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

Use of simulators to investigate complex issues relating to human factors

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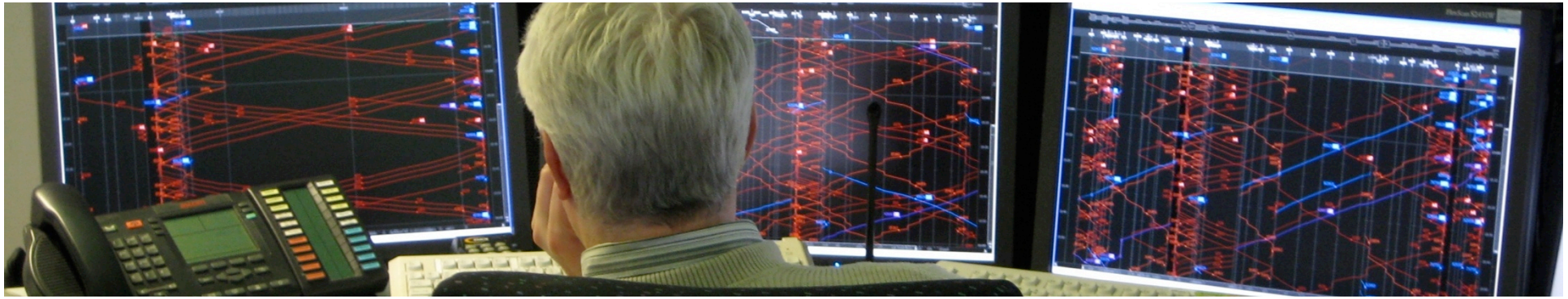
Topic

1. Complexity in railway systems
2. Measuring situation awareness
3. Use of simulators
4. Conclusions

Complexity in railway systems

Automation



Train operator → Centralization

Train driver → Assistance systems

Important changes in working conditions

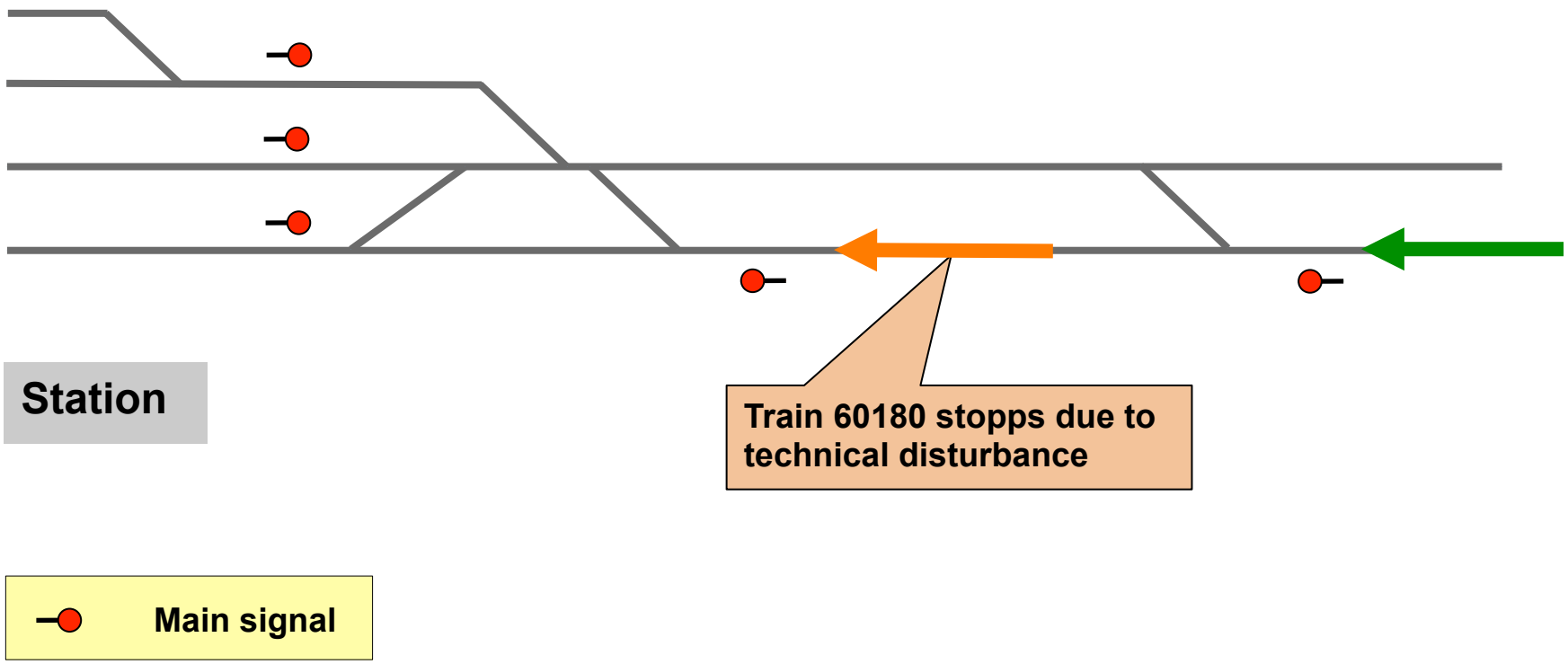
Complexity in railway systems

Changes in working conditions

- Staff: change from operator to controller
- Lack of system knowledge
- No more direct communication
- Requirements for management of incidents in a complex socio-technical environment

