Investigating Human-Automation Interaction and Human Error in the Locomotive Cab

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Automated systems are being developed and introduced into the locomotive cab.

Lessons learned from aviation indicate that automation can help—or hurt—human and system performance.

This work was performed to investigate human error potential in the locomotive cab when using different automated systems.

One other key point: human performance researchers benefit from getting into the operational environment, and seeing how operators work in reality. But that’s not always possible.
Approach to the Human Error Work

Performed analyses to investigate human error potential:

- *Walkthroughs in CTIL scenarios using automation*
- Modeling analyses using the Locomotive Cab Analysis Tool
- Fault tree analyses of actions and error probabilities
- Noticing – Salience Expectancy Effort and Value modeling predictions

Locomotive cab automation:

- Positive Train Control (Electronic Train Management System)
- Trip Optimizer
CTIL HAI Human Error Evaluation

Human Error Evaluation
Performed at the Cab Technology Integration Laboratory (Volpe)

- 3 professional engineers participated in 3 scenarios on a simulated 17-mile run.
- Run 1: Training and familiarization / manual mode.
  Run 2: Low workload, automated mode.
  Run 3: High workload, automated mode. (one engineer did this twice)
- Collected human performance data, operator actions, and simulated train data
Scenarios

Manual
- 17-mile segment of track
- Speed restrictions and a quiet zone
- Manual horn and bell control

Automation (PTC or TO) – Low Workload
- Same segment of track, same speed restrictions, etc.
- PTC or TO engaged

Automation – High Workload
- Same segment of track, same speed restrictions, etc.
- PTC or TO engaged
- Three extra events: A workzone, a temporary speed restriction, and a stop-and-protect at a grade crossing.
- Two of the three events were announced by the dispatcher during the run.
Scenarios, Events, and Track Profile

Simple Scenarios – Manual and Low Workload

- Quiet Zone - All conditions (manual, PTC, TO)
- Workzone (Form D)
- Temporary speed restriction
- Stop and Protect

Complex Scenarios – High Workload

- Radio to Foreman
- Radio from Dispatch: Temporary speed restriction
- Radio from Dispatch: Stop and Protect
- Restricted speed zone
- Gate crossing failure checked
Short Summary of Results

- Three errors noted (two in the high workload condition)
  - Failure to notice TO request for information and switch to idle mode
  - Failure to stop before the grade crossing for the stop and protect condition
  - Sustained overspeed by 15 mph
Please indicate track to be taken past CP 844

<table>
<thead>
<tr>
<th>Current MP: 82.1</th>
<th>Track: MAIN1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival in: 05.39</td>
<td>Destination: LACROSSE WI – MP 299</td>
</tr>
</tbody>
</table>

**TRACK INFO NEEDED AHEAD**

Please indicate track to be taken past CP 844

- **TRACK 1**
- **TRACK 2**
Please indicate track to be taken past CP 844

**TRACK INFO NEEDED NOW**

Current MP: 82.1  
Arrival in: 05.39  
Track: MAIN1  
Destination: LACROSSE WI – MP 299

Please select:
- **TRACK 1**  
- **TRACK 2**

**Road No** 55  
**Consist** 12  
**Effort Klb** 3  
**Reverser** Fwd  
**Ind Brk Lead**  
**Auto Brk Freight** L1 2550-0
MANUAL CONTROL NEEDED NOW (CDT)

Current MP: 82.1
Arrival in: 05.39
Track: Destination: MAIN1 LACROSSE WI – MP 299

Ind Brk Lead: L1
Auto Brk Freight: 2550-0

Distance Start
Update Track
Restrictions
TIMED OUT CONTROL

Current MP: 82.1
Arrival in: 05.39
Track: MAIN1
Destination: LACROSSE WI – MP 299

Ind Brk Lead
Auto Brk Freight
L1 2550-0

EXIT
Failure to Stop Before Grade Crossing

- One error (four opportunities) observed
- Overshot the grade crossing by 370 feet
- Did not anticipate the long downhill grade
- Visual representation of the grade was shown, and conductor reminded of the stop and protect
Overspeed

- Overspeed occurred in a 1.2 mile section at the end of a run
  - The speed restriction was for 45 mph
  - Actual average speed was 58.4 mph (max 63.3 mph)
- Stated an incorrect understanding of the speed restriction
- The indications did not trigger recognition of the overspeed.
Summary of Experiences

- Identified errors that could occur when interacting with automation
  - Not noticing a system change
  - Lack of mode awareness
  - Distractions can have a negative impact
- The errors that we found in the CTIL were similar to operating experiences with automation
- Found concerns to investigate further in a human-in-the-loop experiment

*CTIL provides an excellent resource for gaining insights into actual operations and evaluating responses to off-nominal conditions*