Navigation Programs Update

Presented by: Deborah Lawrence
Presented to: Civil GPS Service Interface Committee
Date: September 2016
Agenda

• Performance Based Navigation (PBN) NAS Strategy - 2016
• Wide Area Augmentation System (WAAS) Update
• Ground Based Augmentation System (GBAS) Update
• Resiliency Programs
  – NextGen Distance Measuring Equipment (DME) Program
  – VOR MON Program Update
• Summary
Background

- The PBN NAS Navigation Strategy 2016 builds on the progress of the past decade and refocuses FAA priorities and milestones towards a truly PBN-centric NAS

- Currently under review by the FAA Administrator, to be signed within weeks
PBN Strategy – Nav Programs Alignment

**PBN Strategy**
Strategy for deploying and effectively using PBN as the means of navigating in the NAS

**DME Programs**

**NextGen DME**
Supports PBN with the optimization of the DME infrastructure to expand coverage and eliminate critical DMEs

**DME Sustain**
Supports CAST requirements, replaces ILS markers with DMEs, and replaces DMEs at decommissioned VOR locations

**NESS**
NAS Efficient Streamlined Service

**VOR MON**
Collaborative effort to execute a safe transition from a legacy network of VORs to a minimum operational network (MON) as backup capability in the event of a widespread GPS outage

**ILS Rationalization**
Rationalize the need for duplicate vertical guidance with ILS when LPV approaches are available

**Other NAV Programs**

**VOR**
Establish, dopplerize, and sustain VORs

**ILS Sustain**
Sustain existing equipment as needed and support establishment

**LEGEND**
- **Nav Program w/ CIP funding**: NextGen PLA/Initiative, New/Emerging Initiative

**APNT Research**
Alternate Position, Navigation, & Timing

Research for alternatives for providing higher precision back-up for GPS-based position, navigation, and timing services

**NNE**
NextGen Navigation Eng.

Defines DME service volume to eliminate need for ESVs

**Waas**
Wide Area Augmentation System

A satellite-based navigation system to provide horizontal and vertical navigation for all classes of aircraft in all phases of flight - including enroute navigation, airport departures, and airport arrivals

**Other**
NAV Programs
**PBN Strategy Goals by Benefit Area**

<table>
<thead>
<tr>
<th>More efficient routes &amp; procedures</th>
<th>Near-Term</th>
<th>Mid-Term</th>
<th>Far-Term</th>
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<tbody>
<tr>
<td>- RNAV(GPS) with LPV and LNAV/VNAV approaches at qualifying runways end</td>
<td>- Vertically guided RNAV(GPS) approaches at runways meeting new TERPS criteria</td>
<td>- Vertically guided RNAV (GPS) approaches at qualifying airports with an IAP</td>
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<tr>
<td>- Revised TERPS criteria to increase number of qualifying runways for vertically guided approaches</td>
<td>- ELSO at sites supported by cost-benefit analysis</td>
<td>- A-RNP procedures at sites supported by cost-benefit analysis</td>
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<tr>
<td>- Expand use of ELSO at first two sites</td>
<td>- EoR at sites supported by cost-benefit analysis</td>
<td>- Transition to dynamic UPRs where supported by operator capability</td>
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<tr>
<td>- Expand use of EoR at first site</td>
<td>- Leverage A-RNP at key sites</td>
<td>- Complete the transition to PBN procedures</td>
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<td>- Demonstrate A-RNP at first site</td>
<td>- Leverage reduced separation standards to further expand UPRs</td>
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<tr>
<td>- Expand trans-Pacific User Preferred Routes</td>
<td>- Expand use of RNAV (GPS) approaches with LPV and LNAV/VNAV) with RF turns</td>
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<tr>
<td>- Use of PBN approaches with visual separation standards</td>
<td>- Continue replacing conventional approaches, SIDs and STARs with PBN procedures</td>
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<td>- Implement OPDs at airports using RNAV STARs</td>
<td>- Transition to PBN-based point-to-point navigation</td>
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<td>- Transition from Minimum Performance Specification to PBN in the ICAO North Atlantic Region</td>
<td>- Replace conventional Jet routes and Victor airways where structure is needed</td>
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<td>- Continue replacing conventional approaches, SIDs, and STARs with PBN procedures</td>
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<td>- Initial transition to improved PBN-based point-to-point navigation</td>
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<td>Near-Term</td>
<td>Mid-Term</td>
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<tr>
<td>Improved predictability</td>
<td>• Shorten development and implementation time for new ATS routes by removing rulemaking requirement</td>
<td>• Key airports transitioned to time and speed-based management</td>
<td>• NAS transitioned to time and speed-based management</td>
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<td>• Begin ILS Rationalization at Navigation Service Group (NSG) 4-5 airports</td>
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<td>More cost effective &amp; agile service delivery</td>
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<td>• Develop integrated procedure design tools</td>
<td>• ILS rationalization complete at NSG 4 and 5 airports</td>
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<td>• Digital delivery of navigation chart data</td>
<td>• ILS rationalization analysis for NSG 1, 2, and 3 airports</td>
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<td>• Develop automation for periodic review of procedures</td>
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<td>• Continue ILS Rationalization at NSG 4-5 airports</td>
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<tr>
<td>Increased access</td>
<td>• Update regulations to allow SVGS for qualifying approaches</td>
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<td>• Update regulations to allow EFVS operations to touchdown</td>
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<td></td>
<td>• Criteria for SA CATI/1800 RVR and SA CATII for LPV</td>
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<td>Improved resiliency</td>
<td>• DME/DME coverage expanded for NSG 1 and 2 airports based on site-specific evaluations</td>
<td>• DME/DME coverage expanded for NSG 1 and 2 airports based on site-specific evaluations</td>
<td>• Re-evaluation of need for remaining VOR facilities</td>
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<td></td>
<td>• Class A airspace is covered by DME/DME (IRU not required) redundancy</td>
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WAAS UPDATE
WAAS Phase IV - Dual Frequency Operations (2014-2044)

