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SOFTWARE-DEFINED MULTI-LATERATION TRACKING FOR NEAR-SPACE, SUBORBITAL AND SPACE VEHICLES: DEVELOPMENT OF THE STRAINS EXPERIMENT

Abstract

The rising concepts of near-space and space missions will be soon requiring a multiplicity of innovative high-capacity navigation systems. In particular, the transition from a space exploration era to a true space exploitation phase will see an increasingly high number of satellite launches, a higher congestion of the orbital environment and a particular importance of the Space Traffic Management operations. The introduction of innovative concepts of navigation systems shall result in a significantly low dependability, in order to preserve the trackability of each near-space and space payload during its operations. As an example, the utilization of multi-lateration systems aimed at performing TDOA (Time Difference of Arrival) or FDOA (Frequency Difference of Arrival) navigation can achieve good accuracy from the already available on-board and on-ground resources. For example, nano-satellite and scientific satellite missions already transmit beacon telemetry signals at relatively high repetition rates (typically every 15 seconds or 1 minute). This beacon can be received from multi-lateration networks to exploit the TDOA method for time-of-arrival-based position estimation or FDOA for the velocity vector reconstruction. Low-cost architectures of ground sensors, such as Software Defined Radios, can be implemented for testing and exploiting such navigation methods, with the chance of setting up an entire network with reduced costs. The STRAINS (Stratospheric Tracking Innovative Systems) Experiment, conceived by Sapienza University of Rome and ALTEC (Aerospace Logistics Technology Engineering Company, Turin, Italy) and supported by ASI (Italian Space Agency), has the main objectives of exploiting TDOA and FDOA navigation by performing a proof of concept with software defined radio sensors for a stratospheric balloon flight. The experiment can be considered a testbed for estimating the accuracy and effectiveness of such methods in the perspective of a wider utilization on future suborbital and orbital platforms. The experiment has been developed between 2020 and 2021 and will be launched in the framework of the HEMERA Balloon Launch Infrastructure from Esrange Space Center in Q3 2021. The experiment includes a flight unit and a multiplicity of ground stations which will be disseminated around the predicted flight envelope area for achieving multi-lateration. All the radio transmitters and receivers within the STRAINS Experiment are based on SDR hardware. The flight unit also equips reference sensors for the validation of the results. This paper will present the STRAINS Experiment development, qualification and scheduled operations and preliminary results, as well as the extension of the concept to suborbital and orbital vehicles tracking.