Literature Review of Rail Vehicle Structural Crashworthiness (T119)

Background
This work was carried out as part of the Rail Safety and Standards Board (RSSB) research programme covering accident survivability in order to identify significant recent research work and best practice in the areas of railway vehicle structural integrity and crashworthiness.

The work was undertaken and completed in 2003 and is published now for reference purposes.

Method
The aim of the work was to collate a summary of the latest developments in structural crashworthiness of railway vehicles worldwide and hence to avoid unnecessary expenditure on duplicate research.

The work additionally positioned existing Railway Group Standard requirements against those existing or being developed elsewhere in the world, in order to focus future development of domestic standards.

The output from the literature survey was a report providing a reference to recent research worldwide, and identifying key findings of that research. Additionally the report recommends further actions to maintain and improve accident survivability, and to evaluate the cost benefits involved.

Findings
This study identified significant research into structural crashworthiness of railway vehicles, from early developments in Britain leading to the development of the current Railway Group Standard requirements, to recent major projects in Europe and the United States of America, some of which were still ongoing as at 2003 when the review was completed.

The work identified key approaches, findings and differences between research projects. It suggests means of understanding and evaluating these differences and their applicability to future development of standards and of rail vehicles themselves.

Specifically, the following actions are recommended:

- A review of recent British accident statistics to determine whether the perceived benefits of structural crashworthiness are being realised in reduced numbers of casualties. The study could be extended to compare casualty figures across accidents with similar potential outcomes, especially
where crashworthy design features are fitted to some of the vehicles involved and would be expected to play a part. A further outcome of the study would be to identify accident scenarios where current crashworthiness measures have proved of little or no benefit.

- A detailed review of the relevance of United States and European research findings to British rail operations. Specifically this should include:
  
a) The derivation of the 35km/h collision speed for end on collisions in the TSI (Technical Specifications for Interoperability).
  
b) The importance of level crossing scenarios, including the relevance of fenced/gated operation and the possibility of rail vehicle side impact.
  
c) The relevance of rail vehicle mass on collision scenarios and dynamic response, particularly the influence of the trend away from heavier locomotives/power cars to distributed traction rakes and lighter driving vehicles (British Railways work identified mass difference as a key factor in over-ride behaviour).
  
d) The required energy levels to be absorbed.

- A review of the factors involved and measures taken to ensure that trains remain in line, and can hence realise crash energy management performance in a real collision. This should consider and review:
  
a) Coupler vertical and lateral load requirements.
  
b) Anti-climber load requirement, including provision for lateral capability, and a vertical offset between vehicles that should be tolerated during engagement.
  
c) The motion and effect of couplers following shear-out, and any impact this may have on over-ride tendencies.
  
d) The effect of initial vehicle misalignment on rake behaviour during a collision, especially lateral offsets due to track curvature.

- Consideration should be given to the effects of the leading axle weight of modern vehicles. GM/RT2100 currently stipulates 120kN for the leading axle only of vehicles with maximum speed in excess of 160km/h, but there is no such requirement for slower vehicles. Factors to be included are collision with obstacles such as light road vehicles, over-ride, and derailment during a collision, (particularly from lateral loads).

- An assessment of the practicality of including requirements for structural features that have, in the past, improved vehicle crashworthiness, but are currently not included in GM/RT2100. Such features include monocoque bodysheets, continuous load paths at solebar and cantrail, substantial waistrail members, and satisfactory hoop strength. These features provide protection against vehicle buckling, local crushing due to non end-on impact (lineside equipment, oblique collisions, etc), penetration of passenger areas by large objects and rollover strength.

**Next Steps**

Subsequent to and arising from this work, RSSB has progressed a series of further projects, in particular:
R&D Programme: Research Brief

- ‘Whole Train Dynamic Behaviour in Collisions and Improving Crashworthiness’ (T118)
- ‘Optimal design and deployment of obstacle deflectors & lifeguards’ (T189)
- ‘Modelling Collisions of Rail Vehicles with Deformable Objects’ (T305)
- ‘Review of injury causation and human factors in recent vehicle accidents’ (T310)

This work will inform domestic and European standards.

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