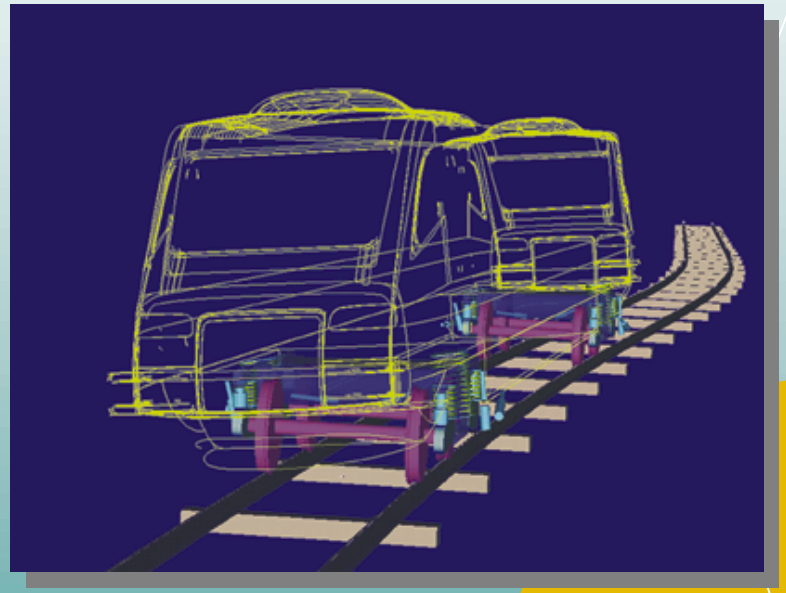
ADAMS/Rail 10.1
A Revolutionary Environment for Railway Vehicle Simulation



Gabriele Ferrarotti
Mechanical Dynamics
5th ADAMS/Rail Users Conference
May 10th, 2000

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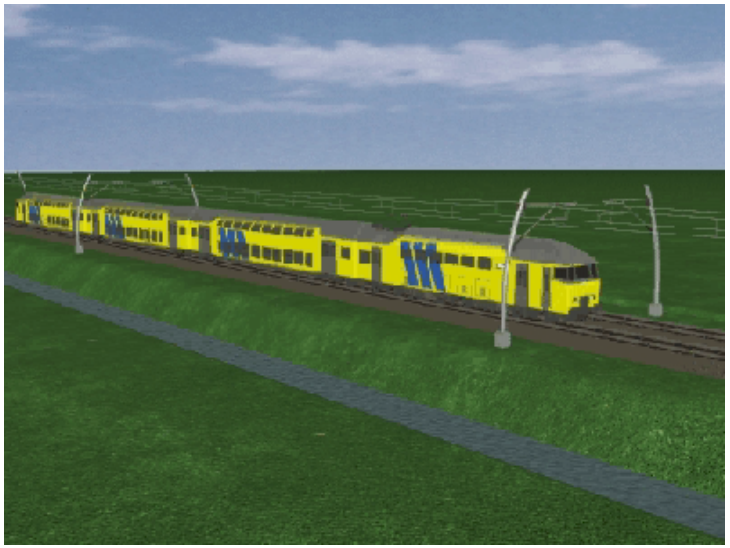
Agenda

- Current Railway User Community
- ADAMS Product Line
- ADAMS/Rail 10.1 Release Highlights
- Future Development Trends



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The ADAMS/Rail Customers Worldwide

- Approx. 350 active ADAMS/Rail seats worldwide
- More than 65 railway organizations and research centers forming the ADAMS/Rail Users Community
- Significant commitments achieved with international companies

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Selected ADAMS/Rail Customers

- ABB
- Alstom
- Bombardier
- China Ministry of Railways
- DaimlerChrysler Railway Systems (Adtranz)
- Deutsche Bahn AG
- FIAT Ferroviaria
- FIAT Research Center (CRF)
- GE Transportation
- GM Electromotive
- Gunderson
- Korea Rail Research Institute
- Nippon Sharyo
- Patentes Talgo
- SKODA Locomotive
- SPOORNET
- Research Design Standards Organization (Indian Railways)

