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

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This work was supported by the FRA under contract DTFR5312D0006L, TPOC: Michael Jones

# Context



- 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

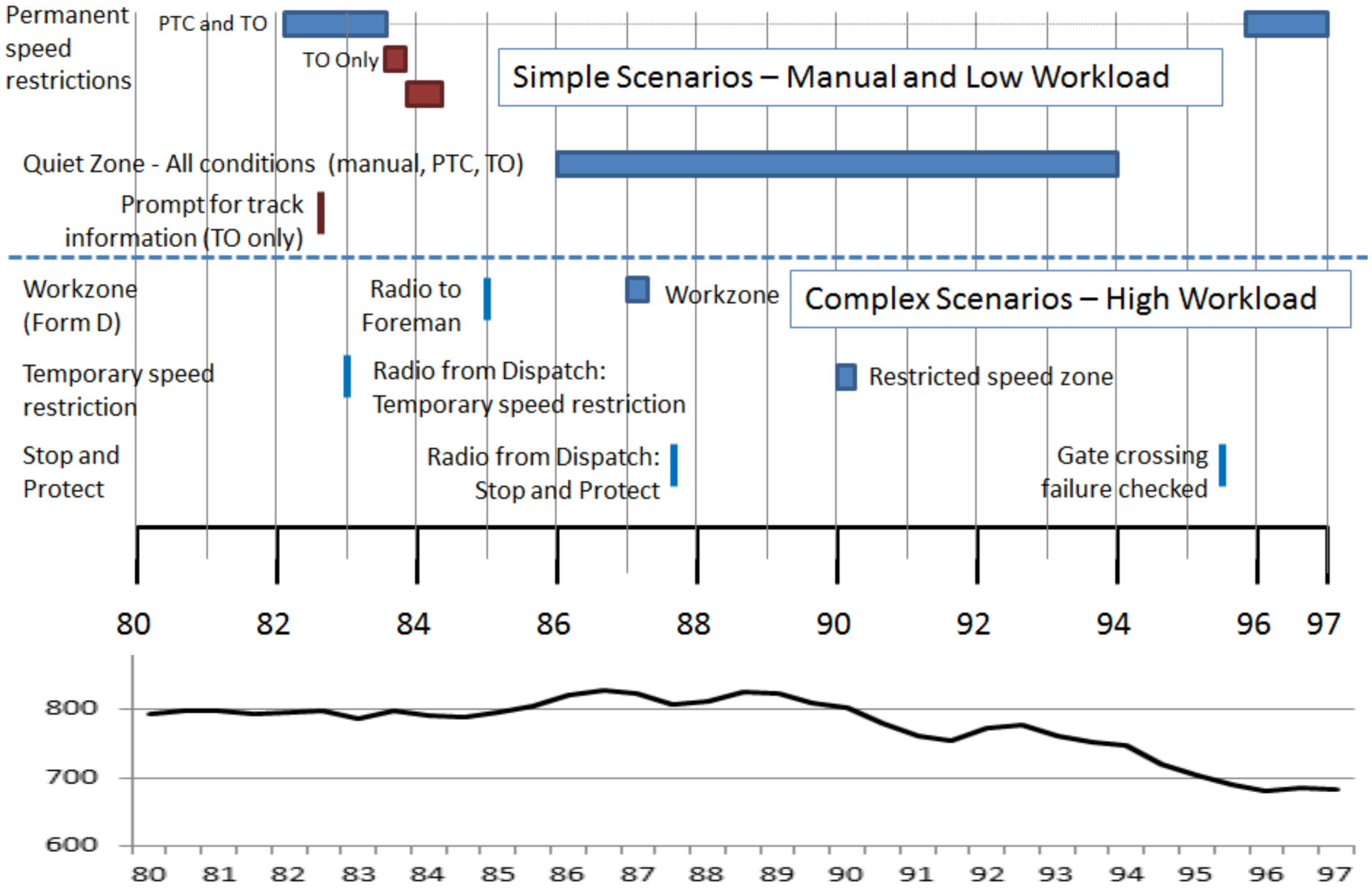
- Same segment of track, same speed restrictions, etc.
- PTC or TO engaged

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.

