Upcoming Industry Mandates and Avionics Technology

SBAS-LPV, RNP, CPDLC and ADS
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Acronyms

• SBAS – LPV (Space Based Augmentation System– Localizer Performance Vertical)

• RNP - AR (Required Navigation Performance – Authorization Required)

• FANS (Future Air Navigation System)
  – CPDLC (Controller Pilot Data Link Communication)
  – ADS – C (Automatic Dependent Surveillance - Contract)

• PM-CPDLC (Protected Mode CPDLC) – Link 2000+

• ADS – B (Automatic Dependent Surveillance – Broadcast)
PM-CPDLC, CVR Mandate Timeline

FAA CVR CPDLC Recording
Part 135 operators (only if A/C has CPDLC)
December 2010

FAA CVR CPDLC Recording
Part 91 operators (only if A/C has CPDLC)
April 6, 2012

Eurocontrol PM-CPDLC
Forward Fit
February, 2013

Eurocontrol PM-CPDLC
Forward Fit, End of FANS1/A Exemption
January 2014

Eurocontrol PM-CPDLC
Retrofit
February 2015

Eurocontrol PM-CPDLC
Non-Compliant A/C can’t fly in Europe
January 2017


= Preliminary Date
= Published Date
ADS-B and TCAS 7.1 Mandate Timeline

- **Eurocontrol TCAS 7.1**: Forward Fit March 2012
- **Australia ADS-B Out**: Ops Requirement above FL290, DO-260B November 2013
- **Eurocontrol ADS-B Out**: Forward Fit, DO-260B January 2014
- **FAA ADS-B Out**: Forward-fit & Retrofit, DO-260B November 2014
- **Eurocontrol TCAS 7.1**: Retrofit January 2015
- **Eurocontrol ADS-B Out**: Retrofit, DO-260B January 2017
- **FAA ADS-B Out**: Ops Requirement in Controlled Airspace

Stars: Preliminary Date

Circles: Published Date
• SBAS – LPV Overview
SBAS Defined

• Provides GPS signal corrections to give better position accuracy comparable to an ILS Category 1 (precision approach) system
• Use of LPV approaches capitalizes on the inherent accuracy of the SBAS signal and will result in lower approach minimums
• Enables vertical approaches at airports where there are no instrument landing systems
• RNP 0.1 capability is enhanced with the improved position accuracy
  – SBAS can provide RNP 0.1 with 99.9% availability as compared to 80% availability for standard (C-129) GPS today
  – NOTE: SBAS is not required for RNP 0.1
SBAS History

• Prior to SBAS, GPS was not able to provide the accuracy or integrity to CAT 1 minimums
• FAA and DOT began developing WAAS in 1994 to allow for precision approaches
• In 2003, the WAAS signal was activated for public use
• In 2004, Garmin was the first to produce a WAAS LPV receiver
GPS - Wide Area Augmentation System (WAAS)
Space Based Augmentation System (SBAS)

- Regional SBAS systems around the globe
  - WAAS – Wide Area Augmentation System (US, Canada, Mexico)
  - EGNOS – European Geostationary Navigation Overlay Service (Europe)
  - MSAS – Multifunctional Satellite Augmentation System (Japan)
  - GAGAN – GPS Aided Geostationary Augmented Navigation (India)
### SBAS - GPS – Accuracy Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GPS</th>
<th>SBAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Position Accuracy</td>
<td>10 m</td>
<td>1-2 m</td>
</tr>
<tr>
<td>Vertical Position Accuracy</td>
<td>15 m</td>
<td>2-3 m</td>
</tr>
</tbody>
</table>
The LPV Approach

- Currently over 2300 published in the U.S. as of 4Q 2010
- Plan is for 300 per year into 2011

<table>
<thead>
<tr>
<th>LPV DA</th>
<th>1030 – ½ 250 (250 – ½)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNAV/ VNAV DA</td>
<td>1160 – ¾ 382 (400 – ¾)</td>
</tr>
</tbody>
</table>
SBAS Upgrade Value Proposition

- LPV Approach Capability
- Higher integrity and availability, no Predictive RAIM (PRAIM) required
- Compliance with emerging ADS-B requirements
- Higher accuracy positioning both vertically and horizontally
- Provisions to fly both LNAV/VNAV and LPV approach categories
- GPS-Based altimetry allowing lower minimums than traditional GPS
EGNOS

European Geostationary Navigation Overlay Service
EGNOS APV Testing and Rollout

- First LPV approaches with certified EGNOS system tested by Dassault F900 EX (EASy II) March 2011
- LPV (APV) approaches to be published in Europe in 2012
SBAS Hardware and Software Requirements

- New GPS SBAS receiver and active antenna
- LPV annunciator lights and interface unit (Digital Discrete Adapter) or EFIS symbol generator software update
- New FMS software
- SBAS Constellation

All SBAS regions are designed to be interoperable – WAAS, EGNOS, MSAS and GAGAN will require only one type of SBAS receiver on aircraft
• Required Navigation Performance (RNP) Overview
Required Navigation Performance (RNP)

RNP is a statement of the navigation performance necessary for operations within a defined airspace defined in nautical miles.

