Lafayette Electric Vehicle 2015

ECE 492: Senior Design II
Afternoon Critical Design Review
March 11, 2015
Hugel 100

Roadmap

8. Meet the Afternoon Teams
9. Interface Control Review
10. Vehicle Supervisory Control and Data Acquisition (VSCADA)
    a. Daemon
    b. Interfacing
    c. User Applications
    d. Data Storage
11. Dynamometer (DYNO)
    a. Decomposition and Definition
    b. Integration and Recomposition

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Meet the Afternoon Teams

- Vehicle Supervisory Control and Data Acquisition (VSCADA)
  1. Yiming Chen
  2. Bikram Shrestha
  3. Rameel Sethi
  4. John Gehrig
  5. Sam Cesario
  6. Adam Cornwell
- Dynamometer (DYNO)
  1. Steve Mazich
  2. Brendan Malone
  3. John Bloore
  4. Nate Hand
  5. Alex Hytha

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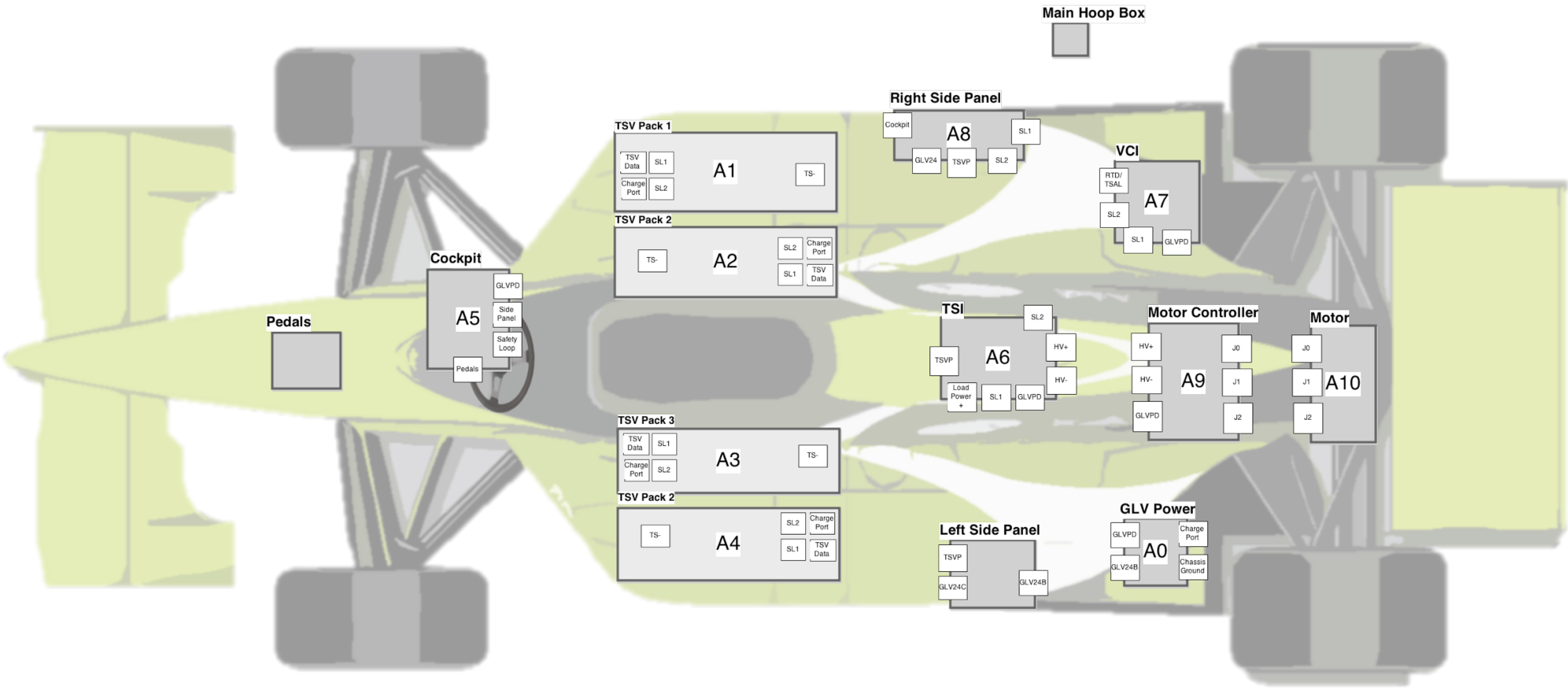
Interface Control

An Interface Control Document was created to accurately and completely define all (electrical, mechanical, semantic) aspects of top-level interfaces to allow different designers to coordinate with each other successfully.

Next, we will discuss these top-level interfaces.

System Assemblies Layout - Top View



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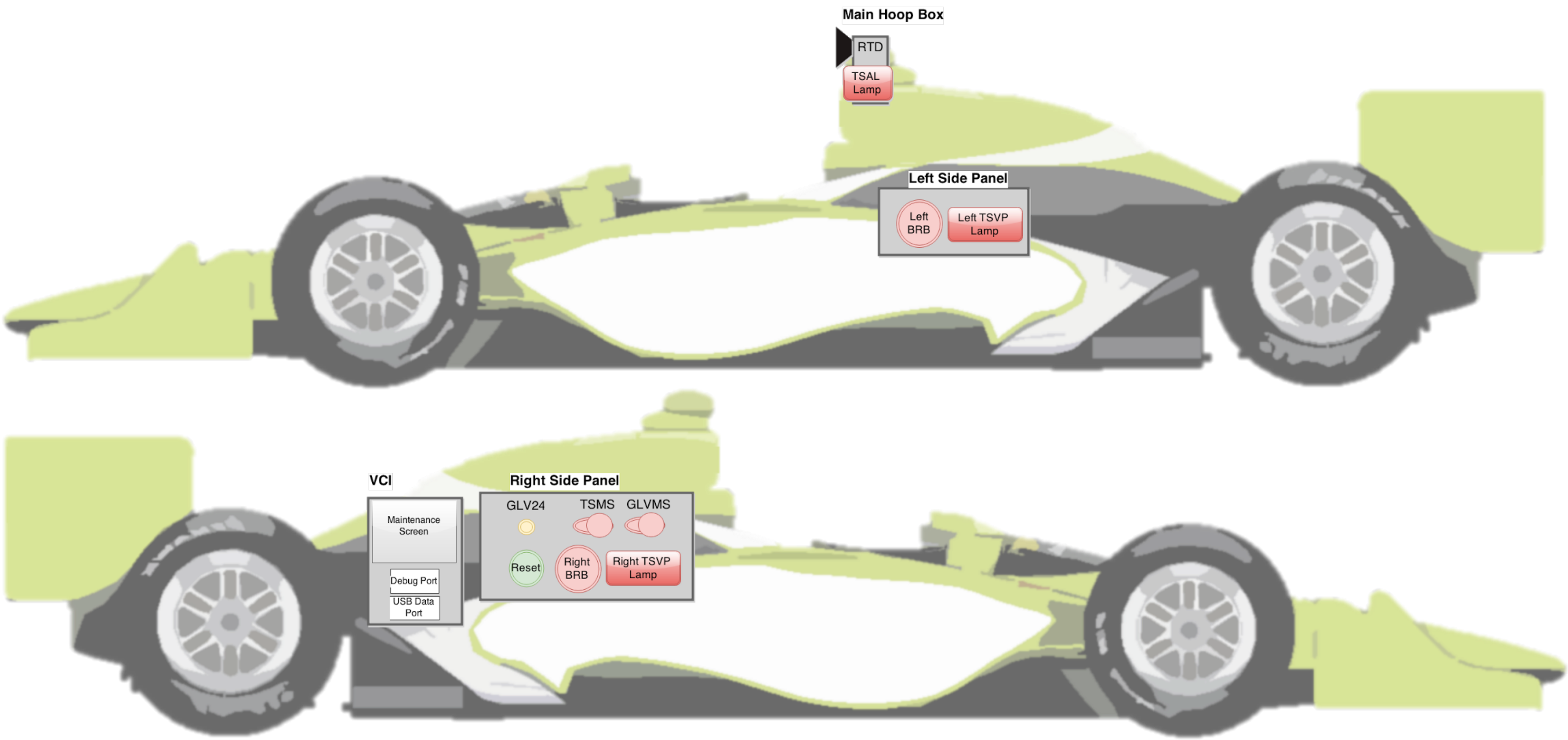
Physical Interfaces Layout - Side View



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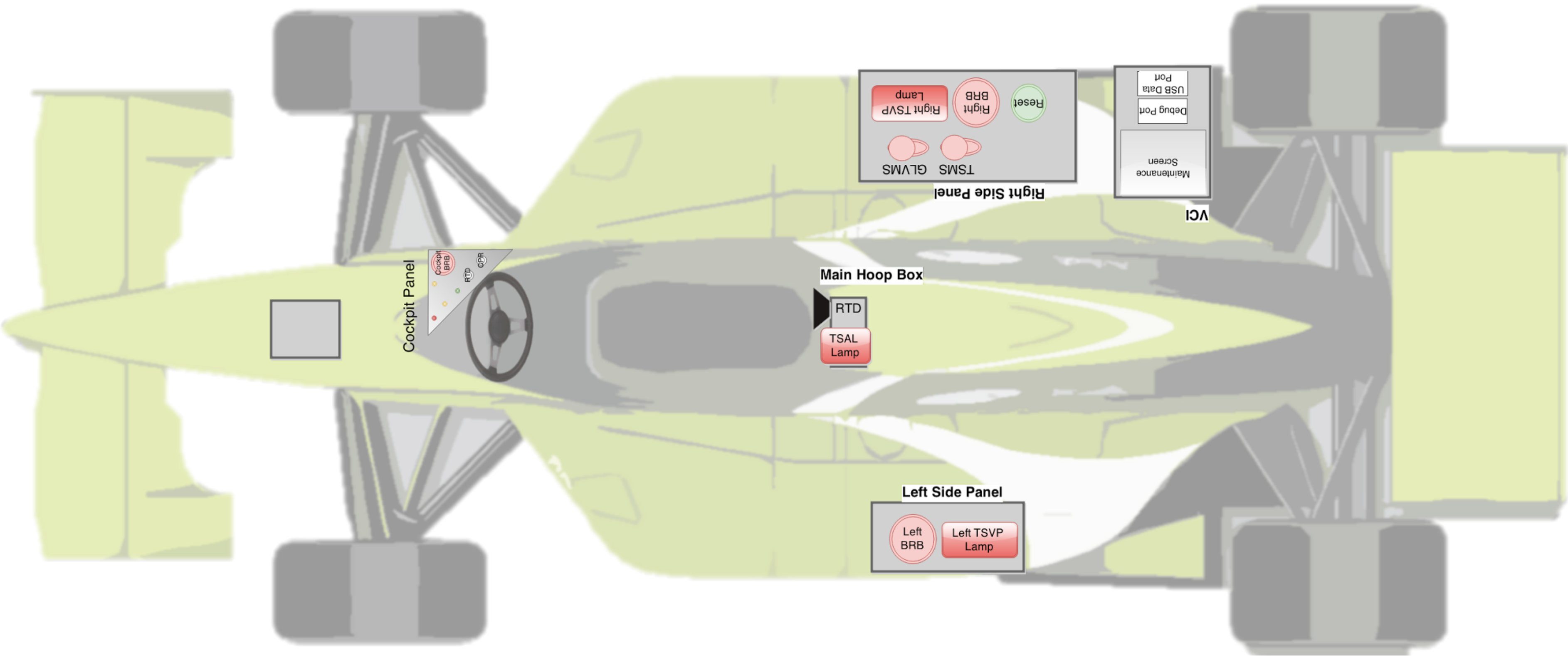
Physical Interfaces Layout - Top View



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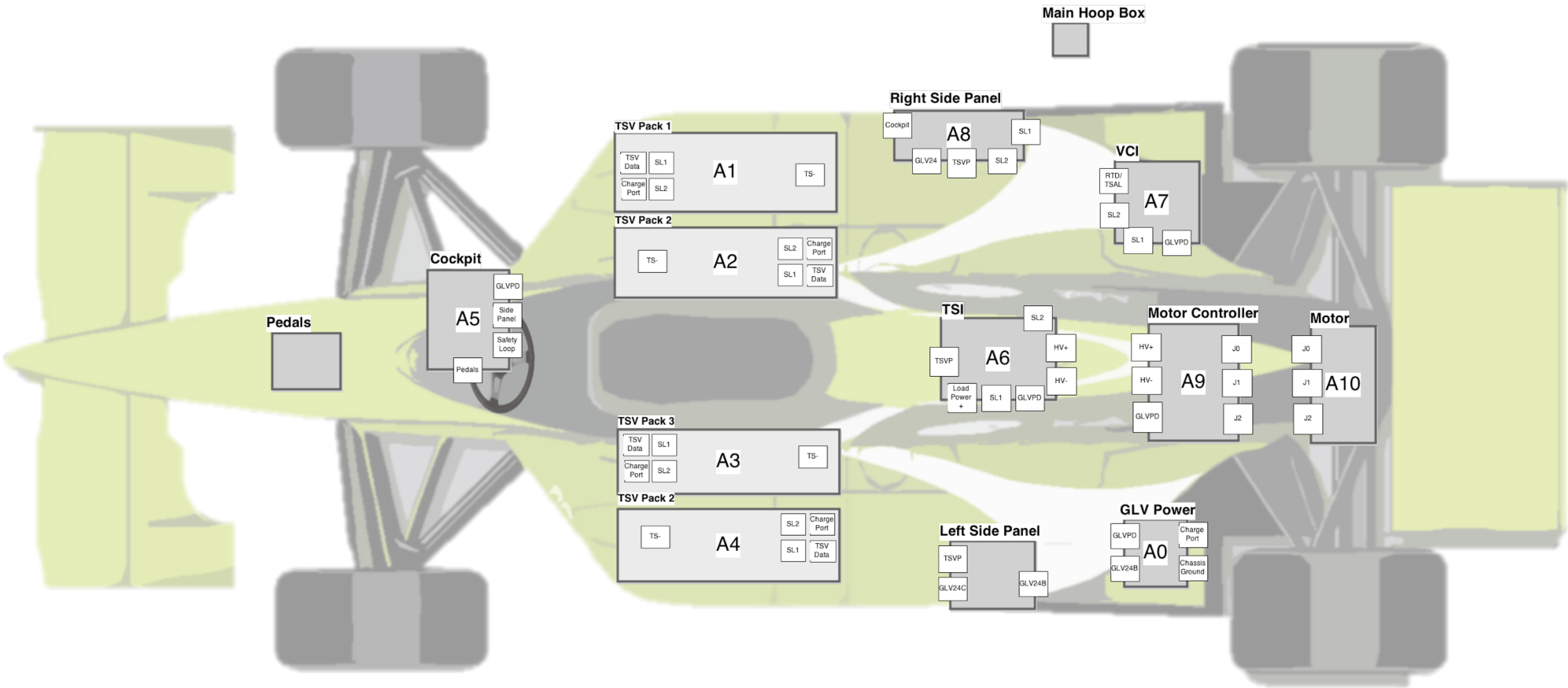
System Assemblies Layout



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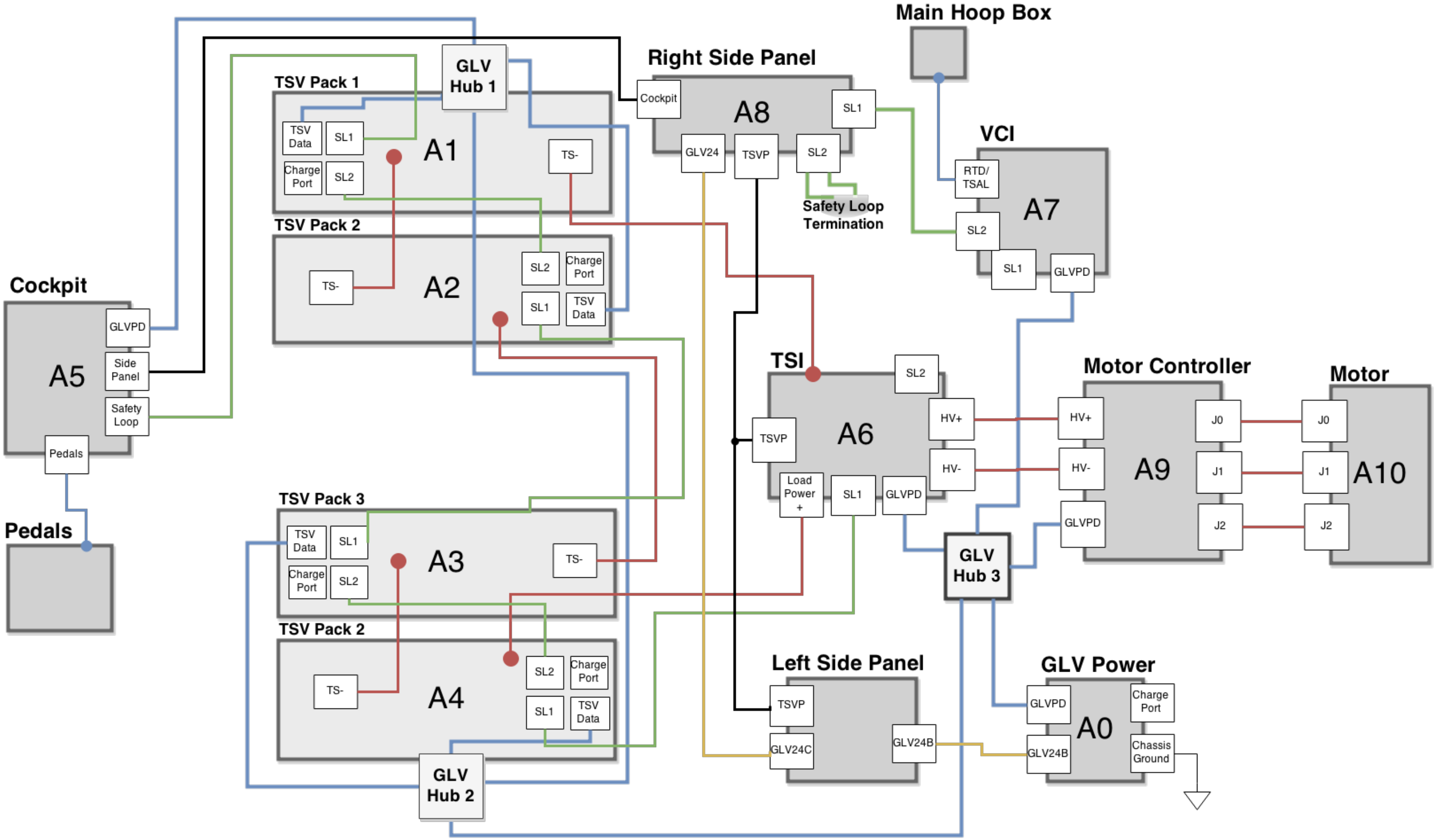

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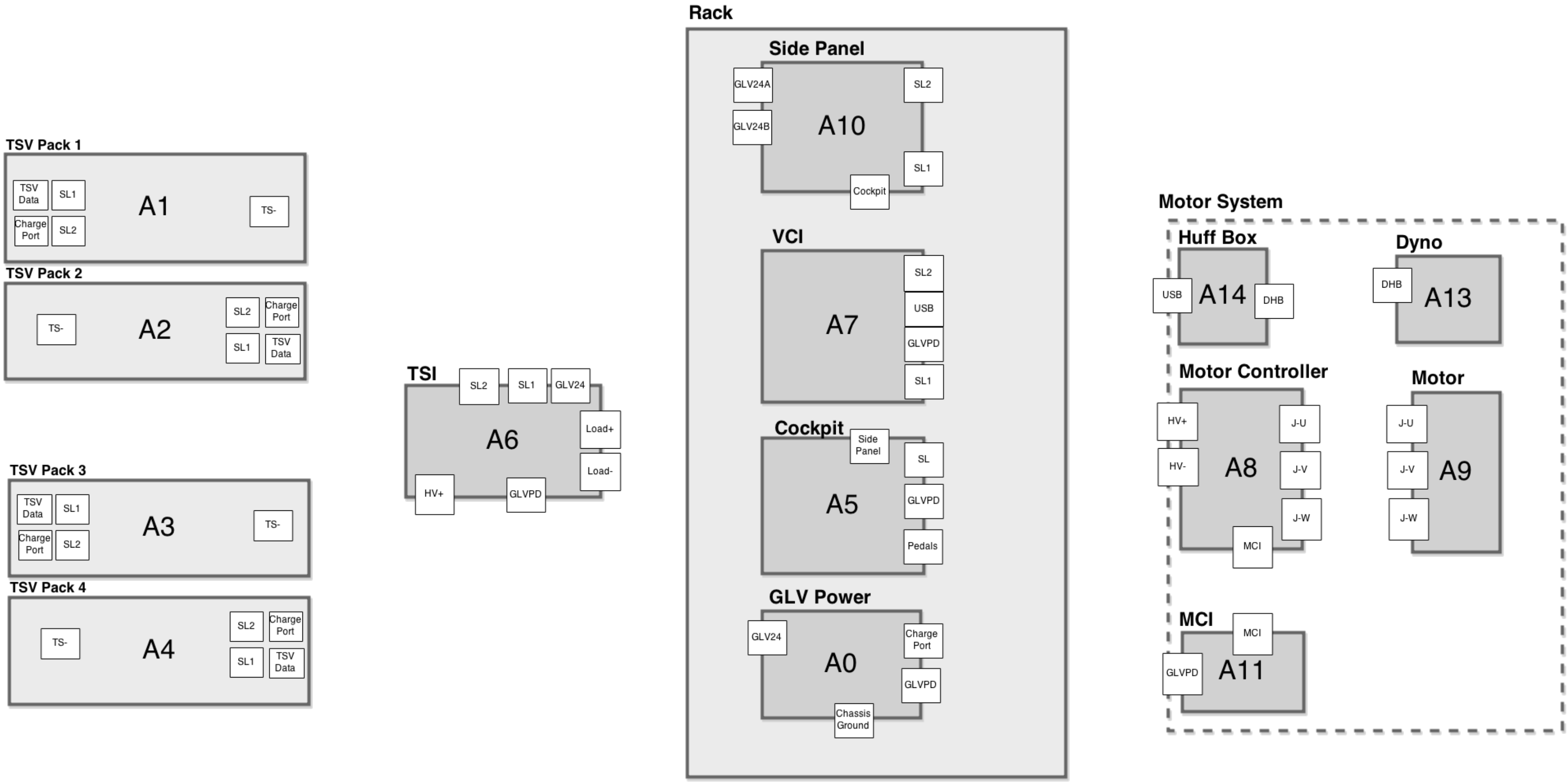

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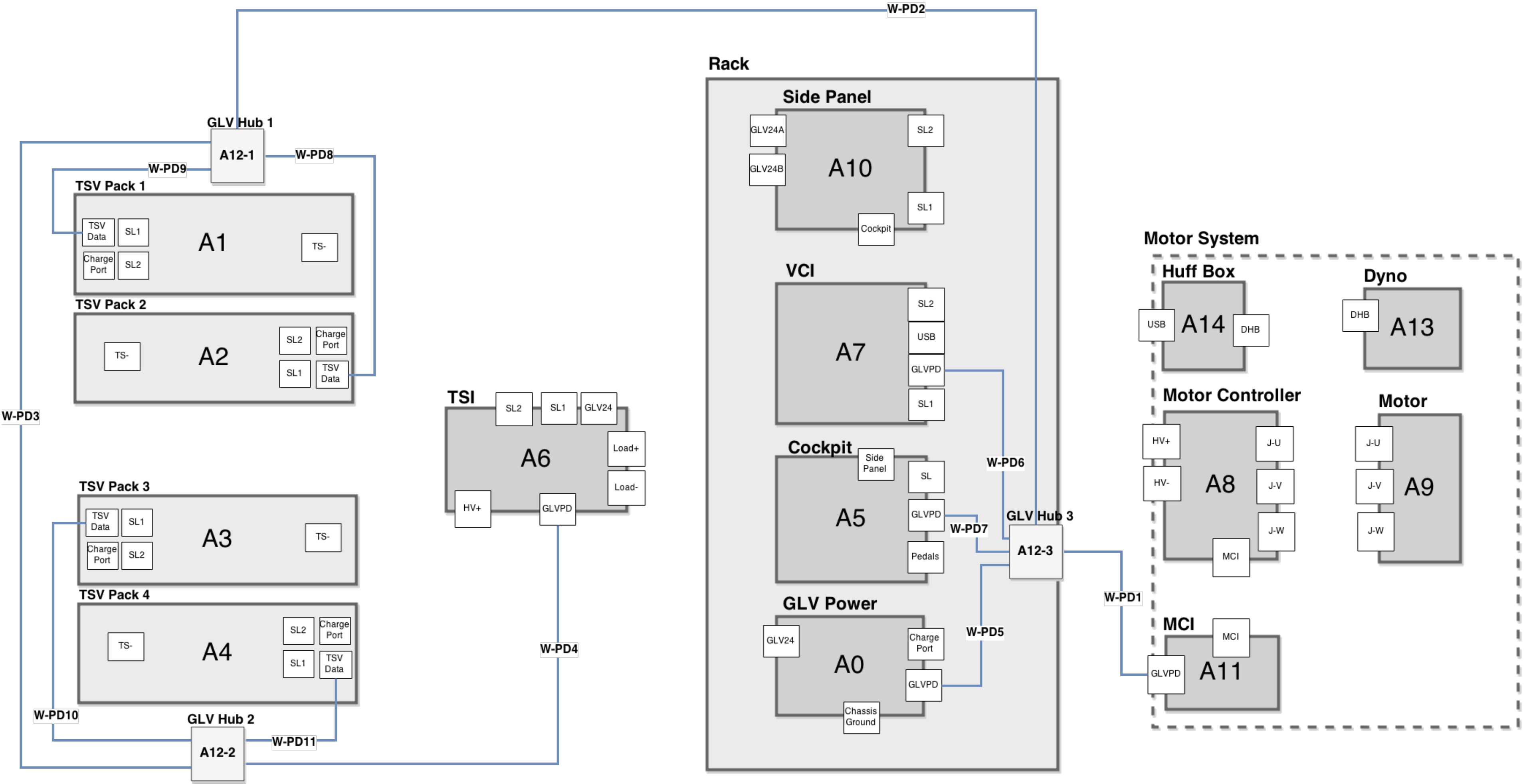

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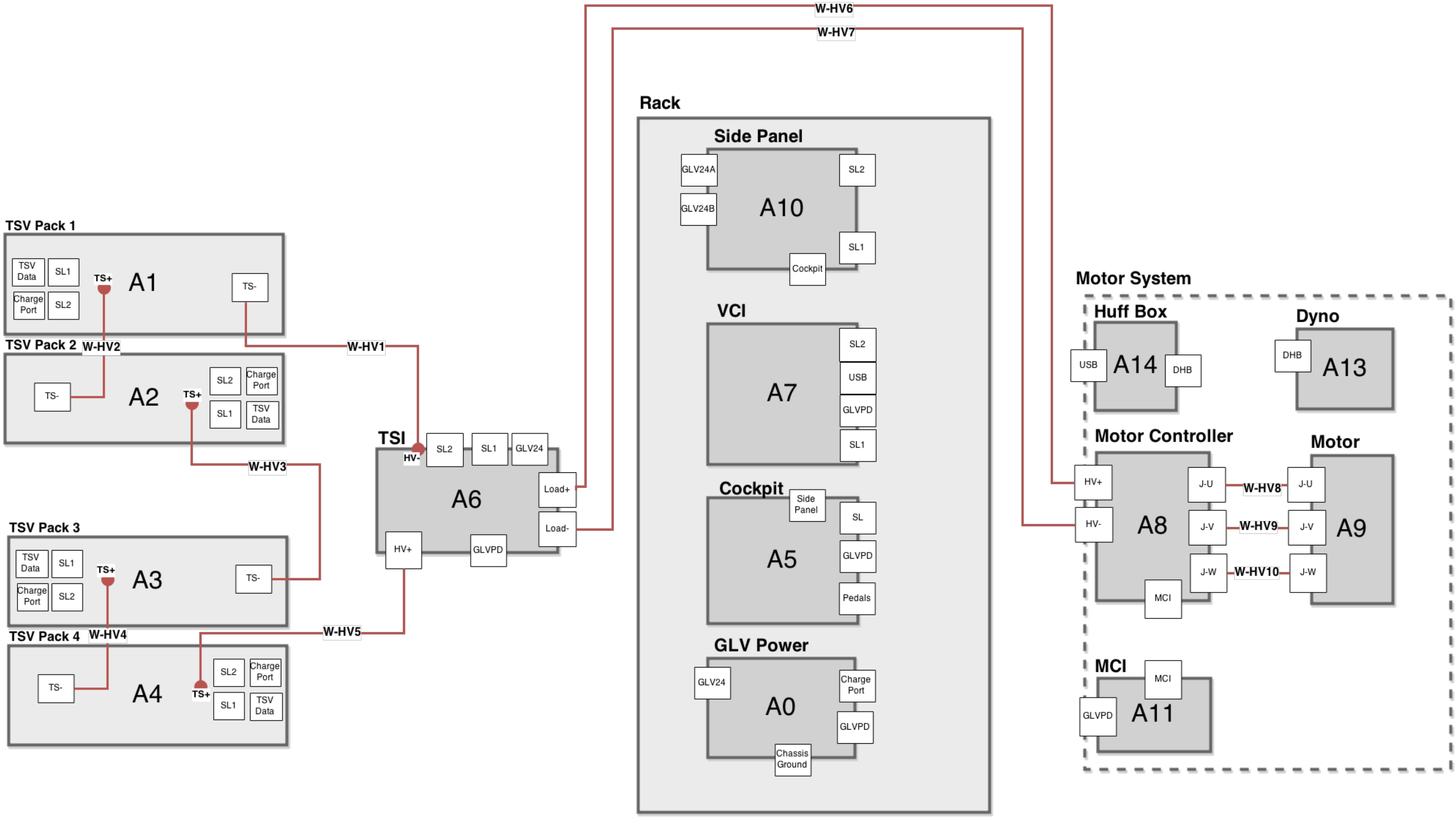

