SCF-Test of Galileo IOV retroreflectors

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INFN, in the framework of the experiment ETRUSCO, thoroughly tested single retroreflectors, arrays and prototypes in use on current GNSS constellations, at the SCF. In particular, measurements performed on old generation GNSS LRAs (Laser Retroreflector Arrays), GPS/GLONASS/GIOVE, explained the experience of ILRS (International Laser Ranging Service) ground stations all over the world: difficulty to track GNSS payloads due to a severe decrease of laser return from such payloads, exspecially for daylight ranging. The SCF-Test showed a significant degradation of CCR (Corner Cube Retroreflector) performance due to illumination by our Solar Simulator, of ~87%. Two were the causes identified for such degradation: the Al back-coating used on the three reflecting faces of the CCR, and a non-optimized thermal isolation between the housing and the CCR. Uncoated CCRs with proper mounting minimize thermal degradation and significantly increase optical performance, and as such, are the design recommended for modern GNSS. In fact the first two IOV (In Orbit Validation) satellites of the Galileo constellation are equipped with 84 uncoated retroreflectors. In 2010 ESA requested INFN a full SCF-Test campaign of a prototype retroreflector in order to characterize in detail its thermal and optical properties in the accurately laboratory-simulated space conditions of the SCF. The basic SCF-Test campaign performed on this CCR showed optical performance better than GPS/GLONASS/GIOVE. We analyzed the variation of the average intensity of the FFDP (Far Field Diffraction Pattern) at an angular distance, VA (Velocity Aberration), of 24 μrad from the center of the FFDP, corresponding to the altitude of Galileo, and we reported a degradation of ~25%, well below the 87% of previously measured Al-coated CCRs (therefore, a better behavior of IOV reflectors compared to the old generation). From thermal data analysis we determined the characteristic heating time of the CCR, τ_{CCR}, at two different temperatures of the CCR, 310K and 370K. We measured a rather low τ_{CCR} for both temperatures, O(100) sec, compared to previously measured CCR of comparable volume, GLONASS CCRs or LAGEOS CCRs. Again a possible cause for this is a non-optimized isolation between the CCR and its housing. After these tests we introduced a improved revision on the basic SCF-Test. Exploiting the positioning/rotating system of the SCF we simulated a critical orbit of Galileo, which is the one whose angular momentum is orthogonal the Sun-Earth direction. Galileo satellites have a semi-major axes of ~29600 Km corresponding to an orbital period of ~14 hrs; we simulated the half orbit in which the Sun rises above the CCR from one side, ~7 hrs, is obscured by Earth shadow, ~1 hrs, and sets on the opposite side, ~7 hrs. Testing a GCO (GNSS Critical half-Orbit) was an important step forward, more realistic and sensitive, in the SCF-Test because it made possible to simulate variable Sun inclination conditions. The GCO was realized rotating the CCR with steps of 2.2° every 5 minutes taking FFDPs and IR pictures each 4 steps, rotating rapidly the CCR in front of the laser. The Earth shadow was simulated just turning off the Solar Simulator and leaving the CCR in front of the laser. The output of the measurement was the variation of FFDP intensity at Galileo VA, which showed, for the GCO, an average FFDO degradation of ~35% and confirmed the non-optimized thermal isolation between the CCR and its mounting. Finally, the continuation of IOV SCF-Testing will be outlined.