ADtranz

A Fast Wheel-Rail Forces Calculation Computer Code

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Contents

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- Methods for the calculation of wheel-rail forces
- Principle of proposed method
- Comparison of proposed method with FASTSIM
- Comparison of simulations using two different methods
- Comparison with measurements
- Experience with use of proposed method
- Conclusions

Methods for Calculation of Wheel-Rail Forces

- Exact theory by Kalker (CONTACT)
- Simplified theory by Kalker (FASTSIM)
- Look-up tables
- Simple saturation functions

Methods for Calculation of Wheel-Rail Forces
Disadvantages of Common Methods

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- Exact theory by Kalker (CONTACT)
  - Very long calculation time
- Simplified theory by Kalker (FASTSIM)
  - Too long calculation time in comparison with other methods

Methods for Calculation of Wheel-Rail Forces
Disadvantages of Common Methods

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- Look-up tables
  - Limited data
  - Pre-calculation necessary
- Simple saturation functions
  - Spin usually not considered
  - Significant differences to the exact theory

Methods for Calculation of Wheel-Rail Forces
Advantages of Proposed Method

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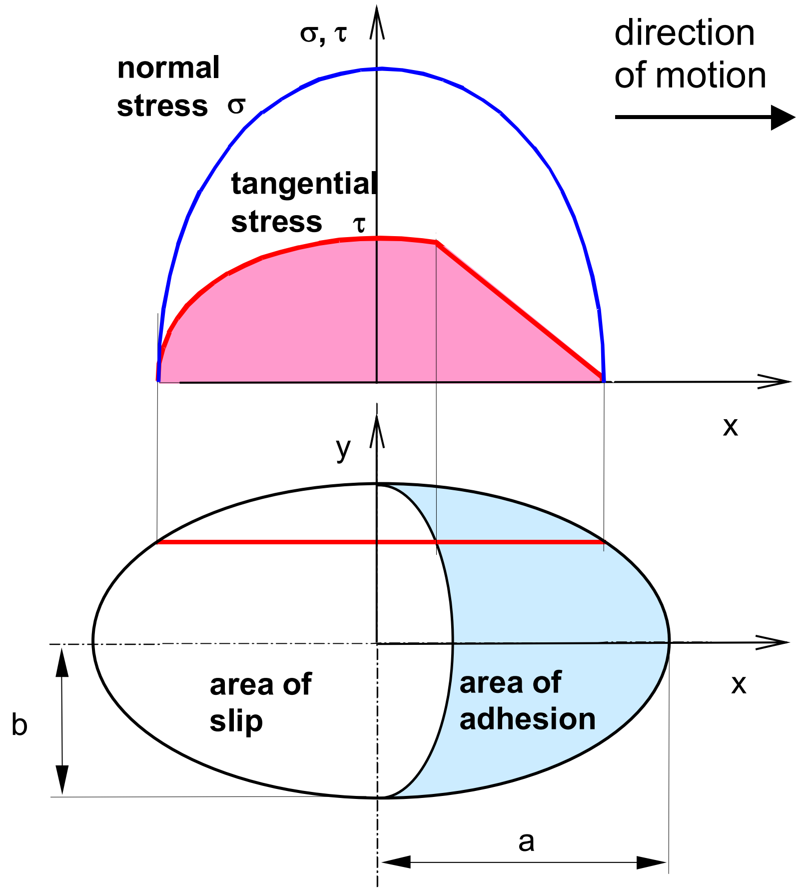
- Compromise between calculation time and necessary accuracy
- Spin taken into account
- Calculation time comparable with saturation functions or look-up tables
- Pre-calculation superfluous
- Accuracy comparable with FASTSIM or look-up tables

Principle of Proposed Method
Assumptions

- Ellipsoidal contact area according to Hertz
- Coefficient of friction is constant
- Contact area is divided into area of adhesion and area of slip
- Maximal tangential stress is

$$\tau_{\max} = f . \sigma$$

- Linear growth of tangential stress in area of adhesion



Principle of Proposed Method
Transformation

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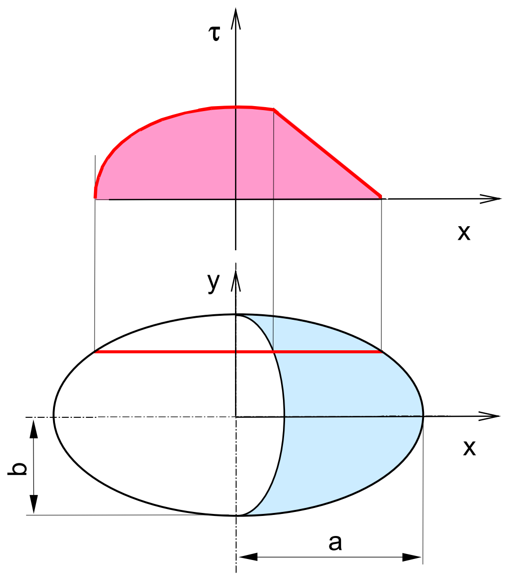
Ellipsoid

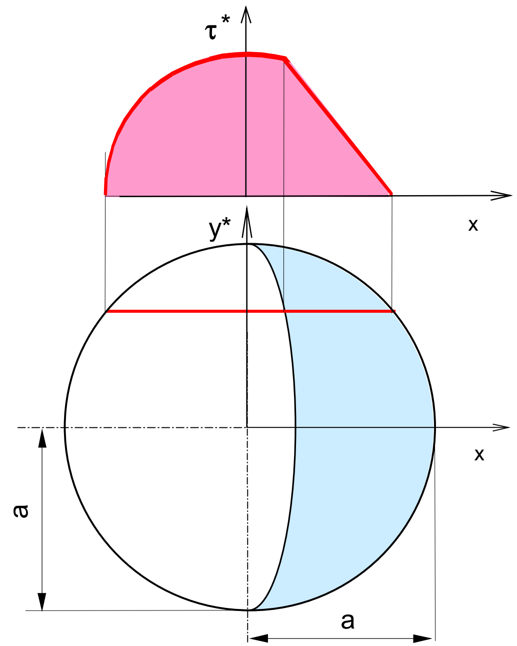


Transformation

$$y^* = \frac{a}{b}\, y$$

$$\tau^* = \frac{a}{\tau_0}\, \tau$$

Hemisphere



Tangential force:

$$F = \iint_{(U)} \tau \; dx\, dy = -\frac{2.Q.f}{\pi}\left(\frac{\varepsilon}{1+\varepsilon^2} + \arctan\varepsilon\right), \quad where \quad \varepsilon = \frac{2}{3}\,\frac{C.\pi.a^2.b}{Q.f}\, s$$

