Paper ID: 4775
student

38th STUDENT CONFERENCE (E2)
Student Conference III (3)

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MEMS BASED INERTIAL NAVIGATION EXPERIMENT ONBOARD STRATOSPHERIC BALLOONS

Abstract

Performances of low-cost inertial navigation sensors, usually poor, can often match different mission requirements by means of a careful signal and data processing and/or an augmentation by means of different observables.

The paper presents a navigation experiment, successfully flown onboard BEXUS 6 balloon mission on 8th October 2008 from ESRANGE Space Center in Kiruna. BEXUS is a bilateral German-Swedish cooperation to offer students opportunities to fly their own experiments on stratospheric balloon. The chance was made available to students from European countries through a collaboration with ESA Education Office. In the BEXUS frame, a students team from Università di Roma La Sapienza proposed, designed and operated the LOWCOINS (LOW Cost Inertial Navigation System) experiment.

LOWCOINS has as the main component a low-cost three-axes inertial unit, integrating three accelerometers and three gyros, together with temperature sensor to help in the in-run output calibration. The slow dynamic typical of a balloon flight is deemed as an ideal test to verify the performances of the unit and to improve the knowledge on the data processing needed to obtain an accurate final navigation solution. In order to enlarge the set of available data, a cluster of magnetometers and a pressure sensor, always belonging to low-cost instrumentation range, are hosted on board. Measurements are both stored on board and downlinked to a ground station. Position and velocity components, computed through an extensive post-flight processing, can be compared with the data gathered by a GPS receiver, which is a standard component of BEXUS balloon avionics, offering a backup solution during short intervals. Moreover, the LOWCOINS experiment may be used to provide a platform for the attitude and heading determination of the payload gondola, inherently part of the navigation process, through-out the entire flight time. Since no such devices are part of the standard avionics, and a wide range of balloon borne experiments may need this kind of data, LOWCOINS opens for a wide range of applications onboard balloon flights requiring platform stabilization and/or attitude determination. Navigation and attitude solution for the BEXUS 6 flights are reported and discussed, together with in-depth description of the mechanization and filtering algorithms involved.

The flight onboard a stratospheric balloon clearly exposes the unit to extreme temperature variations. Variability of the temperature range, as well of the flight duration, add complexity to the design. As a result, substantial attention to thermal aspects has been requested in order to cope with environmental conditions prior of and all along the flight. Specifically, LOWCOINS includes an autonomous heating system together with the relevant power source. The extensive set of environmental test performed to validate LOWCOINS is described.

The experiment results proved that the technology involved behaved extremely well in the severe environment of a stratospheric flight, that is just few steps away from space.