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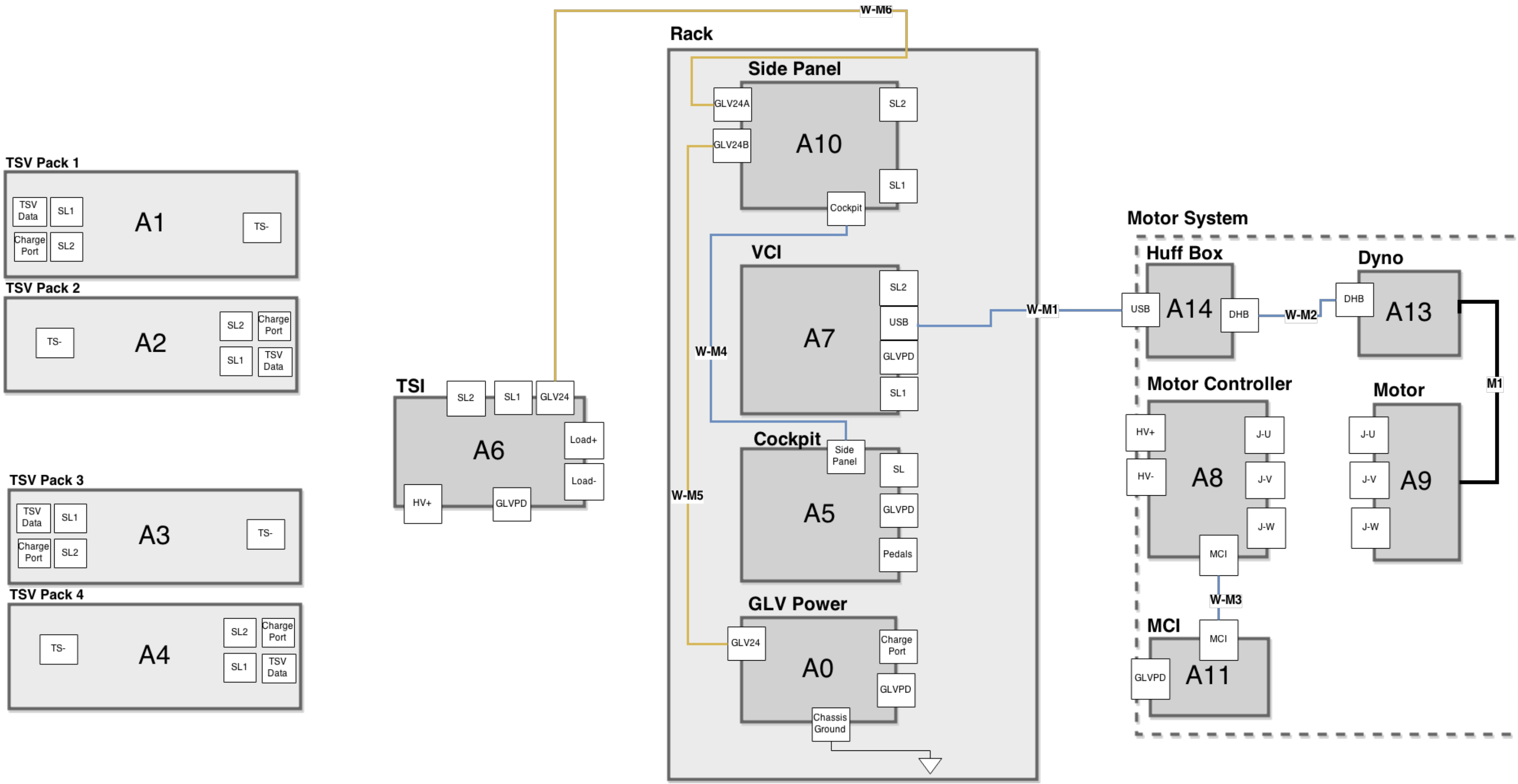

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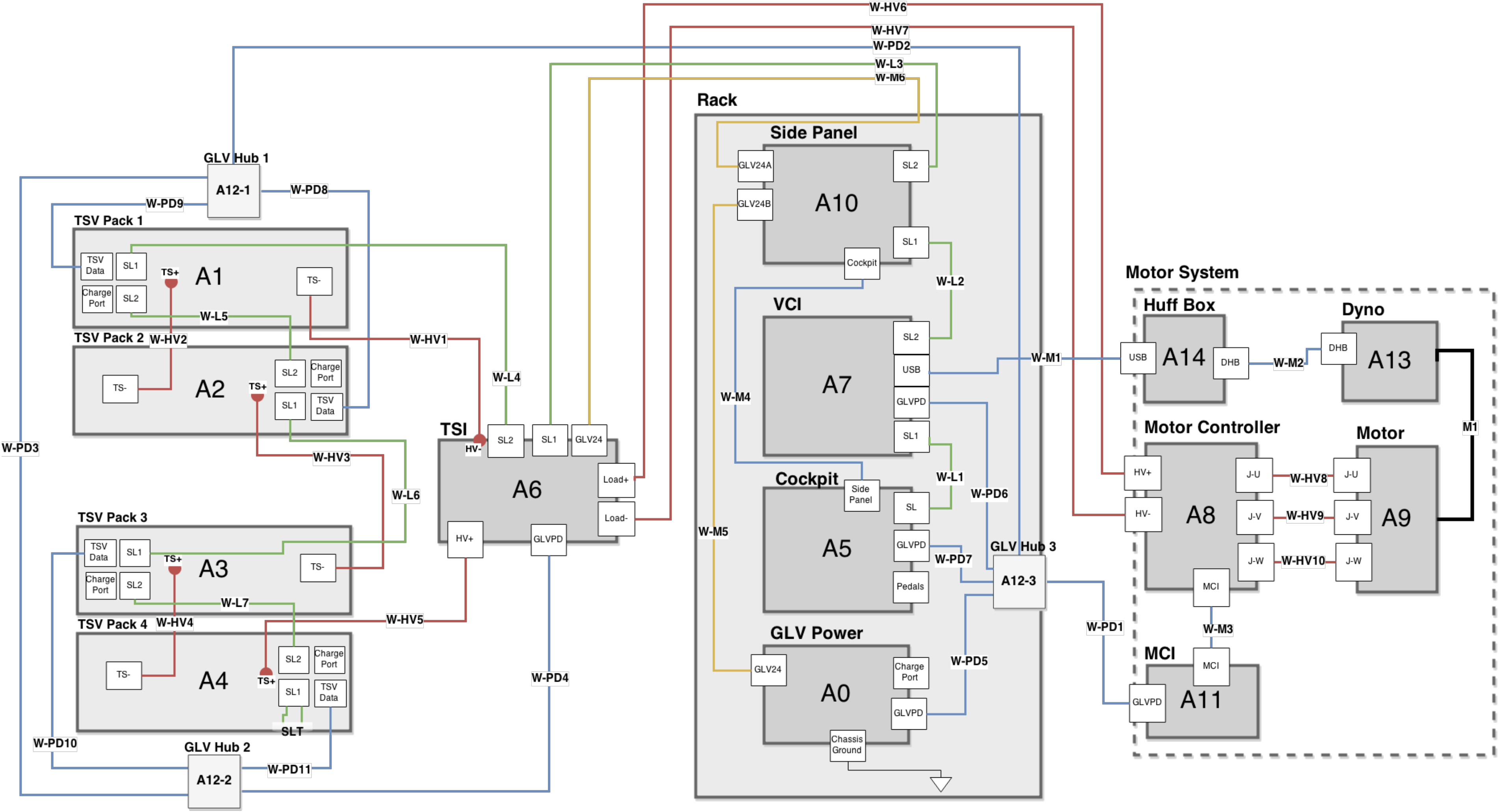

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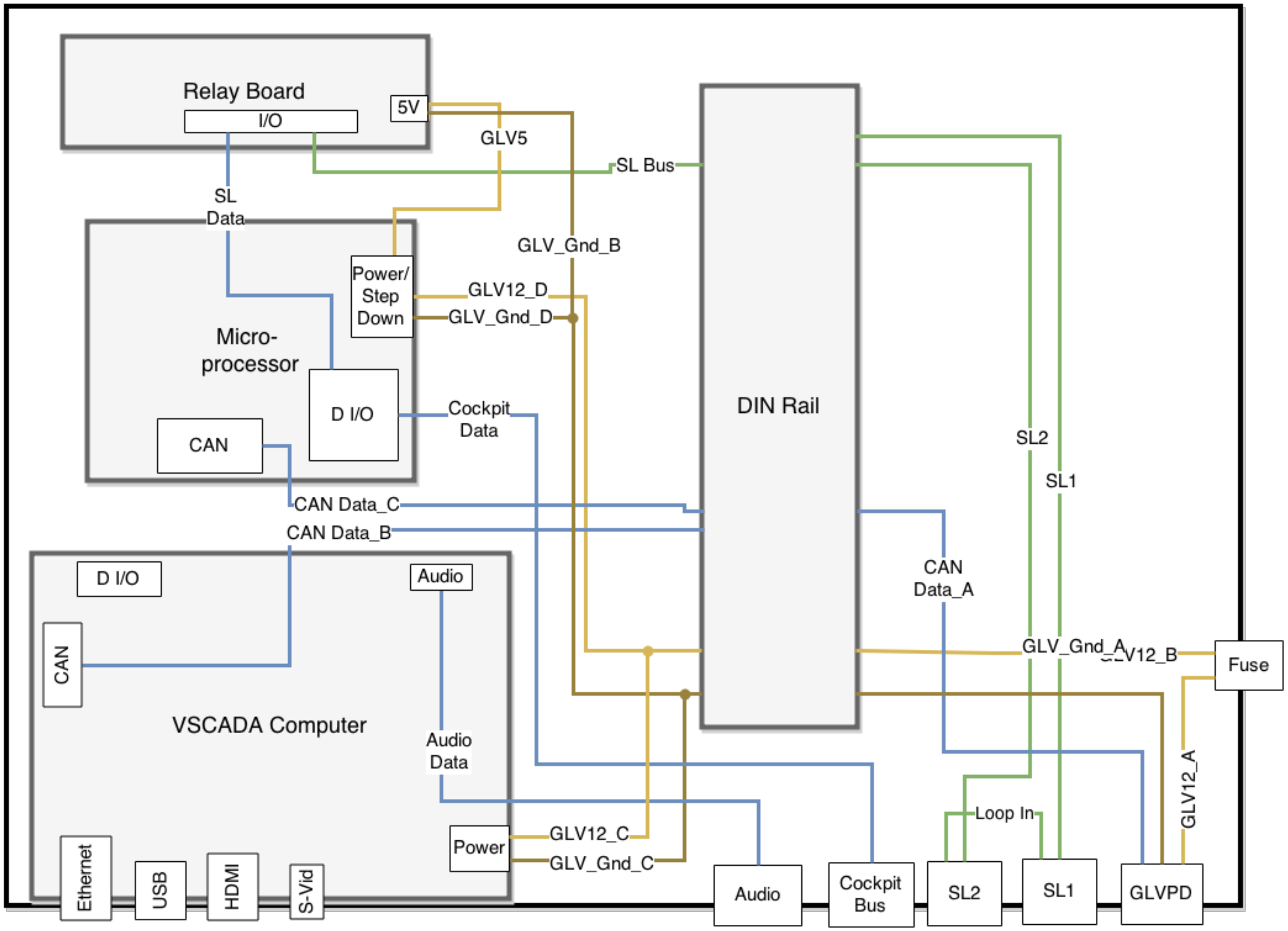
VCI



Daniel Zakzweski, Class of 2015

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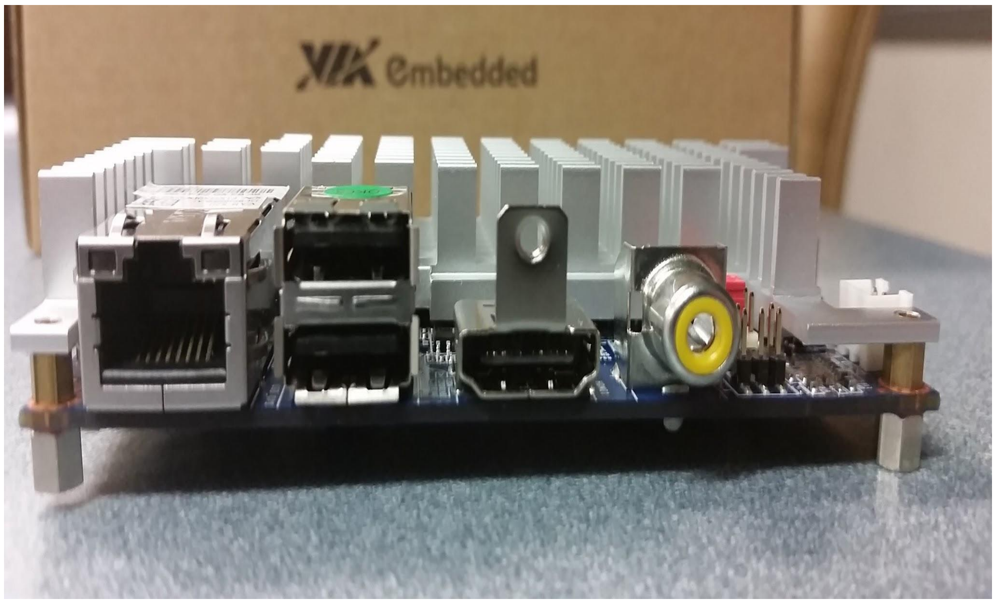
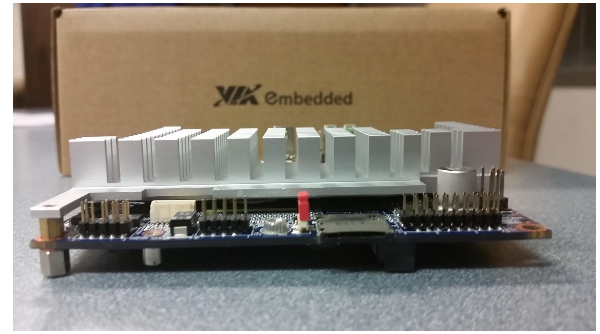
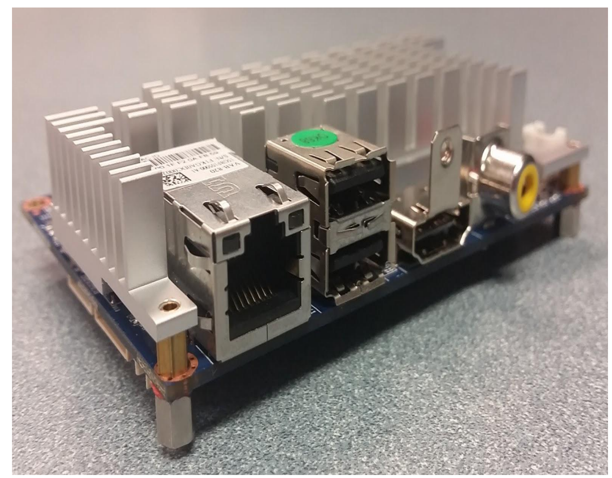
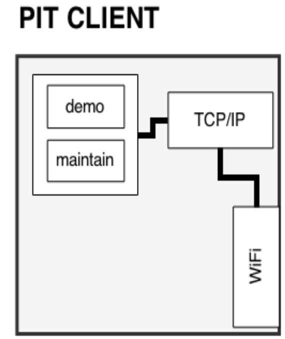
Embedded Computer: VAB-820

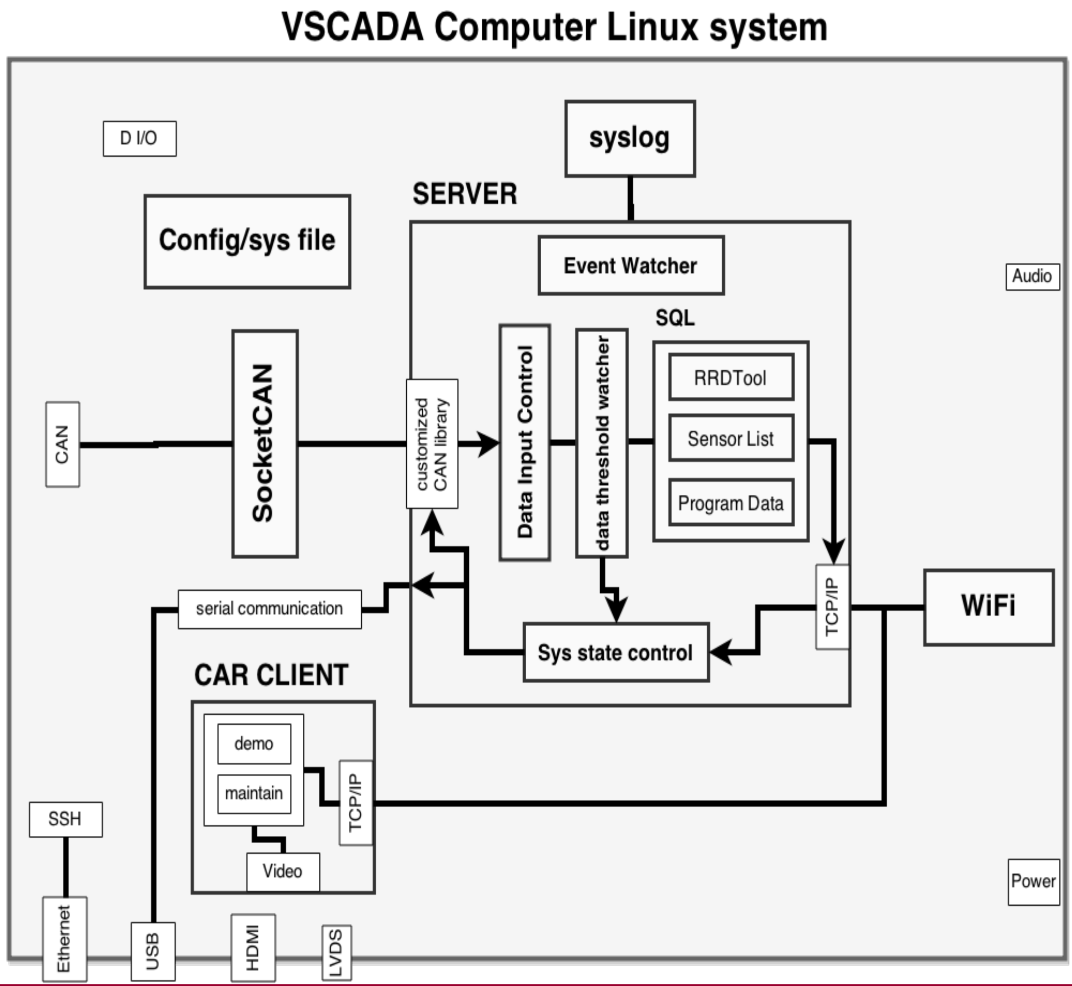






VSCADA





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Logging/Daemons - Main Program

- VSCADA uses systemd to initially launch the main program
    - systemd has most major linux distributions support
- The main program will run in the background as the server with PID registered
- The main program will start by doing system startup procedures

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Logging/Daemons - Startup

- VSCADA uses systemd to initially launch the main program
  - systemd has most major linux distributions support
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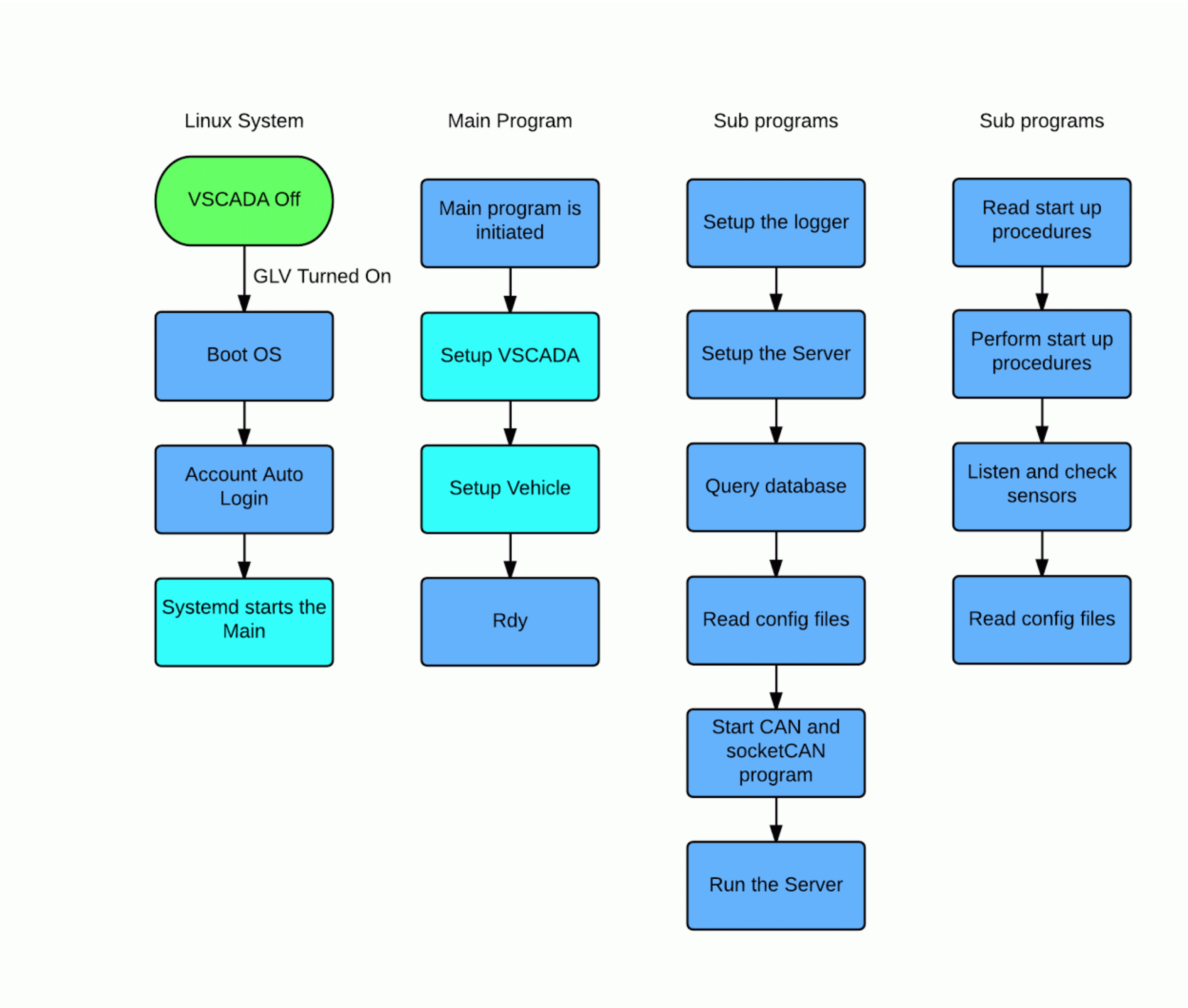
- The main program will start by doing system startup procedures

System Startup



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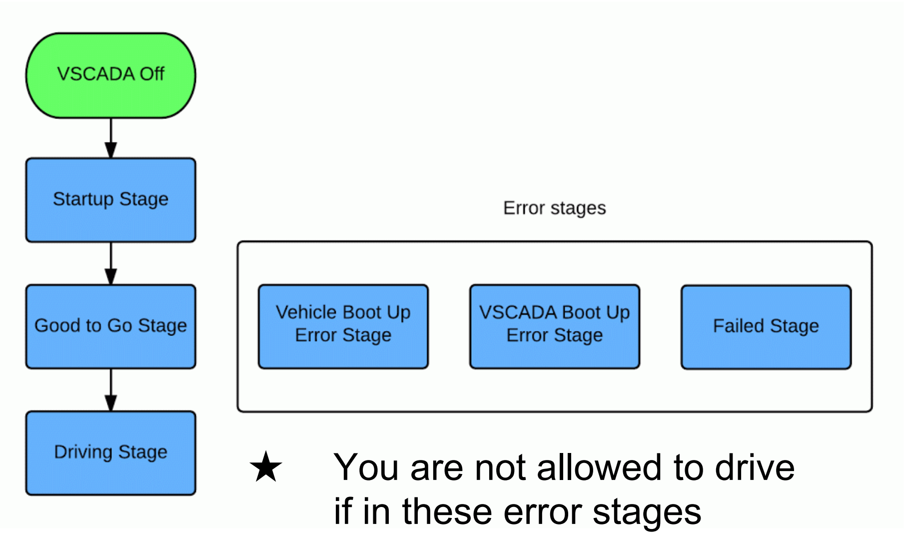
System States and Exceptions



Startup Stage
- **When system boots up and will goto one of the following stages**

Good to Go Stage
- **No error or warning and is ready to be driven**

Driving Stage
- **The car is drving**

Vehicle Boot Up Error Stage
- **VSCADA is functional but other subsystems are not**

VSCADA Boot Up Error Stage
- **VSCADA is not functional**

Failed Stage
- **VSCADA failed to boot up**

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System States and Exceptions

System Errors:

Snytax error

- ➔ **Failed Stage**

VehicleStartupConfigLoadException

- ➔ **Other Boot Up Error Stage**

DatabaseLoadException

- ➔ **VSCADA Boot Up Error Stage**

RRDFileNotFoundException

- ➔ **VSCADA Boot Up Error Stage**

VehicleStartupTimeoutException

- ➔ **Other Boot Up Error Stage**

SensorCheckingTimeoutException

- ➔ **Other Boot Up Error Stage**

SystemFailureError

- ➔ **Failed Stage**

OtherCommunicationException

- ➔ **Vehicle Boot Up Error Stage**

OtherSystemException

- ➔ **VSCADA Boot Up Error Stage**

Sensor Errors:

Logic:

Errors are configurable and specific

If happens before driving, then the car is disabled from driving;

else take actions according to sensor configuration

Possible Errors:

OverHeating

UnderCharged

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Logging/Daemons - Logging

- Have 5 levels, in their respective order:
  - Debug: detailed information, mainly used for debugging
  - Info: general information, should contain important data
  - Warning: Need user's attention
  - Error: Need user to check the source of the error
  - Critical: Opps.
- Logs are stored in syslog of Linux
  - syslog handles storage, update, filter, etc.
  - Python and other library support for syslog
- Can be viewed by clients over the TCP protocol
- Levels can be set by configuration. Info level by default

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Interfaces

- TSV Communication
  - Send/Receive Packets of data from the four PACMAN via CAN
  - will follow API
- GLV Communication
  - JGB act as a hub for groups of sensors via CAN
- DYNO Communication
  - Control Throttle via JGB board
  - Motor Controller CAN
  - Dynamometer - USB interface to read RPM and torque, set valve

CAN Interface

- SocketCAN -Linux Drivers

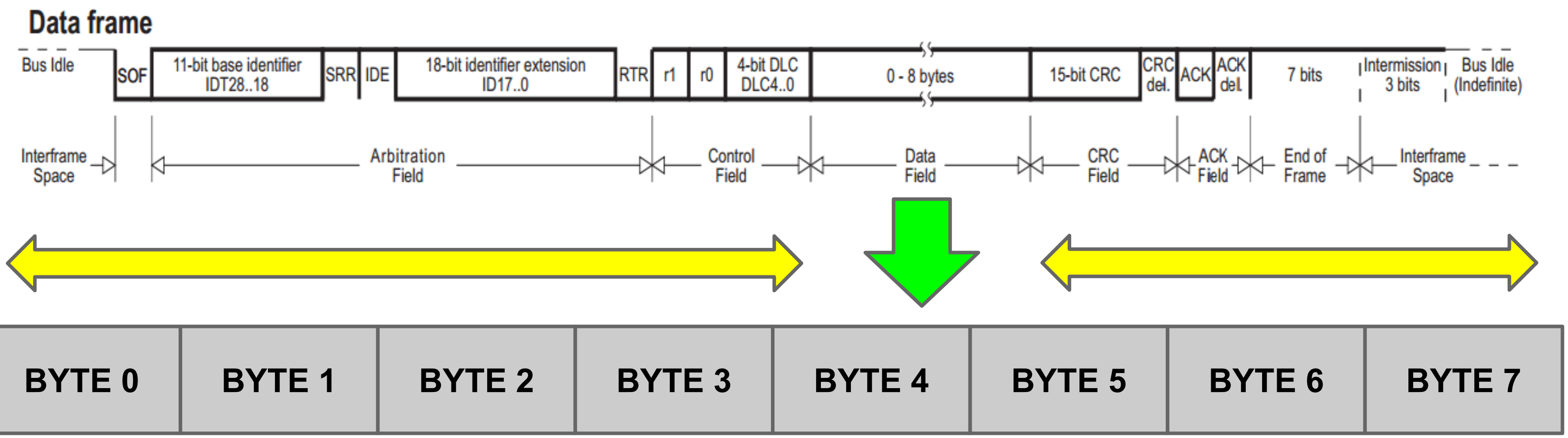
```
sam@bull3:~/Desktop/vscada/can-lib$ cansend vcan0 123#11.02.fe.fe.ee.ee.95.33
```

```
sam@bull3:~/Desktop/vscada/can-lib$ candump vcan0
  vcan0  123   [8]  11 22 33 44 55 66 77 88
  vcan0  123   [8]  11 22 33 44 55 66 77 88
  vcan0  001   [3]  11 12 13
```

- Python-CAN

```
sam@bull3:~/Desktop/vscada/can-lib$ python3 CANexample.py vcan0
Received: can id=123, can dlc=8, data=b'\x01\x02\xff\xff\xee\xee\x952'
```

TSV Pack LevelCAN Frame



Byte 0 - 1,Pack#(1-4)

Byte 1 - Voltage (High)

Byte 2 - Voltage (Low)

Byte 3 - Current (High)

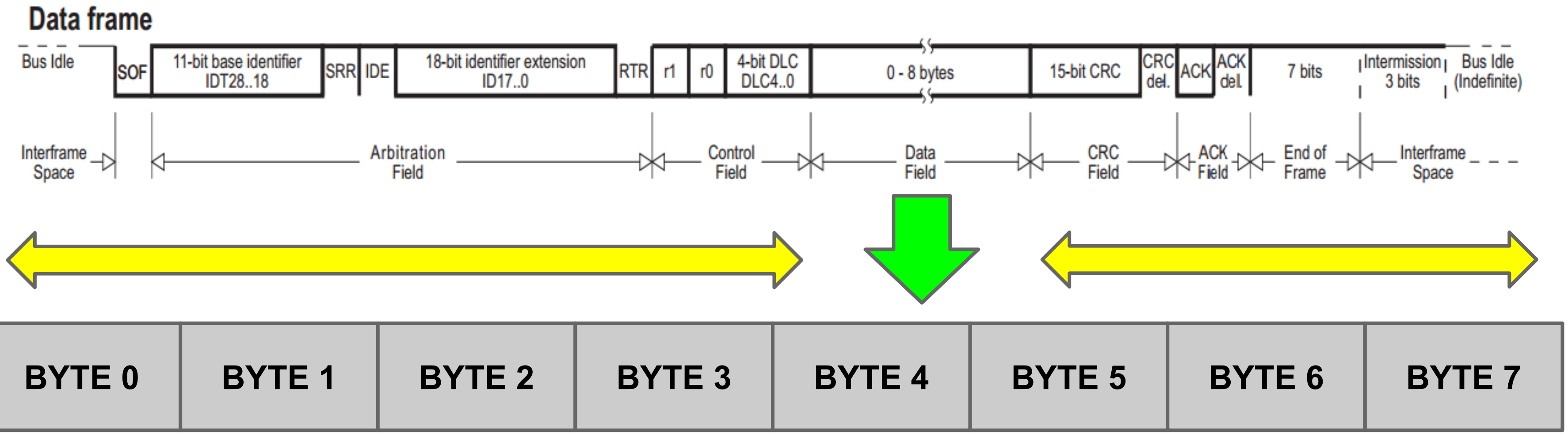
Byte 4 - Current (Low)

