PRELIMINARY DESIGN REVIEW

LFEV-ESCM-2014

February 13, 2014

LAFAYETTE
ELECTRICAL & COMPUTER ENGINEERING

LFEV-Y2-2014

Continuation of Lafayette Formula Electric Vehicle-Energy Storage, Control, and Management (LFEV-ESCM) project for use in the Formula Hybrid Competition.

Website:
http://sites.lafayette.edu/ece492-sp14/

ROADMAP

- Introduction
- 2013 Achievements
- 2014 Goals
- System Design
- 7-cell Pack
- BMS/AMS/PM
- Charger / Pit Station
- Motor/MCS
- Safety Revisions
- Budget

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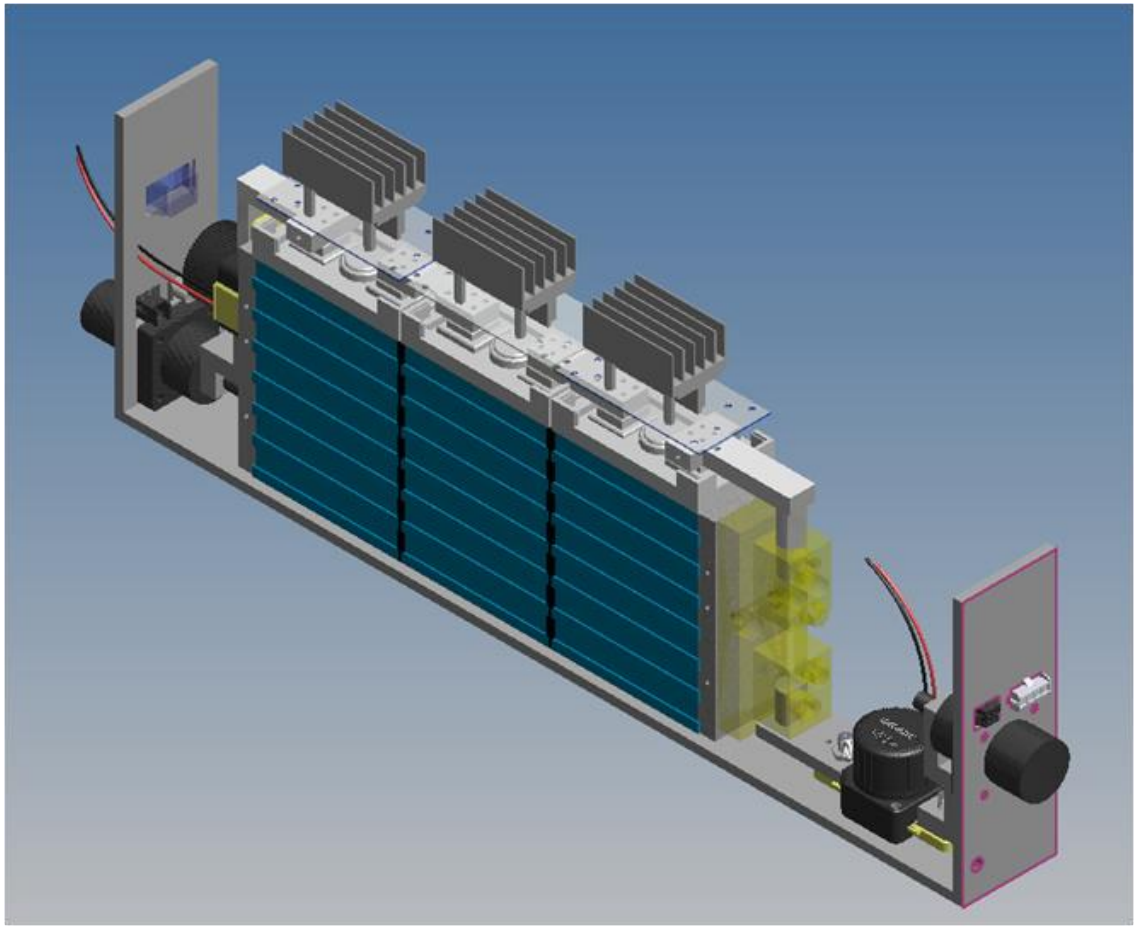
2013 Achievements

- 3-cell pack
  - Good for demo, not for competition
- OBPC-BMS
  - Voltage - some minor range issues
  - Temperature - questionable accuracy
  - Current - java.util.Random
  - PIC Firmware - SOLID!
- SCADA - currently inoperable
- Pit Station - not user-friendly
- GLV - plug-in power supply, not battery
- IMD/Safety Loop

2013 Pack



2013 Integrated System

2014 Goals – Key Deliverables

- BMS with improved sensor performance
- PM - Pack Manager
  - Monitor cell- and pack-level parameters
  - Display key parameters and status on-pack
  - Manage charging (Plug and Forget)
  - Meet Safety Loop requirements (EV3.6.7)
- One, 7-cell, competition-ready pack
  - Improved current path
  - Pack construction
- Pack Charger (part of Pit Station)
- Motor, MCS, & test stand

2014 Goals – Key Non-Deliverables

- Central VSCADA components
  - Logging (Currently in negotiation)
  - Driver Dashboard
  - Off-car data link
  - Pit Station data analysis
- 4 packs
  - Not enough budget or manpower for fab
- Other components (not originally included)
  - GLV system
  - Safety Loop

2014 Scope Considerations

- Aim for quality over quantity
- Object-Oriented Design - HW *and* SW
- Leave "hooks" for future teams

