

25th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Generic Technologies for Nano/Pico Platforms (6B)

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DESIGN, DEVELOPMENT, TESTING AND ON-ORBIT PERFORMANCE RESULTS OF A
LOW-COST STORE-AND-FORWARD PAYLOAD ONBOARD A 1U CUBESAT CONSTELLATION
FOR REMOTE DATA COLLECTION APPLICATIONS**Abstract**

As one of the technology demonstration missions of the three-member 1U CubeSat constellation of the joint global multi-nation BIRDS-2 Project, the store-and-forward (S&F) mission aims to demonstrate the potential use of a 1U CubeSat constellation for collecting data from ground sensor terminals deployed in remote or isolated sites. The three CubeSats, which were built by a team of Bhutanese, Japanese, Malaysian and Filipino students who are enrolled in the space engineering course of the Kyushu Institute of Technology in Japan, are the first university CubeSats of Bhutan, Malaysia, and the Philippines. The BIRDS-2 CubeSat constellation collects various sensor data (water-level, humidity, temperature, soil moisture and magnetic field intensity) from experimental ground terminals deployed in respective home countries for glacial lake outburst flood monitoring, agricultural and scientific purposes. The collected data is downloaded through the BIRDS ground station network and then distributed to the end-users.

Although a 1U CubeSat constellation is an attractive platform for the said application – due to its substantially simpler design, lower cost, and faster development time – it also presents many technical challenges such as tight size, power, and communication link budgets. In this paper, first, we will discuss the design considerations and implementation of our onboard S&F payload. The said payload operates in the VHF amateur band and consists of mostly very low-cost commercial-of-the-shelf components: a deployable 50-cm monopole antenna fabricated in the laboratory, a half-duplex FM transceiver operating at 145 MHz band with transmit power of 0.5W (Radiometrix's BIM1H), an AX.25 KISS terminal node controller (Byonic's TT4), a PIC16F1788 microcontroller, and a 64-Mbyte flash memory (Cypress' S25FL512S). The payload collects data from ground sensor terminals at the rate of 1200 bps and the gathered data are downloaded to a BIRDS ground station through the CubeSat's UHF communication subsystem at the rate of 9600 bps. Then, we will present the investigation results on link budget analysis, as well as results from antenna radiation pattern and communication tests, antenna deployment tests, and space environment tests. Finally, we will present on-orbit performance results during the mission operation from July to September 2018, as well as lessons learned from the mission.