FAMU-FSU College of Engineering
Department of Electrical and Computer Engineering

PROJECT PROPOSAL AND STATEMENT OF WORK

EEL4911C – ECE Senior Design Project I

Project title: SAE Baja Data Acquisition System
Team #: 5

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Project Executive Summary

The Society of Automotive Engineers encourages college students worldwide to apply classroom knowledge to real world design concepts through their annual competitions. SAE International hosts five categories of competition that include Aero, Clean Snowmobile, Formula, Baja, and Supermileage. The SAE team at the FAMU-FSU College of Engineering actively participates in the Baja competition each year and subsequently builds upon their designs from previous competitions for vehicle improvement.

Previously, the SAE Baja Team has made changes to the vehicle based on estimates of the performance of the vehicle. This year, Team E#5 will add a quantitative approach to the Baja design process by adding a data acquisition system (DAQ). The DAQ will record values from various vehicle systems and will be stored for later use. DAQ subsystems will include measurement for fuel, speed, acceleration, tire pressure, and suspension travel. In addition to recording and storing data, the DAQ system will include a communication component to help the team during competition. The communication component will have a signal going from the driver to the pit crew to alert the pit crew of low fuel or low tire pressure. This will allow the pit crew to prepare for the driver and decrease the time it takes for the vehicle to get back on the track.

The system will need to follow the competition design rules outlined by SAE International as well as hold up against the rough terrain of a Baja competition track. The system will be finished by the April 9th competition date in Auburn, Alabama and will stay within the $600 budget.

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Introduction

1.1 Acknowledgements

The SAE Baja DAQ design team would like to acknowledge our head advisor Dr. Frank for any advice, input and ideas offered on how to proceed during the design phase of the DAQ. The team would like to acknowledge the FAMU-FSU Society of Automotive Engineers for any sponsorship and advice they may provide and including this design team in this year's Baja car. The team would also like to thank Arrigo Dodge of South Florida for their contribution of four tire pressure monitoring system sensors to the Baja DAQ team. Finally, the team would also like to thank the FAMU-FSU Electrical and Computer Engineering department for their financial contributions towards the project.

1.2 Problem Statement

The acquisition of data can be a very important part of efficiently optimizing designs of many kinds, especially those involving mechanical systems such as automobiles, provided that the data collected is used in an appropriate manner. The design team aims to design and implement a Data Acquisition System (or DAQ) that will collect and store important data and ultimately make the FAMU-FSU Baja team's vehicle more successful in this year's competition.

In previous competitions, the SAE Baja team had little quantitative information to use when making changes to the vehicle. For example, refueling was done on a whim, determined only by how long the vehicle had been driving. In almost every case, the vehicle did not actually need refueling, wasting precious race time during the endurance portion of the competition. The DAQ will inform the SAE Baja team of the proper changes and procedures needed to improve the vehicle mid-race, allowing them to focus less on problem identification and more on problem solving. The DAQ will tell the driver and the pit crew when a fuel change is needed, when a tire change is needed and when a suspension adjustment is needed, as well as any other information the team may find helpful--all remotely and in real time.

1.3 Operating Environment

The Baja vehicle to which the DAQ will be mounted will be driven on rough terrain in a harsh outdoor environment during competition. The system will potentially be subject to shock and vibration due to the rough terrain, rain, dust, dirt, mud, rocks, heat (both due to weather and ambient engine heat) and RF interference from other similar systems on opposing vehicles. The system will need to withstand temperatures up to at least 120 degrees Fahrenheit. In designing the system, the team will make considerations for the inclement conditions which the system may face during the SAE Baja competition.

1.4 Intended User(s) and Intended Use(s)

1.4.1 Intended User(s)

The intended users of the DAQ are the members of the FAMU-FSU SAE Baja team. As all members of the SAE Baja team must be at least 18 years of age (for liability reasons), any and all users of the DAQ must also be at least 18 years of age. Any user of the DAQ must also be adequately trained in the use of the system. One of the important attributes of the system, as outlined in the Needs Analysis and Requirements Specifications, was usability. This means that the system will be easy to use so that the Baja team can focus on the competition as opposed to the DAQ operation. Thus, just about any engineer on the Baja team will able to use the DAQ. Only DAQ team members should exchange or modify the hardware components of the system itself.

1.4.2 Intended Use(s)

The DAQ is designed to be used by the Baja team members to evaluate various data points about the vehicle and make changes based on the data collected. To begin using the DAQ, the Baja team will have to simply turn the system on and begin running it (the procedure to run the DAQ is TBD based on the design). Once powered on and instantiated, the DAQ will begin collecting and displaying data to the users. The received data will be written to a storage device so that the Baja team can analyze it after testing or competition. During the competition, the Baja team will be able to use this data to make adjustments to the vehicle as needed. Ultimately, it is up to the Baja team to determine what is to be done with the collected and displayed data.

1.5 Assumptions and Limitations

1.5.1 Assumptions

- All components used in the design of the DAQ will be chosen such that their specifications meet or exceed the requirements of the system.
    - The wireless data transmission module(s) will exceed a range of 3 miles urban.
    - The main power source and the subsystem power sources will be chosen such that they allow at minimum 8 hours of system operation.
    - The storage medium will be large enough to accommodate all collected data
        - It is estimated that 1 GB will be more than enough to accomplish this
        - 40 bytes per line * 18000 seconds (5 hours) * 1 Hz = 720KB

- The main MCU will have enough I/O pins to be able to interface with every subsystem of the DAQ.
- The main MCU will be mounted inside of a protective enclosure to shield it from the competition conditions.
- The end product will only be used on the Baja vehicle.
- The system will be subject to inclement conditions outlined above in **Section 1.3 - Operating Environment**

1.5.2 Limitations

- The DAQ will be limited in some ways by the Baja competition rules.
    - The engine of the vehicle cannot be modified in any way.
    - The DAQ must use its own power source separate from the Baja vehicle's power source.
    - The system cannot interfere with any essential vehicle systems.
- The system shall be designed within an initial budget of $600.
- The system shall be able to withstand temperatures up to 120 degrees Fahrenheit.
- The display shall be easily readable by the driver of the vehicle.

1.6 Expected End Product and Other Deliverables

Before April 9th, 2014, the team will deliver a data acquisition system to the SAE Baja team. This system will collect, use, and display important data about the Baja vehicle to the team during the SAE Baja competition. This data includes fuel levels, suspension travel, acceleration, speed and tire pressure. This data will be written to removable media so that the Baja team can import it to a computer and analyze it as they see fit. The system will consist of two sections, the collection system mounted other vehicle (outlined in section 1.6.1), and the pit station where a readout of the collected data will be given to the pit crew (outlined in 1.6.2).

The Baja team will also be provided with a copy of each deliverable report upon completion, so that they may stay up to date on the development of the DAQ. The Baja team will also receive schematics of the system, top-level block diagrams, and data sheets and information about each component used. Additionally, they will be given a copy of all source code used in development of the project, so that future Baja teams may learn and improve on the design further.

The end product will be a standalone data acquisition that will collect data about the following subsystems:

- Fuel
- Suspension
- Acceleration
- Speed

- Tire Pressure

The data will be logged onto a removable memory host that can stored for later use.

In addition, there will be a signal traveling from the driver to the pit crew alerting the pit crew of low fuel and tire pressure allowing the pit crew to prepare for the drivers return.

There will also be a display of the car's subsystem status on the vehicle for driver awareness.

1.6.1 On-vehicle Data Collection

The actual data acquisition system itself will be mounted to the vehicle. The unit will collect data about the vehicle from several sensors, store that data to a removable media device in a CSV file, and display some of that data to the driver and the pit crew. The vehicle will also have indicator lights that will warn the driver of low fuel or tire pressure. The unit will consist of the following:

- 1 - Hercules LAUNCHXL-TMS57004
- 9 - MSP430G2332IN30 Microcontrollers
- 2 - US1881 Hall effect sensors
- 1 - Forman 911-008 fuel sender
- 4 - Schrader 20398 TPMS Sensors
- 4 - TPMS Sensor readers (TBD based on modulation type)
- 1 - ADXL335 accelerometer
- 1 - Xbee-PRO 900HP wireless transceiver
- 2 - $LiFePO_4$
- 1 - High-gain Dipole Antenna
- 2 - Indicator lights
    - One for fuel, one for tire pressure
- 1 - SD card module

1.6.1 Pit Unit

The pit unit will include a display for the collected information as well as mirrored indicator lights that warn the pit when the vehicle requires fuel or tire pressure. This unit will include the following items:

- 1 - Raspberry Pi (B)
- 1 - Xbee-PRO 900HP wireless transceiver
- 1 - Display
- Fuel and tire pressure indicator lights

1.6.2 Deliverable Reports

During the designing of the system, the DAQ team will fulfill several milestones, three of which occur in the Fall 2014 semester. The SAE Baja team will be provided with copies of each deliverable report as they are completed. This is to ensure that the Baja team is satisfied with the progress of the DAQ and all of its components, and to ensure that the system fulfills the needs set forth by the team. The SAE Baja team will receive electronic copies of the following:

- Needs Analysis and Requirements Specifications (Completed Friday, October 17th)
- Project Proposal and Statement of Work (This document)
- System-Level Design Review (Due November 13th, 2014)

The SAE Baja team will also be provided with any other deliverable reports due in the Spring semester of 2015.

1.6.3 Documentation and Configuration Files

Along with the actual system itself, the Baja team will be provided with documentation about the implementation of the system. This includes a top-level block diagram, information about each component, and all source code for the project. Those items are outlined below.

1.6.3.1 Top-Level Block Diagram

The top-level block diagram of the system will provide the Baja team with an idea of how the system is laid out at a glance. This diagram will show each different DAQ components and illustrate how they interface with each other. The diagram will be stored as a PDF to allow for portability between platforms. This will also allow the Baja team to make comments on the document to share amongst themselves.

1.6.3.2 Component Information

The Baja team will also be provided with information about each component used in the system. For each component used in the DAQ, the Baja team will receive:

- Datasheet
- Part number
- Information about how the part is interfaced with the overall system

This information will allow this the current and future Baja teams to easily find and replace any failed components with the same components or components with similar specifications. In the event that future teams with to improve on the DAQ design, they will be able to choose new components that will be compatible with the rest of the system.

1.6.3.3 Source Code
All of the source code used to implement the system will be given to the SAE Baja team. This will allow future members of the SAE Baja team to learn from the DAQ team's implementation of the system and improve on the design further. The files will be added to a *.zip or *.rar archive and given to the team with all of the other deliverables.

2 Concept Generation

2.1 Sensor Network/Data Bus
In order to collect sensor data as easily as possible, a data bus will be used to connect the sensors to the vehicle's main MCU. The use of such a bus allows all sensors to be connected to only a few pins, freeing up GPIO for use with other peripherals. There are a handful of widely used standards that can be used to achieve this.

2.1.1 I^2C (Inter-Integrated Circuit)
I2C is a half-duplex synchronous serial data interface. Often referred to as "TWI" or "Two Wire Interface", it uses only 2 pins to communicate with up to 112 slave devices.

2.1.1.1 Benefits
- Only 2 pins needed
- Native slave addressing
- Commonly supported in MCUs and peripheral devices

2.1.1.2 Drawbacks
- Only half duplex (requires pins to be used bidirectionally)
- Proprietary address space
- Slow

2.1.2 SPI (Serial Peripheral Interface)
SPI is a full duplex synchronous serial data interface. It uses multiple pins to address a theoretically infinite number of devices on a single bus. Most commonly found in 3-wire (single slave) or 4-wire (multiple slave) implementations, its use of a slave-specific chip select line eliminates the need for address overhead in data transmissions.