Byte 5 - SOC (High)

Byte 6 - SOC (Low)

Byte 7 - Fuse Temp

TSV(1) AMS Level CAN Frame



Byte 0 - x1,Pack#(1-4)
Byte 1 - AMS#(1-7)
Byte 2 - Voltage (High)
Byte 3 - Voltage (Low)
Byte 4 - Current (High)
Byte 5 - Current (Low)
Byte 6 - Temperature (High)
Byte 7 - Temperature (Low)

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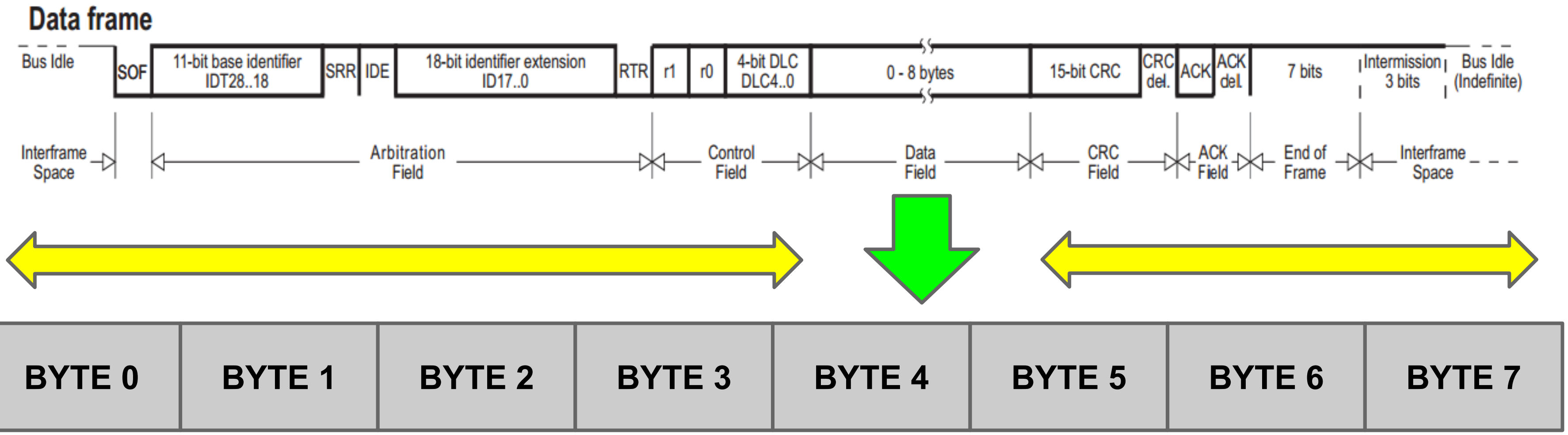
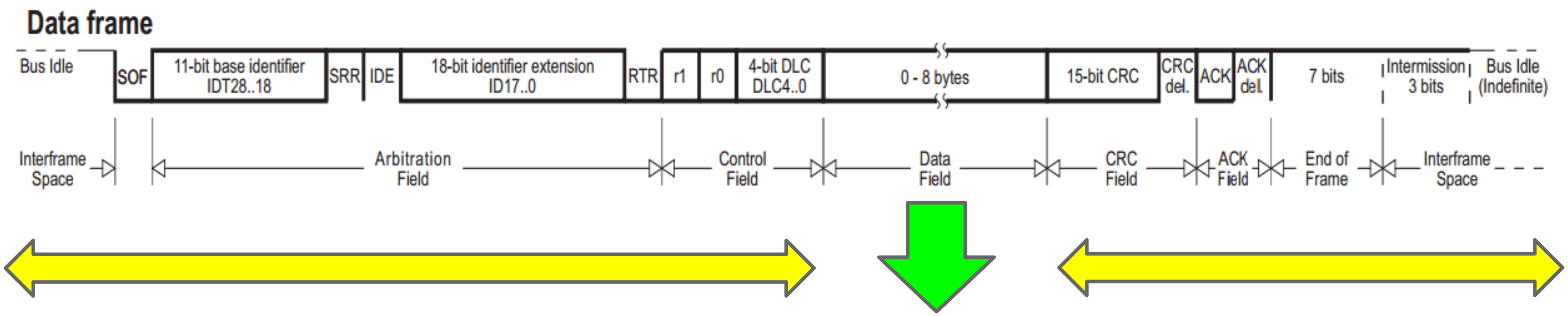
GLV(2) Cockpit CAN Frame



Byte 0 - x21 (Cockpit)
Byte 1 - Ambient_temp (High)
Byte 2 - Ambient_temp (Low)
Byte 3 - Failure_LED (High)
Byte 4 - Failure_LED (High)
Byte 5 - Warning_LED(High)
Byte 6 - Ok_LED (High)
Byte 7 - Ok_LED (Low)

GLV(2) TSI CAN Frame



BYTE 0	BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5	BYTE 6	BYTE 7

Byte 0 - x22 (TSI)
Byte 1 - Temperature (High)
Byte 2 - Temperature (Low)
Byte 3 - x00

Byte 4 - x00
Byte 5 - x00
Byte 6 - x00
Byte 7 - x00

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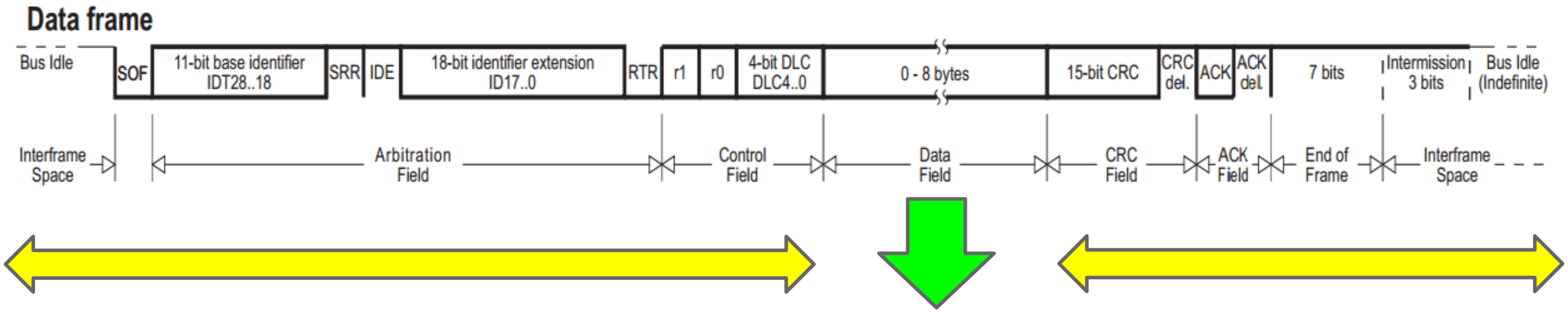
GLV(3) GLV_Power CAN Frame



BYTE 0	**BYTE 1**	**BYTE 2**	**BYTE 3**	**BYTE 4**	**BYTE 5**	**BYTE 6**	**BYTE 7**

Byte 0 - x13

Byte 1 - Voltage (High)

Byte 2 - Voltage (Low)

Byte 3 - Current (High)

Byte 4 - Current (Low)

Byte 5 - Temperature (High)

Byte 6 - Temperature (Low)

Byte 7 - SOC

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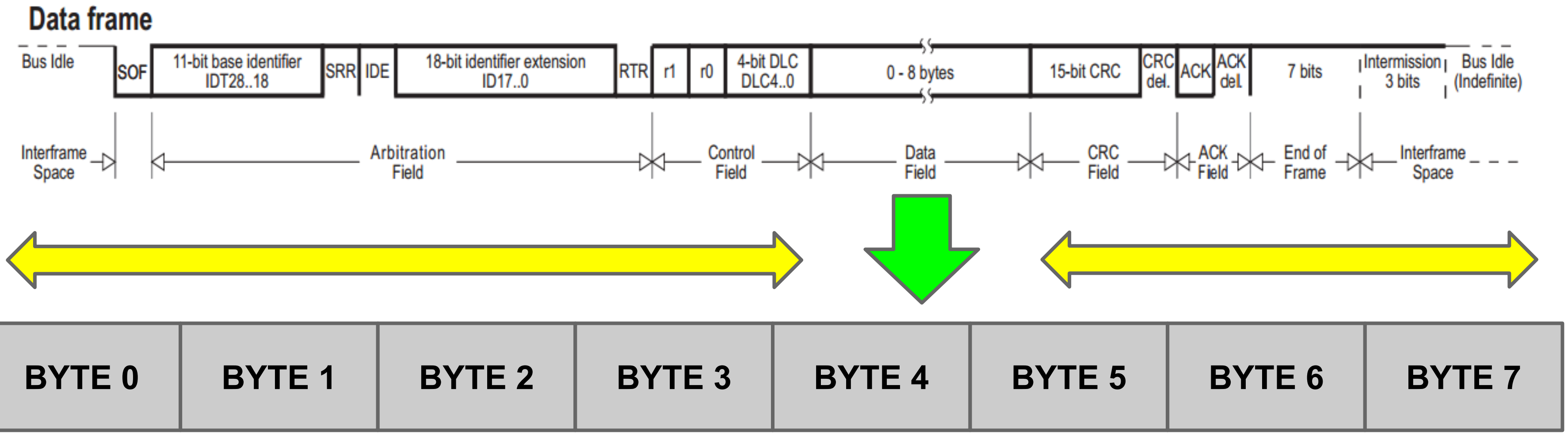
Motor Controller CAN Frames (1 / 2)



Byte 0 - RPM (High)
Byte 1 - RPM (Low)
Byte 2 - Motor Temp
Byte 3 - Controller Temp

Byte 4 - RMS Current (High)
Byte 5 - RMS Current (Low)
Byte 6 - Capacitor V (High)
Byte 7 - Capacitor V (Low)

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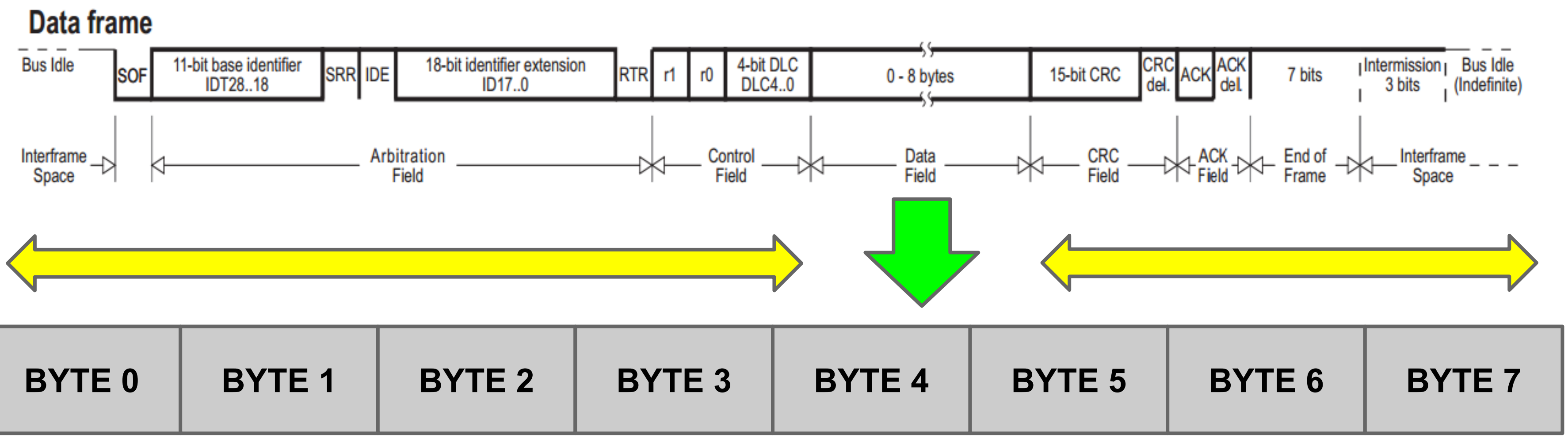
Motor Controller CAN Frames (2 / 2)



Byte 0 - Stator Freq (High)
Byte 1 - Stator Freq (Low)
Byte 2 - Controller Fault P
Byte 3 - Controller Fault S

Byte 4 - Throttle Input
Byte 5 - Brake Input
Byte 6 - System Bits
Byte 7 - (UNUSED)

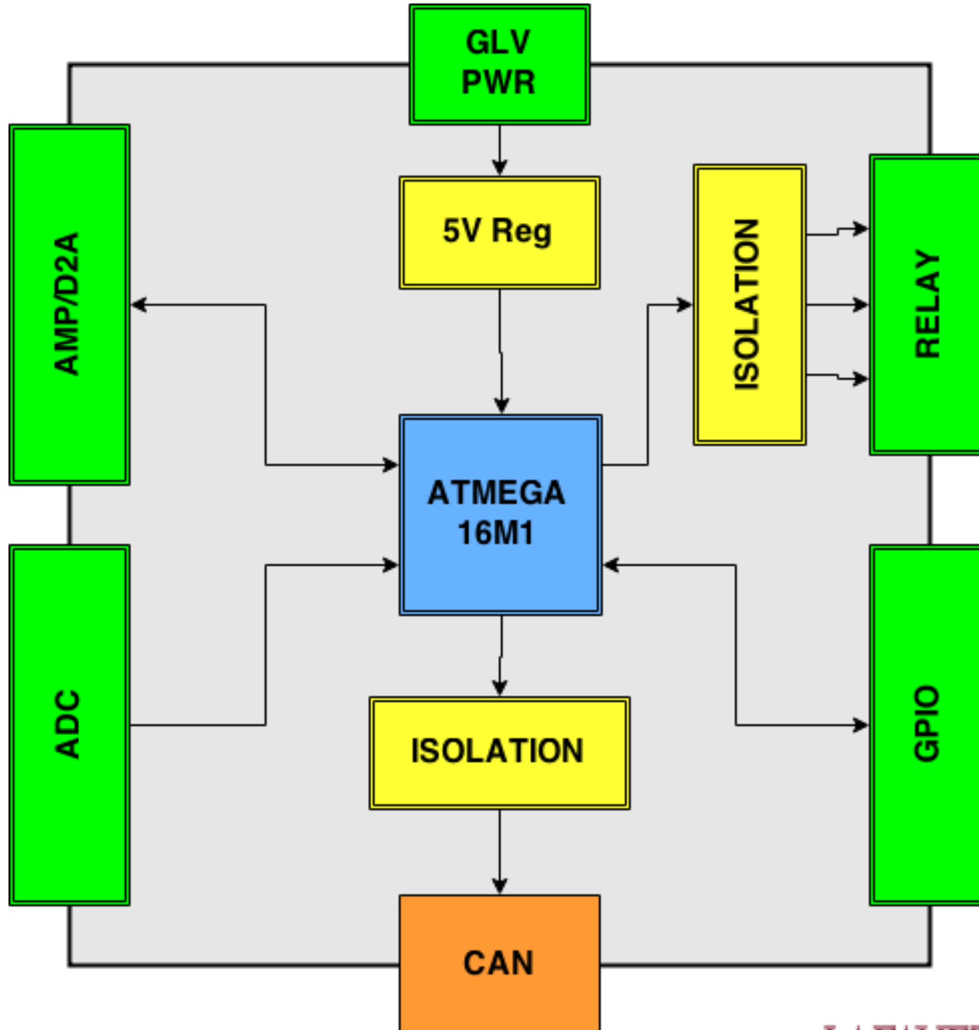
CAN Microcontroller Board (JGB)

Automotive AVR

- CAN Bus
- LIN
- UART (RS-232)

Board Inputs/Outputs

- Internal Temperature
- 5 ADC Channels
- 3 PWM Channels
- 1 DAC Channel
- 6 GPIO/SPI
- 2 Differential ADC
- USB - UART



Microcontroller Firmware Design

UART

- Send/Receive
- Test/Debugging Information

CAN

- SCADA Communication

TIMER

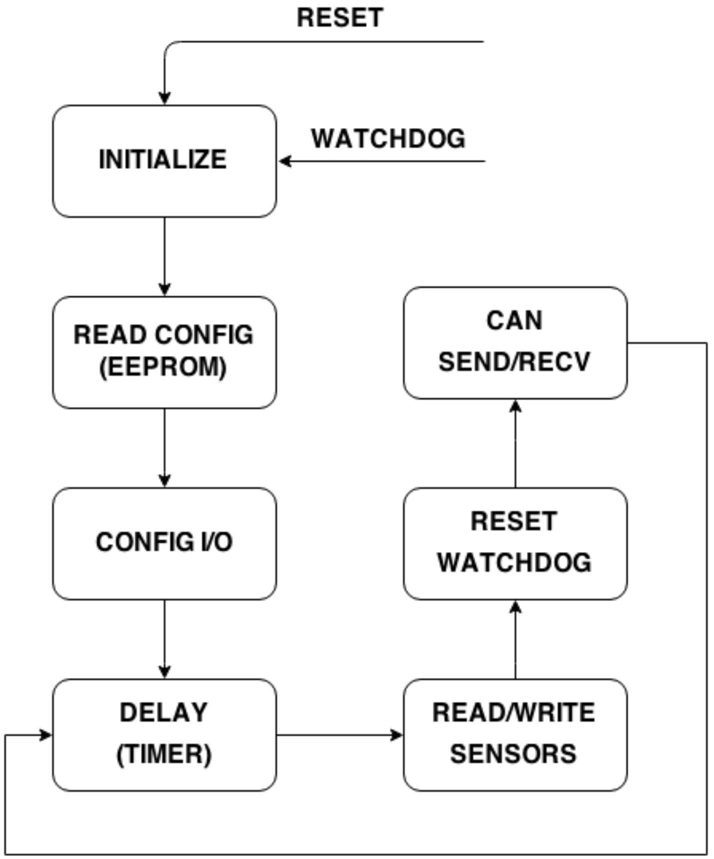
- PWM, Sensor Timing

WATCHDOG TIMER

- Crash Prevention

I/O

- System Control Interface



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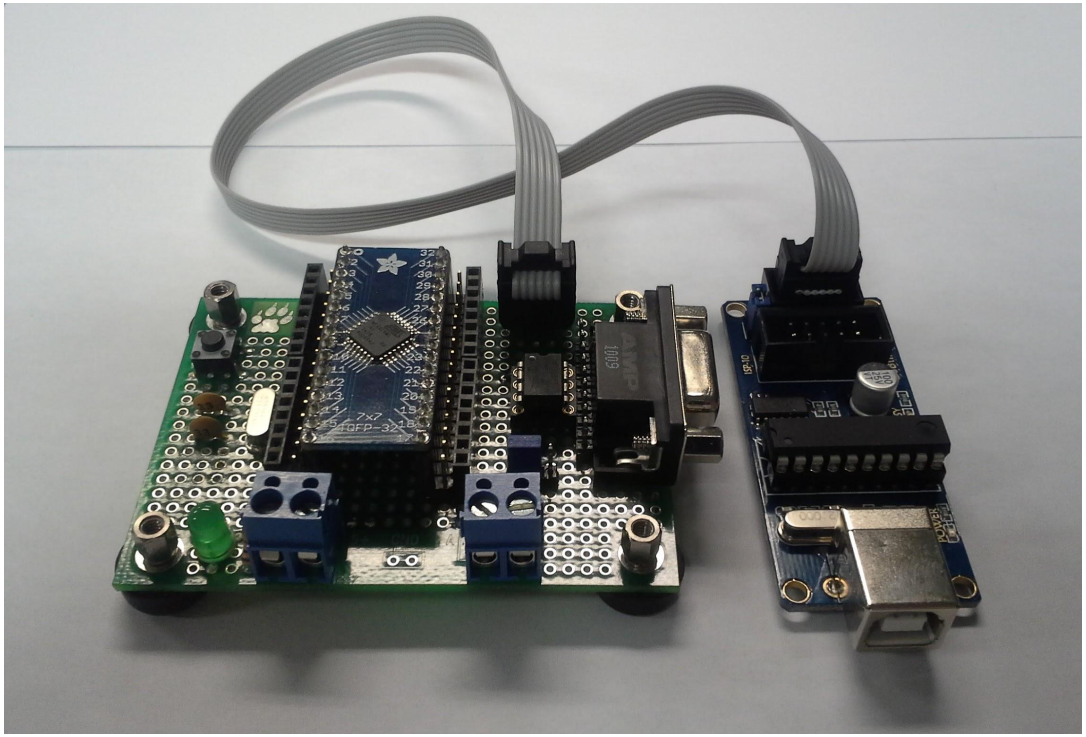
Microcontroller Prototype Hardware

WORKING:

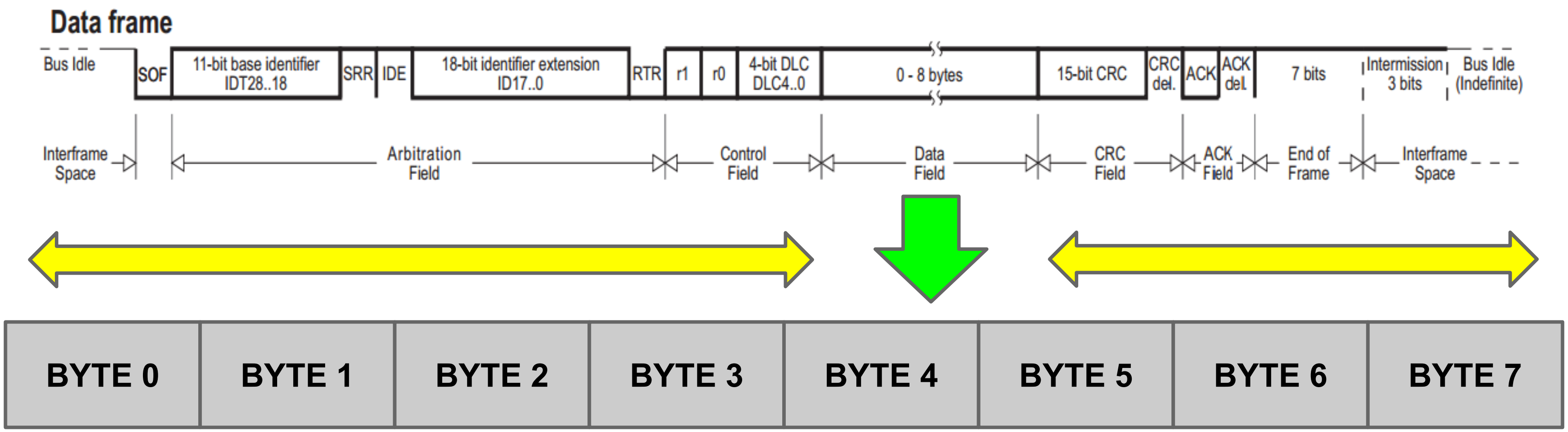
- ADC
- D2A
- PWM
- GPIO

NOT WORKING:

- CAN
- UART



Microcontroller CAN Frames



Byte 0 -

Byte 1 -

Byte 2 -

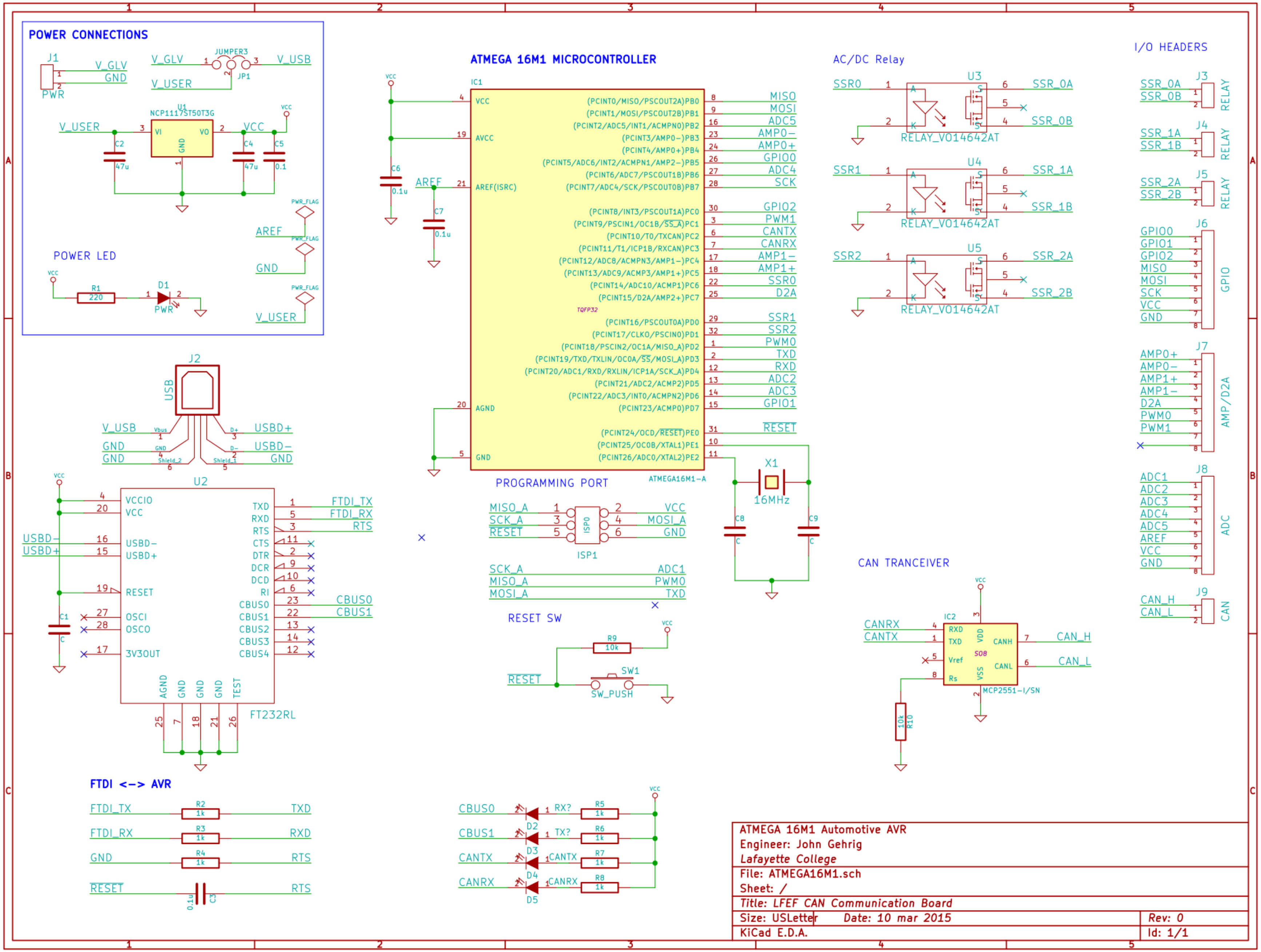
Byte 3 -

Byte 4 -

Byte 5 -

Byte 6 -

Byte 7 -

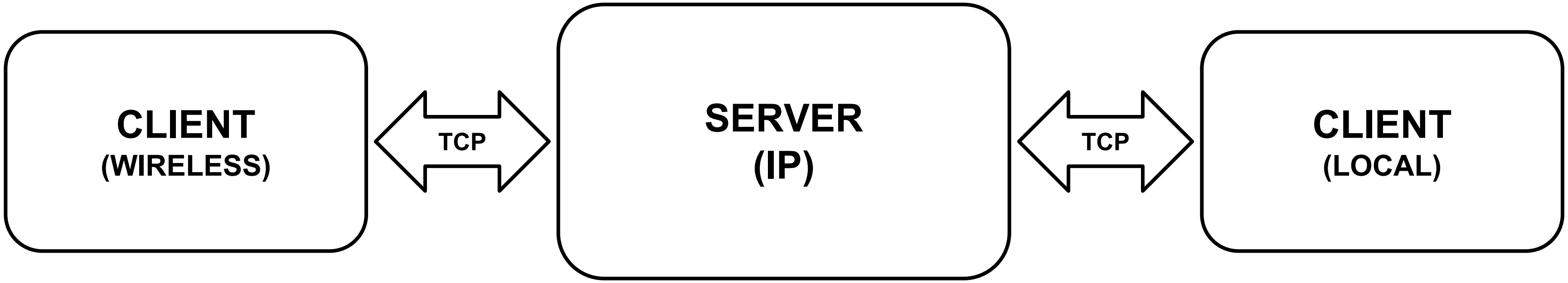


POWER CONNECTIONS
J1
V_GLV
GND
PWR
JUMPER3
JP1
V_USB
V_USER
NCP1117ST50T3G
U1
VCC
POWER LED
R1
220
D1
PWR
PWR_FLAG
AREF
GND
ATMEGA 16M1 MICROCONTROLLER
IC1
VCC
AVCC
AREF(ISRC)
AGND
GND
(PCINT0/MISO/PSCOUT2A)PB0
(PCINT1/MOSI/PSCOUT2B)PB1
(PCINT2/ADC5/INT1/ACMPN0)PB2
(PCINT3/AMP0-)PB3
(PCINT4/AMP0+)PB4
(PCINT5/ADC6/INT2/ACMPN1/AMP2-)PB5
(PCINT6/ADC7/PSCOUT1B)PB6
(PCINT7/ADC4/SCK/PSCOUT0B)PB7
(PCINT8/INT3/PSCOUT1A)PC0
(PCINT9/PSCIN1/OC1B/SS_A)PC1
(PCINT10/T0/TXCAN)PC2
(PCINT11/T1/ICP1B/RXCAN)PC3
(PCINT12/ADC8/ACMPN3/AMP1-)PC4
(PCINT13/ADC9/ACMP3/AMP1+)PC5
(PCINT14/ADC10/ACMP1)PC6
(PCINT15/D2A/AMP2+)PC7
TQFP32
(PCINT16/PSCOUT0A)PD0
(PCINT17/CLKO/PSCIN0)PD1
(PCINT18/PSCIN2/OC1A/MISO_A)PD2
(PCINT19/TXD/TXLIN/OC0A/SS/MOSI_A)PD3
(PCINT20/ADC1/RXD/RXLIN/ICP1A/SCK_A)PD4
(PCINT21/ADC2/ACMP2)PD5
(PCINT22/ADC3/INT0/ACMPN2)PD6
(PCINT23/ACMP0)PD7
(PCINT24/OCD/RESET)PE0
(PCINT25/OC0B/XTAL1)PE1
(PCINT26/ADC0/XTAL2)PE2
ATMEGA16M1-A
MISO
MOSI
ADC5
AMP0-
AMP0+
GPIO0
ADC4
SCK
GPIO2
PWM1
CANTX
CANRX
AMP1-
AMP1+
SSR0
D2A
SSR1
SSR2
PWM0
TXD
RXD
ADC2
ADC3
GPIO1
RESET
X1
16MHz
C6 0.1u
C7 0.1u
C8
C9
AC/DC Relay
SSR0
U3
SSR_0A
SSR_0B
RELAY_VO14642AT
SSR1
U4
SSR_1A
SSR_1B
RELAY_VO14642AT
SSR2
U5
SSR_2A
SSR_2B
RELAY_VO14642AT
I/O HEADERS
J3 RELAY
J4 RELAY
J5 RELAY
J6 GPIO
GPIO0
GPIO1
GPIO2
MISO
MOSI
SCK
VCC
GND
J7 AMP/D2A
AMP0+
AMP0-
AMP1+
AMP1-
D2A
PWM0
PWM1
J8 ADC
ADC1
ADC2
ADC3
ADC4
ADC5
AREF
VCC
GND
J9 CAN
CAN_H
CAN_L
J2
USB
V_USB
USBD+
USBD-
GND
U2
VCCIO
VCC
USBD-
USBD+
RESET
OSCI
OSCO
3V3OUT
AGND
GND
GND
GND
TEST
TXD
RXD
RTS
CTS
DTR
DCR
DCD
RI
CBUS0
CBUS1
CBUS2
CBUS3
CBUS4
FTDI_TX
FTDI_RX
RTS
CBUS0
CBUS1
FT232RL
C1
PROGRAMMING PORT
MISO_A
SCK_A
RESET
VCC
MOSI_A
GND
ISP0
ISP1
SCK_A ADC1
MISO_A PWM0
MOSI_A TXD
RESET SW
R9
10k
SW1
SW_PUSH
RESET
CAN TRANCEIVER
IC2
CANRX
CANTX
RXD
TXD
Vref
Rs
VDD
VSS
CANH
CANL
SO8
CAN_H
CAN_L
MCP2551-I/SN
R10
10k
FTDI <--> AVR
FTDI_TX
R2 1k
TXD
FTDI_RX
R3 1k
RXD
GND
R4 1k
RTS
RESET
C3 0.1u
RTS
CBUS0
D2
RX?
R5 1k
CBUS1
D3
TX?
R6 1k
CANTX
D4
CANTX
R7 1k
CANRX
D5
CANRX
R8 1k
ATMEGA 16M1 Automotive AVR
Engineer: John Gehrig
Lafayette College
File: ATMEGA16M1.sch
Sheet: /
Title: LFEF CAN Communication Board
Size: USLetter
Date: 10 mar 2015
Rev: 0
KiCad E.D.A.
Id: 1/1

Microcontroller Code/Toolchain

{INSERT CODE HERE/TOOLCHAIN IMAGES}

Client - Server Architecture



Request - Response Model

- Client Initiates Request
- Server Responds to Request
- JSON Object Passing

Unix-Style Commands

- Modular, Flexible, Expandable

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Server Command Architecture

Server Command Syntax:

CMD NAME	FLAGS	OPTIONS	ARGUMENTS

CMD NAME -

Unique command name, identifies specific server task to carry out.

