

VIRTUAL VEHICLE Research Center

ICRI – Friction Modelling

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ICRI – Friction Modelling Task

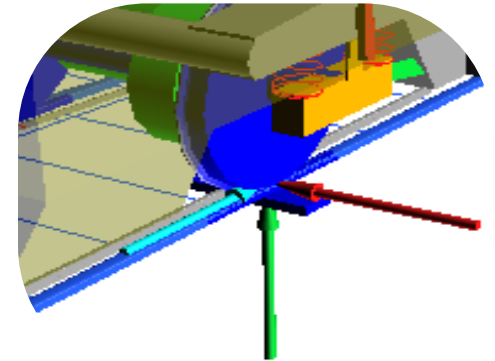
Recent Discussions about Wheel-Rail Creep Forces and their Consequences

Task leaders:

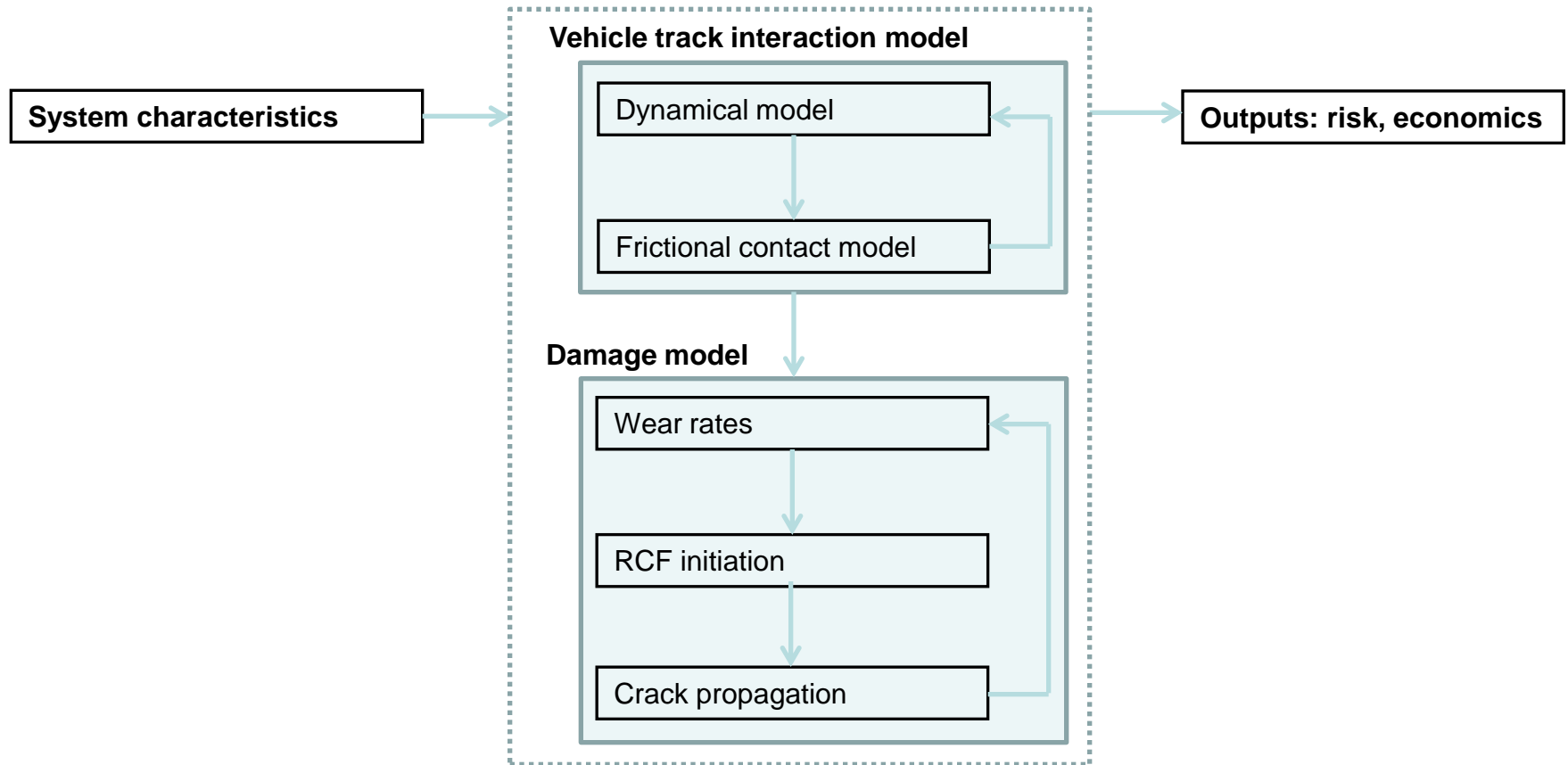
- Klaus Six (VIRTUAL VEHICLE Research Center)
- Edwin Vollebregt (VORtech)

