Simulation of freight train during braking operation using SIMPACK

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Introduction

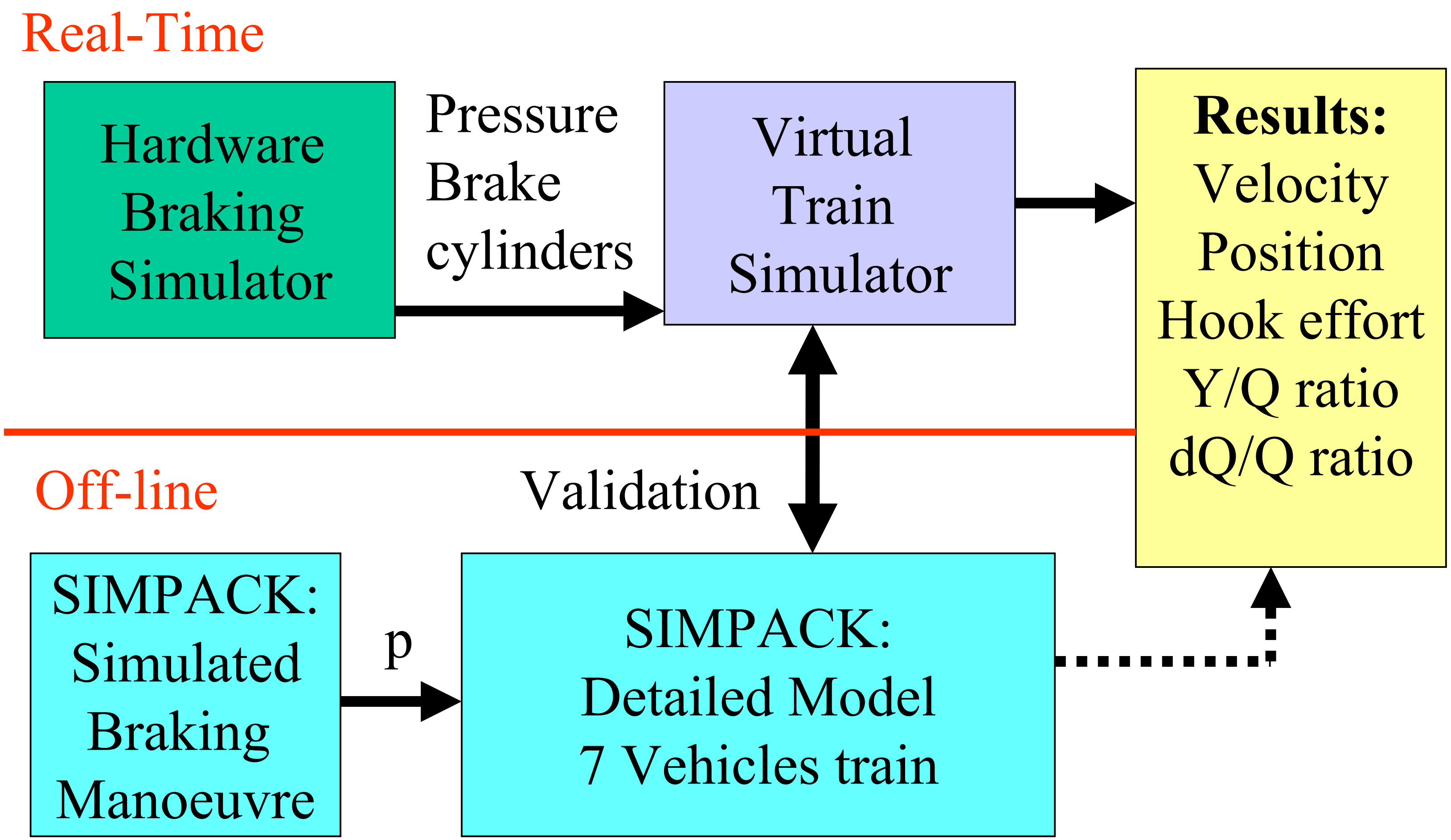
- This activity has been made in a research project together with SAB-WABCO S.P.A (Piossaco, Torino).
- SAB-WABCO has realized a full-scale hardware simulator of the braking system of an entire train long up to 2 km.
- The simulator includes all the pneumatic and control device up to the braking cylinders.
- In this context, has been individuated the necessity to link the braking simulator with a virtual simulator to obtain the dynamic response of the train.

Objectives

- Aim of the work was to realize a real-time virtual simulator of a long train to be integrated with the hardware simulator of the braking system (Hardware in the loop).
- Results expected from the virtual simulator were : the braking distance, the hook effort and some indications for the risk of derailment.

Method

- The virtual train simulator has been realized using analytical simplified models.
- SIMPACK has been used to realize more complex models (limited to few vehicles train) in order to develop and validate the simplified models, and evaluate the effect of approximations.

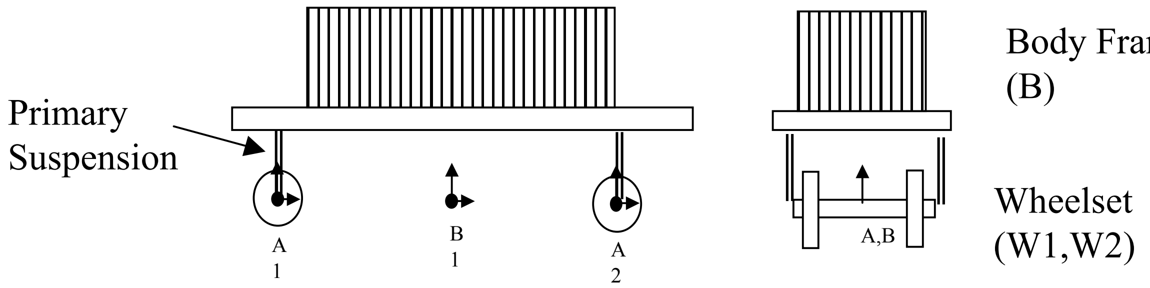

Real-Time
Hardware Braking Simulator
Pressure Brake cylinders
Virtual Train Simulator
Results:
Velocity
Position
Hook effort
Y/Q ratio
dQ/Q ratio
Off-line
Validation
SIMPACK: Simulated Braking Manoeuvre
p
SIMPACK: Detailed Model 7 Vehicles train