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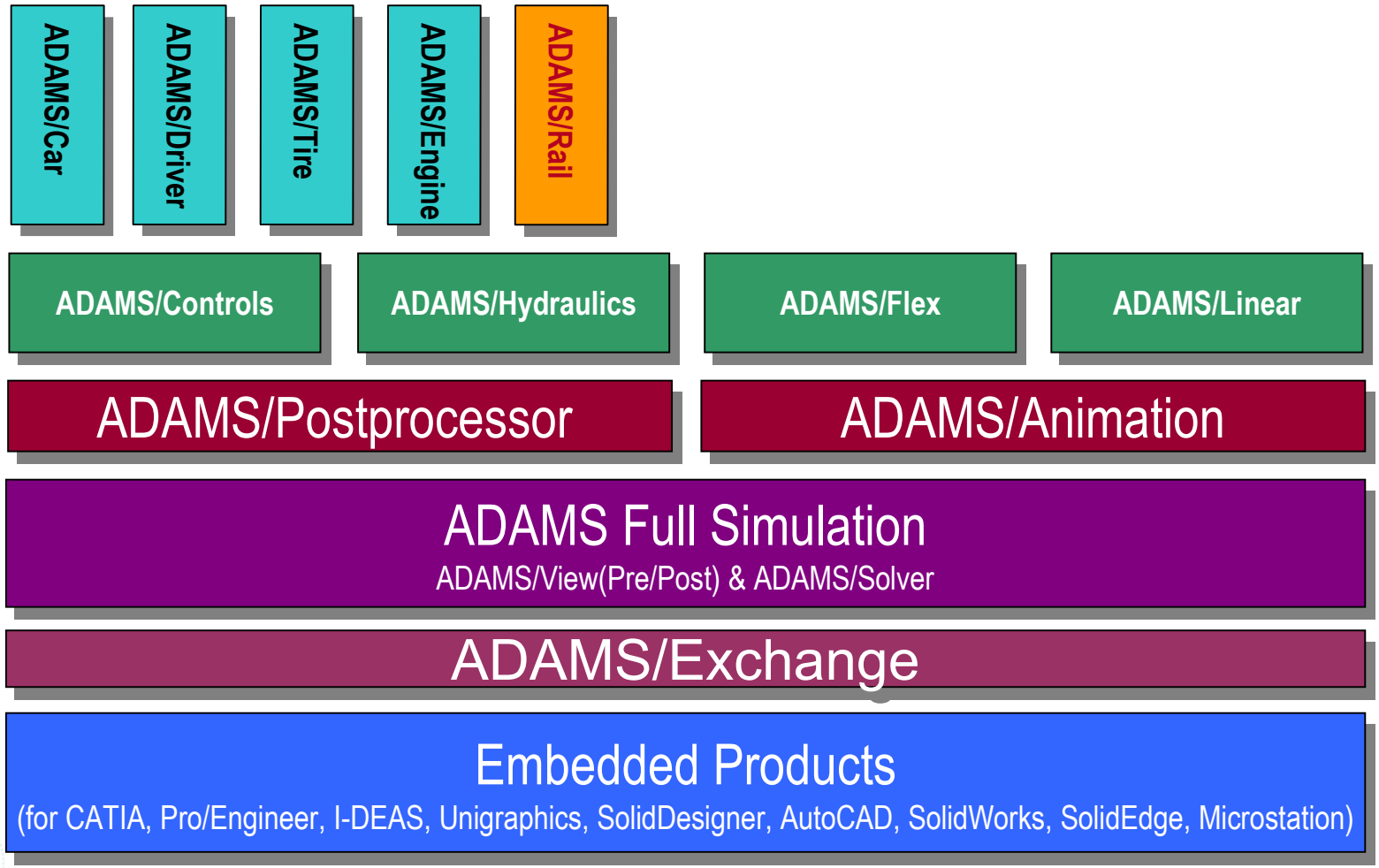
ADAMS Virtual Prototyping Product Line



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Major Enhancement Requests

- Vehicle Model
  - Standardized GUI
  - Extended library of fully tested railway elements
  - Modular modeling and automatic parameterization
- Track Model
  - Independent rails
- Wheel/Rail Contact Model
  - Independent wheel formulation
  - Multi point contact
- Postprocessing
  - Enhanced comfort toolkit
  - Easy customization of postprocessing procedures

