Optimization of Crossing Geometry in Railway Turnouts

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SIMPACK User Meeting

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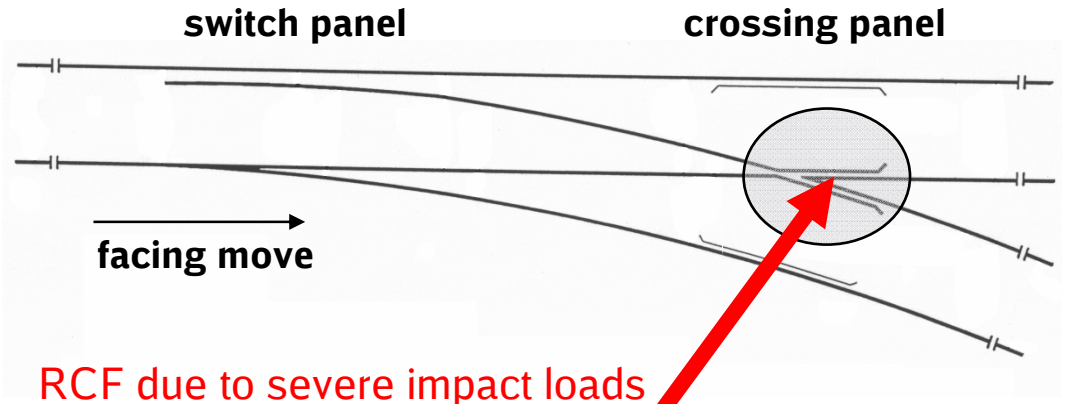
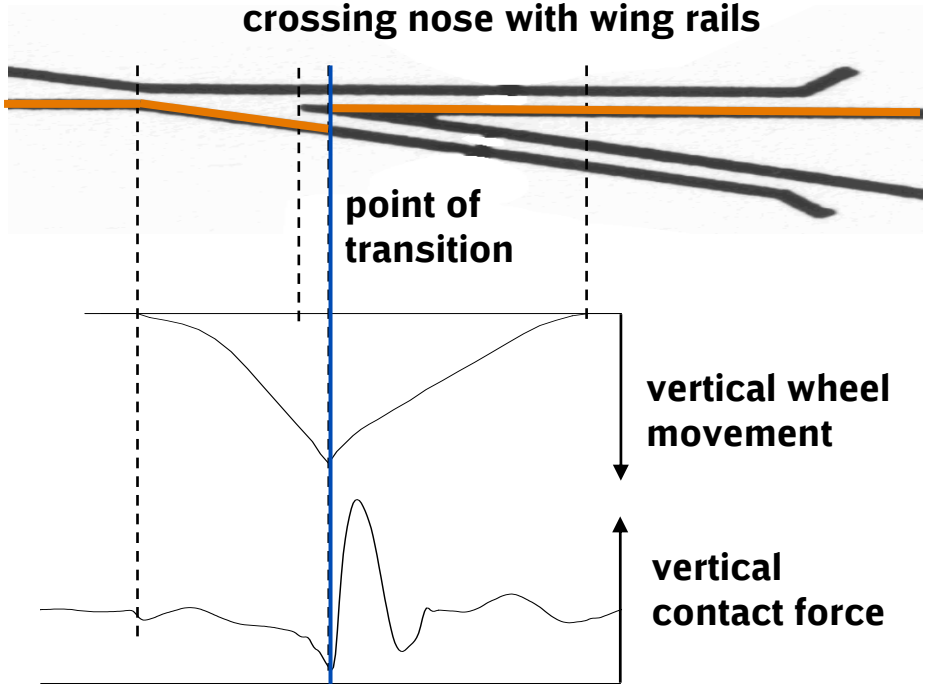
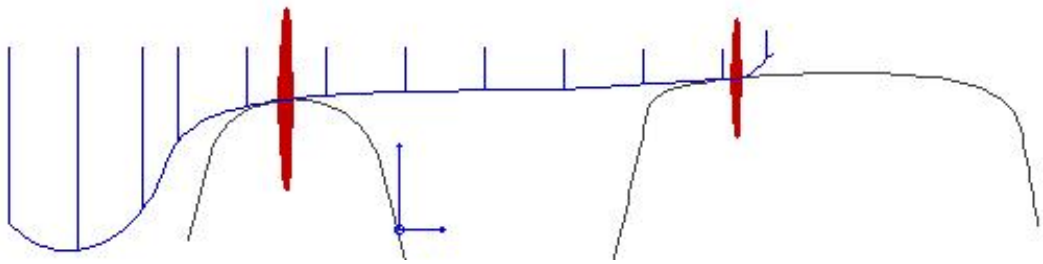
Introduction