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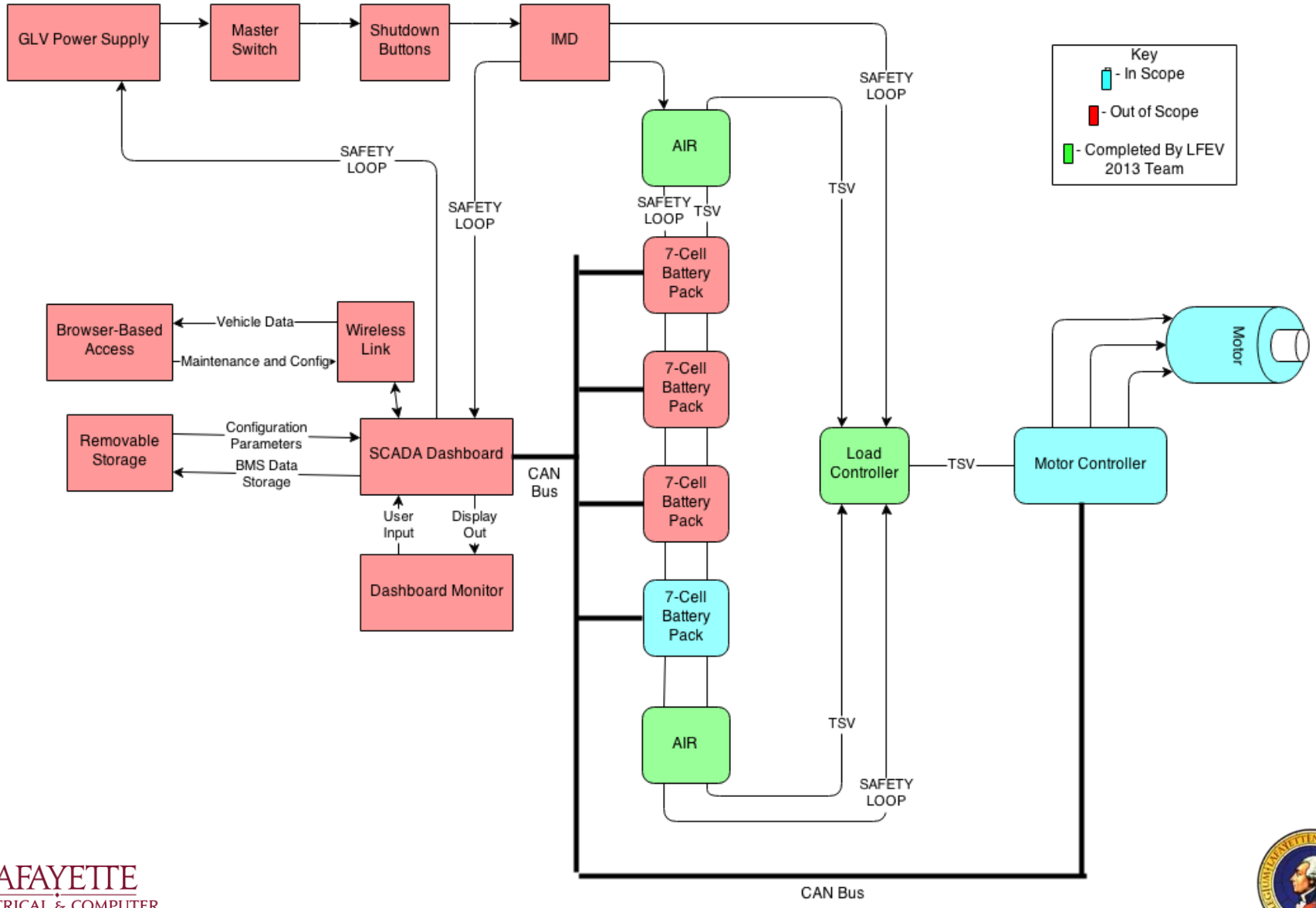
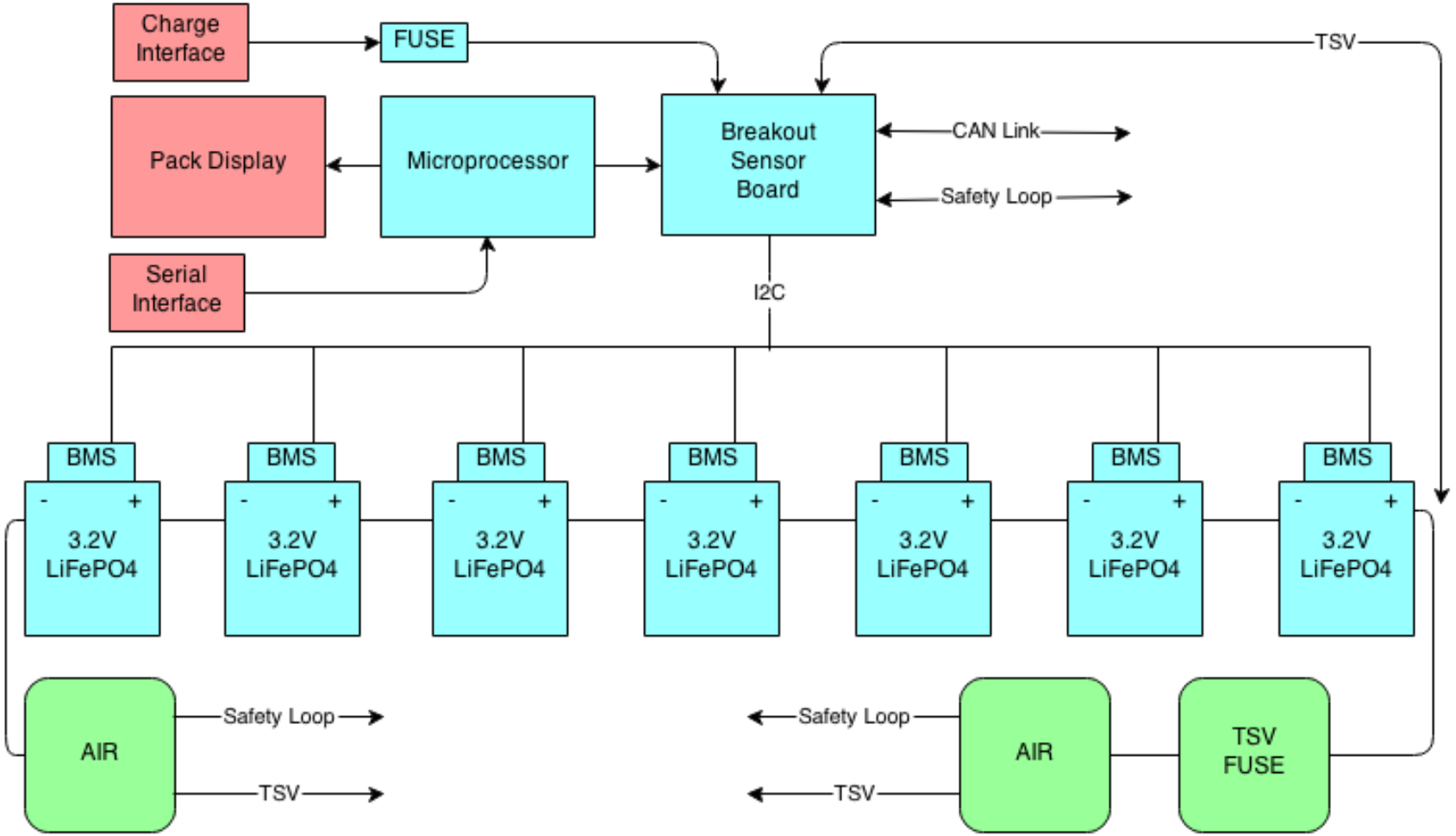
System Block Diagram



