voestalpine Railway Systems

Design, Simulation & Validation of modern high speed turnouts

POLSPEED2023 - Scientific and technical Conference
“Development of high speed rail in Poland”

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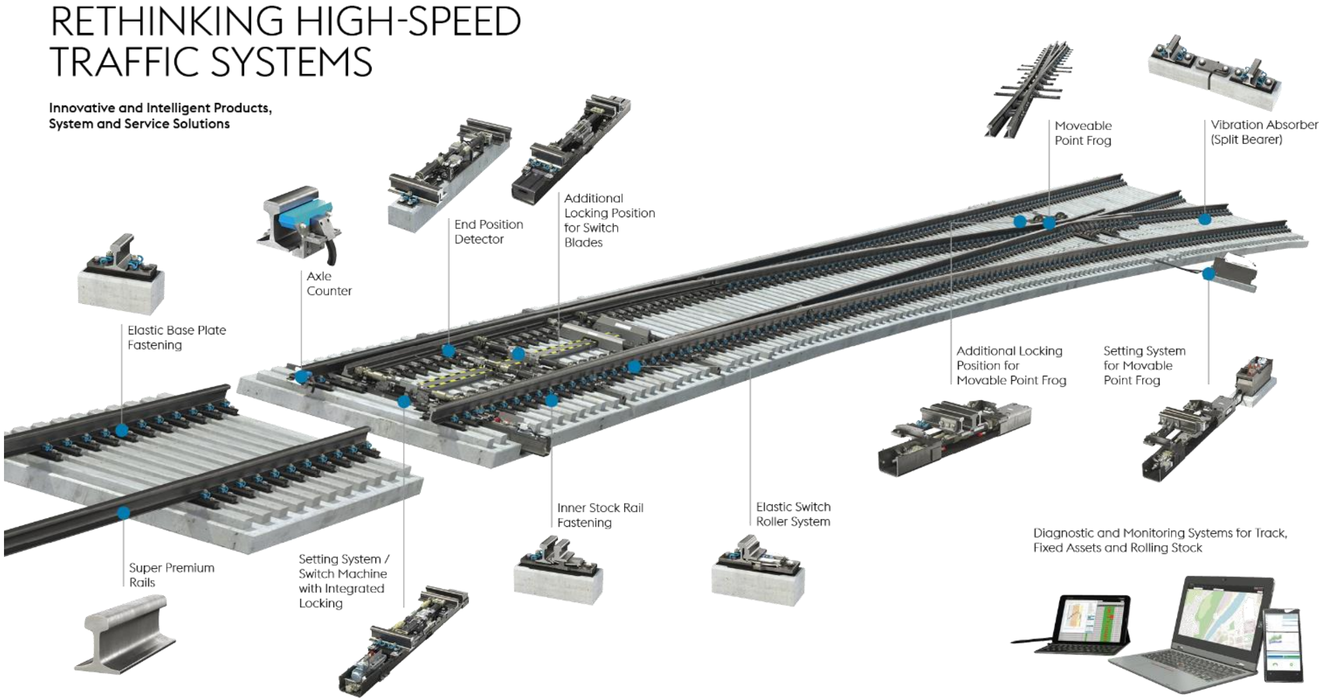
www.voestalpine.com/railway-systems

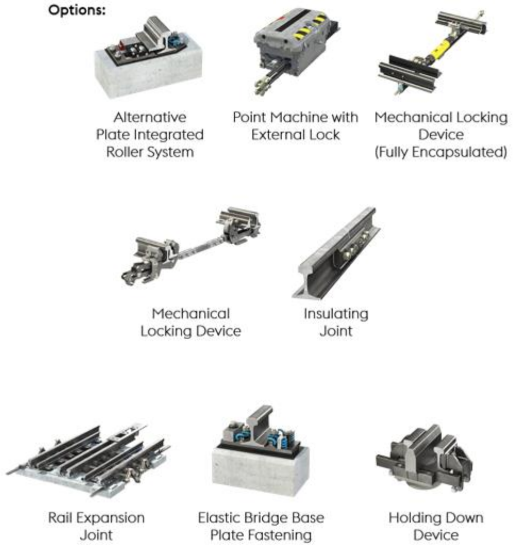
HS – Turnouts @ voestalpine Railway Systems

- voestalpine Railway Systems (vaRS) is a full-range supplier of High Speed railway infrastructure
- Our integrated High Speed Turnout System approach is supervised by the vaRS Competence Center High Speed, located in Brandenburg Germany
- Current focus on
  - Increase speeds in turnouts to 350km/h +
  - Raise the train frequencies and reliability
  - Optimize life cycle costs and maintainability
  - Ensure maximum safety, availability and passenger comfort
- To guarantee these objectives, an embedded engineering approach is necessary

