THE BDS APPLICATIONS ON CIVIL TRANSPORT AIRCRAFTS

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1 | Requirements
2 | Applications
3 | Conclusions
1 Requirements

- Rapid growth of civil aviation requires safe & efficient navigation technologies
1 Requirements

- **Performance Based Navigation (PBN)**

**Departure**
- RNAV 1
- RNP 1

**En Route**
- RNAV 2, 5, 10
- RNP 4

**Arrival**
- RNAV 1
- RNP 1

**Approach**
- RNP APCH
- RNP AR APCH

* CAAC PBN Roadmap

The PBN Space-based navais include GNSS elements as defined in ICAO Annex 10 - Aeronautical Telecommunications.

-Doc 9613 PBN Manual
## Requirements

### Onboard Navigation Equipment

<table>
<thead>
<tr>
<th>Onboard Navigation</th>
<th>Pros</th>
<th>Cons</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite-based</td>
<td>Global coverage, High accuracy</td>
<td>Vulnerability from interference</td>
<td>GNSS</td>
</tr>
<tr>
<td>Ground-based</td>
<td>High reliability</td>
<td>Limited coverage, Low accuracy</td>
<td>NDB, VOR, DME, ILS...</td>
</tr>
<tr>
<td>Inertial navigation</td>
<td>Work without external signal source</td>
<td>Error accumulation</td>
<td>IRS</td>
</tr>
</tbody>
</table>

### Advantages of Multi-constellation GNSS

- Redundant backup
- Reduced signal acquisition time
- Improved position and time accuracy
- Ability to resist single GNSS system fail

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1. BDS
2. GPS
3. GLONASS
4. Galileo

NDB, VOR, DME, ILS, Inertial navigation

Instrument Landing System
1. Requirements

- Aviation Requirements for Multi-constellation GNSS

- Safety
- Cost-effective
- Eco-Friendly
- Comfortable

Onboard Navigation System

GNSS
- Multi-frequency
- Multi-Constellation

Augmentation
- ABAS
- SBAS
- GBAS/GLS

PBN
- The Space-based nav aids include GNSS
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2 Applications
  • The BDS Applications in COMAC
  • Future Plan in COMAC

3 Conclusions
2.1 The BDS Applications in COMAC

- **COMAC Civil Transport Aircrafts**

  **ARJ21**
  - A turbofan regional aircraft
  - Layout: 78 to 90 seats
  - Range: 2225 to 3700 KM
  - Production Certificate (PC) from CAAC
  - Route operation

  **C919**
  - A large civil jet aircraft
  - Layout: 158 to 168 seats
  - Range: 4075 to 5555 KM
  - Finished the first test flight
  - Will be delivered in 3 to 4 years

  **CR929**
  - A dual-aisle civil aircraft
  - Layout: 280 seats
  - Range: 12000 KM
  - The Joint Conceptual Development Program of CR929 has been initiated
2.1 The BDS Applications in COMAC

- New Multi-Mode Receiver (MMR) Prototype Development and Flight Experiment Modification

New MMR prototype supporting BDS/GNSS
2.1 The BDS Applications in COMAC

- BDS/GNSS Based GBAS Installation in Dongying Airport
2.1 The BDS Applications in COMAC

- Flight experiment at Dongying airport (Oct. 2017)

- 5 days
- 4 sorties
- 10 hours data

<table>
<thead>
<tr>
<th>No.</th>
<th>Test subjects</th>
<th>Altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Circle Flight</td>
<td>10000ft</td>
</tr>
<tr>
<td>2</td>
<td>Circle Flight</td>
<td>5000ft</td>
</tr>
<tr>
<td>3</td>
<td>Arc Flight</td>
<td>2000ft</td>
</tr>
<tr>
<td>4</td>
<td>Level Flight</td>
<td>2000ft</td>
</tr>
<tr>
<td>5</td>
<td>Level Flight</td>
<td>3000ft</td>
</tr>
<tr>
<td>6</td>
<td>Level Flight</td>
<td>4000ft</td>
</tr>
<tr>
<td>7</td>
<td>Approach/Continuous Approach</td>
<td>As required</td>
</tr>
</tbody>
</table>
The BDS Applications in COMAC

- Average number of BDS satellites in view & GDOP

![Chart showing average number of BDS satellites in view and GDOP](chart_image)

