Dynamic Gauging

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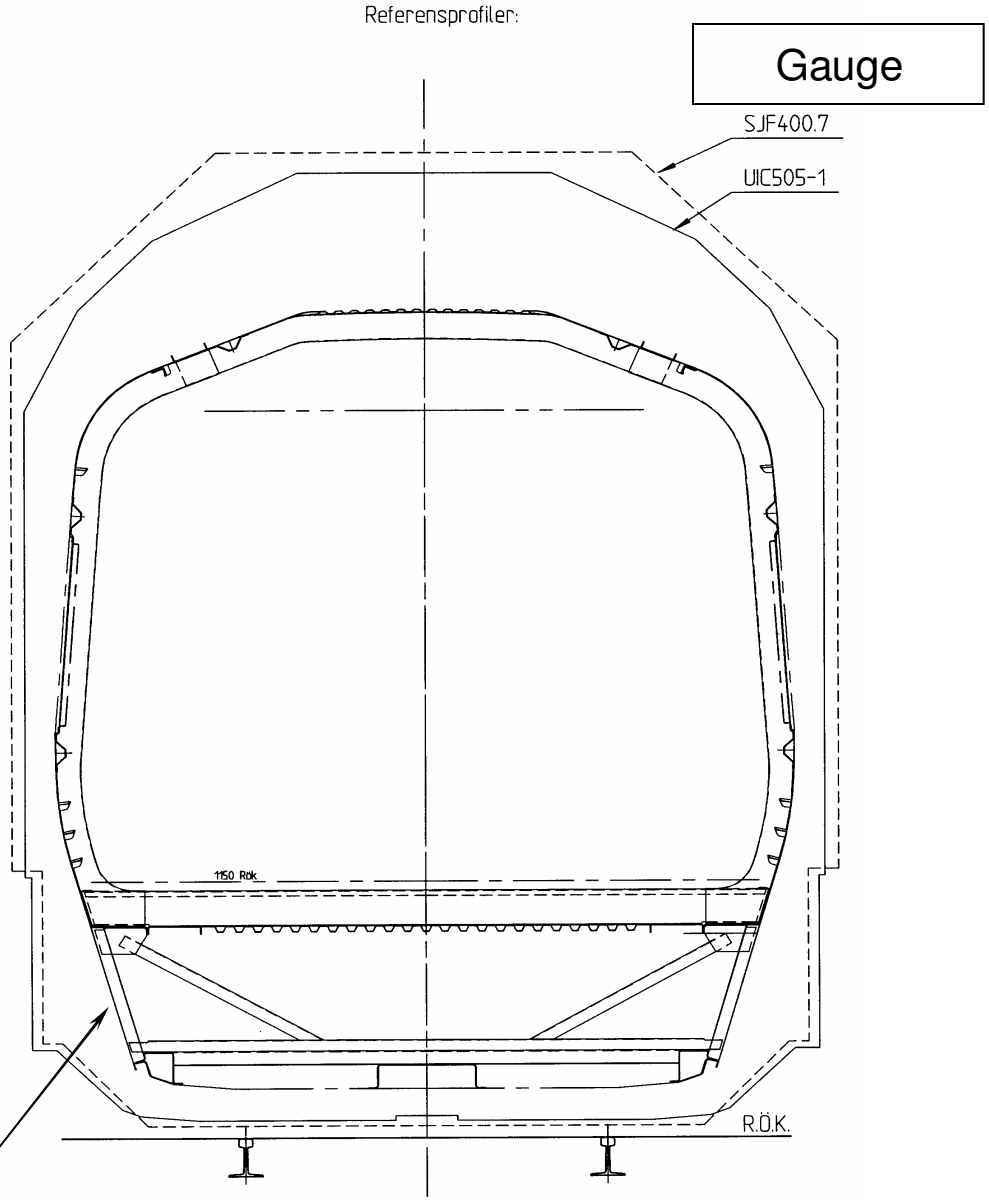
What is gauging?

- **Comparison of movements against a reference contour / gauge**

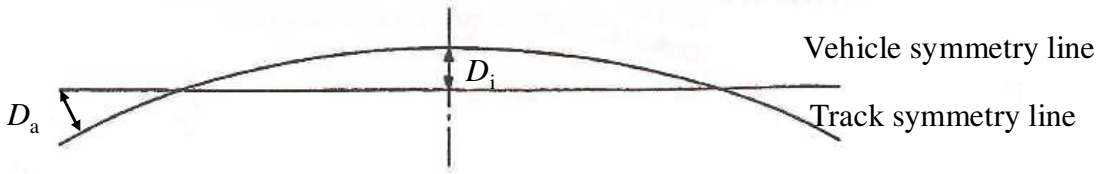
Why gauging analysis?