Principle of Proposed Method
Case of Pure Spin

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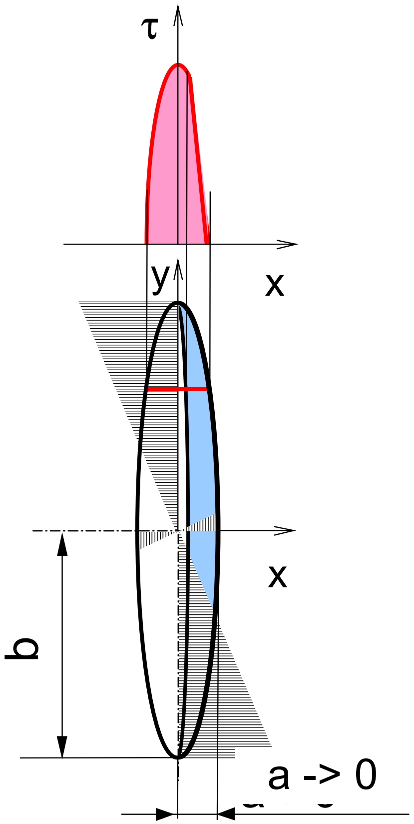
a -> 0



Using the transformation to a hemisphere:

$$F_y = -\frac{3}{8}\pi \,.\, \tau_0 \,.\, a \,.\, b \left[|\varepsilon| \left(\frac{\delta^3}{3} - \frac{\delta^2}{2} + \frac{1}{6} \right) - \frac{1}{3}\sqrt{\left(1-\delta^2\right)^3} \right]$$

$$where \quad \delta = \frac{\varepsilon^2 - 1}{\varepsilon^2 + 1}$$

Principle of Proposed Method
Use of the Proposed Method

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- On the basis of experiment

  Constant C given by comparison with experiment

- As a fast solution with the constants from Kalker

$$C = \frac{3}{8}\frac{G}{a}c_{jj} \qquad where \quad c_{jj} = \sqrt{\left(c_{11}\frac{s_x}{s}\right)^2 + \left(c_{22}\frac{s_y}{s}\right)^2}$$

$$C_S = \frac{4}{\pi}\frac{G.\sqrt{b}}{\sqrt{a^3}}c_{23}$$

Principle of Proposed Method
Full Solution: Programme ADH

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INPUT :

- Wheel load
- Coefficient of friction
- Modulus of rigidity
- Semiaxis of contact ellipse
- Kalker‘s constants
- Longitudinal and lateral creep
- Spin

OUTPUT :

- Longitudinal force
- Lateral force

Comparison with Programme FASTSIM

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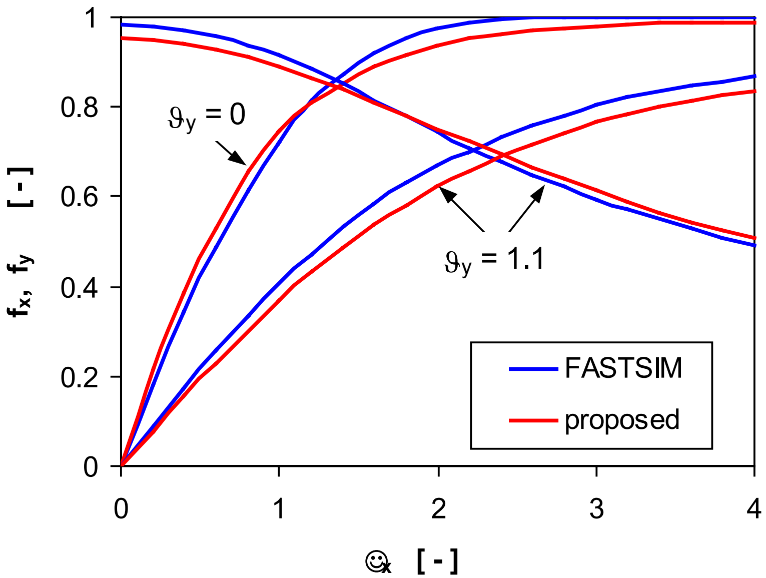
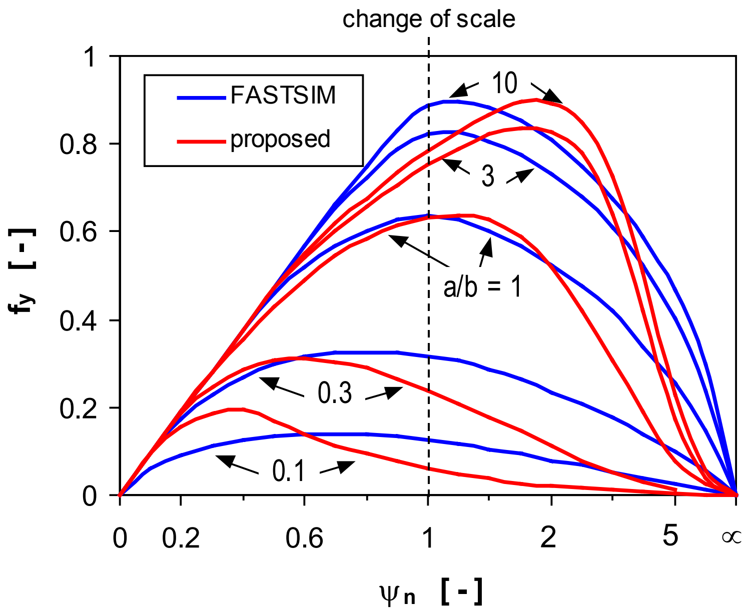
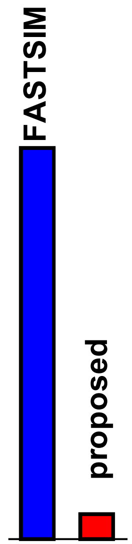
longitudinal and lateral creep



pure spin



calculation time



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Comparison with Programme FASTSIM