2.1.2.1 Benefits
- Reduced data overhead
- Full duplex
- Commonly supported in MCUs and peripheral devices

2.1.2.2 Drawbacks

- Can require many pins (or the addition of a shift register) for chip selects
  - Slaves can be custom programmed to add addressing if needed

2.1.3 CANBUS

CANBUS is an industry standard CAN protocol used in a wide range of production vehicle. It allows the various subsystems of the vehicle to communicate on a common line and allows a passive listening device to record and analyze the passing data for errors or troubleshooting.

2.1.3.1 Benefits

- Built in device addressing
- Network based - any device can send packets to any other device
- Very fast
- Industry standard

2.1.3.2 Drawbacks

- Specialized silicon required on every node to interface to the bus
- No master/slave relation - does not fit with design paradigm
- Packet formatting adds significant overhead
- Requires balanced twisted pair data lines

2.1.4 Sensor Network/Data Bus Selection

The team has decided that CANBUS, the automobile industry standard for subsystem communication, is too costly to implement and is frankly overkill for this project. The team also decided that having full duplex operation was important, and so the I^2C bus was removed as an option. Despite its drawbacks (namely the use of slave select lines), the team chose to use an SPI bus because it offers high throughput with low overhead. It is also supported on a wide range of devices which will make it easier to implement in software.

2.2 Processing

2.2.1 Central Vehicle Microcontroller

The center of the Data Acquisition, the main controller unit will collect and process data from the sensors. The MCU will also be responsible for establishing communication between the driver and the team as well as sending data for display on a screen for the driver. As the central intelligence to the DAQ, there were several criteria to be considered for choosing the MCU.

- Processor Speed - It is important that the data collected paints an accurate picture of the vehicle's status. Missing a piece of data put the DAQ at risk of giving incorrect values. For example skipping a rotation due to slower task completion for the previous rotation could throw the entire speed calculation off. Having a faster processor will complete tasks at a quicker pace so that data collection is not missed due to slow processing.

- Memory - The MCU will need to have enough memory to hold the programs and a drivers written for the accessories. Most microcontrollers work on a flash memory write system so the team will be looking for the amount of flash memory in the microcontroller specifications.

- I/O Pins - Since data is being collected externally, it is important that the MCU provides a means of retrieving this data. The team has determined that 20 digital input pins would be enough to be able to interface the sensors and any hardware accessories (i.e. SD card slot that may need to be added).

- USB Compatibility - There are many MCU development boards on the market with the cheapest ones being very basic. The MCU chosen will need to have a USB port for user interaction. This will allow the team to immediately begin accessing the board and uploading code for development.

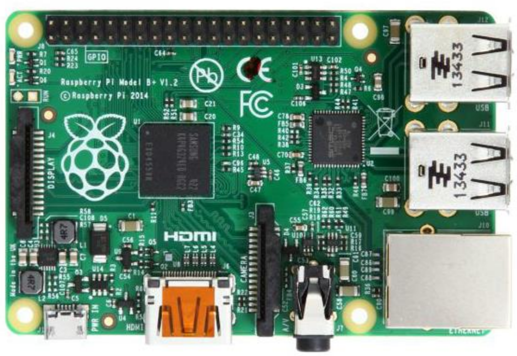
- Development Support - With the time constraint placed on the project, the team will need access to resources for hardware support. With a larger community of users there is more help available with MCU troubleshooting. This allows the team to quickly solve development problems and move forward.

With these criteria in mind, the following boards were chosen for comparison.

2.2.1.1 Raspberry Pi

The raspberry pi is a powerful development board designed to be a portable computer. The applicable specifications are as follows:

- CPU: 700 MHz ARM1176JZF-S core (ARM11 family)
- Memory RAM: 512 MB
- Video outputs: Composite RCA, HDMI
- Audio outputs: 3.5 mm jack, HDMI
- Onboard storage: SD, MMC, SDIO card slot
- Storage via SD/ MMC/ SDIO card slot
- 2 USB ports
- Power: 1mA at 5V



2.2.1.1.1 Benefits

- Very Fast

- Built in SD card slot
- Built in USB Ports

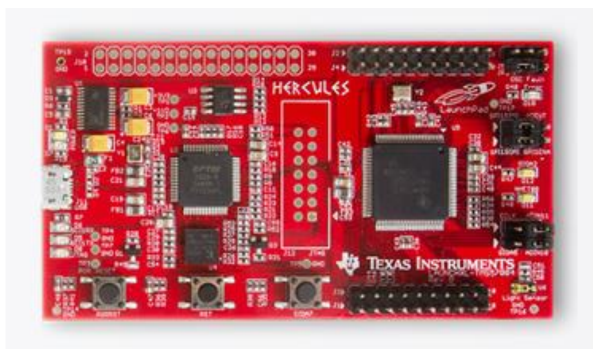
2.2.1.1.2 Drawbacks

- Consumes a significant amount of power
- Optimized for video and audio media
- Not many hardware accessories available

2.2.1.2 Hercules LAUNCHXL-TMS57004

This board made from Texas Instruments was designed with automotive applications in mind. It has the following features

- 32-bit ARM Cortex-R4 CPUs running in lock-step
- 80MHz operating frequency
- 384kB Flash with ECC
- 32kB RAM with ECC
- 16ch 12-bit multi-buffered ADC
- 19 pin programmable High-End Timer (N2HET)
- Multi-buffered SPI
- LIN/SCI (UART)
- Pulse Module
- Up to 45 GPIO pins



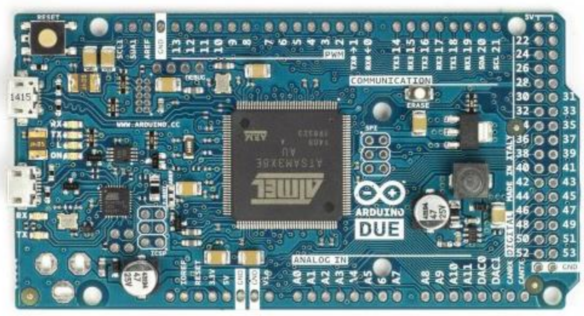
2.2.1.2.2 Benefits

- Large amount of flash memory
- SPI compatible
- More than enough GPIO pins
- Unique lock-step feature
- Low price

2.2.1.2.3 Drawbacks

- Does not have many plug and play accessories
- Support forums are developing

2.2.1.3 Arduino DUE



This popular hobbyist board has a large community of enthusiast for a wide variety of projects. The board contains:

- ARM Cortex-M3 CPU
- 84Mhz operating frequency
- Operating Voltage : 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins: 54 (12 that support PWM)
- Analog Input Pins: 12
- Flash Memory: 512KB

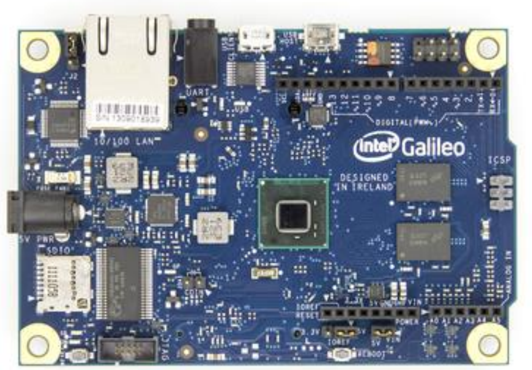
2.2.1.3.1 Benefits

- Many digital input pins
- Arduino community
- Many shields available
- Low operating voltage

2.2.1.3.2 Drawbacks

- Uses nonstandard programming language

2.2.1.4 Intel Galileo



- 400MHz 32-bit Intel® Pentium instruction set architecture (ISA)-compatible processor
- An integrated Real Time Clock (RTC.
- USB 2.0 Host connector
- Support up to 128 USB end point devices
- USB Client connector
- 8 MByte Legacy SPI Flash
- Between 256 KByte and 512 KByte dedicated for sketch storage.
- micro SD card with 32GByte of storage

2.2.1.4.1 Benefits

- Extremely fast operating frequency
- On-board SD storage
- 8MB Flash

2.2.1.4.2 Drawbacks

- Cost (6$5.25)

2.2.1.5 MCU Selection

The decision for this component was a difficult one. Each board had its own strengths that would have benefitted the DAQ system greatly. Ultimately, the board chosen for the MCU was the Hercules model. This board was designed with automotive applications in mind and while it is not the most powerful board of the options, it is the most applicable to the project.

2.2.1.6 Pit Crew Controller Selection

While the decision for the MCU was a difficult one, the pit crew controller was more clearly defined. The team has decided to use the Raspberry Pi for the pit crew controller. The Raspberry Pi's optimization for media has made this controller the most applicable to the tasks required of the pit crew controller.

2.2.2 Sensor Microcontrollers

Since the team has decided on using digital interfacing, namely SPI, the team decided it best to use low-cost microcontrollers in order to convert the sensor readings--which are analog outputs--into digital signals. These MCUs will also be used to offload some of the calculations from the central MCU so that it may efficiently control the overall system. For example, the sensor MCU that converts the Hall effect sensor input from analog to digital will also convert the speed to miles per hour and send that value directly to the main MCU, so that it can be quickly displayed and written to the removable media. Several criteria were used to determine which MCU to use for this task.

2.2.2.1 Atmel ATtiny85

The ATtiny85 is a very small 8-pin AVR microcontroller made by Atmel. The device is a full-featured, high-performance, low-power MCU. Some general specs include:

- 8-bit word length
- 8KB ISP Flash memory
- 512B EEPROM
- 6 GPIO pins

- 20 MHz maximum operating frequency
- 4-channel 10-bit A/D converter

2.2.2.1.1 Benefits

- Small form factor
- Low cost - Starting at $0.73/unit
- 20 MIPS at 20MHz
- 8KB Flash memory
- On-board A/D convertor
- Low power consumption
- Internal oscillator

2.2.2.1.2 Drawbacks

- Only supports USI interfacing
  - SPI or I^2C must be implemented in software
- Small 8-bit word size

2.2.2.2 Texas Instruments MSP430F5132

The MSP430 line of mixed-signal MCUs are low-cost, low-power MCUs built around a 16-bit CPU. This MCU in particular is full-featured and supports many communication interfaces. Some specifications include

- 16-bit word length
- Active power consumption: 180 uA/MHz
- 32x32 multiplier
- Three 16-bit timers
- Supports Universal Serial Communication Interfaces
  - UART, IrDA, Synchronous SPI, I2C.
- 10-bit 200-ksps A/D converter
- 40-pin packages

2.2.2.2.1 Benefits

- Onboard A/D converter
- 25 MHz maximum operating speed
- 8KB Flash memory
- Internal oscillator

2.2.2.2.2 Drawbacks

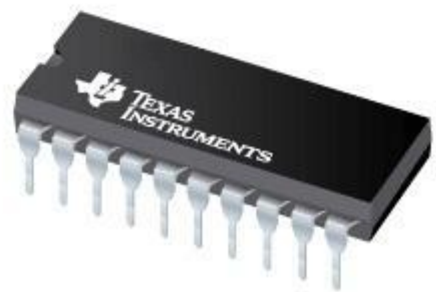
- Surface mount - cannot be done at FAMU-FSU CoE
- Far more pins than necessary

- Price - $3.35 per unit

2.2.2.3 Texas Instruments MSP430G2332IN20

This particular MCU is again based off of the MSP430 CPU but comes in a smaller form factor with far fewer wasted features as opposed to the MSP430F5132. Some general specifications include

- 16-bit CPU
- 16 MHz operating speed
- 16 I/O pins
- 4KB flash memory
- 256 x 8 RAM
- 20-DIP package
- On-board 10-bit A/D converter



2.2.2.3.1 Benefits

- Through-hole mounting
- On-board 10-bit A/D converter
- Cost: $1.86 per unit
- 4KB flash memory
- Internal oscillator

2.2.2.3.2 Drawbacks

- 20 pin - more than necessary

2.2.2.4 Sensor Microcontroller Selection

In choosing a sensor microcontroller, the team heavily considered the mounting options available with each microcontroller as well as the number of excess pins. The team plans to buy discrete MCU ICs and mount them to PCBs made in-house at the FAMU-FSU College of Engineering. The College of Engineering PCB milling facility does not have reliable surface-mounting capabilities, so through-hole designs are needed to reduce fabrication cost.

