Dynamisches Eisenbahn System Modell
Modèle dynamique d'un système ferroviaire
Dynamic model of a railway system

Fachhochschule Nordwestschweiz
Hochschule für Angewandte Psychologie

Technische Universität Braunschweig

Use of simulators to investigate complex issues at human-machine interfaces HMI of railway systems

Jürg Suter, Nicole Stoller

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Topic

Increasing complexity

Research laboratory

Situation awareness

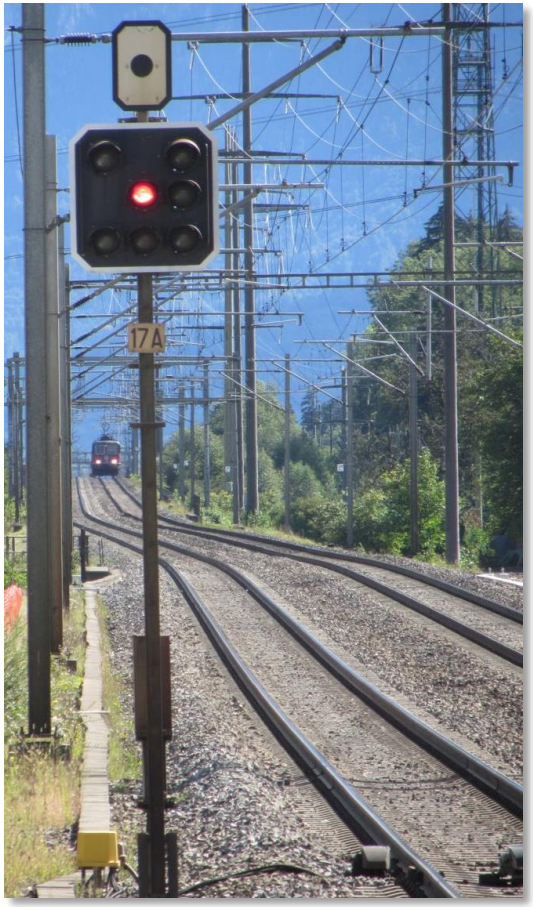
Conclusions

Jürg Suter, Nicole Stoller

Increasing complexity

Signal passed at danger

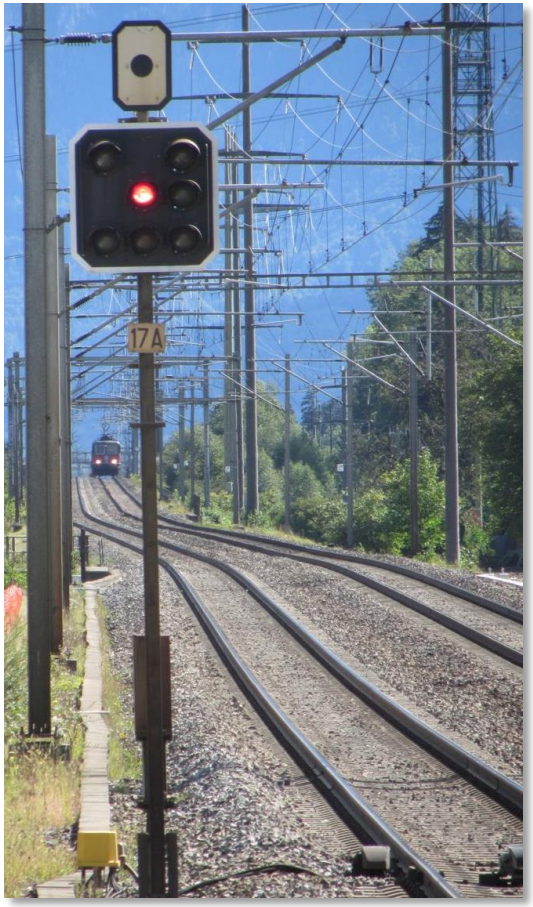
(SPAD)



Increasing complexity

Danger of confusion

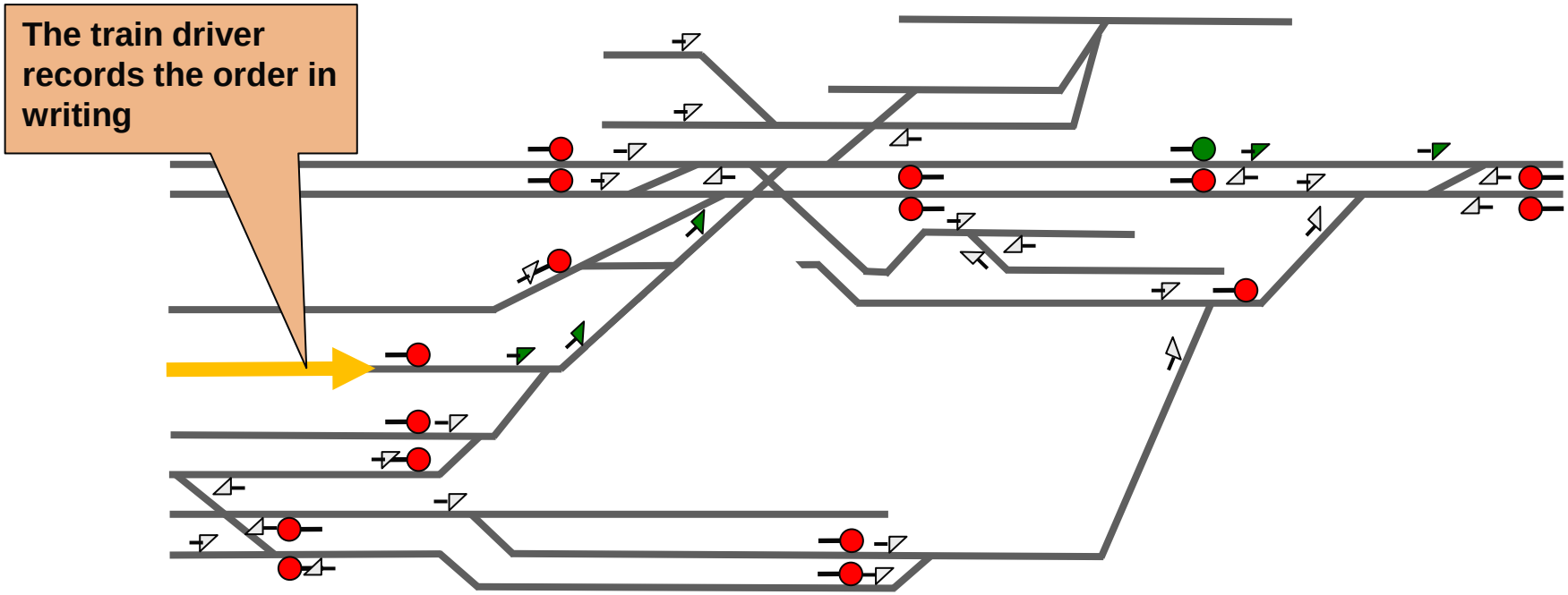
- In the event of malfunction, it is necessary to pass signals at danger.



