	Car Model	Range (Miles)
15	Tesla Model S Performance	310
14	Hyundai Kona Electric	245
13	Polestar 2	235
12	Porsche Taycan 4S	230
11	Jaguar I-PACE EV	225
10	KIA Soul EV 64 KWH	225
9	Volkswagen ID.3 Pro	210
8	Renault Zoe ZE50 R135	190
7	Audi E-Tron 50 Quattro	175
6	Peugeot E-208	170
5	BMW I3 120 AH	145
4	Volkswagen E-UP!	120
3	Mini Electric	115
2	Honda E	105
1	Smart EQ ForFour	55

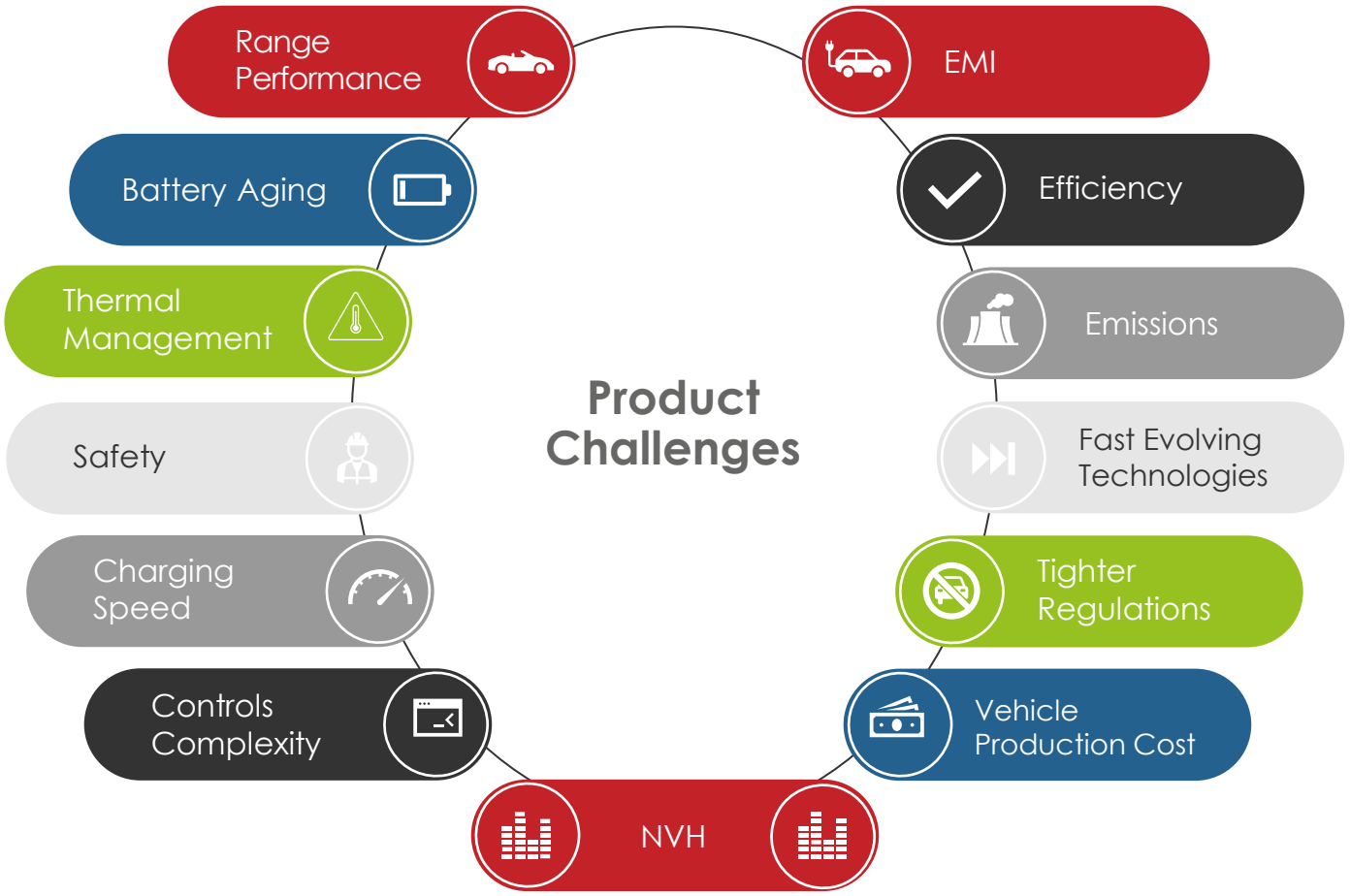
https://leasecar.uk/blog/how-far-can-you-go-in-an-electric-car/

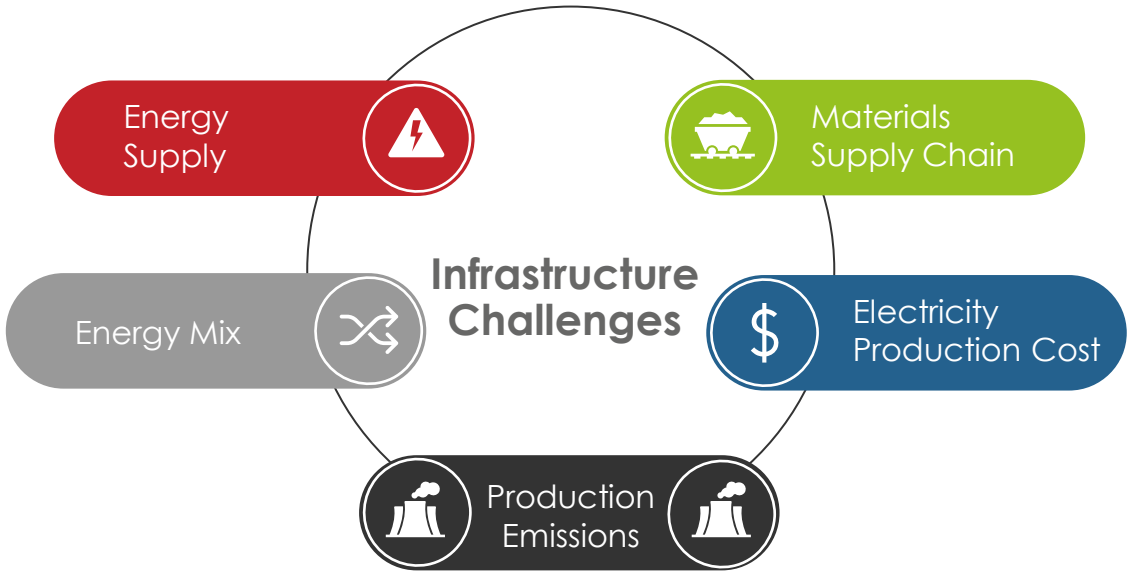
What will
my BEV's range
be after
2 - 5 - 8 years ?

