Using SIMAT Co-simulation to integrate ABS technology into Simpack virtual vehicle models

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Durability and Robustness CAE

Jaguar Land Rover

Agenda

- ABS introduction & why D&R CAE needs ABS in Simpack models
- Timeline
- How we got where we are today
- Findings and correlation
- Current status and remaining work
- Questions

‘Anti Blockier System’ (ABS)

Why ABS?

–Maximum deceleration, Directional control, Safer

How does it work?

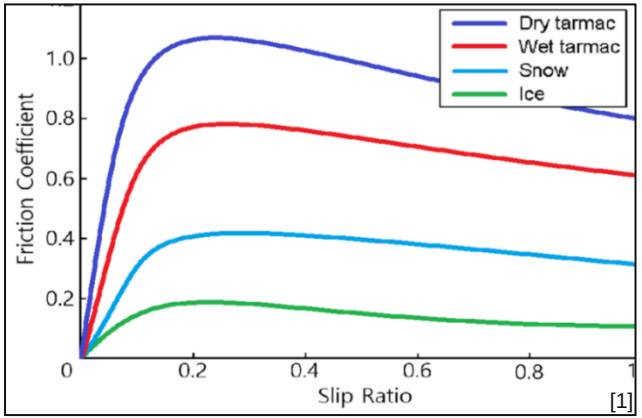
- Brake pressure is altered to maintain the optimum wheel slip for maximum tyre/ surface friction coefficient
- Wheel lock is not allowed

What does it monitor?

–Wheel rotational speeds

–Vehicle ‘velocity’ and acceleration in $\mathrm{x}, \mathrm{y}, \mathrm{z}, \alpha, \beta$ and γ

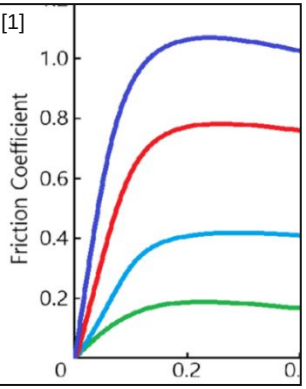
–Steering angle and rate

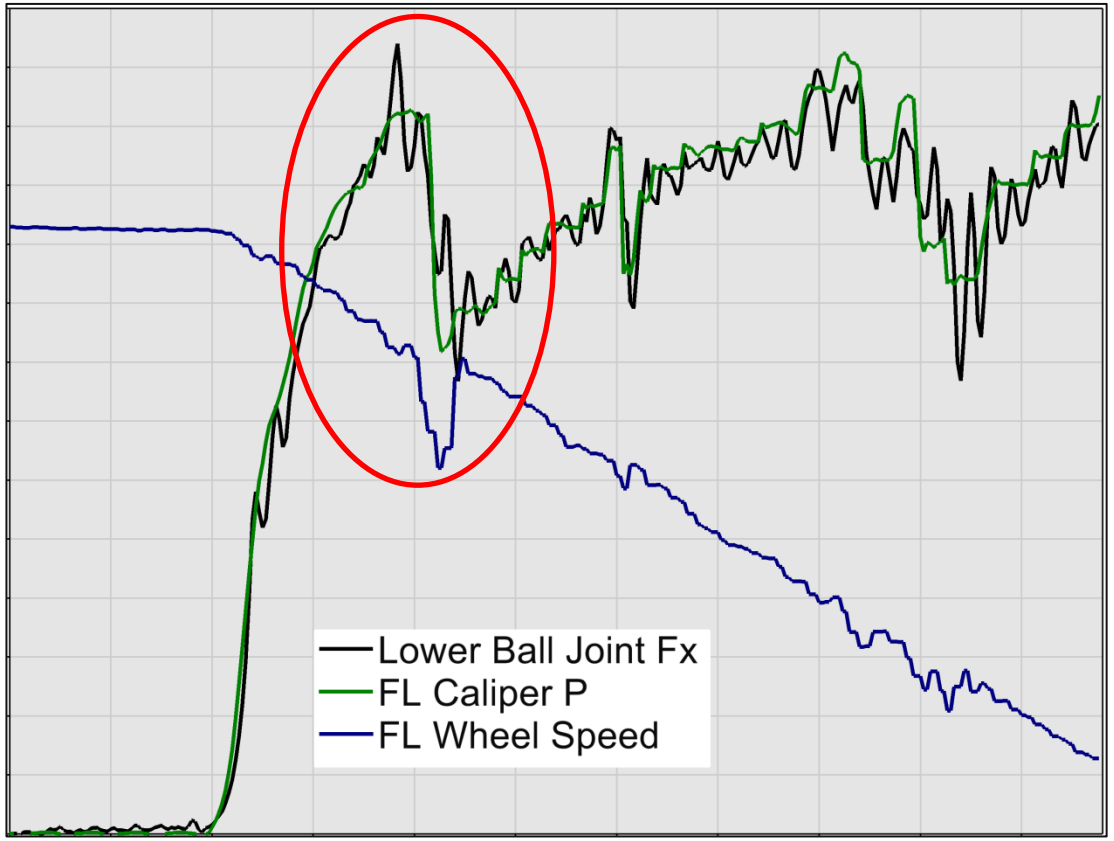


[1]

$$Slip\ Ratio = \frac{Vehicle\ V\ - Wheel\ V}{Vehicle\ V}$$

Physical Test – ABS Stop





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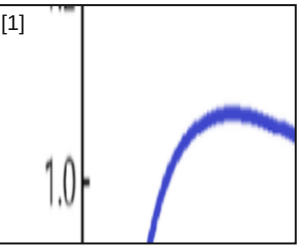