The ATtiny85, with its through-hole mounting and small amount of pins, was considered by the team to be the best option. However, the fact that the MCU does not natively support SPI ultimately led the team to decide against it.

The MSP430F5132 seemed to be a good option, however the fact that it is not available with through-hole mounting made it infeasible to use for every sensor. Additionally, the chip’s 40 pins were far too many for the application.

The team has decided to use the MSP430G2332IN20 as the microcontroller for each sensor in the system. The MCU comes in a 20-DIP package, so an in-house PCB for the controller is feasible. The controller does have an excess of pins, however it is not a significant amount and can be overlooked. The controller natively supports SPI, which was a must for the team. Ultimately this controller provides the best performance for the price, and adequately fills its intended role.

2.3 Data Logging

2.3.1 File Types

The team has considered some different file types to be used for storing the logged data. The file type can affect how the logged data files behave with regard to how they are written and how they are used by the Baja team. Since only text will be written to the files, the file sizes will be very similar if not the same. Thus, size will not be a concern when comparing the file types. It is unlikely that the DAQ will require a significant amount of storage space (>1 GB).

2.3.1.1 .txt

A pure text file. These files have no limit as to what kind of characters can be written in them. Additionally, they have no restrictions on the formatting of the text entered in the file.

2.3.1.1.1 Benefits

- Readable by humans if formatted correctly
- Can write any type of character to them
- No formatting restrictions

2.3.1.1.2 Drawbacks

- Not parsable by software
- Formatting must be heavily controlled by writing software

2.3.1.2 .csv

A csv file is a file of “comma separated values” (hence the name .csv), or sometimes “character separated values,” since the character does not necessarily need to be a comma. A .csv file stores tabular data in a plain-text form.

2.3.1.2.1 Benefits

- Easy to write as the formatting is standard and simple
- Parsable by many pieces of software (most importantly excel)

2.3.1.2.2 Drawbacks

- Not easily readable by humans

2.3.1.3 File Type Selection

The team has decided to write the sensor data to a .csv file. The format of a .csv file is standard and easy to write. Very little formatting has to be done by the MCU. The most important attribute is the ability of several software suites to parse .csv files, namely Microsoft Excel. When the Baja team wishes to view the data collected by the DAQ, all they have to do is open the .csv file in Excel and all of the data will be presented to the Baja team in a table.

2.3.2 Storage Medium

In order to store the data being collected, there are two different storage mediums being considered by the team, Universal Serial Bus Mass Storage (USB flash drive) and Secure Digital (SD).

2.3.2.1 USB Mass Storage

The team are considering the use of a USB flash drive in order to store the data collected by the DAQ. A USB flash drive has (among other things) 4 important attributes:

1. USB Standard Male plug
2. USB mass storage controller device
3. Flash memory chip
4. Crystal oscillator

A USB flash drive essentially has a microcontroller on board which controls the reading and writing of data to and from the drive. The crystal oscillator provides an onboard clock for the drive's microcontroller and the memory, eliminating the need for an external clock.

2.3.2.1.1 Benefits

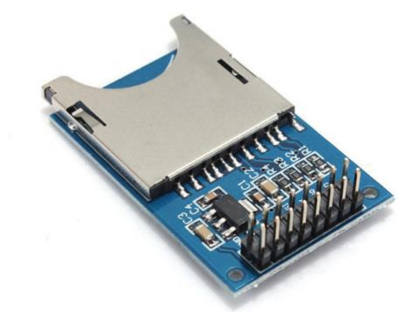
- Used drives can be obtained through FSU for cents

- Onboard microcontroller to control reading and writing
- Uses fewer microcontroller pins
- Internal clock
- Can be used in any modern computer to retrieve data

2.3.2.1.2 Drawbacks

- Requires a separate host controller
  - More costly to implement
- Longer flash drives could break from stress
- Longer flash drives could fall out easily
- Write speed can vary widely between systems
- Data is easily corrupted by removing power during reads or writes

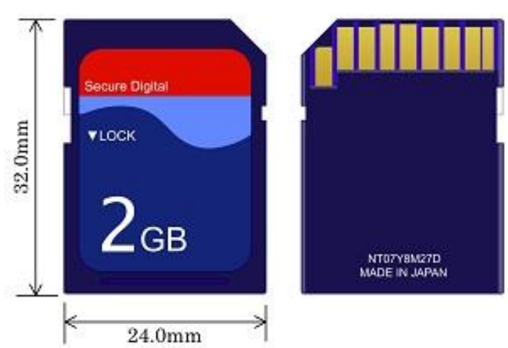
2.3.2.2 Secure Digital



Secure Digital is a standard for removable memory storage which has been implemented in many brands and models. The format includes four different card families (Standard-Capacity, High-Capacity, eXtended Capacity, and Secure Digital Input Output) in three different form factors (regular, mini, and micro).

2.3.2.2.1 Benefits

- Does not require a separate host controller
- Easier to implement
- Cheaper to implement
- Very small form factors available
- Faster write speeds
- TI Hercules has onboard SD



2.3.2.2.2 Drawbacks

- Uses more microcontroller pins than USB
  - No internal clock
- Easily lost or broken
- Many computers cannot natively read SD cards
- Card could accidentally be put in read-only mode

2.3.2.3 Storage Medium Selection

The team has decided to use the Secure Digital medium. This choice was made because of the availability of a TI Booster Pack SD Card slot for $9.99 that should connect directly to the Hercules. The ease of implementation, cost, and form factor ultimately lead to the team's decision to use SD.

2.4 Wireless Data Communication

The DAQ system will need to wirelessly transmit real time data to the pit. The system will need to operate with minimal data loss over an outdoor range of up to 3 miles. Additional antennas or amplification may be required to increase range.

2.4.1 XBee Pro 802.15.4

The XBee Pro 802.15.4 utilizes a 2.4 GHz band, which increases power consumption and decreases the effective range, but also increases possible data throughput. The XBee Pro 802.15.4 uses IEEE standard wireless communication (IEEE 802.15.4) to create a long range Personal Area Network (or PAN). It has point-to-point, point-multipoint, and peer-to-peer connection capabilities, although only the point-to-point features will be used.

2.4.1.1 Benefits

- Standardized RF technology
- Fast 115.2 kbps effective throughput
- Multiple channels and MAC addressing reduces the effects of interference
- Low cost

2.4.1.2 Drawbacks

- Low effective range (1 mile RF LOS) out of the box
- High power consumption (710 mW transmitting)

2.4.2 XTend High Power RF Module

The XTend High Power RF Module offers a high power, high range digital wireless solution. The XTend implements greater output power and a lower RF band (900 MHz), which greatly improves the effective range. Industrial grade models are also available which can withstand greater temperatures and other environmental hazards. It is capable of both point-to-point and multipoint networking, and offers signal encryption and mesh networking on certain models.

2.4.2.1 Benefits

- High output power (1W)
- High effective range (up to 14 miles RF LOS, or 3000 ft indoors)
- Throughput is comparable to 2.4 GHz band devices

2.4.2.2 Drawbacks

- Very high cost
- Very high power consumption (up to 3 W while transmitting)

2.4.3 XBee-PRO ZB

The XBee-PRO ZB utilizes the standard ZigBee wireless networking protocol in the 2.4 GHz frequency band. It offers high throughput and industrial grade temperature and humidity tolerances.

2.4.3.1 Benefits

- Uses standardized ZigBee RF mesh networking protocol
- Very low cost
- Digital and analog I/O
- Many interfacing options
- High temp and humidity tolerance

2.4.3.2 Drawbacks

- Low range (2 miles outdoor RF LOS) out of the box
- Low power output (63 mW)
- High power consumption (677 mW transmitting)

2.4.4 XBee-PRO 900HP

The XBee-PRO 900HP RF module is designed for low power consumption, high range applications in the 900MHz band. It uses proprietary XBee RF communications. It boasts features such as a selectable channel mask as well as digital I/O, onboard ADCs, and PWM output.

2.4.4.1 Benefits

- High power output (250 mW)
- High throughput (up to 200 kbps)
- High range (4 miles RF LOS with 2.1 dB dipole antenna at 200 kbps)
- Low power consumption (as compared with the output power, only 710 mW transmitting)
- Selectable channel mask to prevent interference
- Digital and analog I/O
- Low cost

2.4.4.2 Drawbacks

- Few interfacing options (only UART or SPI)
- Proprietary RF communication

2.4.5 Selection

The team has prioritized range and output power in their selection, however the unit with the highest of these (the XTend unit) was found to be too costly to implement at nearly $200 per unit. The next best unit in these regards is the XBee-PRO 900HP with a 4 mile RF LOS range out of the box and 250mW output power. The 900HP is also remarkably cheap at around $40 per unit. For these reasons, the team has chosen the XBee-PRO 900HP as their main RF module to communicate between the Baja and the pit.

2.5 Power System

The DAQ will need to run on its own power system. The endurance portion of the Baja competition lasts for 4 hours. As such, the team is looking to achieve 5 hours of battery life with the DAQ running continuously. This will allow the Baja team to collect data throughout the entirety of the endurance competition.

2.5.1 Battery Technology

2.5.1.2 Nickle-metal Hydride (NiMH)

Nickel-metal Hydride batteries are a type of rechargeable battery whose chemical reactions are similar to those of the NiCd battery. However, NiMH cells have a much higher energy density. Some general specifications about the technology are as follows:

- Energy density: 140-300 Wh/L
- Energy/consumer-price: 2.75 Wh/$
- Nominal cell voltage: 1.2V

2.5.1.2.1 Benefits

- Can last up to 2000 recharge cycles
- Up to twice the energy density of NiCd batteries

2.5.1.2.2 Drawbacks

- Low nominal voltage: 1.2V per cell
- High rate of self-discharge: 4% per day

2.5.1.3 Lithium-Ion (Li-ion)

Lithium-Ion batteries are another type or rechargeable battery. To delivery electricity, lithium ions move from the negative electrode to the positive electrode during discharge. To charge the battery, the ions are moved back to the negative electrode. Li-ion batteries are found commonly in consumer portable electronics. In recent times, the Li-ion battery has grown in use for military, electric vehicle, and aerospace applications. Some specifications about the technology are as follows:

- Energy density: 250-730 Wh/L
- Price: 2.5 Wh/$
- Cycle durability: 400-1200 cycles
- Nominal cell voltage: 3V-4V depending on type

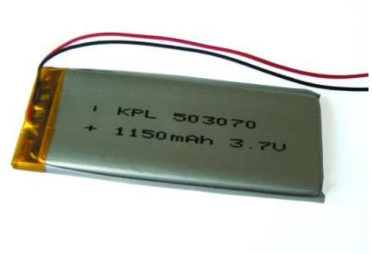
2.5.1.3.1 Benefits

- High energy density: 250-730 Wh/L
- Price: One of the cheaper battery technologies
- No memory effect
- Slow charge loss when not in use
- Battery packs available in a wide range of voltages

2.5.1.3.2 Drawbacks

- Can be dangerous under some conditions
- Manufacturing presents potential environmental and health hazards

2.5.1.4 Lithium Polymer (LiPo)



Lithium polymer batteries are a subset of Lithium-ion batteries that come in a “pouch” format. They are essentially flat cells as opposed to round cells. They have an energy density identical to that of Li-ion batteries. In fact, the technology's specifications almost exactly mirror that of the Li-ion battery.

