SAE Baja Data Acquisition System

Team E#5

Milestone #2
Project Proposal and Statement of Work

October 24th, 2014

Introduction

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The Design Team

Project Manager - Christopher Riker (CpE)
cdr11c@my.fsu.edu

- Ensures deadlines are met
- Maintains communication between team members
- Actively monitors and encourages project progress

Financial Manager - Dewey Williams (CpE)
dmw10g@my.fsu.edu

- Keeps inventory of project parts
- Maintains project budget ledger
- Requests funds and purchase orders from ECE department
- Writes and delivers sponsorship requests

Data Coordinator - Tyler Dudley (EE)
dudleyt2004@gmail.com

- Keeps meeting minutes
- Maintains an organized report archive
- Collects and organizes data from the DAQ prototype

DAQ Leader - Hebe Perez (CpE)
hp09d@my.fsu.edu

- Acts as an ambassador between the DAQ team and the SAE Baja team
- Assists financial manager with sponsorship requests
- Coordinates project tasks

2 Christopher Riker

Background

- SAE International holds an annual Baja series competition
- Each team is supplied with 10 Hp Briggs & Stratton engine that cannot be modified in any way, and the team must build a reliable off road vehicle around it
- The vehicle is judged on various design characteristics, and competes in a number of performance based competitions
  - Acceleration
  - Hill Climb
  - Endurance race
- The DAQ system will be designed to improve the FAMU-FSU COE Baja team's placement in the 2015 competitions

3 Hebe Perez

Problem Statement

- In previous competitions, the SAE Baja team had little quantitative information to use when making adjustments to the vehicle.
- The design team aims to design a data acquisition system (DAQ) that will collect, display and store important data about the vehicle
- The system will allow the design team to focus on problem solving rather than problem identification during the competition
- With a successful design, the Baja team will be able to tune the vehicle properly to get the best performance in competition

4 Hebe Perez

Assumptions

- All components 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 5 hours of system operation
  - The storage medium will be large enough to accommodate all collected data
- The main MCU will have enough I/O pins to be able to interface with the subsystems and have room for expansion.
- 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.

5 Hebe Perez

Limitations

- The DAQ will be limited in some ways by the competition rules
  - The engine cannot be modified in any way
  - The DAQ must use its own power source for safety reasons
  - The system cannot interfere with any essential vehicle systems
- The system shall be designed within an initial budget of $600
- The system may be subject to temperatures up to 120º Fahrenheit
- The display must be easily readable by the driver of the vehicle

6 Hebe Perez

Expected End Product

- On-Vehicle Data Collection Unit
  - Securely mounted to the baja vehicle
  - Will collect, store, and display information about
    - Speed
    - Fuel level
    - Acceleration
    - Tire pressure
  - Will send data to the pit unit for display
  - Will warn the driver and pit when refueling/tire change is needed
- Pit unit
  - Will allow the pit crew to actively monitor the vehicle

7 Hebe Perez

Operating Environment

- Vehicle will be driven on extremely rough terrain
- System will be subject to a number of environmental factors, including:
  - Shock
  - Vibration
  - Rain
  - Dust
  - Dirt
  - Mud
  - Rocks
  - Heat
  - RF Interference
  - High temperatures

8 Hebe Perez

Statement of Work

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Project Management

- The DAQ is being designed independently of the Baja car itself
    - The baja team has set forth needs and requirements of the system
    - Teams will collaborate on some design decisions such as mounting
    - The DAQ team's project management will only be concerned with the DAQ system
- The goal of project management is to ensure that this project results in a deliverable product which fulfills all of the baja team's needs
- The project manager and the rest of the team will decide on the division of work based on each team member's strengths, as well as the chronological sequence of tasks.

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Tyler Dudley

Concept Generation

- Within the concept generation task, the team will:
    - Create a list of integral design components and features
    - Choose components and methods to fulfill design needs and fit within project constraints

This section will cover:

1. Sensor Network/Data Bus
2. Processing
3. Power Source
4. Wireless Data Communication
5. Sensors

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Tyler Dudley

Concept Generation

Processing - Central Vehicle MCU/CPU

Component	Clock Frequency	Flash Memory	Onboard Interfaces	GPIO Pins
TI Launchpad Hercules*	80 MHz	384 KB	SPI, I^2C, UART, DCAN	45
Arduino DUE	84 MHz	512 KB	SPI, I^2C, UART	54
Intel Galileo (SoC)	400 MHz	N/A	SPI, I^2C, UART	20
Rasberry Pi (SoC)*	700 MHz	N/A	SPI, I^2C, UART	17