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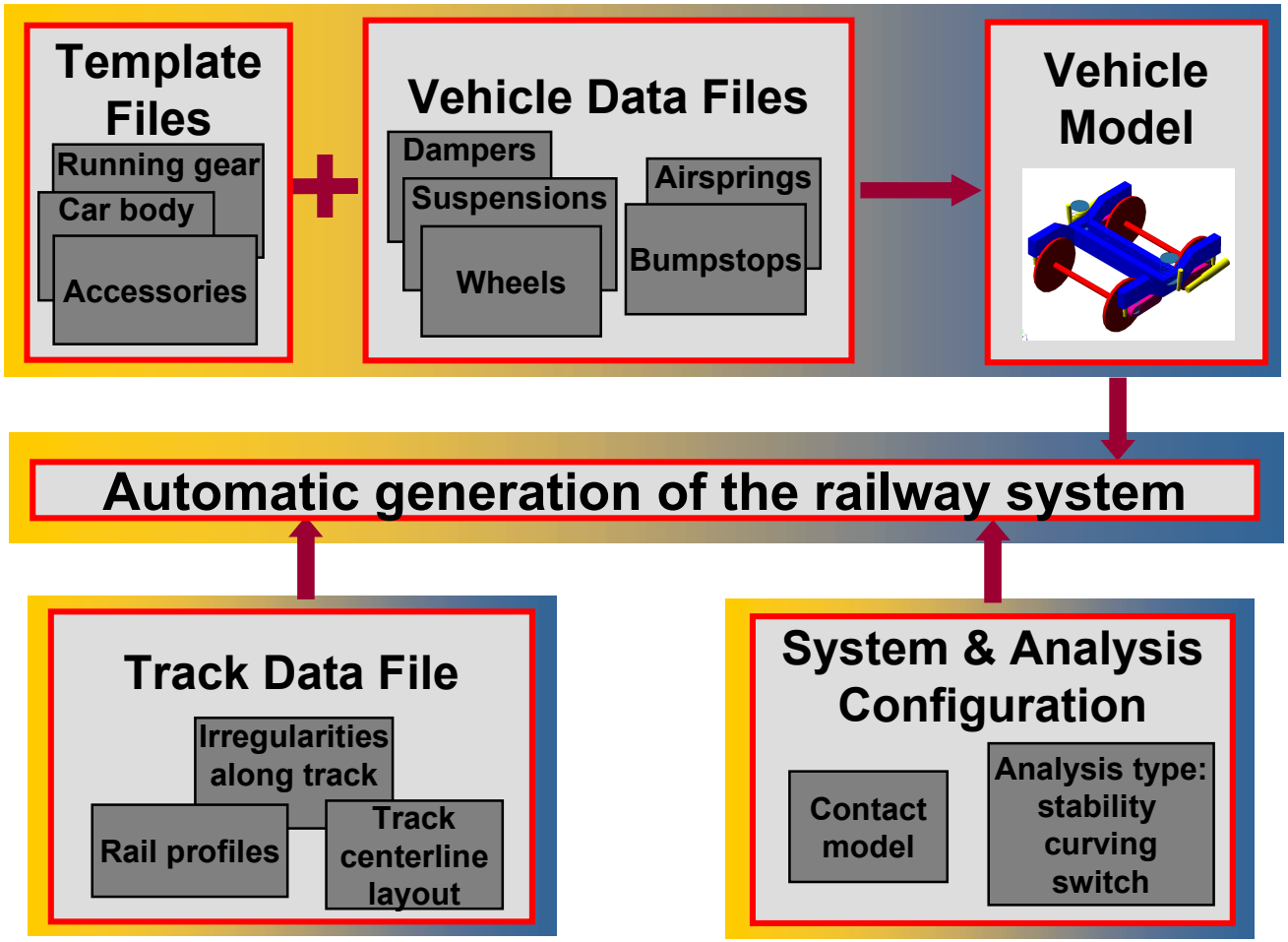
Solution: New ADAMS/Rail Structure