- **Final Investment Decision for Phase IV Segment 1 (2014-2019) Dual Frequency Operations (DFO) approved**
  - Segment 1 (2014-2019) - Develop infrastructure improvements to support L5 & Tech Refresh
  - Segment 2 (2019+) - Implementation of L1/L5 user capability

- **Planning to transition from use of L2 P(Y) to L5 within 2 years of GPS L5-signal Full Operational Capability (FOC)**

- **GEO sustainment will occur during both segments**

- **Future considerations**
  - Dual-Frequency Multi-constellation Capability
    - International Focus is on taking advantage of other GPS like constellations
  - User Equipment Standards for Dual-Frequency Operations
    - FAA working with Interoperability Working Group (IWG) on definition document that provides the basis for interface design and MOPS development for L1/L5 and multi-constellation
  - Advanced RAIM (ARAIM)
    - Avionics-centric approach to dual-frequency multi-constellation
Airports with WAAS LPV-200/LPV/LP Instrument Approaches

As of August 18, 2016
- 4,323 LP/LPVs combined
- 3,710 LPVs serving 1,806 Airports
- 942 LPV-200’s
- 2,561 LPVs to Non-ILS Runways
- 1,149 LPVs to ILS runways
- 1,767 LPVs to Non-ILS Airports
- 613 LPs serving 457 Airports
- 610 LPs to Non-ILS Runway
- 3 LPs to ILS Runways
GEO Sustainment (GEOs 5/6/7)

- **GEO 5/6 Satellite Acquisition**
  - GEO 5
    - Payload development complete
      - EUTELSAT 117 West B (ex SatMex 9) satellite
        - Located at 117 West, provides full coverage of CONUS and Alaska
    - Launch planned June 2016
      - Date affected by Space X Falcon 9 launch failure June 2015
    - Completed Ground Uplink Subsystems installation, integration and checkout April 2016
    - Signal in Space Testing in to begin early CY2017
    - Expected operational in 2018
  - GEO 6
    - Preliminary Design Review (PDR) completed June 2015
    - Critical Design Review (CDR) completed February 2016
    - Host satellite is SES-15, planned for 129 West
      - Provides full coverage or CONUS and Alaska
    - Expected Operational in 2019
  - **GEO 7 Satellite acquisition**
    - Targeting 2019 for a contract award
GBAS UPDATE
FAA GBAS Program

- Validation of ICAO SARPS for the baseline set of GBAS Approach Service Type D (GAST-D) / CAT III Requirements
  - FAA validation efforts included producing commercial prototypes (Avionics/Ground)
  - Date for Final Close of Validation/Final SARPS acceptance – December 2016

- System Design Approvals (SDA) for GBAS GAST-D (CAT III) systems
  - FAA system design review for Honeywell SLS-5000 started, GAST-D SDA expected 2019 (depending on Honeywell schedule)