Onboard avionics capable of navigating the aircraft within a tightly specified airspace corridor.
RNP AR Definition

- **RNP AR**
  - Same as AR – Special Aircraft and Aircrew Authorization Required
  - Guidance per AC 90-101 and AMC 20-26
  - Special approaches which require additional LOA and FAA approval
  - Aircraft requires AFM statement detailing compliance to AC 90-101
  - Pilot training currently being conducted at FSI and CAE as an enrichment course (pilots only need one sign off to fly all approaches)
Conventional vs. RNP Route Comparison

- Two new FAA Advisory Circulars (ACs) define the move to lower RNP
  - AC 90-101 – Approval Guidance for RNP Procedures with AR
  - AC 90-105 – Approval Guidance for RNP Procedures (non-AR)
  - EASA NPA 2008-14 / AMC 20-26 RNP- Authorization Required

*RNP keeps aircraft in a tightly defined corridor*
RNP Defined – Approach Design Criteria

**ILS or LPV Straight In Approach**

- Trapezoidal buffer for obstacle clearance

**RNAV Approach**

- Secondary buffer for obstacle clearance

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RNP Defined – Approach Design Criteria

RNP AR Approach

Secondary buffer removed for obstacle clearance

RNP AR Approach with RF Guided Turn

RF Leg provides navigation around obstacle
Approach Design Criteria

Approach with RNP 0.3
- For RNP AR (AC 90-101)
  - Obstacles will be assessed within 2 X RNP (2 X 0.3 = 0.6) NM from either side of course
- For RNP Non-AR (AC 90-105 & GPS Approaches)
  - Obstacles will be assessed within ~3 X RNP (3 X 0.3 = 0.9) NM from either side of course
  - Similar to how GPS approaches are designed today
- For WAAS LPV
  - Obstacles will be assessed with a trapezoidal containment region similar to an ILS
RNP Operational Benefits

- **Improved Access to Airports & Airspace**
  - Obstacle clearance enabling better access to
    - Terrain challenged airports
    - Congested Airspaces
    - Restricted airspace challenged airports
  - Lower minimums

- **Efficiency of Operations**
  - Time savings
    - Shorter routes
  - Fuel savings
  - Improved noise footprint

- **Safety**
  - Clearly defined lateral and vertical flight paths = stabilized approach
  - Enhanced situational awareness
  - Missed approach procedures clearly defined

*RNP AR Supports Green Initiatives!*
US RNP AR Airports

- Atlanta KATL
- Atlanta Fulton KFTY
- Atlanta Peachtree KPDK
- Atlantic City KACY
- Baltimore KBWI
- Birmingham KBHM
- Bishop KBIH
- Boise KBOI
- Bozeman KBZN
- Burbank KBUR
- Charlotte KCLT
- Chicago KMDW
- Cincinnati KCVG
- Colorado Springs KCOS
- Columbus KCMH
- Corpus Christi KCRP
- Dallas/Ft. Worth KDFW
- Ft Lauderdale KFLL
- Gary KGYY
- Glacier Park MT KGPI
- Guam PGUM
- Gunnison KGUC
- Hailey KSUN
- Hayden KHDN (Steamboat)
- Helena KHLN
- Honolulu PHNL
- Idaho Falls KIDA
- Indianapolis KIND
- Jackson Hole KJAC
- Kalispell KGPI
- Kansas City KMCI
- Lewiston KLWS
- Lihue PHLI
- Long Beach KLGB
- Los Angeles KLAX
- Louisville KSDF
- Lubbock KLBB
- Manchester KMHT
- Medford KMFR
- Memphis KMEM
- Miami K Mia
- Minneapolis KMSP
- Missoula K MSO
- Monterey KMRY
- Nashville KBNA
- New Orleans KMSY
- New York KJFK
- New York K LGA
- Newark KEWR
- North Bend KOTH
- Oklahoma City KOKC
- Ontario KONT
- Orlando KMCO
- Palm Beach KPBI
- Palm Springs KPSP
- Philadelphia KPHL
- Phoenix KPHX
- Pittsbug KPIT
- Portland KPDX
- Prescott KPRC
- Raleigh KRDU
- Reno KRNO
- Rifle KRIL
- San Francisco KSFO
- Savannah KSAV
- San Jose KSJC
- Scottsdale KSDL
- Seattle KBFI
- Sebring KSEF
- Tampa KTPA
- Teterboro KTEB
- Tucson KTUS
- Tulsa KTUL
- Washington KDCA
- Washington KIAD
- Wenatchee KEAT
- West Palm Beach KPBI
- White Plains KHPN
- Windsor Locks KBDL
- Wichita KICT

