics: Satellite Based Augmentation System/Wide Area Augmentation System Avionics
- GNSS/GPS Avionics: Global Navigation Satellite System/Global Positioning System Avionics
- DME Avionics: Distance Measuring Equipment Avionics

- External Commitment
- Primary Benefit
- Secondary Benefit
- Operationally Available
- Complete
- Access & Equity
- Capacity
- Flexibility
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- Environment
- Predictability
- Safety
- Bravo



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# Performance-Based Navigation

## Increments/Enabling Activities

**B** [108209-23] Established-on-RNP Independent Duals and Triples with RF Procedures (2017 - 2020)

### Increment Overview

This increment includes development of Established-on-RNP for independent dual and triple approaches with Radius-to-Fix procedures. RNP-established will allow suitably equipped RNP-capable aircraft to turn onto final to parallel runways using an RNP curved path without requiring 1000 feet of vertical or 3 nautical mile lateral separation. This would allow shorter downwind legs for the suitably equipped aircraft.

### Increment Status

Complete

### Success Criteria

- ✓ 2017 : Completion of RF Duals and Triples Safety Analysis. This will satisfy a NAC/NIWG Commitment.
- ✓ 2018 : Establish a new National Standard for Duals and Triples (DCP to paragraph 5-9-7 of 7110.65) that can be applied to RF Procedures. This will satisfy a NAC/NIWG Commitment.
- ✓ 2018 : Begin EoR RF Duals and Triples Operations at Denver and Houston.

### Implementation Approach

Research leads to the creation of NAS-wide Document Change Proposals (DCPs). Implemented through the development of procedures and flight inspection.

#### Benefits

- Access & Equity
- Capacity
- Flexibility
- Efficiency
- Environment
- Predictability
- Safety

Efficiency (P): Improvements in flight efficiency result from the ability to have curved path approaches operating simultaneously to the same runway.

### System Interactions

STARS (S): STARS provides controller displays and aids to monitor the Established on RNP (EoR) operations.

TBFM (S): Metering needs to account for RNP capable aircraft to the runway.

FMS (A): FMS must meet RNP requirements.

External Commitment  
 Primary Benefit  
 Secondary Benefit  
 Operationally Available  
 Complete

Access & Equity  
 Capacity  
 Flexibility  
 Efficiency  
 Environment  
 Predictability  
 Safety  
 Bravo

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# Performance-Based Navigation

## Secondary Systems

-  TBFM: Time Based Flow Management
-  STARS: Standard Terminal Automation Replacement System

## Avionics Systems

-  FMS: Flight Management System

-  External Commitment
-  Primary Benefit
-  Secondary Benefit
-  Operationally Available
-  Complete 
-  Access & Equity
-  Capacity
-  Flexibility
-  Efficiency
-  Environment
-  Predictability
-  Safety
-  Bravo



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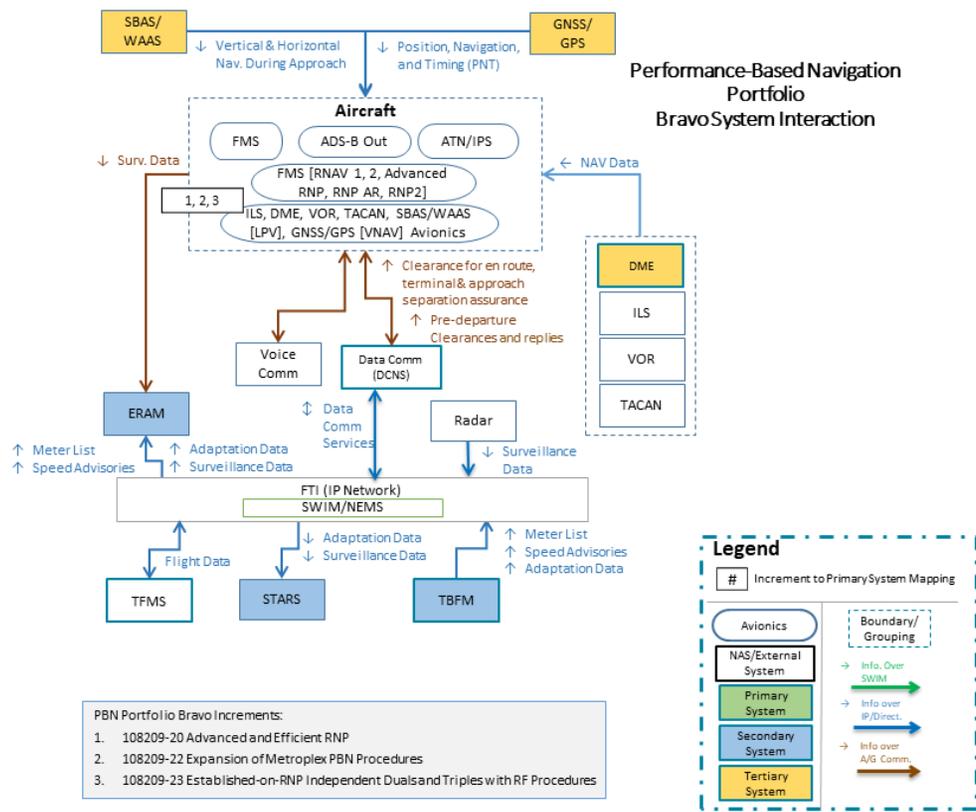
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# Performance-Based Navigation

