

# Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

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- Tram model
- Linear analyses
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- Works in progress
- Conclusions





# Ufficio Calcoli Strutturali

## Direzione Sistema Veicolo (Pistoia)

- 6 Persons

### Competencies

- Static analysis (linear and non linear)
- Fatigue analysis
- Dynamic analysis
- Running behaviour / Comfort
- Crash analysis





# Introduction

- **Main features of SIRIO tram:**
  - Completely low floor tram, with pavement height at 350mm over the top of rail,
  - Architectural modularity,
  - Bogies having independent wheels.
- **Purpose of analyses:**
  - Simulation of SIRIO tram with SIMPACK.
- **The activities on this project are not finished yet**





# Tram model

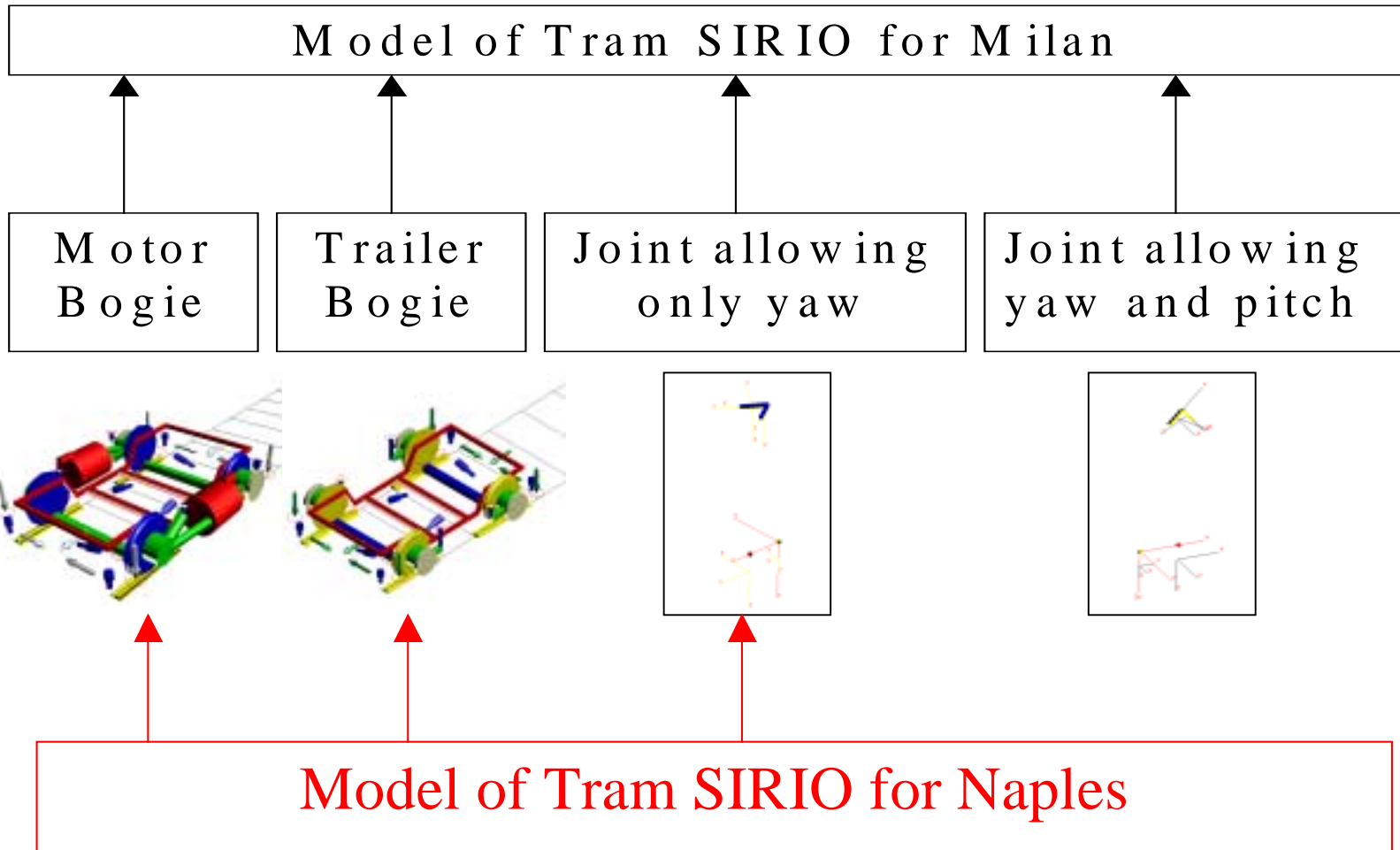


In order to reuse the sub components of tram SIRIO for Milan in other projects the database concept of SIMPACK is very useful



