Results in rail research using SIMPACK

Politecnico di Torino - Dip. di Meccanica

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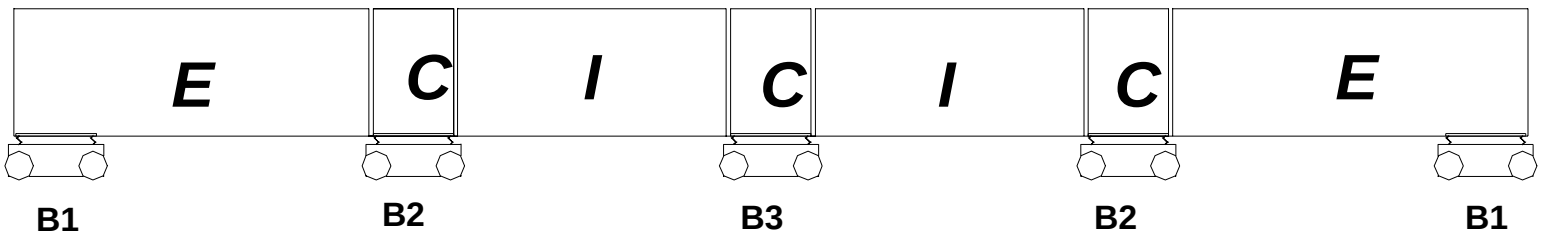
Preface

The railway dynamic research group of the Mechanical Department of the Politecnico of Torino mainly direct its activities to carry out studies on the dynamic behaviour on railway vehicles in order to analyse stability and safety of rolling stock, using Multibody simulation codes.

Introduction

- The behaviour of light rail vehicles during curving is analysed.
- Different bogie types are compared.
- Particular attention is given to the understanding of the influence of different traction systems and of the disposition of the traction bogie in the vehicle.

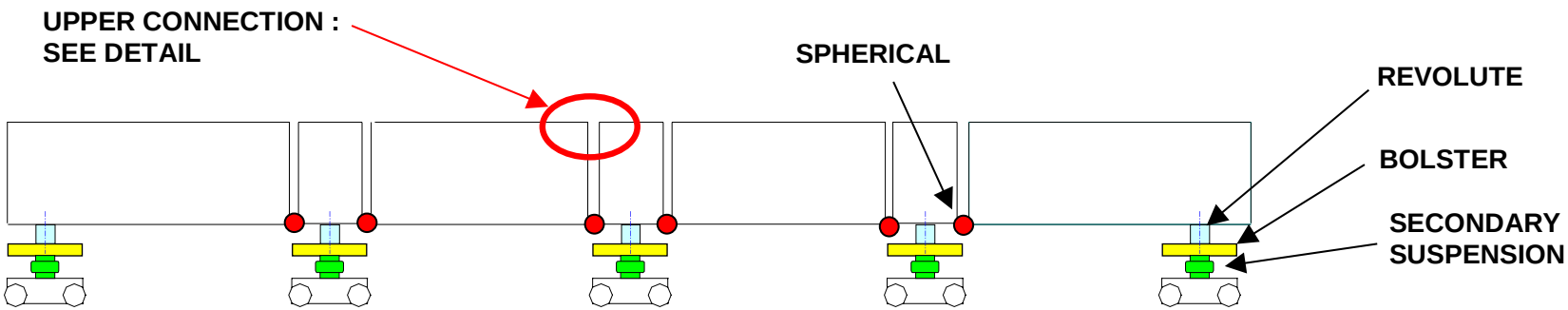
Vehicle Layout



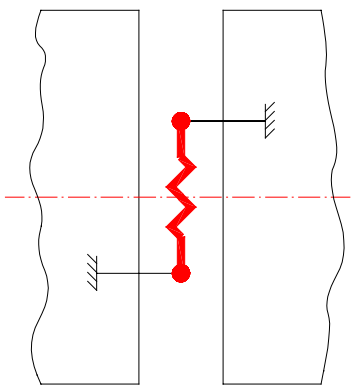
- **2 External Coaches (E)**
- **3 small connecting Coaches (C)**
- **2 Internal Coaches (I)**

BOGIE / CONFIGURATION	B1	B2	B3	B2	B1
1	TRACTIVE	CARRIED	CARRIED	CARRIED	TRACTIVE
2	CARRIED	TRACTIVE	CARRIED	TRACTIVE	CARRIED

Wagon Inter-connections



UPPER CONNECTION



Coach connections :

- Lower : spherical joint (rigid)
- Upper : connecting rod (elastic)

Bolster -Coach connection :

- Revolute joint (rigid)

Bogie

Different Bogie type have been considered :

