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Measures to raise the reliability of human performance in railway fallback operations

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Abstract

The safety of the railway system is guaranteed by the extremely high reliability of the technical systems. In fallback mode the human operator performs safety critical tasks to allow for a certain level of performance. Experience shows that errors by performing these tasks can cause significant damage. The paper describes how technical and non-technical measures were derived which alone or in combination make the railway system as a whole safer. To allow for a systematic evaluation, aspects like the applicable rules, performance shaping factors as well as the contribution to risk by specific failures are discussed and considered.

Keywords: fallback mode, human operator, safety, operational rules

1 Introduction

Railway operations today is highly dependent on control and safety technology. Continuous technical development and striving for higher safety have made the railway in Germany one of the safest and most reliable means of transport.

However, even modern technology can fail which makes it necessary for the operator to perform safety relevant tasks. In a project for the German Centre for Rail Traffic Research (Deutsches Zentrum für Schienenverkehrsforschung, DZSF) the reliability of railway operator's performance in fallback mode was analysed and

technical and non-technical measures for raising the reliability of operations in fallback mode suggested.

To assess this problem, the authors relied on knowledge which was gained by projects e.g. concerning the German Railway rulebook or the train driver performance with a focus on performance shaping factors and risk assessment, but also by application of the practical knowledge which is available at Technische Universität Berlin due to having and using an extensive model railway laboratory with several real life interlockings. Therefore, extensive knowledge about the operation of interlockings and problems when performing operation in fallback mode is available. Especially when needing the practitioner`s view during the project, people working at the laboratory were consulted. Furthermore, Mr. Lichtenberg has worked several years as an interlocking operator and therefore has an even more inside view of how operators work and think. The ideas regarding control structures are based on the works of Nancy Leveson and John Thomas (e.g. [1,2]) and her concepts relating to systems thinking.

2 Methods

The database of the Federal Bureau of Railway Accident Investigation (BEU) was evaluated to get an overview of all accidents attributed to human failure in fallback mode (relay and newer interlockings). The analysis suggested three groups of actions which led to events:

1. actions overriding the safety layer: Human actions directly override partially or completely the technical safety layer; in some cases, the interlocking is put manually in the home positioning;
2. actions bypassing the safety layer: Actions which allow a train to bypass a stop signal (allowing a train to run with a signalled special order);
3. actions to secure the track without direct intervention in the safety layer: This category includes actions which are necessary in fallback operation for the securing of route elements.

Events of group three were not further considered as core aspect of the project as they can be seen as prerequisite to events of group one and two.

The events of the database were analysed to identify performance shaping factors (PSF), that is aspects which have an influence on the likelihood of human failure while performing actions. However, specific aspects were missing in the database. Therefore, we performed a literature research with regards towards PSF and combined this with a questionnaire in which we asked practitioners to subjectively rate PSFs for particular scenarios (derived from events of group one and two). This resulted in a rating of the importance of PSF which was later used to identify especially effective measures.

In parallel to the PSF analysis, operational rules relevant to actions of group one and two were analysed and possible weaknesses identified. This was done using a control structure which shows the operational processes for the event categories and the interdependencies between the individual actors.

To focus efforts on measures with the largest effect on risk reduction, a simplified risk assessment was performed. The methodology of DIN V 0831 103 [2] was modified and applied. The resulting risks allow a relative comparison between the different event types.

A literature research was done as well as workshops to derive a set of potentially effective measures to counteract human failure while performing in fallback mode. Measures were grouped as technical measures and operator-based measures and set in relation to all groups of action, considering the results of all pervious steps.

3 Results

Two technical measures are considered especially promising for reducing risk and increasing safety.

The delayed route cancellation (time release) already exists in Germany in interlockings of certain WSSB designs and is also used by foreign railways. After taking back a route, the relevant infrastructure elements remain under lock for a defined time. This prevents individual route elements from being switched directly and thus other routes from being set shortly after a route cancellation. Due to the time delay any approaching train would have come to a halt in time before a new and potentially conflicting route is set.

The axle counter preparatory reset ensures that an occupied track section is not indicated as free immediately after being brought in the home position, by this forcing the operator to send a train completely through the affected section on sight.

The operator-oriented measures focus on enabling the interlocking operator to perform operations in fallback mode as safe as possible. A large set of measures were identified and qualitatively rated in relation to their effect on PSF. Measures with the most positive influence were included in a more detailed analysis.

The detailed analysis was done for crosschecks, checklists, eye-tracking and assisted self-assessment, with a special focus on the different realisations of checklists.

Checklists help to execute actions in the right order. Within the project, the focus is on checklists that facilitate the transition from regular operation to operation in fallback mode. In the simplest form it is a paper checklist, irrespective of the interlocking type or layout. Checklists can also be presented on electronic media. This makes it easier to tailor the checklist to the local peculiarities of the interlockings and potentially to the current operational cases. In modern interlockings checklists can be

integrated into the user interface. This makes it e.g., possible to create a dependency between the checklist and the safety systems.

4 Conclusions and Contributions

The project has shown that the derived measures can have a significant effect on the reliability and safety of processes in fallback mode.

For the delayed route cancellation, it can be shown that its introduction results in a significant risk reduction by mostly excluding hazards of groups of action one and two. The axle counter preparatory reset can also produce a significant risk reduction. 'Driving on sight' ensures an additional human barrier and a lower potential accident speed. However, the safety gain overall is somewhat lower than with the delayed route cancellation. It is suggested that both technology changes should be taken into consideration for new developments.

The operator-oriented measures could not be rated for their risk reduction effects like the technical measures using the risk assessment method. For their evaluations, the effect of the measures was set in relation to the implementation of the axle counter preparatory reset, the delayed route cancellation as well as the original set up without additional measures. In expert interviews, it was discussed to which extent the operator-oriented measures could reduce the risk in these set-ups. Checklists which are integrated into the interlocking setup rated especially well but the usefulness of checklists was agreed on widely.

The project is a first step to better understand human failure in fallback mode. Measures to raise reliability and by such raising the safety of railway operations were derived. The effectiveness of the technical measures was conclusively demonstrated. Before implementing the operator-oriented measures it is desirable to conduct more research involving people with practical experience and to prove the effectiveness of the measures. In addition, further studies must be carried out to look at the concrete possibilities of implementation.

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