Increasing complexity

Danger of confusion

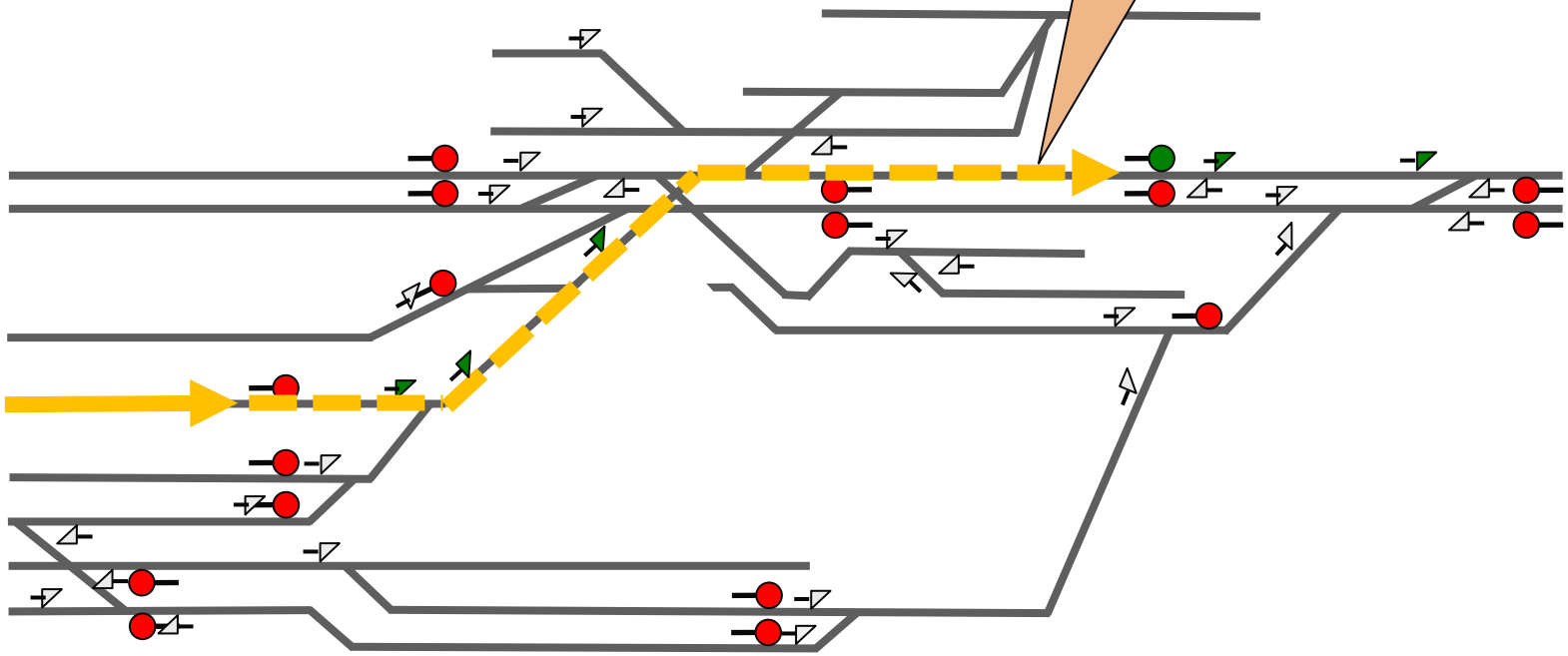
- In Switzerland, the relevant regulation states: when passing a signal at danger = “line-of-sight driving”



Increasing complexity

Danger of confusion

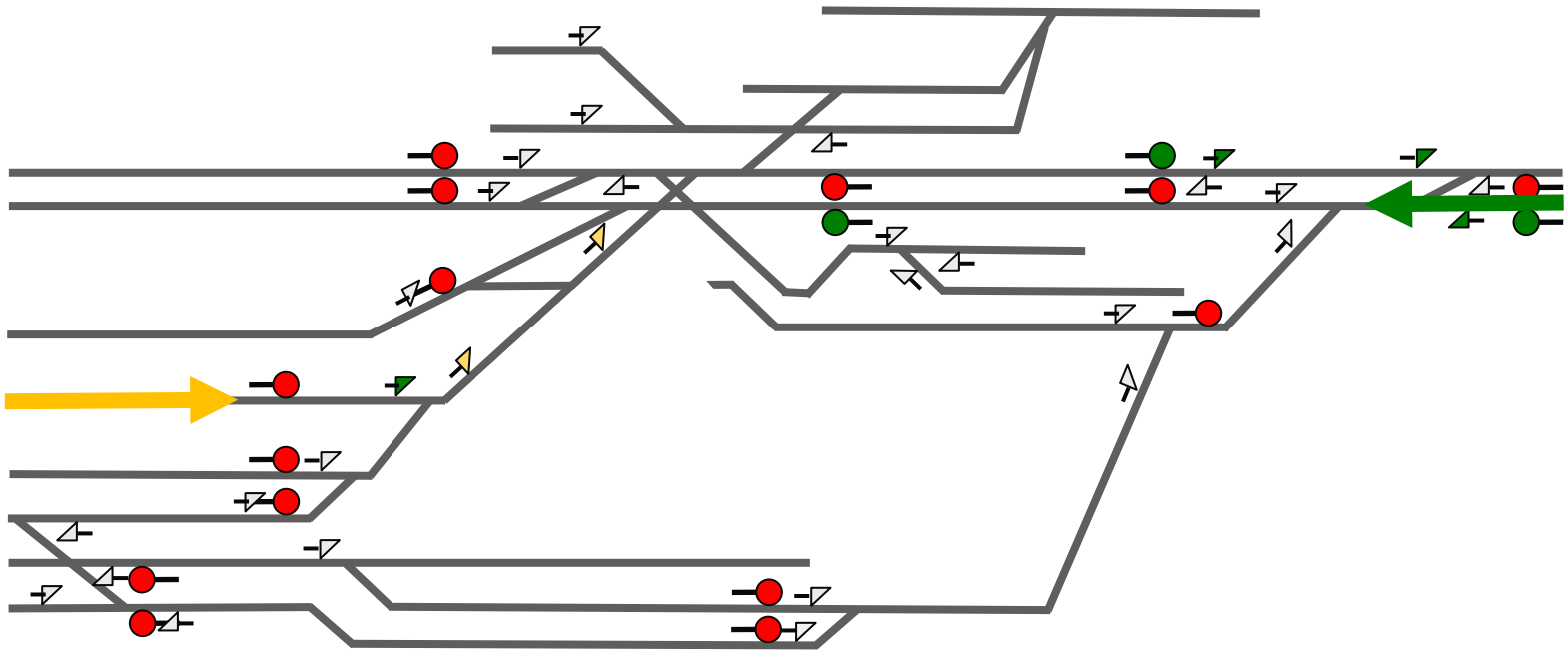
- In Switzerland, the relevant regulation [illegible]es: when passing a signal at danger = “line-of-s[illegible]t driving”



Increasing complexity

Danger of confusion

- Converse argument not valid:
  “Line-of-sight driving” ≠ to pass signal at “danger”



Increasing complexity

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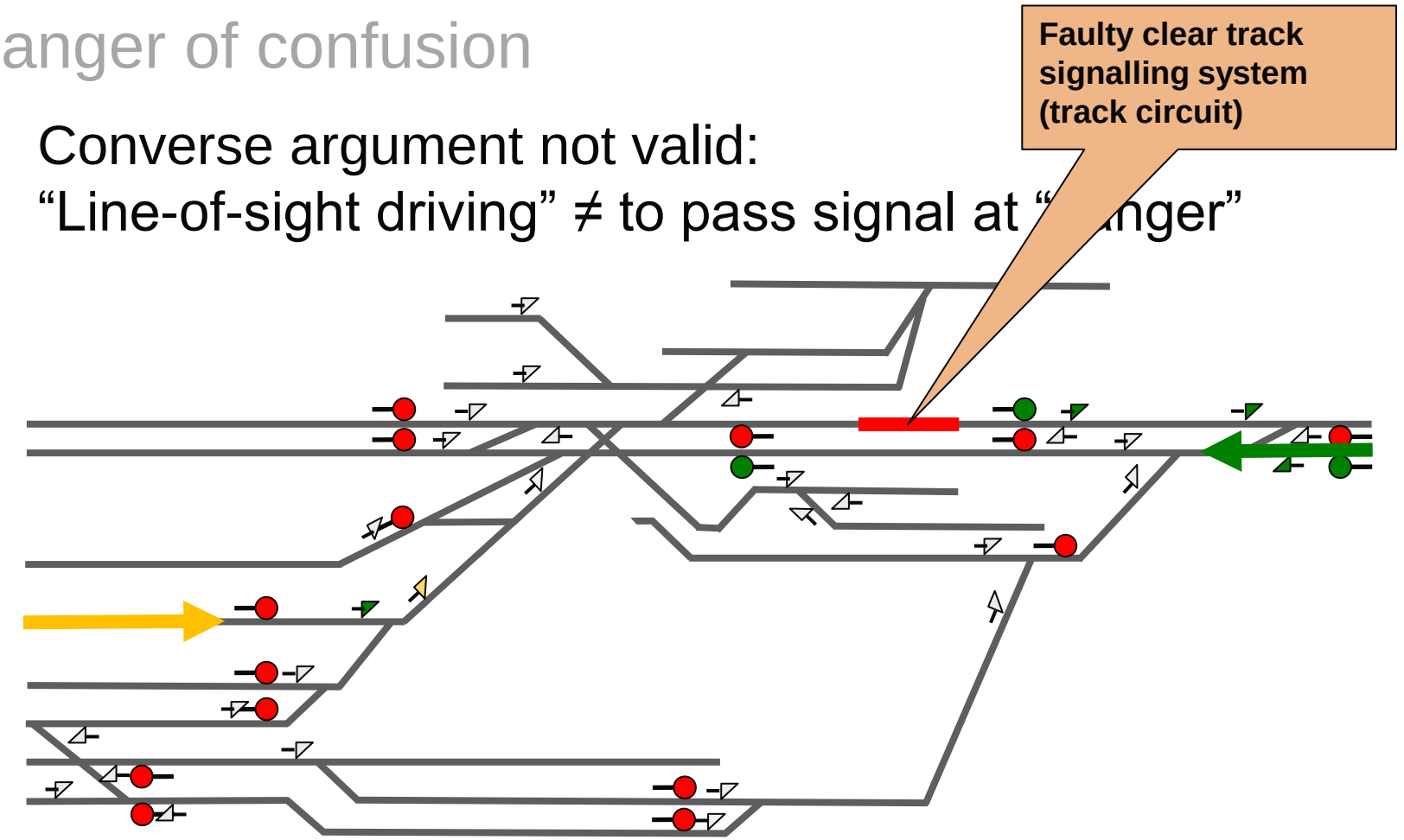

