Preliminary Design Review Report

ECE 492 - Spring 2016

Table of Contents

- Abstract
- General Requirements Analysis
  - Team Breakdown
  - Full System Requirement and Deliverables
  - Team Requirement Analysis
    - TSV Team
    - VSCADA Team
    - GLV/Cabling Team
    - Motor Characterization/Dynamic Modeling Team
- Acceptance Test Strategy Outline
  - Introduction
  - TSV
  - VSCADA
  - GLV/Cabling
  - Motor Characterization/Dynamic Model
- System Design
  - TSV
  - GLV/Cabling
    - Summary
    - Current Omission
    - Throttle
    - Vehicle User Interface Panels (VUI)
    - VCI
    - TSI
    - CAN Bus
    - Safety Loop System
  - VSCADA
  - Motor + Controller Characterization and Dynamic Model
- System States Analysis
- Calibration and Accuracy Analysis
  - TSV
  - VSCADA
  - GLV/Cabling
- Cost Analysis
- Work Breakdown Structure
  - TSV Team
  - VSCADA Team
  - GLV/Cabling Team
  - Motor + Controller Test and Characterization and Dynamic Model Team

Abstract

This document will present the preliminary schedule and design that the spring 2016 Electric Vehicle team of senior electrical and computer engineering students will complete. Each team has a detailed schedule and breakdown of work that outlines individual responsibilities within requirements taken from the statement of work. The motivation for this project is to put future teams in a place to be able to understand the progress that was made and be able to put together the vehicle for competition. To reach these goals the current team hopes to finish characterizing the motor and controller, debug the VSCADA system, meet formula-EV requirements for the GLV and TSV as well as integrating them.

General Requirements Analysis

Team Breakdown

Leadership: Geoff Nudge and Timothy Andrews
TSV Team: Geoff Nudge, Joe Cericola and Jae Yang
GLV/Cabling Team: Timothy Andrews, Brandon Martinez and Bryan James
Motor Characterization/Dynamic Model Team: Dan Bolognini, Armen Mkhitarian
VSCADA Team: Brendon Carroll and Domenick Falco

Full System Requirement and Deliverables

Requirement	Description	Team Member
Deliverables		
D000	PDR	Jae
D001	CDR	Geoff
D002	User Manual	Bryan
D003	Final Report/Maintainability Problem	Bryan
D004	ATP	Nick
D005	ATR	Tim
D006	QA Results Report	Brendon
D007	Website	Brandon
D008	Complete System, Final Presentation Demo/Delivery	Joe
D009	Conference Paper, Presentation, and Paper	N/A - waived

D010	Poster	Armen
D011	Calibration and Accuracy	Dan
D012	Maintainability Plan	Brendon
D013	Purchasing Report	Joe
D014	Individual Progress Report, Project Status Letters, and Status Presentation	Dan
General Project Requirements		
GPR001	Documentation	Jae
GPR003	EMI/EMC	N/A - waived
GPR004	Hazmats	Bryan
GPR005	Safety and Good Practice	Nick
GPR006	Reliability	Tim
GPR007	Maintainability	Brendon
GPR008	Manufacturability	Brandon
GPR011	Project Video and Final Documentation	Armen
GPR012	Final Disposal of Projects	Dan
R000: General Rules and Requirements		
R000/EV	General Rules and Requirements	Jae
R001: TSV Battery Pack Accumulator		
R001a	Charge Algorithm	Geoff
R001b	Data Acquisition	Geoff
R001c	Displays and Indicators	Joe
R001d	Pack Controls	Jae
R001e	Low Current Output	Jae
R001f	1 Complete Accumulator	Joe
R002: VSCADA		
R002a	Car Dash Display	Brendon
R002b	Safety System	Brendon
R002c	VCI	Brendon
R002d	Cell Phone Interface	Brendon
R002e	Remote PC Interface	Nick
R002f	Throttle Control Interface	Nick
R002g	Maintenance Mode	Brendon
R002h	Drive Mode	Tim
R002i	Drive Demo Mode	Brendon
R002j	Plug and Forget Charging	Geoff
R002k	Shutdown Mode	Nick

R002l	Monitoring and Data Acquisition	Nick
R002m	Modular Data Acquisition System	Nick
R002n	Closed Loop VSCADA Control	Nick
R002o	Event/Error Logging	Brendon
R002p	Capability Additional Features	Brendon
R002q	Robust API	Nick
R003: Grounded Low Voltage System		
R003a	GLV Power	N/A - waived
R003b	GLV Safety Loop	Tim
R003c	Vehicle User Interface	Bryan
R003d	TSI	Brandon
R003e	VCI Hardware	Bryan
R003f	Throttle	Tim
R003g	GLV CAN Bus	Brandon
R004: System Cabling and Interfaces		
R004a	Cabling	Tim
R004b	Interface Control Document	Bryan
R005: Motor+Controller Test and Characterization		
R005a	Static Characteristics	Armen
R005b	Dynamic Characters	Dan
R005c	Efficiency and Cooling	Armen
R006: Dynamical Model		
R006a	Physical Model	Dan
R006b	Simulation	Armen
R006c	Results and Conclusion	Dan

Team Requirement Analysis

Detailed breakdown of tasks associated with requirements found in the statement of work.

TSV Team

R001: TSV Battery Pack Accumulator

R001a - Charge Algorithm

- Develop and Analyze mathematical Model appropriate for Accumulator - Geoff

- Implement in Software on PacMan - Geoff

R001b - Data Acquisition

- Develop PacMan Hardware, allowing interfacing with AMS, sensors, controls, and VSCADA - Joe
- Develop PacMan Software to allow for desired state transitions - Geoff
- Develop PacMan Software to communicate with AMS/LCD over I2C, VSCADA over CAN - Geoff

R001c - Displays and Indicators

- Choose and insure proper interfacing of displays with PacMan - Joe

R001d - Pack Controls

- Choose and insure proper interfacing of controls with PacMan - Jae

R001e - Low Current Output

- Choose and insure proper interfacing of charging circuitry with PacMan - Jae

R001f - Delivery of 1 complete accumulator

- Creation of annotated photographs of pack assembly/wiring - Jae
- Demonstrate System States - Geoff
- Demonstrate Pack Voltage - Joe
- Documents (User's/Maintenance Manual) - Jae