- **Avoid interfering with obstacles along the track**
- **Define the maximum allowed vehicle cross-section**

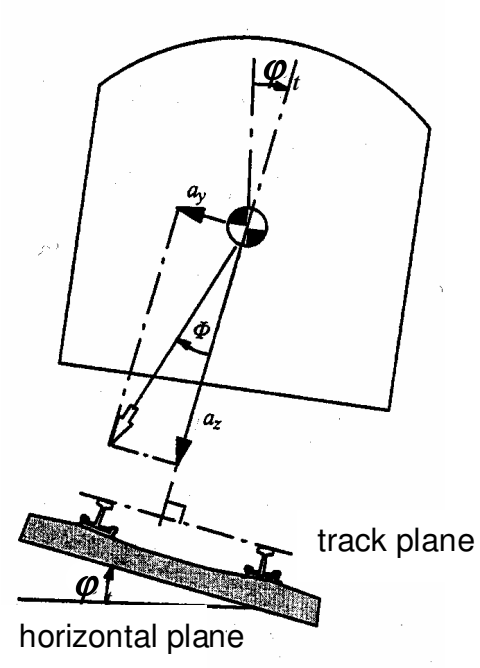


Which effects to consider?

- **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 then 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

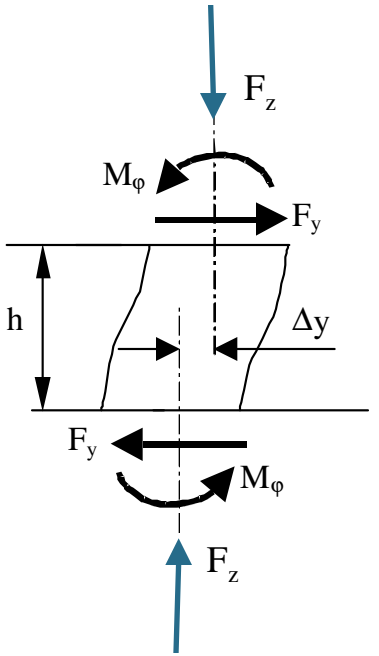
Simulation of movements for dynamic gauging requires