Integrated High Speed Turnout System by voestalpine Railway Systems

RAILWAY SYSTEMS by voestalpine





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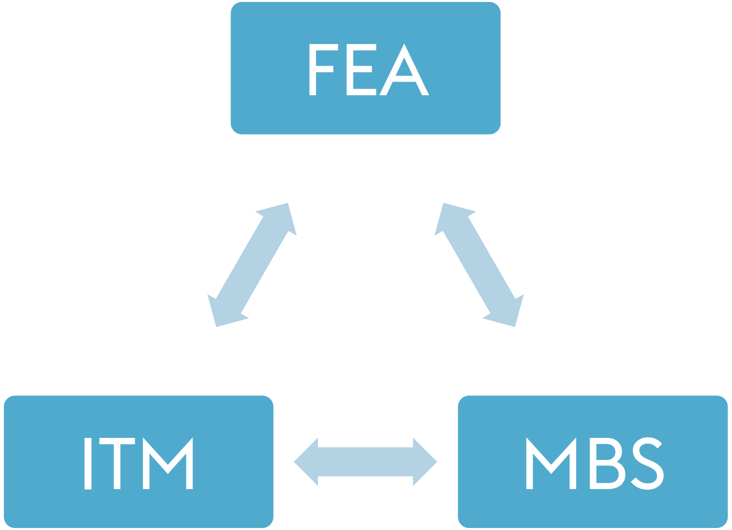
Motivation

- High speed turnouts are one of the key technologies for building and operating a high speed (HS) railway network
- Turnouts have a big impact on the safety and stability of passing by trains, especially in case of HS applications
- Combining theoretical investigations with practical in-track measurements during the engineering phase of a HS turnout, bring the chance to close the loop and validate the proposed theoretical assumptions
- This embedded engineering approach is necessary to guarantee the safety, availability and reliability of a modern HS turnout over the full life time in track
- The embedded engineering approach for HS turnouts at voestalpine Railway Systems is presented by some insights on the following slides

Embedded engineering approach @ vaRS

- Combination of theoretical
  - Finite Element Analysis (FEA)
    - structure’s mechanical behavior
  - Multi Body Simulations (MBS)
    - dynamical vehicle/ track interaction
  - and practical in-track measurements (ITM)
    - validate the proposed theoretical assumptions
- Possibility to learn from simulations and on-site measurements and validate the proposed theoretical assumptions

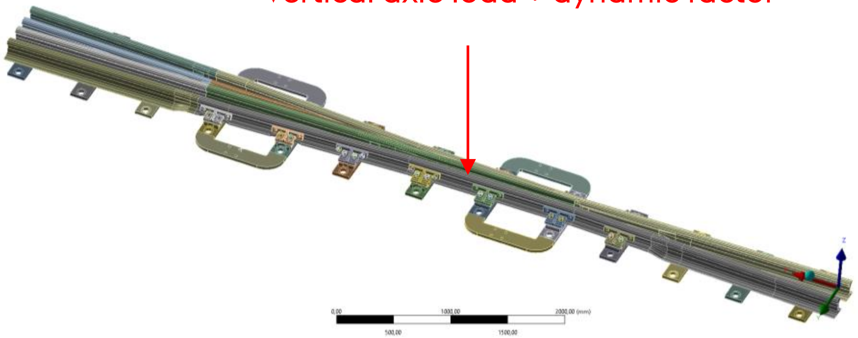


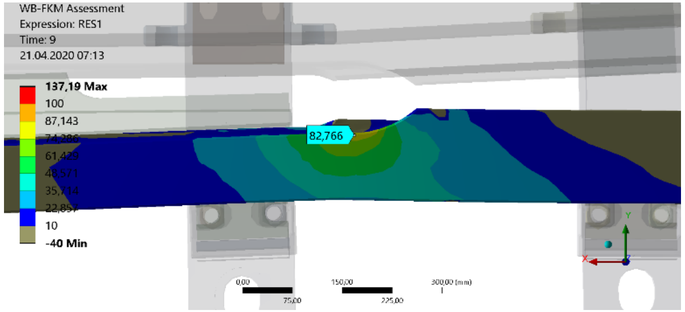
Simulation

FEA – Static approach

» The classical procedure, linear elastic FEA with dynamic factor at load assumption, ...

Vertical axle load + dynamic factor





...is not fully sufficient to describe the occurring dynamics!

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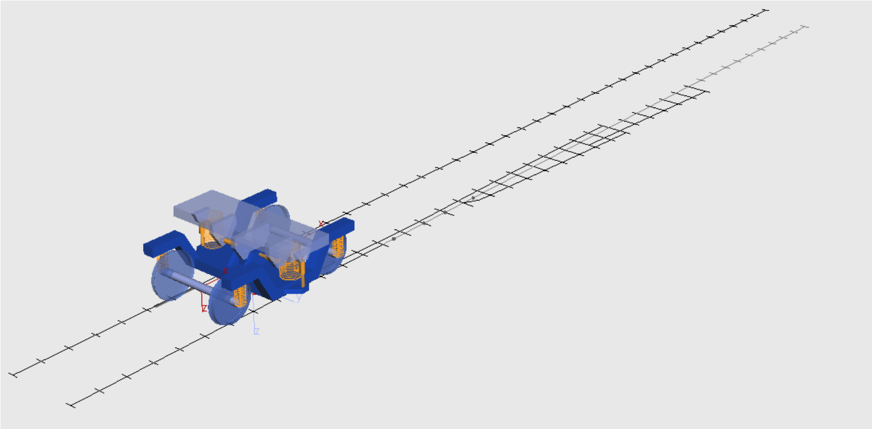
Simulation