Pack Block Diagram



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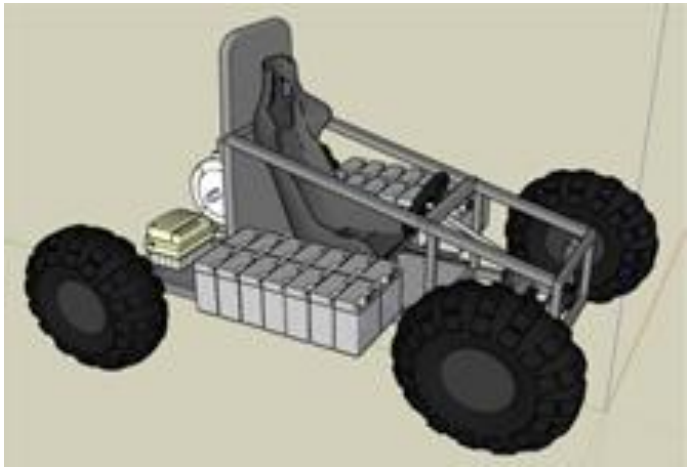
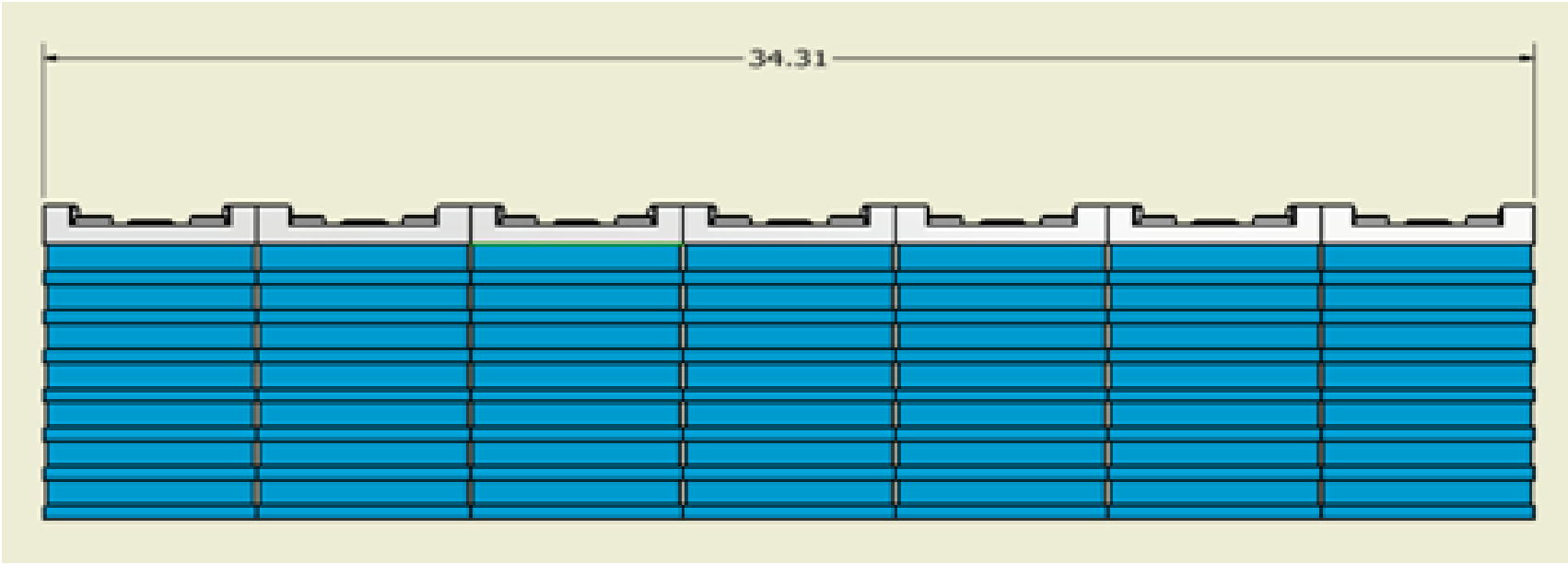
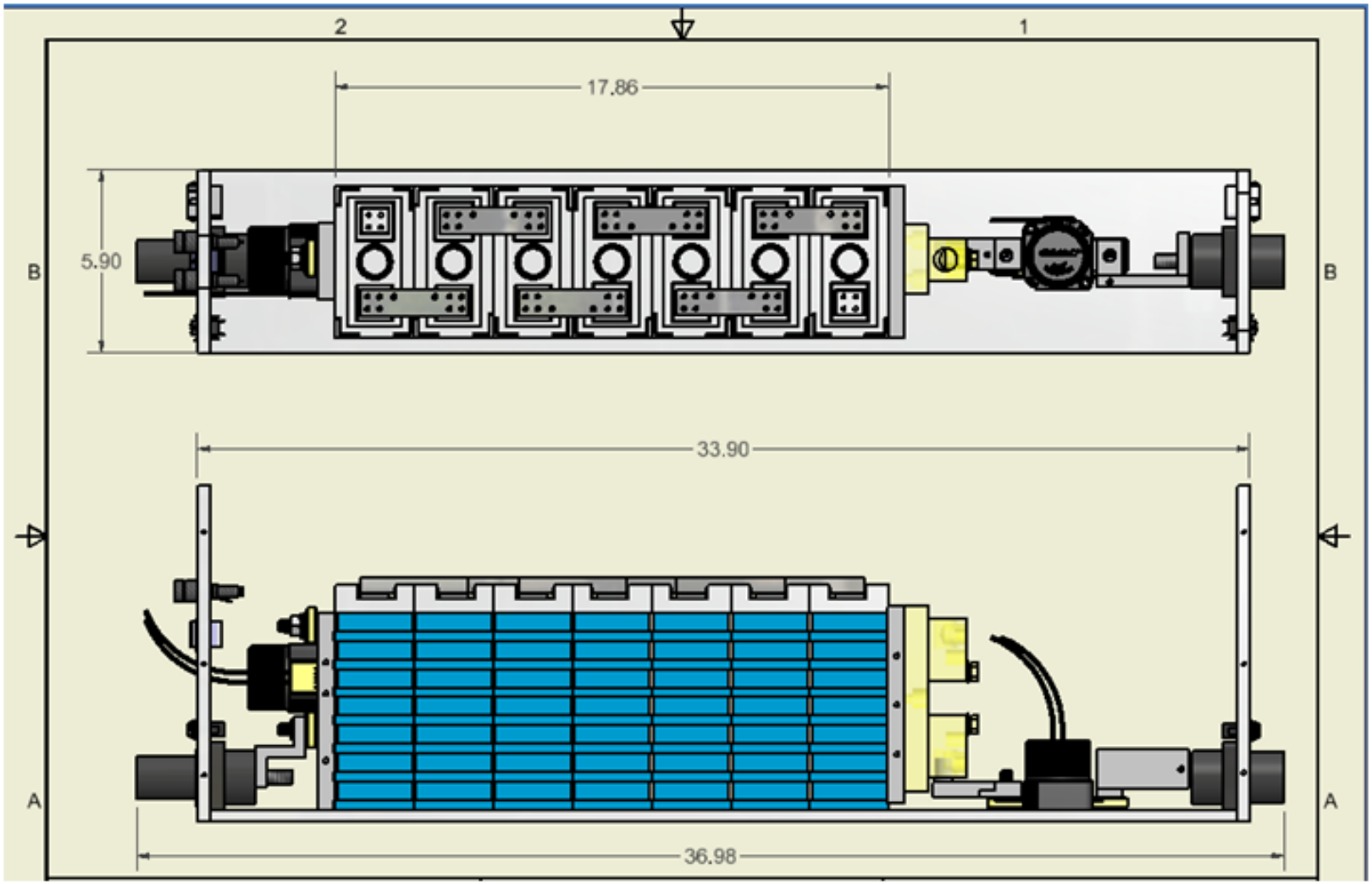
2013 Pack Layout

