Performance-Based Navigation (RNAV and RNP): Implementation in the U.S.

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Overview

- “Snapshot” of current U.S. Implementations
- Enroute
- Terminal
- Approach
Performance-Based Navigation In All Phases of Flight
“Snapshot” of Current U.S. Implementations

RNAV SIDs
RNAV Q Routes, T Routes
RNAV STARs
RNP SAAAR approaches
RNAV approaches
Enroute
Performance-Based Navigation Domestic (Continental) Enroute Operations

- All current U.S. Enroute implementations are RNAV
  - Does not rely on aircraft on-board containment monitoring and alerting as elements of the overall safety of the operation
  - The overall level of safety is achieved through a combination of aircraft navigation accuracy, radar monitoring, and / or additional airspace for separation buffers
Enroute RNAV routes FL 180 and above: Q-Routes

- Aircraft must maintain a track keeping accuracy bounded by ±2 NM for 95% of total flight time
- Radar monitoring required
- Track to track spacing at least 8 NM
- GPS Required or
  - Authorized for DME/DME or DME/DME/IRU as infrastructure supports
- 20 routes in operation; 23 in development

Allows qualified traffic off crowded conventional routes:
   Capacity, efficiency
Terminal
Performance-Based Navigation
Terminal Control Area (TMA) Operations

• All current U.S. terminal implementations* are RNAV
  ▪ Does not rely on aircraft on-board containment monitoring and alerting as elements of the overall safety of the operation
    ➢ The overall safety of the operation is achieved through a combined use of aircraft navigation accuracy, route separation, and/or air traffic control intervention
  ▪ Terminal RNAV implementations
    ➢ Transit Routes – RNAV IFR Terminal Transition Routes (RTTRs)
    ➢ Standard Terminal Arrival Routes (STARs)
    ➢ Standard Instrument Departures (SIDs)

* U.S. considers Approach a separate domain from Terminal
RNAV Routes Below FL180: T Routes
RNAV Terminal Transition Routes (RTTRs)

Benefits of “T” Routes
• Better access to Class B and C airspace for general aviation
• Lower Minimum En Route Altitudes
• Increased stratification
• Segregates transiting aircraft from arrivals/departures at primary airport
• Reduced mileage

T Route Implementations
• Charlotte, North Carolina
  • 4 routes published 1 Sept 05
• Jacksonville, Florida
  • 4 routes planned publication 22 Dec
• Cincinnati, Ohio
  • 4 routes planned publication 22 Dec
RNAV Departures and Arrivals (SIDs, STARs)

Benefits

- Increased arrival/departure throughput and efficiency
- Increased predictability
- Decreased departure delays
- Decreased taxi-times
- Reduced track distances
- Reduced voice communications and vectoring
- More efficient vertical profiles
- Reduced fuel consumption

The FAA published 36 RNAV SIDs and 16 RNAV STARs in FY2005
Atlanta: RNAV Standard Instrument Departures (SIDs)

**BEFORE**
- Departures vectored
  - Headings, altitudes and speeds issued by controllers
  - Large number of voice transmissions required
- Significant dispersion
  - Tracks are inconsistent and inefficient
- Limited to 4 exit points to enroute environment

**AFTER**
- Departures fly RNAV tracks (not vectored)
  - Headings, altitudes and speeds are automated
  - Voice transmissions reduced by 30-50%
- Reduced Track Dispersion
  - Tracks are more consistent and more efficient
- 6 exit points available
Atlanta SIDs continued
Issues/Lessons Learned:

- Dallas (KDFW)
  - 16 RNAV SIDs implemented 22 November 04
  - Procedures suspended on 24 November 04 due to wide track dispersion in crosswind segments
Issues/Lessons Learned: continued

- Significant variation in flight tracks can result when RNAV procedures are designed with
  - Fly-over waypoints
  - Turns with angles larger than 070 degrees
  - Conditional leg types (VA, VM)

- Flight Management Computers (FMC) from various manufactures have different capabilities which may affect flight tracks
  - Leg sequence coding differences
  - Speed management with vertical constraints
  - Bank Angle limiters

- Mitigations to reduce track dispersion:
  - Implement ‘at or below’ speed restriction of 220kts or less on the initial (10NM) segments of the DFW procedures
  - Emphasize operational guidance that direct flight crews not to limit bank angles while executing RNAV procedures
  - Provide operational guidance emphasizing the use of flight director and/or use of the autopilot as referenced in Advisory Circular AC-90-100
Issues/Lessons Learned:

• Dallas (KDFW)
  ▪ 16 RNAV SIDs turned back on 6 September 05
    ➢ Tested in August
Approach
RNAV Approaches

- Have been in use in some form since 1969
  - VOR/DME RNAV
  - GPS (overlay of conventional procedures)
  - RNAV (GPS)
- Over 2,600 RNAV approach procedures currently published in U.S.
Public RNP SAAAR* Approach Criteria
Enabling Features