VSCADA Team

R002: VSCADA

R002a: Car Dash Board - Brendon

- Hook up a display to VSCADA
- Navigate to functioning website display to act as dashboard

R002b: Safety loop integration - Brendon

- Able to throw safety loop
- Able to monitor safety loop

R002c: Vehicle Computer Interface - Brendon

- Display all measured values in modular tabs
- Allow full control of Dyno parameters

R002d: Cell Phone Access - Brendon

- Navigate to functioning website display to act as app

R002e: Remote PC Interface - Nick

- Navigate to functioning website display to act as control board

R002f: Throttle Control - Nick

- By default control throttle using remote PC interface
- Allow this control to be bypassed by physical interface

R002g: Car Dash Board - Brendon

- Boot into it as default mode
- Display all measurands
- Allow all values to be controlled via VSCADA

R002h: Drive mode - Tim

- Receive throttle over CAN to control motor via embedded system
- Switches between drive mode and maintenence mode

R002i: Drive mode demo - Brendon

- Demoable test for the VSI

R002j: Plug and Forget Charging - Geoff

- Start charging when plugged in if not fully charged
- Stop charging when fully charged or a fault occurs

R002l: Monitoring and Data Acquisition - Nick

- Allow website to pull from database to display stats
- Constantly update database with recorded parameters

R002m: Read Sensors - Nick

- Read individual and overall battery voltages
- Display temperature of all available thermometers
- Display torque, RPM, load, power, and throttle as read from Dynamometer
- GPS is waived
- Calibration to show meaningful units

R002n: Automated VSCADA - Nick

- Allow parameters to be scripted and run in correct sequential fashion

R002o: Alarm Extension - Brendon

- Produce software that will be capable of sounding alarms when thresholds are breached

R002p: Modular Design Concepts - Brendon

- Process for adding new nodes or sensors should be straightforward
- Future students should not be required to modify existing core code
- As many cases as possible should be anticipated

R002q: API Documentation for Future Students - Nick

- Process required by by R002p should be intuitive and manageable with ease by someone with a senior ECE's skillset
- Process required by by R002p should be as documented as possible to facilitate this

GLV/Cabling Team

R003: Grounded Low Voltage System

R003b: GLV Safety Loop - Tim

- Develop and fabricate a new or revised safety loop system - Brandon
- Test the operation of the safety loop system - Bryan
- Analyze cabling requirements for the safety loop - Tim
- Generate a safety loop analysis document - Tim
- Interface safety loop with car and VSCADA - Brandon

R003c: Vehicle User Interface - Bryan

- Assess needed controls, indicators, switches, displays, and Big Red Buttons - Tim
- Design the layout of the interfaces - Bryan

R003d: TSI - Brandon

- Tie TSI to GLV safety loop and VSCADA - Tim
- Ensure that TSI meets Curtis motor controller requirements - Bryan
- Observe interfacing of TSI with SCADA and CAN bus - Brandon

R003e: VCI Hardware - Bryan

- Ensure required components for display are present - Bryan
- Ensure required interface components are present - Tim

R003f: Throttle - Tim

- Ensure dyno setup can interface with some type of throttle

R003g: GLV CAN Bus - Brandon

- Ensure that GLV and TSV segments of CAN bus are properly connected - Bryan

R004: System Cabling and Interfaces

R004a: Cabling - Tim

- Design cabling setup for dyno and car - Bryan
- Test cabling within system - Brandon

R004b: Interface Control Document - Bryan

- Document cables within the system - Tim
- Document assembly instructions - Brandon
- Document signals transmitted - Brandon
- Wiring Interface Document - Draft

Motor Characterization/Dynamic Modeling Team

R005: Motor + Controller Test and Characterization

R005a - Static Characteristics : Armen

- Familiarize with Labview - Armen & Dan
- Setup development environment and get drivers to work with curtis controller - Armen
- Anticipate limits of operation for torque and RPM of formula car - Dan
- Prepare list of desired static data characteristics - Dan
- Work with Curtis controller to understand programmable parameters - Armen
- Collect operating data using current VSCADA system - Armen
- Prepare performance curves based on collected data - Dan
- Prepare Accuracy Analysis for Static Data - Dan

R005b - Dynamic Characteristics : Dan

- Assess limits of operation for torque and RPM of formula car - Dan
- Prepare list of desired dynamic data characteristics - Dan
- Use acquired static data to create estimates for dynamic model parameters - Armen
- Prepare Accuracy Analysis for Dynamic Data - Dan

R005c - Efficiency and Cooling : Armen

- Analyze efficiency data from static data collection - Armen
- Prepare and measure efficiency and cooling requirements in static scenarios - Armen
- Determine measurands for finding cooling system performance - Dan
- Run test and analyze cooling system performance - Dan

R006: Dynamic Model

R006a - Physics Model: Dan

- Prepare list of required parameters (mass, gear ratios, etc.) - Dan

- Coordinate with MechE team to find estimates for desired parameters - Armen
- Develop physics model based on analytical estimates and empirical data - Dan

R006b - Simulation : Armen
- Explore previously generated Simulink model for understanding - Armen
- Build Simulink model for simulating motor + controller setup - Armen
- Run multiple simulations using empirical and predicted data - Dan
- Demonstrate working simulation to professors - Armen

R006c - Results and Conclusions : Dan
- Determine energy requirements for competition and optimal values for gear ratios and throttle - Armen
- Prepare rough draft of results and conclusions documentation - Dan
- Review rough draft with Professor Yu - Dan
- Finalize results and conclusions documentation - Armen

Acceptance Test Strategy Outline

Introduction

This is a preliminary document, to be discussed at PDR. It will be improved and the details of each test defined prior to CDR. It describes a high level plan that will prove that the final fabricated system meets all requirements.