New simulation approach

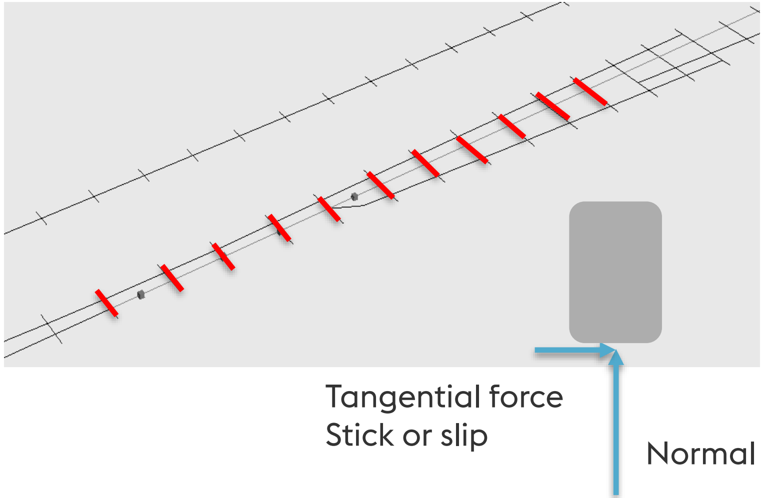
- Combining FEA and MBS to describe the mechanical behavior of the structure under dynamic load
- Set up a MBS simulation with sophisticated model therefor
  - SIMPACK with Manchester Benchmark vehicle
    - with modified suspension for HS
    - and 18 tons axle load
  - Flextrack model
    - Beams for base plates and rails
    - Bushing elements to model couplings between swing nose and crossing panel
  - 350 km/h (worst case) unless otherwise stated



Simulation

MBS – Detailed model features

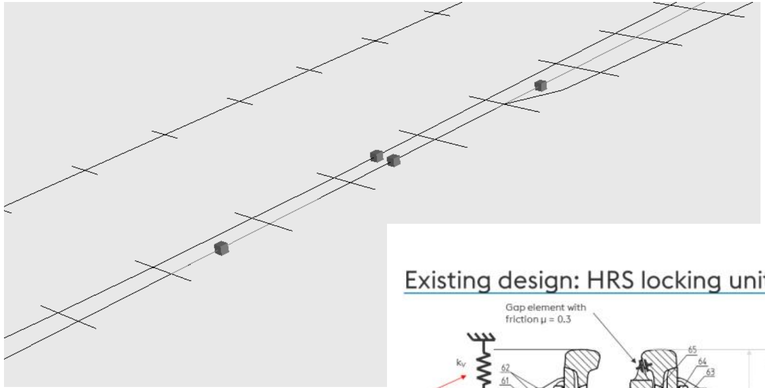
» Baseplates:

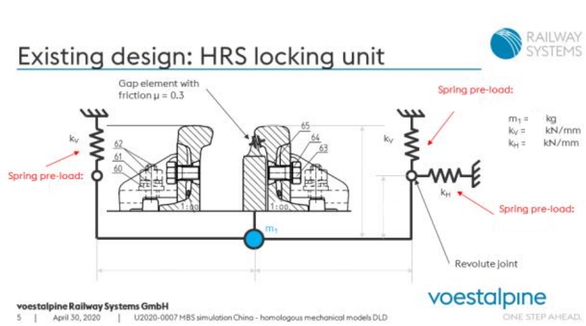


Tangential force
Stick or slip

Normal force

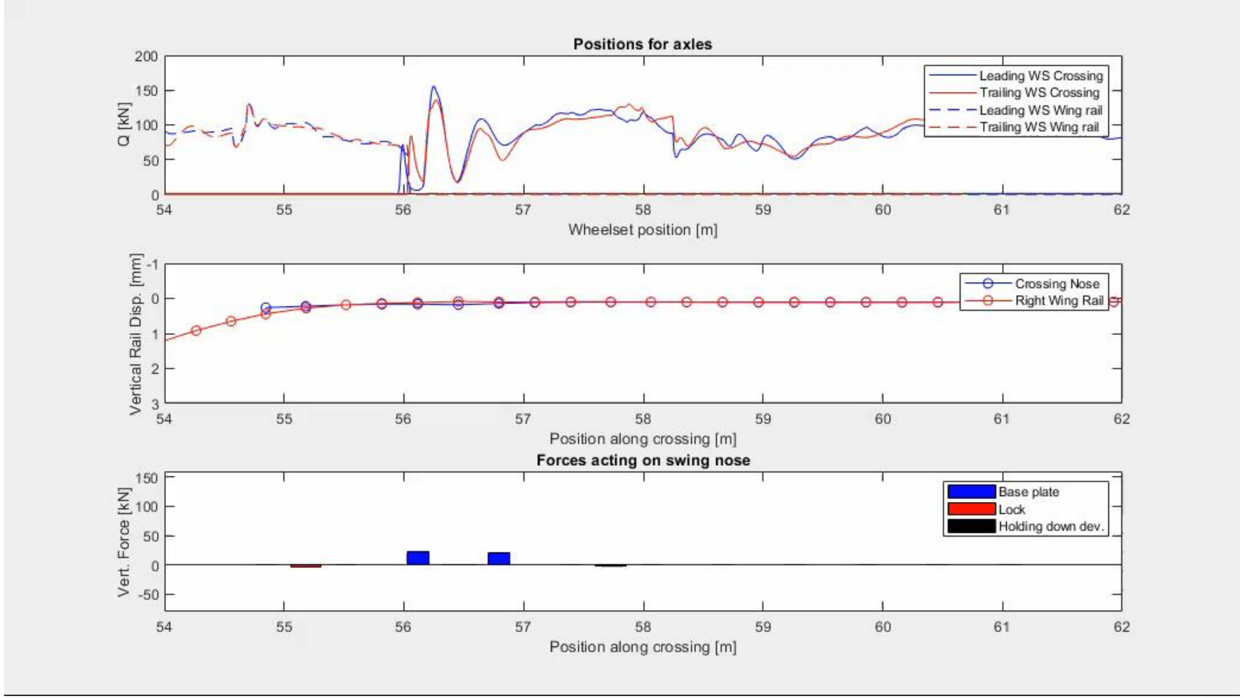
» Locks:





Simulation

MBS – Results



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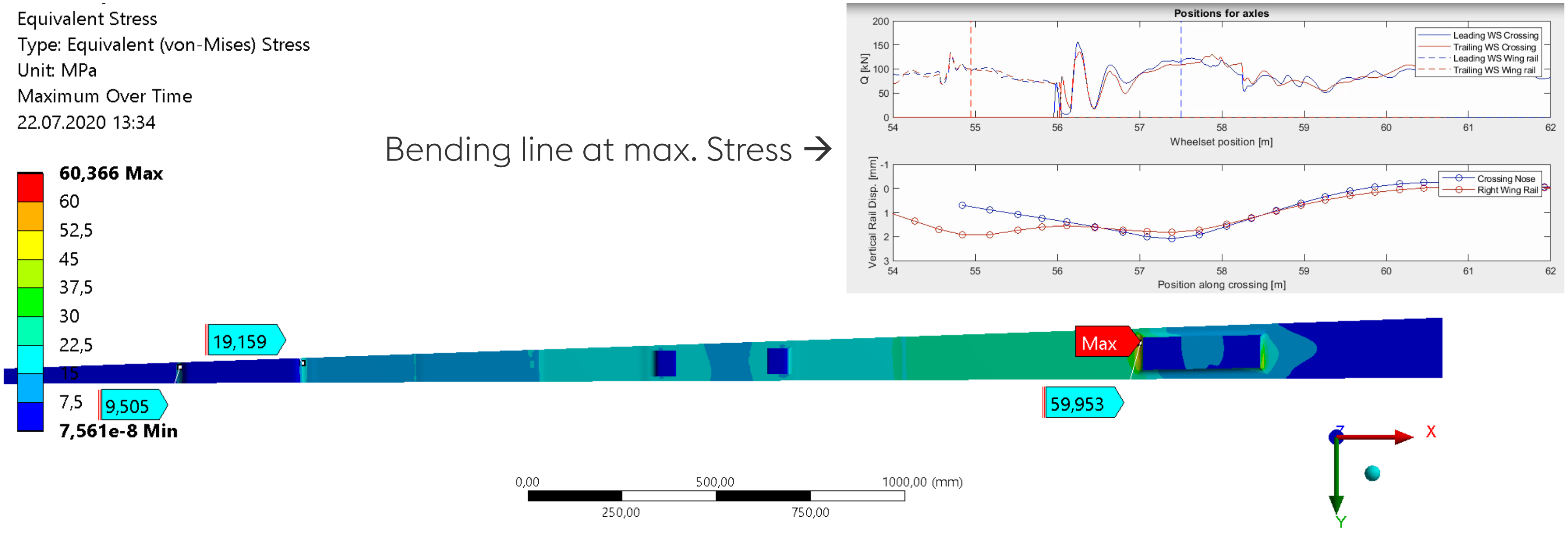
Simulation