2.5.1.4.1 Benefits

- Come in larger capacities than typical Li-ion batteries
- High energy density
- Available in a wide range of voltages

2.5.1.4.2 Drawbacks

- Can fail catastrophically under certain conditions
  - overcharge, over-discharge, over-temperature, short circuit, crush and nail penetration
- Some packages lack safety devices found in Li-ion cells
- Cost: 14.8V 1Ah pack: $167.99

2.5.1.5 Lithium Iron Phosphate (LiFePO4)

The LiFePO4 battery is a type of Li-ion battery that uses $LiFePO_4$ as a cathode material. While they are a type of Li-ion battery, they are inherently safer than typical Li-ion batteries. Some specifications about the technology follows:

- Energy Density: 220 Wh/L
- Energy/consumer-price: 0.7-3Wh/$
- Nominal Cell voltage: 3.2 V

2.5.1.5.1 Benefits

- High performance: practical capacity as high as 1 mAh/g
- Safe and stable chemistry
- High power capability
- Charges quickly: 10Ah battery can be fully charged in around 1h our
- Environmentally Friendly

2.5.1.5.2 Drawbacks

- Nominal cell voltage of 3.4 V
  - Would need to wire 2 batteries in series
- Does not perform well below 0^{o} C

2.5.1.5 Selection

When weighing the different energy storage options, the team has ruled out Nickel-Metal Hydride, Lithium-Ion and Lithium-Polymer. The Nickel-Metal Hydride battery simple does not store enough energy for the DAQ to run for 5 hours, and the Li-ion and LiPo batteries pose potential safety hazards that the team is not willing to risk. As such, the team has decided to use $LiFePO_4$. Not only are LiFePO4 batteries safer than Li-ion and LiPo batteries, they store much more energy and charge much more quickly.

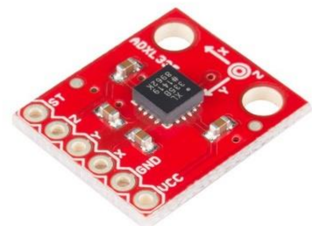
2.6 Sensors

2.6.1 Acceleration

One of the features of the DAQ system will be to measure the value of acceleration and deceleration of the vehicle, as well as measuring the ergonomics of the vehicle's ride and detect any physical shock to the vehicle such as a collision.

2.6.1.1 Triple Axis Accelerometer Breakout - ADXL335

This accelerometer model has 3 axis sensing, a low power operation at 3.6V, and 10,000g shock survival.



2.6.1.1.1 Benefits

- Low price ($14.95)
- Temperature Stability (up to 85 ºC)
- High shock survival Rating

2.6.1.1.2 Drawbacks

- No built-in through hole mount
    - Headers can be soldered on by hand

2.6.1.2 MMA7455 3-AXIS ACCEL MODULE

This accelerometer model features an SPI output, sensitivity options of 2g/4g/8g/10g, and 3 axis sensing.

2.6.1.2.1 Benefits

- Through hole mount
- Temperature Stability (85 ºC)
- Several sensitivity options

2.6.1.2.2 Drawbacks

- Cost ($29.99)

- High Operating Voltage (5V)

2.6.1.3 Selection

The team places a high priority on features that will withstand the conditions of off road terrain. Out of the two options, the ADXL335 Model was the clear choice. It had a high shock survival rating and a lower operating voltage of the two. This model had a lower acceleration measurement scale than the MMA7455 however this measurement scale is high enough to measure the acceleration of the Baja vehicle.

2.6.2 Fuel Level

The SAE Baja team currently uses a casual approach to measuring the fuel in the vehicle. They estimate the time to refuel based on how long the vehicle has been running. The DAQ team has decided to use a Fuel Level Sensor to quantify to amount of fuel left in the tank. The team has considered the following fuel level sensors.

2.6.2.1 Marshin Fuel Level Sensor Float 12" Lead B08

This sensor provides the basic functionality of a fuel level sensor at a reasonable price. This part can also be used in any vehicle model.

2.6.2.1.1 Benefits

- Cost ($9.99)
- Vehicle Flexibility

2.6.2.1.2 Drawbacks

- Little information on specification

2.6.2.2. Dorman 911-008 Fuel Level Sensor

This sensor undergoes rigorous quality control testing to ensure it meets the manufacturers high standard. This sensor is also interchangeable between different vehicle models.

2.6.2.2.1 Benefits
- High product ratings
- Has undergone quality testing

2.6.2.2.1 Drawbacks
- Cost ($22.20)

2.6.2.3 Selection
After consideration of the advantages and disadvantages of each fuel level sensor, the team has decided to choose the Dorman 911-008 model. The primary reason is the quality of the sensor. The team is willing to pay a higher price up front if there is assurance of sensors accuracy.

2.6.3 Suspension Travel
Measuring the suspension will be valuable to the Baja team members during normal practice to determine how the terrain is affecting the suspension as well as dynamic events during the competition such as the rock crawl.

2.6.3.1 Shock Absorber Suspension Travel Sensor LPPS-25 potentiometer
These are industry grade suspension sensors with a traveling range of 1 inch. These sensors have a maximum input voltage of 12V and a resistance of 1kΩ

2.6.3.1.1 Benefits
- High quality
- Compact

2.6.3.1.2 Drawbacks
- Price ($145.00)

2.6.3.2 Suspension Selection
While researching the suspension sensor options available, the team has noticed that the price range for these sensors are too high to purchase and still remain on the project budget. The team has decided to instead design and build a customized suspension sensor for the Baja vehicle.

2.6.4 Speed

To measure the speed, the team will utilize Hall effect sensors. These sensors will output a voltage signal each time a magnet passes the sensor. The team has found the following options:

2.6.4.1 Hall Effect Sensor US1881

This sensor has a wide operating voltage range that goes from 3.5V to 24V. With a temperature threshold at 125 ℃ it is suitable for automotive applications.

2.6.4.1.1 Benefits

- Temperature threshold above our engine overheat estimation
- Through hole pins
- Cost ($0.95)

2.6.4.1.2 Drawbacks

- Fragile

2.6.4.2 55505 Hall Effect Flange Mount Geartooth Sensor

This industrial strength Hall effect sensor is perfect for automotive applications. Its sturdy casing protects the sensor from harsh elements, and its built in circuit protection prevents electrical faults. It is also available with an onboard 10bit ADC.

2.6.4.2.1 Benefits

- Industrial Strength
- Sturdy Casing
- Operating Temperature (-40-125℃)

2.6.4.2.2 Drawbacks

- Cost ($18.72)

2.6.4.3 Selection

When comparing the two sensors, the 55505 Hall effect sensor is a higher quality sensor for a higher price. The price was the deciding factor in the decision to choose the US1881 Hall effect sensor because this sensor fulfilled all the requirements at a fraction of the cost of the 55505.

2.6.5 Tire Pressure

While researching tire pressure monitoring sensors, it became clear that very few marketed solutions existed for the type of tire that the baja vehicle uses. In fact, there were none designed specifically for ATVs (the type of tire that the Baja vehicle uses). There are many automotive sensors on the market, however very little information about their sensitivity range exists. A very generous Dodge/Chrysler/Jeep dealership in South Florida took the time to test a sensor for the team, and determined that the sensor they tested was accurate to 6 PSI. Upon learning this, Arrigo Dodge of South Florida donated four Schrader 20398 TMPS sensors to the team, which retail at ~$53 per sensor. As such, those are the sensors that will be used for the tire pressure monitoring component of the DAQ.

2.7 Display

One of the final stages of the DAQ system is to display data collected on a screen to inform the driver of the vehicle's status. This screen will display information about the amount of fuel in the vehicle and its speed. The following LCD displays were considered.

2.7.1 Adafruit **TFT LCD 2.2" 18-bit color display**

This display from Adafruit features a 2.2" diagonal display measurement with a 4 SPI pin communication medium. The manufacturer of this screen boasts its compatibility with all microcontrollers.

2.7.1.1 Benefits

- Support from the arduino community
- SPI Compatible
- Can display color

2.7.1.2 Drawbacks

- The size (2.2")

2.7.2 TFT SPI 2.2" Serial LCD Module Display

This LCD display features a 2.2” diagonal screen with 4 LED backlights. This screen requires four SPI pins to interface with the MCU.

2.7.2.1 Benefits

- LED backlights
- SPI compatible
- Price ($10.13)

2.7.2.2 Drawbacks

- Size (2.2”)
- Low Color Depth 262K/65K

2.7.3 Selection

The team has decided to use the adafruit LCD screen. The main draw of this display is that it comes with libraries and examples from the manufacturers website. This will allow the team to immediately begin interfacing to the MCU with minimal troubles.

3 Proposed Design

3.1 Overview

The DAQ system will be composed of two discrete parts - the central DAQ system attached to the baja, and a remote unit for use in the pit. The central system will perform the main data collection and processing, while the pit unit will be a remote data viewing tool for the baja team to receive important data and warnings about the vehicle.

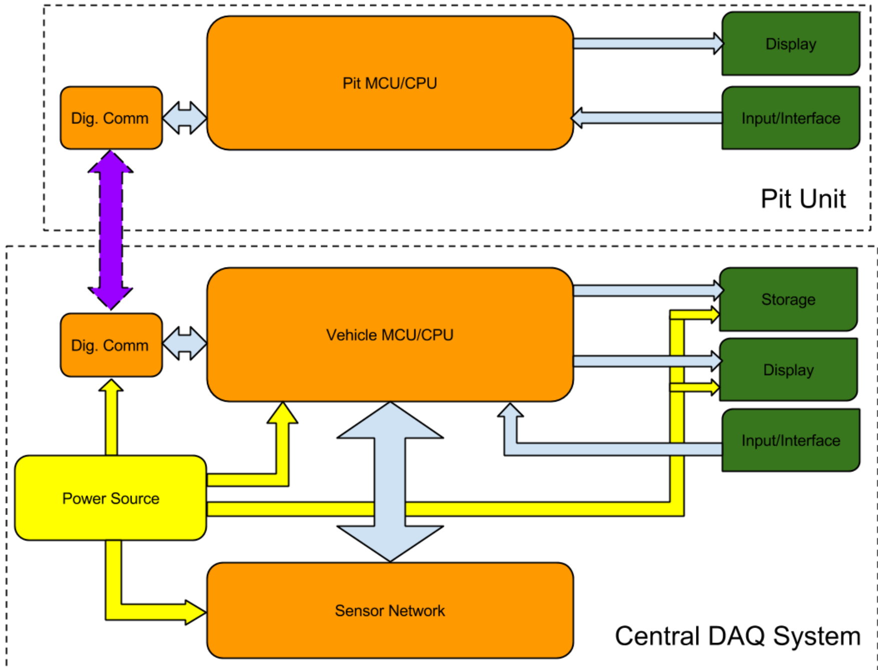


Figure 3.2.1 - Top Level Block Diagram

3.2 Vehicle MCU/CPU

This is the central "brain" of the DAQ. It will read in sensor data and facilitate the storage and transmission of that data to other subsystems. This will probably take the form of a standard MCU circuit or a commercial development board that the team will program. It is attached to a storage medium to record data logs, a display to share information with the driver, some sort of input which can alter the display or alert the pit crew of an emergency, and of course the wireless comms and sensor network.