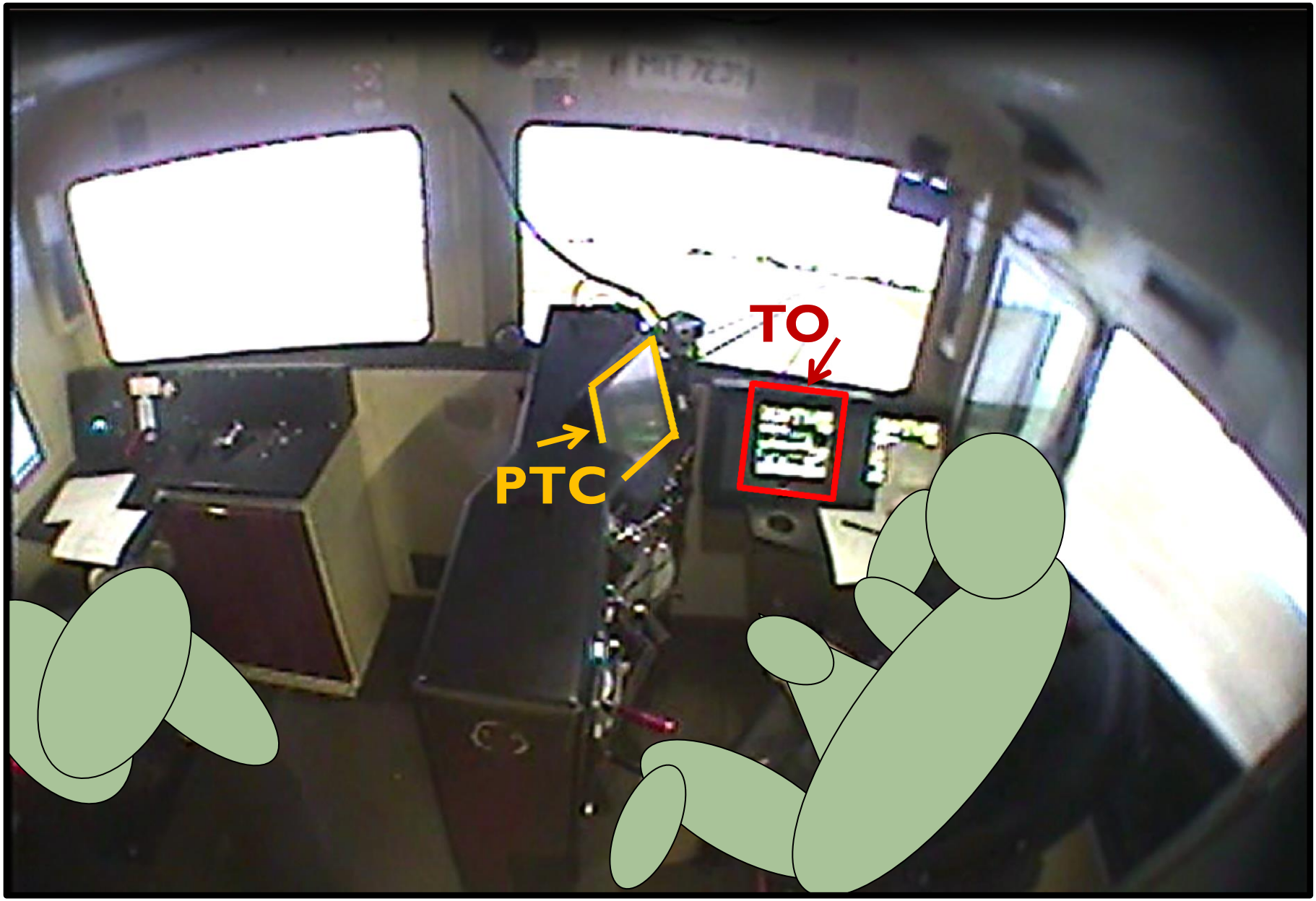
# Scenarios, Events, and Track Profile





# CTIL Human Error in HAI Evaluation





# Short Summary of Results

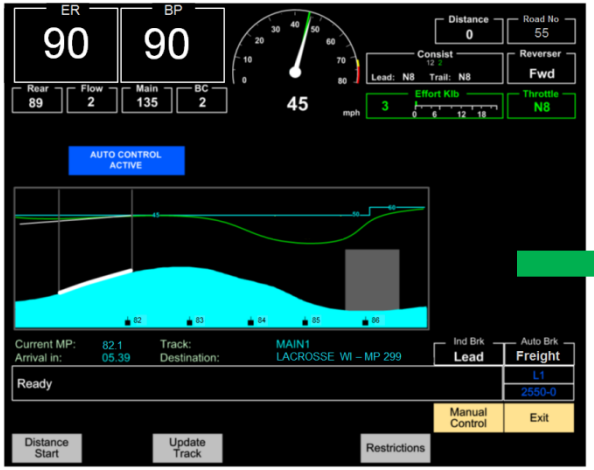


- Three errors noted (two in the high workload condition)
  - Failure to notice TO request for information and switch to idle mode
  - Failure to stop before the grade crossing for the stop and protect condition
  - Sustained overspeed by 15 mph

# Trip Optimizer Requests and Changes



1

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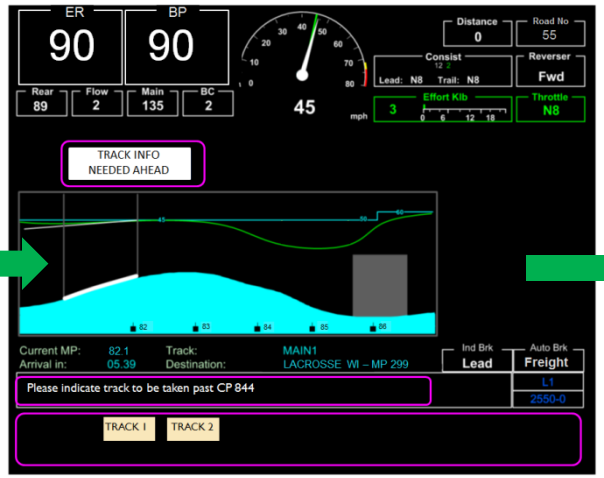


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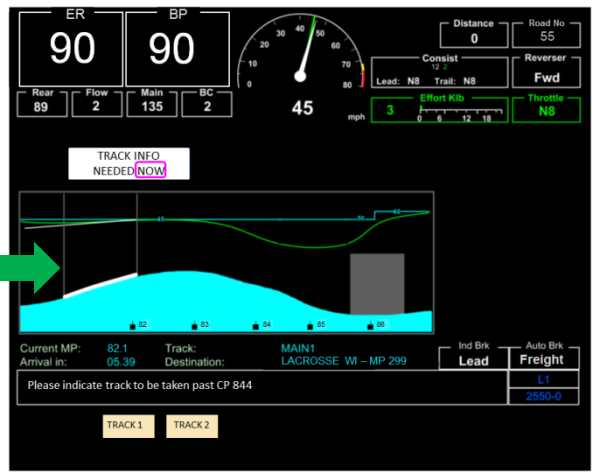


