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The Spectrum Bogie

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Problem definition:

- The Spectrum train aimed to exploit the Low Density High Value (LDHV) goods market for containerised loads
- High speed (up to 160 km/h) was necessary to integrate with passenger services, with potentially lower axle load, fragile cargo, and an articulated wagon design
- An optimised running gear design was required

Aim:

Produce a novel bogie concept with:
- High speed stability
- Safe running (compliant with Standards)
- Good ride quality
- High curving performance (low track damage)

Process:

- Review of existing bogie designs and identify an appropriate base concept
- Determine initial values for suspension component parameters (lengths, stiffnesses, damping rates etc.)
- Construct a mathematical vehicle model (in Vampire) to optimise those parameters
- Implement an iterative optimisation process with dynamic simulations to achieve the aims
- Produce a CAD model of the viable bogie concept

Base Concept:

- A review of existing bogie designs led to a chosen base concept
  - Trailing arm primary suspension
  - Coil sprung
  - Viscous damped
- UIC secondary suspension
  - Standard centre bowl and side-bearer arrangement
- Axle mounted disc brakes
  - Required to operate alongside passenger stock
  - Dictated external axle boxes

Initial Parameters:

- Initial parameters can be determined in a number of ways:
  - Calculation from fundamental principles
  - Application of accepted vehicle design principles
  - Engineering judgement/application of experience
  - Derivation: for example the trailing arm bush parameters were determined by calculating their influence on primary yaw stiffness

\[ K_Y = \frac{GR^2 \theta^2}{2} \]

\[ K_{Y_{def}} = Y_{def} Y_{y_{def}} \]

- \( K \) - Stiffness in given direction
- \( \theta \) - Wheelset yaw angle
- \( Y_{def} \) - Trailing arm bush semi-spacing
- \( Y_{y_{def}} \) - Trailing arm bush longitudinal and lateral directions

Final Bogie Design:

- The Spectrum train aimed to exploit the Low Density High Value (LDHV) goods market for containerised loads
- High speed (up to 160 km/h) was necessary to integrate with passenger services, with potentially lower axle load, fragile cargo, and an articulated wagon design
- An optimised running gear design was required

Analysis and optimisation:

- The vehicle parameters were used to create a Vampire multi-body dynamics model

Mathematical Vehicle Model:

- The vehicle parameters were used to create a Vampire multi-body dynamics model

What was achieved?

- A novel bogie concept was developed - featuring conventional/proven suspension components and technologies, but in a novel arrangement and application. Swing links were introduced to the UIC secondary suspension to improve lateral ride and stability.
- Improved dynamic performance with reductions of between 8% and 16% in Variable Usage Charge compared to a conventional Y-series container vehicle (calculated with Network Rail’s Variable Track Access Charge Calculator)