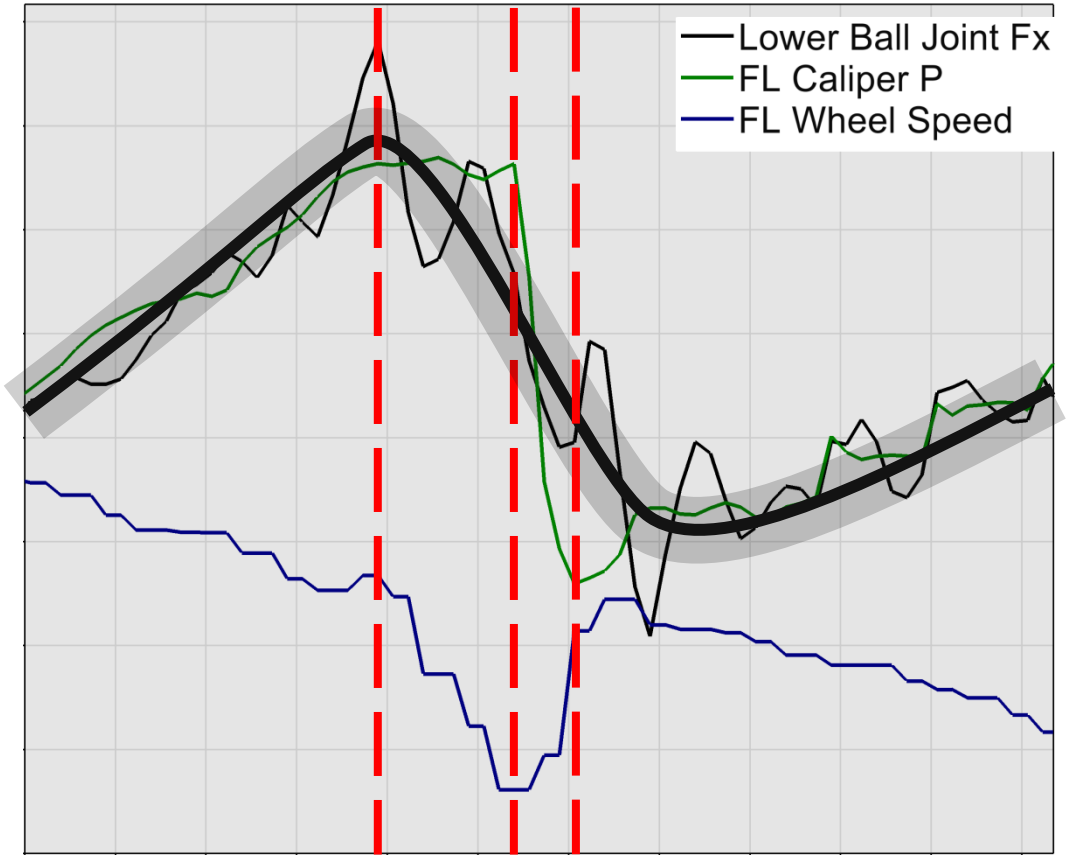

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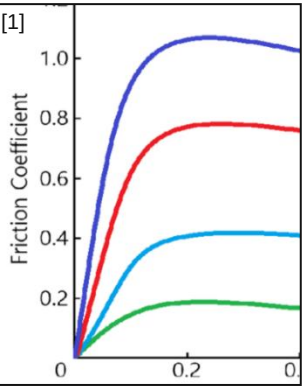
