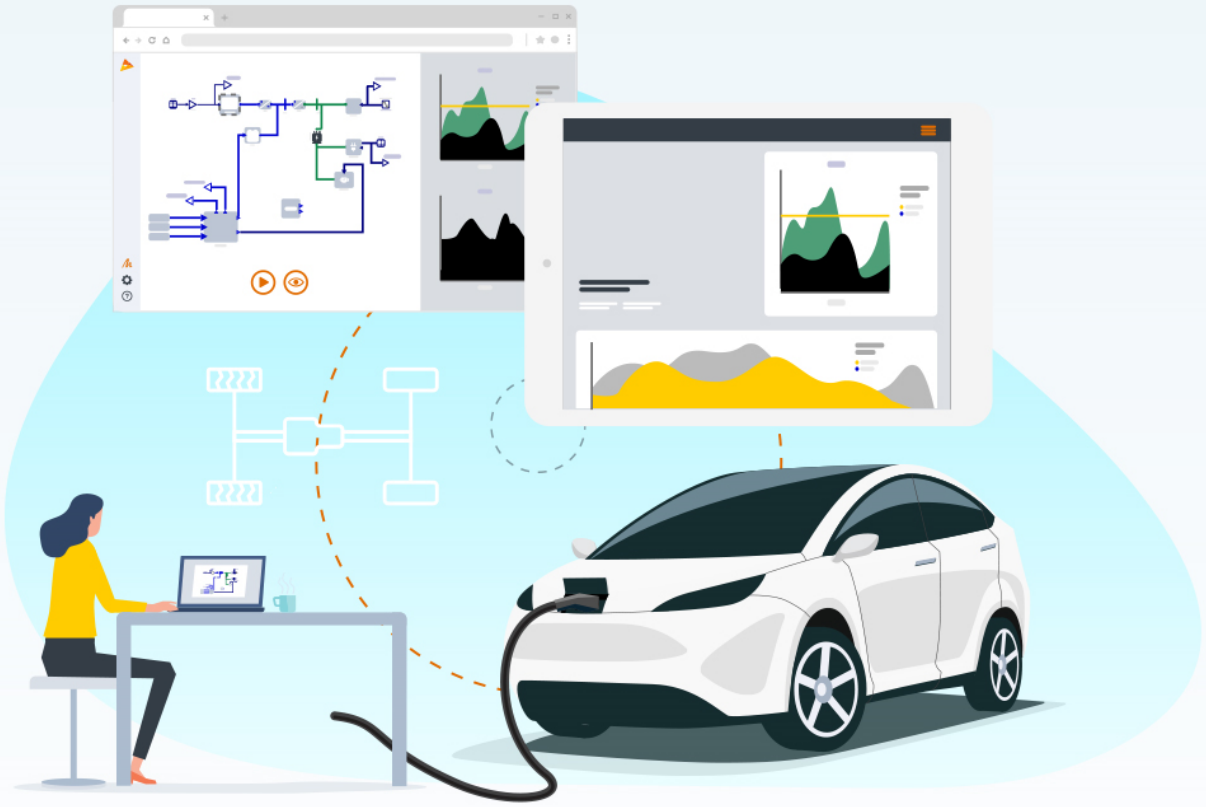
Different models for different purposes

Presented by Erik Durling



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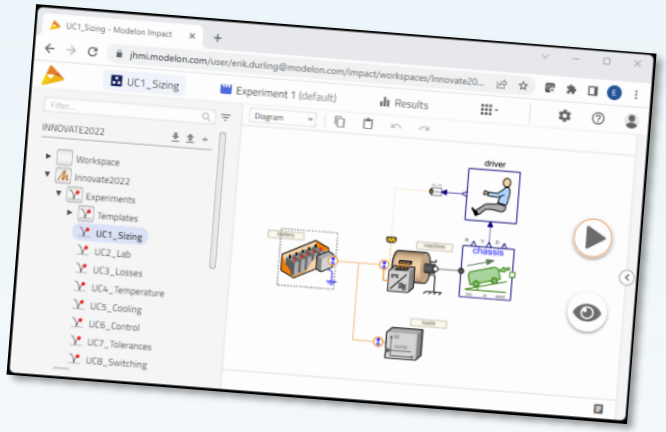
Use cases

