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Driver behaviour at roadworks

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ABSTRACT

There is an incompatibility between how transport engineers think drivers behave in roadworks and how they actually behave. As a result of this incompatibility we are losing approximately a lane's worth of capacity in addition to those closed by the roadworks themselves. The problem would have little significance were it not for the fact a lane of motorway costs approx. £30 m per mile to construct and £43 k a year to maintain, and that many more roadworks are planned as infrastructure constructed 40 or 50 years previously reaches a critical stage in its lifecycle. Given current traffic volumes, and the sensitivity of road networks to congestion, the effects of roadworks need to be accurately assessed. To do this requires a new ergonomic approach. A large-scale observational study of real traffic conditions was used to identify the issues and impacts, which were then mapped to the ergonomic knowledge-base on driver behaviour, and combined to developed practical guidelines to help in modelling future roadworks scenarios with greater behavioural accuracy. Also stemming from the work are novel directions for the future ergonomic design of roadworks themselves.

1. Introduction

1.1. Background

There is an abundance of anecdotal information about how drivers behave when confronted with roadworks. In some regions of the world drivers will merge seamlessly, like a zip, in order to flow smoothly into a reduced number of lanes. In other regions the conventions which normally govern polite civil society will collapse into chaos as everyone jockeys for position at the front of the queue. In regions like the UK, for example, to avoid the aggression and social exclusion of attempting to 'push in' at the head of a long queue, drivers will merge into a reduced number of lanes sometimes miles ahead of the actual lane reduction. Despite this global body of anecdotal experience there is comparatively little practical information about how driver behaviour, and the resulting impact on wider traffic conditions, is affected by roadworks. There are the Minnesota studies examining different queuing and merging strategies (e.g. Beacher et al., 2004a, b), a reasonable body of literature on safety in roadworks (e.g. Allpress and Leland, 2010; Bai et al., 2010) and transportation engineering information on capacity, throughput and other traffic parameters (e.g. Transportation Research Board, 2000). What none of this work directly confronts, however, is a persistent feature of roadworks found the world over: a greater than expected reduction in traffic throughput. According to the Design Manual for Roads and Bridges (DMRB; Highways Agency, 2004) a lane of motorway is designed to carry in the region of 2000 vehicles per hour, but when roadworks require the number of those lanes to be reduced, the capacity on the still open lanes drops significantly below this value. This feature is so pervasive it is represented in design guidance (e.g. Transport Research Board, 2000) and has been for many decades. Depending on the number of lanes closed by roadworks, the flow on the still open lanes can reduce by anything between 25 and 40%. Worse still is that the reasons for this reduction are not well understood. What we have, therefore, is an engineered environment where there is an expectation that people will behave in certain ways, except they do not. As a result, this paper argues that roadworks represent a novel applied ergonomics problem. To begin tackling it a large-scale observational study of real traffic conditions was used to identify the issues and impacts, which were then mapped to the ergonomic knowledge-base on driver behaviour, and combined to developed practical guidelines to help model future roadworks scenarios with greater behavioural accuracy. Also stemming from the work are some novel departures from the current state of the art in roadworks best-practice.

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1.2. Designing roadworks

Traffic Management (TM) is provided at roadworks for the principle purpose of protecting contractors and plant operating on the site. Its secondary function is to control traffic through the roadworks. Advanced warning signage ahead of the roadworks informs drivers of the works ahead and any action to take, such as reductions in speed, instructions to stay or move lanes, and indications of when to merge and/or turn. Barriers and cones are deployed to temporarily reconfigure the road layout, offer protection to site workers, and provide unambiguous visual cues for drivers to help them know what is expected and what to do. Extensive guidance on how these traffic management measures should be implemented are given in various guidance documents (e.g. Highways Agency, 2009) and the physical properties of similar interventions have been the topic of ergonomic analysis previously (see Zhang et al., 2013 for a recent example).