TSV

<u>R001a</u> - Charge Algorithm
- Mathematical analysis of battery charging. Model shall include voltage and temperature, and include coulomb counting.
- Testing on accumulator test stand.
    - charging starts appropriately, normal operation
    - charging stops appropriately, normal operation
    - charging stops appropriately, all failure modes
- Charging a discharged TSV accumulator with LiFePO4 cells

<u>R001b</u> - Data Acquisition
- Calibration Accuracy and Analysis (D011)
- Test I2C messages
- Test all CAN messages with Lab Terminal, in test stand, in all states

- Test all CAN messages with VSCADA board, in test stand, in all states
- Test all CAN messages with Lab Terminal, in Accumulator with LiFePO4 cells, in all states
- Test all CAN messages with VSCADA board, in Accumulator with LiFePO4 cells, in all states

R001c - Displays and Indicators

- Test all desired displays in test stand, in all states.
- Test all desired displays in Accumulator with LiFePO4 cells, in all states.

R001d - Pack Controls

- Test navigation to each desired data, or set value, in all states.
- Set a range of values via controls, in all states.
- Reset PackMAN in all states.
- Reset each AMS in all states.

R001e - Low Current Output

- Apply load to draw 29 A.
- Apply load to draw 31 A.
- Test Charging functionality.

R001f - Delivery of 1 complete accumulator

- Annotated photographs of wiring harness.
- Documentation (Maintenance, User's Manual, BOM, etc.)
- Demonstration of System States, and availability of TSV power

VSCADA

R002a R002c R002d R002e - General UI

- Demonstrate dashboard UI functionality over wide range of time and values
- Simulate CAN BUS
- Receive actual CAN BUS from a working system

R002f - Throttle Control

- Use Scripting to demo

R002g - Maintenance mode

- Ability to view and control system aspects

R002l - Data Logging

- View and transfer data

R002m - Data display

- Display all promised statistics compare to what we have in the old setup

R002n - Data Scripting

- Demonstrate values automatically being set

R002p R002q - Modularity and documentation

- Present professors the completed design for approval

GLV/Cabling

R003b - GLV Safety

- Test for safety loop operation under system faults

R003c - Vehicle User Interface Panels

- Test that buttons and interfaces operate as expected

R003d - Tractive System Interface

- Test that the TSI interacts properly with the safety loop and trips it as needed
- Monitor that TSV remains isolated from the GLV and ground

R003e - Vehicle Computer Interface Hardware

- Observe various items displayed on the interface
- Ensure interface hardware connects and acts properly

R004a - Cabling

- Test continuity and resistance of cables and connections at various points

R004b - Interface Control Document

- Present a completed document for review and approval

Motor Characterization/Dynamic Model

R005a - Static Characteristics

- All specified data measured across full range of operation for torque and RPM
- Data calibration/accuracy falls within specified tolerances

R005b - Dynamic Characteristics

- All desired model parameters estimated
- Accuracy analysis determines that parameters are calibrated correctly within proper tolerances

R005c - Efficiency and Cooling

- Motor + controller efficiency and cooling requirements have been successfully measured
- Tests comparing expected cooling system behavior to measured values are successfully completed

R006a - Physics Model

- Physics model output provides reasonable prediction of fully integrated system performance

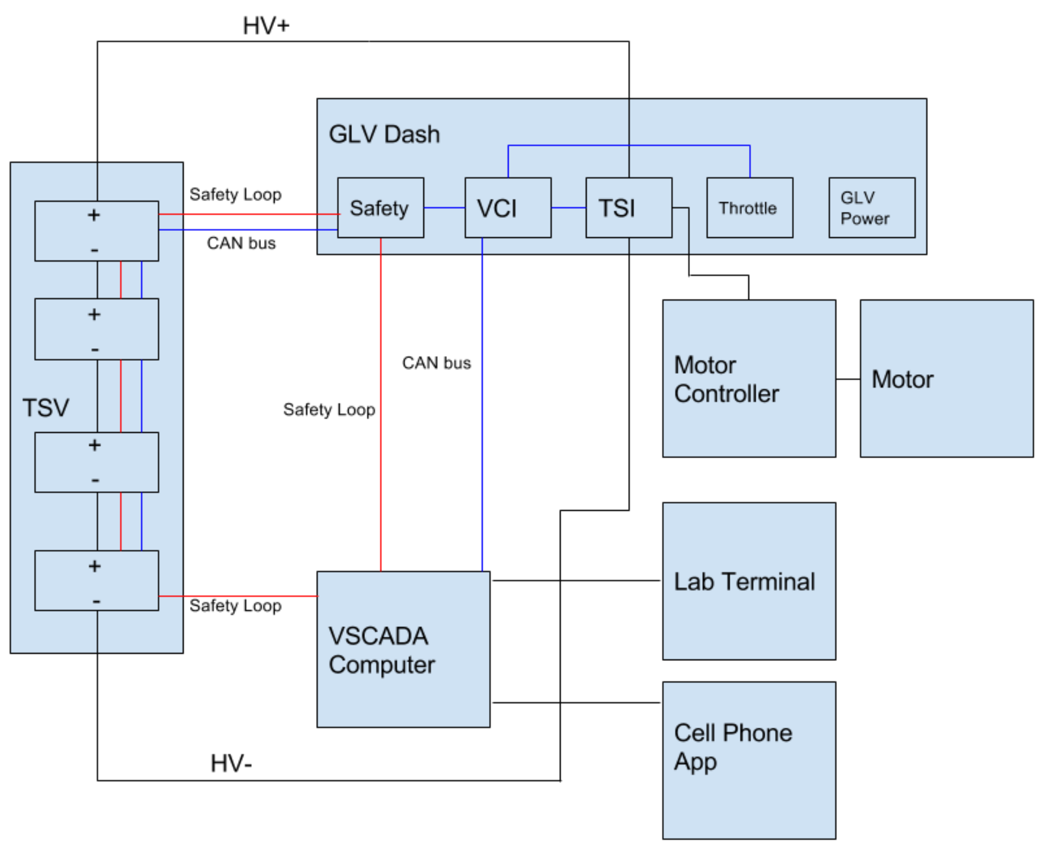
R006b - Simulation

- Simulation is able to provide outputs expected by the generated physics model
- Working demonstration to professors successfully completed