FLAGS -

Enables or disables specific command functionality or output.

OPTIONS -

Utilized to pass data from the client to server.

ARGUMENTS -

End objects affected by the server command.

Syntax Notes:

All command Options, Flags, Arguments space separated.
Flags begin with the "-" character.
Options are followed by a string containing no spaces.

Server - Client Demonstration

{INSERT VM/Host Images Here}

Server - Client Code Review

{INSERT PYTHON TCP SERVER CODE HERE}

Roadmap

8. Meet the Afternoon Teams
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    a. Daemon
    b. Interfacing
    c. **User Applications**
    d. Data Storage
11. Dynamometer (DYNO)
    a. Decomposition and Definition
    b. Integration and Recomposition

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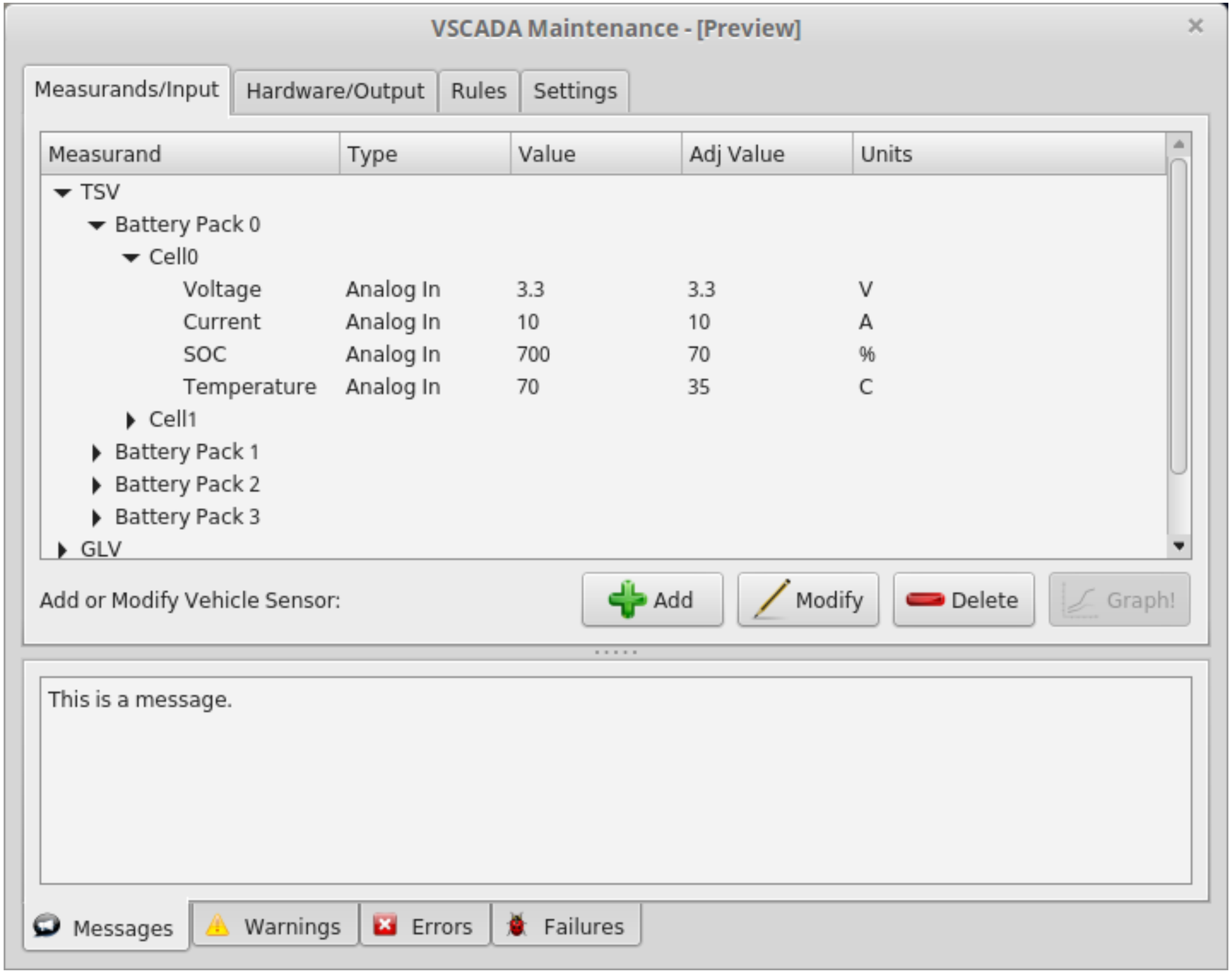
Front-End User Application

- VSCADA Maintenance Application
  - Contains all required user functionality in one program
  - Runs on remote PC (pit station PC) and vehicle embedded computer with touchscreen
  - Demo mode can be selected in the maintenance application
  - Password is used to protect maintenance mode from unauthorized access

Maintenance App - Measurands/Input



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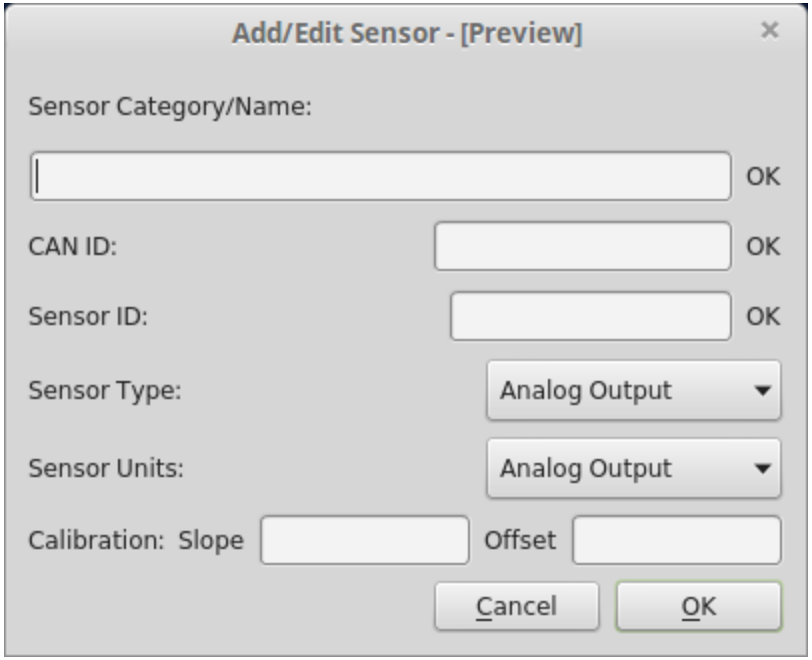
Maintenance App - Add/Edit Sensor Window



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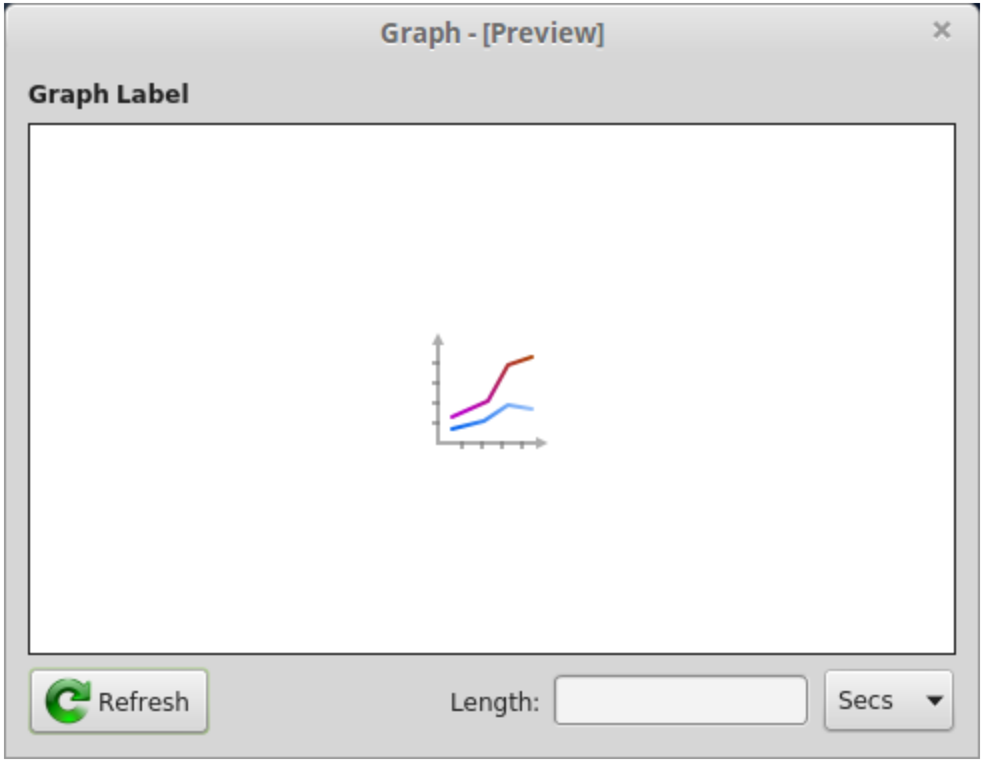
Maintenance App - Measurand Graph Window



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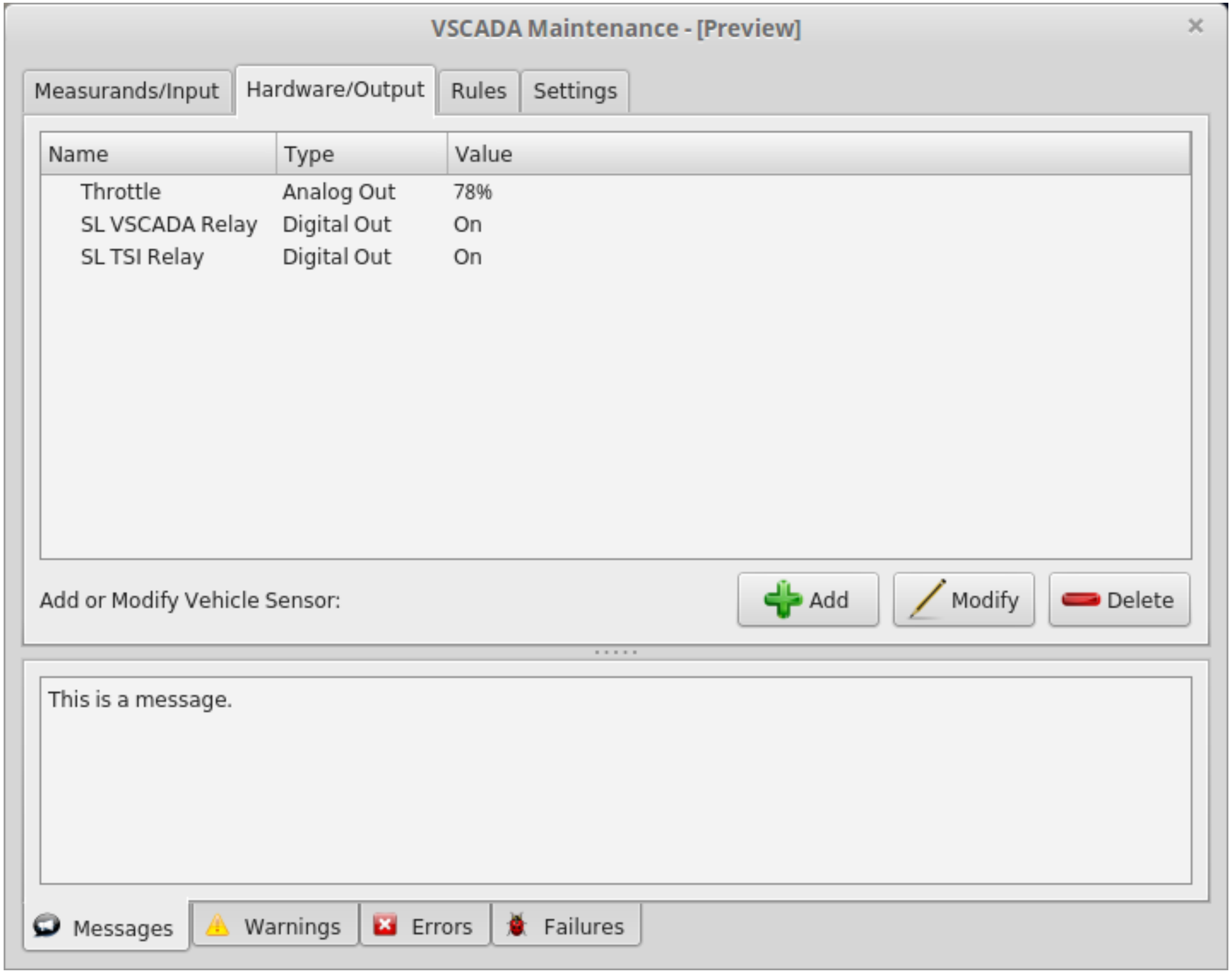
Maintenance App - Hardware/Output



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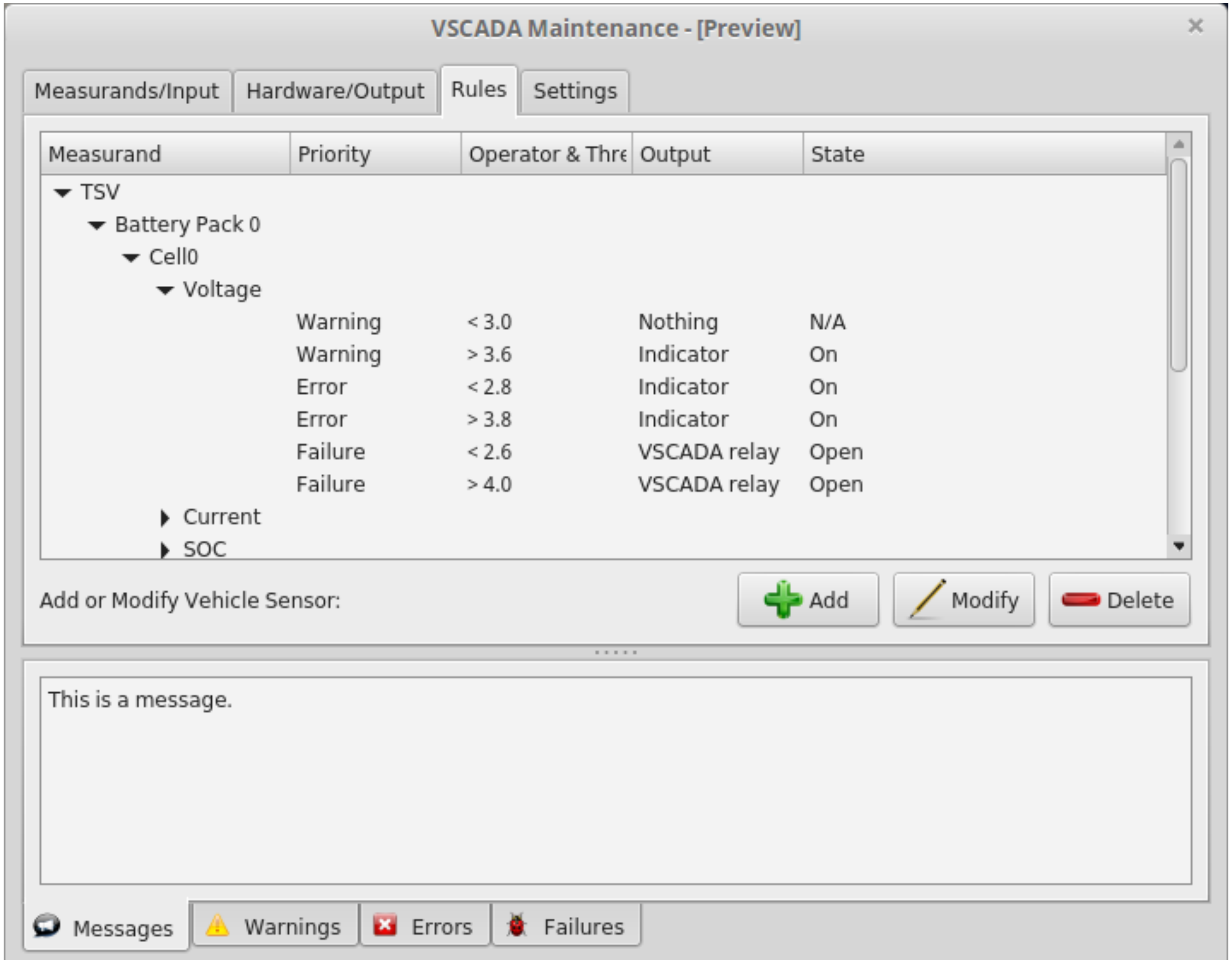
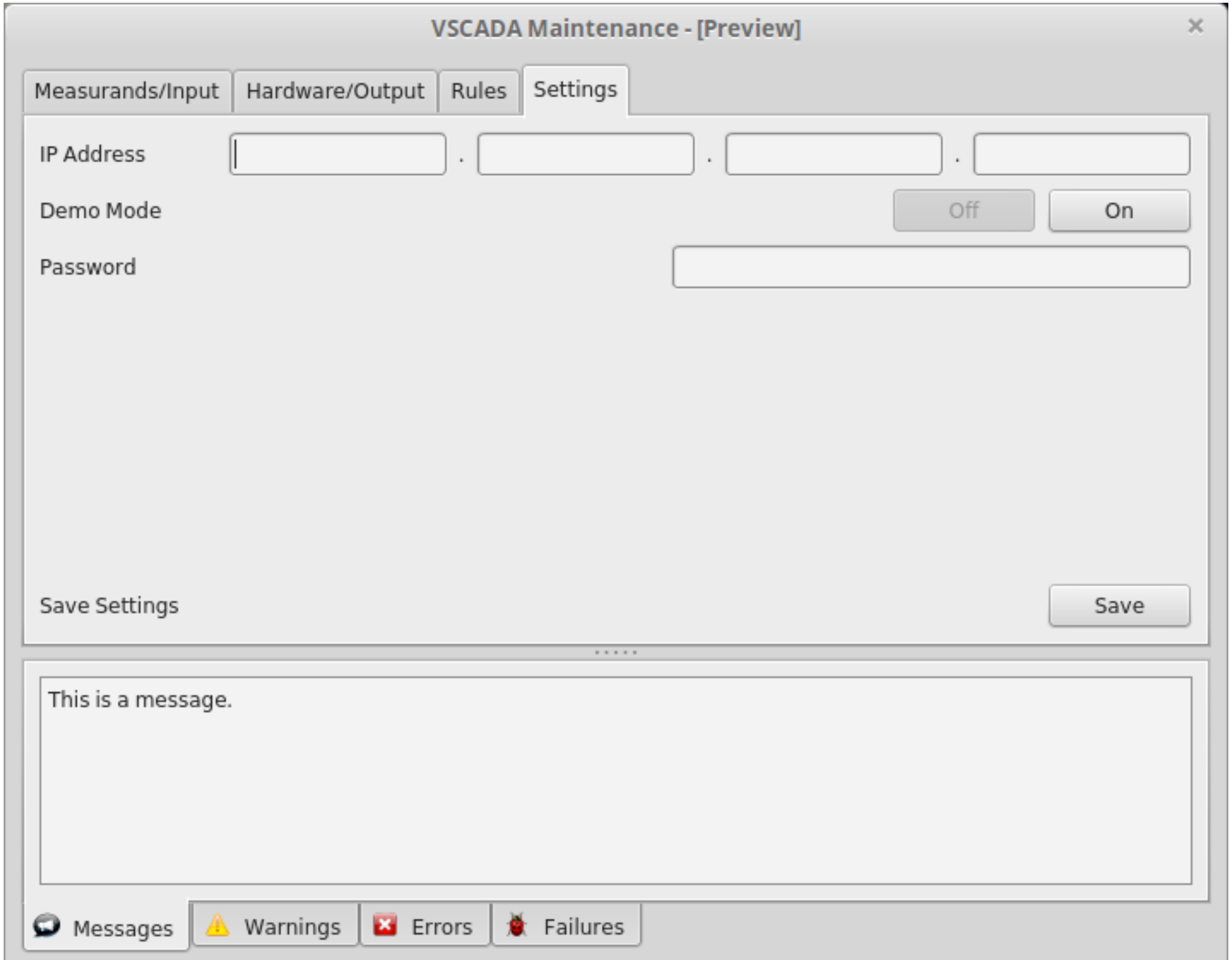
Maintenance App - Rules



Maintenance App - Settings



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Round Robin Database (RRD)

- High performance data logging and graphing system for time series data

- Uses circular buffer to store data
    - Data size does not expand with time.
    - Overwrite the data once it reach the starting point

- Framework for storing measurement averages, min,max and derivative

- Graphical presentation for both stored and archived data.

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RRD Creation

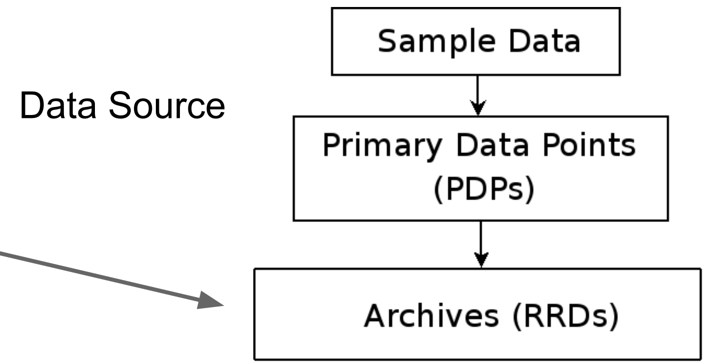
- Size of the database can be determined at creation time.

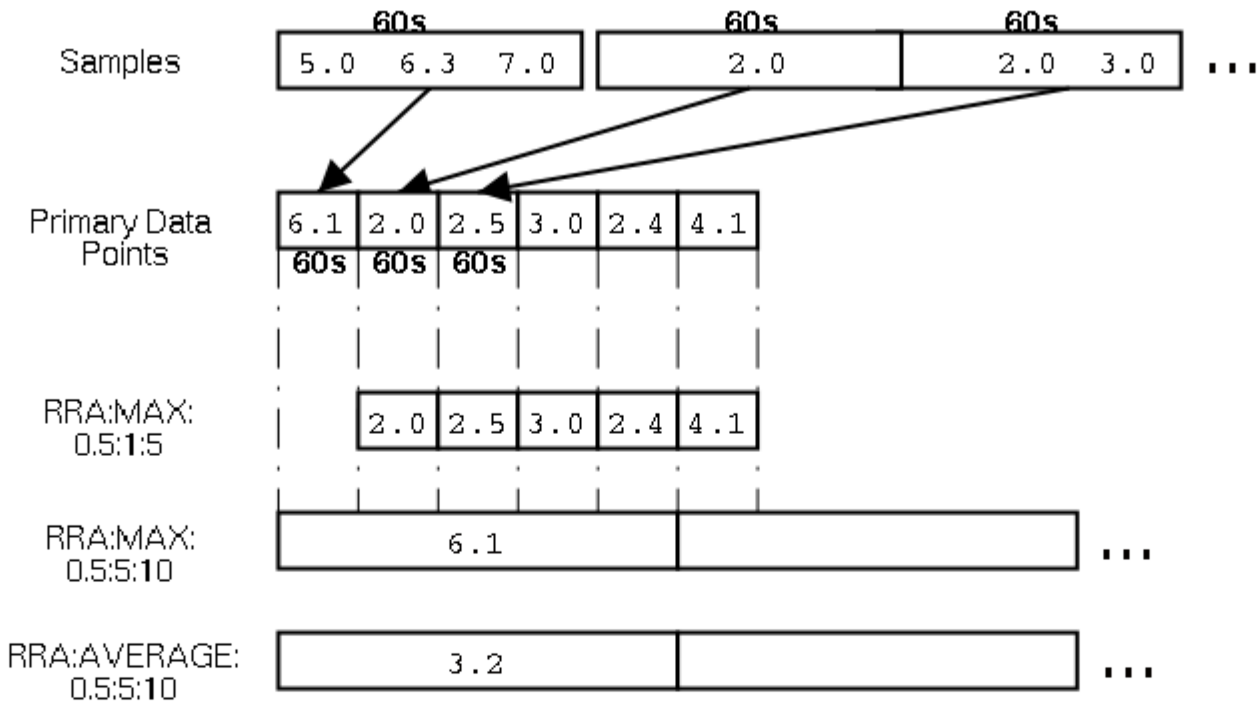
- Specify the step time (rate at which the database update the data)

- Specify the step time for archives too. For different archives, different time step can be applied.

Round Robin Archives (RRA)

- Average
- Minimum
- Maximum
- Last





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RRD for this project

- Monitor the time series data.
- Take care of time and space complexity.
- Very simple in structure.
- Manipulate the stored data and archived the data.
- Graphing tools.