Task activities so far

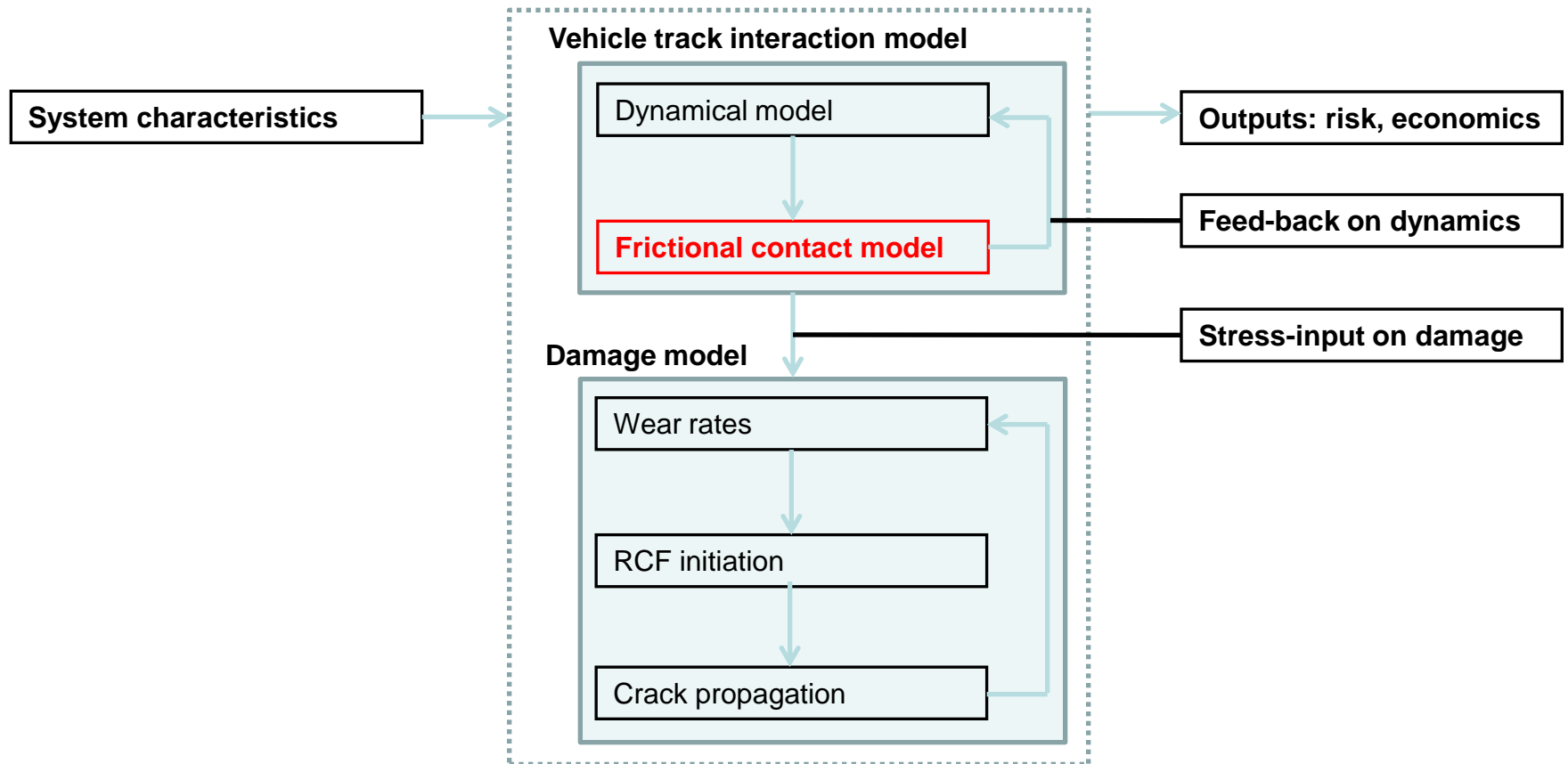
- Several WebEx discussions 2013 - 2014
- Presentations at
 - Railways 2014
 - Rail Tech Europe 2014
- Development of project outline
- Several related activities