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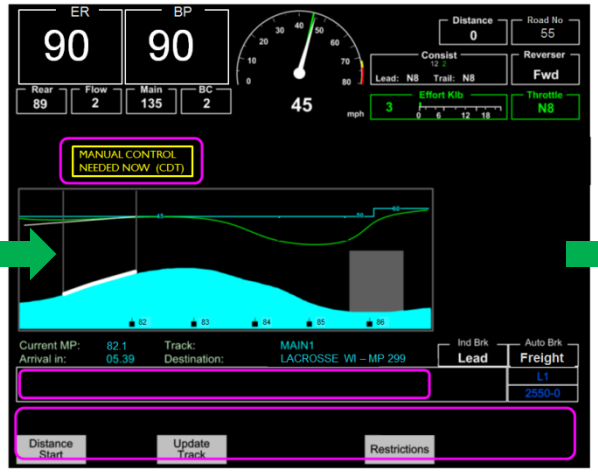


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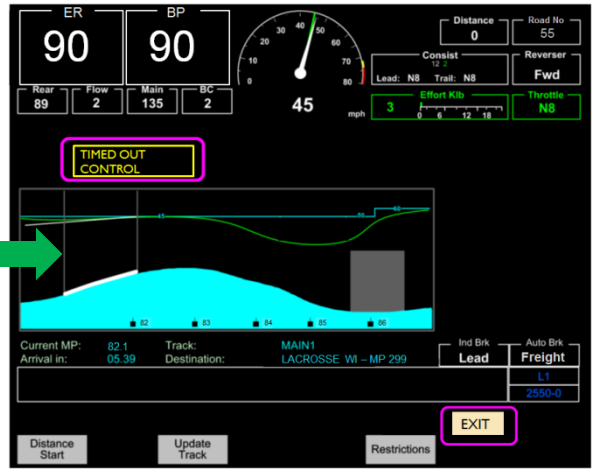

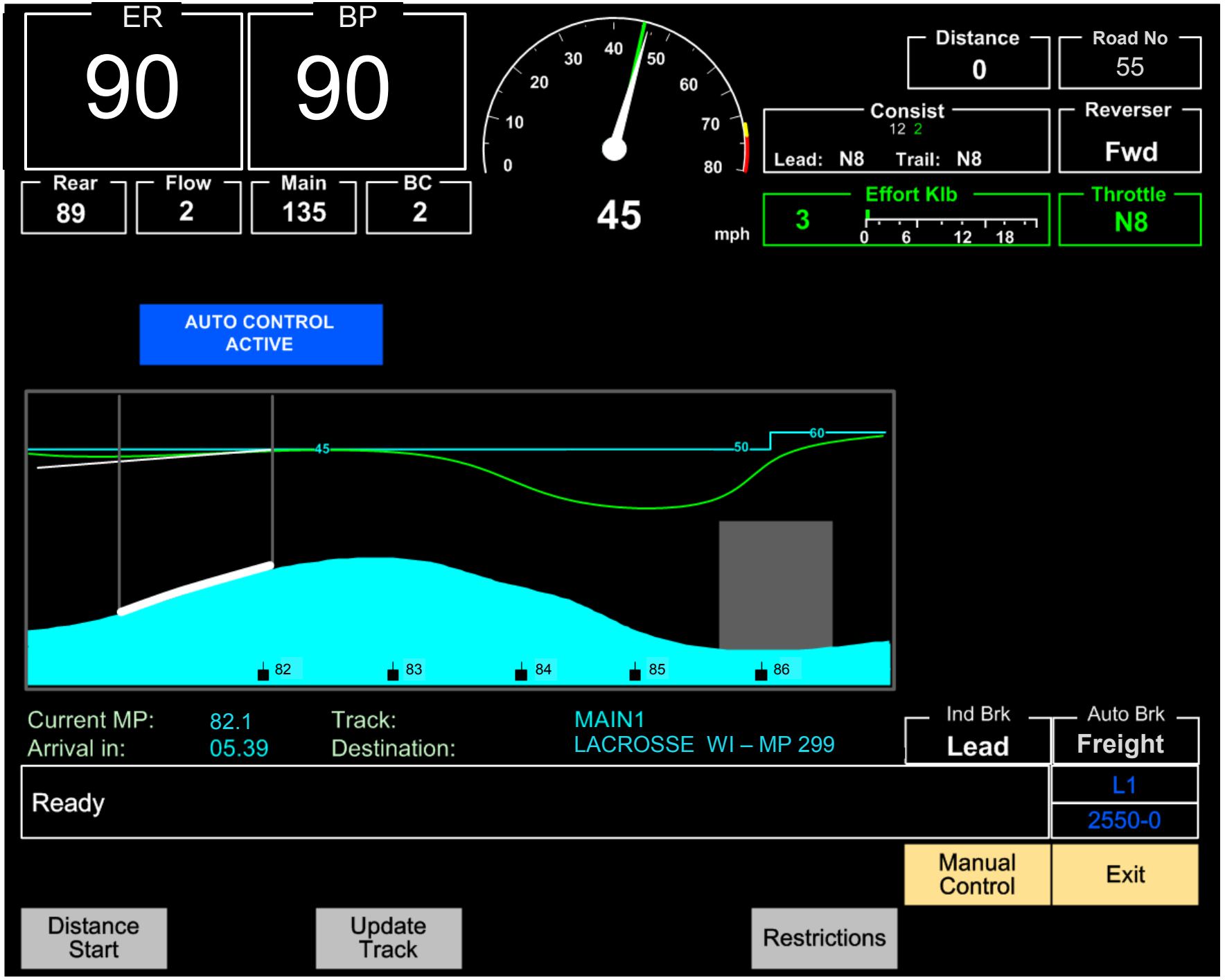
ER
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BP
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Rear
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Flow
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Main
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45
mph
Distance
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Road No
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Consist
12 2
Lead: N8 Trail: N8
Reverser
Fwd
Effort Klb
3
0 6 12 18
Throttle
N8
AUTO CONTROL ACTIVE
45
50
60
82
83
84
85
86
Current MP: 82.1
Arrival in: 05.39
Track: MAIN1
Destination: LACROSSE WI – MP 299
Ind Brk
Lead
Auto Brk
Freight
L1
2550-0
Ready
Manual Control
Exit
Distance Start
Update Track
Restrictions