R006c - Results and Conclusions

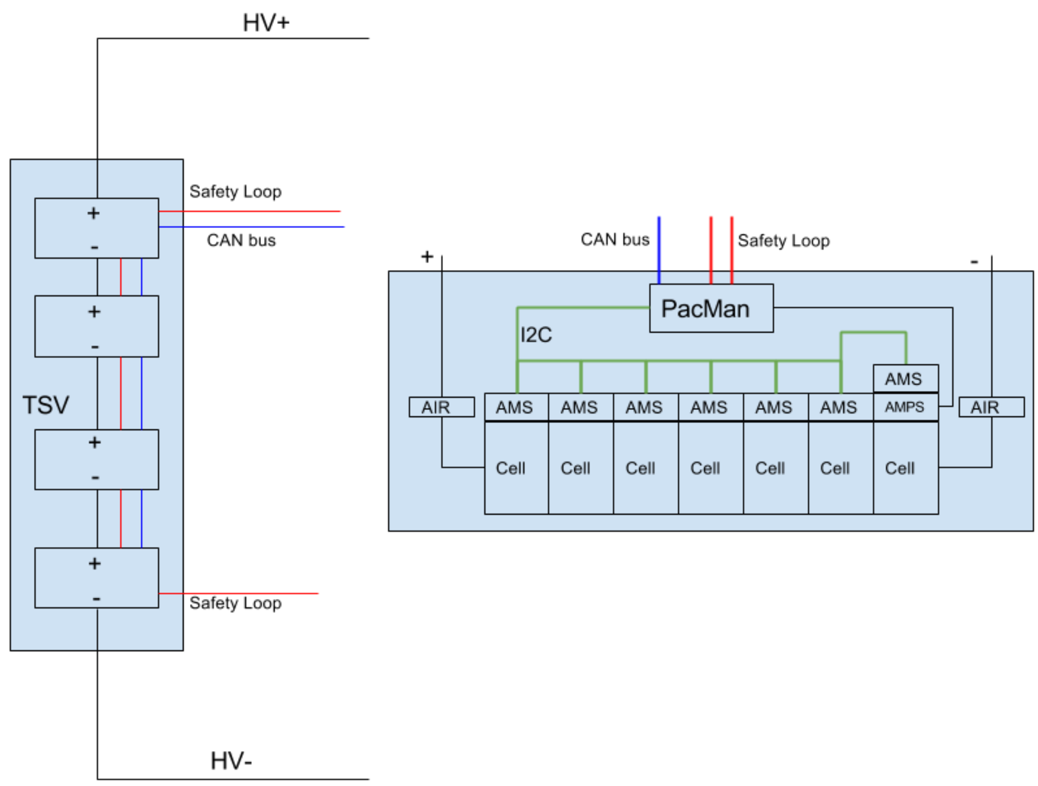
- All data and calculations included in results and conclusions documentation falls within required tolerances, and model provided generates expected outputs for fully integrated system

System Design



TSV

The Tractive System Voltage consists of 4 Accumulator packs. Each Pack contains 7 LiFePO4 cells, each monitored by an Accumulator Management System (AMS) board. All AMS boards communicate via I2C with a PacMan (Pack Manager) board. PacMan communicates with VSCADA computer via CAN bus.
The safety loop also interfaces with the PacMan board. Should a safety loop fault occur, TSV can be disconnected from the rest of the vehicle by opening AIRs (Accumulator Isolation Relays). Twist lock connectors/pigtails allow for packs to be disconnected from the system for maintenance. A current sensor (AMPS in the above figure) also provides the current delivered by/to the pack to the PacMan via GPIO.



Charging is accomplished by connecting to a 30 amp fuse protected input on the pack. This may also be used as a max 30 amp accessory power supply while not charging. An LCD display and push buttons allow for navigation to available information on cell voltage, temperature, current, and system state.

GLV/Cabling

*Note we felt that the 2015 GLV design was headed in the right direction and our GLV system design was created referencing their GLV design.

Summary

The GLV system has been divided into the following subsystems: Safety,TSI, VUI , and VCI). System state diagrams and explanation are included in the system state analysis. Much of what the GLV system provides is essential to a functioning demo. For instance, the VCI must implement sensors to take data, convert this data, and provide it to the VSCADA. This is a linear data path, which is not appropriate for a state analysis. As a result, much of the information given in this System State Analysis will be done in paragraph form, explaining what information the GLV collects, where the information comes from, and where it is stored.

Current Omission

R003a -GLV Power

We made the decision to omit the GLV Power requirement. We felt that GLV power system requirements in the scope of the 2016 team could be met with lab power supply. With this decision we also believe that incorporation of the GLV system wide power can be met with almost no modification to the work will do in the Spring of 2016. Considerations for this will be made in our design decisions and there also be an effort to reduce the variety of voltages used throughout GLV so interfacing with GLV will be easier in the future. But we believe this to be a general GLV requirement and outside of the GLV Power requirement.

Throttle

We intend to add in a separate computer for handling the drive mode and a discrete potentiometer for handling the throttling of the motor. The plan is to have a small CPU as the go between the SCADA system and the motor controller and car drive systems. That way the drive systems are handled independently of the SCADA system. Within the scope of this year the only function this will provide is throttling via a stand alone potentiometer.

Vehicle User Interface Panels (VUI)

We believe that this will be one of the simpler requirements to accomplish. This will be heavily VSCADA dependant or safety loop dependant. We intend to use the existing buttons, switches, and LCD display to generate this system. The intention is to make the buttons and interfacing systems for the car highly modular so they car be moved directly from the rack to the car.

VCI

One task of the VCI subsystem is to work with VSCADA to collect and implement data from sensors. The breakdown between VSCADA and GLV (VCI specifically) will be determined by the switch from analog to digital data. VCI in conjunction with TSV will be responsible for sensor systems on the car this will directly interface with VSCADA. That way VSCADA team can monitor car sensors and faults. The intention to put the bulk of the work for this into VSCADA so we can focus purely on hardware.

