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OPERATIONAL RESULTS OF A GNSS PAYLOAD FOR PRECISE POSITION AND ORBIT DETERMINATION OF BEESAT-9

Abstract

Technology demonstration on miniaturized satellites is one of the main research topics of the Chair of Space Technology at Technische Universität (TU) Berlin. The 1U CubeSat BEESAT-9 implements several components that had not been flown by TU Berlin before. A GNSS receiver was integrated to achieve the primary mission objective, a precise position and orbit determination package.
The launch in July 2019 from the Vostochny Cosmodrome in Russia with a Soyuz/Fregat rocket was provided by EXOLAUNCH free of charge. Since July the satellite is operated on a daily basis using three ground stations in Berlin, Buenos Aires and San Martin in Antarctica.
The miniaturized GNSS receiver from Hyperion Technologies [1] provides position and velocity measurements with an accuracy better than 10 m and 0.1 m/s by processing the signals from two constellations, GPS and BeiDou. Data from the GNSS receiver are recorded several times a day and are regularly being analyzed by researchers at TU Berlin.
First of all, the position data are compared to the position computed by a SGP4 model, which relies on publicly-available [2] Two-Line Elements (TLEs). This provides further knowledge about the accuracy of TLEs and therefore their usability on CubeSats regarding attitude control maneuvers, automatic passes over ground stations and picture georeferencing.
Furthermore, the position data is used for orbit determination and subsequently for generating better TLEs than those publicly available. The quality of the orbit determination highly depends on the quantity and frequency of the input data. Usually 1U CubeSats are not capable of operating a GNSS receiver continuously due to the limited power available. Moreover, the downlink speed in UHF band is limited, which affects the sampling rate during GNSS operations. Therefore, different strategies were carried out to improve the quality of the orbit determination.
1U CubeSats offer limited area for outside-facing components and can therefore only accomodate small GNSS antennas, which on the contrary should preferably have a big ground plane for an improved signal reception. For BEESAT-9 a relatively small antenna with an integrated LNA is used. The performance and degradation of the antenna and its LNA over time are investigated using the Signal-to-Noise Ratio (SNR) of the GNSS channels combined with the attitude data of the satellite.
The capabilities of BEESAT-9 regarding the power budget are pushed to the limit to figure out which applications, requiring accurate timing and position information, could be possible on a 1U CubeSat.

[1] Hyperion Technologies, "GNSS200 data sheet," visited on 06/03/2020. [Online]. https://hyperiontechnologies.nl/wp-content/uploads/2015/07/HT_GNSS200_v2.1-flyer.pdf

[2] Dr. T.S. Kelso, "Celestrak," visited on 06/03/2020 [Online]. https://celestrak.com/