Croydon Tram Accident
9 November 2016

Source: Rail Accident Investigation Branch

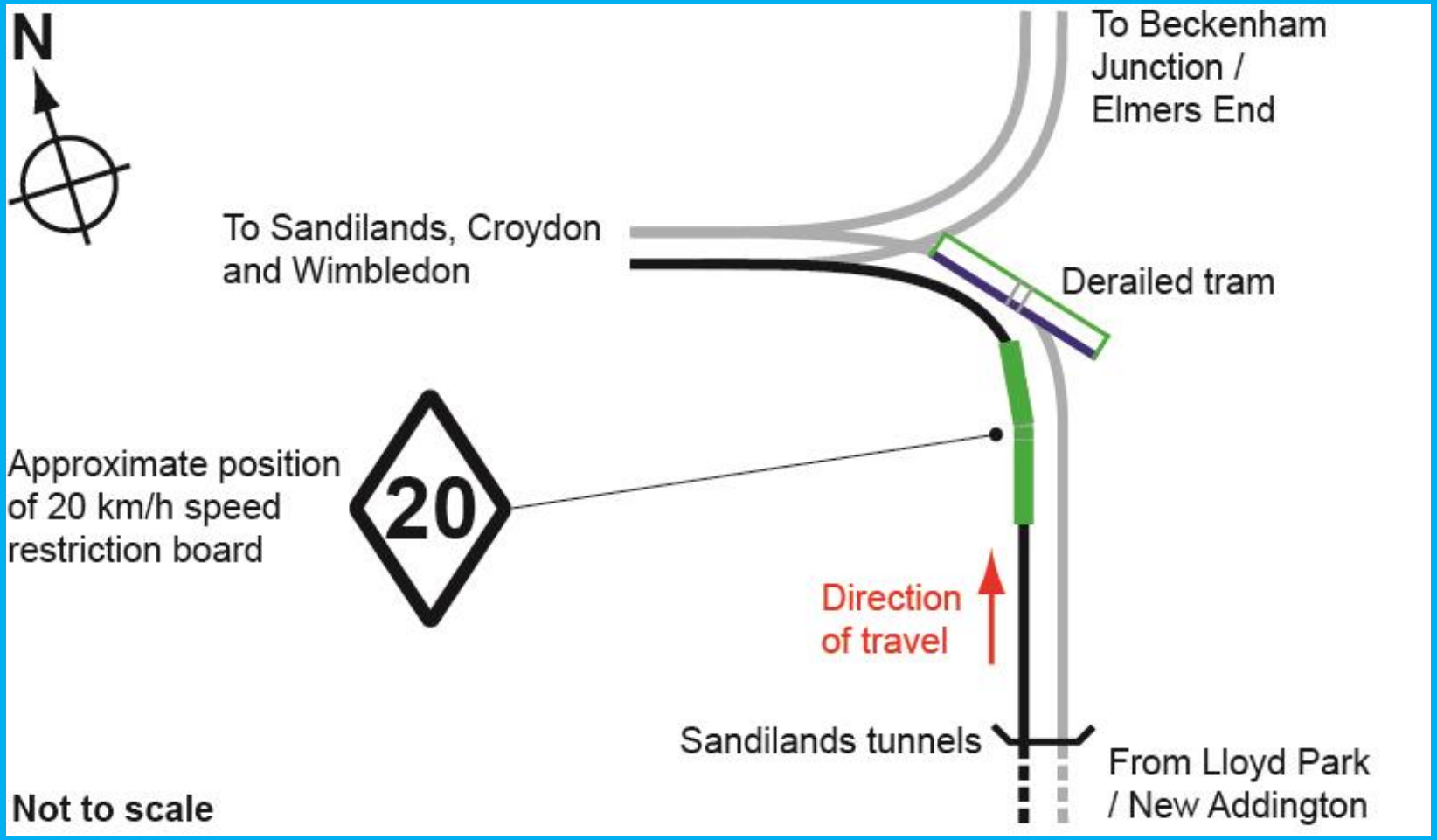
The Accident

- 9 November 2016 at 06:07
- Dark, raining
- Sandilands Curve, 30m radius, limit 20 km/h
- Tram entered curve at 73 km/h
- Tram overturned and slid 20 metres
- 7 passengers killed, 62 injured (19 seriously)
  - Only 1 passenger escaped injury
- Passengers killed by being ejected through broken windows and doors