- FAA GBAS CAT I Implementation Status
  - Honeywell SLS-4000 GBAS GAST C approved for CAT 1 operations and deployed at Newark, NY and Houston, TX for public use as non-Federal systems
  - Moses Lake, WA and Charleston, SC are operational as Boeing private systems
  - FAA provides performance monitoring/service prediction for Newark, Houston, Moses Lake
  - Operators using GBAS at Newark and Houston include United Airlines, Delta Airlines, Lufthansa, Emirates, Cathay Pacific, British Airways, Cargolux
  - Over 3,300 GBAS approaches as of August 2016
  - Successful demonstration of GBAS advanced capabilities (RNP to GLS, noise abatement, variable glidepath, displaced threshold..) at San Francisco, August 2016

- International Coordination
  - ICAO, SESAR, FAA International MOUs (Brazil, Australia, etc.)
  - International GBAS Working Group (IGWG) – June 2016 IGWG sponsored by Avinor, Norway
RESILIENCY
NextGen DME
Near-term (2016-2020): “DME/DME coverage expanded for NSG 1 and 2 airports based on site-specific evaluations…Class A airspace is covered by DME/DME (IRU not required) redundancy

Mid-term (2021-2025): “DME/DME coverage expanded for NSG 1 and 2 airports based on site-specific evaluations”
## Benefits

<table>
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<tr>
<th>Benefit</th>
<th>Description</th>
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<td><strong>Access</strong></td>
<td>Enables aircraft to continue PBN operations to an ILS approach during Global Navigation Satellite System (GNSS) disruptions.</td>
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<td><strong>Capacity</strong></td>
<td>Increased capacity in transition airspace for arrivals and departures.</td>
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| **Efficiency**| More efficient point-to-point routing  
Decreased pilot/controller communications                                                   |
| **Environmental** | Reduced emissions and fuel burn through the use of Optimized Profile Descents (OPDs)                                                           |
**Description and Scope of Initiative**

- New DMEs will be installed to fill coverage gaps and eliminate single points of failure (Critical DMEs) to provide a backup to GNSS as part of a resilient navigation infrastructure.
- Existing DMEs with limited capacity will be replaced, and select DMEs not needed for RNAV will be targeted for discontinuance.
- DME systems will be procured using the existing DME contract.
- The baselined DME Specification will not be changed.

### Description and Scope of Initiative

- **924 FAA Owned DMEs**
  - **698** RNAV Capable DME
  - **135** Targeted for Discontinuance
  - **114** TACANs Retained for DoD
  - **52** (DME) T-Class, Unmonitored, No-NOTAM Maintenance
  - **60** DMEs Outside CONUS

- **183 New DMEs Installed**

- **972 FAA Owned DMEs**

- **746 Needed for RNAV**

- **226 Not Needed for RNAV**
VOR MON Update
The VOR MON Program will be completed in 2 phases:
- Phase 1: FY16 – FY20
- Phase 2: FY21 – FY25

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<tr>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
<th>FY17</th>
<th>FY18</th>
<th>FY19</th>
<th>FY20</th>
<th>FY21</th>
<th>FY25</th>
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<tr>
<td><strong>External Drivers</strong></td>
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<td>WAAS LPV procedures at qualified runways</td>
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<td>ADS-B equipage mandate</td>
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<td><strong>VOR MON Program Milestones</strong></td>
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<td>IARD</td>
<td>Phase 1 FID</td>
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<td>Phase 2 FID</td>
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<td>Initial: 957</td>
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<td>Program Target: 649</td>
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**Phase 1**
- Publish Final Policy FRN: “Provision of Navigation Services for the Next Generation Air Transportation System (NextGen) Transition to Performance Based Navigation (PBN)”
- Remove, Replace, Amend affected Instrument Flight Procedures (IFPs)
- Discontinue Phase 1 VORs (74)
- Plan for Phase 2 Final Investment Decision (FID)

**Phase 2**
- Continue IFP work
- Discontinue Phase 2 VORs (234)
Summary

• The Performance Based Navigation (PBN) NAS Strategy is awaiting FAA Administrator signature
• Navigation Programs is updating the NAV Strategy
• WAAS is replenishing GEOs, Performing Tech Refresh
• GBAS feasibility for CAT II/III targeted 2019
• Resiliency
  – VOR MON implementation underway (3 VORs Discontinued to date)
  – NextGen DME in program approval process
Navigation Strategy
En Route and Terminal Strategy