3.3 Sensor Network

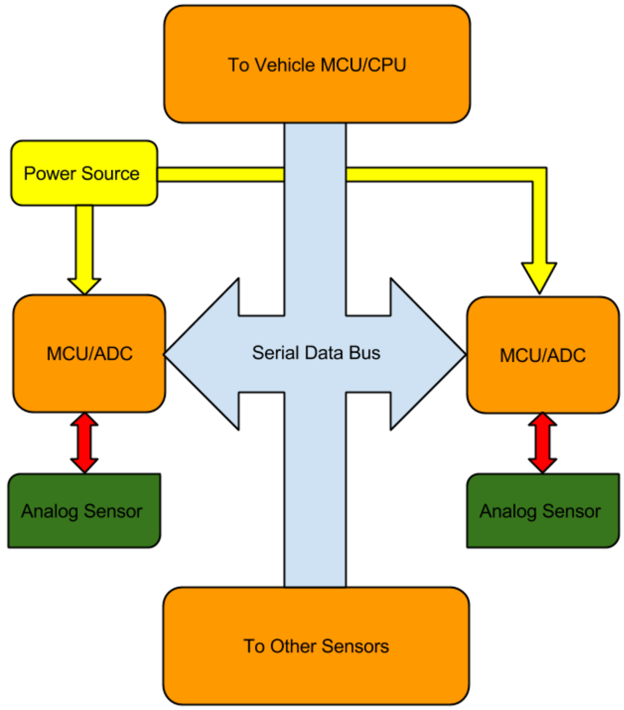


Figure 3.3.1 - Sensor Network Block Diagram

The sensors and central MCU will be interconnected by an SPI bus (as outlined in section 2.1). The bus will consist of a synchronous clock signal (generated by the master device, the central MCU), dual data lines (for full duplex operation), and may also consist of a number of slave select lines. Each MCU and/or sensor will need a power input which will be provided by the main DAQ power source.

3.4 Power Source

The power source will consist of the DAQ's battery system and voltage regulation circuitry. Due to SAE baja competition regulations, this power must be completely separate from the baja's existing power system so that in the event of a malfunction in the DAQ, the baja's essential safety functions are still operational. The power system will need to allow for charging or replacement of batteries, as well as regulating the battery's output to any voltages needed by the other subsystems.

3.5 Digital Communications

The wireless communications will connect the central DAQ system with the pit unit. It consists of 2 wireless transceivers and antennae, and will send serial sensor data long range to be displayed on the pit unit. This serial data will be generated by the vehicle MCU and will be decoded and displayed by the pit CPU. The transceivers will be capable of two way communication so it may also be possible for the pit to send messages or display information to the driver.

3.6 Pit MCU/CPU

The pit CPU will control the display of data to the pit crew. It will probably take the form of a SoC based single-board computer in order to simplify the display and manipulation of collected data. This will also allow the pit unit to read the logs generated by the vehicle MCU on its removable media. It may also be capable of sending messages to the driver or activating alerts on the driver’s DAQ display.

4 Statement of Work

4.1 Task 1: Project Management

Being an Electrical/Computer engineering project, the design of the Baja car itself is being done by the SAE Baja team, independent of the DAQ team. The two teams will collaborate on some things, but the DAQ team will have little to no involvement in the mechanical engineering side of the design. The DAQ team will seek information and advice from the SAE Baja team regarding the mounting of the DAQ to the vehicle as well as the user interface.

Christopher Riker, Project Manager, will control the overall structure of the team and its completion of the project. The project manager will maintain communication between all team members, actively monitor and encourage project progress, and ensure that all deadlines are met. In effect, the project manager will maintain constant contact with all team members about their progress and any concerns they may have with the particular tasks they have been assigned. This will ensure that the project is completed and delivered within the allotted time frame. In addition to project management, Mr. Riker will be responsible for general programming on the project.

Dewey Williams, Financial Manager, is charged with the task of managing the budget of the project. He will keep an up-to-date ledger to keep track of the finances of the project. In addition to the ledger, an inventory of all project parts will be kept. Any parts purchases will be approved by the financial manager to ensure that the project stays on budget. The financial manager will also seek outside sponsorships and funding if possible or necessary. In addition to financial tasks, Mr. Williams will be responsible for general programming and interfacing the various subsystems into the DAQ.

Hebe Perez, DAQ Leader, will act as the ambassador between the DAQ team and the SAE Baja team, as she is the sole DAQ team member that is involved in SAE at this point in time. The DAQ Leader is in charge of the overall integration of the DAQ into the Baja car itself. The DAQ Leader will maintain regular contact with the SAE Baja team in order to ensure the DAQ can be as useful to the Baja team as possible and stay within the limitations of the competition regulations. In addition, the DAQ Leader will assist the FM with sponsorship requests. The DAQ Leader will also ensure that, if possible, the proper arrangements are made such that the DAQ team can attend the Baja competition (April 9th 2015, Auburn AL).

Tyler Dudley, Data Coordinator, is in charge of all of the data associated with the project. This includes, but is not limited to, deliverables, testing data and part schematics. The Data Coordinator is also in charge of taking and keeping meeting minutes. As the sole Electrical engineer on the project, Mr. Dudley will be tasked with all of the electrical systems used in the DAQ.

4.1.1 Objectives

The objective of project management for the SAE Baja Data Acquisition System is to effectively apply solid engineering design principles to efficiently design a Data Acquisition System that meets or exceeds the requirements set forth by the SAE Baja team. In order to accomplish this, the team will apply their knowledge of Electrical and Computer engineering design principles to design a robust system to IEEE standards. Each of the team members above play a vital role in the completion of the project. As such, efficient management of the project and its design team is vital to the timely completion of the project.

4.1.2 Approach

To successfully design the Data Acquisition System, the technical and administrative tasks of the project will be divided into several areas including component selection, component purchasing, circuit design, component interfacing, programming and documentation. For each technical subtask, a team of one engineer and one SAE member will be assigned based on their technical skills. Since SAE members are not a part of the core engineering team, the engineer from the DAQ team assigned to the task will have total control over the design decisions to ensure that the end product meets or exceeds all requirements set forth by the SAE Baja team. Administrative subtasks, such as component selection and component purchasing, will be handled by engineers based on their project roles. Documentation of each subtask will be handled by the engineer assigned to that task.

4.2 Task 2: Concept Generation

4.2.1 Objectives

The objective of concept generation is to choose components and interfaces which have the proper operating characteristics for the system. The most important characteristics of the system are performance, usability and modularity. The components shall also be selected with budget in mind, as the team is working on a very limited budget. It is paramount that the components be selected correctly the first time around, as choosing and ordering improper components will directly affect the budget, and thus the rest of the project. The team will ensure that each component selected will be compatible with the overall system to prevent reordering of components.

4.2.2 Approach

Extensive research was done in order to choose the best possible components for the project. For each subsystem, various solution alternatives were considered. Their benefits and drawbacks were listed and discussed when making final component selections. The cost of each component also factored heavily into the selection. Once these parameters have been collected, the team will congregate and review each component chosen for comparison and come to a final decision based on the benefits and drawbacks of each unit.

4.2.2.1 *Subtask 2.1: Main Microcontroller Selection*

4.2.2.1.1 Objectives

As the main MCU controls the whole system, it is paramount that a microcontroller be selected such that it meets or exceeds the requirements of the design. The MCU must be able to quickly collect information from the sensor microcontrollers, process that information, and send the information to the appropriate places. If the main MCU fails or does not meet the requirements of the system, the DAQ will not function.

4.2.2.1.2 Approach

When considering the main MCU, the team will consider several attributes in order to make the correct selection.

- Flash memory size
- GPIO pin count
- SPI support
- Clock speed
- Price
- Power consumption
- Component compatibility

The main MCU chosen will be a development board so that the team can be sure the main MCU is feature-complete, and has all of the connections necessary. The team believes this will save fabrication time and cost, leaving more time for development of the system.

4.2.2.1.3 Test/Verification Plan

Before purchasing the main MCU, the team will thoroughly check the chosen MCU for compatibility with all other components selected for the DAQ. If necessary, device vendors will be contacted for compatibility information if the team cannot find it themselves. If a compatibility issue arises, a different microcontroller will be selected using the approach outlined above, and this test/verification plan will be applied to that controller.

4.2.2.1.4 Outcome of Task

With the selection of a microcontroller development board that suits the teams needs, the system can be designed without the use of a discrete programmer. Using a development board will also allow the team to make changes to the main MCU program on the fly without the need for special equipment (i.e. a programmer). Additionally, the team can focus on designing a robust Data Acquisition System without concerns about whether or not the main MCU will be sufficient enough for the task at hand.

4.2.2.2 *Subtask 2.2: Wireless Transceiver Selection*

4.2.2.2.1 Objectives

The wireless transceiver will allow the central DAQ system to communicate with pit unit. The communication will allow the pit crew to monitor the vehicle mid-race, giving them quantified information about the vehicle. This will give them a basis on which to make adjustments to the vehicle.

4.2.2.2.2 Approach

There are two main attributes the team is looking for in the selection of a wireless transceiver: cost and transmission range. Since the competition takes place on an outdoor track whose length varies from 2 to 3 miles, a transmission range of 3 miles is desired by the team.

4.2.2.2.3 Test/Verification Plan

The system will be tested in a variety of locations in order to determine what range the team can expect to achieve on the track. The team will experiment with a wide range of antennae to achieve the best possible performance. Performance will be measured by the transceivers' reported link strength, as well as data throughput and dropped packets.

4.2.2.2.4 Outcomes of Task

A wireless data connection is necessary in implementing the pit unit portion of the project. The expected link strength and throughput may dictate the design of other portions of the DAQ system. A successful wireless system will allow the team to send sensor data long range in a wide variety of terrains and topologies.

4.2.2.3 *Subtask 2.3: Sensor Microcontroller Selection*

4.2.2.3.1 Objectives

The sensor microcontrollers will convert the analog sensor outputs into digital signals. Additionally, these microcontrollers will convert the values put out by the sensor into the units that will be displayed and recorded by the DAQ. For example, the microcontroller that controls the Hall effect sensor will convert the analog input to a digital signal, convert the reading to miles per hour, and send the speed to the main MCU. Selecting the appropriate MCUs for this purpose will allow the team to implement the A/D and unit conversions in a cost efficient manner while still allowing the use of an SPI bus.

4.2.2.3.2 Approach

The sensor MCUs will be chosen based on a few attributes that the team determined to be of great importance:

- Size: must be small form factor
- Minimal pin count: easier PCB design and printing
- Onboard A/D converter
- Flash memory size
- Through-hole mounting: surface mount is not possible at the FAMU-FSU College of Engineering PCB milling facility

Discrete MCUs that have these attributes will be compared by the team for selection. The team plans to use discrete MCUs with custom PCBs to reduce cost while still providing the necessary functionality to meet the design requirements.

4.2.2.3.3 Test/Verification Plan

The sensor-MCU combination will be prototyped before a PCB is milled and before the sensor is installed in the vehicle to verify that data can be accurately collected and transmitted by the MCU. This is where a majority of the programming will occur. The MCU must successfully collect and convert data from a sensor and repeat this converted data over the SPI bus when requested.

4.2.2.3.4 Outcome of Task

The sensor MCUs will allow data from analog sensors to be sent quickly and efficiently to the main MCU for display and transmission. They will help to offload some of the conversion and calibration from the main MCU and allow it to spend its cycles on sampling.

4.2.2.4 *Subtask 2.4: Sensor Network/Data Bus Selection*

4.2.2.4.1 Objectives

The sensor network/data bus will provide a way for the sensor microcontrollers to communicate with the main MCU. The objective of the selection of a sensor network/data bus is to provide a fast, efficient method of communication between the main MCU and the DAQ components. The advantage of using a data bus is that it only uses 2-4 pins on the main MCU, freeing GPIO pins for other additional components in the future.

4.2.2.4.2 Approach

The team aims to interface the sensor MCUs with the main MCU via a data bus. This bus must offer sufficient throughput and allow all sensors to be connected to only a few pins on the microcontroller. Because only one sensor will be read at a time, the bus does not need to have special features such as mailboxes or "headless" operation - a simple master/slave relationship will work fine and, in fact, this type of bus fits better with the design paradigm. The bus must also be synchronous - simplifying the reading and transmitting of data.

4.2.2.4.3 Test/Verification Plan

The chosen bus must be easy to implement on a wide range of microcontrollers. In order to test the feasibility of the chosen bus, multiple microcontrollers will be connected and predictable data will be sent from each slave in turn to the master. The test will be successful if a sufficient amount of data can be sent reliably and without collisions or errors.

