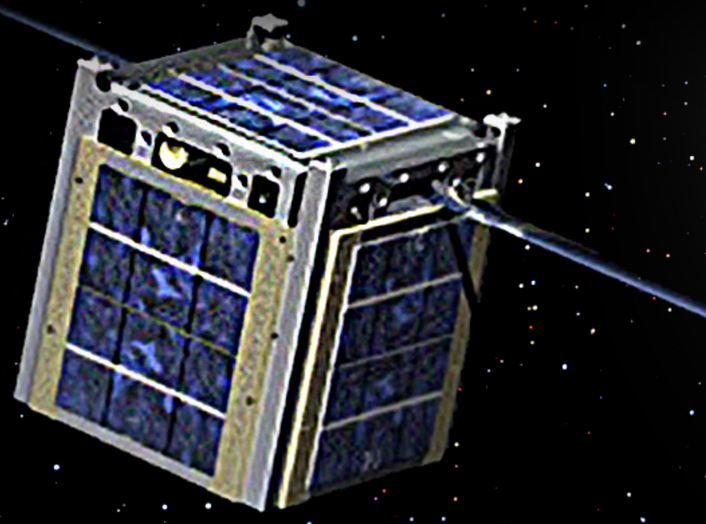
Vermont Technical College

CubeSat Flight Control Software

Project Description

We are designing the flight control software for a CubeSat Satellite that is scheduled to launch later this summer. The purpose of this CubeSat is to test our Spark/Ada implementation of GEONs and other high integrity software systems for a future mission where we will land a CubeSat on the moon.

GEONs is a software system developed by NASA, it provides onboard orbit determination and control in real time with a high level of accuracy and without human interaction. It also greatly improves the accuracy of GPS receiver point solution fixes. Implementing this software in Spark/Ada will help identify and correct any existing software bugs.



A CubeSat is a type of miniaturized satellite for space research that usually has a volume of exactly one liter (10 cm cube), has a mass of no more than 1.33 kilograms, and typically uses commercial off-the-shelf electronics components.

Spark/Ada

Why Use Ada?

- If the software fails, we would also lose the satellite
- Ada offers a greatly improved probability of error-free software when compared with C, which is used in most CubeSat projects.
- The development and debugging time would be less, which is helpful with our smaller resource base

Ada and SPARK

- Allows for a further increase in software reliability
- Allows for various conditions to be checked by static analysis
- The elimination of the run-time system for the CubeSat

AdaMagic

- There is no Ada compiler for the Texas Instruments MSP430 series of processors that we are using
- The AdaMagic compiler front end which produces ANSI C as the intermediate language allows us to do the projects in SPARK/Ada
- The C output from AdaMagic is then run through the Rowley Crossworks cross compiler to produce object code for the MSP430

Software Development Process

Software is written in SPARK/Ada using Adacore's GNAT Programming Studio (GPS)

Checked with the Praxis High Integrity Systems' SPARK Toolset from within GPS

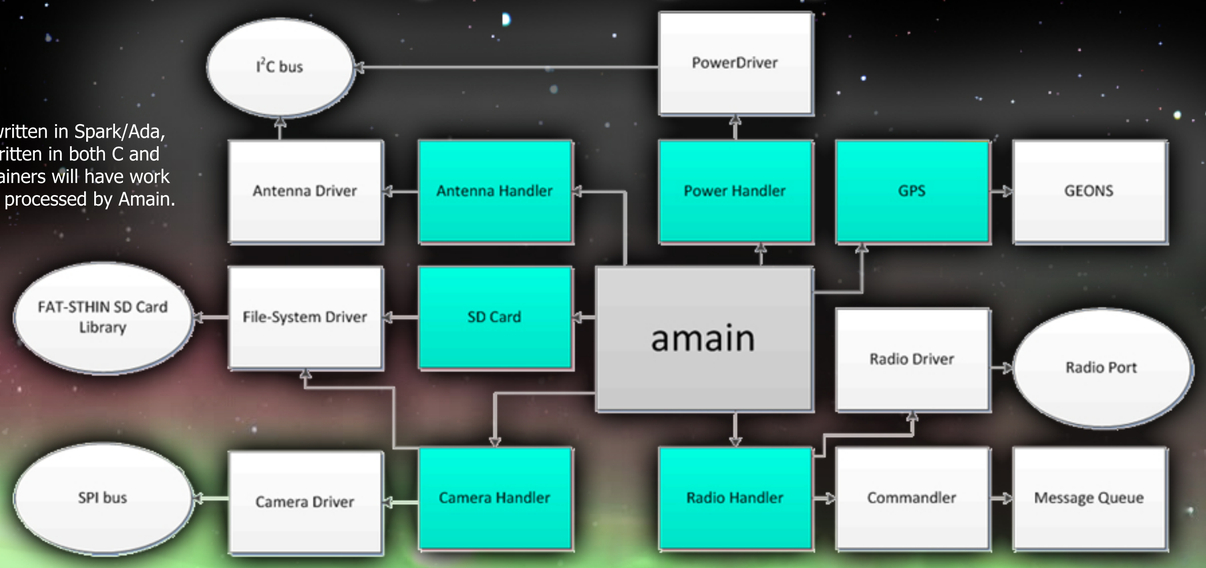
Compiled and checked with Adacore's GNAT Pro compiler

