

Title: Field Reprogrammable and Reusable Avionics Unit

Sponsor: NASA Johnson Space Center, Engineering Directorate, Avionics Systems Division

Personnel: 10-12 Comp/Electrical/Mechanical Engineers/Technology

Expected person-hours: 2500-3000

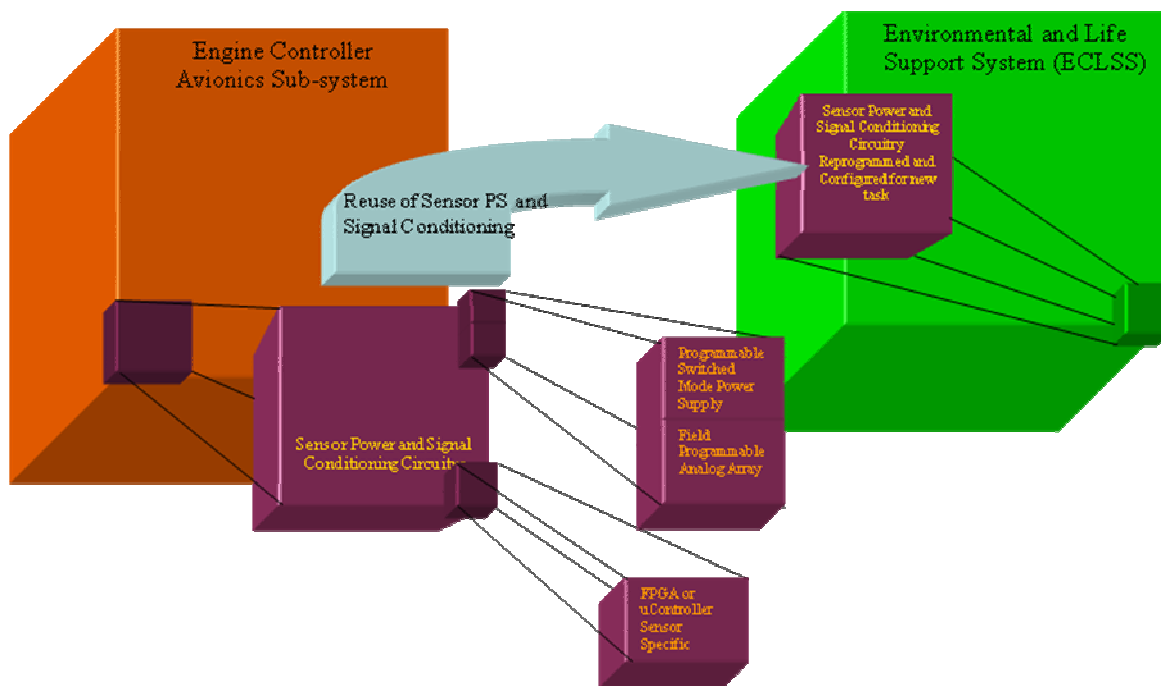
Deadline: Spring 2010

Project Overview and Motivation

One concept for future space flights is to construct building blocks for a wide variety of avionics systems. Once a unit has served its original purpose, it can be removed from the original vehicle and reused in a similar or dissimilar function, depending on the function blocks the unit contains. For example: Once a lunar lander has reached the moon's surface, an engine controller for the Lunar Decent Module would be removed and used for a lunar rover motor control unit or for a Environmental Control Unit for a Lunar Hab.

This project will include the investigation of a wide range of functions of space vehicles and possible uses. Specifically, this includes:

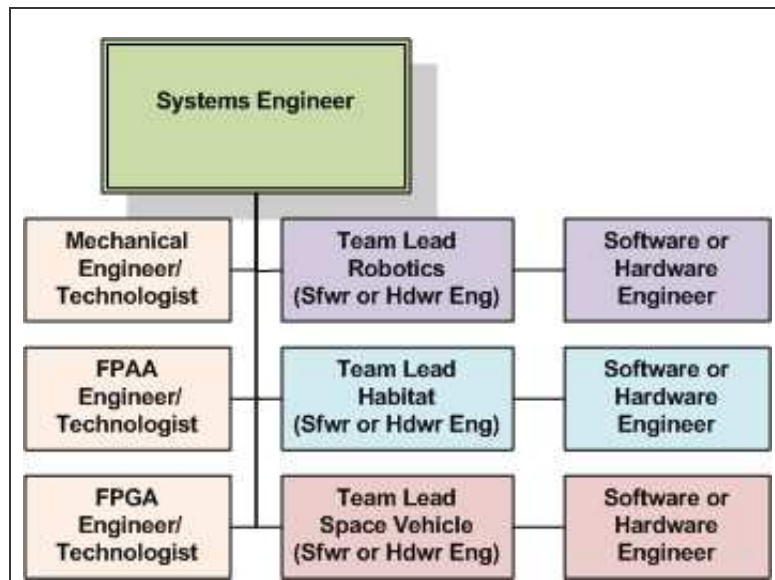
- Determining and specifying the basic functioning blocks of space vehicles.
- Building and demonstrating a concept model.
- Showing high reliability is maintained.



