IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Extra-Terrestrial and Interplanetary Communications, and Regulations (5)

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BEPICOLOMBO "MMO": ON-OFF KEYING COMMUNICATION AND NAVIGATION CHALLENGES WITH LIMITED TRACKING DATA

Abstract

JAXA's Mercury Magnetospheric Orbiter (MMO), one of the two orbiters of the BepiColombo mission, will reach Mercury in 2026. MMO is a spin-stabilized satellite, and after Mercury Orbit Insertion (MOI) by ESA's Mercury Planetary Orbiter (MPO), it will take one month to extend its booms and antennas for observing magnetic and electric fields. However, to prioritize the stability of the probe during the boom and antenna deployment, the High Gain Antenna (HGA) with a despan function cannot be used, and instead, communication will be performed using the body-fixed Medium Gain Antenna (MGA). This gives MMO two unique features.

The first is that for one month after MOI, on-off keying communication is performed by MGA, which represents binary 0 and 1 depending on the presence or absence of modulation of the carrier wave. The second is that during on-off keying communication, the accuracy of orbit prediction is reduced because no tracking data is available, but appropriate sweep conditions must be set so that the ground station can reliably capture the satellite. In modern times, probes that use on-off keying communication are rare. However, by not giving the MGA a despan function, the satellite has been made lighter and less expensive.

In this presentation, we will first introduce the signal visualization of on-off keying communication to improve operational efficiency. Signals above a certain S/N level are displayed in a time series and converted into binary 0 and 1 information. Then, the binary information received over several dozen minutes is converted into engineering values to obtain telemetry information.

Next, we will introduce the settings of the ground station to ensure that planetary orbiters are captured even with inaccurate orbit prediction. Since the MMO flies in an elliptical orbit at an altitude of 590 x 12,000 km, the Doppler frequency changes by 100 kHz at periapsis. Therefore, it is necessary to set up the

ground station so that it can reliably capture and keep tracking the satellite even if a large frequency error of 100 kHz occurs at a timing that is different from the predicted time. We will introduce the accuracy of orbit prediction and discuss the appropriate settings for the ground station.

It is expected that there will be an increase in small deep space probes that aim to be lightweight and low-cost, so we believe that the method taken by MMO will be one of the ultimate options in the future.