TSI

The main purpose of the TSI system is to control high voltage line between the Accumulator Isolation Relays (AIRS) of the TSV and the motor controller. The TSI system must accomplish this task while keeping the TSV system galvanically isolated from the rest of the vehicle. When GLV power is present in the load controller, an LED will light up indicating that the load controller is on. The TSI system is controlled directly from the VSCADA system. The load controller will also connect VSCADA to a voltage sensor that constantly measures the voltage of the high voltage line. The load controller is also an integral part of the safety loop because of the high voltage lines. The Isolation Monitoring Device constantly monitors the TSI system for an isolation failure. When a failure is detected, the AIRs are automatically opened, shutting down the high voltage power from the rest of the system. TSI is meant to house or interface with the safety procedures in TSV.

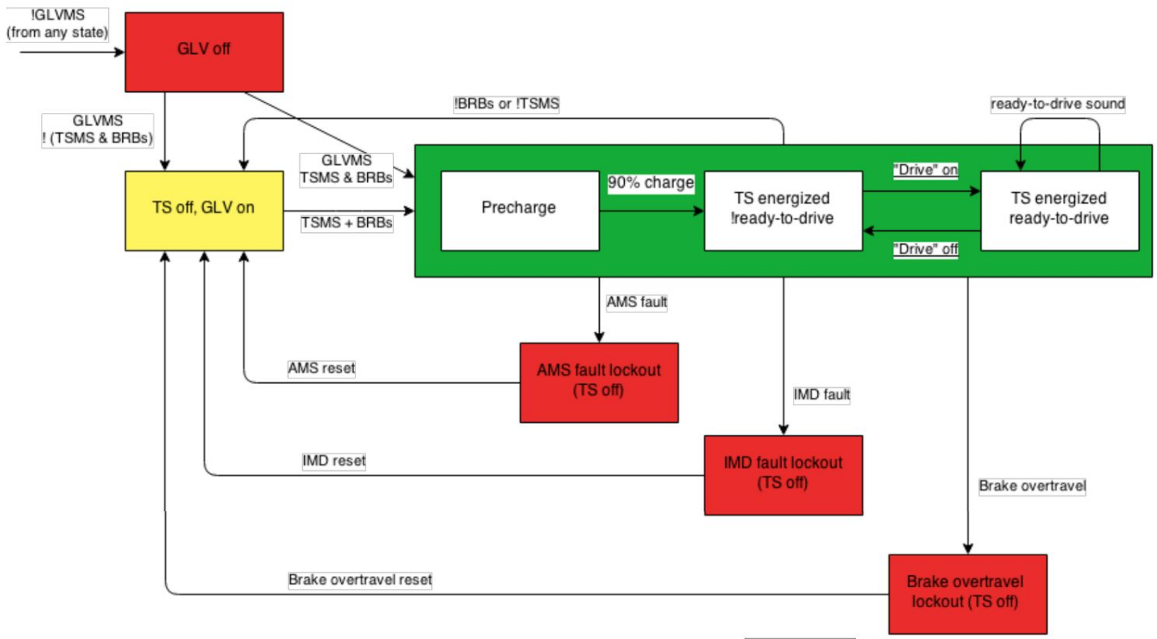
CAN Bus

The majority of the CAN bus system relies on the GLV, but the CAN into the Curtis relies on TSV. Additionally, there is a CAN bus isolator that separates the GLV and TSV-reliant sections.

		Controlled Systems			
		Engine Starter (High Current)	GLV Supply to: Instrumentation, Data Acquisition, Computers, Telemetry, Etc.	I.C. Engine, Ignition, Fuel Pumps, Starter Solenoid, Etc.	AIRs (TS Voltage)
Shutdown Sources	TSMS				OFF
	Cockpit BRB			OFF	OFF
	AMS			OFF	OFF
	IMD			OFF	OFF
	Brake Over-Travel			OFF	OFF
	Side-Mounted BRBs		OFF	OFF	OFF

