Rail Research UK

The universities' centre for railway systems research

Enhanced information design for high speed train displays

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Whole System Performance

Background:

Train drivers have traditionally navigated by processing direct sources of information seen outside the cab, such as trackside signals, route signage and familiar landmarks, and combined it with that of a rigorously developed and carefully maintained level of expert knowledge of route information in order to optimise their speed choices and adjust to movement authority, speed limits, temporary restrictions and so on. Though the advent and invariable demand of high speed operation has advanced performance in the industry, the nature of the task has largely remained unchanged. Consequently, sourcing such direct information from outside the cab at high speeds can be unreliable and difficult to see; moreover the faster decision-making required at high speed may produce temporary increases in workload and fatigue, reduce overall situation awareness (SA) and imbue optimisation of driver speed choices with greater difficulty. A general solution is to develop cab displays containing an array of enhanced features that effectively support decision-making processes and reduce the drivers' reliance on the trackside infrastructure; methods so far uncommon within UK rail systems but standard fare in maritime navigation, aviation and process control.

Method:

The lack of a well developed research base for such applications drove the first phase of work which aimed to produce a more informed model of the driver-cab interface. Data from a number of train drivers and rail industry experts were collected via a series of interviews, observations and ethnographic studies, using cognitive work analysis (CWA; Vicente, 1999[1]; Rasmussen, 1994[2]), and a range of additional CTA techniques (e.g. Critical Decision Method, Klein et al, 1989[3]. Data analysis considered how drivers acquire and use route knowledge to influence their decision making, what information is effective for different driving tasks, and how their SA is affected by different driving conditions. Analysis was conducted using concept maps and process modelling methods (see Figs 1 & 2) to illustrate the dynamism of feed-forward and feedback and overall cyclicality of train control in a continuous stream of two time spheres.

Fig. 1 – *Concept map of train driver SA*

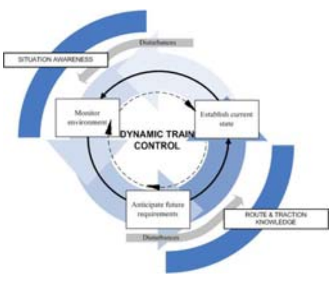

Fig. 2 – *Routine train driving model*

In short, the analysis indicated that drivers employ quasi-mathematical operations to optimise speeds and evaluate safe and efficient journey trajectories, and highlighted a list of information needs for route knowledge, train state indicators and environmental conditions most pertinent to these computations.

The second phase of work set out to design an enhanced train display capable of facilitating the SA of current speed and braking requirements, signal aspects and so on. In the absence of a proprietary simulator capable of rendering 3D graphics, the display was programmed in Matlab utilising real-world train and track physics. Track-based route knowledge requirements derived from the model of information needs were satisfied by illustrating the data across a number of different axes. The enhanced features include preview and predictive information, real-time topographical track characteristics, advisory time-keeping details, tasks to capture spare mental capacity and fuel economy data (*see Fig 3*). The display incorporates real-life track configurations and station schedules in order to explore how different aspects of ride quality and display feature variables aid decision-making, information needs & SA.

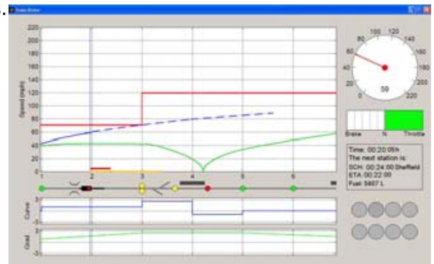

Fig. 3 – *Enhanced Display Research Tool for Hi-Speed Trains*

Progress:

The third phase of work has now commenced and experimentation with students is currently underway. Twenty five postgraduate participants were recruited from various engineering departments in order to ensure a high level of basic task competence with the type of skill-sets required. After a number of extensive training sessions, skill acquisition and patterns of learning were found to be sufficient enough to endorse the display and proceed with further study. Experimentation has employed a repeated measures design protocol structured around multiple baseline conditions, and analysis has thus far investigated optimal performance across various dimensions of ride quality. The results from several experiments indicate that a maximum configuration of trajectory aiding results in the closest adherence to the optimum profile, so much so that performance under both minimum and medium conditions was negligible. To illustrate this, figures 4 and 5 chart near optimum performance for both distance-speed & distance-time under the different levels of support.

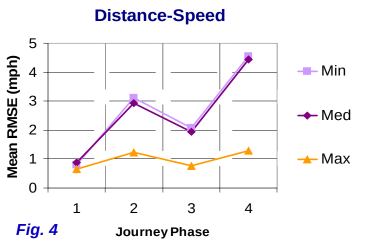

Fig. 4

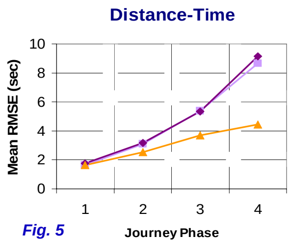

Fig. 5

These findings are supported by individual workload assessments canvassing the difficulty of the task across the various phases. However, though they may deviate from the optimal trajectory for any particular journey, the data generally support the view that these systems allow the participants to stabilise train management activities based on feedback to their own idiosyncratic actions. Furthermore the development of these train management skills appears to clearly encompass safety, punctuality and fuel economy as basic tenets of ride quality. Testing has thus far evaluated the utility of different braking and pursuit tracking conditions, but by far the most trying skill subset to acquire has been that of braking optimally and efficiently at high speed. Further study will explore this issue among others.

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