State-of-the-Art in Tramway Safety Technology

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Overview

The spectrum of rail operating environments

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
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


› 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
› 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?