Report on Standardization of Optical Communications by CCSDS

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1. Introduction

The Consultative Committee for Space Data Systems (CCSDS)[1] was founded in 1982 by the major space agencies under the common understanding that it is important to cooperate on space activities including developing a mission device, supporting satellite operations, and sharing related data. CCSDS is focused on developing and recommending international standards for space data systems while incorporating demonstration results. Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communication Technology (NICT) of Japan are CCSDS members.

The Interagency Operations Advisory Group (IOAG)[2] prioritizes technical fields for which CCSDS develops standards. IOAG also identifies issues for future space systems and interoperability among space agencies in accordance with a policy set by the Interoperability Plenary (IOP)[3]. During 2011—2012, the Optical Link Study Group (OLSG) was set up within IOAG to make an intensive study on the operation of optical communications. In CCSDS, the Optical Communication Working Group (SLS-OPT) was established in 2014 (see Fig. 1).

This paper reports on the background, objectives, and plans of SLS-OPT and its first meeting held during March 30—April 3, 2014.

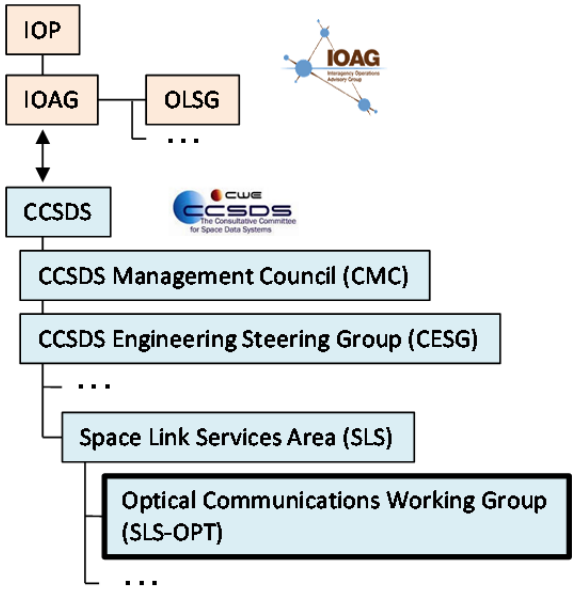


Fig. 1 IOAG-CCSDS Relationship

2. SLS-OPT

Since 2011 spring when a report was made in the Space Japan Review[4] to SLS-OPT establishment in January 2014, discussions have been made on the following issues.

From 2011 autumn, OLSG studied to clarify operation scenarios for optical communication. This resulted in OLSG report[5] and OLSG addendum report[6]. OLSG report confirmed the benefits of cross-support operation of optical communication while identifying two types of use cases. One is direct communication between spacecraft and ground stations. According to distance, it was further divided into six cases: low earth orbit, geostationary orbit, moon, Sun-Earth Lagrange 1/2, and deep space. Another is relay communication between multiple spacecraft. OLSG addendum report

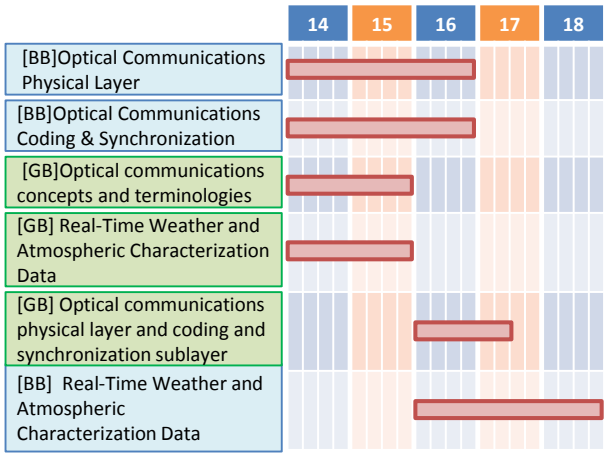
presented issues for implementing optical cross-support operations including pointing, acquisition and tracking method, meteorological information exchange method for confirming station availability, and eye-safety policy.