1. Sizing an ideal battery
2. A virtual battery lab
3. Heat losses
4. Temperature dynamics
5. Cooling
6. Temperature control (software)
7. Cell imbalances (parameter uncertainty)
8. High frequency ripple



Live demo

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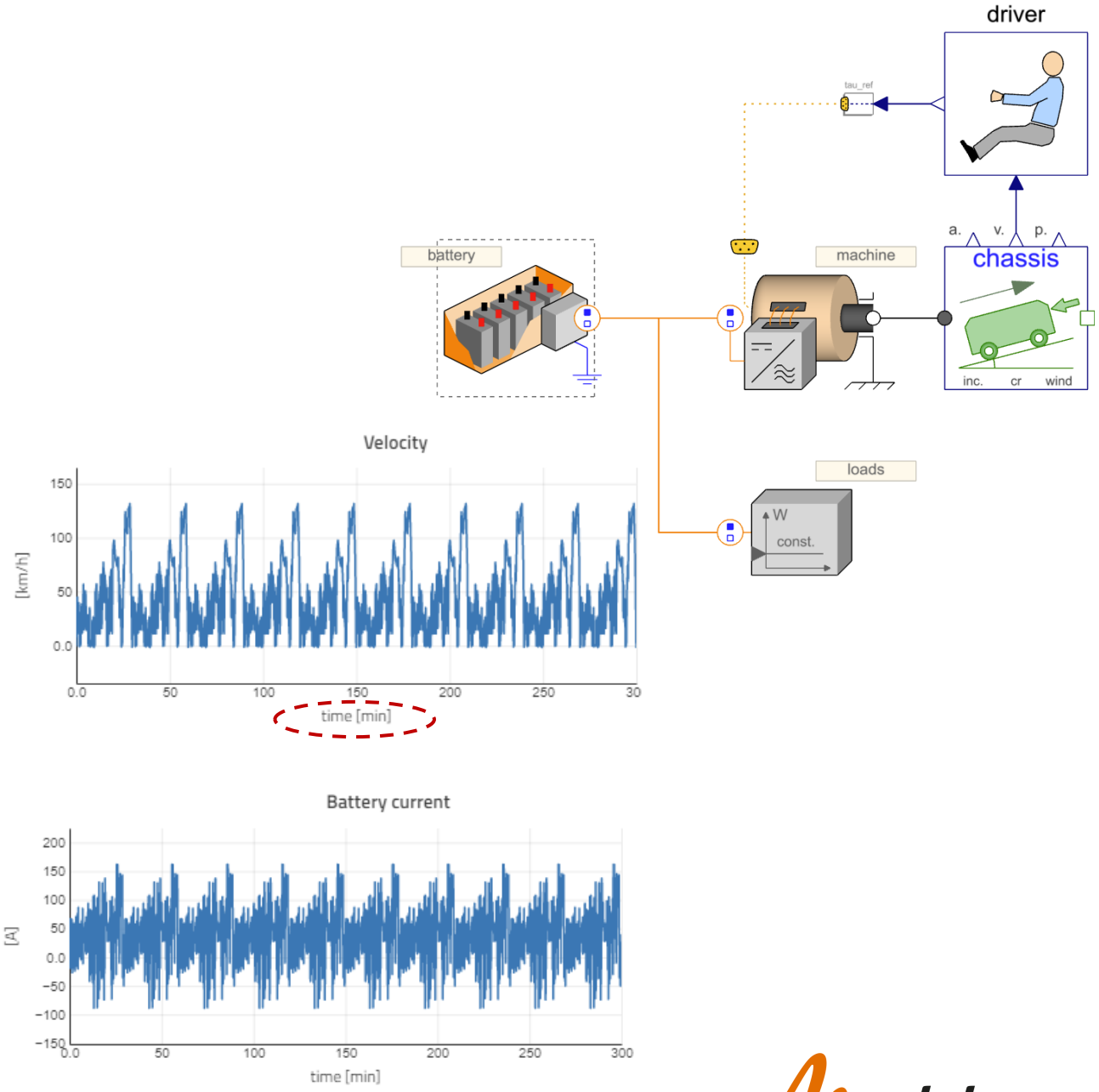
Use case 1

Sizing a battery pack

- Identify battery usage in system
- Vehicle drive cycle (5 hours long)
- No parameter data available
- Lowest possible model fidelity