- Table data:
  - **Sv in View**
  - **GDOP**

- **Applications**
  - Circle-10000ft: 10.8623
  - Circle-5000ft: 9.7668
  - Semi-circle #1: 3.13
  - Semi-circle #2: 9.8646
  - Semi-circle #3: 11
  - Constant altitude - 2000ft: 11
  - Constant altitude - 3000ft: 11
  - Continuous Approach #1: 10
  - Continuous Approach #2: 10
  - Continuous Approach #3: 9.9572
  - Approach #1: 8
  - Approach #2: 11
  - Approach #3: 10
  - Approach #4: 10
2.1 The BDS Applications in COMAC

- BDS vertical positioning accuracy of every sortie

<table>
<thead>
<tr>
<th></th>
<th>GPS &amp; BDS Accuracy (95%)</th>
<th>GPS</th>
<th>BDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand-alone</td>
<td>Horizontal Positioning Accuracy</td>
<td>1.2~3.9m</td>
<td>1.1~3.2m</td>
</tr>
<tr>
<td></td>
<td>Vertical Positioning Accuracy</td>
<td>1.2~7.5m</td>
<td>2.1~8.5m</td>
</tr>
<tr>
<td>Differential</td>
<td>GLS Horizontal Positioning Accuracy</td>
<td>0.3~2.0m</td>
<td>0.6~2.0m</td>
</tr>
<tr>
<td></td>
<td>GLS Vertical Positioning Accuracy</td>
<td>0.8~3.0m</td>
<td>1.1~3.3m</td>
</tr>
</tbody>
</table>
2.1 The BDS Applications in COMAC

- GBAS Signal Coverage Range

VDB Coverage Radius: 20NM
2.1 The BDS Applications in COMAC

- BDS short message flight tracking experiment at Yangtai airport (Oct. 2018)

- The unique short message function of BDS provides a new technological approach of real-time flight surveillance, tracking and emergency communication.
## 2.1 The BDS Applications in COMAC

- BDS short message flight tracking experiment at Yangtai airport (Oct. 2018)

<table>
<thead>
<tr>
<th>Date</th>
<th>Test Subjects</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-Oct-2018</td>
<td>Taxiing &amp; Circle Flight (10000ft)</td>
<td>3 hours</td>
</tr>
<tr>
<td>12-Oct-2018</td>
<td>Circle Flight (30000/32000/35000ft) Through Field (600ft)</td>
<td>3 hours</td>
</tr>
<tr>
<td>13-Oct-2018</td>
<td>Circle Flight (10000ft) Through Field (600ft)</td>
<td>2.5 hours</td>
</tr>
</tbody>
</table>
2.1 The BDS Applications in COMAC

- BDS short message flight tracking experiment at Yangtai airport (Oct. 2018)

Test results show that short message success rates meet the designed objectives.
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   • The BDS Applications in COMAC
   • Future Plan in COMAC

3. Conclusions
2.2 Future Plan in COMAC

- Future plan focus on BDS/GNSS avionics system integration

- Test the **interface**, **functions** and **performance** of onboard BDS/GNSS equipment

- Verify the **interaction** between BDS/GNSS equipment and Flight Management System (FMS) & Core Process System
2.2 Future Plan in COMAC

- Functions and Performance Test

What to test

- Time to First Fix
- Sensitivity
- Reacquisition Time
- Accuracy
- Resilience to Interference
- Integrity
2.2 Future Plan in COMAC

- Interaction Verification

✓ **Step 1**: Use BDS as a backup navigation source, provide position and velocity information separately
✓ **Step 2**: Multi-constellation integrated navigation

**BDS/GNSS**

Interaction between onboard navigation equipment and FMS & Core Process System

**FMS**

Capability of navigation & flight guidance

**Display**

**ADS-B**

Capability of surveillance

**IRS**

Capability of integrated navigation

Integrated Modular Avionics (IMA)
Onboard Maintenance System (OMS)
Emergency Locator Transmitter (ELT)
...
2.2 Future Plan in COMAC

- **Flight test plan**

  **2017-2018**
  - No Interactions to other system
  - Installed in main cabin
  - Not affect other avionics
  - Verify functions and performance under real environment
  - BDS short message flight tracking experiment

  **2018-2020**
  - Partly integrated to other system
  - Installed in forward EE cabin
  - Partly integrated with avionics
  - Verify integration, navigation & guidance capability

  **2020-**
  - Totally integrated flight test
  - Complete integration
  - Verify performance of aircraft when using BDS/GNSS as navigation resource
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Conclusions

- COMAC will definitely push forward the applications of BDS/GNSS on domestic civil aircraft.
- We suggest to strengthen international cooperation, and co-ordinate resources with navigation system service providers and airborne system providers.
- We will work with international experts to make BDS onboard equipment MOPS and other related RTCA standards get approved, so BDS can provide better service to international civil aviation.
THANK YOU!