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VHF OMNIDIRECTIONAL RANGE (VOR) RELIABILITY DETERMINATION IN STRATOSPHERE: STRATONAV EXPERIMENT

Abstract

The VHF Omnidirectional Range (VOR) is a mature and reliable radio-navigation system, used since the late 1940s by civil and commercial aircraft. This navigation system is still used nowadays as back-up for inertial, satellite and other radio-frequency navigation systems. The VOR architecture is based on ground stations transmitting a complex signal in VHF band and on passive and simple receivers that evaluate the "radial", the angle between the Magnetic North direction and the line that connects the ground station to the receiver. The Airport Information Publications (AIPs) indicate the service volume of each ground station, that extends up to 185 km in range and 18 km in altitude. The service volume size is based on prescribed minimum power density levels. The vehicles in charge of verifying the correct operations of the VOR stations are traditional fixed-wing planes, inherently unable to reach the guaranteed VOR service limit height. Nevertheless, simple link budget calculations indicate a possible applicability of the VOR to stratospheric aircraft. STRATONAV (STRATOspheric NAVigation) Experiment is a scientific project developed by a joint students team from both Sapienza - University of Rome and Alma Mater Studiorum - University of Bologna, aimed at evaluating the VOR accuracy rates in the stratosphere, above the prescribed service volume limit. The experiment was selected in December 2015 to participate in the ninth cycle of the REXUS/BEXUS Programme (Rocket and Balloon-borne EXperiments for University Students). STRATONAV was designed, developed and tested in the first half of 2016 and it was launched on-board BEXUS 22 stratospheric balloon on October 5th, 2016 from Esrange Space Center in Kiruna,

Sweden. The experiment collected VOR radials for nearly five hours, reaching a balloon float altitude of 32.2 km. The acquired signals accuracy was evaluated in order to define the VOR performance above its service volume end. Moreover, the flight area was characterized by the presence of multiple VOR stations, whose dense service volumes intersection pattern allowed to perform a VOR-standalone-based ground track determination by interfacing two (or more) radials at a time. This paper deals with the STRATONAV Experiment design, development, test and flight, with particular emphasis on the general architecture, mission analysis and on-board systems design. Moreover, a detailed report of the stratospheric flight, including an overview of the achieved results, will be presented.