Workshop for the implementation of Navigation Infrastructure to support PBN and GNSS precision approach in NAM/CAR/SAM Region

Session 3: Current GNSS Situation and Evolution

Brazilian GBAS experience

Alessander de Andrade Santoro - Brazil
August 16th, 2016
Continuos increase of demand

Necessity for synchronization of CNS/ATM deployment in the world

Increased efficiency = increased safety and lower costs
Objective

Present Brazilian Ground Based Augmentation System (GBAS) experience
Brazilian FIR

22,000,000 Km²

FIR AMAZÔNICA
FIR RECIFE
FIR BRASÍLIA
FIR CURITIBA
FIR ATLÂNTICO

DEPARTMENT OF AIR SPACE CONTROL - DECEA
13 International Adjoint FIR
Area comparison

AMAZON FIR
5,200,000 km²

32 European countries

USA: 30 States
Radar Coverage FL290
## Air traffic operations

<table>
<thead>
<tr>
<th>ANO</th>
<th>REGRA DE VOO</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
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## CNS Equipments

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<td>Primary radar</td>
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<tr>
<td>Secondary radar</td>
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<tr>
<td>Weather radar</td>
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<td>VOR</td>
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<td>DME</td>
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## Procedures

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<td>CONVENTIONAL ROUTES</td>
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</table>
Standards (Annex 10 ICAO)

According to the phase of flight:

- Accuracy
- Availability
- Continuity

Integrity
ADVANTAGES

• Well known technology
• Operational confidence
• Large network

DISADVANTAGES

• Analogic modulation – interference and channel management
• Low range
• Low procedure flexibility
• Site constraints
Performance Based Navigation

- Less distance
- Less fuel
- Less $$$
- Less CO2
Gate to gate

Conceito GATE TO GATE
First come, first served ➝ On time, first served
Global Positioning System

- Enroute
- Non precision Approach (reduction of MDA)
- Need of augmentation
- Accuracy
- Integrity
- Availability
- Continuity
Honeywell SLS-2000

- 1998
- SCAT I operations in Joinville (Rio Sul)
- São José dos Campos
- Flight Inspection Aircraft EMB-110
- Type of technology Operational in Norway till present

www.flygls.net
Wide Area Augmentation System

Communication Satellite

GPS Satellites

Ground Uplink Station

Wide Area Master Station

Wide Area Reference Station

Alaska

Hawaii

San Juan
SBAS Test Platform

FAA Master Station

Master Station

Reference Station

VHF-DL

Cities:
- RIO DE JANEIRO
- CURITIBA
- BRASILIA
- MANAUS
- RECIFE
- TEGUCIGALPA
- BOGOTA
- LIMA
- ANTOFAGASTA
- SANTIAGO
- EZEIZA
- BALMACEDA
- El Alto
• SBAS augmentation trials in the CAR/SAM Regions
• MOU – ICAO/FAA: signed on 2 June 2001
• First flight trials - 2002 in Brazil
• It was proven that the ionosphere effect over the GPS signal did not guarantee NPA approaches with vertical precision requirements
• Final report – RCC/5-RLA/00/009-WP/03
SBAS in Equatorial Regions

- RLA/00/009 PROJECT – GNSS AUGMENTATION TRIALS
- NAVIGATION SYSTEMS PANEL (NSP) - Ionospheric Effects on GNSS Aviation Operations
- ICAO Doc 9849 - GNSS Manual
- IATA Report on User Requirements for Air Traffic Services – “Do not support the continued investment, development, and implementation of SBAS.”
GBAS – Ground Based Augmentation System

GPS Satellites

Ranging Sources

Differential Corrections, Integrity Data and Path Definition

GBAS Ground Facility

GBAS Reference Receivers

Omnidirectional VHF Data Broadcast (VDB) Signal

Status Information
Benefits

- One GBAS multiple approaches - up to 48 approach procedures
- Flexible sitting requirements
- Improved accuracy of positioning service
- Reduced building restrictions - construction of new terminals and hangars
- Flexible use - curved approach paths, different glide path angles, off set thresholds, etc
FAA / DECEA Cooperative History

MOC / NAT-I-0801
Development of Civil Aviation
Jan 2000

- Annex 1 (Oct, 2001)
  GNSS Flight Test
  Trials and Demonstrations

- Annex 2 (Oct, 2001)
  Ionosphere Research
  Loan of equipment

- Annex 3 (Ago, 2003)
  LTP
  Loan of equipment

MOA / NAT-I-0019
Technical Assistance
Jun 2000

- Annex 1 (Nov, 2000)
  Purchase of equipment

- Annex 2 (Nov, 2002)
  CARSAMMA
  Establishment

- Annex 3 (Nov, 2003)
  GNSS Flight Trials
  Purchase of equipment

- Annex 4 ETMS

MOC NAT-I-4016
Technical Assistance
Jul 2015

- Annex 1 (In Coord)
  Atmospheric Ionospheric Research

LAAS Test Prototype

- SGBL
- MoU DECEA/FAA 2003
LAAS Test Prototype

- GEIV Aircrafts
- MMR – GNU 930 (Rockwell Collins) – Red label
- Achievements
- 120 approaches
- 03 airports (SBGL, SBRJ, SBAF)
- 06 runway thresholds
LAAS Test Prototype
LAAS Test Prototype