- Current Formula SAE design
  - Recycled into next year's EV
- 2013 design too long
  - 41 inches between wheels
- Under-driver mount raises COG





2014 Seven-Cell Pack

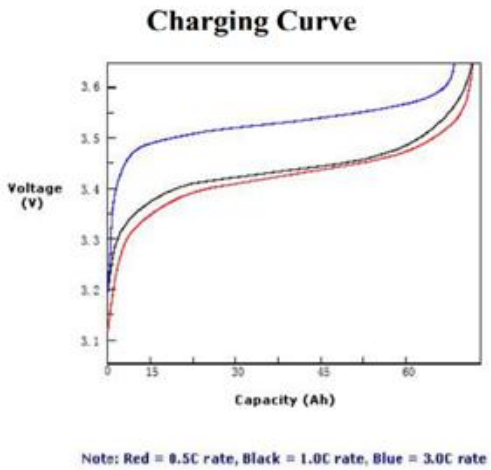


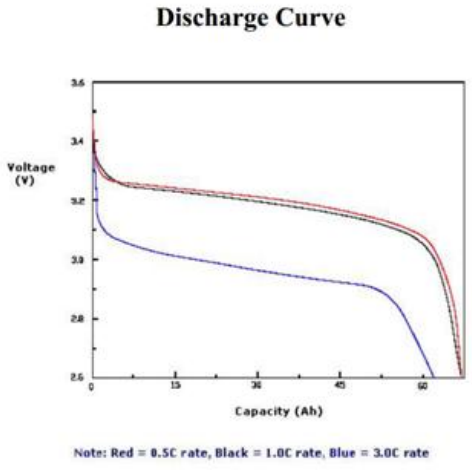
2014 Improvements

- Nominal pack voltage: 24 VDC
  - Using 7 cells at 3.2V nominal voltage (~22.4 VDC)
- Temperature Control
  - Alternate arrangement may increase heating
- Lower Resistance of Current Path
  - Reduce number of mating surfaces

Pack Risk Analysis

- LFEV 2013 team verified AA Portable Power Corp LiFePO4 3.2 V, 60 Ah prismatic cells were a good fit
- Cells identified as "risky – company stability unknown"
- AA Portable Power website: "since 1995"
  - Benefit: "Made in USA"





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AMS / BMS / PM

BMS:

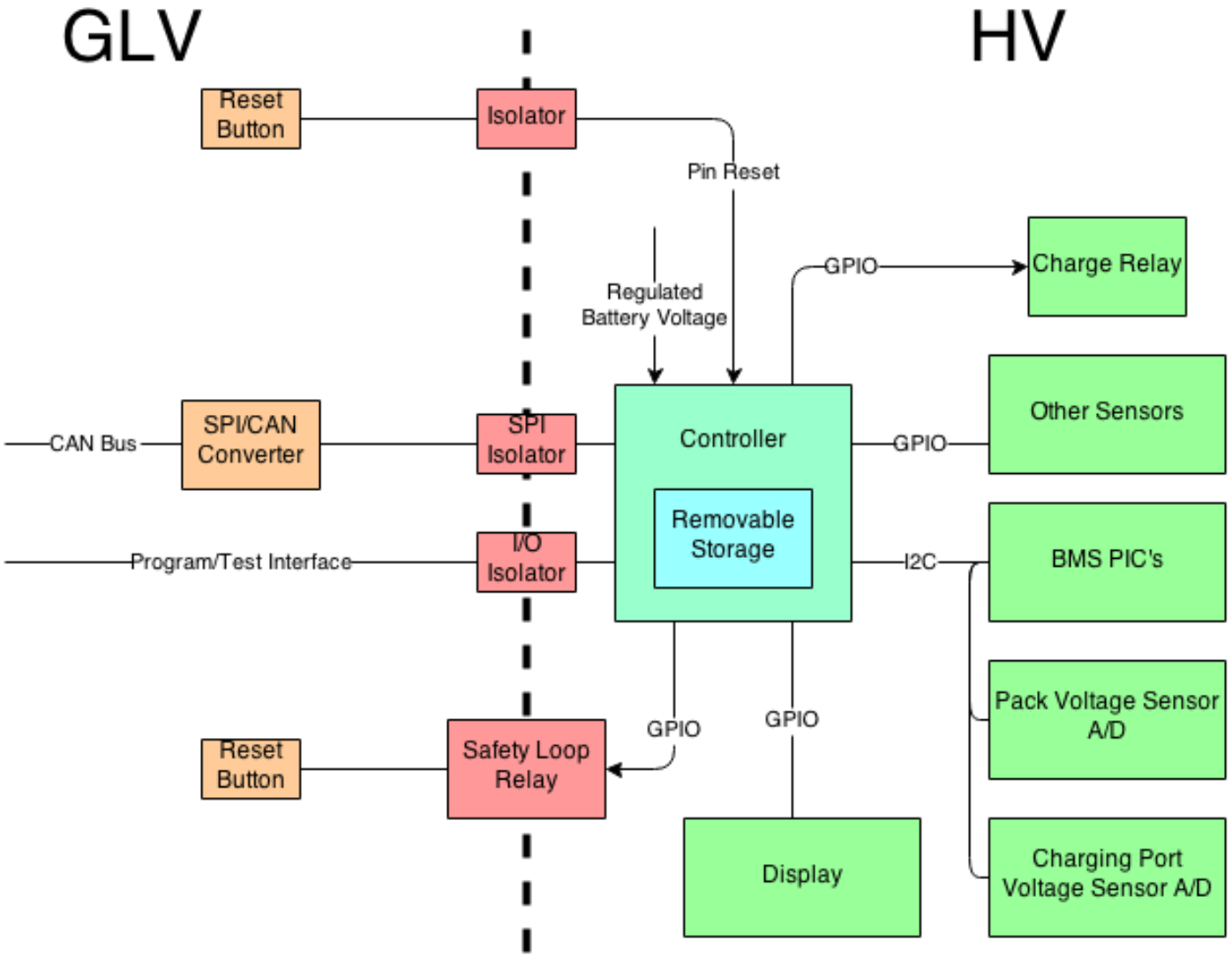
- Voltage
  - 2013 BMS Sensor Memo contains suggestions
- Temperature
  - Placement is potential issue
- Current
  - Use current-shunt op-amps
  - Increase shunt resistance
    - 2013 shunt: R = 26 μΩ
    - Drop @ 600A: 15 mV
    - Drop @ 30A: 750 μV

PM – Pack Manager

New in-pack component: PM

- Aggregate OBPC-BMS sensor data
- Monitor pack voltage, etc.
- Operate safety loop per EV5.1.5
- Display pack status and parameters
- Communicate with central SCADA
- Support pack charging
- Automatic configuration (cell count)

PM Block Diagram



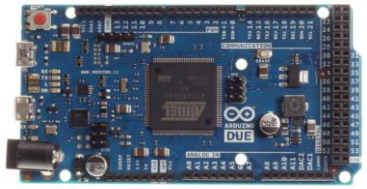
PM Controller Choice

µController or µComputer (or something else?)

