Chapter 6

A Hybrid Analysis Method for Train Driver Errors in Railway Systems

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ABSTRACT

The main objective of this chapter is to analyze safety in railway systems through studying and understanding the train drivers' tasks and their common errors. Different approaches to classifying and analyzing driver errors are reviewed, as well the factors that affect driver performance. A comprehensive overview of the systems theoretic process analysis (STPA) method is presented, along with how it could be applied for controllers and humans. Quantitative risk assessment, along with some methods for quantifying human errors, are overviewed, and a Bayesian network is selected to study the effects of the identified driver errors. A case study aims to present a detailed quantitative safety analysis at European Train Control System (ETCS) system Levels 1 and Level 2, including driver errors. The STPA and Bayesian methods are combined to identify the hazards and quantify the probabilities of hazards when trains fail to stop at red signals.

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INTRODUCTION

The introduction of new technologies and digitalized solutions in railway systems has led to increased complexity, and thus to the emergence of unintended system performance. Train drivers are also changing their roles to the supervisors of more automatic systems.

Many investigations have been conducted to identify vulnerabilities in railway systems and reinforce railway safety (Baysari, Caponecchia, McIntosh, & Wilson, 2009; Felipe, Sallak, Schön, & Belmonte, 2013), and human errors are found as the most significant source of accidents or incidents in railway systems (Felipe et al., 2013; Kyriakidis, Pak, & Majumdar, 2015). For example, at least 75% of fatal accidents in European railway systems between 1990 and 2013 occur due to human errors. In UK, accidents due to driver error made up more than 50% of all accidents between 1945 and 2012 (Kyriakidis et al., 2015). The ratio of accidents associated with human errors increases to more than 80% of all major railway accidents worldwide (Kyriakidis, Majumdar, & Ochieng, 2018).

Drivers need to integrate the various sources of information to achieve the following goals: 1) moving the train according to the authority of movement, 2) moving the train within the safe speed limits, and 3) making safe and accurate scheduled stops (Hamilton & Clarke, 2005). It is obvious that any errors of drivers will be dangerous and can result in fatal accidents if no effective further mitigation measures work.

Queensland Rail Driver Training Centre have identified three major types of driver errors: wrong brakes (too early or too late), failure to respond to in-cab station protection and vigilance systems and driving at a speed that exceeds the limit (Dorrian, Roach, Fletcher, & Dawson, 2007). Australian Transport Safety Bureau (ATSB) (Baysari et al., 2009) highlights that major driver errors occur when drivers fail to detect and respond to signals or when they cannot judge aspects of the train correctly. The impact of errors depends on both the speed of error detection and the effectiveness of recovery.

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The underlying factors causing driver errors are summarized in (Cacciabue, 2005): inadequate communication with crew, poor interaction with equipment, weak compliance with rules, and lack knowledge and experience. In addition, Hamilton & Clarke (2005) highlight that driver errors occur when the driver meets limited time for executing a task or limited resources within the cognitive system. The driver performance depends on how and when the driver controls speed, observes signs, signals and other visual targets, responds to safety devices, and acts with requirements of stations.

The Human Factors Analysis and Classification System (HFACS) released by ATBS (Baysari et al., 2009), divides drive failures into: failure of organizational influences, supervisory factors, preconditions for unsafe acts, and unsafe acts.
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