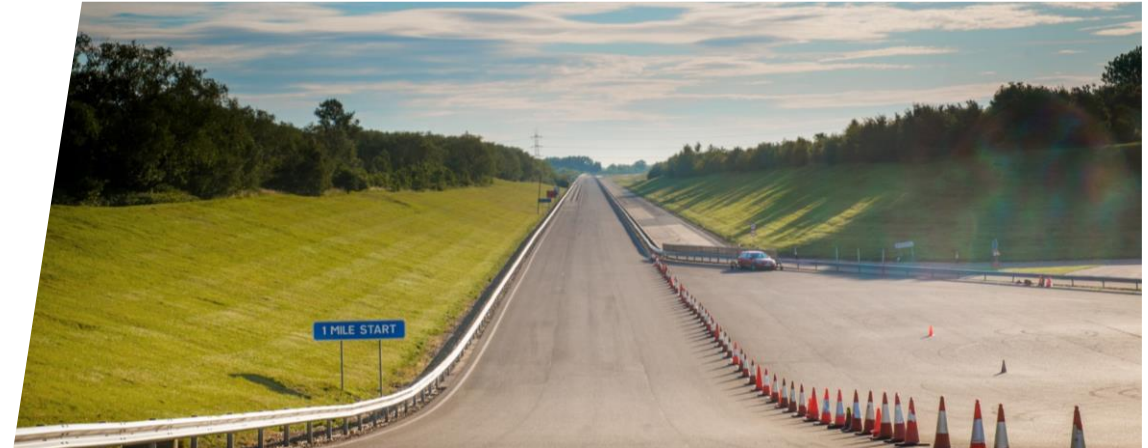




Good Design = Simulation + Testing

Dr Peter Miller
Chief Engineer – Battery
UTAC - Millbrook



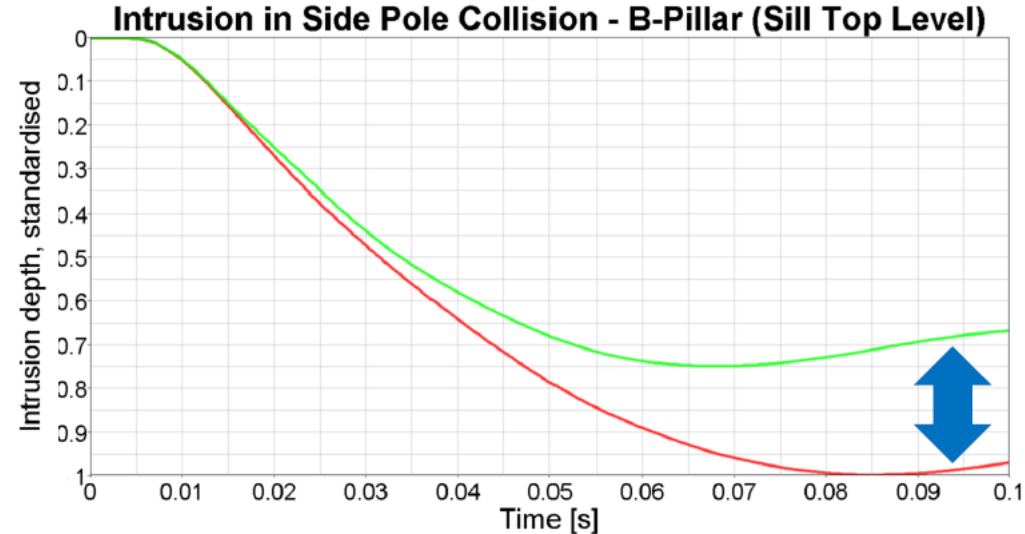
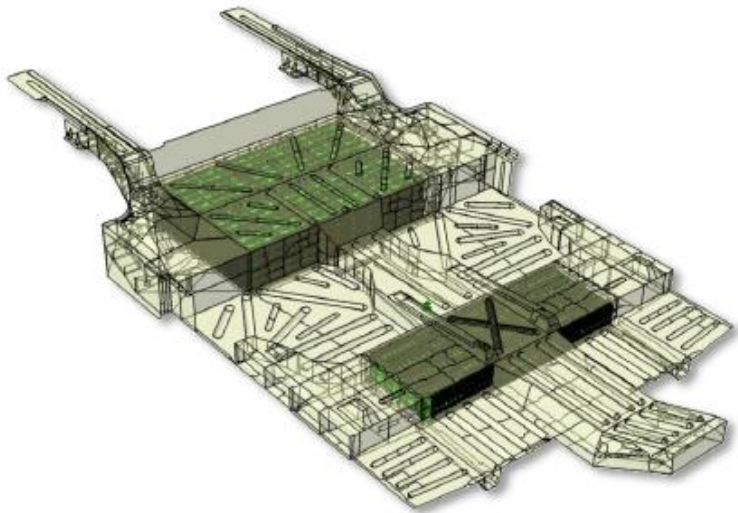
- This short presentation will provide an overview of the pro's and con's of simulation and testing to demonstrate that they are best used in combination.
- Some real examples will be presented to illustrate these points – these are mainly provided by the EU FP7 SmartBatt program - <http://www.smartbatt.eu/>



