Investigation of active bogie stabilisation using SIMPACK Control and SIMAT

C. Kossmann, SIMPACK User Meeting 2003

BOMBARDIER

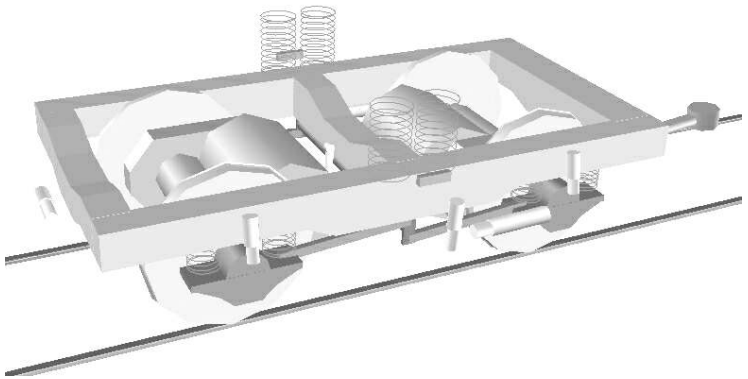
Experience the Extraordinary

Present and further activities

4 System Locomotive:

New bogies based on BR 145/146:

- Unsuspended Drive
- Suspended Drive
- Each variation with or without coupling system for radial steering



Co-simulation:

- Getting more experience using SIMAT
- Building up additional know-how
- **Applying co-simulation in further fields of bogie engineering**

Last slide at SIMPACK User Meeting 2001

Investigation of active bogie stabilisation
using SIMPACK/Controls and SIMAT

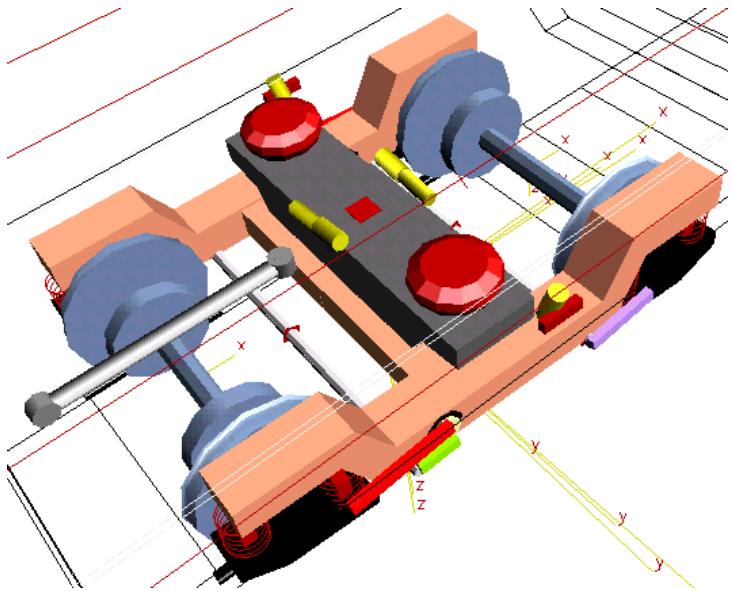
- **Contents**

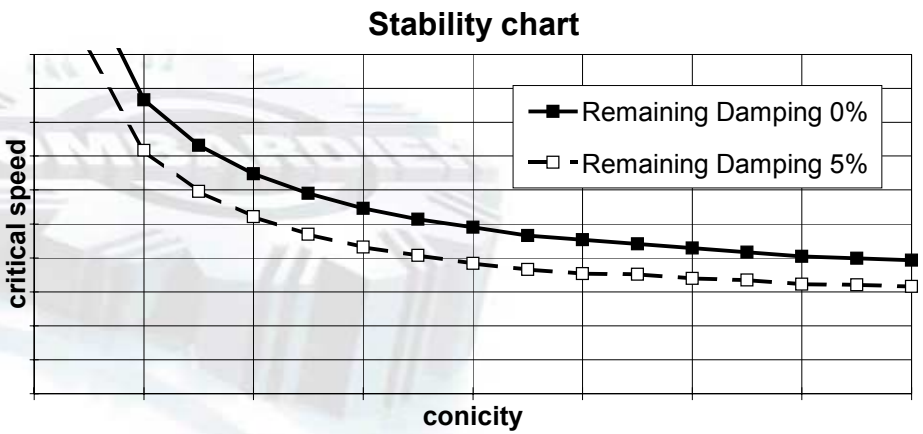
- Overview of stability investigations
- Control principle and SIMPACK model
- Implementation of “simple” controller in SIMPACK/Controls
- Co-simulation with advanced controller using SIMAT
- Measurement results from tests on roller rig
- Further activities

Stability investigation (1)
Eigenvalue calculations

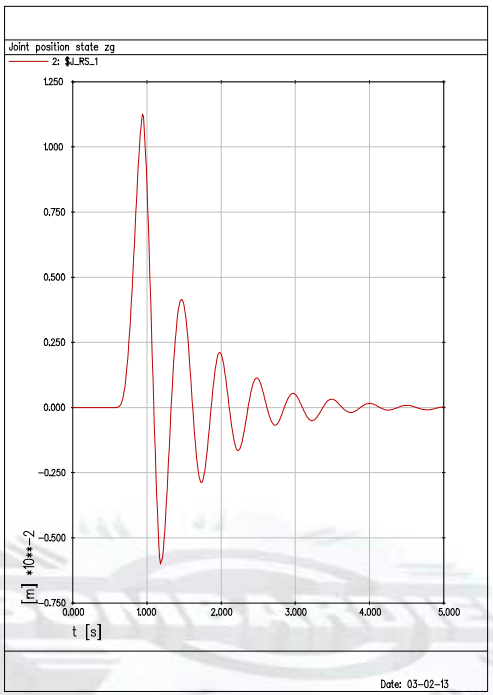
- **Determination of critical speed for hunting eigenmode**
- **Determination of remaining damping**
- **Variation of conicity and velocity**
- **Generation of stability charts using Critical Parameter Variation**