Example of Sensor Sub-element of Engine Controller Avionics package, note the sensor sub-element may be further divided into fundamental functioning blocks

The specific implementation of this project will require a large project team made up of Systems, Electrical, Computer, and Mechanical Engineers/Technologists. The efforts are made up of several sub-groups that each work on a part of the entire project.

FPGA = Field Programmable Gate Array, FPAA = Field Programmable Analog Array



General support (4): Systems Engineering, FPGA Engineer/Technologist, FPAA Engineer/Technologist, Mechanical Engineer/Technologist

Project 1 (2-3): Robotic Sensing, Control, and Communications

Project 2 (2-3): Lunar Habitat Sensing, Control, and Communications

Project 3 (2-3): Space Vehicle Sensing, Control, and Communications

Project Benefits

This is one of the most complex projects offered by the senior design program. Students working on this project will be given the experience of working on a typical industry effort, with respect to size and scope. The Faculty Advisor, Dr. Conrad, will work closely with all team members to ensure success. Students who participate in this project will also be co-authors on several technical papers which will be written to describe the effort and results. This effort will truly be a bright spot on anyone's resume.

Students working on this project will have the opportunity to work at NASA's Johnson Space Center as an intern in the summer of 2010. Interested students will need to apply for the internship in the fall of 2009. Summer employment is not guaranteed, but working on this project will provide proof of a strong commitment to NASA's goals.

Expectations of Students

It is expected that any skills not yet learned but required for the job will be either taken as a course during the first semester of this project, or will be learned on the students own time. In any case, the student must have a "Practitioner" level of knowledge by December.

The entire project team will meet once a week to report progress. Other one-on-one meetings will be needed to discuss and work on technical matters. Students are encouraged to seek assistance if technology poses a specific problem. Nonetheless, this is NOT a project for

students who expect to coast during their project. You will work, but not for excessive amounts of time. It is expected that student effort will be consistent during the semesters and not with a large peak at the end of the semesters.

Job Descriptions

Each position below lists certain skills needed for the project. Please indicate which position interests you in your cover letter. Make sure you address your skills and how they map to the requirements below.

Systems Engineer (1): This position requires a solid background in multiple disciplines, i.e. computer, software, electrical, and mechanical engineering or technology. This person will be responsible for ensuring that the project not only stays on track but also remains technically sound. As a result, this person will need to have a working understanding of all of the technologies in the project (of at least an "apprentice" rating). While this person will not necessarily be writing code, designing circuits, or drawing mechanical parts, they should understand the underlying technologies. This person will also have excellent leadership and organizational skills. This is especially suited for a mature student with previous work experience.

FPGA Engineer/Technologist (1): This position requires a solid background in developing electronic systems using skills learned as a junior, including analog and digital circuits. This person must also have additional knowledge of computer architecture and hardware. Knowledge of VHDL/Verilog and the Xilinx tool set is required. This person will help in the selection of an off-the-shelf FPGA development board and will be responsible for creating the programming and test fixture interfaces. This person will also assist the hardware engineers in the project sub-teams.

FPAA/Analog Processor Engineer/Technologist (1): This position requires a solid background in developing electronic systems using skills learned as a junior, including analog and digital circuits. This person must also have additional knowledge of analog-to-digital and digital-to-analog conversion hardware. Knowledge of VHDL/Verilog and the Xilinx tool set is required. This person will help in the selection of an off-the-shelf FPAA development board and will be responsible for creating the programming and test fixture interfaces. This person will also assist the hardware engineers in the project sub-teams.

Mechanical Engineer/Technologist (1): This position requires a solid background of the design of mechanical enclosures, cabling, and air-handling equipment for the electronics industry. This person will create the enclosures for all three of the subprojects and will ensure that, mechanically, the main processor boards can be easily removed and inserted into each of the projects. This person will also work with the FPGA and FPAA positions to build the test

fixture and cabling needed for the sub-projects. They will also help with the robotic vehicle and other sub-projects that need mechanical assistance.