RCF due to severe impact loads

Damage on running surface of crossing nose





wheel passing a crossing

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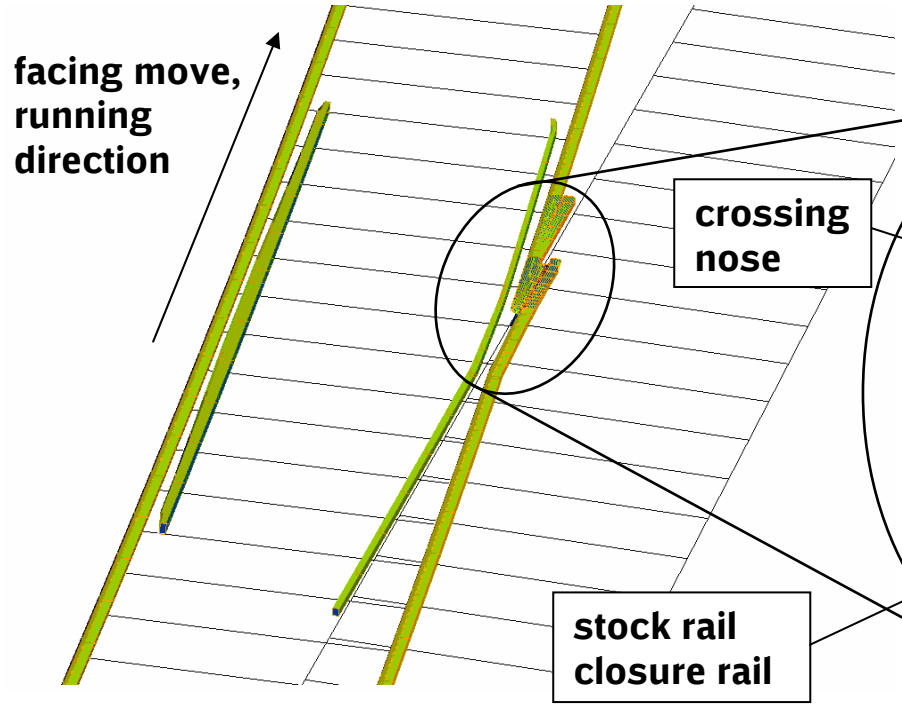
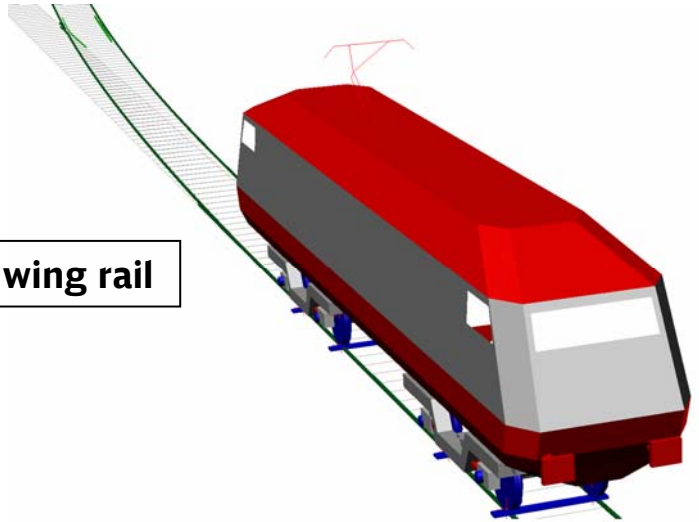
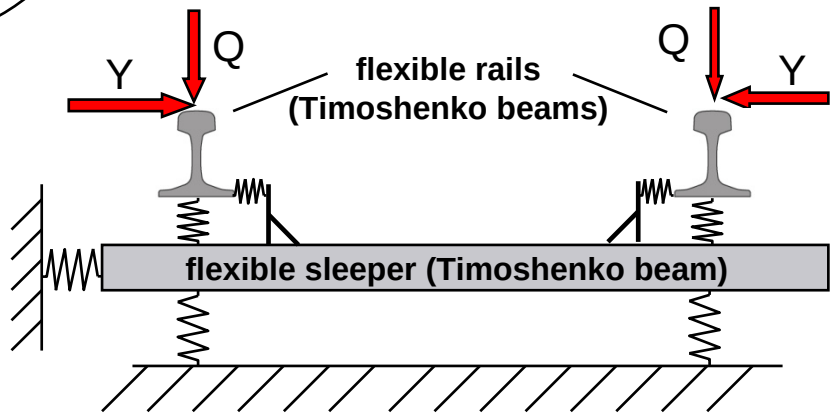
SIMPACK simulation model



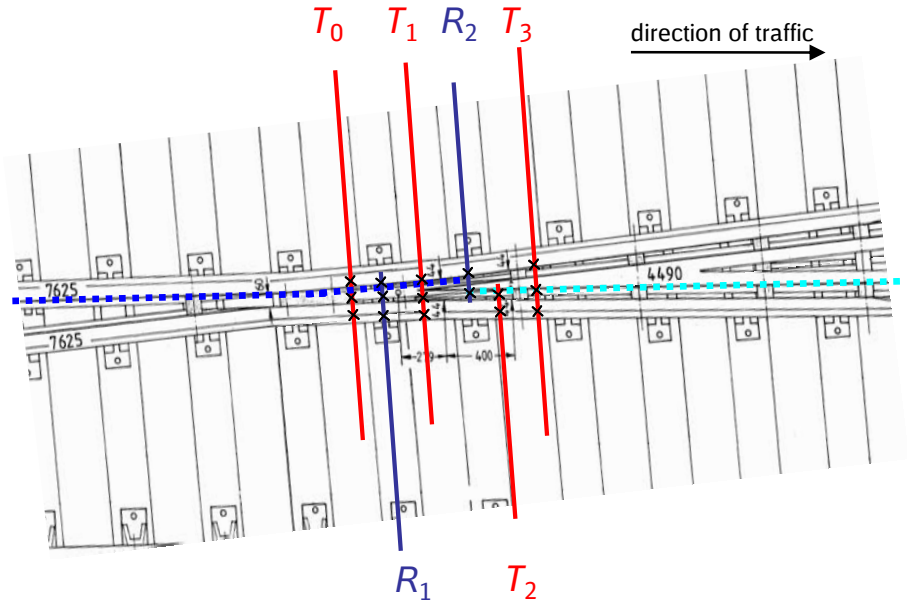




Elastic track model (FEM) implemented in SIMPACK (user routine of DB Netz AG)

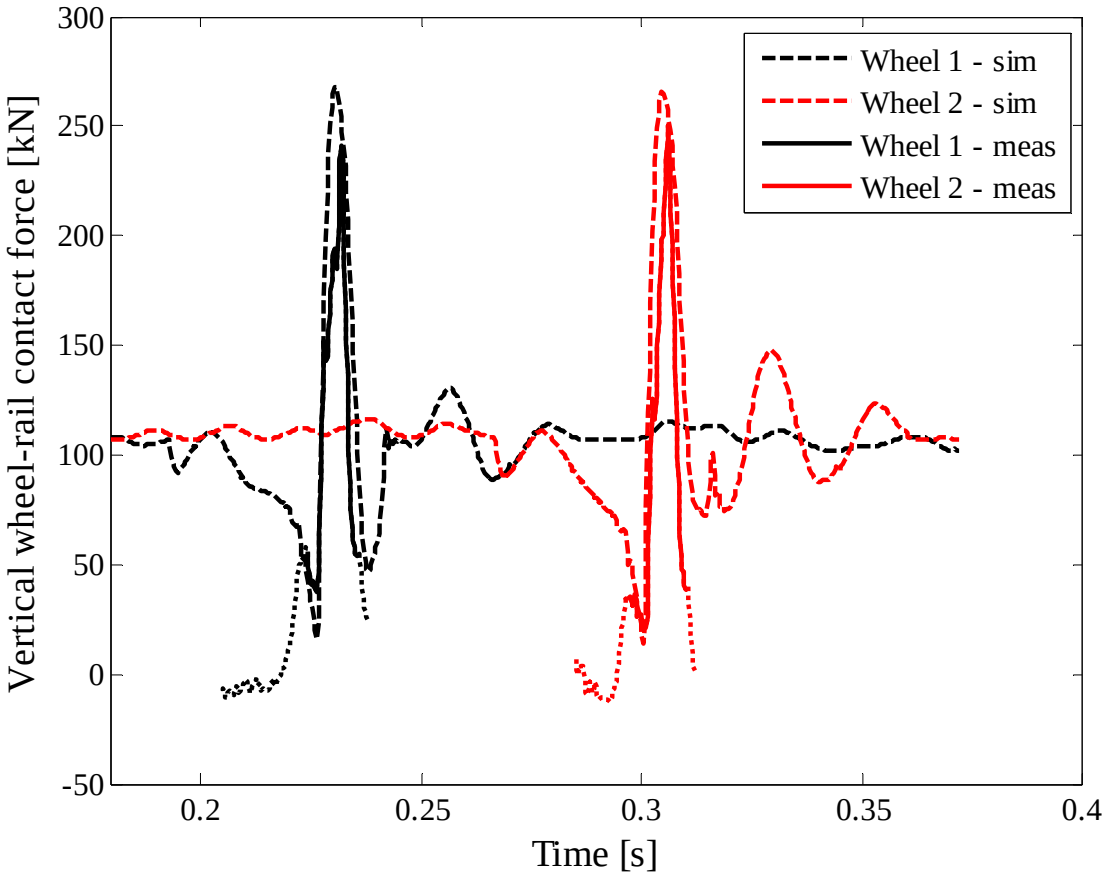
Model validation

Comparison of measured and simulated vertical contact forces of two passing wheels



