Zurich University
of Applied Sciences

School of Engineering

IAMP Institute of Applied Mathematics and Physics


# CAST Analysis of a Railroad Accident in Switzerland

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# Outline

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Introduction → Project description → CAST Analysis → Conclusion

**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

## 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

# Outline



Introduction → **Project description** → CAST Analysis → Conclusion

# Project description

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**RISK**

related to the considered hazard

is a function of

**SEVERITY OF HARM**

that can result from the considered hazard

and

**OCCURENCE**

of that harm

Two points of action for risk reduction

# Project description

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## Severity of harm

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

**Physical model for train collisions**

## Occurrence of harm

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

**CAST**

# Project description

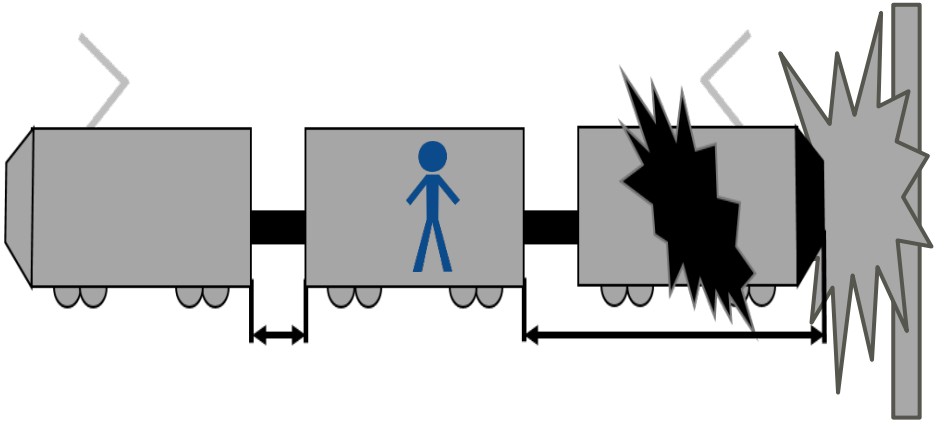


## Severity of harm

- 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

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## Severity of harm

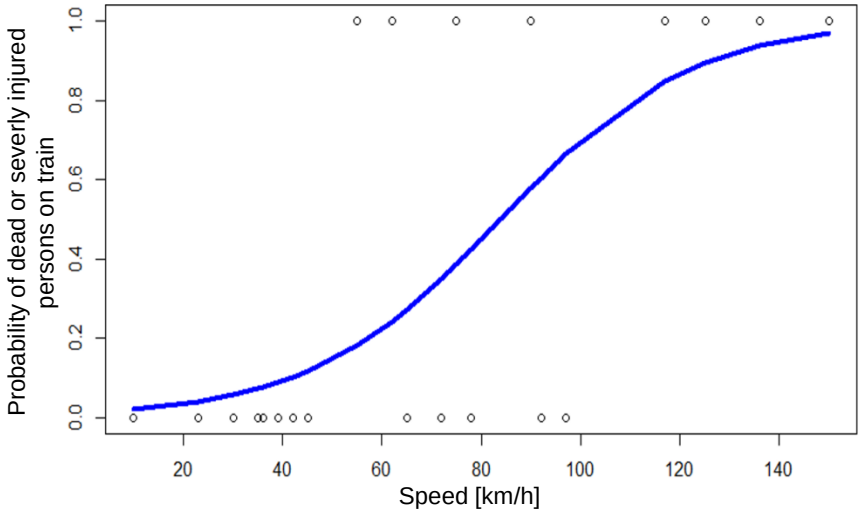
- Analysis of speed sensitivity of railroad crossing accidents

