Australian and New Zealand Second Generation Satellite Positioning Augmentation System (Technical Overview)

Speaker
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Why an Augmentation System?

- Clock and Ephemeris Error
- Ionospheric Delay
- Troposferic Delay
- User Receiver Error
What is Augmentation System?

Second Generation Real Time GEO-based SBAS-PPP Combined System for Australia and New Zealand
IGNSS 2018, 7th February

Regional/Global
- SBAS
- PPP

Local
- DGPS
- RTKP
- GBAS
SBAS and PPP Augmentation

- PPP algorithm uses a more accurate observable (Phase) than SBAS (Code) leading to a more accurate user solution, but it needs better SV corrections

- It needs of the estimation of a the phase ambiguities which leads to a greater convergence time

<table>
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<tr>
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<th>SBAS</th>
<th>PPP</th>
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<td>Observables</td>
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<td>User Accuracy (*)</td>
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(*) RMS For static geodetic receivers and antennae
(**) For decimetric accuracy
WHY HIGH ACCURACY?

New Generation SBAS for high accuracy services in Australia and New Zealand

23/11/2017

GPS alone
WHY HIGH ACCURACY?

New Generation SBAS for high accuracy services in Australia and New Zealand

23/11/2017

SBAS L1
AUS & NZ SBAS Test Bed through L1

• Non-SoL SBAS L1 Legacy Service
  ✓ Augmentation for GPS L1 single-frequency users.
  ✓ Compatible with COTS SBAS-enable receivers (Septentrio, Novatel, Arrow, Honeywell, etc...)

• Non-SoL PPP augmentation through SBAS L1 signal
  ✓ Augmentation for GPS L1/L2 dual-frequency users.
  ✓ Service accessible from magicAPK and magicUT user terminals

Compliant with RTCA/DO-229D
Second Generation Real Time GEO-based SBAS-PPP Combined System for Australia and New Zealand
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AUS & NZ SBAS Test Bed through L5

- **Non-SoL SBAS L5 DFMC for GPS L1/L2 and Galileo E1/E5a**
  - Augmentation for GPS L1/L2 + Galileo E1/E5a dual-frequency users.

- **Non-SoL PPP augmentation through SBAS L5 signal**
  - Augmentation for GPS L1/L2 + GAL E1/E5 dual-frequency users.
  - Service accessible from *magicAPK* and *magicUT* user terminals

Compliant with WG62 GAL GPS SBAS MOPS v0.3.8_10 Mar 2017

Inmarsat-4F1 (143.5E)
# SBAS Enable Receivers

<table>
<thead>
<tr>
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<th>L1 Signal</th>
<th>L5 Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SBAS Service</strong></td>
<td>GPS L1 Legacy RTCA/DO-229</td>
<td>GPS L1/L2 + GAL E1/E5a WG62 GAL GPS SBAS MOPS</td>
</tr>
<tr>
<td><strong>SBAS Enable</strong></td>
<td>GNSS only solution is combined when SBAS information when available. Restrictions specified by aviation SBAS standards are not applied.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The service focus on accuracy and solution availability but doesn’t provide protection levels.</td>
<td></td>
</tr>
<tr>
<td><strong>PPP Service</strong></td>
<td>GPS L1/L2 Proprietary ICD Embedded bits</td>
<td>GPS L1/L2 + GAL E1/E5a Proprietary ICD Embedded bits</td>
</tr>
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AUS & NZ SBAS Test Bed Schedule

SBAS L1 Service is active since: 28/05/2017
SBAS L5 Service is active since: 18/09/2017
PPP L1 and L5 Services are active since: 18/09/2017
End of Transmission: 01/02/2019

Other considerations:
• Monthly Maintenance Slot each Month (coordinated with GA and CRCSI)
• Capability to switch to GPS L1/L5 service during 2018
• Backup Internet Stream for situations without GEO visibility.
AUS & NZ SBAS and PPP infrastructure

Reference Stations → GNSS
Reference Stations → GEO
User Segment → GEO
User Segment → Processing & Uplink Infrastructure
Processing & Uplink Infrastructure → User Segment
Reference Stations

Message Generation (Uralla)
- magicSBAS
- magicODTS
- MT0 Safety SIG Control
- System Monitoring

Uplink Infrastructure (Uralla)