Positions of strain gauges (x)
(T_i – shear forces, R_j – rail seat forces)

Summation: $Q = T_0 + R_1 + R_2 + T_3$



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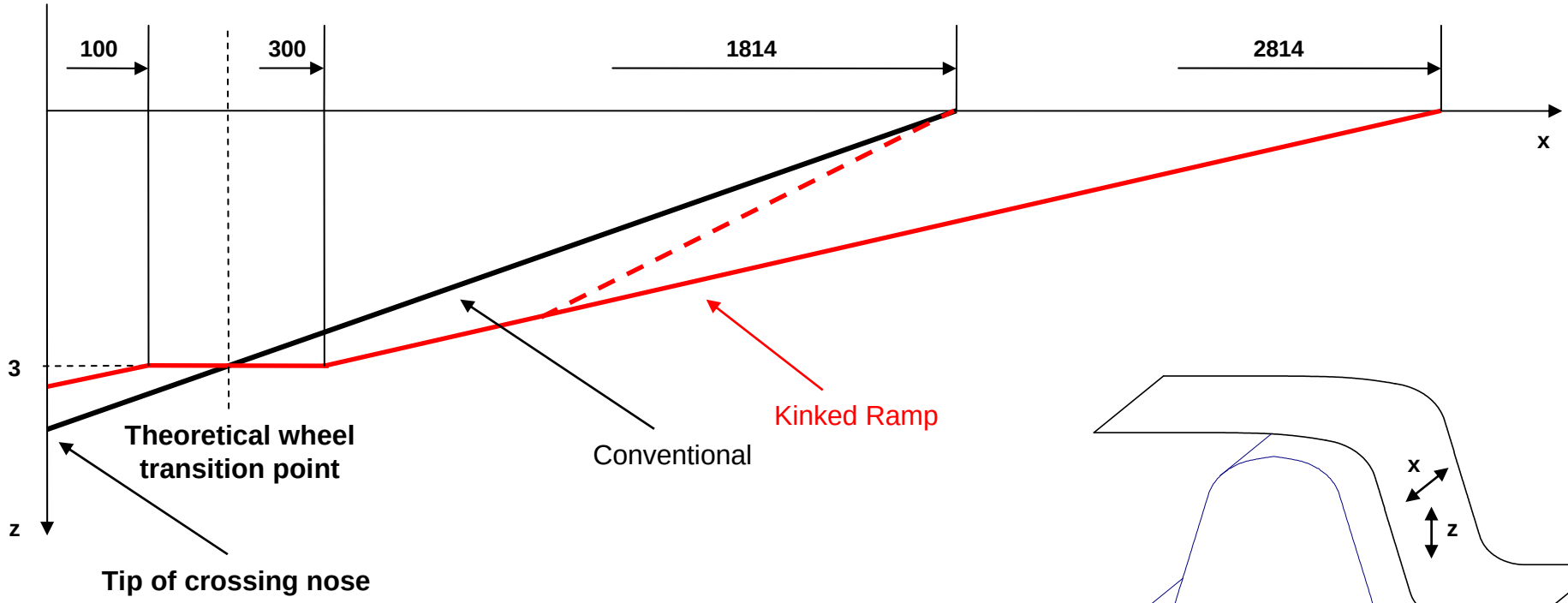
3. Investigation of alternative crossing designs
4. Simulation of material degradation in service
5. Conclusion and future work

Crossing geometry „Kinked Ramp“ for EH 60-500-1:12 (Trajectory of profiling tool)