Considerations:

- I/O capability (analog/digital)
- Support/Market Longevity
- Power Consumption
- Dev Environment
- Communication
- Form Factor

MicroController vs MicroComputer



+ Autonomous operation
+ Negligible boot cycle
+ Cheaper:
  ~$3 - $10 for bare DIP
+ Low power consumption (10mW)

- OS availability??
- Limited display capabilities
  (bit-banging/serial)
- Limited program size
- External dev environment
- Lacks storage interface

+ Display, networking support
+ External storage (SD card)
+ Integrated dev. environment
+ Familiarity with platform
+ OS Available (Linux, Android, etc)

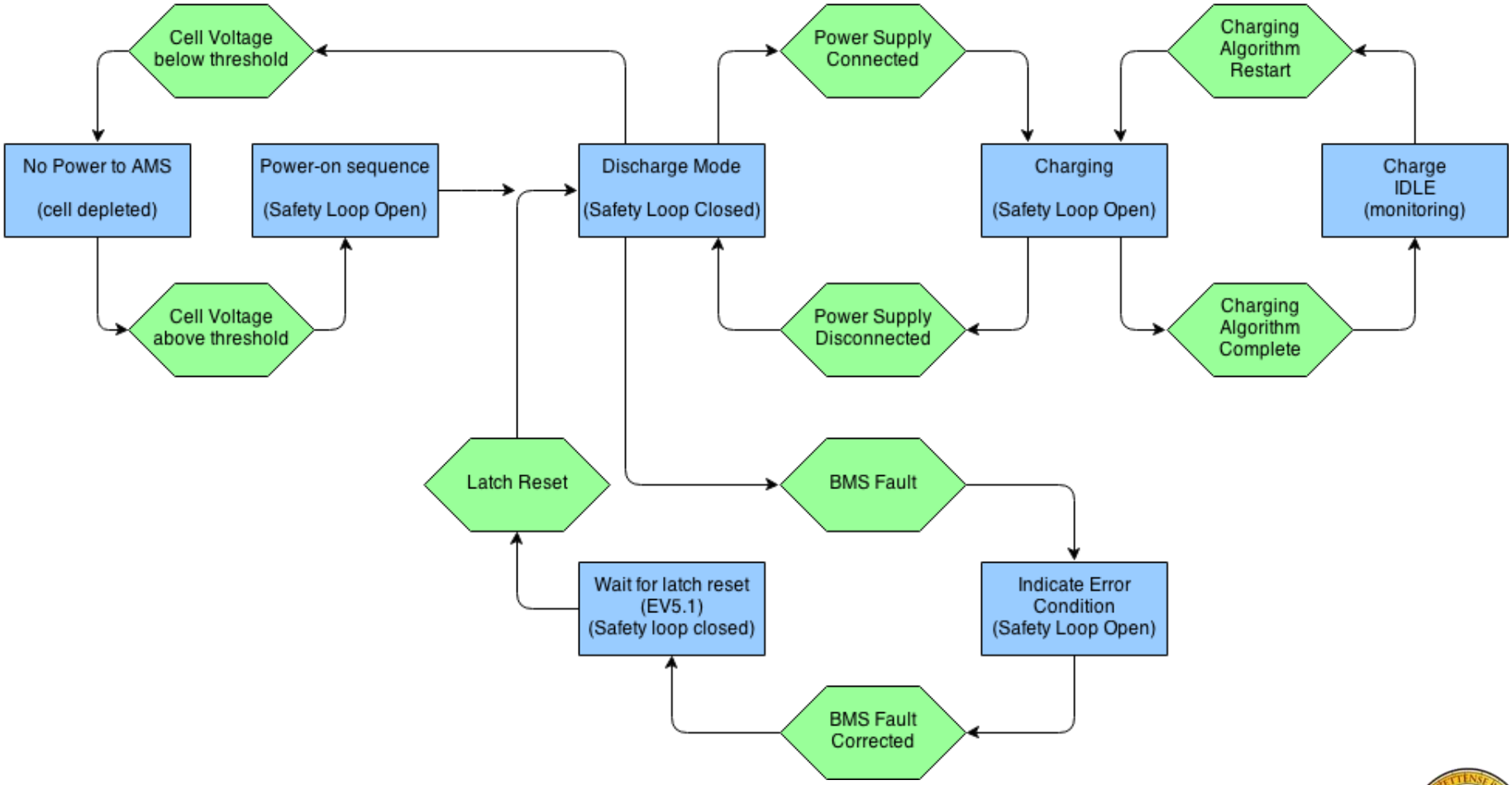
- More expensive (~$30)
- Potential interaction required
- 1-2 minute boot cycle
- Lacks analog input
- High power consumption (5W)
- SD card estimated MTBF: 2 years

This Just In!