ER 90

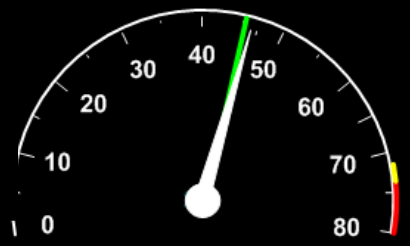
BP 90

Rear 89

Flow 2

Main 135

BC 2




45 mph

Distance 0

Road No 55

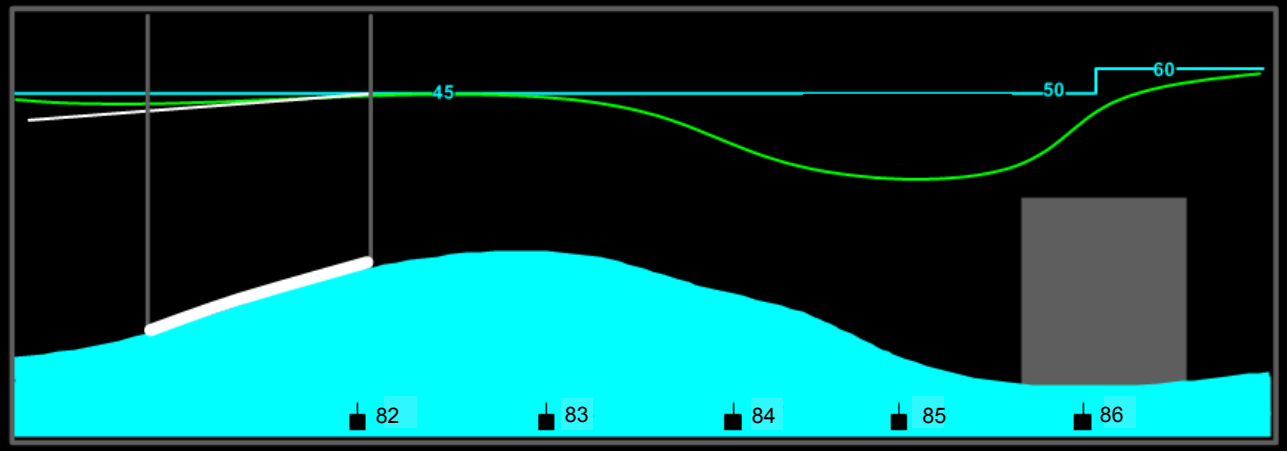
Consist 12 2
Lead: N8 Trail: N8

Reverser Fwd

Effort Klb 3
0 6 12 18

Throttle N8

TRACK INFO NEEDED AHEAD




Current MP: 82.1
Arrival in: 05.39

Track: MAIN1
Destination: LACROSSE WI – MP 299

Ind Brk Lead

Auto Brk Freight

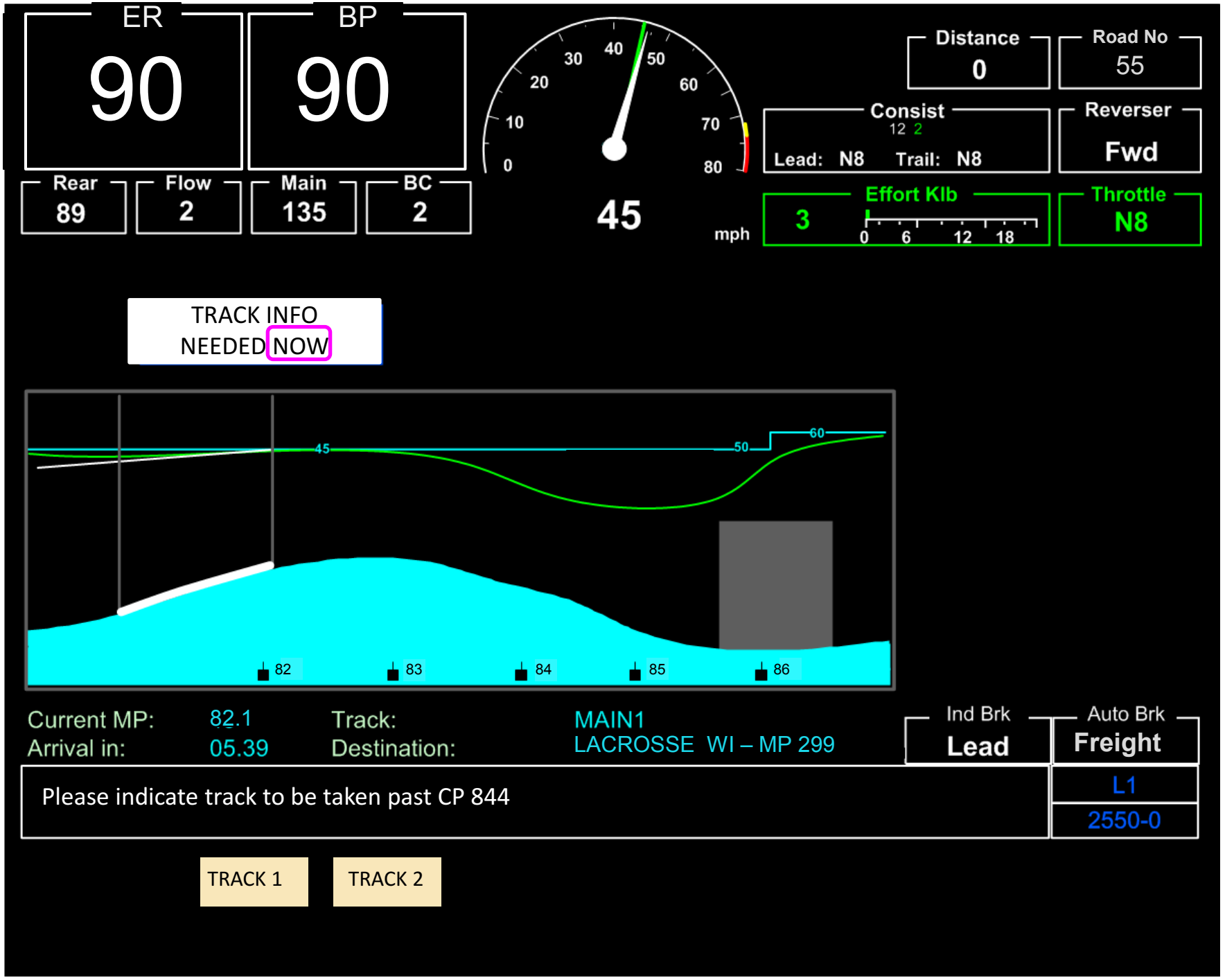
L1

2550-0

Please indicate track to be taken past CP 844

TRACK 1

