

5 International Campaign of Laser Communication Experiments using OICETS

5-1 GOLCE Overview

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The Ground-to-OICETS Laser Communications Experiments, GOLCE, that was carried out in 2008 and 2009 is introduced.

Keywords

Space laser communications, Satellite-to-ground, OICETS, GOLCE

1 Introduction

The regular operation of OICETS ended in September 2006. After that, the experiment functions of JAXA's ground facilities were partly removed. Then NICT agreed with JAXA to redevelop necessary experiment functions and conduct satellite experiments. Communication experiments between

OICETS and the NICT optical ground station thus started in collaboration with JAXA in October 2008. In April 2009, an international joint experiment started using OICETS and the optical ground stations of JPL, DLR, ESA, and NICT, and all of these institutes succeeded in optical communications with the satellite before the end of September 2009 [1]. In the experiment schedule in Fig. 1, experiments in

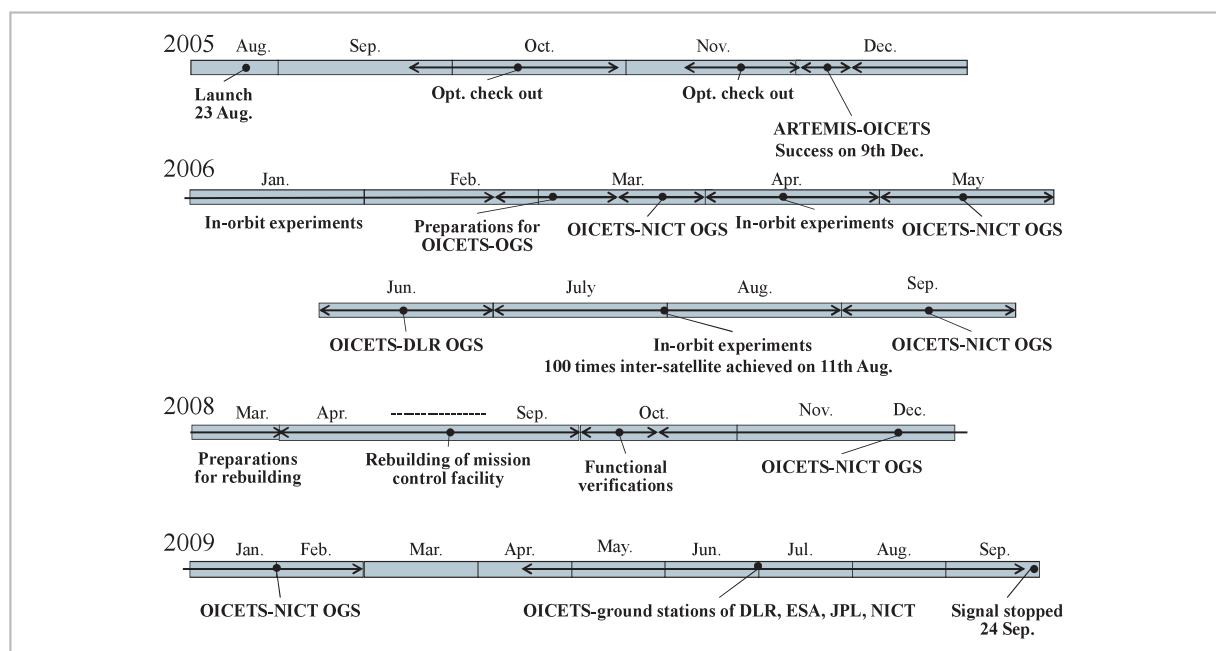


Fig.1 OICETS experiment schedule

and after 2008 are called Ground-to-OICETS Laser Communication Experiments (GOLCE). The obtained results were presented in an international workshop in May 2010. The institutes that conducted the experiments using OICETS participated in the workshop and shared the data that had been measured and the results of their analysis results [2]. An overview of GOLCE is given below.

2 Ground-to-OICETS Laser Communications Experiments

The redevelopment of the necessary functions for NICT to conduct experiments using OICETS, and the training of operators were finished in September 2009 and the performance of Laser Utilizing Communications Equipment (LUCE) mounted on OICETS in orbit was checked. The check items were open pointing accuracy of LUCE utilizing a planet, the noise characteristics of the coarse tracking sensor, and the alignment of the optical axis for transmitting and receiving. Compared with the results of a check of OICETS functions in 2005, this check indicated a little degradation. However, considering that it was not going to affect the experiments, we conducted Ground-to-OICETS Laser Communications Experiments on October 21, 2008.