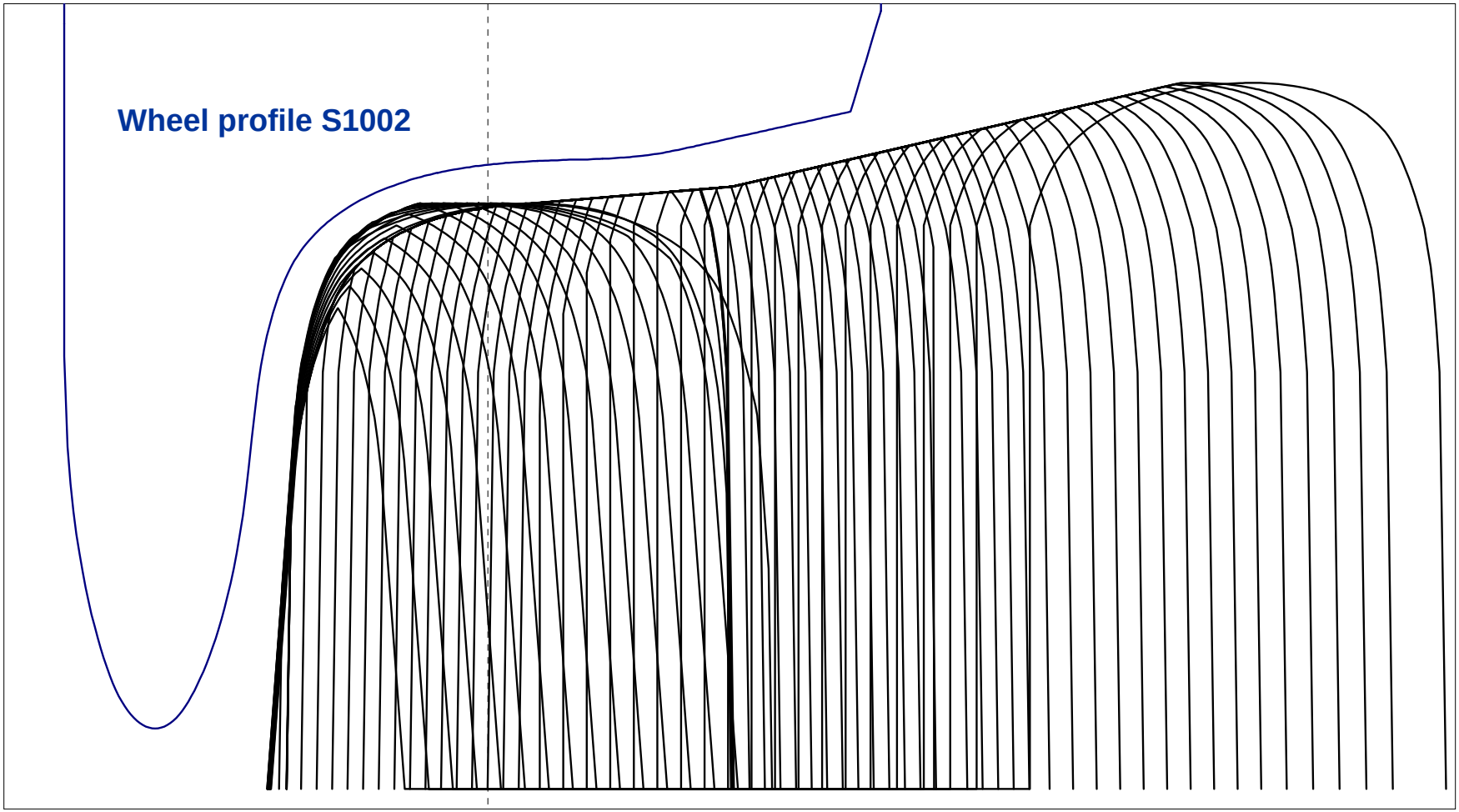


All measures given in mm.

Shape of profiling tool

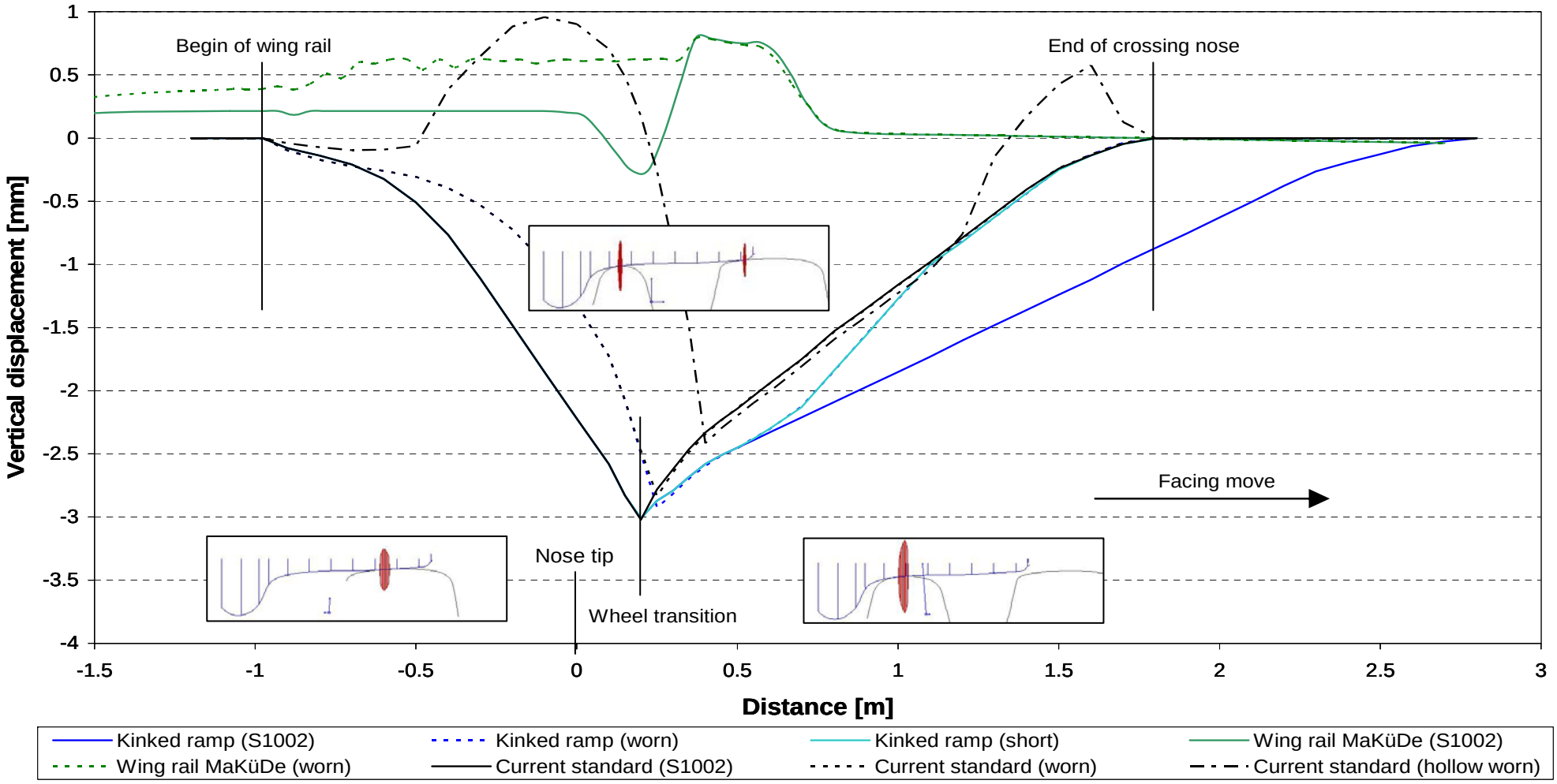
Optimization of geometry

Crossing geometry „MaKüDe“ for EH 60-500-1:12



Vertical wheel movement

Comparison of vertical wheel movement (quasi-static)