SmartBatt Battery Pack

Advantages of Simulation

- Simulations can be much faster than building a prototype and then testing it.
 - This means much more of the potential design space can be explored and allows use of optimisation systems to find the “best” solution.
- As an example, in the SmartBatt program around 10,000 crash simulations were conducted looking at different positions of the battery pack within the vehicle, different shapes of pack and various techniques to direct the energy around the pack using the body of the vehicle.

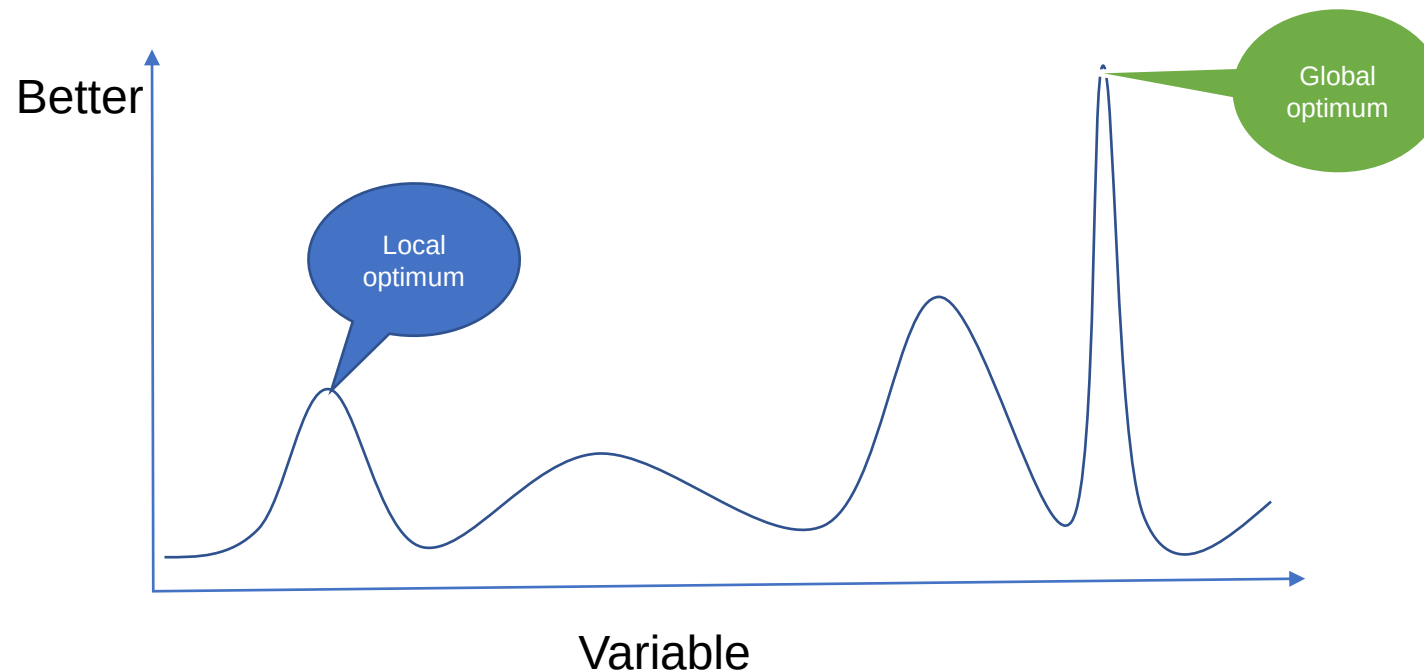


~30%

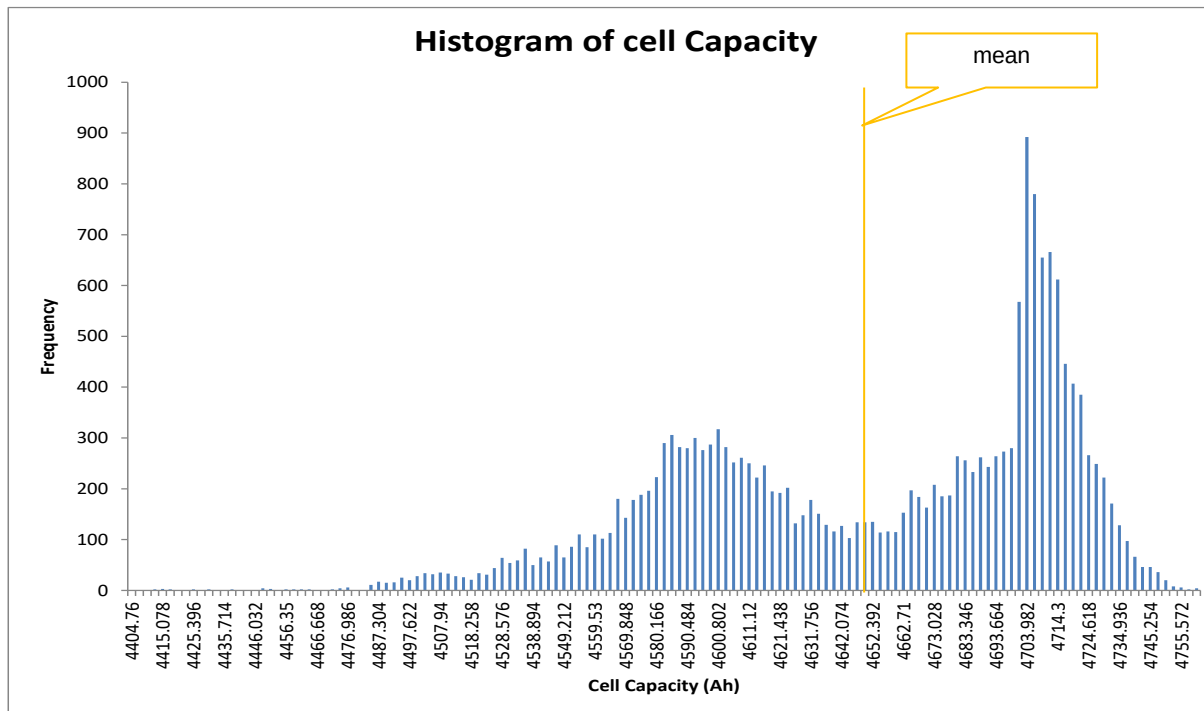
- The result was a safe battery housing, but also improvements at the vehicle level.

Disadvantages of Simulation

- Simulations are only an approximation and in most cases don't provide an estimate of their accuracy.
 - A good simulation can take a significant time to setup and simulators / the computers to run them cost money.
- If simulations are used to extrapolate beyond conditions that have been validated then the results can become meaningless.
- If used as part of an optimisation approach then its possible that a local optimum is found which might be a long way from the global optimum. When many parameters can be varied that have complex interactions this becomes more likely.
 - Machine learning / Deep learning approaches and the availability of massive amounts of computing power help here.



- Can tell if (tested samples) do actually meet specific criteria (or not).
- If enough samples are tested can provide variabilities
 - A good test provider should be able to separate out testing variables to just leave the variabilities of the item being tested.
 - Note that End Of Line testing (even for prototypes) can provide a good source of information on variabilities.
- Tests can be optimised to provide information for simulations



- The histogram shows the range of capacity (Ah) in a typical purchased batch of cells from a major automotive cell manufacturer.
 - This is mean +2.4%/-5.3%
- The self discharge rate for the same batch of cells was mean+88%/-76%
- “Flexible hardware architecture for battery management systems: what architecture best suits your needs?”, Dr Peter Miller, IQPC Conference Automotive Battery Management Systems, September 2016.