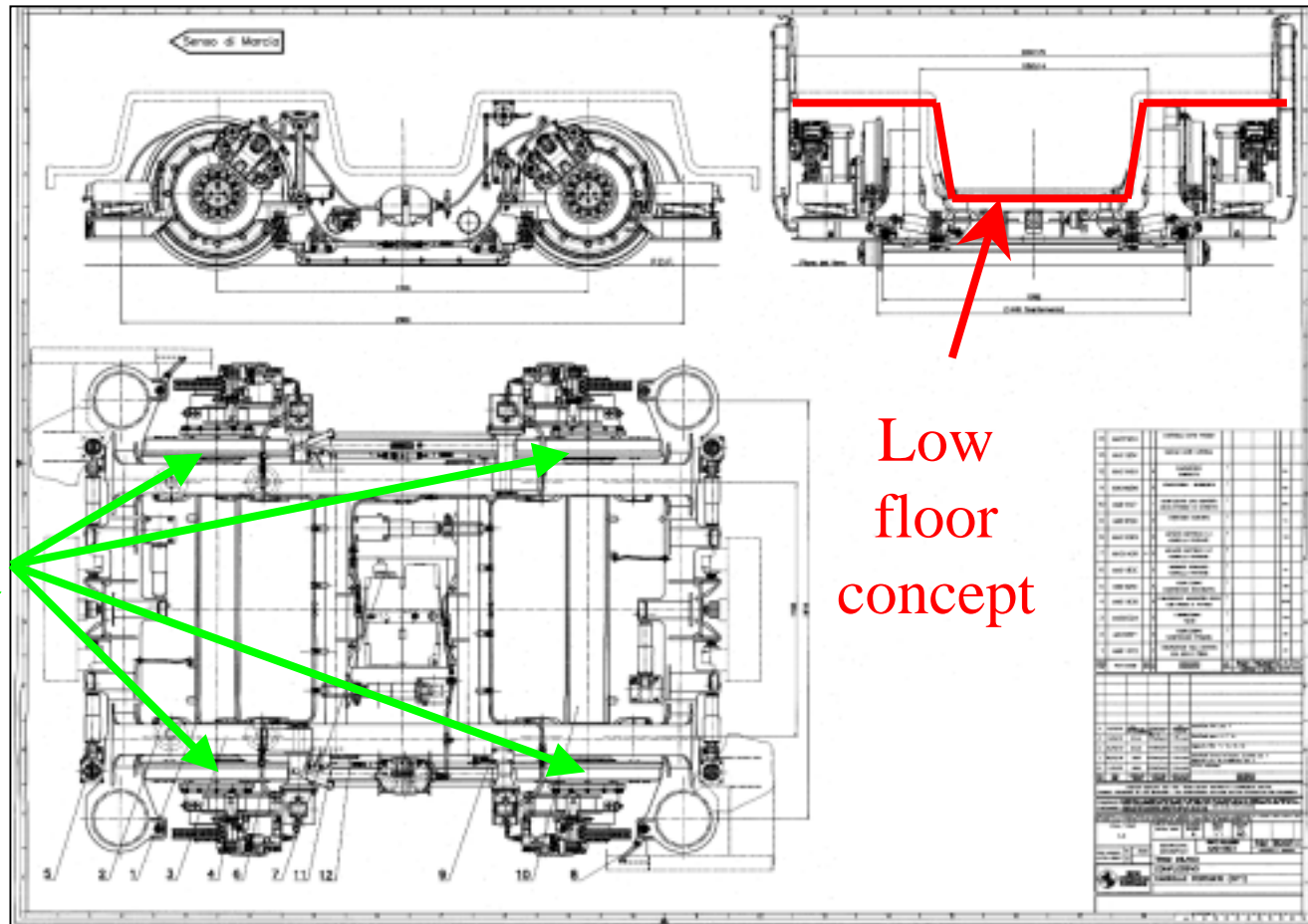


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# Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan



Independent wheels

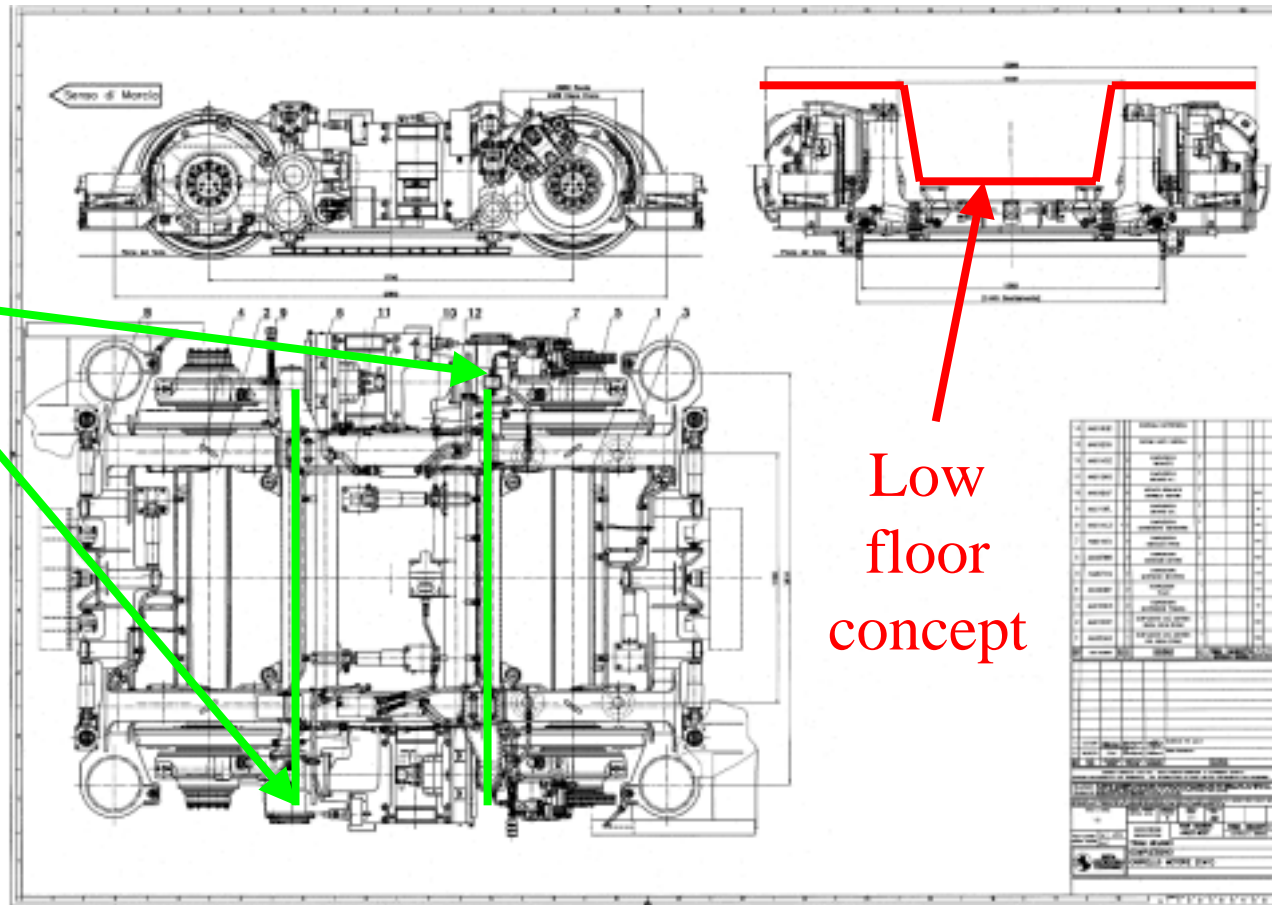
Low floor concept

- Trailer bogie drawing





# Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan



Mechanical differential with locking couple

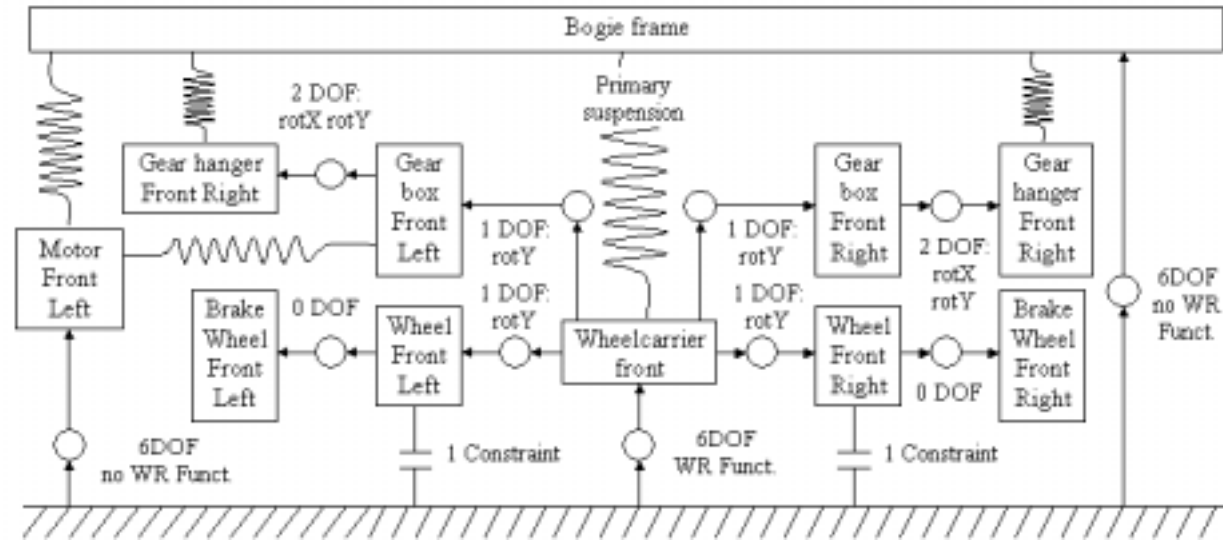
Low floor concept

- Motor bogie drawing





Independent wheels topology