* Models listed: Hercules LAUNCHXL-TMS57004, Raspberry Pi Model B

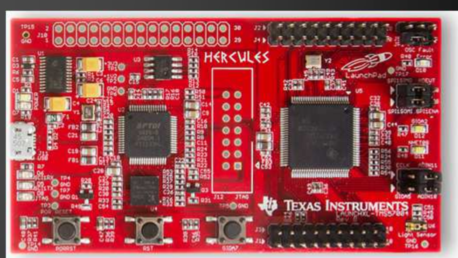
12 Christopher Riker

Concept Generation

Processing - Central Vehicle MCU/CPU

The team has chosen the TI Launchpad Hercules development board for the main MCU/CPU due to the following desirable qualities:

- 80 MHz 32-bit CPUs running in lock-step
- 384 KB Flash - far more than necessary
- SPI support
- 45 GPIO pins
- Price: $20 (potentially available for free through TI)

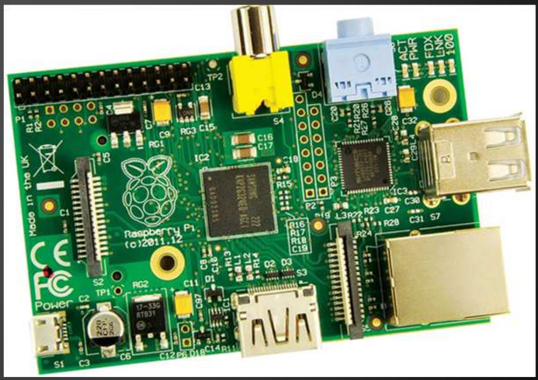


13 Christopher Riker

Concept Generation
Processing - Pit MCU/CPU

Although there are many options for single-board computers and SoC's on the market, the team has decided to use a Raspberry Pi Model B as the base for the pit unit.

Desirable traits of the Raspberry Pi:
- Integrated video processing with multiple outputs
  - Capability of more advanced UI
- Standard USB host interface to interact with a wide range of peripherals
- Large community for support
- Multiple linux and non-linux operating systems to choose from



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Concept Generation
Processing - Sensor Microcontroller

MCU	Clock Frequency	Flash Memory	Onboard Interfaces	GPIO	Per-Unit Cost	Package
ATTiny85	20 MHz	8 KB	USI	6	$0.73	DIP-8
MSP430F*	25 MHz	8 KB	UART, SPI, I^2C, IrDA	29	$3.15	TSSOP-38
MSP430G*	16 MHz	4 KB	SPI, I^2C	16	$1.87	DIP-20

*Devices listed: MSP430F5132, MSP430G2332IN20

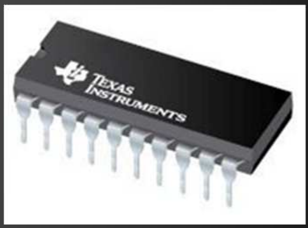
15 Christopher Riker

Concept Generation

Processing - Sensor Microcontroller

The TI MSP430 G series MCU was chosen due to the following desirable qualities:

- Through hole package allows it to be removed from its circuit for programming
  - Simplifies embedded circuit design
  - Through hole circuit boards can be easily milled and assembled on site
- Reduced pin waste compared to F series
- Onboard interfaces



16 Christopher Riker

Concept Generation

Power System - Battery Technology

Technology	Energy/$USD	Energy Density	Nominal Cell Voltage	Time/Cycle durability
Lithium Ion	2.5 W·h/$USD	250–730 W·h/L	3.6-3.7 V	400-1,200 cycles
Lithium Polymer	0.93 W·h/$USD	250-730 W·h/L	3.3-3.7 V	400-1,200 cycles
Lithium Iron Phosphate	0.7-3 W·h/$USD	220 W·h/L	3.2 V	10 years 2,000 cycles
Nickel-Metal Hydride	2.75 W·h/$USD	140–300 W·h/L	1.2 V	500-2,000 cycles

17 Christopher Riker

Concept Generation
Power System - Battery Technology

The team has decided to use Lithium iron phosphate ($LiFePO_4$) batteries due to the following desirable qualities:

- High Energy/$USD - 1.19Wh/$USD
- Cycle durability - 2,000 cycles on average
- Energy density - 220 Wh/L
- Eliminates safety concerns associated with Li-ion and LiPo
- 10 Ah battery can be charged in 1 hour

18 Christopher Riker

Concept Generation
Wireless Communication

Module	Band	RF LOS Range	Output Power	Tx Power Draw	RF Standard	Per-Unit Cost
XBee Pro 802.15.4	2.4 GHz	1 mi	63 mW	710 mW	IEEE 802.15.4	$32.00
XTend RF Module	900 MHz	14 mi	1 W	3 W	Proprietary	$179.00
XBee Pro 900HP	900 MHz	4 mi	250 mW	710 mW	Proprietary	$39.00
XBee Pro ZB	2.4 GHz	2 mi	63 mW	677 mW	ZigBee	$29.00

19 Dewey Williams

Concept Generation
Wireless Communication

The DAQ system will use the XBee-PRO 900HP for its wireless communication due to its desirable features in:

- Cost
- Range
- Power consumption

20 Dewey Williams

Concept Generation
Sensor Network/Data Bus

Method	Service Type	Synchronization	Device Select	Device Relation	Implementation	GPIO Consumption
I²C	Half-duplex	Synchronous	Addressed frame	Master/Slave	Onboard hardware or software	2 pins
SPI	Full-duplex	Synchronous	Per-chip select line	Master/Slave	Onboard hardware or software	4+ pins
CANbus	Half-duplex	Self-Synchronizing	Chip-specific ID	Nodes (Headless)	External hardware	Depends on hardware

21 Dewey Williams

Concept Generation
Sensor Network/Data Bus

The team chose to use an SPI bus due to the following desirable qualities:

- Full duplex operation
  - Simplifies software implementation if necessary
- No overhead from addressing or collisions
- Hardware implementation found in most MCUs
  - Can also be easily implemented in software with USI or even bare GPIO if needed
- Can be implemented very efficiently within the current design paradigm
- GPIO consumption by the chip selects can be mitigated somewhat

22 Dewey Williams

Concept Generation
Sensors

Sensors were chosen using the following criteria:

- Form factor or mounting style
  - Through hole or frame mount
- Cost
- Measurement range
- Output
  - Linear or analog preferred
- Circuit design complexity

Sensors needed:

- Accelerometer
- Fuel Level Sensor
- Tire Pressure Sensors
- Hall Effect Sensor

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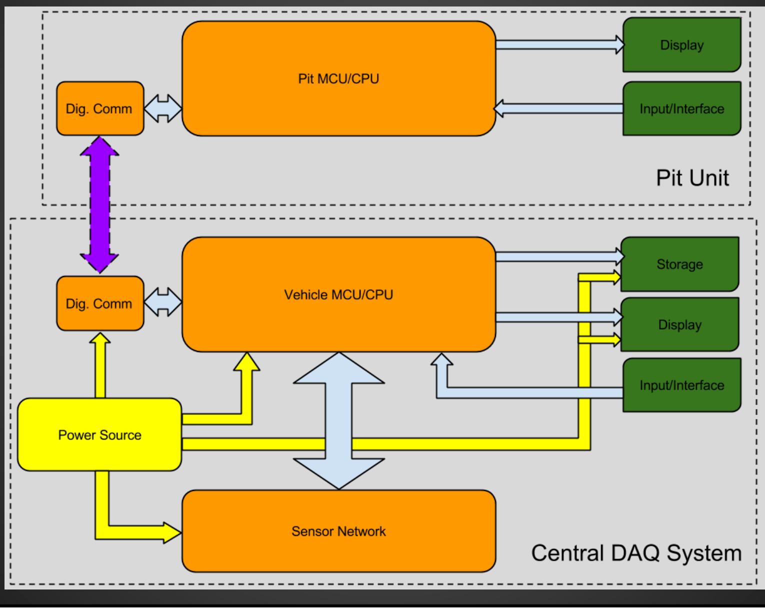
Proposed Design