Evaluation of Contact Stresses

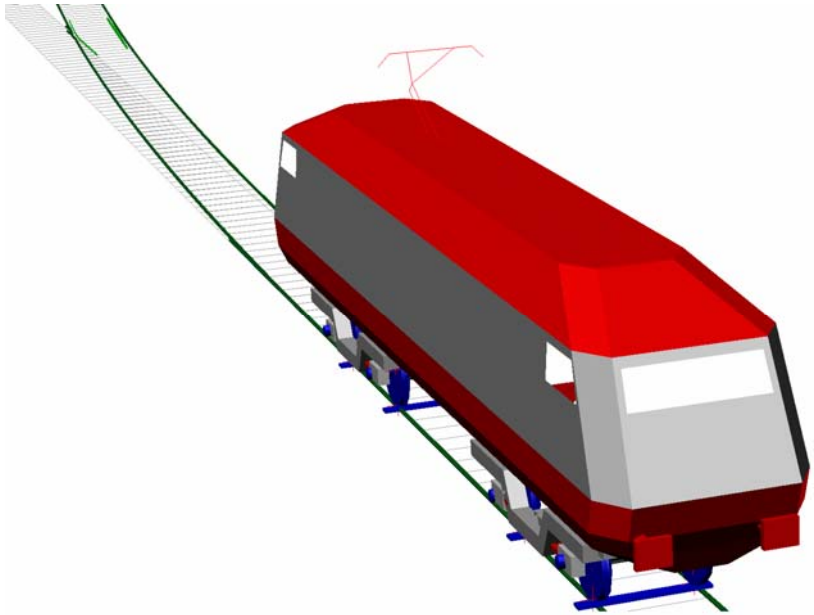
MBS simulation

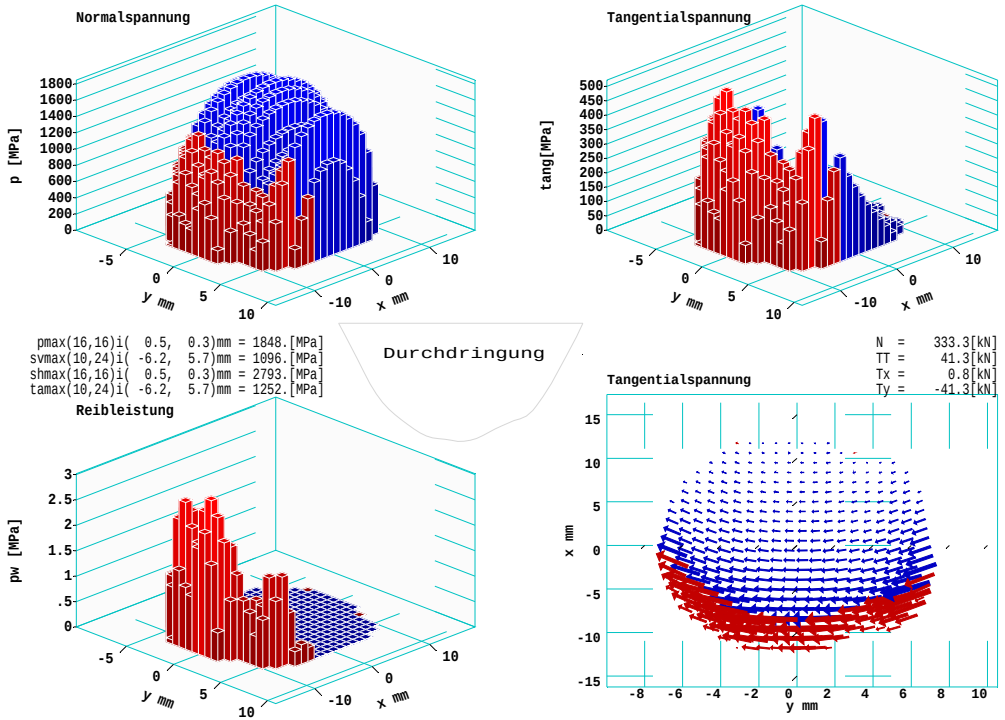
SIM PACK

Creepages, Friction coeff.,
Penetration in contact patch

3D Stress calculation

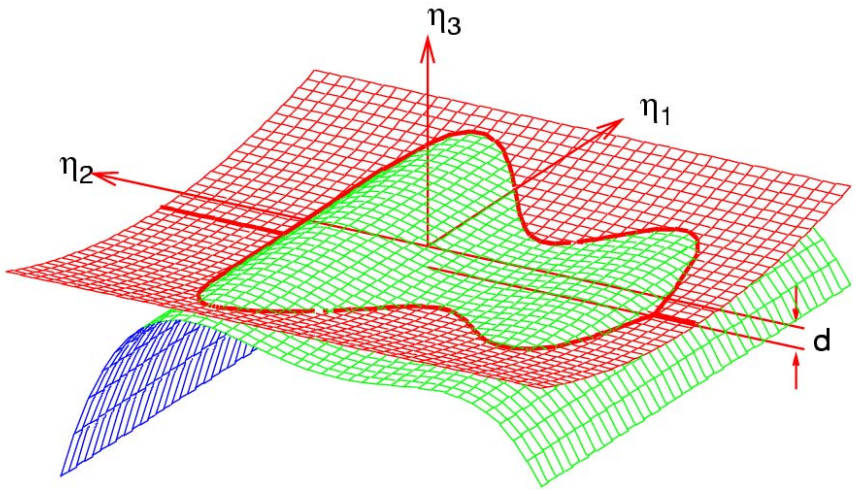
CONTACT
(Prof. J. J. Kalker)

