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Author: Dr. Junichiro Kawaguchi
Australian National University (ANU), Australia

Mr. Shingo Nishimoto
Australian National University (ANU), Australia
Mr. Hayato Kokubo
Tohoku University, Japan
Ms. Saki Komachi
Tohoku University, Japan
Mr. Kohei Takeda
Tohoku University, Japan
Dr. Yuji Sakamoto
Tohoku University, Japan
Dr. Shinya Fujita
Tohoku University, Japan

ON-ORBIT DEMONSTRATION OF AN INNOVATIVE ASYNCHRONOUS ONE-WAY RANGING DEVICE ONBOARD A 3U SATELLITE

Abstract

The authors have developed the asynchronous one-way ranging (AOWR) device over the past few years. It is the method of determining the range and synchronizing the clocks between the ground station and the spacecraft through asynchronous bilateral communication. Conventional radio transponders provide the round-trip time between the ground station and the spacecraft. The measurement is not the distance but the sum of the up and down traveling times. It is processed through the navigation estimation effort combined with ephemeris and flight dynamics. In the cis-lunar and interplanetary fields, distance information is typically obtained a few days or more after the data collection, once the estimation process is complete and the orbit is determined. Even with an accurate clock on board, such as a chip-scale atomic clock (CSAC), precise clock synchronization is not feasibly achievable due to the time elapsed in the estimation process. Different from conventional radio transponders, the AOWR scheme here directly provides distance information almost in near real-time and enables rapid clock synchronization. Furthermore, the AOWR devices are derived from global navigation satellites system (GNSS) technology and are available at a low cost. Since the scheme works autonomously and independent of the range measurement facilities at the space agencies, the use of AOWR scheme enables non-space agency organizations, small organizations such as universities and start-ups to perform autonomous spacecraft operations beyond GNSS altitude, where no other range measurement method is available. In terms of the cis-lunar distance, a standard-sized antenna meets the communication requirements. Now, the team is going to conduct an on-orbit capability demonstration aboard a 3U CubeSat, HOKUSHIN-1, from Tohoku University in Japan next February. It will be launched and released from the international space station (ISS). The model demonstrated is built on a 10 cm by 15 cm circuit board. The team has developed the model and has performed various kinds of tests by now. The tests include the retrieval of range and timing data, verification of communication link margin, as well as acquisition/tracking tests under anticipated Doppler with acceleration. The team has conducted field radio tests three times to

ensure the systems' performance. Now the AOWR device is ready for flight. The paper will present the AOWR system description, explaining how it works, and provide details on radio communication. It will introduce the hardware/model developed based on the test results obtained thus far. The presentation is well-suited for the session.