TRACK 2


ER
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Road No
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Lead: N8 Trail: N8
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TRACK INFO
NEEDED NOW
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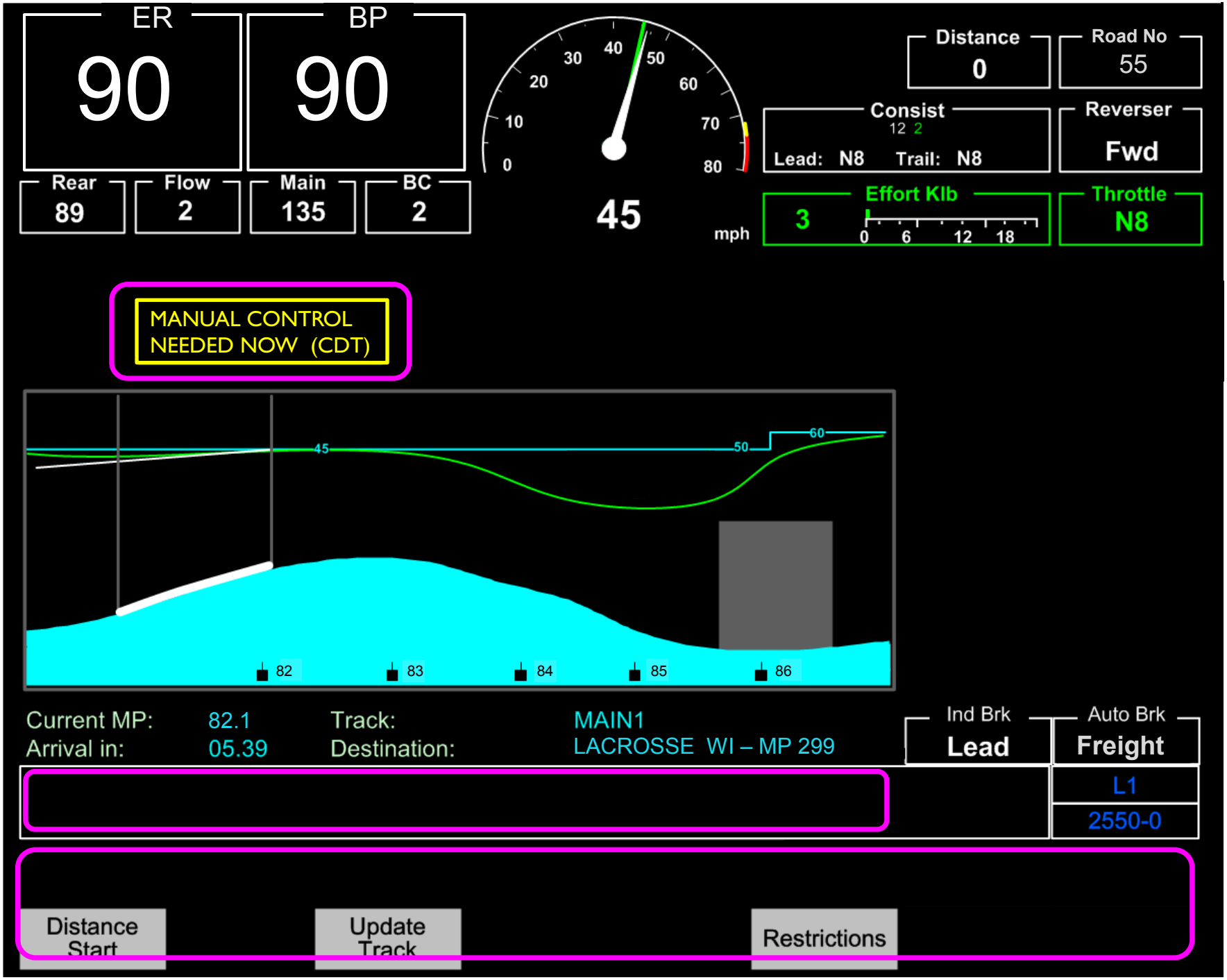
86
Current MP: 82.1
Arrival in: 05.39
Track: MAIN1
Destination: LACROSSE WI – MP 299
Ind Brk
Lead
Auto Brk
Freight
L1
2550-0
Please indicate track to be taken past CP 844
TRACK 1
TRACK 2


