State-of-the-Art in Tramway Safety Technology

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Overview

The spectrum of rail operating environments

Mixed traffic / Line-of Sight Driving

Driverless Metro

Streetcar / Tramway already a very safe mode, and the industry continues to develop further safety improvements

- Background- System Safety Baseline
- Recent Innovations
- Industry Initiatives

Background- System Safety Baseline

- A holistic Safety Management System (SMS) approach is required
- Technology offers many helpful tools, but is not a substitute for a system-level approach to safety management
- Line-of-Sight operation in an urban environment has many design challenges
  - Clearances
  - Sight lines
  - Segregation from mixed traffic (including minimizing left turns) and signal priority

Implemented at best level the corridor will permit

Background- Vehicle Baseline

Safety "Checklist" for urban in-street operating environment

- ***General:***
  - **Low-floor design**
  - **High-performance braking**
  - **Door obstacle detection (anti-entrapment)**
  - **Following industry standards for CEM carbody, RAMS, Fire Safety**
- ***Tramway Specific:***
  - **Full skirting including trucks and ends, no exposed coupler**
  - **Rounded ends / low bumper (deflect, not trap, objects)**
  - **Improved cab visibility and operator ergonomics**
  - **Lighting and audible warnings optimized for operating environment (e.g. headlights flash with horn/bell, LED brake light "stop bars")**
  - **Additional standee accommodations**

Recent Innovations

- **Refinement of leading end geometry**
- **Driver Assist**
- **Other carbody design aspects**

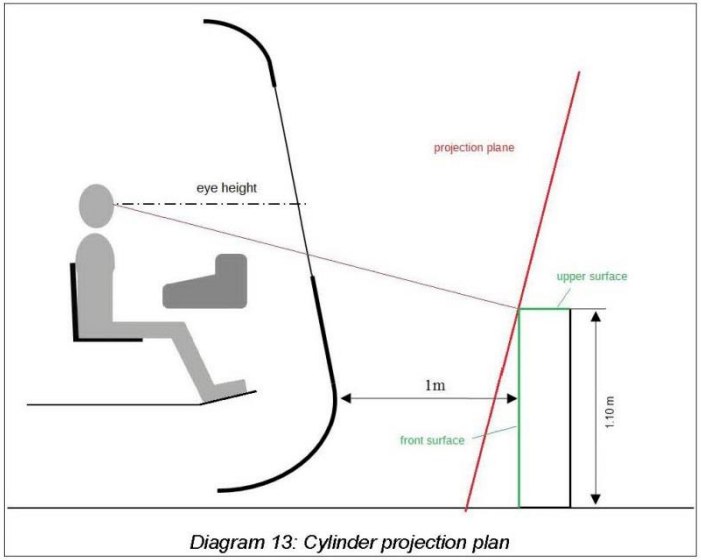
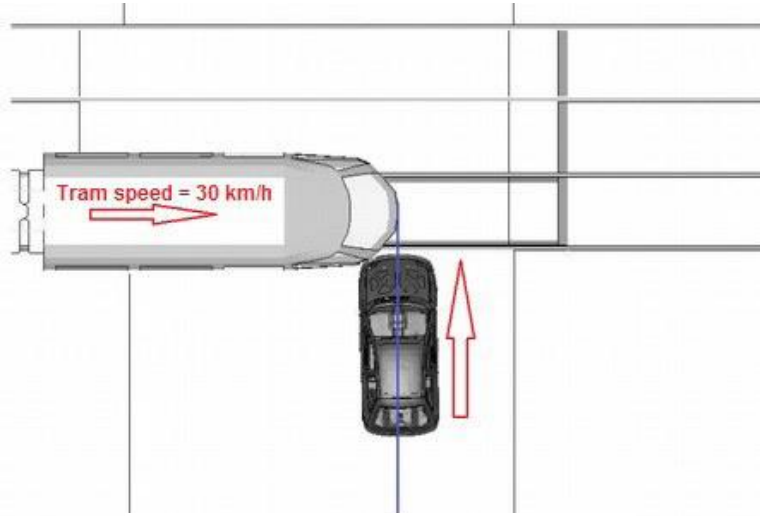
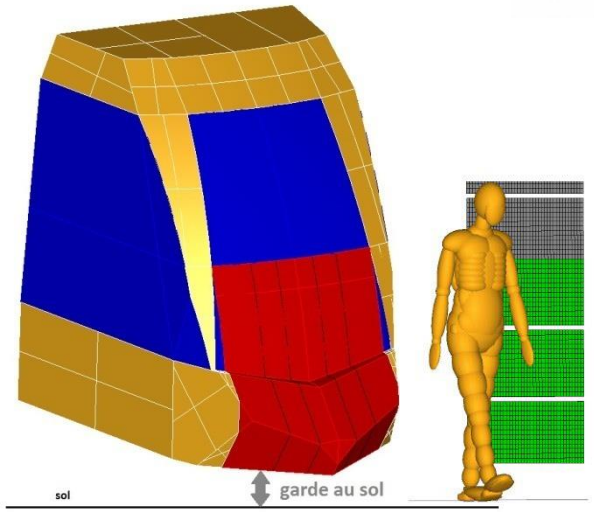