Simulation model



Simulation model



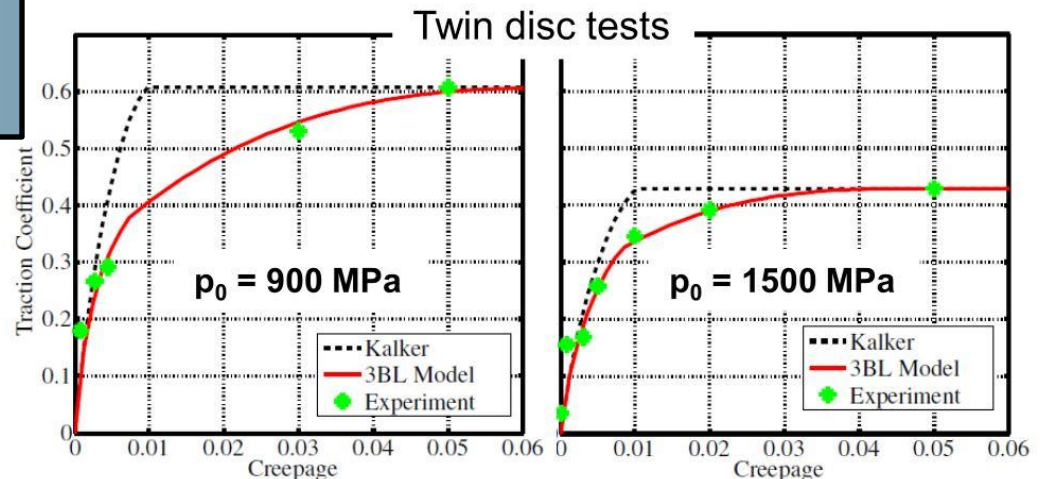
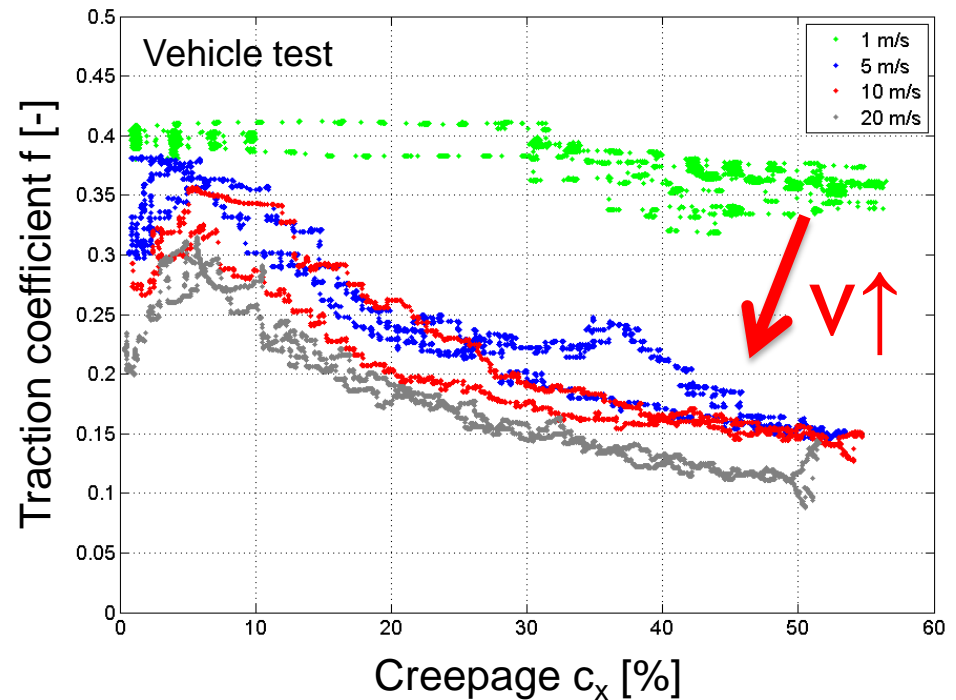
High relevance of reliable creep force prediction models

Creep force depends on:

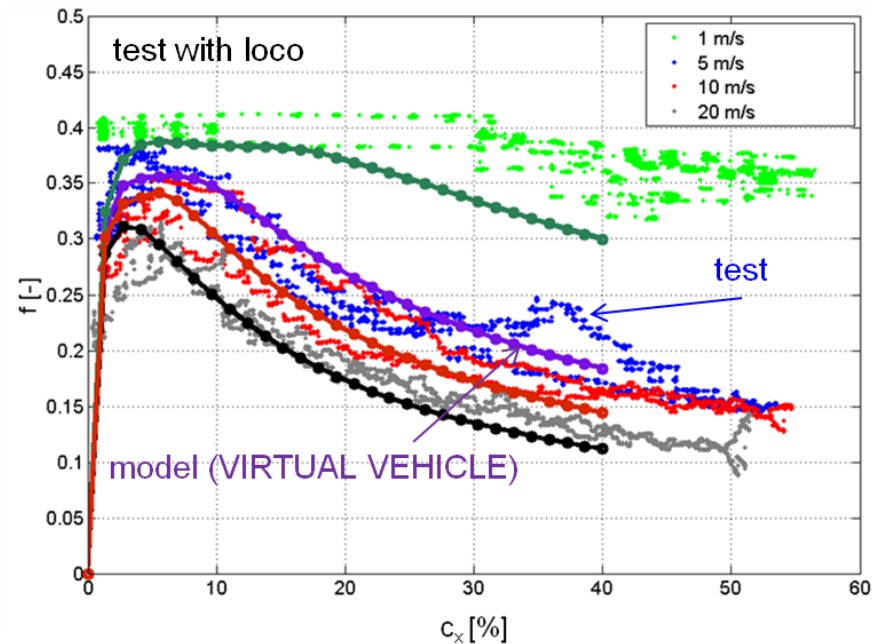
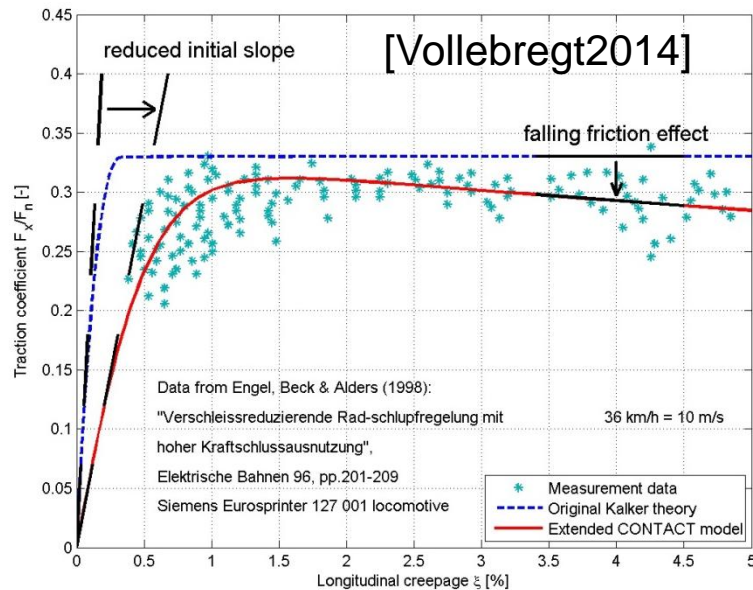
- Creepages
- Vehicle velocity
- Normal load and geometry
- Contact conditions
- Frequency range
- etc.

⇒ **Complex behaviour**

⇒ **How to model friction ?**

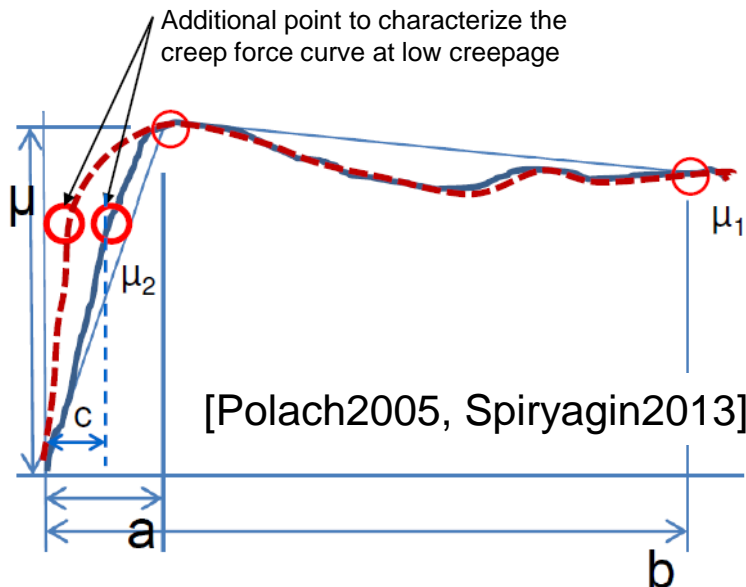


Examples for Enhanced Modelling



[Tomberger2011, Meierhofer2012, Six2015]