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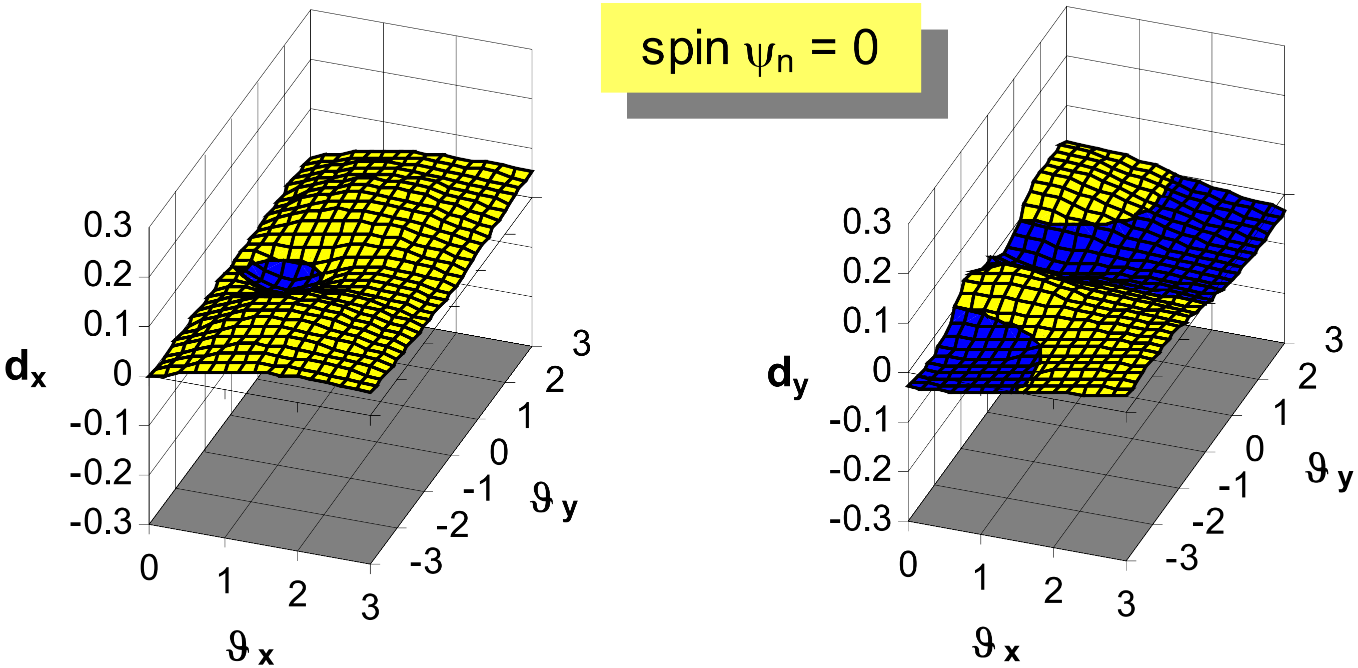
Difference between the two methods:

$$d_i = f_{iK} - f_{iP} \qquad\qquad i = x, y$$



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Comparison with Programme FASTSIM

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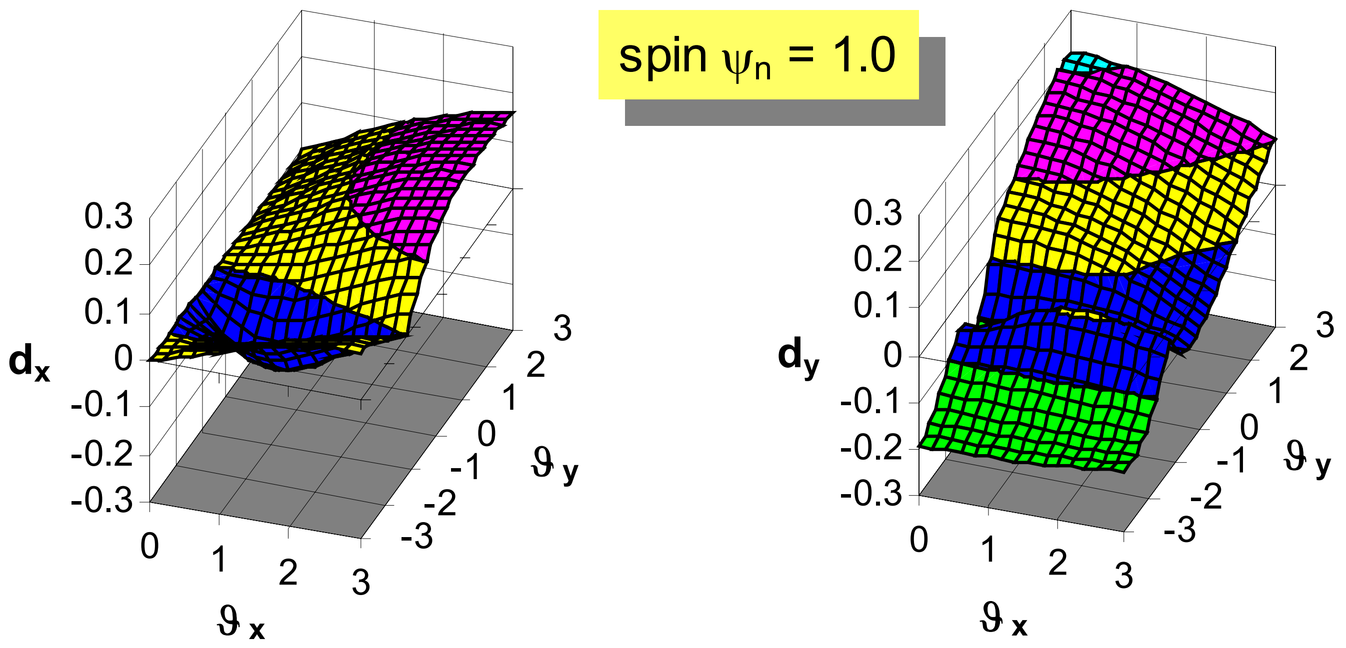
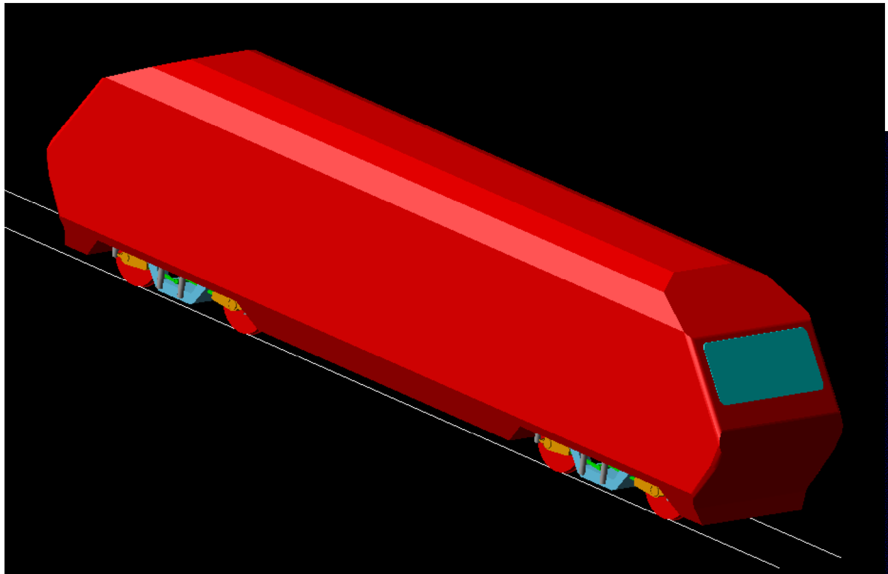
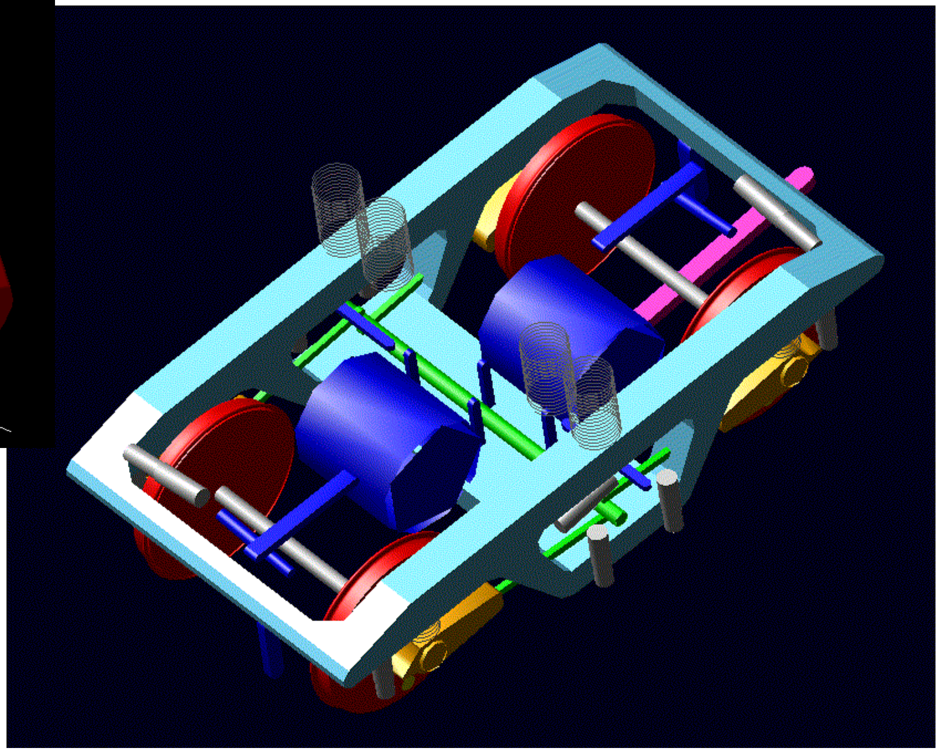