	GLVMS	OFF	OFF	OFF	OFF

Shutdown Priority Table

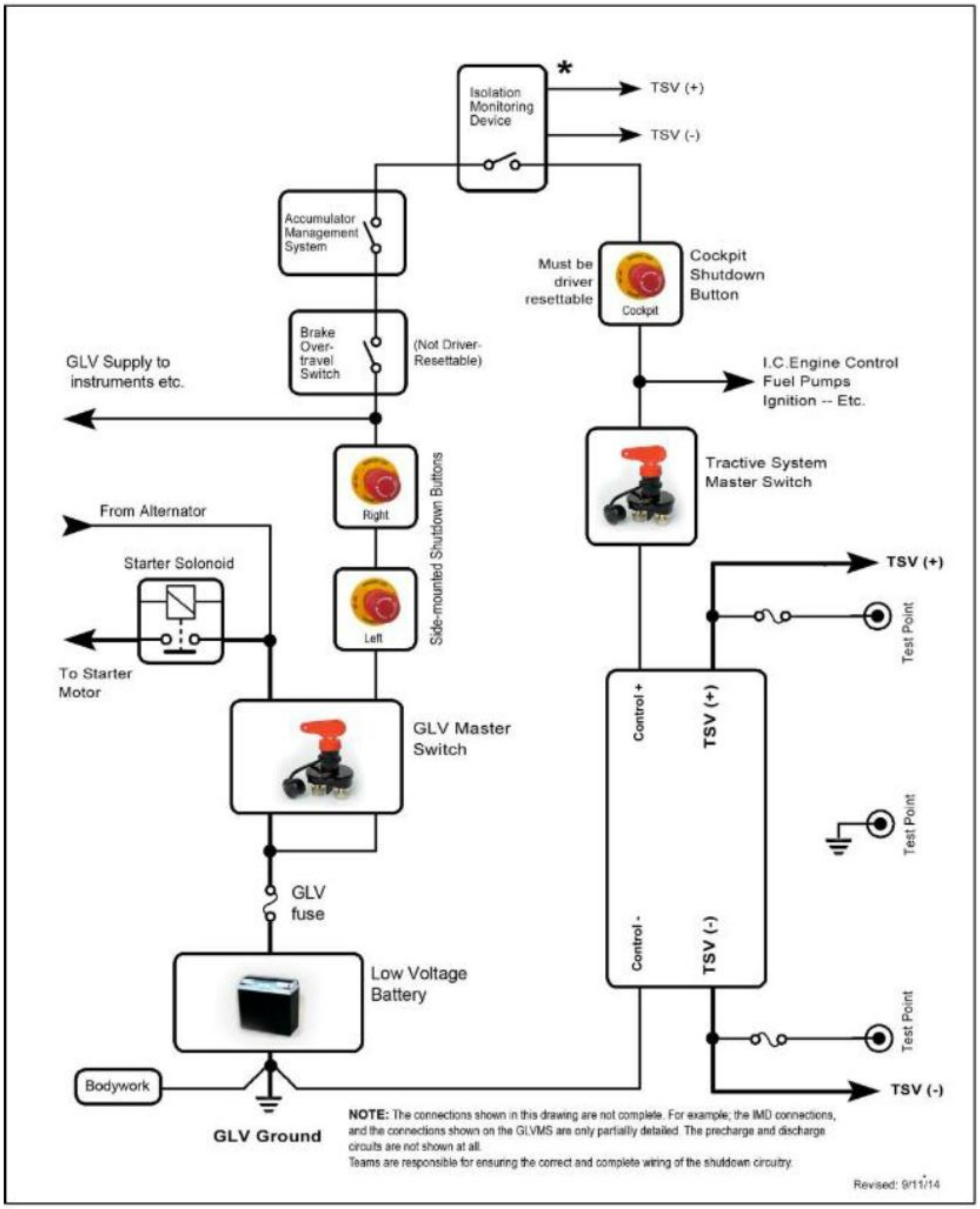


Shutdown State Diagram

The state diagram here indicates the shutdown behavior of the system. If the GLV is turned off, the entirety of the system shuts down. However, if the system encounters a fault that does not cut the power to the GLV, the tractive system loses power.

Safety Loop System

This year's design is based off the 2015 model, which implements a two tiered safety loop system that essentially isolates the driver from controlling the entire loop. In this manner, there is an internal safety loop that contains the controls that the driver should be allowed to reset, and there should also be an external safety loop that contains controls that the driver has no control over. This is a new specification that was added after the 2013 design. Therefore, we will finish what 2015 has started. The figure below, "Safety Loop System Diagram," depicts the required system by the EV spec. The 2015 design currently satisfies and exceeds the nested system.



Safety Loop System Diagram

VSCADA

VSCADA will be largely refactored in order to best accommodate the current requirements and the needs of future Lafayette teams. All UI and Displays will be accessible from anywhere via web page hosted on the VSCADA card. This web page will run a javascript app that improves the current GUI in every way. Any computer or mobile device will have full access to all controls and statuses. Also located on the site will be the dashboard, to which the dashboard screen will auto-navigate to.

The new system will also be designed to be far more sustainable, something not at all accomplished by the existing code base. The current code base is lacking in both clarity and documentation, aspects we hope to focus on. Teams years from now should have no issue looking at our code and figuring things out.

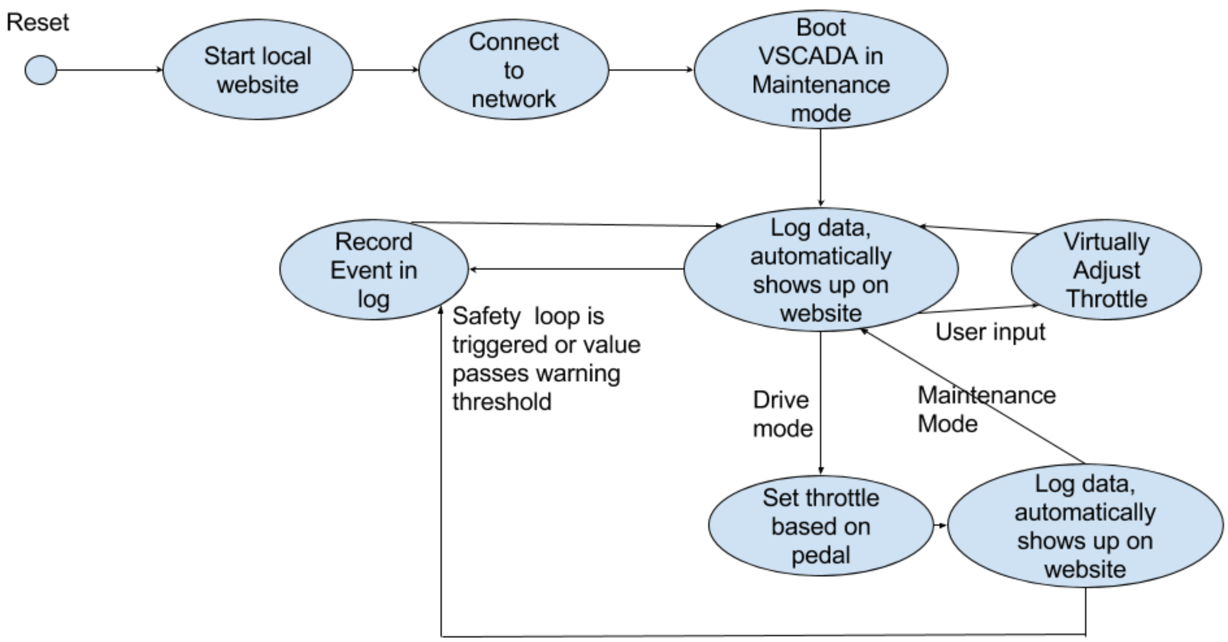
To accomplish friendliness, we are planning an API approach. A python based “sensor API” is planned. A requirement of making the code sustainable is to make adding new modes, like drive demo, or sensors, such as GPS, as simple as possible. After this year it should not be necessary for any group to touch the core VSCADA code.

Necessary sensor readouts will be organized into managers which can be thought of similar to tabs. These managers will contain similar sensors and provide full readout and control of their parameters. The sensor data will be acquired over CANBus protocols and sent to the web server for interpretation.