## Systems Interactions

PBN capabilities are enabled through a combination of legacy and new NAS services to include but are not limited to communications, navigation, surveillance, and automation. This figure depicts the primary enabling services and infrastructure necessary to enable PBN operations. A number of emerging capabilities and new technologies will be implemented to enable PBN capabilities. The functional connections among these programs are captured in the NAS Infrastructure section of this document and the Airspace and Procedures Roadmaps of the NAS EA. 222



# Performance-Based Navigation

Increment	DME Avionics	ERAM	FMS	GNSS/GPS Avionics	GPS	LP/HP DME	SBAS (WAAS)	SBAS (WAAS) Avionics	STARS	TBFM
<b>B</b> [108209-20] Advanced and Efficient RNP		S	A	A	T		T	A	S	S
<b>B</b> [108209-22] Expansion of Metroplex PBN Procedures	A	S		A	T	T	T	A	S	S
<b>B</b> [108209-23] Established-on-RNP Independent Duals and Triples with RF Procedures			A						S	S

Operationally Available

**P** Primary Systems

Complete

**S** Secondary Systems

In Service System

**T** Tertiary Systems

Planned System

**A** Avionics Systems

**B** Bravo

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# Performance-Based Navigation

## Stakeholders

Specific roles and responsibilities for the implementation of all increments are outlined in the RASCI (Responsible, Accountable, Supporting, Consulted, and Informed) matrix that follows below. All stakeholder organizations involved in the delivery of capabilities are listed across the top. Portfolio capabilities are listed on the left side of the table, organized by OI and increment. AAJV-1 is accountable and responsible, and AIR-100 and AFS-400 have responsibility, for the following increments: RNP and RNP AR Approaches, RNAV SIDs and STARs at Single Sites, Advanced and Efficient RNP, Metroplex, Large-Scale Redesign of Airspace, and Transition to PBN Routing. The design, implementation, and air traffic aspects of these capabilities will rely on support from AJT-2, ARP, AJM-32, and AEE and consultation with offices within ANG-C7, AJT-2, and ARP. ANG-C5 will provide F&E resource management and program management support for Metroplex and Advanced and Efficient RNP and is responsible for delivering the safety case for the latter. AJM-1 is accountable and responsible for implementing PBN Route Eligibility Check, in consultation with AOV and AFS-400. AJT supporting the implementation through automation development. ANG-C7 is consulted on all increments in this portfolio. APO provides support by developing policies for incentivizing operators for the increments RNP Approaches, RNAVSIDs/STARs, Metroplex, and PBN Route Eligibility Check. For the increment RNAV (GPS) Approaches, AJM-32 is accountable and responsible, AJV-3, AIR-130, and AFS-400 have responsible roles, and ARP, AEE, and APO provide support.

- A** Accountable for the completion of NextGen capability. The highest level within the RASCI matrix, this office is charged by the FAA to deliver a particular capability. Typically, this designation is provided via an Acquisition Program Baseline. To foster a clear line of accountability, two different offices can never be Accountable for the same increment, and Accountability can never be delegated to another office.
- R** Responsible for the successful completion of NextGen capability or a critical component of the capability. This office is responsible to the Accountable office. The Responsible office is responsible for initiating an actual change to the NAS such as automation changes, and is often also designated as the Accountable office for that increment. However, there are examples in the NSIP where one office is Accountable for an increment while another office (or offices) is actually making a change in the NAS on behalf of the Accountable office.
- A/R** Accountable for the completion of NextGen capability as well as Responsible for its implementation.
- S** Supports the Responsible office in the implementation of NextGen capability. Typically, this support is in the form of subject matter expertise, procedural guidance, or training activities.
- C** Consulted for input during the implementation of NextGen capability. Provides input on a specific aspect in the development and implementation of a capability, such as safety analysis or approval. Input may or may not be used as determined by the Responsible and Accountable offices.
- I** Informed about the progress of implementation.

 Operationally Available

 Complete

 External Commitment

**B** Bravo



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# Performance-Based Navigation

## RASCI Matrix

	ANG			AOV	APO	AJT		AJW	AJM			AJI			AFS		AAE	ARP	AIR	AJV
	C	C5	C7	001	001	2	0	1	322	32	3	0	1	2	3	001	400	001	001	001
<ul style="list-style-type: none"> <li><b>B</b> [108209-20] Advanced and Efficient RNP (2013 - 2020) </li> </ul>		A/R	C			S							S	S		R	S	S	I	
<ul style="list-style-type: none"> <li><b>B</b> [108209-22] Expansion of Metroplex PBN Procedures (2017 - 2021) </li> </ul>	R	R	C		S	S			S	S			S	S	R		S	S	R	
<ul style="list-style-type: none"> <li><b>B</b> [108209-23] Established-on-RNP Independent Duals and Triples with RF Procedures (2017 - 2020) </li> </ul>		A/R	C			S							S	S		R	S	S	I	

Operationally Available

Complete

External Commitment

**B** Bravo



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