Dynamic Gauging

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What is gauging?

- Comparison of movements against a reference contour / gauge

Why gauging analysis?

- Avoid interfering with obstacles along the track
- Define the maximum allowed vehicle cross-section
Which effects to consider?

- **Static effects**
  - Curving overthrow
  - Cant

- **Quasi-static effects**
  - Cant deficiency/excess

- **Dynamic effects**
Different approaches to gauging

- **Static**
  - Limited by a static reference gauge
  - All movements accounted for by the infrastructure
  - Example: freight stock according to UIC 505

- **Kinematic**
  - Limited by a kinematic reference gauge
  - Geometrical formulas which cover most of the vehicle movements (still some movements accounted for by the infrastructure)
  - The largest likely displacement considered is based on years of experience
  - Example: Passenger stock according to UIC 505

- **Dynamic**
  - Limited by a dynamic reference gauge or a varying reference gauge
  - All vehicle movements are included
  - Realistic movements are simulated using MBS
  - Example 1: Defined reference gauge – new CEN 256 / WG32
  - Example 2: Varying reference gauge – UK Group Standard
### Dynamic gauging – two different approaches

#### Defined reference gauge
- Uses a defined reference gauge, slightly larger than to the kinematical gauge
- Calculates all the movements (including dynamic) with MBS instead of geometric formulas
- The new CEN standard will include this approach as a complement to the geometric formulas
- Calculations show that dynamic gauging may give up to 40 mm wider carbodies than the old UIC 505 procedure

#### Varying reference gauge (UK)
- Used where a defined reference gauge would result in too small vehicle cross sections
- State of the art in UK
- **Absolute method:** Refers to the actual obstacles along the track
- **Comparative method:** Refers to the swept envelope of one or more already accepted vehicles
Simulation of movements for dynamic gauging requires

General
- Validated MBS models
- Increased focus on accurate prediction of body movements
- Statistically representative track irregularities

SIMPACK specific
- A simple method to perform the sway test calculation
- A shear spring force element – User Element 22
- Possibility to measure movements relative to the real track position – Present work around, dummy wheel/rail markers on the rail heads
Dynamic gauging for UK – varying reference gauge

- Gauging was identified early as an important issue for UK applications
- This work has been carried out to facilitate the introduction of SIMPACK on Bombardier Transportation’s UK sites
- Electrostar Class 375 was used to repeat simulations already carried out in the existing Software, e.g. VAMPIRE
- Sway test
- Simulation of dynamic movements
Validation through sway test

- In UK validation tests are carried out to get confident in the MBS models
  - dQ/Q, wheel unloading
  - X-factor, bogie rotational test
  - Sway test, roll behaviour

- During the sway test the vehicle is jacked up in steps to achieve a cant excess of ±250 mm

- The movements of certain datum points are measured using a theodolite system

- The body sway, roll and drop movements are presented versus the equivalent cant for -250 to 250 mm (±1.63 m/s²)
Cartographic track for the sway test excitation

Speed 0.1 m/s
One sample per step
Sway test results, tare inflated, solebar sway
Sway test results, tare inflated, cantrail sway
Sway test results, tare inflated, carbody drop

![Graph showing sway test results with equivalent cant (mm) on the x-axis and drop (mm) on the y-axis, with data points and lines representing different simulations (T5, VAMPIRE, T5, SIMPACK, T9, Measurement, T9, VAMPIRE, T9, SIMPACK).]
Sway test results, tare inflated, body roll
Simulation of dynamic movements for UK gauging acceptance

- A certain software, ClearRoute, uses the vehicle movements to analyse the vehicle envelope versus a swept envelope
- ClearRoute requires the standard deviation and the mean values of the movements for a defined number of cases:
  - 5 km of track irregularities
  - 7 different speeds
  - 7 different cants
  - Inflated and deflated air spring
  - Tare and crush load
- The whole matrix of results are feed into ClearRoute to assess the vehicle cross-section design
Typical output of gauging calculation
100 mph, mean value of carbody sway
Typical output of gauging calculation
100 mph, standard deviation of carbody sway
Summary

- Dynamic gauging will be an option in the new European Standard developed by CEN 256/WG32
- Sway test excitation has been successfully defined using cartographic track input
- Using the new SIMPACK User Element 22, the shear spring, it is possible to reproduce sway tests
- Accordingly gauging analysis against UK Standards can be carried out using SIMPACK
- Calculations show that when using dynamic gauging, carbodies may be up to 40 mm wider then when using the old UIC 505 procedure