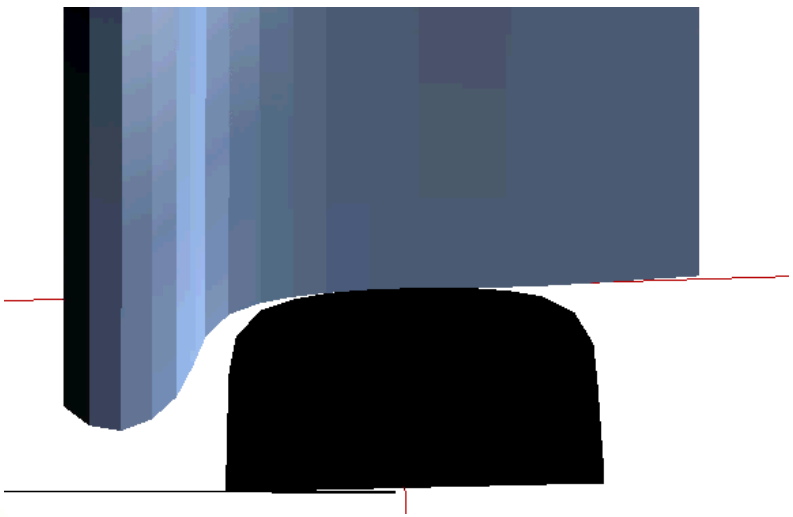
No.	Nat. Damping [-]	Frequency[Hz]
59/ 60	0.9983	4.6098
61/ 62	0.0210	4.7601
63/ 64	0.2962	4.7928
65/ 66	-0.0443	4.9148
67/ 68	0.9964	5.2026
69/ 70	0.5737	5.2561
71/ 72	0.9961	5.3638
73/ 74	0.2379	5.7868
75/ 76	0.1827	6.5382