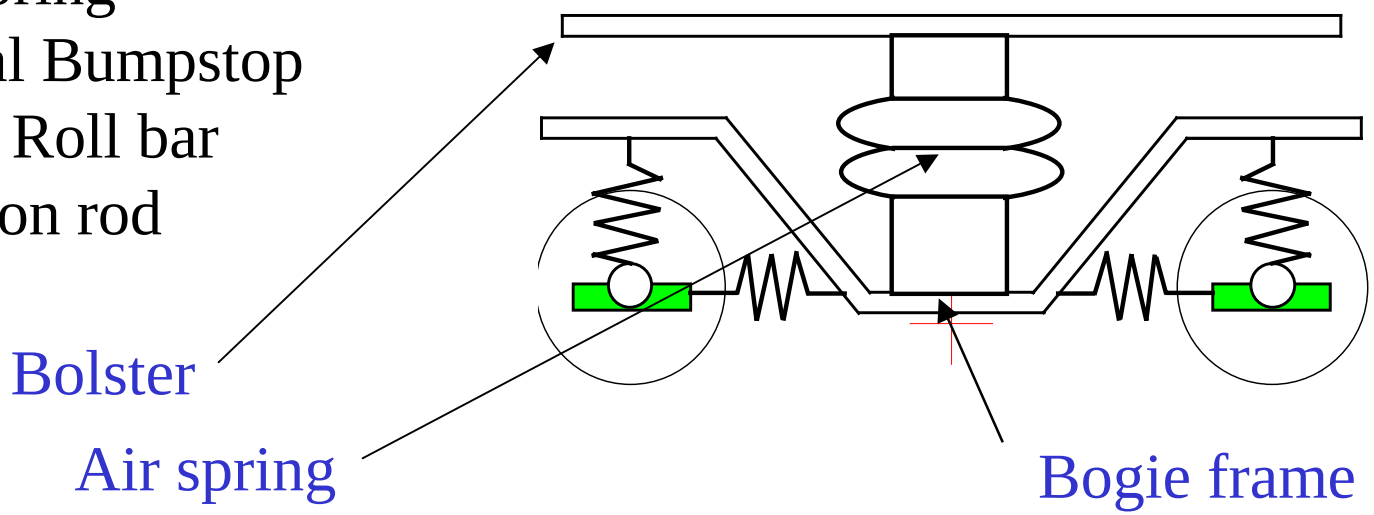
- Conventional Bogie - both wheelset traction
- Conventional Bogie - No traction
- Articulated Bogie - Motor wheels
- Articulated Bogie - Side traction
- Articulated Bogie - No traction

Conventional Bogie

- Rigid Bogie Frame
- Rigid Wheelset
- Elastic primary suspension between frame and axle box.

Secondary suspension between frame and bolster :

- 2 Air Spring
- 2 Lateral Bumpstop
- 1 Anti - Roll bar
- 2 Traction rod

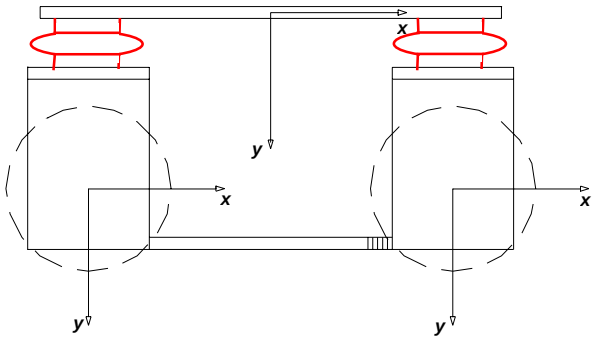


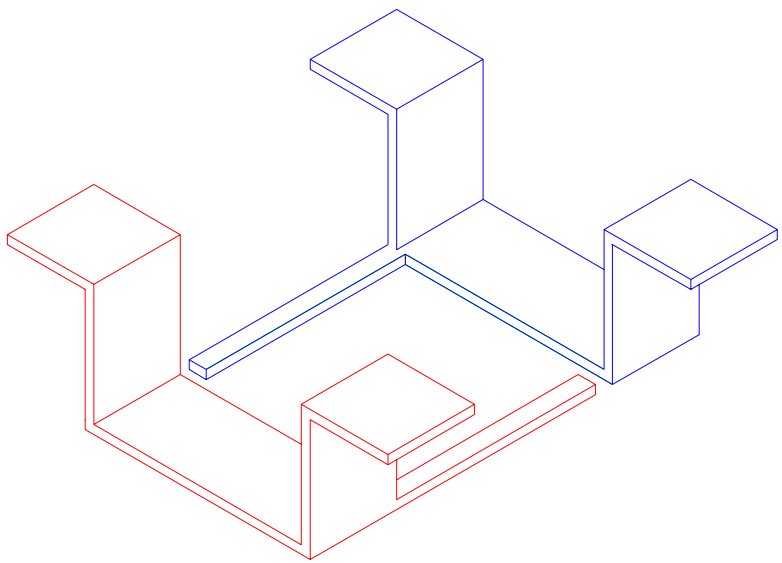
Articulated bogie

- Bogie frame divided in two rigid body
- Elastic element connecting the two frame
- No primary suspension
- Independent wheels

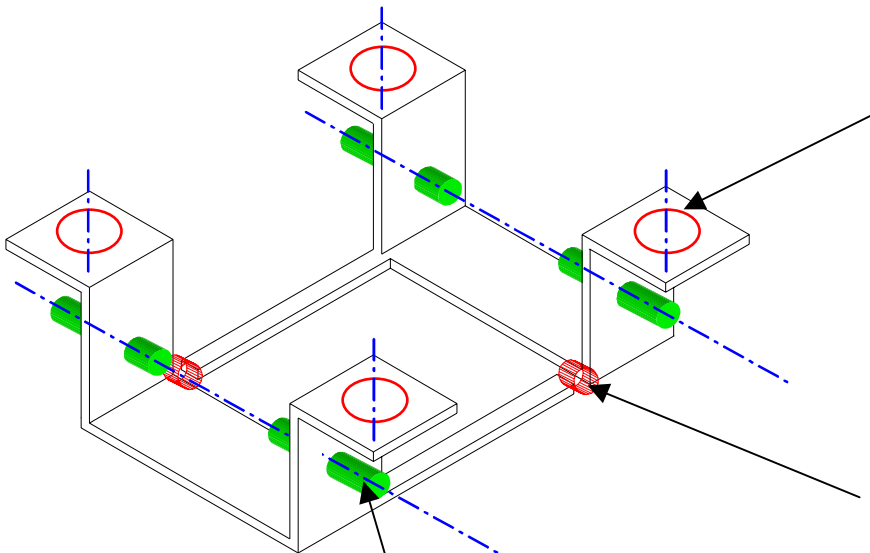
Secondary suspension :