Increasing complexity

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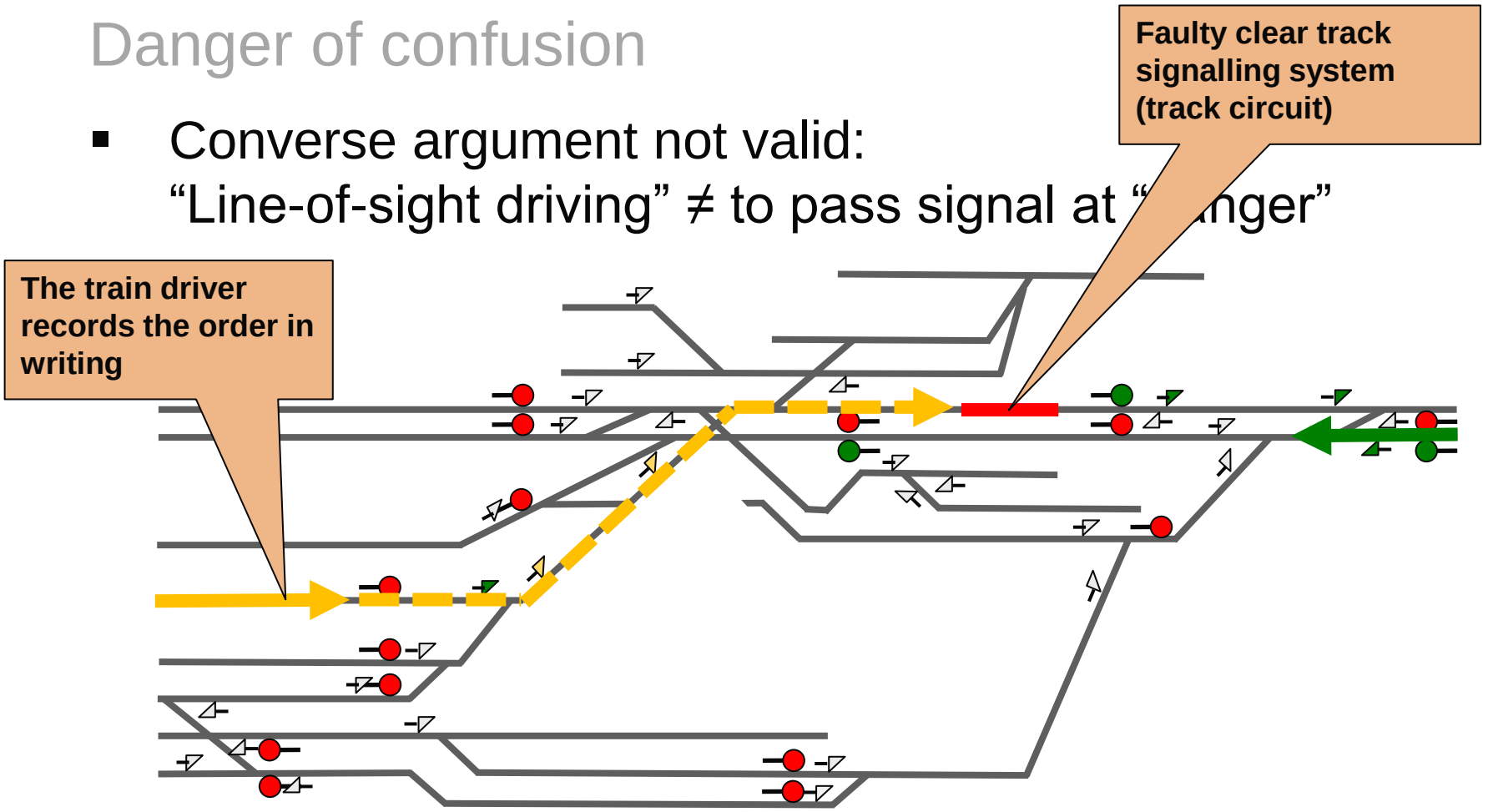

Increasing complexity

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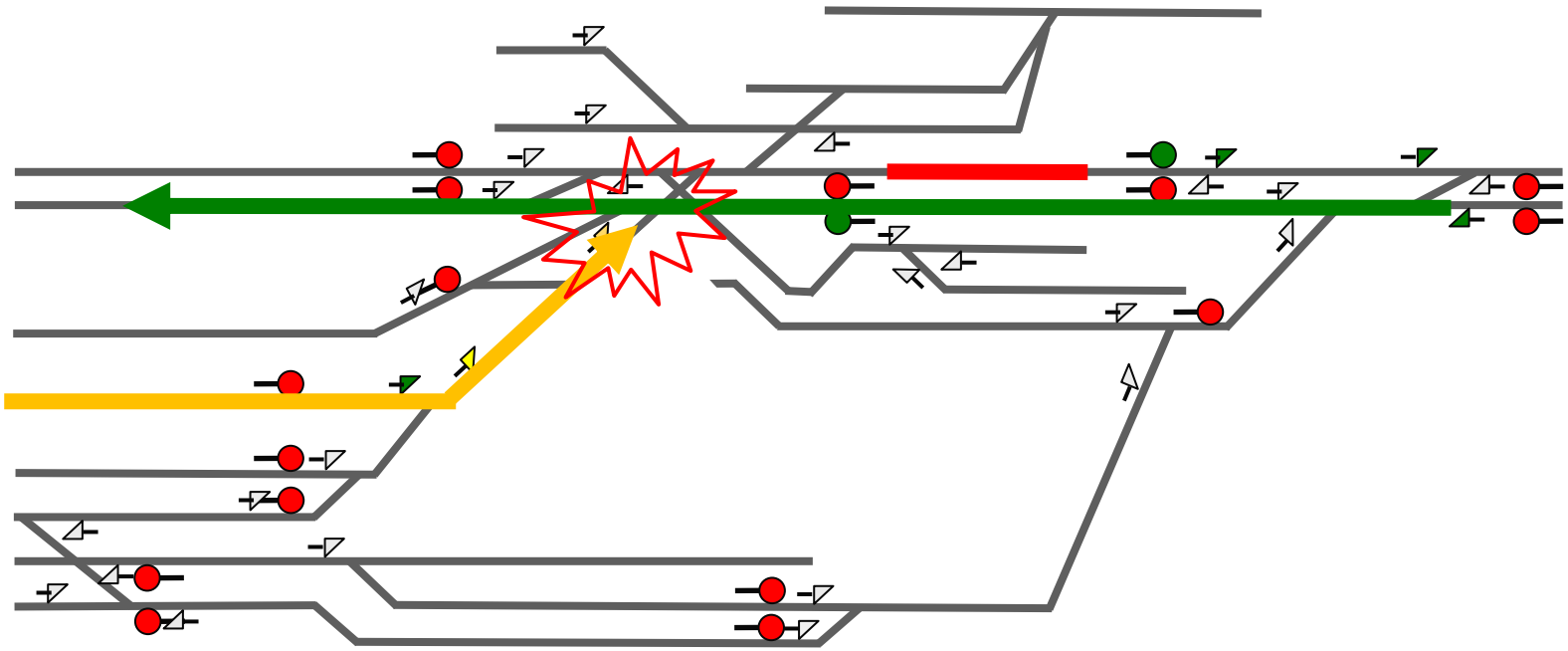


