TramTrain and its safety issues

- experience and approaches

Axel Kühn, Karlsruhe
TramTrain and its safety issues

- and what does the new EN15227 mean for TramTrain schemes?

Axel Kühn, Karlsruhe
Definitions

TramTrain <-> TrainTram
What are we talking about?
Definitions

Heavy Rail network

Urban rail network (existing/planned)
Tramway derived vehicles operate on heavy rail infrastructure; dual-mode operation

- Karlsruhe
- Saarbruecken
- Kassel
- Nordhausen
- Chemnitz
- Rijn-Gouwe-Lijn
- Alicante
- Mulhouse
- Liberec
- ...

...
Railway derived (Diesel) vehicles operate on urban rail (tramway) infrastructure

- Zwickau
- Riverline
- Camden-Trenton
- Aachen (planned)
- ...
Former railway alignments are converted for light rail/tramway operation; electrification with tramway voltage; with or without track-sharing

- Manchester
- Karlsruhe (partly)
- Kassel (partly)
- Chemnitz (partly)
- Oporto
- Aulnay-Bondy
- ...
Metro vehicles use heavy rail infrastructure

- Tyne&Wear Metro Sunderland
Crashworthiness?

Tramway ≥ 200kN
LightRail (EU) ≥ 600kN
TramTrain ≥ 600kN
Train (EU) ≥ 1500kN
LightRail (US) ≈ 1500kN
Train (US) ≥ 3000kN
German approach (derived from Karlsruhe pilot)

Operational patterns similar to track-sharing have been introduced in Karlsruhe as early as 1960, when tram-way vehicles equipped with ATP started to operate under 750V overhead power supply on the reshaped private “Albtalbahn” railway together with Diesel freight trains.
German approach (derived from Karlsruhe pilot)

Karlsruhe’s first TT-services to Pforzheim and Bretten (1991/92) approved by DB at this time without detailed risk and safety assessments!

Concentration was on the pure technical side with regard to the technical equipment of the vehicle (ATP, radio communication etc.) and derailing issues at specific railway points.
German approach
(derived from Karlsruhe pilot)

Approval for early projects was always only for specific routes or network sections!

Not possible in these days to operate the Karlsruhe vehicles elsewhere without additional route specific approval procedures!
A general light rail vehicle safety approach was taken in 1993-95 by the German ministry of transport, the starting point being not only the Karlsruhe model, but the aim to develop lighter (and cheaper) Diesel rail vehicles for rural railway services (e.g. Siemens REGIOSPRINTER).
LNT-regulations
Leichte Nahverkehrs Triebwagen (=LNT)

Eisenbahn-Bundesamt

Nachweis gleicher Sicherheit

- Gesamtrisiko darf sich gegenüber regelgerechtetem EBO-Betrieb nicht erhöhen
- Risikokompensation innerhalb des Gesamtsystems ist zulässig

Dipl.-Ing. (TU) Hans-Heinrich Grauf
LNT-regulations

Leichte Nahverkehrs Triebwagen (=LNT)

Eisenbahn-Bundesamt

Lösungsansatz

- Crashvermeidung statt Crashfestigkeit
- Schutz des leichten Fahrzeugs vor Regelfahrzeugen durch die Sicherungselemente der Eisenbahn
  - Zugbeeinflussung
  - Strecken- / Bahnhofsblock
  - Gleisfreimeldeanlagen
  - Zugfunk
- Eigenschutz des leichten Fahrzeugs durch hohes Bremsvermögen gem. BOStrab

Dipl.-Ing. (TU) Hans-Heinrich Grauf
Leichte Nahverkehrstriebwagen (LNT)

LNT-regulations

Dipl.-Ing. (TU) Hans-Heinrich Graul
DIN 5560

New (additional) approach from 2002

Eisenbahn-Bundesamt

neuer Ansatz: EBO-Kompatibilität

- Bemessung der Fahrgastzelle nach DIN 5560
- Crash-Kompatibilität zu EBO-Fahrzeugen
- definierte Stoßableitung in unkritische Bereiche der Fahrzeugzelle
- mittleres Bremsvermögen mind. 2,8 m/s²

LNT → Tram-Train

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DIN 5560

Siemens AVANTO first TT-vehicle with crash-nose according DIN 5560!