Transfer back to FEA

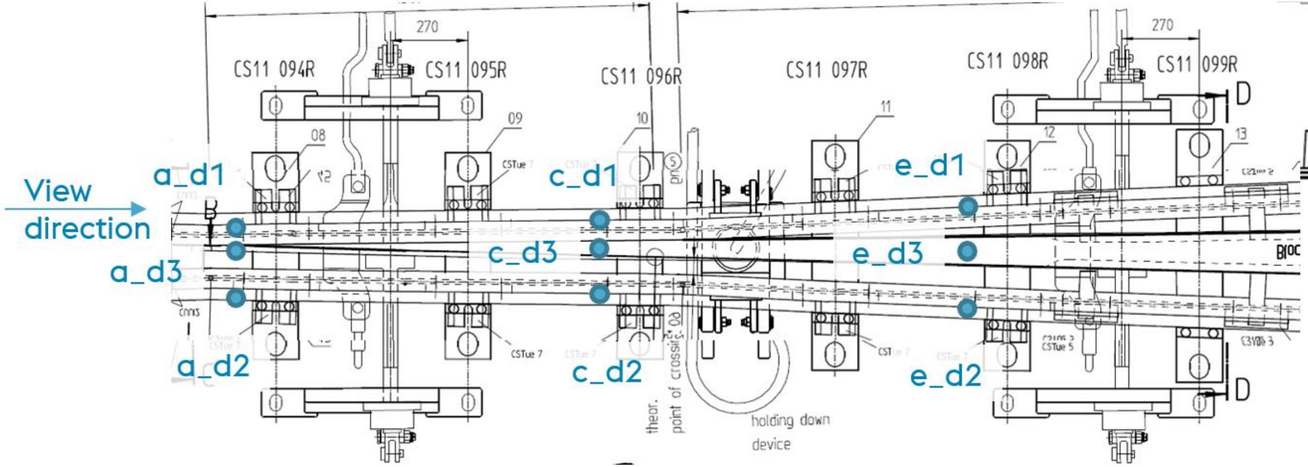
» Transfer back the loads from MBS results to FEA as input parameter

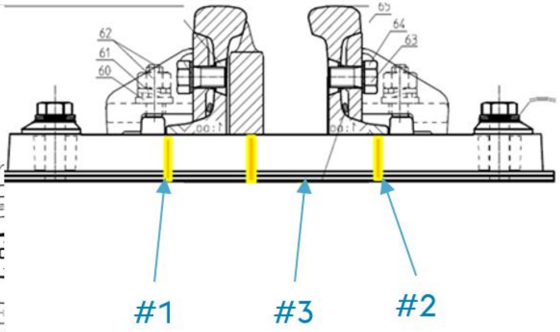


On-site measurements

Deflection – Measurement setup

» Deflection measurements on swing nose crossing





Displacement sensor (inductive)

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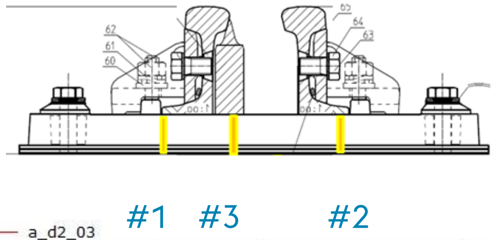
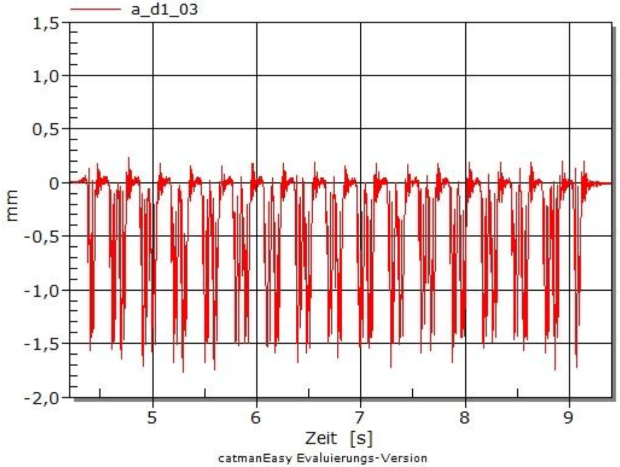
On-site measurements

