Preliminary Design Review

TSV

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Past Projects

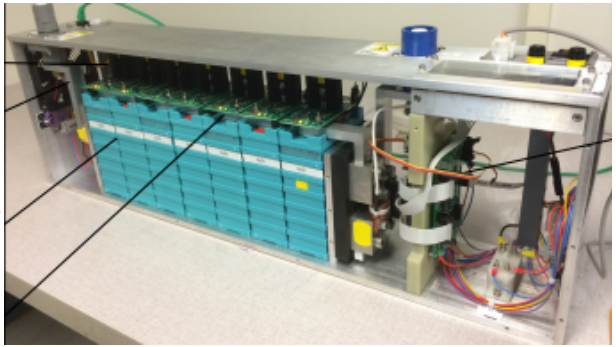


Photo Courtesy of LVEV-2014 project poster

- LFEV-2014 produced a nearly ready 7-cell pack
  - Some bugs left over from 2013 BMS system
  - Several errors on the BoB, and in PacMan
  - PacMan communicates well with AMS boards
  - No workable VSCADA interface
  - Several Formula EV requirements not addressed

System Design

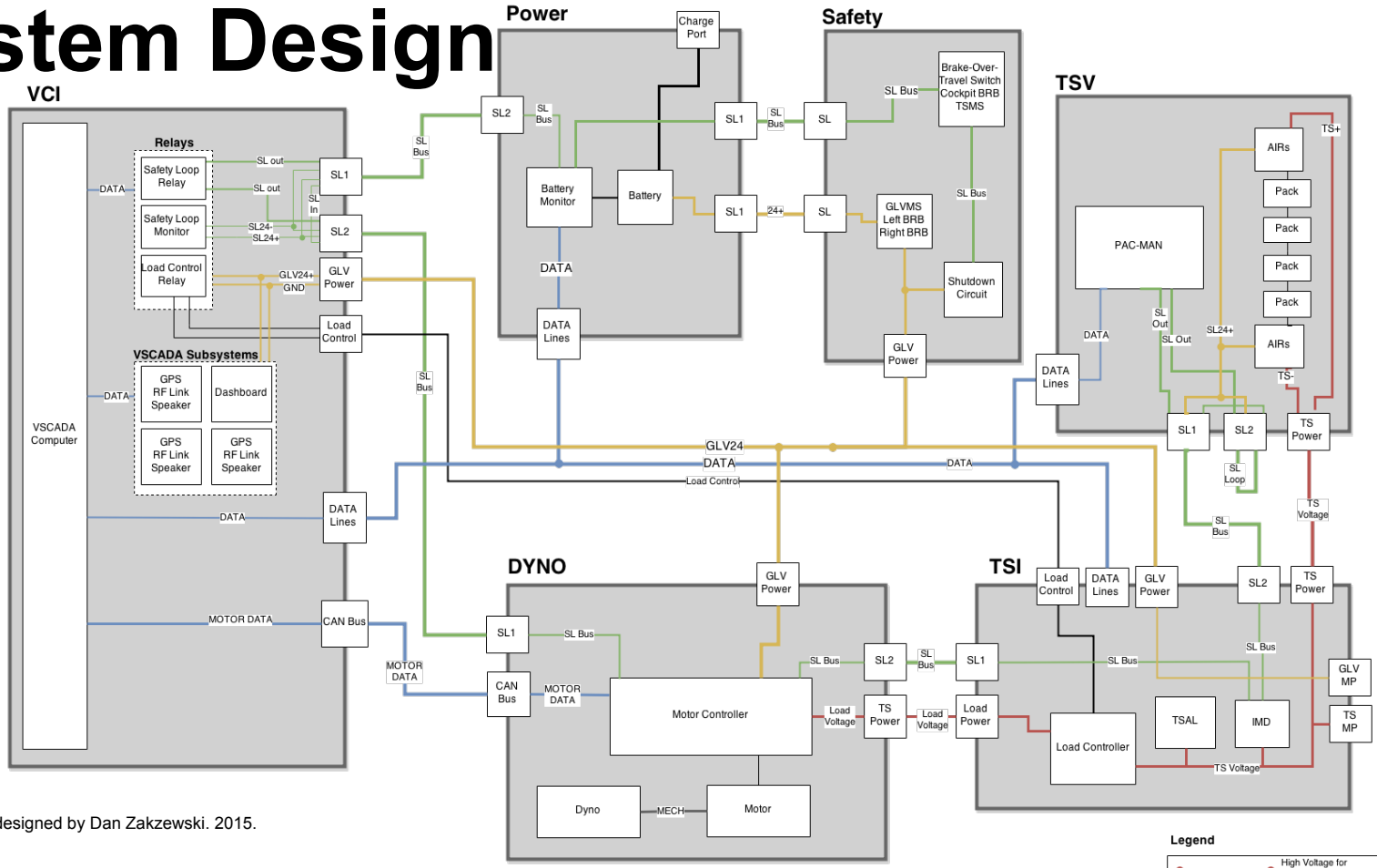
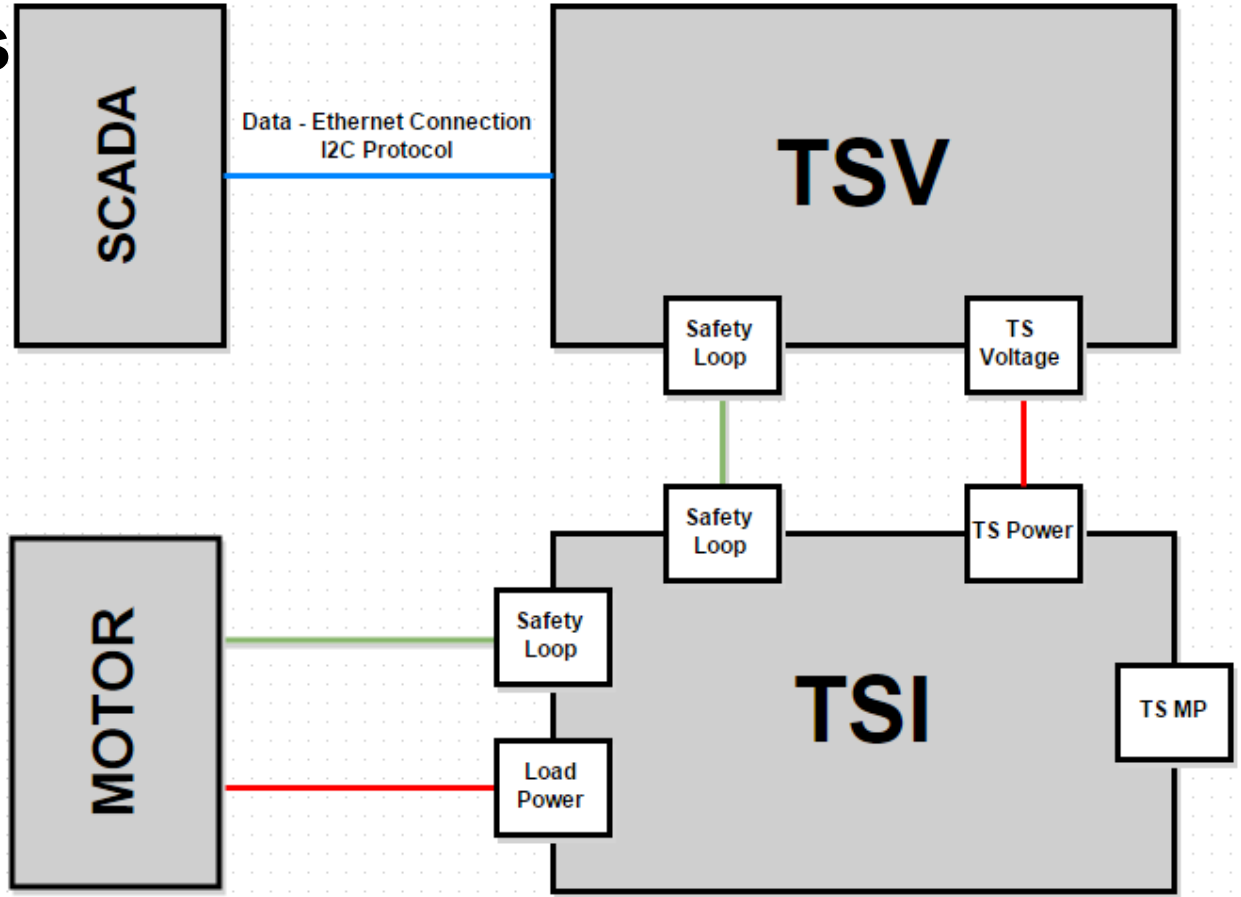