Narrow lateral linear segments
(RNP-0.3 or less with no secondary buffers)

Curved segments anywhere along the approach
(Radius-to-fix legs with shorter leg lengths)

Guided, narrower turns on missed approaches
(Radius-to-fix legs, and RNP-1 or less)

Performance-based Vertical Buffers
(Vertical Error Budget)

*Special Aircraft and Aircrew Authorization Required
RNP SAAAR* Implementation: An FAA National Initiative

- Implementation of the initial RNP SAAAR projects is considered a national initiative
- Implementation concept
  - Initial projects processed as “Special” (i.e. not public) procedures using FAA Notice 8000.287 (July 2004)
    - FAA Notice 8000.287 provides
      - Procedure development criteria (TERPS)
      - Aircraft evaluation requirements
      - Operator approval requirements
    - Reissued July 2005 as FAA Notice 8000.300

* Special Aircraft and Aircrew Authorization Required
RNP SAAAR* Implementation: An FAA National Initiative continued

- Implementation of public RNP SAAAR approaches
  - FAA Order 8260.52 published June 2005
    - Procedure development criteria (TERPS) for public procedures
    - Submitted to ICAO Obstacle Clearance Panel in Sept 05 for adoption into PANS OPS
  - FAA Advisory Circular (AC) 90-RNP SAAAR planned for October 2005
    - Public procedures remain SAAAR (similar to ILS CAT II/III)
  - First public RNP SAAAR procedure
    - Washington’s Reagan National (KDCA) RWY 19
    - Charted 01 September 2005
  - FAA’s National Flight Procedures Office in Oklahoma City begins regular production in Fiscal Year 2006
    - Based on sites identified by FAA-industry Performance-Based Aviation Operations Rulemaking Committee (PARC)

* Special Aircraft and Aircrew Authorization Required
Palm Springs RNP SAAAR* Approaches (31L, 13R) (January 2005)

- Replaces non-precision approach into the valley with mountainous terrain
- Safety enhancement, with guided, stabilized 3D path to runway
- Reduced time & distance (~30 miles)
- “VOR or GPS B” minima is 2300 - 3
- RNP SAAAR minima 684 - 1
- Cancellations and diversions avoided
  - 24 flights diverted/cancelled in 6 weeks before implementation
  - 20 “SAVES” since implementation
    - A SAVE is a flight that would have been canceled or diverted if the RNP procedure was not available
- Initial implementation as a “Special” procedure for Alaska
  - Public version planned for 22 Dec 05
  - Public procedure remains SAAAR

SAAAR – Special Aircraft and Aircrew Authorization Required
Questions
Backup Slides
RNAV (US definition)

- A method of navigation that enables aircraft to fly on any desired flight path within the coverage of referenced navigation aids (NAVAIDS) or within the limits of the capability of self-contained systems, or a combination of these capabilities

  - Routes and procedures using RNAV provide improved access and flexibility through point-to-point navigation and are not restricted to the location of ground-based NAVAIDs

- The overall safety of the operation is achieved through a combined use of aircraft navigation accuracy, route separation and/or air traffic control intervention (e.g., via radar monitoring, automatic dependent surveillance (ADS), multi-lateration, communications)
RNP (US definition)

- RNP is RNAV operations with on-board navigation containment, monitoring and alerting

- A critical component of RNP is
  - the ability of the aircraft navigation system to monitor its achieved navigation performance, and
  - to identify for the pilot whether the operational requirement is or is not being met during an operation

- This on-board monitoring and alerting capability can reduce reliance on increased route separation and/or air traffic control intervention (e.g., via radar monitoring, automatic dependent surveillance (ADS), multi-lateration, communications) to maintain the overall safety of the operation
FAA’s Roadmap for Performance-Based Navigation

- Collaborative effort among aviation industry stakeholders
  - Performance-based Operations Aviation Rulemaking Committee (PARC)
- Three Planning Horizons
  - Near-term 2003 to 2006
  - Mid-term 2007 to 2012
  - Far-term 2013 to 2020
- Harmonization considerations
- Focuses on operational capabilities in:
  - En route domain
  - Terminal domain
    - Standard Terminal Arrivals (STARs)
    - Standard Instrument Departures (SID)
  - Approach domain
    - RNP Special Aircrew and Aircraft Authorization Required (SAAAR)

Update scheduled for December 2005
Definition: RNP Containment

• **RNP-\(x\)** is aircraft path conformance (with accuracy \(x\) or better, 95% of time)

• **RNP Containment Region** is an area 2x RNP-\(x\) with accuracy, integrity and continuity generating a probability that aircraft is within the containment area 99.999% of time
  - RTCA DO-236a/ EUROCAE ED-75 has adopted 2xRNP as the lateral containment area
Session 2

RNAV – The First Steps

Applications