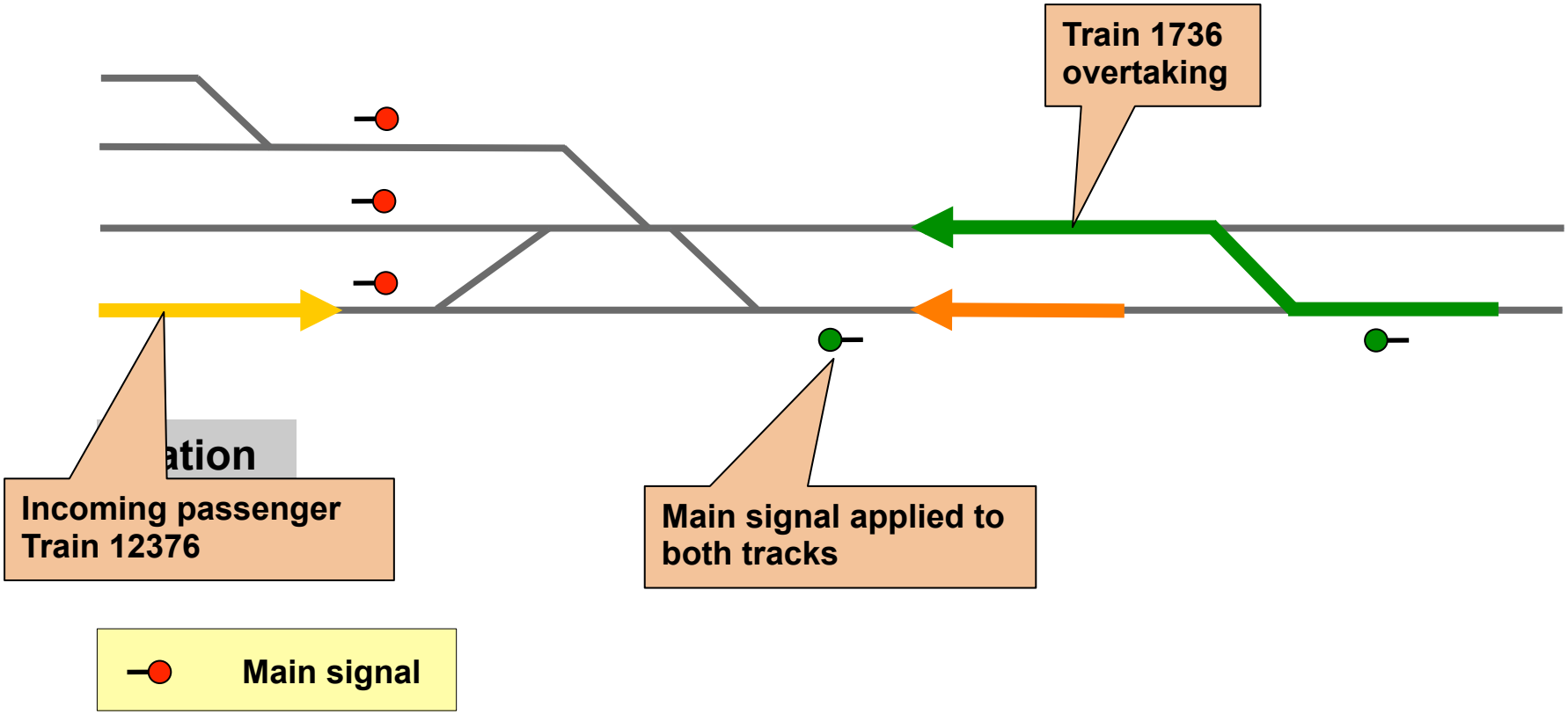
Complexity in railway systems

Example



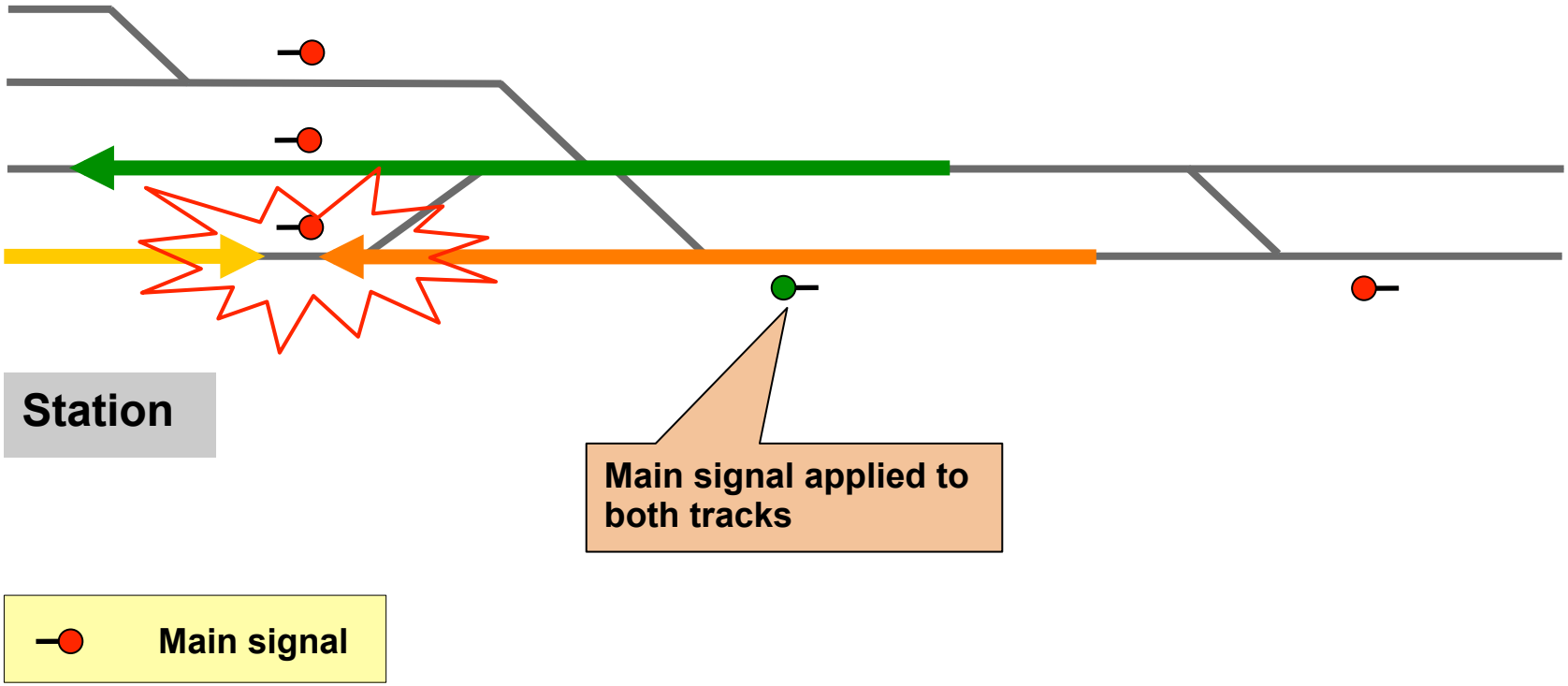
Complexity in railway systems

Example



Complexity in railway systems

Example



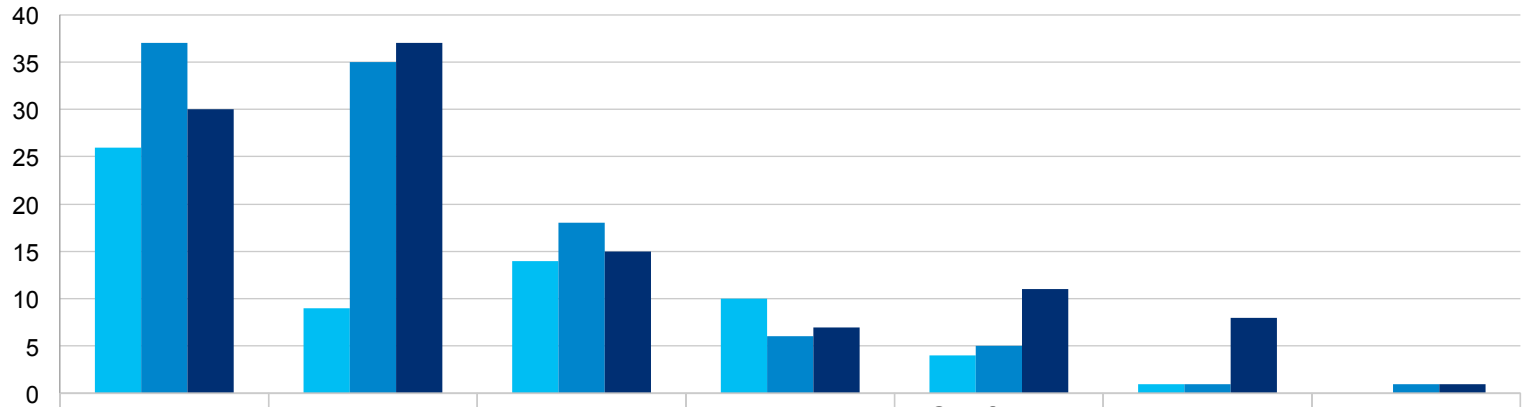
Complexity in railway systems

Problem of SPAD (Signal Passed At Danger)

	Numbers of SPAD in Switzerland	
2010	118	100%
2011	124	+5%