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Database and Configuration

- Database for sensor list and most of the configurations
- Text files for logic related (startup procedures, logic switches, etc)

Database

- SQL is used for the followings:
  - Table 1: restoring sensor information
    - sensor hierarchy
    - CAN id
    - sampling rate
    - rrd file reference
      - This means, all data is going to be stored in RRD, but a reference is kept in SQL as a cleaner solution
  - Table 2: type of sensor
    - analog in, analog out, digital in, digital out
    - need to know this for sending out data on CAN

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Database

- Table 3: warning/error threshold
  - High and low values for warnings, errors and failures
  - Reaching these values will trigger some certain actions, which is referred in the next table
- Table 4: warning/error actions
  - Each of the actions here is generic and configurable
- Table 5: calibration
  - have slop and offsets

SQL DB: ‘Sensor_Table’

Name	id_CAN	id_Sensor	Type	Sample_Rate

Overwrite_Period	Units	Factor	Offset	RRD_DB

SQL DB: ‘Sensor_Type’

id	Description	Type	Direction

SQL DB: ‘Sensor_Levels’

id	Warning_Low	Warning_High	Error_Low	Error_High	Fail_Low	Fail_High

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SQL DB: ‘Sensor_Actions’

id	Action_Name	Priority_Level	Effector_Name	Effector_State

id	Name	id_CAN	id_Sensor	Type	Sample_Rate	Overwrite_Period	Units	Factor	Offset	RRD_DB
1	TSV/Pack1/Voltage	0	1	Analog	20	24	V	1	0	/data/TSV/pack1/voltage.rrd
2	TSV/Pack1/Current	1	2	Analog	21	25	A	1	0	/data/TSV/pack1/current.rrd
3	TSV/Pack1/SOC	2	3	Analog	22	26	%	1	0	/data/TSV/pack1/SOC.rrd
4	TSV/Pack1/Fuse_Temperature	3	4	Analog	23	27	°C	1	0	/data/TSV/pack1/fuse_temperature.rrd
5	TSV/Pack1/AMS1/Temperature	4	5	Analog	24	28	°C	1	0	/data/TSV/pack1/AMS1/temperature.rrd
6	TSV/Pack1/AMS1/Voltage	5	6	Analog	25	29	V	1	0	/data/TSV/pack1/AMS1/voltage.rrd
7	TSV/Pack1/AMS1/Current	6	7	Analog	26	30	A	1	0	/data/TSV/pack1/AMS1/current.rrd
8	TSV/Pack1/AMS2/Temperature	7	8	Analog	27	31	°C	1	0	/data/TSV/pack1/AMS2/temperature.rrd
9	TSV/Pack1/AMS2/Voltage	8	9	Analog	28	32	V	1	0	/data/TSV/pack1/AMS2/voltage.rrd
10	TSV/Pack1/AMS2/Current	9	10	Analog	29	33	A	1	0	/data/TSV/pack1/AMS2/current.rrd
11	TSV/Pack1/AMS3/Temperature	10	11	Analog	30	34	°C	1	0	/data/TSV/pack1/AMS3/temperature.rrd
12	TSV/Pack1/AMS3/Voltage	11	12	Analog	31	35	V	1	0	/data/TSV/pack1/AMS3/voltage.rrd
13	TSV/Pack1/AMS3/Current	12	13	Analog	32	36	A	1	0	/data/TSV/pack1/AMS3/current.rrd
14	TSV/Pack1/AMS4/Temperature	13	14	Analog	33	37	°C	1	0	/data/TSV/pack1/AMS4/temperature.rrd
15	TSV/Pack1/AMS4/Voltage	14	15	Anal	34	38	V	1	0	/data/TSV/pack1/AMS4/voltage.rrd

Configuration

- Bash style
- Read during startup, and bad syntax will raise exceptions and the car will be disabled from driving
- Switches can be updated and modified by maintenance app
- Will be stored under same directory and database in a separate folder
- Is accessible from debug port

http://img.talkandroid.com/uploads/2011/08/seal-of-approval.jpg

Acceptance Testing

- Show that VSCADA meets all requirements as both:
  - part of integrated LFEV system
  - standalone software system
- Strive for maximum amount of test automation/avoid recompiling software
- Main criteria:
  - Exception handling
  - Automated hardware detection/configuration
  - Logging, plotting and storing of measurands
  - Controlling system state

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Acceptance Testing (cont.)

Test configurations:

- Config A: VSCADA powered by 12 V power source
- Config B: VSCADA interfaced with GLV
- Config C: VSCADA interfaced with GLV and TSV
- Config D: VSCADA interfaced with GLV, TSV and DYNO

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Acceptance Testing (cont.)

T000 - System Startup/Shutdown and GLV Data Logging

- Config B
- Tests:
    - Automatic startup without user interaction once GLV power is provided
    - Logging of GLV measurands
    - Keeping of backup in case of unexpected shutdown

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Acceptance Testing (cont.)

T001 - Safety Checking/Exception Handling

- Config D
- Tests:
  - Lighting of Ready LED on cockpit if all subsystems are in a safe state when Ready-to-Drive buttton pressed
  - Lighting of warning LEDs to warn user and prevent drive mode being activated by Ready-to-Drive button if unsafe condition occurs (exception handling)
  - Examples are open safety loop, voltage threshold exceeded, temperature threshold exceeded, missing config file for sensors

Acceptance Testing (cont.)

T002 - Maintenance App Operation

- Config D
- Tests:
  - Requirement of proper user credentials to login to maintenance mode
  - Logging and storing of all subsystem measurands (TSV pack/cell voltages, currents, temperatures, GLV voltage, current, Dyno torque, RPM)
  - Allowing user to control all aspects of VSCADA such as disabling safety checks, disabling data logging, and programming individual shutdown rules

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Acceptance Testing (cont.)

T003 - Drive Mode Operation

- Config D, then repeat with Config A (simulated throttle)
- Tests:
  - Accurate reporting of measurands while driving
  - Logging of exceptions should unsafe condition occur while driving
  - Demo operation of vehicle through software throttle if other subsystems not available

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Acceptance Testing (cont.)

T004 - Pack Charging/Discharging

- Config C
- Tests:
  - Displaying that accumulator is charging
  - Displaying that accumulator is discharging

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Acceptance Testing (cont.)

T005 - Reliability Test

- Config D
- Tests:
  - System can run through series of drive modes/simulations and maintenance configuration changes over period of 24 hours without failure

Acceptance Testing (cont.)

T006 - Maintainability Test

- Config D
- Tests:
  - Novice user can solve frequently occurring problem
  - Expert maintenance individual can solve unexpected problem
  - New sensors can be added to system without software recompilation
  - VSCADA software can be installed easily using “make/install” on different computer

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Schedule

Week 9

Demonstration System Integration & Debugging

System parts designed in the past six weeks will be integrated into a cohesive system demonstration for CDR, and for displaying system capabilities to other groups.

CAN Communication PCB Fabrication

The General Sensor CAN Communication PCB GERBER files will be ready for fabrication and sent out for production.

Week 10

Preliminary Demonstration System

A primitive scada system will be functioning, and ready for demonstration to other groups. This system should be capable of allowing groups to test communications between themselves and the SCADA system in the future.

Week 11

SCADA Server Maintenance Mode

The main system server will be capable of performing all 'Maintenance Mode' tasks, and interfacing with all 'Maintenance Mode' client interfaces.

QA Report Submitted

Deliverable **D006** (QA Report) will be submitted.

Schedule cont'd

Week 12

System Integration & Debugging

Any remaining components not added to the SCADA system will be added at this time. Debugging and integration into other vehicle sub-systems.

SCADA Server Demo **Mode**

The main system server will be capable of performing 'Demo Mode' tasks.

Week 13

Final ATR Report Submitted

Deliverable **D005** (ATR Report) will be submitted.

System Integration & Debugging

Any remaining components not added to the SCADA system will be added at this time. Debugging and integration into other vehicle sub-systems.

Dynamometer Communication Library

The main system is capable of sending messages to the Huff Box over serial ports.

Schedule cont'd

Week 14

System Integration & Debugging

Any remaining components not added to the SCADA system will be added at this time. Debugging and integration into other vehicle sub-systems.

System Documentation

All project documentation will be finalized and completed.

Completed Maintenance **Manual Submitted**

A VSCADA Maintenance Manual Working Draft will be submitted.

Week 15

Final Report & Maintenance Manual Submitted

Deliverable **D003** (Final Report) will be submitted.

System Errata Documentation

Any known bugs, and system errata will be documented for use by future students.

Budget

Item/Group	Total
SCADA	
Embedden Computer System	270
Dashboard LCD display and controller	80
Wireless Radio	50
Slave Sensor Micro Controller Hardware	100
Debugger	80
Programmer	10
Total	590
Budget:	715

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Roadmap

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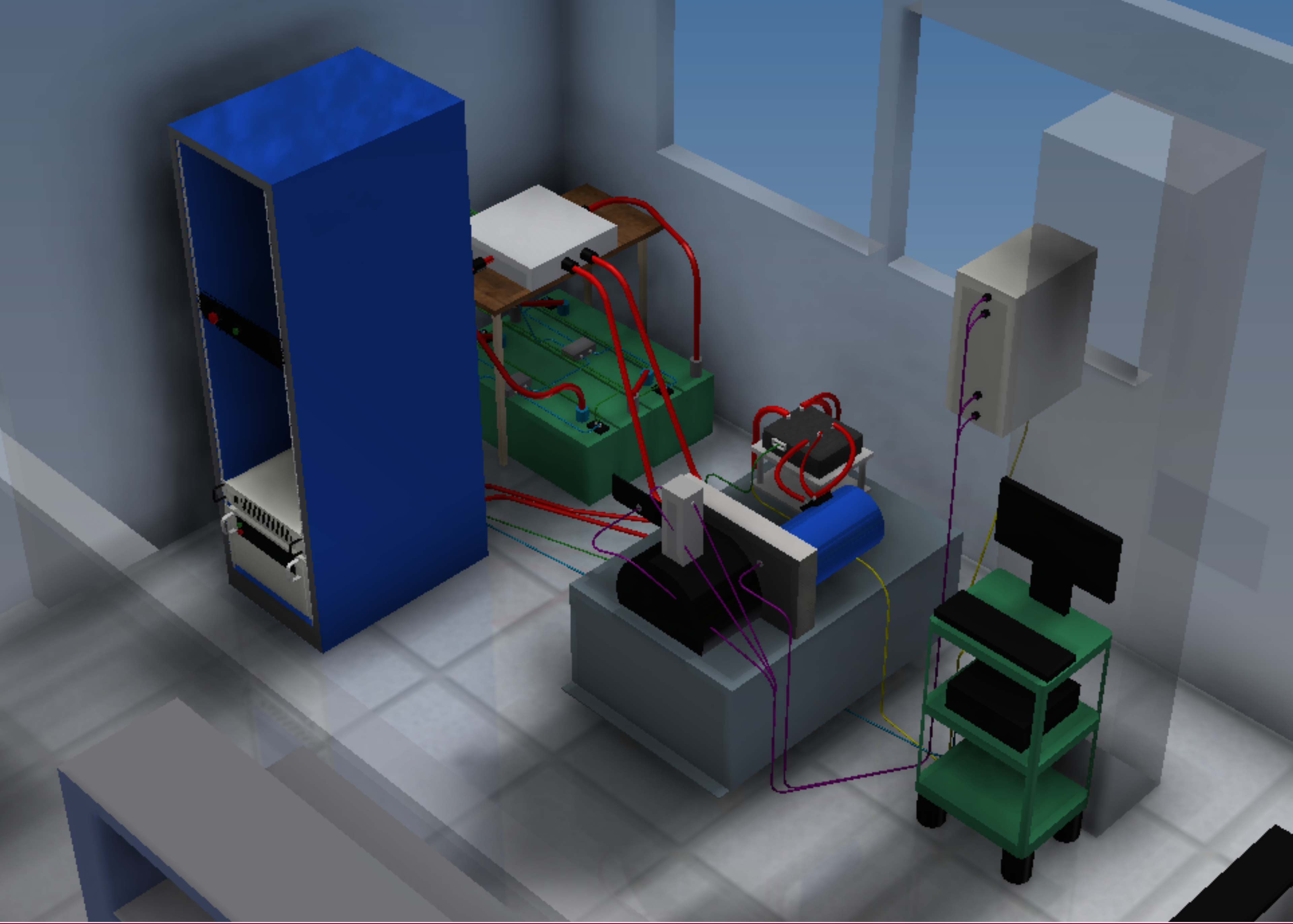

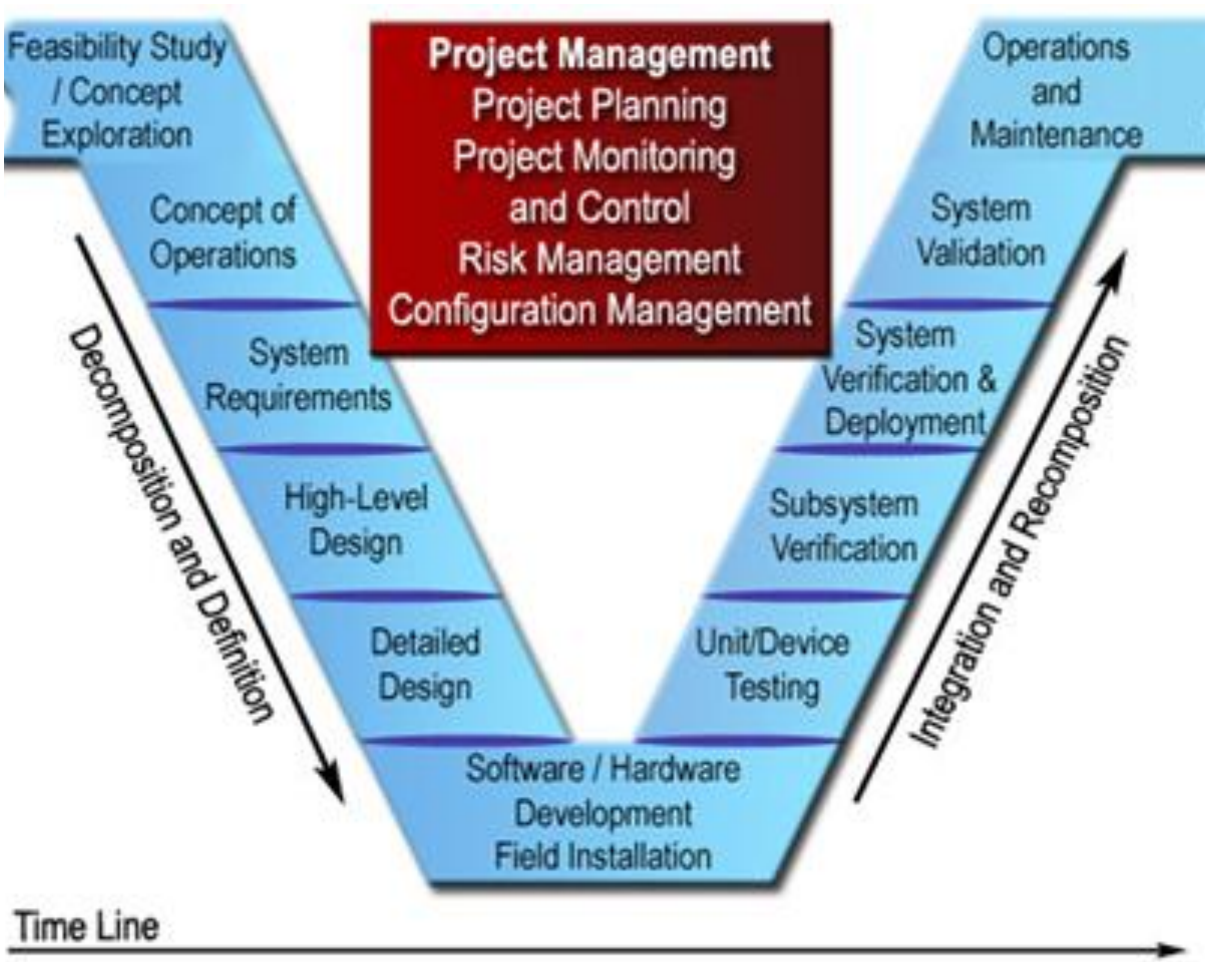

http://ops.fhwa.dot.gov/publications/seitsguide/images/image068.jpg

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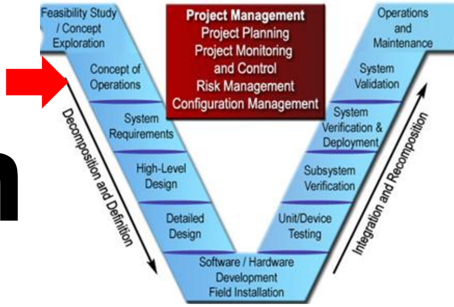
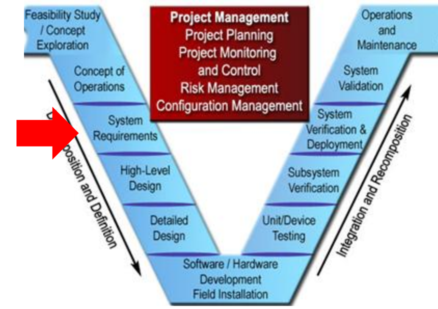
Concepts of Operation

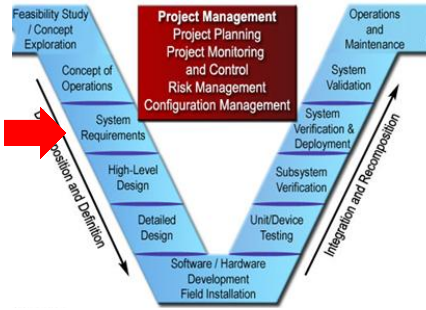


- Generate a torque curve
- Develop a software simulation of the car
- Develop a hardware simulation of the car
- Determine the car gear ratio

System Requirements



- Motor/Dyno Selection
- Motor Controller
- Software
  - Data Acquisition
  - Throttle Control
- Interfaces
  - VSCADA
  - GLV
  - TSV
- Safety



Motor Selection

- HPEVS AC 50-27.28

Photo: HPEVS

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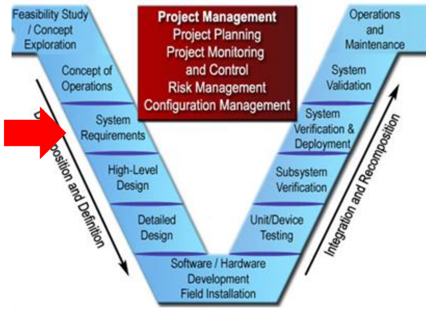
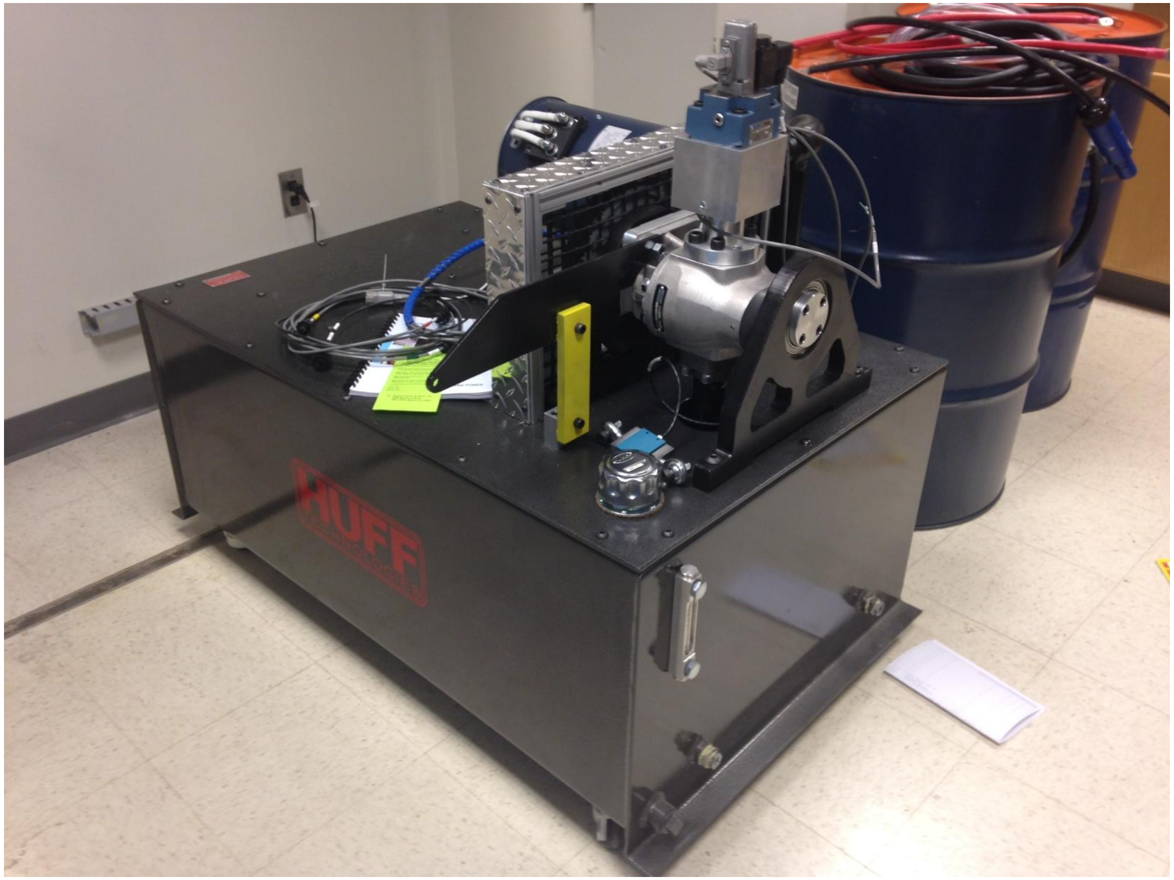


Dynamometer Selection

- Huff HTH-100



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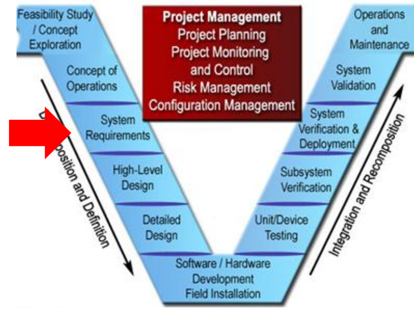

Motor Controller

- Curtis 1238R-7601

Photo: evwest.com

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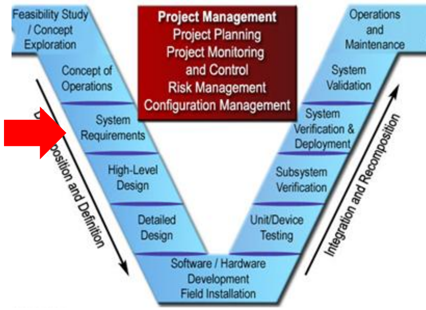
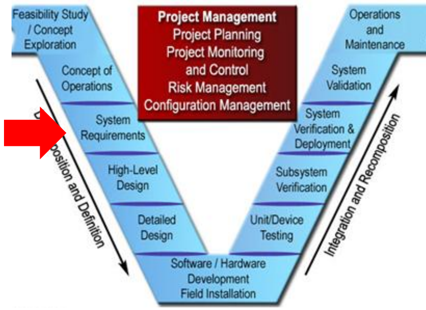
Interfaces



- VSCADA - Interface for data acquisition and throttle control
- GLV - Interface for power and data transmission
- TSV - Interface to power supply



Software

VSCADA - Dyno

- Data Acquisition
  - RPM
  - Torque
  - Temp - Motor and Controller
  - RMS Current
  - Voltage
- Throttle Control

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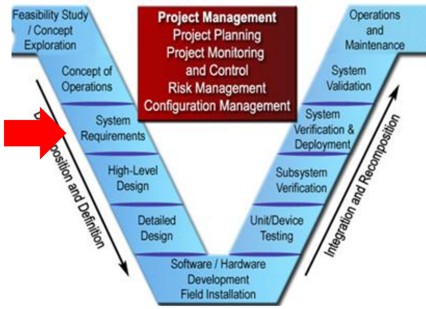

Safety

- Emergency Shutoff
  - Must be have an emergency stop
  - Must be shut down when GLV is down
- Oil Temperature Shutoff
  - Must shut down when temperature limit is exceeded
- Galvanic Isolation
  - Must separate high and low voltage subsystems
- Motor Controller Contact Shield
  - Prevents accidental contact with terminals

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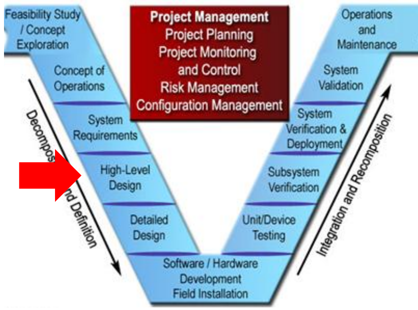
High-Level Design



- ICD Layouts
- Safety Shutoff
- Throttle
- HUFF - VSCADA Interface
- Motor Controller
  - Cooling
  - Safety
- Galvanic Isolation

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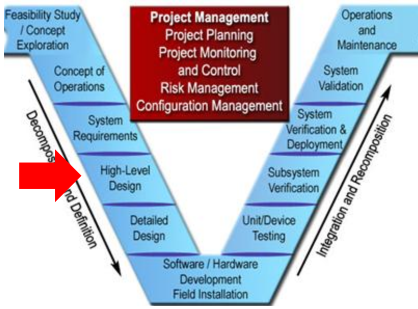
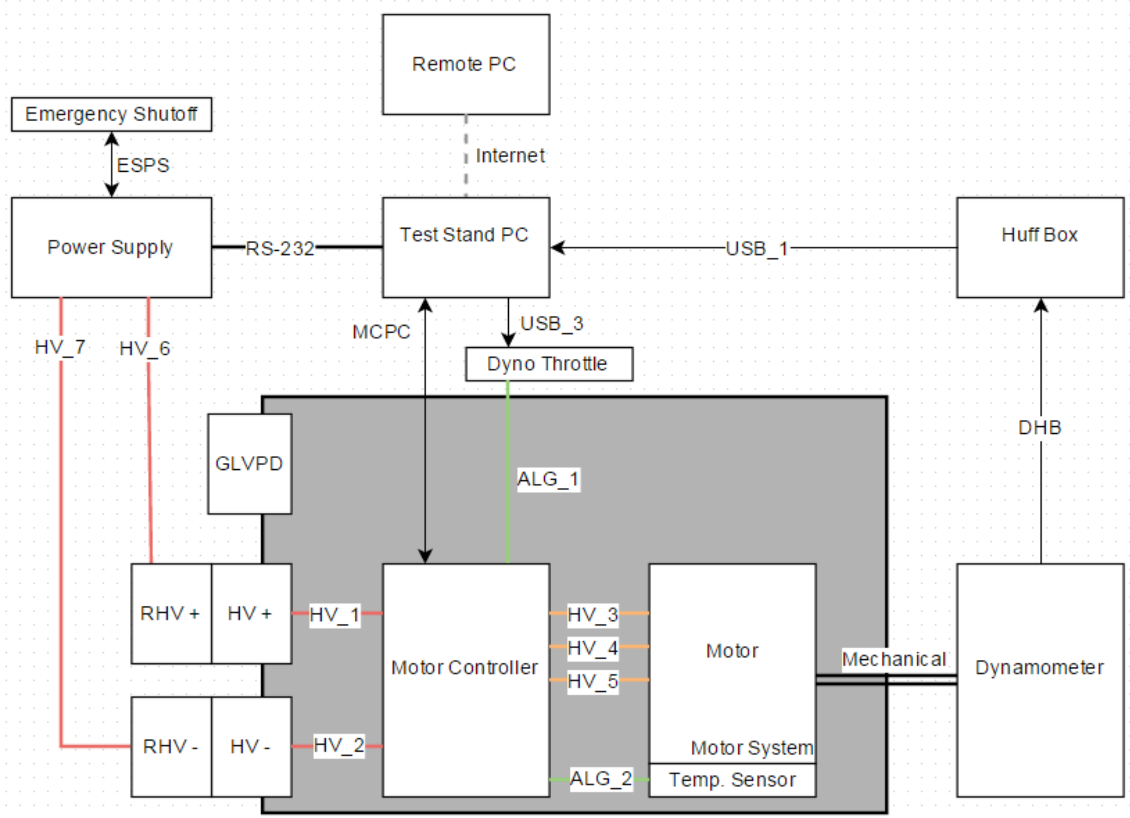
ICD Layout



- Two configurations
  - Dyno Testing Configuration:



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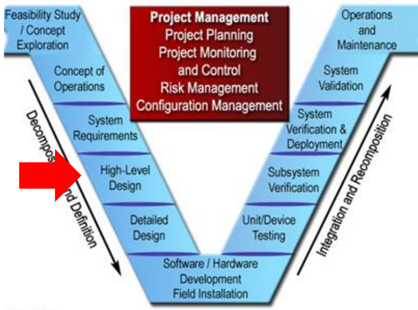
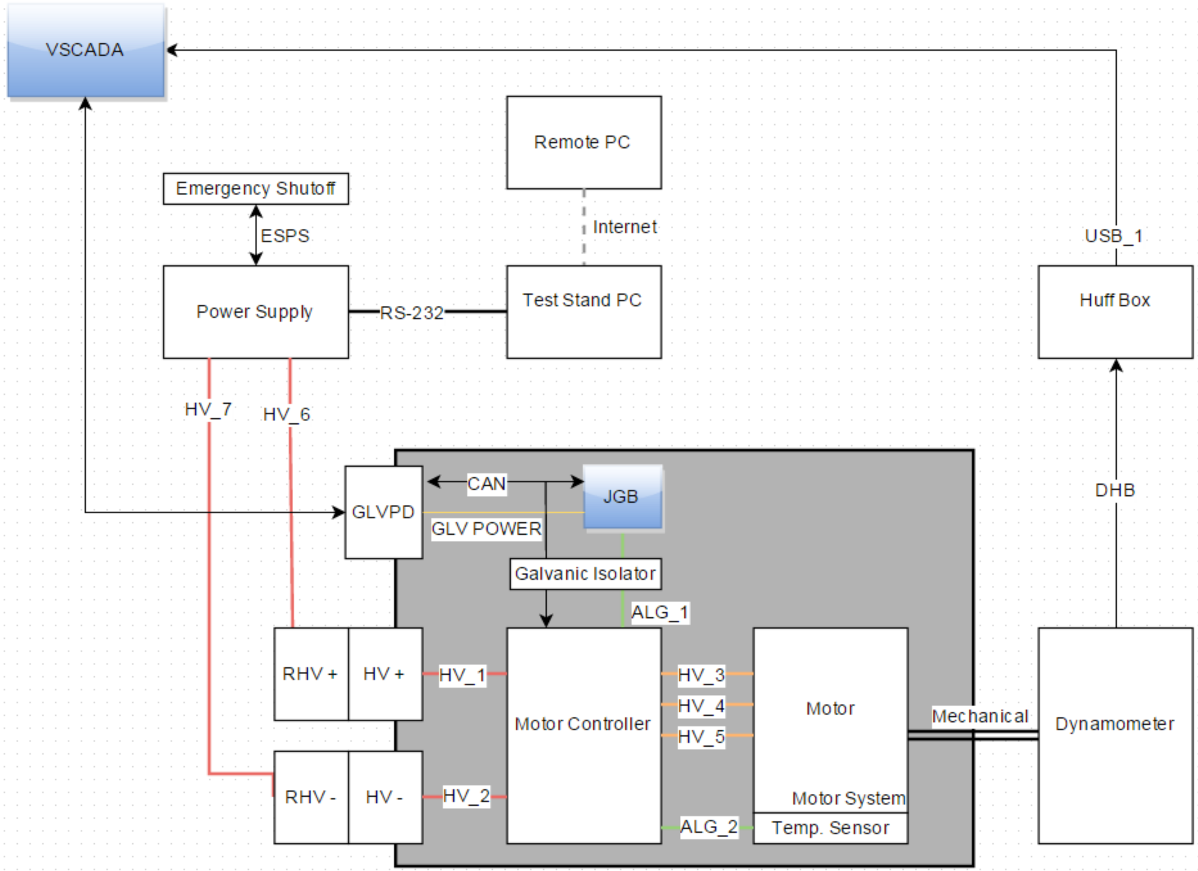


ICD Layout

- Two configurations
  - Integrated Design Configuration:



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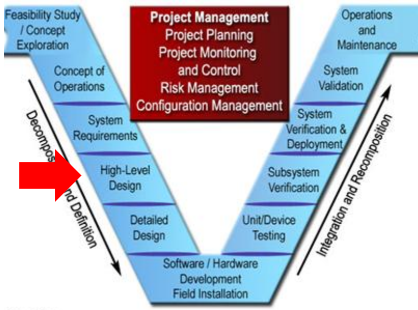
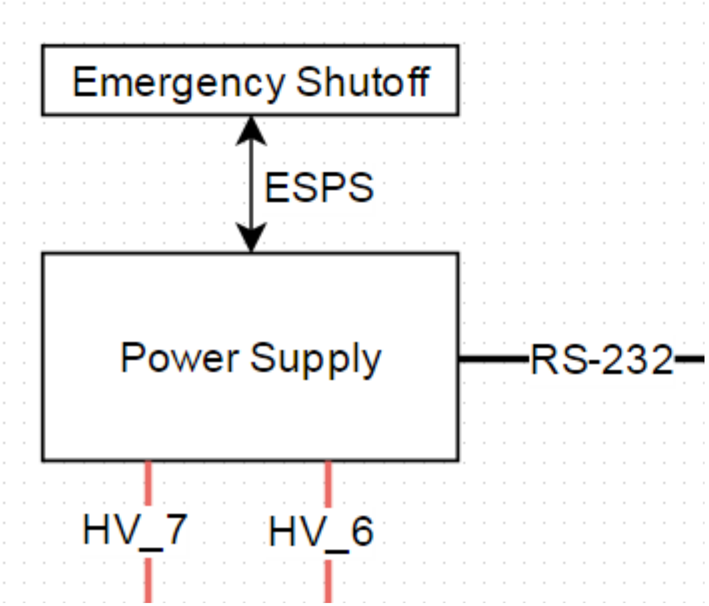
Safety Shutoff



- Requirements -
  - Must include emergency stop
  - Must include temperature shutoff
- Design -
  - Use the power supply control inputs. These control mechan contactors.



