JUICE/GALA-J (3): Performance model simulation of Ganymede Laser Altimeter (GALA) for the JUICE mission

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The laser altimeter GALA (GAnymede Laser Altimeter) is one of the payload instrument of JUICE (JUpiter ICy moons Explorer) project led by ESA to be launched in 2022. GALA is developed by the international collaboration by Germany, Japan, Switzerland, and Spanish teams.

In order to clarify the requirement on the interface conditions between modules of GALA, we developed the performance model of GALA based on the model of BELA (Bepi-Colombo Laser Altimeter). The performance model quantifies the link budget, range accuracy, albedo measurement accuracy, and probability of false detection (PFD). In the performance model, background noise from scattered sunlight from the Ganymede surface, surface and bulk dark currents of APD, noise floor of APD-TIA, shot noise, and speckle noise are taken into consideration. Black-body emission from the Ganymede surface is also taken into account while its influence to SNR is negligible compared with other noises. EMI noise shall be included after the evaluation of the verification model.

Scientific requirements on GALA performance is summarized into the following four criteria: [1] For Europa fly-by, PFD is less than 0.2 from an altitude of 1300 km or lower, [2] Under the worst observation condition for albedo and surface slope of GCO500 (Ganymede Circular Orbit whose height is 500km), the accuracy of the ranging is less than 10 m and PFD is less than 0.2. [3] Under the nominal observation condition of GCO500, the accuracy of the ranging is less than 2 m and PFD is less than 0.1. [4] Under the best observation condition of GCO500, the accuracy of the ranging is less than 1 m and PFD is less than 0.1.

Returned laser pulse is converted to analogue signal in Japanese Analogue Electric Module (AEM), then to digital signal and transferred to Swiss Range Finder Module (RFM). RFM applies matched filtering to the digital signal to determine the range as accurately as possible. The signal processing in RFM constrains the performance of AEM, therefore, GALA-J developed its own matched filter simulation aiming to determine the signal-to-noise ratio (SNR). The matched filtering in RFM is a convolution of signal and Gaussian filter whose width in time domain is adjustable. The filtering is thus equivalent to moving average weighted by Gaussian filter in time domain. In this simulation, the length of range gate is 8192 and the sampling frequency is 66.7 MHz which is lower than the current design of ADC of 200 MHz. The band-pass filtering by trans-impedance amplifier of APD (APD-TIA) is taken into account by filtering the return pulse and APD noise by 100 MHz. By changing input SNR and width of the Gaussian filter, the lower bounds of the output SNR that satisfy the system requirements are investigated. The requirements for the input SNR obtained by the investigation are then confirmed well below the analogue SNRs calculated by the performance model.

The return signal is assumed to have a Gaussian form in both spatial and time domain in this performance model, however, the broadening occurs on a reflection by the surface topographic roughness and filtering processes in AEM and RFM. These effects on the results are now investigated and will be shown at the poster presentation.

Keywords: Jupiter, Ganymede, JUICE, GALA, Laser altimeter, Performance model