Comparison of Simulations
ADAMS/Rail Model





- 51 rigid bodies
- 84 bushings
- 4 bump-stops
- 24 dampers

Comparison of Simulations
ADAMS/Rail Model

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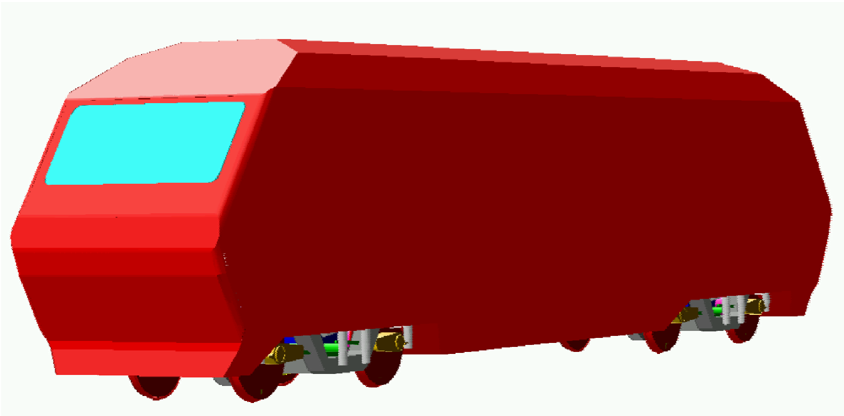