2012	136	+15%
2013	139	+18%

Complexity in railway systems

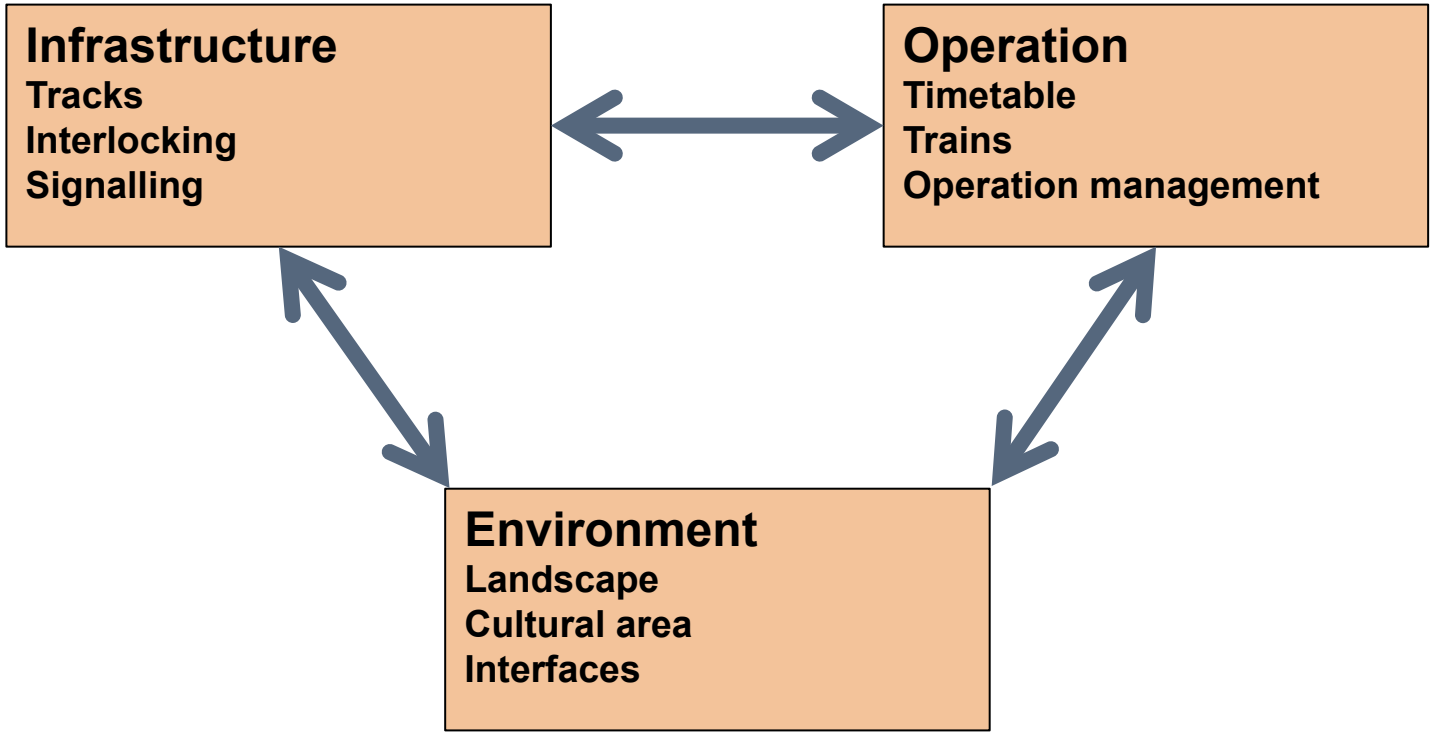
Problem of SPAD (Signal Passed At Danger)



	Departure at danger	Error, mistake	Distraction	Confusion of signals	Confusion train and shunting itinerary	Misinter-pretation of order	Communi-cation
	Q4	Q5	Q3	Q2	Q6	Q1	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