## 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

https://www.sust.admin.ch/en/stsb-homepage/

# 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



## 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

www.kapo.sg.ch/news/kapo/2013/05/goldach--zug-prallt-in-lastwagen.html

# CAST Analysis



## CAST Analysis

### 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

www.kapo.sg.ch/news/kapo/2013/05/goldach--zug-prallt-in-lastwagen.html

# CAST Analysis

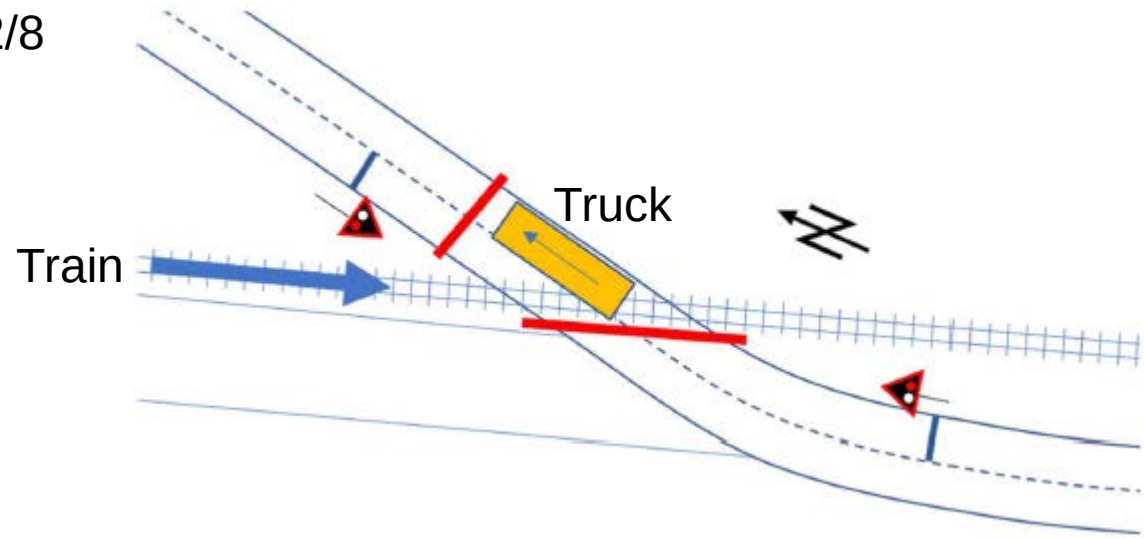
## CAST Analysis

### Train

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

### Truck

- Polish truck driver
- trailer completely destroyed



# CAST Analysis

## 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

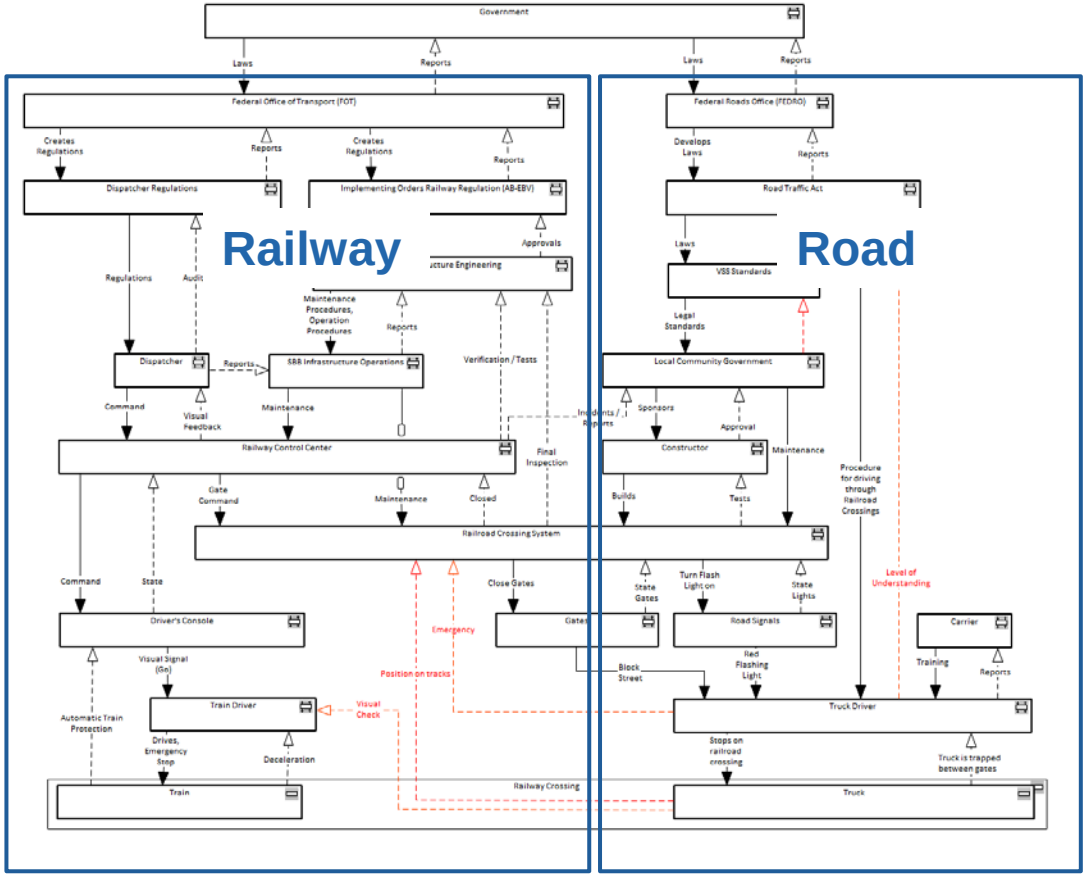
Truck driver and other persons try to lift gate manually

