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Moving Map Displays: Using CTIL and Eye Tracking Technologies to Measure Distraction in Locomotive Cabs

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Distraction is a growing problem in the cab of locomotives. The Chatsworth crash of 2008 points all too clearly to the dangers of distraction inside the cab, texting in this case (Archibold 2008). While many distracting activities associated with personal electronic devices can be banned, there are good reasons to consider introducing new locomotive cab technologies such as Positive Train Control (PTC). While they have obvious safety benefits associated with their introduction there may be some unintended side effects on distraction inside the cab of a locomotive similar to those seen with personal electronic devices in the cabin of an automobile. In particular, if locomotive engineers spend more time glancing inside the cab with PTC technologies installed, the likelihood that the engineer misses a safety-critical wayside visual cue such as a trespasser or a vehicle in the row increases dramatically. Reaction time is of the essence here. Although the locomotive engineer may not be able to stop the train in time to avoid a crash with a vehicle, the sooner they are able to initiate an audible warning by sounding the whistle, the more time the pedestrian or motorist will have to move out of the way.

While PTC systems are still not fully implemented across the rail network, a feature of such systems, the Moving Map Display, is becoming an important part of the rail interface as engineers become accustomed to having it (Figure1). Because moving maps can provide information about the relative location of signals, gradients and curvature over the entire length of the route, and for several miles in advance of the train position, it has been hypothesized that they would lead to an increase in the situation awareness of engineers, improving their performance thereby.

A pilot study was undertaken on the Cab Technology Integration Laboratory (CTIL) at the John A. Volpe National Transportation Systems Center to determine the difference between engineers' performance with a combined moving map and paper chart display vs. only a paper chart display (railroad engineering track profiles that correlate railroad right-of-way milepost locations with physical characteristics relative to rail gradient, curvature, wayside signals & appliances, track switches, stations, highway-rail grade crossings, bridges, terminals, etc.).

There are two ways to measure distraction inside the cab. The first is to use the detection of safety critical events as a proxy for distraction. The second is to use an eye-tracker to determine the frequency of especially long glances inside the cab (glances over two seconds) and the proportion of time spent looking inside that is over two seconds for both the moving map and paper map. The threshold of two seconds is the one used in driving an automobile (Klauer et al., 2006). We used real engineers in a study to determine whether the effects of distraction could be quantified. One of the ways to quantify the level of distraction would be to introduce events on the forward track that could only be mitigated if the locomotive engineer were looking up (and not down inside the cab). These events, what we will call safety critical events, are defined here both as events which are planned (e.g., permanent speed restrictions) and events, which are unplanned (e.g., a vehicle on or near the tracks). Participants were individually scored by a rail safety expert. Each event was rated in a binary fashion, receiving a score of 1 for following the correct procedure or a score of 0 for not following correct procedure. On average, across all 10 safety critical events, 80.8% of them were detected by locomotive engineers using the moving map whereas locomotive engineers using the paper display detected only 75.9%. Excluding the quiet zone events, 77.5% were detected by locomotive engineers using the moving map, 73.7% were detected by locomotive engineers using the paper display.

In order to analyze whether train engineers successfully responded to safety critical events across the different alternating conditions, a logistic regression within the framework of Generalized Estimating Equations (GEE) with a logit link function was used. The model included one between subjects factor – (a) Type of Map: Moving or Paper Map – and two within subjects effects – (b) Scenario (10 unique scenarios) and (c) Run Number (Run A or Run B). All second and third order interactions were also included. This analysis was performed both with and without the quiet zones. When the quiet zones were included the all-higher order interactions were found to be highly significant [Third order: Wald X12=0.008; $p<0.005$]. However, when the quiet zones were taken out of the analysis, using a backwards elimination procedure, the model showed no significance in the main effects for Type of Map [Wald X12=0.674; $p=0.412$] and Run Number [Wald X12=2.142; $p=0.143$].

After it was determined where the participants were looking during their runs we were able to determine head down time. From this we were able to determine the proportion of time looking inside the cab over 2 seconds and the percentage of especially long glances taken by each participant. We defined an especially long glance as any glance inside the cab over 2 seconds. The moving map participants had an average total run time of 3,765 seconds and spent 421 seconds over our 2-second threshold for looking inside the cab compared to the paper map participant whose total run time was 3,793 and spent 550 seconds over the threshold looking inside the cab. These results gave the moving map participant a proportion of 0.112 while the paper map participant had a proportion of 0.145 for the same measure.

Similar results were seen when we looked at the proportion of glances over two seconds. The moving map participant had 140.57 glances and had 141 glances that were over 2 seconds leading to a proportion of 0.258. This is compared to 0.275, the proportion seen for the paper map participant (507 total glances and 139.425 glances over 2 seconds)

The current study examined the distracting effects of a moving map display inside train cabs. The intent of such displays is that they are simply an additional support tool for the engineer, not that they are would be heavily relied upon for constant visual scanning. While more analysis needs to be completed to better understand how locomotive engineers actually interact with and use this device, the current research is a good starting point. If the pattern of a high percentage of especially long glances continues to be seen in participants using the moving map then this is something for the railroads to take into account as they develop their training and procedures.