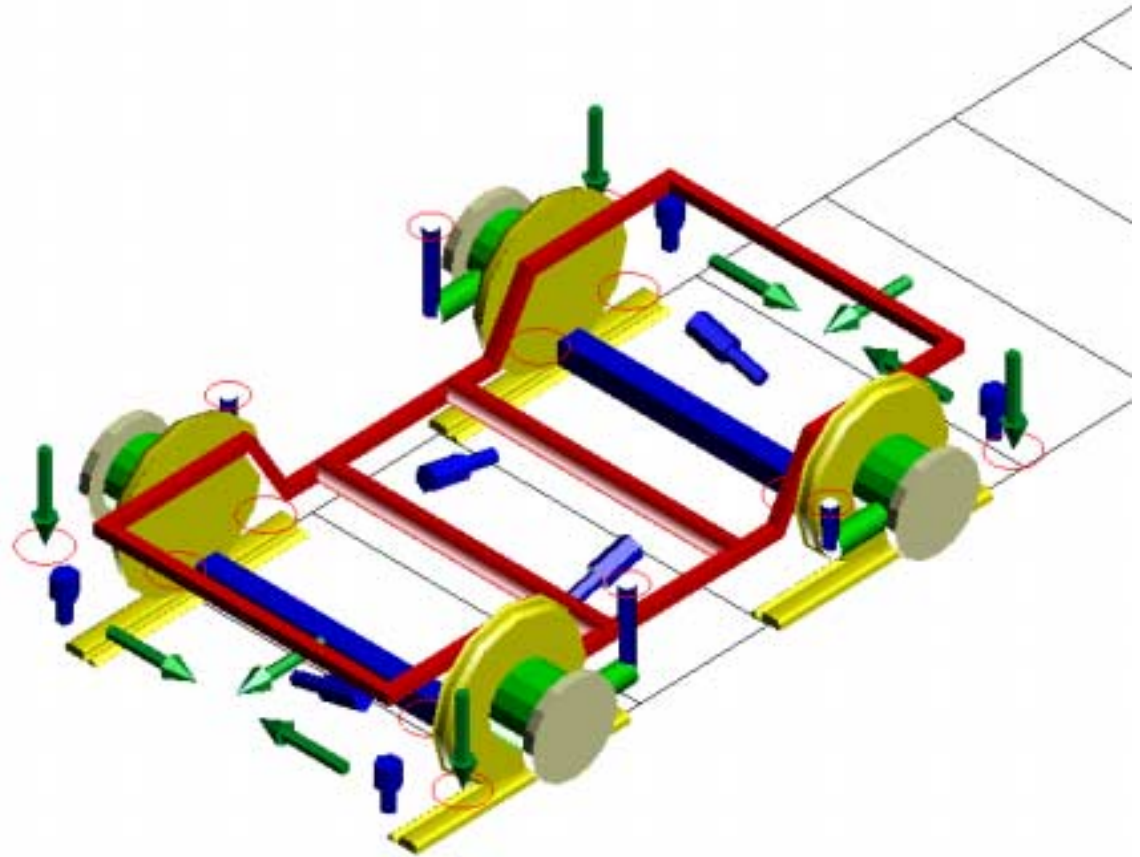
Motor bogie wheelsets

- A) Independent wheels
- B) Connected wheels



## Trailer bogie model

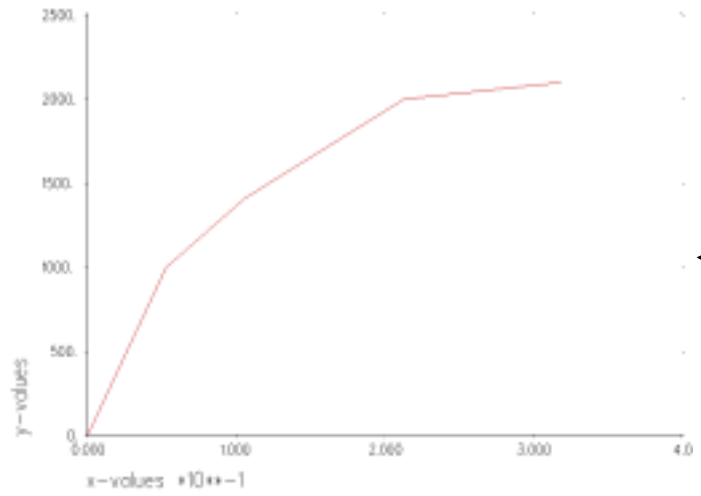
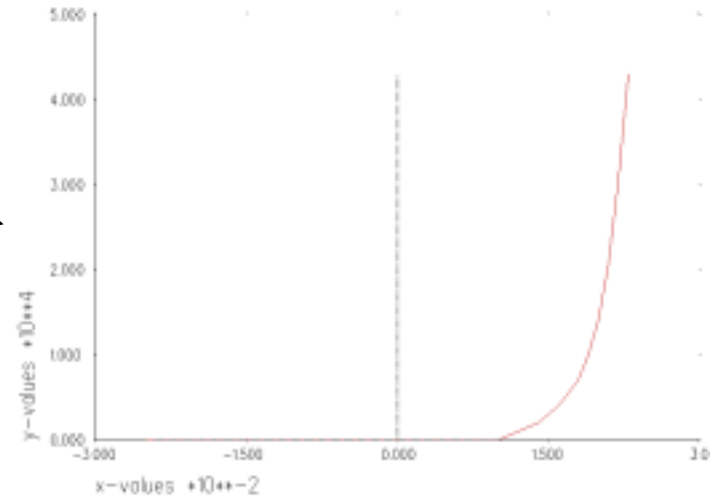
- Stiffness of primary and secondary suspension stage
  - Dampers characteristics
- Bumpers behaviour
- Rubber joints stiffness