- 4 air spring
- 1 Antiroll-bar
- 2 Lateral bumpstop
- 2 traction rod





Articulated bogie



Air Spring support

Bushing Type
Elastic Element

Wheel axle / Rigid connection (Revolute)

Articulated bogie - Traction

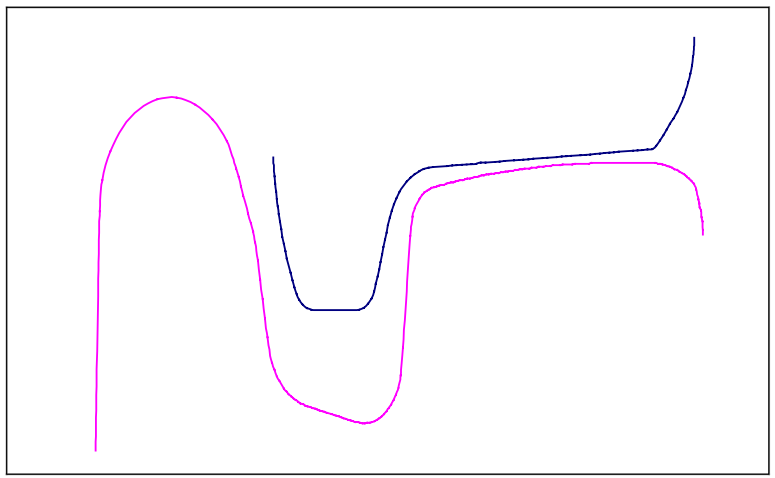
The articulated bogie has been created in different variants:

- trailing bogie
- motor wheels: each wheel is motorised.
- side traction: One motor is present in each side of the bogie frame, connected to the two wheels of the same side with an elastic joint.

- The motor characteristic is given by a constant torque up to the nominal speed followed by a constant power behaviour.
- The overall power is the same for each motorised bogie

Track-Profiles

Wheel Profile : UNI 3322
Rail Profile : UNI 3142
Profiles have been realised using the wheel/rail profile approximation tool of SIMPACK.



The track used for the simulation is composed by a straight section followed by a transition curve and finally a curve section of different radius (15 - 50 -100 m).

Modelling Assumption

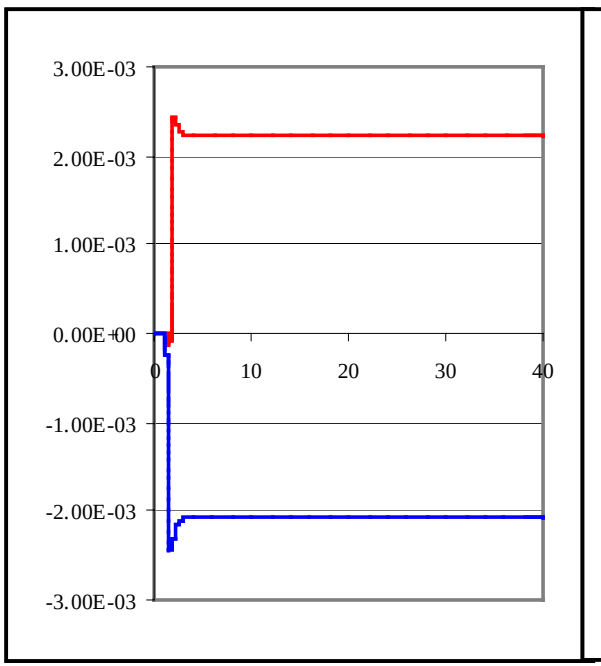
- Rigid coaches and bogie frames
- Linear elastic elements
- No dampers
- Simplified air spring model : constant stiffness and constant preload.
- No track irregularity

Simulation Plan

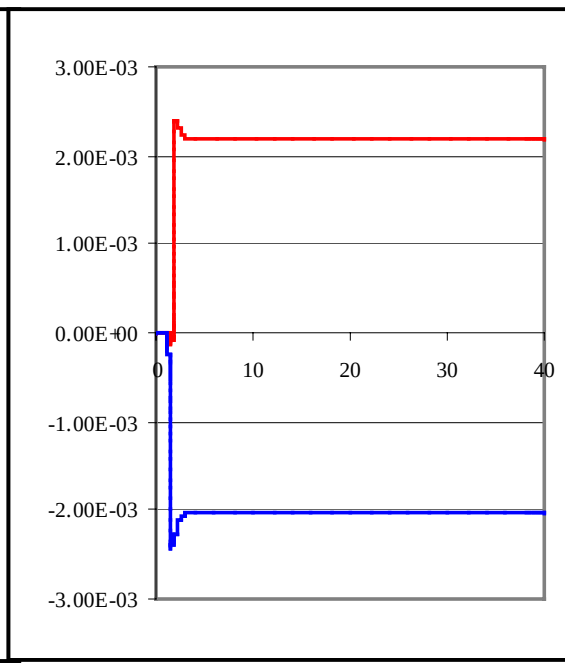
- Comparison of different contact models :
- rigid one point contact.
- 3 point contact.
- elastic contact.
- Comparison of different bogie type
- Influence of bogie disposition

Contact comparison : Y Displacement [m]