A German standard applied by SNCF for their TT-vehicle!

“Quite unbelievable, but the truth ☺️”
DIN 5560 offered additional approach ...
EN 15227 is a “taking further” of DIN 5560 on European level!

Further improves “passive safety” – contradiction to “active safety” approach of TT??
## Crashworthiness of Rail Vehicles

### European railway vehicle categories (prEN 15227, Table 1)

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Examples of vehicle types</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-I</td>
<td>Vehicles designed to operate on TEN routes, international, national and regional networks (which have level crossings)</td>
<td>Locomotives, coaches &amp; fixed units</td>
</tr>
<tr>
<td>C-II</td>
<td>Urban vehicles designed to operate only on a dedicated railway infrastructure, with no interface with road traffic</td>
<td>Metro vehicles</td>
</tr>
<tr>
<td>C-III</td>
<td>Light rail vehicles designed to operate on urban or regional networks, in track-sharing operation, and interfacing with road traffic</td>
<td>Tram trains, periurban tram</td>
</tr>
<tr>
<td>C-IV</td>
<td>Light rail vehicles designed to operate on dedicated urban networks interfacing with road traffic</td>
<td>Tramway vehicles</td>
</tr>
</tbody>
</table>
EN 15227

3 (4) crash scenarios, first two derived from DIN 5560!

Compared to vehicle category I, lower requirements for TT in III!

25km/h takes into account better braking capabilities!

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### Crashworthiness of Rail Vehicles

#### Passive safety basic elements

*European railway design collision scenarios outline (prEN 15227, Table 2)*

<table>
<thead>
<tr>
<th>Design collision scenario</th>
<th>Collision obstacle</th>
<th>Operational characteristics of requirement</th>
<th>Collision Speed - km/h</th>
<th>Collision partner and conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>C-I</td>
<td>C-II</td>
</tr>
<tr>
<td>1</td>
<td>Identical train unit</td>
<td>All systems</td>
<td>36</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>60-tons wagon</td>
<td>Mixed traffic with vehicles equipped with side buffers.</td>
<td>36</td>
<td>Na</td>
</tr>
<tr>
<td></td>
<td>129-tons regional train</td>
<td>Mixed traffic with vehicles with a central coupler</td>
<td>na</td>
<td>Na</td>
</tr>
<tr>
<td>3</td>
<td>15-tons deformable obstacle</td>
<td>TEN &amp; similar operation with level crossings</td>
<td>$V_{th} \leq 50$</td>
<td>na</td>
</tr>
<tr>
<td></td>
<td>3-tons rigid object</td>
<td>Urban line not isolated from the road traffic</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>4</td>
<td>Small, low obstacle</td>
<td>Obstacle deflector requirements to be achieved</td>
<td>See table 3</td>
<td>See table 3</td>
</tr>
</tbody>
</table>

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EN 15227

For category I this means up to 3000kN crashworthiness!
EN 15227 in Germany
Choice continues ...
EN 15227 in other countries

“No choice” as no operational “safety helmet” via LNT-regulations ...

So far apart from Germany “case based” approach with specific safety assessments for each system (France, Netherlands).
EN 15227 in other countries

EN15227 can be fulfilled by TT-rolling stock:
- new Alstom DUALIS does already,
- Siemens AVANTO does for scenario 1+2,
- Alstom RegioCitadis can be adapted!
EN 15227 in other countries

However: more weight and higher rolling stock costs could be involved!

Specific route characteristics (e.g. no level crossings) will also allow to exclude specific scenarios.
Conclusion

EN15227 not “the end” for TT; if all other factors/issues justify the choice of a mixed-mode system, then safety will not be “the killer”.

EN15227 can be even seen as advantageous by delivering a clear EC-rule and avoiding to negotiate endlessly for “local regulations”!