# Simulation of dynamic behaviour of the new low floor tram SIRIO for Milan

- Non linear bumpers behaviour



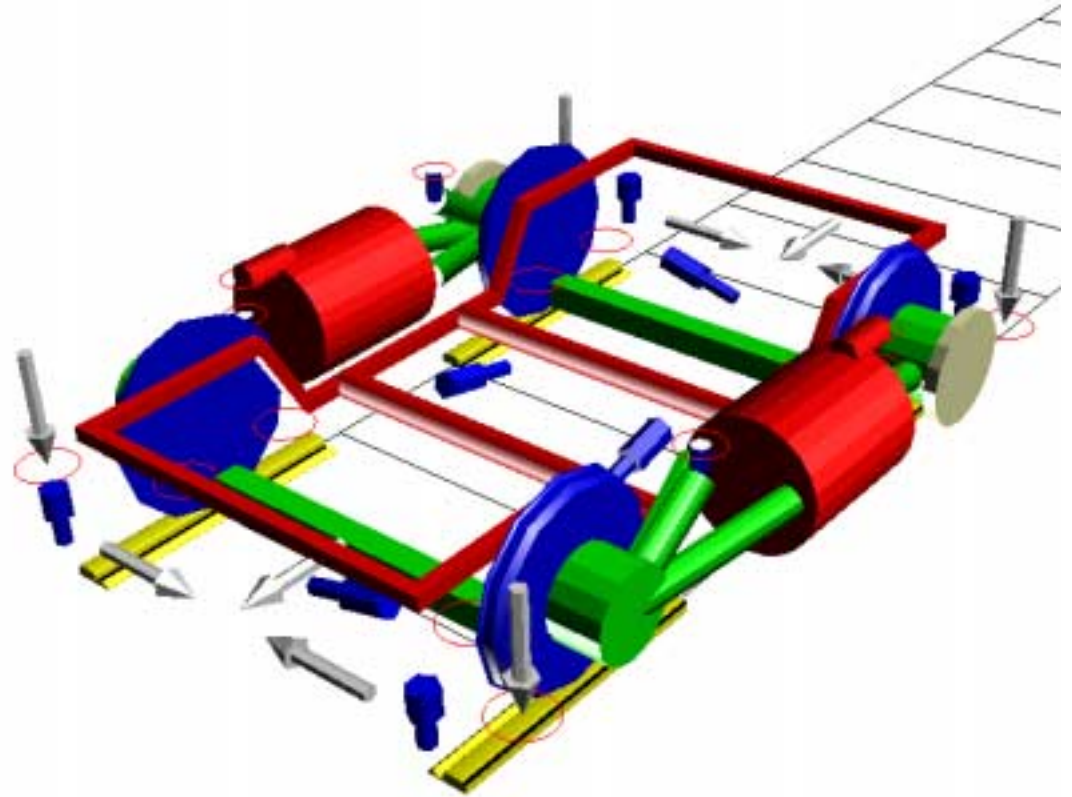
- Non linear dampers characteristics





## Motor bogie model

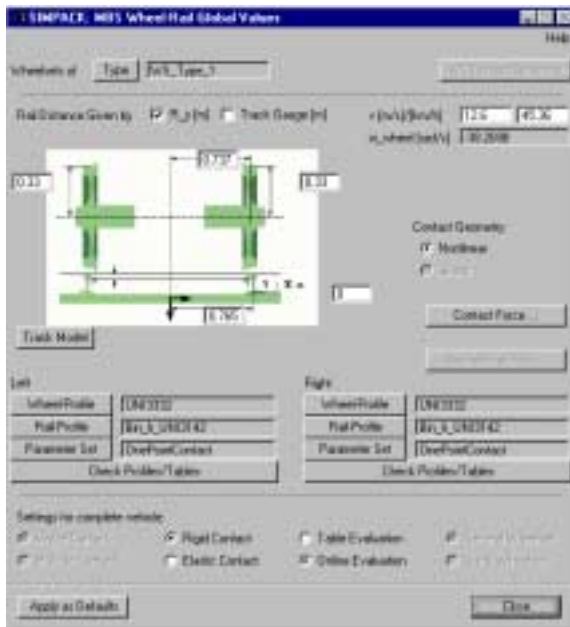
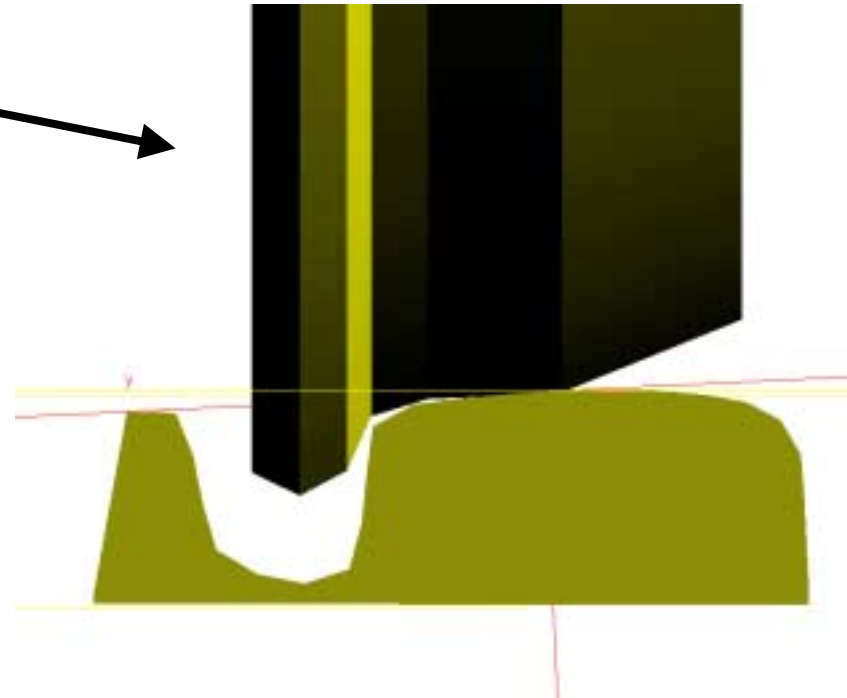
- Stiffness of primary and secondary suspension stage
  - Dampers characteristics
- Bumpers behaviour
- Rubber joints stiffness





## Wheel Rail Profiles

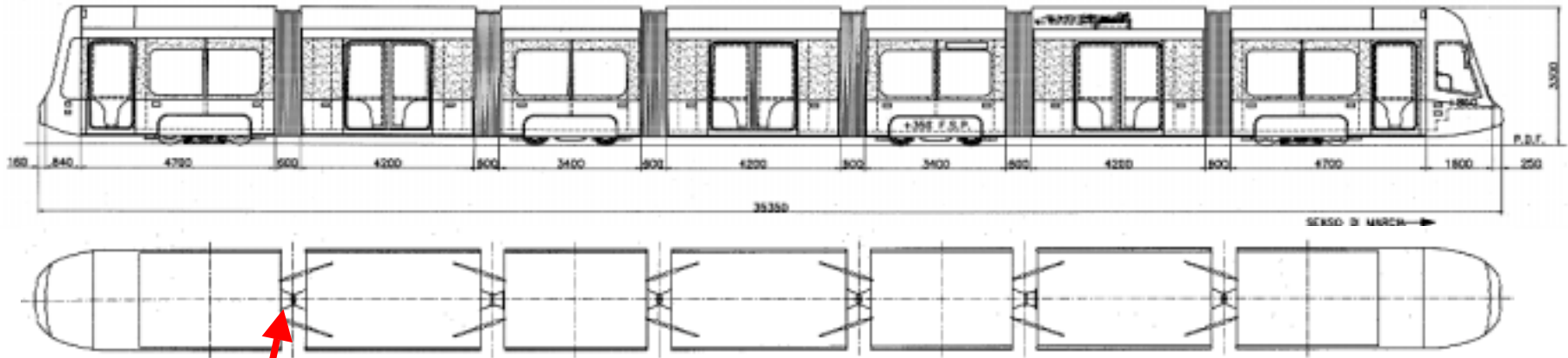
- Rail profile: lr UNI3142
- Wheel profile: UNI3332