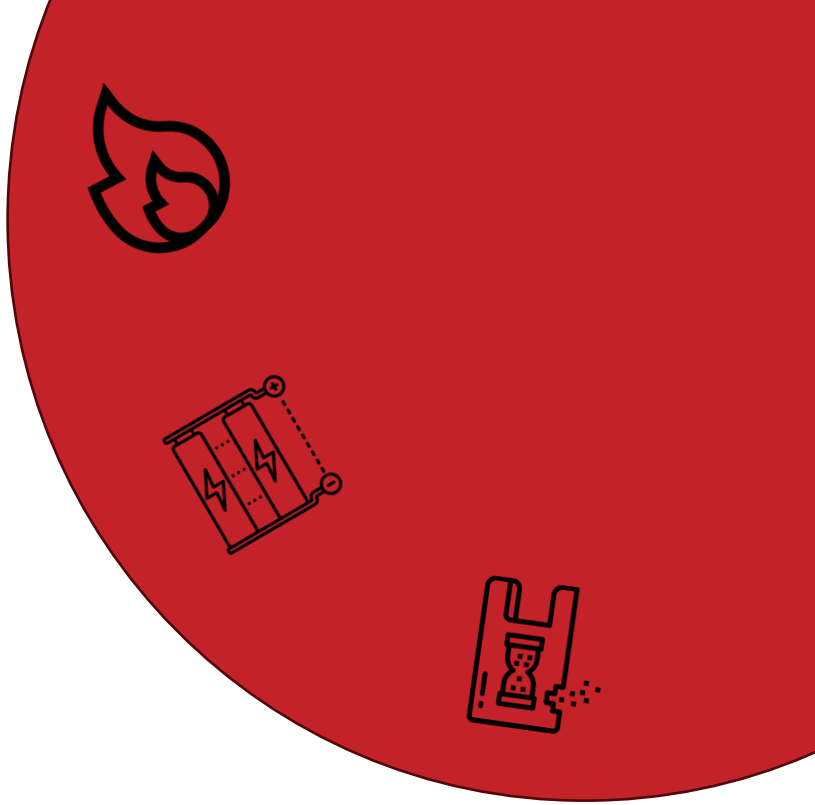
GT


Holistic
Battery study:
Real World
conditions

Challenges





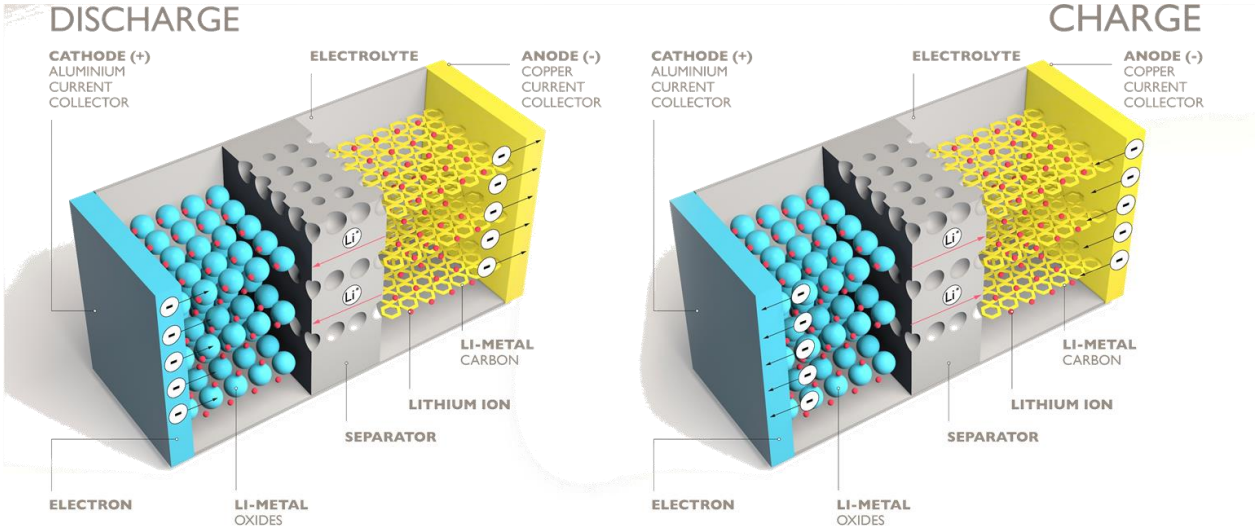


BATTERY SIMULATION

THERMAL BATTERY PERFORMANCE
AND AGING SIMULATION USING GT-AUTOLION

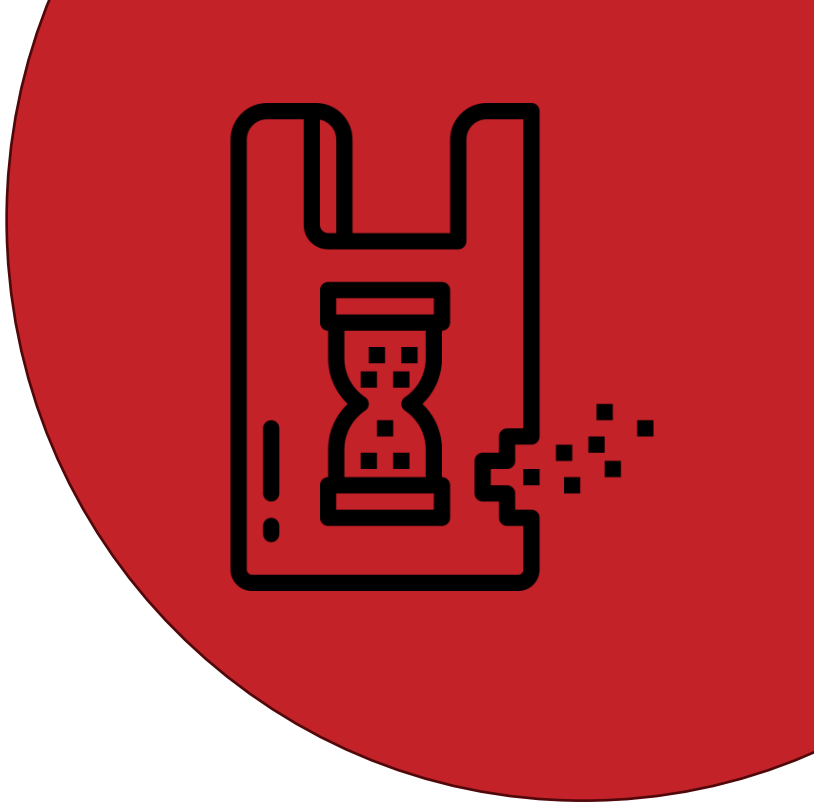
Cell Design

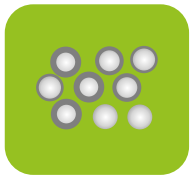
Optimize designs to meet power
and energy requirements