81 Airports Published
Updated: January 2011
More RNP AR Approaches

**International Procedures**

- Hong Kong VHHH - Public RNP approach
- Stockholm ESSA - Public RNP approach
- Innsbruck LOWI - "Special" RNP approaches
- Quito SEQU - "Special" RNP approaches
- La Serena SCSE - "Special" RNP approaches
- Tegucigalpa MHTG - "Special" RNP approaches
- Rotorua NZRO - "Special" RNP approaches

**US Procedures in development**

- Albuquerque KABQ
- Amarillo KAMA
- Boston KBOS
- Bremerton KPWT
- Butte KBTM
- Carlsbad CA KCRQ
- Chicago Waukegan KUGN
- Denver KAPA
- Detroit KDTW
- Eugene KEUG
- Farmingdale NY KFRG
- Grand Junction KGJT
- Great Falls KGTF
- Houston KIAH
- Kahului PHOG
- Kona PHKO
- Moses Lake KMWH
- Norfolk VA KORF
- Omaha KOMA
- Orange County KSNA
- Pasco WA KPSC
- Sacramento KSMF
- Salt Lake City KSLC
- San Antonio KSAT
- San Diego KSAN
- Spokane KEGE
- Trenton KTTN
- Yakima KYKM
Aircraft Certified for RNP AR

- Airbus 320
- Boeing Business Jet
- Boeing 737
- Boeing 747
- Boeing 757 / 767
- Embraer 170 / 190
- Gulfstream 350 / 450 / 500 / 550
- Bombardier Q400
- Cessna Sovereign*
- Dassault EPIC EASy II (In work)
- Hawker 4000 (In Work)
**Improved Access – MSO RWY 29**

- **Circle-to-Land RWy 29**
  - No straight-in procedure for RWy 29
  - Minimums: 2000’ / 3

- **RNAV RNP RWy 29**
  - RF legs used
  - Minimums: 400’ / 1
Improved Access – RNO RNP RWY 16R

**ILS Rwy 16R**
- Minimums:
  - 2100’ / 7

**RNAV RNP Z Rwy 16R**
- Minimums:
  - 500’ / 3/4 (RNP 0.17)
  - 800’ / 2 (RNP 0.3)
RNP AR Benefits – Traffic De-confliction

**Dekalb-Peachtree KPDK**

**RNAV (RNP) Rwy 2R**

- RNP (0.2 NM) AR approach
- Enables IMC operations to Runway 2R to a 340 ft Decision Altitude (DA)
- Mitigates obstacles on the approach course (the extended runway centerline)
- De-conflicts KPDK and KATL traffic flows

*VMC track data to runway 2R (4/11/07)*
RNP AR Benefits – Traffic De-confliction
Getting Operational with RNP AR

Aircraft Equipage

- FMS, IRS, GPS, TAWS
  - RNP AR 0.3 and <0.3 capability
  - RF Legs
  - Coupled VNAV
  - Single IRS
  - Dual GPS

Operational Approval

- Consultancy Services
  - Operational approval submittal package for AMC 20-26 compliance & EASA coordination
  - Timely and efficient integration of requirements into current flight operations
  - 13 operators approved under FAA RNP AR in US

RNP Operations

- Procedure and Database Validation
  - Initial validation of all RNP AR procedures
  - Data validation every 28 day cycle

Honeywell Go Direct helps operators get Operational Approval for RNP AR
RNP AR- Approved Operators

Part 121
- American
- Delta
- Continental
- Qantas
- Air New Zealand
- Alaska
- Horizon
- JetBlue
- WestJet
- United (in work)
- US Airways (in work)
- Southwest (in work)
- SAS
- China Eastern