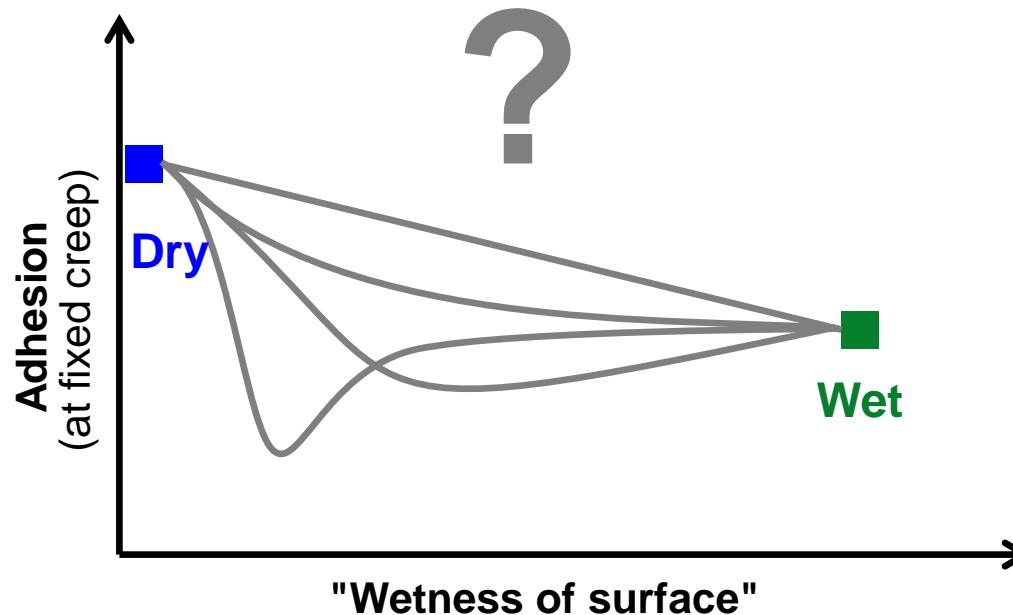
⇒ **Several approaches available**



T1077: Low Adhesion – impact of low amounts of water

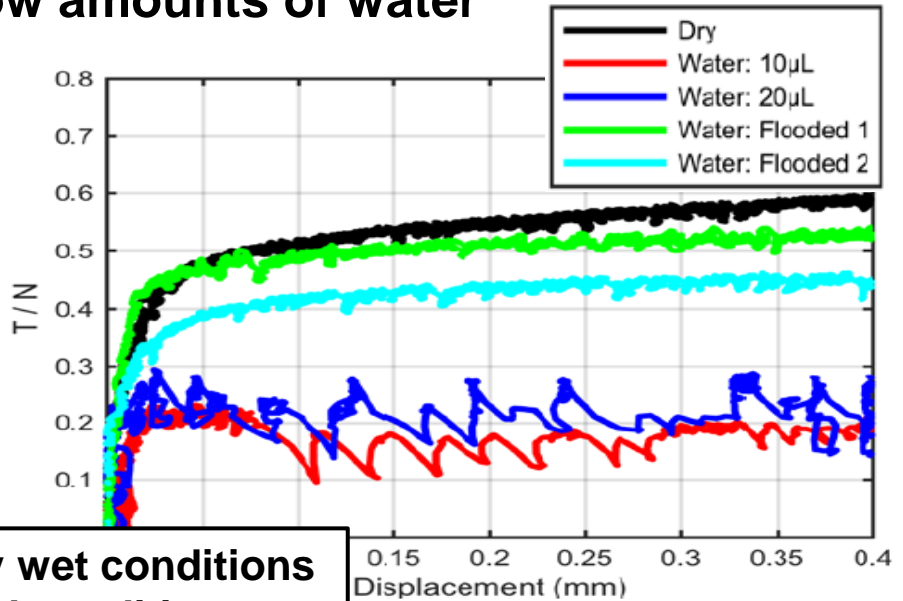
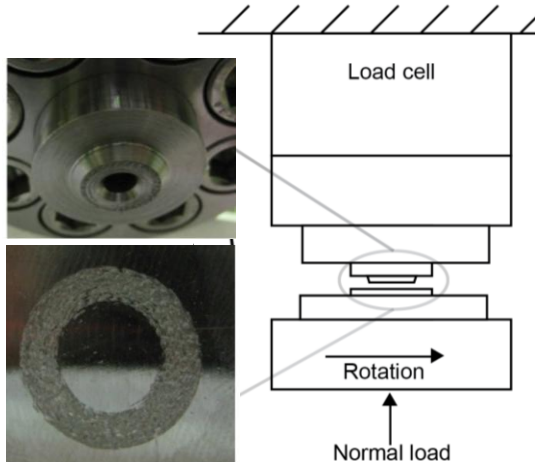
Adhesion & water in wheel / rail contact

- Adhesion values known for dry and wet conditions
- But: Adhesion as a function of amount of water / water rate ??



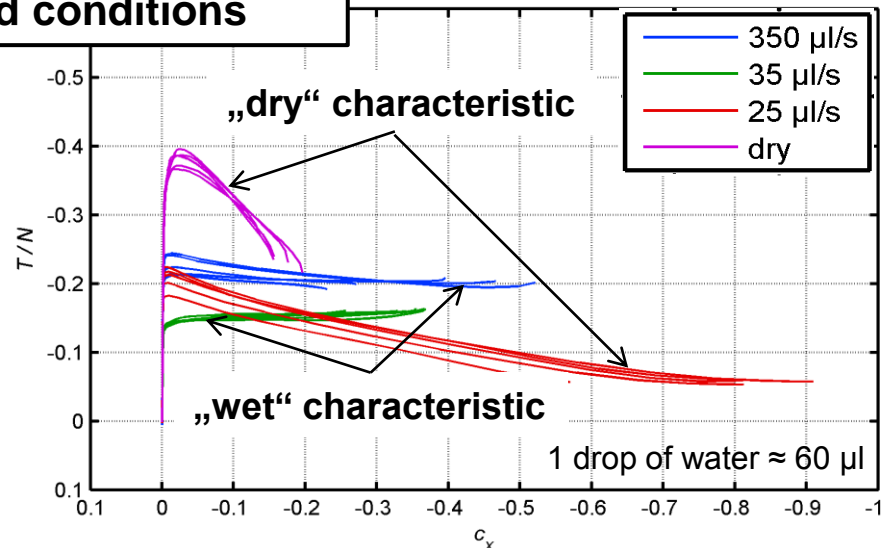
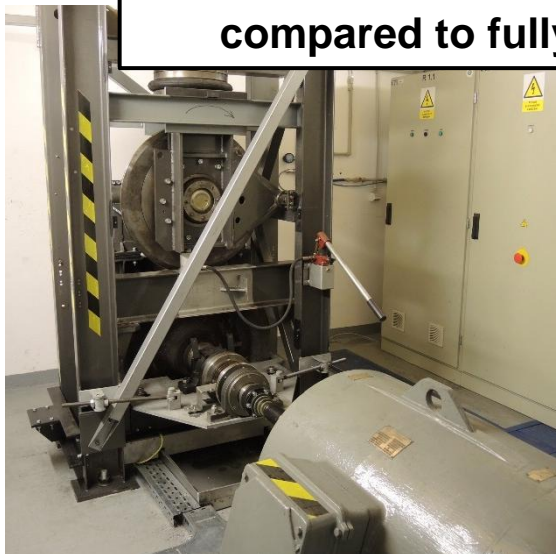
T1077: Low Adhesion – impact of low amounts of water