Degradation Prediction

Physics based Aging Mechanisms

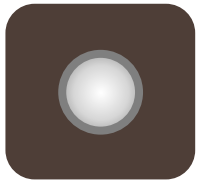




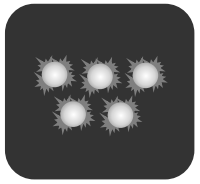
Film Layer Growth

Lithium Plating

Active Material Cracking



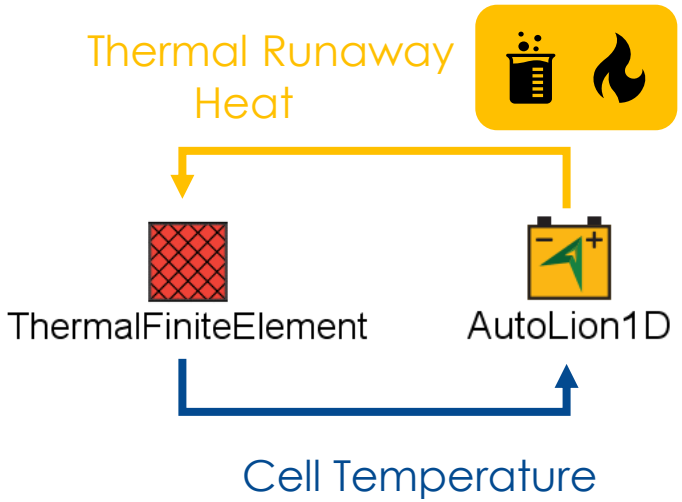
SEI Cracking

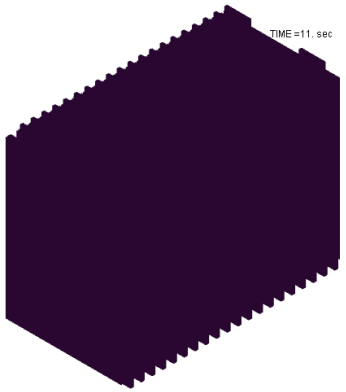


Rock-Salt Layer Formation

Battery Thermal Runaway

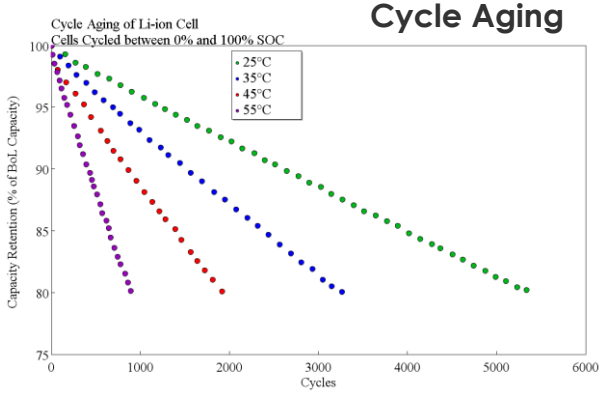
Unique 1D/3D coupled thermal and flow models for accurate and fast solution



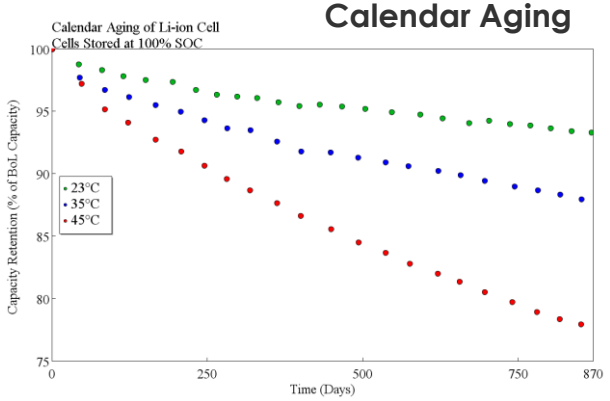


Study steps

Cycle Aging



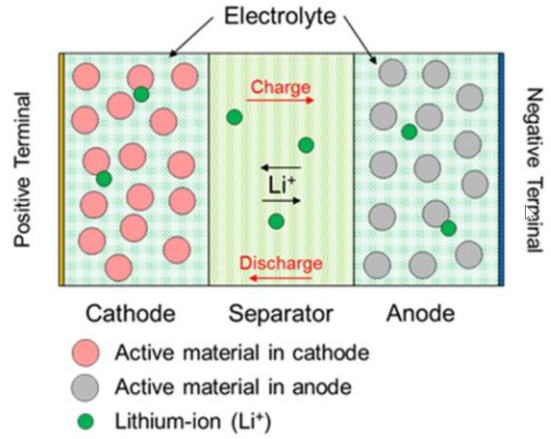
Calendar Aging

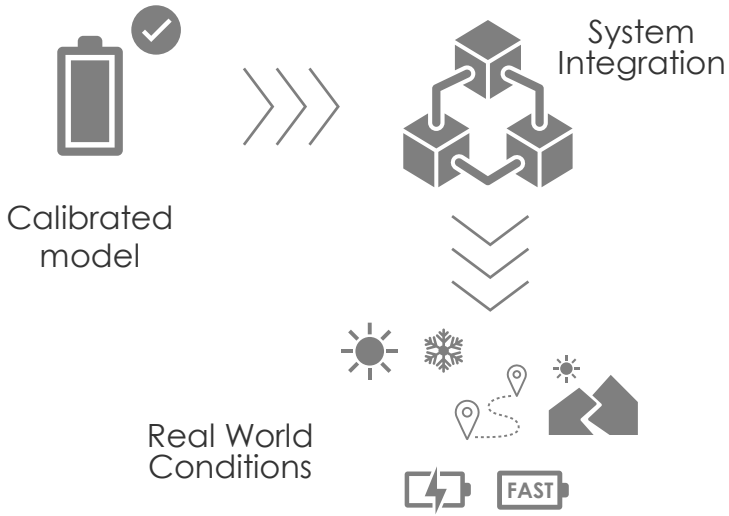


Performance

Cycle/Calendar Aging

Real World Aging





Study Case

Anode	Graphite + Silicon
Cathode	NCM
Geometry	21700
Application	Energy dense

Dynamic Calibration Data Summary

Description	Usage
1/20 C, Constant-current Discharge and Charge	Cell Balancing
0.2 C and 0.5 C Constant-current Discharge	Performance Calibration
Random Power Capacity Profile	Performance Calibration
HPPC at Reference Temp.	Validation