Increasing complexity

Danger of confusion

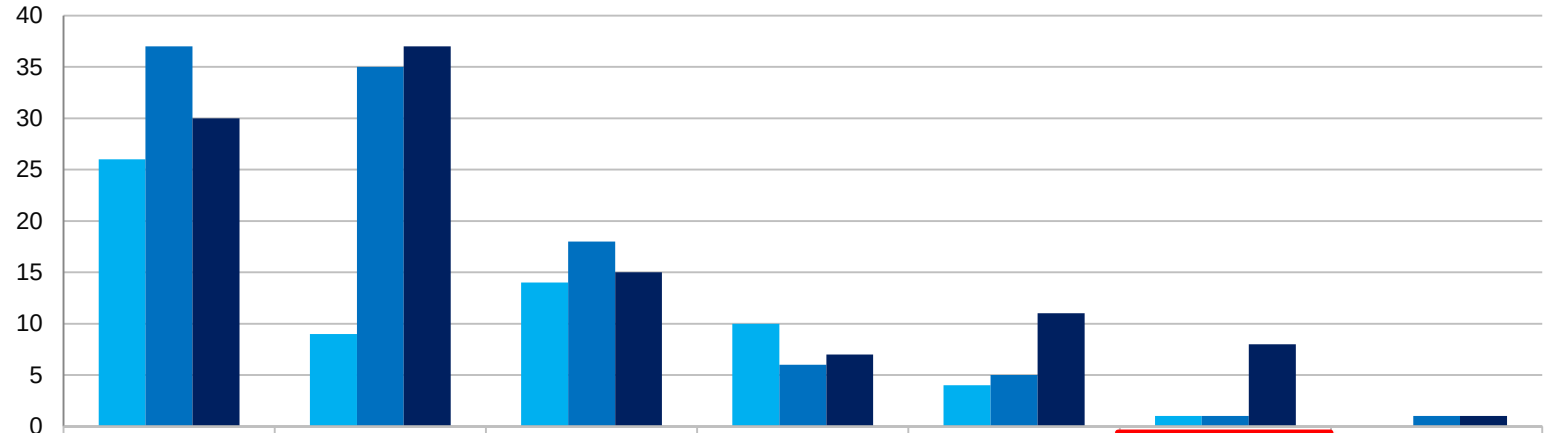
- Increasing number of SPAD cases

	Number of SPAD in Switzerland
2010	118
2011	124
2012	136
2013	139

Increasing complexity

Danger of confusion

- Increasing number of SPAD cases

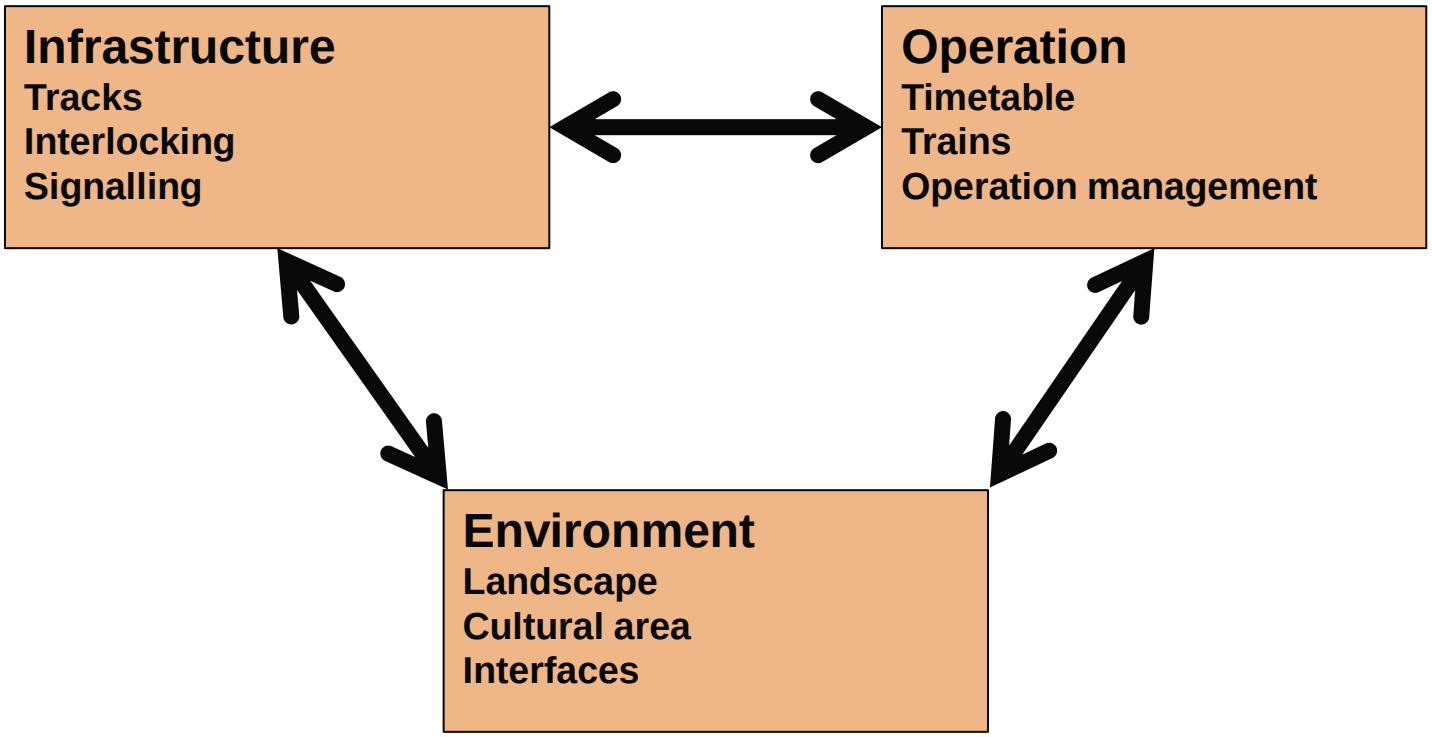


	Departure at danger Q4	Error, mistake Q5	Distraction Q3	Confusion of signals Q2	Confusion train and shunting itinerary Q6	Misinter-pretation of order Q1	Communi-cation Q7
2010	26	9	14	10	4	1	0
2011	37	35	18	6	5	1	1
2012	30	37	15	7	11	8	1

(FOT, 2013)

