OICETS in-orbit experiments

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The Optical Inter-orbit Communications Engineering Test Satellite (OICETS) was developed by Japan Aerospace Exploration Agency (JAXA) to demonstrate the inter-satellite laser communications with the Advanced Relay and Technology Mission (ARTEMIS) geostationary satellite developed by European Space Agency (ESA). On 23rd August 2005, OICETS was successfully launched at the Baikonur Cosmodrome in the Republic of Kazakhstan and thrown into a circular orbit at the altitude of 610 km. OICETS has an optical communication terminal named the Laser Utilizing Communications Equipment (LUCE). The terminal's characteristics are given in Ref. [1].

In this report, the results of the initial verifications of LUCE's optical communication functions and the current progress of the inter-satellite laser communication experiments with ARTEMIS are introduced. Table 1 summarizes the initial verifications of LUCE's communication functions. As shown in the table, first we maintainverified the responses of LUCE's optical detectors such as a CCD and an APD. When we found that the optical detectors showed expected results, the investigations on the optical system as a combination of optical elements were carried out. In these investigations, we employed light emitted from a device previously equipped in LUCE, light coming from pointed stars, and dark directions in the sky where an influence of incoming light can be ignored. With the comparison of the data obtained by the in-orbit experiments with the one previously measured at ground facilities, we found that the LUCE's communication functions were in fine conditions. During this period, we also investigated the moving accuracy of the two axes gimbals as well as the influence of reflected or scattered light in the optical system. The gimbals' moving accuracy preserved the angular error less than 0.2 deg for open pointing. The angular error in fine pointing was kept within 1 micro-rad. Besides, no significant influence of such the undesired light was detected. After the verification of the optical system, we started on examinations of automatic procedures to acquire and track fixed stars or planets. We also tried a mock examination of the inter-satellite laser communications with ARTEMIS. With the satisfactory results, we concluded that entire system of LUCE was in fine condition for the forthcoming inter-satellite laser communications experiment.

We proceeded to the trials of the inter-satellite laser communications between ARTEMIS and OICETS. Prior to the inter-satellite trials, we reconfirmed the sequence of the automatic acquisition and tracking of ARTEMIS as well as the function to count the number of erroneous bits. The first success in the inter-satellite laser communications was achieved on 9th December, 2005. The quality of communication link was estimated as the criterion of BER (bit error rate) using the number of erroneous bits measured by mutual data transmission between ARTEMIS and OICETS. On 9th December, at the first success in the inter-satellite trials, the data transmission quality from OICETS to ARTEMIS was about 10^-4 while that from ARTEMIS to OICETS was regard as almost error-free. However in the following experiments, the bit error rate was improved to be less than 10^-9 or almost error-free by adjusting a point ahead angle given to the communication beam from OICTES to ARTEMIS. By the end of 2005, the trials of ARTEMIS-OICETS bi-directional laser communication were conducted 7 times and succeeded in all the trials. In 2006, we will repeat the inter-satellite laser communications as well as the periodical verification of LUCE's optical communication functions. In addition to these experiments, we have a plan to perform the optical laser communications between OICETS and a ground station of NICT (National Institution of Information, Communications and Technology). In the experiments continuously carried out from the beginning of this year, we confirmed that the LUCE's optical elements and optical system was in a good condition and the data transmission quality was high with holding a proper point-ahead angle. By 20th Feb. 2006, we succeeded 15 times in the ARTEMIS-OICETS bi-directional laser communications. The precious data obtained in the in-orbit experiments have been partially published [1] and the detail analysis are in progress.

Taking advantage of this opportunity, we, OICETS project team, would like to express the appreciation for ESA's continuous cooperation over 10 years. We also would like to express our gratitude to NEC Toshiba Space Systems, Ltd., for constructing OICETS and LUCE and for the cooperation in the experiments, and to Space Engineering Development Co., Ltd., Fujitsu, Ltd., Sorun corporation, and Daiko Denshi Tsushin, Ltd., for constructing the satellite operation systems and for the cooperation in the experiments.

Table1. Initial verification items.

Date (2005)	Estimated items
22-28, Sep.	CCD sensor's threshold value for light sensitivity Affection of undesired light to optical sensors

	CCD sensor's performance for light detection QD and APD sensor's performances for light detection Open pointing accuracy of two axes gimbals Bit error count function
29 Sep. - 10 Oct.	Acquisition and tracking sequences Point ahead mechanisms operation LD emission Affection of undesired light when pointing dark sky Alignment of optical axis between LD and PA sensor
11 Oct. - 29 Nov.	Automatic acquisition and tracking of the Sirius Alignment of optical axis between ORX and FPS Automatic acquisition and tracking of Mars Automatic sequences for ARTEMIS communications
5 – 22 Dec.	ARTEMIS-OICETS inter-satellite communications Beam pointing
10 Jan. -	ARTEMIS-OICETS inter-satellite communications Beam pointing CCD, QD and APD s sensor's performance for light detection and alignment of the optical system

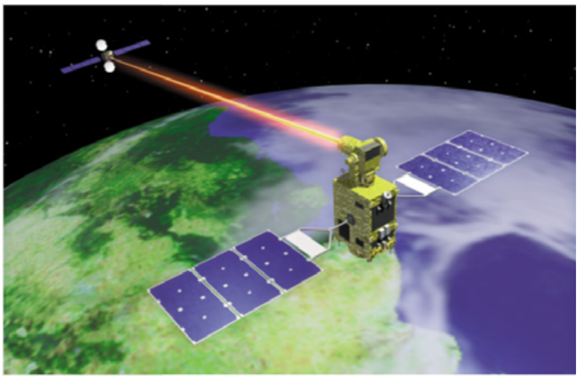

Figure1. In-orbit laser communications between ARTEMIS (left-hand) and OICETS (right-hand).

[1] T. Jono et al., "OICETS on-orbit laser communication experiments", Proc. SPIE 6105, to be published.