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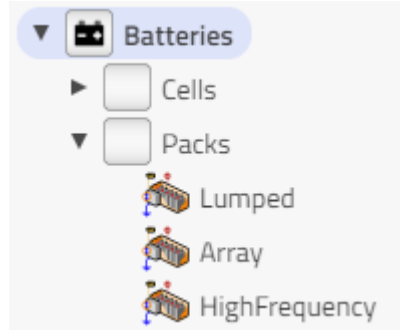
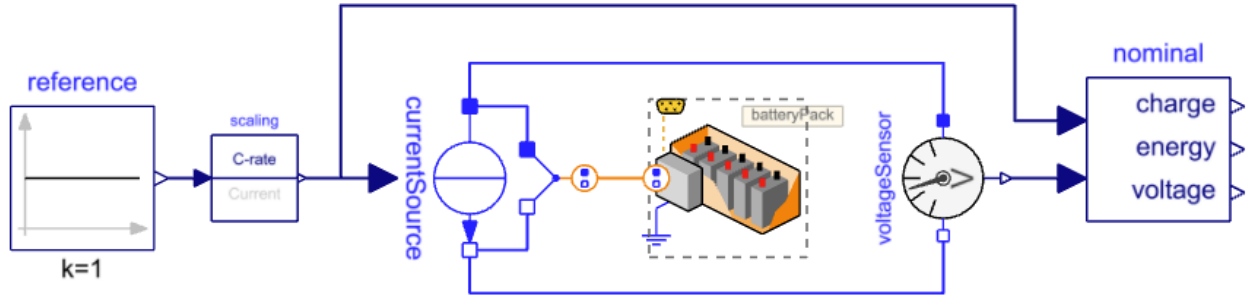
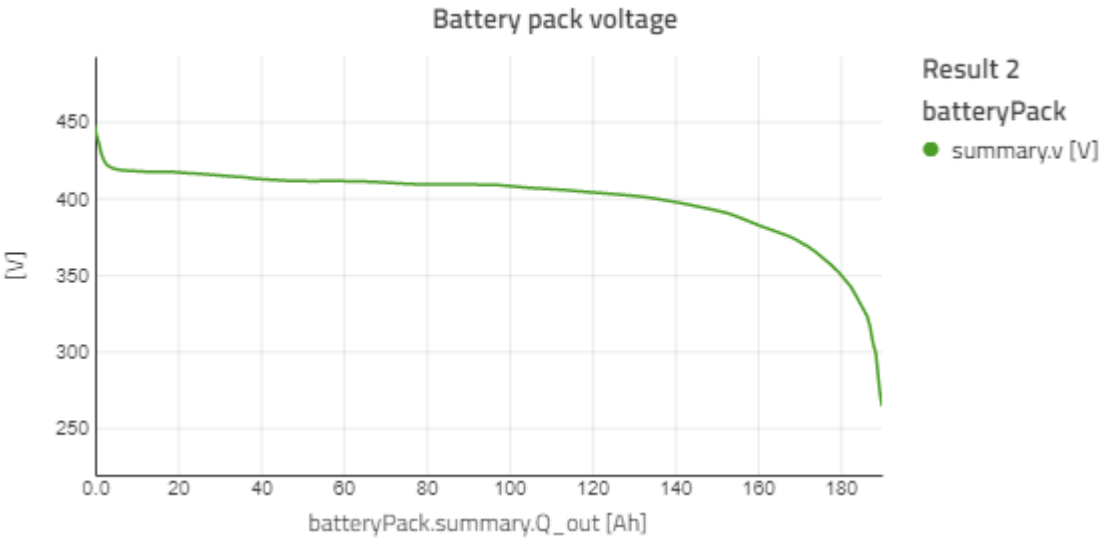
Use case 2

Virtual battery lab

- Verify model of specific battery
- Detailed parameter data
- Re-usable battery model
- Re-usable experiment
- Simple load case







