The University Of Sheffield.

Rail Research UK

The universities' centre for railway systems research

Whole System Performance

Enhanced information design for high speed train displays

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Background:

Train drivers have traditionally navigated by processing information from trackside signals, signage and familiar landmarks, though such direct sources may be unreliable and difficult to use at high speeds. In practice, drivers have to rely on expert knowledge about specific route information, in order to adjust to movement authority, speed limits, temporary restrictions, and so on, to implement appropriate throttle or braking control. However, effective use of route knowledge can be compromised by the faster decision-making required at high speeds, and by temporary increases in workload and fatigue, which may reduce drivers' situational awareness (SA). 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 CTA techniques such as the 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 (see Fig 1) and indicated that drivers employ quasi-mathematical operations to 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.

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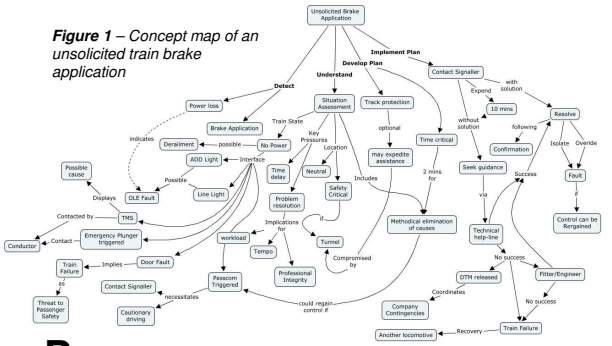

Figure 1 *– Concept map of an unsolicited train brake application*

Progress:

The second phase of work researched current display design initiatives in order to develop a novel enhanced display research tool, and 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 multiple dimensions (see Fig 2).

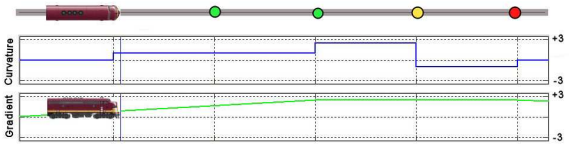

Figure 2 *– Direction of travel and track characteristics shown on X, Y & Z axes*

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 final phase of work aims to incorporate real-life track routes and schedules in order to explore how alternative display interfaces and variables support the effective use of route knowledge, information needs, and driver SA; considerations especially apposite to an industry where continually increasing speeds appear to equate with performance and service delivery.

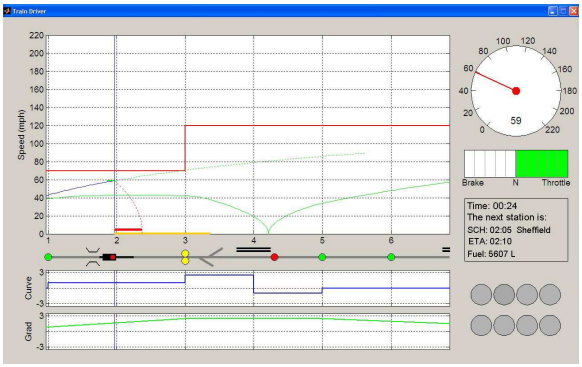

Figure 3 *– Enhanced Display Research Tool for High-Speed Trains*

[1]Vicente, K. J. (1999). *Cognitive work analysis. Toward safe, productive, and healthy computer- based work.* Mahwah, NJ: Lawrence Erlbaum Associates.
[2]Rasmussen, J., Pejtersen, A.M., & Goodstein, L.P. (1994). *Cognitive systems engineering.* New York: Wiley.
[3]Klein GA, Calderwood R, & MacGregor D. (1989). Critical decision method for eliciting knowledge. *IEEE Transactions on systems, man and cybernetics, 19(3)*: 462-472

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