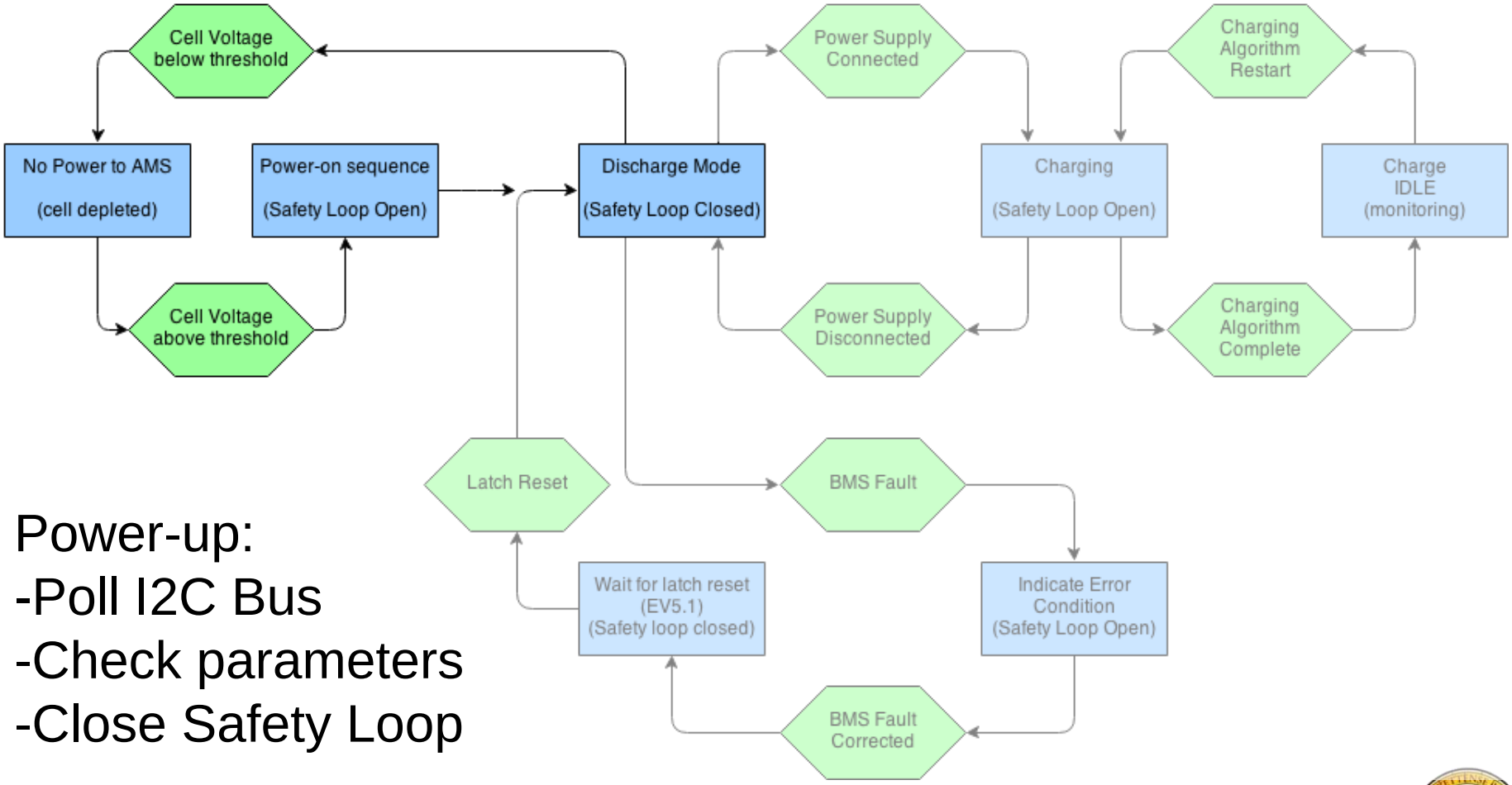
Power consumption issues:

- Pi consumes max. 5W
  - 1.3 kWh available in pack
  - 1.3 kWh / 5W = ~11 days
- Not suitable for demo...
  - Requires charge every week
- Not suitable for competition...
  - 9% energy loss per day

PMS States

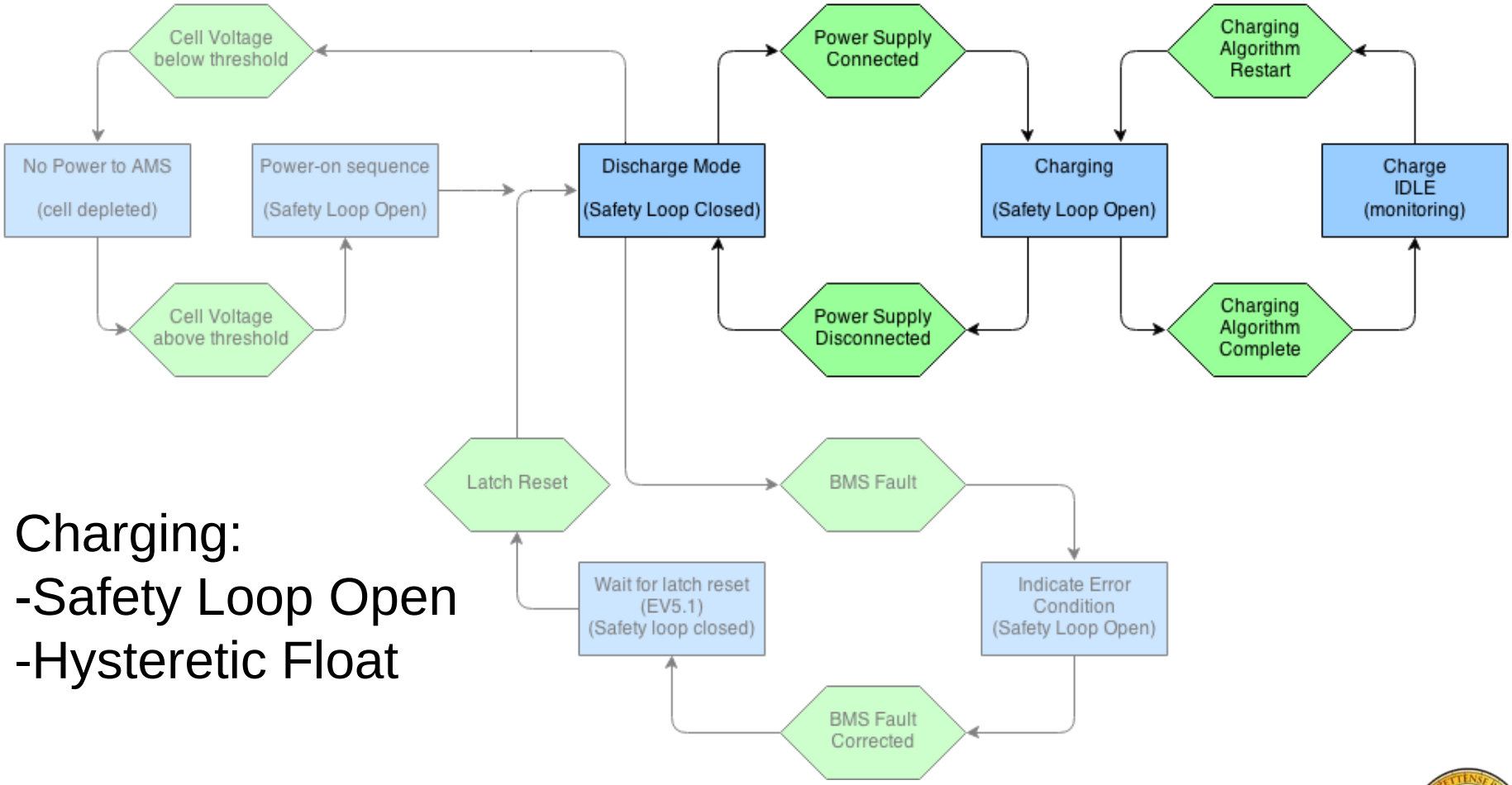

Cell Voltage below threshold
Power Supply Connected
Charging Algorithm Restart
No Power to AMS (cell depleted)
Power-on sequence (Safety Loop Open)
Discharge Mode (Safety Loop Closed)
Charging (Safety Loop Open)
Charge IDLE (monitoring)
Cell Voltage above threshold
Power Supply Disconnected
Charging Algorithm Complete
Latch Reset
BMS Fault
Wait for latch reset (EV5.1) (Safety loop closed)
Indicate Error Condition (Safety Loop Open)
BMS Fault Corrected