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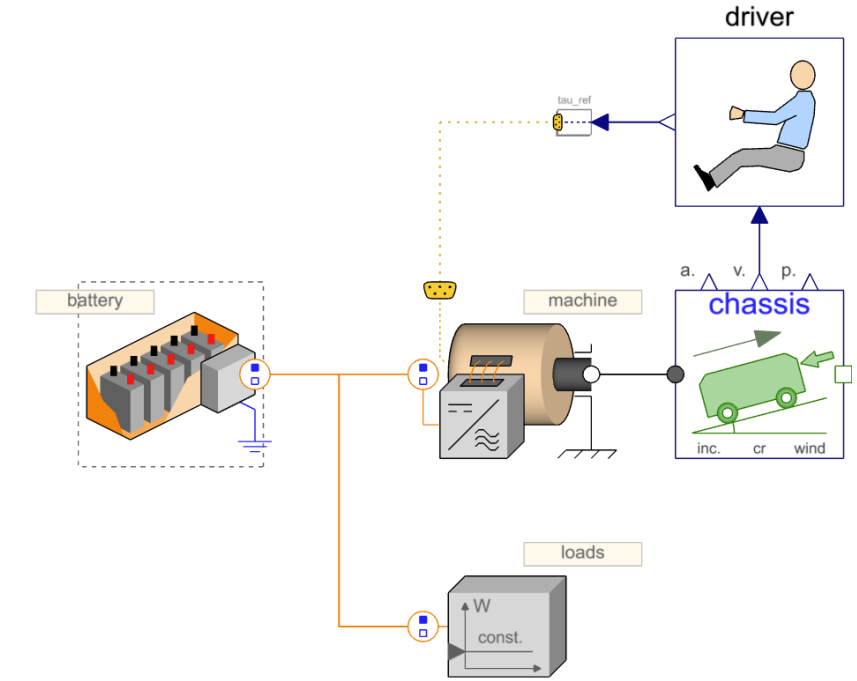
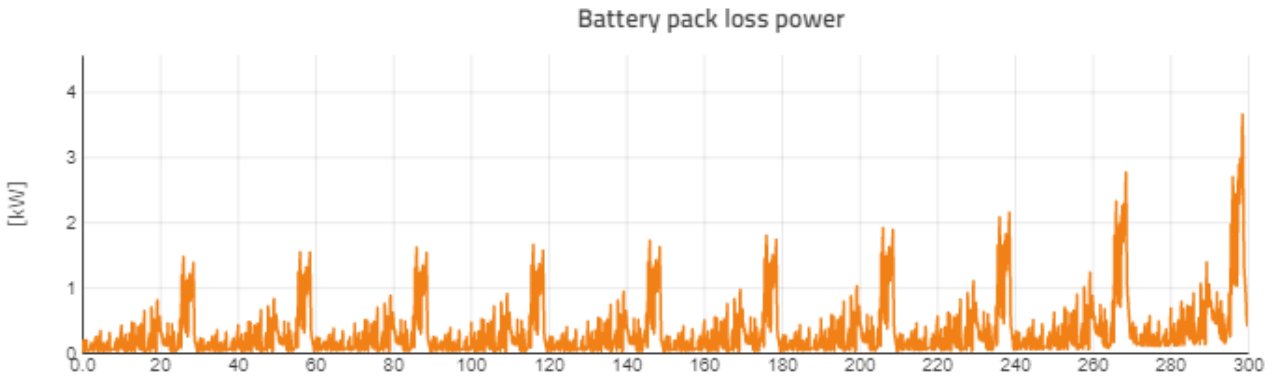
Use case 3

Battery heat losses

- Identify heat losses
- Dynamic load defined by system
- Same system experiment is re-used
- Different fidelity models are compatible
- Fixed temperature





