Integrating Human Factors and Systems Thinking for Transport Design: Rail level Crossing Case Study

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Abstract

Rail level crossings (RLXs) represent an intractable problem. Safety gains achieved through traditional approaches appear to have plateaued. We describe a program of research that took an innovative research approach to this longstanding problem. This involved integrating human factors and systems thinking methods to provide a whole of design lifecycle approach to analyze the performance of existing RLXs, design novel RLX environments, and evaluate and test these designs. The research program culminated in a series of tested design concepts, recommendations for further research into promising infrastructure changes, as well as recommendations for improving management of RLXs more generally.

Background

Collisions at rail level crossings (RLXs) are a longstanding transportation safety issue. These represent a persistent source of trauma, accounting for approximately 45% of Australian rail fatalities (ONRSR, 2015). Worringly, in line with broader road safety trends, such as increases in the road toll in several states (BITRE, 2016), safety gains at RLXs appear to have plateaued.

To improve RLX safety, it is argued that new approaches are required. Specifically, there is a need to depart from traditional reductionist approaches which focus on improving individual parts of the system (e.g. preventing driver errors, making a warning more conspicuous), to approaches that consider how these parts interact, and how the functioning of the overall transport system can be optimized.

Approach

Systems thinking involves taking the overall system as the unit of analysis, looking beyond the individual, and considering the interactions between humans and between humans and technology within a system. This view also considers factors relating to the wider organisational, social and political environment. Taking this perspective, safety emerges not from the decisions or actions of an individual, but from interactions between humans and technology across the wider system. This approach was adopted as part of a research program that aimed to improve safety at RLXs.

The research program comprised the following four phases:

1. Data collection. On-road and questionnaire-based studies were conducted to understand road user and pedestrian behavior at RLXs, in addition to document review and interviews with subject matter experts (e.g. Beanland, Lenné, Salmon & Stanton, 2016; Salmon, Lenné, Young & Walker, 2013).

2. Systems analysis. Systems analysis methods were applied to understand the behavior of RLX systems (e.g. Mulvihill et al., 2016; Salmon et al., 2016).

3. Generation of innovative designs. A participatory design approach, the CWA Design Toolkit, was used to generate novel designs for RLXs (Read, Salmon & Lenne, 2016).

4. Evaluation of designs. Following initial desktop evaluation incorporating the systems analyses from phase 2, the design concepts were formally testing through driving simulation and questionnaire-based studies.

A number of human factors and systems thinking methods were applied throughout the research program (Figure 1). A number of the methods were used across multiple phases. For example, vehicle measures were collected at the beginning of the research program during on-road studies to understand driving behavior at existing crossings and again in the final phase during driving simulator studies to understand responses to the innovative RLX designs.

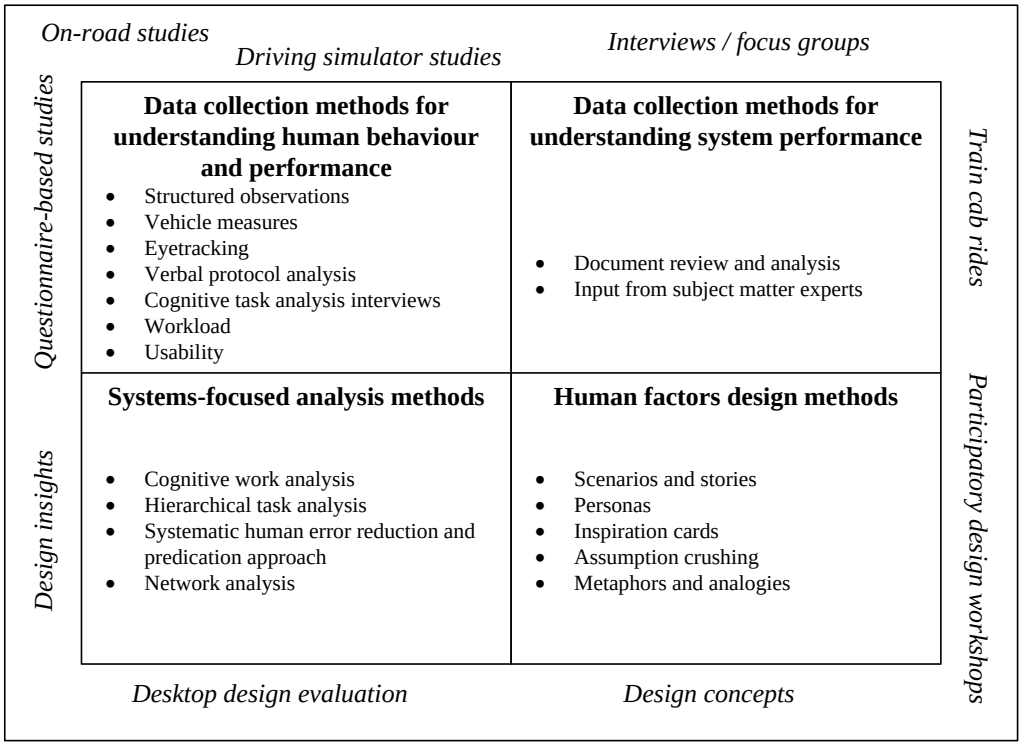

Figure 1. Human factors and systems thinking methods and approaches applied

Findings and implications

The research program produced novel findings about user behavior at RLXs, identified risks associated with RLX functioning, generated innovative design concepts for RLXs and provided initial evidence of the likely effectiveness of the designs. A core outcome was a set of recommendations which addressed the development of in-vehicle devices, changes to infrastructure at RLXs, and improvements to RLX safety management. An important recommendation was the integration of systems thinking approaches into various aspects of safety management including risk assessment processes, investigation methodologies and data collection tools.

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