Dissemination GEO in L1 and L5

Trials Coordination
AUS & NZ Test Bed Real Time Monitoring

Monitoring Platform:
✓ Real Time Signal Availability
✓ Real Time SBAS Availability
✓ SVs Monitoring
✓ Ionospheric Monitoring
✓ PPP Performances

[Map of real-time monitoring]

https://www.globalsbasalliance.com/
AUS & NZ Test Bed User Segment

magicGNSS User Terminal
- SBAS and PPP Handheld User Terminal
- Integrated Novatel OEM7 board
- Stand-alone user tool.
# AUS & NZ Test Bed Integrity Targets

Second Generation Real Time GEO-based SBAS-PPP Combined System for Australia and New Zealand
IGNSS 2018, 7th February

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<th>SBAS L1 (LEGACY)</th>
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<tr>
<td><strong>Non-Sol Integrity</strong></td>
<td><strong>SBAS Integrity</strong></td>
<td><strong>Autonomous</strong></td>
</tr>
<tr>
<td>APV-I (50m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPV200 (35m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aeronautical Receivers</td>
<td><strong>SBAS Integrity</strong></td>
<td><strong>Configurable</strong></td>
</tr>
<tr>
<td></td>
<td>LPV200 (35m)</td>
<td><strong>Confidence</strong></td>
</tr>
<tr>
<td></td>
<td>CAT-I (15m)(*)</td>
<td><strong>Wider Range</strong></td>
</tr>
<tr>
<td>Aeronautical Receivers</td>
<td></td>
<td><strong>Receivers</strong></td>
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</table>

(*) Upon complete GPS+GAL constellations

SBAS L1 LPV-200 Availability 3/12/2017
Example SBAS GPS vs GPS+SBAS

Horizontal Error (Colour Map)

North vs East Errors (GPS_only)

North vs East Errors (GPS_SBAS)
Example SBAS GPS vs GPS+SBAS

Vertical Error (Histogram)
Example PPP through SBAS L1

More Details on Test Bed PPP Performances on Friday at PPP Technical sessions
THANK YOU

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## SBAS and PPP Augmentation

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<td><strong>Constellations</strong></td>
<td>GPS only</td>
<td>Multi-constellation</td>
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<td><strong>User Type</strong></td>
<td>Single-frequency</td>
<td>Dual-Frequency</td>
<td>Dual-Frequency</td>
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<td><strong>Augmentation</strong></td>
<td>SV Clk + Ephem</td>
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<td>At Augmentation</td>
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<td>At Receiver</td>
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<tr>
<td><strong>Dissemination</strong></td>
<td>GEO L1 (Regional)</td>
<td>GEO L5 (Complete footprint)</td>
<td>Internet, Satellites (World-Wide)</td>
</tr>
<tr>
<td><strong>Standardization (SoL)</strong></td>
<td>Yes (MOPS, ICAO)</td>
<td>In progress</td>
<td>No</td>
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AUS & NZ Test Bed Analysis Tools

Performance Analysis SW

- SBAS and PPP tools capable of processing external receivers in PPP or SBAS mode
- **SRX-10** for accessing to SBAS L5 signal
- **magicGEMINI** for SBAS Processing (RT and Post-processing)
- **magicAPK** for PPP processing (only RT)

**CRCSI** coordinates the use of user equipment's made available within the Test Bed.
AUS & NZ SBAS Reference Network

- Different Networks for SBAS L1 and SBAS L5
- ~60 Reference Stations are configured. Number of stations is oversized to mitigate issues with regular internet access to the data.

SBAS L1 Regional Network for IONO monitoring

SBAS L5 DFMC World Wide Network
Uplink Safety Monitor

The **USM (Uplink Safety Monitor)** is the SW+HW element that runs in a microcontroller. It is in charge of performing the safety checks:

- the SBAS data broadcasted meets the requirements:
  - MT0 message is broadcast at least once each 6 seconds.
  - MT1 mask contains only one GEO (PRN 122).
  - GEO PRN and Service Provider ID in message MT17 are according to TB definition
  - IGP Mask (MT18) is according to TB definition
  - Service Area information in MT27 is according to TB definition

- The data is broadcast using the correct PRN

- Any data received was previously sent.
Figures and Photographs References.


- [RD-3] Maps generated with open street maps

- [RD-4] Satellite views generated with Google Earth