Diagram designed by Dan Zakzewski. 2015.

TSV Interfaces

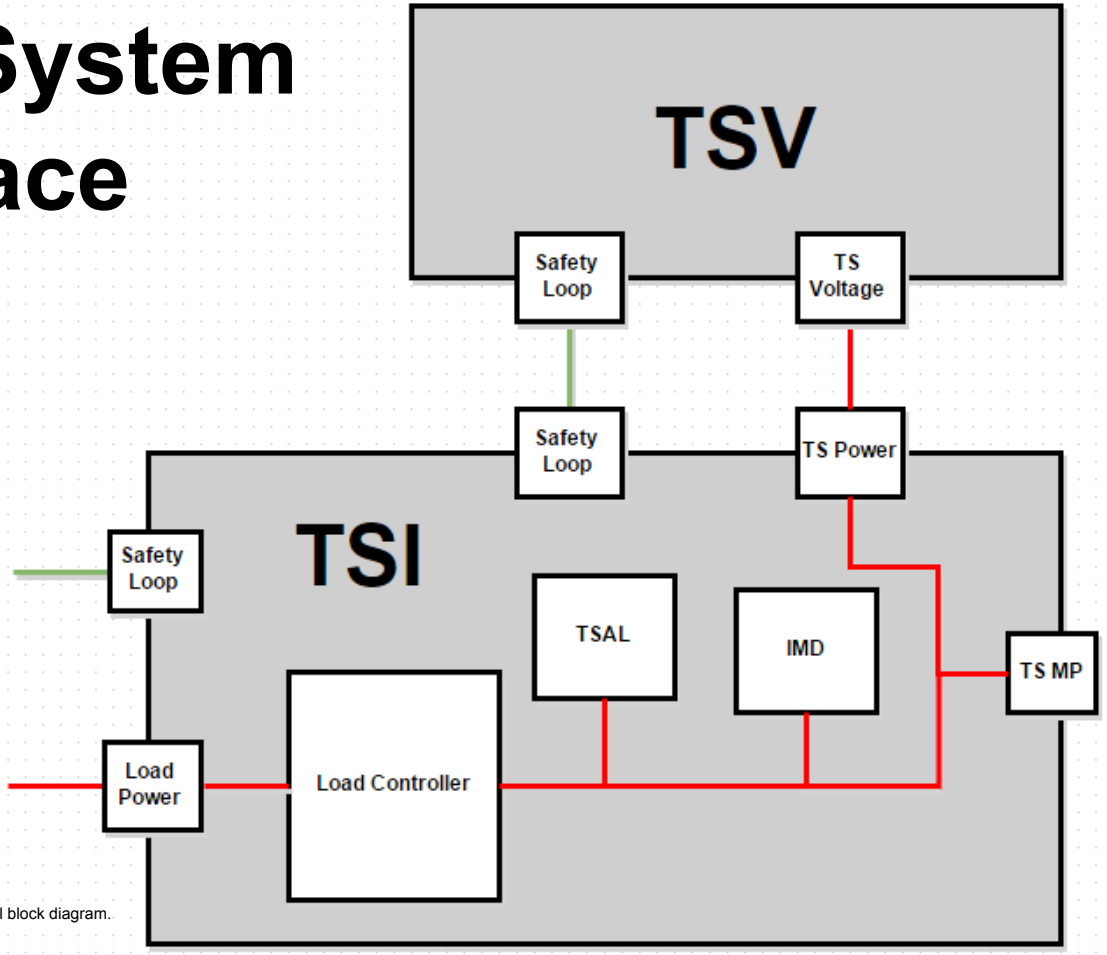
- GLV - Tractive System Interface (TSI)
- VSCADA



Compiled by Katherine Nellis. Modeled after Dan Zakzewski's top level block diagram.

Tractive System Interface

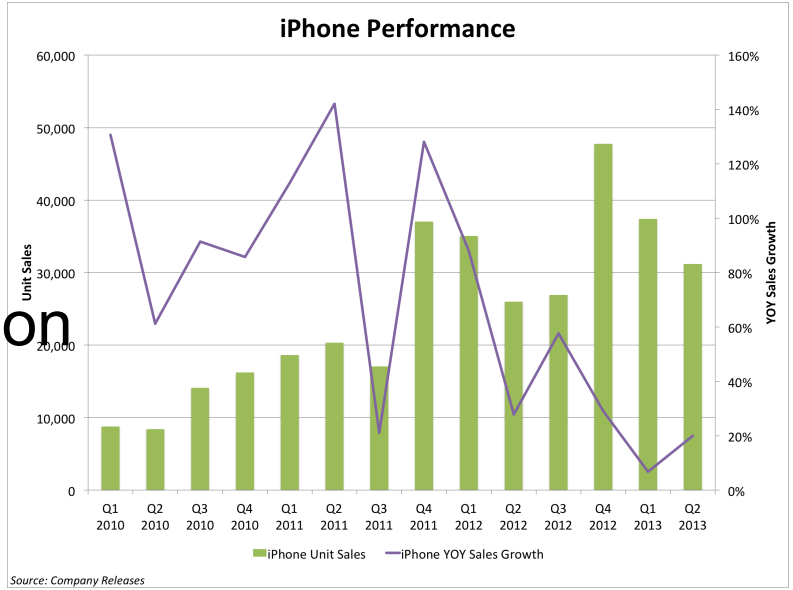
- Tractive System Activity Light
- Insulation Monitoring Device
- Tractive System Measurement Point



Compiled by Katherine Nellis. Modeled after Dan Zakzewski's top level block diagram.

VSCADA

- Pack Manager → VSCADA
- LFEV 2014: RS-485 communication
- LFEV 2015: Ethernet
    - I2C Protocol



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- Voltage & Current Levels
- Temperature
- State of Charge

Pack Design

Mechanical

- Plating
  - Redesign to include “window” to allow access for maintenance without disassembling pack.
- BMS Board Security
  - Design a clip mechanism to secure boards to cells and reduce movement
- 30 V DC Indicator → LED