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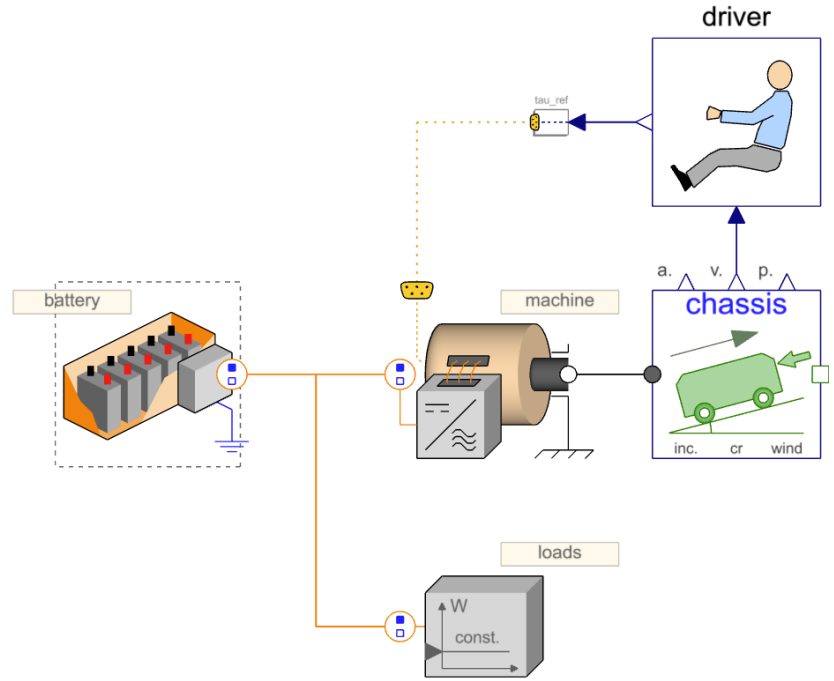
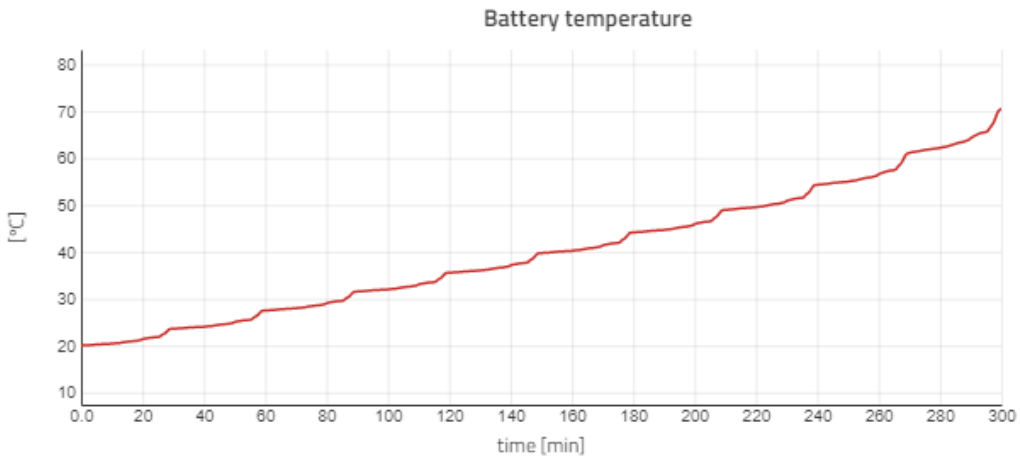
Use case 4

Temperature dynamics

- Predict temperature variations
- Include a thermal model in battery
- Re-use same system experiment