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**

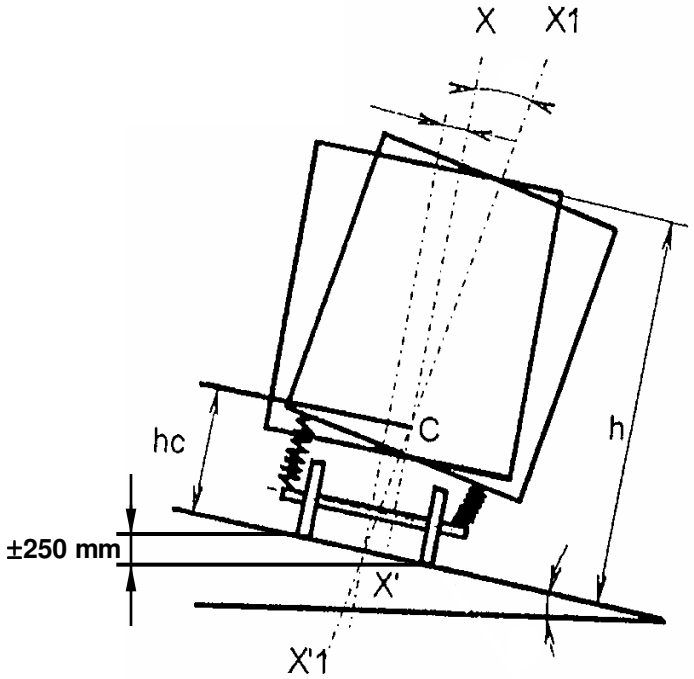


Dynamic gauging for UK – varying reference gauge

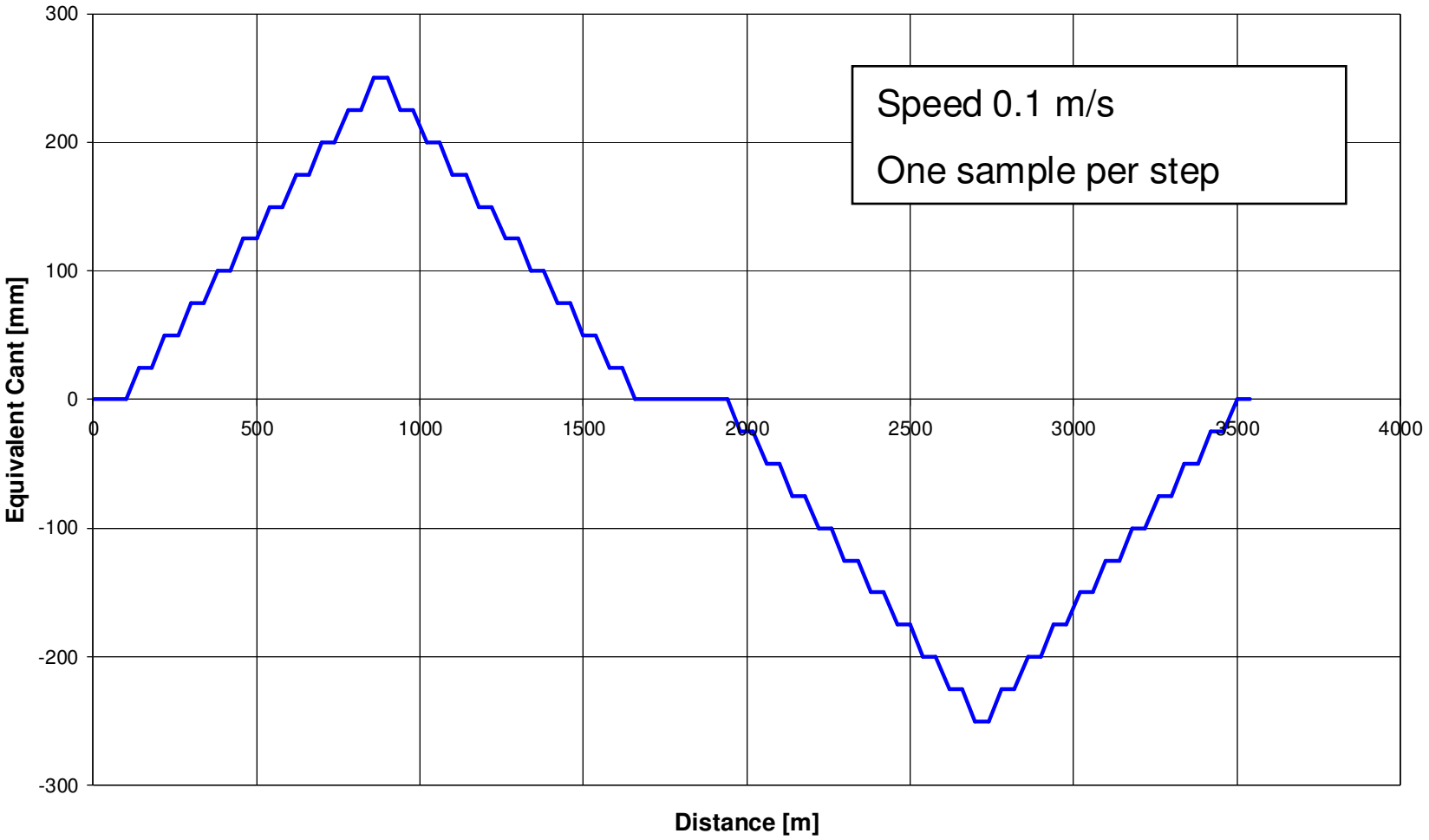
- Gauging was identified early as an important issue for UK applications
- This work has been carried out to facilitate the introduction of SIMPACK on Bombardier Transportation's UK sites
- Electrostar Class 375 was used to repeat simulations already carried out in the existing Software, e.g. VAMPIRE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