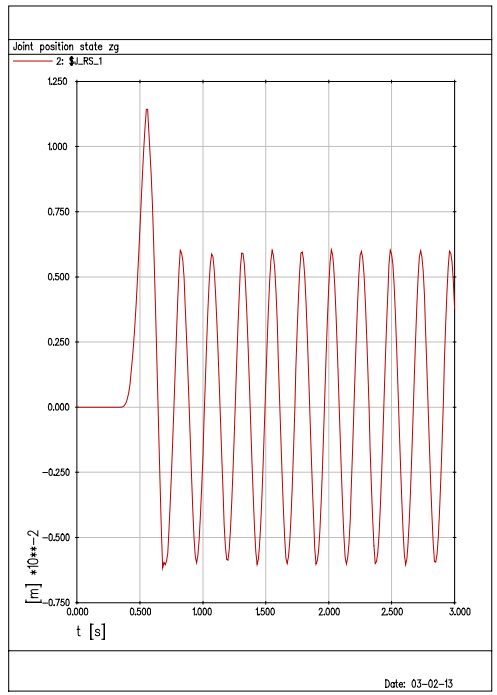




Stability investigation (2)
Reaction to single lateral track input





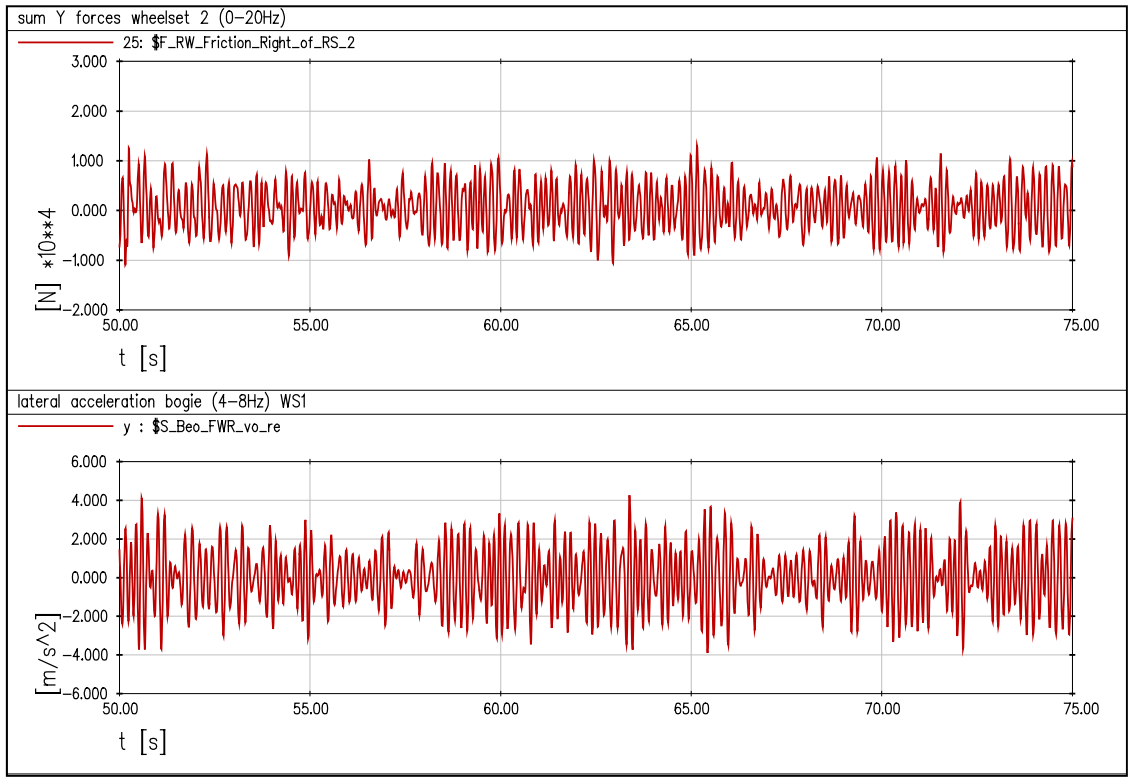


stable

unstable

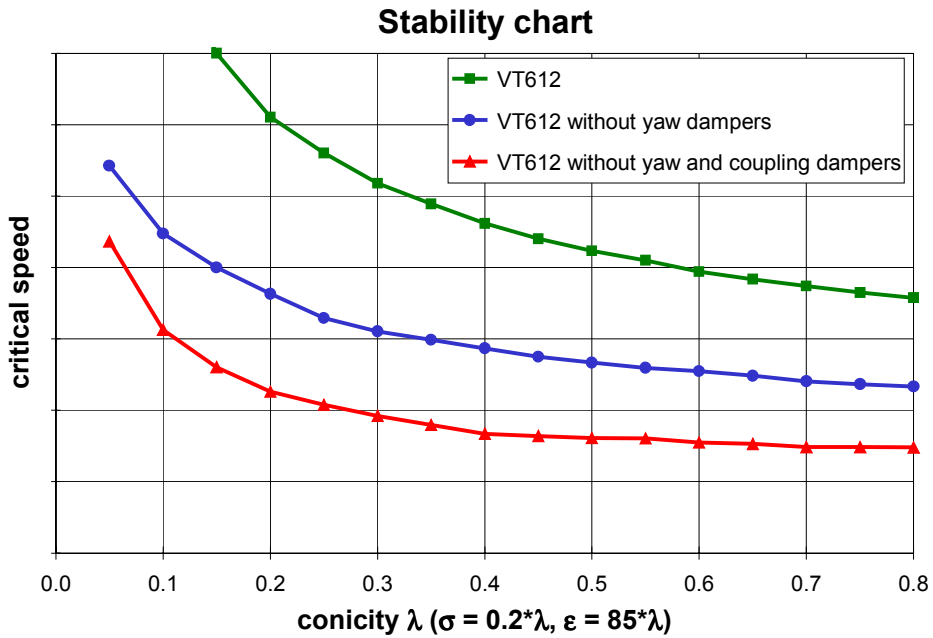
Stability investigation (3)
Behaviour on track with irregularities

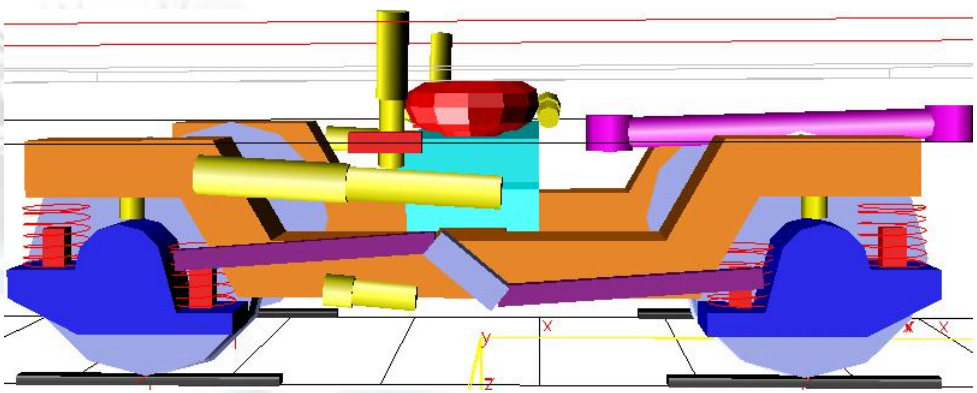
- **Evaluation of:**
  - Sum of lateral wheel/rail forces
  - Lateral acceleration at bogie frame



Stability behaviour of passive bogie

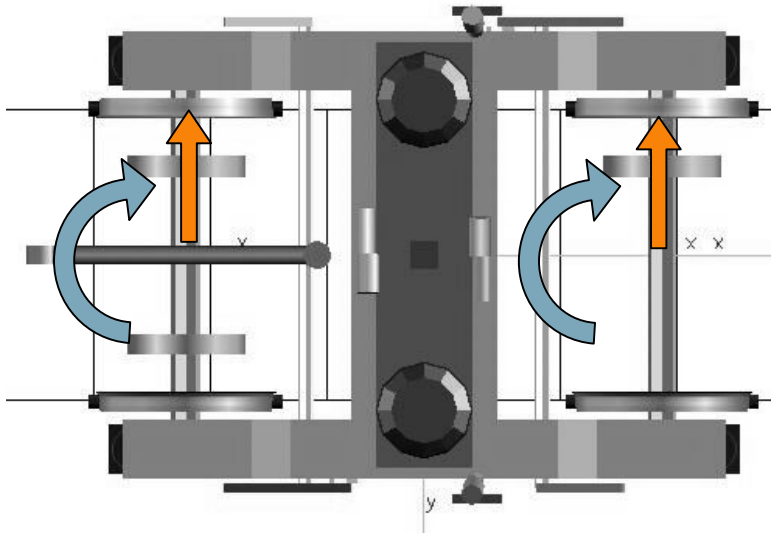
- **Yaw dampers between bogie frame and carbody are essential for stability**
- **(VT612 has additional coupling dampers)**
- **“Basis stability” is provided by longitudinal and lateral stiffness of primary suspension**





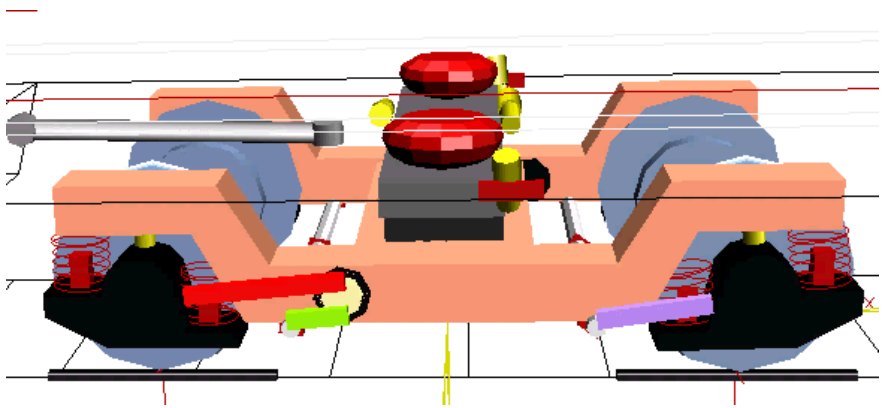
Principle of stability controller

- **Applied yaw torque on wheelset proportional to lateral velocity**
  (R. Goodall, Loughborough University)