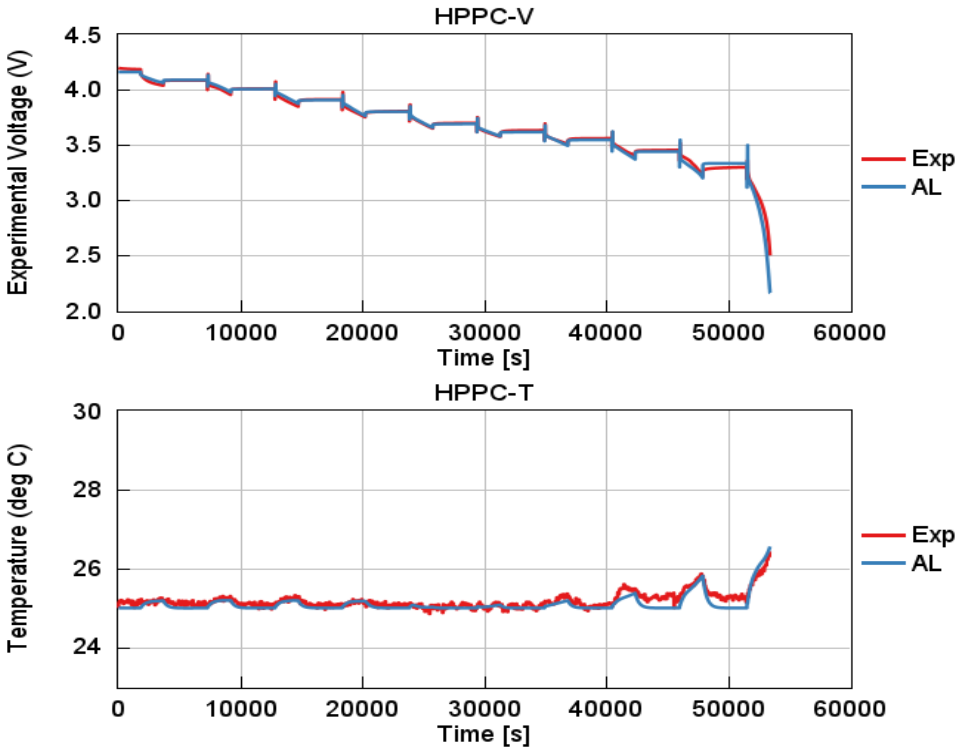
Aging Calibration Data Summary

Description	Usage
30%, 50%, and 80% SOC at Ref. Temp. Storage for 280 days	Calendar Ageing Calibration
30% and 50% SOC at 45 °C Storage for 280 days	Validation
Test 2 and 3 – Cycling	Cycle Ageing Calibration
Test 6 and 8 – Cycling	Cycle Ageing Calibration 2
Test 1 and 5 –Cycling	Validation

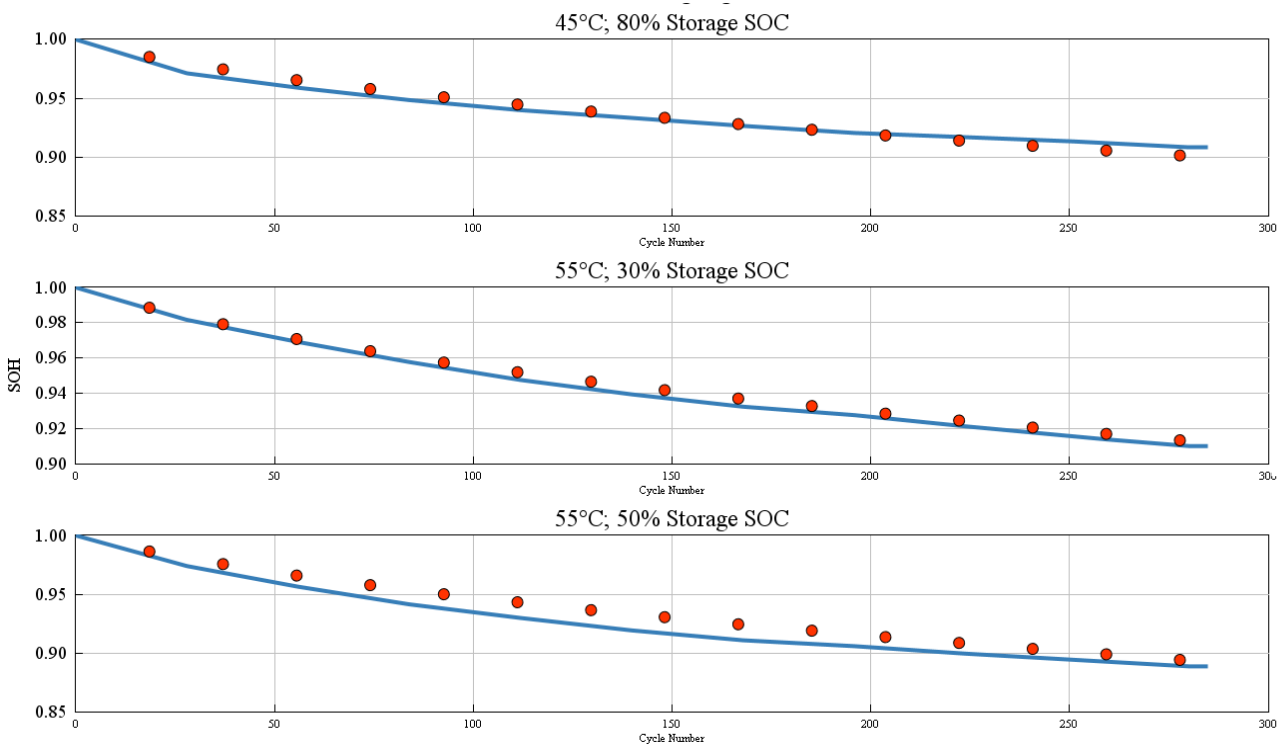
Experimental results provided by **Southwest Research Institute's battery testing consortium, **Electrified Vehicle and Energy Storage Evaluation (EVESE)***

Validation

Performance

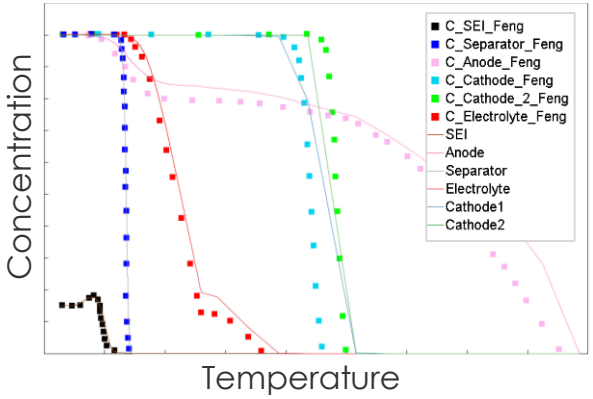


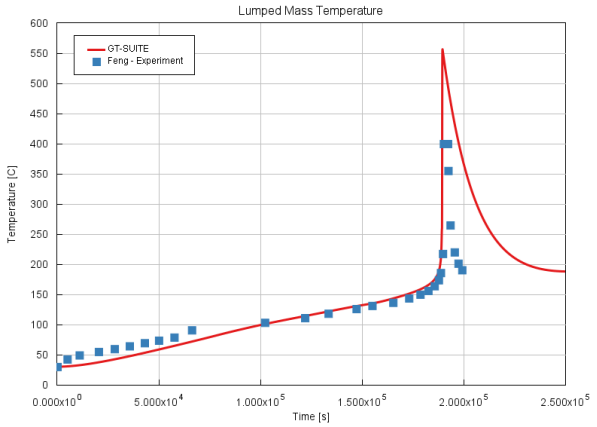
Aging



Thermal Runaway

- For this investigation, the **runaway reactions** were modeled based on the research by **Feng et al***
- The reactions considered in this simulation were:
  - SEI layer decomposition
  - Anode, Cathode and Separator reactions
  - Electrolyte reactions





