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

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Technological developments and increases in rail traffic are resulting in ever more complex rail systems. This involves, among other things, automating and improving certain processes. The automation of the HMI in the drivers' and the train dispatchers' environments has taken different forms, depending on the relevant requirements.

It is often difficult to investigate in any depth the problems arising at the interface between people and machines, known as human-machine interface (HMI), because many of the influencing factors cannot be measured discretely and the context is not always clear. At the same time, the demands placed on the staff who manage rail operations are growing as a result of the increase in automation, which places greater responsibility on a smaller number of people. Train dispatchers and train drivers are directly affected by these changes. For this reason, findings in areas such as the stress and workload limits of staff (human factors), the user friendliness of controls (usability engineering) and the causes of inappropriate behaviour and operator error are becoming increasingly important in risk assessment. Understanding the complexity of these requirements can improve safety levels across an entire rail system.

In order to investigate these issues, a set of specific problems for rail operators are devised that cannot be evaluated using linear methods because of their complexity. These are typically situations where the development is directly dependent on the perception and the decision-making behaviour of the driver and the train dispatcher, and which cannot be determined in advance with complete certainty. The problems give rise to objects for investigation which are subjected to as many repetitions as possible by the test subjects on the integrated realistic simulation models. The only full simulator available in Switzerland – of a type Re 460 locomotive – is used for the tests. The findings from these tests are evaluated together with additional data that have been acquired using qualitative methods (systematic questioning of the test subjects).

One such problem is the signal passed at danger (SPAD), which occurs when a driver passes a stop signal without the authority to do so. These cases involve complex human-machine interactions with influencing factors that are difficult or impossible to quantify. It is, however, possible to survey a representative sample by running simulations with test subjects (train drivers and train dispatchers). This gives rise to the question of how the level of detail and the realism of the models influence the behaviour of the test subjects and, therefore, the results of the investigation.

The aim of this research study is to gain a better understanding of the railway as a complex socio-technical system by proposing an approach to modelling as the basis for integrated simulations. Using driving and signalling simulators, it has been possible to obtain findings concerning both the necessary level of detail of the models and the requirements for integrated simulation models used to investigate HMI.. Specific problems and objects for investigation are used to explain how the demands on train drivers and train dispatchers change as systems become increasingly automated.