Optimized Profile Descent (OPD) Implementation

Presented to: ICAO Asia-Pacific Region
PBN Implementation Seminar 2010

By: Nick Tallman, RNP Technical Lead,
RNAV/RNP Group,
Air Traffic Organization, FAA

Date: February 1, 2010
Overview: OPD Implementation

- OPD Procedures – What are they?
- Site Selection and Implementation Status
- How full-time OPD is being achieved at LAX today
- Additional OPD examples and demonstrations
- Implementation process
Optimized Profile Descent (OPD) Arrivals

What are they?

- Reduce the amount of time spent in level flight on published arrival procedures (i.e., STARs)
- Published procedures will principally consist of PBN procedures although not exclusively (e.g., LAX arrivals)
- Leverages RNAV STAR implementations
Descent Optimized for a Variety of Aircraft

RIIVR ONE STAR
CDA Simulation Results
11/30/2006

RIIVR
Gramm (65nm AER) 300 kt
HABSO
RUSTT
FL210

EMMEY (104nm AER)
DYPSO
HEC (FL 375)
DIKES (128nm AER)

FL 430 (FL 410)

FL 330
FL 310

B-757
B-767 HEC transition
B-767 ATC speed intervention (slow)
B-767 PGS transition
Top Of Descent @ FL350
Calculated TOD @ FL230 and FL410

(XXX) Calculated descent windows

xxx Published altitude restrictions

OPD Implementation
1 February 2010

Federal Aviation Administration
Airspace Considerations

**OPD with Altitude Constraints in Terminal Airspace**

![Diagram showing geometric descents and idle descents with altitude constraints and along-track distance](image)
RNAV OPD Site Selection Process

• FAA Administrator tasking
• Conducted a NAS-wide high-level analysis for prioritization of OPD implementation sites (Feb 09)
• Analyzed 4,000 flows at 1,800 airports and ranked by benefits and PBN implementation status
  o High and Medium benefits rank site by potential gain
  o PBN implementation status identifies sites that are currently planned for RNAV implementation
• Next steps
  o Compare various weighted rankings
  o Develop a composite site list for detailed site evaluation
  o Continue targeted site development and implementation
RNAV Implementation of OPD

- Three OPD (conventional) procedures implemented at Los Angeles (LAX)
- Other Procedures published:
  - Atlanta (ATL) - One full OPD Published 8/2009
  - Phoenix (PHX) - Two published with vertical profiles
  - Las Vegas (LAS) - Four published with vertical profiles
  - San Diego (SAN) - One OPD published
- OPD demonstrations:
  - Louisville (SDF) 2004-2005
  - Atlanta (ATL) 2007-2009
  - Miami (MIA) 2008
  - Anchorage (ANC) 2009
- Other OPD developments are:
  - San Diego (SAN) - OPD RNAV STAR under development
  - Louisville (SDF) - Joint effort with UPS. Five RNAV STARs under development. Publication date TBD
  - Charleston (CHS) - FAA/Air Mobility Command/DAL effort; Four procedures developed. C-17 flight sim work 8/2009. January 2010 demo. FY11 publication
  - Hawaii (HCF) - Five Honolulu/Hilo STARs developed. Pub date 4/10 and 6/10
  - Reno (RNO) - Three optimized RNAV STARs developed. Pub dates 1/2011
  - Las Vegas optimization of RNAV STARs. Pub date TBD
  - Atlanta (ATL) - Additional OPDs pending.
*Several other RNAV STAR workgroups in progress*

- Tailored Arrival Demonstrations:
  - Los Angeles (LAX)
  - Miami (MIA)
  - San Francisco (SFO)

Additional coastal sites pending for FY11
Descend Via Phraseology Development

• Leverages modern flight management system (FMS) capabilities to fly precise lateral and vertical paths and manage aircraft speed when flying published STAR
• Reduces phraseology and pilot/controller workload
• Provide flexible tool for controllers to amend procedure or to vector off and rejoin
• Restates procedure restrictions with any exceptions
• Does not apply to segments with “expect” altitudes
• Pilot should maintain last assigned/modified/restated altitude without a “descend via” clearance
Descend Via Implementation

- Descend Via phraseology was established in 2005 for STAR/RNAV STAR/FMSP with vertical restrictions
- Clearance to “descend via” authorizes pilots:
  1. To vertically and laterally navigate on a STAR/RNAV STAR/FMSP.
  2. When cleared to a waypoint depicted on a STAR/RNAV STAR/FMSP, to descend from a previously assigned altitude at pilot's discretion to the altitude depicted for that waypoint, and once established on the depicted arrival, to navigate laterally and vertically to meet all published restrictions. ATC is responsible for obstacle clearance when issuing a “descend via” clearance from a previously assigned altitude.
  3. Pilots cleared for vertical navigation using the phraseology “descend via” shall inform ATC upon initial contact.
Los Angeles OPD Project

RIIVR TWO ARRIVAL
(Optimized Profile Descent)

• Affords 50% of LAX traffic an OPD arrival – a 5-year + process
• 96% compliance with the vertical profile
• Fuel savings of over 2 million gal annually
• Reductions in CO₂ emissions estimated at over 41 million metric tons annually

NOTE: DME or RADAR required.