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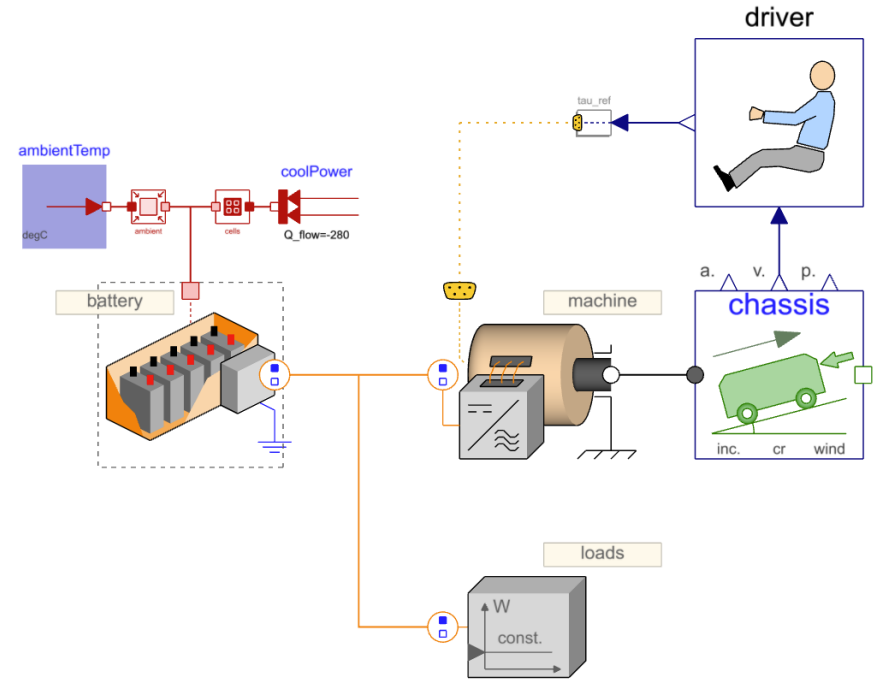
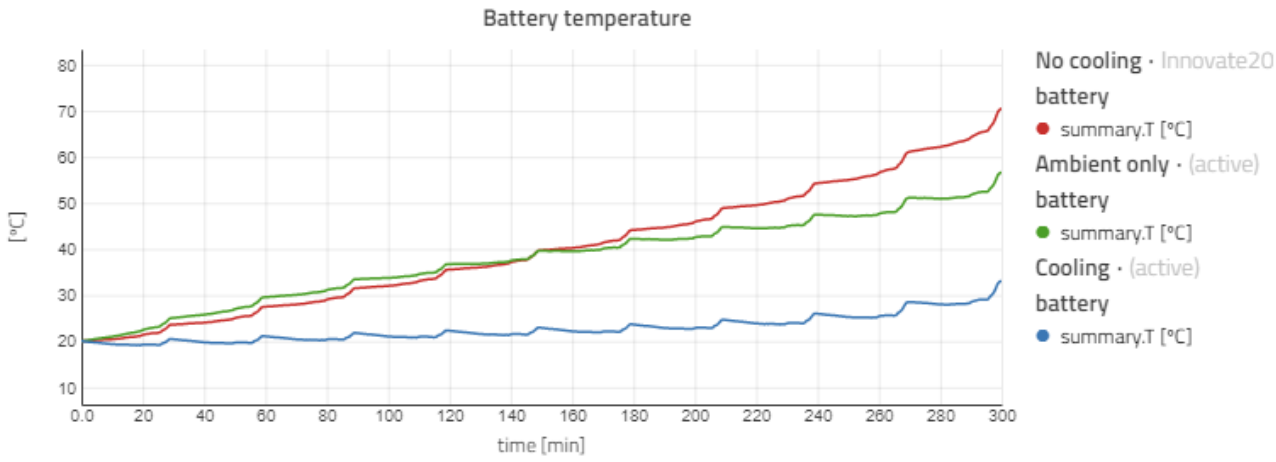
Use case 5

Cooling

- External heat dissipation
- Ambient temperature
- Thermal interface for liquid cooling (LCL)





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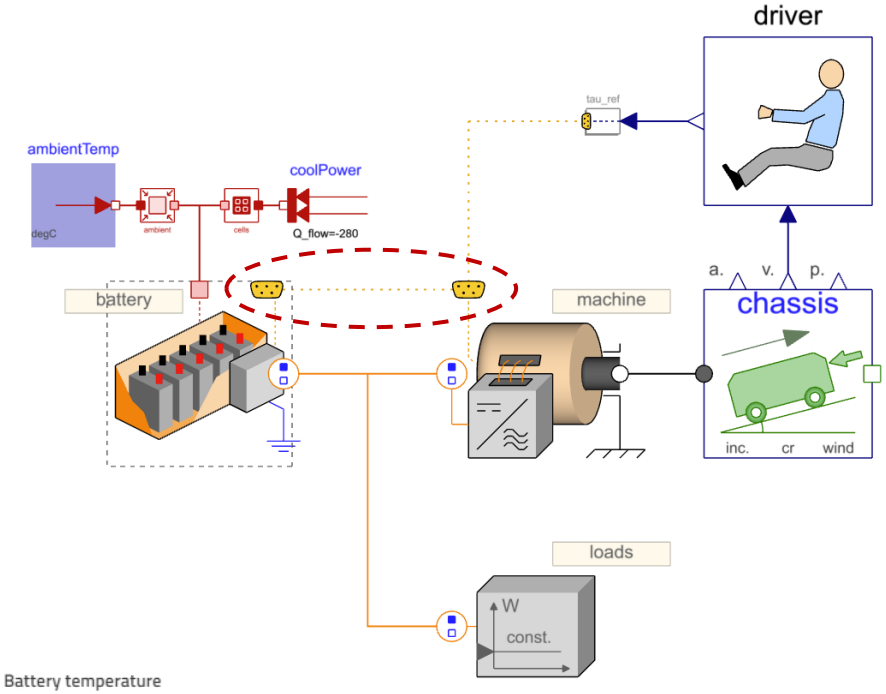
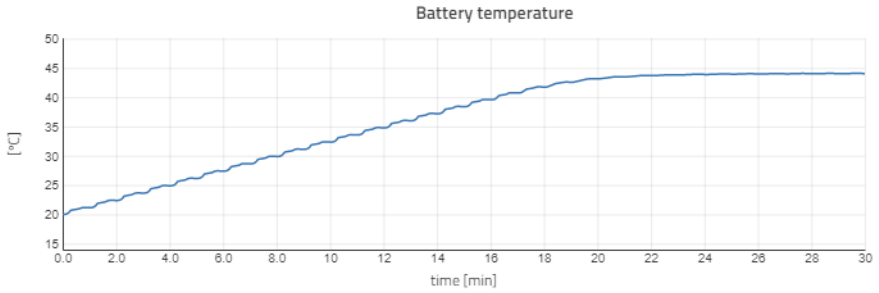
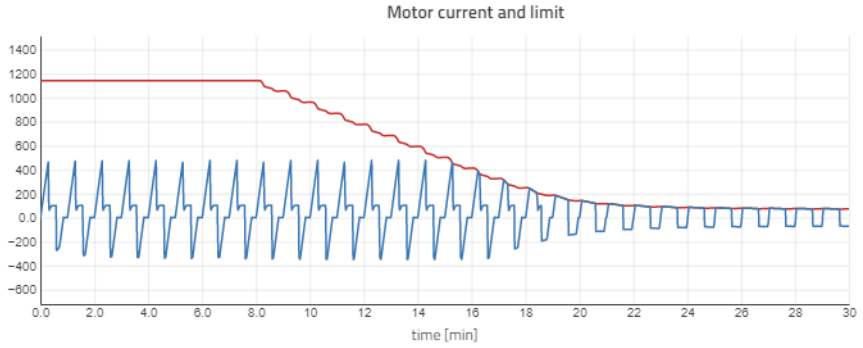
Use case 6