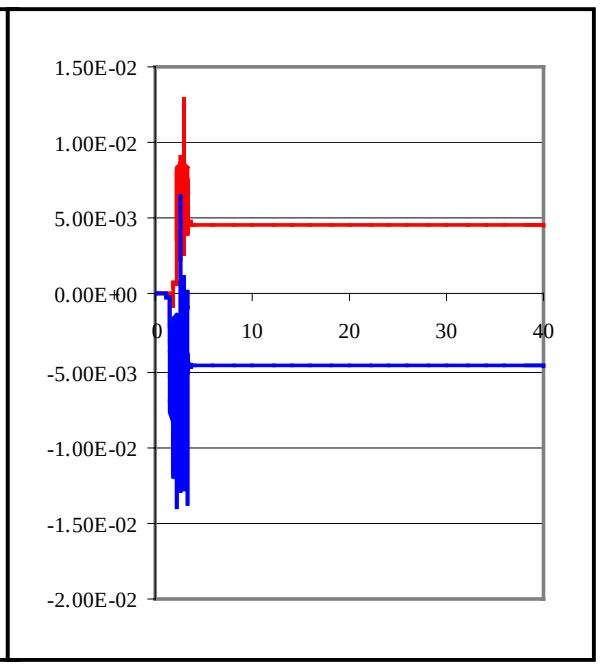
Rigid contact



3p Contact



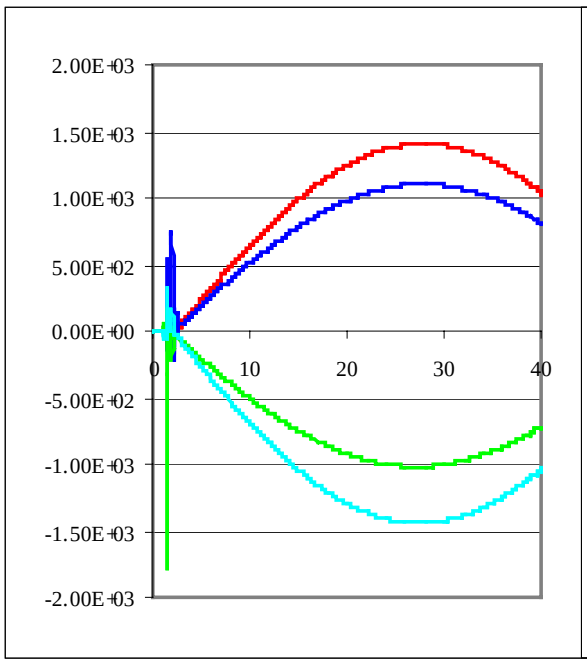
Elastic Contact



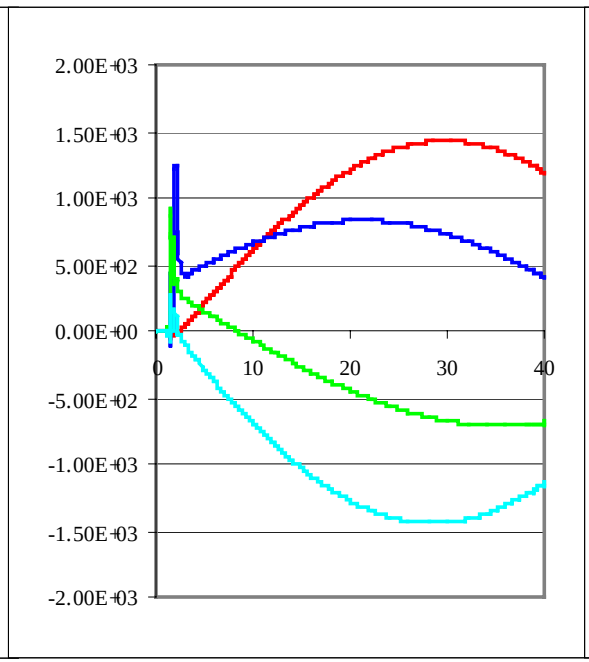
Front wheelset — Rear wheelset

Contact comparison : X Friction Force [N]

