Chapter 15

Integration of Human Factors to Safety Assessments by Human Barrier Interaction

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ABSTRACT

Human factors have a strong impact on railways safety. However, the assessments of these factors still follow traditional and inadequate approaches. While failure probabilities of technical systems can be measured in sufficient precision, human error probabilities are still estimated in a very rough and vague way. Upon this motivation, the contribution presents a method analyzing human influence in railway applications. The approach of human-barrier-interaction relies on a new model of human behavior, a classic model of human-machine-interaction and a model of safety measures by barriers. Applying the method, human reliability can be assessed in comparative way. An advantage over existing approaches is the substantial combination of cognitive psychology and engineering expertise without unpractical complexity.

INTRODUCTION AND BACKGROUND

The European standards on railway safety request a risk oriented approach assessing hazards within the railway system. These analyses need data not only on the reliability of technical systems but also of human factors. The rail specific standard EN 50126-1 (CENELEC, 1999) as well as the European regulation on “Common Safety Methods” (EC 352/2009) prescribe a detailed human factors analysis in risk assessment. The methods used up to now rely on old-fashioned or even outdated approaches and are therefore inadequate in coping with the requested integration of human factors.

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Often, engineers still follow the classic maxims of continuous automation or protection of human actions by technical systems. In spite of a high level of automation and protection, humans still bear responsibility for railway safety. This particularly goes for disrupted modes of operation when technical protections are deactivated. Continuous automation involves problems as not all human operations can be replaced by technical systems. Due to the automation the operator becomes unfamiliar with a lot of formerly well-known tasks. In case of technical disturbances, suddenly the operator has to fulfill these rarely practiced tasks. This can directly lead to work and stress overload and finally to an augmented error proneness. Another possibility increasing the safety level is the use of technical systems as safeguards: the system reacts in times operators do not fulfill their tasks correctly. The engineering can be very costly in this case. A third traditional approach is the gradual extension of instructions, which tends to result in complex and incomprehensible rules and standards. This fact rather provides new starting points for different human errors. In any way, the human remains in the system with a non-negligible responsibility and the need for reliable statements about the influence of human factors in risk analyses persists.

In European railway engineering practice, often the fixed error probability $10^{-3}$ is chosen. But due to the variability of human behavior, fixed human error probabilities do not model the human impact in an adequate way. For many human actions the fixed value $10^{-3}$ seems to be very conservative which lead to oversized system designs. More sophisticated analyses use a set of 18 fixed error probabilities published by Hinzen in German literature (Hinzen, 1993). These 18 fixed values vary in dependence of stress level, surrounding conditions and the human information process. Hinzen’s model is predicated to failure rates from other industries and obsolete human-machine-interfaces. Furthermore performance shaping factors can’t be integrated. In the latter study, human behavior is classified along of stress and difficulty levels. Studies on working places at nuclear plants in the 1980s served as background of this principle. Over the years, the working profiles of operating staff in particular in the railway domain has changed intensively so that the comparability to 1980s working places is not given. So, neither the fixed value of $10^{-3}$ nor the set of values by Hinzen are suitable approaches.

In other industry domains, a lot of energy has been spent in research on human reliability assessment (HRA). Particularly to the so-called first generation of HRA methods, a certain criticism has been raised in literature. Methods are said not to include all error types and not to integrate the operator’s goals when performing a task (Sträter, 2005). The only prospective railway specific HRA-method is called rail-HEI/rail-HEQ (Human Error Identification/ Quantification) and was published by the British Rail Safety & Standard Board (RSSB, 2004). Rail-HEQ is based on the “Human Error Assessment and Reduction Technique – HEART” (Williams, 1986). Like HRA-methods designed in other industries rail-HEI/rail-HEQ is very complex and presupposes expertise in cognitive psychology. Unfortunately, the method has consistency issues between the two parts error identification and error quantification (Hickling, 2007). The second generation of HRA, generally, integrates the phenomenon of errors of commission: human actions that are not required from a system’s point of view and aggravate the scenario’s evolution. But, the high complexity of HRA methods remains a problem. Due to difficulties in obtaining reliable data, the validity stays questionable, particularly for human error quantification in railways.

One reason that human error assessment remains not perfectly solved so far is the lack of suitable data to validate theory. Incident databases are not always accessible and subject studies in simulation environments are time-consuming.