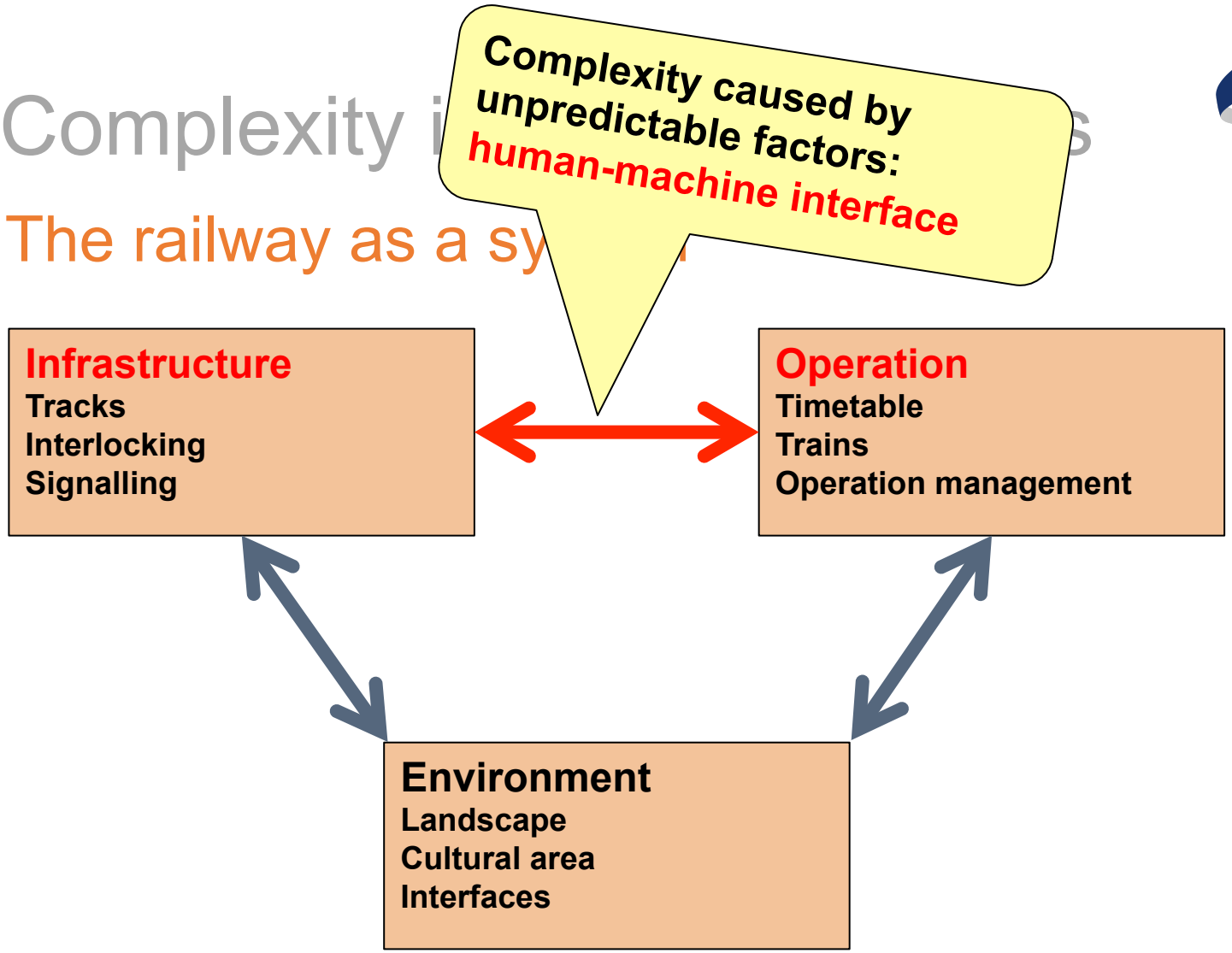
Complexity in railway systems

The railway as a system



Complexity i s

The railway as a sy



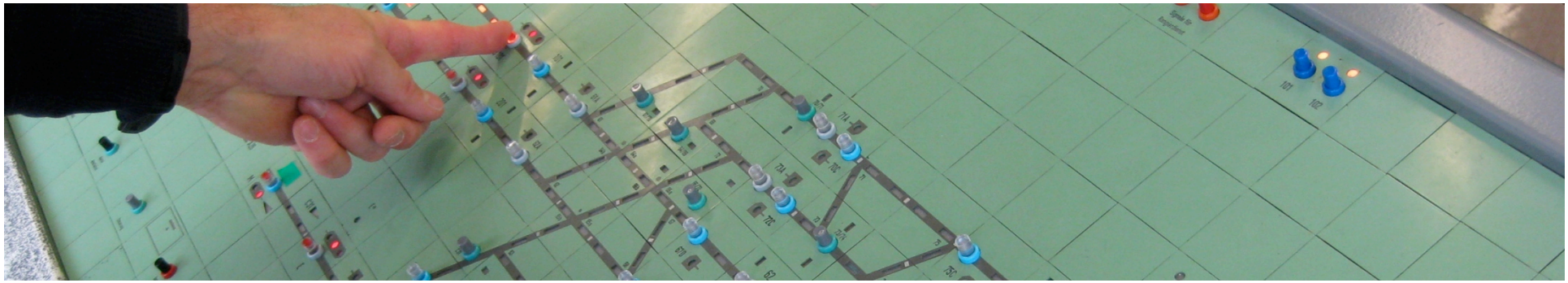
Complexity in railway systems

The railway as a system

- 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.

Measuring situation awareness

Why situation awareness?



- Integral part of the education and training of pilots / air traffic controllers
- Many human factors research studies in aviation, medicine, nuclear power plants