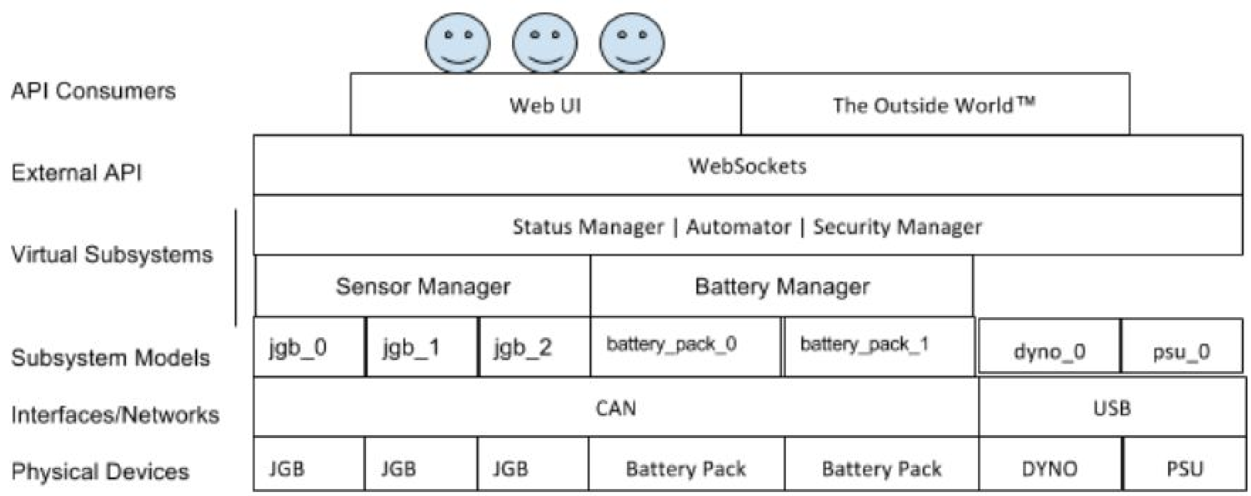
The webserver will also keep logs of all the data in a database. This database will be network transferable and physically transferable via SD card.

The webserver will also be capable of sending commands back to VSCADA in order to adjust parameters as needed. Parameter adjustment can be done manually or it can fed in using a script which will run automated tests for you.

As far as ordering goes for the system the following is a brief preliminary State transition diagram that covers our proposed requirements we intend to meet.



Lastly, a summary of the proposed architecture with example modules and sensors is below.



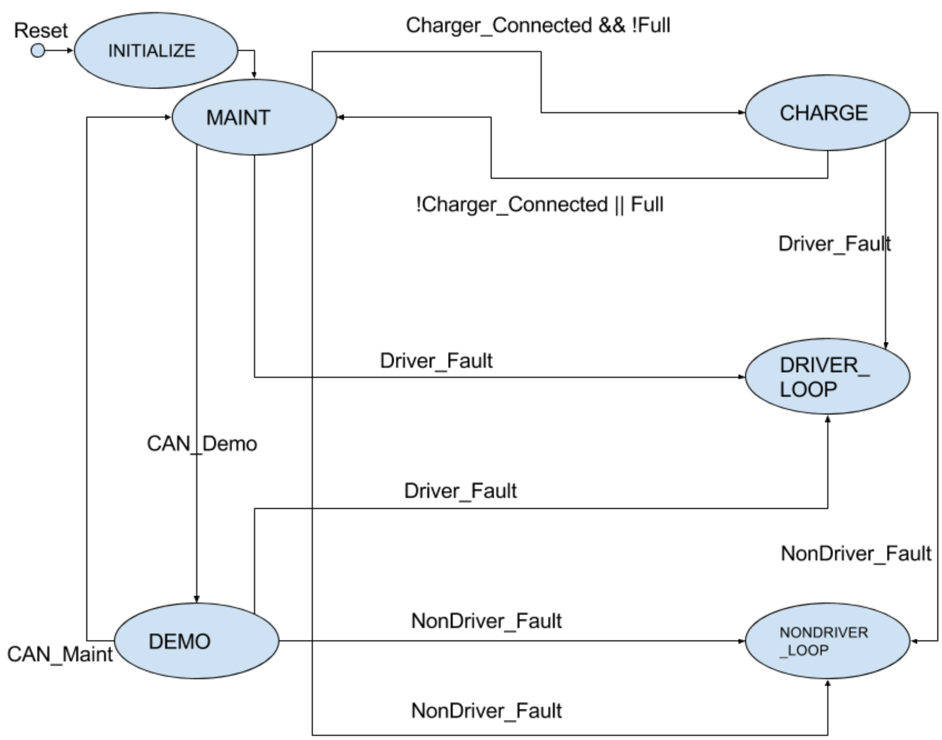
Motor + Controller Characterization and Dynamic Model

Empirical test data for the combined motor and controller system on the dynamometer test stand need to be used for characterizing the setup. In order to do this, limit for the full range of torque and RPM for the car must be determined, and data will be collected across this range. This data will be considered within the constraints of the throttle input and Curtis controller. From this data, dynamic model parameters will be will be determined. Additionally, efficiency and cooling requirements will be measured, and cooling system performance will be determined. All of these measurements will be presented in an analysis report with a confidence interval dependent on the range of measurement.

The data and parameters acquired above will be used in conjunction with predicted parameters for the fully integrated vehicle in order to create a dynamic model for the vehicle. The predicted parameters will be determined in coordination with the MechE team. Upon reaching a final working demonstration of simulation, a document detailing the results and conclusions from the simulation will be prepared, including estimates of optimal vehicle operating parameters (gear ratios, accumulator current, throttle operation, etc.).

For sustainability and usability in the future, the programs created in labview will be documented with a user guide.

System States Analysis



System states are stored in the VSCADA computer. The TSV PacMan board will also maintain a mirror of the system state, but is a slave to VSCADA. The single exception is an AMS Fault (NonDriver), in which case the VSCADA computer will update its state to match.

Upon state up, an INITIALIZE state is entered, followed immediately and unconditionally by a MAINT state. This state allows repairs, testing and data collection, but without TSV voltage present outside the Accumulators. VSCADA may set the state to DEMO, enabling TSV voltage, if all systems are ready.

CHARGE state is requested by PacMan via CAN, and set by VSCADA. The request occurs when a power source is present at the 30A input/output of an Accumulator, and it is not fully charged. When charging is completed the PacMan notifies VSCADA over CAN and the state returns to MAINT. TSV voltage is not delivered in this state.