4.2.2.4.4 Outcomes of Task

Once the data bus has been selected the team will be able to program the interface and begin programming each controller to retrieve and send data. This is an essential part of the DAQ system building process and so it is very important that the selected interface is up to the task.

4.2.2.5 *Subtask 2.5: Data Logging Filetype and Medium Selection*

4.2.2.5.1 Objectives

The DAQ will not only display, it will record snapshots of that data for later analysis. In order to accomplish this, the team will decide on a storage file type as well as a storage medium. Since this data will be used by the SAE Baja team for analysis, it is important that the data be parsable by software. There will be tens of thousands of data points collected by the DAQ. As such, there is virtually no way that a human will be able to sift through this data if it is represented as plain text. The team aims to store the collected data in a manner that is easily usable by the Baja team.

4.2.2.5.2 Approach

To approach this selection, the team will consider different file types and storage mediums and their benefits and drawbacks. When selecting a file type, the team will select a type based on its ease of implementation and parsability by software. When selecting a storage medium, the team will consider pin usage, ease of implementation, compatibility and of course cost.

4.2.2.5.3 Test/Verification Plan

First and foremost, the team will ensure that the solution chosen is compatible with the main MCU. If it is not, other solution concepts will need to be researched. In order to test the storage system, the team will write various data points to the storage media. The team will measure the rate of transfer to confirm that it is indeed fast enough to fulfill the requirements of the design. The team believes that speed will be a non-issue, as the DAQ will be writing ~20-40 bytes per second, which is relatively small compared to data transfer rates of todays storage solutions (in the order of MB/s). The team will also verify that the data transmission occurred without error. The output file will then be tested for parsability by various pieces of software.

4.2.2.5.4 Outcome of Task

Once a suitable storage medium is chosen the team will incorporate it into their circuit designs, and begin prototyping code to write files in the selected format. This a central piece of the DAQ design - being able to read and analyze data collected while the car is racing - and so it will be a top priority when designing the system's specifics.

4.2.2.6 *Subtask 2.6: Battery Selection*

4.2.2.6.1 Objectives

Since the DAQ will be used in a 4-hour endurance race, it is important that it receives a constant power source during that time. The power system of the DAQ is one of the most important pieces of the system. Without power, the DAQ cannot run and thus cannot complete the task for which it was designed.

4.2.2.6.2 Approach

In order to select the proper battery technology, the team looked at the energy density, watt-hours per dollar, and nominal voltage per cell. Of course, safety was considered. However, many battery packs today have protective PCBs that protect the battery from failure due to overcharging, over-discharging, short circuiting, and incorrect polarity. A full power analysis will be done on all **final** component selections before a specific battery pack is selected. It is vital that this is done once every other component is set in stone, as the battery pack will likely be the most costly component of the entire system.

4.2.2.6.3 Testing/Verification Plan

The chosen batteries will be used while prototyping the other circuitry in order to test their longevity as well as the time to charge them. This may include placing a static load on the batteries and monitoring their voltage until it drops below a threshold to ensure that the batteries will be able to last for the required time while the DAQ system is active.

4.2.2.6.4 Outcomes of Task

Batteries are absolutely essential to the system because in accordance with the SAE Baja competition rules, the DAQ is unable to use any existing electrical systems on the baja. The batteries will provide a source of power to all of the DAQ components without which the DAQ system would be unable to function.

4.2.2.7 *Subtask 2.7: Accelerometer Selection*

4.2.2.7.1 Objectives

The SAE International Baja series has several design testing events the day before the endurance event. One of these events is an acceleration test. Having an on-board accelerometer will give the Baja team an accurate measurement of the vehicle's acceleration, allowing them to fine tune the CVT in order to achieve the maximum acceleration possible by the vehicle.

4.2.2.7.2 Approach

In deciding on a specific accelerometer, the team will pay close attention to the mounting style, sensitivity durability, and cost. Through-hole mounting is the preferred method, as surface-mounting at the FAMU-FSU College of Engineering PCB Milling Facility is not feasible. Since the vehicle is rather slow relatively speaking, the accelerometer must be able to read between +/- 1g.

4.2.2.7.3 Testing/Verification Plan

Accelerometers can be easily tested using the force of gravity. During the prototyping phase, the chosen accelerometer can be used as a "dummy" data source, by rotating and turning the accelerometer by hand. This will also provide calibration measurements to the team who can then implement code to convert the digital signals from the accelerometer into proper human-readable units.

4.2.2.7.4 Outcome of Task

An appropriately selected accelerometer will allow the team to move forward in system development and programming the sensor MCUs. The team needs to know the tolerance of the accelerometer as well as its range in order to complete the circuit design and MCU programming tasks.

4.2.2.8: *Subtask 2.8: Fuel Sensor Selection*

4.2.2.8.1 Objectives

The objective of this task is to choose a fuel sensor that will adequately measure the fuel level in the vehicle. This measurement does not need to be precise, but it does need to be fairly close so that the Baja team does not refuel the vehicle unnecessarily.

4.2.2.8.2 Approach
When selecting a fuel sender, as they are called in the automotive industry, the team will look mostly at cost and ease of installation. These devices can vary widely in their design, form factor, and price. The team will look at low-cost, universal options when choosing the fuel sender.

4.2.2.8.3 Testing/Verification Plan
In order to test the proper functionality of the fuel sender, the team will fill the tank to a predetermined, pre-measured percentage of the tank's full capacity. The team will check the sensor's reading with what is already known to determine whether or not the sensor is accurately reporting the fuel level.

4.2.2.8.4 Outcomes of Task
When this task is complete, the team will have chosen and confirmed the correct operation of an accurate, low-cost fuel sender that suits the needs of the project and fulfills all requirements set forth by the FAMU-FAU SAE Baja team.

4.2.2.9: *Subtask 2.9: Suspension Measurement Sensor Selection*

4.2.2.9.1 Objectives
The objective of this task is to select a device of solution concept that will allow the team to accurately measure the suspension travel of the vehicle. This will be important in the maneuverability and endurance parts of the competitions, where the vehicle may be asked to transverse rock terrain and tight turns.

4.2.2.9.2 Approach
The team will look at several different solution concepts to determine whether it is best to purchase a marketed solution to the problem or to design its own. These sensors can be expensive, so the design of a custom module is not out of the question. The team will make the decision with budget and easy of use in mind.

4.2.2.9.3 Testing/Verification Plan
When a solution is chosen and the device is installed, the team will preload the suspension and measure the travel with conventional methods. The measurement will be checked against the sensor's reading to ensure that it is reading the suspension travel accurately.

4.2.2.9.4 Outcome of Task
When this task is completed, the team will have an accurate measure of the suspension travel that can be used by the Baja team to make adjustments to the vehicle to improve its performance.

4.2.2.10: *Subtask 2.10: Hall Effect Sensor Selection*

4.2.2.10.1 Objectives

The Hall effect sensor will measure the speed of the vehicle, another important piece of information when the Baja team is tuning the vehicle. In addition to reading and recording the speed, the DAQ will also display this speed to the driver. It is important that the speed displayed is accurate. The objective behind Hall effect sensor selection is to provide the Baja team with accurate measurements and data about the speed of the vehicle.

4.2.2.10.2 Approach

When deciding on a specific Hall effect sensor to use, the team placed focus on the durability and survivability of the sensor due to the operating environment of the system. It is important to the Baja team that an accurate speed is collected by the DAQ. The team will choose a Hall effect sensor with this in mind. Hall effect sensors can range from cheap and simple to industrial grade in terms of build quality and performance.

4.2.2.10.3 Testing/Verification Plan

The team will test the sensor and speed measurement apparatus in the lab using a stationary wheel with a magnet attached. The team will need to verify that the sensor can pick up a magnetic pulse from a safe distance away (far enough that the sensor cannot be damaged by the spinning apparatus), and that the attached MCU is able to properly detect the pulses at a high rate of speed. The team will also need to determine what output voltage can be expected from the sensor when a pulse is produced with the sensor at a safe distance, as this will need to be programmed into the MCU.

4.2.2.10.4 Outcomes of Task

The Hall effect sensor fulfills one of the required tasks of the project - measuring the speed of the vehicle. Because most Hall effect sensors operate and interface in a similar fashion, circuit design may be performed in parallel with this task, however the specific sensor and its input and output voltages will need to be considered in the MCU programming phase.

4.2.2.11 *Subtask 2.11: Display Panel Selection*

4.2.2.11.1 Objective

The display panel on the Baja vehicle will show the driver the speed and fuel level of the vehicle. This will give the driver a sense of awareness as to when a fuel change may be coming up, allowing him to prepare adequately. It will also allow the driver to have full control over the exact speed that the vehicle is traveling at, giving the driver more control over the vehicle.

4.2.2.11.2 Approach

The team set out to find a display that used SPI and was easily readable by the driver. The driver sits relatively close to the steering wheel, so the display size can be relatively small and still be read. The team will choose a nice looking display that is easy to interface with when choosing the display panel.

4.2.2.11.3 Test/Verification of Task

The team will test the display by writing a “fake” speed and fuel gauge onto the display. A person will then drive the vehicle and determine any changes that need to be made to the dispaly to make it useful.

4.2.2.11.4 Outcome of Task

When the task is complete, the vehicle will have a display that allows the driver to easily view the speed and fuel gauge of the vehicle.

4.2.3 Test/Verification Plan

Throughout the component selection process, the team will ensure that all selected components conform to the design specifications and the design paradigm, as well as compatibility with other chosen components or interfaces. If necessary, the team will reach out to device manufacturers or distributors to confirm that components are compatible with each other. During the prototyping phase, the components’ compatibility and feasibility will be established and steps may be taken to remedy any issues that arise.

4.2.4 Outcomes of Task

Upon completion of component selection, the team will be ready to begin designing the specifics of each subsystem. That includes circuit design, PCB design and milling, and programming. This is an essential step in moving the project forward - as no work can be done without specific knowledge of each component.

4.3 Task 3: Circuit Design

In order to implement the conceptualized design, there are some custom circuits that need to be designed. These include a regulator circuit as well as custom circuits for each of the sensor microcontrollers.

4.3.1 Objectives

Since the microcontrollers work on a voltage of 5V input, the output voltage of the selected battery will need to be regulated down to avoid overloading the MCU. Additionally, the sensor microcontrollers are discrete chips, meaning they come with no circuitry. Custom circuits will have to be designed for these MCUs so that they can be mounted to a custom PCB with all the proper pin connections and powered appropriately.

4.3.2 Approach

The team will decide on a software package to use in designing circuitry before any design work is done. The FAMU-FSU College of Engineering has a number of options available, and the

FAMU-FSU branch of SAE has some software licenses available as well. The team will collaborate on the design of the required subsystems, using circuit simulation tools to verify the design before prototyping.

4.3.2.1 *Subtask 3.1: Regulator Circuit Design*

In order to supply the proper voltage to the MCU and all other design components, the voltage of the chosen battery will have to be regulated down to the operating voltage of the components.

4.3.2.1.1 Objectives

The objective of regulator circuit design is to supply all of the DAQ components with the proper voltage to prevent damage and to ensure that they are operating properly. This is required because the chosen battery will likely output a voltage that is far above that of the operating voltage of the various DAQ components.

4.3.2.1.2 Approach

The team will apply fundamental circuit analysis along with circuit simulation to ensure that the circuit being designed will behave as it is intended. The design will be confirmed before the circuit is built to eliminate waste.

4.3.2.1.3 Test/Verification Plan

As stated above, extensive simulations and calculations will be done to ensure that the circuit is designed in the correct manner. Once the physical circuit is built, it will be tested for accuracy before any components can be connected to it.