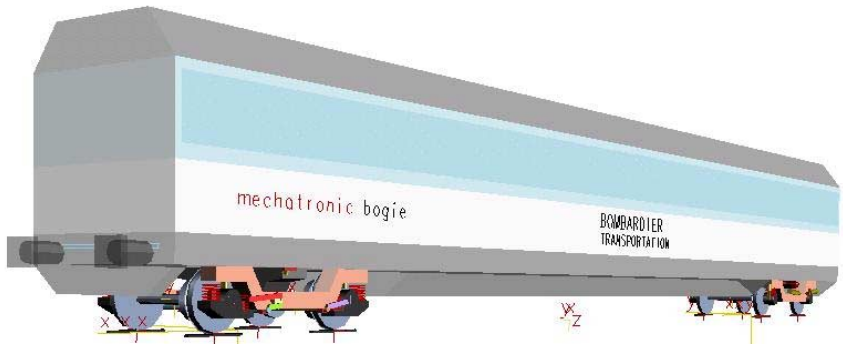
Realisation of torque application

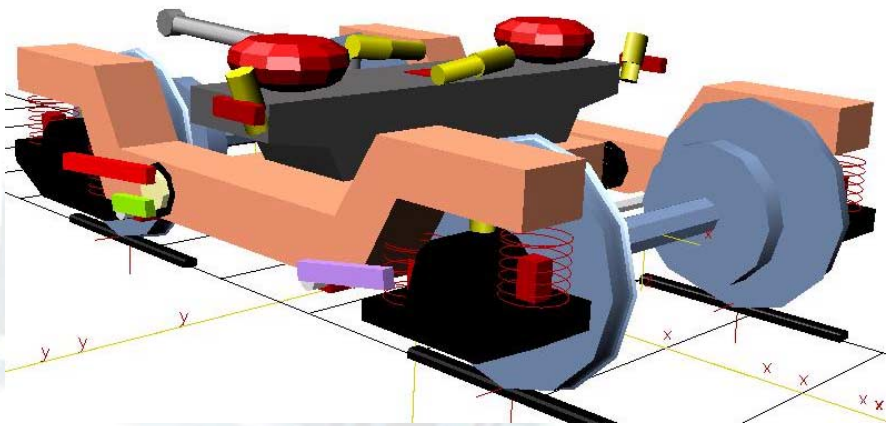
- **Actuators (one for each wheelset) apply torque via steering linkages and torsion bars.**



Mechanical SIMPACK Model

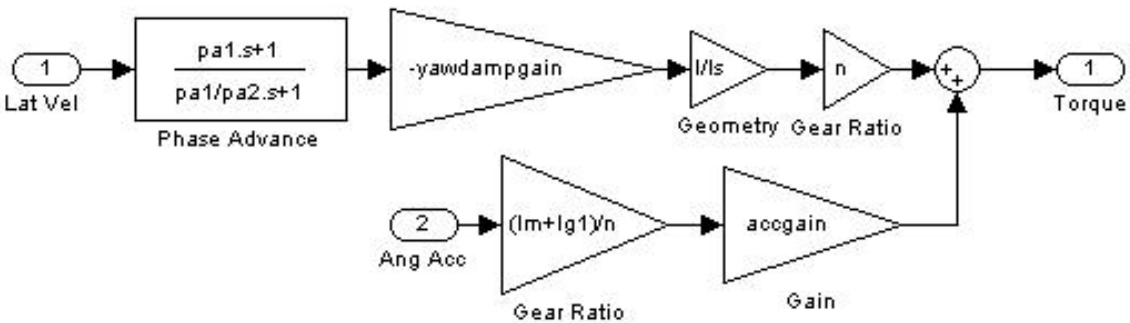
- **Passenger coach on two bogies:**
  - simple dummy bogie
  - detailed modelled active bogie

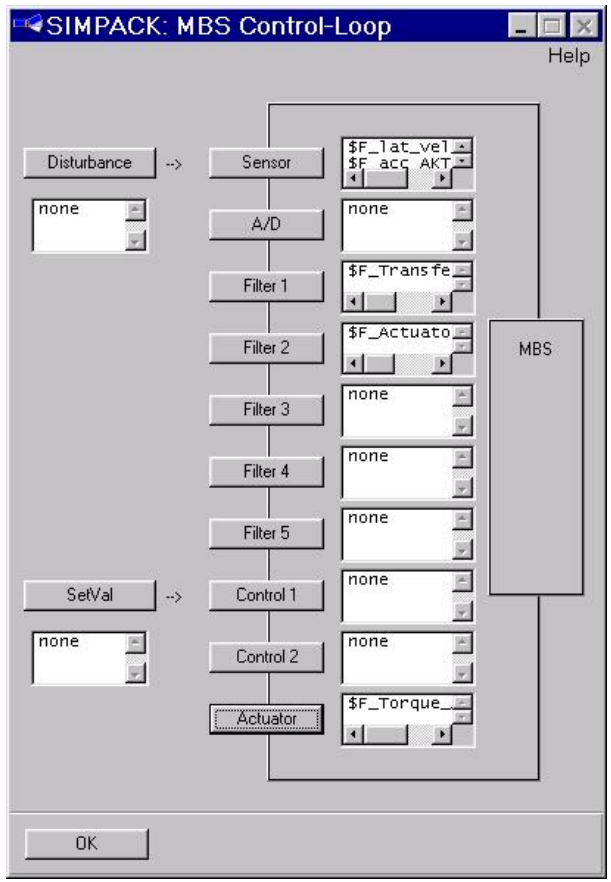




Implementing of controller in SIMPACK

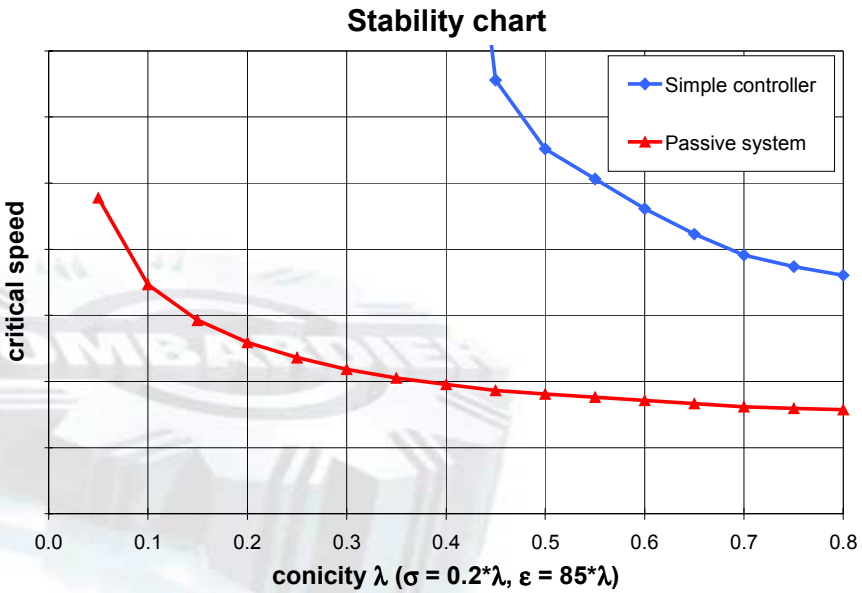
- **“Simple” controller with:**
  - 2 inputs per wheelset
  - 1 output per wheelset

