



6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the
Affiliated Conferences, AHFE 2015

Human Factors and Ergonomics in transportation control systems

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Abstract

Employing case studies taken from work experience in the UK, USA, Canada and Japan this paper observes the evolution of Human Factors (HF) and ergonomics in the railroad from a practitioner's point of view. Practical areas for application of HF at specific points in railroad signaling and control systems are described. HF considerations in advanced train control systems and the movement towards automation are discussed as well as the impact of these new technologies on the context of operation itself. There is now a greater reliance on the operator to remain vigilant and react efficiently when intervention on automation is required both within the control room and driver cab environments. This paper illustrates some of the human performance concerns for novel transportation control systems that are faced today and discusses how this area of cognitive attention, human error and workload is difficult to assess and predict.

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Peer-review under responsibility of AHFE Conference

Keywords: Automation; Human failure; User interface design; Mental workload; Cognitive attention

1. Introduction

A strong modern transportation system is a vital solution to the economic, environmental, and societal challenges faced around the world today. As investment and expansion of public transportation increases, new train control technologies are introduced. Some of the new technologies are implemented for delivery of improved operational performance, some for interoperability some for reputation but all ultimately for the purpose of safety. As the future public transit industry moves towards higher supervisory control systems to increase safety, the operator's performance and reliability becomes ever more crucial. With the application of Human Factors (HF) and Ergonomics, the likelihood of human error can be significantly reduced if transit control systems are designed to be

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intuitive and effective through iterative user centered design lifecycles. A holistic assessment approach is necessary to support the required human intervention points within any transit control system.

2. Some observations on the evolution of Human Factors and Ergonomics in the railroad

In the UK, HF really became established in the railroad industry, as a result of an enquiry into the Ladbroke Grove rail crash in 1999. The incident report[1] identified that the signal passed at danger was due to the number of tasks the driver had to perform and the visual attention required controlling the train. As a result, the importance of understanding the HF of train control design became recognized, such that UK rail infrastructure owners and operators now have mandatory HF integration standards[2][3] in place to demonstrate compliance with regulations. These include requirements for a Human Factors Integration Plan (HFIP) which is used to govern all the HF activities within a project and defines how the outcomes of the activities are linked into the overall project plans. These HFIPs are then evaluated by HF engineering departments that oversee project specific human factors engineering plans. These plans help to illustrate to project managers at what program milestones human factors specialists should be engaged and what deliverables for safety assurance would be expected. Of course this best practice approach is not always followed and all too often HF experts are only engaged following an incident involving human error where some failure has already occurred. This is often an expensive and ineffective way to manage HF in control system design.

In Europe the European Rail Agency has developed technical specifications for interoperability to ensure the interoperability of the European Community's high speed and conventional railroad systems. Sections of these technical specifications dictate layouts of driver machine interfaces incorporating some good HF design principles[4]. Regulation in other countries such as Thailand and South Africa evidence adoption of European control technologies and the associated standards. For example, a metro project in Bangkok required HF support to endorse a new Japanese train design as fit for purpose for the client against UIC (*French International Union of Railways*) standards[5].

In comparison, in North America HF seems to be a relatively unknown discipline, not yet actively regulated. Certainly light rail or metro rail system projects are not expected to engage HF experts to comply with regulations, although the American Public Transportation Association (APTA) has published some procurement guidelines for light rail vehicles that recommend car design shall take into consideration human factors engineering[6]. Only two guidance documents are currently registered with the American National Standards Institute [7][8] and prescribed in the Code of Federal Regulations for Positive Train Control Safety Plan (PTCSP) submissions[9]. These are viewed by the industry as comprehensive specifications that present an arduous task for the designer in collating the evidence as well as a laborious task for review. In a recent review of a Class 1 Railroad's PTCSP submission it became evident that a level of interpretation is needed to determine what specifically should be included in a PTCSP HF analysis.

3. Human Factors applied in railroad control systems

There are a wide variety of types of train control and train protection systems in operation across the world, and therefore a broad array of user interfaces for both drivers and signalers alike. This paper discusses the HF considerations for: European Train Control System (ETCS) installed across Europe and the UK; Positive Train Control (PTC) mandated across the USA; and Communications Based Train Control (CBTC) in operation in high performance metro transit environments. These in cab signaling and wireless solutions require far less line-side equipment than conventional signaling systems, reducing costs associated with maintenance and repair from damage, theft or vandalism[10].

3.1. European Train Control System

Currently there is a drive across Europe and the UK toward interoperability: converting conventional signaled railroads to European Rail Traffic Management Systems (ERTMS). ETCS is the in-cab signaling and Automatic Train Protection (ATP) element that gives the train driver movement authority to proceed until the next

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