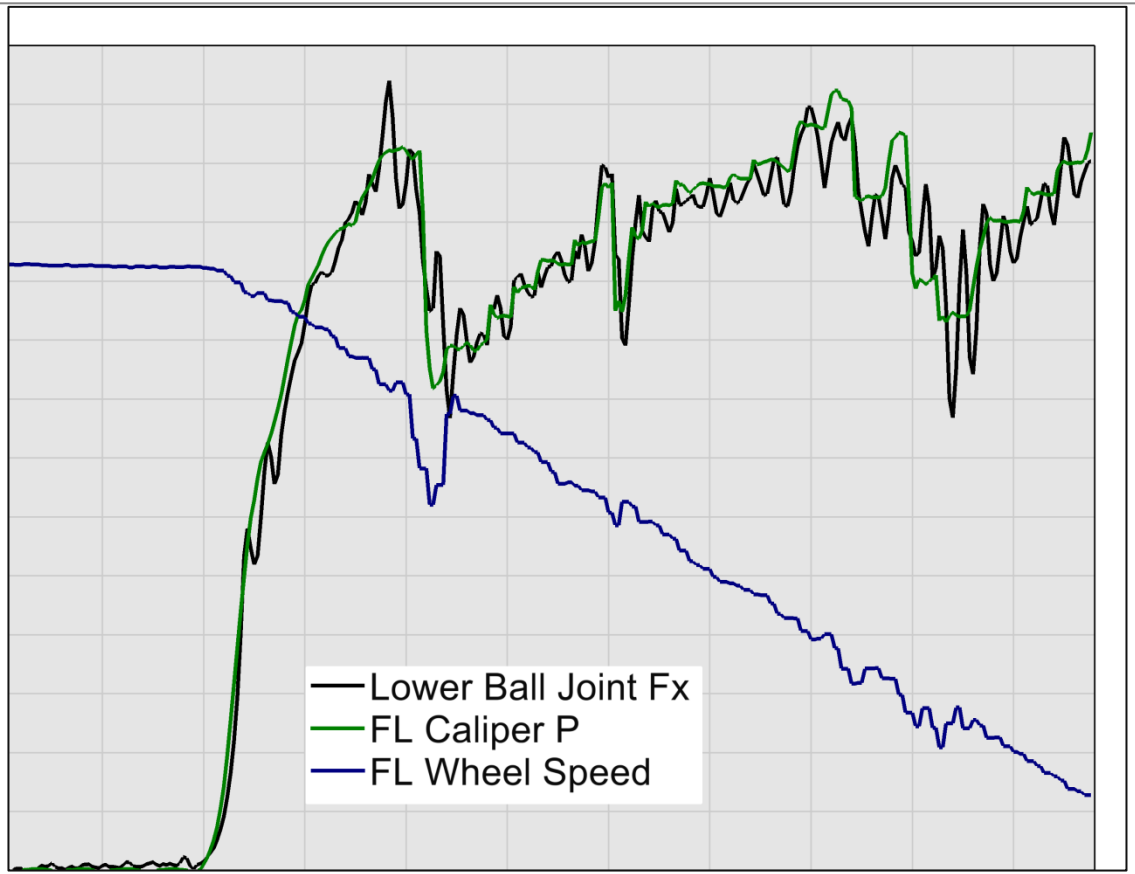
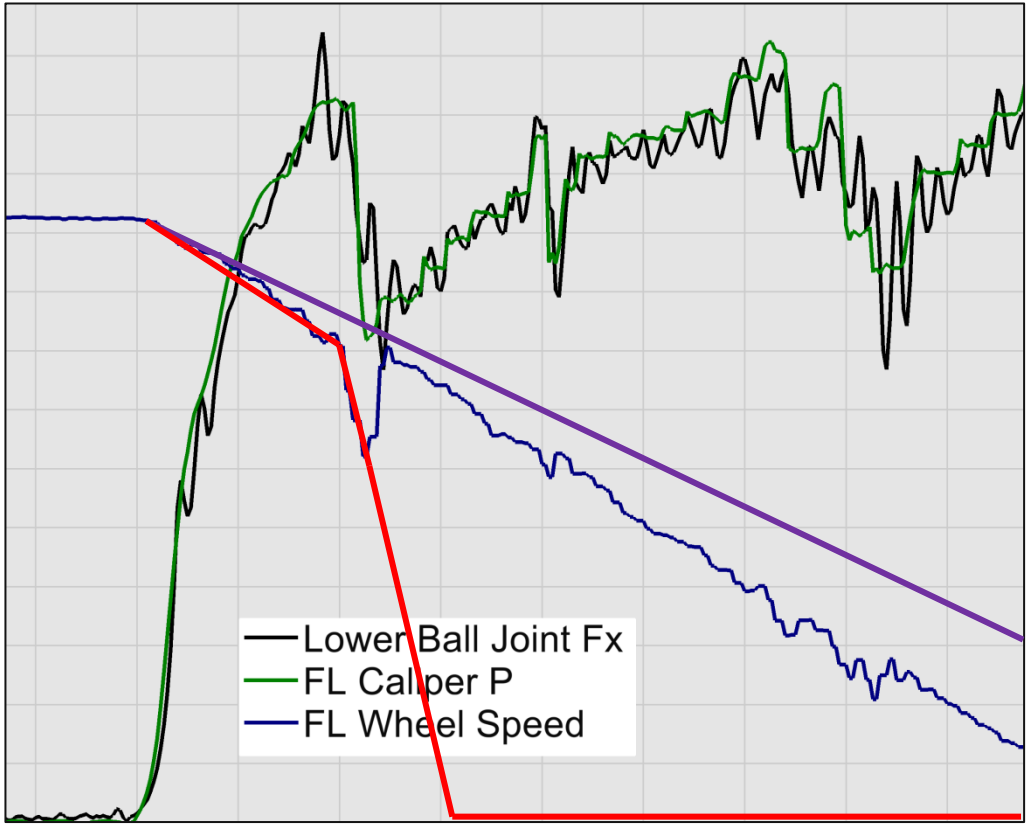
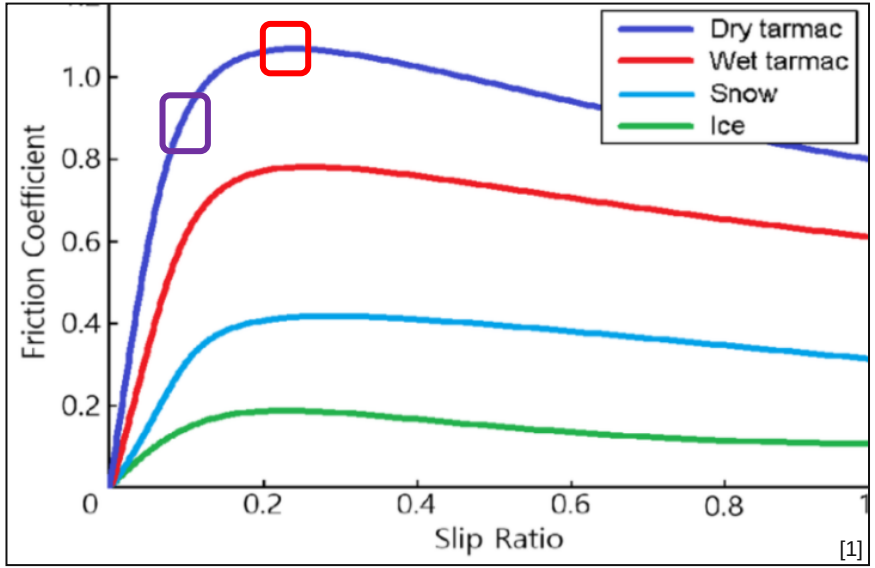