Pack Manager (PacMan) Program

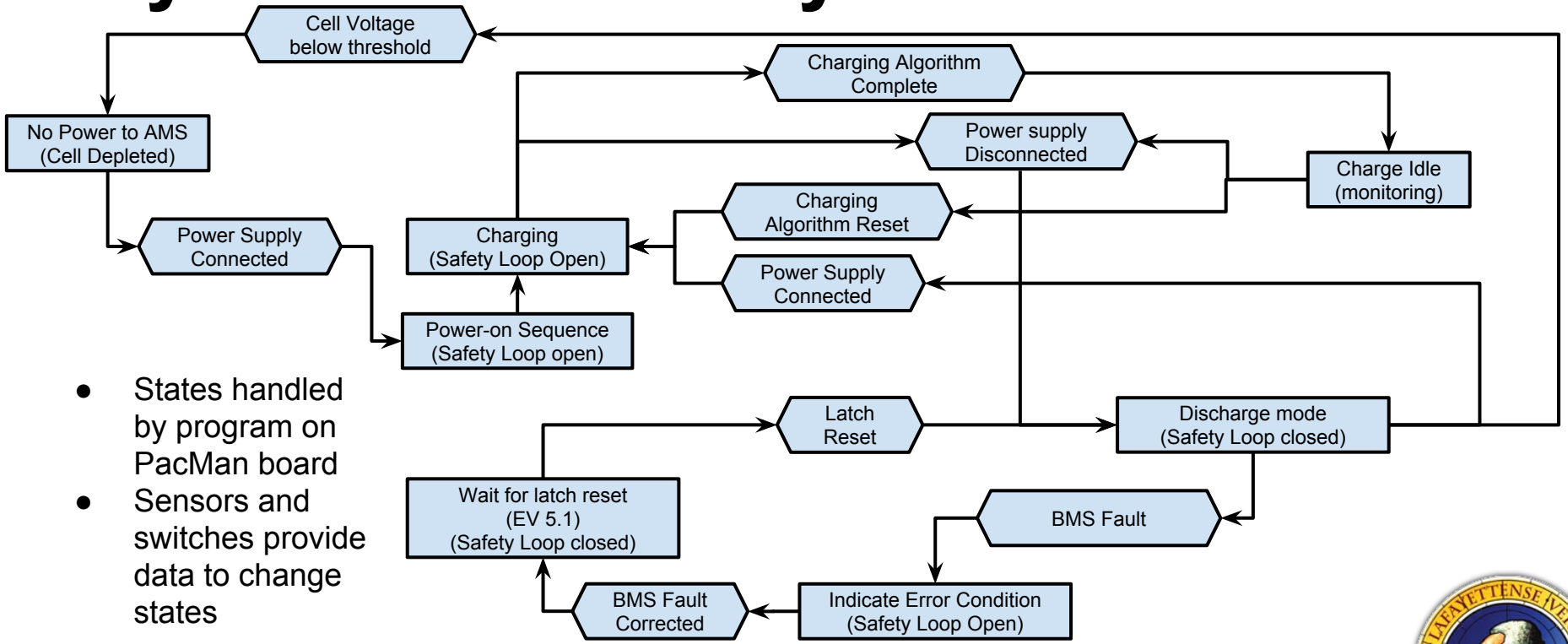
LFEV 2014:

- gathers data from BMS boards
- relays data to VSCADA when requested

LFEV 2015:

- reformat LCD display
- eradicate “patched” bug from LFEV 2013
- charging relays

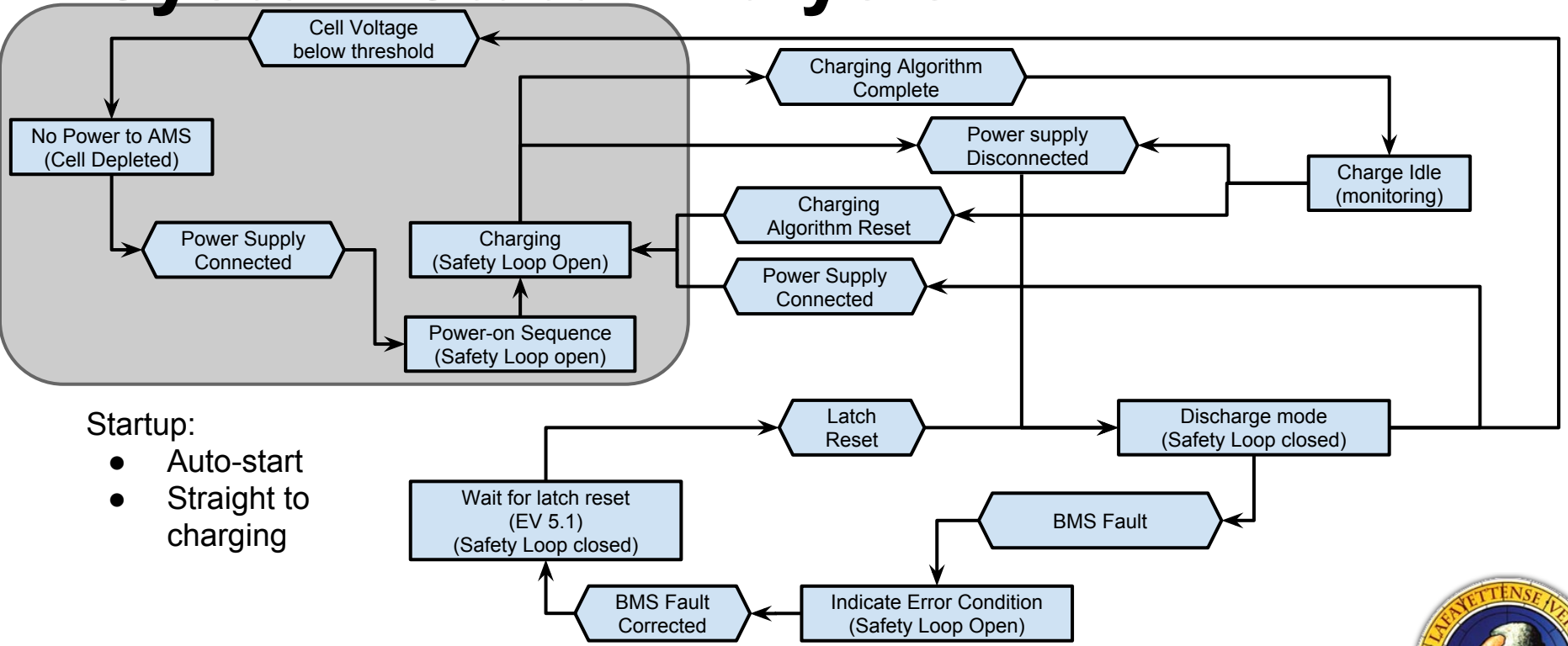
System State Analysis



- States handled by program on PacMan board
- Sensors and switches provide data to change states