Validation through sway test

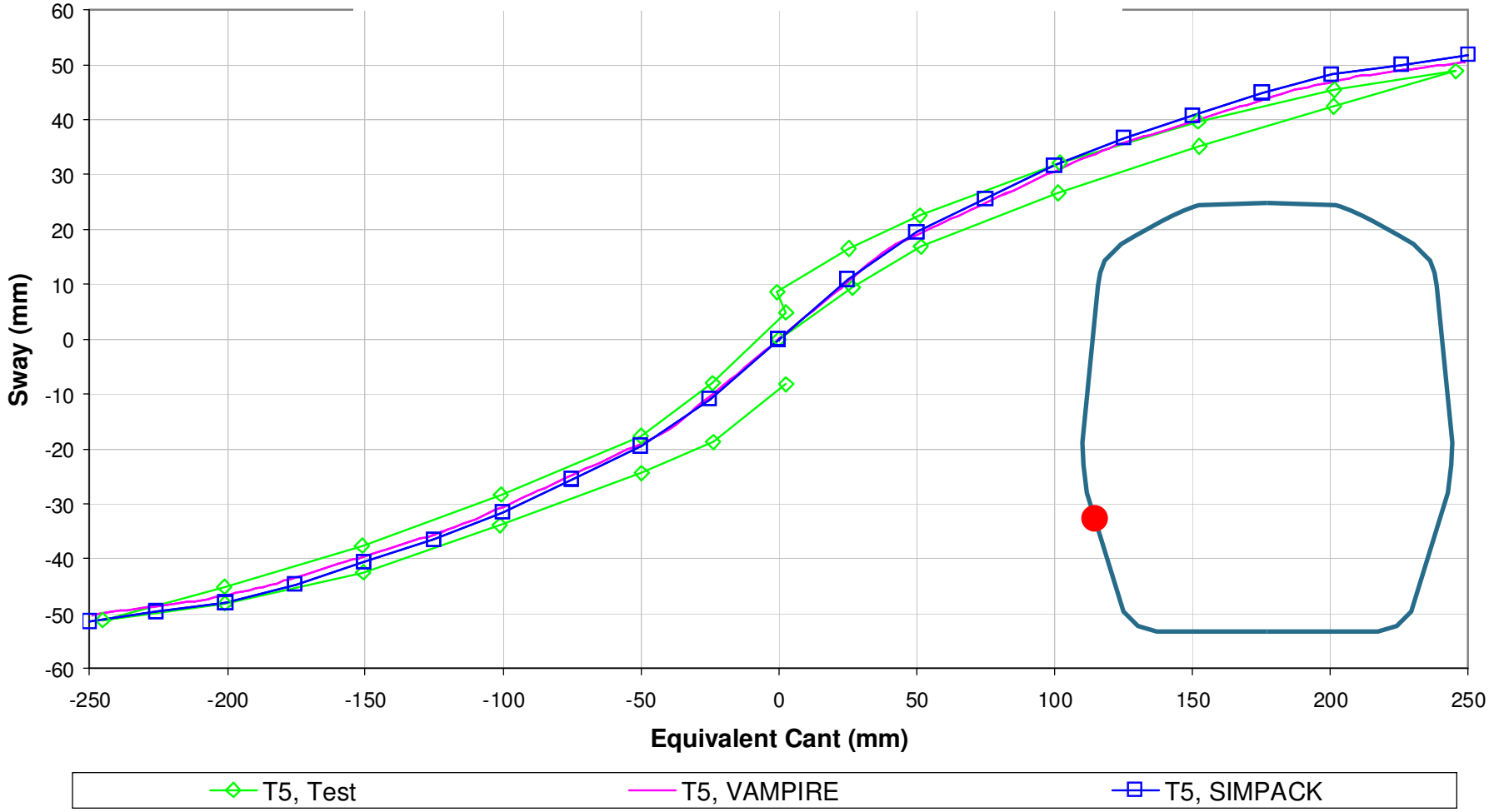
- **In UK validation tests are carried out to get confident in the MBS models**
  - dQ/Q, wheel unloading
  - X-factor, bogie rotational test
  - Sway test, roll behaviour
- **During the sway test the vehicle is jacked up in steps to achieve a cant excess of ±250 mm**
- **The movements of certain datum points are measured using a teodolite system**
- **The body sway, roll and drop movements are presented versus the equivalent cant for -250 to 250 mm (±1,63 m/s²)**