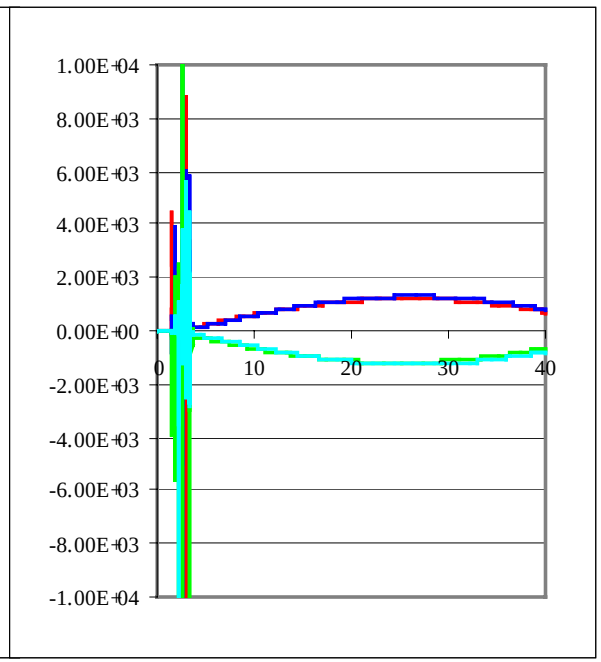
Rigid contact



3p Contact



Elastic Contact



Wheel Front Left

Wheel Front Right

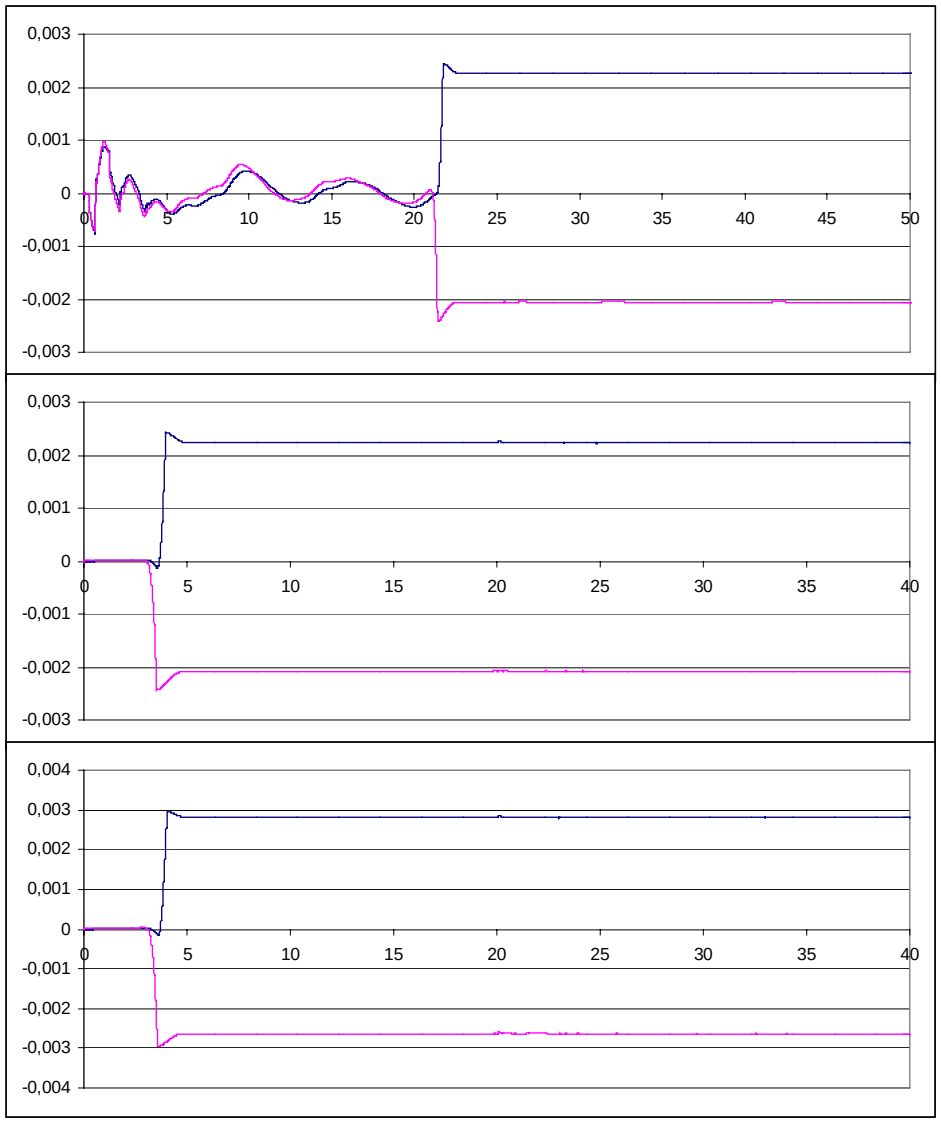
Wheel Rear Left

Wheel Rear Right

Considerations : contact model

- 3 point contact model and rigid contact give similar Y displacement and yaw angle for the wheelsets (difference < 2%).
- Elastic contact shows numerical problems : higher displacements, higher forces especially when entering the curve.
- 3 point contact gives higher friction forces in the first part of the curve (when flange contact occur).
- The lower computational time is obtained with the rigid contact model, while the 3 point contact lead to computational time up to 4 time higher.
- The 3 point contact model seems to be the more accurate, however due to the higher simulation time required the simulation on the entire vehicle have been performed using the rigid contact model.