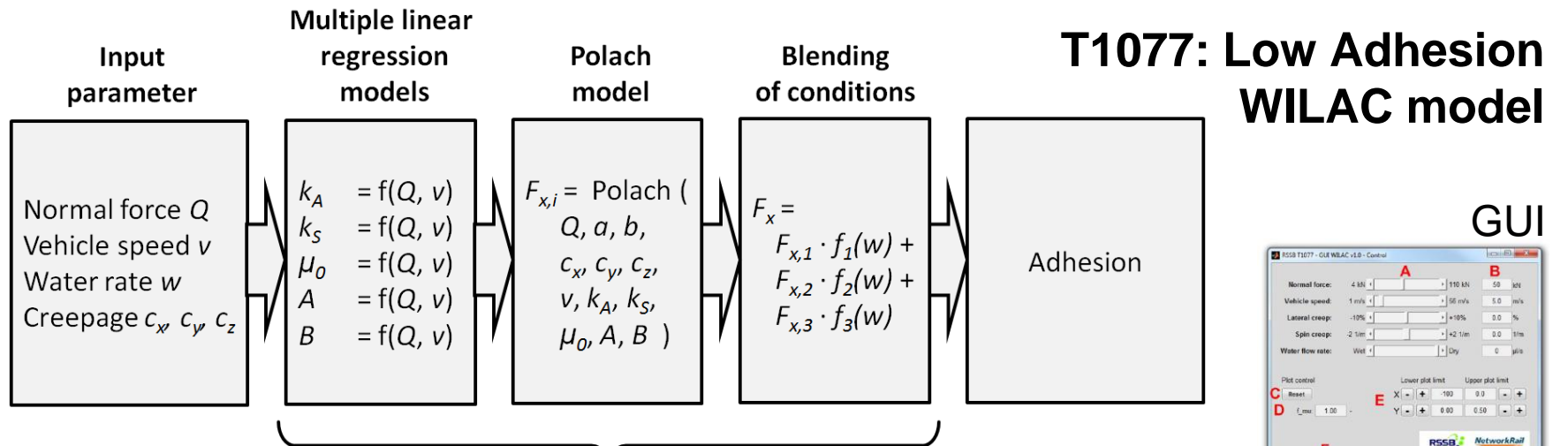
High Pressure Torsion



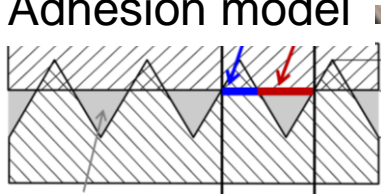
Lower friction under slightly wet conditions compared to fully flooded conditions