Diagram modified from 2014 State Diagram by Jordan Blake. 2015.

System State Analysis

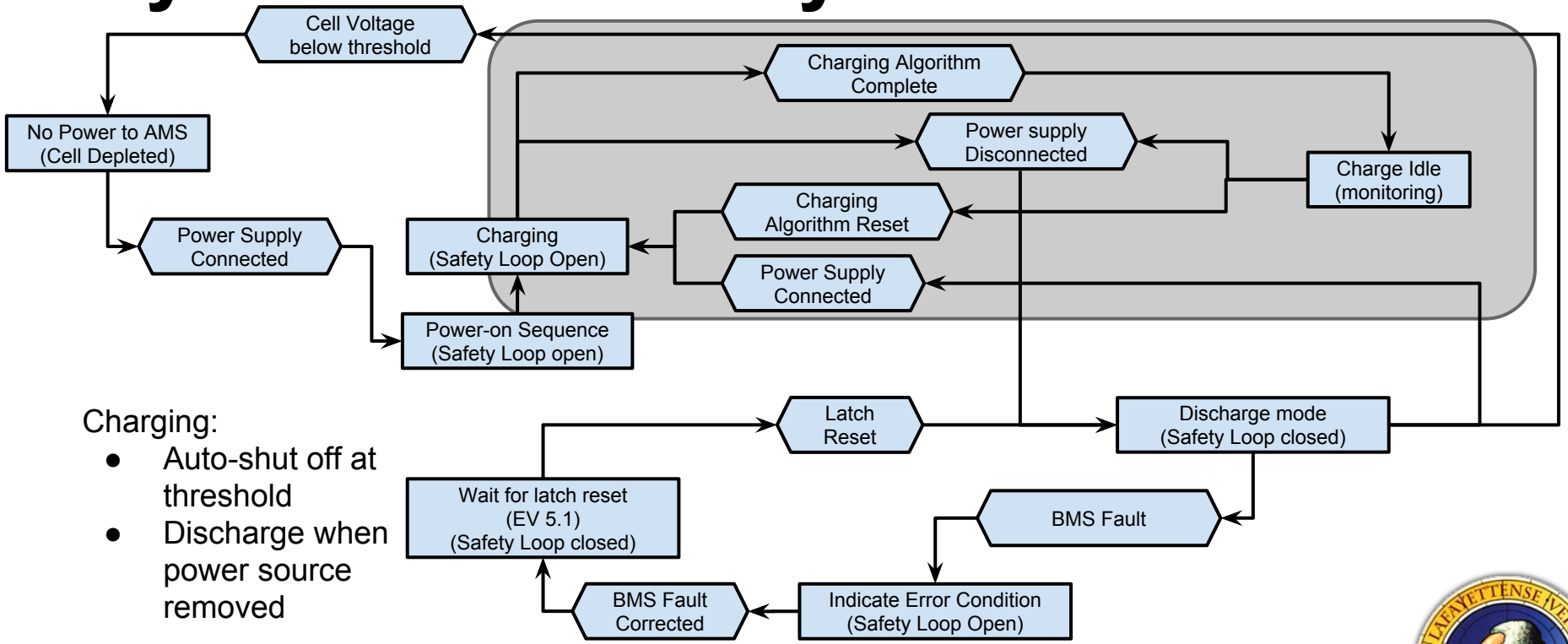


Startup:

- Auto-start
- Straight to charging

Diagram modified from 2014 State Diagram by Jordan Blake. 2015.