Y Lateral Displacement - First Bogie



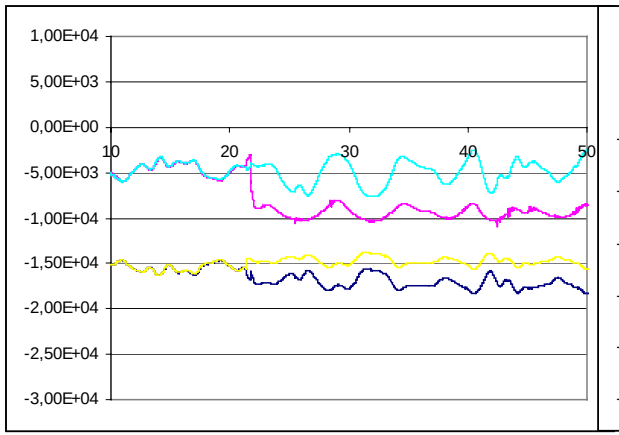
Conventional Bogie

Articulated Bogie
Side traction

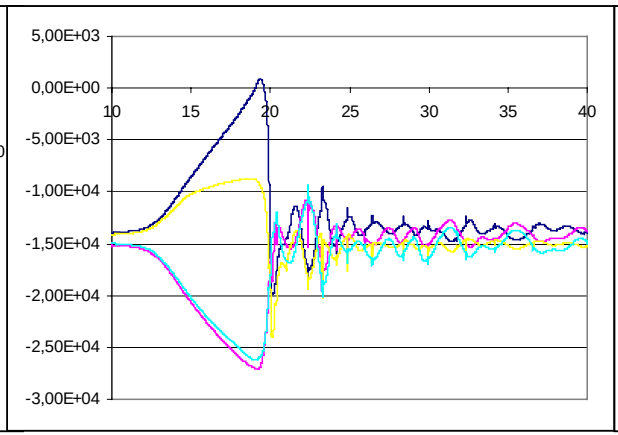
Articulated Bogie
Motor wheels

Constraint Forces [N] - First Bogie

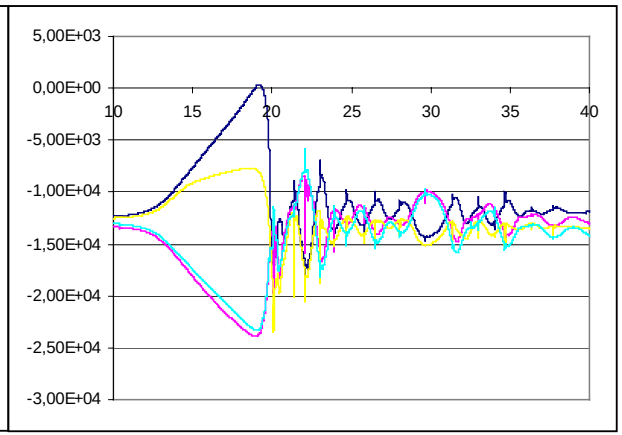
Conventional Bogie



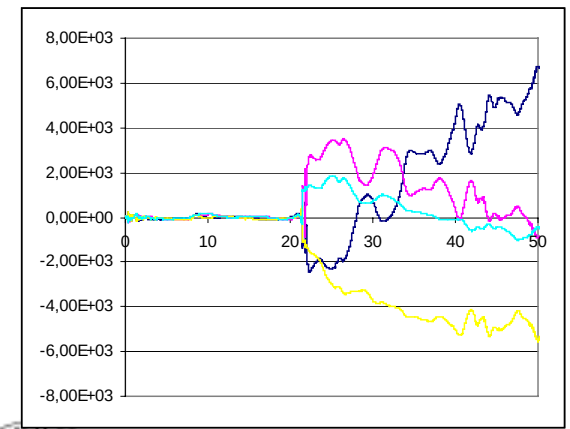
Articulated Bogie - side traction

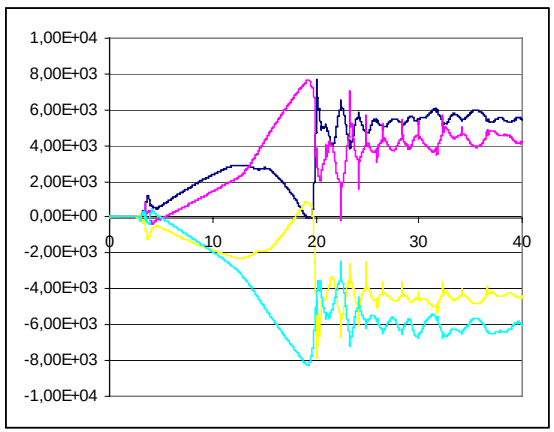


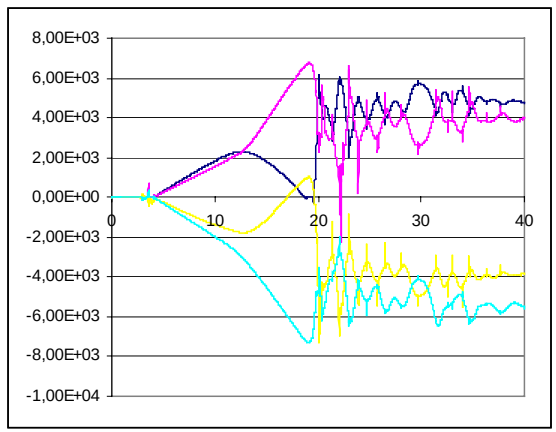
Articulated Bogie - motorwheels



X -Friction Forces [N] - First Bogie



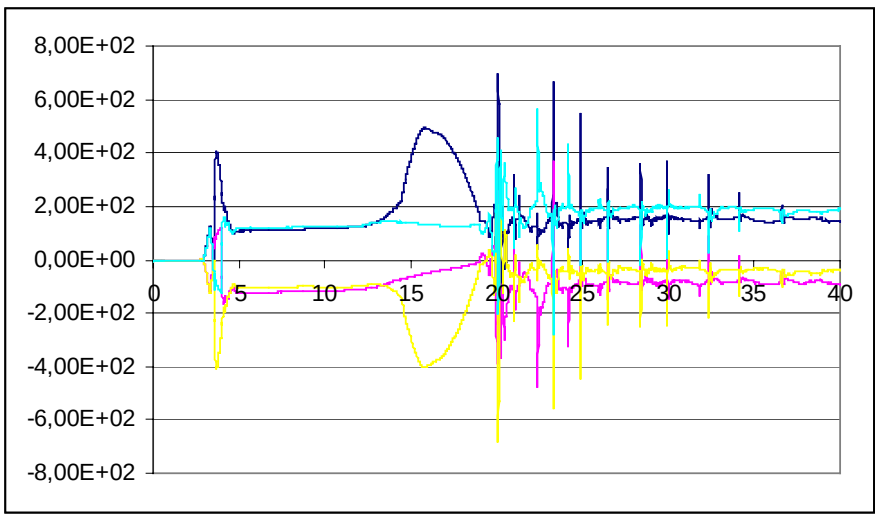




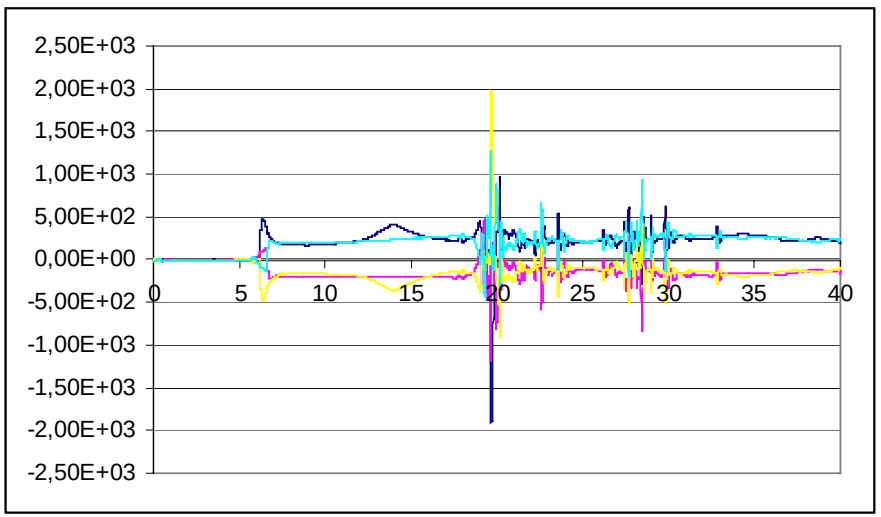
Side Traction Bogie

Traction joint torque [Nm]