**A Coupled Electrochemical-Thermal Failure Model for Predicting the Thermal Runaway Behavior of Lithium-Ion Batteries*

Thermal Runaway

- For this investigation, the **runaway reactions** were modeled based on the research by **Feng et al***
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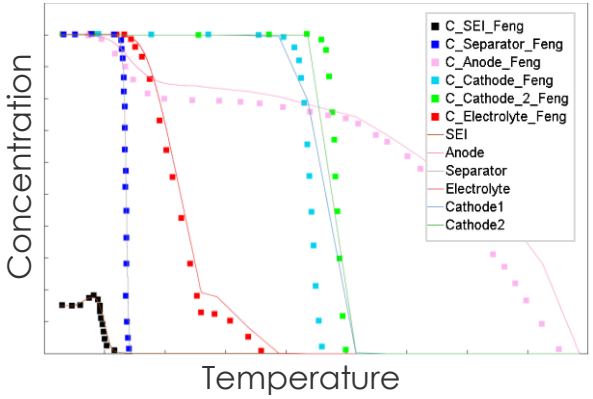
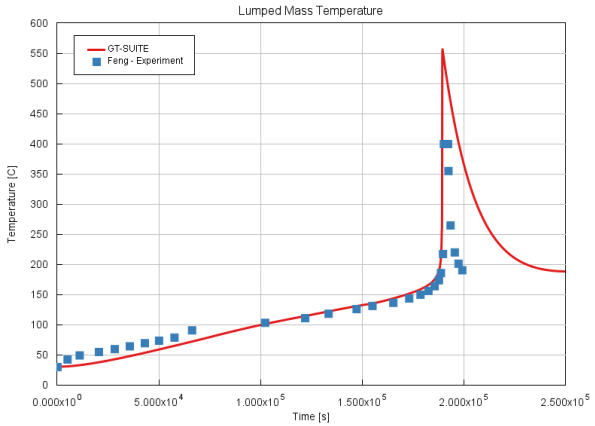
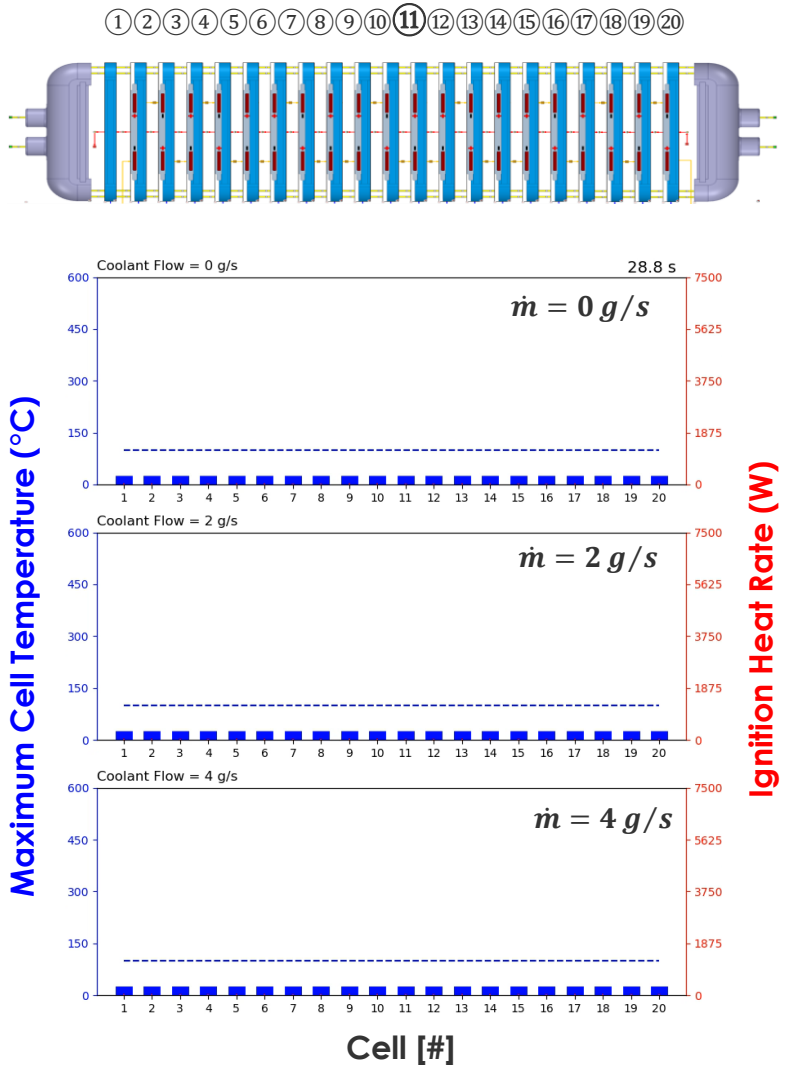




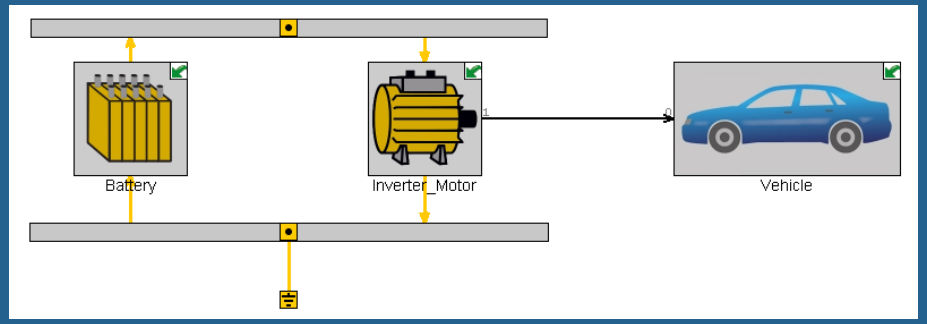
A Coupled Electrochemical-Thermal Failure Model for Predicting the Thermal Runaway Behavior of Lithium-Ion Batteries