Modelling without ABS

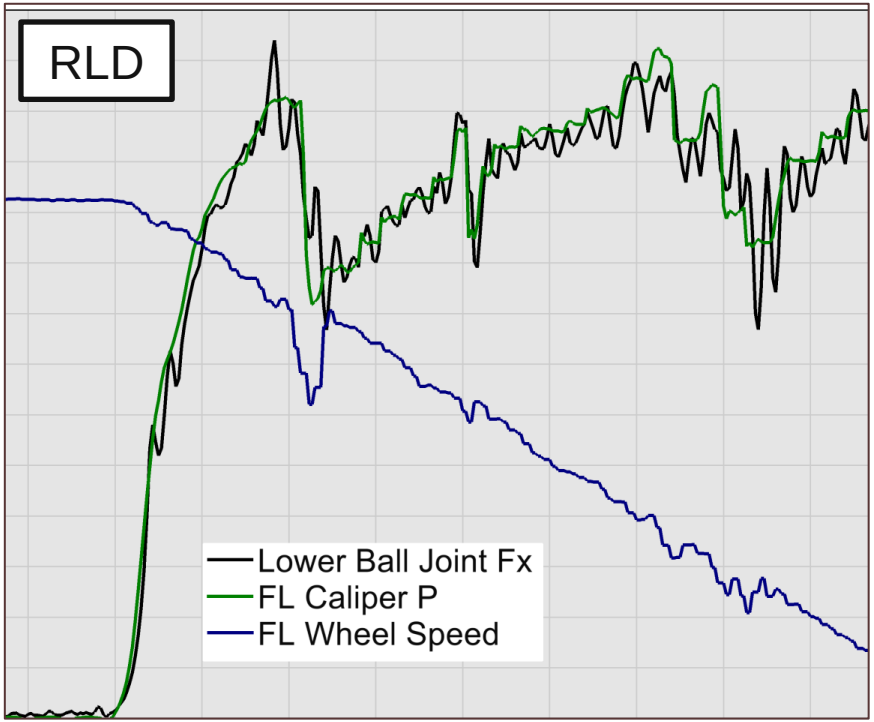


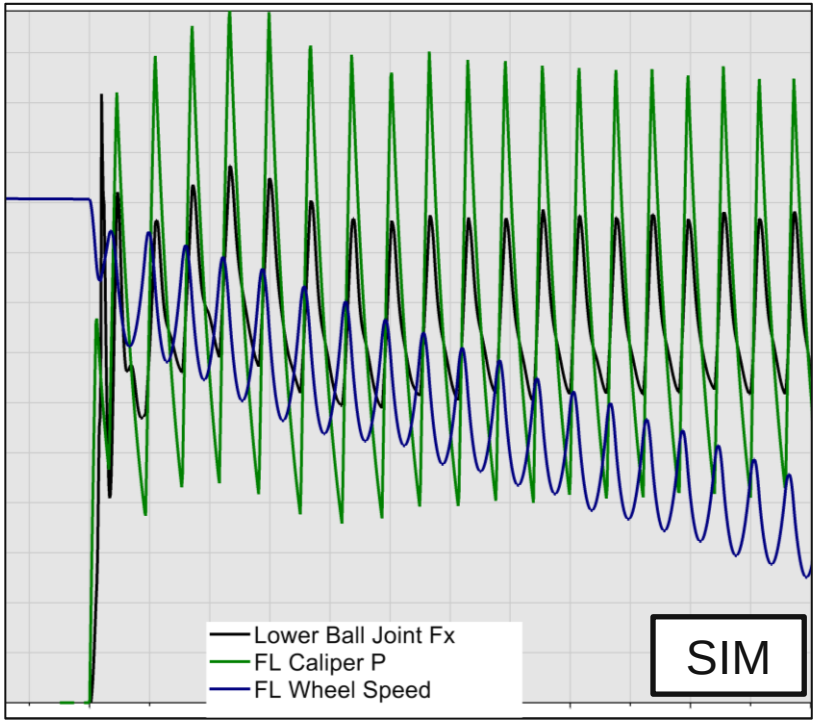


[1]

- Reduced braking force
- Lower fx loads/ stored energy
- Higher risk of instability
- Incorrect modelling of brake modulation frequency

Modelling with a Simplistic ABS





Timeline

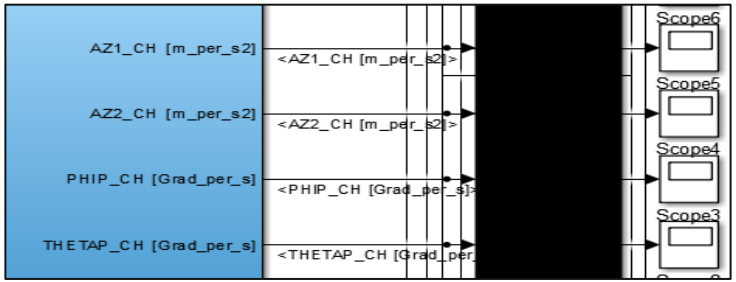
Being in the correlation stage of this project, the biggest roadblock is the acquisition of quality physical test data which includes all non-geometric data in order to replicate the test condition as close as possible.

Official release of this ABS system into the JLR MBS community is estimated to occur in May 2017 – providing improvement in correlation sufficiently outweighs any additional time required to run the simulation.

How ABS was implemented

Departmental Collaboration - Deceleration and Stability Attribute (DSA)

- Knowledge Transfer
  - The ABS Logic
  - Expected wheel speeds
  - Caliper pressures
- CM model reduced complexity
  - EBS to ABS
  - Scopes
  - Constant blocks
  - ‘.m’ scripts
  - Units/ conversions



Co-Simulation Method - MATSIM

Controller to Simpack

- Brake Torque FL
- Brake Torque FR
- Brake Torque RL
- Brake Torque RR

- **Simulink Model Embedded into Simpack**
- **Variable Step Size**
- **Simple, linear control systems**

Simpack to Controller

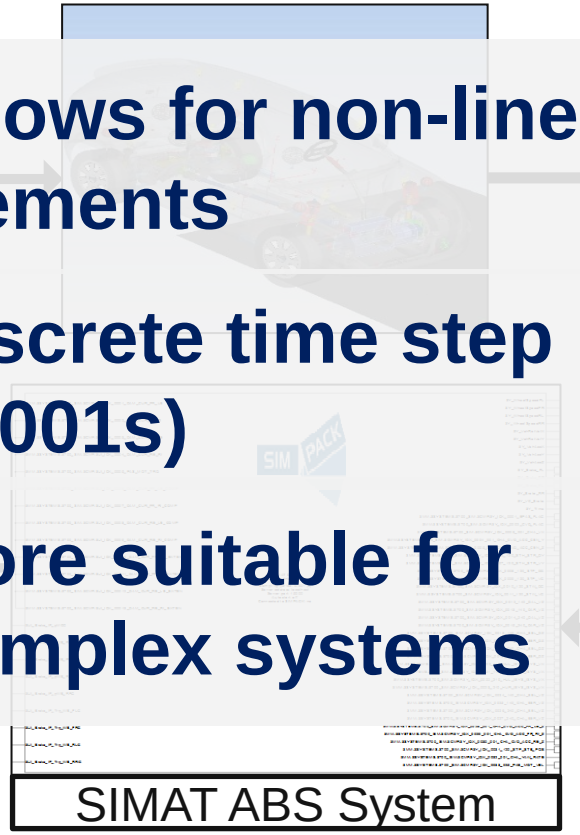
- Vehicle Speed
- Wheel Speed FL
- Wheel Speed FR
- Wheel Speed RL
- Wheel Speed RR

Co-Simulation Method - SIMAT

Controller to Simpack

- Brake Torque FL
- Brake Torque FR
- Brake Torque RL
- Brake Torque RR

- **Allows for non-linear elements**
- **Discrete time step (0.001s)**
- **More suitable for complex systems**



Simpack to Controller

- ~~Vehicle Speed~~
- Wheel Speed FL
- Wheel Speed FR
- Wheel Speed RL
- Wheel Speed RR

+

- Cha Rotational Velocity in α,β,γ
- Cha Acceleration in X, Y, Z
- Time
- Steering Angle
- Steering Rate

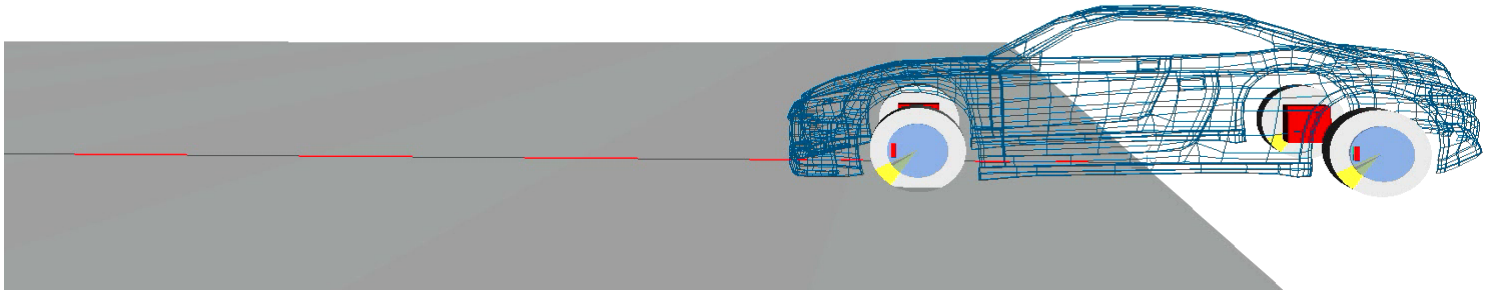
PLUS

Ability for further inputs: Powertrain, HDC, TC, DSC, TVBB.

