# Indoor verification tests of a free space optical time and frequency transfer for the COMPASSO mission

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German Aerospace Center's COMPASSO mission is aiming for an in-orbit validation on the international space station (ISS) of optical key technologies for future application in GNSS. The optical payload of COMPASSO consist of optical frequency reference systems based on molecular iodine, optical frequency comb technology, high-performance GNSS disciplined oven-controlled crystal oscillator (OCXO) and a laser communication and ranging terminal (LCRT). The LCRT is based on the TESAT's SMART70 design. The main modification of the SMART70 terminal is introducing an Optical System for Communication and Ranging unit (OSCAR) which implements the required signal processing to transfer data, time and frequency and derive the ranging information. The mission goals are miscellaneous and range from in-orbit optical clock characterization to precise bi-directional time-transfer between ground and the ISS.

In our contribution to EFTF 2024, we provide an overview of the indoor verification tests of the free space optical time and frequency transfer between two lab-based LCRTs. These represent an early stage in the ongoing development process of the OSCAR to be implemented in the modified SMART70. The lab tests are a part of the validation process and verification plan of German Aerospace Center's COMPASSO mission. The indoor tests are carried out with two identical OSCAR systems and free space optical (FSO) communication terminals along a basement corridor with a distance of 30m. Each side has a commercial cavity stabilized laser systems ORS1500 and optical frequency combs FC1500-ULN both from Menlo Systems GmbH. Additionally, an optical fiber infrastructure connects the two setups to establish performance baseline. Fiber-based optical communication between the two OSCARs as well optical frequency transfer stability measurements between the two ORS1500 systems and the respective homodyne receiver units within the OSCARs are carried out to verify and compare the optical frequency transfer via fiber and free space. The optical frequency combs bridge the wavelength gap between the two ORS1500 and the two OSCAR setups operating at 1542nm and 1564nm. For time transfer experiments the OSCAR units can be referenced on OCXOs, on radiofrequency signals synthetized from the optical frequency combs referenced to the cavities or to an active hydrogen maser (AHM) for common mode measurements.

Bidirectional FSO frequency transfer experiments show a stability better than $1.4 \times 10^{-15}$ at 1s in terms of Allan deviation with an overall stability of the measurement systems, the cavity over fiber infrastructure compared to the optical frequency comb referenced to complementary cavity, of about $2.0 \times 10^{-15}$ at 1s in terms of Allan deviation. Bi-directional FSO time transfer experiments in a common mode setup with the AHM show a stability of $1.0 \times 10^{-13}$ at 1s in terms of Allan deviation. Both results are sufficient to fulfill the COMPASSO mission objectives.