OLSG discussions converged by December 2012 and their report was made to IOAG. At the IOP-3 meeting in June 2013, space agencies confirmed benefits of interoperability of optical communication as a future technique in the 2020s and showed a guideline to accelerate demonstration and standardization in the field of optical communication. with this guideline, IOAG requested CCSDS to develop those standards. In October 2013, a birds-of-a-feather meeting was held within CCSDS and a SLS-OPT action plan was drafted. The CCSDS Management Council (CMC) held in December 2013 approved this action plan, leading to the foundation of SLS-OPT in January 2014.

With a purpose of introducing cross-support capability into optical communication, SLS-OPT will complete its standardization activities by December 2018 under the action plan shown in Table 1.

First, SLS-OPT will develop four Books: recommendation reports (BB: Blue Book) of Optical Communications Physical Layer (to be drafted by NASA) and Optical Communications Coding & Synchronization (ESA) and informational guides (GB: Green Book) ofReal-time Weather and Atmospheric Charatrerization Data (NICT) and Optical Communications concepts and terminologies (ESA) including optical link design, terminologies and so on. Depending on the progress that would be made, SLS-OPT will further publish two more books: one GB about physical layer and coding & synchronization sub-layer and one BB about meteorological data exchange. The discussion and coordination will be made in face to face meetings held twice a year and teleconferences held once a month.

Table 1　SLS-OPT Schedule



3. Summary of the first SLS-OPT meeting

The first face to face meeting of SLS-OPT took place during March 31 to April 2 in the CCSDS 2014 spring meeting period. Space agencies of the US, China, Europe and Russia as well as a number of related companies participated in the meeting.

Fig. 2　First SLS-OPT Meeting

The main discussion points at this meeting are summarized as follows:

(1) Regarding the BB about physical layer, classification of modulation-demodulation methods was discussed. Reflecting the statement from Japan that it is necessary to consider requirements of missions with low communication speed, the book will be developed to include three methods: (A) PSK for relay missions with a speed of several gigabit per second, (B) PPM for Moon and deep space missions, and (C) OOK for small satellites on LEO with a transmission speed less than 1 gigabit per second. NICT has developed the Small Optical TrAnsponder (SOTA)[7][8] implementing (C) to fly onboard a small satellite called "SOCRATES," which was launched on May 24, 2014. It is expected that SOTA's achievements will be incorporated into this BB.

(2) A detailed technical report was made on the Laser Communication Terminal (LCT)[9] onboard the European Data Relay System (EDRS) developed by ESA. This is because technical specifications of LCT will be reflected in the aforementioned books development as far as they are acceptable to other agencies as well. SLS-OPT intends to leverage EDRS/LCT in demonstration phase because a publication of BB requires two demonstration cases between different implementations. NASA is currently developing a terminal for Laser Communication Relay and Demonstration (LCRD),[10] however, LCRD has different specifications from EDRS/LCT such as wavelength, communication speed and coding method. SLS-OPT does not intend to define wavelength specification in this BB.

(3) Regarding the GB about meteorological data, discussed topics included which meteorological data to be exchanged, observational instruments for use, and exchange method for these data. The GB will be developed mainly by NASA and NICT. At the meeting its development schedule was rearranged.

(4) For the GB about utilization of optical links, the structure and contents of the Book were discussed while referring to prior demonstration results.

4. Conclusion

In this paper recent standardization activities by SLS-OPT within CCSDS were introduced.

Recently optical communication is drawing people's attention as a prospective technology to meet demands for increasing data transmission volume with advanced space activities and/or to achieve significantly faster communication speed in commercial use. We will keep participating in these activities that will form standards for a wide variety of future optical communication users in space.

5. References

[1] http://public.ccsds.org/default.aspx

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[5] "Optical Link Study Group Final Report", 5 June 2012, OLSG/IOAG

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[7] “Small Optical Transponder for SOCRATES mission” Maki Akioka, Yoshihisa Takayama, Yoshisada Koyama(NICT), Proceedings of 57th Space Sciences and Technology Conference 1H05, JSASS-2013-4125

[8] “Preparative Demonstration of Optical Link Establishment by Using Small Optical Transponder” Yoshihisa Takayama et.al., 6S3, International Conference on Space Optics and Systems and applications (ICSOS) 2014.

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[10] “A Space Based Optical Communications Relay Architecture to Support Future NASA Science and Exploration Missions” Bernard Edword et. al., 6S1, International Conference on Space Optics and Systems and applications (ICSOS) 2014.