Increasing complexity

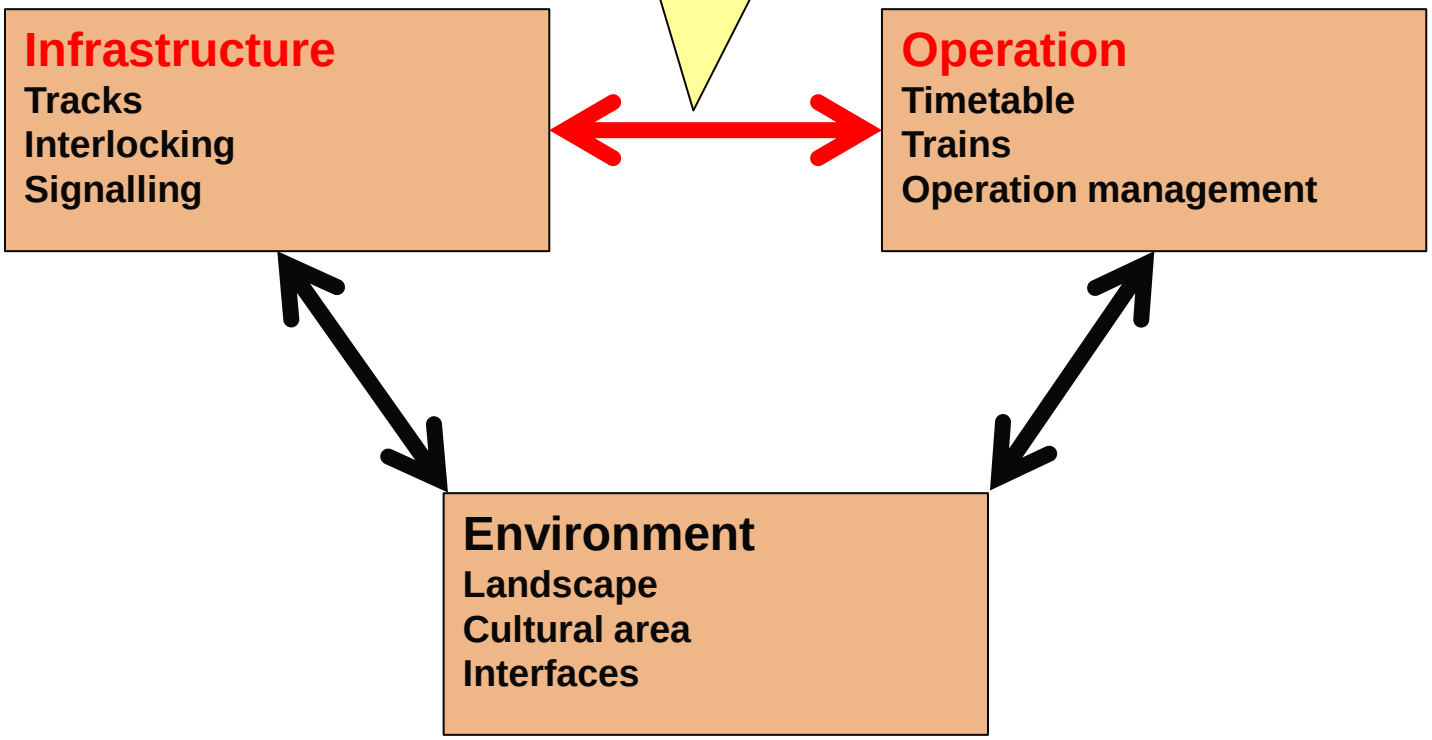
Important system elements



Increasing complexity

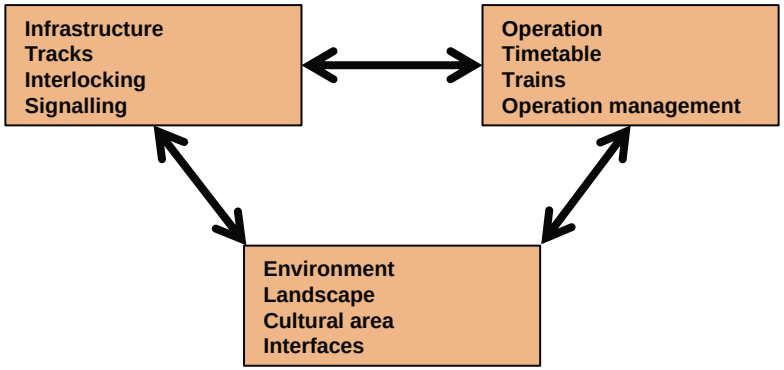
Complexity caused by unpredictable factors: human-machine interface

Important system elements



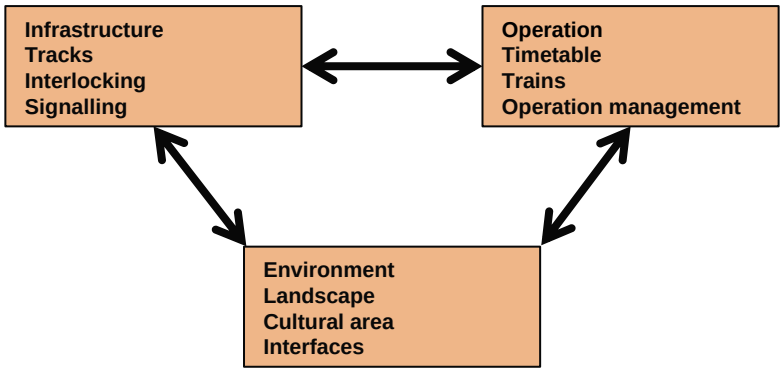
Increasing complexity

- The automation of train operation makes higher demands: oral communication in cases of emergency is of crucial importance.
- Investigating human factors in the railway sector (still) seems unusual.

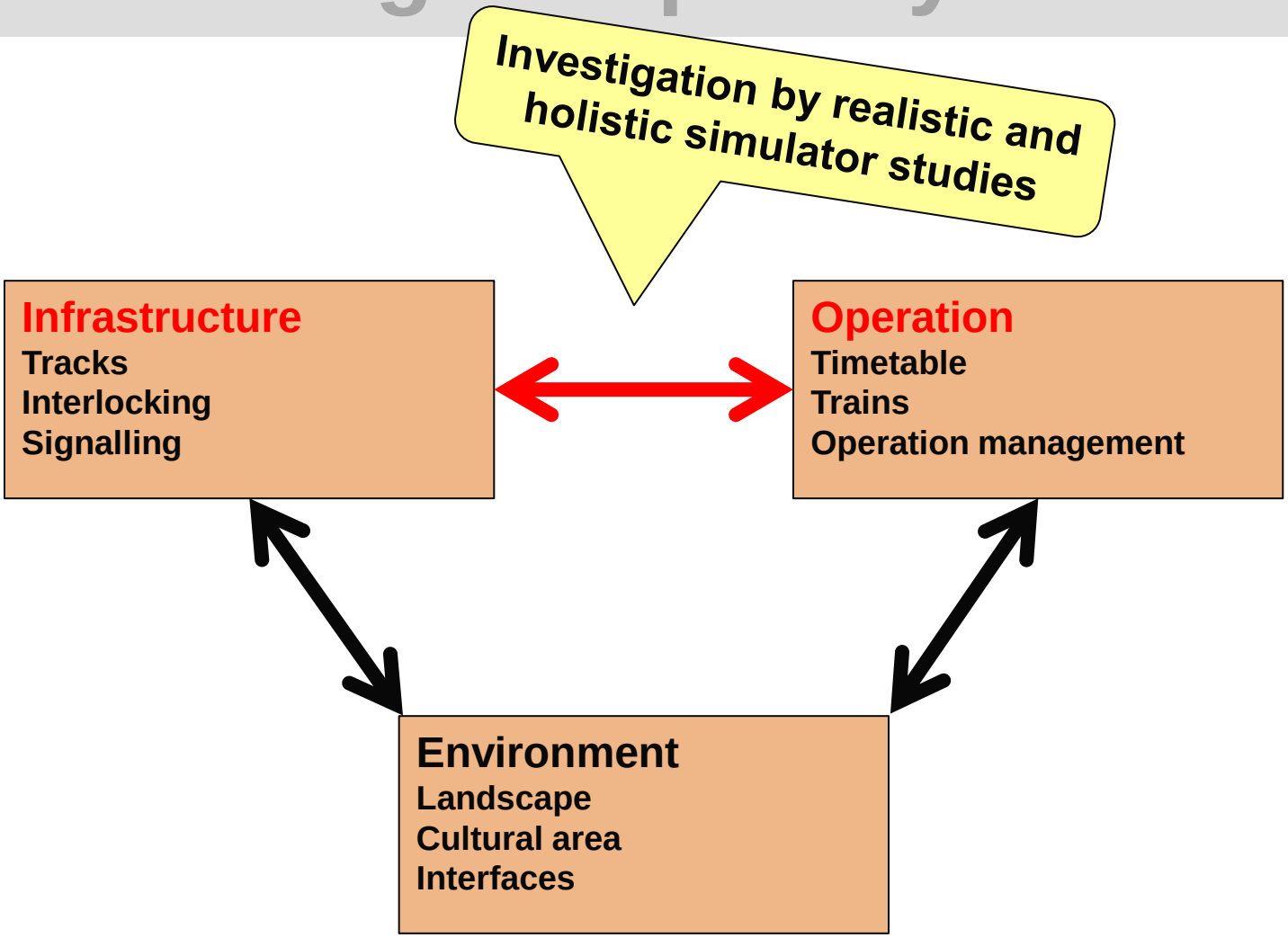


Increasing complexity

- The repercussions on the system of particularly spurious actions are not entirely predictable.
- Human factors are not quantifiable.
- Complexity often arises at human-machine interfaces.
- Simulators are necessary for investigating complex problems.



