CAST Analysis of a Railroad Accident in Switzerland
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Credits:
This presentation is based on the bachelor thesis «Analyse und Modellierung von Eisenbahnunfällen» by Martin Moser and Gregor Schibig supervised by Monika Reif together with ENOTRAC AG, Switzerland.
Introduction

Background
- Bachelor thesis with industrial partner ENOTRAC AG, Switzerland

Research Objectives
- Validation of ENOTRAC’s physical model for train collisions
- Show applicability of CAST for accident analysis for a real railroad crossing accident

Talk Focus
- CAST analysis

www.labroye.ch/galerie/accident-de-train-%C3%A0-granges-marnand
Project description

Risk related to the considered hazard is a function of the severity of harm that can result from the considered hazard and the occurrence of that harm.

Two points of action for risk reduction:
Project description

Severity of harm
- Understand, evaluate and reduce severity of harm
- Train manufactures can improve passive safety measures by mechanical design changes

Occurrence of harm
- Understand and reduce occurrence of harm
- Objective is to prevent harm
- Many stakeholder involved

Physical model for train collisions
CAST
Project description

Severity of harm

- Physical model of train accidents
- Model validation with the help of several train-train accidents
- Model validation with the help of several railroad-crossing accidents

Result

- Validated physical models for estimating the effects of mechanical design changes on severity of harm for train drivers and passengers (intellectual property of our project partner)
Project description

Severity of harm

- Analysis of speed sensitivity of railroad crossing accidents

Result for train driver and passengers

- Higher severity of harm at higher collision speed for train-truck collisions
- No speed sensitivity found for train-car collisions

Remark

- Effect for car or truck drivers not in scope of the model
Project description

Occurrence of harm
- Understand accident analysis performed actually
- Use CAST for a Swiss railroad crossing accident
- Goal: Prevent future accidents (occurrence of harm)

Different stakeholders involved
- Road operator
- Truck operator and driver
- Rail operator
- Train operator and driver
Project description

Understand and reduce occurrence of harm according to the mandate of the Swiss Transportation Safety Investigation Board (STSB)

- determine not only the direct causes of accidents but also the more deep-seated reasons and other risks associated with them
- acquire insights by means of which future accidents and hazardous situations can be prevented and which result in improved safety
- the results of such a safety investigation are not intended to clarify questions of blame and liability

Compliant with the goals of CAST

Project description

STSB Accident investigation

Steps
- Gathering the information
- Analyzing the information
- Identifying risk control measures
- The action plan/safety recommendations and its implementation

Scope
- Often strongly focused on only one part (e.g. railway part)

Extend to complete system
- Analysis of complete socio-technical system with the help of CAST (Causal Analysis based on Systems-Theory)

https://www.sust.admin.ch/en/topics/investigation/
Outline

Introduction ➔ Project description ➔ CAST Analysis ➔ Conclusion
CAST Analysis

Accident
- Railroad crossing accident in Goldach (Switzerland) in 2013

Goal
- Show interactions of all elements involved
- Extend the scope on railway and road
- Identify all causal factors

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Accident
- Collision of train and truck at railroad crossing
- Date: 06. Mai 2013
- Place: Goldach, Switzerland

Result
- 2 severely injured persons
- ~2.000.000 CHF damage

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Train
- Thurbo, Type Stadler GTW 2/8
- Train No. 23743
- derailed

Truck
- Polish truck driver
- trailer completely destroyed
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System(s) and hazard(s) involved in the loss

Systems
- Train control system
- Railway control center
- Gate system
- Railway infrastructure
- Dispatcher
- Train driver
- Road infrastructure
- Truck driver
- …

Hazards
- Train-truck collision
CAST Analysis

Proximal events

- Gate lights blinking red and acoustical signal
- Truck drives on railroad crossing
- Gates close
- Train receives greenlight and accelerates up to 114 km/h
- Truck stops on track
- Truck driver leaves truck
- Truck driver and other persons try to lift gate manually
- Train driver realizes obstacle and brakes
- Train-truck collision at 78 km/h

System(s) and hazard(s) involved in the loss

Proximal Events

Hierarchical control structure

Safety constraints and related responsibilities

Analysis of elements

Findings
CAST Analysis

Hierarchical Control Structure

System(s) and hazard(s) involved in the loss
Proximal Events
Hierarchical control structure
Safety constraints and related responsibilities
Analysis of elements
Findings

Railway

Road

Road

Railway

Proximal Events

Hierarchical
control structure

Safety constraints and related responsibilities

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CAST Analysis

Hierarchical Control Structure

First missing feedback were found directly in the HCS
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Missing Feedback

Railway

- No feedback to control system if railroad crossing is really free
- Visual control of train driver is not effective due to bending track
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Missing Feedback

Truck Driver

- No feedback if truck driver has correct level of understanding and is reacting in intended way on signaling
- No means for driver to report emergency situation
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Responsibilities: Detail Railway

Dispatcher
- Guide train according to Swiss regulations
- Operate technical equipment according to requirements

Train driver
- Obey signalization
- Handle the train appropriately
- Realize dangerous situations and react appropriately
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Responsibilities: Detail Road

National Road Regulating Authority
- Safety regulation of roads
- Safety level comparable to leading countries

Carrier
- Educate drivers for different countries
- Employ well educated drivers
- Use sustainable scheduling

System(s) and hazard(s) involved in the loss
Proximal Events
Hierarchical control structure
Safety constraints and related responsibilities
Analysis of elements
Findings
CAST Analysis

Analysis of elements, e.g. gate system:

Safety related responsibilities violated

- Crossing has to be free when gates are closed and crossing free is transmitted

Context

- Road has a S-bending at the crossing
- No area monitoring legally required (required only when allowed train speed is >140km/h)
- Big distance between gates
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Analysis of elements, e.g. gate system:

Inadequate decisions and control actions
- State gate closed (crossing free) is transmitted to train control center without knowing the exact state of the crossing

Process models flaws
- No obstacle awareness given
- Gate design not adequate for this context (distance and length of gates)
CAST Analysis

Findings

Railway
- Requirement for area monitoring of railroad crossing is linked to allowed train speed and not to situational awareness

Street
- Distance of gates to big (not exactly defined for such a context)
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Findings

Truck Driver

- Does not really know what to do in this situation, tries to open gate, no means to report an emergency situation
- It is not clear whether truck driver knows the meaning of red flashing lights in Switzerland
- Could he see the flashing lights from his perspective?
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Recommendations (short term):

Railway
- Area monitoring for this crossing due to reduced view

Road
- Change gate position parallel to track
- Use short gates for one part of the road

Recommendations (long term):

Railway and Street
- Educate drivers about how to behave on railroad crossings
- Emergency button at gates
- Uniform signaling for railroad crossings in Europe
- Communication between road vehicles and railroad crossing
Conclusion

Physical Model
- Train manufacturers have only limited means to reduce risk
- Train manufacturers can mainly reduce severity of harm by improving passive safety
- Physical model is required in order to judge design options

CAST Analysis
- No findings or recommendations for train manufacturer, may change when active train safety systems are involved
- CAST analysis is well suited for the global context, especially for safety board investigations
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