System State Analysis

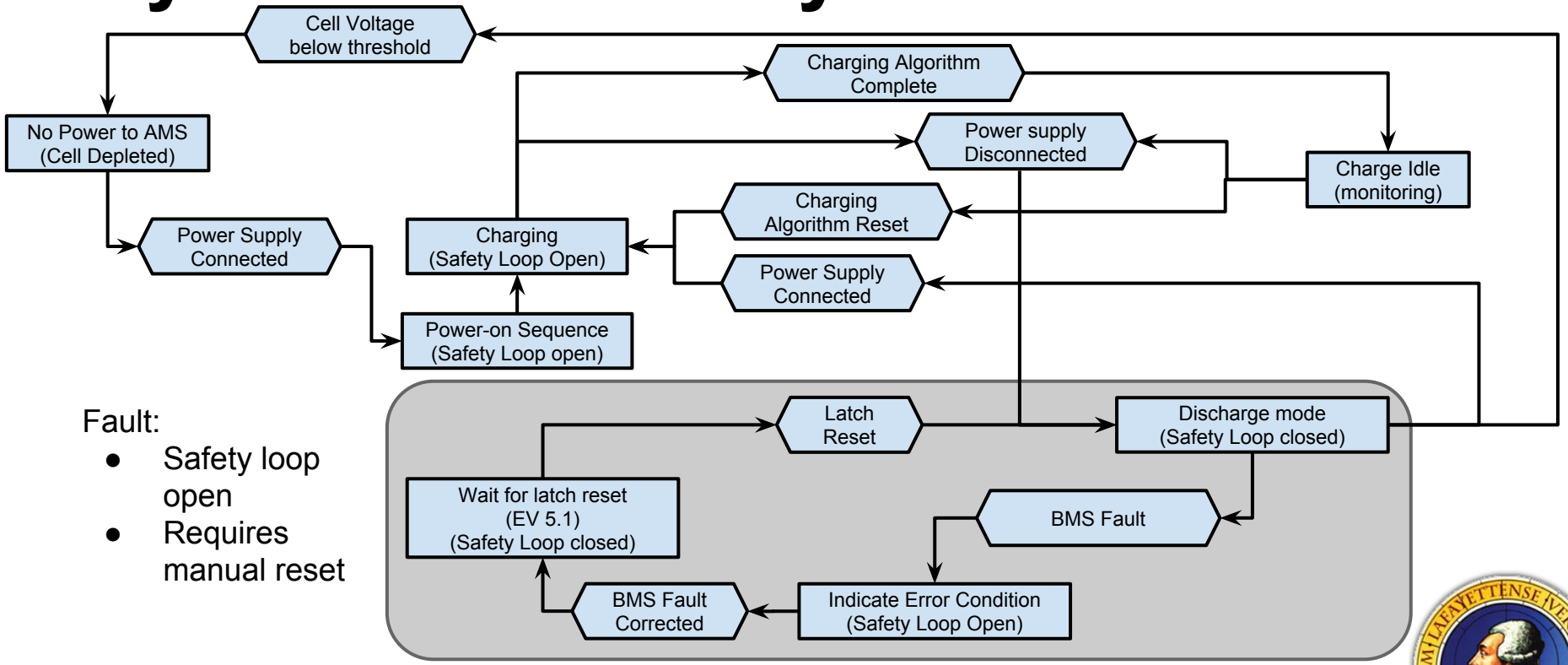


Charging:

- Auto-shut off at threshold
- Discharge when power source removed

Diagram modified from 2014 State Diagram by Jordan Blake. 2015.

System State Analysis



Fault:

- Safety loop open
- Requires manual reset

Diagram modified from 2014 State Diagram by Jordan Blake. 2015.

Battery Management System (BMS)

LFEV 2014:

- 1 BMS board/cell
- unique configurable address
- monitors voltage & temperature of each cell

LFEV 2015:

- Improve inefficient communication with PacMan
- Implement temperature sensors
- System reset

PacMan Breakout Board (BoB)

LFEV 2015:

- Fix necessary layout flaws & suggestions documented by LFEV 2014

- **OVER CHARGING ISSUE**
  - Design circuit to open relays within charging circuit should a PacMan malfunction occur during charging

Requirements Analysis

- Critical
  - Fix issue where battery will not charge once it is depleted
  - Correct sensor readings
  - Full system reset button
- Mechanical
  - Add way to hold AMS boards in place
  - Add sliding panel for maintenance
  - shock, vibration, humidity, temperature testing

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www.dreamstime.com

Requirements Analysis

- Address AMS/BoB board errata
- PacMan
  - Create detailed logging of data on microcomputer
  - Better state of charge algorithm
  - Communication protocols with VSCADA
- Misc.
  - TSVP lights
  - Low voltage indicator
  - AIR/main fuse failure sensors

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prc.dartmouth.edu

Scope

We have not scoped much new design, because much of our time will be spent in the fabrication of **four working battery packs**.

Thus, of all requirements, fulfilling the LFEV rules is a top priority.

Acceptance Test Strategy

- Preliminary test plan
- Based on requirements and subject to change
- Test without other teams' components when possible

Acceptance Test Strategy

- T000: Maximum Operating Voltage Test
  - Max voltage < 300VDC
- T001: TSV/GLV Galvanic Isolation Test
  - Resistance measurements at various points
- T002: TSV/Chassis Isolation Test
  - Resistance measurements
- T003: Accumulator Pole/Inside Wall Isolation Test

Acceptance Test Strategy

- T004: Accumulator Container Grounding Test
  - Outside walls must be GLV grounded
- T005: TSAL Light Test
  - Tractive System Active Light on when voltage present
- T006: Voltage Error AMS Shutdown Test

Acceptance Test Strategy

- T007: Temperature Error AMS Shutdown Test
- T008: Tractive System Driver Reset Test
  - Driver reset (not after AMS or IMD shut down)
- T009: Tractive System Driver Re-activation Test
  - Driver reactivation (not after AMS or IMD shut down)