Increasing complexity



Research laboratory

Dynamic model of a railway system

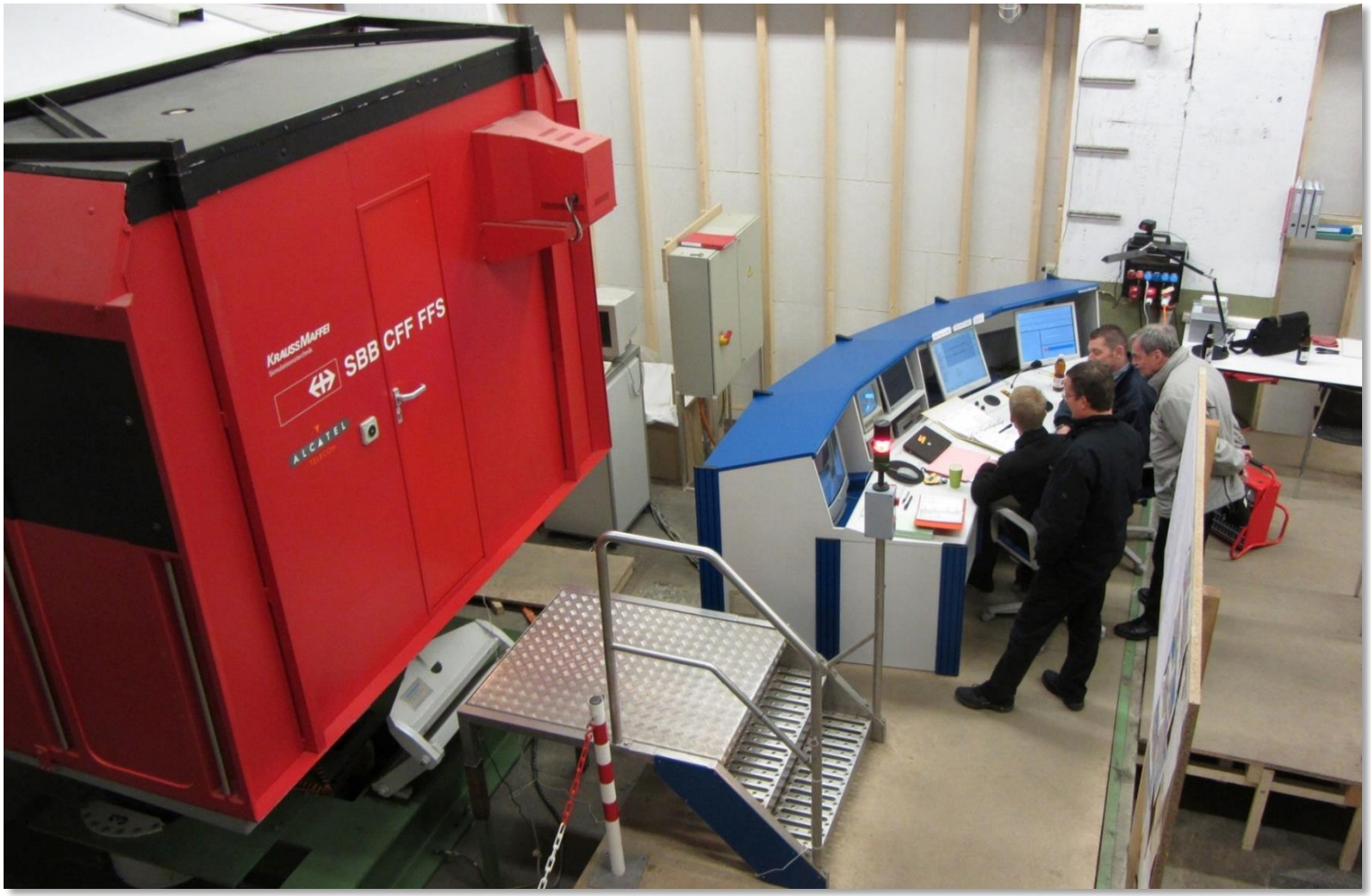
- Driving and interlocking simulators to investigate complex problems related to human-machine interfaces (HMI).

The driving simulator (Re 460)

Experiments with train drivers

- The drivers are familiar with locomotive (Re 460) and the route (Olten – Zürich).
- Each driver is given exactly the same tasks:
  - Passenger train from Olten to Brugg
  - Passenger train from Baden to Zürich
- The drivers act according to a specified timetable; half of scenarios are under time pressure.

Simulator and situation awareness



Why situation awareness?

- Integral part of the education and training of pilots / air traffic controllers
- Many human factors research in aviation, medicine, nuclear power plants
- Railways = “the forgotten branch” (Wilson & Norris, 2006)

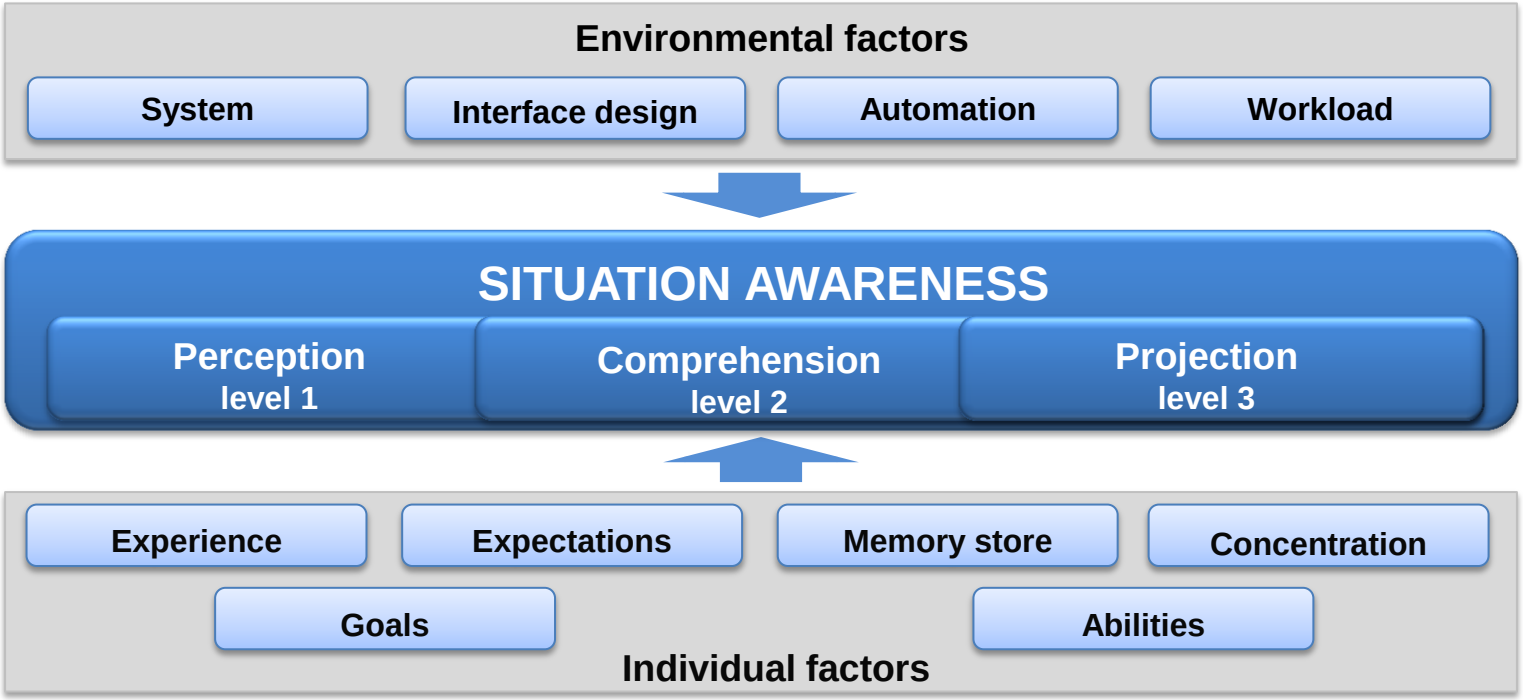


➢ Situation awareness is also relevant for train drivers

- **How can we measure situation awareness?**
- How is situation awareness influenced by time pressure?