The Ground-to-OICETS Laser Communications Experiments were performed at the NICT optical ground station during the period from October 2008 to February 2009. In the period from April to September 2009, international joint experiments of optical communications with OICETS were conducted at the DLR, ESA, JPL, and NICT optical ground stations. Table 1 shows the planning times and the number of established optical links. Each institute planned 10 experiments and succeeded in all optical communications except where

due to weather influences such as cloud or rain. Through the experiments conducted by the multiple optical ground stations in different environments targeting the same satellite, we obtained valuable data to evaluate the influence of the atmosphere to the transmitted light.

3 International workshop

The workshop GOLCE 2010 (International Workshop on Ground-to-OICETS Laser Communications Experiments 2010) was held at Hotel Parador in Tenerife Island, located in the Canary Islands, Spain [2]. At this workshop, participants presented their research results and exchanged information about the laser communication experiments between the low earth orbit satellite and the ground stations using the Optical Inter-orbit Communications Engineering Test Satellite (OICETS) in March 2006, and about the joint international experiments that DLR, ESA, JPL, and NICT performed up to September 2009. Not only the analysis of the atmospheric propagation of laser beams, but also the latest research achievements such as the success of coherent ground-to-satellite laser communications and the application of adaptive optics were presented. Figure 2 shows the workshop poster, Fig. 3 shows group photograph and Table 2 presents the program.

The meeting was held from May 13 through 15, 2010. At the workshop, 33 people from 6 countries (Switzerland, Germany, Netherlands, United States, Spain, and Japan) participated, and 22 papers were presented. The research results were so valuable that they were used for examinations at the technology standardization meeting, which started with the aim of the mutual linking operation of space laser communications.

Table 1 Number of experiments conducted with OICETS

	NICT	JPL	DLR	ESA
Planning times	10	7 (3 cancelled)	10	9 (1 cancelled)
Link times	2	4	5	8

4 Conclusions

This paper gave an overview of GOLCE, the optical communications experiments be-

tween OICETS and ground stations, which was conducted in and after 2008, and introduced the international workshop, which was held to share the results. If a satellite with an optical communication function is launched in the future, we expect that joint experiments will be performed in collaboration with other countries just as with GOLCE.

Acknowledgements

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Fig.2 Workshop GOLCE 2010



Fig.3 Group photograph

Table 2 GOLCE 2010 Program

13th May, 2010 (1st Day)

Opening Session 〈Session Chair: R. Suzuki, NICT (Japan)〉

◆ Opening Address - N. Kadowaki, NICT (Japan)

◆ Opening Address - C. Stavrinidis, ESA (Netherlands)