Temperature control

- Software model (MiL or SiL)
- Battery controller (BMS)
- Temperature sensing
- Communicating power limit
- Control bus signals between controllers







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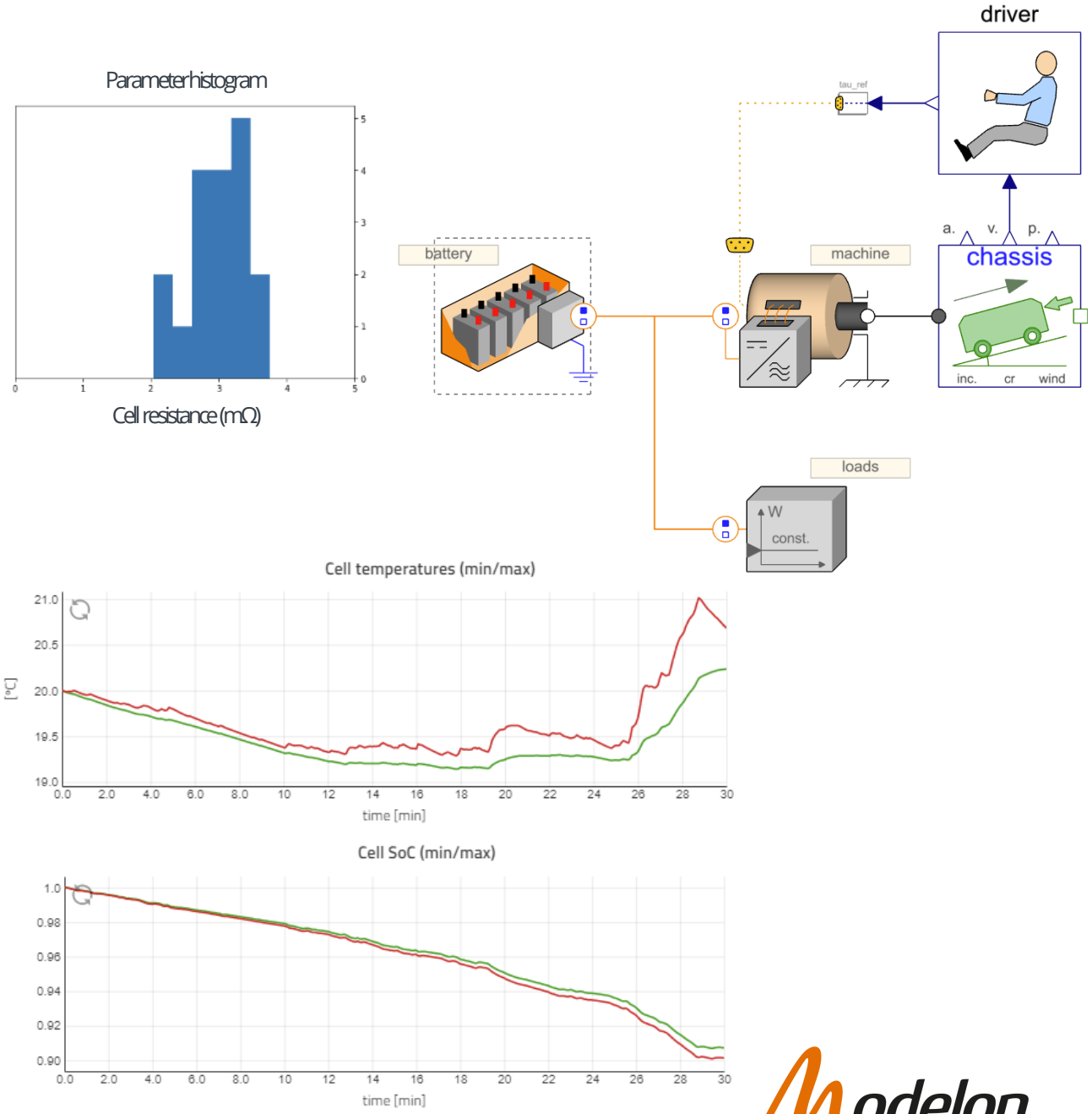
Use case 7