PMS States



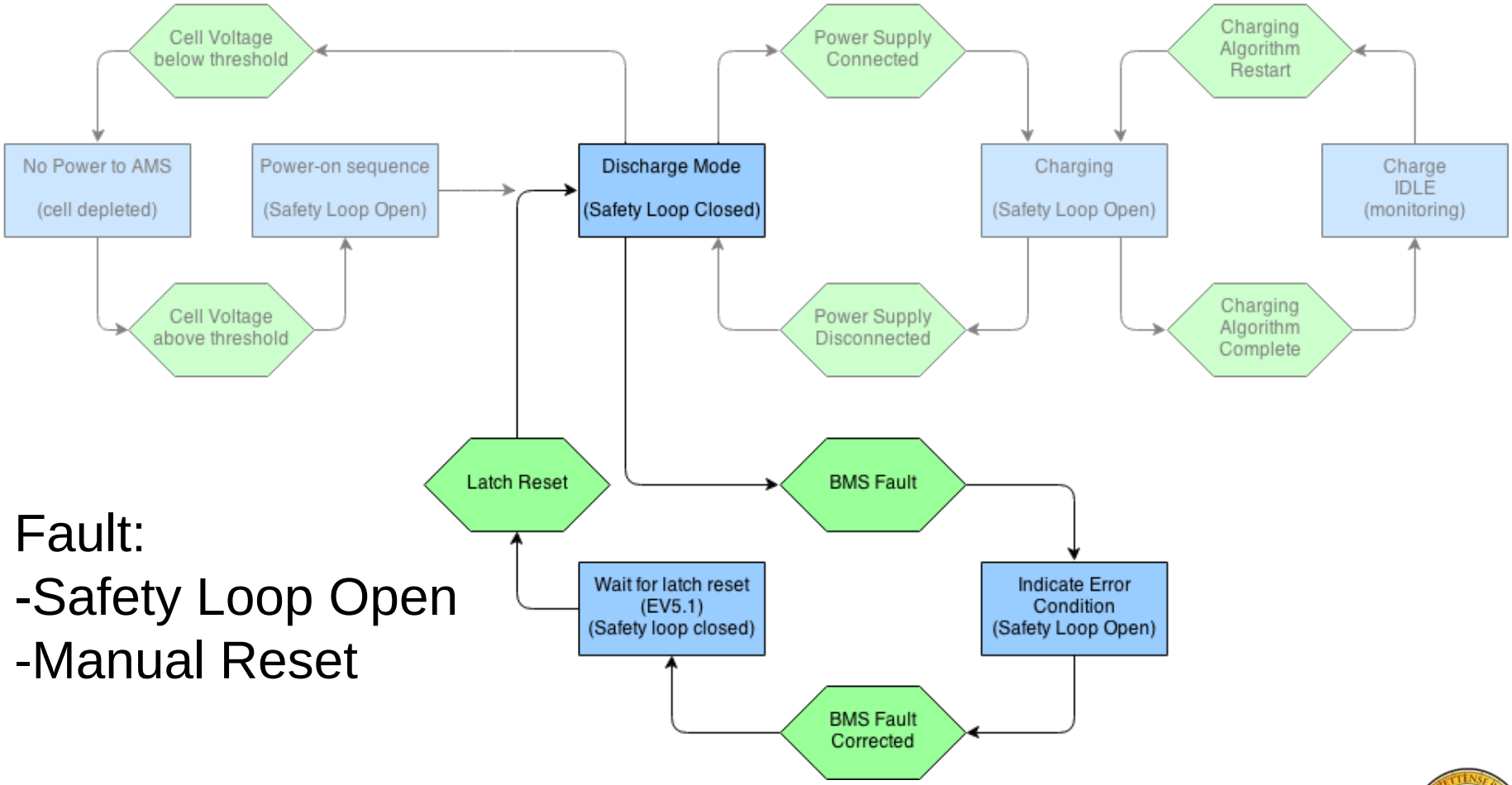
Power-up:
-Poll I2C Bus
-Check parameters
-Close Safety Loop

PMS States



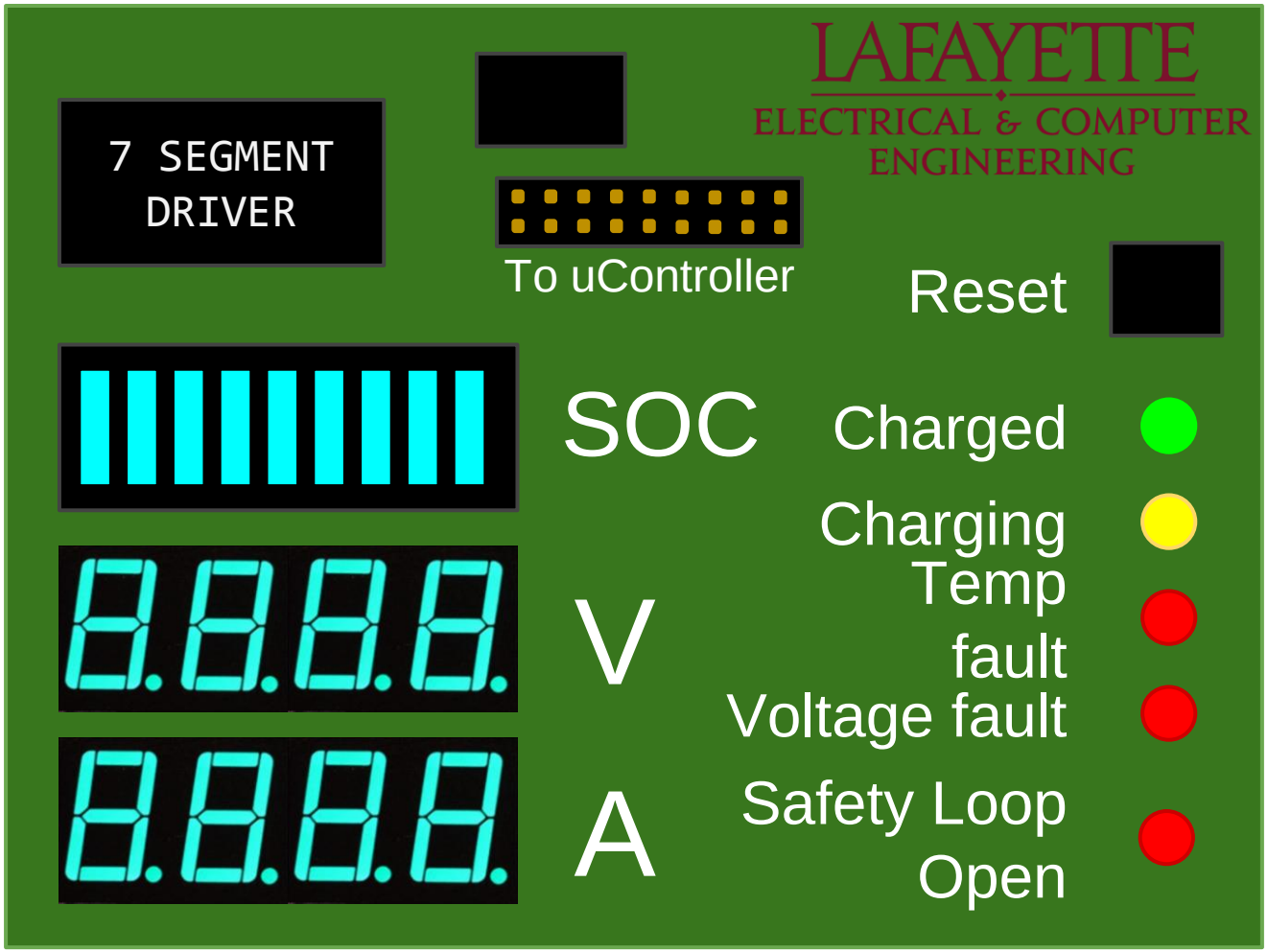
Charging:
-Safety Loop Open
-Hysteretic Float

