Performance-Based Navigation

Program Status and Initiatives

Presentation to: ICAO Workshop on PBN Airspace Redesign, Mexico City

Presented by: Sharon Abhalter / Nick Tallman
PBN Policy and Support Group (AJV-14)

Date: August 27-30, 2012
Briefing Overview

- PBN implementation status update
- Selected PBN project site examples
  - Memphis – post implementation
  - Denver – Integrated PBN
  - Atlanta – ELSO and RNP SIDs
  - Seattle – Greener Skies
- Key initiatives update
  - Optimization of Airspace & Procedures in the Metroplex (OAPM)
  - NAV Lean
  - PBN Harmonization
Benefits and objectives

- Reduce mileage, delays, fuel use, fuel loading requirements and emissions
- Reduce fuel burn and emissions with more continuous climbs and descents
- Improved airport access and de-confliction
- Reduce controller workload and pilot-controller communications
- Simplify flight planning, coordination and phraseology
- Expand routing options
- Improve Global Harmonization
End-to-End PBN Example: Seattle (or Portland) to Oakland

- 99 percent of flights on this route filed it
- 8 miles shorter than Jet Route
- Average savings of 1 minute per flight
- Annual savings of about $350k compared to previous J-route
End-to-End PBN Example: RNAV STAR joined to RNP AR approach
Program Status – PBN Projects

- **Current PBN Inventory**
  - 538 RNAV SIDs/STARs and 320 RNP ARs at 293 airports
  - 317 RNAV routes include 94 En route (Q), 79 Low Altitude (T) and 2 helicopter (TK)
  - More than 11,000 WAAS (LPV), LNAV/VNAV, RNAV (GPS) procedures

- **PBN Projects Underway**
  - 107 SIDs/STARs, 52 RNP ARs, and 20 Q/T Routes scheduled for FY12
  - Coordinating Q and T route plans with OAPM and NextGen
Transition to Q Routes Network

12 Q Route Projects Identified --Each project would involve multiple Q-routes spanning multiple ARTCCs and OAPM projects

Coordinating T-Route Plan with NextGen Office/Internal/External stakeholders

Connect metroplexes and busy city-pairs

<table>
<thead>
<tr>
<th>Project</th>
<th>Facility/Proponent</th>
<th>Publication Date</th>
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<tbody>
<tr>
<td>QP1 (13 routes)</td>
<td>Oakland Center - ZOA</td>
<td>May 2011</td>
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<td>QP2 (9 routes)</td>
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<td>QP3</td>
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<td>QP12</td>
<td>Denver Center - ZDV</td>
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Current Conventional J Routes network in the NAS

- Preferred ATC Routes
- Special Purpose Routes
- ATCSCC Playbook Routes
- ATCSCC Wind Routes
On-going PBN Projects

• More than 190 RNAV SIDs/STARs and more than 110 RNP AR procedures are scheduled to be implemented in the next 12-18 months with specific objectives including:
  ▪ SID/STAR decoupling and airspace de-confliction
  ▪ Optimized Profile Descent (OPD) STARs
  ▪ Net track mile reductions
  ▪ STARs merged to RNP AR and other approaches
  ▪ Improved safety and access with vertically guided approaches
  ▪ Interaction with OAPM

• ATC procedures and phraseology supporting PBN implementation
  ▪ Simultaneous parallel runway operations
  ▪ Climb via and speed adjustment
  ▪ Initial Heading (RNAV OTG)
  ▪ Approach clearance, including Radius to Fix (RF) segments
  ▪ Development of new PBN applications and separation standards
OPD RNAV STAR – RNP AR Merge

- Increases efficiency and shortens initial segments
- Allows continuous flight path to runway
- Reduces ATC and Pilot workload
- Eliminates crossing of parallel runways and runway transition branches
- De-conflicts airspace (over-flight corridor)
- Suitably equipped and authorized operators will reap significant benefits from the vertical profiles and reduced track miles
- Inherent noise and carbon reductions
- Projects underway at SEA, RDU, MCO, IND, ELP, PBI, BHM, MSP, JAX, SAV, ABQ, and OKC
Memphis Project Update

- 18 RNAV SIDs implemented 4/5/2012
- 7 RNAV OPD STARs implemented 7/26/2012
- New procedures are meeting or exceeding expectations of ATC and Industry
- Initial analysis and user comments suggest significant efficiencies gained
- More detailed analysis results expected by mid October 2012

Example of before (red) and after OPD (green)
Denver Project Update

- **Procedures**
  - 12 RNP ARs, 20 SIDs & 24 STARs – phased implementation plan to be complete by January 2013
  - Environmental assessment result (ROD/FONSI) expected 8/30/12