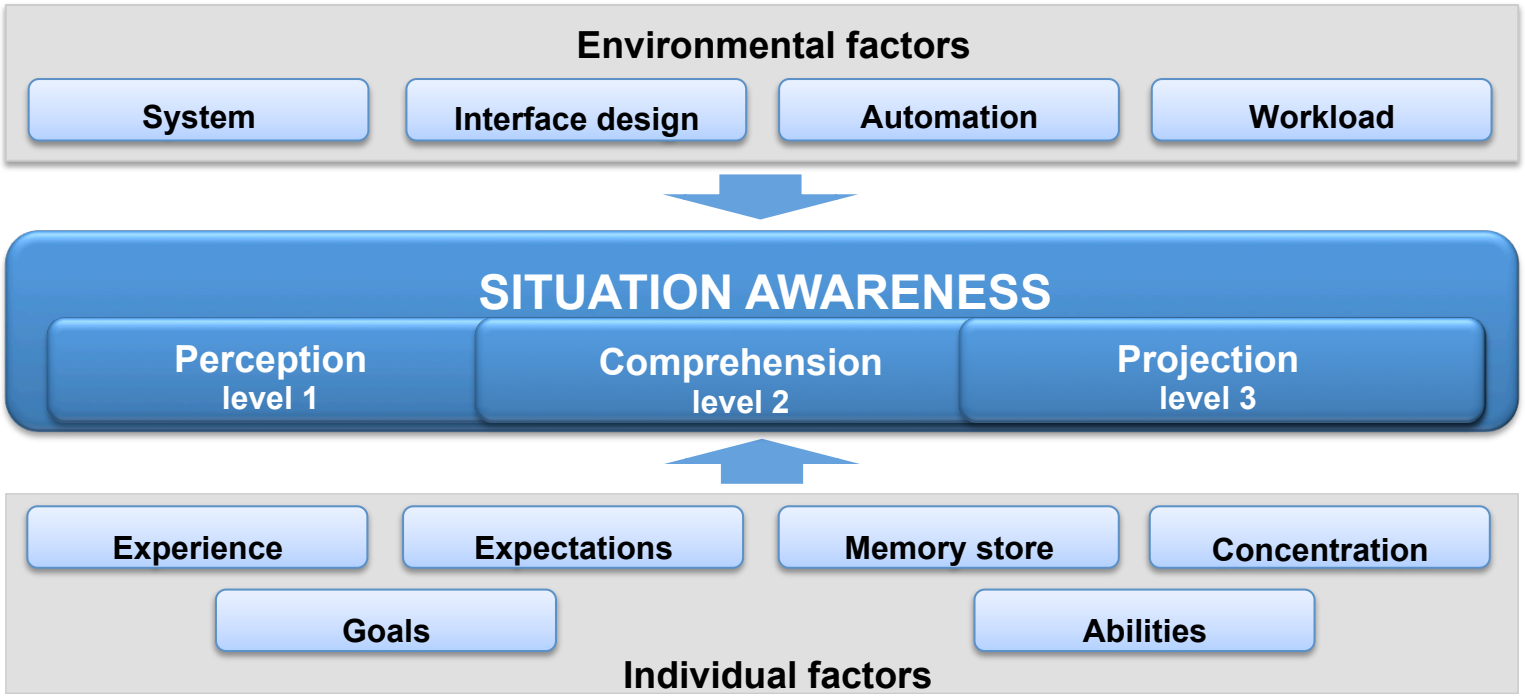
→ Situation awareness is also relevant for train drivers

→ **How can we measure situation awareness?**

Measuring situation awareness

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)



Measuring situation awareness

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

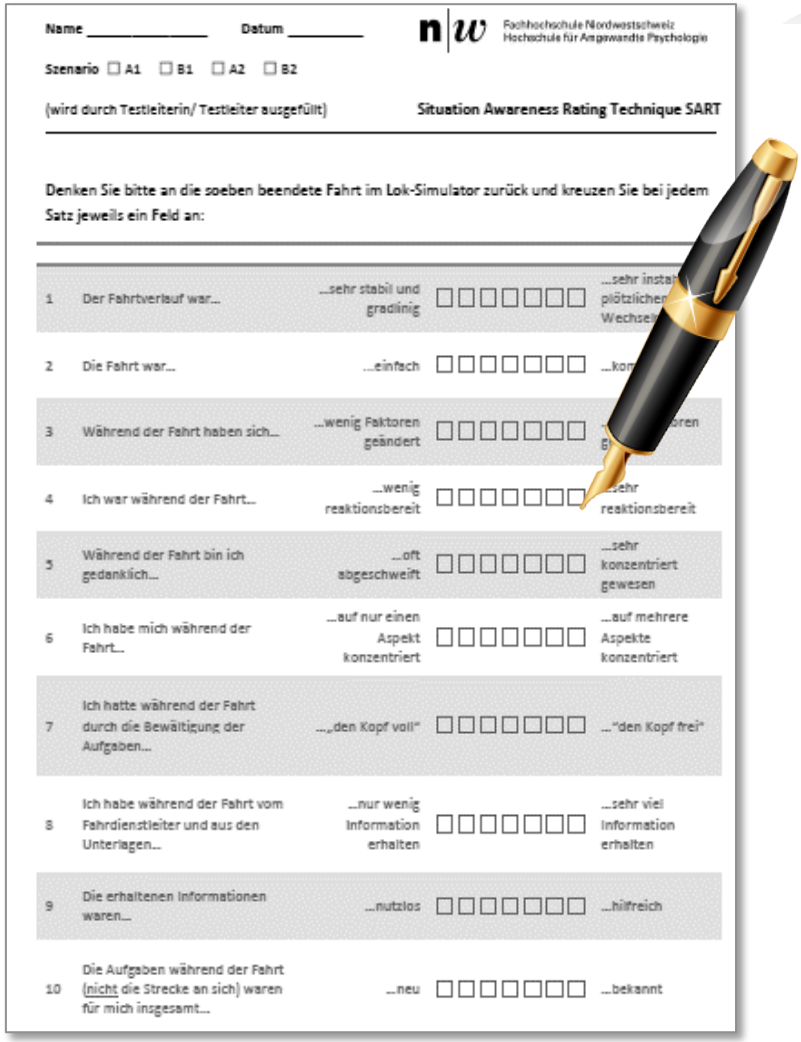
Performance measure

	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

Measuring situation awareness

Self rating assessment



Name _____ Datum _____

Fachhochschule Nordwestschweiz
Hochschule für Angewandte Psychologie

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 Wechsel
2	Die Fahrt war...	...einfach	☐☐☐☐☐☐☐	...kom
3	Während der Fahrt haben sich...	...wenig Faktoren geändert	☐☐☐☐☐☐☐	...oren g
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

Use of simulators

Requirements for simulators

- Case studies with train drivers
- Interaction between train dispatchers and train drivers

Use of simulators

The driving simulator (Re 460)

Use of simulators

Execution of tests

- 20 train drivers
- Each train driver drove the two scenarios:
  - one with time pressure
  - one without time pressure

  → 2 performance scores
- Self-rating SART after each scenario

  → 2 self-rating scores

Use of simulators

Situation awareness

- Effect of time pressure on performance: not significant
- Effect of time pressure on self-rating: not significant