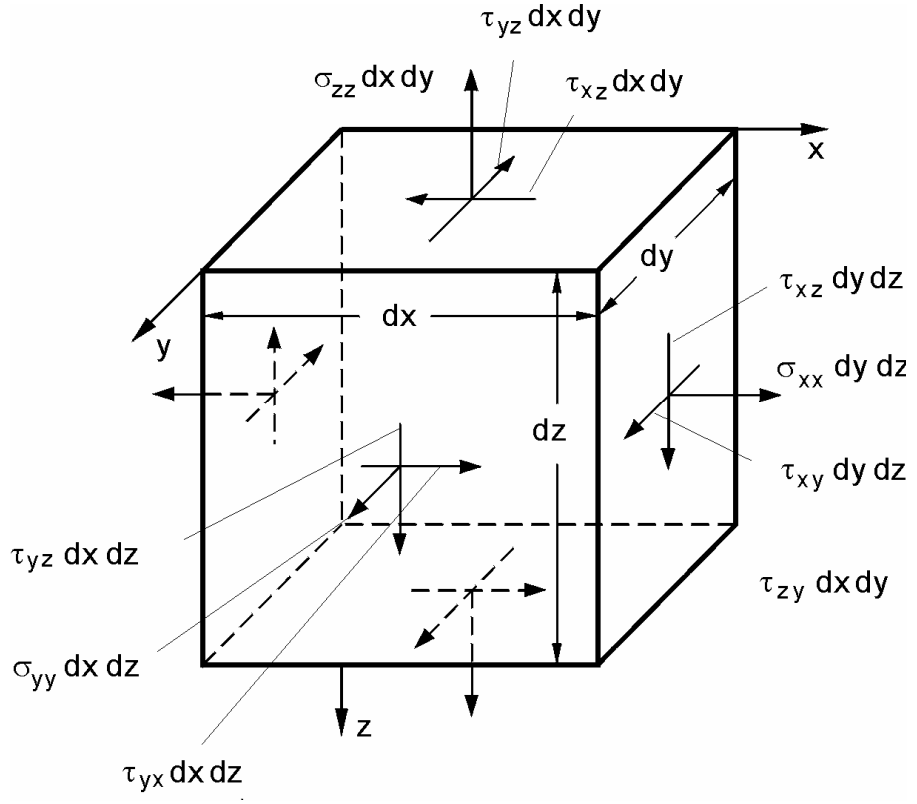




Equivalent Contact Stress

Calculation of equivalent contact stresses according to v. Mises



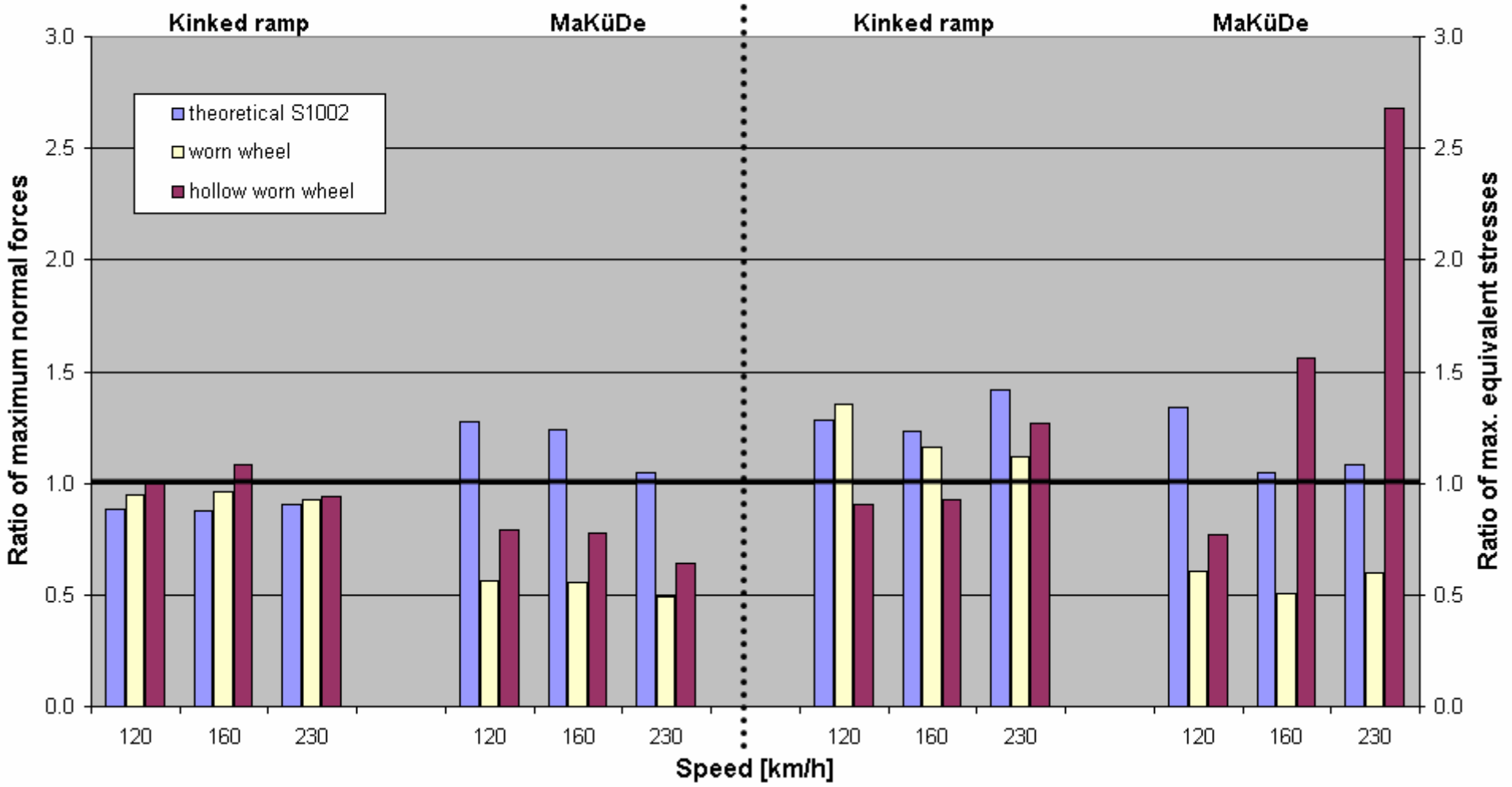


$$\sigma_e = \sqrt{\frac{1}{2}\left[(\sigma_{xx}-\sigma_{yy})^2+(\sigma_{yy}-\sigma_{zz})^2+(\sigma_{zz}-\sigma_{xx})^2\right]+3\cdot(\tau_{xy}^2+\tau_{yz}^2+\tau_{zx}^2)}$$

(Figures from PhD thesis of Dr. André Theiler, IfB Berlin [1])