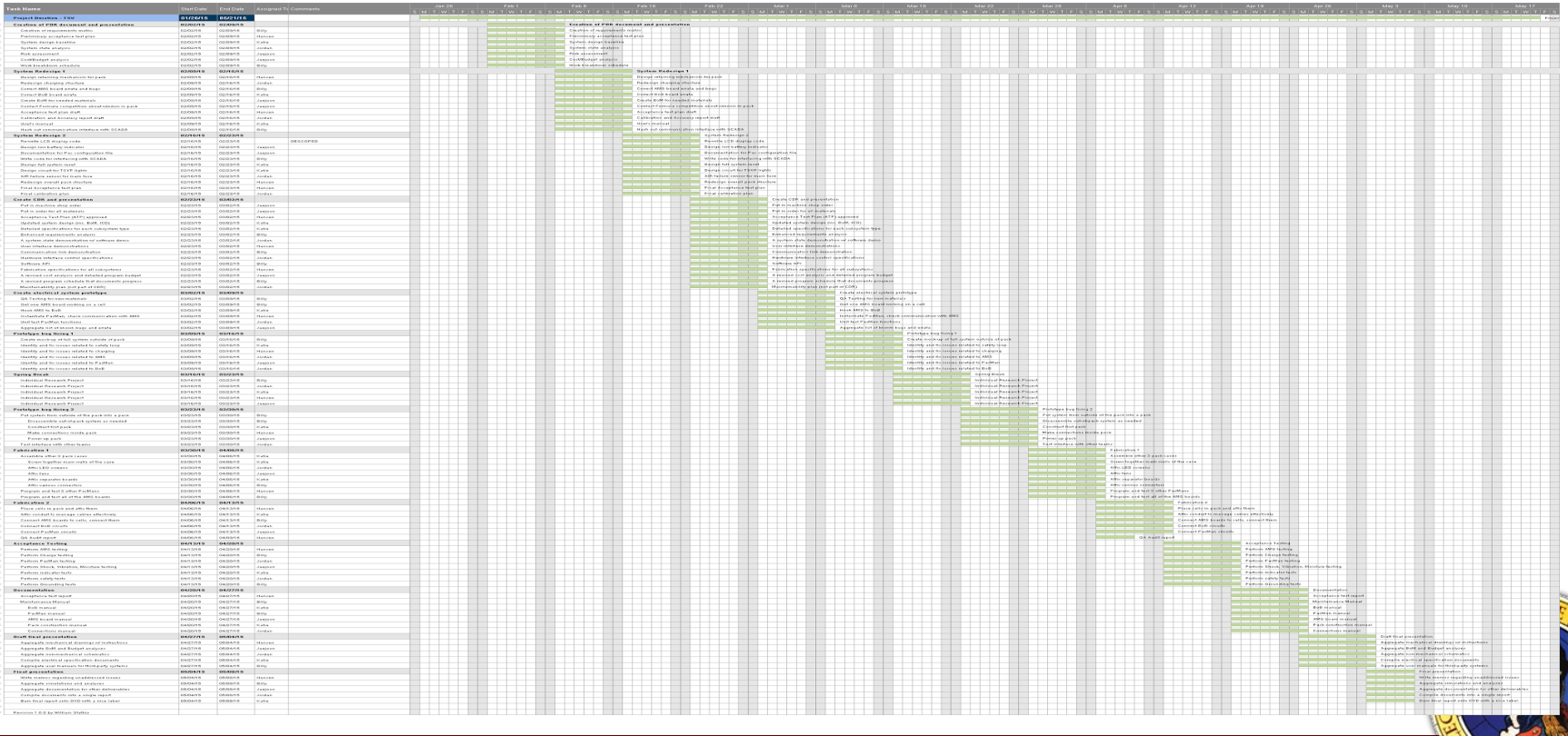
Acceptance Test Strategy

- T010: TSVP Lamp Test
- T011: Shutdown Circuit Current Test
  - Shutdown circuit must carry same current as AIRs
- T012: Insulation Monitoring Device Test
  - IMD opens AIRs immediately when error detected
- T013: Pack Recharge After Depletion Test
- T014: Accumulator Pack External Reset Test

Acceptance Test Strategy

- T015: AIR & Main Fuse Failure Detector Test
  - Clear indicator for failures detected
- T016: Low Battery Indicator Test

Work Breakdown



Work Breakdown - Overview 1

- Weeks 2, 3 - System redesign
  - This includes previous year bug fixing and newly implemented requirements
- Weeks 4, 5 - CDR and system prototyping
  - Week 3 is constrained mainly to documentation for CDR, as well as ordering materials and submitting schematics to the machine shop.
  - Week 4 will be building an out-of-pack prototype to reveal any glaring design errors.

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Work Breakdown - Overview 2


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- Weeks 6 - 8 - Bug Identification, Fixing
  - These weeks will be devoted to fixing bugs and issues that will arise with our out-of-pack system prototype.
  - For week 8, we will place our prototype into a pack that will be build.
- Weeks 9, 10 - Fabrication
  - These are designated to be fabrication weeks, this is where we will build the remaining 3 packs
- Weeks 11 - 14 - Documentation and Final
  - These weeks are reserved for system acceptance testing, finalizing documentation, and development of the final presentation.