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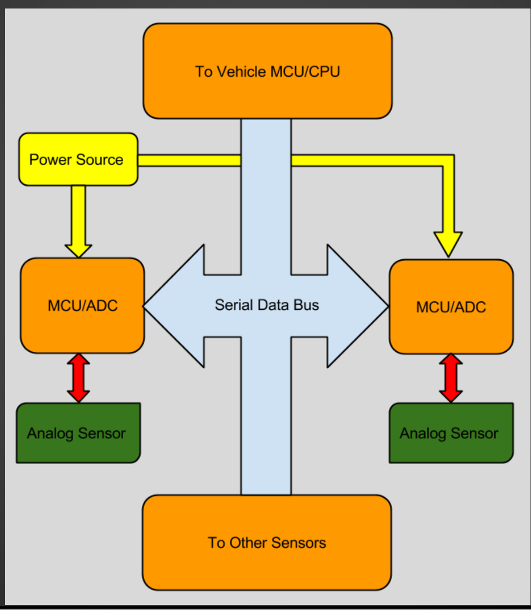
Dewey Williams

Proposed Design



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Dewey Williams

Risk Assessment

- Financial
  - Component Destruction
  - Component Failure
  - Project Cost Overrun
- Safety
  - System Mounting Failure
- Design
  - Tire Pressure Monitoring System
  - Wireless Vehicle-to-Pit Data Transmission
  - In-house Sensor MCU PCBs

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Tyler Dudley

Task Assignment & Project Planning

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Task	Subtask	Title	Assignment	Due Date	Skills and Knowledge
1		Project Management	Chris	19-Sep	Leadership
2		Concept Generation	ALL	17-Oct	Power Systems/ Communictions/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	
		Accelerometer Programming	Chris	31-Jan	
		Suspension Travel Programming	Hebe	16-Feb	
		Tire Pressure Sensor Programming	Chris	28-Feb	
		Fuel Level Sensor Programming	Hebe	28-Feb	

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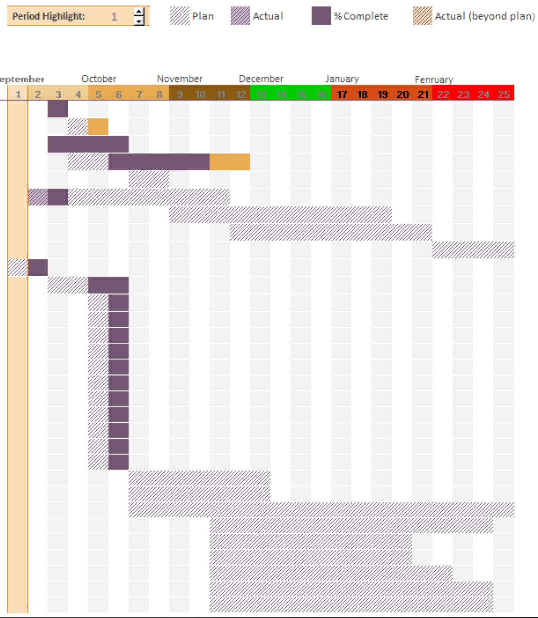
Project Planner

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 Microcontroller Selection	5	2	6	1	100%
Subtask 2.2: Wireless Transceiver Selection	5	2	6	1	100%
Subtask 2.3: Sensor Microcontroller Selection	5	2	6	1	100%
Subtask 2.4: Sensor Network/Data Bus Selection	5	2	6	1	100%
Subtask 2.5: Data Logging Filetype Selection	5	2	6	1	100%
Subtask 2.6: Battery Selection	5	2	6	1	100%
Subtask 2.7: Accelerometer Selection	5	2	6	1	100%
Subtask 2.8: Fuel Sensor Selection	5	2	6	1	100%
Subtask 2.9: Suspension Sensor Selection	5	2	6	1	100%
Subtask 2.10: Hall Effect Sensor Selection	5	2	6	1	100%
Subtask 2.11: Display Panel Selection	5	2	6	1	100%
Task 3: Circuit Design	7	7			0%
Subtask 3.1: Regulator Circuit Design	7	7			0%
Subtask 3.2: Sensor MCU Circuit Design	7	25			0%
Task 4: Programming	11	14			0%
Subtask 4.1: Hall Effect Sensor Programming	11	10			0%
Subtask 4.2: Accelerometer Programming	11	10			0%
Subtask 4.3: Suspension Travel Programming	11	12			0%
Subtask 4.4: Tire Pressure Sensor Programming	11	14			0%
Subtask 4.5: Fuel Level Sensor Programming	11	14			0%



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Budget Estimate
Personnel

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**

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Budget Estimate
Expenses and Overhead

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**

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