Simplified Model

Inputs, outputs, senders and receivers from a simplified Simpack model replaced those coming in/out of CarMaker.

The benefits of using brake torque compared with disc and caliper braking was investigated using this simple model.

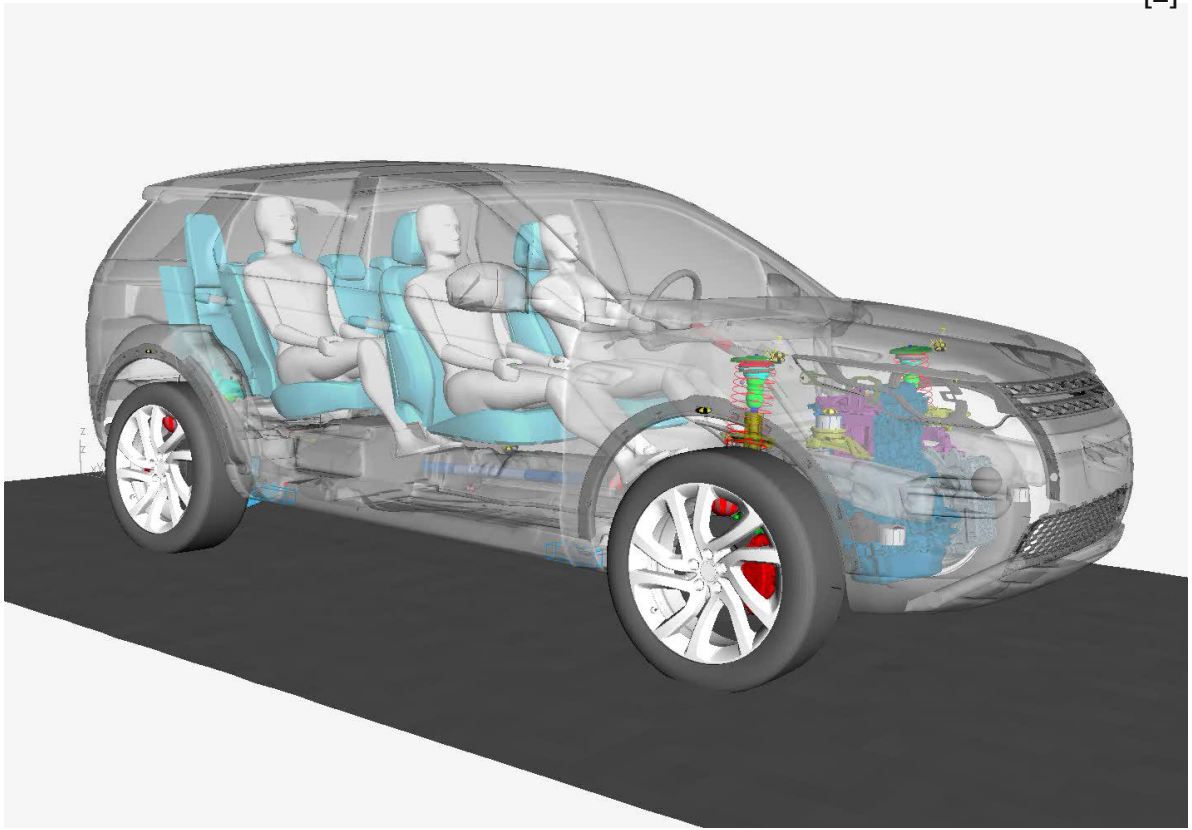


Full Simpack Virtual Vehicle Model

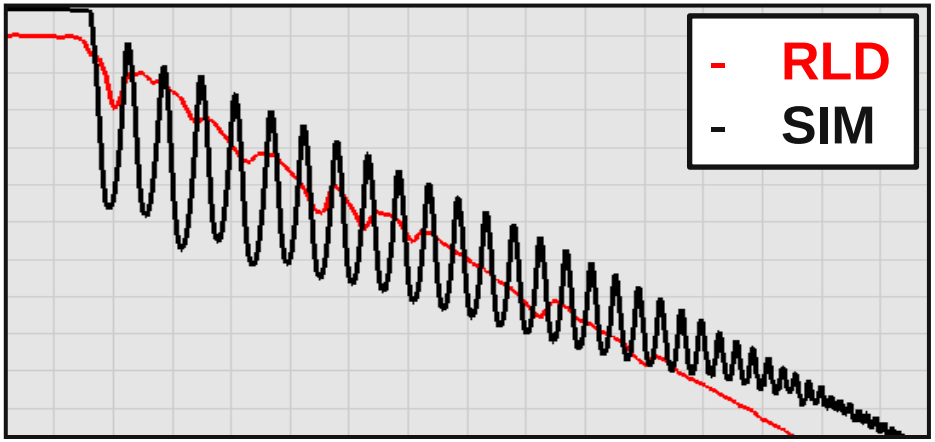
[2]

Senders and receivers were then added in Simpack pre-processer to a full virtual vehicle model to work with the SIMAT ABS block.

The need for a suitable settling time and ramp function was identified at this stage in order to achieve an improved ABS response.