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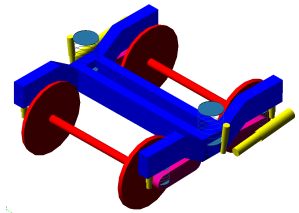
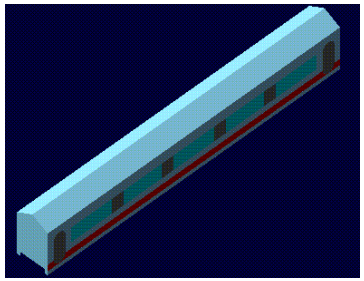
Separated model topology and data

- Template Builder
  - Topology Definition for:
    - Running Gear Templates
    - Car Body Templates
    - Accessories Templates
- Standard Interface
  - Data definition for:
    - Wheels
    - Suspensions
    - Airsprings
    - Dampers





```
$-------------------------------------------------------------MDI_HEADER
'** A/Rail 10.x WHEEL PROPERTIES FILE **'
'>> WHEEL PROFILE SPLINE COEFFICENTS & AUXILIARY PARAMETERS'
'Profile name           test'
'Spline type            xxx'
'Points                 56'
'Approx method data     3,4,0'
'Statistic data         5.7955E-10  4.4342E-06  5.6781E-05'
$-----------------------------------------------------------MATERIAL
[MATERIAL]
Y_MODULUS                = 2.1E11
P_RATIO                  = 0.25
$---------------------------------------------------------PROFILE_XC1C2
[PROFILE_XC1C2]
{          X                    C1                        C2          }
-6.50000000000000E-02     -2.29356671669987E-02      -1.05033549009833E+00
-6.36910821595123E-02     -2.42707074824209E-02      -9.59200940239750E-01
-6.22477626095915E-02     -2.55068243013761E-02      -7.51410970796369E-01
-6.06537639936451E-02     -2.65273101204782E-02      -5.36292127227798E-01
-5.88896545810632E-02     -2.72969825391625E-02      -3.43232117508801E-01
```

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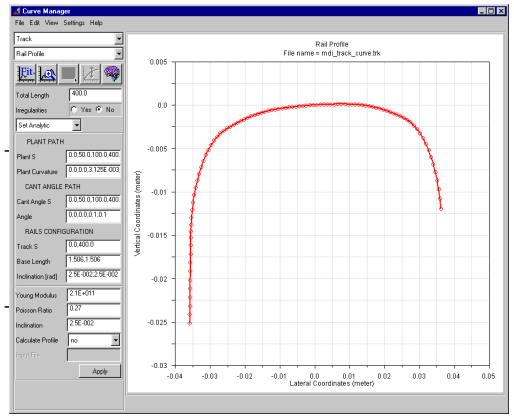
Specifying track layout

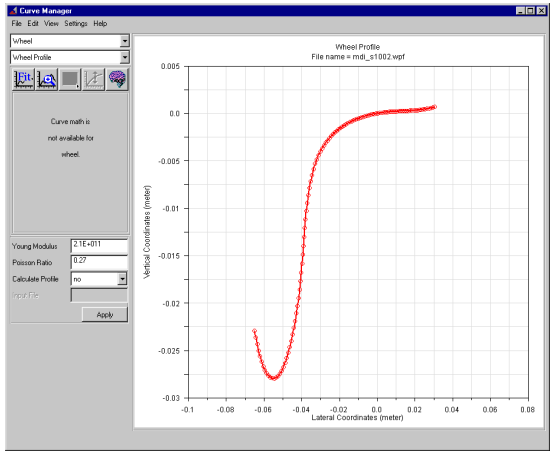
- Track definition
  - Analytic layout
    - Curvature
    - Cant
    - Nominal gauge
    - Rail inclination
  - Irregularities
    - Left - right lateral and vertical alignment
  - Rail profiles

```
$-------------------------------------------------------------------------GLOBAL
[GLOBAL]
TOTAL_LENGTH   = 400.0
CANT_MODE      = 'CENTER'
IRREGULARITIES = 'YES'
$---------------------------------------------------------------IRREGULARITIES
[IRREGULARITIES]
TYPE                    = 'MEASURED'
FORMAT                  = 'ASCII_Z'
INTERPOLATION           = 'LINEAR'
DATA_FILE               = 'track_erri_z.dat'
DATA_STEP               = 0.266
ACTIVE_LENGTH           = 400
$-----------------------------------------------
[PLANT_PATH]
{ plant_s   curvature   kink }
     0.0    0.0         0.0
    50.0    0.0         0.0
   100.0    0.003125    0.0
   400.0    0.003125    0.0
$-----------------------------------------------
[CANT_ANGLE_PATH]
{ cant_angle_s   angle [rad] }
     0.0         0.0
    50.0         0.0
   100.0         0.1
   400.0         0.1
$-----------------------------------------------------------RAILS_CONFIGURATION
[RAILS_CONFIGURATION]
{   track_s    gauge    vdg      inc[rad]  rail_id  }
      0.0       1.50    0.014     0.025       1
    400.0       1.50    0.014     0.025       1
$-------------------------------------------------------------RAIL_1_MATERIAL
[RAIL_1_MATERIAL]
Y_MODULUS               = 2.1E11
P_RATIO                 = 0.27
$-----------------------------------------------------RAIL_1_PROFILE_PROPERTIES
[RAIL_1_PROFILE_PROPERTIES]
INCLINATION             = 0.025
$-----------------------------------------------------------RAIL_1_PROFILE_XC1C2
[RAIL_1_PROFILE_XC1C2]
{          X                    C1                          C2          }
-3.58822960980E-02 -2.51644041730E-02  4.00500050761E+01
-3.58573350880E-02 -2.41647157067E-02  4.00499917499E+01
```