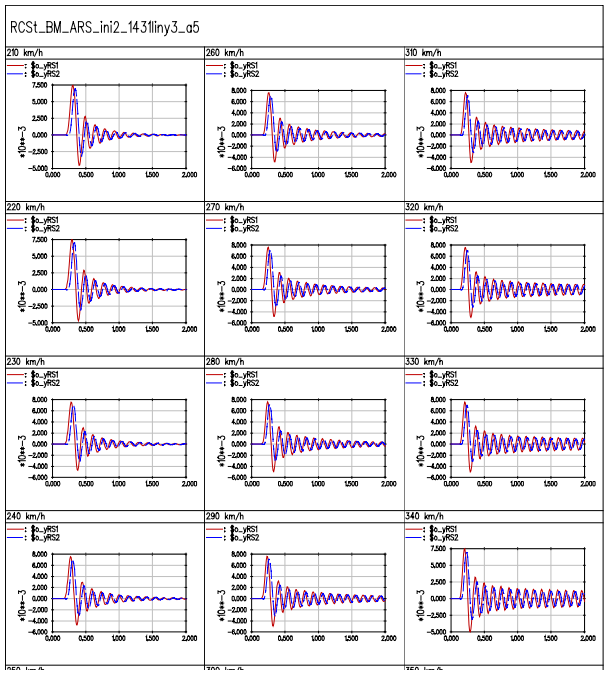




Controller implemented in SIMPACK

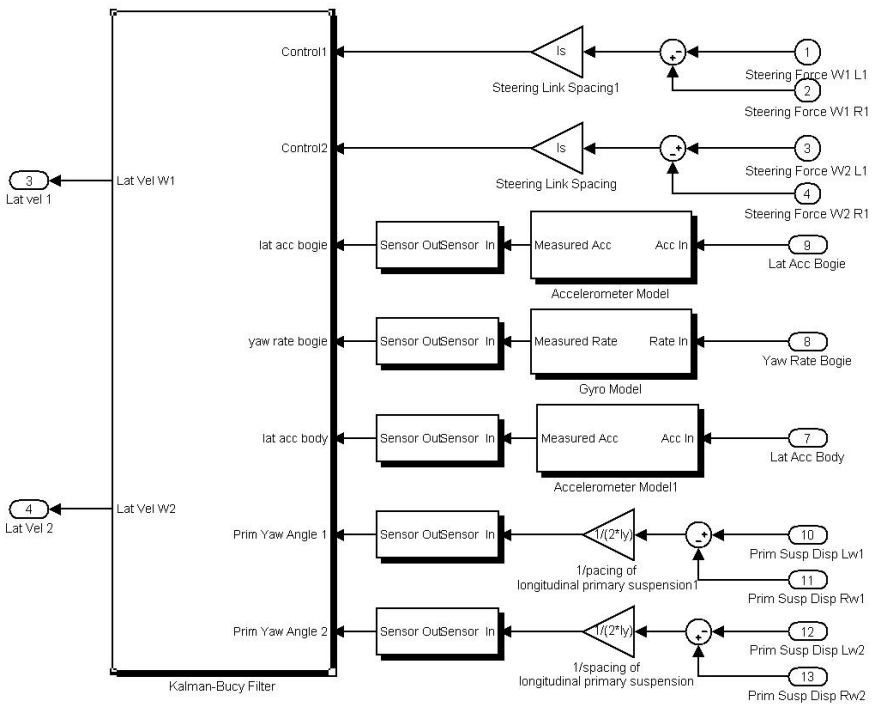
- **Calculations with “simple” controller**
  - Eigenvalue calculation
    Critical parameter variation
    for generating stability chart
  - Time integration using parameter variation for investigation of reaction to single track input

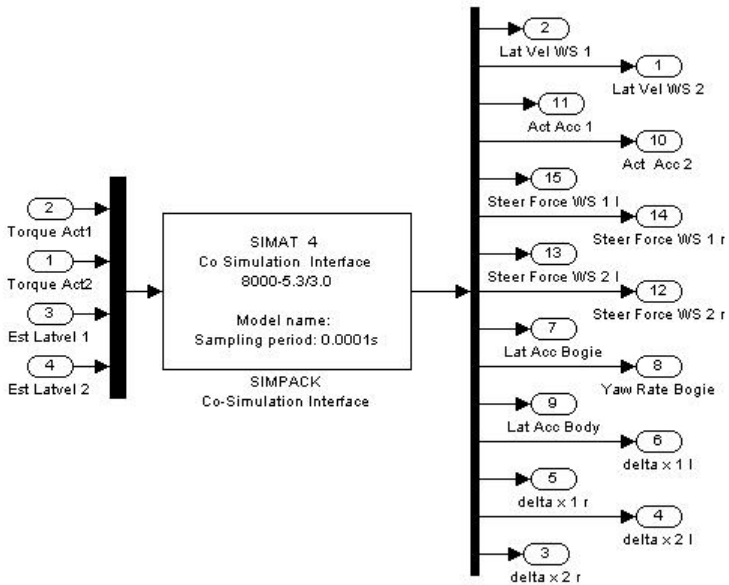




Investigation of advanced controller model with SIMAT

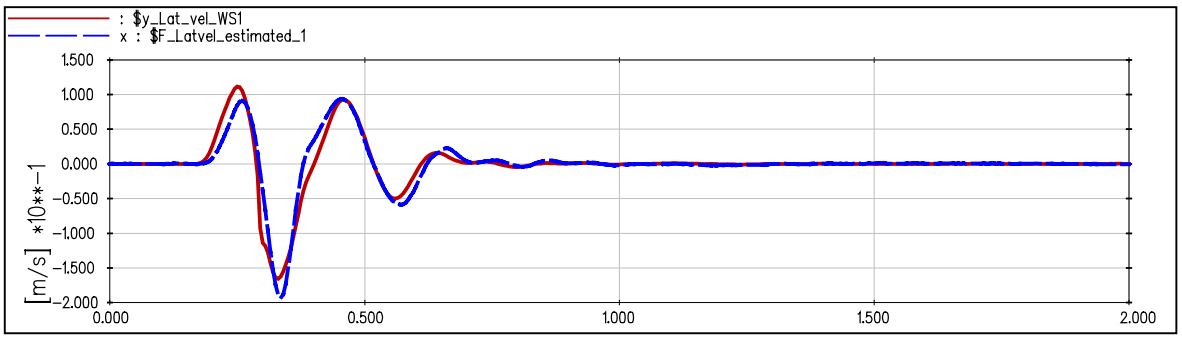
- **MATLAB model of controller with estimator for lateral wheelset velocity**
- **Sophisticated model needs several input values**
- **Co-simulations performed with SIMPACK/MATLAB interface SIMAT**