Full Scale Test Rig





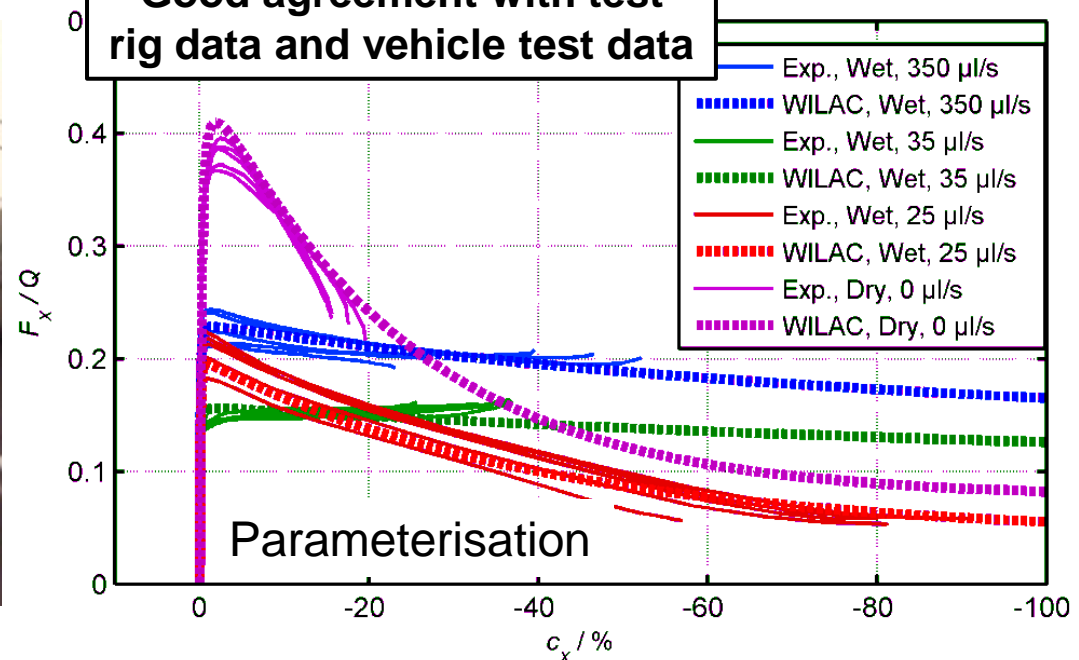
Adhesion model



running band

paste existing of water & wear debris/iron oxides

Good agreement with test rig data and vehicle test data



Rocking Phenomenon

Roller rig – eigenmodes:

Vertical motion:

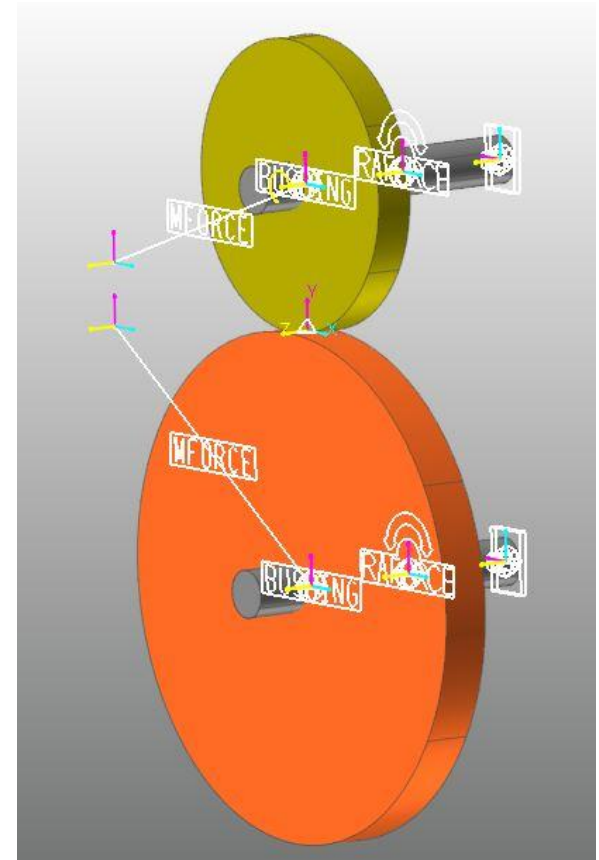
1. In phase on bushing
2. Out of phase on contact spring

Horizontal motion:

3. In phase against bushings
4. Out of phase against bushings

Angular motion:

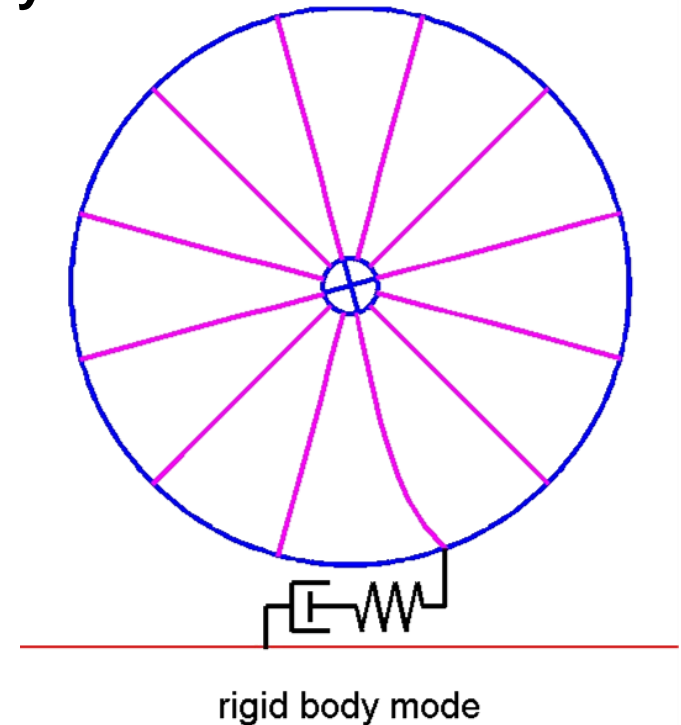
5. (Free) rolling motion
6. Rocking motion