4.3.2.1.4 Outcome of Task

4.3.2.2 *Subtask 3.2: Sensor MCU Circuit Design*

In addition to regulator circuits, the sensor MCUs will also need circuits designed for them before their custom PCBs are made and they are attached. This is absolutely necessary as the sensor MCUs are discrete chips without supporting circuits.

4.3.2.2.1 Objectives

The objective of the sensor MCU circuit design is to provide the discrete sensor MCUs with a driving circuit. Since they come as discrete chips, they will need a custom PCB milled for them, and a circuit to drive them.

4.3.2.2.2 Approach

The approach to this design step will depend heavily on which microcontroller is selected. Some controllers require external oscillation (for which an external crystal needs to be included), which some microcontroller require some external resistor ladder to set internal voltages. In general, however, these circuits are simple and premade designs are readily available in the online electronics community.

4.3.2.2.3 Test/Verification Plan
The circuits will be designed in software, and then prototyped on a breadboard to ensure proper operation. The microcontroller will be flashed with a simple program to verify that essential pins operate as expected before a PCB is milled.

4.3.2.2.4 Outcomes of Task
The design of the sensor MCU circuits will finalize the other tasks related to sensors and the way they interface with the central MCU. The sensor MCUs will be attached to the boards using a DIP socket and so final programming of the MCUs can be done at any time - before or after the circuit design and milling stage.

4.3.3 Test/Verification Plan
Provided that each component is selected and tested properly, the team does not expect that any problems will arise when the systems are combined. The system will be prototyped and tested before being installed in the vehicle, and this will allow the team to work out any bugs, and begin optimizing and testing the limits of the DAQ system.

4.4 Task 4: Programming

4.4.1 Objective
The objective of programming DAQ is to tell the main microcontroller how it is to proceed in order to control the DAQ, and to tell the sensor microcontrollers when to convert data to digital signals, how to process that data, and when to send that data to the main microcontroller.

4.4.2 Approach
In order to approach this efficiently, the programming tasks will be broken up into small subtasks that can be completed by the team members in a timely fashion. An incremental design approach will be applied to all programming subtasks in order to make the programming progress more efficiently. Additionally, the team will use standardized coding format so that reading code that other team members write will be easier.

4.4.2.1 *Subtask 4.1: Hall Effect Sensor MCU Programming*

4.4.2.1.1 Objective
The Hall effect MCU will be programmed to obtain an analog input from the Hall effect sensor and send the data received to the main MCU in Miles Per Hour (MPH).

4.4.2.1.2 Approach
First, the MCU will be instructed to read the analog input of the Hall effect sensor and convert it to a digital signal. The MCU will then be instructed to transform that digital signal from

whatever representation it is in to MPH. The MCU will then be instructed to send that data to the main MCU, where it can be written, displayed, and sent to the pit unit.

4.4.2.1.3 Test/Verification Plan

All programming subtasks will be tested and verified using the same method, outlined in **Section 4.4.3,** unless otherwise noted.

4.4.2.1.4 Outcome of Task

When this task is complete, the Hall effect sensor MCU will be able to read the sensor and accurately report the speed in Miles Per Hour.

4.4.2.2 *Subtask 4.2: Accelerometer MCU Programming*

4.4.2.2.1 Objective

The accelerometer MCU will be programmed to obtain the analog input from the accelerometer and send the data received to the main MCU in m/s^2.

4.4.2.2.2 Approach

First, the MCU will be instructed to read the analog input of the accelerometer and convert it to its digital equivalent. The MCU will then be instructed to convert this data to m/s^2. The MCU will do this with all 3 axes. The MCU will then be instructed to send that data to the main MCU, where it can be written, displayed, and sent to the pit unit.

4.4.2.2.3 Test/Verification Plan

All programming subtasks will be tested and verified using the same method, outlined in **Section 4.4.3,** unless otherwise noted.

4.4.2.2.4 Outcome of Task

When the task is complete, the team will have an accelerometer controlled by an MCU can read the analog input of the accelerometer and send the acceleration of the vehicle (on all 3 axes) to the main MCU in proper SI units.

4.4.2.3 *Subtask 4.3: Suspension Travel MCU Programming*

4.4.2.3.1 Objective

The suspension travel MCU will be programmed to obtain the analog input from the suspension travel measurement device and send the data to the main MCU in centimeters.

4.4.2.3.2 Approach

The MCU will be instructed to read the analog input of the suspen travel measurement device. It will then convert that input to a digital signal. The MCU will then be instructed to convert that data into centimeters of suspension travel and send that the newly converted measurement to the main MCU where it can be written, displayed, and sent to the pit unit.

4.4.2.3.3 Test/Verification Plan

All programming subtasks will be tested and verified using the same method, outlined in **Section 4.4.3,** unless otherwise noted.

4.4.2.3.4 Outcome of Task

Upon completion of this task, the team will have an MCU that can quickly and efficiently read the analog input of a suspension travel measurement and relay the value of the travel, in centimeters, to the main MCU.

4.4.2.4 *Subtask 4.4: Tire Pressure Sensor MCU Programming*

4.4.2.4.1 Objective

The tire pressure sensor MCUs will all be programmed the same way, as they will all interface with the same kind of sensor and require the same kind of processing. The MCU will be instructed to obtain the inputs from the RF sensors that read the tire pressure sensors. If the tire pressure falls below a certain threshold, the driver and pit will be notified of this via an indicator light.

4.4.2.4.2 Approach

The MCU will be instructed to read the RF sensor that communicates with the tire pressure sensor. The MCU will convert the reading to digital if necessary. The MCU will then be instructed to convert the signal to a quantified pressure value in PSI. If that value is below a certain threshold, the main MCU will be notified and a light on the dash will illuminate.

4.4.2.4.3 Test/Verification of Plan

All programming subtasks will be tested and verified using the same method, outlined in **Section 4.4.3,** unless otherwise noted. Only one sensor will be implemented at first. When it works as expected, the code will be copied onto the other tire pressure sensor MCUs.

4.4.2.4.4 Outcome of Task

When this task is complete, the team will have a fully function TPMS on the vehicle. The four tire pressure sensors will be polled every so often by their host MCUs, and a warning light will be triggered if any of the tires fall below a certain threshold (which can be changed by the Baja team if they so choose).

4.4.2.5 *Subtask 4.5: Fuel Level Sensor MCU Programming*

4.4.2.5.1 Objective

The fuel level sensor MCU will be programmed to obtain the analog voltage reading from the sensor and send the data to the main MCU.

4.4.2.5.2 Approach

The MCU will be instructed to read the analog input of the fuel sender. The MCU will convert that input to a digital signal. The MCU will then be instructed to convert that signal into a percentage of fuel remaining, which will then be sent to the main MCU where it will be displayed, written, and sent to the pit unit.

4.4.2.5.3 Test/Verification Plan

All programming subtasks will be tested and verified using the same method, outlined in **Section 4.4.3,** unless otherwise noted.

4.4.2.5.4 Outcome of Task

Upon completion of this task, the team will essentially have a fully function fuel gauge for the vehicle. The fuel sender MCU will be able to read the value of the sender and display a fuel gauge appropriately based on the value the sender puts out.

4.4.3 Test/Verification Plan

The design will be developed incrementally. After an instruction is programmed, the team member assigned to the task will run the program and ensure that the correct instruction was given to the microcontroller and verify that the instruction was executed as desired. This can be accomplished using whatever debugging features they wish to use which are included in whichever IDE they wish to use.

4.5 Documentation

4.5.1 Weekly Meeting Minutes and Reports

The team will document and publish weekly meeting minutes and reports on the project webpage. The minutes will detail all meeting proceedings, and the reports will detail all technical work done for that week. These documents will be compiled and delivered at the end of the year for review by project advisors and additional reviewers.

4.5.2 Conceptual and Critical Design Reviews

There are six milestones associated with the project, three that occur in the fall and three that occur in the spring. The fall milestones are the Needs Analysis and Requirements Specifications, Project Proposal and Statement of Work, and System Level Design Review. These milestones and the three that take place in the Spring will be turned over to the project advisors and any additional reviewers at the end of the year along with the final report.

4.5.3 General Documentation

The team will use a number of methods to document the DAQ system and its constituent parts. The team website and blackboard page will be used as a repository for data sheets, source code, and circuit diagrams, as well as articles or white papers written by the team detailing how parts and subsystems interact with the whole. The Data Coordinator will ensure that this repository is kept up to date and well organized so that future and present baja teams have this necessary information readily available.

The team will consider and experiment with open source projects such as GitHub and MediaWiki in order to find the best and most effective way to save and organize this information. At the end of the year, all of this documentation will be made available to the project advisor and any additional reviewers.

5 Risk Assessment

5.1 Financial

When working with electrical components, there is always some financial risk involved. Microchips and circuit boards are susceptible to static shock, and can be short circuited quite easily when in contact with water or other conductive materials. The possibility of short circuiting, and thus destroying, a component of the DAQ is very real and will be continually considered throughout the development of the system. If an electrical component of the DAQ fails, the project budget could be affected greatly (depending on which component fails). If an important component of the DAQ were to fail, low priority subsystems could be left out of the final product.

5.1.1 Component Destruction

Risk

Electrical components are very sensitive to the presence of static electricity, and can be permanently damaged by a static discharge. Destruction of any components of the DAQ could potentially consume a large portion of the budget (depending on which component is destroyed) and/or prevent the team from delivering the fully functional system on time.

Solution

The team will handle the DAQ components with the utmost caution at all times. An anti-static wristband will be worn by any team member that is working with sensitive or expensive electrical equipment.

5.1.2 Component Failure

Risk

At any time, electrical components can fail for a variety of reasons. As with component destruction, component failure could potentially consume a large portion of the budget and/or prevent the team from delivering the fully functional system on time.

Solution

As component failure can be random and depend on many different factors, there is no bona-fide solution to mitigate the risk of component failure. However, the team will thoroughly test all components regularly to ensure that nothing goes unnoticed and any problems that may arise are handled with haste.

5.1.3 Project Cost Overrun

Risk

There is a potential that the actual cost of the project may be above that of the preliminary estimations. As with any project, unforeseen issues and changes can occur during project development.

Solution

The team will do their best to provide a budget estimate that is as accurate as possible, and one that represents the worst case scenario and accounts for potential changes during project development.

5.2 Safety

There are some safety risks associated with the project at hand. Safety of the team members, users of the DAQ, and other competition attendees is of the utmost importance. The team will do everything possible to mitigate those risks to the best of their ability.

5.2.1 System Mounting Failure

Risk

It is possible that the system could become detached from the vehicle via a mounting failure. This poses a safety risk to not only the driver of the FAMU-FSU Baja car, but every driver in the competition as well as spectators of the competition.

Solution

Assistance with mounting options and solutions will be solicited from Mechanical Engineering members of SAE at the FAMU-FSU College of Engineering. The mounting system for the DAQ will be tested heavily before competition to ensure sound operation.

5.3 Design

5.3.1 Tire Pressure Monitoring System

Risk

The team found during their research of potential solutions for the Baja TPMS that there exist virtually no marketed solutions for ATV tires. While the project team was donated 4 automobile TPMS sensors, there is a chance that they are not sensitive enough to measure pressures in the ranges that the project requires.

Solution

In the event that the donated TPMS sensors do not provide accurate measurements below 10 PSI, the design team will diligently research other possible solutions. However, in the event that no solutions are found, the TMPS may be left out of the design entirely.

5.3.2 Wireless Vehicle-to-Pit Data Transmission

Risk

The team was hard-pressed to find information about the urban data transmission range using high-gain dipole antennas. The Xbee-PRO 900HP is capable of a 4-mile LOS range with a 2.1 dB dipole antenna at 200 kbps, but no information is given about the urban range with a high-gain antenna. If the transmission range does not meet the requirements, the pit may only get a transmission once per lap. Depending on the topology of the endurance course, this could last anywhere from seconds to minutes.

