SBAS solution 
GCC, Yemen and Iraq

System baseline and performance

ACAC Workshop Rabat 7 & 8 November 2017
SBAS services definition for Civil Aviation

NPA : Non Precision Approach - LNAV
- Provided to ensure horizontal guidance approach for aircraft using augmented GNSS.
- Vertical guidance being ensured by aircraft baro-altimeter or other conventional means.

APV-I : Precision Approach - LNAV/VNAV
- Provided to ensure precision approaches using augmented GNSS for horizontal and vertical aircraft guidance
- Decision Height: 250ft

SBAS performance allows RNAV5 and RNAV1 capabilities for “En-Route” and “Terminal Area” for aircraft using augmented GNSS.
Targeted Service Performances

Services performance:

1- Aeronautical (Safety of Life)

<table>
<thead>
<tr>
<th></th>
<th>En route</th>
<th>Terminal</th>
<th>NPA</th>
<th>APV-I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Alarm</td>
<td>300 s</td>
<td>15 s</td>
<td>10 s</td>
<td>10 s</td>
</tr>
<tr>
<td>Horizontal Alert Limit</td>
<td>2 NM (3704m)</td>
<td>1NM(1852m)</td>
<td>0.3 NM (556m)</td>
<td>40m</td>
</tr>
<tr>
<td>Vertical Alert Limit</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>50 m</td>
</tr>
<tr>
<td>Integrity risk</td>
<td>1e-7 / h</td>
<td>1e-7 / h</td>
<td>1e-7 / h</td>
<td>2e-7 / approach</td>
</tr>
<tr>
<td>Continuity risk</td>
<td>2.5 to 5 10-4/h</td>
<td>2.5 to 5 10-4/h</td>
<td>2.5 to 5 10-4/h</td>
<td>10-3 to 10-5/15s</td>
</tr>
<tr>
<td>Horizontal accuracy (95%)</td>
<td>3700m (2.0 NM)</td>
<td>740m(0.4NM)</td>
<td>220 m(720feet)</td>
<td>16m(52 feet)</td>
</tr>
<tr>
<td>Vertical accuracy (95%)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>20 m (66 feet)</td>
</tr>
<tr>
<td>Availability</td>
<td>0.99 to 0.999</td>
<td>0.99 to 0.999</td>
<td>0.99 to 0.999</td>
<td>0.99</td>
</tr>
</tbody>
</table>

2- Non Aeronautical (Positioning service -Non Safety of Life)

<table>
<thead>
<tr>
<th></th>
<th>Positioning Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal accuracy</td>
<td>1 m</td>
</tr>
<tr>
<td>Vertical accuracy</td>
<td>2 m</td>
</tr>
</tbody>
</table>

APV-I the most demanding performance
Applicable Standards

- **SBAS and GPS applicable standards**
  - MOPS D with Change 1 (RTCA/DO-229D)
  - SARPS (ICAO Annex 10 Vol 1)

**SBAS interoperability ensured with international Standards**
APV-I proposed Service Area

This Service Area includes the following countries: Bahrain, Iraq, Kuwait KSA, Oman, Qatar, UAE, Yemen. (GCC states plus Yemen and Iraq).
En route and NPA proposed Service Area

Targeted service area:

25°<Longitude East <65°
5°<Latitude North <45°
Definition of an Autonomous SBAS on GCC, Yemen and Iraq

Main features:

- **Services**: En route, NPA, APV-I for aviation and Positioning service for other domains.
- **APV-I Service Area**: Bahrain, Iraq, Kuwait, Kingdom of Saudi Arabia, Oman, Qatar, United Arab Emirates, Yemen.
- **Satellite configuration**: 24 GPS and 2 GEOs with SBAS ranging payloads
- **Reference station network**:
  - 24 Reference stations in total.
  - Most of the Reference stations will be installed inside the countries listed above and some outside the targeted area.
  - 5 Reference stations out of 24 will be located far from the Service Area. Need of these Reference stations for orbit algorithms.