All the above states transition to DRIVER_LOOP if a fault occurs in the Safety Loop that the driver may reset. Similarly, all these state transition to NONDRIVER_LOOP in the event of a fault that the driver may not reset. Transitions from these states will always be to MAINT, but the condition will depend on the fault. Fault states are similar to MAINT, allowing data collection, but no TSV voltage is delivered.

State information and data will be accessible on the VCI, Lab Terminal (if connected), and mobile app in all states. Throttle inputs will only be passed to the motor controller through the TSI in DEMO, but can be monitored in all other states.

Calibration and Accuracy Analysis

List of measurands for system test plan (calibration and uncertainty data to be determined prior to CDR):

TSV

- TSV Battery Pack Current
- TSV Battery Pack Voltage
- TSV Battery Pack Individual Cell Voltage
- TSV Battery Pack Individual Cell Temperature
- TSV Battery Pack 30A input/output Voltage
- TSV Battery Pack 30A input/output Current

VSCADA

- Individual Battery Voltages
- Combined Battery Voltages
- Temperature of anything hooked up to CANBus
- Motor Torque
- Motor RPM
- Motor Load
- Motor Power

GLV/Cabling

- AIRS voltage
- Ready to Drive sound length
- TSEL blinking frequency
- Pre-charge relay open/close time
- Main relay open/close time
- Discharge and pre-charge circuit voltages
- GLV Operating Voltage
- Conductive material spacing
- Cable tension tolerances

Cost Analysis

Gives money allocated to each team group. Note that $300 has also been allocated to cover shipping costs across all groups.

Item	Quantity	Unit Price	Total
TSV			
		Group Subtotal	**$850**
VSCADA			
		Group Subtotal	**$400**
GLV			
		Group Subtotal	**$900**
Cabling			
		Group Subtotal	**$300**
Motor Characterization and Dynamic Modeling			
		Group Subtotal	**$250**
Shipping and Handling/Tax/General			
		Group Subtotal	**$300**
		Project Grand Total	**$3000**

Work Breakdown Structure

TSV Team

Task Name	Person Responsible	Task Due
Schematic for Display/Controls	Jae	Week 3
State Diagram + Tool Chain	Geoff	Week 3
Order Parts, mech Drawing for Panel	Jae	Week 4
PCBs and Parts Ordered	Joe	Week 4
Demonstrate Code for CAN and I2C packets	Geoff	Week 4
Build Panel	Jae	Week 5
1 Built Board	Joe	Week 5
Wiring Diagram for Pack Internals	Jae	Week 6
Confirm/Disprove Operation of Board by QA	Joe	Week 6
Choose and order wiring parts	Jae	Week 7
Demo of system on Test Stand	Geoff	Week 7
Build Pack	All	Week 8
Charge Algorithm Chosen	Geoff	Week 10
Charge Algorithm Demoed	Geoff	Week 11
Charge Pack Successfully	All	Week 12
Spin Motor Successfully	All	Week 13
Complete ATP and QA Checklist	All	Week 14
FDD Demo Prepped	All	Week 15

VSCADA Team

Task Name	Person Responsible	Task Due
Dev environment operational	Brendon	Week 3
Sketch of the UI	Nick	Week 3
Read in Virtual CANbus	Brendon	Week 4
Graph Spoofed CANbus	Nick	Week 6
Add Logging to Subsystem Models	Nick	Week 6
Implement CANBus abstraction on the Dev Machines. Read in real traffic.	Nick	Week 7
Basic read-only user interface for maintenance	Brendon	Week 8
Add Write Functionality to web interface	Brendon	Week 8
Basic setup of onboard computer	Brendon	Week 10
Onboard computer interfaces with onboard touch-screen dashboard	Nick	Week 11
Move Software from dev machines to actual on board computer	Nick	Week 11
Implement subsystem models that use CAN	Brendon	Week 13
Implement Local subsystem models	Brendon	Week 13
Integration with other groups for final integration	Brendon	Week 13
Tutorial and documentation for future groups	Nick	Week 13

GLV/Cabling Team

Task Name	Person Responsible	Task Due
Confirm/ Disprove JGB Operation	Tim, Brandon	Week 3
Spec Drive Computer CPU and CAN shield	Tim	Week 4
List of GLV/Cabling Require Purchases	Brandon	Week 5
Order Necessary Parts and Cables	Tim	Week 5
Schematic for Interface	Bryan	Week 5
Build Safety Loop	Tim, Brandon	Week 6
TSI Design/Construction	All	Week 7
Demo Safety Loop	All	Week 10
Test Safety Loop Interface with Car/VSCADA	All	Week 11
Integrate and Test TSI	Tim, Brandon	Week 12
Safety Loop Documentation	Bryan	Week 12
Demo Proper CAN Bus Operation	Tim, Bryan	Week 13
Final Cabling Test	Brandon	Week 13
Complete ATP and QA Checklist	All	Week 14
Cabling Interface/Interconnection Document	Bryan	Week 14
FDD Demo Prepped	All	Week 15

Motor + Controller Test and Characterization and Dynamic Model Team

Task Name	Person Responsible	Task Due
Paper Discussion with Professor Yu	Dan	Week 3
List of Measurands for Analysis	Armen	Week 3
Modeling Technique Chosen	Dan	Week 4
Range of of measurement/expected values chosen	Armen	Week 4
Data Acquisition	All	Week 5
Data Analysis For Static Cases Completed	Dan	Week 6
Dynamic Model Parameters Chosen	Armen	Week 6
Data Analysis For Dynamic Cases Completed	Dan	Week 8
List of Measurands for Cooling System Performance	Armen	Week 8
Analysis for Cooling System Performance	Dan	Week 9
Car Parameter Estimates from discussion with MechEs	Armen	Week 10
Physics Model Completed for fully integrated car	Dan	Week 12
Simulink Model Set Up	Armen	Week 12
Simulations Run Using Completed Simulink Model	Armen	Week 13
Energy Requirements for Competition and Optimal Gear Ratio/Throttle Outlined	Armen	Week 13
Results and Conclusion Documentation	Dan	Week 14
Final Demo of Characterization + Model	All	Week 15