Model

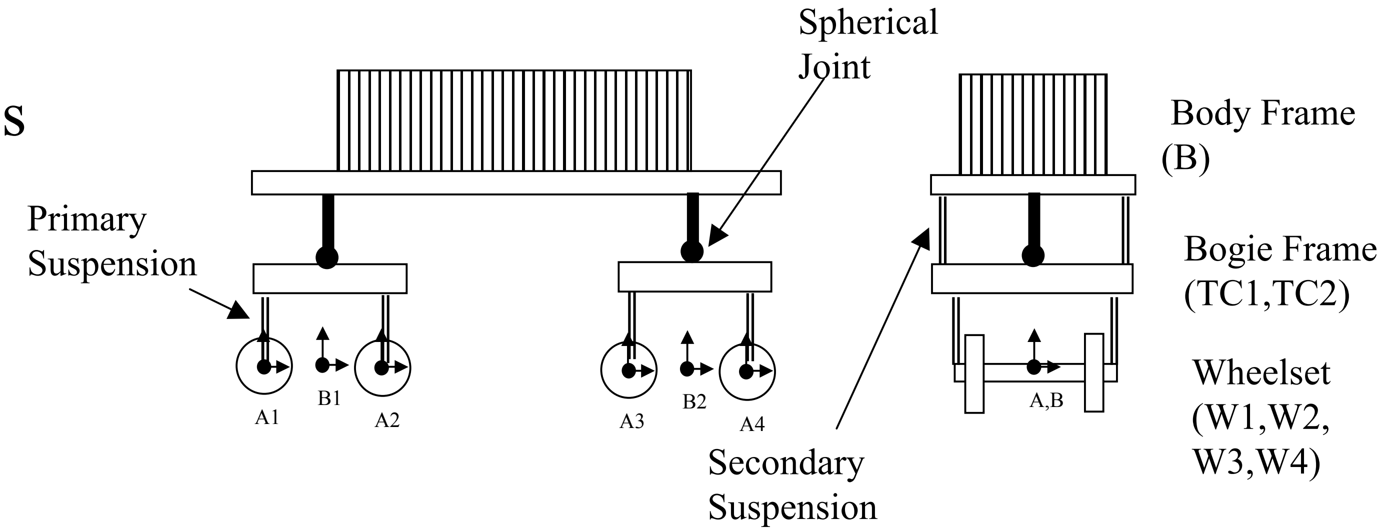
- In order to simulate different train configurations, a series of models of common freight vehicles have been created.
- The models are divided in two typology: bogie vehicles and 2-axle vehicles.
- The various vehicles have been connected using different models of buffers/drawn gear.