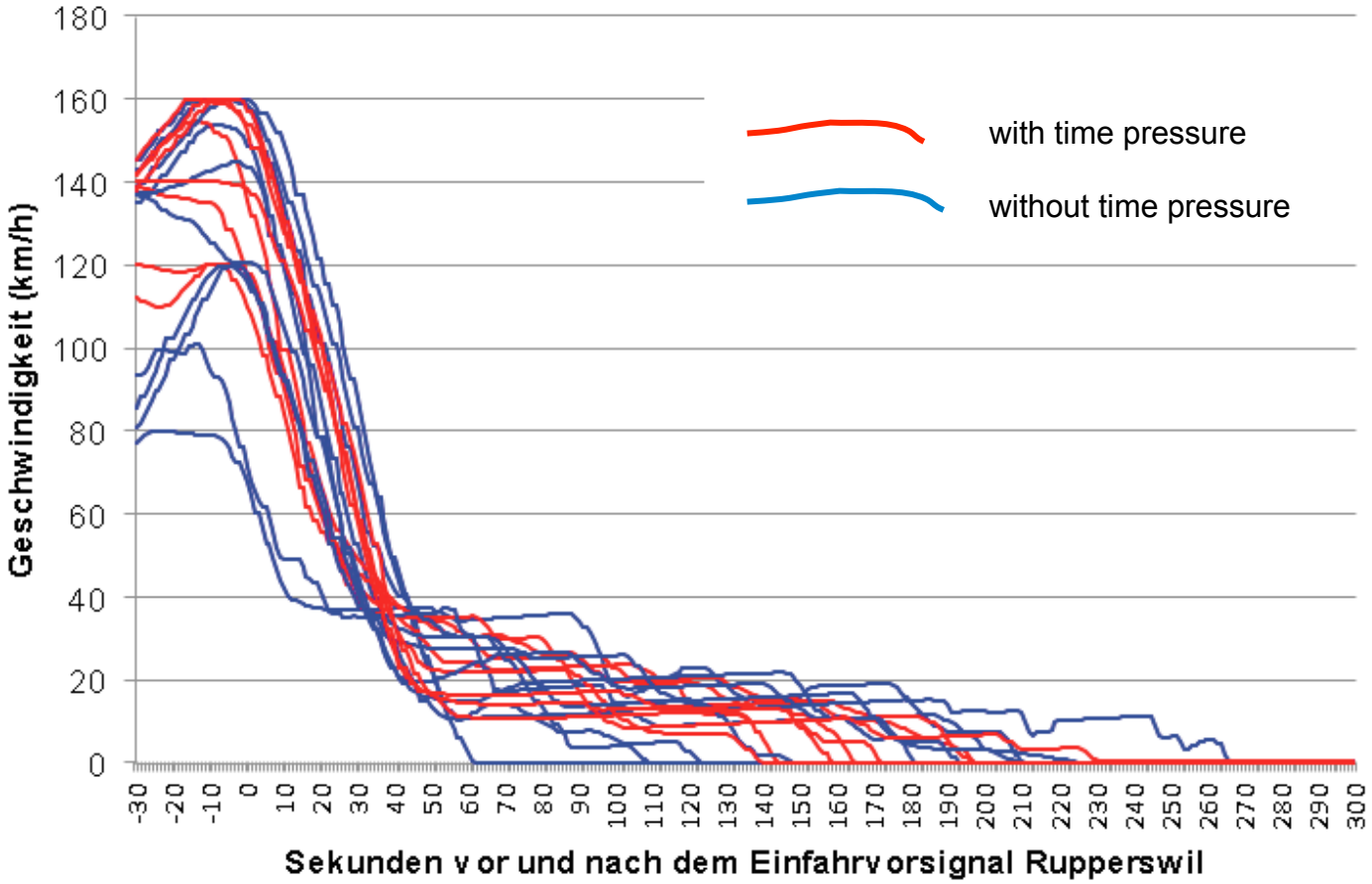
- BUT final sequence of scenario (dilemmas 8-11): significantly lower performance in scenarios with time pressure

→ Time pressure has a negative effect on performance in situations with an <u>increased</u> workload

→ The effect of stressors on a train driver's situation awareness should be further investigated