Train driver realizes obstacle and brakes

Train-truck collision at 78 km/h

# CAST Analysis

## Hierarchical Control Structure




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

Proximal Events

Hierarchical control structure

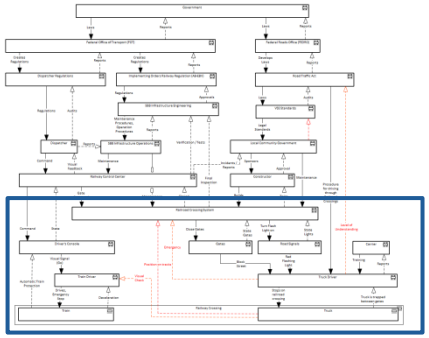
Safety constraints and related responsibilities

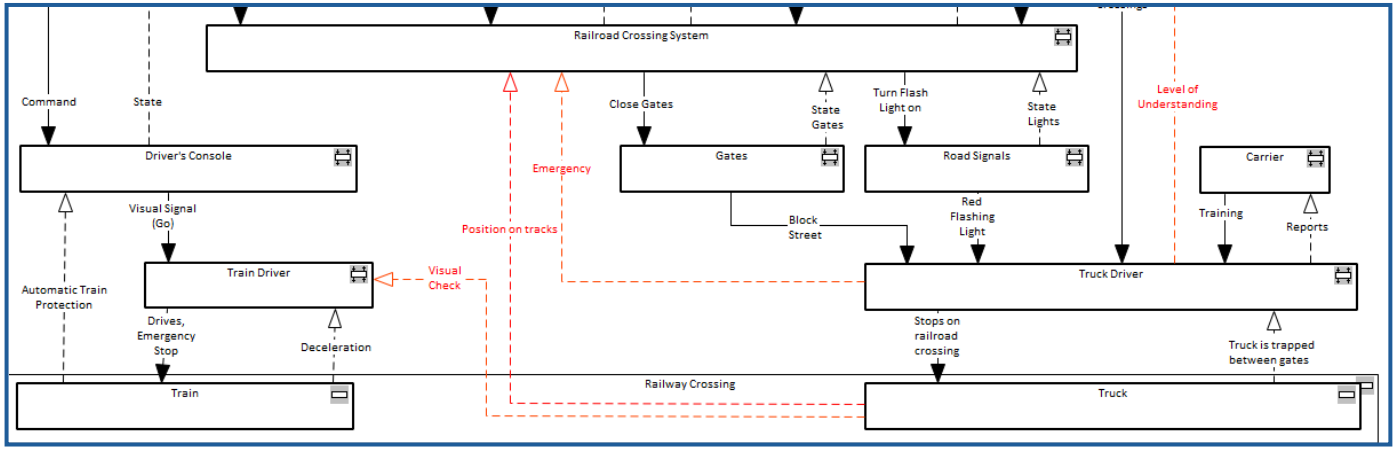
Analysis of elements

Findings

# 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

First missing feedback were found directly in the HCS

# CAST Analysis



## 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

# CAST Analysis



## 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

# CAST Analysis



## 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

# CAST Analysis



## 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

# CAST Analysis

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## 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

# CAST Analysis

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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)

# CAST Analysis



## 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?

# CAST Analysis

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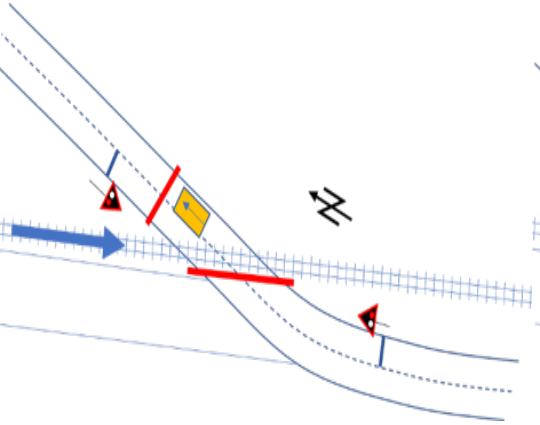
## Recommendations (short term):