Thermal-Flow Integration



Real World Aging

1 Integrated Vehicle

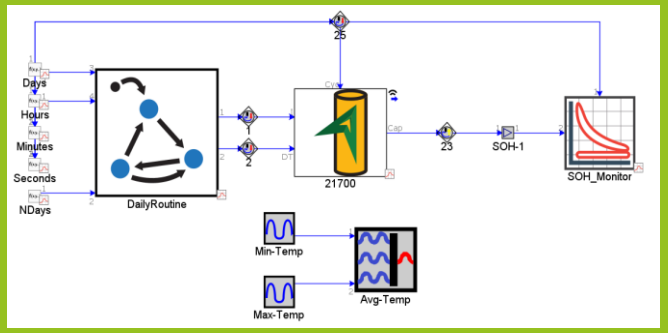


Real World Conditions
- Home to Work Routes
- Vacation Routes

Power Profile

Battery State

2 Standalone Battery



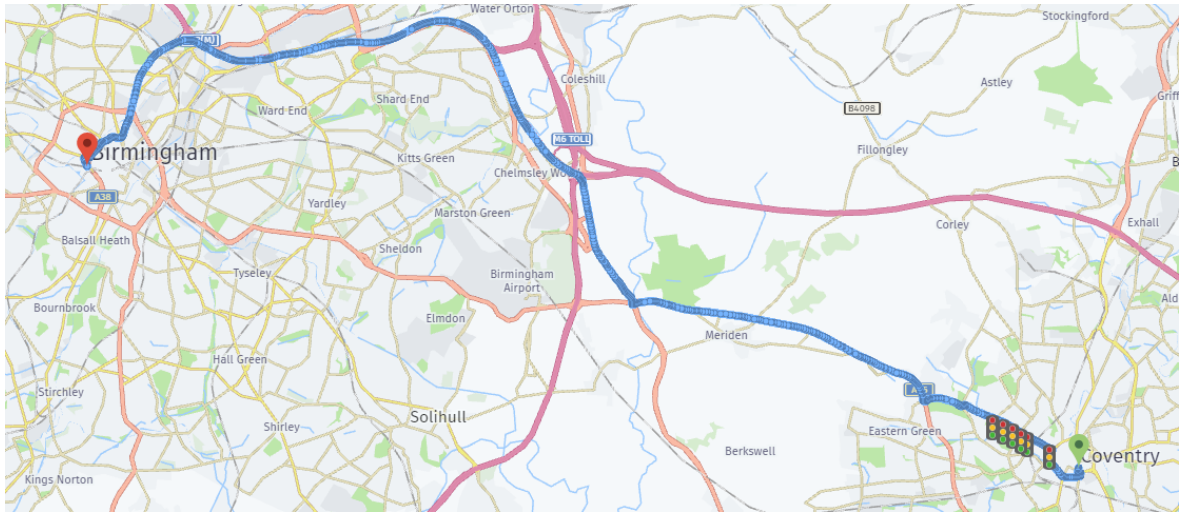
Aging Simulation
- Destination
- Rest
- Charging

Profile Generation: GT-RealDrive

mapbox here

Inputs → GT-RealDrive → Outputs

- Start Location
- End Location
- Car/Truck
- Stoppages
- Vehicle Limitations (acc/speed)



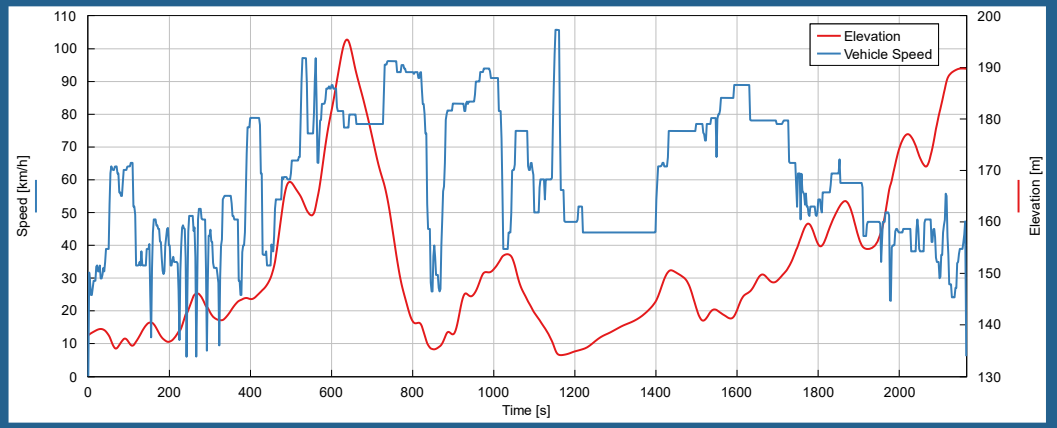
- Latitude/Longitude
- Elevation
- Distance
- Intersection/Traffic Signal
- Stop Sign
- Target Speed
- Traffic Congestion Level
- Speed Limit