Part 135/91k
- NetJets

Part 91
- Honeywell*
- Verizon*
- Johnson & Johnson*
- Anadarko Petroleum*
- Qualcomm*
- WR*
- Motorola*
- Baxter Healthcare*
- Coke
- Friedkin Aviation*
- Reyes Holdings*
- Skybird
- Yum Brands *
- Guthy-Renker (in work)*
- JM Family Enterprise (in work)*
- Ameriprise Financial (in work)*

* Operators who have used Honeywell’s Go Direct™ Services

The FAA created the RNP AR Consulting Program to ease the approval burden for operators

Honeywell was granted RNP AR Consultant Designation by the FAA in November 2007
What does it cost the operator?

- Honeywell offers 3 service pricing options:
  
  **RNP AR Familiarization Service**
  Price: $20K
  - 1-day onsite RNP AR approval process orientation course

  **Essential Consultancy**
  Price: $53K
  - RNP AR application with minimal operator manpower

  **Premium Consultancy**
  Price: $99K
  - RNP AR application with all FAA coordination and Honeywell onsite support
RNP Basic / Advanced

- FAA recognized that not all aircraft are equipped for RNP AR
  - Dual GPS
  - Dual FMS
  - IRU
  - Coupled VNAV

- New procedures (per AC 90-105) will be developed using basic RNP criteria
  - Terminal Procedures (SIDs and STARs)
  - Basic Approaches – Virtually identical to current GPS approaches
  - Advanced Approaches – Incorporate curved flight paths

- Aircraft currently approved for AC 90-100A will automatically comply for RNP Basic / Advanced (with certain restrictions…)

- First procedure scheduled to be published in 2011
# Key Differences

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<th>RNP – Basic AC 90-105</th>
<th>WAAS LPV</th>
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<td><strong>Equipment Requirements</strong></td>
<td></td>
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<tr>
<td>FMS Required</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>GPS</td>
<td>Dual</td>
<td>Single</td>
<td>Single</td>
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<tr>
<td>WAAS Required</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>IRU Required</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Coupled VNAV Required</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Operational Requirements</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curved Paths</td>
<td>Yes</td>
<td>Prior to FAF</td>
<td>No</td>
</tr>
<tr>
<td>RNP &lt; 0.3</td>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Secondary Buffer for Obstacle Clearance</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Operational Approval Required</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
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Agenda

- CPDLC (Controller Pilot Data Link Communication) Overview
CPDLC and FANS

• FANS 1/A
  – Uses an early version of CPDLC (AFN protocol) and has been used for almost 25 years as a version of oceanic surveillance and communication by airliners.
  – Encompasses two main parts:
    ➢ Automatic Dependant Surveillance – Contract (ADS-C)
    ➢ Controller Pilot Data Link Communication (CPDLC)

• PM CPDLC (Link 2000+)
  – PM (protected mode) CPDLC is a higher speed data link service using Protected Mode (PM) CPDLC under the ATN protocol and is being tested in Europe today (Link 2000+ trials).

• FANS 2
  – Hardware that combines FANS 1/A and PM CPDLC into one unit
  – Supports both FANS 1/A (oceanic) and PM-CPDLC
FANS 1/A - Background
Typical FANS 1/A Architecture

- EFIS / Flight Director / Autopilot
- SATCOM
- Printer
- IRS
- GPS
- VHF Data Radio
- CMU / DMU
- FMS
ATC Logon Procedures

- Enter Logon information into the CDU and Press Send (LSK 6R)
- System establishes connection with ATC
CPDLC Message Responses

• When a clearance uplink is received, the crew will have to respond with ACCEPT, REJECT, or STANDBY.
• If the ACCEPT response is selected, a WILCO message is inserted that will be downlinked to the ATSU.
• A response is required within one minute of receiving message.
• If the flight crew determines they will need a significant amount of time to respond to a message, they should send a STANDBY Message.
ATC Request Page

- The ATC REQUEST page is used to input requests for altitude, speed, offset and flight plan changes
FANS 1/A Benefits

- Preferred / more direct oceanic routing
- Fewer delays on the ground while awaiting clearance
- Fully automated position reporting
- Digital data link communication with ATC
- Request / receive clearances on (M)CDU
- Auto acceptance of clearances into flight plan
- HF radio used only as backup - no noisy comm
Link 2000+ (PM-CPDLC)

- European airspace above FL 285

- Some ANSPs with cruising levels <FL285 may have letters of agreement between adjacent units