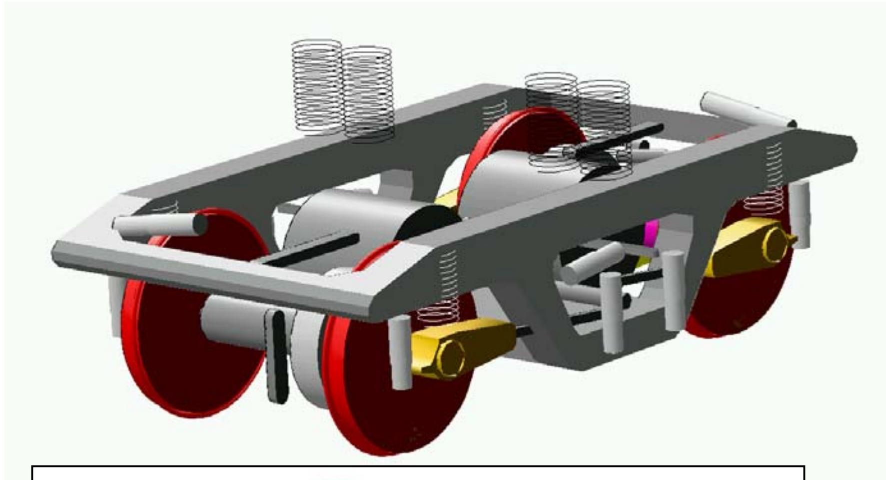

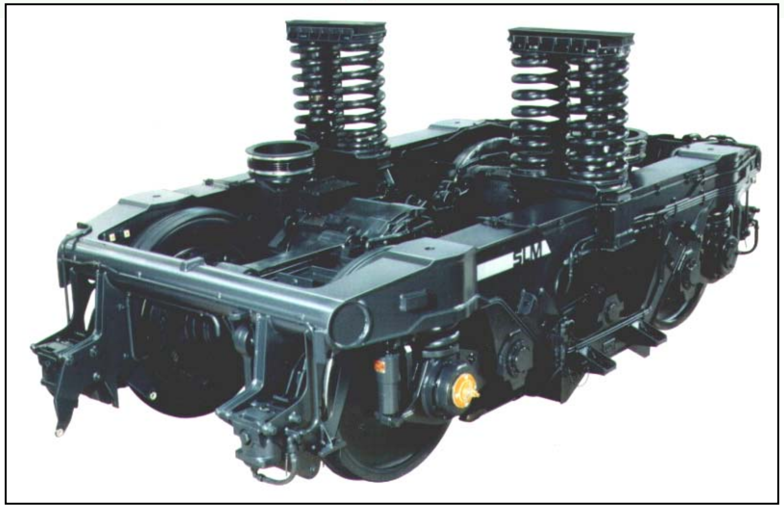

Comparison of Simulations
Use of FASTSIM and of Proposed Method

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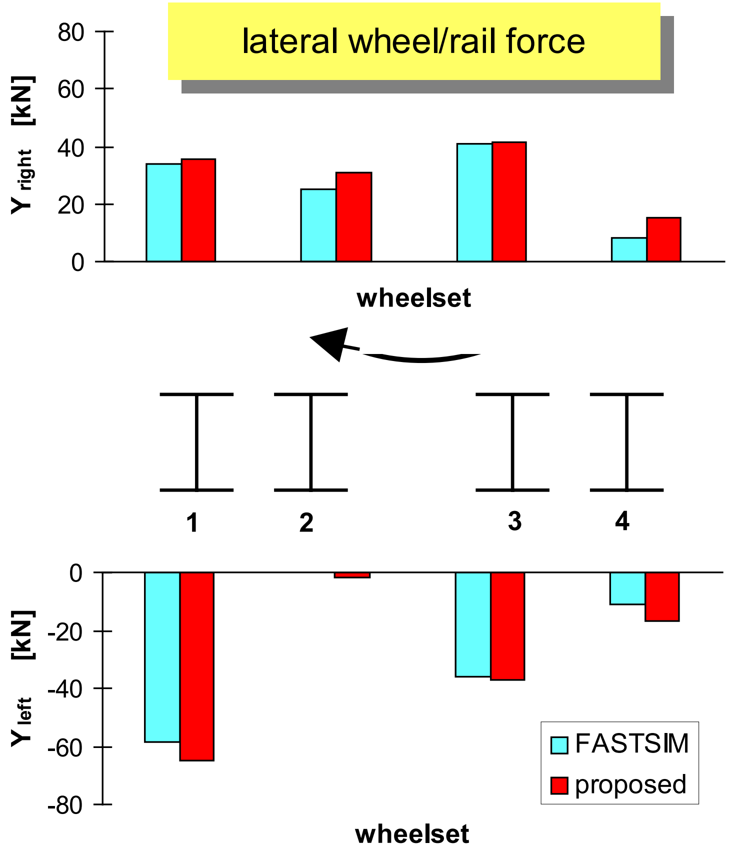
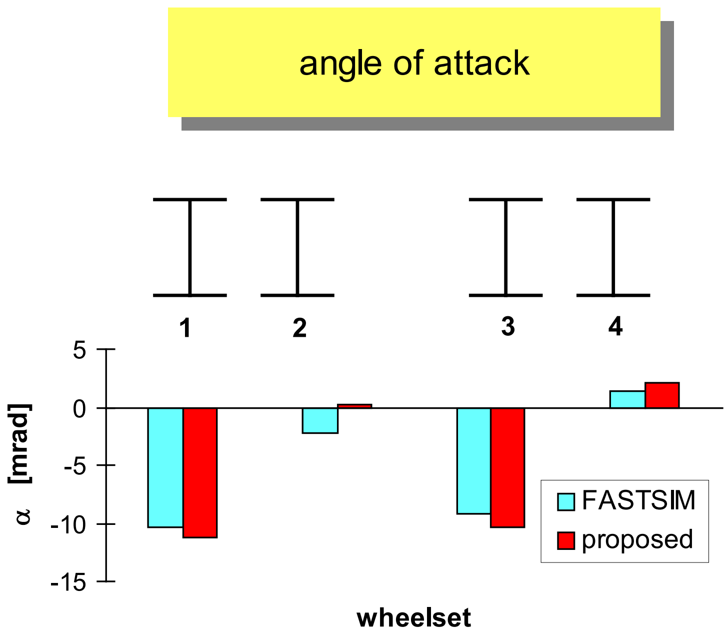
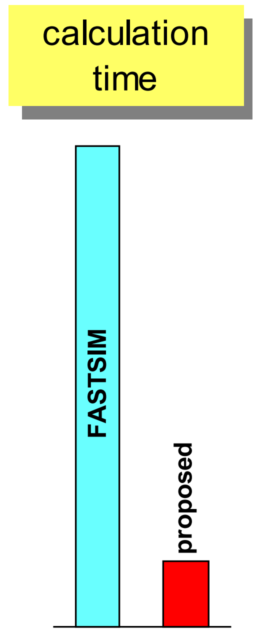
R = 150 m, a_{lat} = 0 m/s²
soft axle guidance