Vehicles Typology

2-Axle Vehicles

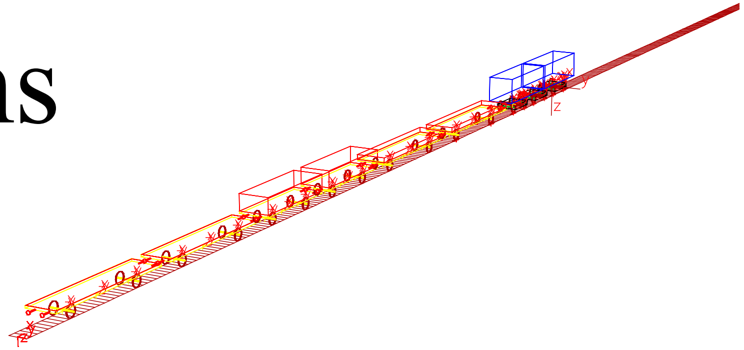


Bogie Vehicles

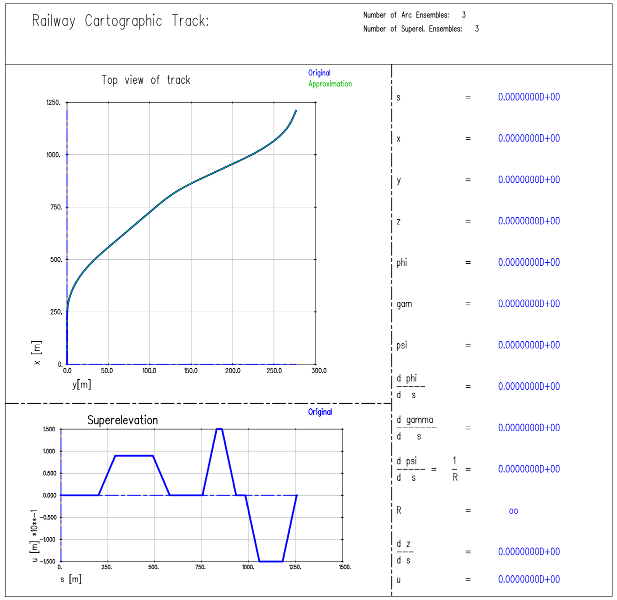


SIMPACK User Meeting 2004

Simulations

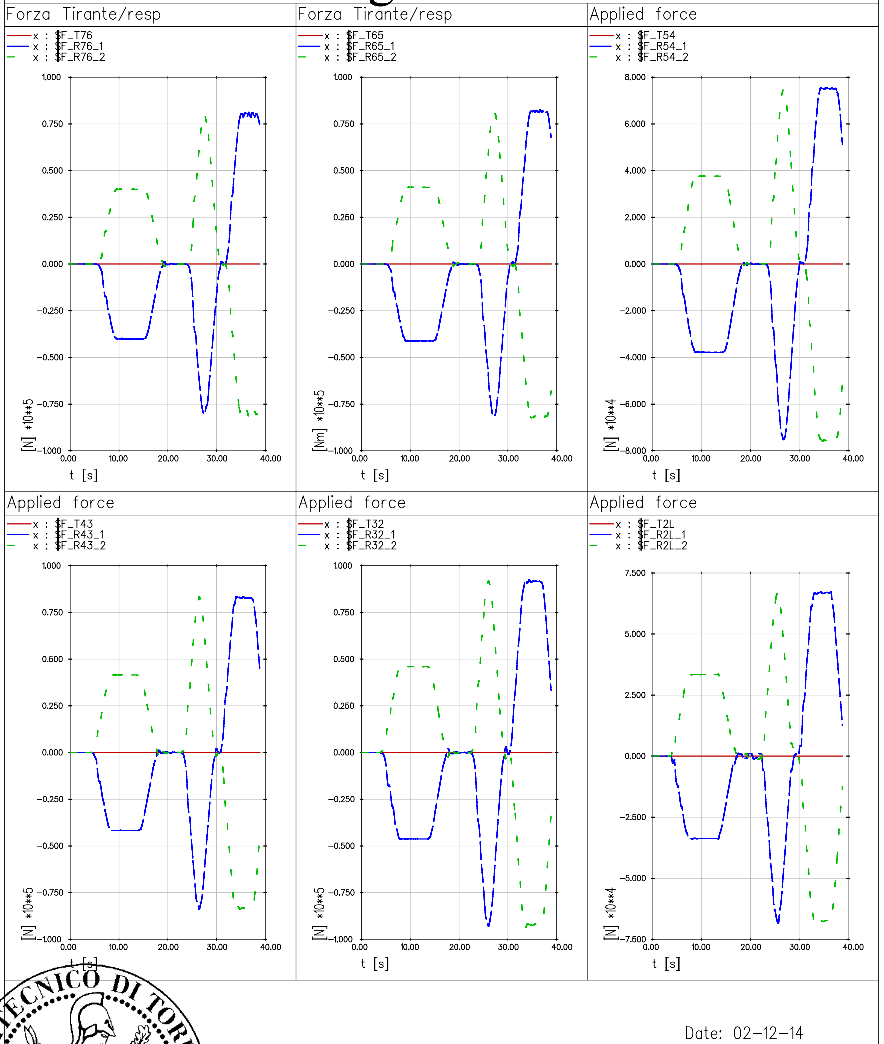


- The vehicles have been composed in trains with different configurations and assembled on different track.
- Simulation are performed both at constant speed than during a braking maneuver.
- A set of critical parameter are analyzed on each analysis: Y/Q, dQ/Q, Y Forces, Longitudinal Effort, Vehicle kinematics.