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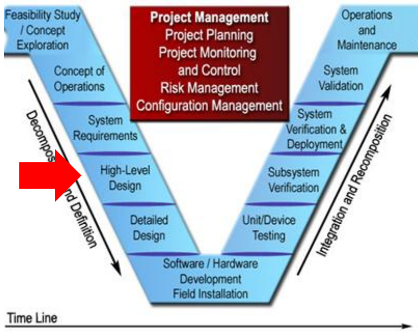
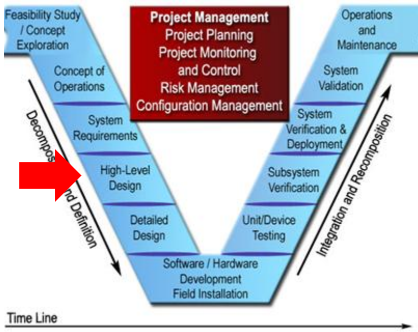
Huff - VSCADA interface

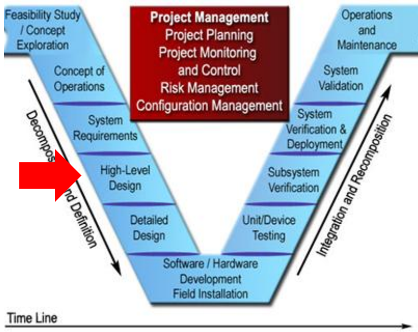


- USB interface
- Utilizes serial communication
- Based on a call and response system
- Used to acquire data and set values
- Protocol is defined by the chip on data acquisition board

Motor Controller Cooling



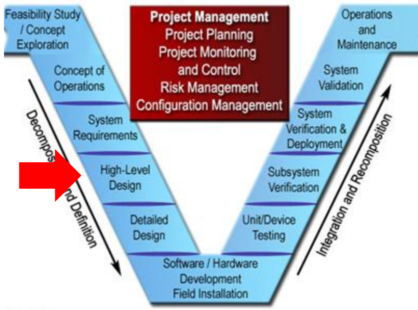
- Must regulate MC temperature
  - Storage ambient temperature range:-40°C to 95°C
  - Operating ambient temperature range:-40°C to 50°C
  - Internal heatsink operating temperature range:-40°C to 95°C
- Utilize a Water Cooling system
  - Pump→ MC→ Radiator→ Pump
  - Mounted Cooling Housing
  - Effectiveness to be determined upon delivery of parts



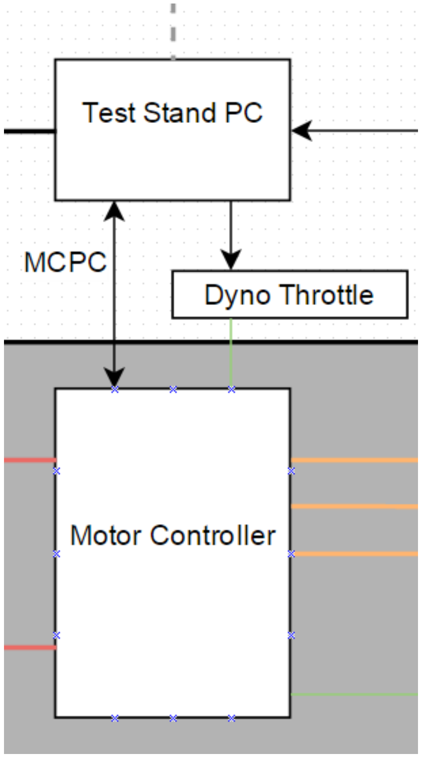
Motor Controller Safety

- Must prevent conductive injury from MC ports
  - High Voltage
- Cover all electrical hazards to prevent accidental contact
  - Use non-conductive plastic cover

Throttle



- Must control the throttle input of the MC
  - Throttle input is 0 to +5 volts
  - VSCADA must be connected
  - Must be scriptable for testing
- Use two systems:
  - Use a VSCADA CANbus node with an analog output for the integrated system
  - Use an Arduino connected over USB to control an analog output



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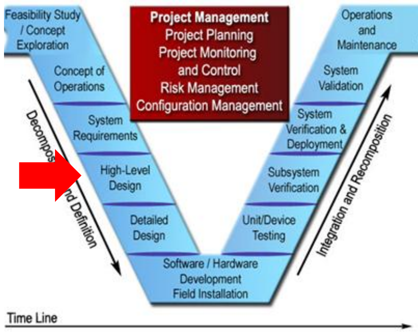

Galvanic Isolation

- High/Low voltage CAN must be separated
- High/Low Voltage Throttle must be separated

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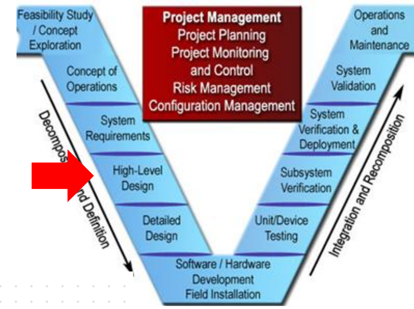
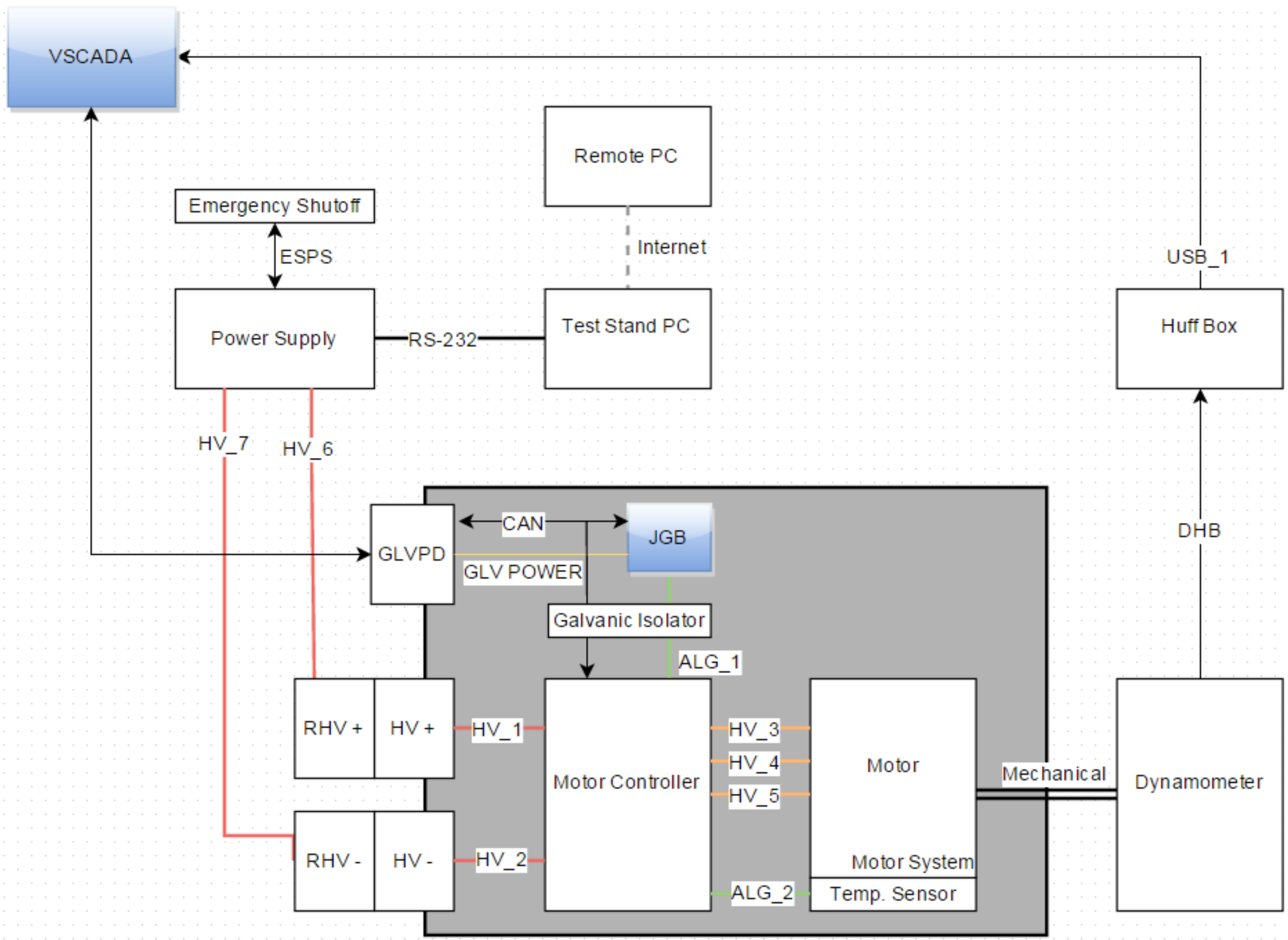
Layout Review:





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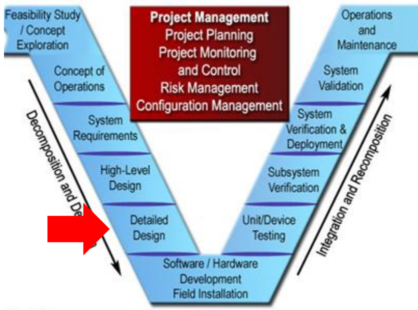
Detailed Design



- Simulations
  - Motor
  - Car
  - Track
- Safety
  - Independent shutoff
  - Insulating covers
- Throttle
  - Independant solution
  - VSCADA solution
- Motor Controller
  - Isolation
  - Parameters
  - Wiring Diagram
  - Cooling
  - Safety
- Room Wiring
  - Testing config
  - Integrated config

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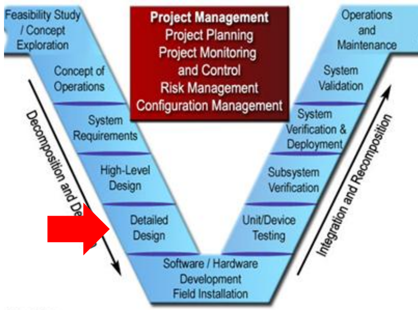
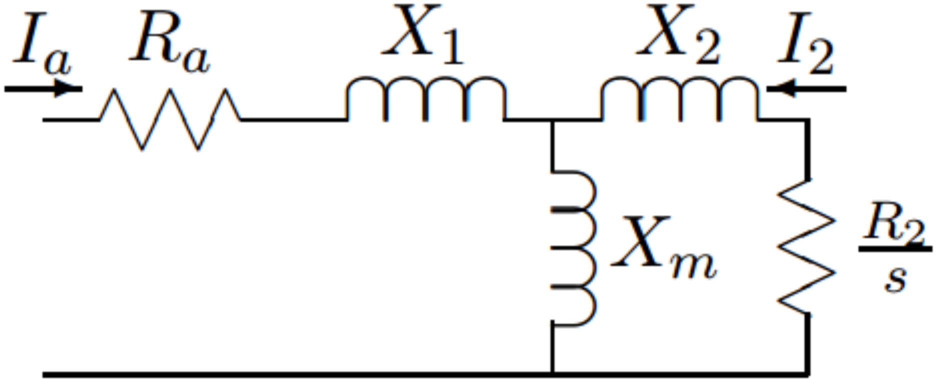
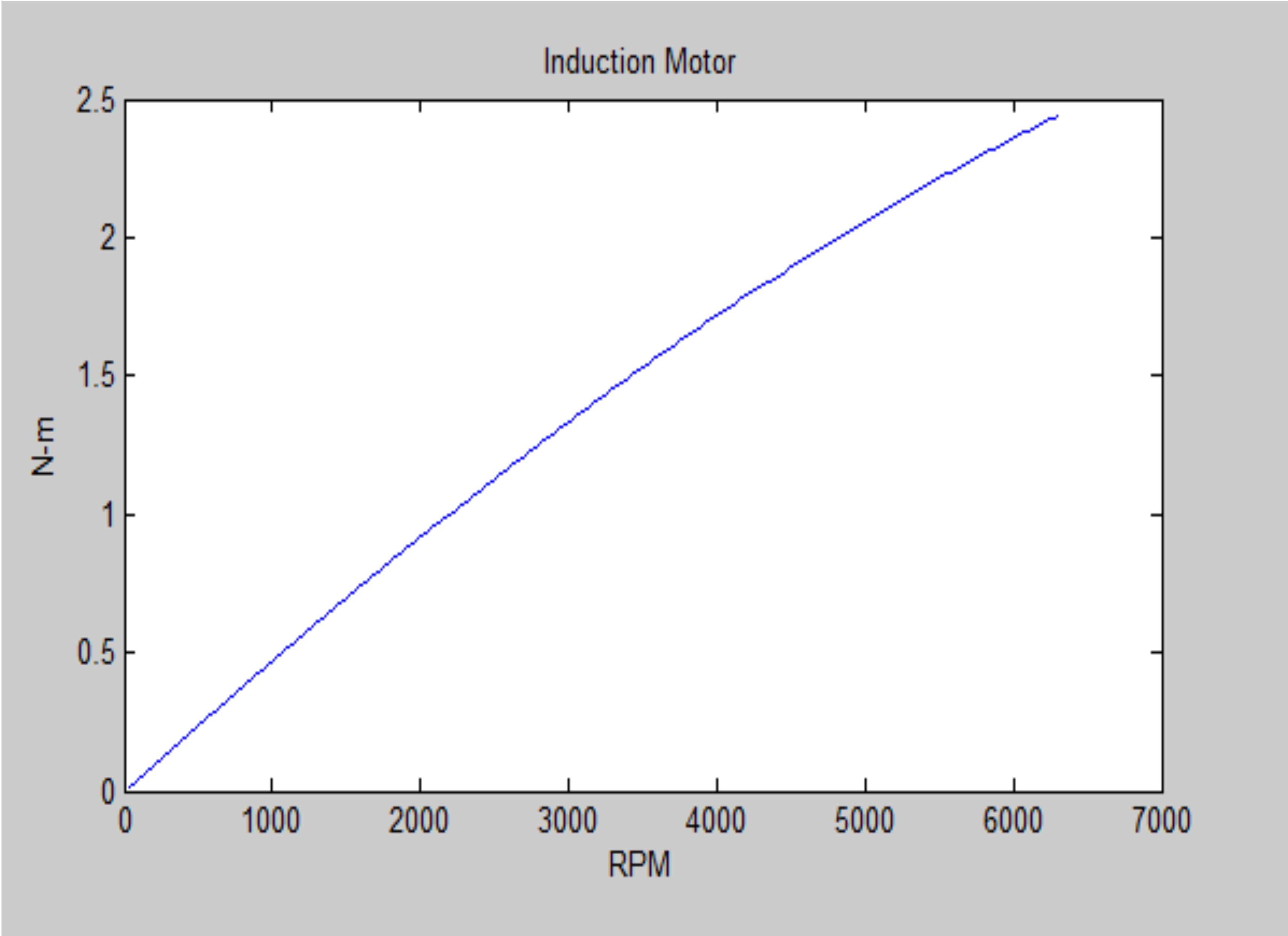


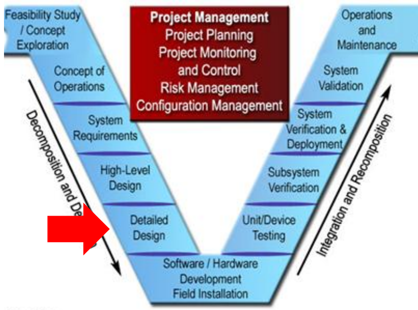
Simulations - Motor

Using IEEE circuit equivalent model developed the following torque curve




Induction Motor
N-m
RPM
2.5
2
1.5
1
0.5
0
0
1000
2000
3000
4000
5000
6000
7000

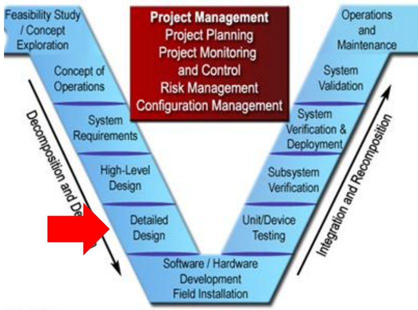
Simulations - Car/Track

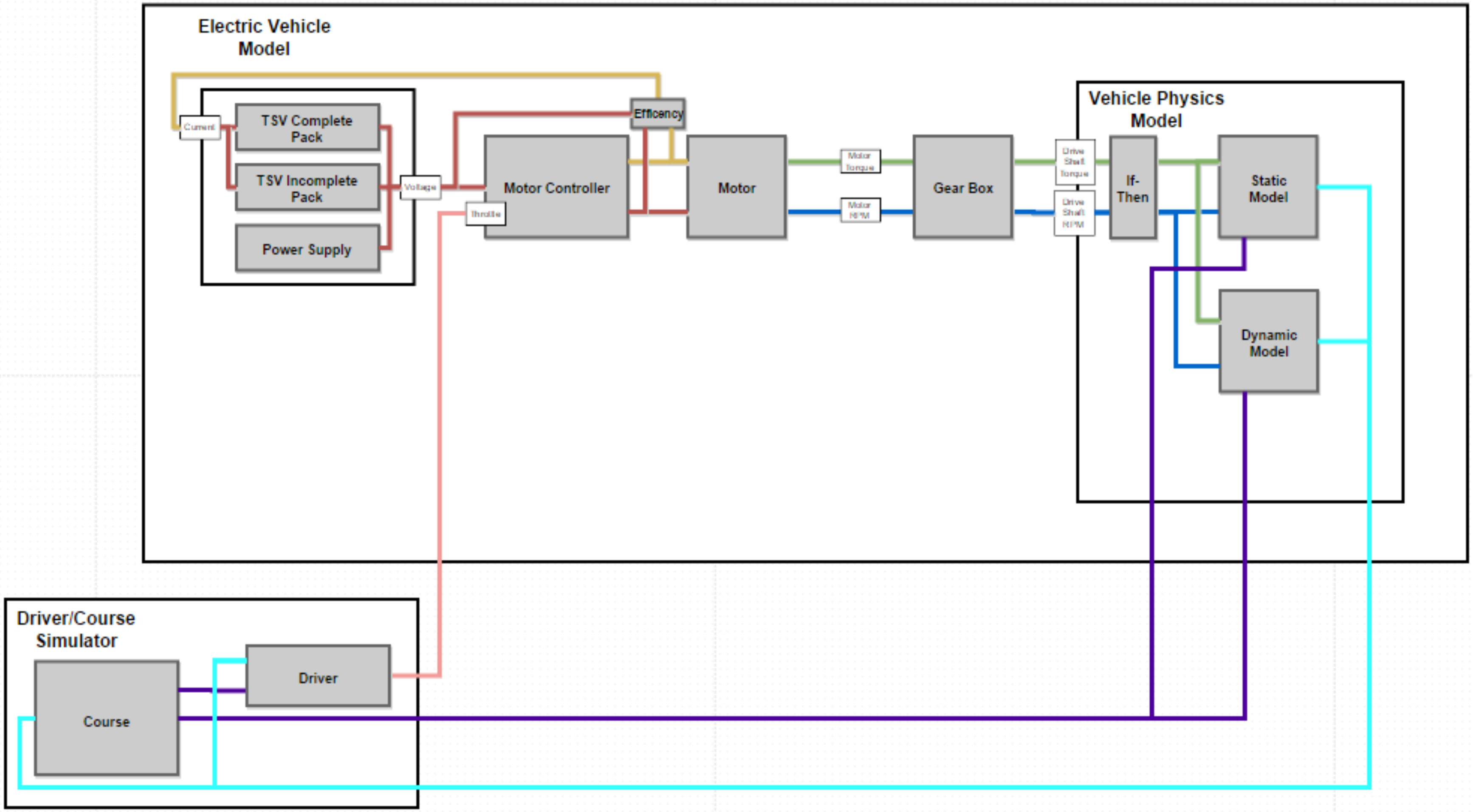


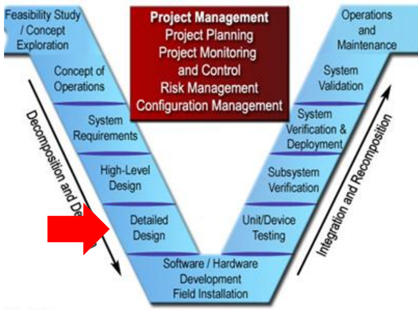
Car will be reduced down to a singular body in order to simplify the static and dynamic equations required.

The track will be simulated by an array of values that will dictate the curvature and incline of the track based on position.

Simulations Layout







Safety - Independent Shutoff

- Use the input control lines
  - Directly linked to mechanical contactors
- Interface is a 37-pin D-Sub connector
  - Need only the start and stop inputs

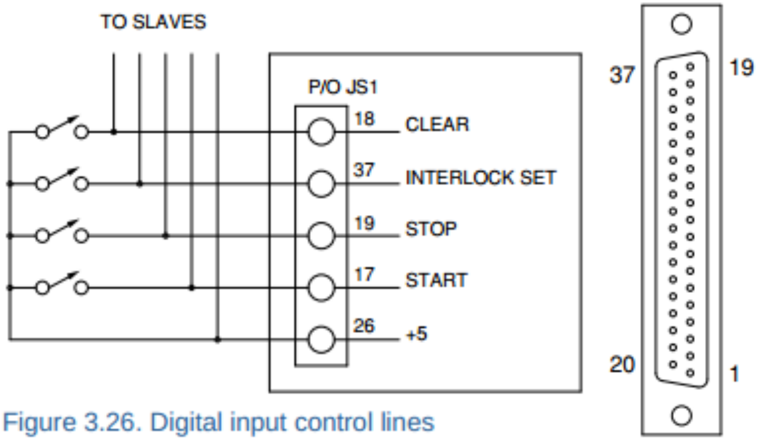
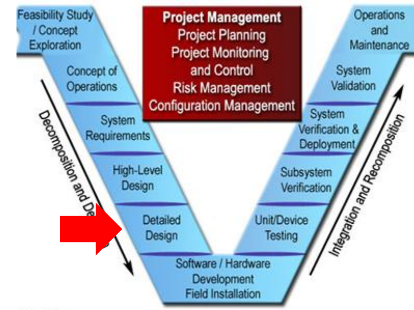
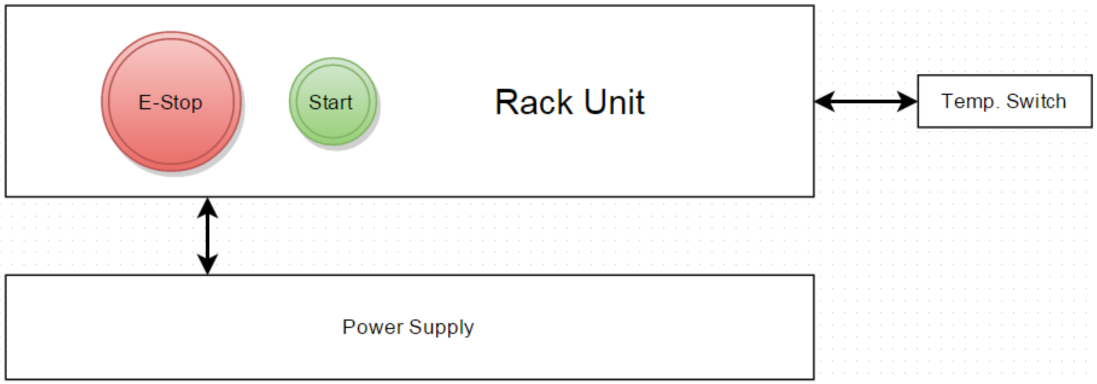


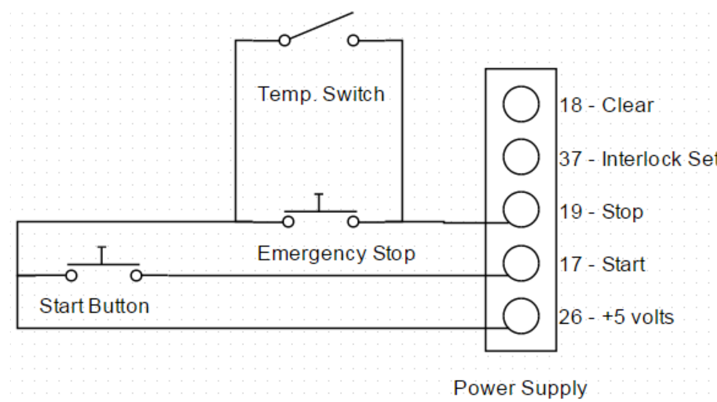
Figure 3.26. Digital input control lines



Safety - Independent Shutoff

- Solution: simple rack mounted unit





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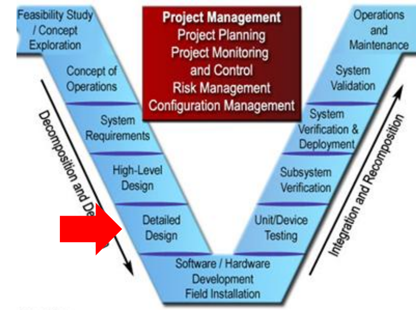
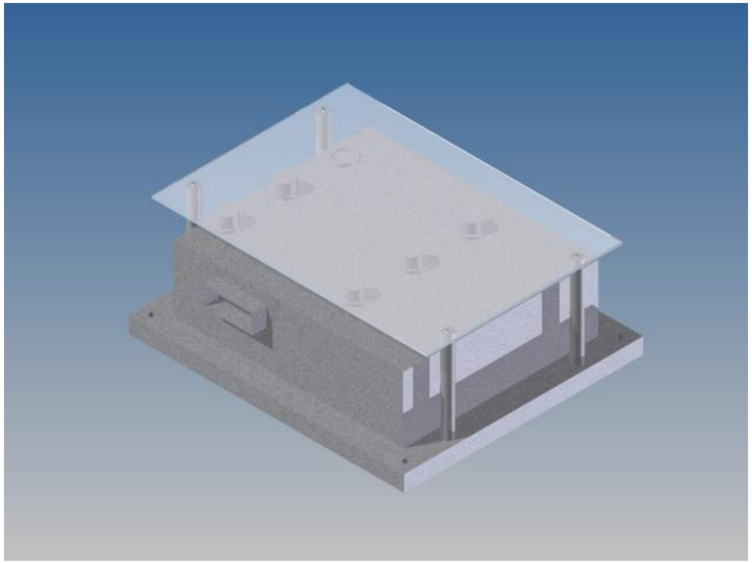


Safety - Insulating Covers

- Plastic Cover
  - Non-conductive
  - Transition temperature higher than cutoff temp
- Aluminum connecting rods



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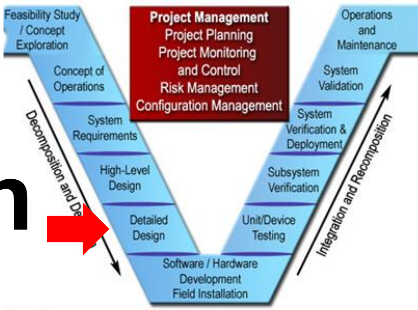
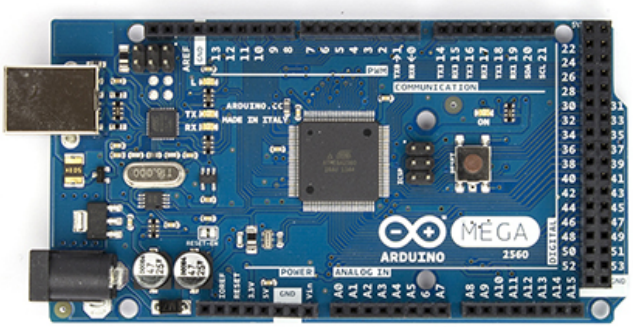
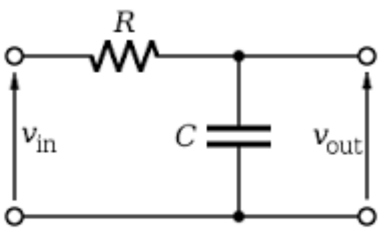


