www.adeepakpublishing.com

Parham, J. B. et al. (2019): JoSS, Vol. 8, No. 1, pp. 801–814
(Peer-reviewed article available at www.jossonline.com)

www. JoSSonline.com

Networked Small Satellite Magnetometers for Auroral Plasma Science

J. Brent Parham, Maria Kromis, David Einhorn, Phillip Teng, Sergei Posnov, Hannah Levin, Osi Van Dessel, Aleks Zosuls, Brian Walsh, and Joshua Semeter

Boston University
Massachusetts US

Abstract

Motivated by small-scale auroral plasma science, ANDESITE (Ad-hoc Network Demonstration for Spatially Extended Satellite-based Inquiry and Other Team Endeavors), a 6U CubeSat with eight deployable picosatellites, will fly a local network of magnetometers through the electrical currents that cause the Northern Lights. With the spacecraft due to launch on NASA's upcoming Educational Launch of Nano-satellites (ELaNa) mission, this work details the science motivation for this type of mission architecture, the mathematical framework for current field reconstruction from a magnetometer swarm, the particular hardware implementation selected, and the calibration procedures. Each three-axis Amorphous Magneto-resistive (AMR) magnetometer is hosted by a deployable picosatellite about the size of a piece of toast. Calibration of the sensors included a test of the integrated picosatelites in a Helmholz cage that swept a wide range of magnetic environments. Here, we show that even in the small package—operating under a Watt with a compact power system, radio, and GPS—we were able to sample at 30 Hz with an uncertainty under 20 nT in each axis in standard conditions. We develop an analysis framework for the network to understand the spatial frequency response of the kilometer-scale 3D filter created by the swarm as it flies through various current density structures in the ionospheric plasma.

1. Introduction

Auroras are a visible manifestation of the release of electromagnetic energy from the magnetosphere into the outer atmosphere. This energy flow is mediated by magnetic field-aligned currents (FACs) which close through the ionosphere in the altitude range of 120 to 180 km (Thayer and Semeter, 2004). Our modern understanding of the auroral current circuit has come from space-based sensors. While the main structure was postulated early in the 20th century (Birkeland, 1908), direct observational evidence had to await the arrival of the space age, when magnetic sensors on polar orbiting satellites confirmed the presence of field-aligned currents that mediate the flow of energy between the magnetosphere and Earth's outer atmosphere. Figure 1a shows an early statistical map of the Region 1 and Region 2 Birkeland currents derived from 493 passes of the TRIAD

Corresponding Author: J. Brent Parham – jbparham@bu.edu
Publication History: Submitted – 08/17/18; Revision Accepted – 02/09/19; Published – 05/06/19