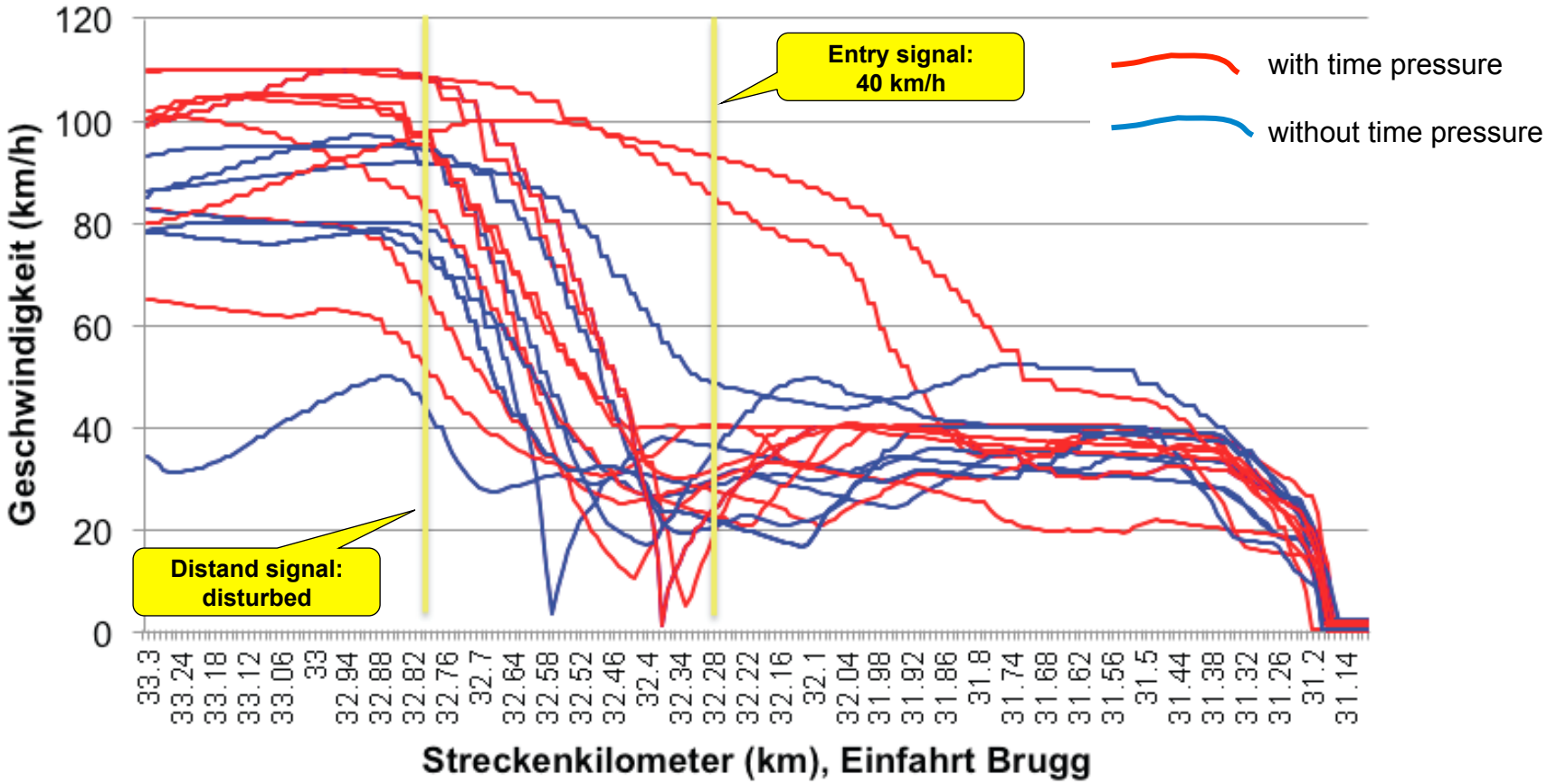
Use of simulators

Data sample of driving simulator



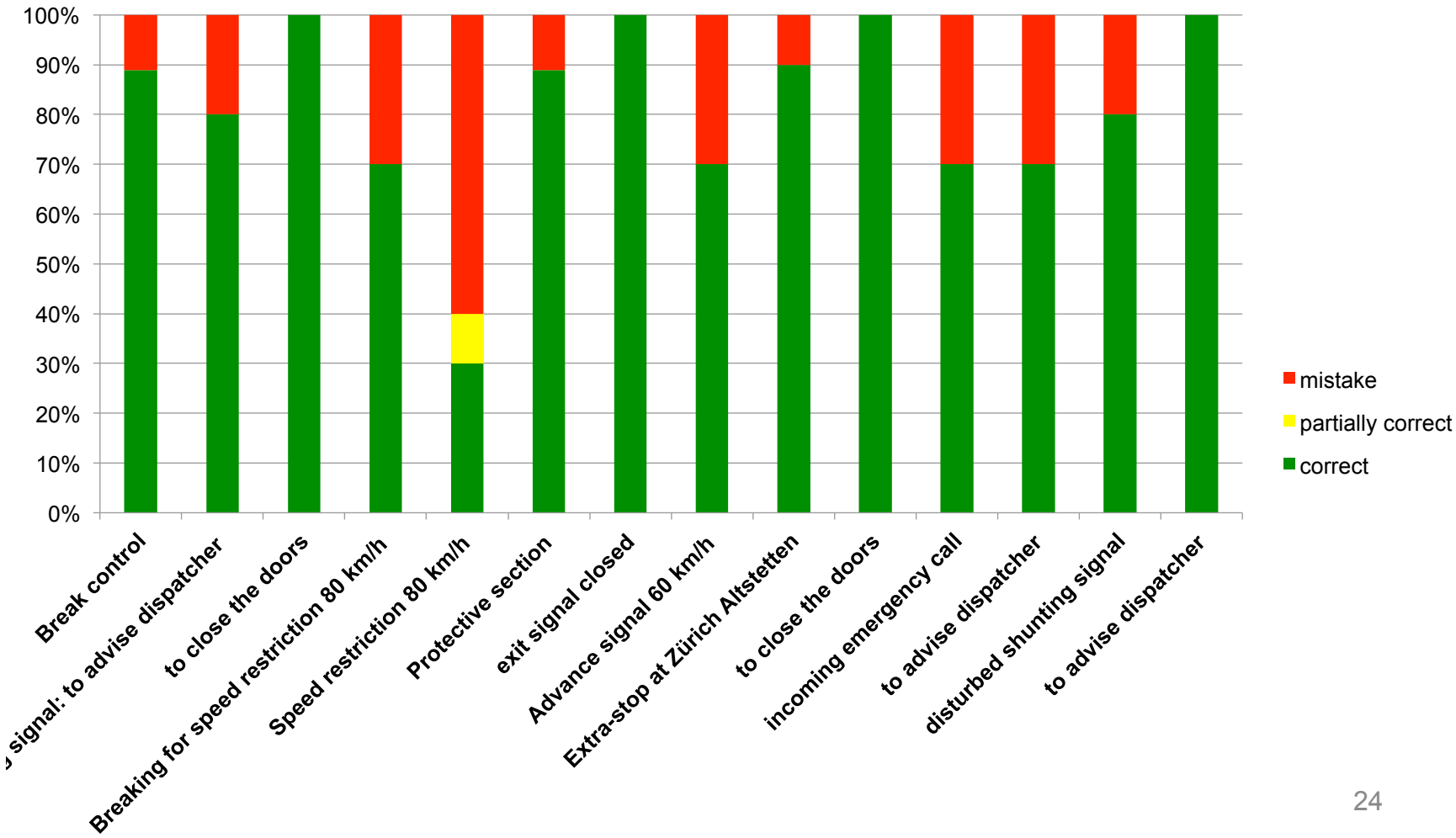
Use of simulators

Data sample of driving simulator



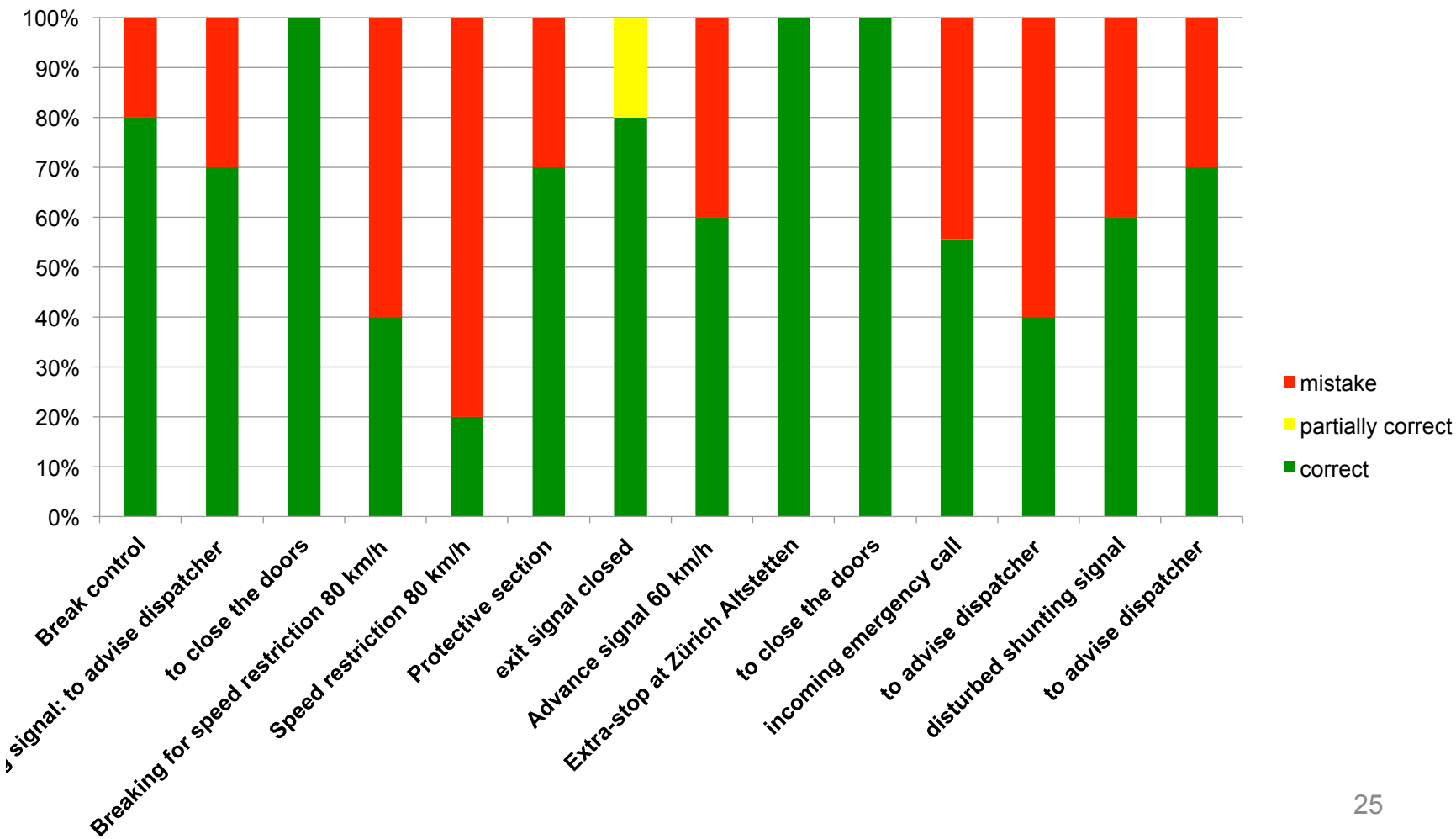
Use of simulators

Mistakes **without** time pressure



Use of simulators

Mistakes **with** time pressure



Conclusions

Need for detailed simulators