The crash site

Source: Rail Accident Investigation Branch

Diagram of the crash site



Source: Rail Accident Investigation Branch

Immediate Cause

- The tram entered the curve much too fast
- No evidence of defects in the track or infrastructure
- No evidence of defects in the vehicle or its braking
- Driver was experienced, had good record, had no health problems, and was not fatigued

Why did the driver fail to slow down?

- Distracted?
  - No evidence of any distraction inside or outside
- Fatigue?
  - Driver said he had had sufficient rest
  - Work rosters complied with fatigue management
- Asleep?
  - Possibility of “micro-sleep”
- Driver probably “lost awareness”
  - Did he think he was going the opposite way?

Main findings of the RAIB investigation

- So the basic cause was driver error
- But RAIB also criticised :
  - No mechanism to monitor driver alertness or apply the brakes automatically
  - Inadequate signage
  - Windows broke when people fell against them
- Designers, regulators and operators did not recognise the risk of overturning

Why was risk of overturning not recognised?

- Risk profile analysis identified *derailment* as a hazard but not *overturning*
- It was expected that a derailed tram would stay upright - overturning was not identified as a credible risk
- Expected risk of derailment:
  - 1 derailment per 18 months, mostly minor injuries
  - 1 fatality per 100 derailments / 150 years

But overturning accidents do happen

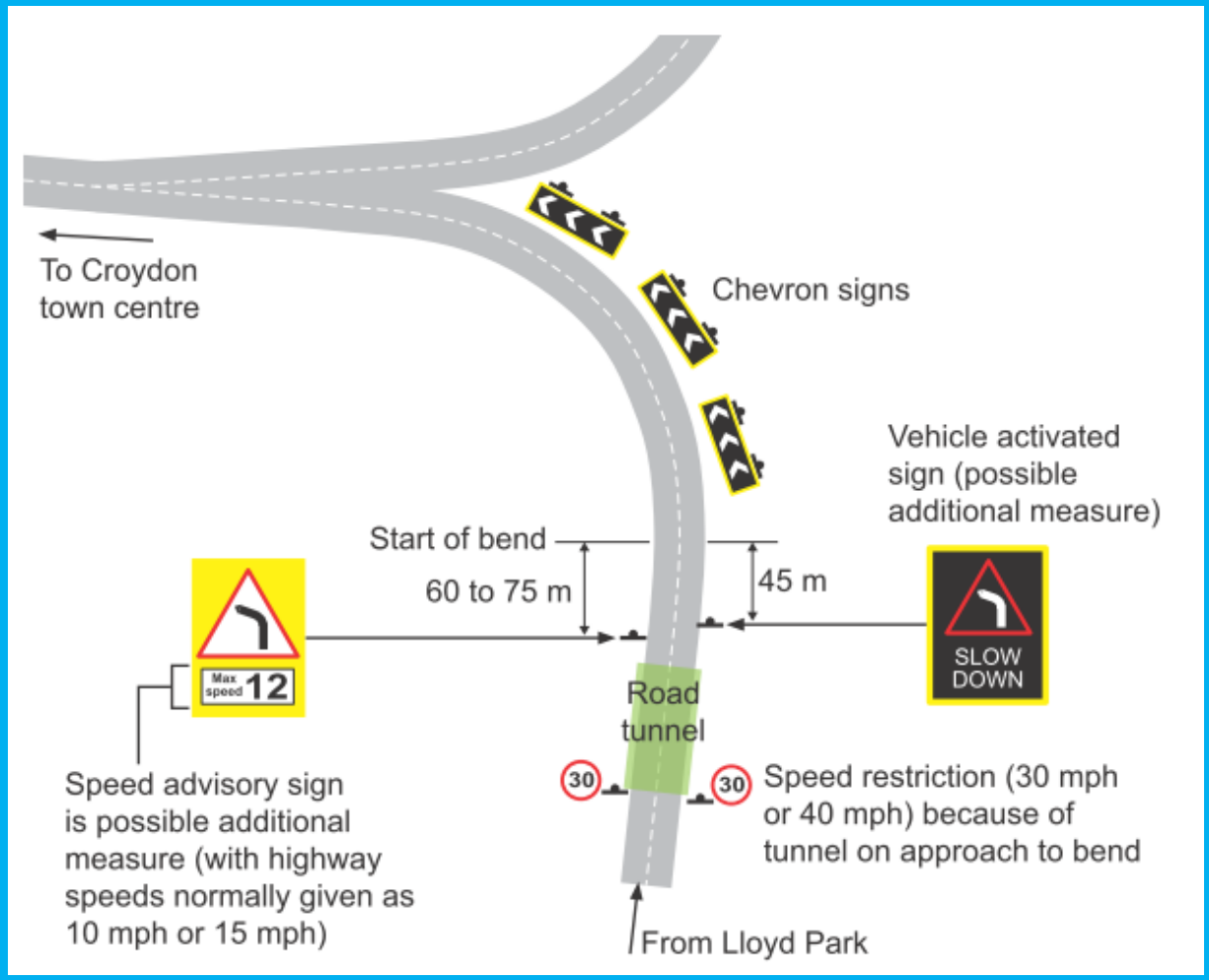
- 6 tramway overturning incidents in various countries 1993–2014, total 48 fatalities
- 6 railway overturning incidents in UK 1969–1994 , total 15 fatalities
- 7 railway overturning incidents in other countries 2003–2016 , total 205 fatalities
- Serious over-speeding incident at Sandilands on 31 October 2016

Measures to reduce speed on bends

- Other regimes anticipate over-speeding:
  - Germany: BOStrab standard requires advance warning signs
  - France: STRMTG guidance requires stepped speed limits of 60, 40, 30 km/h
  - Netherlands: Amsterdam tramway uses advance speed limit warnings

UK Road signs for a similar bend

"Bend ahead" signs, advance warnings, chevrons



Source: Rail Accident Investigation Branch / TRL

Signage – Immediate actions

- “Count-down” speed limits and chevron signs installed at Sandilands curve
- All other bends on Croydon tramway reviewed and extra signs installed
- Overall speed limit reduced from 80 km/h to 70 km/h
- All other UK tramways reviewed their signs and installed extra signs where necessary

Summary of RAIB Recommendations

- Use of technology, such as automatic braking and monitoring driver alertness
- Improve strength of doors and windows
- Better understanding of tramway risks
- Improvements to Safety Management Systems, so that staff can report mistakes, and other safety issues
- Review how tramways are regulated
- Set up a dedicated safety body for UK tramways

UKTram industry response

- Technical aids for tram safety:
  - Driver alertness detection, Driver Inattention Devices,
  - Over-speed indicators,
  - Automatic braking systems
- Human factors:
  - Fatigue monitoring,
  - Biometric devices for monitoring health and fatigue,
- Other factors:
  - glazing of tram windows, emergency lighting equipment, emergency exits, signage

UKTram looked at
Driver alertness detection

- For public re-assurance, “Guardian” driver protection device installed on all Croydon trams
- 29 possible systems identified
- Shortlist of 7 selected according to:
  - Driver alerted or automatically applies brakes?
  - Does the system record data, and if so in real time?
  - Is the system in use in the tram and light rail industry?
- These 7 systems being demonstrated and evaluated as at October 2018

