Level Crossings of Light Rail Systems
Safety Review of a Man-Machine Interface

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Safety – what is it?

- **direct Safety** – prevents – fences („doesn’t work“)
- **indirect Safety** – avoids – Z-Crossing, rules
- **indicating Safety** – training, knowledge – (introduction in proper application of rules)
- **Methods and technics of safety** depend on the intended type of safety.

![Diagram]

Person

→ Technics ↔ Organisation
Safety Gaps
in reference to safety at level crossings

- the gap in the scope of safety analyses
  - which rather focus on technical interaction
  - than on the interaction between technical elements and human behaviour,

- the gap between
  - “safety delivered” and
  - “safety perceived”,

wherefore LRT operators are frequently blamed by public opinion for running an “unsafe system” or building “unsafe crossings”,

- the gap between
  - the operators’ sphere of influence and
  - the responsibility of pedestrians.
Light Rail Safety
SSB’s holistic approach

Infrastructure

Vehicles

Drivers

Passengers and road users
Swiss-Cheese Model

- Safety barriers, co-ordinated and matched
- Physical and non-physical measures

(following Schwartz)
Level Crossings
Choice of Design Type

Which type?

on the line?
- on-street?
  - crossing in accordance with Street Traffic Regulations

- segregated alignment?

at the tramstop?
- high-floor platform?
  - Crossing at right angle with traffic lights
- low-level platform?
  - Crossing at right angle with visibility triangle
Infrastructure
Intersections with motorised traffic

Conventional crossings with traffic lights

Roundabouts

Railway level crossings with level crossing sign Andreaskreuz (St. Andrew’s cross)
Infrastructure
Intersections with pedestrians: the Stuttgart “Z”

- Z-shaped crossings to guide vision and attention in the direction of approaching trains
- Lights flash when trains approach
- Floor-mounted tactile guidance for visually impaired
Vehicles
Getting safer with every generation

- DT 8.10: retractable couplers, front aprons
- DT 8.12: rounded front, improved oversight for drivers
Drivers
prepared for routine and exceptional situations

- Use of new media, simulation tools and computer-based driver training
- Training of exceptional situations in a real-sized train simulator
- Stress reduction training
- Targeted surveillance and inspection of driving personnel

- Support and mentoring of drivers after heavy accidents
- Seminar for drivers and inspectors „mental handling of accidents“
Passengers and road users
Our training commitment

- destined for target groups with special requirements
  - elderly people
  - mobility-impaired persons
  - people with prams or wheelchairs

- Figures
  - 4 sessions (3 hours each) in spring and autumn respectively
  - 12 people per session
  - 96 people trained per annum

- The training is performed by SSB’s driving school

- The training is complementary to the self-explanatory design of stations, vehicles, and information
Modernisation of Light Rail alignment

alignment on street 2011: 8,3 km

segregated alignment 2011:
- alignment in tunnel: 26,6 km
- grassed reservation: 21,4 km

+ Rack Railway: 2,2 km
+ Cable Car: 0,5 km
Evaluation of Incidents
Correlations (1)

- 498 level crossings, of which
  - 83% no accident in 15 years
  - 5% more than one accident in 15 years (max. 7 accidents)

- increased distance between waiting zone and spot of accident (e.g. through lane or track)
  - No: 71%,
  - Yes: 28% of all accidents

- Distribution of accidents in the week
  - Mon-Fri: 18% each, Sat: 5%, Sun: 3%

- accidents in accordance to position of level crossing
  - approaching stop: 64%,
  - after stop: 16%,
  - open line: 20%
Evaluation of Incidents
Correlations (2)

- consequences of accident in relation to the position of the level crossing / the tram
  - dead:
    - approaching tramstop 64%
    - departing from tramstop 0%
    - open line 36%
  - heavily injured:
    - approaching tramstop 62%
    - departing from tramstop 7%
    - open line 20%
  - lightly injured
    - approaching tramstop 51%
    - departing from tramstop 26%
    - open line 23%
Evaluation of Incidents
What may determine an incident turning into an accident?

- distraction by
  - mobile phone, MP3 Player, talking, absent-minded
- pedestrians lacking partially a general awareness, if focused on one aim (e.g. reaching the tram waiting already at the tramstop)
- misinterpretation of the bell’s sound
- misjudgement of situation through dissferent designs of level crossings
- physically impaired
  - limited mobility, visually impaired, under influence of alcohol
- malfunctioning of safety installations
  - warning lights do not work properly
- driver misjudges situation and does not behave appropriately
Evaluation of Incidents
How do pedestrians use level crossings?

- Awareness
- rules are mostly known
- despite this, pedestrians often behave inappropriately
  - paying attention just to warning lights (not to tram)
  - walking „just with the ears open“
  - noticing the approaching tram, but still crossing track ahead of tram
  - looking down – not up
  - people are talking to each other while waiting at the level crossing. The tram arrives – and people start to cross the tracks.
Evaluation of Incidents
Correlations

- no changes in frequency of accidents within 15 years
- distribution of accidents:
  - peak in the afternoon
  - relatively few accidents during weekends
- Age of victims correlate with age of people typically being present at tram stops at a certain period of day
- no correlation between design of level crossing and number/severity of accidents
- fewer accidents when tram is departing from tram stop than when arriving at tram stop
- smaller ratio of accident if there is a greater distance between waiting zone and actual danger spot (e.g. another track or a lane).
Evaluation of Incidents
Conclusions

- Maintaining a constantly high level of overall safety, thus
- Strongly focusing on improving the matching and interaction of the components of SSB’s Light Rail system:
  - concerning infrastructure – the design of level crossings was improved,
  - concerning vehicle design – the front end of newer vehicles was designed to be protective and defensive,
  - concerning operation: operational practice (driving on sight) and signaling were matched to allow coherent use of level crossings.
- All reasonable technical means are being applied.
The LRVs’ determinability might tempt pedestrians to take higher risks:

“I know exactly where the tram is going – so I do not have to pay too much attention to the situation.”

Public Awareness Campaigns on how to negotiate level crossings:

- in 2003 and 2012
- With these campaigns, SSB addresses how signalization is understood and how this is transformed into action, mainly in the “last second ante”.
- SSB communicates the meaning of core signals, especially of the warning lights installed at most of the level crossings.
Determining critical influences from the environment on how a situation might develop:

- visibility of (and visual distraction from) the signals relevant for safely negotiating a level crossing,
- the state of pedestrians which are about to negotiate a crossing,
- the level of noise and sounds surrounding a level crossing.

Quantitative Analyse on use of level crossings:

- How many pedestrians are negotiating a particular level crossing?
- How many of these crossings are critical in terms of safety?
- How many of these critical crossings will lead to accidents?
Passengers and road users
Prevention campaigns

- New safety campaign „sicher zu Fuß“

- Safety campaign addresses the main problem areas
  - Hurry and negligence at level crossings
  - Failure to notice blinking lights
  - Behaviour of road users: cell phones, smartphones, music players...
Further Information

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