Correlation – A first check



MATSIM ABS

Sinusoidal response

High frequency

Incorrect deceleration

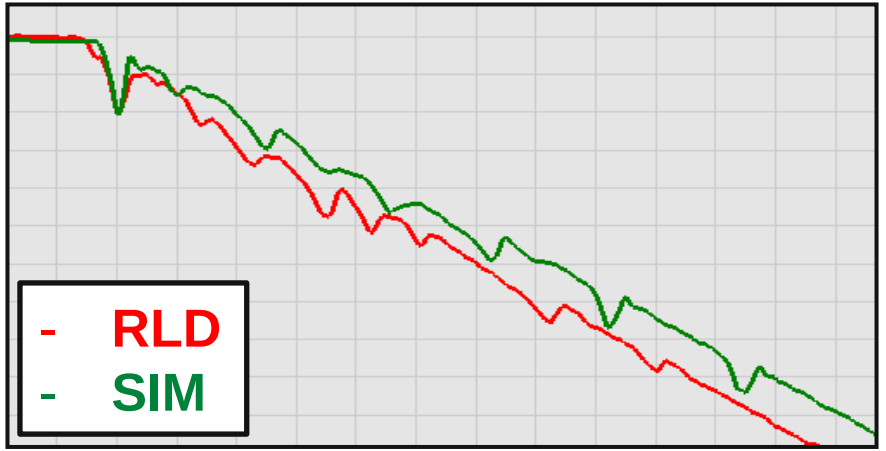
Wheels not locked

SIMAT ABS

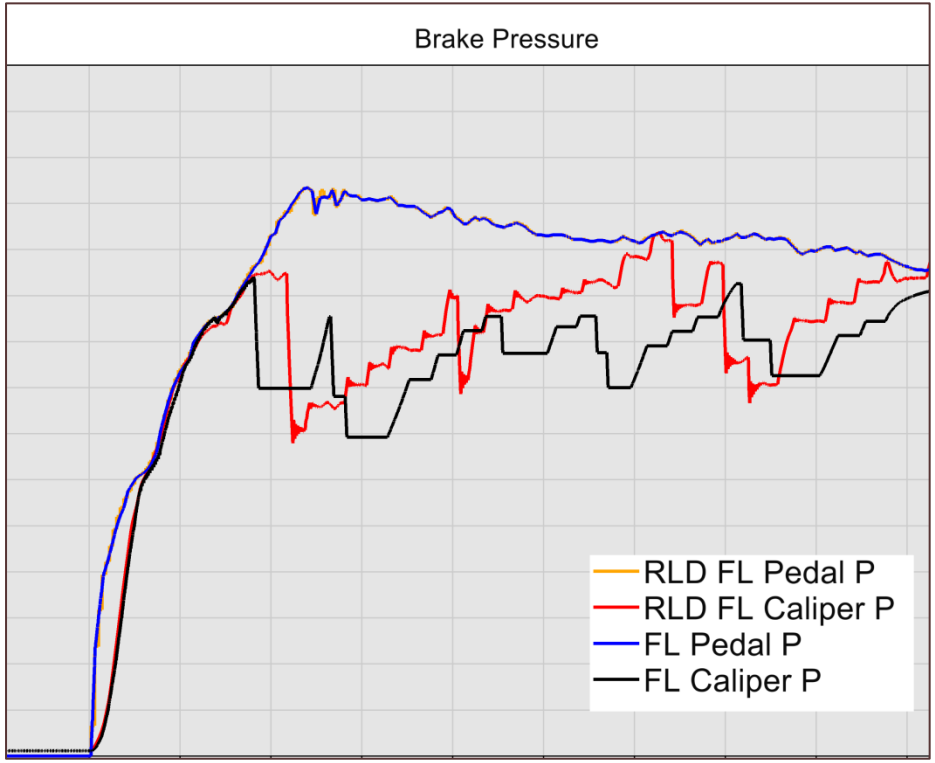
Non-linear response

Frequency matching RLD

Incorrect deceleration



Correlation – RR Evoque ABS Stop

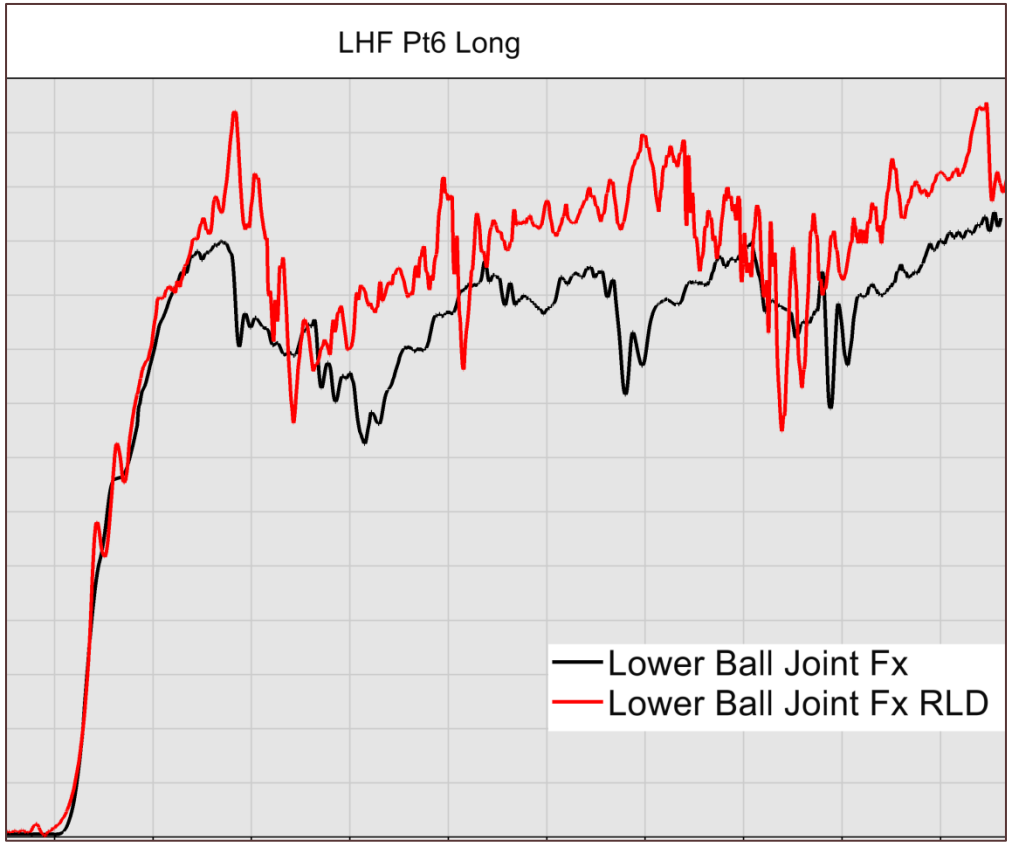


Correlation and Findings

Brake pedal max pressure and rate has a significant effect on ABS response

Settling time of 5s is not adequate and it was noticed Brake pMC was activating before pedal activation