ER
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mph
Distance
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Road No
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Consist
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Lead: N8 Trail: N8
Reverser
Fwd
Effort Klb
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0 6 12 18
Throttle
N8
MANUAL CONTROL
NEEDED NOW (CDT)
45
50
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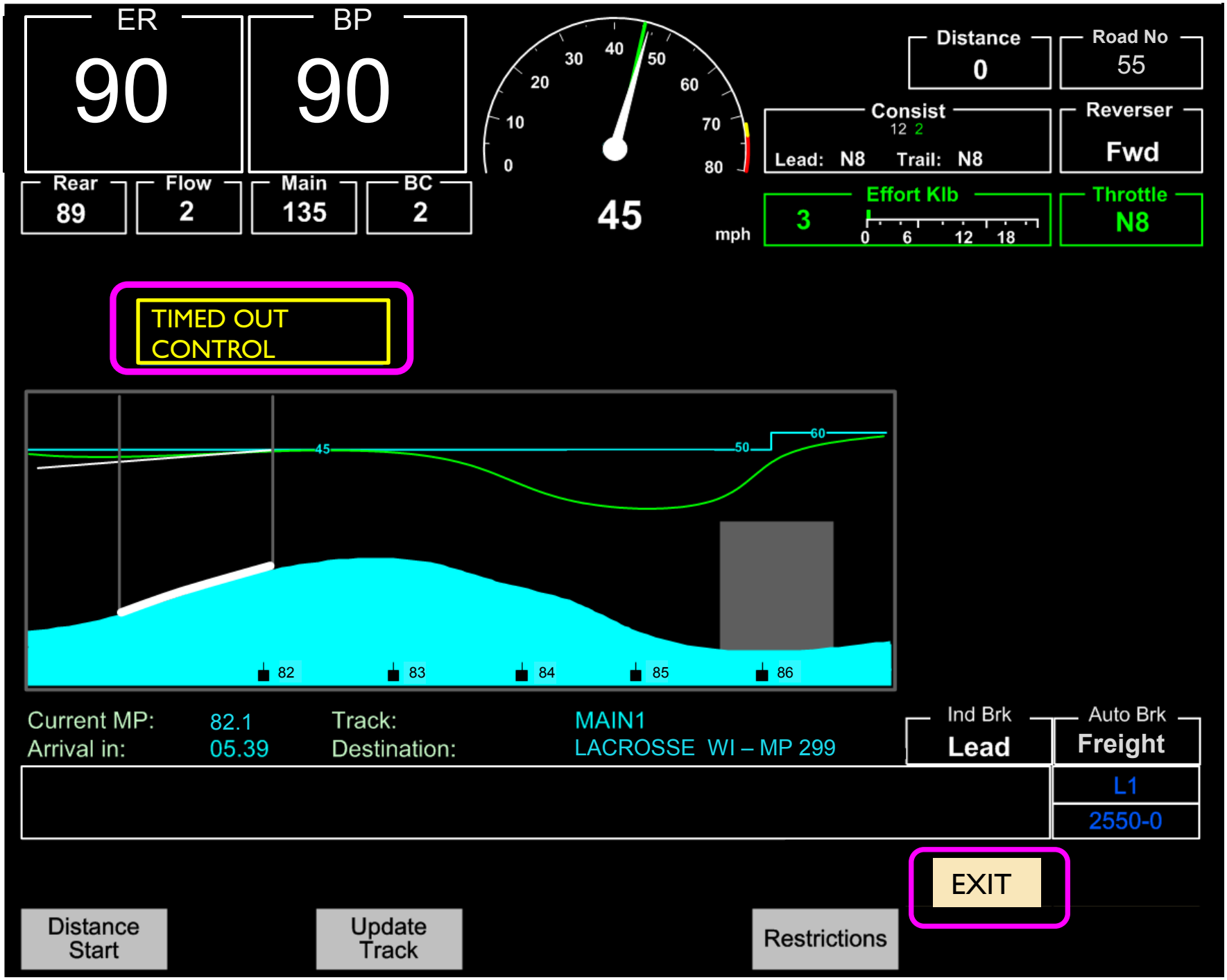
82
83
84
85
86
Current MP: 82.1
Arrival in: 05.39
Track: MAIN1
Destination: LACROSSE WI – MP 299
Ind Brk
Lead
Auto Brk
Freight
L1
2550-0
Distance
Start
Update
Track
Restrictions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Road No
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Lead: N8 Trail: N8
Reverser
Fwd
Effort Klb
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0 6 12 18
Throttle
N8
TIMED OUT
CONTROL
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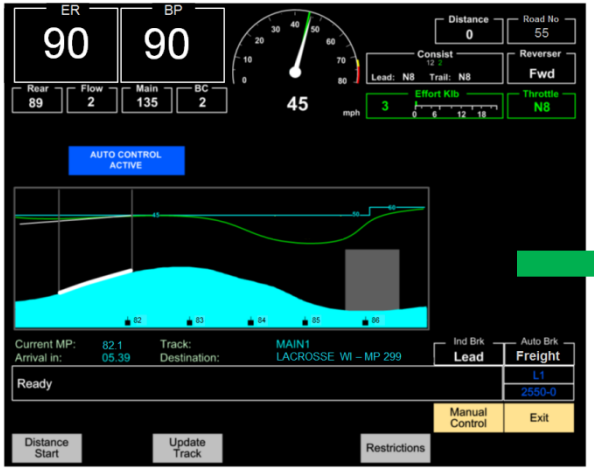
82
83
84
85
86
Current MP: 82.1
Arrival in: 05.39
Track: MAIN1
Destination: LACROSSE WI – MP 299
Ind Brk
Lead
Auto Brk
Freight
L1
2550-0
EXIT
Distance Start
Update Track
Restrictions