Definition and model

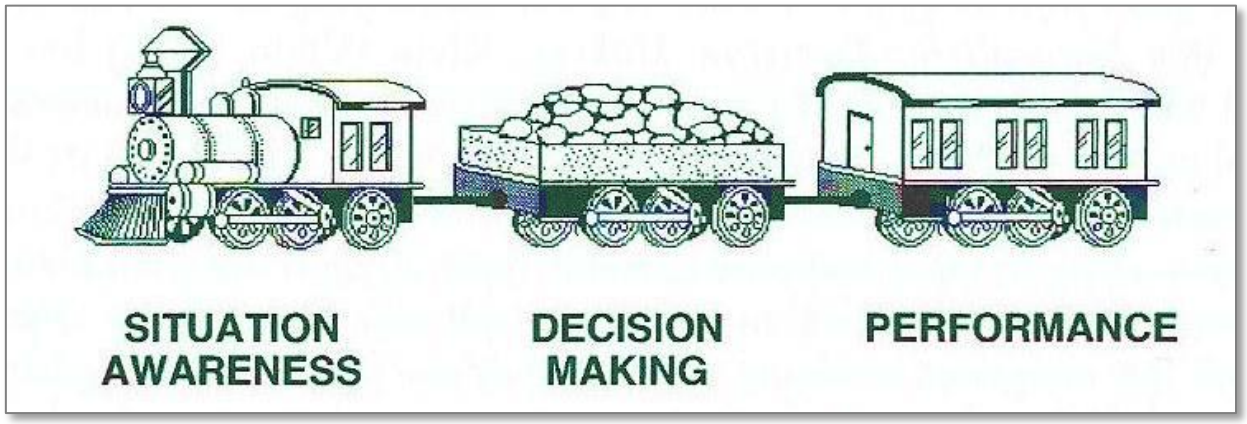
"The **perception** of the elements in the environment (…),
the **comprehension** of their meaning and
the **projection** of their status in the near future" (Endsley, 1995)



Example of situation awareness in railways

Perception level 1	Comprehension level 2	Projection level 3
The train driver sees a light signal	He knows what this light combination means	He knows what has to be done in the next few seconds/minutes

Measuring situation awareness



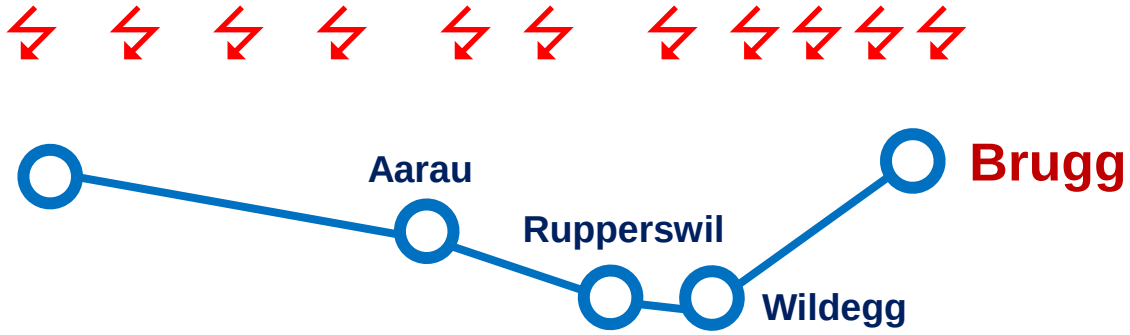
(Endsley, Bolté & Jones, 2003)

Two methods selected:

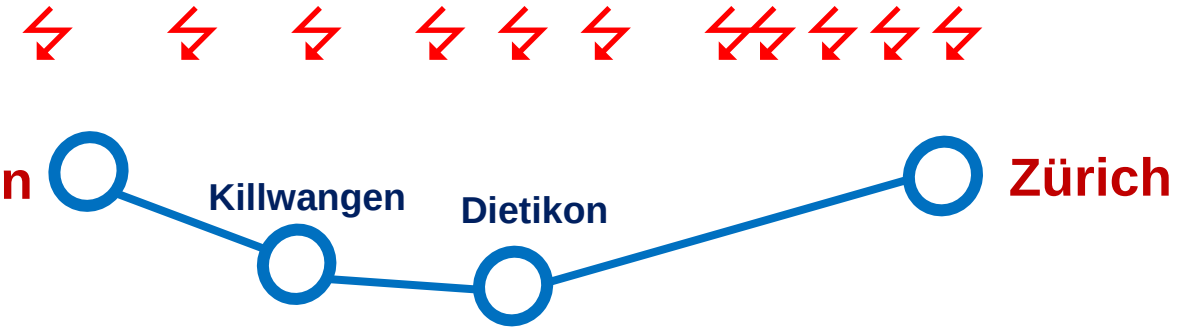
- Performance (objective observation)
- Situation Awareness Rating Technique SART (subjective self-rating)

Developing simulator scenarios

Scenario A



Scenario B



SA-relevant tasks (dilemmas)