GT

Profile Generation - Examples

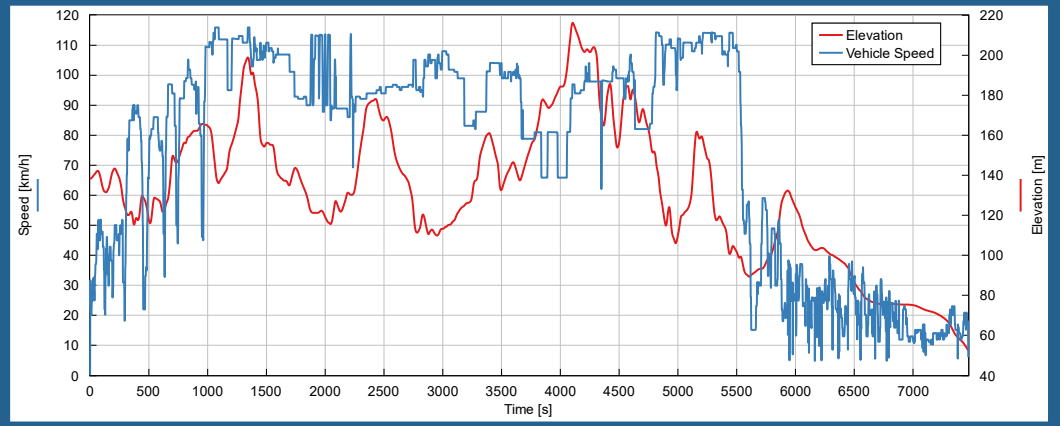
Work Week

Coventry to Birmingham

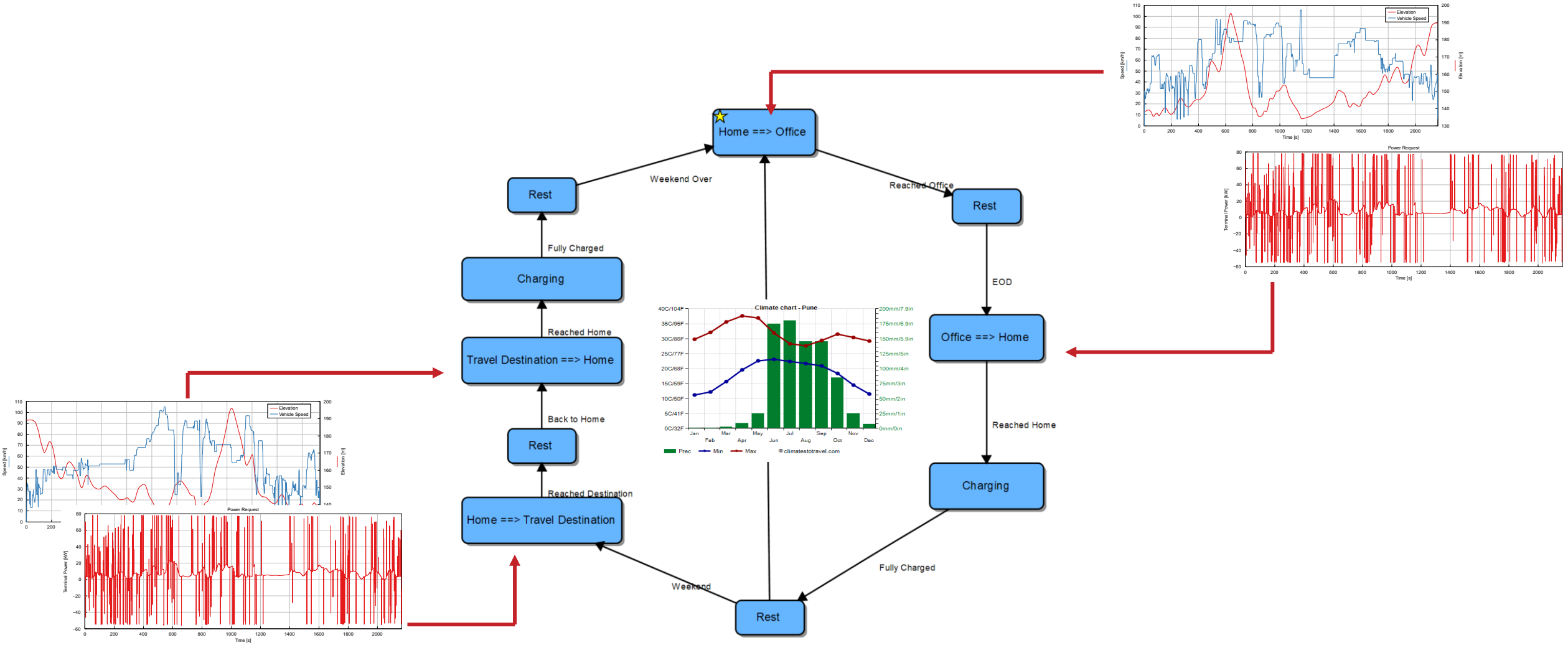


Vacation Week

Coventry to London

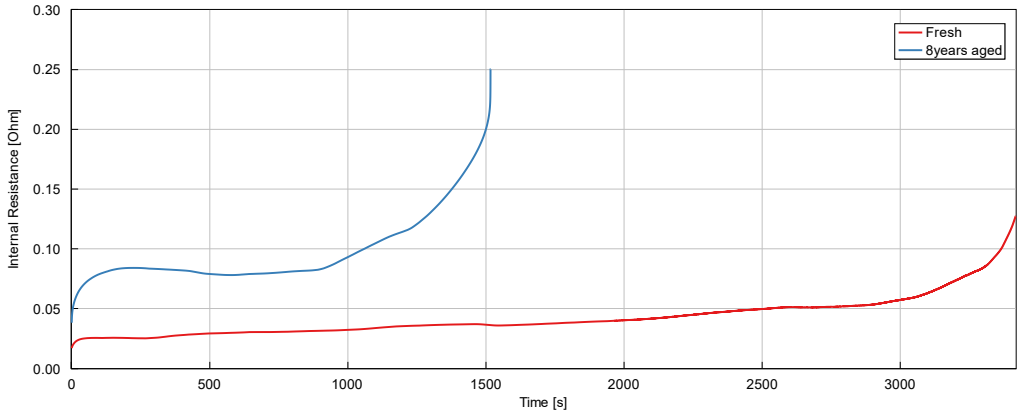


Real World - Week

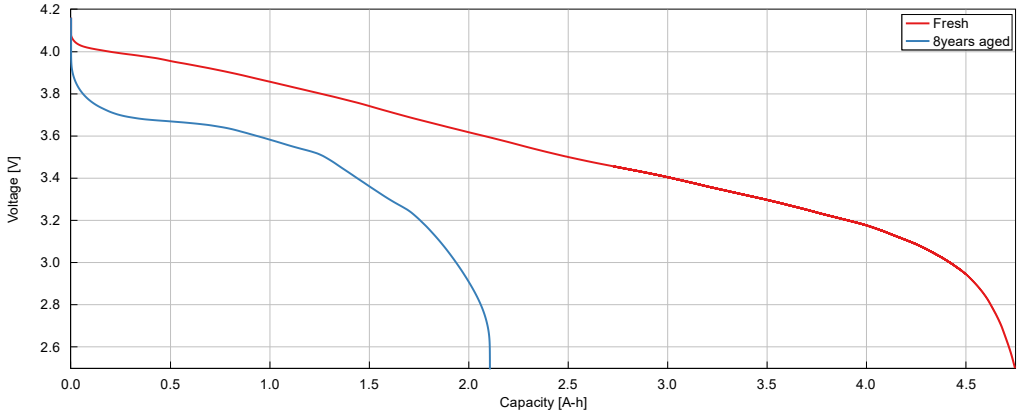


Results

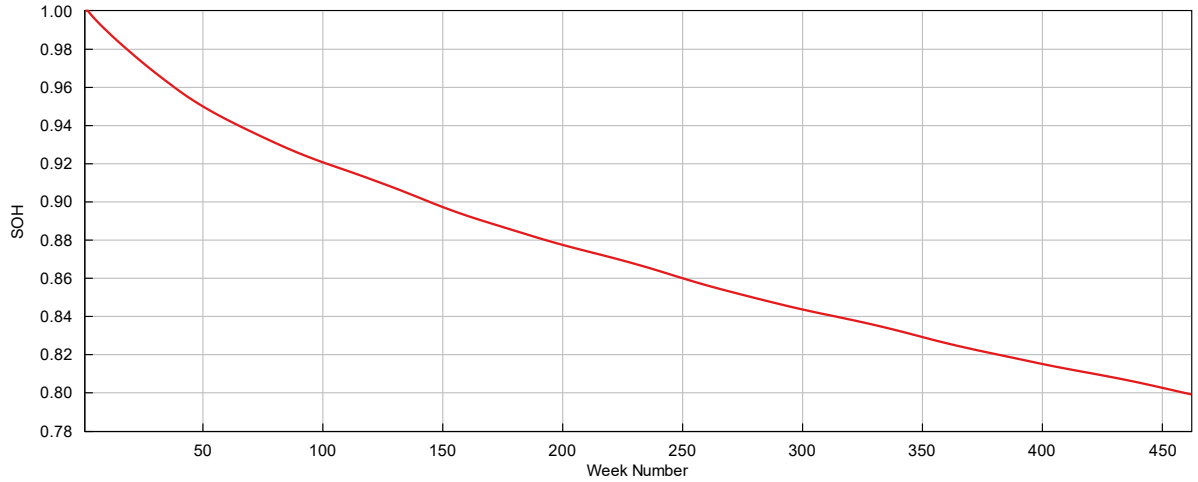
Internal Resistance



Voltage



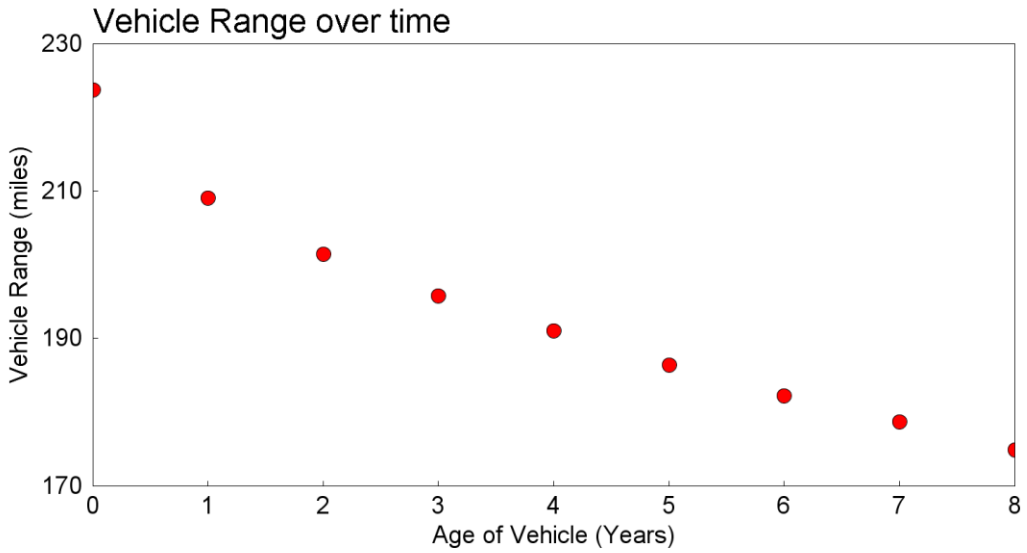
SOH



Performance of Aged Battery

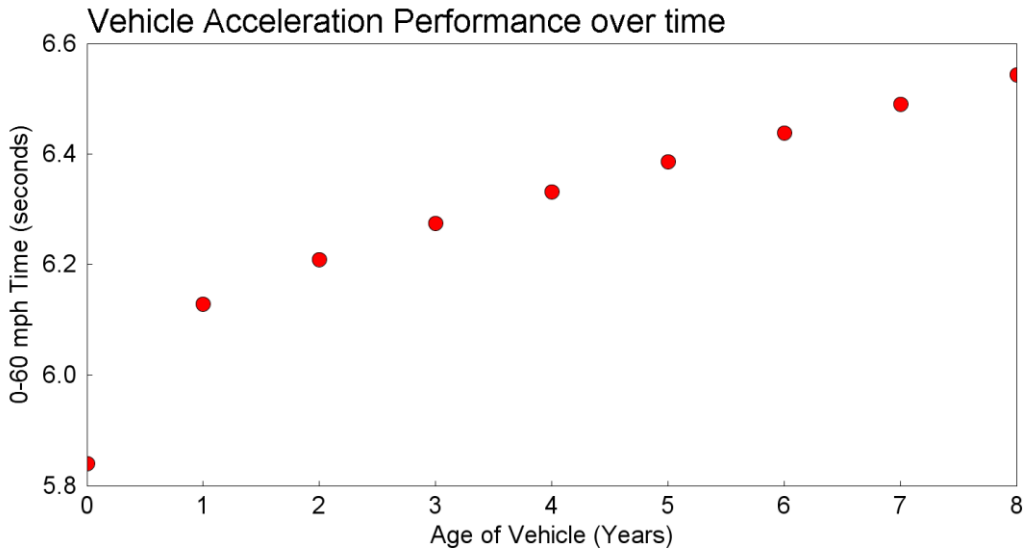
EV Range over time

Distance over SAE J1634



EV Performance over time

Time to 100 kph



A1

Central London to Central Edinburgh

396 miles

	Car Model	Range (Miles)
15	Tesla Model S Performance	310
14	Hyundai Kona Electric	245
13	Polestar 2	235
12	Porsche Taycan 4S	230
11	Jaguar I-PACE EV	225