Correlation – RR Evoque ABS Stop

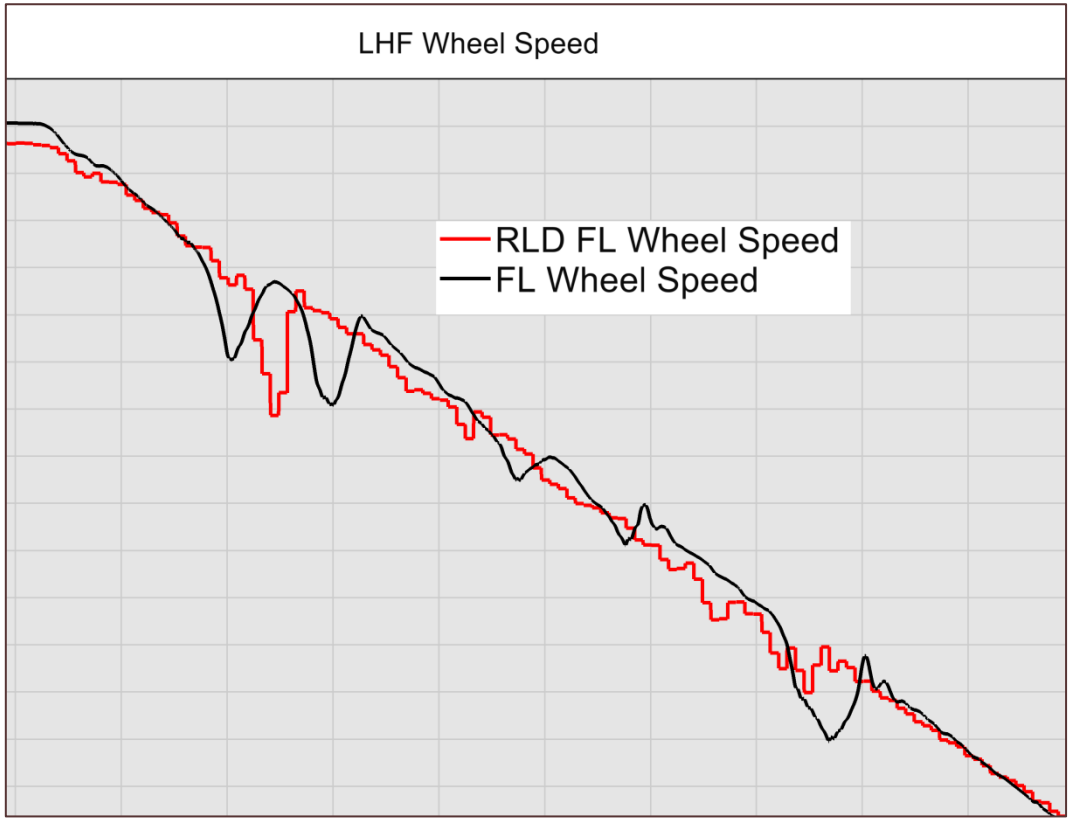


Correlation and Findings

Vehicle setup such as front/ rear split, CoG height, spring rate, damper splines..etc. All had an effect on the resulting longitudinal load.

An incorrectly assigned marker was found to be causing low longitudinal load at the ball joint.

Correlation – RR Evoque ABS Stop

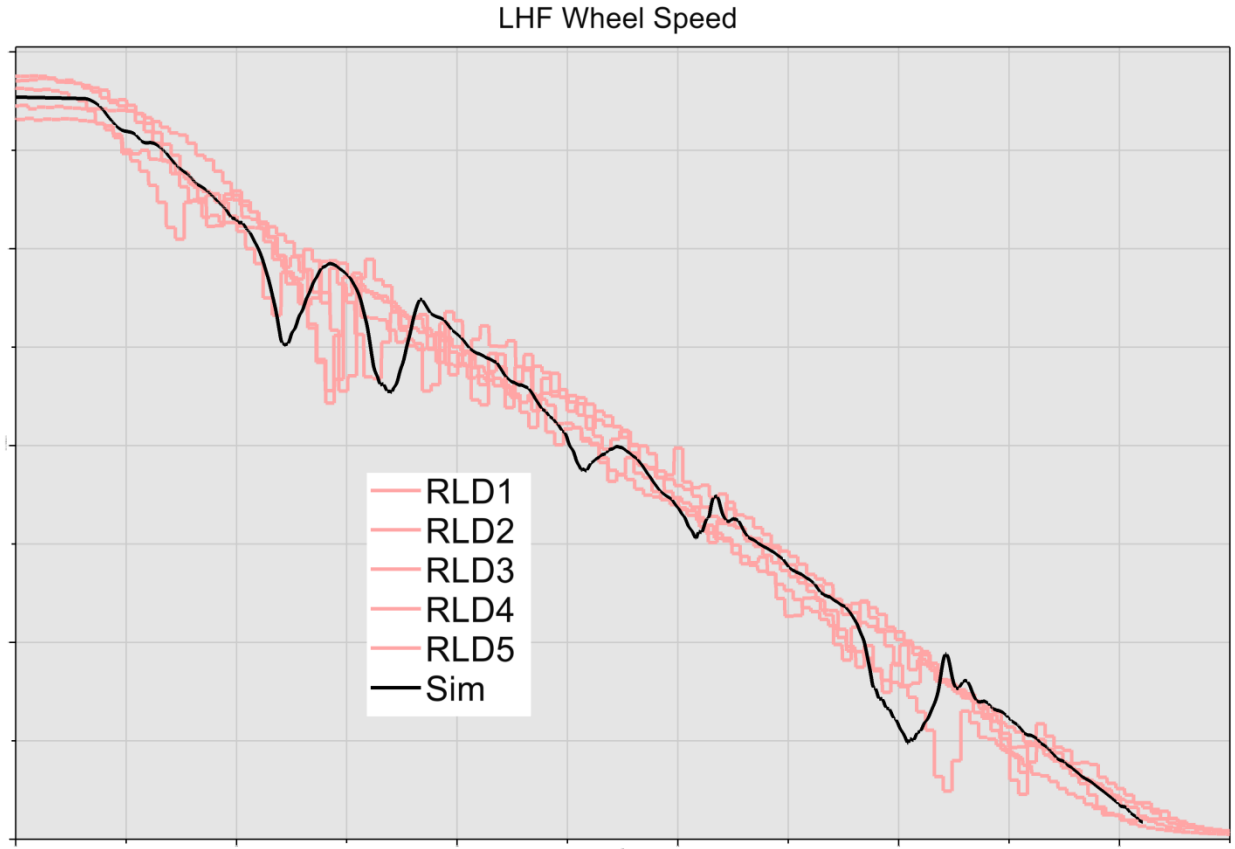


Correlation and Findings

Friction coefficient had to be altered within the model to achieve correct deceleration and improve wheel speed correlation.

More complex coding within the ABS had to be considered such as ‘Anti-Dive’ and brake pedal assist.