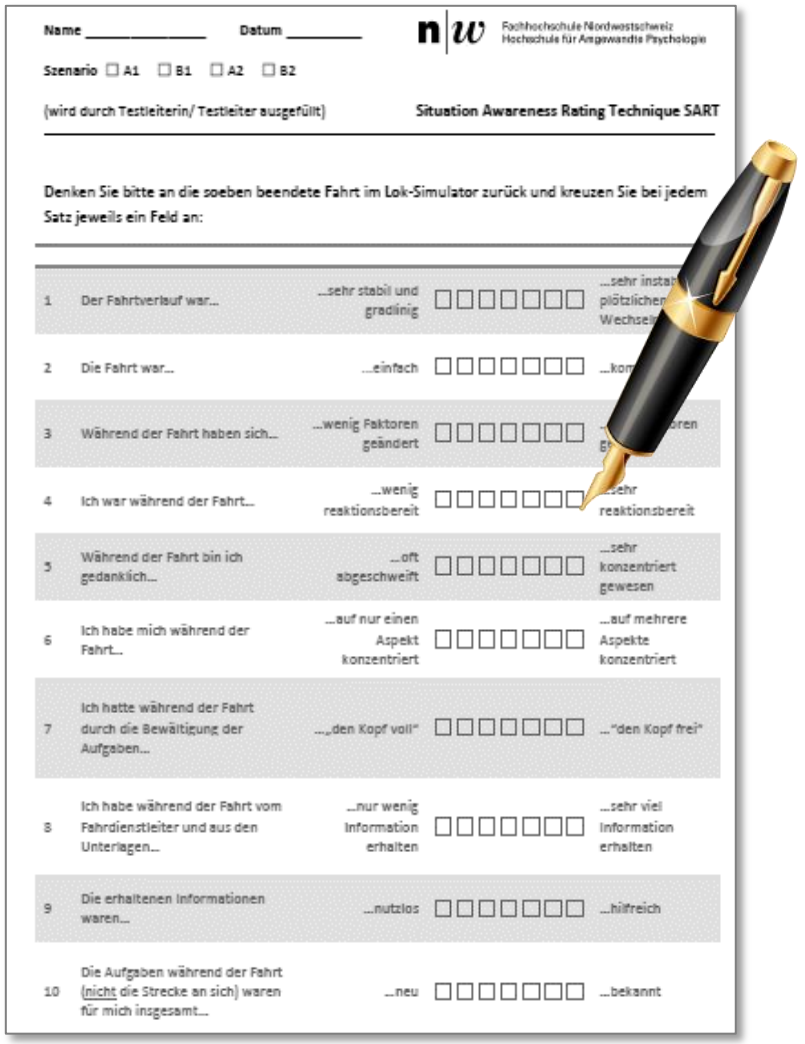
Performance measure

	Dilemmas in scenario B	Criteria	yes=2 / no=0
1	**Only upper lamp of shunting signal working**	**Has dispatcher been advised?**	
2	Traction loss	Start breaking before advance signal?	
3	Speed restriction section 80 km/h	V_{IST} 80 km/h begin signal?	
4	Protective section	Correct process protective section?	
5	Exit signal closed (neighbouring signal open)	Is process correct?	
6	Advance signal 60 km/h	Main signal 60 km/h?	
7	Extra-stop at Zürich-Altstetten	Has train stopped at Zürich-Altstetten?	
8	**Incoming emergency call/unclear voice**	**Line-of-sight driving (V_{max} 40 km/h)?**	
9		**Has dispatcher been advised?**	
10	Only lower lamp of shunting signal working	Has train been stopped?	
11		Has dispatcher been advised?	

→ Performance score

Simulator and situation awareness

Self-rating measure SART



Name _____ Datum _____

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Szenario ☐ A1 ☐ B1 ☐ A2 ☐ B2

(wird durch Testleiterin/ Testleiter ausgefüllt)

Situation Awareness Rating Technique SART

Denken Sie bitte an die soeben beendete Fahrt im Lok-Simulator zurück und kreuzen Sie bei jedem Satz jeweils ein Feld an:

1	Der Fahrtverlauf war...	...sehr stabil und gradlinig	☐☐☐☐☐☐☐	...sehr instab... plötzlichen Wechseln
2	Die Fahrt war...	...einfach	☐☐☐☐☐☐☐	...kom...
3	Während der Fahrt haben sich...	...wenig Faktoren geändert	☐☐☐☐☐☐☐	...oren ge...
4	Ich war während der Fahrt...	...wenig reaktionsbereit	☐☐☐☐☐☐☐	...sehr reaktionsbereit
5	Während der Fahrt bin ich gedanklich...	...oft abgeschweift	☐☐☐☐☐☐☐	...sehr konzentriert gewesen
6	Ich habe mich während der Fahrt...	...auf nur einen Aspekt konzentriert	☐☐☐☐☐☐☐	...auf mehrere Aspekte konzentriert
7	Ich hatte während der Fahrt durch die Bewältigung der Aufgaben...	..."den Kopf voll"	☐☐☐☐☐☐☐	..."den Kopf frei"
8	Ich habe während der Fahrt vom Fahrdienstleiter und aus den Unterlagen...	...nur wenig Information erhalten	☐☐☐☐☐☐☐	...sehr viel Information erhalten
9	Die erhaltenen Informationen waren...	...nutzlos	☐☐☐☐☐☐☐	...hilfreich
10	Die Aufgaben während der Fahrt (nicht die Strecke an sich) waren für mich insgesamt...	...neu	☐☐☐☐☐☐☐	...bekannt

→ Self-rating score

Execution of tests

- 20 train drivers

- Each train driver drove the two scenarios:
  - one with time pressure and
  - one without time pressure
  - ➢ 2 performance scores

- Self-rating SART after each scenario
  - ➢ 2 self-rating scores

Results

- effect of time pressure to performance: not significant
- effect of time pressure to self-rating: not significant

- BUT final sequence of scenario (dilemmas 8-11): significant lower performance in scenarios with time pressure

➢ time pressure has a negative effect on performance during increased workload

➢ the effect of stressors to a train driver's Situation Awareness should be further investigated

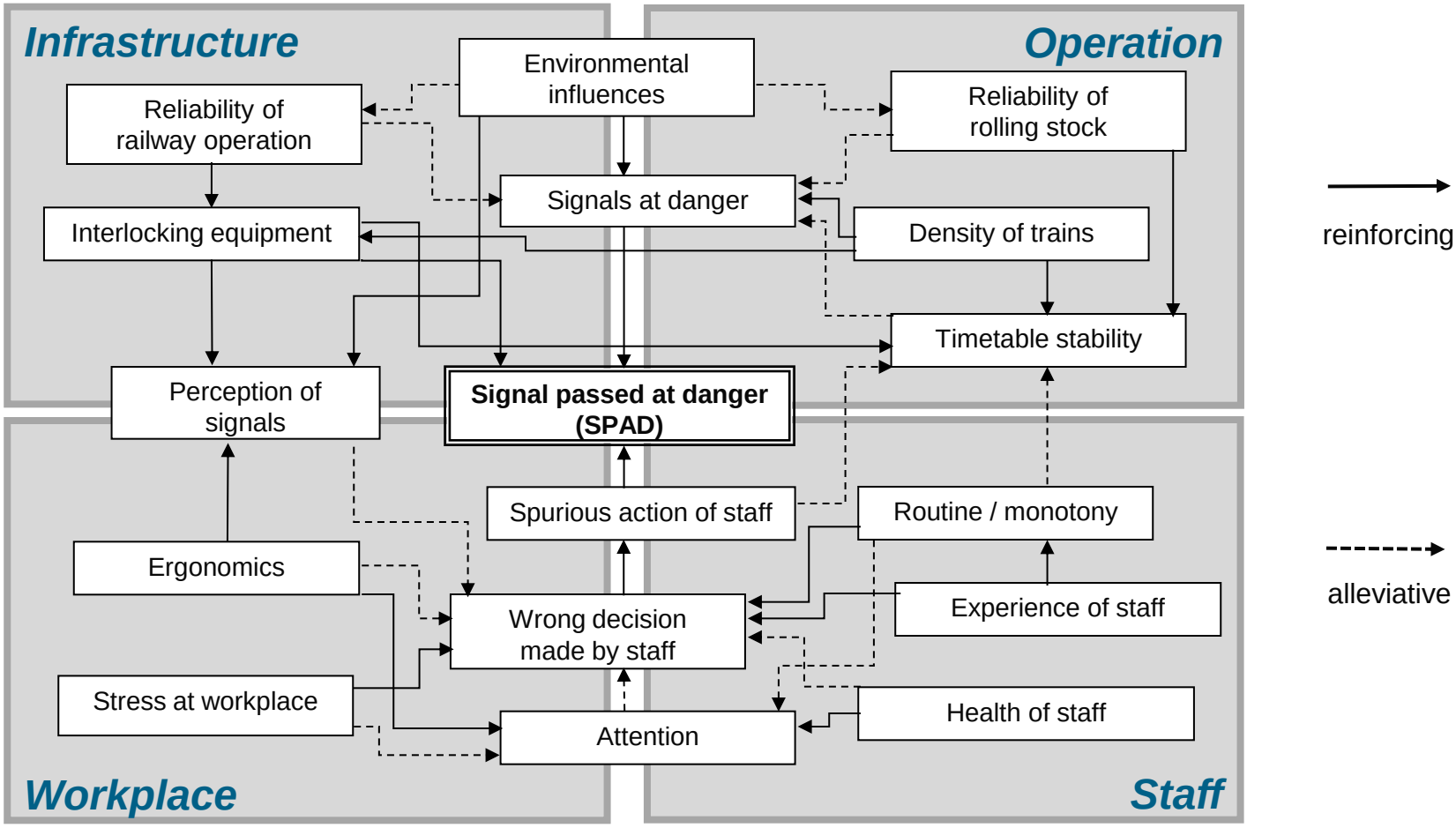
Conclusions

Design requirements for simulators

- A detailed replica of the workplace and the human-machine interfaces is important: drivers and operators must be absorbed in their work.
- A modular structure of the systems allows the use of different types of driving and interlocking simulators.

Conclusions

SPAD as complex system



Conclusions

Interlocking and driving simulator

- The investigation of complex problems in the fields of railway operation needs an integrated simulator system: Simultaneous participation of train drivers and train operators at the same time.

Questions

Thank you for your attention.

Contact

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Reference

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