**Autonomous SBAS with a full sovereignty**
Reference stations network

24 reference stations network defined as baseline to ensure performance over the requested countries

19 Core stations network for GPS satellite and ionosphere delays monitoring

5 Stations for better GPS satellite orbit determination

These Reference Station locations are depending upon many criteria such as:
- Optimisation of SBAS system performance;
- Clear RF environment;
- Availability of Hosting site with access to power supply and Data communication;
- Easiness of access for operation and maintenance.
SBAS proposed architecture

2 geostationary satellites with L1/L5 ranging navigation payload

24 GPS satellites constellation

Uplink C or Ku band

L1 band

L1+L2 bands

Users

Network of Reference Stations (NRS)
Receive GPS data and send it To MCC

Mission Control Centre (MCC includes NPS+CCS):
Process data, generate SBAS message, perform system operations 1 master and 1 backup

Navigation Uplink Stations (NUS):
Uplink SBAS message with corrections and integrity flags to Geo satellite 2 by GEO satellite (master and backup)

Distributed architecture with flexible location choices
Ionosphere scenario for performance assessment

Middle East region undergoes equatorial ionosphere conditions which are impacting
- GNSS signals acquisition and tracking
- Positioning accuracy.

Nominal ionosphere condition day
(B-Class Solar Flare level)

Day chosen for SBAS performance demonstration
(M-Class Solar Flare level) (March 8th 2014)

Performance assessment must be done with disturbed ionosphere condition day
Performance Results

SBAS Services Performance achieved using disturbed ionosphere data.

Full performance achievement for APV-I and NPA services
Development of SBAS system

- **Development schedule** (until technical qualification)
  - About 4 years

- **Dates of need for GEO1 and GEO2 payloads in orbit** (for system testing)
  - Geo 1: 2.5 years
  - Geo 2: 3 years
  => First Signal in Space available 3 months after Geo1 availability (for System testing period)

- **Service lifetime**: at least 20 years and more with upgrade.

- **Service available for all categories of airspace users**: Major Airlines, Regional aviation, General and Business aviation, Helicopters, Aerial work and Light aviation.

SBAS system suitable and certified to enhance Aviation Safety and foster adoption of ADS-B with integrity
SBAS: a Spreading Trend

SBAS implementation is driven by benefits for Aviation and ICAO Policy “A37-11 resolution”.
### Acronym definition

<table>
<thead>
<tr>
<th>SBAS: Space Based Augmentation system</th>
<th>ICAO: International Civil Aviation Organization</th>
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<tbody>
<tr>
<td>EGNOS: European Global Navigation Overlay System</td>
<td>MOPS: Minimum Operational Performance Standards</td>
</tr>
<tr>
<td>NRS: Navigation Reference Station (Reference sensors)</td>
<td>SARPS: Standards and Recommended Practices</td>
</tr>
<tr>
<td>WAN: Wide Area Network (Data Communication Network)</td>
<td>NAVAIDs: Navigation Aids</td>
</tr>
<tr>
<td>NPS: Navigation Processing Station (Processing Set &amp; Check Set)</td>
<td>ILS: Instrument Landing System</td>
</tr>
<tr>
<td>CCS: Centralized Control Station</td>
<td>GBAS: Ground Based Augmentation System</td>
</tr>
<tr>
<td>MCC: Mission Control Center</td>
<td>CAT I: Category I</td>
</tr>
<tr>
<td>NUS: Navigation Uplink Station</td>
<td>ADS-B: Automatic Dependent Surveillance Broadcast</td>
</tr>
<tr>
<td>TAS: Thales Alenia Space</td>
<td>LPV: Localizer Performance with Vertical Guidance</td>
</tr>
<tr>
<td>GPS: Global Positioning System</td>
<td>PBN: Performance Based Navigation</td>
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<tr>
<td></td>
<td>GPS L1: Aviation Radio Navigation Service (Cent. Freq. = 1575.42 MHz)</td>
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<tr>
<td></td>
<td>GPS L2: Radio Navigation Satellite Service (Cent. Freq. = 1227.6 MHz)</td>
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