Traction bogie 1-5



Traction bogie 2-4



Left side - Front

Right side - Front

Left side - Rear

Right side - Rear

Consideration : bogie

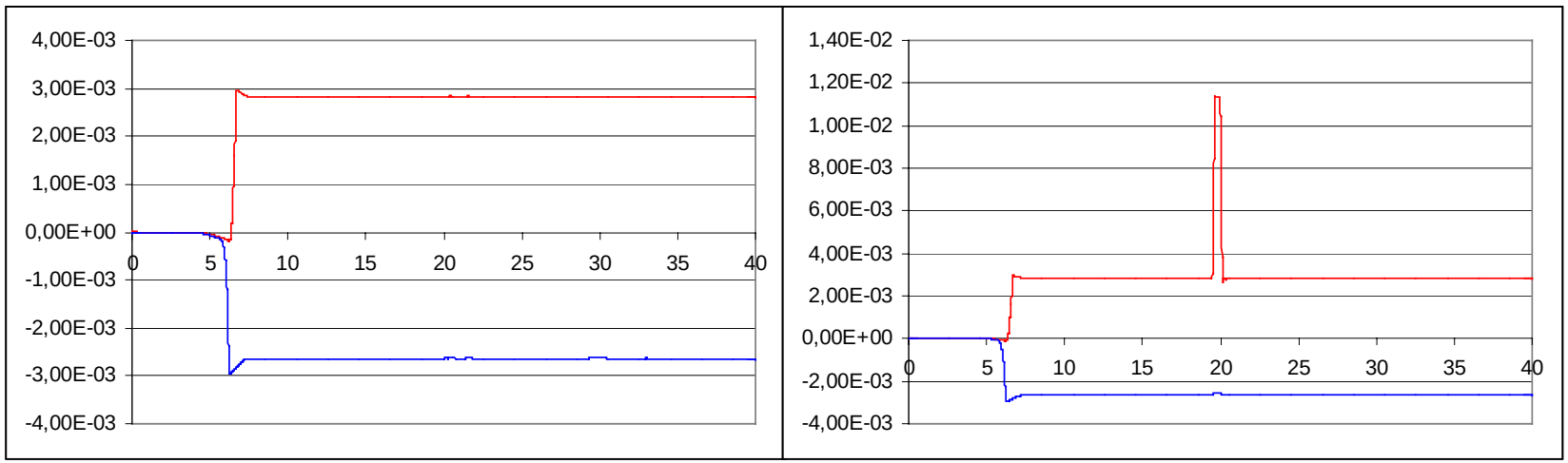
- The conventional bogie shows an high instability in the longitudinal direction, due to the presence of only 2 air-springs.
- Lateral displacement is similar for all bogies, the lower is obtained with the side traction bogie.
- Friction and constrain forces are lower in the motor-wheel model, while with the side-traction bogie some wheels are unloaded.
- The side traction bogie leads to high torque in the transmission joint during curving.

Influence of Disposition
Articulated bogie - Motorwheels (2nd bogie)

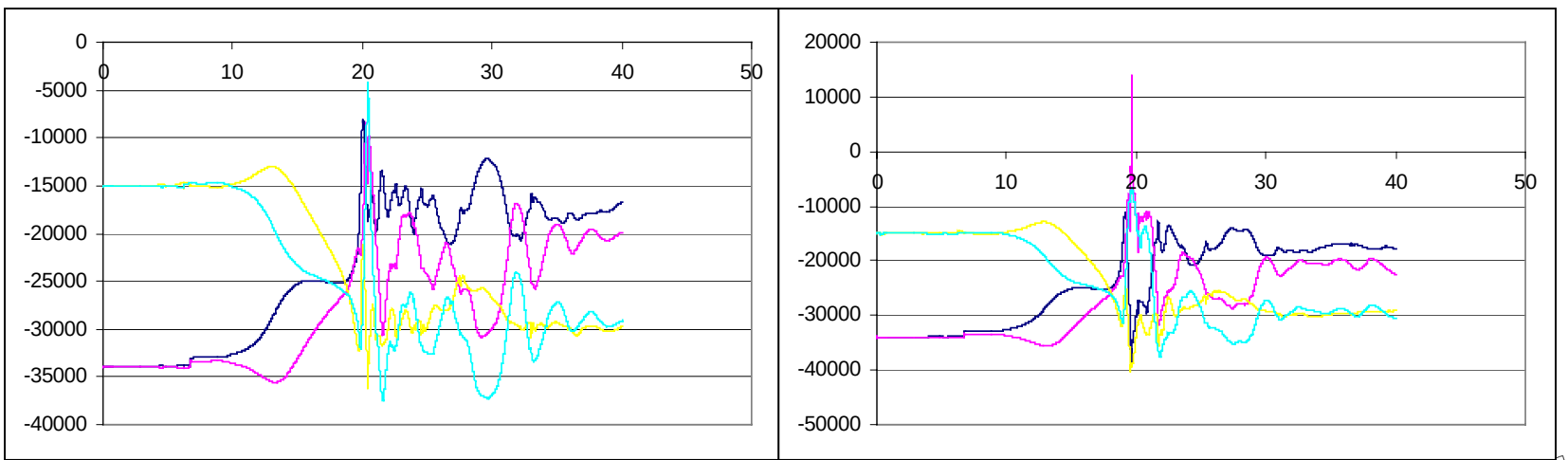
Case 1 (Traction 1-5)