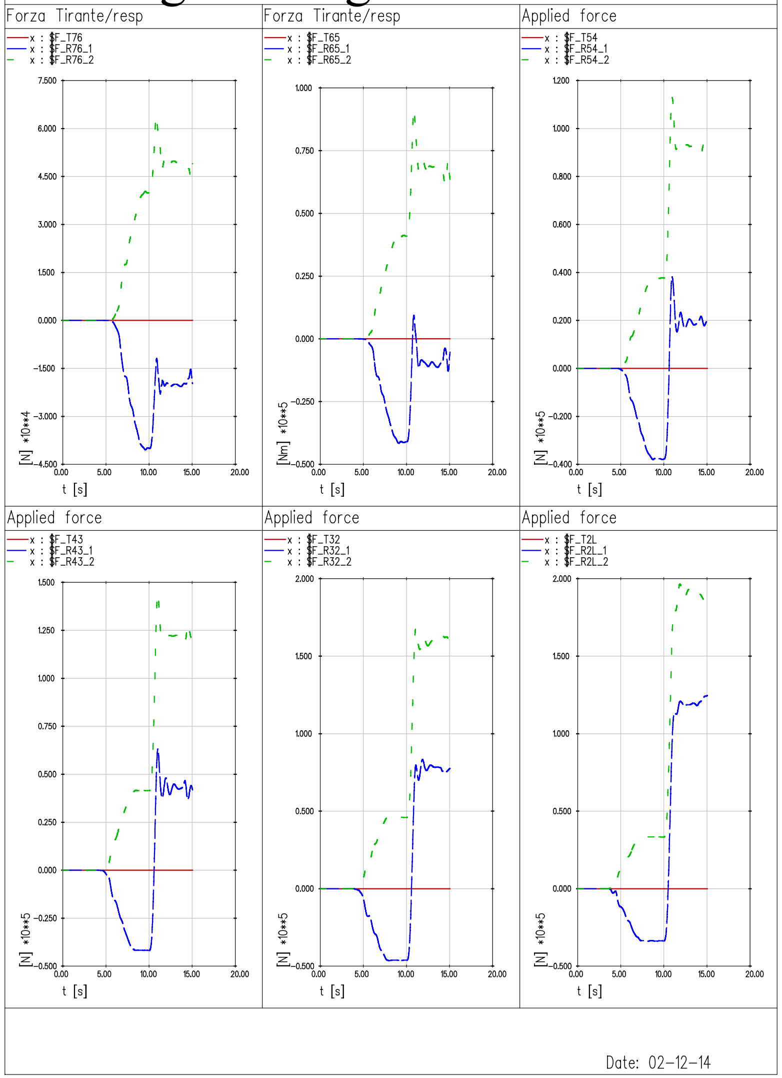


Buffers Effort

Without Braking

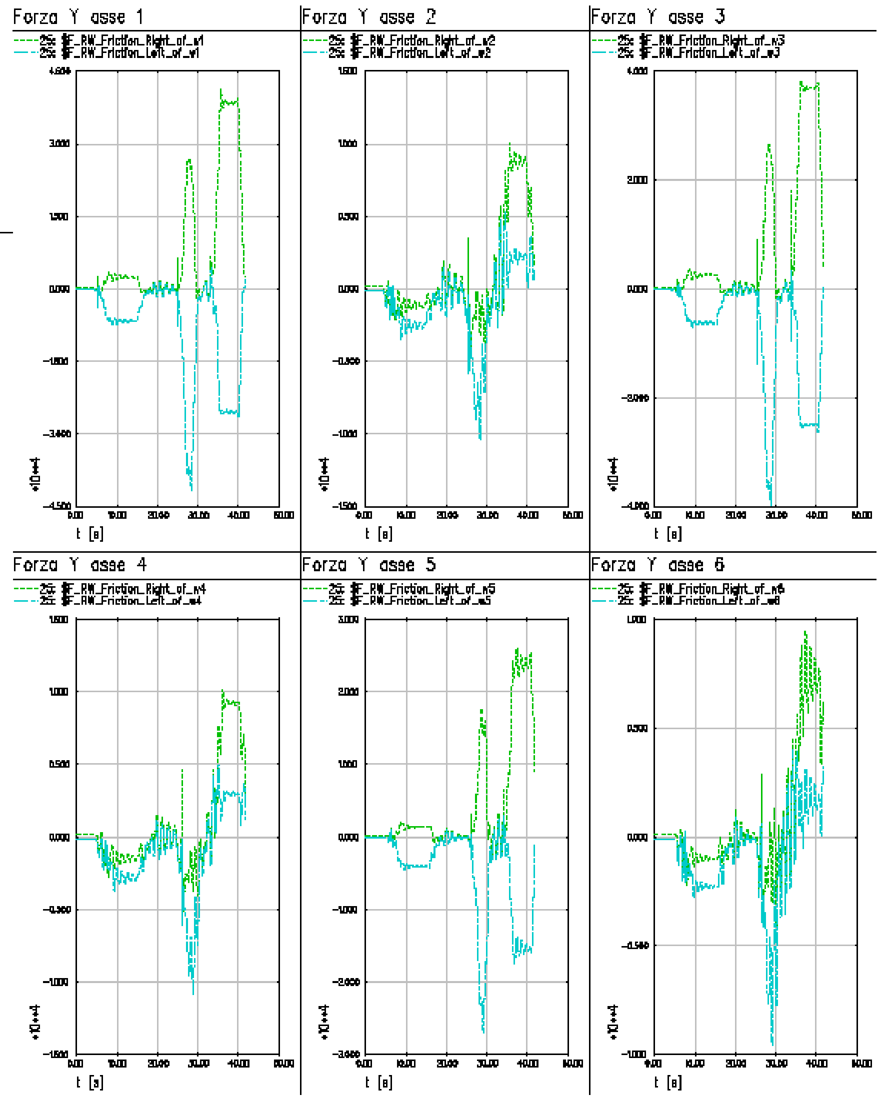


During Braking

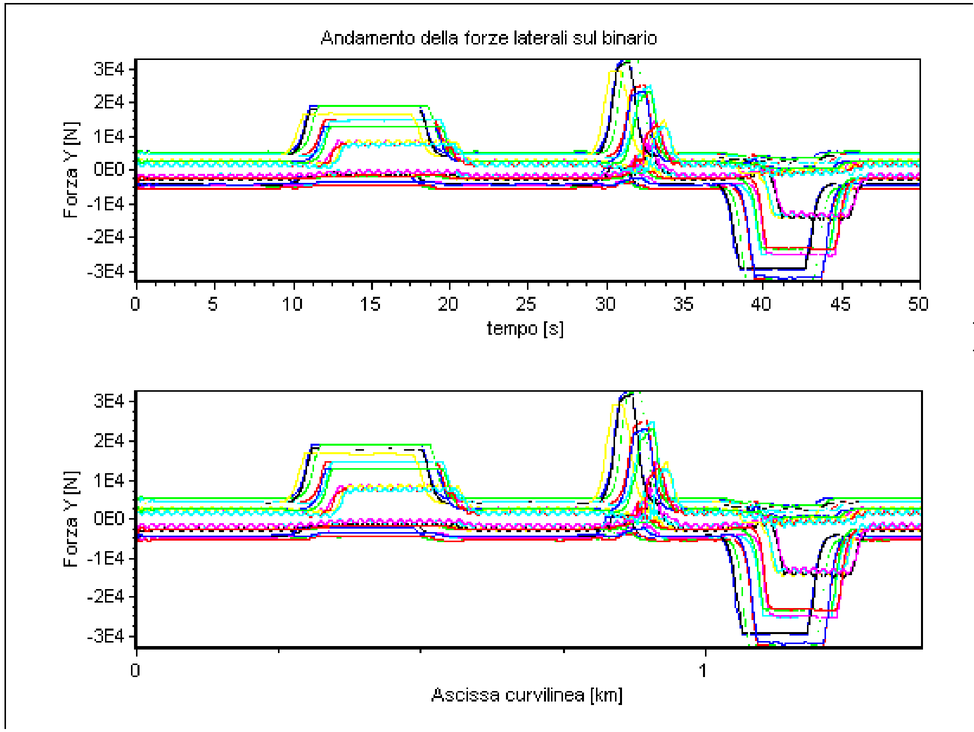


Y Forces

SIMPACK



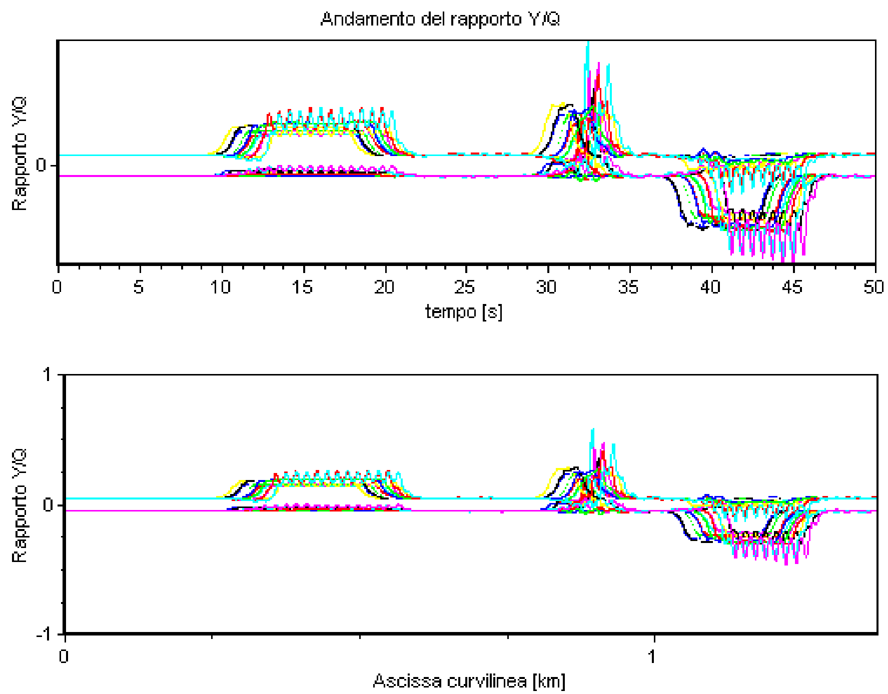
Simplified Model

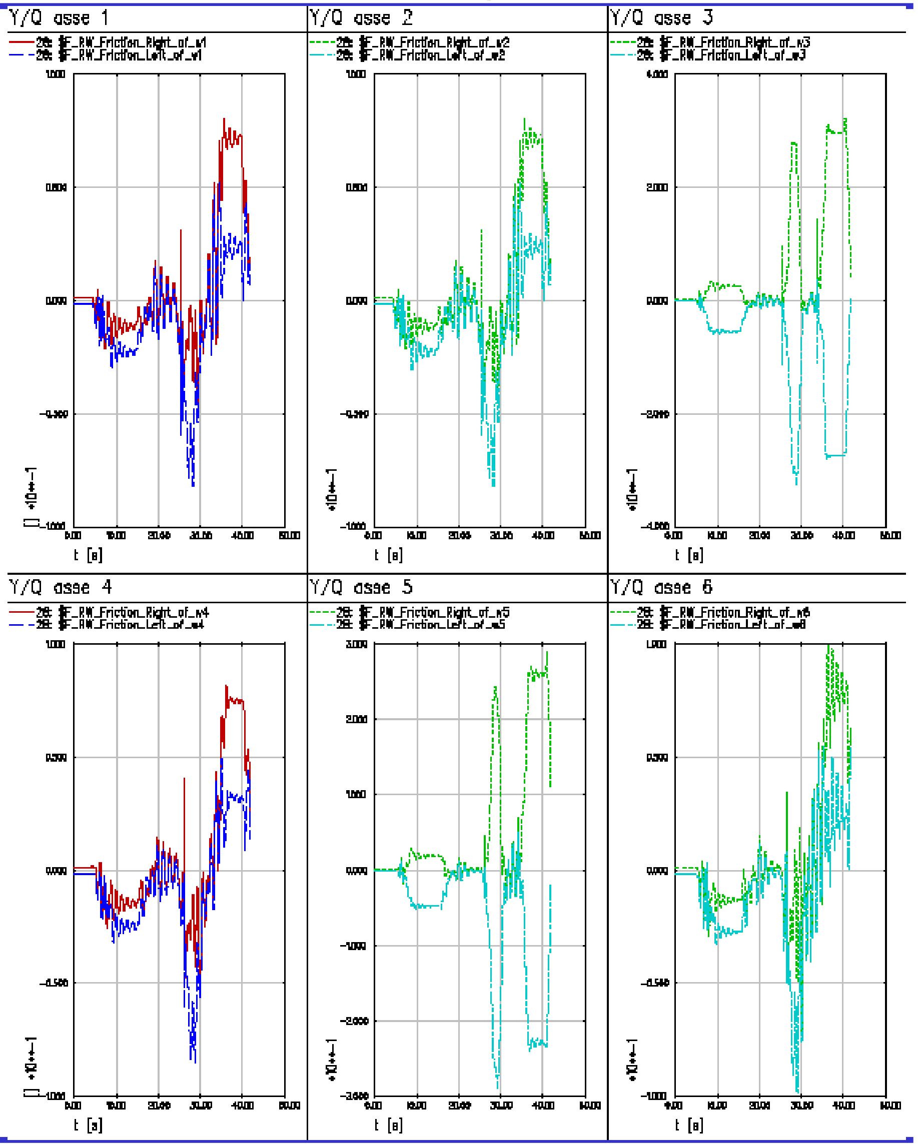


Y/Q RATIO

SIMPACK →

Simplified Model





Relevant conclusions

- Results obtained using SIMPACK, demonstrate that during braking operations the risk of derailment in curved track is increased.
- Considering a wide range of freight vehicles it was possible to develop a simplified (real-time) code, to obtain a first-level indication of derailment risk during braking.

Other Research Activities

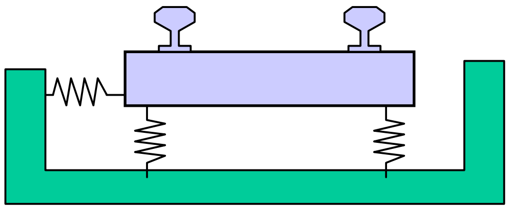
- Enhancements to the discrete track flexibility model
- Model validation using a Roller-Rig

Discrete Track Flexibility

- In the following will be described an easy method to enhance the SIMPACK model of discrete flexible track.
- The model allow to introduce a lateral flexibility between the sleeper and each rail.
- This flexibility can be expressed as function of the position along the track.
- Possible application is the simulation of a track with damage in the rail-sleeper connections.