Parameter uncertainty

- Parameter tolerances (variations)
- Imbalances between battery cells (some cells get warmer than others)
- “Stochastic parameters” defined as statistical distributions
- Monte Carlo simulations (many batteries)



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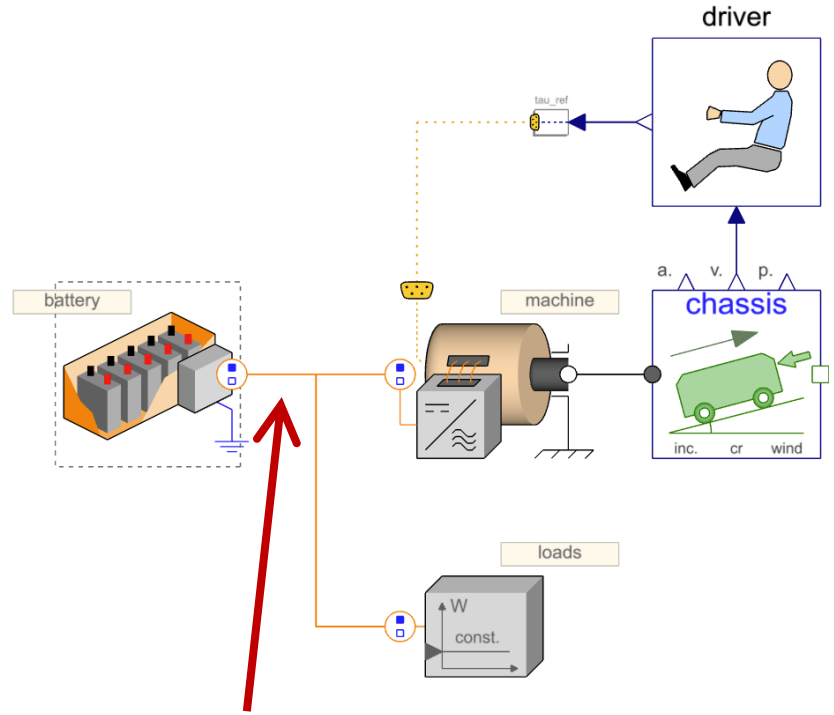
Use case 8

High frequency ripple

- Power electronics switching at 10 kHz
- Exclude slow dynamics!
  - Vehicle load does not change
  - State of charge does not change
  - Temperature does not change
- Battery model only includes fast dynamics



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“Model fidelity is not just more or less”

- Fidelity dictated by available data
- Model boundaries (sub-system)
- Physical domains (electrical, thermal, liquid, …)
- Co-dependencies (thermal ←→ electrical)
- Software models (MiL and SiL)
- Discretization (individual cells or lumped)
- Different dynamics (time constants)

- As simple model as possible!

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Accurate Simulations. Better Decisions.