Correlation – RR Evoque ABS Stop

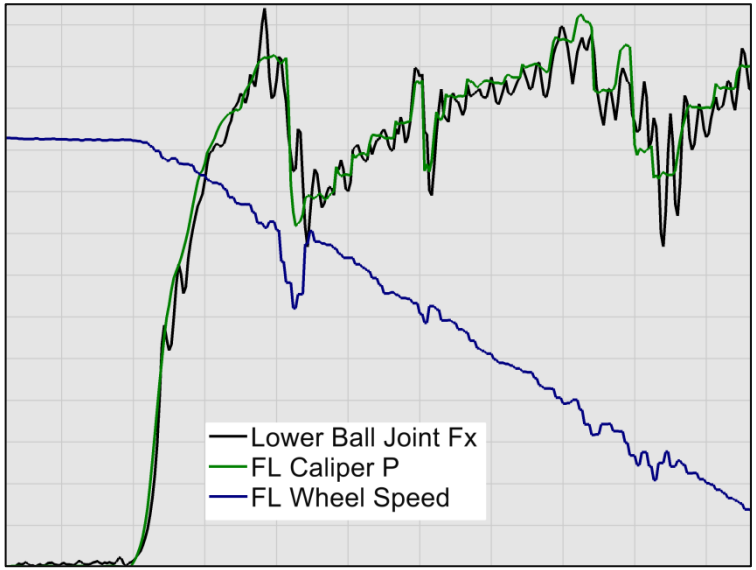


Perfect correlation does NOT always mean perfect loads prediction.

Suitable tolerances have to be considered.

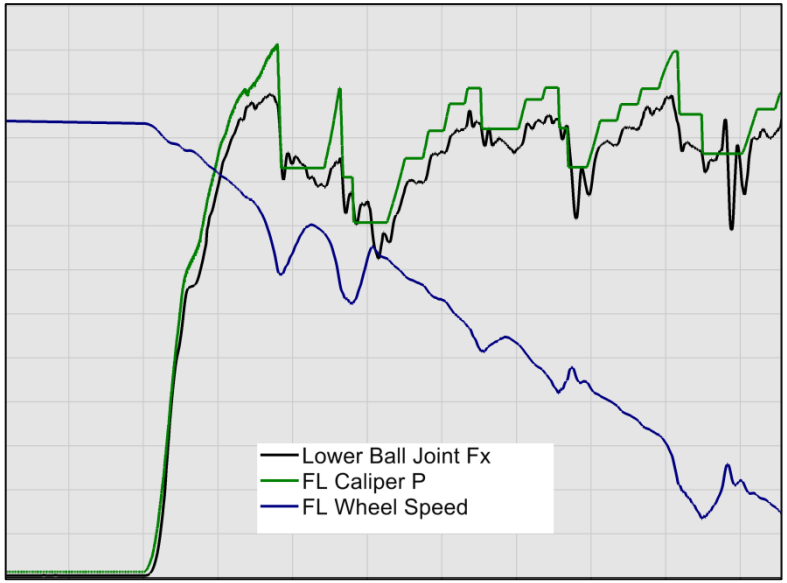
An idealistic virtual model will never match every physical model test.

Correlation – RR Evoque ABS Stop



Physical Test Data

Virtual Simulation



Current Status

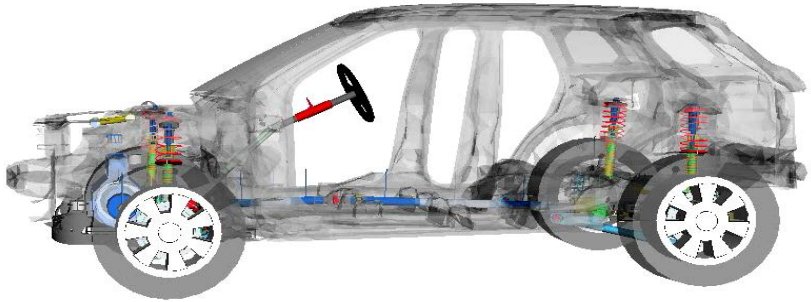
Vehicle	Surface	Status
RR Evoque	ABS Stop	99%
RR Evoque	Pothole Brake	99%
Discovery Sport	ABS Stop	99%
Discovery Sport	Pothole Brake	99%
RR Evoque	Belgian Block	80%
RR Evoque	Cobblestones	50%
Discovery Sport	Belgian Block	50%
Discovery Sport	Cobblestones	50%
?Data Dependant	All 4	10%
?Data Dependant	All 4	10%

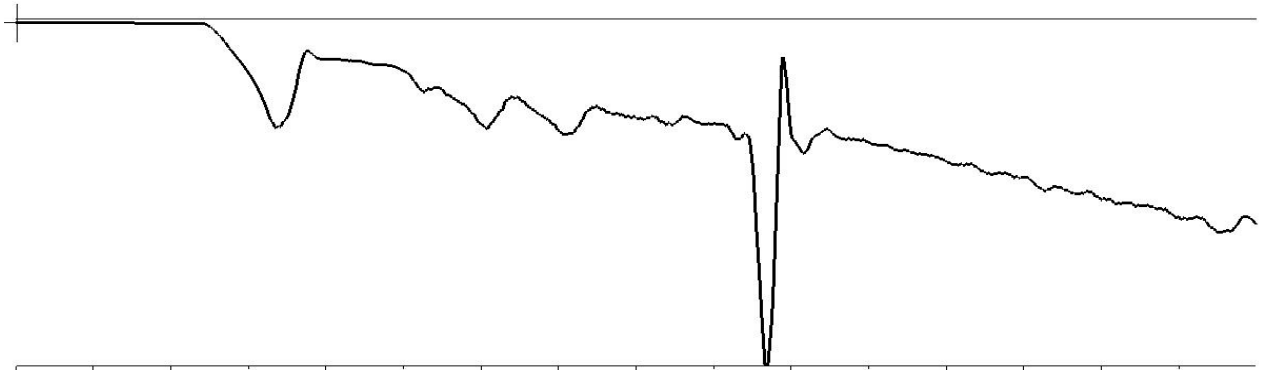
Image of Belgian block surface **[3]**

Image of Cobblestone surface **[4]**

Review and Questions

- Core function of an ABS system
- Why D&R CAE needed ABS
- Steps to where we are today
- Correlation and findings
- Remaining work





Thanks for your attention

Any Questions?

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References

1. Park, J., Jeong, H., Jang, I.G. and Hwang, S.H., 2015. Torque Distribution Algorithm for an Independently Driven Electric Vehicle Using a Fuzzy Control Method. *Energies*, *8*(8), pp.8537-8561.
2. Garci, A, 2015. L550 Kerb Drive Over Simpack Simulation Video.
3. "Belgium Block Used." Patios & Walks — Bedford Stone & Masonry Supply Corp., Bedford Hills NY. Accessed October 12, 2016. http://bedfordstone.com/products/patios-walks/158/photo/164/.
4. Image of Cobblestones. Accessed November 4, 2016. http://www.hotel-r.net/im/hotel/gb/cobble-stones-13.jpg.