GBAS - 09 Approaches GL RWY10 23 OCT 04

Distance from runway threshold (nm)

Error (m)

East(m) North(m) Up(m)
LAAS Test Prototype

- Data collection errors
- Ionosphere
- Solar Cycle
- Reduce variables
SLS4000 – SmartPath - SBGL

- June, 2011 – Operation for testing purposes;
- Availability issues (ionosphere);
- Disabling monitors for data collection purposes;
- Approach procedures RWY 10, 15, 28 and 33.
SmartPath Components

**GPS Antennas**
- Four GPS RRA/RSMU per GBAS
- Multipath limiting design
- Sharp cut-off/rejection at horizon

**GPS Receivers**
- 48-channel, L1 C/A GPS
- Signal Quality Monitoring

**Corrections Processor**
- Pentium M, 1.8 GHz CPU
- Real time monitoring for GPS failures, local error sources
- Differential corrections

**VHF Antenna**
- Horizontal polarized (HPOL)
- Omni-directional

**VHF Radios**
- Nav band, 108-118 MHz
- D8PSK modulation, TDMA
- Digital data broadcast

**Maintenance Data Terminal**
- Windows OS
- System mode & control
- Component status
- Approach control

**Air Traffic Status Unit**
- Windows OS
- System mode
- Current/Predicted Availability
RWY 10/28 SBGL
Ionosphere
Ionosphere
BRAZILIAN CONTINUOUS MONITORING NETWORK (RBMC)
IONO DATA COLLECTION STATIONS
CONUS THREAT MODEL

Chart Courtesy Stanford University

Ionosphere Front Speed (m/s)

Ionosphere Maximum Slopes in Slant (mm/km)

Also bounds on:
Front speed wrt. ground: ≤ 750 m/s
Front width: 25 – 200 km
Total differential delay ≤ 50 m
• Brehmen (Germany), Newark (USA), Houston (USA), Malaga (Spain), Sydney (Australia)
IONO Research

- Network – 180 receiver L1/L2 and scintillation
- 127 dates March 2011 / March 2014 (S4, Kp and Dst);
- Lowest cycle in 100 years (cycle 24);
- DECEA, ICEA, FAATC/NAVTAC, USTDA, Mirus Tech, SDTP, Stanford University, INPE, Boston College, UNESP, KAIST
IONO RESEARCH

LTIAM Verified Low Latitude Threat for GBAS

- Low Latitude Verified Threat Points
- CONUS Threat
CONCLUSIONS of RESEARCH

- The highest gradient identified exceeds 850 mm/km which far exceeds the events used to define the CONUS GBAS Threat Model.

- Ionospheric events in the low latitudes are greater in frequency and magnitude than those in the Northern Latitudes.

- The current threat model implemented in SLS-4000 installation at GIG does not comply with ICAO/FAA requirements for integrity or availability.
Flight Inspection

EMB110 / H-800XP / LEGACY 5000
Flight Inspection

- MANINV-BRASIL (2014)
- GNLU-930 / GLU-925
- UNIFIS3000
Remarks about GBAS CAT I (GAST C)

- Only Honeywell SLS-4000 certified for CAT I (Mid Latitudes)
  - DA within 6km (integrity)
  - VDB coverage
  - Block II – Iono improve (only for CONUS)
- Expensive receiver for general aviation
- Cost ILS x GBAS (CBA)
- Concurrent technologies
Concurrent technologies to GAST C

- GAST D (CAT II/III) – new receivers (SLS-5000)
- GBAS MF (L5) / MC (GLONASS, BEIDOU, GALILEO)
- SBAS LPV200 (WAAS, EGNOS) – Mid latitudes
- SBAS MF
- BARO VNAV
- RNP-AR
Concurrent technologies to GAST C

APP RNP AR RWY02R
Concurrent technologies to GAST C
Concurrent technologies to GAST C
SIRIUS Program

- March, 2012 (PCA 351-3 );
- Aligned with the GANP and ASBU;
- Subprograms and projects CNS, ATM, MET, AIS, SAR
  - PFF 12 – Navigation Systems Upgrade (GBAS evaluation);
  - PFF 04 – Approach RNP Implementation (GBAS CAT I procedures).

Information available in http://www.decea.gov.br/novo_sirius/
CONCLUSION

- GBAS GAST C is operational in a few countries in mid latitudes but is still a challenge to low latitudes
- Since 2003 Brazil tests GBAS stations in SBGL and technology did not meet ICAO SARPs for availability and integrity
- Brazil continues in the effort to set SLS-4000 at SBGL operational for public use
- New Technologies are coming to challenge GBAS GAST C
Questions?

Thank you   Gracias   Merci   شكرا   谢谢

Obrigado!

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