Development Status of JAXA's New SLR Station in Tsukuba

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Abstract

This paper reports current development status of JAXA's new SLR station. JAXA started developing a new SLR station in the Tsukuba Space Center to replace the old one in Tanegashima. The new Tsukuba station follows the concept of modern and flexible. By mounting lasers and detectors onto the telescope, simple and compact design is realized. Tsukuba station is undergoing an acceptance test, and the laser ranging to some satellites including Galileo is already performed.

1. Introduction

Tanegashima station (GMSL) (Fig. 1) had been operated by JAXA since 2004 and had provided satellite ranging data as a part of the ILRS network. However, the operation of GMSL was terminated on 1st April 2021 due to aging and repeating system failures.

To take its place, JAXA started to develop a new SLR station in 2017 (Matsumoto et al., 2018, 2019). The new SLR station is built in the Tsukuba Space Center (JAXA) where our office is located, and thus it is referred to as "Tsukuba station." The locations of Tsukuba and Tanegashima in Japan are depicted in Fig. 2. The much better accessibility from our office than GMSL makes it easier to change the H/W configuration for experiments and investigate the cause of a system failure. We expect our knowledge and skills of SLR will be enhanced through operation of this new station.

In this paper, we will report current development status of Tsukuba station and some

Figure 1- Tanegashima station

Figure 2- Locations of Tsukuba and Tanegashima in Japan

preliminary ranging results will be shown.

2. Station Design

Tsukuba station is mainly developed by KDK (Japan), TOYO (Japan), and DiGOS (Germany). The design of Tsukuba station is modern and flexible which follows a standardized concept and based on the ESA's new SLR station, Izaña (IZN-1) in Tenerife, Spain, which was also developed by DiGOS. Tsukuba station has the capability of ranging from LEO to GEO satellites.

Overall station design is illustrated in Fig. 3 and specifications of Tsukuba Station are summarized in Table 1. The receiving telescope provided by ASA has 800 mm optical diameter. 4 Nasmyth foci are prepared and 2 of them are used for the laser package and the detector package. Total weight of the telescope is about 900 kg. Two lasers with the wavelength of 532 nm and 1064 nm are installed and the repetition rate of the lasers is 1 kHz. 532 nm laser will be used as a primary and 1064 nm laser is for experimental purpose. Both lasers have very short pulse width: 7 ps for 532 nm and 8 ps for 1064 nm, respectively. To receive each wavelength laser, detectors for 532 nm and 1064 nm are implemented. For 532nm, C-SPAD provided by Peso Consulting is used. It has a function to compensate time walk effect caused when return energy exceeds the single photon level. On the other hand, the detector for 1064 nm does not have such a function, thus return energy needs to be monitored more carefully when using 1064 nm to avoid range bias. As shown in the right picture in Fig. 3, the laser package (red boxes) and the detector package (blue box) are mounted on the telescope directly to avoid any Coudé Path, which results in the simple and compact design.

As an aircraft detection system, radar and ADS-B are used. If either the radar or ADS-B detects an aircraft that is in the laser pointing direction, the laser safety system immediately stops the laser emission.

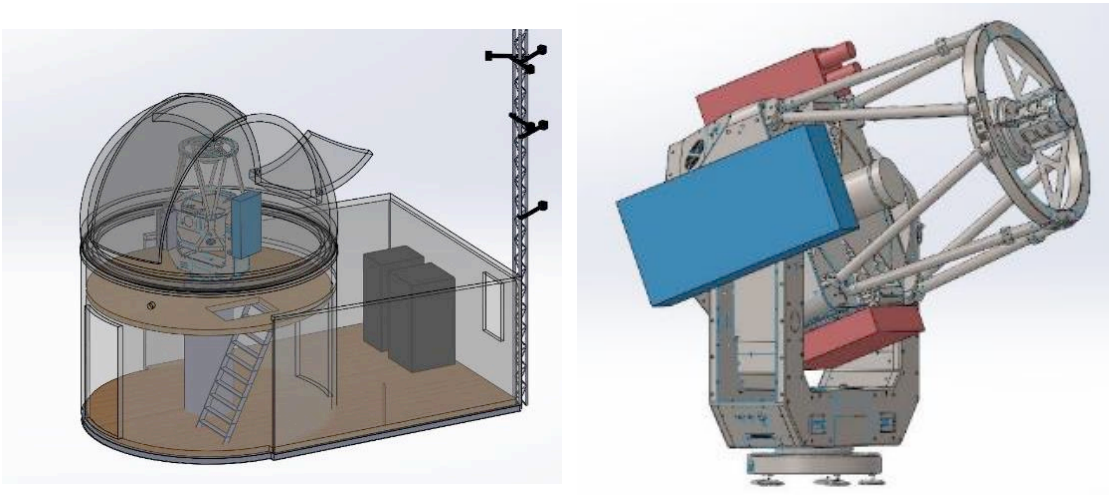

Figure 3- Overall station design (left) and telescope with laser package and detector package (right)

Table 1- Specifications of Tsukuba Station

Telescope		
Model	AZ800 (ASA)	
Type	Ritchey-Chrétien	
Optical Diameter	800 mm	
Laser		
Model	Compiler Compact (Passat)	
Wavelength	532 nm	1064 nm
Repetition Rate	1 kHz	1 kHz
Pulse Energy	260 μJ	350 μJ
Pulse Width	7 ps	8 ps
Detector		
Model	C-SPAD (Peso Consulting)	PGA-200 (RMY)
Wavelength	532 nm	1064 nm
Quantum Efficiency	> 40 %	> 30 %
Timing Jitter	< 40 ps	< 100 ps

3. Development Status

Although the operation of Tsukuba station was planned to start in April 2021 at the beginning of the project, the development is about 2 years behind schedule due to the coronavirus pandemic. The construction was suspended in November 2020 and re-started in June 2022. As of November 9, 2022, the construction has already finished, and Tsukuba station is undergoing an acceptance test (Fig. 4). Some fine tunings regarding the mount model and the infrared laser remain. We plans to start the operation of Tsukuba station from April 2023.