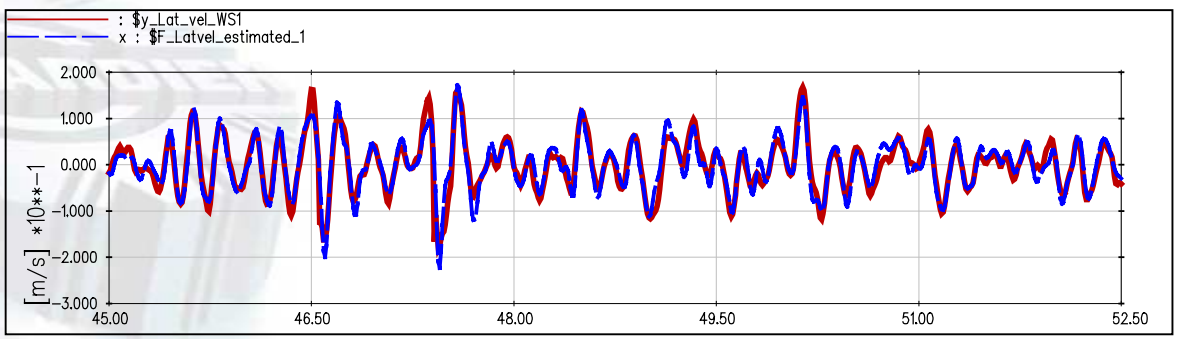


Investigation of advanced controller model with SIMAT

- **Examination of estimator performance: difference between actual and estimated lateral velocity**
  - Investigation of reaction to single track input



  - Behaviour on track with irregularities

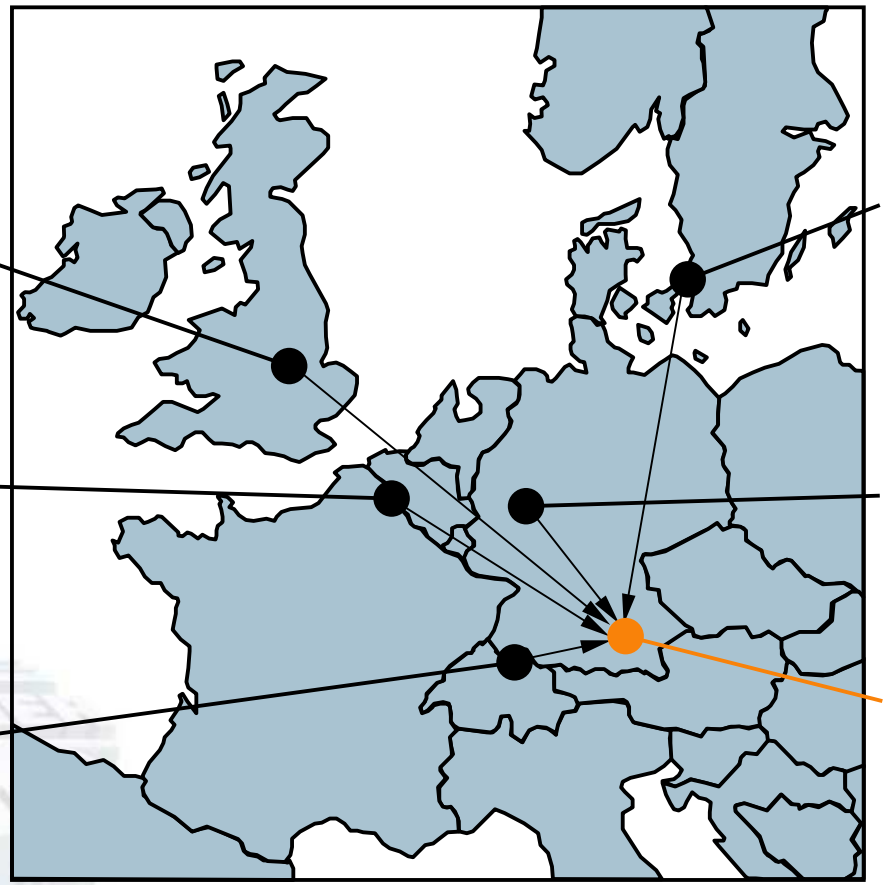


Project Team

Loughborough University (GB)
Controller Development

Bombardier Transportation Crespin (F)
Controller and Actuator Hardware

Bombardier Transportation Winterthur (CH)
Controller Validation with MBS Simulation



Bombardier Transportation Helsingborg (S)
Project Managing

Bombardier Transportation Siegen (D)
Bogie Design and Manufacturing

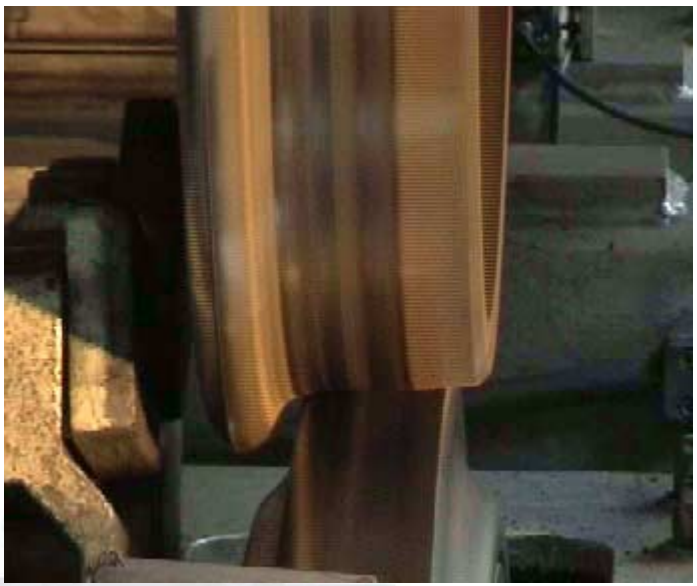
DB Roller Rig München (D)