- Data Link will not completely replace voice
  - CPDLC is supplementary and is for non-critical communications
Link 2000+ Operation (PM-CPDLC)

1. Crew must ‘Log on’ once to establish flight plan and other necessary info
2. CPDLC connection established
   - Connection request is auto generated by ground system and confirmation is auto generated by aircraft
3. CDA message is auto generated by FMS notifying Area control centre (ACC) that aircraft considers ACC as current data authority
   - Message generated thru FMS
   - NOTE: Flight may still be under control of previous ACC
4. When transferring to next CPDLC-equipped ACC, current data authority (CDA) designates another ACC as next data authority (NDA)
   – Message sent to aircraft
   – Crew sends confirmation msg to ground

5. Upon leaving CPDLC airspace, disconnection will be initiated by ground
   – Crew acknowledges with ‘WILCO’

http://www.eurocontrol.int/link2000/public/subsite_homepage/homepage.html
Agenda

• ADS-B (Automatic Dependant Surveillance – Broadcast)
ADS-B Overview

• **What is it?**
  – Intended to replace traditional ATC radar surveillance
  – Aircraft transmits position, velocity and other information to ground-based receivers

• **Deployments**
  – Canada (including oceanic)
  – Gulf of Mexico
  – Australia
  – China

• **Mandates**
  – Australia – December 2013 (FL290 and above)
  – Europe – 2015
  – U.S.A. - 2020

*LOA required for US-registered aircraft operating in Canadian ADS-B*
# ADS-C vs. ADS-B

<table>
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<tr>
<th>Item</th>
<th>ADS-C</th>
<th>ADS-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas of Operations</td>
<td>Oceanic / Remote North Atlantic North Pacific South Pacific</td>
<td>Semi-Remote Hudson Bay Gulf of Mexico</td>
</tr>
<tr>
<td>Network</td>
<td>Satellite and VHF ACARS</td>
<td>Ground-Based receiver stations / Aircraft to Aircraft / Line of sight only</td>
</tr>
<tr>
<td>Equipment Requirements</td>
<td>FMS SATCOM-DATA VHF VDL (ACARS)</td>
<td>Transponder Extended Squitter FMS / GPS</td>
</tr>
<tr>
<td>Crew Requirements</td>
<td>Must log onto system</td>
<td>Automatic. No crew interaction required</td>
</tr>
<tr>
<td>LOA Requirements</td>
<td>Yes (LOA A056)</td>
<td>Yes (Separate LOA)</td>
</tr>
</tbody>
</table>
ADS-B Deployments

- Hudson Bay
  - 35,000 flights per year are participating
  - 5NM lateral separation
  - 20NM vs 80NM in-trail
  - Priority handling and Preferred routes in use
  - Plans to make FL350 to FL400 exclusionary airspace
  - A FAA LOA and Transport Canada OpsSpec is required to operate in this area
ADS-B Deployments

- Canadian ADS-B Airspace
ADS-B Airspace

TIS-B
- Traffic Information Service - Broadcast
- Datalink Traffic Information from non ADS-B equipped aircraft from existing SSR network
- Fills in the holes in ADS-B coverage

FIS-B
- Flight Information Service - Broadcast
- Uplink Weather and current Flight Information (TFRs, etc)
- UAT only

No ADS-B

Dual Mode ADS-B
Ground Station

Classic SSR

ITT Corp

Air Traffic Control

1090 (Mode S)

UAT

UAT only

Allows 1090 & UAT to Interoperate
ADS-B In Applications – Airborne

Some application types:

- **ATSA – AIRB**
  Enhanced Traffic Situational Awareness during Flight Operations

- **ATSA – VSA**
  Enhanced Visual Separation on Approach

- **ATSA – ITP**
  In Trail Procedure

- **ATSA – SURF**
  Enhanced Airport Surface Situational Awareness

*ADS-B-In shown as concept only; not used for broad service applications*
Summary

• New technologies all have industry mandates and operational benefits coming in the next decade (2010 – 2020)
  – SBAS-LPV
  – RNP
  – CPDLC
  – ADS

• Honeywell has planned software and hardware solutions for all of our customers
  – Classic aircraft retrofit include:
    ➢ Gulfstream IV and V, Hawker 800, Challenger 601, Falcon 900B, 900C/EX, Global Express/G-5000, Embraer Legacy 600/650, Citation X, others
  – Primus Epic aircraft include:
    ➢ Gulfstream 450/550 PlaneView, Falcon F900, 2000 and 7X EASy, Cessna Sovereign, Hawker 4000, others