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A MOBILE COST-EFFECTIVE SATELLITE GROUND STATION TO RECEIVE WEATHER IMAGES IN REMOTE COMMUNITIES

Abstract

This paper outlines the design, verification, and validation of a satellite ground station developed to provide a cost-effective solution to receive weather images from the National Oceanic and Atmospheric Administration (NOAA) polar satellites. Operation in remote and isolated places such as First Nations communities within the northern territories of Canada is a primary design consideration. The ground station can receive and process Automatic Picture Transmission (APT) and High-Resolution Picture Transmission (HRPT) image formats. The ground station consists of four subsystems: Structure, Tracking, Radio Frequency (RF), and Digital Processing.

The Structure subsystem is a mobile and robust platform to host and protect other subsystems against harsh environments. This subsystem is designed in Onshape, an online design platform and built from Commercial Off-The-Shelf (COTS) and additive-manufactured parts. The Tracking subsystem steers the antennas in real-time using open-source software and COTS hardware. GPredict, an orbital prediction software,is used to send live satellite azimuth and elevation coordinates to an Arduino. The EasyComm II protocol and middleware Hamlib are implemented for interfacing between custom-written firmware on the Arduino and Gpredict. The firmware control loop converts the received coordinates into drive commands for azimuth and elevation stepper motors. The RF subsystem receives the satellite signals using in-house developed Yagi antennas, then amplifies the analog signals with COTS low noise amplifiers before passing them to software defined radios (SDR). The design and iterative optimization of the antennas is accomplished with EZNEC and AutoEZ programs. The Digital Processing subsystem sends SDR output signals to a laptop to demodulate, decode and save the weather images by employing open-source programs like SDR-Sharp and GNU Radio.

Verification tests are conducted on each assembled subsystem to evaluate its specifications, constraints, internal interfaces, and external interfaces. For instance, the RF subsystem is verified using a portable vector network analyzer and live satellite signals. Then, an iterative testing procedure is devised to validate the operation and performance of the fully integrated ground station against the satellite images published by Environment Canada. In each iteration, signal-to-noise ratio and image quality are quantitatively assessed, and the hardware and software are incrementally modified. The modifications improve the overall performance while minimizing the required resources for ground station installation and operation comprising of electrical power, operator input, implementation cost, and preparation time.