UKTram looked at
Automatic Speed control

- 78 possible systems identified
  - Some combine speed control and alertness detection
- Shortlist of 12 selected according to:
  - What safety and other beneficial functions?
  - Driver alerted or automatically applies brakes?
  - In use or still being developed?
- These 12 systems being demonstrated and evaluated as at October 2018

UKTram looked at
Fatigue Management

- Review the literature, identify best practice and disseminate it across the industry
- Investigate current biometric devices to monitor health and fatigue
  - Health sector
  - Mobile phones
- Support R&D for developing biometric devices for the transport industry

UKTram looked at
Other factors

- Doors and windows
  - Manufacturers now fit fully-welded doors as standard
  - Only Sheffield trams and some Croydon vehicles have older bolted doors
  - Manufacturers can fit laminated glass as an option
    - Cost and weight penalty
    - Might restrict escape, for example in case of fire
- Emergency battery lighting can be supplied
- Escape hatches in roof or floor not practicable
  - Would introduce additional risk

A safety body for the light rail industry

- Light Rail Safety and Standards Board (LRSSB)
- Complies with RAIB Recommendation 1, to set up a dedicated safety body for UK tramways
- Close links to UKTram, but functionally separate
- The light rail equivalent of the Railway Safety and Standards Board (RSSB)

LRSSB – Primary functions

- Custodian of light rail standards and guidance
- Dissemination of safety information and lessons learned
- Interface with UK government and international bodies
  - ORR, RAIB, DfT, BEIR, DWP
  - UITP, VdV, STRMTG, TII, EBA
- Undertake safety work for the benefit of all UK light rail systems
  - Develop an industry-wide risk model
  - Light rail innovation and research
  - Accident and near-miss reporting and analysis
  - Training and competence assessment

LRSSB members

- All UK tramway systems
- Invitation to other UK light rail systems
  - Tyne and Wear Metro
  - London Docklands Light Railway
  - Glasgow Subway
- Potential membership for non-UK tramways
  - Isle of Man Railways
  - Dublin Luas
- Membership is not mandatory (unlike RSSB)

LRSSB – Initial workstream

- Set up the new body – currently exists as a shadow Board
- Review resources and funding
- Recruit key posts and supporting staff
- Assess and agree work programme
- Commence work on Phase 1 (Risk model) and Phase 2 (Standards development and safety verification)

LRSSB Phase 1 – Risk Analysis Model

- Complies with RAIB Recommendation 2, to develop a better understanding of tramway risks
- To develop a Risk Analysis Model for all UK tramways (and other light rail systems)
- Enables all operators to review their Safety Management Systems and see how well they are managing risk

LRSSB Phase 1 – Development of the Risk Analysis Model

- Explore available models
  - West Midland Metro model, developed as a subset of the RSSB model
- Develop training materials
- Apply and test with one tram system
  - probably West Midland Metro
- Roll out to all systems

LRSSB Phase 1 – Tram Accident and Incident Reporting

- Accident and near-miss reporting and analysis
- Update the existing Tram Accident and Incident reporting (TAIR) database
- Ensure it is appropriate for all systems
- Use as input into the Risk Model

LRSSB Phase 2 – Standards and accreditation

- Set up a library of current UK and European standards, guidelines and best practice
- Set up technical working groups
  - Engineering, maintenance and operational safety
  - Vehicles and infrastructure
- Identify gaps in highway legislation on tramway safety
- Accreditation of Independent Competent Persons
  - Establish a register of ICPs
  - Develop training and development programme

LRSSB Phase 3 and beyond

- Future Workstreams beyond Phase 2 will be developed when LRSSB is up and running
- Resources and budget are key

Thank you

New Sheffield Class 399 tram-train vehicle at Meadowhall South, about to join the railway to Rotherham.
Photo: D Walmsley