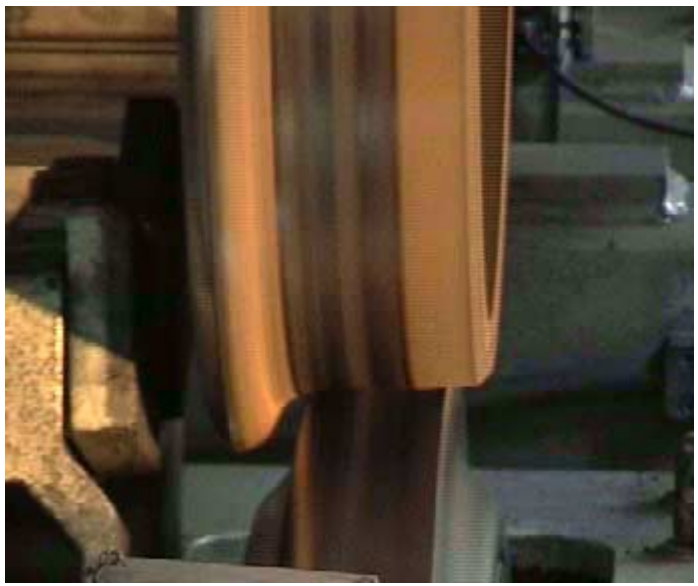
Tests at Roller Rig in Munich

- **Assembling of carbody, prototype bogie and controller**
- **Stability tests with passive system**
  - Variation of conicity by changing of roller gauge
- **Commissioning of controller with open loop tests**
- **Stability tests with active system**
  - Variation of speed up to 300 km/h
- **Running on track irregularities**

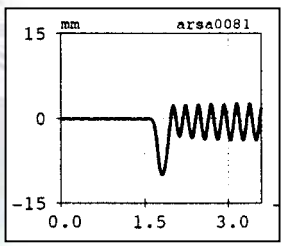
Measurement results from roller rig

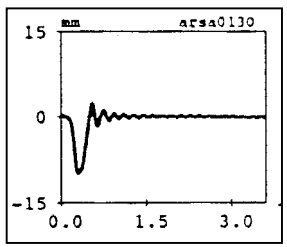
- **Stability tests with single lateral track input**





passive system
(without controller)

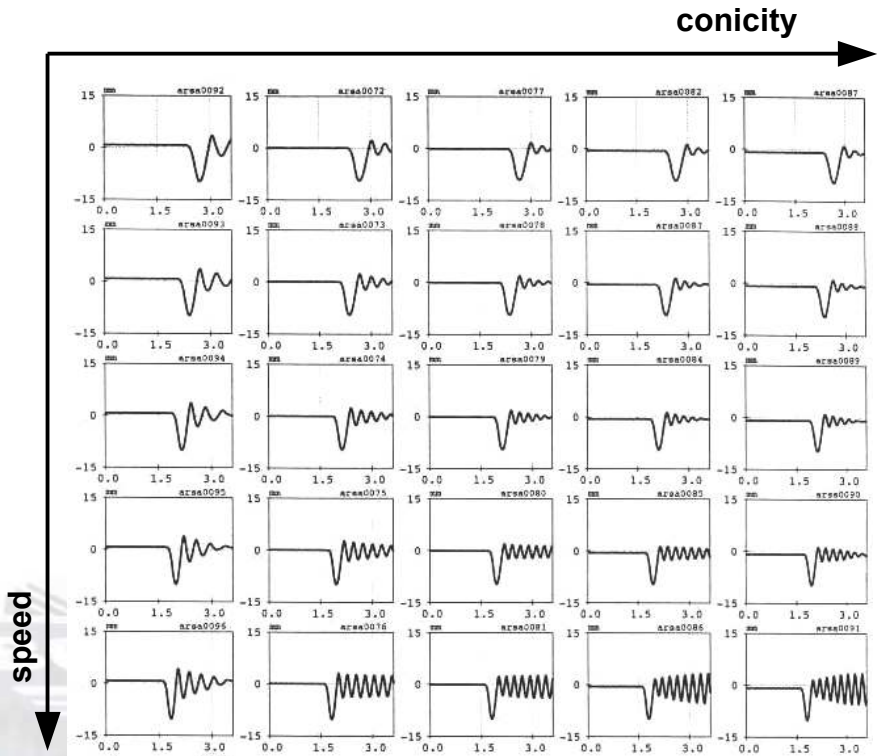




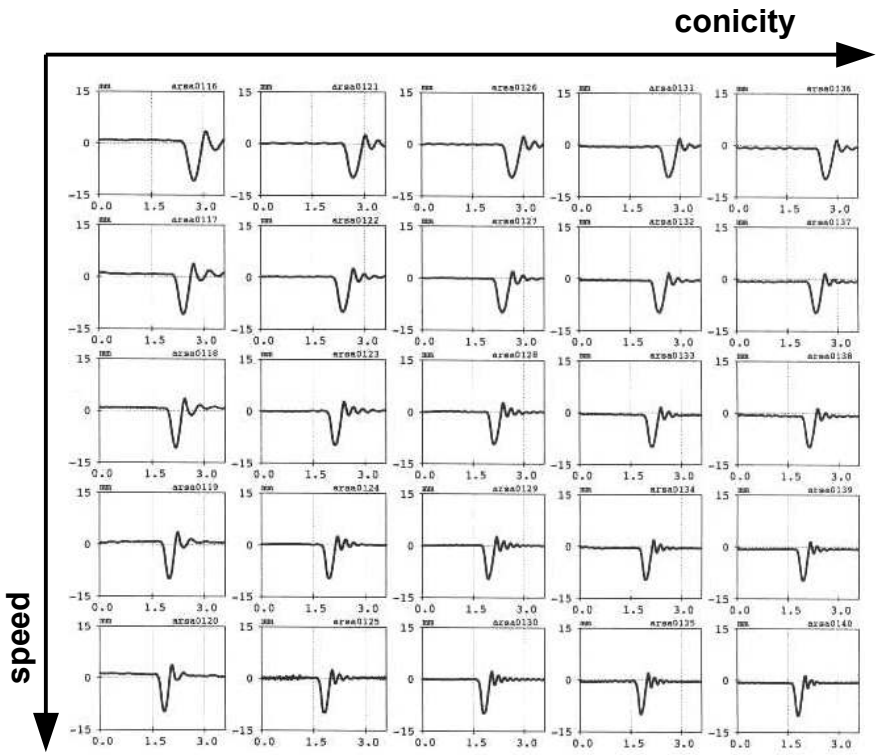
active system
(with stability control)