# Trip Optimizer Requests and Changes



1

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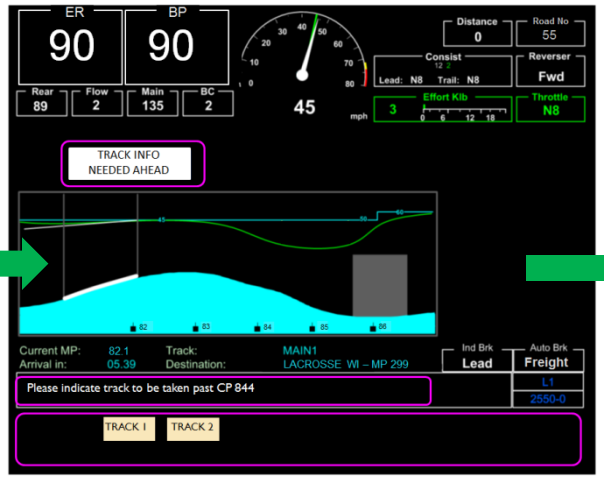


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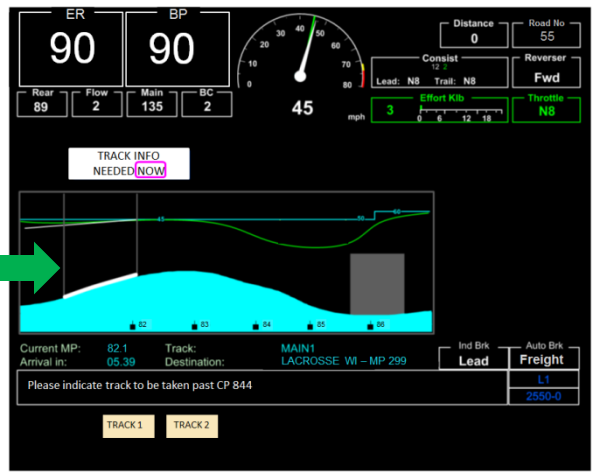


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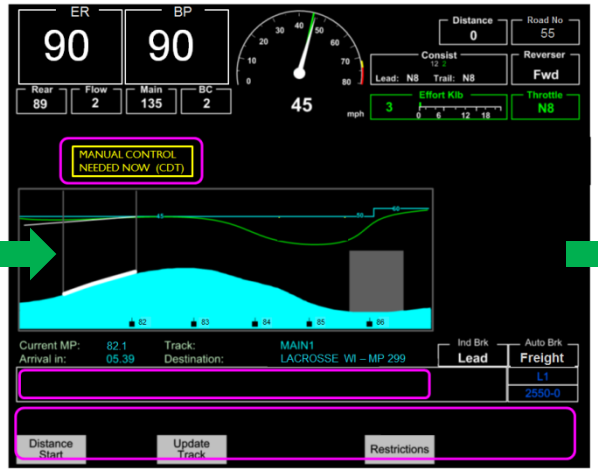


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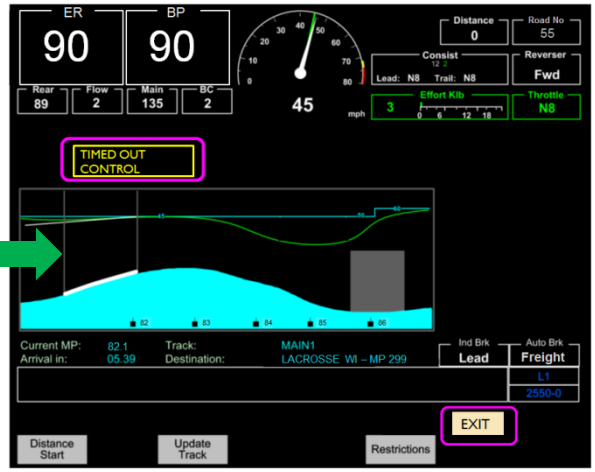
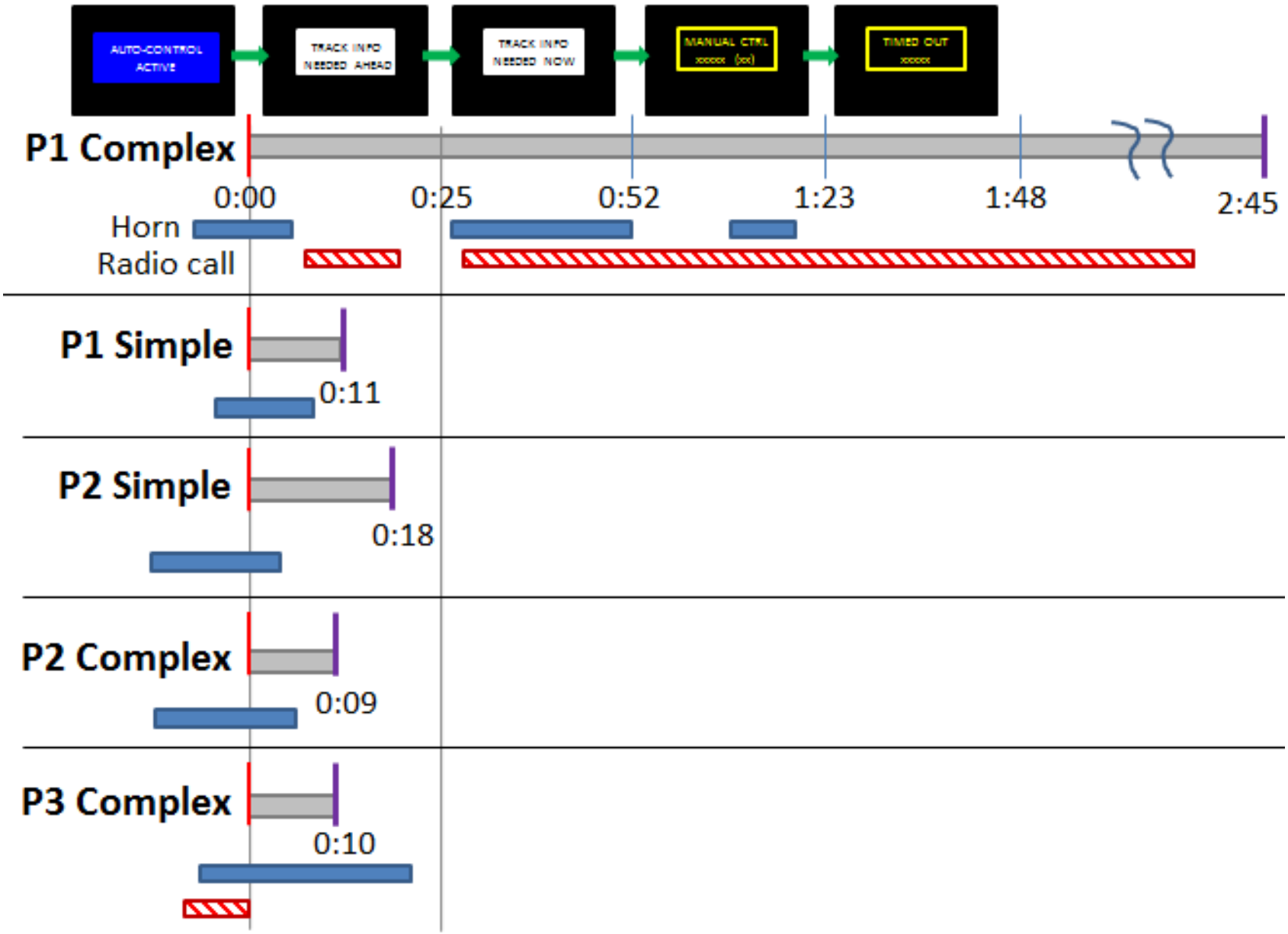