Specifying contact configuration

- Contact configuration
  - Specifies for every wheel/rail interconnection:
    - Contact elements type
    - Contact elements properties




```
$----------------------------------------------------CONFIGURATION
[CONFIGURATION]
{ track_x     ctc_type  }
    0.0          1
 1000.0          2
 2000.0          1
$-------------------------------------------------------CONTACT_1
[CONTACT_1]
TYPE                    = 'WRTAB'
MODE                    = 1
FORMAT                  = 'CTC_1'
CTB_CALC_METHOD         = 'VARIABLE_STEP'
CTB_LATERAL_DISP_INC    = 0.001
CTB_STEPS_NUMBER        = 16
VERTICAL_STIFFNESS_HERTZ = 1.0E9
VERTICAL_DAMPING_HERTZ  = 1e4
MUX                     = 0.4
MUWY                    = 1.0
DERAIL_Y                = -0.045
KALKER_FACTOR           = 1.0
CREEP_FORCE_CALC_METHOD  = 'FASTSIM'
MXFSIM                  = 10
MYFSIM                  = 11
$-------------------------------------------------------CONTACT_2
[CONTACT_2]
TYPE                    = 'WRGEN'
MODE                    = 1
FORMAT                  = 'CTC_1'
HERTZIAN_DAMPING_RATIO  = 0.001
MUX                     = 0.4
MUWY                    = 1.0
DERAIL_Y                = -0.045
KALKER_FACTOR           = 1.0
CREEP_FORCE_CALC_METHOD  = 'FASTSIM'
MXFSIM                  = 10
MYFSIM                  = 11
```

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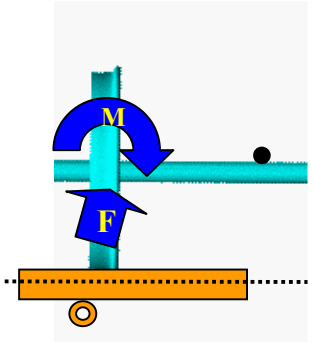
New Contact Modeling Approach

- Tabular element - Basic Features
  - Enhancement of previous Level III
  - Forces applied to wheel rotation axis center (rigid rim model)
  - Contact forces dependent on wheel/rail relative position
  - Irregularities applied as contact table entry