Throttle - Independent Solution

- Need to control throttle from a computer
  - Arduino with USB connection
- No analog outputs
  - Low pass filter on a PWM
- Scripting
  - Write values in a python script



http://arduino.cc/en/uploads/Main/ArduinoMega2560_R3_Fronte.jpg



https://www.python.org/static/community_logos/python-logo.png

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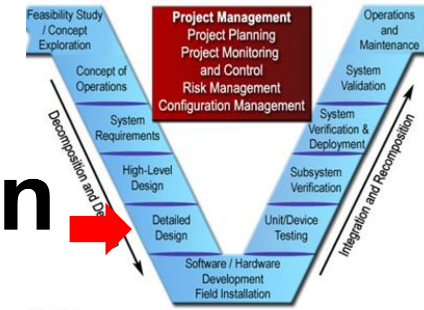
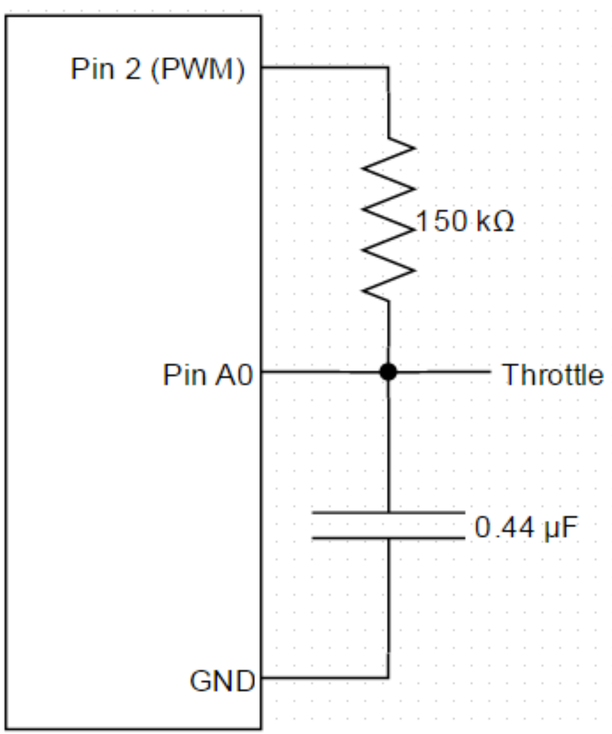
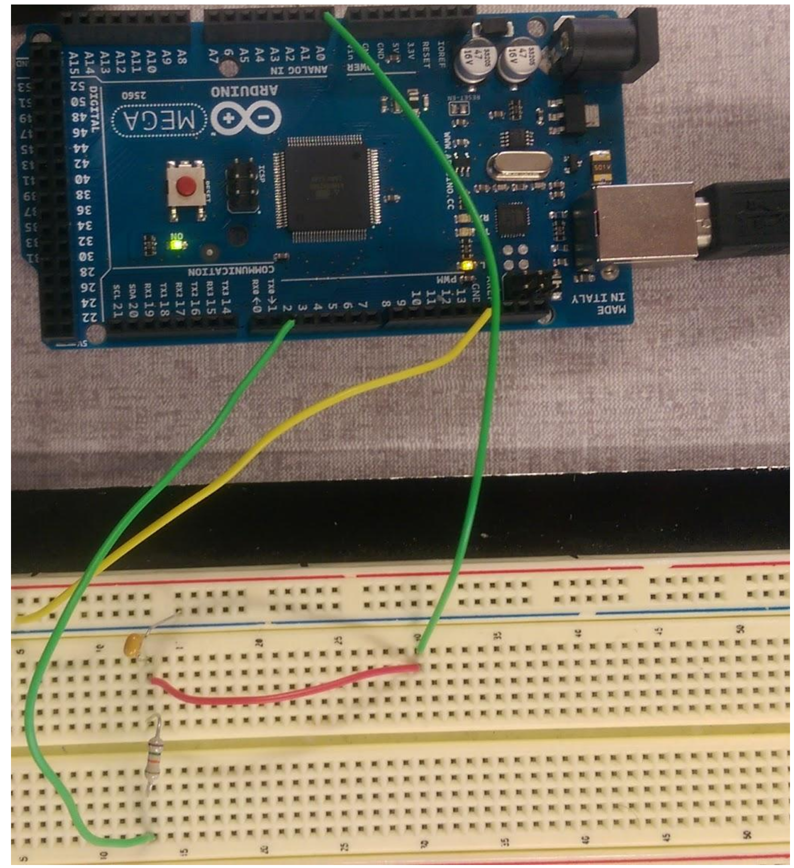


Throttle - Independent Solution

Python script writes PWM values, which are filtered to analog voltages





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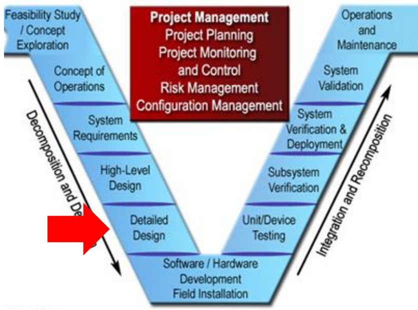
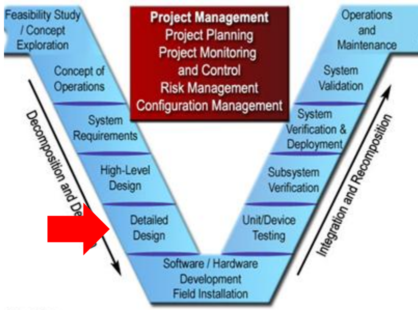
Throttle - VSCADA Solution



- USB connection from VSCADA to Huff Box
- Serial communication
- Call and response
- Protocol dictated by DAQ chip
- Generate PWM signal
  - Relates RPM to voltage
  - PWM is low pass filtered

Motor controller - Isolation



- Isolates motor controller from GLV systems
  - Isolate CANbus
    - Using TI ISO1050DUBR
    - Voltage step down using LM7805
  - Isolate throttle
    - Using 6N135 optocoupler
    - low pass filter PWM signal

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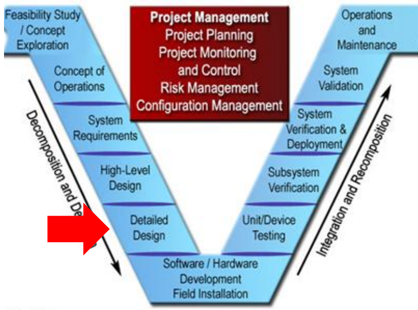

Motor Controller - Parameters

Program		
User Settings		
Speed Settings		
Forward Speed	6500	rpm
Reverse Speed	6500	rpm
Econo Speed	6500	rpm
Accel Rates		
Normal Accel Rate	0.4	Seconds
Econo Accel Rate	1.0	Seconds
Throttle Settings		
Throttle Type	2	
Deadband	0	Volt
Throttle Max	5	Volt
Mapped Throttle	50	%
Brake Pedal Settings		
Brake Type	0	
Brake Deadband	0.30	Volt
Brake Max	3.50	Volt
Regen Brake Light Th...	50	Ampere
Current Limits		
Normal Neutral Braking	15	%
Econo Neutral Braking	25	%
Shift Neutral Braking	7	%
Normal Drive Current...	100	%
Econo Drive Current ...	60	%
Brake Current Limit	10	%
Idle Setup		
Idle Enable	Off	
Clutch Start Enable	Off	
Idle Speed	600	rpm
Idle Torque	50	%
Creep Torque	0	%

Motor Tuning		
Motor Type	50	
Base Speed	3000	rpm
Field Weakening	50	%
Econo Field Weakening	20	%
Weakening Rate	60	%
Main Contactor		
Main Contactor Voltage	48	Volt
Main Holding %	80	%
Display Menu Items		
Auto Scroll	On	
Scroll Delay Time	10	Seconds
Display SOC	Off	
Display Motor RPM	On	
Display Battery Amps	On	
Display Voltage	On	
Display Motor Temp	On	
Display Controller Temp	On	
Display Minimum Volt...	On	
Display Maximum Cur...	On	
BMS		
BMS Installed	Off	
BMS Address	768	
User Undervoltage	80	%
Low Cell Begin Cutback	2.800	Volt
Low Cell Full Cutback	2.300	Volt
Max Current at Full C...	50	%
Maximum Cell Voltage	3.700	Volt
Low SOC Cutback	20	%
Max Current at Low ...	30	%
Dual Drive		
Dual Drive Mode	Off	
Response Timeout	200	ms

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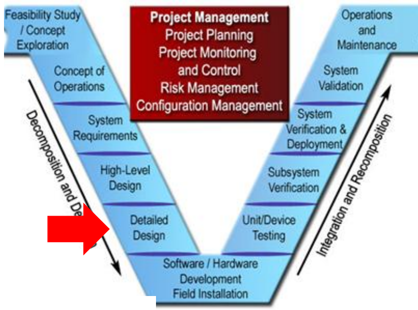
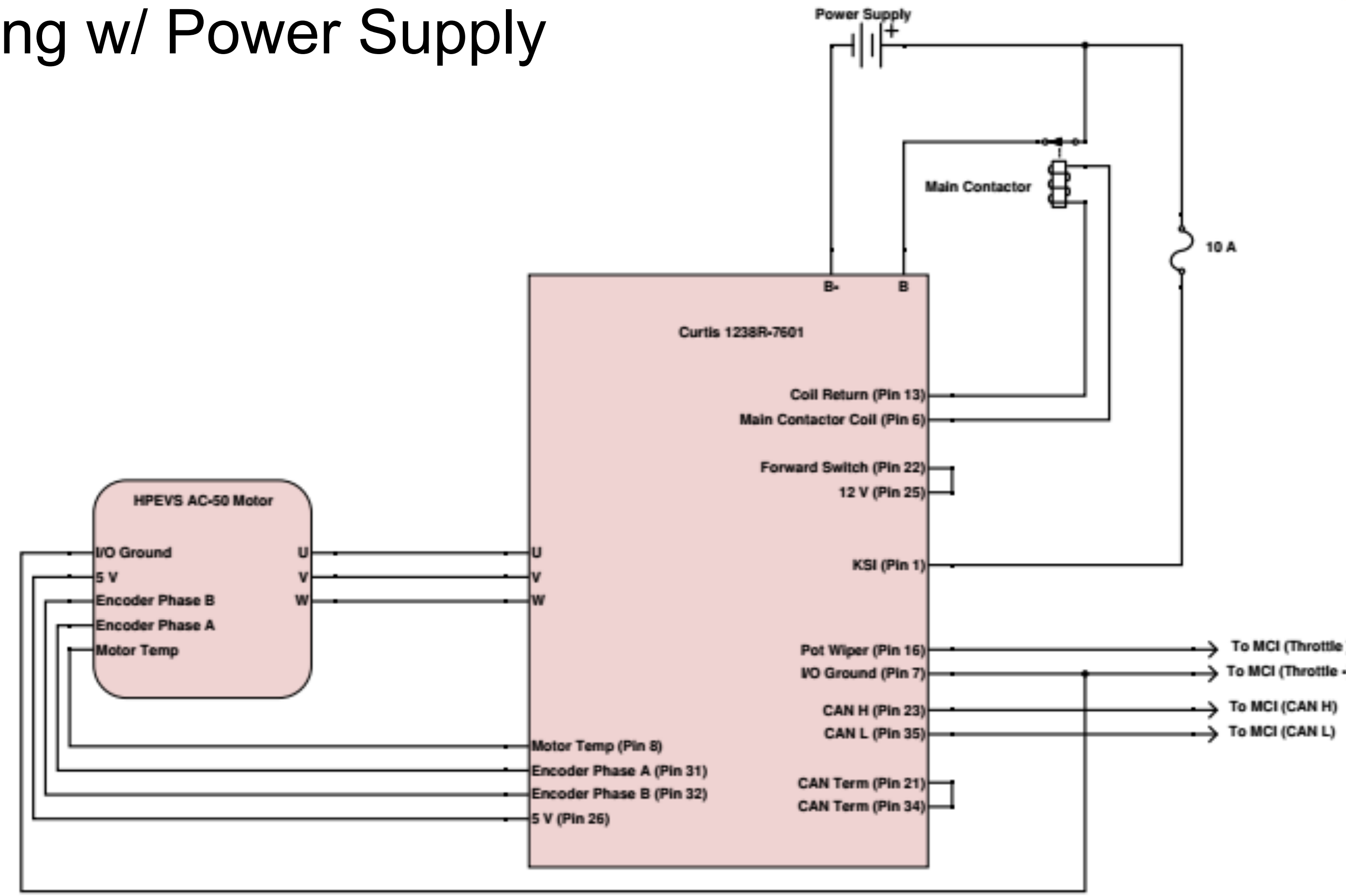


Motor Controller - Wiring

Testing w/ Power Supply



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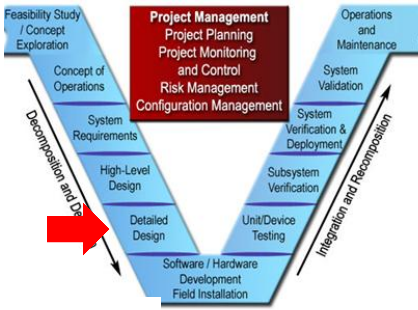
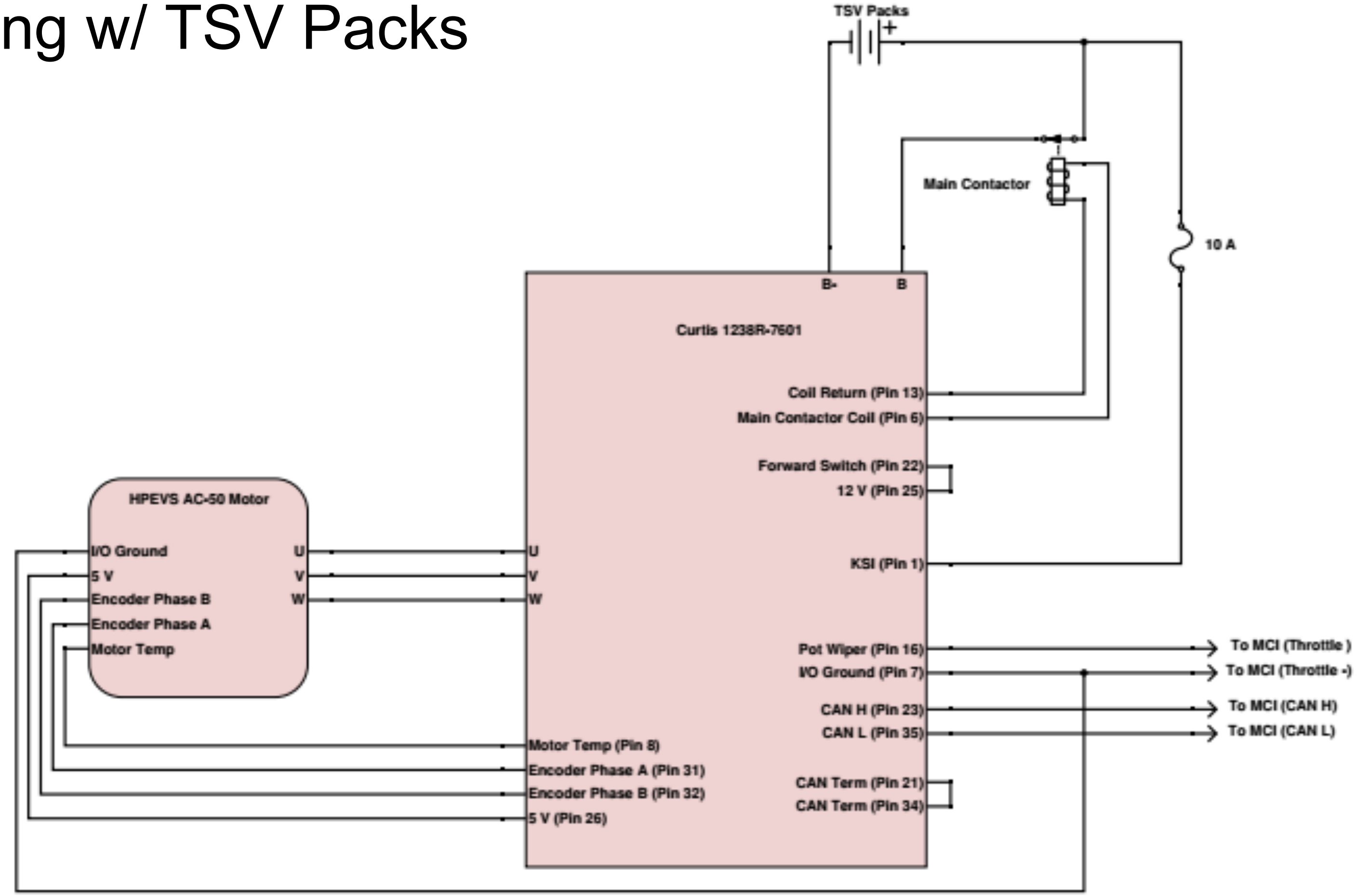
Motor Controller - Wiring



Testing w/ TSV Packs



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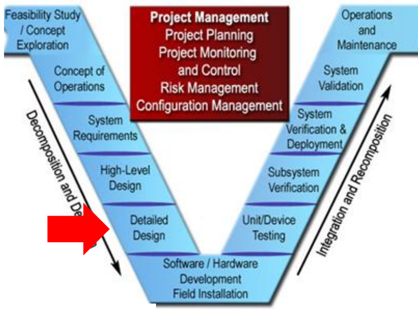
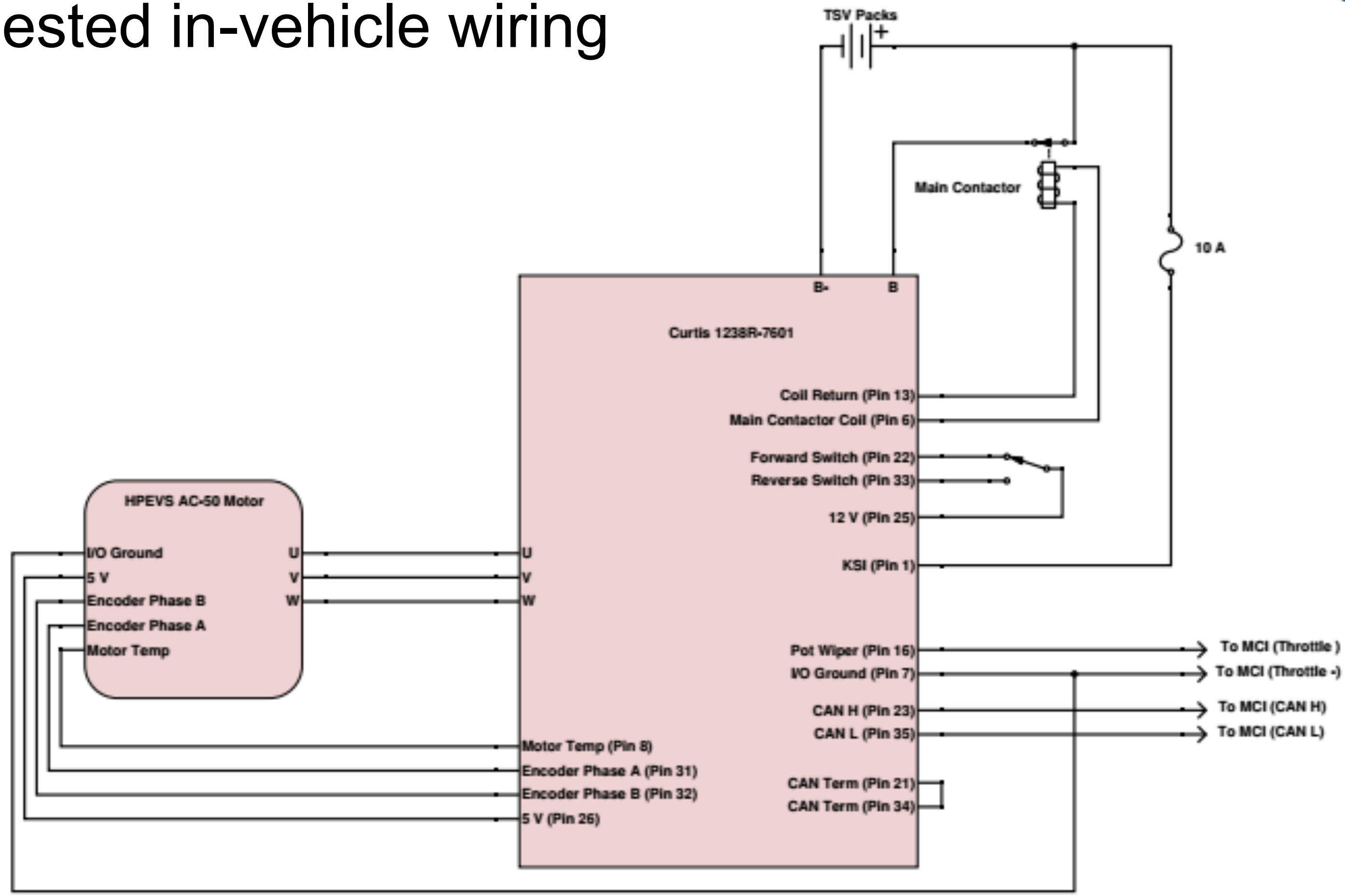


Motor Controller - Wiring

Suggested in-vehicle wiring



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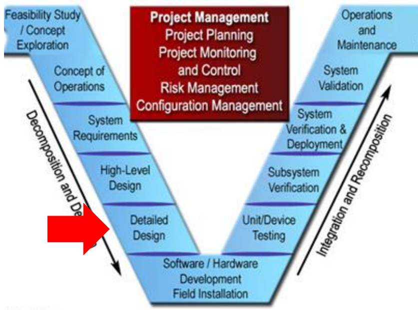
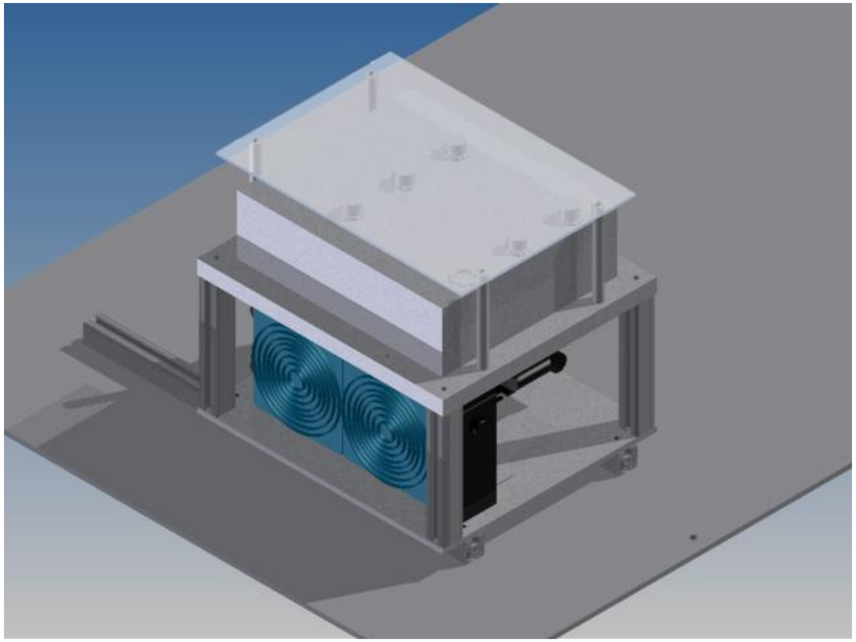
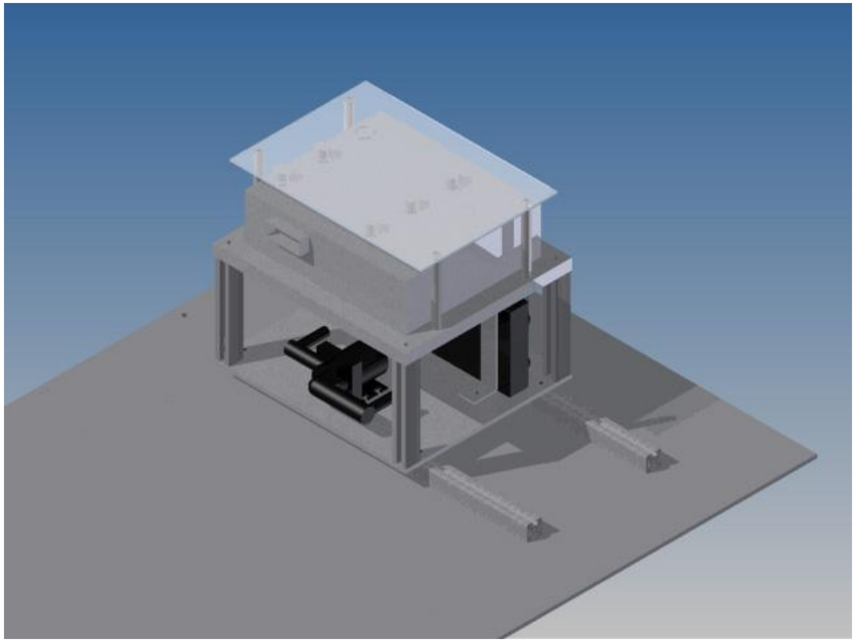
Motor Controller - Cooling







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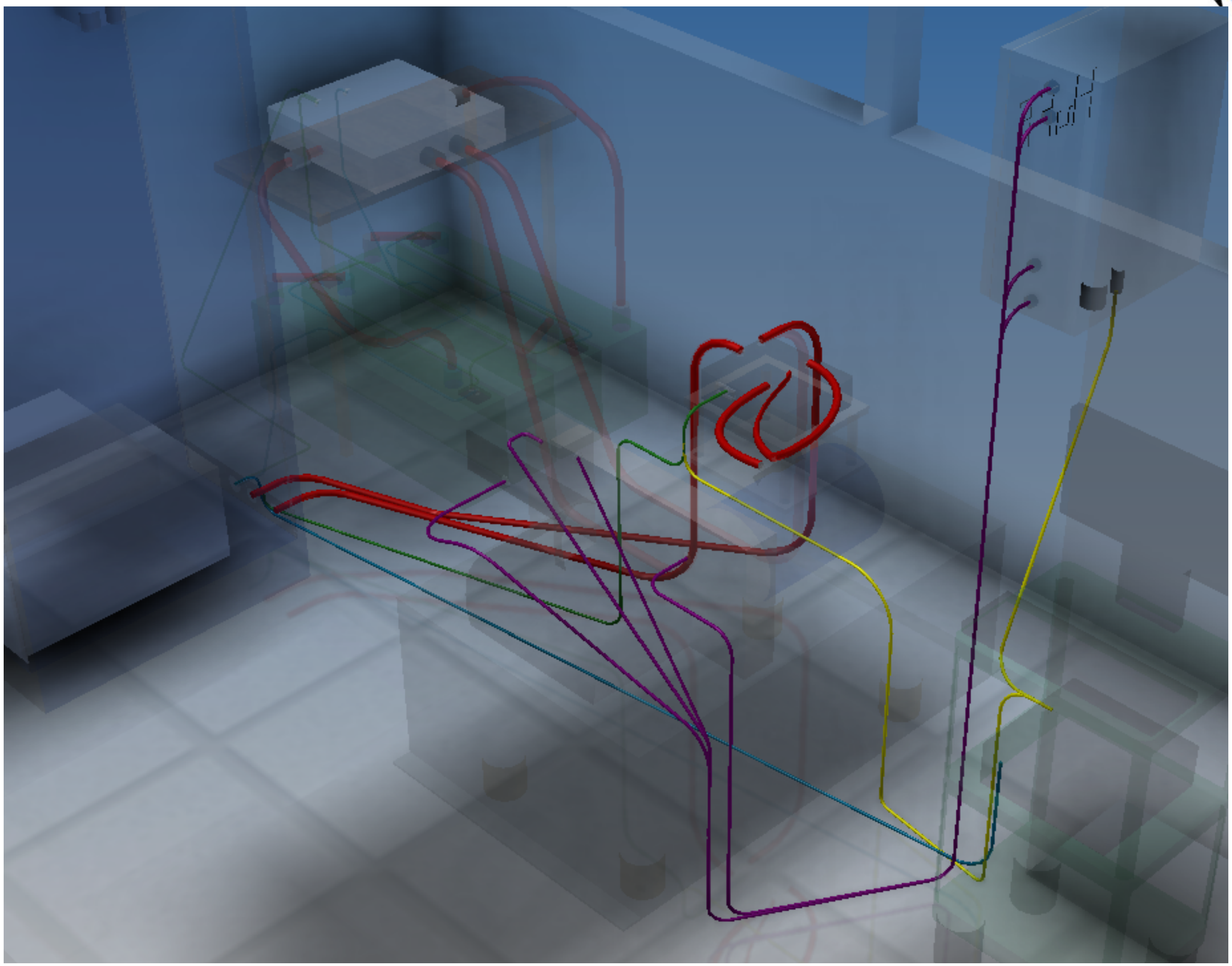
Room Wiring - Testing Config