Discrete Track Flexibility

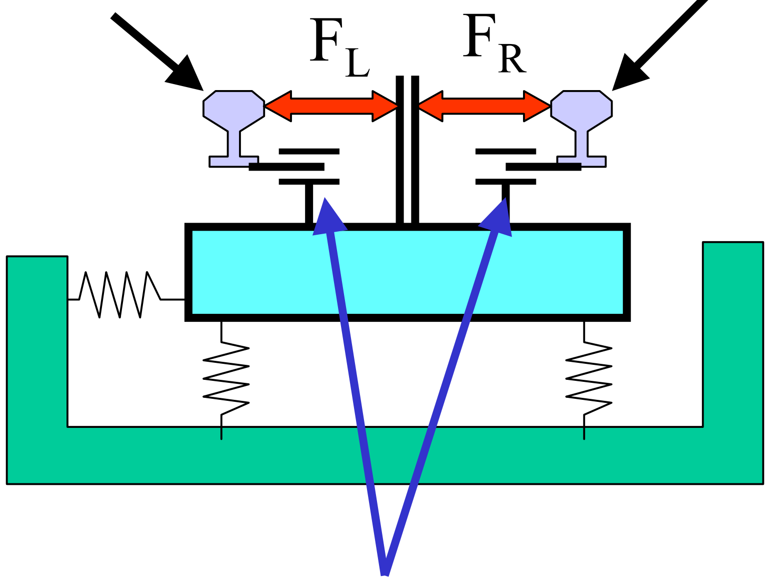
Basic SIMPACK Model



(*) Additional Elements:

1 for each wheelset

F_L, F_R= Force elements



- Force elements are defined by expression (1 expression for each additional rail element).
- The stiffness can be changed as function of the track position using an input function (different for the right and left side).

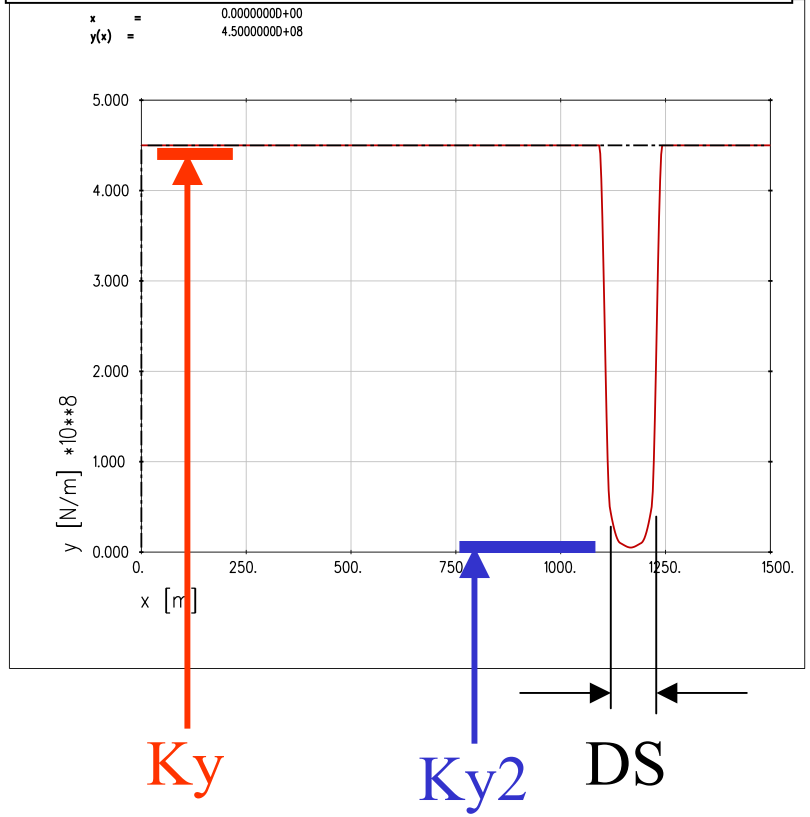
```
express.str  ($X_r1r)  =
   'IFCTN(JOINTST($J_W1,1),$I_Yrstiff)*
JOINTST($J_R1R,1)'
```

As an example, 4 cases are considered:

- Constant stiffness (1,2)
- Localized low stiffness with short (3) and large extension (4)

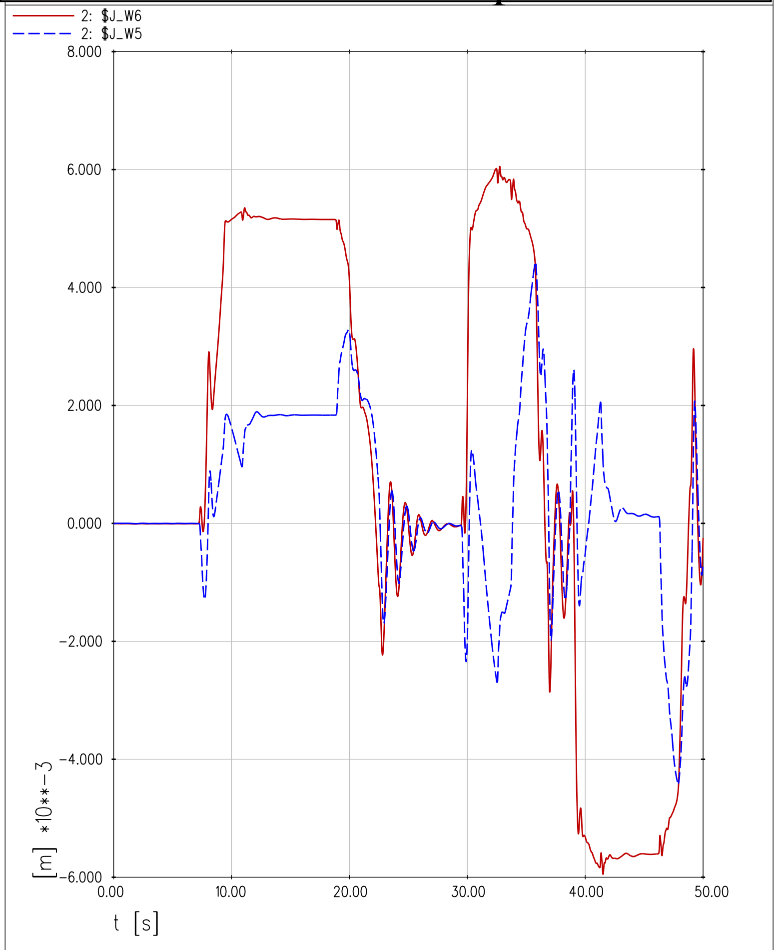
CASE	Ky KN/m	Ky2 KN/m	DS m
1	450	-	-
2	200	-	-
3	450	5	2
4	450	5	75