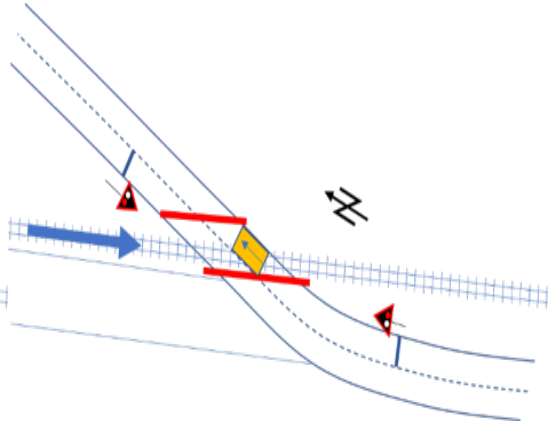
### Railway

- 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

# Agenda



Introduction → Project description → CAST Analysis → Conclusion

# Conclusion



## 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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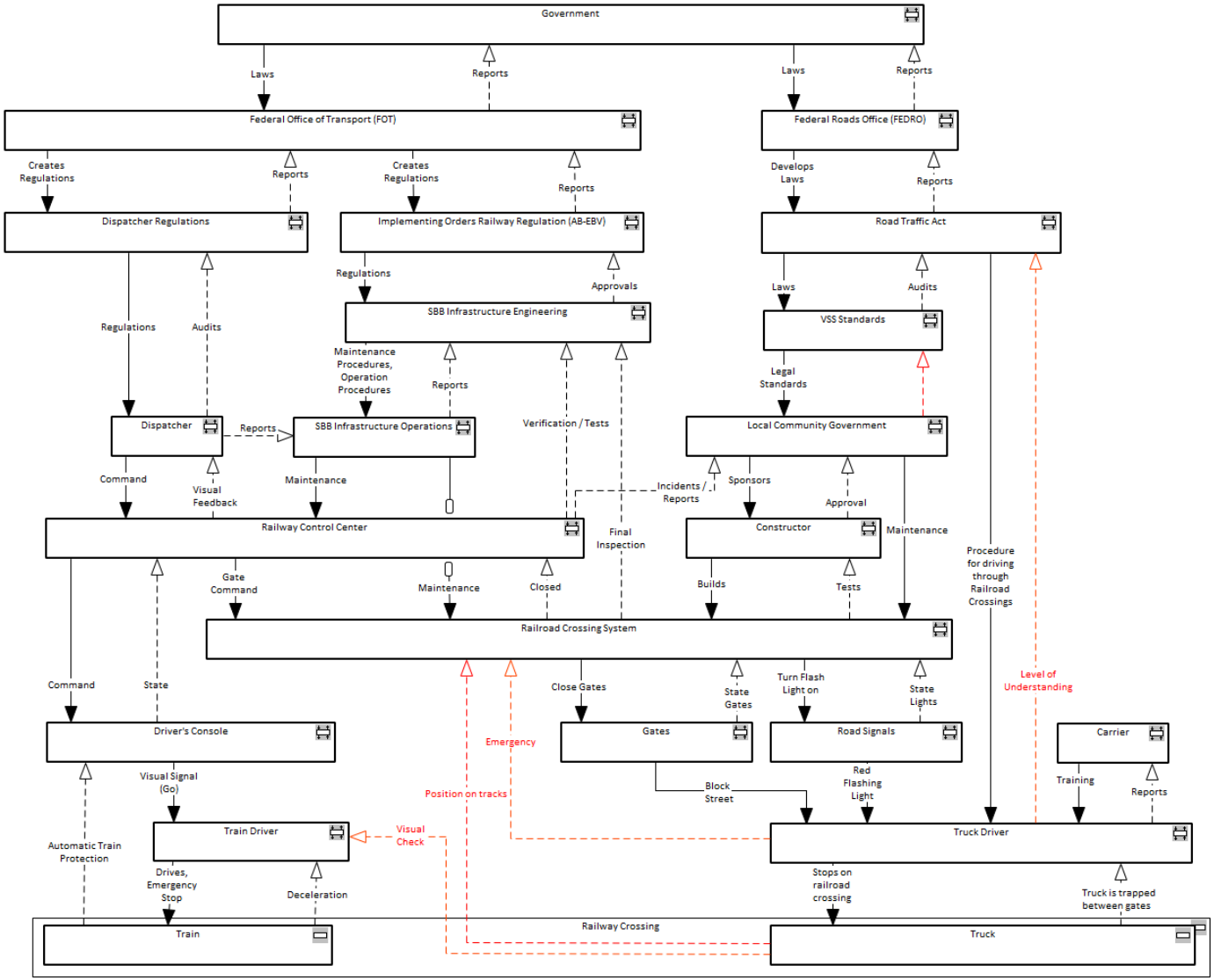
http://www.iamp.zhaw.ch/sks


Government
Laws
Reports
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Federal Office of Transport (FOT)
Federal Roads Office (FEDRO)
Creates Regulations
Reports
Creates Regulations
Reports
Develops Laws
Reports
Dispatcher Regulations
Implementing Orders Railway Regulation (AB-EBV)
Road Traffic Act
Regulations
Approvals
Laws
Audits
SBB Infrastructure Engineering
VSS Standards
Regulations
Audits
Maintenance Procedures, Operation Procedures
Reports
Legal Standards
Dispatcher
Reports
SBB Infrastructure Operations
Verification / Tests
Local Community Government
Command
Visual Feedback
Maintenance
Incidents / Reports
Sponsors
Approval
Railway Control Center
Final Inspection
Constructor
Maintenance
Procedure for driving through Railroad Crossings
Gate Command
Maintenance
Closed
Builds
Tests
Railroad Crossing System
Command
State
Close Gates
State Gates
Turn Flash Light on
State Lights
Level of Understanding
Driver's Console
Emergency
Gates
Road Signals
Carrier
Visual Signal (Go)
Position on tracks
Block Street
Red Flashing Light
Training
Reports
Train Driver
Visual Check
Truck Driver
Automatic Train Protection
Drives, Emergency Stop
Deceleration
Stops on railroad crossing
Truck is trapped between gates
Railway Crossing
Train
Truck