Expect runway assignment on initial contact with Southern California TRACON.
In the event of lost communications prior to runway assignment proceed via ILS RWY 25L.
Improvements to CIVET5 create the RIIVR1
RADAR Flight Tracks, Side View -

RIIVR STAR
OPD

18,000'

10,000'

LAX

Optimization process also used for RNAV STARs
New KLAX OPD System –
Designed with FMS Programming in Mind

OPD Integrates STAR & Approach Design

FMS Programming in 3 Easy Steps
New KLAX OPD STARS –
Designed with FMS Programming in Mind

1. Select the STAR
2. Select the Approach for the landing runway

OPD Implementation
1 February 2010
New KLAX OPD STARS – Designed with FMS Programming in Mind

3. Select the ILS/RNAV Transition. Note how the name of the STAR is contained in the transition.

4. When the change is executed, the path to the runway links all the way to touchdown.
New KLAX OPD STARS – Designed with FMS Programming in Mind

When a runway change is received from ATC, reprogramming the FMS is as simple as just selecting the new approach procedure, the appropriate runway transition for the STAR and executing the change.

Due to the new design changes, it is no longer necessary to reprogram the entire STAR.
KLAX OPD Results to Date

- RIIVR2/SEAVU2/OLDEE1 and 4 revised ILS approaches implemented September 25, 2008 and in use full-time at KLAX

- SCT issues “Descend via…” and ILS clearance on initial contact
  - “Descend via” phraseology works and is easily understood/communicated to pilot
  - Common speed constraint makes flow manageable for ATC

- About 300-400 aircraft per day fly RIIVR2/SEAVU2/OLDEE1 OPD representing approximately ½ of all jet arrivals into KLAX (over 150,000 OPD flown since inception

- 50%+ reduction in radio transmissions during critical phase of flight

- Early LNAV/VNAV engagement allows for a stabilized approach

- Significant fuel savings – avg. 125 pounds per flight
  - 300 flts/day X 125 #/flt X 365 days/yr = 13.7 million pounds/year
  - 2+ million gallons/year saved = 41+ million pounds of CO2 avoided
OPD Development – Anchorage, AK

- NEELL OPD, June 4, 2009
- JAL/ATLAS/POLAR/QFA/ASA and EVA flying the procedure, FL to touchdown
- 4.2 million gallons/yr (source: AEDT)
- 83 million lbs CO2/yr (source: AEDT)
- NEELL, TYOWN, PORTJ, KROTO OTTRR June 2010
• KAENA, KLANI, REEEF, HARBR OPD
  ✓ Fully integrated/linked to approach, FMS friendly
  ✓ Descend via from cruise flight levels
  ✓ Simulation results complete at JAL & at UAL
  ✓ Projected Fuel Savings 4.3 million gallons/yr – 84 million lbs/CO2/yr (source AEDT)
  ✓ Publication, April 2010
**Phoenix OPD – Phased Implementation**

*EAGUL RNAV STAR Procedure Using Descend Via (DV) Operations*

- **DOJOE**
  - No altitude constraint
- **FL360**
- **FL310**
- **FL260**
- **FL240**
- **SLIDR**
  - No altitude constraint
- **HOMRR**
  - 12000’
  - 250 kts
- **BADNE**
  - 9000’
- **QUENY**
  - 8000’

**Conventional step-down arrival operations**

- **Oct 20, 2008**
  - ZAB issues DV
  - As early as DOJOE

- **Sep 22 – Oct 20, 2008**
  - ZAB issues DV shortly after SLIDR

- **FL240**
  - 280 kts
- **PAYSO**
  - FL240
- **PICHR**
  - 16000’
  - 280 kts

- **Oct 20, 2008**
- **FL360**

- **DOJOE**
  - FL240
  - 280 kts

- **FL260**
- **FL240**
- **FL310**
- **FL360**
- **SLIDR**
  - No altitude constraint

**Handoff to Final**

**OPD Implementation**

1 February 2010

- **ZAB**
  - 8000’

- **PHX TRACON**
  - 9000’

- **Saved 5 gallons per arrival since implementation**

- **Oct 2006 – Sep 2008**
  - PHX TRACON issues DV on EAGUL

- **ZAB**
  - 12000’
  - 250 kts

- **PHX TRACON**
  - 16000’
  - 280 kts

- **Saved 5 gallons per flight of fuel savings**

- **Sept/October 2008 use from FL310 to FL360**
  - Savings up to 23 GAL per flight

- **October 2006:**
  - Terminal use generated 5 GAL per flight of fuel savings

- **Reductions in CO$_2$ emissions estimated at 2,500 metric tons annually**
Opd demonstration demonstrations - ATL and MIA