Comparison of Simulations
Use of FASTSIM and of Proposed Method

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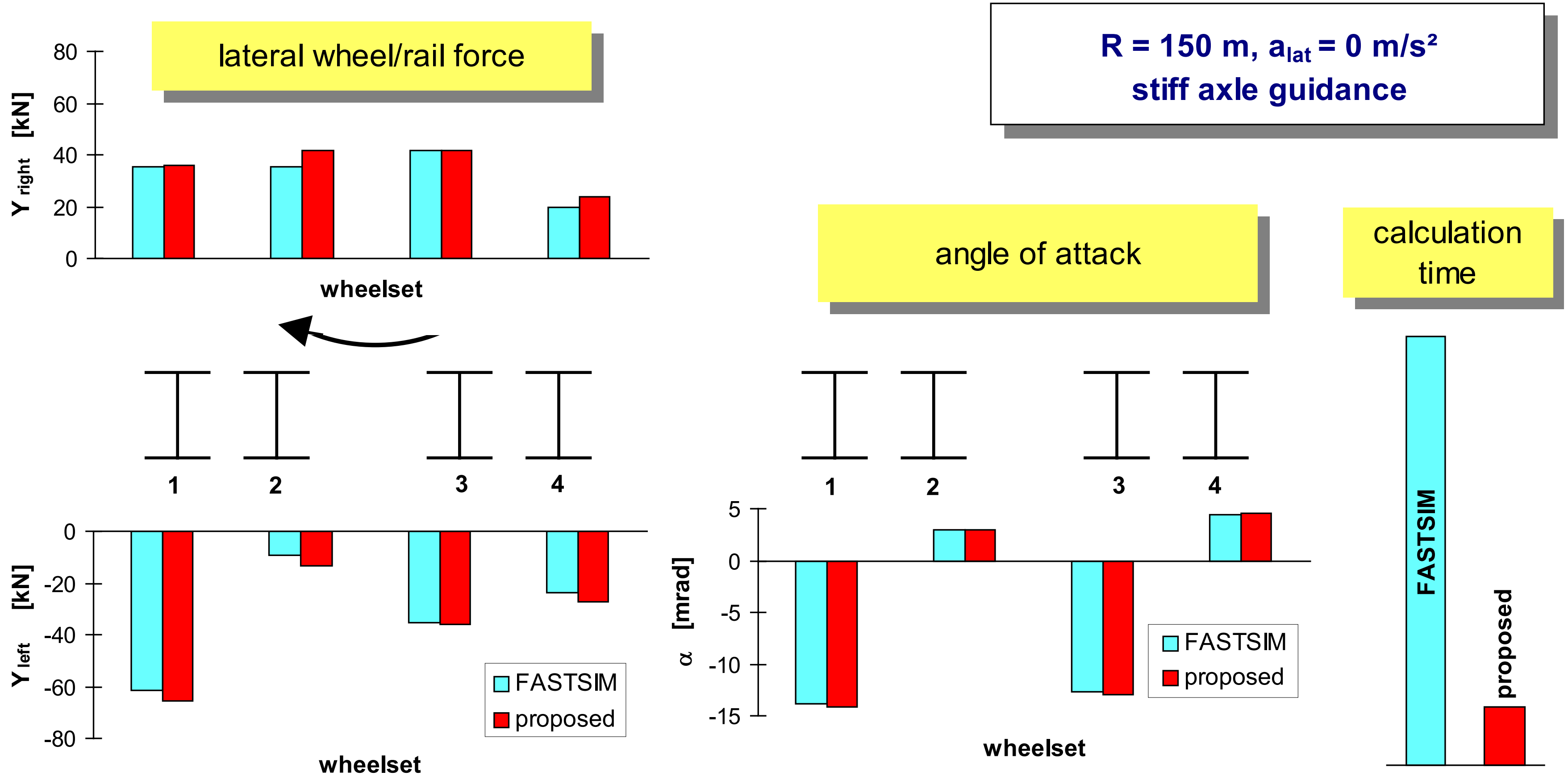
R = 150 m, a_{lat} = 0 m/s²
stiff axle guidance



Comparison of Simulations
Use of FASTSIM and of Proposed Method

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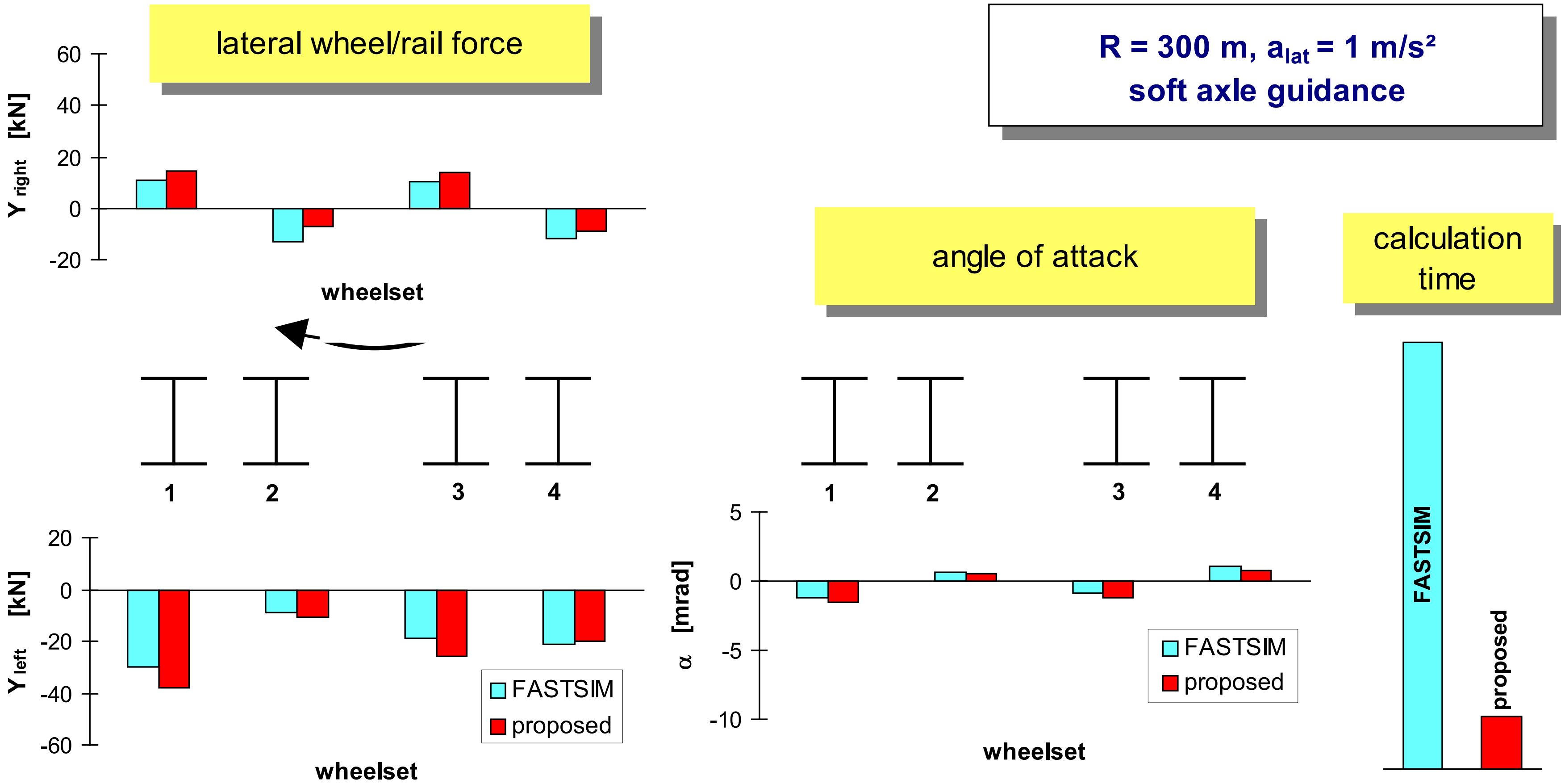
R = 300 m, a_{lat} = 1 m/s²
soft axle guidance