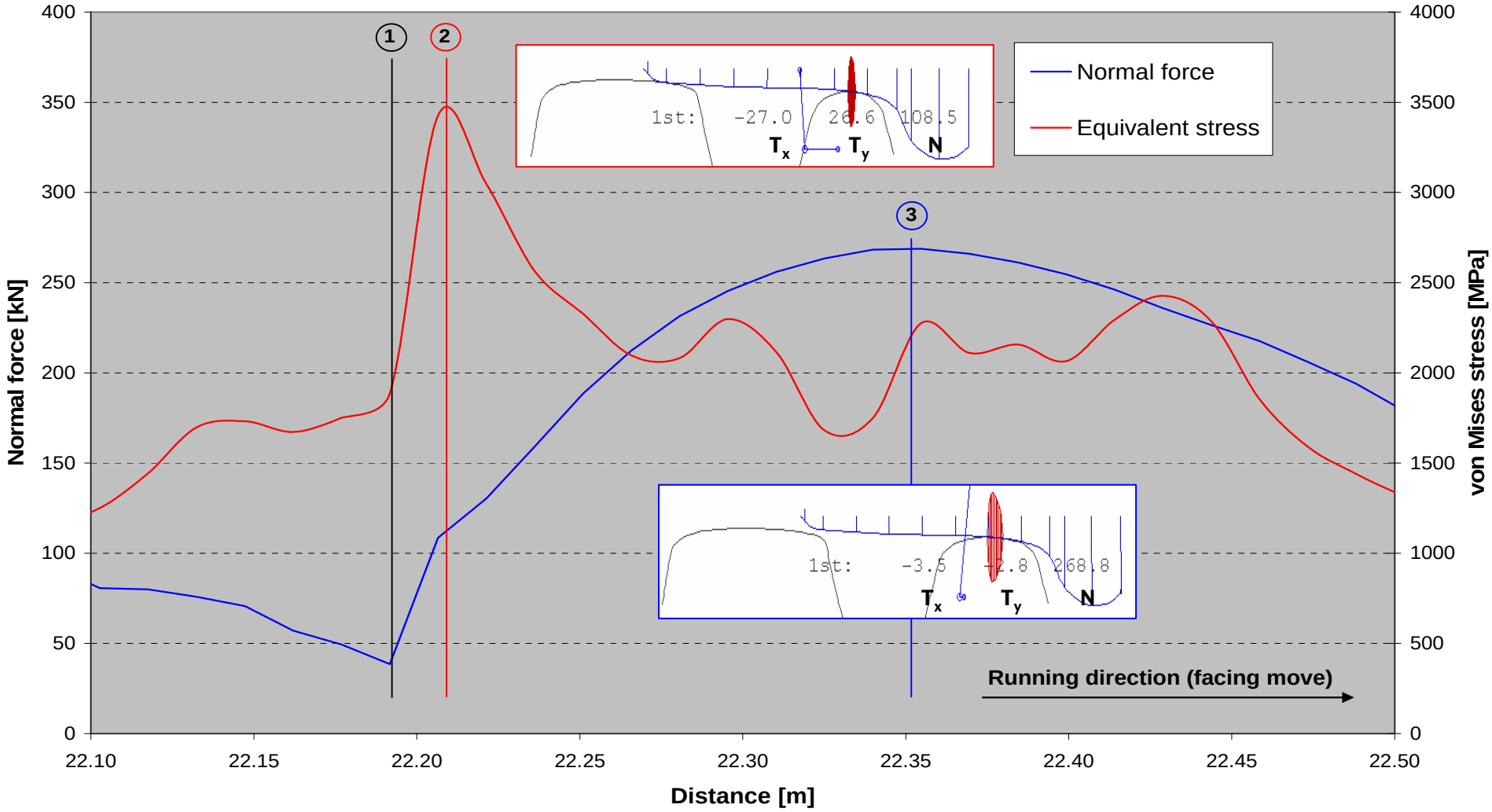
Discussion of simulation results

Normal forces and equivalent stresses in relation to Standard geometry



Discussion of simulation results

Time histories of Normal force and von Mises stress



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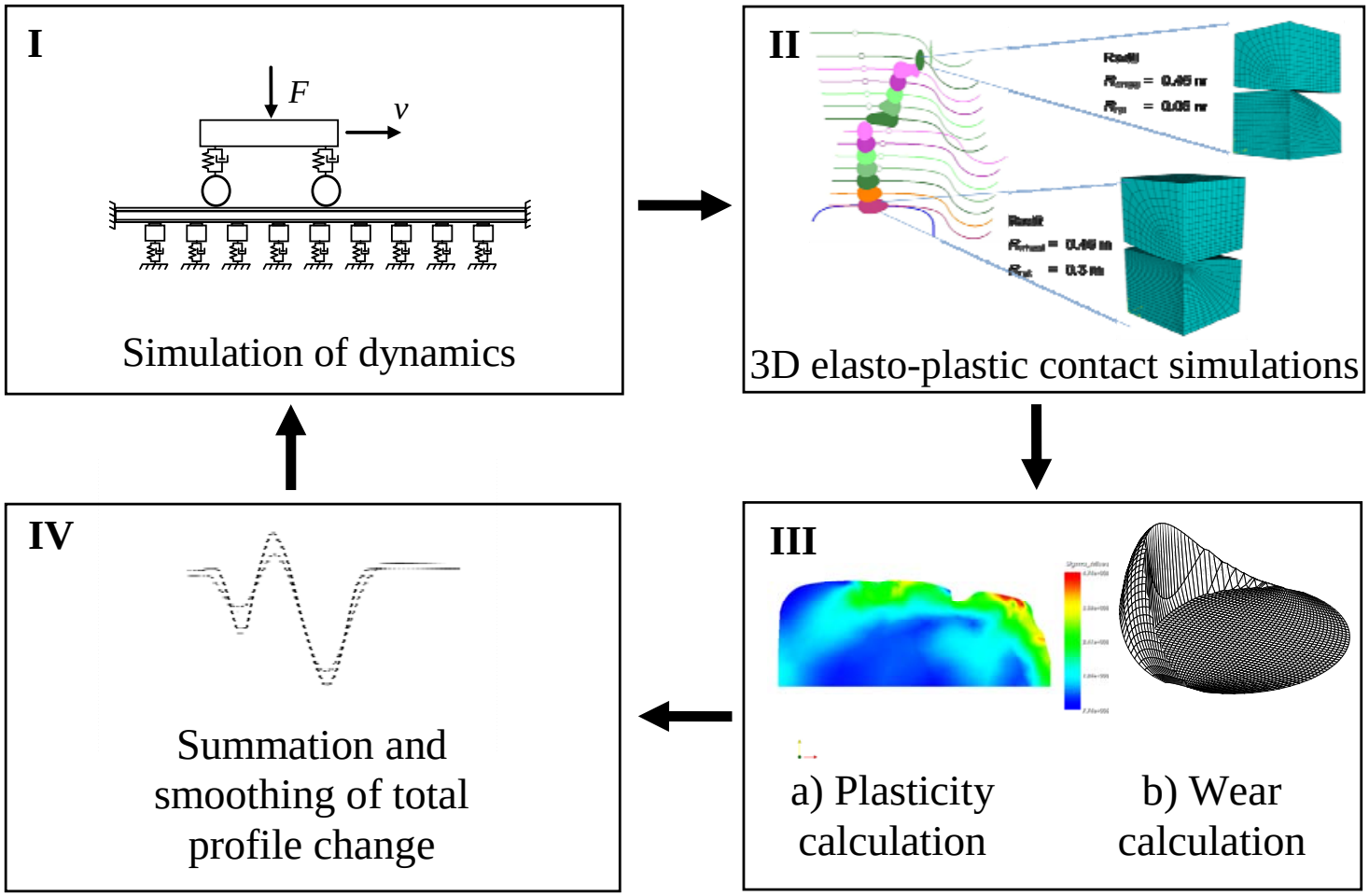
Simulation methodology