Risk Assessment

TSV Risk Assessment

Risk Category	Descriptions of Risks	Possible Consequences	Risk Level	Contingency Plan
Safety "Always Expect The Unexpected"	Working Alone	Injuries/Death	H	Always work with someone else when working with any physical parts related to the cells or anything that can possibly cause an electrical shock, arc, or blast especially when assembling the cells and charging the pack.
	Presence of food/drinks	Malfunctioning of the pack and/or lowering the resistance in human touch which can cause injuries	H	No food or drinks when working with any physical parts of the project.
	Unsafe dress code	Unexpected electric shock, arc, or blast	H	Always wear insulated gloves when working with the cells or live wires. Avoid metal accessories such as watches, necklaces, bracelets, rings, etc. Avoid wearing conductive clothes.
Time Management / Efficiency	Procrastination of the documentation/proofs until the final report is due	This can result in an incomplete project without you even knowing or not having enough time to finish the documentation.	H	The work is not finished until there is documentation proving that the work is successful. Always remember to thoroughly document your work every time: providing simulations, timing diagrams, all physical components you used for a task.

Risk Assessment

Time Management / Efficiency	Lack of constructive communication between groups and members of the group. Each group relies on clear communication between another group or inner members. EVERYTHING IS INTERRELATED. Designing a system without discussing with other groups who might be related to the work may cause a minor or major problems later. Another example of the risk would be that one team member's task or one group's task can be only achievable after another member's task or another team's task is finished.	Lack of communication can lead to compatibility issues within the projects themselves. The risk can cause conflicts between groups and failure to meet the desired program schedule.	H	When determining tasks for individuals or a team, always discuss what should be done beforehand to accomplish the task and determine which tasks may influence other group and vice versa. Let your teammates or other group know about the problem accordingly.
	Focus only on one self's task	There can be mistakes and errors that an individual cannot see.	M	Have frequent group meetings in the middle of the week, not just at the beginning or end of the week and proof read or comment on what other members have been working on.

Risk Assessment

Technical Issues	Assembling 4 packs can be a disaster because of the countless components that make up each pack such as wires, wire housing/casings, boards, screws, chips, etc. We are also redesigning the pack architecture.	Even for the most perfect pack assembly design that we might come up with, there are definitely going to be unexpected problems and conflicts our team will face. New modifications on the design may be required in the middle of building a pack, forcing us to modify all four packs, re-build them or order more parts.	M	Work on one pack only and finish it before building the other three packs. First purchase order should include four of the same major parts that will definitely be needed even with any unexpected extreme modifications and the other minor parts for just one pack. Finish and document what goes into the first pack thoroughly and then you can order three of the same parts that went into the pack after completely finishing the first pack. Always discuss with mechanical engineering students and professors on ideas and designs that make up the pack.
	To debug last year's errata and make improvements, we have to completely read and understand their codes. Lack of comments on codes can lead to confusions. It is always a hassle to understand other's codes.	Our group might become frustrated or confused about why and how certain algorithms and parts were implemented and how we will deal with it.	L	Trying emailing previous year's engineers or build new algorithms. Make many comments in details while coding to facilitate future users.

Cost Analysis

AMS (Accumulator Management System)

Description	Unit Price	QTY	Total Price
Advanced Circuits PCB 28 AMS Boards and 4 BOB	$33.00	32	$1,056.00
parts from Mouser	N/A	N/A	~ $459.29
parts from Digikey	N/A	N/A	~ $141.7
	Minimum AMS Total:		**~ $1656.99**

PacMan (Pack Manager)

Description	Unit Price	QTY	Total Price
Microcontroller	$308	4	$924.00
Micro SD Card 4GB Class 10 Industrial	$10.54	4	$42.15
	Minimum PacMan Total:		**~ $966.15**

Cost Analysis

Pack Mechanical Parts

Descriptions	Unit Price	QTY	Total Price
25 Mechanical parts - casings, aluminium bars&plates, stainless screws, etc.	N/A	N/A	~ $2700
Minimum Pack Mechanical Total:			**~ $2700**

Pack Electrical Parts

Description	Unit Price	QTY	Total Price
Fuse, 200A, Class T, A3A, 300VAC/160VDC	$28.34	4	$113.36
Fuse Holder, 200A AC, 300V, 1 Pole, Molded	$71.81	4	$287.24
Fans 119x25 24DC 100CFM 5W 2900RPM 43dBA BB	$40.95	4	$163.80
AIR - 350A Contractor, 24VDC coil, 24-in flying leads, no auxiliary contact	$94.35	8	$754.80
50A miniTactor, 24VDC coil	$40.00	8	$320.00
Panel Drain, Line 3, Grey	$51.26	4	$205.04
Panel Source, Neutral, Blue	$54.33	4	$217.32
LCD Character Display Module STN Y/G	$27.00	4	$108.00
Fixed Bridges (10 Position)	~ $8.50	8	$68.00
Galvanically Isolated Ethernet	~ $130.00	4	~ $520.00
other 55 parts - fuses, fuse holders, pin&socket connectors, headers, plugs, wire housings&casings, wire ducts, BOB parts, etc.	N/A	N/A	~ $1600
Minimum Pack Electrical Total:			**~ $4357.56**

Cost Analysis

Total TSV Minimum Budget Required

AMS	PacMan	Pack Electrical Parts	Pack Mechanical Parts	Mininmum Grand Total Budget
~ $1656.99	~ $966.15	~ $4357.56	~ $2700	~ $9680.7