Case 2 (Traction 2-4)

Y Displacement [m]



Normal Load [N]

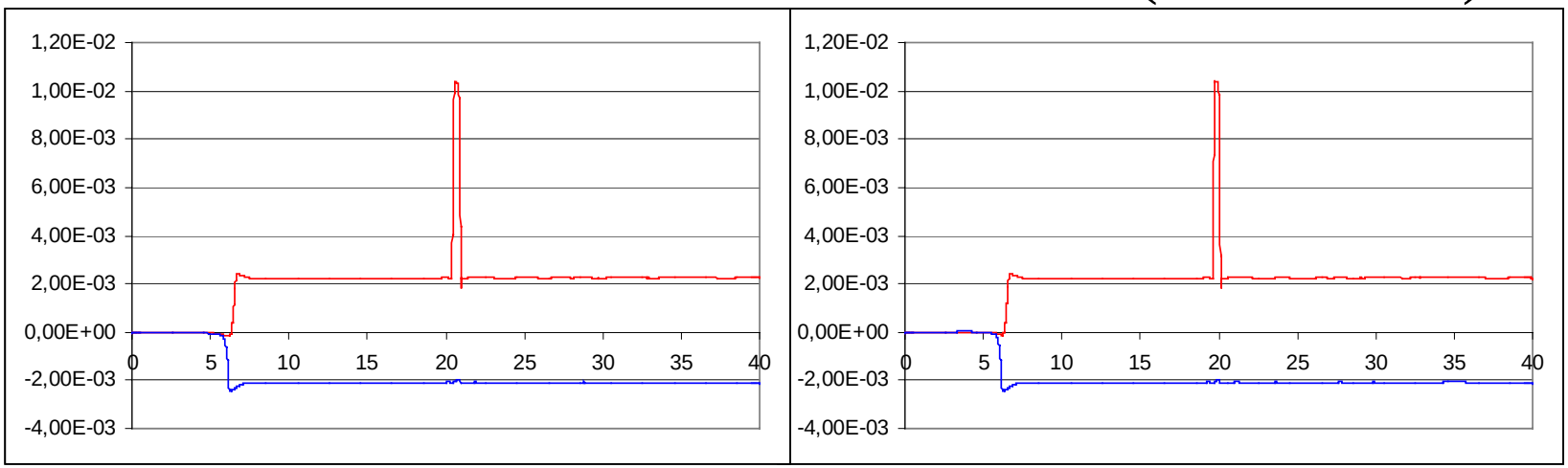


Influence of Disposition
Articulated bogie - side traction (2nd bogie)

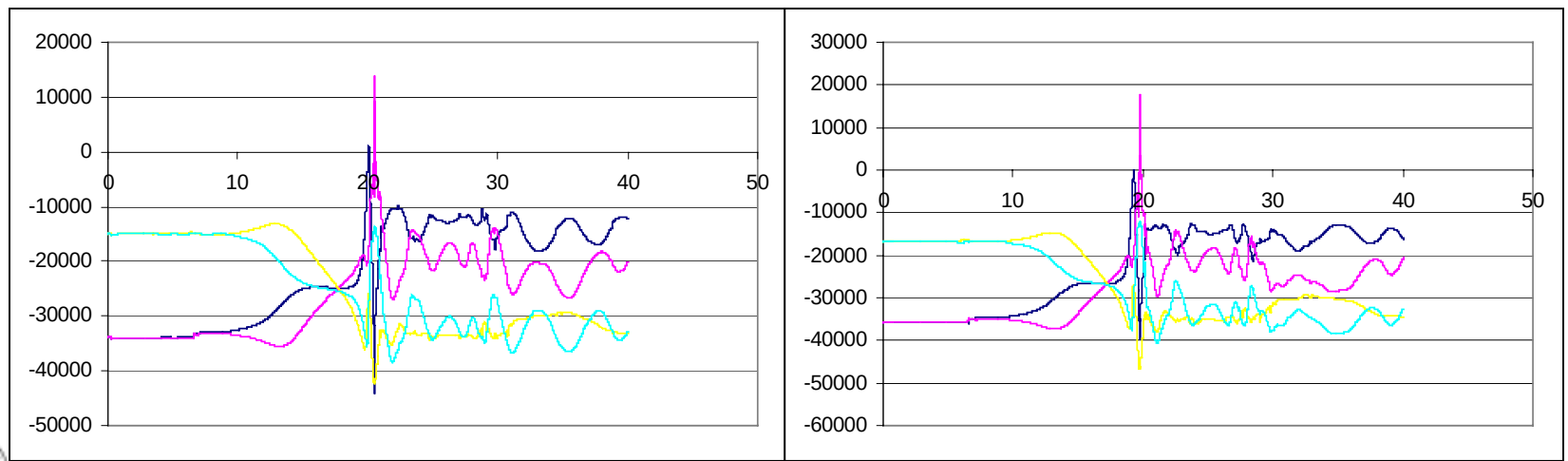
Case 1 (Traction 1-5)

Case 2 (Traction 2-4)

Y Displacement [m]



Normal Load [N]



Consideration : disposition

- The better disposition obtained is the one with motor in the first and the last bogie.
- The higer influence of disposition is noticeable on the motor - wheel bogie (wheel unloading appear on the 2nd bogie).
- The side traction bogie shows unloading in both disposition.

Future development

- Comfort study :
- Introduction of body flexibility
- Introduction of dampers
- detailed air-spring model
- Introduction of an intelligent motor wheel control loop.
- Lower contact forces
- Self steering capability