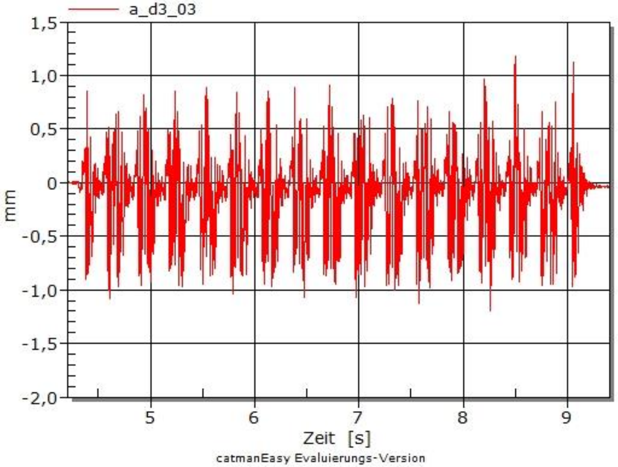
Deflection – Measurement results

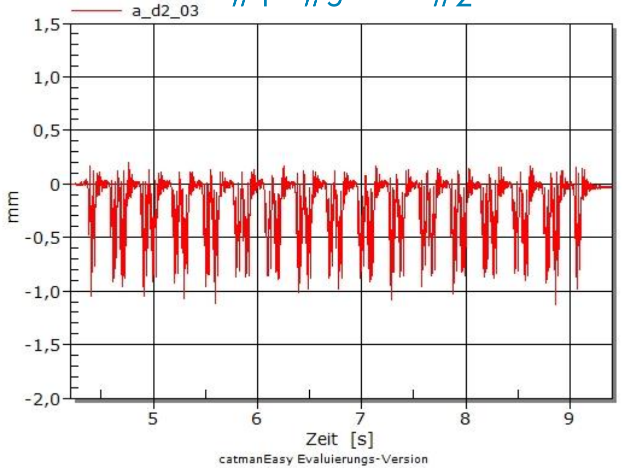
» 1st Measurement plane: a – Trailing move – 300 km/h

» Wheel load on left wing rail, vibration load on crossing nose



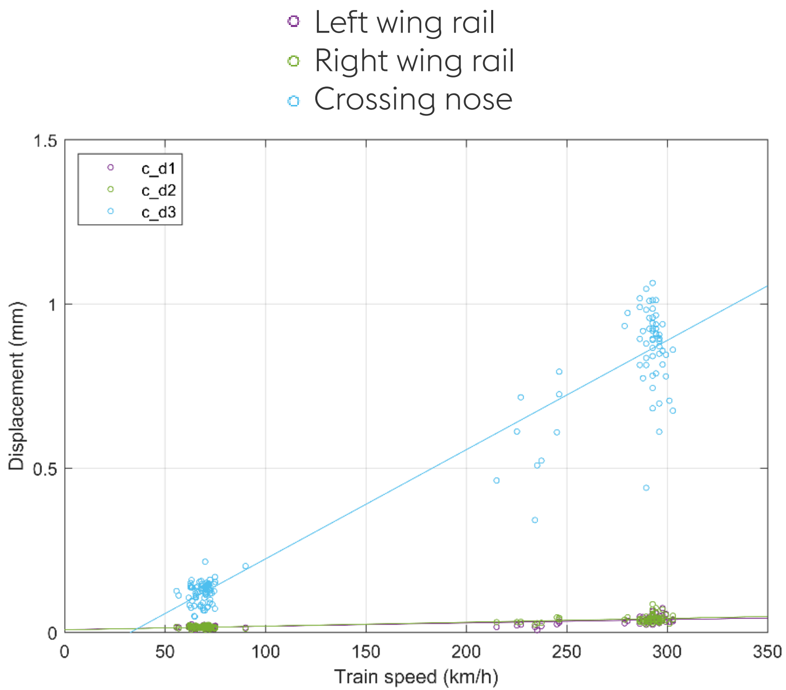






On-site measurements

Deflection – Measurement results interpretation



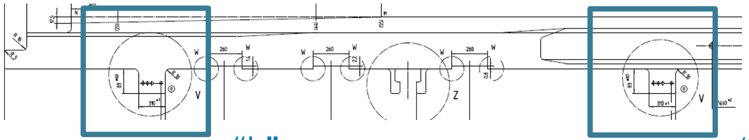
» Speed dependence for upwards movement of crossing nose can be clearly seen

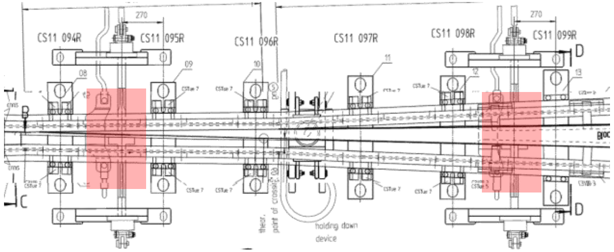
» The dynamic effects are also visible on the wing rail, but significantly lower

On-site measurements

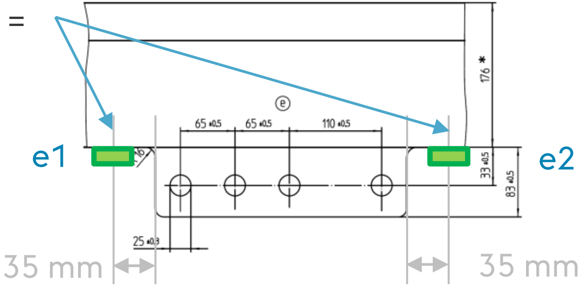
Strain gauges – Sensors Positions

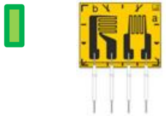
» Crossing nose and drive connection strain gauges :