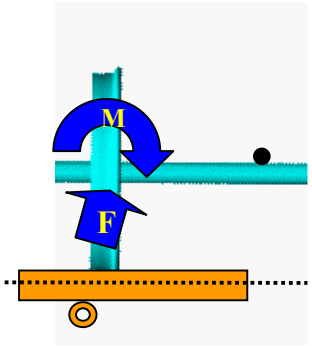
F = {Fx,Fy,Fz}

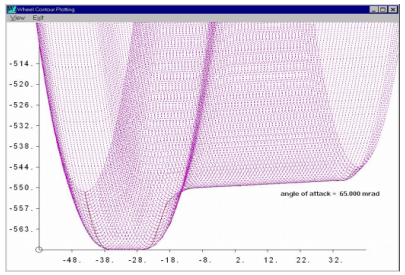
M = {Mx,My,Mz}

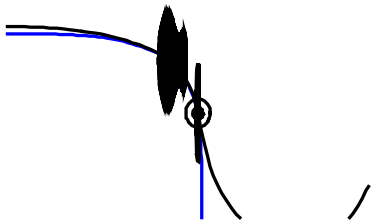
Mechanical Dynamics

New Contact Modeling Approach

- General element (KE21)
  Basic Features
  - On-line computation of contact points due to relative position of wheel and rail surface
  - Three dimensional contact, computation of contact line as envelope of wheel disks
  - Flexible, non elliptical multi-point contact
  - Various wheel and rail irregularities (flats, out-of-round wheels,...)
  - Guiding rails of variable length



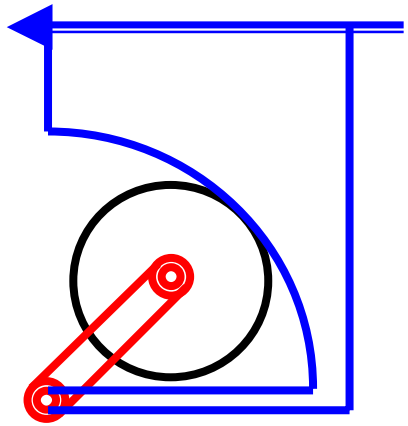




Mechanical Dynamics

New Contact Modeling Approach

- Quasi linearized element (KE22)
  Basic Features
  - Extension and improvement of former Level IIa
  - Input: conicity, gravitational stiffness, roll angle parameter
  - Kalker coefficient can be inputted or calculated
  - Equivalent circular wheel - rail profiles are calculated and applied



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Advantages of the New Environment

- Vehicle modeling
  - Working at system level
  - Use of a standardized working platform
  - Database structure allows easy data exchange
  - Extended library of railway elements (parts and interconnections) for easy template building
  - Modeling with symmetrical approach
  - Automatic parametrics
  - Multiple use of same subcomponent in the full system
  - Data stored in property files (ASCII format)
  - Efficient subsystem debugging

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Advantages of the New Environment

- Track modeling
  - Analytic track description decoupled from irregularities description
  - Possibility of superimposing deterministic irregularities
  - Gauge variation
- Outlook:
  - Rail profile variation along the track (i.e. frog, switch, gap)
  - Open architecture for modeling track permanent way with the desired accuracy (from linear stiffness to FE model)

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Advantages of the New Environment

- Wheel-rail contact modeling
  - Wheelsets or independent wheels can be modeled and automatically recognized as wheel parts
  - Contact properties created on-the-fly for every wheel-rail interconnection, according to wheel/rail profiles and contact type
  - Contact is modeled between one wheel and one rail with generalized force elements
- Outlook:
  - Possibility of switching along the track between different contact models

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Advantages of the New Environment

- Wheel-rail contact modeling
  - Elastic contact
  - Multi point contact (no equivalent contact point)
  - Accurate description of 3D contact (no contact tables used)
  - Traction simulation starting from Vx = 0 (use of not normalized creepages)
  - Different creep force theories implemented
- Outlook:
  - Friction coefficient can depend upon creepages or upon rail profile coordinate

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Advantages of the New Environment

- Postprocessing
  - User defined names can be associated to user defined result set components and requests and stored in a configuration file
  - User defined plot formatting can be stored in a plot configuration file and associated to any result set
  - Enhanced curve edit toolkit
  - Toolkit for comfort results according to UIC - ISO
  - Useful requests generated by default (dQ/Q, Sum Y, Anc, force and displacement in suspensions...)