PMS States



Fault:
-Safety Loop Open
-Manual Reset

PMS Display


LAFAYETTE
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7 SEGMENT DRIVER
To uController
Reset
SOC
Charged
Charging
Temp fault
V
Voltage fault
A
Safety Loop Open

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Charger / Pit Station

- "Smart Pack, Dumb Charger" model
  - Support Plug 'n Forget operation
  - No manual configuration
- Charge algorithm integrated into PMS
  - Monitor multiple parameters
    - Voltage
    - Temperature
    - Current
    - SOC ("Coulomb Counting")
  - Potential Calibration Issue with SOC
    - Determining the "Integration Constant"
    - Drift over multiple charge/discharge cycles
    - Drift due to self-discharge

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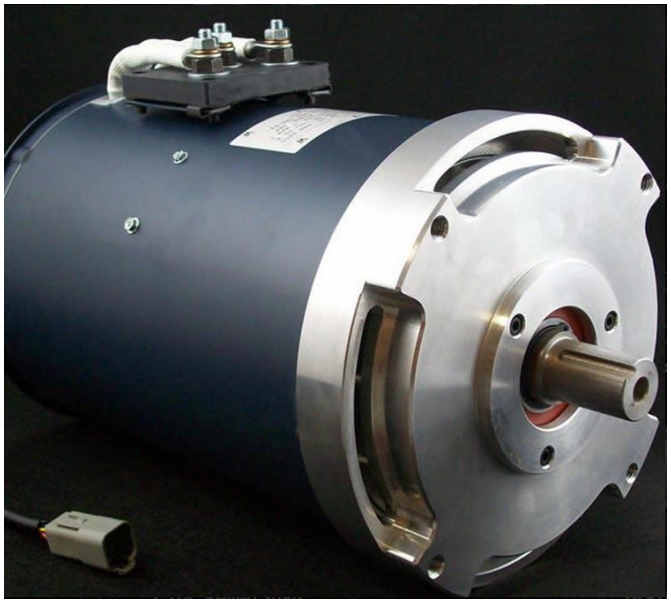
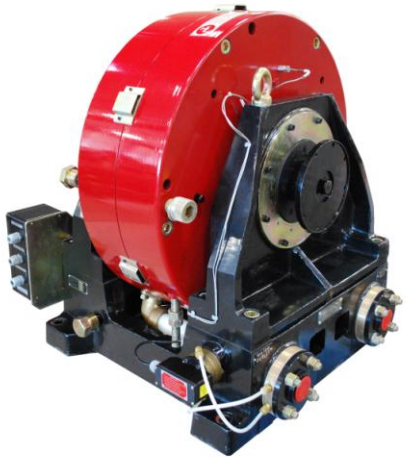
Motor and Motor Controller

- Chosen by 2013 team
  - Based voltage and current provided by the pack
  - Electric Motor: **HPEVS AC-50**
  - Motor Controller: **Curtis 1238R**
- To-Do
  - Safe testing environment
  - Proper testing equipment
  - Funding approval



Motor and Motor Controller

- Action Steps:
  - Motor, Motor Controller etc. outside of budget
  - Create a proposal demonstrating the need to buy
    - Motor
    - Test Stand
    - Dynamometer
    - Software
    - Accelerator Pedal
    - Building infrastructure modifications



Motor and Motor Controller

- Deliverables:
  - Procurement proposal
- Pending approval:
  - Motor running through the motor controller
  - Safely running within the test fixture
  - Providing power using power suppy

Motor Risk Analysis

- Funding not approved:
  - Motor / Controller
  - Test Stand
  - Power Supply
  - Installations done by plant ops
    - Water Line / Water Pump
    - Specialized Electrical Outlet
- Plant Ops can't provide test infrastructure
  - Water
  - Electric
- Something doesn't come in on time
- Cannot properly control motor

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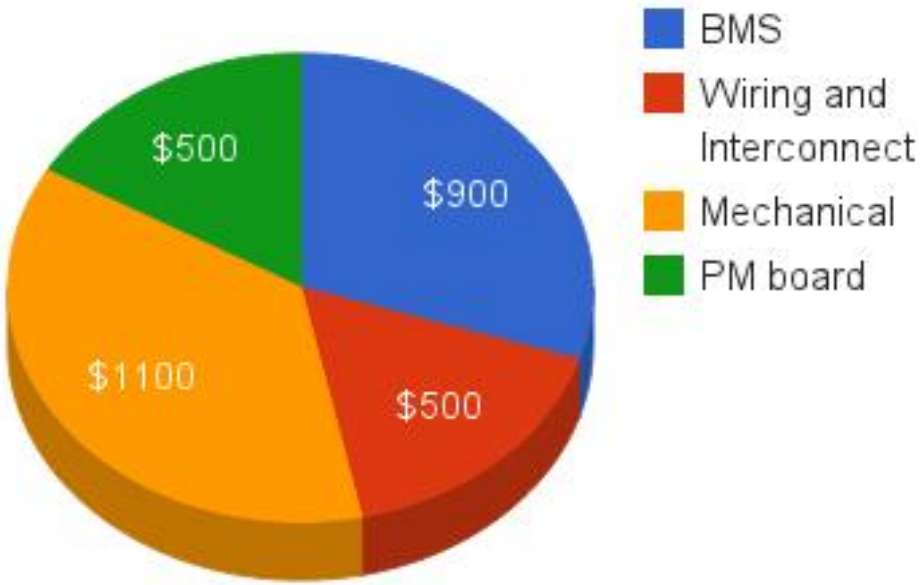
2013 Safety Plan

- Last year's plan primarily encompasses tractive system safety loop
- Divided into sections
  - General Responsibility
  - System Definitions
  - Equipment Guidelines
  - Reporting and Consequences
- Sufficient for 2014 safety plan on safety loop

2014 Safety Plan Additions

- PMS will require
  - Safety loop scope modifications
- Motor will require
  - Complete test plan
  - Safety documentation for rotating machinery

Budget


$900
$500
$1100
$500
BMS
Wiring and Interconnect
Mechanical
PM board

Mark The Calendar

CDR.....	13 March
Integration Testing Begins.....	18 April
System Delivery Date.....	2 May

QUESTIONS?