Preliminary Design Review

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TSV
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Past Projects

- 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
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
- 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

System State Analysis

Startup:
- Auto-start
- Straight to charging

System State Analysis

Charging:
- Auto-shut off at threshold
- Discharge when power source removed
System State Analysis

Fault:
- Safety loop open
- Requires manual reset
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
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
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

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsibility</th>
<th>Start Date</th>
<th>End Date</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1</td>
<td>John Doe</td>
<td>01/01/2023</td>
<td>02/01/2023</td>
<td>1 month</td>
</tr>
<tr>
<td>Task 2</td>
<td>Jane Smith</td>
<td>01/02/2023</td>
<td>02/02/2023</td>
<td>1 month</td>
</tr>
<tr>
<td>Task 3</td>
<td>Mike Brown</td>
<td>01/03/2023</td>
<td>02/03/2023</td>
<td>1 month</td>
</tr>
<tr>
<td>Task 4</td>
<td>Sarah Lee</td>
<td>01/04/2023</td>
<td>02/04/2023</td>
<td>1 month</td>
</tr>
</tbody>
</table>

*Note: This is a simplified example of a work breakdown structure. In practice, this would be a much more detailed and complex document.*
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.
Work Breakdown - Overview 2

● **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

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Descriptions of Risks</th>
<th>Possible Consequences</th>
<th>Risk Level</th>
<th>Contingency Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety “Always Expect The Unexpected”</td>
<td>Working Alone</td>
<td>Injuries/Death</td>
<td>H</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Presence of food/drinks</td>
<td>Malfunctioning of the pack and/or lowering the resistance in human touch which can cause injuries</td>
<td>H</td>
<td>No food or drinks when working with any physical parts of the project.</td>
</tr>
<tr>
<td></td>
<td>Unsafe dress code</td>
<td>Unexpected electric shock, arc, or blast</td>
<td>H</td>
<td>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.</td>
</tr>
<tr>
<td>Time Management / Efficiency</td>
<td>Procrastination of the documentation/proofs until the final report is due</td>
<td>This can result in an incomplete project without you even knowing or not having enough time to finish the documentation.</td>
<td>H</td>
<td>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.</td>
</tr>
<tr>
<td>Time Management / Efficiency</td>
<td>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.</td>
<td>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.</td>
<td>H</td>
<td>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.</td>
</tr>
<tr>
<td>Focus only on one self's task</td>
<td>There can be mistakes and errors that an individual cannot see.</td>
<td>M</td>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>
## Risk Assessment

<table>
<thead>
<tr>
<th>Technical Issues</th>
<th>Rationale</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembling 4 packs can be a disaster because of the countless components that</td>
<td>Even for the most perfect pack assembly design that we might come up with,</td>
<td>M</td>
</tr>
<tr>
<td>make up each pack such as wires, wire housing/casings, boards, screws, chips,</td>
<td>there are definitely going to be unexpected problems and conflicts our</td>
<td></td>
</tr>
<tr>
<td>etc. We are also redesigning the pack architecture.</td>
<td>team will face. New modifications on the design may be required in the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>middle of building a pack, forcing us to modify all four packs, re-build</td>
<td></td>
</tr>
<tr>
<td></td>
<td>them or order more parts.</td>
<td></td>
</tr>
<tr>
<td>To debug last year’s errata and make improvements, we have to completely read</td>
<td>Our group might become frustrated or confused about why and how certain</td>
<td>L</td>
</tr>
<tr>
<td>and understand their codes. Lack of comments on codes can lead to confusions.</td>
<td>algorithms and parts were implemented and how we will deal with it.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trying emailing previous year’s engineers or build new algorithms. Make</td>
<td></td>
</tr>
<tr>
<td></td>
<td>many comments in details while coding to facilitate future users.</td>
<td></td>
</tr>
</tbody>
</table>
# Cost Analysis

## AMS (Accumulator Management System)

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit Price</th>
<th>QTY</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Circuits PCB, 28 AMS Boards and 4 BOB</td>
<td>$33.00</td>
<td>32</td>
<td>$1,056.00</td>
</tr>
<tr>
<td>parts from Mouser</td>
<td>N/A</td>
<td>N/A</td>
<td>~$459.29</td>
</tr>
<tr>
<td>parts from Digikey</td>
<td>N/A</td>
<td>N/A</td>
<td>~$141.7</td>
</tr>
</tbody>
</table>

**Minimum AMS Total:** ~$1656.99

## PacMan (Pack Manager)

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit Price</th>
<th>QTY</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller</td>
<td>$308</td>
<td>4</td>
<td>$924.00</td>
</tr>
<tr>
<td>Micro SD Card 4GB Class 10 Industrial</td>
<td>$10.54</td>
<td>4</td>
<td>$42.15</td>
</tr>
</tbody>
</table>

**Minimum PacMan Total:** ~$966.15
Cost Analysis

### Pack Mechanical Parts

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit Price</th>
<th>QTY</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 Mechanical parts - casings, aluminium bars&amp;plates, stainless screws, etc.</td>
<td>N/A</td>
<td>N/A</td>
<td>~$2700</td>
</tr>
</tbody>
</table>

**Minimum Pack Mechanical Total:** ~$2700

### Pack Electrical Parts

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

**Minimum Pack Electrical Total:** ~$4357.56
Cost Analysis

<table>
<thead>
<tr>
<th>AMS</th>
<th>PacMan</th>
<th>Pack Electrical Parts</th>
<th>Pack Mechanical Parts</th>
<th>Minimum Grand Total Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ $1656.99</td>
<td>~ $966.15</td>
<td>~ $4357.56</td>
<td>~ $2700</td>
<td>~ $9680.7</td>
</tr>
</tbody>
</table>