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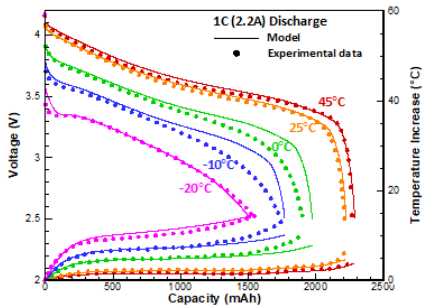
5	BMW I3 120 AH	145
4	Volkswagen E-UP!	120
3	Mini Electric	115
2	Honda E	105
1	Smart EQ ForFour	55

Jaguar I-PACE EV	200	2 years
Jaguar I-PACE EV	185	5 years
Jaguar I-PACE EV	175	8 years

GT

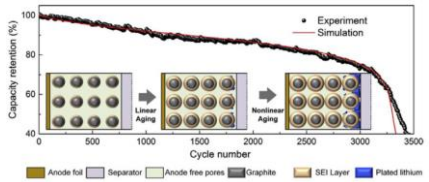
Summary

Performance

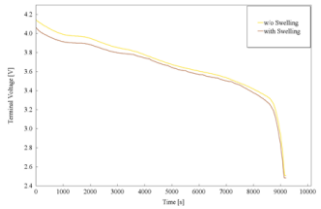


Degradation

Aging

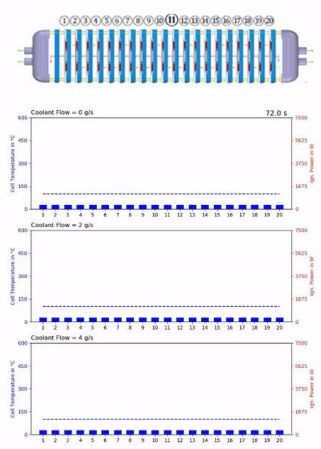


Swelling



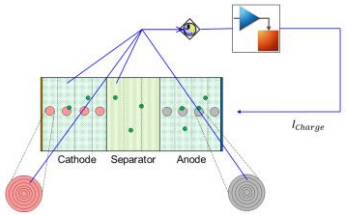
Safety

Thermal Runaway

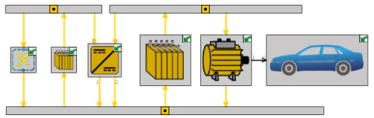


Process Integration

Virtual plant for BMS



System integration



Thank You

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h.sara@gtisoft.com

Website
www.gtisoft.com

Meet us @ Stand 17

GAMMA TECHNOLOGIES