Figure 4- Tsukuba station: located in the Tsukuba Space Center (JAXA)

4. Preliminary Results of Laser Ranging

After finishing the construction, Tsukuba station started laser ranging to evaluate its performance. Some examples of laser ranging results are shown in Fig. 5 and Fig. 6. Fig. 5 is a result of LAGEOS1 whose orbit altitude is about 5,850 km, and Fig. 6 is a result of COMPASS-I5 that is a GEO satellite. From observation residuals after curve fitting (lower left plot in Fig. 5 and Fig. 6), single-shot RMS of LAGEOS1 and COMPASS-I5 are 6.04 mm and 16.97 mm, respectively. These values are smaller enough than our required specifications: 20 mm for LAGEOS and 100 mm for GEO satellite.

Tsukuba station keeps tracking satellite during the acceptance test, and these data are under analysis to assess the quality, especially range bias.

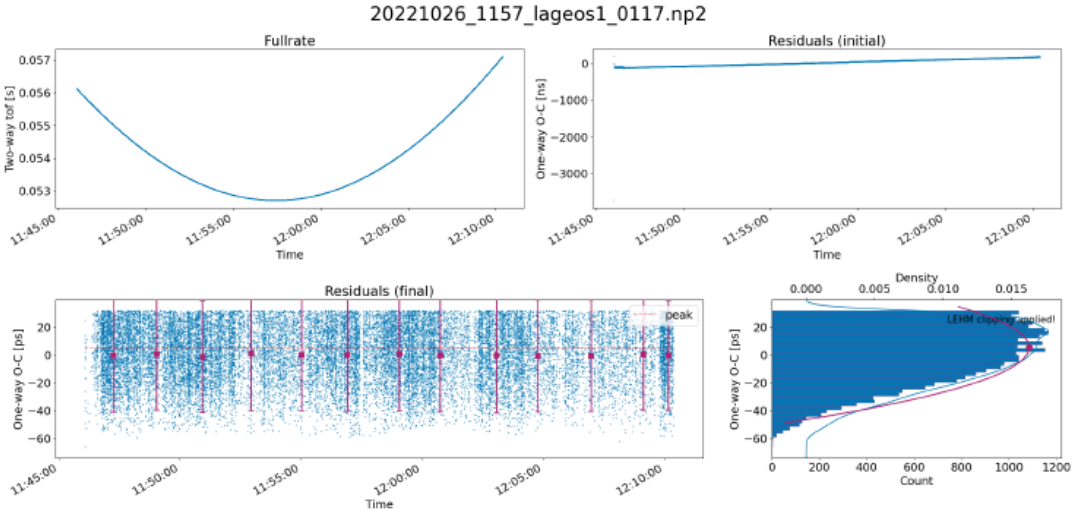

Figure 5- Laser ranging results of LAGEOS1 with 532 nm laser (October 26, 2022)

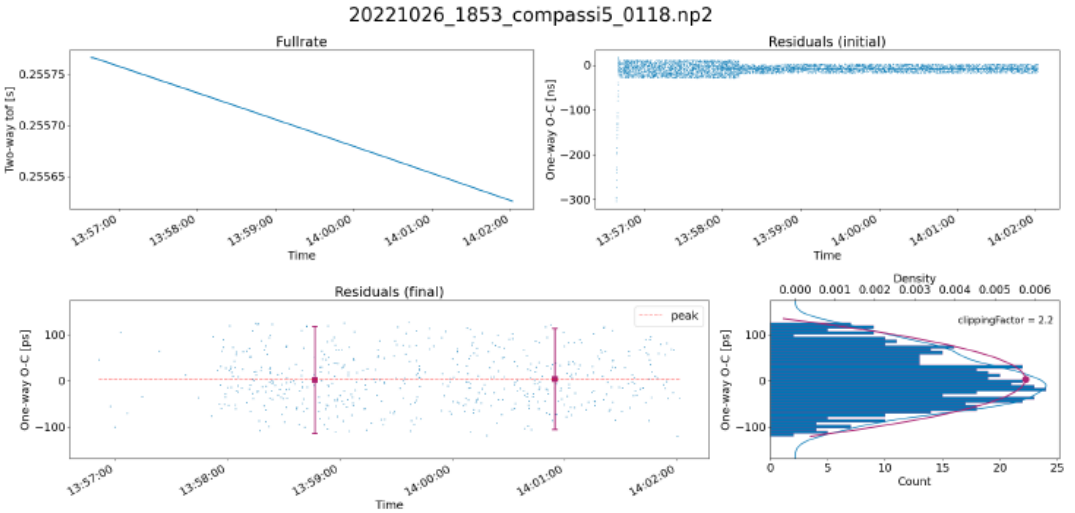

Figure 6- Laser ranging results of COMPASS-I5 (bottom) with 532 nm laser (October 26, 2022)

5. Summary

JAXA is developing a new SLR station in TKSC (Tsukuba, Japan). State-of-the-art SLR technology such as kHz repetition rate, infrared wavelength, or piggyback system is introduced. Although the development is about 2 years behind schedule due to the coronavirus pandemic, the construction has finished, and Tsukuba station is undergoing an acceptance test. Tsukuba station is already able to track some satellite including GEO, and the performance meets our required specification in terms of single-shot RMS. JAXA plans to start the operation of Tsukuba station from April 2023.

References

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