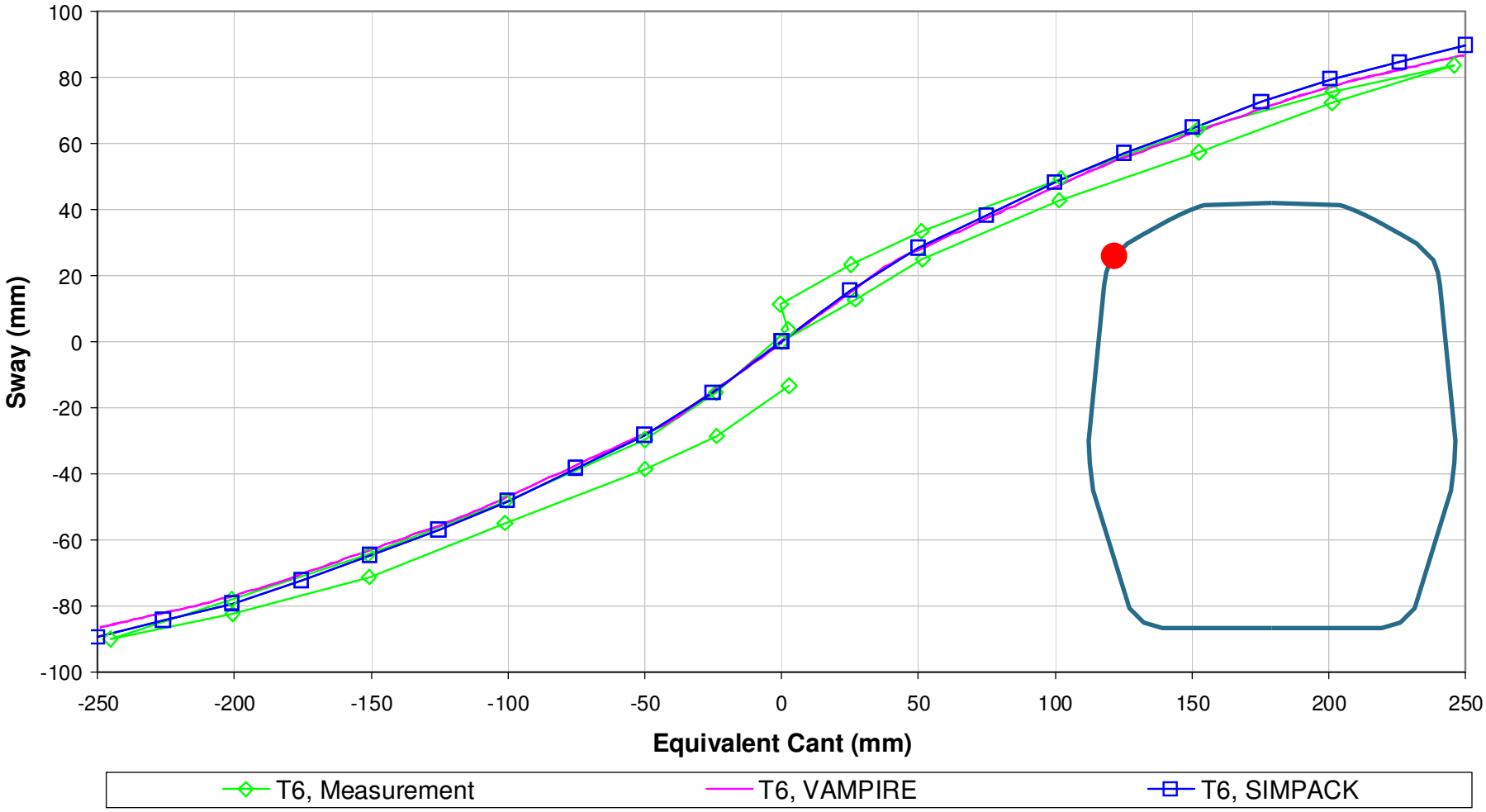
Cartographic track for the sway test excitation



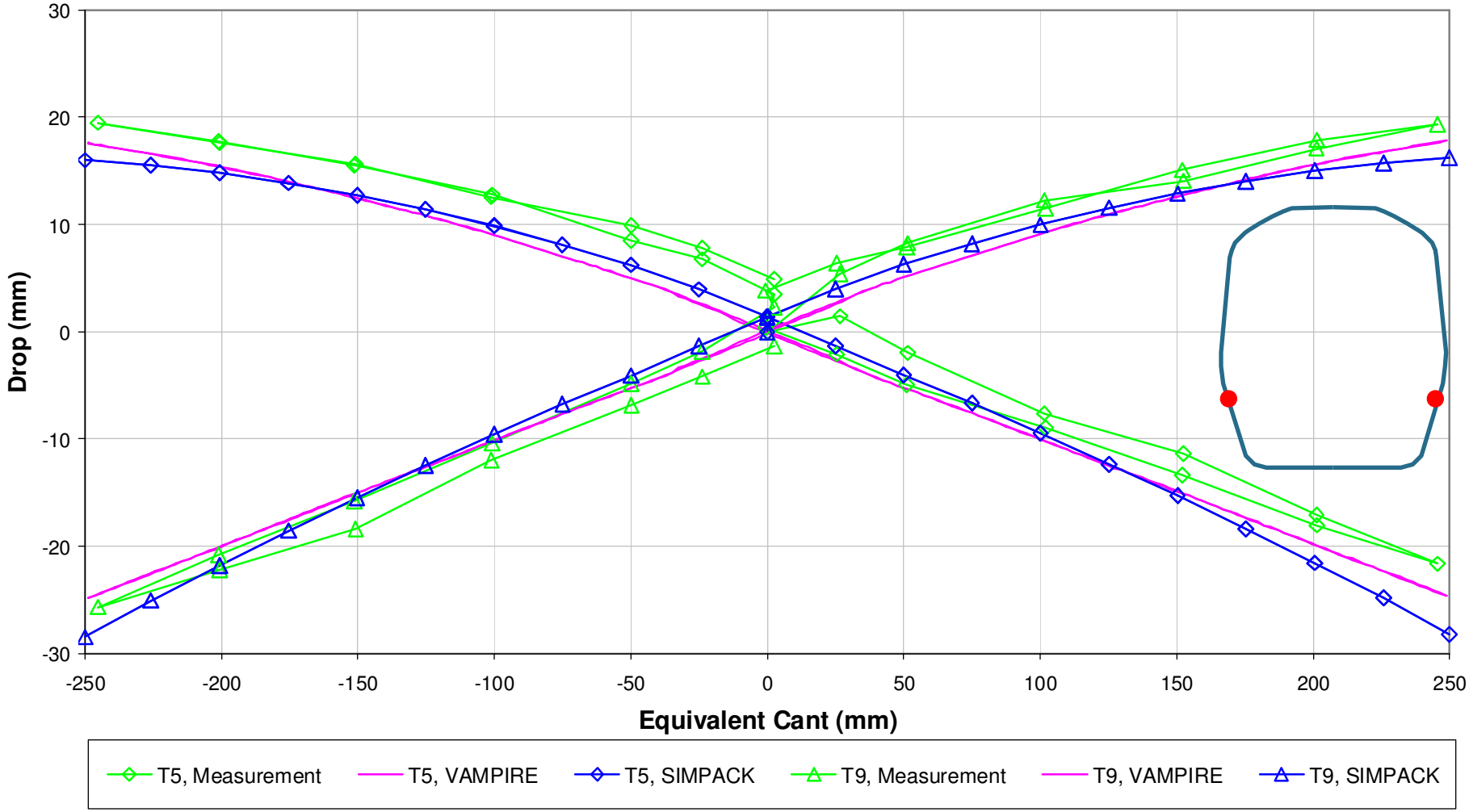
Sway test results, tare inflated, solebar sway