- **Benefits analysis update**
  - Arrivals offer de-confliction and noise reduction benefits
  - Pre-implementation study indicates departures could offer annual savings of 3.7 million gal fuel/ 37K metric tons carbon emissions, assuming 75% of departures issued unrestricted climb
  - Post-implementation benefits analysis will be conducted to confirm modeled benefits
Equivalent Lateral Spacing Operations (ELSO) Project at Atlanta Hartsfield - Jackson International Airport (ATL)

- ELSO allows less than 15-degree course divergence in dual and triple departure operations that were not possible before
- Optimized departure paths and increased airport arrival/departure throughput
- RNAV SIDs with reduced divergence – effective October 20, 2011
- March 7, 2012, full operational use; analysis commenced

Normal Departure Operations Utilizing the ELSO Standard

Dual

Triple
Primary Operational Changes at ATL

- **ELSO-Enabled Diverging Departure Operations**
  - Runways 08R, 27R
  - Increased departure efficiency

- **Separate Routing for North and South Departures**
  - Additional routes with increased route lengths
  - Potential need for level-offs at 10,000 feet for departures on additional routes

2006 Routes based on conventional divergence
2011 design based on ELSO Reduced Divergence
Evaluation of Operational Change Benefits at ATL

- ELSO-Enabled Diverging Departure Operations
  - Average delay reduction benefit per ATL departure

- Increased Route Length
  - Average track mile cost increase per ATL departure

- Increased Level-Offs
  - Average level-off cost increase per ATL departure

- ELSO-Enabled Net Benefit (2011 demand)
  - $44 per ATL departure
ELSO-Enabled Benefits at ATL

- **Benefits Per Departure**
  - $44 (2011 departure demand)
  - Approximately $100 if demand increases about 10 percent

- **Annual Benefits**
  - $19.2 million (2011 departure demand level)
  - Approximately $50 million if demand increases about 10 percent

- **Other Benefits**
  - RNAV *off the ground all the time*
  - Reduced voice communications

- **Future Work**
  - Design changes enabling more direct routing of North and South-bound departures (OAPM)
  - Potential to expand concept to en route
Current Application of Transitional Separation

- **Example: ATL Departures**

  - Terminal controllers must level-off departures or wait until required separation is established before initiating the hand-off to Center
  - Larger divergence angles ensure that lateral separation is established more quickly
Proposed Separation Standard

- Established-on-Departure Operation (EDO) Concept*
  - Aircraft are established on PBN courses and one aircraft has crossed the projected course of the other and the angular difference between their courses is determined to be equivalent to 15-degree radar vector / conventional separation.
  - Separation is constantly increasing on the PBN procedures until a minimum of 5 NM lateral separation is established
  - The procedure is covered by a LOA between the facilities involved and limited to specific routes and/or sections/positions
  - Terminal controllers must ensure that aircraft tracks are monitored to ensure that the primary targets, beacon control slashes, or full digital terminal system primary and/or beacon target symbols do not touch prior to transferring control to en route
  - Future research may support reduction of the 5 NM standard
EDO Expected Benefits

• Reduced Air Traffic Control (ATC) Task Complexity
  ▪ Use of a defined PBN procedure as opposed to the use of controller judgment to determine a mileage requirement

• More Continuous Departure Climbs
  ▪ Reduced level-offs at intermediate altitudes

• Increased Airspace Design Flexibility
  ▪ Possibility of more closely and/or additional routes through a given airspace

• Key Benefit-Enabling Operational Changes Include:
  ▪ Reduced route length
  ▪ Increased number of departure procedures and associated egress waypoints
  ▪ Earlier route divergence
  ▪ Reduced level-offs at intermediate altitudes
RNP SID Prototype Projects

• RNP departure procedures and operations are not available today (in U.S.)

• RNP SIDs will enhance path predictability and de-conflicting capability – RF legs feature

• Developing pilot projects for five airports (ATL, BOS, PSP, CLT & LAS) to evaluate special RNP standard instrument departure prototypes

• CPARK RNP SID at ATL under development - will keep heavy jets away from noise sensitive areas – March 2013
RNP SID Initial Assumptions

• RF is distinguishing design feature

• SIDs will be designed to RNP-1 criteria

• SIDs will be Specials with Transition path to public

• Industry participation as collaborative effort

• First beta site will be Atlanta (CPARK)
Greener Skies over Seattle Project Scope

i1 – Design/Implement PBN instrument procedures into a complex airspace, while providing an environment for research
- OPD STARs and RNAV (RNP, GPS) approaches
- Flight Simulation and Flight Trials
- Environmental Assessment of West-side proposed changes

i2 - Evaluate concepts, research alternatives and establish requirements resulting in full implementation of PBN technologies within SEA/BFI airspace and NAS-wide
- RNP - Established for parallel dependent operations
- Concurrent Operations
- RNP to ILS Capture
- Procedural separation of arrivals and departures

i3 – Implementation of new separation standards
- Procedures, rule changes, charting, training
“RNP-established” for Greener Skies Over Seattle
RNAV (RNP) next to ILS or RNAV (RNP or GPS)
Today (i1)
3 Mile stagger or Standard Separation
(Reduced track miles and reduced arrival rates)
i2 enables
RNP Established
1 ½ Mile stagger
Maintain arrival rates
Integrated Approach to Executing Greener Skies over Seattle Project

Oversight leadership team

2012

2013

... 

