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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 for the required performance
- 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 spring
  - 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 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

\[ KY_{Y_{BY}} = \frac{\rho Y_{BY}}{2}, \quad KY_{Y_{BX}} = Y_{BY_{2}} - KY_{Y_{BX}} \]
- \( K \) – Stiffness in given direction
- \( \rho \) – Wheelset yaw angle
- \( Y_{BY} \) – Trailing arm bush semi-aperture
- \( KY_{Y_{BX}} \) – Trailing arm bush longitudinal and lateral directions

**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

**Final Bogie Design:**

**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)