The PreLIBS Project:
What can be Learned from EV Battery Safety

May 2019

Jonathan Buston
# The Faraday Challenge

## ISCF Faraday Battery Challenge

**£246 million (2017-2021)**  
Advisory Group, Programme Board

### Challenge Director

<table>
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<tr>
<th>Research: £78m</th>
<th>Innovate: £88m</th>
<th>Scale: £80m</th>
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<td>‘Application-inspired’ research programme coordinated at national scale</td>
<td>Innovation programme to support business-led collaborative R&amp;D with co-investment from industry</td>
<td>Scale up programme to allow companies of all sizes to rapidly move new battery technologies to market</td>
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<td>Creation of the <a href="#">Faraday Institution</a> – responsible for coordination of research and training programmes</td>
<td>Address technical challenges and build UK supply chain</td>
<td>Develop manufacturing tools and methods for mass production</td>
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<td>Four ‘fast-start’ projects announced 23rd Jan 2018 (£42m) – Battery Degradation, Multi-scale Modelling, Recycling, Solid State Batteries</td>
<td>£38 committed in Round 1 (2017) to Collaborative R&amp;D and Feasibility Study projects – projects addressing range of areas from cell materials to pack integration and BMS to recycling</td>
<td>Demonstrate production-rate reliability and quality</td>
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| **Wave 2** call for proposals launched 10/01/19  
Outline submissions received 28/02/19 | £22 million Round 2 to 12 CR&D and Feasibility Study projects announced in June 2018 | **CWLEP & WMG** building open-access scale up facility: [UK Battery Industrialisation Centre](#) |
|  | **Round 3** competition due to be announced. | Planning consent granted for 193,750 sq ft facility. |
Faraday Challenge: Technical Gaps

Cost
NOW: $130/kWh (cell)
$280/kWh (pack)
2035: $50/kWh (cell)
$100/kWh (pack)

Energy Density
NOW: 700 Wh/l, 250 Wh/kg (cell)
2035: 1400 Wh/l, 500 Wh/kg (cell)

Power Density/ Fast Charging
NOW: 3 kW/kg (pack)
2035: 12 kW/kg (pack)

Safety
2035: Eliminate thermal runaway at pack level to reduce pack complexity

1st Life
NOW: 8 years (pack)
2035: 15 years (pack)

Temperature
NOW: -20° to +60°C (cell)
2035: -40° to +80°C (cell)

Predictability
2035: Full predictive models for performance and ageing of battery

Recyclability
NOW: 10-50% (pack)
2035: 95% (pack)
The PreLIBS Project: Project Aims

- Recognise that the current generations of lithium ion technology is likely to be used in EVs for the next 3-10 years.

- Understand these safety issues
Project Partners

- Jaguar
- Land Rover
- Potenza
- Health & Safety Laboratory
- Warwick Manufacturing Group
- Lifeline Fire & Safety Systems Ltd.
- 3M
- Warwick University

HSE Science and Research Centre

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Project Outline

WS1: Programme Management

WS2: Literature & Standards
What is known about cell failure? What battery testing is required?

WS3: Real Life Hazard Mapping
How might EV batteries fail throughout their life cycle? Do the prescribed tests adequately cover these failures? Where do mitigation methods fit? Are we mitigating the right things?

WS4: Sensing for Active Mitigation
How can we spot a failing cell? How can we spot that a cell has failed and initiate methods to mitigate the consequences? And how is it all controlled reliably?

WS5: Mitigation Strategies
What could be done? Standardising screening tests for different mitigation methods. Assessing

WS6a: Single Cell Failure Characteristics
How various initiation methods compare? What happens when different cells fail? Production of key characteristics/parameters for future WSs

WS6b: Multi-cell scale testing
How do cell failures scale to module/pack levels? Do this pose different mitigation challenges? How do different module assemblies behave? What is the best way to arrange/build/vent packs?

WS6c: Standardised Battery Fire
Describing a standardised, reasonably well characterised fire typical of batteries. Can be used to demonstrate mitigation effectiveness

WS7: Computational Modelling
Refinement of model using key parameters derived in WS6a. And validation of models against module/pack scale testing

WS8: Dissemination & Communication
Project Aims

• Understanding the consequences of:
  • Thermal Runaway
  • Thermal Propagation
• Sensing the start of Thermal Runaway
• Hindering or Mitigating the effect of Thermal Propagation
  • Active mitigation
  • Passive mitigation
• Validated Computation Modelling
Project Aims

• One Example: the proposed thermal propagation test
Thermal Propagation Test

• New developments from the Chinese Standards

• Key Requirement:
  • Alarm of a ‘thermal event’ 5 minutes before the event impacts upon the passenger compartment
Thermal Propagation Test

- Reliable detection of an event
- ‘Managing’ the event for 5 minutes
- Developing a testing strategy to reliably put a pack into thermal propagation, according to the standard specifications
Cell Size

18650
Up to 3.5 Ah

21700
Up to 5 Ah
What does the event look like?

Some videos of EH1
What does the event look like?
### Snapshot of Results - Gas Detection

<table>
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<tr>
<th>SoC</th>
<th>CO₂</th>
<th>SOC</th>
<th>CO₂</th>
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</thead>
<tbody>
<tr>
<td>100%</td>
<td><img src="image1" alt="Graph" /></td>
<td>50%</td>
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<tr>
<td>100%</td>
<td><img src="image3" alt="Graph" /></td>
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<td><img src="image4" alt="Graph" /></td>
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<tr>
<td>75%</td>
<td><img src="image5" alt="Graph" /></td>
<td>5%</td>
<td><img src="image6" alt="Graph" /></td>
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Snapshot of Results - Initiation methods

Video EH1 vs EH17
Snapshot of Results- Initiation methods

Video EH1 vs EH6
Snapshot of Results- Modelling

Modelling against ‘ARC’ data

Modelling against open field data
Video with water extinguisher
Box with flame
Thanks to

All project partners

HSE Staff
Jason Gill
Dan Howard
Rhi Williams
Caroline Adams
Keith Tremble