Roadworks, and their associated Traffic Management, have an impact on traffic conditions. Given the heavily loaded (often congested) conditions on many strategic road networks these effects can propagate dramatically if not fully understood prior to the work taking place. The method adopted to anticipate these effects, and therefore design and schedule individual roadwork activities, is to undertake traffic microsimulation studies. Traffic microsimulation is a form of agent-based modelling that tries to capture “the actions and interactions of individual vehicles, in simulated time steps typically less than one second, as they travel through a road network. Traditional models […] assign a matrix of trips to a network calculating average journey times across timeframes of one hour or more, using empirical relationships between flow and theoretical capacity. Through its focus on simulating individual vehicles, microsimulation is capable of providing a real time visual display, which represents the second key distinction compared to traditional models.” (Woods, 2012, p. 339) Microsimulation is an increasingly prominent theme in transportation research (e.g. Farooq and Miller, 2012; Liu et al., 2006; Roorda et al., 2008) and the possibilities it provides for understanding the collective effects of individual driver behaviours are tantalizing (e.g. Hackney and Marchal, 2011; Casucci, Marchitto & Cacciabue, 2010). A surprising feature of microsimulation (and agent-based techniques in general) is the comparatively limited extent to which they capture the complexities of real human behaviour. The rules governing the simulated behaviours of the modelled vehicles are comparatively simple. Despite this, the collective effects of these simple behaviours are extremely powerful and lifelike, but in order for the robustness of these effects to be tested microsimulation models need extensive calibration. This is the process by which, given the same parameters, a microsimulation model will replicate a known state of affairs. If not, the model parameters need to be iterated and the model re-run until it converges on observed data. The key issue is that if the behaviours of the simulated vehicles could be referenced more closely to what is known about driver behaviour in the ergonomics domain, then the need for extensive model calibration could be significantly reduced. In addition, the possibility of disconnects between actual and modelled driver behaviour, and roadworks are a prominent case in point, can also be reduced. This would mean model predictions would become more accurate and more quickly produced.

In the case of roadworks, government agencies such as Transport Scotland use microsimulation models covering very large geographical areas as a platform for testing proposed roadworks scenarios in a number of future years. For the planning of roadworks in the Glasgow metropolitan area, for example, the Clyde Strategic Microsimulation Model is used (SIAS, 2011). This model contains 250 km of roads, 1.5 million individual simulated vehicles, 50 grade separated junctions and provides a continuous simulation of traffic conditions over a full 24 h period (SIAS, 2011). Models like this enable roadworks to be scheduled in optimum ways, and for road users to be provided with accurate information about potential delays before the roadworks have started. As noted above, for models like these to work accurately it is critical to have an understanding of how driver behaviour at roadworks may differ from “normal” circumstances. There is anecdotal evidence that these differences are significant and, if so, the effects on capacity, delays, safety and emissions could also be significant (e.g. Jin et al., 2008; Khattak et al., 2002; Lee, 2009; Lepert and Brillet, 2009; Li and Bai, 2008; Weng and Meng, 2011; 2012; Zhang et al., 2011). The first step, therefore, is to compare the outputs produced by the Clyde Strategic Microsimulation Model with a real roadworks scenario in order to reveal the extent of the issues at hand, before moving on to a review of the ergonomic knowledge base to explain the discovered results and offer solutions.

2. Study of driver behaviour at roadworks

2.1. Arkleston Bridge Strengthening Works

Like many cities around the world, Glasgow (in Scotland, UK) has a strategic road network constructed largely in the 1960's and 70's. Many of the structures are currently 40 or more years old and approaching a phase in their life cycle when critical maintenance and upgrading is required. An example of this was the Arkleston Bridge Strengthening Works, a £1.2 m upgrade which took place between 17th July and 8th September 2009 on the principle route into Glasgow from the West. This case study provides an ideal test of the traffic flows the Clyde Strategic Microsimulation Model predicts will occur in this situation, and the actual traffic flows which emerged when real drivers encountered this engineered environment. The question to be explored is whether people behaved in ways predicted by the model, and if not, to what extent the actual traffic flows differed from those that were modelled.

2.2. Details of the roadworks

The Traffic Management (TM) measures associated with the roadworks were implemented on both the eastbound and westbound carriageways of the M8 motorway, with full closures and associated diversions implemented during night works. Details of the traffic management scenario are presented in Fig. 1. The Traffic Management measures included a temporary speed limit of 40 mph, reduction of the main carriageway from three lanes to two lanes, and cylinders added to the on-ramp of Junction 26 (J26) to prevent early merging, reducing the effective ramp length by approximately 75%.

2.3. Collection of modelled and observed traffic flows and speeds

The roadworks shown in Fig. 1 were implemented in the Clyde Strategic Microsimulation Model, the model was run 10 times, and the mean predicted traffic flows across each of the 24 h periods averaged. For the real roadworks, actual traffic count data from permanent Automated Traffic Count (ATC) sites within the study area were obtained for the period January 2006 to February 2009. In addition, specific data for the study was gathered from the area local to the Arkleston Bridge Strengthening Works for the remainder of 2009. In order to further establish the impact of the roadworks on traffic conditions, speeds from the ATC sites in the locality of the works were also provided.