Lateral position = centred



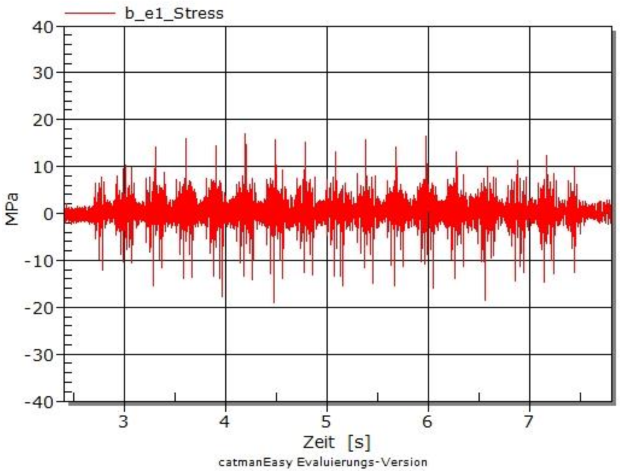


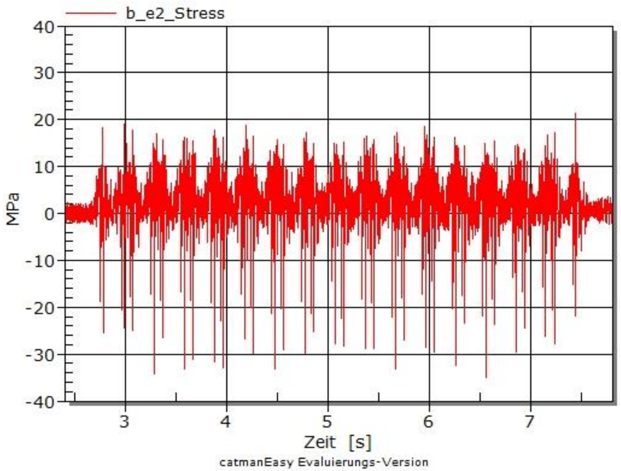
Strain gauges with wires, half bridge (1 sensor)

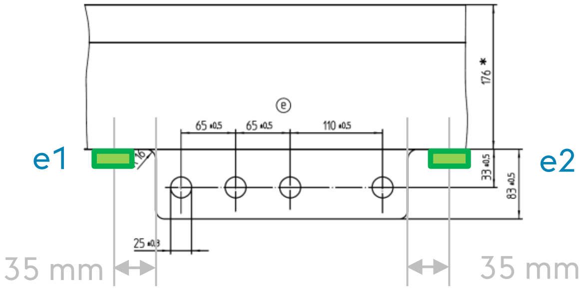
On-site measurements

Strain gauges – Measurement results

- Train 46, Section “b”, first drive
- Calculation with Young's Modulus E=207.000MPa from strain to stress
- Highest stress after forged lap with 35MPa







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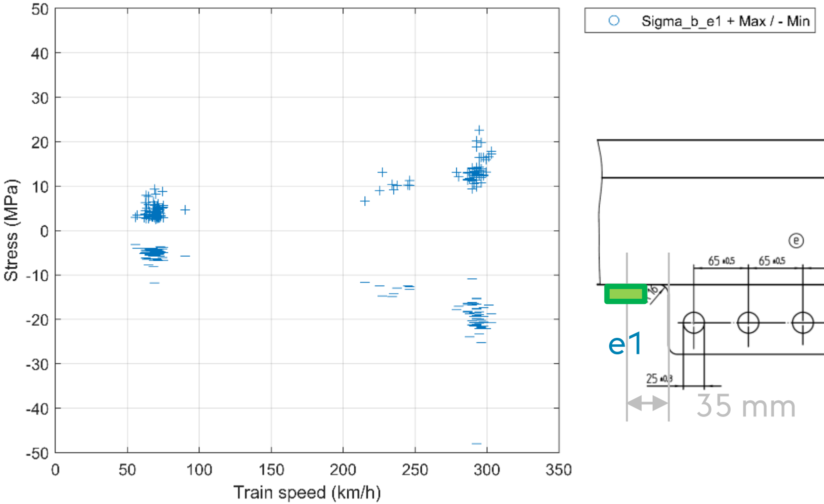
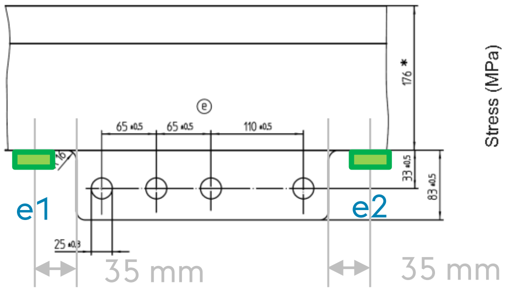
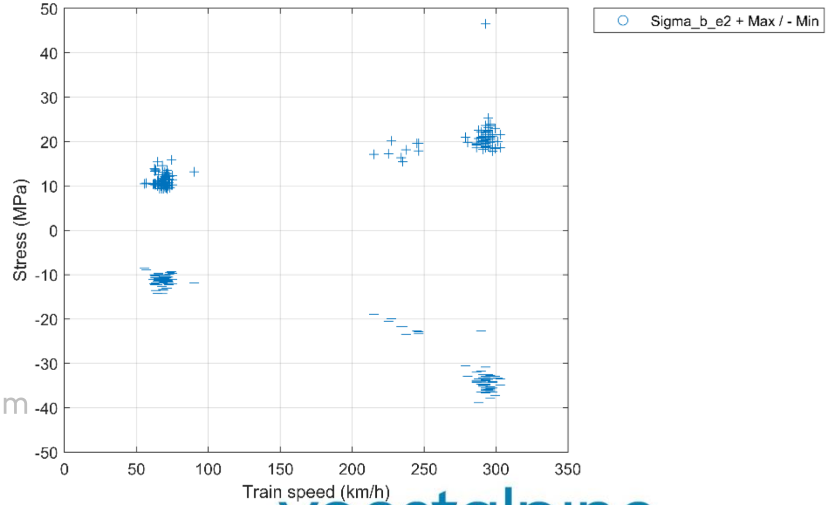
On-site measurements