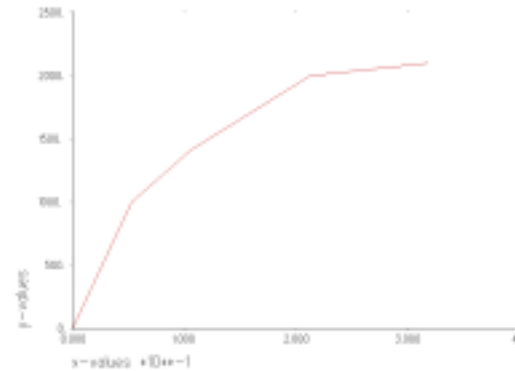
Wheel Rail Global Values



- Layout of tram SIRIO for Milan

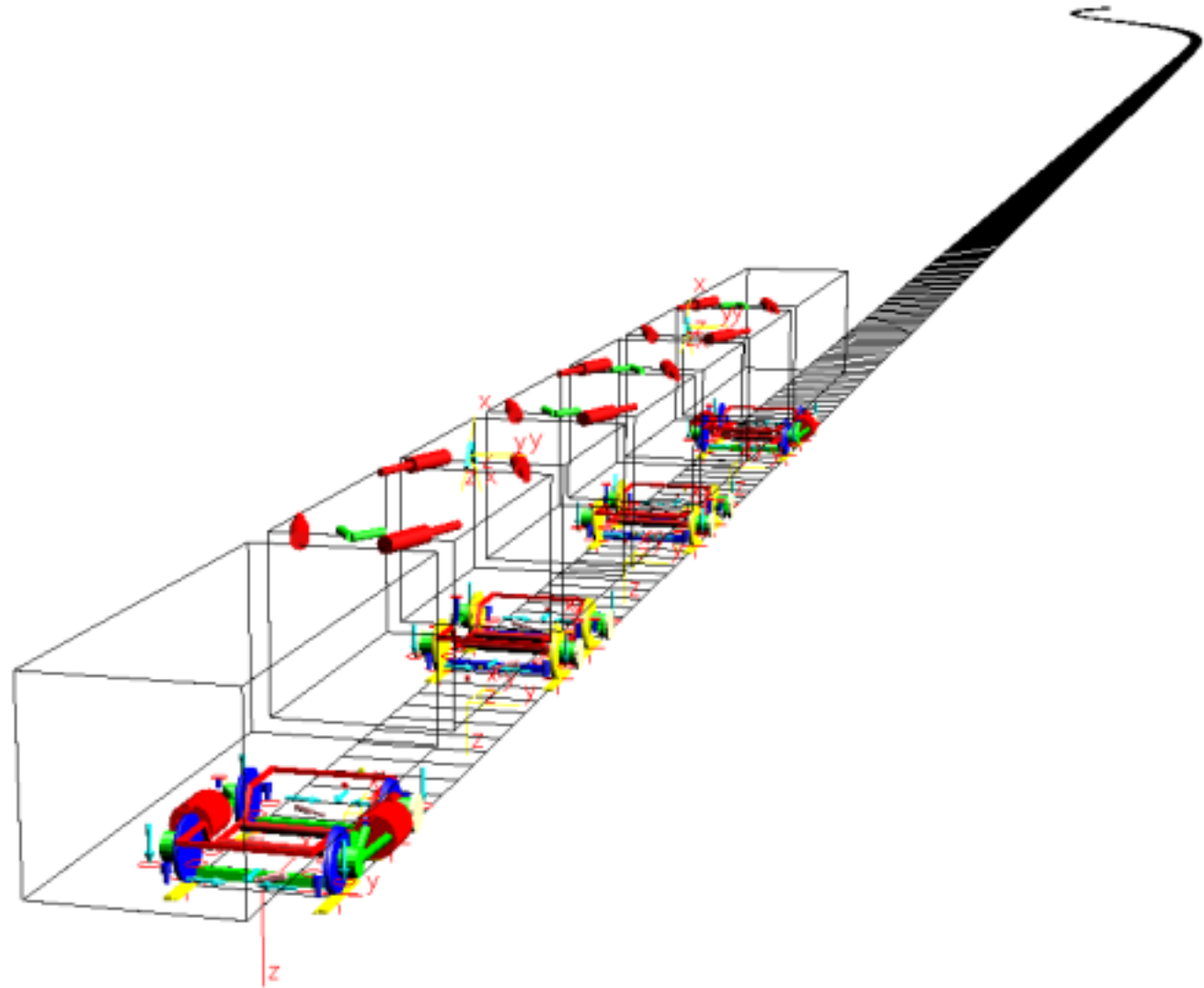


Dampers between coaches





# Model of tram SIRIO for Milan



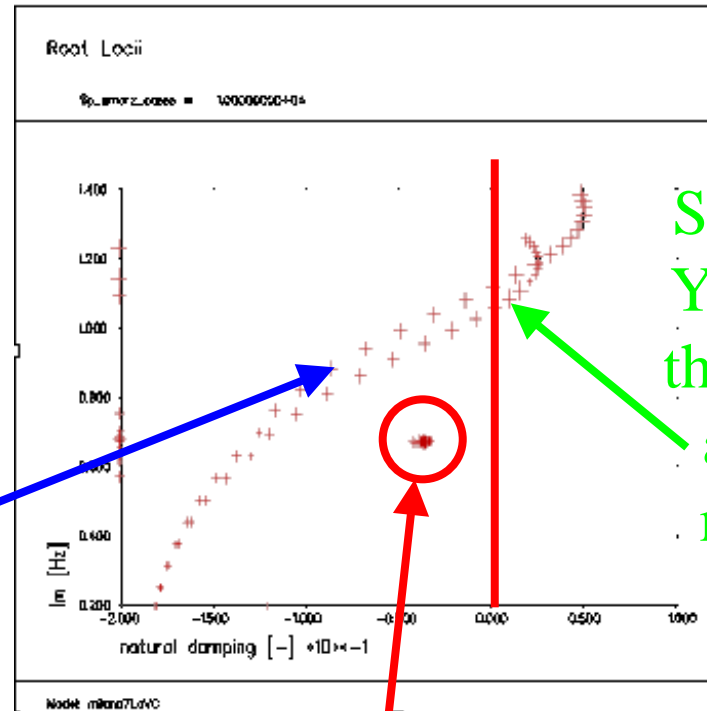


# Linear analyses

## Instability analyses

- Modal analysis
- Parameter variation
- Transient phenomena

Third mode:  
Yaw mode for  
the rear coach  
and the last  
motor bogie



Second mode:  
Yaw mode for  
the front coach  
and the first  
motor bogie

First mode: Roll mode is not influenced by speed



## Modal analysis

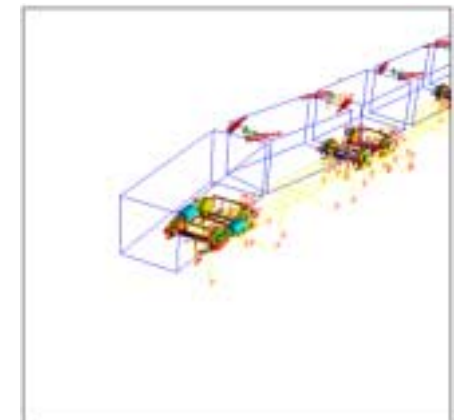
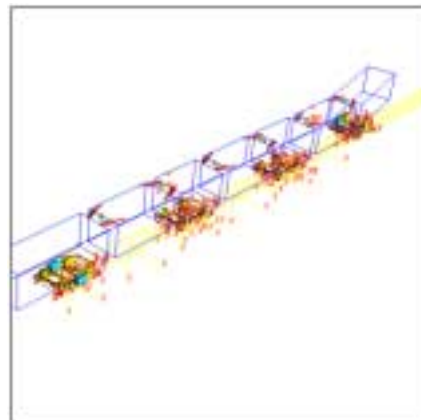
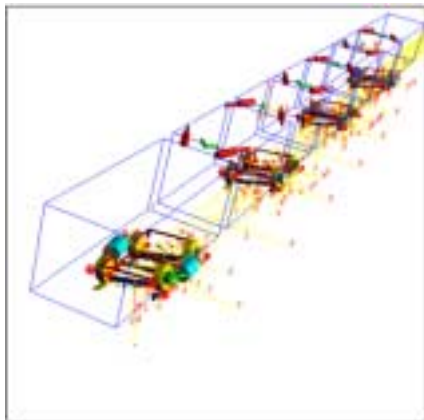
First mode:  
Roll mode