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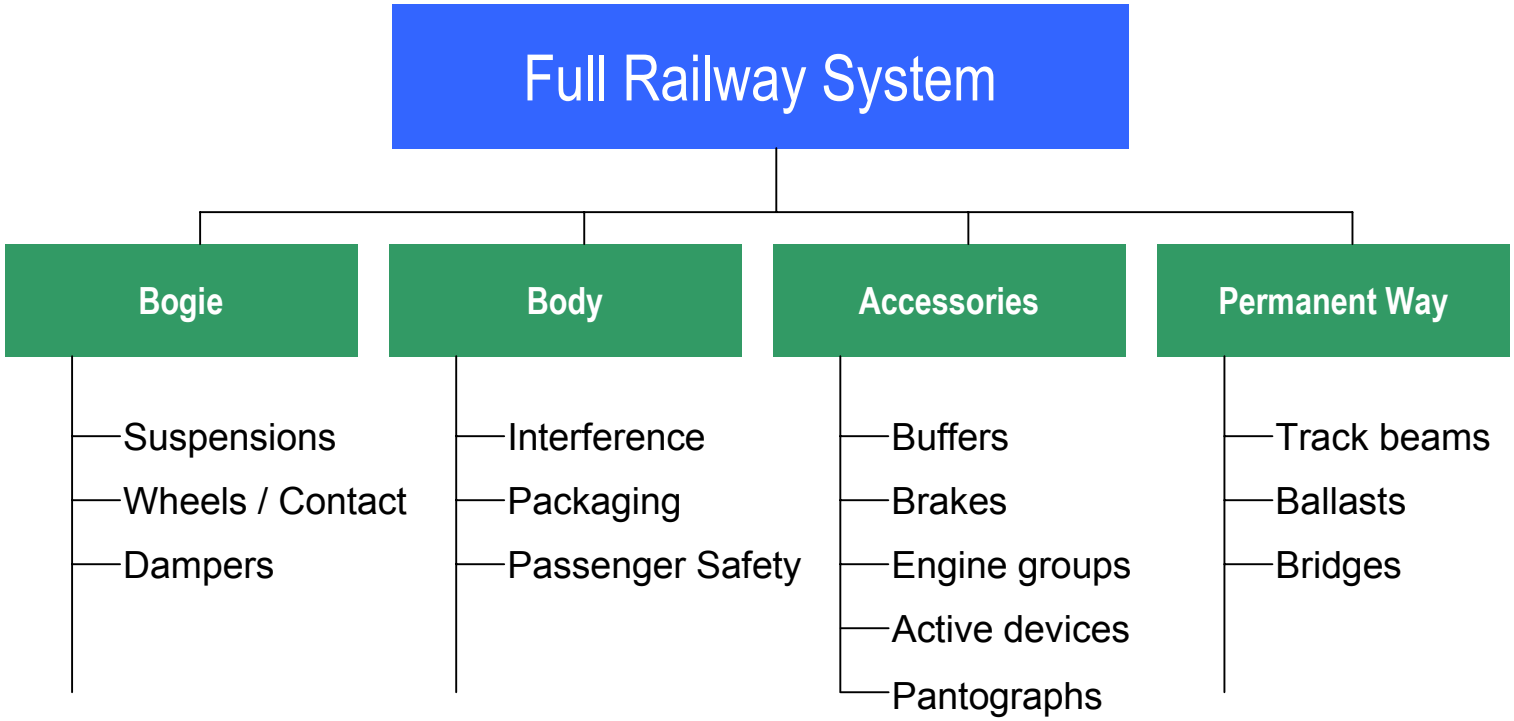
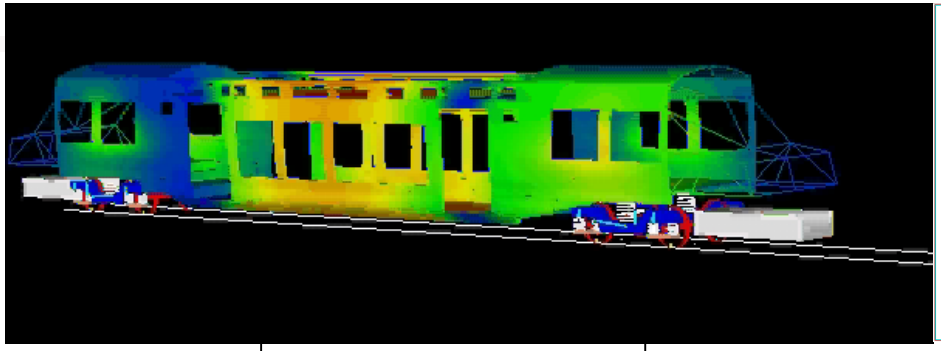
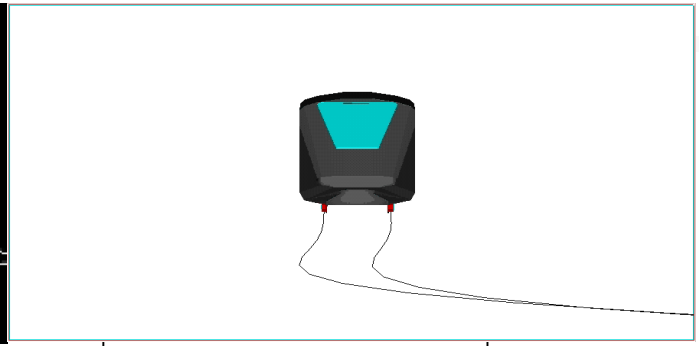
Towards the Digital Functional Train



