IAF SYMPOSIUM ON COMMERCIAL SPACEFLIGHT SAFETY ISSUES (D6)
Commercial Spaceflight Safety and Emerging Issues (1)

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INNOVATIVE TRACKING TECHNIQUES APPROACHES: FROM STRATOSPHERIC VEHICLE TESTING TO COMMERCIAL SPACE TRANSPORTATION APPLICATIONS

Abstract

The future manned space transportation systems require safe, reliable, high-capacity tracking and surveillance systems to ensure safety of the operations. Differently as aircraft surveillance that is mainly performed by traditional primary and secondary radar systems, novel, dedicated tracking systems should be applied to space transportation vehicles due to the inherent differences between aircraft and spacecraft mission profiles in covered distance, speed range, typical elevation and elevation rate of the targets.. Quasi-passive tracking systems, exploiting multi-lateration techniques such as the TDOA (Time Difference of Arrival) and FDOA (Frequency Difference of Arrival), could offer a significant contribution to the achievement of acceptable safety levels of the tracking systems for space transportation vehicles. These systems rely on a spaceborne transmitter downlinking dummy signals (without any information content) and a distributed network of ground-based sensors achieving position and velocity determination through multi-lateration algorithms. The TDOA algorithm consists in retrieving the spaceborne target position by analyzing the reception times of the signals from multiple locations, while FDOA is able to reconstruct the velocity vector of the target on the base of the observed Doppler shift frequency from the distributed receivers. The reduced dependability on the effective transmitting system well-functioning compensates the great difficulties in building and managing active tracking systems, e.g. primary radars, needing to extend their range to near-space and space operational conditions. The effectiveness of those multilateration systems is being tested by the S5Lab research team at Sapienza University of Rome and ALTEC (Aerospace Logistics Technology Engineering Company) through the development and launch of a stratospheric experiment, named STRAINS (Stratospheric Innovative Systems), on a Zero-Pressure Balloon in the framework of the HEMERA H2020 Balloon Launch Infrastructure. The stratospheric experiment will be launched in September 2020 from the Esrange Space Center in Kiruna, Sweden, and it is under integration at Sapienza University of Rome. The results of the experiment, applied to a stratospheric vehicle and to the Near-Space environment, will be immediately applicable to the mission scenario of space transportation systems, with particular focus on suborbital spaceplanes for commercial and scientific missions. This paper describes the future perspectives of TDOA and FDOA tracking systems for Near-Space and space transportation vehicles. Particular focus will be given to the system architecture, to the experimental set-up and results of the STRAINS experiment on-board a stratospheric platform and on its future applications to space transportation systems, with regards to suborbital spaceplanes mission profiles.