Rocking Phenomenon

The whole wheel may rock as a rigid body:

- **The frequency f depends on:**
 - the masses
 - the moments of inertia
 - the tangential stiffness K_x
- **The stiffness K_x depends on:**
 - the materials used,
 - the normal load,
 - contact geometry,
 - saturation of tangential force
- **The amount of damping is unknown**



Rocking Phenomenon

- **Transient effects** don't die out quickly.
- The contact force has a **tendency to oscillate**.
- This is a rigid body vibration, with *floating frequency f*
- Rocking is triggered by **sudden changes** like dipped joints or welds
- It may explain **short pitch corrugation** as well.



(picture: S.Grassie)

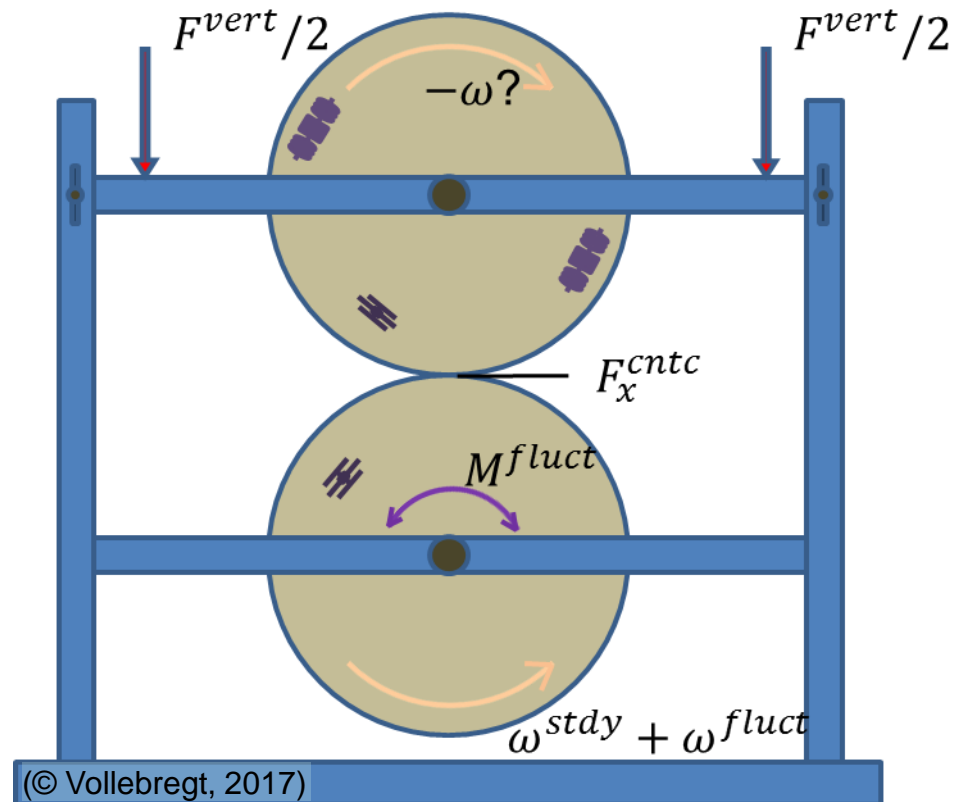
Rocking Phenomenon

Seeking assistance for a proposed experiment

Rubber rollers, to reduce
the oscillation frequency

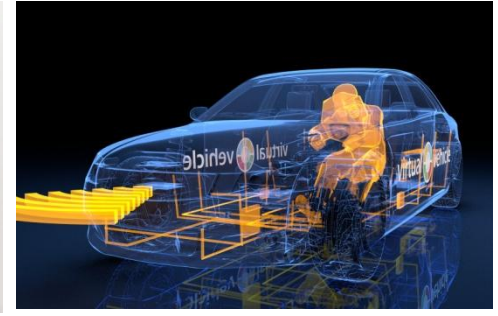
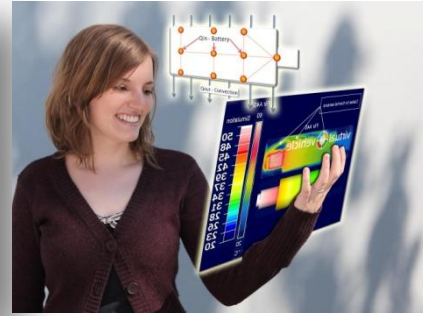
Torque fluctuation, to
trigger resonance

**Demonstrate that rocking
exists & validate its
predicted properties**



Relevant Issues

- **Implementation in MBD simulations**
 - To avoid extensive field-testing of FM materials
 - To enable detailed stress-calculation for damage modelling
- **Further validation**
- **Modelling of contaminants**
 - e.g. Friction Modifiers (FRA call)
- ... ?



Thank you for your attention

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