Results on Australia and New Zealand Second Generation SBAS and PPP Augmentation System

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ABSTRACT

During 2017 and 2018 a second generation satellite positioning augmentation system is being demonstrated in Australia and New Zealand. This system provides Satellite Based Augmentation (SBAS) and Real Time Precise Point Positioning (PPP) capabilities through the SBAS L1 and L5 signals broadcasted from the Inmarsat 4F1 geostationary satellite.

In the frame of this Testbed, the transmissions of SBAS signals started in May 2017, while the transmission of the PPP services started in October 2017. The present paper will describe the architecture and services provided by the system signals as well as an evaluation on its performances during the first half of 2018.

The Australia and New Zealand SBAS and PPP Testbed is promoted by Geoscience Australia (GA), Land Information New Zealand (LINZ), and the Australia and New Zealand Cooperative Research Centre for Spatial Information (CRCSI). The system is developed in collaboration with industry partners, including Lockheed Martin, Inmarsat and GMV. The primary objective of the Testbed is to assess the benefits of satellite navigation technologies, including integrity and high precision techniques, for applications in different transport and industrial sectors.

The services and signals broadcast during the Testbed consist of:

- SBAS L1 legacy service in accordance with RTCA/DO-229D (as EGNOS and WAAS). This signal provides GPS L1 augmentation for single-frequency user over Australia and New Zealand. This service is accessible to receivers available in the market with SBAS-enabled mode. The service is declared for test purposes only (don't use for safety applications) and therefore is broadcasting MT 0 message each 6 seconds.
- SBAS DMFC L5 service in accordance with WG62 GAL GPS SBAS MOPS v0.3.8_10. This signal provides GPS L1/L2 + GAL E1/E5a augmentation for dual-frequency users over the Inmarsat 4F1 footprint. The service is declared for test purposes (don't use for safety applications) and therefore is broadcasting MT 0 message each 6 seconds.
- PPP corrections through SBAS L1 message, targeting GPS L1/L2 dual-frequency users working with magicGNSS PPP Processing SW. This service is available in the Inmarsat 4F1 footprint.
- PPP corrections through SBAS L5 message, targeting GPS L1/L2 + GAL E1/E5a dual-frequency users working with magicGNSS PPP Processing SW. This service is available in the Inmarsat 4F1 footprint.

This second generation SBAS Testbed brings together two of the most demanded augmentation needs for the GNSS users: integrity and high accuracy. On one side, SBAS technologies are primarily designed and implemented to support regional aviation procedures, which have integrity of the navigation solution as its main interest. Also, multimodal users of the SBAS signal in sectors such as agriculture, maritime, transportation or general industry can benefit from a GNSS signal improving the GPS SPS accuracy. On the other side, PPP services are primarily designed to support high accuracy needs with a typical RMS

user error between 5 and 15 cm.

The two positioning technologies, PPP and SBAS, are put together by combining the common elements of the required infrastructure, particularly at ground segment level. Both solutions needs a set of ground reference stations whose measurements are used to support the estimation of satellite orbits and clock correction applicable in the service area. The SBAS message can be used to broadcast satellite ephemeris and clock correction that will be used by SBAS and PPP users. Additionally the ground segment computes the ionospheric corrections and satellite integrity information specific to the SBAS services. In this context one the objectives of the Testbed is to demonstrate the feasibility to use both L1 and L5 SBAS signals to support PPP services:

The main goal of this paper is to provide, from the point of view of the system developers, an update on the Testbed service definition, infrastructure status and performances achieved during the several months of experimentation. The paper is organized in the following sections.

- Description of the Australia and New Zealand Augmentation System four different services including SBAS L1 signal, SBAS DFMC L5 signal, PPP through SBAS L1 and PPP augmentation through SBAS L5 signal. The paper will discuss the benefits and synergies of the provided augmentation with regards to other GNSS positioning mechanism.
- Description of the Australia and New Zealand Augmentation System architecture and discussion of the technologies used in the deployment of the system, as well as an insight of the challenges faced and the evolutions implemented during one year of Testbed operation. The deployment of the system has involved the development of elements covering very different technological aspects within the ground and user segment, as for example:
    - Detail of the reference network used for the single-frequency and dual-frequency services. The reference data are obtained from the CORS stream supported by Geoscience Australia and New Zealand Land Information.
    - Technologies used for the SBAS signals construction and uplink. This includes the mechanism used to assure the safety of the GEO broadcasted signal (e.g. inclusion of MT 0 message, use of PRN and Service provider ID assigned and adequate synchronization of the signal preamble).
    - Ground segment centre development including satellite precise orbit and clock estimations by magicODTS; as well as ionospheric monitoring and SBAS integrity computation (GIVE, UDRE and DFRE) by magicSBAS.
    - Testing terminal user elements to access and benefit from the PPP and SBAS L5 DFMC services.
    - Development of system and services operation and monitoring technologies.
- Analysis of the results and performances achieved in the Testbed during the almost one year of operation through the review of the Testbed service monitoring data. This will include:
    - Evaluation of the SBAS messages SiS performances over the service area.
    - Evaluation of User Performances achieved at ground stations distributed over Australia.