Diagram 13: Cylinder projection plan

Refinement of Leading End Geometry

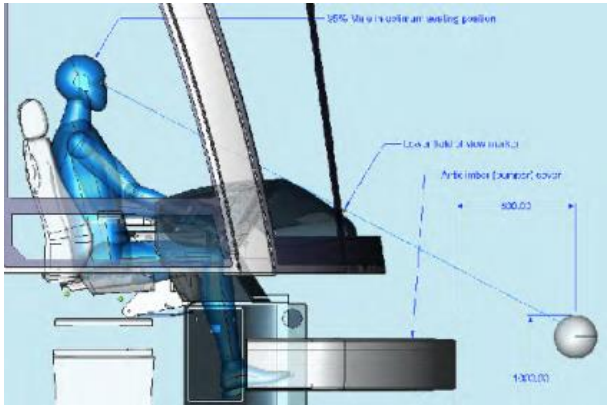
- **New (2016) STRMTG (France) *Tramway Front End Design* standard requires:**
  - **Designing and validating shape of leading end to minimize pedestrian injury**
  - **Validating effectiveness of underrun protection**
  - **Evaluating propensity to derail when struck in a perpendicular collision with auto at front corner**

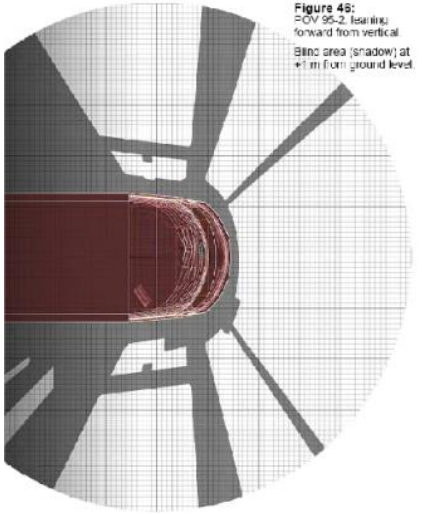




Refinement of Leading End Geometry

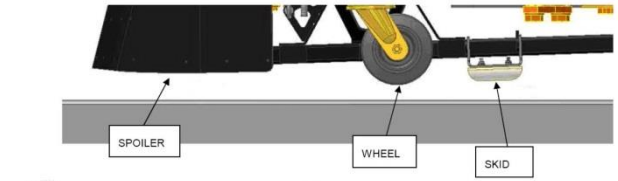
- **2016 revision of STRMTG (France) Technical Guide *Safety in Tramway Driver's Cab***
  - **Covers cab visibility and ergonomics**
  - **Quantifies testing for visibility / blind spots**
- **ASME RT-1 (2015)**
  - **Section 3.2 *Leading End Design for Protection of Street Vehicles* includes requirements for front end geometry / bumper height, but no criteria for visibility**

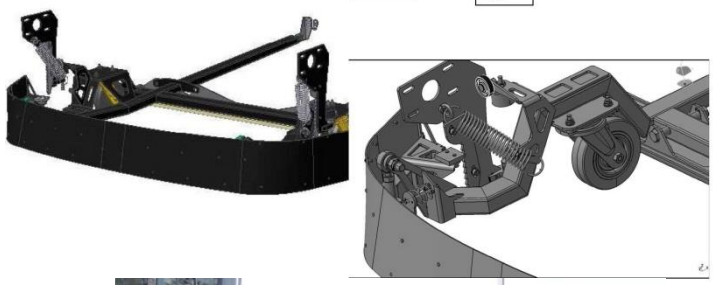


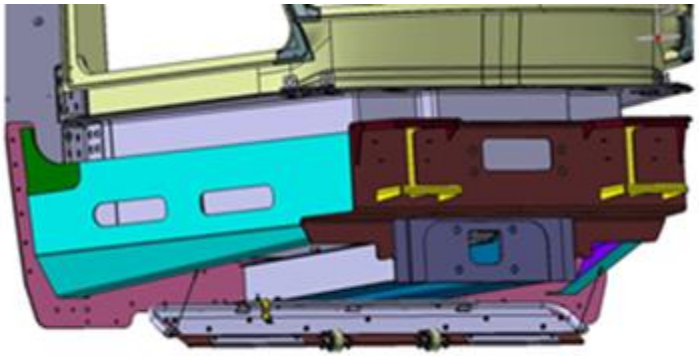


Refinement of Leading End Geometry

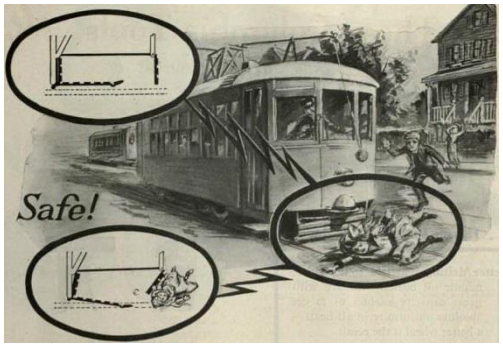
- **Supplementing bumper / underrun protection**
  - **Alstom underfloor fender**
  - **Bombardier airbag**
  - **CAF obstacle deflector**