Major Milestones

- i1 Procedure Design
- i2 Research Program
- I3 Implementation

Key

Draft Procedures

Conops

OA (normal assessment)

SRMD

Analysis, Modeling & Sim, HITLs to support SMS

Operational Assessment Plan

SEA Flight Trial

Published Procedures Available Record of Decision

Special Procedure Available Flight Trials

Procedure Design

Published Procedures Available Record of Decision

SEA Dependent Operations Approval

Safety Case Approval

NAS-wide Rule Change Complete

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NAS-wide Rule Change Complete
What is OAPM?
(Optimization of Airspace & Procedures in the Metroplex)

• Takes a **systems approach** to PBN initiatives and airspace design
• Provides a **geographic focus** to problem solving
• Delivers an **expedited process** for integrated airspace and procedures efforts
• Uses **collaborative teams**
• Uses an educated **prioritization process**
• Enables **predictable and repeatable** flight paths
• Reduces task complexity while maximizing **safety and efficiency**
Metroplex and OAPM

Metroplex is large geographic area

- Services a diverse set of aviation customers
- Many airports, many stakeholders, multiple municipalities

**Challenges in today’s metroplexes require multi-faceted solutions**

Optimization of Airspace and Procedures is part of the larger “Metroplex” solution approach

**The “big” view of Metroplex requires the integrated set of solutions**
OAPM Sites

Annual Savings: Northern California
$6.5M - $15.5M fuel costs
2.3M – 5.6M gallons of fuel
23K – 56K metric tons of CO2
1.5M nautical miles (filed)

Annual Savings: Charlotte
$10.2M - $17.0M fuel costs
3.7M – 6.2M gallons of fuel
35K – 59K metric tons of CO2
2.5M nautical miles (filed)

Annual Savings: Washington DC
$6.4M - $19.0M fuel costs
2.5M – 7.5M gallons of fuel
25K – 75K metric tons of CO2

Annual Savings: Southern California
$10.1M - $22.9M fuel costs
$4.0M aircraft direct operating costs
3.4M – 7.8M gallons of fuel
34K – 78K metric tons of CO2
1.5M nautical miles (filed)

Annual Savings: North Texas
$10.3M - $21.7M fuel costs
4
4
1

Annual Savings: Houston
$9.2M - $26.1M fuel costs
3.0M – 8.6M gallons
31K – 87K metric tons
648K nautical miles (filed)

Annual Savings: Florida
TBD: Initiated 15 May 2012

Annual Savings: Atlanta
$8.3M
2.9M
30K
1.2M

Federal Aviation Administration
OAPM: Notional Timeline

Study Team
- Study and Scoping
  - Scope of effort defined

Design and Implementation (D&I) Team
- Design and Procedure Development
  - 90 percent designs developed
- Operational, Environmental, and Safety Review
- Implementation and Training
  - Preferred design determined
- Implementation completed

Total elapsed time averaging approximately 3 years

Note: Environmental involvement required at all stages of the process
### OAPM Waterfall

<table>
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<tr>
<th>Site</th>
<th>FY12</th>
<th>FY13</th>
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- Plan meets commitment to implement changes and provide benefits at all sites by the end of 2017
- Streamlining techniques from Houston may be applied to future sites to further accelerate benefits
NAV Lean Project

Purpose

- To improve and streamline processes used for optimizing air traffic procedures to include: requests, processing, approval, and implementation
- Results will be safe, repeatable, beneficial, and more efficient processes that comply with applicable regulations

Approach

- Reviewed all Instrument Flight Procedure (IFP) processes, tools, and procedures related to standards, policies, development, approval, publication, and utilization including environmental, safety & operational approval
- Used Lean principles to improve processes by eliminating waste
**NAV Lean Project – Implementation Overview**

**NAV Lean Report**
- Six Working Groups - 102 SME’s – 4 months
- Approximately 250 initial recommendations
- Anticipated benefits include reduction in processing time with better data integrity
- Final Report with 21 recommendations was approved and published in September 2010

**Implementation Plan**
- Two project leads coordinated with offices of prime responsibility (OPR) – 6 months
- Developed implementation plan including time line and preliminary cost estimates
- Implementation Plan signed delivered June 2011