Input Function : Ky(s)



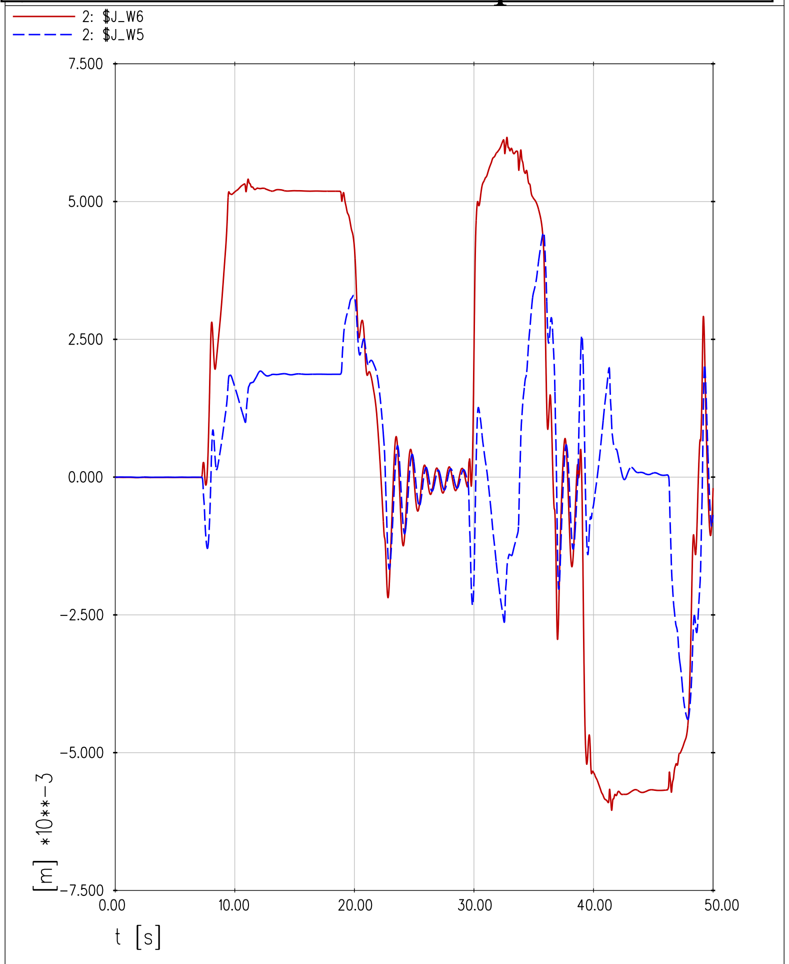
Discrete Track Flexibility

Lateral Wheelset Displacement



CASE 1

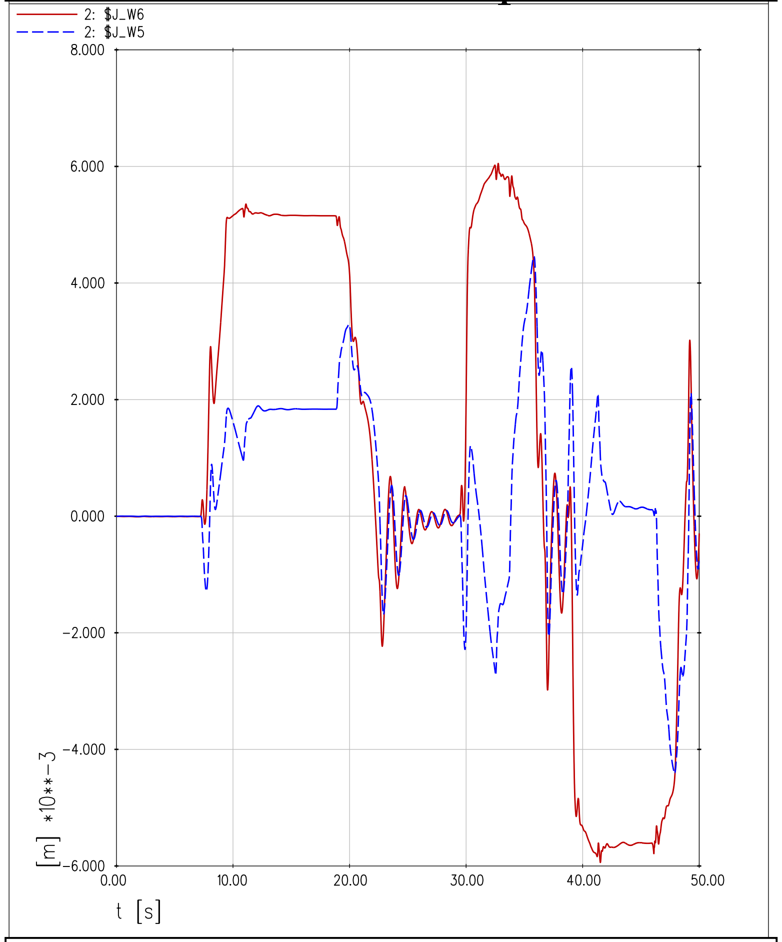
Lateral Wheelset Displacement



CASE 2

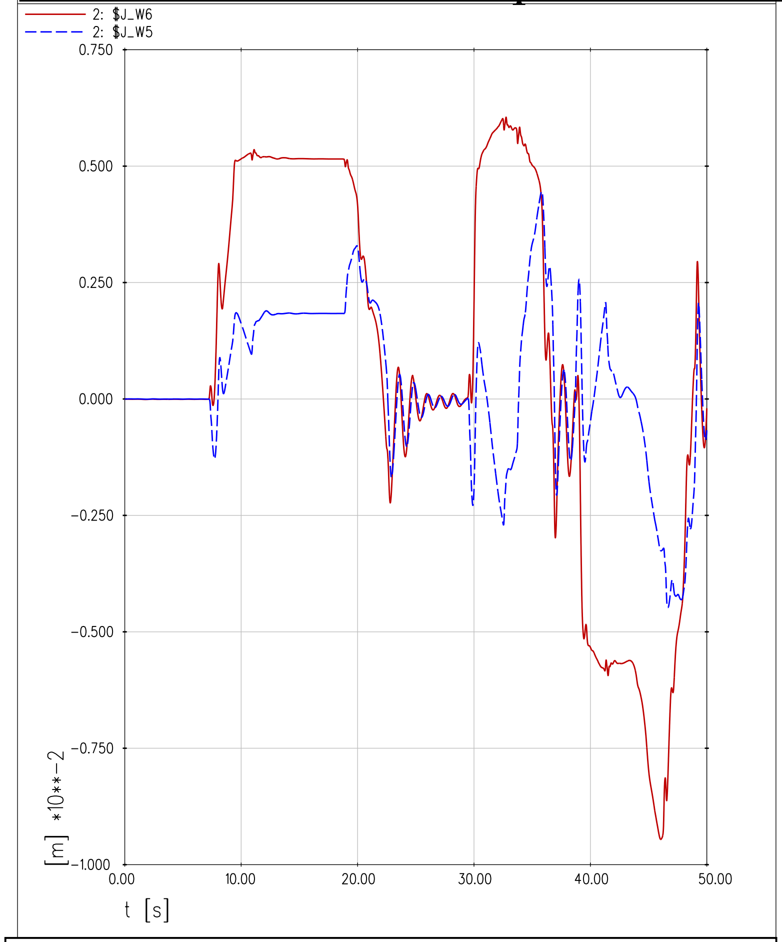
Discrete Track Flexibility

Lateral Wheelset Displacement



CASE 3

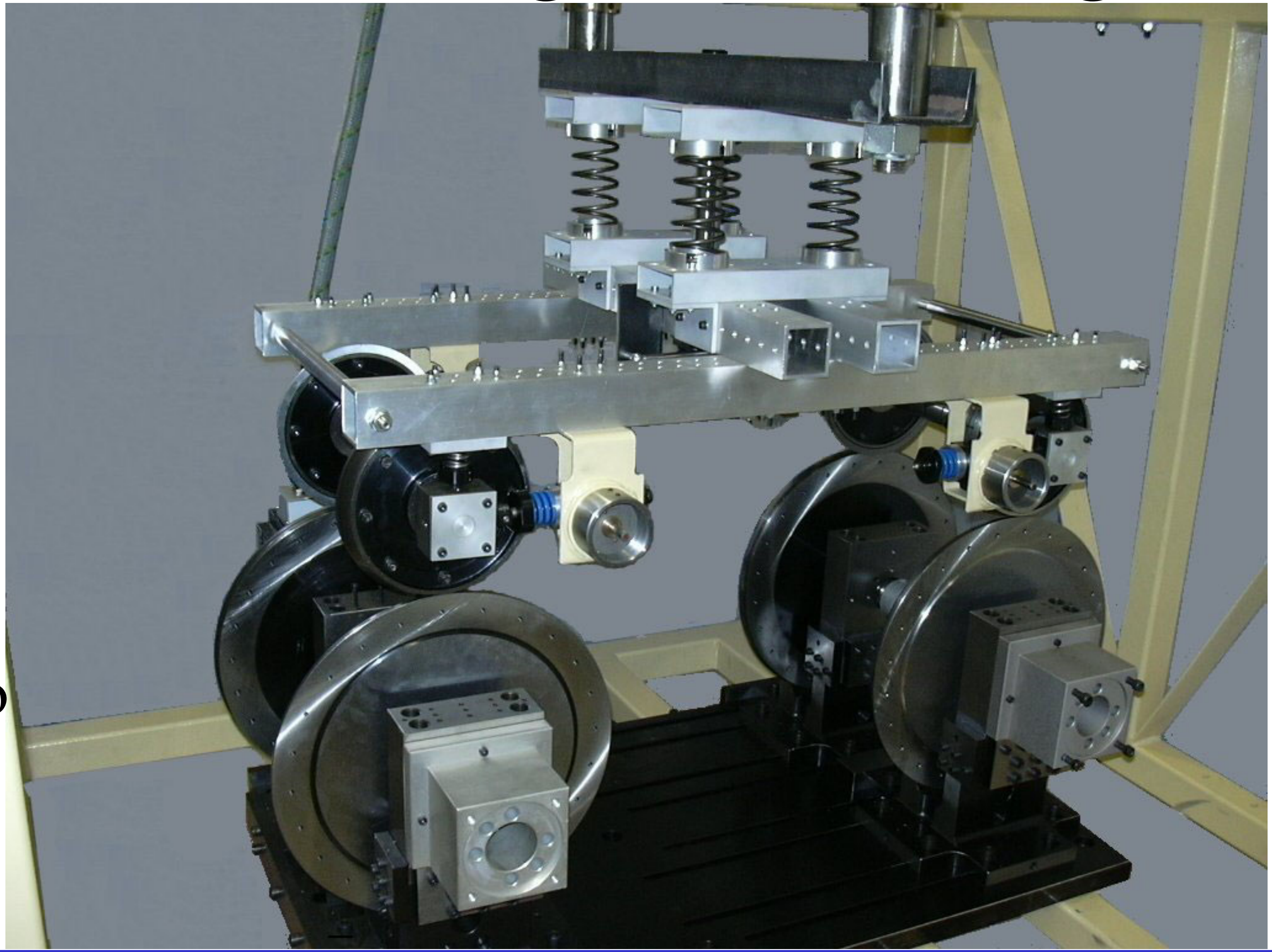
Lateral Wheelset Displacement



CASE 4

Model validation using a Roller-Rig

Roller-Rig realized at Politecnico di Torino



Model validation using a Roller-Rig

- A new 1:5 scale roller-rig has been developed and built at Politecnico di Torino.
- The Roller is designed in order to carry on tests both on a single suspended wheelset then on a railway bogie with wheelbase in the range 1.8 – 3.5 m.
- Current activity is to validate a numerical model of a passenger train using the roller-rig.