<p>Plenary Session I 〈Session Chair: N. Kadowaki, NICT (Japan)〉</p> <p>GOLCE2010-01 An Overview of Current Programs and Future Plans for NASA's Optical Communication Capability J. Rush, NASA Space Communication & Navigation Systems Planning Division (USA)</p> <p>GOLCE2010-02 Status of Lasercom Technology Development at JPL H. Hemmati, NASA JPL (USA)</p> <p>GOLCE2010-03 ESA's Activities in Optical Communications and Quantum Entanglement B. Furch, Z. Sodnik, J. Perdigues (TEC-MMO), ESA ESTEC (Netherlands)</p>
<p>Plenary Session II 〈Session Chair: H. Hemmati, JPL (USA)〉</p> <p>GOLCE2010-04 Investigation of Optical Ground Station Networks for Small LEO Missions D. Giggenbach, DLR Institute of Communications and Navigation (Germany)</p> <p>GOLCE2010-05 Laser Communication Terminal, TDP-1 and EDRS, LEO-GEO Optical Data Relay Networks M. Lutzer, DLR (Germany)</p> <p>GOLCE2010-06 TESAT LCTs LEO-LEO LEO-OGS LEO-GEO Data Links F. Heine, U. Sterr, Tesat-Spacecom GmbH & Co.KG (Germany)</p> <p>GOLCE2010-07 TESAT LCT for the EDRS F. Heine, U. Sterr, Tesat-Spacecom GmbH & Co.KG (Germany)</p> <p>GOLCE2010-08 Joint United States-Germany Satellite Laser Communications Project: NFIRE-to-TerraSAR-X ISLs and NFIRE-to-Ground SGLs C. Lunde, R. Fields, R. Wong, J. Wicker, D. Kozlowski, The Aerospace Corporation (USA); J. Skoog, General Dynamics-AIS (USA); G. Muehlnikel, Tesat-Spacecom (Germany); J. Hartmann, General Dynamics-AIS (USA); U. Sterr, ST2C (Germany); M. Lutzer, DLR-Bonn (Germany)</p>
<p>Technical Session I 〈Session Chair: D. Giggenbach, DLR (Germany)〉</p> <p>GOLCE2010-09 Development of Optical Inter-orbit Communications Engineering Test Satellite (OICETS) T. Jono, JAXA (Japan)</p> <p>GOLCE2010-10 Rebuilding and Operations of Ground Functions for OICETS-OGS Experiments Y. Takayama, M. Toyoshima, NICT (Japan); S. Yamakawa, JAXA (Japan); N. Kura, Space Engineering Development Co., Ltd. (Japan)</p> <p>GOLCE2010-11 Comparison of the Data Received by OICETS Y. Koyama, M. Toyoshima, Y. Takayama, Y. Shoji, H. Takenaka, NICT (Japan)</p> <p>GOLCE2010-12 Preliminary Analysis of OICETS to OGS Downlink A. Alonso, IAC (Spain); Zoran Sodnik, J. Perdigues, ESA ESTEC (Netherlands)</p>
<p>Technical Session II 〈Session Chair: Z. Sodnik, ESA ESTEC (Netherlands)〉</p> <p>GOLCE2010-13 OCTL Planning, Tests and Operations for the Bi-directional Link to the OICETS K. E. Wilson, J. Kovalik, A. Biswas, M. Wright, W. T. Roberts, NASA JPL (USA); Y. Takayama, NICT (Japan); S. Yamakawa, JAXA (Japan)</p> <p>GOLCE2010-14 KIDDO 2009: Trials and Analysis F. Moll, DLR Institute of Communications and Navigation (Germany)</p> <p>GOLCE2010-15 Study of Fiber Coupling Efficiency for Ground-to-Satellite Laser Communication Links Using OICETS H. Takenaka, M. Toyoshima, NICT (Japan)</p> <p>GOLCE2010-16 Results of the KODEN Experiments and Invitation to the Common Analysis Campaign M. Toyoshima, H. Takenaka, Y. Shoji, Y. Takayama, Y. Koyama, NICT (Japan)</p>

GOLCE2010-17

Optical Space Communications in ITU and CCSDS

T. Mukai, JAXA Consolidated Space Tracking and Data Acquisition Department (Japan)

14th May, 2010 (2nd Day)

Plenary Session III (Session Chair: R. Suzuki, NICT (Japan))

GOLCE2010-18

JAXA's Future Plan in Optical Space Communications Technology - Activities beyond OICETS -

S. Yamakawa, T. Hanada, H. Kohata, Y. Fujiwara, JAXA Space Application Program - System Engineering Office (Japan)

GOLCE2010-19

R&D on Deep-space Link Experiments

T. Dreischer, RUAG Space Ltd, Switzerland

GOLCE2010-20

Adaptive Optics for Optical Satellite Downlinks

M. Knapik, DLR Institute of Communications and Navigation (Germany)

GOLCE2010-21

A Miniature Adaptive Optics System for the ESA OGS

D. Soltau, Kiepenheuer Institute for Solar Physics (Germany)

GOLCE2010-22

Adaptive Optics and ESA's Optical Ground Station

Z. Sodnik, ESA (Netherlands); R. Czichy, Synopta GmbH (Switzerland);

D. Soltau, T. Berkefeld, Kiepenheuer Institute for Solar Physics (Germany)

◆ Concluding Remarks - R. Suzuki, NICT (Japan)

References

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- 2 Morio TOYOSHIMA and Yoshihisa TAKAYAMA, "Trends of Laser Communications in Space — Focusing on International Workshop GOLCE2010 —," IEICE Technical report OPE2010-26, 2010-27, pp. 21-26, 2010.

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