Mechanical Dynamics

Towards the Digital Functional Train



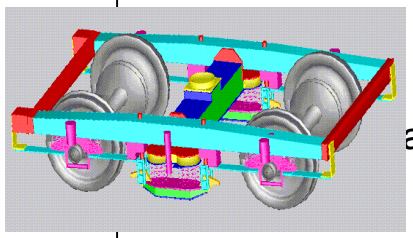


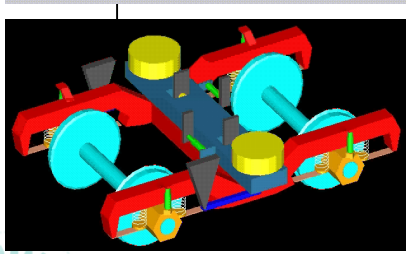
Bogie

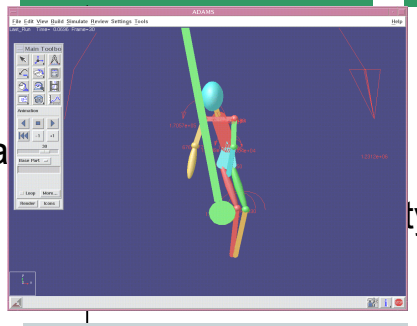
Body

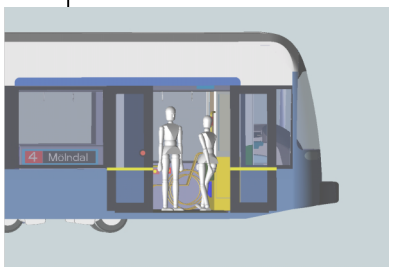
Accessories

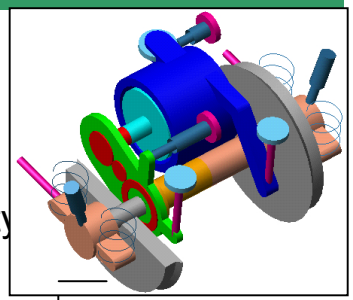
Permanent Way

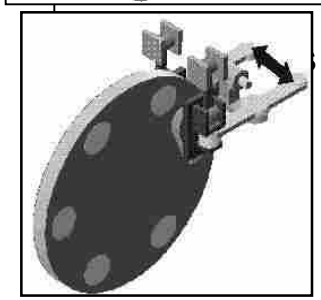


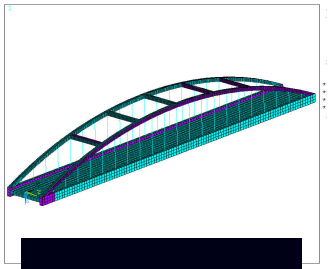


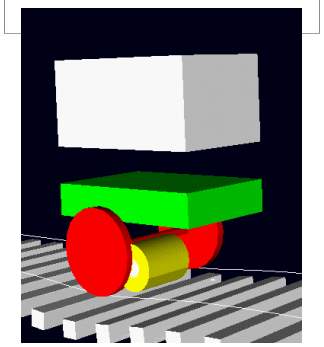












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