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Comparison of Simulations
Use of FASTSIM and of Proposed Method

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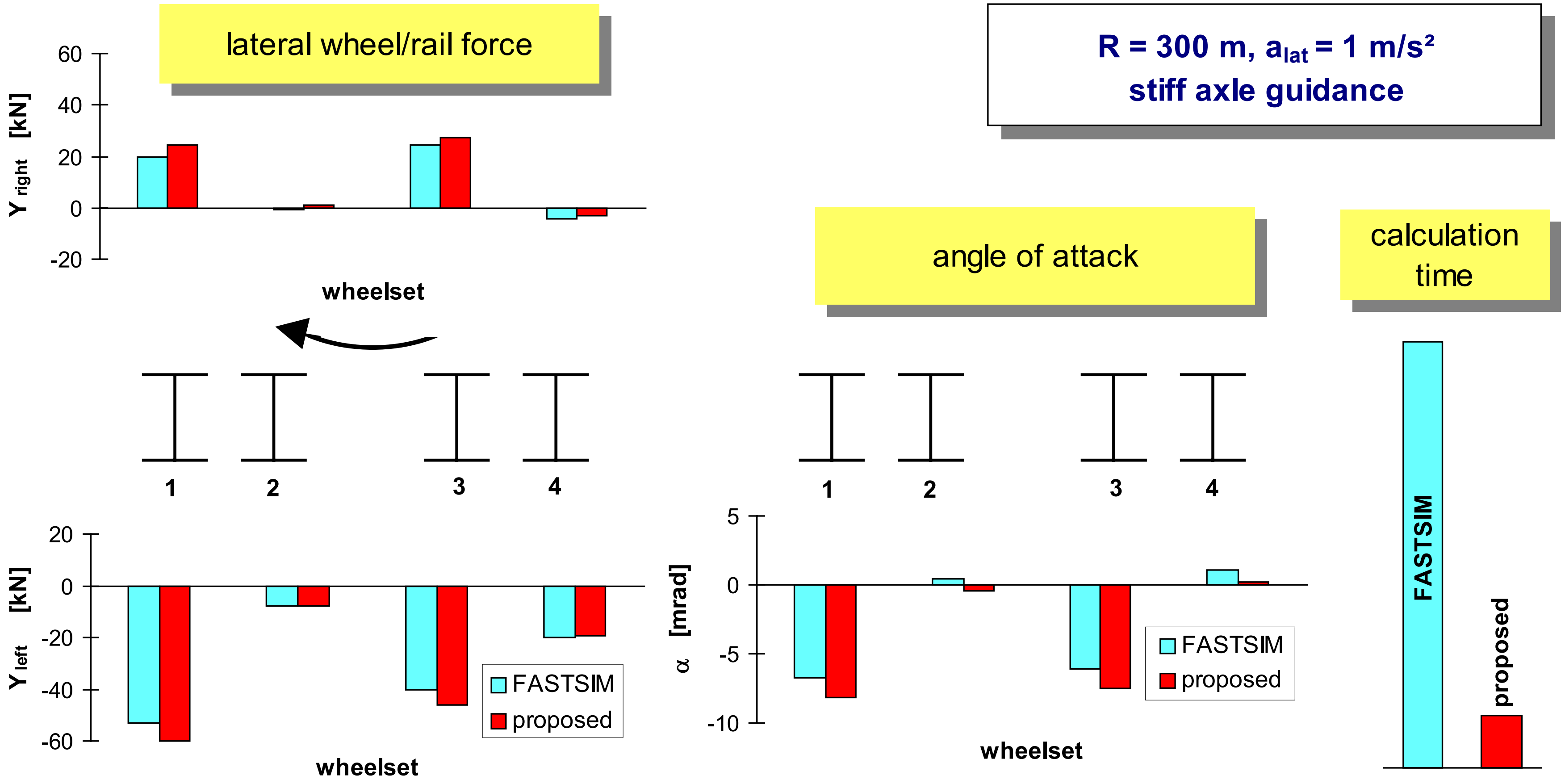