NextGen DME Program

- **IARD**
- **FID**

DME/DME (No IRU) to Class A
DME/DME (No IRU) to NSG 1-2 Airports

924 DMEs
135 DMEs Discontinued
183 New DMEs Installed
974 DMEs

The number of DMEs added or discontinued is subject to change prior to FID in 2017

NextGen DME Program

- **231** Q/T Routes
- **301** Jet Routes
- **669** Victor Airways
- **857** Conventional SID/STAR/ODPs
- **907** RNAV SIDs and STARs
- **957** VORs

**VOR MON Program**

- **Phase 1**
- **Phase 2**

- **2015**
- **2020**
- **2025**
- **2030**

- **883 VORs**
- **650 VORs**

NextGen DME will provide unrestricted RNAV to enable implementation of Q/T Routes and cancellation of Jet Routes and Victor Airways

NextGen DME and VOR MON will enable replacement of conventional SID/STAR/ODPs with RNAV

Removal of VORs will require Jet Routes, Victor Airways, and SID/STAR/ODPs to be replaced with PBN, if required

The number of DMEs added or discontinued is subject to change prior to FID in 2017.
En Route and Terminal Strategy

- GNSS is the primary enabler of En Route and Terminal Navigation
- The DME network will be improved to enable DME/DME RNAV (without IRU) in Class A airspace and all NSG 1 airports and select NSG 2 airports
- PBN Route Structure (PBNRS) will provide Q/T Routes where needed and direct point-to-point where structure is not necessary
- VORs will be discontinued to a Minimum Operational Network (MON)
  - VOR Airways will be removed, where not needed
  - Conventional SID/STARs will be cancelled
  - PBN SID/STAR/ODPs will be implemented
## Approach Strategy

<table>
<thead>
<tr>
<th>Year</th>
<th>CAT-II/III ILSs</th>
<th>CAT-I ILSs</th>
<th>RNAV(GPS) with LPV or LNAV</th>
<th>RNAV(GPS) with LP or LNAV</th>
<th>RNAV(RNP)</th>
<th>NDB Approaches</th>
<th>VOR Approaches</th>
<th>VORs</th>
<th>VOR MON Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>310</td>
<td>1,100</td>
<td>3,672</td>
<td>6,071</td>
<td>724</td>
<td>586</td>
<td>1,925</td>
<td>957</td>
<td>FID - 1</td>
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<td>2020</td>
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<td>883 VORs</td>
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<td>2025</td>
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<td>649 VORs</td>
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- **Potential ILS Rationalization at NSG 4-5 Airports**: Continue LPVs to all qualifying runways.
- **Potential ILS Rationalization at NSG 1-3 Airports**: LPVs replace LPs; Where needed, VOR / NDB approaches will be replaced with RNAV(GPS) approaches.
- **Metro-Plex and PBN Single Sites projects will add new RNP AR approaches, where beneficial**.
- **Instrument approaches tied to discontinued VORs will be cancelled**.
Instrument Approach Strategy

- LPVs will provide new CAT I vertically guided service needs
  - By 2016, WAAS LPV approaches will be available at all qualifying runways
  - New qualifying runways will only receive LPVs
- CAT I ILS approach service will be retained where needed
  - To support safe recovery at VOR MON Airports in the event of a GNSS outage
  - Potential for CAT I ILSs to be rationalized to retain systems where needed
- CAT II/III ILS will be retained
  - Retain for the foreseeable future to support commercial aircraft
- Explore the feasibility of achieving:
  - WAAS CAT II precision approach service (w/single & dual frequency GPS)
  - WAAS CAT I/II Autoland
- VOR and LOC approaches will be retained as needed to provide a backup in the event of a GNSS outage
- NDB approach procedures will be discontinued
**GBAS Overview**

- The Ground Based Augmentation System (GBAS) augments the Global Positioning System (GPS) signals to support terminal and precision approach procedures in the NAS.
- GBAS will provide all-weather approach capabilities to aircraft within line-of-sight distances from airports using GPS error corrections and integrity information.
- A single GBAS system is capable of providing precision approach capabilities to multiple runways at an airport.
- GBAS will satisfy the all-weather approach and landing capability with significant improvements in service flexibility; capacity, safety, and user operating costs.
- High quality navigation services will be provided with a minimum investment in ground facilities compared to existing technology.
- Aircraft operators will benefit from reduced fuel expenses due to more efficient terminal area routing (RNP to GLS) and improved access to airports during extremely low visibility operations (reduction of ILS critical areas).
- Variable glide path and displaced threshold capability provides service flexibility for wake avoidance and noise abatement procedures.