Refinement of Leading End Geometry



Video: Courtesy of Alstom

Driver Assist

- **Application of automotive collision avoidance technologies to trams- reduce stopping distance by improving reaction time**
- **Driver vigilance and speed enforcement also taking on new urgency following recent accidents**

Driver Assist

- Application of automotive collision avoidance technologies
  - "Early Warning" only
  - Warning + automatic braking
- Other "assist" functions:
  - Provision of energy efficient driving advice ("Eco Driving")
  - Platform spotting assistance, wrong-side door inhibit
- Driver Assist in use / testing:
  - Bosch "Tram Forward Collision Warning System" testing in Hannover
  - Bombardier / Bosch "DAS" Prototype applications in Frankfurt and Berlin
  - Survey underway to identify other applications
- Wayside Supplements
  - Active speed warning signs similar to traffic signs

Speed / Signal Enforcement

Approaches:

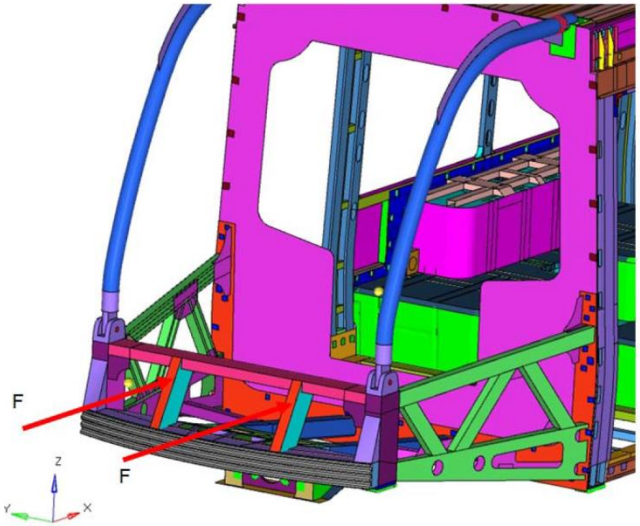
- Alerting the driver
- Communicating driver non-compliance to control
- Preventing overspeed / signal violations through technology (ATP)

Some examples:

- SIMOVE (GPS-based speed enforcement), developed by tram operator in Tenerife, Spain
- Alstom Pegasus- Brussels, Marseilles, Rouen, Constantine trams
- Siemens CTS/M- Portland Streetcar- train stop on bridge shared with LRT, Houston LRT signal enforcement

Other Carbody Design Aspects

- CEM principles firmly established in standards and continuing to evolve:
  - Holistic concept of safety in place of older approach relying solely on strength
  - ASME RT-1 and EN 12663/15227 continue to converge
  - Upcoming revision of CPUC GO-143
- Longer modular vehicles instead of coupled consists
- Energy absorbing bumpers
- Interior safety improvements



Industry Initiatives

- **European Cooperation in Science and Technology (COST) TU1103** ***Operation and Safety of Tramways in Interaction with Public Space***
  - **Analysis of accident statistics**
  - **Value of standardized data collection and recommendations for ideal accident report**
  - **Study of tramway infrastructure elements and associated hazards**
  - **Success stories**

- **UNIFE Technical Report for Interior Passive Safety in Railway Vehicles (2014)**
- **ASME RT Committee examining “mixed fleet” question (newer CEM and older strength-specified designs) as part of next RT-1 revision.**

- **Driverless trams- e.g. Alstom 2017 test in Paris; autonomous operation to depot**
- **Others?**

Literature Review (work in progress)

- Compact Train Stop / Magnetic Transmission (CTS/M), Siemens brochure 2014
- Technical Report for Interior Passive Safety in Railway Vehicles, UNIFE 2014
- European Cooperation in Science and Technology (COST) TU1103 *Operation and Safety of Tramways in Interaction with Public Space* Final Report, December 2015
- ASME RT-1 Safety Standard for Structural Requirements for Light Rail Vehicles (Revised 2015)
- Can Driver Assistance Systems (DAS) deliver safer LRT? UITP Workshop 3/25/15
- Drive assistance systems spread from cars to trams UITP 4/14/15
- Driver Assistance System, Bombardier brochure 2015
- CBTC for tram: towards higher levels of automation, Sebastien Lacroix, SYSTRA 2015
- Driver assistance system for avoidance of collision on LRVs, Alex Robinson Bombardier CORE 2016 Conference
- Driver assistance systems, BOSCH brochure 2016
- Alstom Pegasus System presentation 2016
- Is the world ready for driverless trams? Tramways & Urban Transport 1/23/17

Summary

- More new tools for the toolkit!
- Assembling working group
- Research questions:
  - Identify issues related to applying Driver Assist / ATP technologies in line-of-sight operations (e.g. in mixed traffic tramway)
  - Identify other examples / suppliers- collaboration with carbuilders / suppliers
- A lot has happened with standards in the last 10 years, including new ones mentioned here; which might be useful for application here in the USA?

Questions?