Solution

Extensive range testing will be done to try and replicate the urban transmission range of the chosen wireless transceiver. If the range does not meet the requirements, the team has no choice but to transmit data to the pit only when the transceiver is in range. This is not desirable, but it may very well be the best the team can do given the time and budgetary constraints.

5.3.3 In-house Sensor MCU PCBs

Risk

The team has decided to buy discrete MCUs for each sensor and fabricate custom PCBs for each one. If the PCB printing is not possible in-house, the team may have to alter the design paradigm.

Solution

The team will determine whether or not the custom PCBs can be fabricated before ordering the discrete MCUs. If they cannot be fabricated, other options will be considered for the sensor MCUs. However, a possible change in design paradigm could occur. Because of this risk, the task of designing circuits will occur before parts are ordered so that the team can be sure that the parts they order will be used in the design.

6 Qualifications and Responsibilities of Project Team

6.1 Christopher Riker

Christopher Riker is a 5th year senior at Florida State University, majoring in Computer Engineering. His primary responsibilities as project manager are to control the overall structure of the team and its completion of the project, actively monitor and encourage project progress, and ensure that all deadlines are met. He will maintain constant contact with all team members about their progress and concerns with the particular tasks they have been assigned. In addition to administrative responsibilities, he will also be tasked with general programming and microprocessor programming. He has taken relevant courses to adequately prepare himself for these tasks including: Programming up to COP4530, Microprocessors, and Real-Time DSP. He is also prepared to perform circuit design and analysis by taking Circuits I & II and Electronics I.

6.2 Hebe Perez

Hebe Perez is a senior at Florida State University and currently pursuing a degree in Computer Engineering. Due to her three year Society of Automotive Engineers membership, she was chosen to be the DAQ leader for this project. As the DAQ leader, she serves as the liaison between the Electrical and Computer Engineering department and the FAMU-FSU chapter of SAE by keeping the club members informed on the DAQ system developments as well as bringing in outside help for the DAQ team as necessary. In addition to the role as DAQ leader, she will be working with the other programmers on the DAQ team to write source code for the MCU and the satellite microcontrollers.

Hebe's background include two years of experience researching embedded system applications for smart grids at the Center for Advanced Power Systems. She also has experience with Microsoft's .Net Framework and other higher level software development tools such as github source code repository through her software developer position at VR Systems Inc.

6.3 Dewey Williams

Dewey is a senior at Florida State university majoring in Computer Engineering. He specializes in hardware design, digital interfaces, and digital signal processing. He has been appointed to the position of Financial Manager to manage the team's funds and purchases over the course of the project.

Dewey has been a hobbyist in electronics since he was 10 years old, and has also completed coursework in all areas of computers and electrical systems, focusing on system architecture and digital signal processing. He also has extensive experience with linux and windows system administration and system development. He will be tasked with designing and implementing the DAQ system's digital interfaces as well as overseeing the DAQ's overall design.

6.4 Tyler Dudley

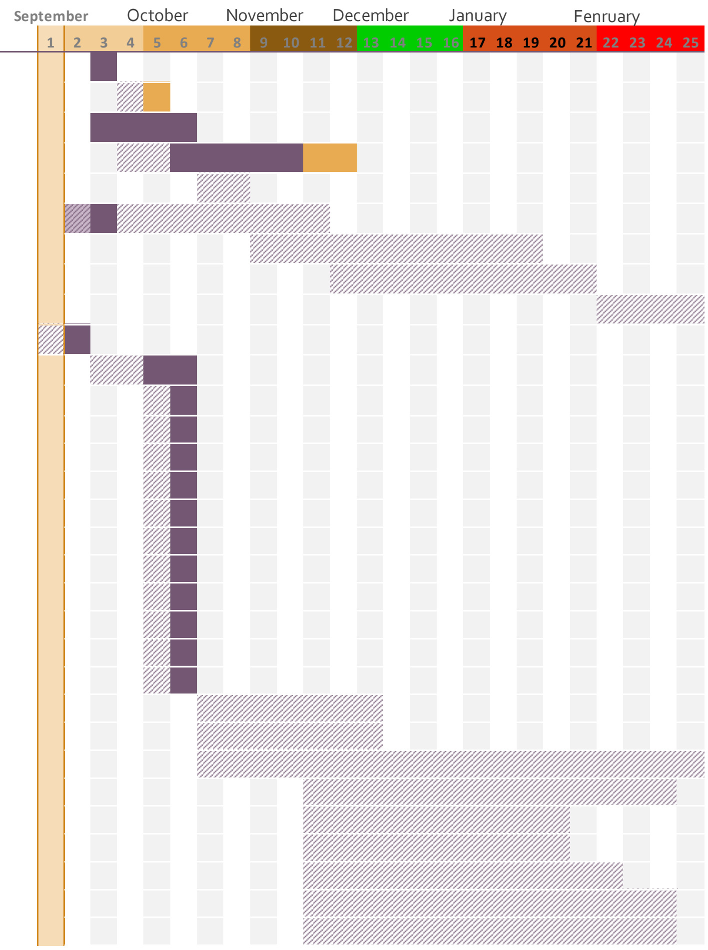
Tyler Dudley is a 6th year senior at Florida Agricultural & Mechanical University, majoring in electrical engineering. He is the Data Coordinator the Baja Design team. His responsibility is to keep, organize, and store all data that is given from the DAQ system. Other task that are assign to this group member is the design of the power system for the DAQ system. He has taken relevant courses in Circuits I, Circuits II, Electronics, Power Electronics, Renewable Energy I.

6.5 Task Assignment Responsibilities

Task	Subtask	Title	Assignment	Due Date	Skills and Knowledge
1		Project Management	Chris	19-Sep	Leadership
2		Concept Generation	ALL	17-Oct	Power Systems/Electronics/Microprocessors
	1	Main Microcontroller Selection	Hebe	15-Oct	
	2	Wireless transceiver selection	Dewey	13-Oct	
	3	Sensor Microcontroller Selection	Chris	15-Oct	
	4	Sensor Network/Databus Selection	Dewey	13-Oct	
	5	Datalogging Medium Selection	Chris	13-Oct	General Programming
	6	Battery Selection	Tyler/Dewey	17-Oct	
	7	Accelerometer Selection	Hebe/Chris	15-Oct	
	8	Fuel Sensor Selection	Hebe	15-Oct	
	9	Suspension Sensor Selection	Hebe	15-Oct	
	10	Hall Effect Sensor Selection	Hebe	15-Oct	
	11	Display Panel Selection	Chris/Dewey	17-Oct	
3		Circuit Design	Dewey/Tyler	21-Nov	Electronics
	1	Regulator Circuit Design	Tyler	21-Nov	
	2	Sensor MCU Circuit Design	Dewey	21-Nov	
4		Programming	Chris/Hebe	28-Feb	C Programming/Embedded Systems
	1	Hall Effect Sensor Programming	Hebe	31-Jan	
	2	Accelerometer Programming	Chris	31-Jan	
	3	Suspension Travel Programming	Hebe	16-Feb	
	4	Tire Pressure Sensor Programming	Chris	28-Feb	
	5	Fuel Level Sensor Programming	Hebe	28-Feb	

7 Schedule

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Needs Analysis Report	3	1	3	1	100%
Needs Analysis Presentation	4	1	5	1	100%
Project Research	3	4	3	4	100%
Project Proposal	4	7	6	7	100%
Design Review	7	2			0%
Design	2	10	3		75%
Parts Purchasing	9	11			0%
Subsystem Implementation	12	10			0%
Testing	22	7			0%
Task 1: Project Management	1	2	2	1	100%
Task 2: Concept Generation	3	4	5	2	100%
Subtask 2.1: Main Microcontr	5	2	6	1	100%
Subtask 2.2: Wireless Transcei	5	2	6	1	100%
Subtask 2.3: Sensor Microcont	5	2	6	1	100%
Subtask 2.4: Sensor Network/	5	2	6	1	100%
Subtask 2.5: Data Logging File	5	2	6	1	100%
Subtask 2.6: Battery Selection	5	2	6	1	100%
Subtask 2.7: Accelerometer Se	5	2	6	1	100%
Subtask 2.8: Fuel Sensor Selec	5	2	6	1	100%
Subtask 2.9: Suspension Senso	5	2	6	1	100%
Subtask 2.10: Hall Effect Senso	5	2	6	1	100%
Subtask 2.11: Display Panel Se	5	2	6	1	100%
Task 3: Circuit Design	7	7			0%
Subtask 3.1: Regulator Circuit	7	7			0%
Subtask 3.2: Sensor MCU Circu	7	25			0%
Task 4: Programming	11	14			0%
Subtask 4.1: Hall Effect Sensor	11	10			0%
Subtask 4.2: Accelerometer Pr	11	10			0%
Subtask 4.3: Suspension Trave	11	12			0%
Subtask 4.4: Tire Pressure Sen	11	14			0%
Subtask 4.5: Fuel Level Sensor	11	14			0%



8 Budget Estimate

The following budget estimate was made using the following assumptions:

- The base salary for all engineers on the project is $30 per hour
- All engineers worked 12 hours per week
- All engineers worked for 32 billable weeks (2 semesters)
- The fringe rate on personnel is 29%
- The overhead rate is 45% of the direct costs
- Direct costs include personnel and expense

A. Personnel					
Engineer		**Billable Hours**		**Base Pay**	**Total Pay**
Tyler Dudley		384		$30	$11,450.00
Hebe Perez		384		$30	$11,450.00
Christopher Riker		384		$30	$11,450.00
Dewey Williams		384		$30	$11,450.00
				Personnel Subtotal	**$46,080.00**
B. Fringe Benefits				29%	**$13,363.20**
C. Total Personnel					**$59,443.20**
D. Expense	**PN/Description**	**Distributor**	**Qty**	**Per Unit**	**Total Price**
Hercules Microcontroller	LAUNCHXL-TMS57004	Texas Instruments	1	$19.99	$19.99
Sensor Microcontrollers	MSP430G2332IN20	digikey	10	$1.86	$18.60
SD BoosterPack	SD Launchpad BoosterPack	43oh	1	$9.99	$9.99
Accelerometer	ADXL335	sparkfun	1	$14.95	$14.95
Fuel Sender	Dorman 911-008	CAE_Services	1	$25.00	$25.00
Xbee-PRO 900HP	XBP9B-DMST-002	Parallax	2	$39.00	$78.00
LiFePO4 Battery	LiFePO4 Battery Packs	All-battery.com	2	$40.99	$81.98
Battery charger	LiFePO4 Charger	Batteryspace	1	$19.95	$19.95
Magnets (x30)	Bundle	Amazon.com	1	$6.88	$6.88
Hall effect sensor (x5)	US1881	Amazon.com	1	$4.49	$4.49
Blank PCB	5.9in x 5.9in	Jameco	3	$3.95	$11.85
LCD Display Module	2.2" Serial TFT SPI LCD	Adafruit	1	$20	$20.00
Pit Computer	Raspberry Pi (B)	Allied Electronics	1	$35	$35
				Extra Parts	$50
				Shipping	$150
				Expenses Subtotal	**$546.68**
E. Total Direct Costs				Total Personnel + Expenses	**$59,989.88**
F. Overhead Costs				45% of Total Direct Costs	**$26,995.45**
G. Total OCO					**$86,985.33**

9 Deliverables

Upon project completion, the team will have a fully-functional, fully operational data acquisition system for the FAMU-FSU SAE Baja vehicle. It is the hope of the team members that they are able to fully meet and/or exceed all requirements set forth by the SAE Baja team. The DAQ will include any hardware used in the construction of the DAQ as well as all of the software used to program the system.

In addition to the system itself, the team will have completed all six milestones associated with the project, as well as several design reviews of the system. All documentation, as outlined above in **Section 1.6** of this document, will be delivered at the end of the year to the project advisor and any additional reviewers.

10 References

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