Measurement results from roller rig

- **Stability tests with single lateral track input**



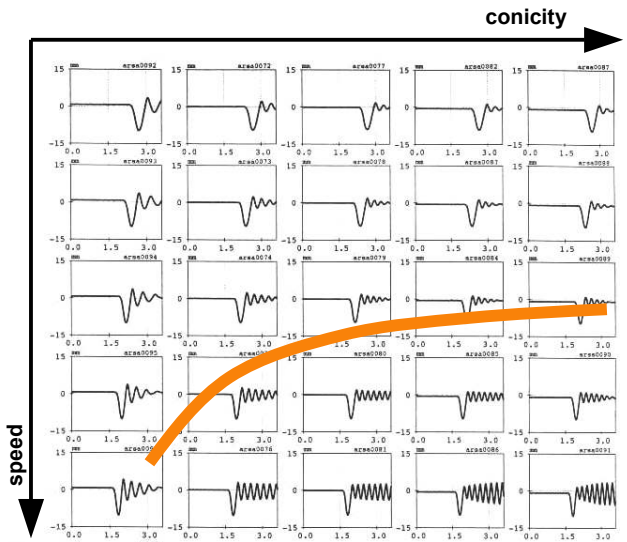
passive system (without controller)



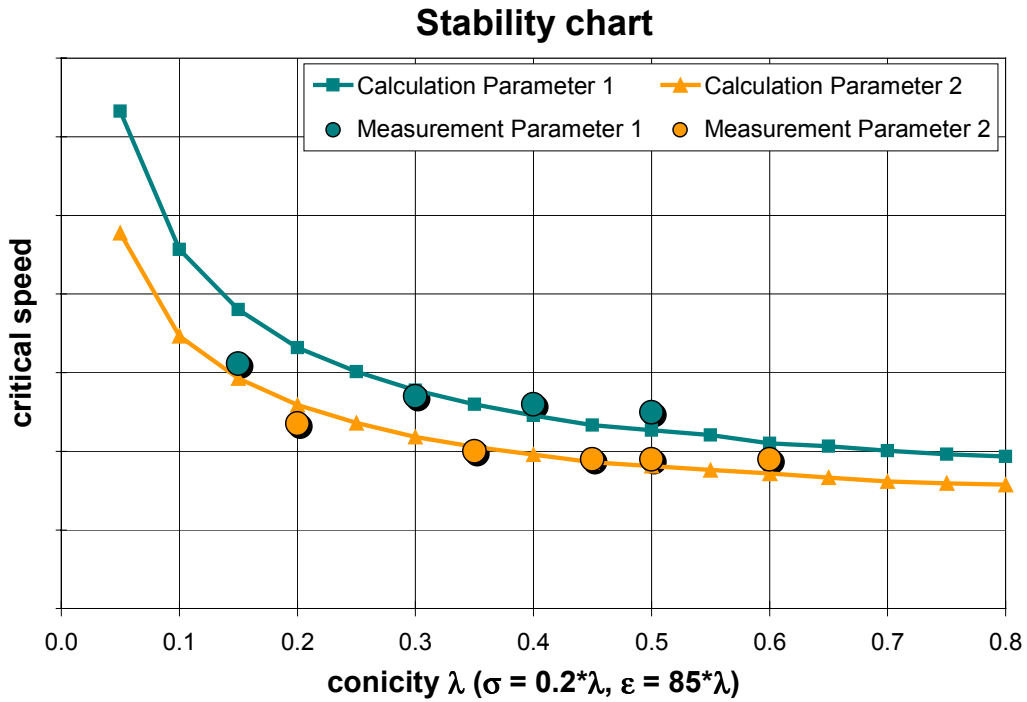
active system (with stability control)

Comparison of calculation and measurement

- **Generation of stability chart**



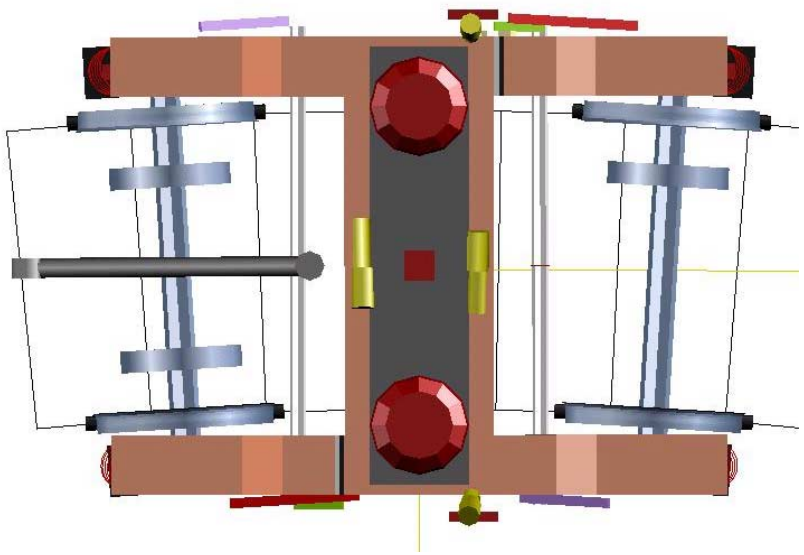
passive system (without controller)



- **Comparison for different bogie parameters**
  (linear calculation compared with non-linear measurement)

Further activities

- **Disadvantage of passive bogies:**
  Compromise necessary between stable behaviour on straight track and good curving behaviour
- **Active system:**
  Actuators and steering linkages can provide torque on wheelsets for
  - active stabilisation
  - active radial steering



Further activities

- **Development of controller for active radial steering**
- **Simulation with steering controller**
- **Combination of stability and steering controller**
- **Simulation of combined controller**
- **Testing of both controllers on track**

Last slide at SIMPACK User Meeting 2003