Comparison with Measurements

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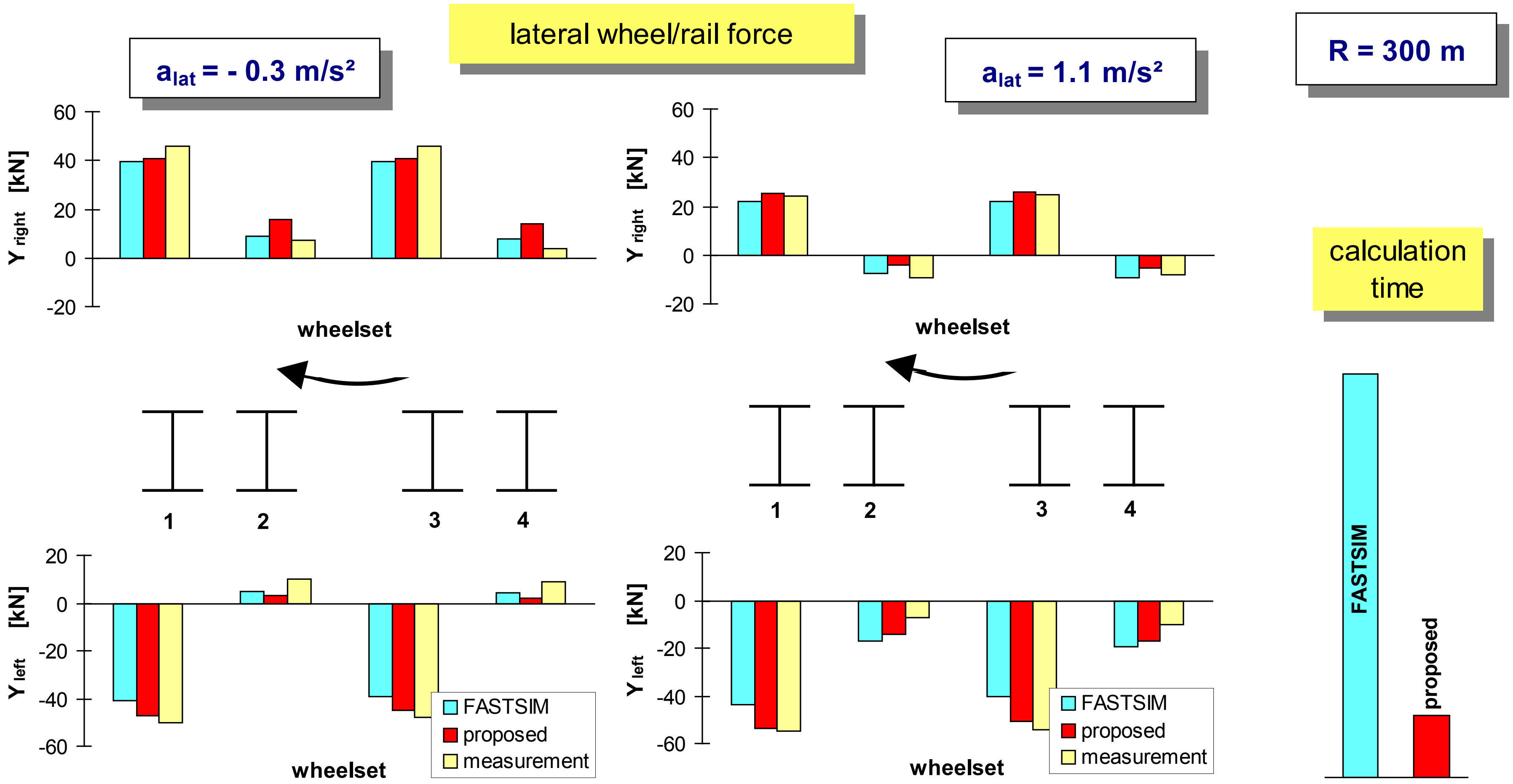

Comparison with Measurements

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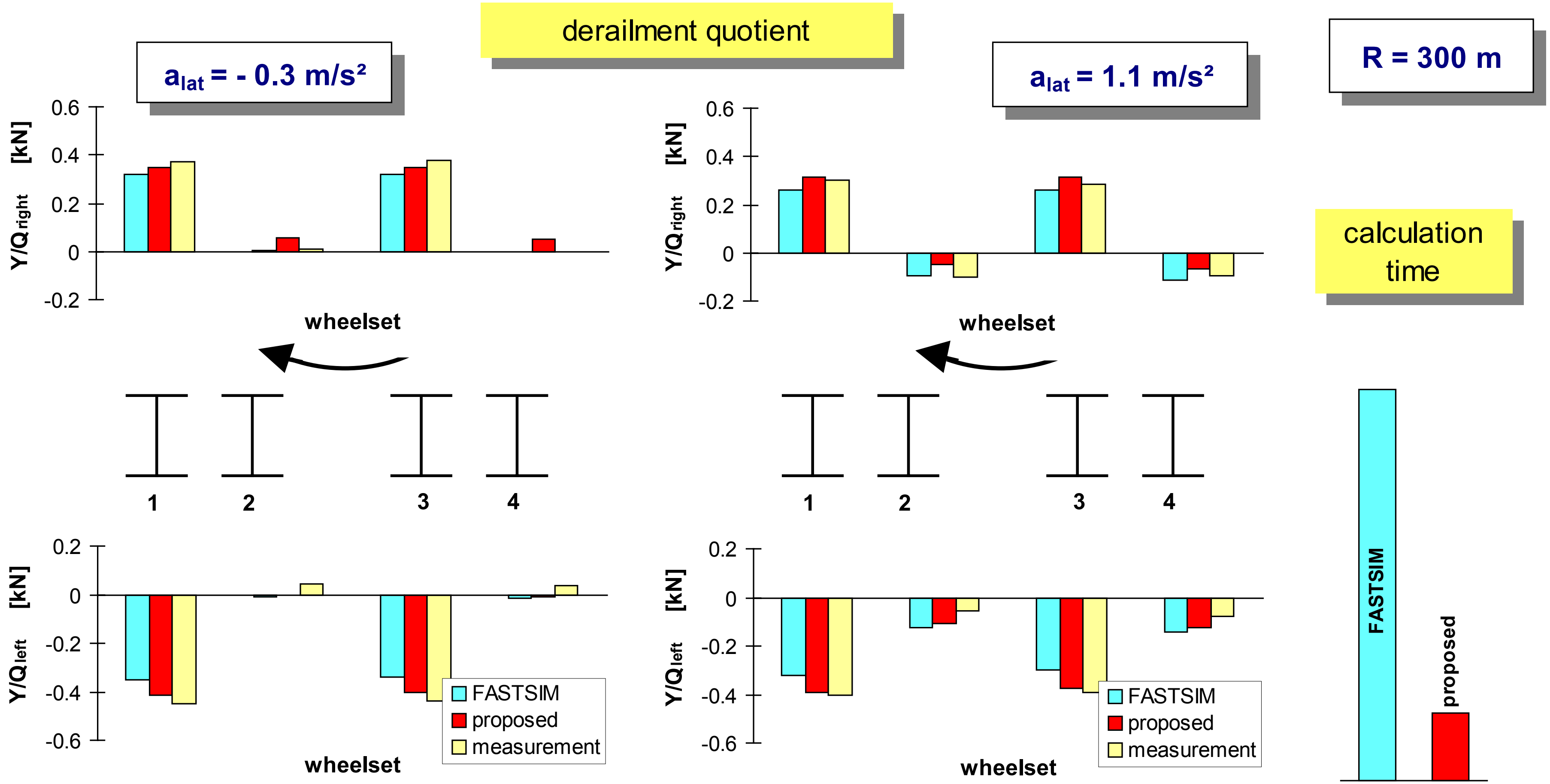

Experience with Use of Proposed Method

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- Algorithm in use in different programmes since 1990
- Positive experience in research as well as in industrial application
- Standard method in the programme ADAMS/Rail
- Tested and possible for use as user routine in programmes: SIMPACK, MEDYNA, GENSYS, SIMFA

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Proposed method

- Is a fast alternative to Kalker's method
- Allows calculations of full non-linear wheel-rail forces
- Takes spin into account
- Makes saving of pre-calculated values superfluous
- Shows good agreement in comparison with measurements
- Has been used in different simulation tools with very good experience