CanarySat: A Virtual CubeSat Model for Cybersecurity Research and Education

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Presented here is an overview of **CanarySat**, which is an open, virtual model of a cube satellite (CubeSat) and a satellite ground station. The goal of this project was to produce a high-fidelity, extensible modeling framework that will allow cybersecurity researchers and satellite designers to investigate cybersecurity solutions targeted specifically at CubeSats and other small satellite platforms. Unlike the typical desktop and server computer systems, space-based systems have significant limitations in terms of their computational resources, the available energy resources, and communication bandwidth. CanarySat facilitates evaluation of competing cybersecurity solutions based upon the effectiveness of the technique, the computational overhead, and the energy consumption.

To guide development of CanarySat, we have acquired the ISISpace CubeSat Development Platform, which is a flight-proven, cost-effective system which serves as the engineering model for training, development, and testing. Prior to selection of this cubesat platform, we performed a trade study which examined and compared the available commercial-off-the-shelf cubesat and ground station systems. The platform we selected includes the actual flight computer, electrical power system, communications system, and attitude control system as well as the ground station.

Our student researchers have constructed both a ***Satellite Power Scheduling Application*** and the **baseline CanarySat model.** The ***Satellite Power Scheduling Application*** is an application that allows satellite designers to estimate the energy requirements of their missions and explore trade-offs between performance and power consumption for different on-board computer systems. The application includes a database of performance and power consumption data that was collected via a sequence of experiments performed on representative single-board computers (SBCs).

The **baseline CanarySat model** includes an orbital physics model built within Simulink and the open-source COSMOS command and control software which serves as the satellite ground station. The orbital physics model is deployed on a representative single board computer, and the COSMOS ground station software executes on a desktop or laptop computer. Our student team demonstrated the ability to issue commands from the ground station and view the satellite attitude changing in the Simulink model. The students have also demonstrated successful operation of an image processing workload to simulate an earth observation mission.

We are currently engaged in the development of proof-of-concept cyberattacks against the CanarySat model to demonstrate the utility of CanarySat for cybersecurity research.