- OPDs provide large benefits for fuel, emissions, and flight time
- May 2008 Demos
  - DIRTY STAR at Atlanta (ATL), 38 gallons of fuel savings and 360kg reduction in CO2 emissions per flight
  - RUTLG STAR at Miami (MIA) 48-52 gallons of fuel savings and 460-500kg reduction in CO2 emissions per flight
- 600 OPD night demos at ATL from Aug - Nov 2008
- VIKNN and NOTRE STARs
  - 40-60 gallons of fuel savings and 380kg reduction in CO2 emissions per flight
OPD Human in the Loop (HITL) Simulations

• OPD Operational impacts identified through HITLs at ATL and MIA
  o Crossing traffic impacts sequencing/issuing descent clearance
  o Departure traffic frequently uses same gates as arrivals
  o Intra-facility sector point-outs for coordination of high and low airspace
  o Inter-facility coordination is not automated; requires voice coordination

• Airspace and airport impacts of OPD
  o Sector geometries from high to low en route and terminal complicate design
  o Traffic flows in one sector may impact other high/low/terminal sectors
  o OPD top-of-descent location is not fixed for performance based procedures

• Procedure viability
  o Easier to manage from lower altitude sectors due to reduced complexity
  o More workable in low to medium density traffic situations - fewer conflicts
  o Adverse efficiency impact in high density traffic situations - multiple conflicts
  o Current automation tools are not adapted for unique OPD requirements
FAA Guidelines for Implementing Terminal RNAV Procedures

- A systematic, repeatable approach to the design and implementation of terminal RNAV procedures
- Includes key stakeholders and subject matter experts
- Published as Appendix 5 (18 Step Process) of FAA Order 7100.9D, *Standard Terminal Arrival Program and Procedures*
- Provides guidance and serves as a tracking mechanism to expedite the development, review, and implementation of a terminal RNAV procedures
- Used in conjunction with FAA Orders and other applicable documents addressing RNAV procedure development
FAA RNAV Procedure Development Process

- FAA Guidelines
- RNAV Working Group
- Facilitator
- FAA Design Tool
- Project Timelines

Published Terminal RNAV Procedure
The RNAV Working Group
Key Stakeholders and Subject Matter Experts

- Terminal Air Traffic Facilities
- En Route Air Traffic Facilities
- Airline Operators
- Airport Authority
- Procedure Designer
Guidelines - “18 Step” Process

1. Kickoff Meeting
2. Adapt TARGETS
3. Reserve Waypoint Names
4. Design the Procedure
5. Simulator Evaluation
6. Working Group Review of Procedure
7. Process Decision
8. Procedure Documentation
9. Automation
10. Environmental Review
11. Advise Industry of Project Development
12. AVN Flight Check
13. Video Maps
14. Training and Notification
15. Process Verification
16. Lead Operator Flight Trials
17. Publish Procedure for Public Use
18. Post Procedure Implementation Analysis
Components of the Guidelines

- Preliminary Activities
  - Establish Working Group
  - Adapt TARGETS
  - Kickoff Meeting

- Procedure Design
  - Develop
  - Validate
  - Document and Submit

- Pre-Implementation
  - NFPG Process
  - Notification and Training
  - Automation
  - Flight Trials

- Post-Implementation
  - Validate Objectives
  - Feedback to Process
Awareness Information and Training

- Every implementation requires some level of information to be provided to both controllers and flight crews
- Complexity of implementation drives type of information needed
  - Awareness
  - Education
  - Training
OPD Implementation Lessons Learned

• Experienced cadre employing a proven implementation process greatly contributes to timely success
• Phased implementations provide incremental benefits – an “all or nothing” stance is not constructive
• Common speed constraints are key to managing flow (spacing and merging)
• Planning the implementation for a brief period after publication has proven value for success
• Additional tools for OPD design and analysis would help facilitate development and optimization
Additional Tools Coming - Monte Carlo FMS/Aircraft Simulation Tool (MFAST) Development

• MFAST is a trajectory model built to estimate fuel/emissions benefits and airspace impacts of SID/STAR procedures
  • Currently resides in iTRAEC (SLX)
  • Creation of standalone module and integration into TARGETS underway
• MFAST constructs modeled flight profiles on TARGETS-generated SIDs and STARs (including Optimized Profile Descents)
  • BADA flight performance (now using latest version 3.7)
  • Flight Management Computer VNAV path construction
• MFAST accounts for operational variability in flight profiles by allowing user to specify/vary:
  • Fleet mix, cruise altitude, wind, temperature, weight, FMC, descent speed, cruise speed
MFAST Profile Generation Process

TARGETS Procedure (current or future)

VNAV Path Construction Rules

BADA Aircraft Performance Model

STAR and SID Trajectories

Monte-Carlo Simulation

Wind Profiles

Fleet Mix

FMS Equipage

OPD Implementation
1 February 2010
Summary – OPD Implementation

- OPDs promise numerous benefits – and deliver.

- OPD from top of descent to runway is the ideal, but not an essential goal for initial implementations.

- Site selection priority based on both potential benefits and practical considerations.

- A comprehensive, collaborative and repeatable process will ensure effective implementation.