HUMAN ERROR ANALYSES ASSOCIATED WITH LOCOMOTIVE CAB AUTOMATION

SUMMARY

From July 15, 2015, to September 4, 2016, the Federal Railroad Administration (FRA) sponsored Alion Science and Technology to conduct a project to examine cab system automation displays and the risk of human error. Figure 1 depicts a typical system display.

![Figure 1. Locomotive Cab Automation](image)

This research addressed the potential for errors that may occur during human-automation interaction with automated systems. Specifically, the engineer and conductor examined the Trip Optimizer (TO) and the Positive Train Control (PTC) systems while in operation. The research team performed four different types of analyses:

- A qualitative assessment based on human-in-the-loop (HITL) performance in scenarios run at FRA’s Cab Technology Integration Laboratory (CTIL).
- A model-based workload analysis using the Locomotive Cab Analysis Tool (LOCAT) to predict operator workload (Plott, C., 2011) and human error probabilities (HEPs) associated with individual tasks or task sequences while LOCAT uses a discrete event simulation engine (Law, A. M., 2014) and algorithms (e.g., the Keystroke Level Model technique (Card, S. K., Moran, T. P., & Newell, A., 1980)).
- An attention and noticing model analysis to predict engineer visual scanning behavior and detection of changes in the locomotive cab (Wickens, C. D., 2015).
- A fault tree analysis (FTA) of human errors related to locomotive cab operations and the use of automation (Swain, A. D., & Guttmann, H. E., 1983).

The error analyses provided different, yet converging, perspectives on the possibility for error when operating these systems.

BACKGROUND

To improve railroad safety and efficiency, automation is being introduced into the locomotive cab. While automation can support operators as they perform their tasks, dependent upon system design, it can also create a potential for human error.

The research team based the human error analyses on a set of 10 simulator sessions at the CTIL. In each session, engineers ran a 17-mile section of track. Three professional engineers participated in the sessions: two worked for the same railroad (Railroad 1 [RR1]), and one worked for another railroad (Railroad 2 [RR2]). The engineers were specifically recruited for the sessions based on their experience using TO and PTC systems. The simulator’s TO is based on the General Electric TO, while the simulator’s
PTC is based on a Wabtec Interoperable Electronic Train Management System (I-ETMS).

The simulator sessions were not strictly controlled experimental sessions, but they primarily served as data gathering sessions. Further, the research team was unable to identify an engineer with extensive experience using both I-ETMS and TO.

OBJECTIVES
The purpose of conducting this research was to qualitatively assess whether there was a potential for human error during train operation using TO and PTC systems. If so, then to define what types of errors may be prominent (see Figure 2).

METHODS
The research team spent 4 days at FRA’s CTIL at the Volpe National Transportation Systems Center in Cambridge, MA, developing, testing, and running scenarios.

The development process occurred as follows:

Day 1 – A 17-mile section of track CGI from the CTIL’s existing database was selected for use representing an actual rail line in the Midwestern part of the United States. Six events or scenarios were programmed for presentation to participants: permanent speed restriction, quiet zone, prompt for track information, work zone, temporary speed restriction, and stop and protect. Scenarios were designed to be presented in manual operation, simple (low workload), complex (high workload), and complex PTC and TO conditions.

Day 2 – The scenarios were tested and refined.

Day 3 – The first six sessions were conducted with the two engineers from RR1.

Day 4 – The last four sessions were run with the engineer from RR2.

All scenarios ran approximately 25–30 minutes, and engineers were responsible for manually sounding the horn at rail grade crossings.

Figure 3 shows a graphical timeline representation of the simple scenario and the complex scenario.

RESULTS
During the 10 sessions in the simulator, 3 errors related to train control and automation were observed:

1. Overlooking the TO request for track information, and failure to notice the eventual switch to manual mode which TO implemented
2. Failure to stop the train before the grade crossing at milepost 95.5 (i.e., the stop and protect)
3. Speed restriction violations, one of which can be classified as a major violation
TO purposes; increasing the visibility of presented information on the TO; and duplicating the PTC and TO displays at the conductor’s workstation.

Researchers found that further training could benefit engineers, conductors, and dispatchers. Training should cover known automation concerns (e.g., the TO switching to manual mode without the engineer being aware of it). The training simulators should include situations where engineers experience automation failures (Sauer, J., Chavaillaz, A., & Wastell, D., 2015) (Wickens, C. D., Clegg, B. A., et al., 2015).

**FUTURE ACTION**

The research team recommends future investigations into the timing of automation transitions. An examination of possible propagation of errors through the system with increased use of automation should occur. There should be additional investigations on the benefits of a conductor noticing and warning the engineer about potential errors. Future investigators should examine the lack of salience regarding an overspeed indication in the TO when the TO is running in manual. Lastly, there should be an investigation regarding PTC switching off without the engineer’s or conductor’s awareness; further studies in the CTIL could investigate these issues.

**REFERENCES**


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