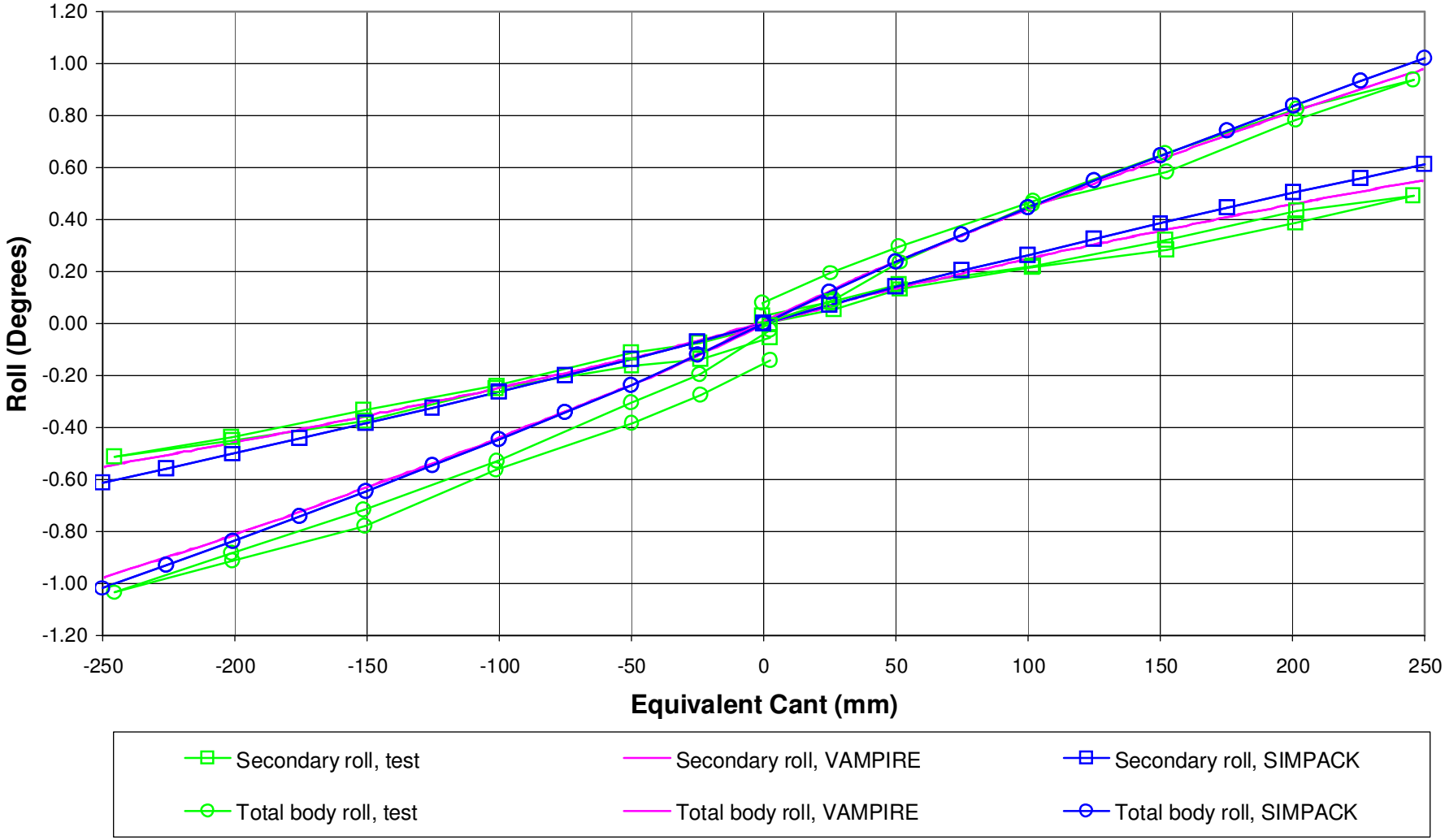
Sway test results, tare inflated, cantrail sway