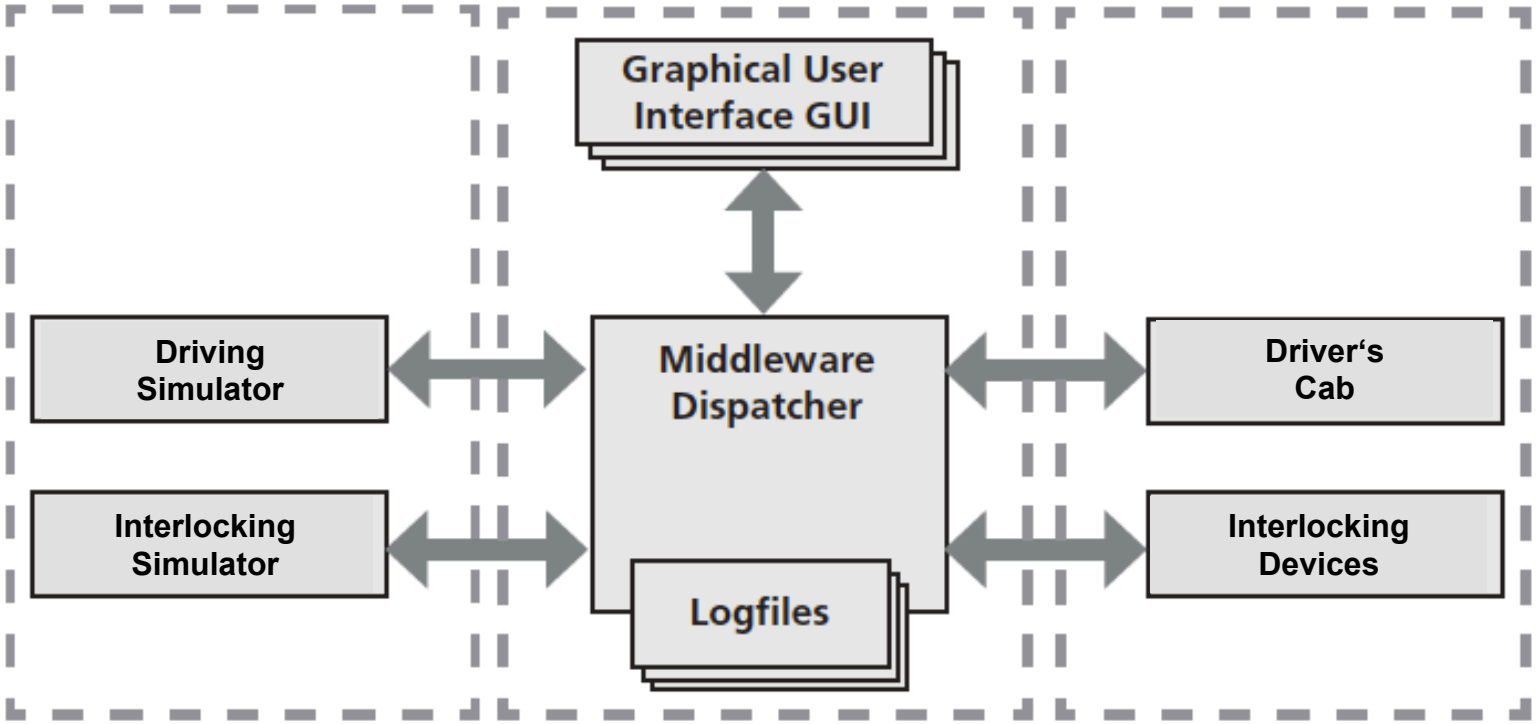
Conclusions

Interlocking and driving simulator

The investigation of complex problems in the fields of railway operation requires an integrated simulator system: simultaneous participation of train drivers and train operators.

Conclusions

Interlocking and driving simulator



Thank you for your attention
Any Questions?

→ www.desm.ch