**Project Execution**
- Ensuring dedicated management and oversight support
- Refining OPR assignments and responsibilities
- Establishing funding needs
- Program Reviews held quarterly with OPR’s to:
  - ensure structure
  - assess progress
  - confirm intent and scope are met
  - evaluate issues or concerns
  - Nov 2011
  - Feb 2012
  - May 2012
  - August 2012

* Target Completion Goal 2015
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<th>Issue</th>
<th>Rec</th>
<th>Recommendations (Related Recommendation #s)</th>
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<td>1</td>
<td>1</td>
<td>Expedited processing for minor revisions of IFPs (3, 4, 19)</td>
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<td>Approve TARGETS for electronic transfer (1, 3, 4, 19)</td>
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<td>Direct to QA for STARS development in TARGETS (1, 2, 4, 19)</td>
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<td>Establish abbreviated STAR amendment process in FAA Orders (1, 2, 3, 19)</td>
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<td>5</td>
<td>Establish standardized databases with custodianship and stewards (6, 7, 8, 9, 15, 19)</td>
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<td>Provide access to, and mandate use of, a single set of databases (5, 7, 8, 9, 19)</td>
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<td>Electronic transfer of data (2, 3, 5, 6, 8, 9, 15, 19)</td>
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<td>Standardize software and data formats (2, 3, 5, 6, 7, 9, 15, 19)</td>
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<td>Standardize data precision, resolution, and rounding values (5, 6, 7, 8, 19)</td>
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<td>10</td>
<td>Amend FAAO 1050.1E to allow ‘focused’ approach to EAs and tracking (11, 12)</td>
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<td>Issue interim guidance for use of focused approach to EAs (10, 12)</td>
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<td>Enhance EA screening tools (more user friendly, efficient, comprehensive (10, 11, 13, 14, 18)</td>
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<td>Standardize management and environmental specialist training (10, 11, 12, 14)</td>
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<td>Modify FAAO 8260.19 to define responsible federal official (10, 11, 12, 13)</td>
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<td>USIFPP as focal point for criteria changes and new requests (3, 7, 8, 19)</td>
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<td>Standardize SMS process (17)</td>
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<td>Interim guidance for SRM (16)</td>
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<td>Establish a web-based IFP portal (19, 20, 21)</td>
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<td>Amend FAA Order 8260.19 to define life cycle policy for IFP development (1, 4, 5, 6, 10, 11, 12, 15, 16, 17, 18, 19, 20, 21)</td>
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<td>Develop outreach/communication plan to educate users on IFP Portal (18, 19, 21)</td>
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<td>Establish a web-based Operations (Ops) Approval portal (18, 19, 20)</td>
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### NAV Lean Implementation Percentage Completion

| Rec # | Recommendation Description                                      | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
|-------|---------------------------------------------------------------|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1     | IFP minor revisions                                           |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 2     | TARGETS electronic transfer                                   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 3     | Direct to QA for STARS                                        |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | July 2014 |
| 4     | Abbreviated STARS amend                                       |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | December 2013 |
| 5     | Standardized databases                                        |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | March 2013 |
| 6     | Single set of database providers                              |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | September 2015 |
| 7     | Electronic transfer of data                                  |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | Sept 2015 |
| 8     | Standardized & accessible data formats                       |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | May 2015 |
| 9     | Standardized data precision                                  |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | September 2015 |
| 10    | Amend FAAO 1050.1E for focused EAs                           |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | December 2013 |
| 11    | Interim guidance on focused EA (complete)                    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | September 2015 |
| 12    | Enhanced environmental screening tools                       |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | September 2015 |
| 13    | Mgmt & environ specialist training                           |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | March 2014 |
| 14    | Modify FAAO 8260.19 defining signing authority               |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | December 2012 |
| 15    | Establish USIFPP focal point                                 |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | September 2012 |
| 16    | Publish new FAAO standardizing SMS process                   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | July 2013 |
| 17    | Interim SRM compliance guidance                               |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | December 2012 |
| 18    | Establish Web-based request and access portal                 |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | Sept 2014 |
| 19    | Modify FAAO 8260.19 defining IFP life-cycle policy           |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | January 2014 |
| 20    | Plan web based portal training and awareness                 |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | September 2015 |
| 21    | Ops approval portal                                          |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | December 2014 |
International Harmonization

- 11 presented in 2007-2009

Participate in PBN implementation seminars/workshops
- FY 2011 - Canada; India; Ukraine; Thailand;
- FY 2012 – Mexico; Canada and Belgium scheduled

ICAO panels and study groups
- PBN Study Group – new draft PBN Manual
- Separation and Airspace Safety Panel (SASP)
- Instrument Flight Procedures Panel (IFPP) ATM WG
Discussion