Sway test results, tare inflated, carbody drop



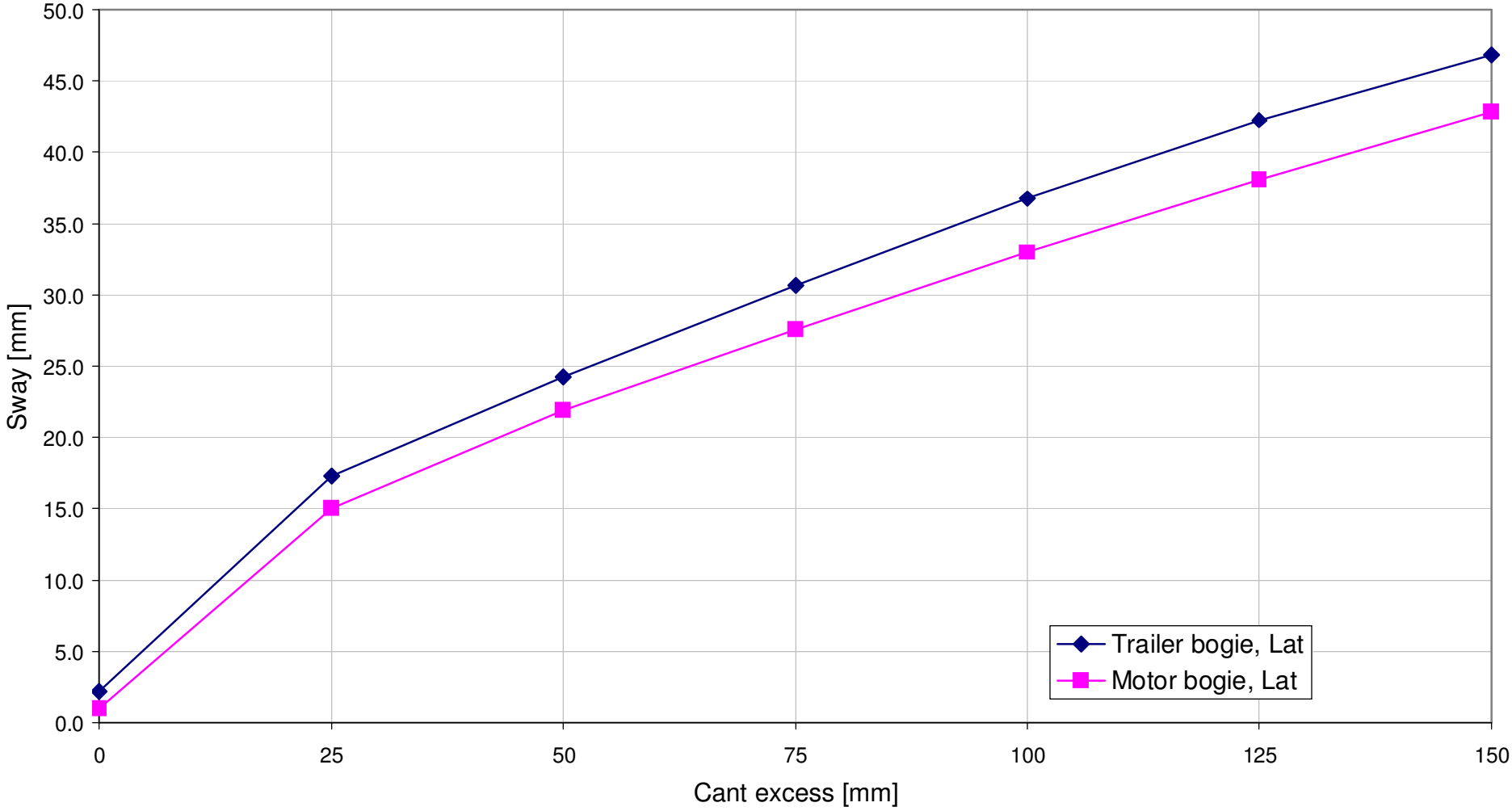
Sway test results, tare inflated, body roll