Second mode:

Yaw mode for the front coach and for the first bogie plus roll mode

Third mode:

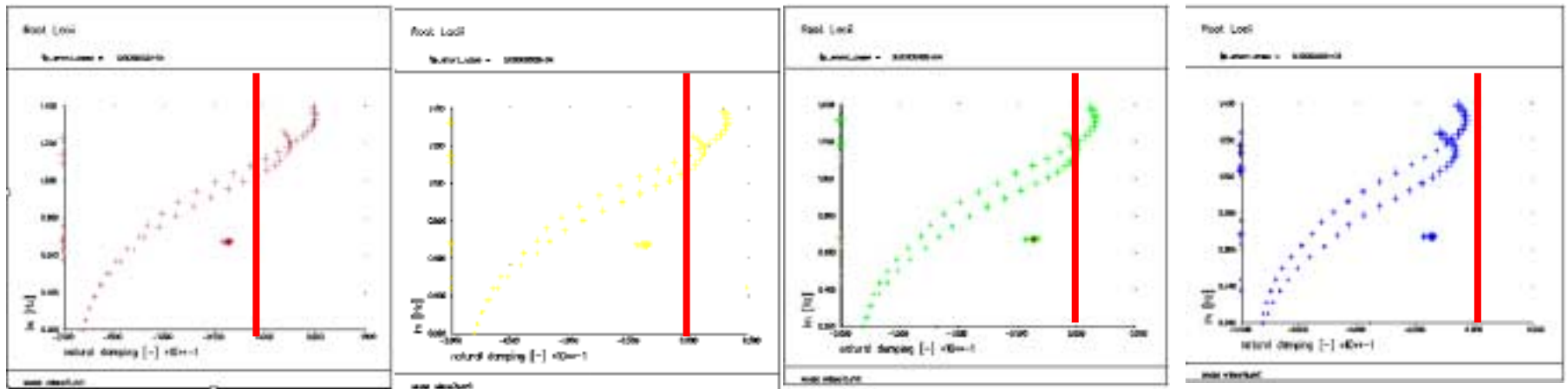
Yaw mode for the rear coach and for the last bogie plus roll mode





## Parameter variations

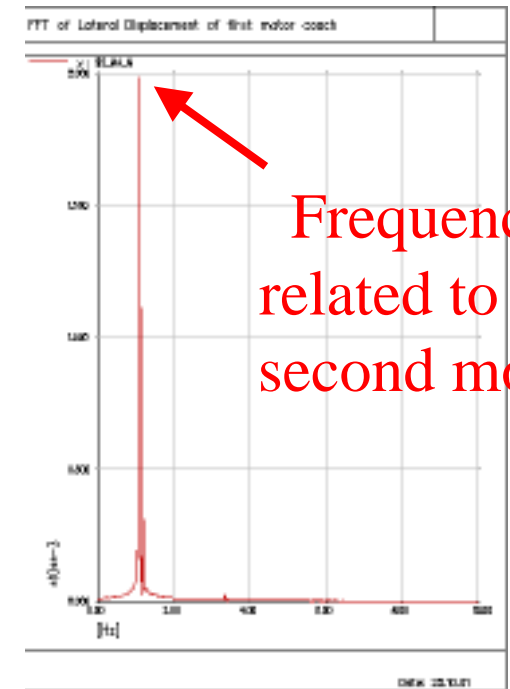
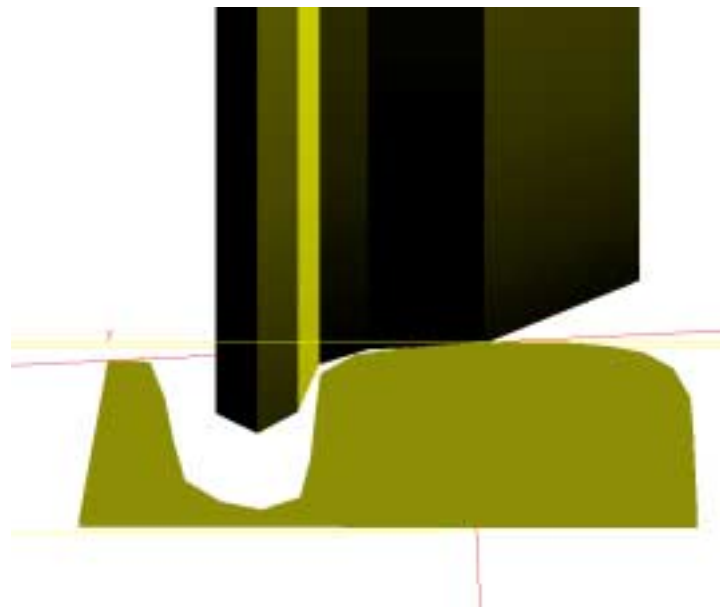
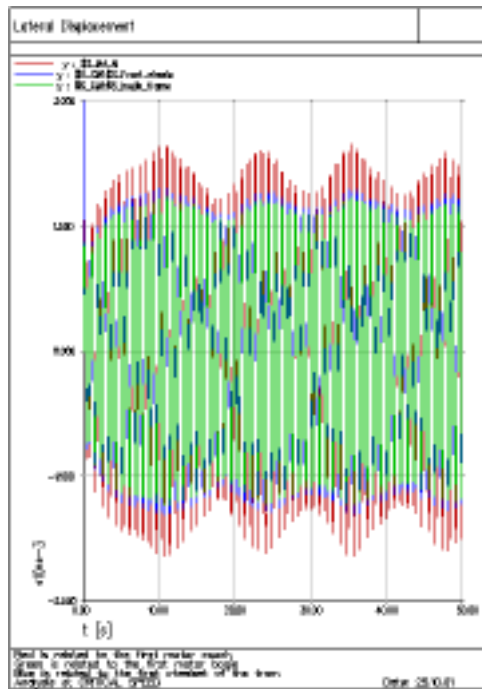
- The damping of the longitudinal damper doesn't change the critical speed
- The damping of the dampers between coaches has a big influence for the critical speed





## Transient phenomena

The tram is running over a straight and perfect track; but it is introduced one initial condition in order to study the transient phenomena due to it.