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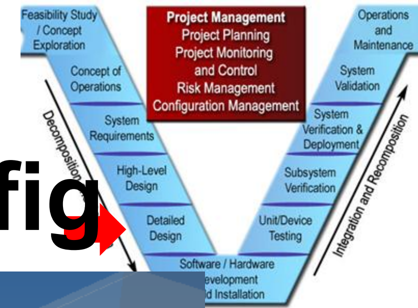
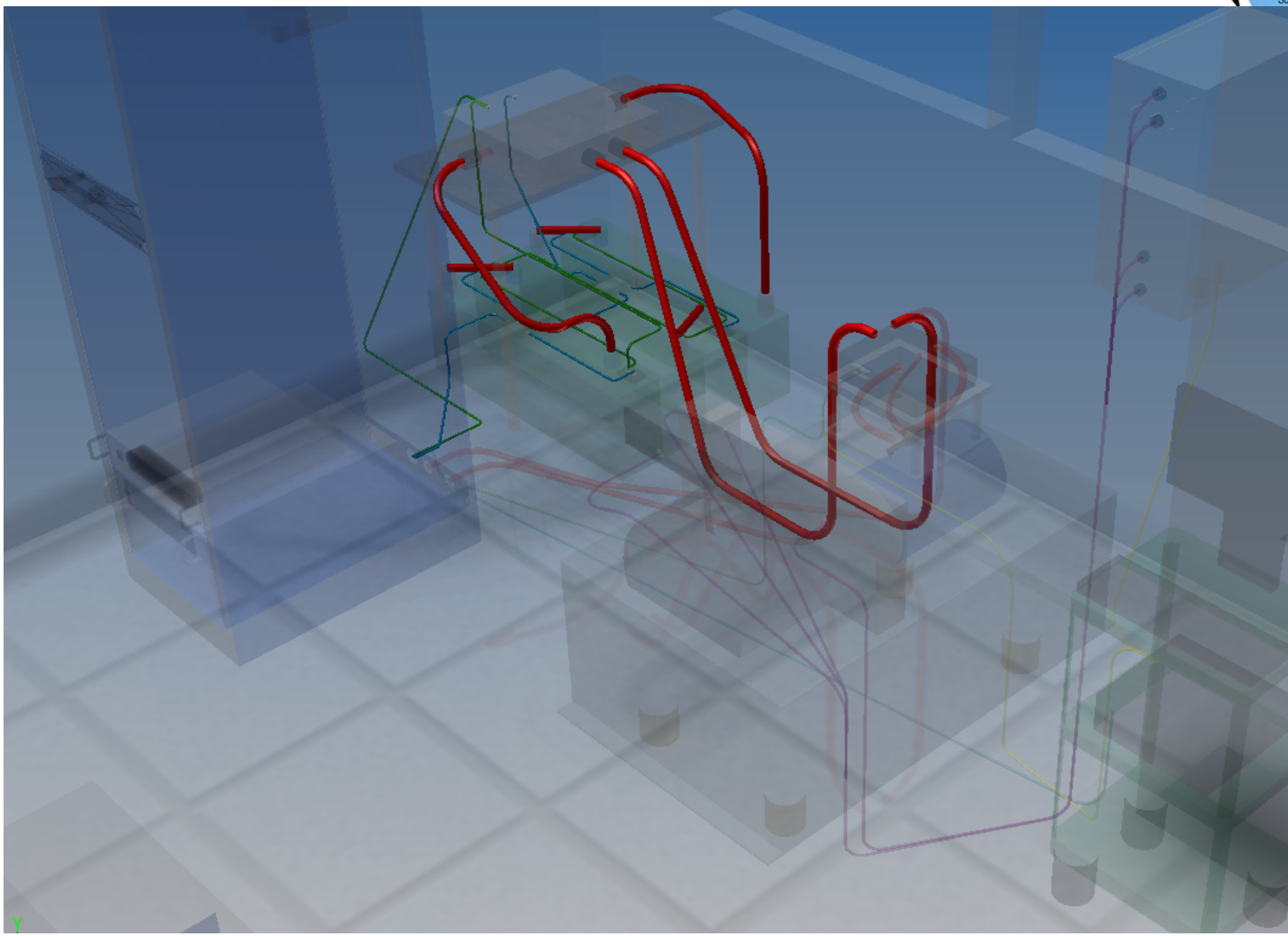
Room Wiring - Integrated Config





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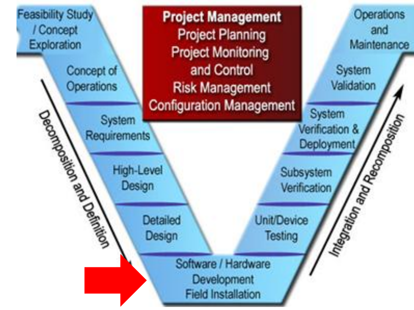
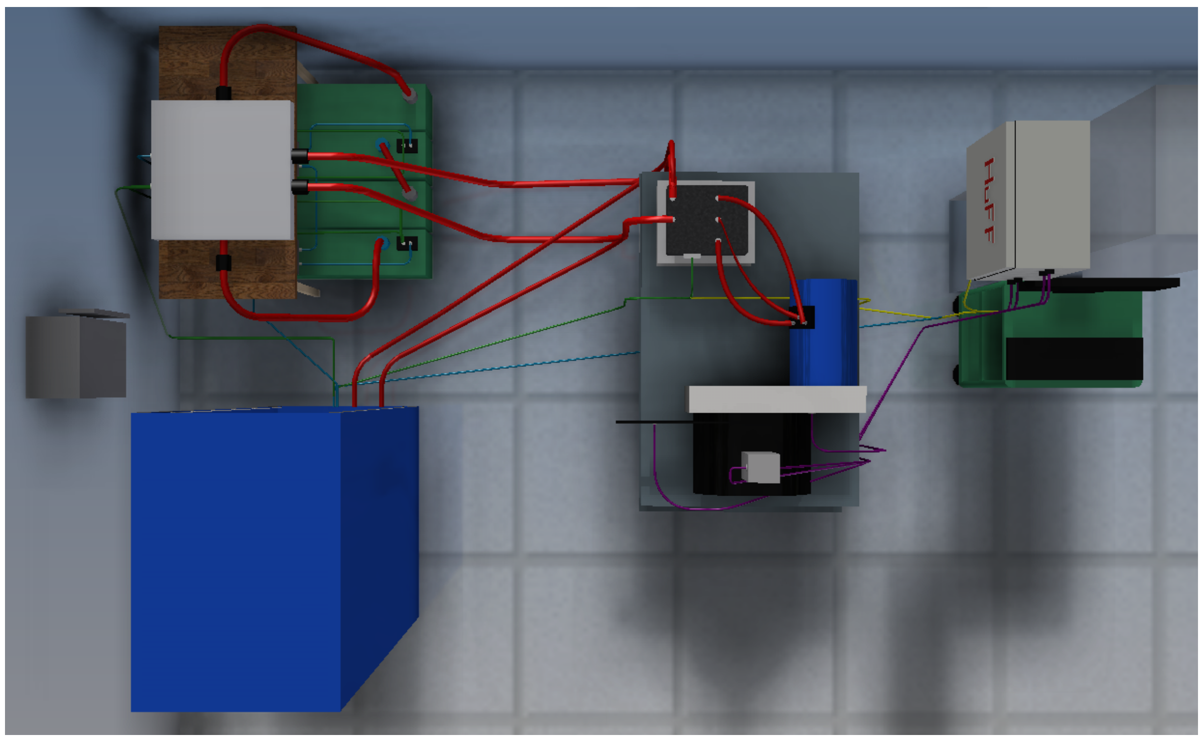


System Integration

- Two configurations
  - Dyno Testing Configuration
  - Integrated Design Configuration



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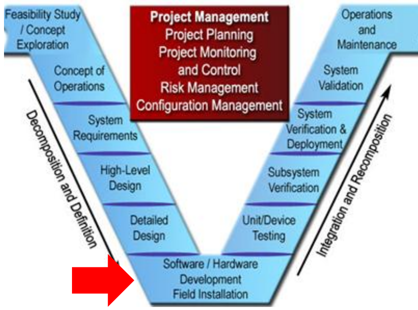
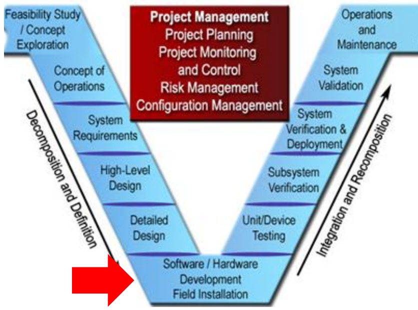
Dynamometer



- Dyno Testing Configuration
  - Utilizes Windows PC with software
  - Records RPM and Torque
  - Controls dynamometer
- Integrated Design Configuration
  - Utilizes VSCADA computer
  - Records RPM and Torque
  - Controls dynamometer



System Wide

- VSCADA
  - CAN data acquisition
  - Dyno data acquisition and control
  - Throttle
- TSI
  - Galvanic isolation from TSV packs
- TSV
  - Supplies power

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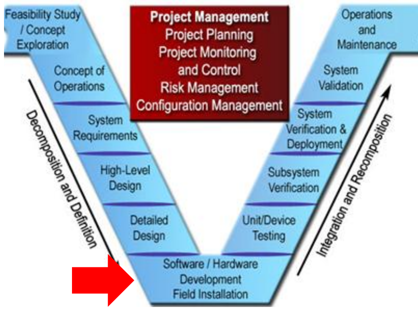
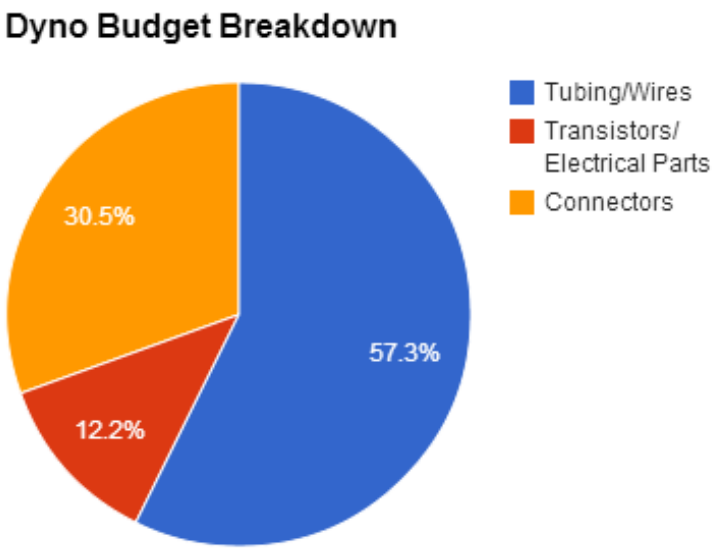
Budget



- Wires/Tubing: $203.92
  - Water cooling tubes - $15.30
  - Power supply cables - $188.62
- Transistor/Electrical Parts - $43.22
  - Button switches - $15.76
  - Transistors - $27.46
- Connectors - $108.52
  - Panels - $107.37
  - Pin Connector - $1.15
- Total - $362.19



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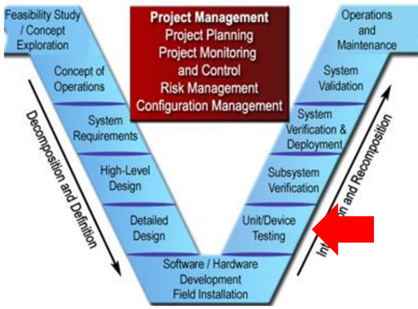
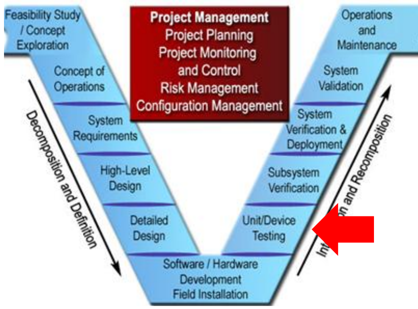
Roadmap

8. Meet the Afternoon Teams
9. Interface Control Review
10. Vehicle Supervisory Control and Data Acquisition (VSCADA)
    a. Daemon
    b. Interfacing
    c. User Applications
    d. Data Storage
11. Dynamometer (DYNO)
    a. Decomposition and Definition
    b. **Integration and Recomposition**



Unit/Device Testing

- Throttle Testing
- Safety Shutoff
- Galvanic Isolation



Throttle Testing

- Independant Solution - T001-2
  - Using Arduino system
  - Sweep the throttle in increments of 100 RPM
  - Value must be within 5 RPM with 90% confidence

if complete:

- VSCADA Solution - T002-3
  - Using VSCADA system
  - Sweep the throttle in increments of 100 RPM
  - Value must be within 5 RPM with 90% confidence

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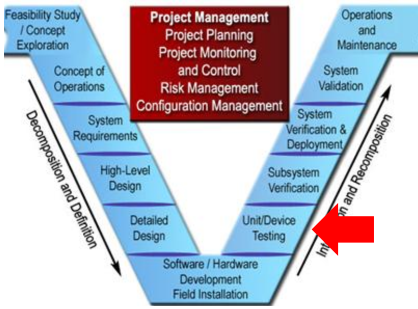
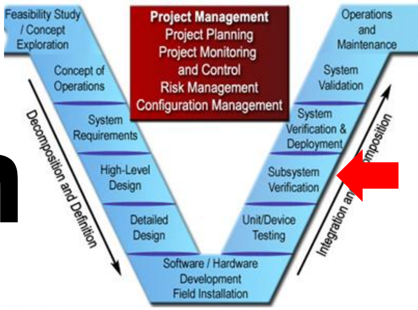
Safety Shutoff



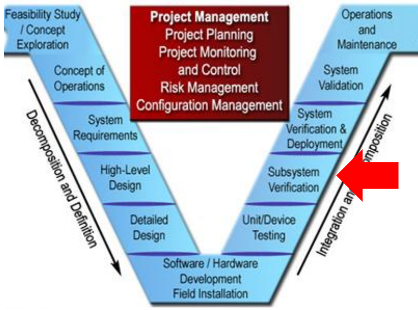
- Emergency Stop - T000-1
  - Press the stop, check that the system powers down
- Oil Temp. Shutoff - T000-3
  - Heat up sensor, check that the system powers down

Subsystem Verification

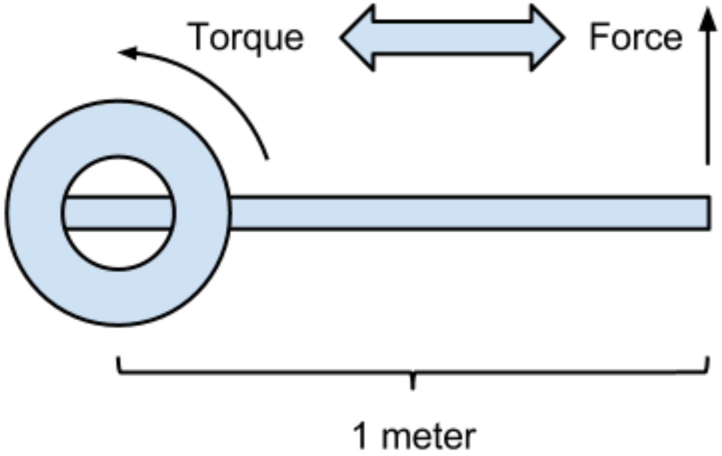


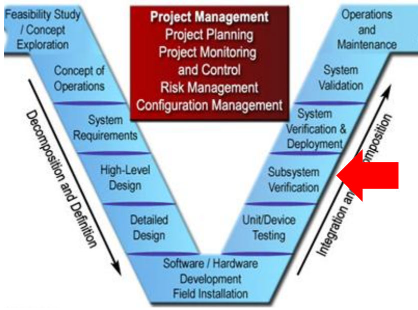
- Data Acquisition
  - Verification tests for:
    - Torque
    - Velocity
    - Current
    - Voltage
    - Temperature
    - Load control
- Simulation Results Comparison

Data Acquisition



- Verify sensor accuracy - T001-1
  - Torque - verified with first principles
    - Calibrate with weights on the arm
    - Verify calibration with different weights

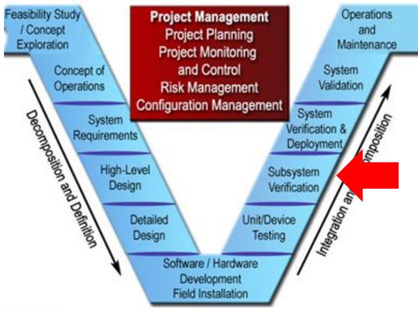




Data Acquisition

- Verify sensor accuracy - T001-2
  - Motor Velocity - redundant measurements
    - Dynamometer encoder
    - Motor encoder
    - Handheld tachometer
  - Verified statistically

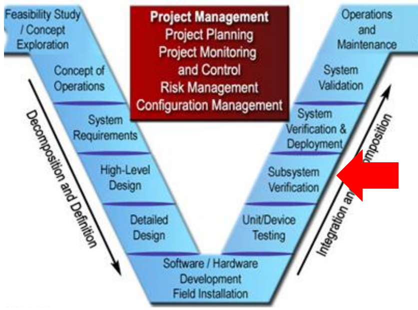
http://www.abqindustrial.net/store/images//products/ET-2109LSR/main_small.jpg



Data Acquisition

- Verify sensor accuracy - T001-3
  - Motor Current - redundant measurements
    - Motor controller output
    - Clamp sensor
  - Verified statistically

http://www.hiokiusa.com/images/products/m9709.gif



Data Acquisition

- Verify sensor accuracy - T001-4
  - Motor Voltage - redundant measurements
    - Motor controller output
    - Power supply reading
  - Verified statistically

http://www.magna-power.com/products/programmable-dc-power-supplies/ts-series

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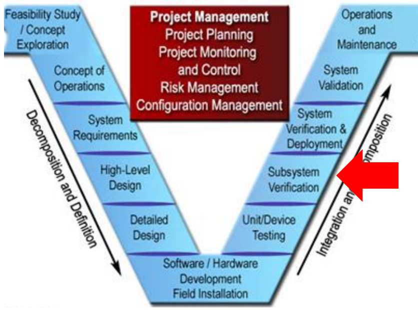

Data Acquisition

- Verify sensor accuracy - T001-5
  - System Temperature - redundant measurements
    - Motor controller output (Motor/Controller temp.)
    - Handheld sensor
  - Verified statistically

http://www.chinoamerica.com/products/sensors/mc1000/img/sensor_mc1000.jpg

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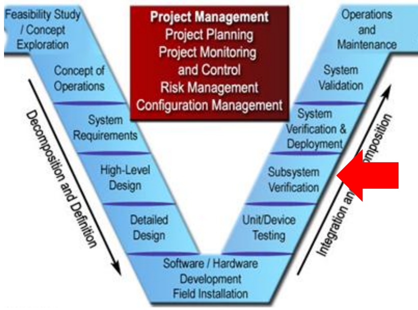
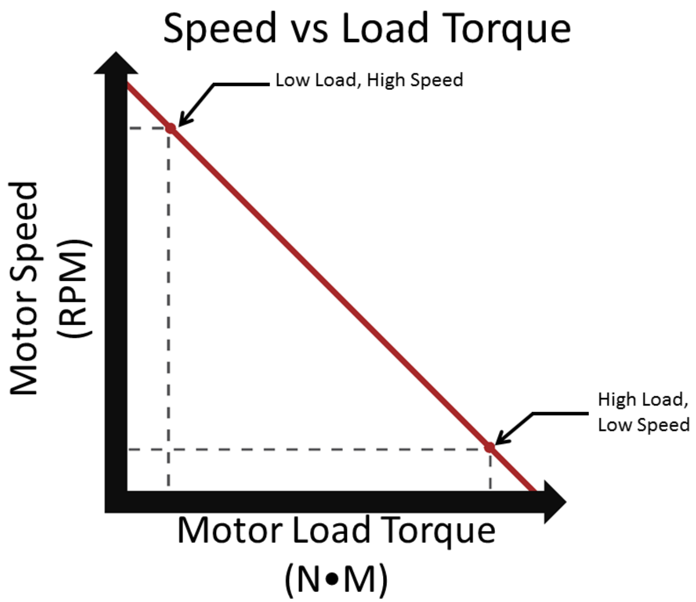


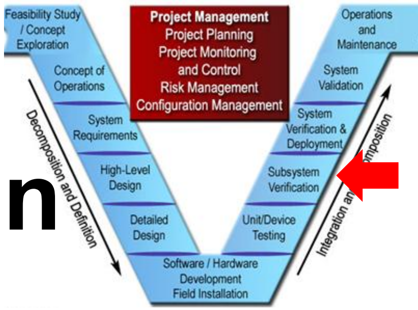
Data Acquisition

- Verify sensor accuracy - T001-6
  - Load Variance - check torque response
    - Use steady motor RPM
    - Vary load and check that torque varies



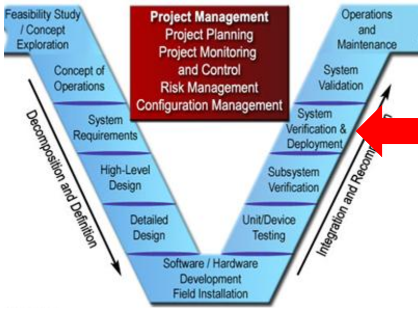
http://curriculum.vexrobotics.com/sites/default/files/7.7.1%20Torque%20vs.%20Speed.PNG

Simulation Results Comparison

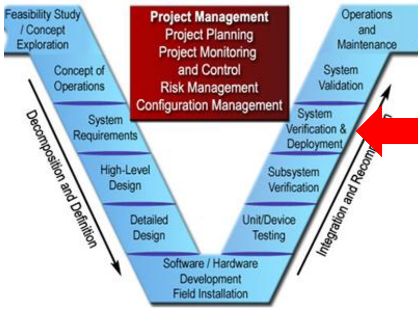


Create scripts to mimic the MATLAB simulations in hardware. This will be done in automatically controlling the valve opening in the dynamometer.

System Verification



- VSCADA Tests
  - Data acquisition
  - Throttle control
- TSI Tests
  - Checks for galvanic isolation
- TSV Pack Tests
  - With 4 packs
  - With 1 pack



VSCADA Tests

- VSCADA data acquisition via CAN
- VSCADA data acquisition from Huff Box
- VSCADA throttle control
  - Uses data from CAN and Huff Box
  - Control Dynamometer valve via Huff Box

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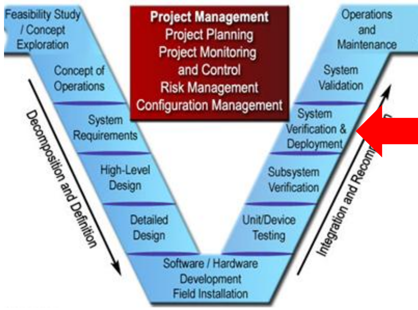

TSI Tests

- Run the dynamometer with the TSI attached
  - T002-4 (assumes the TSI works properly)
  - If the system powers down:
    - It is not galvanically isolated
  - If the system runs:
    - It is properly isolated

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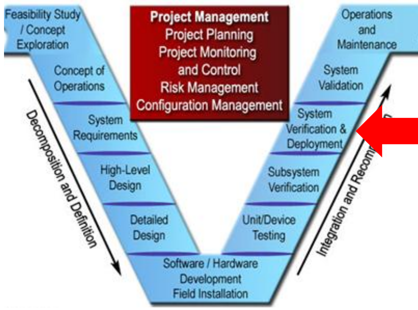
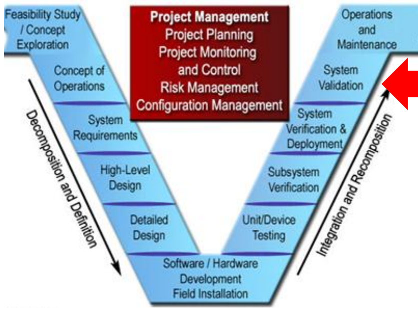
TSV Tests

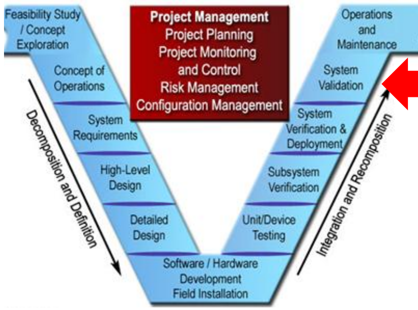


- Run the dynamometer with TSV power
    - If 4 packs have been completed:
        - Connect the packs to the TSI
    - If only 1 pack has been completed:
        - Connect the pack in series with the power supply
        - Power supply will make up voltage difference

System Validation

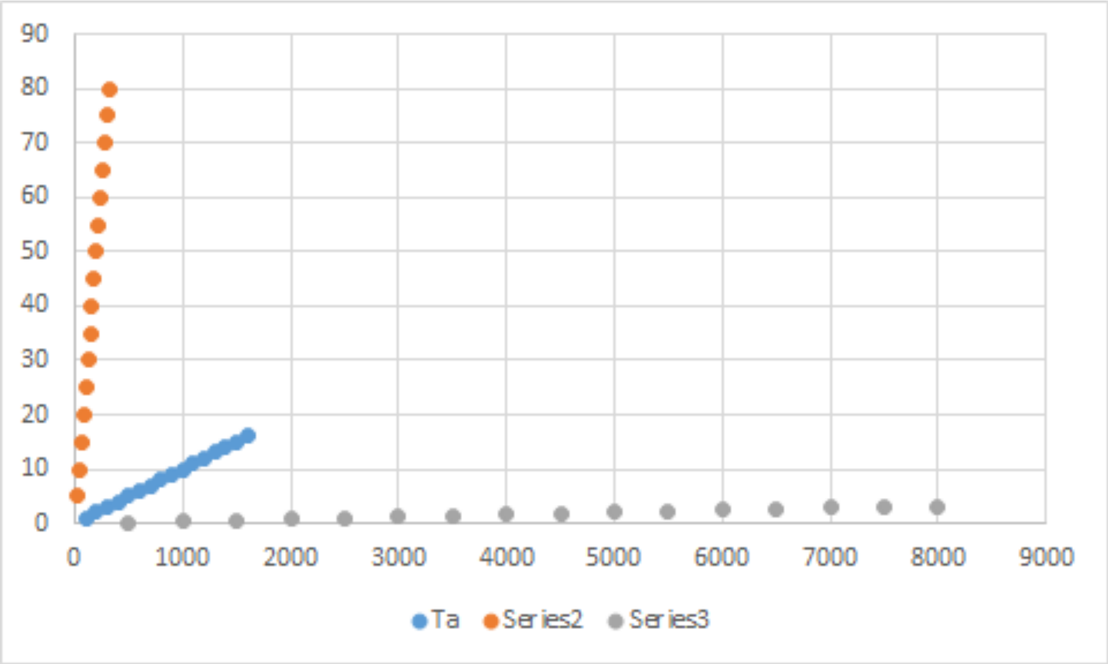


- Gear Ratio
- Torque Curve
- Final Demonstration



Gear Ratio

Knowing the maximum rpm and our desired maximum velocity we can solve for the gear ratio



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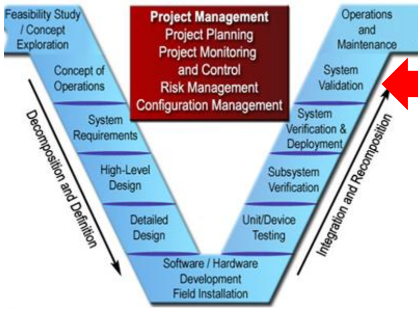
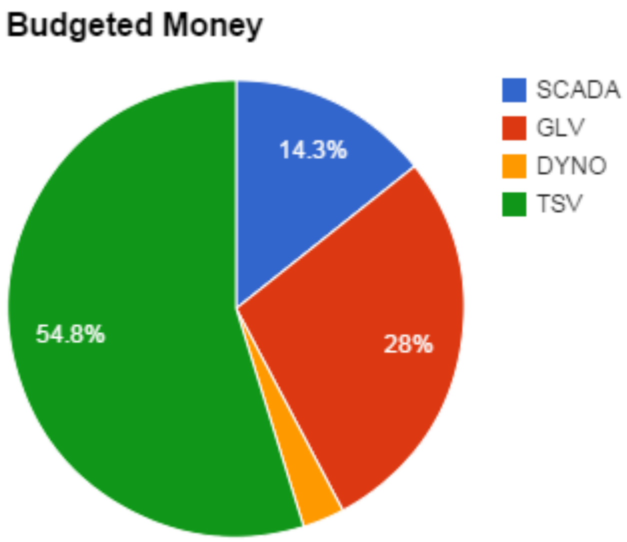


Torque Curve

- At minimum:
  - Must show velocity vs. torque at an estimated load
- Goal:
  - Will show velocity vs. torque at several load points
  - Will show power consumption
- Ideal:
  - 3D graph of velocity, torque, and load

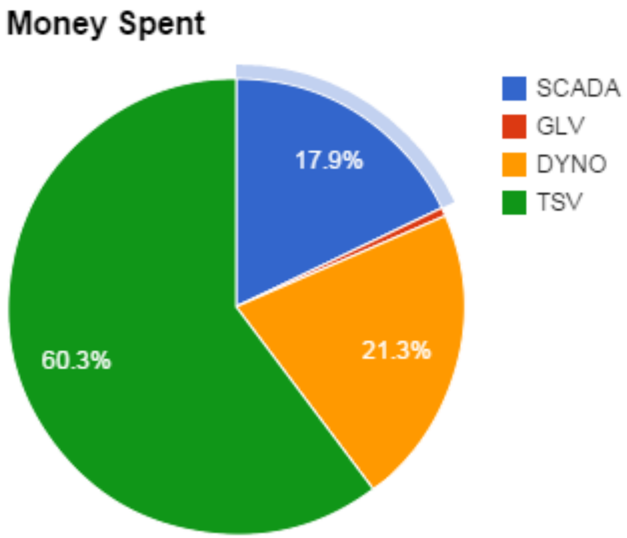
Budget

- Initially allocated money:
    - Dyno - $148
    - SCADA - $715
    - GLV - $1397.90
    - TSV - $2739.10



Budget

- Money Spent so far
  - Dyno - $362
  - TSV - $1026.03
  - SCADA - $304.26
  - GLV - $10.24



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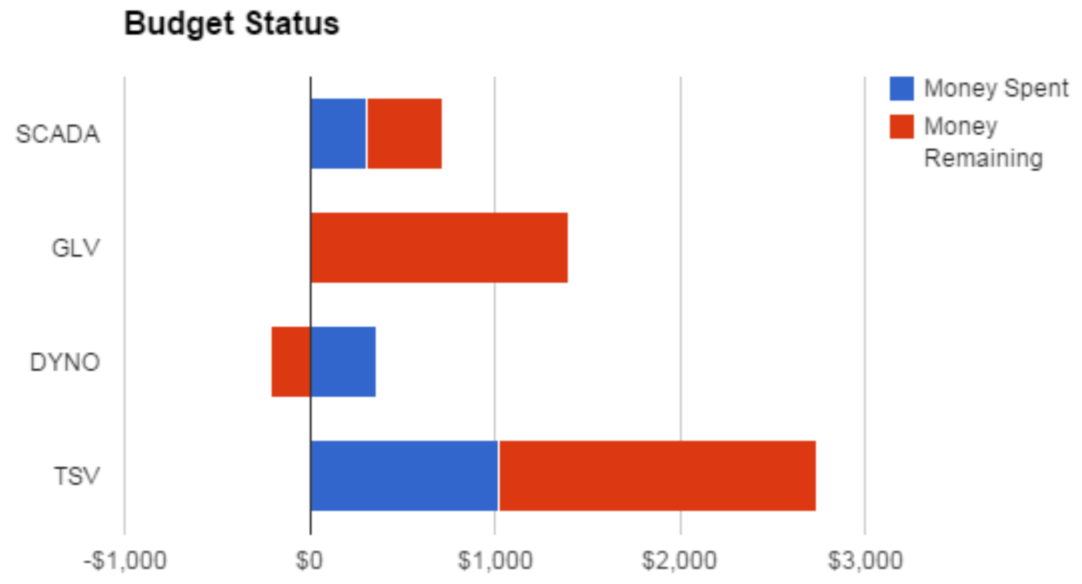
Budget

Current status of money:



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