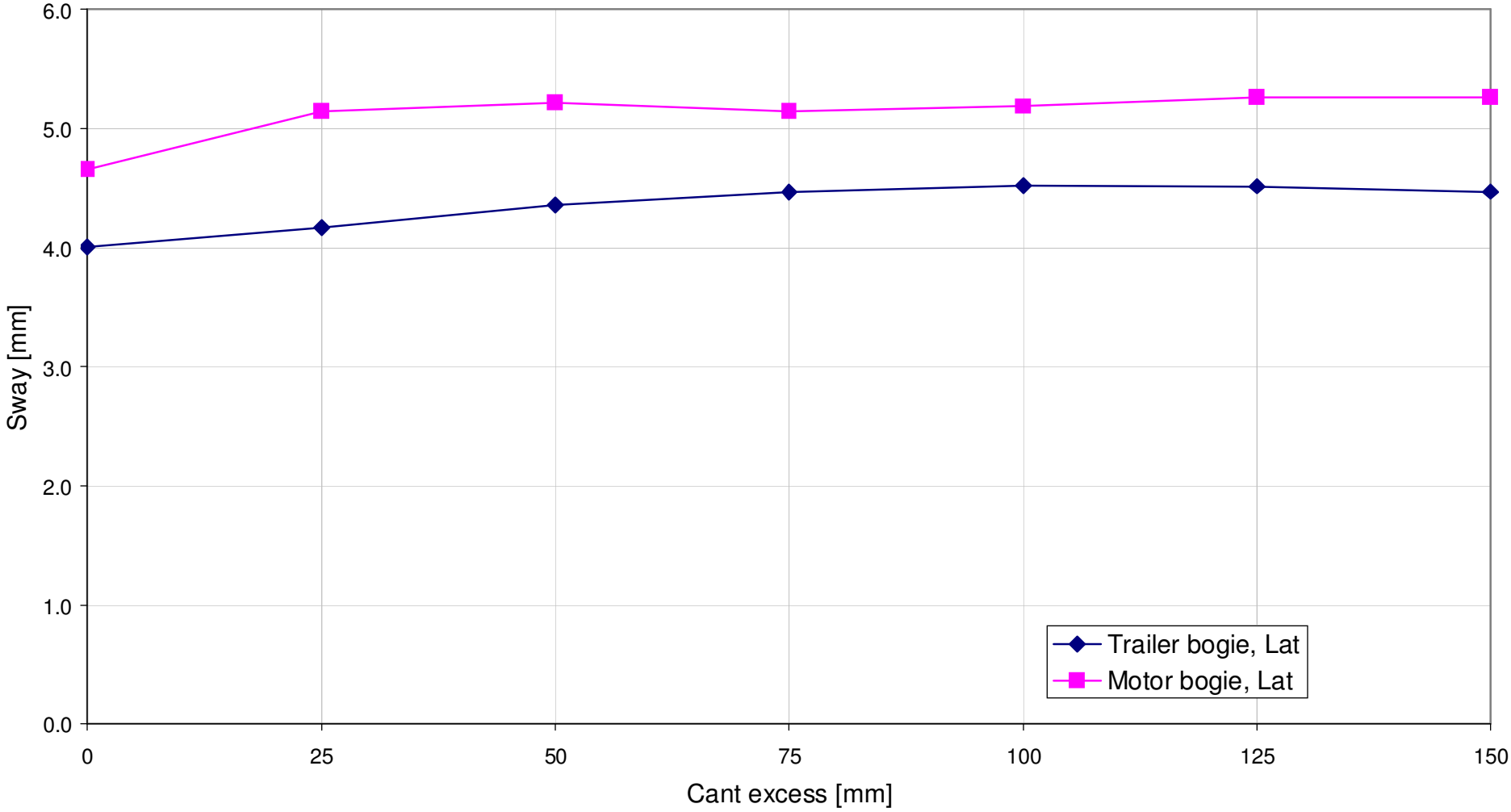
Simulation of dynamic movements for UK gauging acceptance

- **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