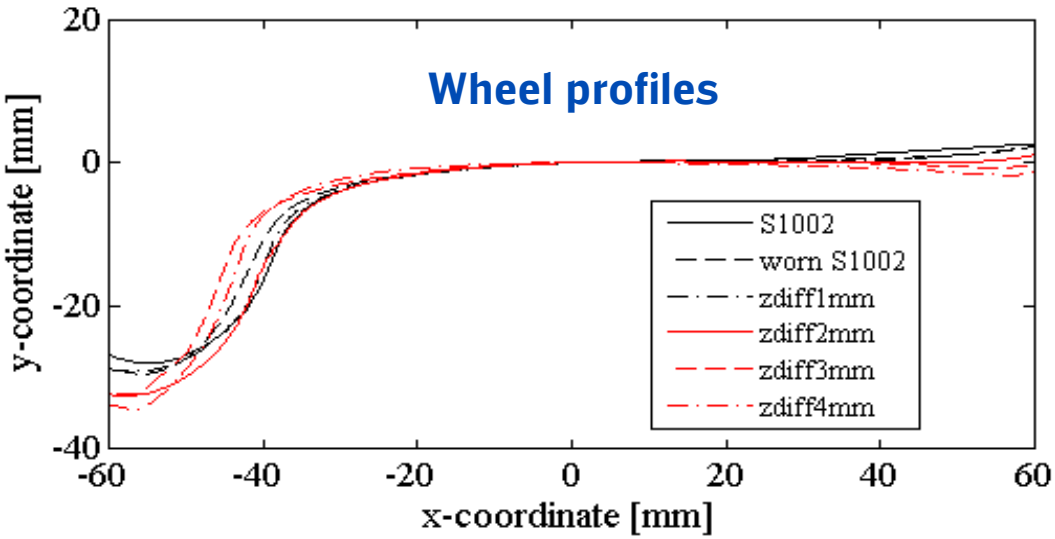


Source: CHARMEC, see [2]

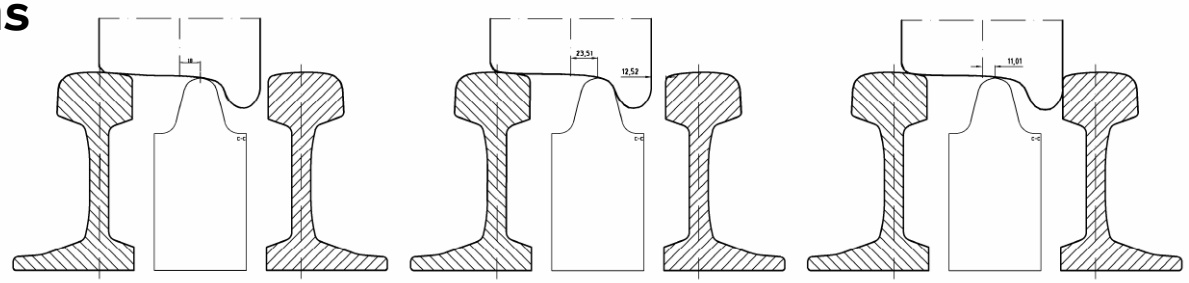
Parameter variation

Simulation Schedule

- **Facing move on through route**
- **Stochastic vehicle parameters:**
  - Six different wheel profiles
  - Three lateral wheel positions
  - Three vehicle speeds: 90, 120, 160 km/h
  - Two vehicle types: BR101 and BR411
- **6·3·3·2 = 108 possible combinations**
- **Creation of a sample set based on estimated probability distributions**
- **Reduction of sample size by Latin Hypercube Sampling**



Initial lateral wheel positions on crossing entry

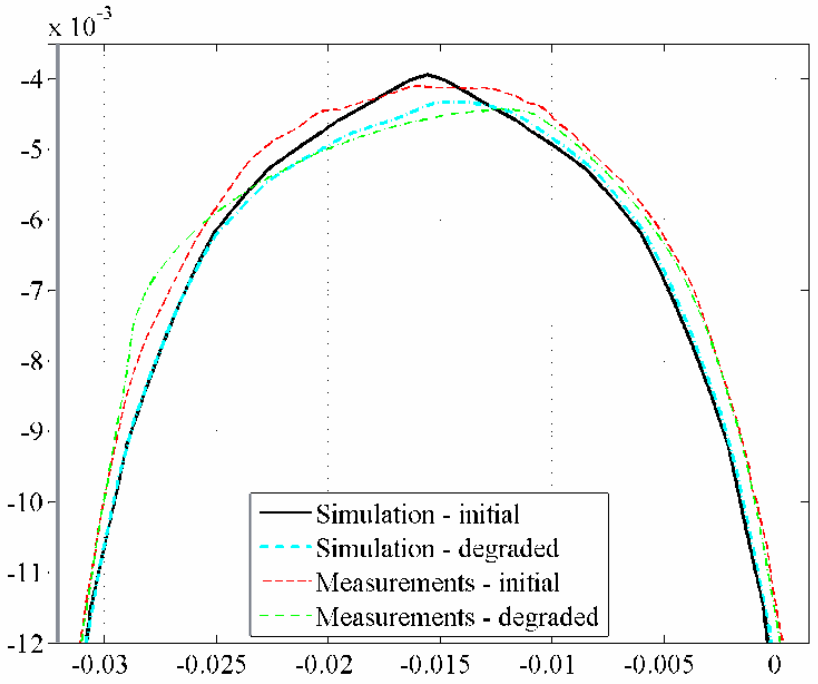


”centred” **”close”** **”far”**

Simulation results

Comparison with field measurements

- **Degradation rate is larger during the first weeks after installation and then it seems to stabilise**
- **Comparison of measured and simulated profiles after five weeks of traffic**
- **Good qualitative agreement**
  - Largest degradations found for similar longitudinal positions along crossing nose
  - Same order of degradation magnitude



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Conclusions

- **Optimization of crossing geometry is essential to reduce the dynamic loads and consequently the Life Cycle Cost of railway turnouts.**
- **The simulation model developed by DB has been successfully validated by wayside force measurements on an in-service crossing of type EH 60-500-1:12.**
- **When comparing different crossing designs the maximum equivalent stresses calculated with CONTACT may show different trends than the maximum normal forces as the locations of the maximum stresses may differ significantly from those of the maximum forces.**
- **For relevant conclusions regarding material degradation the elasto-plastic material behavior has to be taken into account using calibrated non-linear material models.**
- **The related simulation methodology developed in INNOTRACK has been demonstrated on a crossing of R350HT steel showing good qualitative agreement between simulation and measurement after five weeks of train traffic.**

Remaining tasks

- Validation of simulation methodology for a longer period of operation (done for 5 weeks of traffic only)
- Investigation of 3 different crossing materials regarding plastic deformation and wear
- Further improvement of crossing geometry „MaKüDe“
- Comparison of long-term degradation of innovative crossing geometries

Thank you for listening!

The author wishes to acknowledge the support of the European Commission under the FP6 project INNOTRACK and would like to thank all the project partners for the constructive and fruitful cooperation.

[1] A. Theiler: Numerische Untersuchung der Beanspruchung im Rad-Schiene-Kontakt, Dissertation TU Berlin, 2005

[2] D. Nicklisch, J. C. O. Nielsen, M. Ekh, A. Johansson, B. Pålsson, J. M. Reinecke, A. Zoll: Simulation of wheel rail contact forces and subsequent material degradation in switches & crossings, Proceedings 21st International Symposium on Dynamics of Vehicles on Roads and Tracks, Stockholm, 2009