Sofcheck's AdaMagic compiler fron end is used to produce ANSI C as the intermediate code

Rowley's Crossworks C cross compiler for Texas Instruments' MSP430 CPU produces the object code

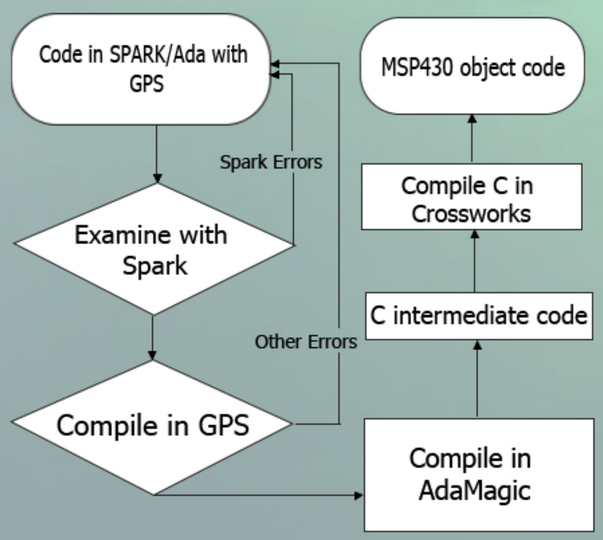
Pumpkin's Salvo RTOS is used as the operating system

System Design Diagram



*Square containers will be written in Spark/Ada, Circular containers will be written in both C and Spark/Ada and Orange containers will have work units that will be continually processed by Amain.

Software Development Process



System Design

Amain Initializes the subsystems and continuously loops, sending calls to each subsystem to process work units.

Radio Handler Enables communication to and from Earth ground stations. The program encodes transmitted packets and decodes received packets. Received packets will be sent over to be handled by the Commandler (Command Handler). The Commandler will then execute the commands or forward them to the message queue to be executed by other subsystem handlers.

Antenna Handler Deploys the antenna at an appropriate time. This subsystem also allows antenna deployment status to be queried Camera Handler Allows pictures to be obtained when requested.

GPS/GEONS Allows access to GPS data and interaction with the navigation program.

Power Handler Queries the status of the power supply.

SD Card Due to the limited memory resources of the spacecraft an SD Card subsystem shall be provided where large data sets can be stored in an external system.

Other Information

Radio telecommunications are provided by the Helium HE-100 radio running at a baud rate of 9600bps and using GMSK modulation. A subset of the AX.25 packet protocol is included in the default firmware.

Command and control along with file transfers are accomplished through the implementation of a custom protocol within the payload of the AX.25 packets. This protocol is similar to most selective repeat protocols.

The separate hardware and software sub-systems of the satellite are broken down into service handlers. Each service handler is given a work unit every iteration of the Super Loop, each can use this work unit to execute required procedures.

A medium resolution camera with on-board JPEG compression will take images of earth throughout our 7 year orbit. The images will be stored on SD card an then available to Ground Control via our file transfer protocol.

Machine vision software is being written to prioritize and rank captured images such that we can maximize our file transfers by only requesting worthwhile images.

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