Software Engineer (3): This position requires a solid background in embedded systems and software development. The person in this position is expected to know the C programming language and basic computer architecture. Knowledge of Linux and VHDL is helpful but not necessary. This person will program the microprocessors to use the hardware developed by team members.

Hardware Engineer (3): This position requires a solid background in developing electronic systems using skills learned as a junior, including analog and digital circuits. This person must also have additional novice knowledge of analog-to-digital and digital-to-analog conversion and computer hardware. Knowledge of VHDL/Verilog and the Xilinx tool set is required. This person will program the FPGA and FPAA boards, with the help of the FPGA/FPAA support Engineer/Technologist. They will also build any other hardware needed

Other skills, helpful but not required, are:

- Linux and Linux tools
- Communications hardware/software like RS-232, USB, CAN, Wi-Fi, ZigBee/802.15.4, Bluetooth
- Robotics and motor control (or plan to enroll in the Introduction to Robotics course in the spring of 2010).

Project Requirements

The project has four subprojects. The main objective is to demonstrate that the same FPGA and FPAA board can be moved between three different systems. Each of the Systems will have some basic functionality, i.e. the Robotic Vehicle will move in its environment and avoid obstacles. There are four deliverable products from this project:

1. A robotic vehicle that uses the common FPGA and FPAA boards
2. A simulated lunar habitat that uses the common FPGA and FPAA boards
3. A simulated space vehicle that uses the common FPGA and FPAA boards
4. A programming and test fixture for the FPGA and FPAA boards

General Requirements

All projects will use the same FPGA and FPAA board. All systems will be based on the Linux Operating System.

Robotic Vehicle Requirements

This vehicle can be either a small electric (0.75 by 0.60 meters) vehicle or an All Terrain Vehicle, both of which are available from Dr. Conrad's lab for use by the team. This vehicle will

need to be controlled by the avionics (FPGA, FPAA, and other added electronics and cabling).

This device should also demonstrate the ability to:

- Communicate via 802.15.4 or 802.15.4/ZigBee
- Communicate via Ethernet (on the bench)
- Communicate via USB (on the bench)
- Communicate via CAN bus
- Sense its environment with Ultrasound, compass, accelerometer, and gyroscope (Inertial Measurement Unit)
- Sense its environment (temperature, humidity, light).
- Sense the battery temperature and voltage during charging and operation.
- Report on the vehicle's status via wireless messages every 10 seconds.
- Perform a movement and sensing mission (i.e. move in a 100 meter by 100 meter square).

Lunar Habitat Requirements

This "habitat" will need to be controlled by the avionics (FPGA, FPAA, and other added electronics and cabling). This device should also demonstrate the ability to:

- Communicate via 802.15.4 or 802.15.4/ZigBee
- Communicate via Ethernet (on the bench)
- Communicate via USB (on the bench)
- Communicate via CAN bus
- Sense its environment (temperature, humidity, light).
- Sense the battery temperature and voltage during charging and operation.
- Report on the habitat's status via wireless messages every 10 seconds.
- Maintain a constant temperature in the "habitat" by controlling air flow (fan) and a heater.
- Control LED-based lighting in the "habitat" based on times programmed by the user and motion.
- Charge batteries using a solar collector.
- Provide a touch screen-based display to show this same status and allow the user to change the temperature via the touch screen

Space Vehicle Requirements

This "vehicle" will need to be controlled by the avionics (FPGA, FPAA, and other added electronics and cabling). This device should also demonstrate the ability to:

- Communicate via 802.15.4 or 802.15.4/ZigBee
- Communicate via Ethernet (on the bench)
- Communicate via USB (on the bench)
- Communicate via CAN bus

- Sense its environment with Ultrasound, compass, accelerometer, and gyroscope (Inertial Measurement Unit)
- Sense its environment (temperature, humidity, light).
- Sense the battery temperature and voltage during charging and operation.
- Report on the vehicle's status via wireless messages every 10 seconds.
- Perform a movement and sensing mission (i.e. open a valve to maintain its position above the moon's surface).

Programmer/Test Fixture Requirements

This fixture will need to program and test the avionics (FPGA, FPAA). This device should also demonstrate the ability to:

- Communicate via Ethernet
- Communicate via USB
- Communicate via CAN bus