# Trip Optimizer Changes

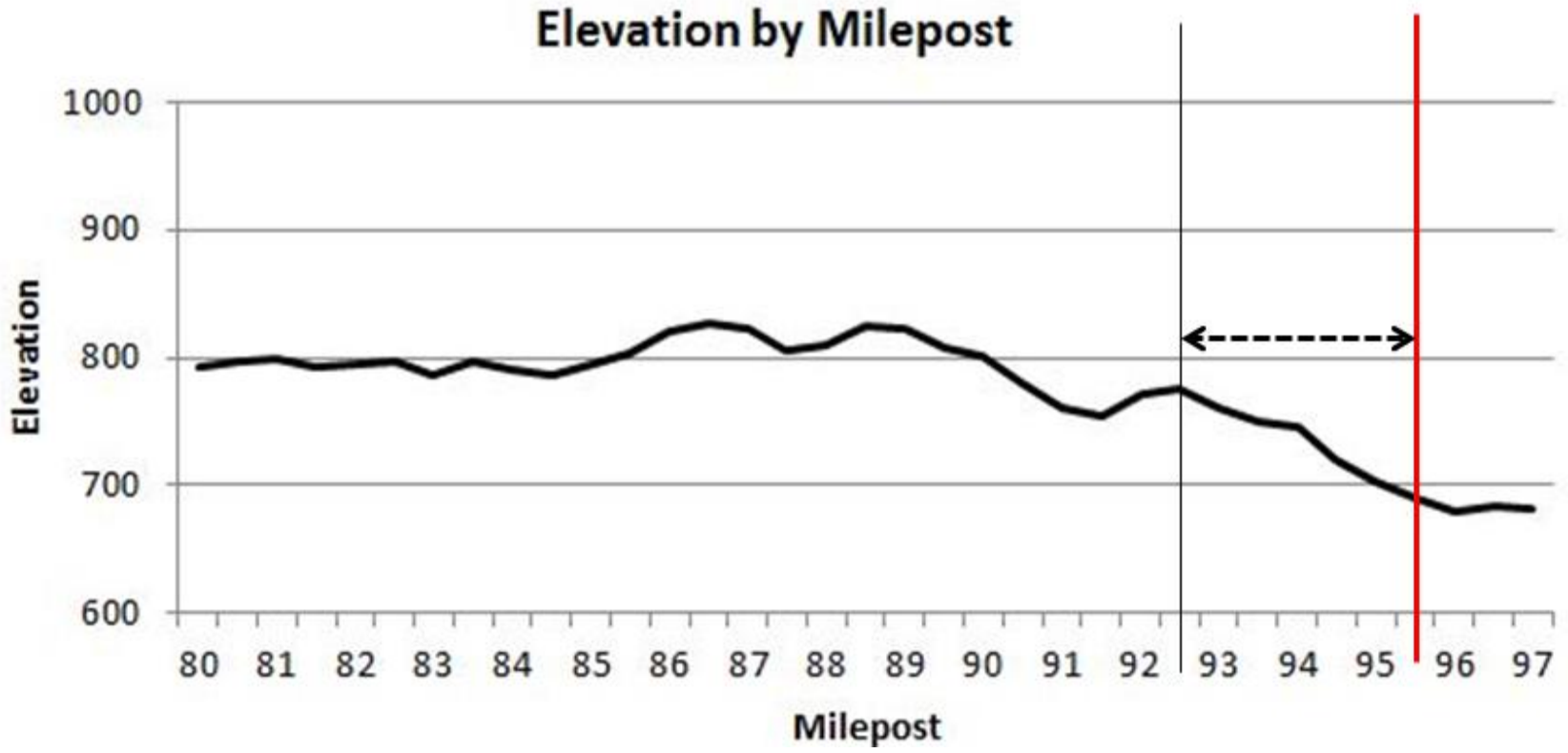




# Failure to Stop Before Grade Crossing



- 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*