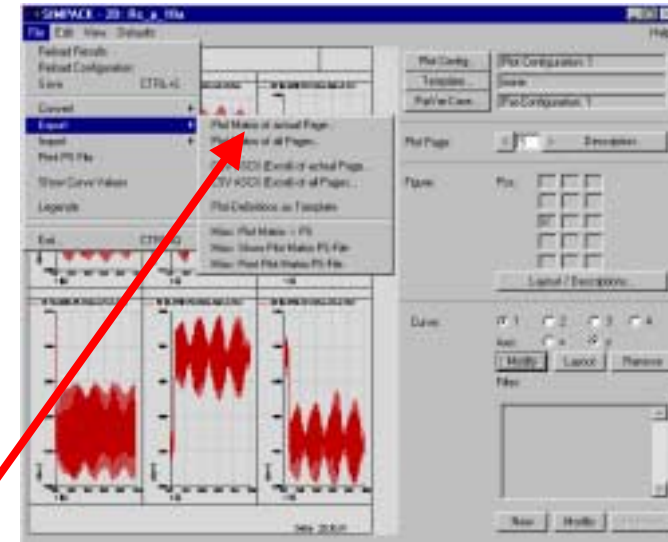
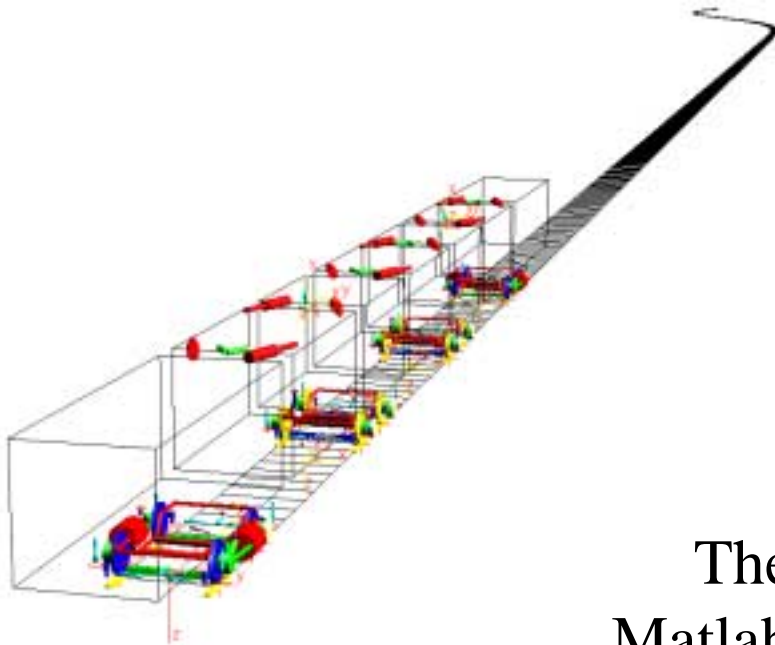


Frequency related to the second mode



# Non linear analysis

Time integration analysis of the runs of the tram over some curved and irregular tracks

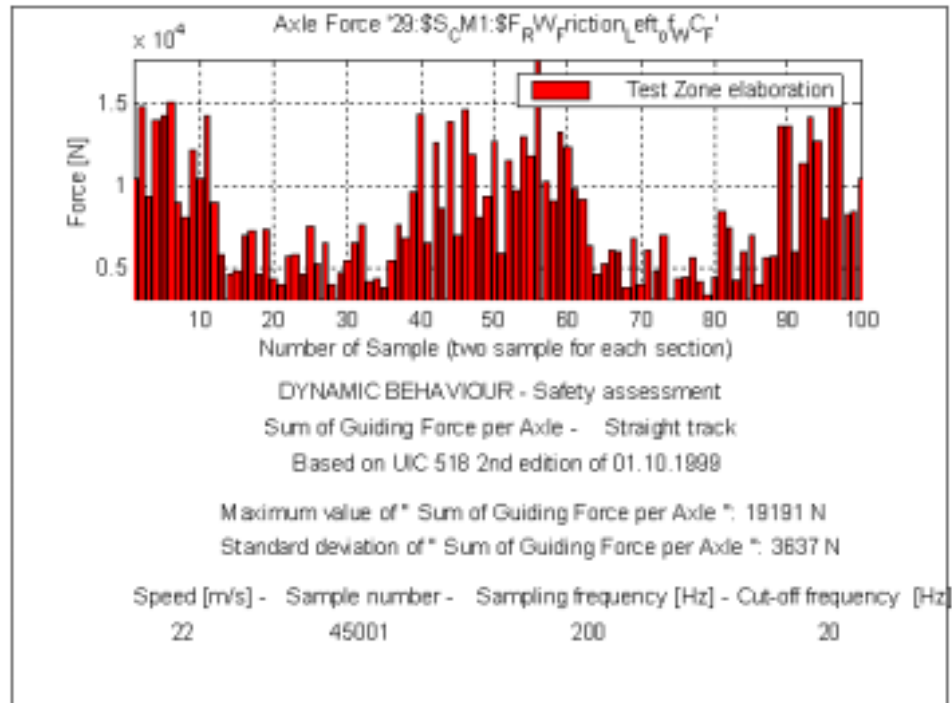


The analysis of WR forces is done with a Matlab elaboration, which reads the file created with the graphical 2D post processing





## Post processing of the WR forces





# Works in progress

- Adding into the simulation the model of mechanical differential with locking couple
- Study of tram behaviour in case of worn WR profiles
- Comparison between calculation and test results





# Conclusions

- SIMPACK is very useful for the design of rail vehicles
- The parameter variations module is a powerful method to explore the design configuration.
- The time integration module is fast