Strain gauges – Measurement results

- Section "b" first setting level
- Speed dependence visible
- R ratio around R=-1 ("e1") for all speeds / R=-1,7 ("e2") for 300 km/h







Simulation & Measurement

Validation of the simulation results

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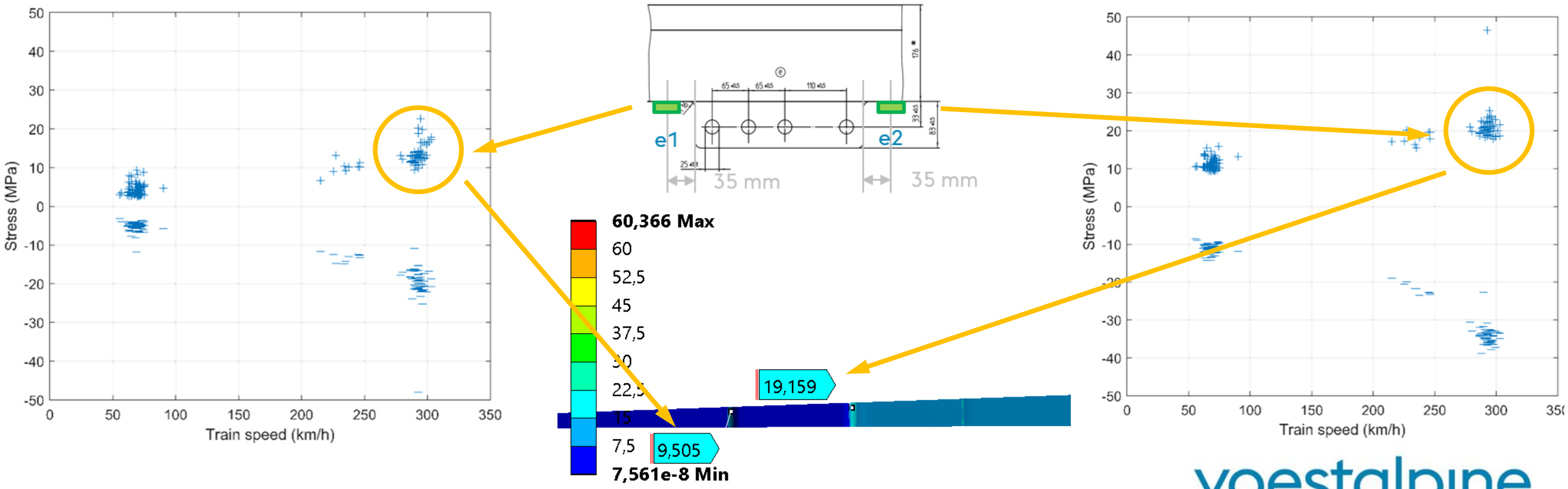
» Closing the cycle of the embedded engineering approach by the validation of the FEA simulation results with the on-site measurements



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Summary

» The conventional static simulation approach is not sufficient to describe the dynamical behaviour of a turnout, especially in the case of high speed applications

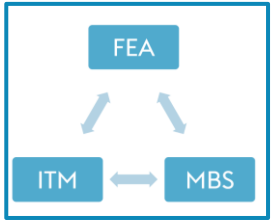
» Therefore an embedded engineering approach is necessary to fully cover the dynamic behavior and understand the highly dynamic system of an High Speed turnout holistically

» Conventional simulation setup

Axle load & dynamic factors → **Static FE-Model** → **Strength Assessment**

» Embedded simulation setup

MBS model with flexible structures → **Quasi-static FE-model** → **Strength assessment** ↔ **Validation with measurement data**



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Lookout HS @ vaRS department R&D T/O

- Future HS – Project
  - Rail Baltica
  - HS2 in the UK

- Planed and running R & D activities in regard to HS T/O
  - Several running projects, internal as well as external with scientific partners – focus:
    - Product development and product improvement
    - Predict maintenance operations and life time of turnout components
    - Knowledge generation in concerning whole system understanding, material degradation and failure modes
  - Monitoring solution at ADIF HS network as part of Europe’s Rail Iam4Rail

FP3 Iam4Rail

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Thank you

Thomas Titze

T. +43/50304/28-786

thomas.titze@voestalpine.com