Disadvantages of Testing

- You need something to actually test, a test process and equipment to implement the test.
 - This takes time and money, and tests may destroy device being tested.
- Failing a test can require an expensive redesign (especially if it happens near product launch)
 - But not testing can result in extremely expensive recalls
- Test results can be “misused” - e.g., ignoring variability and only testing one sample.



Reg. 100 fire test on SmartBatt pack.

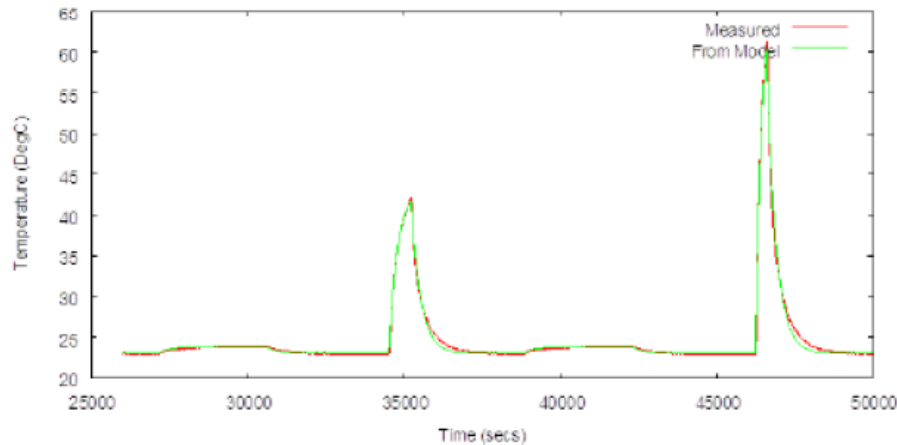
Combining simulation and test

- Initial tests focused at providing data required for simulations
 - Then use simulations to explore design space – focusing on key design targets
- Test to validate key outputs of simulations.
 - If significant differences found more work may be required to regain confidence in the simulations.
- Don't leave type approval/homologation testing to the very last minute

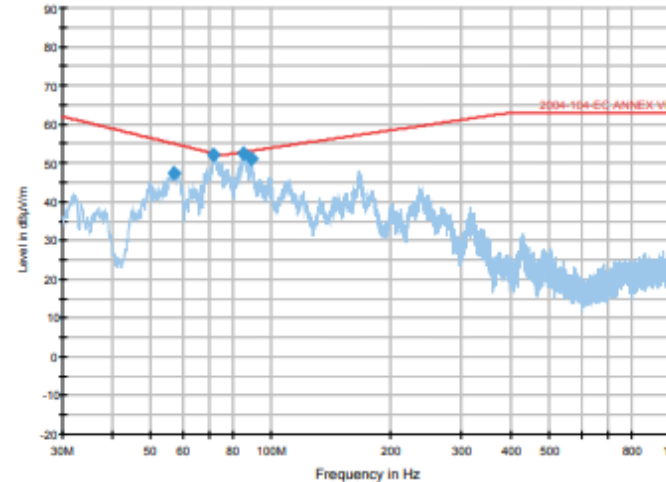


SmartBatt: Failed overcharge test, test passed at cell level but failed at module level, which was not predicted by simulation.

Good Design = Simulation + Testing



Temperature rise, simulation vs measured



EMC - emissions



Crash

- The SmartBatt program showed this approach works – it explored a very large range of options, starting with basically all li-ion cells available on the market at the time, which were down selected to 3 cells. These 3 cells were all tested to generate simulation models which were used to create virtual modules and packs. Some module testing allowed the best cell/module design to be selected and the final pack was designed using these.
 - The resultant pack passed all its tests (Mechanical & electrical safety tests (including Reg. 100), Performance tests and EMC).



Dr Peter Miller
Chief Engineer – Battery
UTAC - Millbrook Proving Ground, Bedford, UK
peter.miller@UTAC.com
www.millbrook.co.uk/ev-battery-testing

www.utac.com