HUMAN ERROR POTENTIAL IN HUMAN AUTOMATION INTERACTION: INVESTIGATIONS OF PERFORMANCE IN THE LOCOMOTIVE CAB

(AKA "THE HUMAN ERROR STUDY")

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TiER1
PERFORMANCE SOLUTIONS

THE 2016 FRA HUMAN ERROR STUDY

Goal: to investigate human error potential when using automation in the locomotive cab

Method: Engineers / conductors participated in simulator scenarios

- To familiarize the team with the simulator's technology and its operational practices (exploratory versus controlled study).
- To observe and discuss the potential vulnerable situations that could contribute to human error with actual observers.
- To gather task and timing data for quantitative analyses.

This work was performed by the PI and research consultant under contract DTFR5312D00006L

SCENARIOS

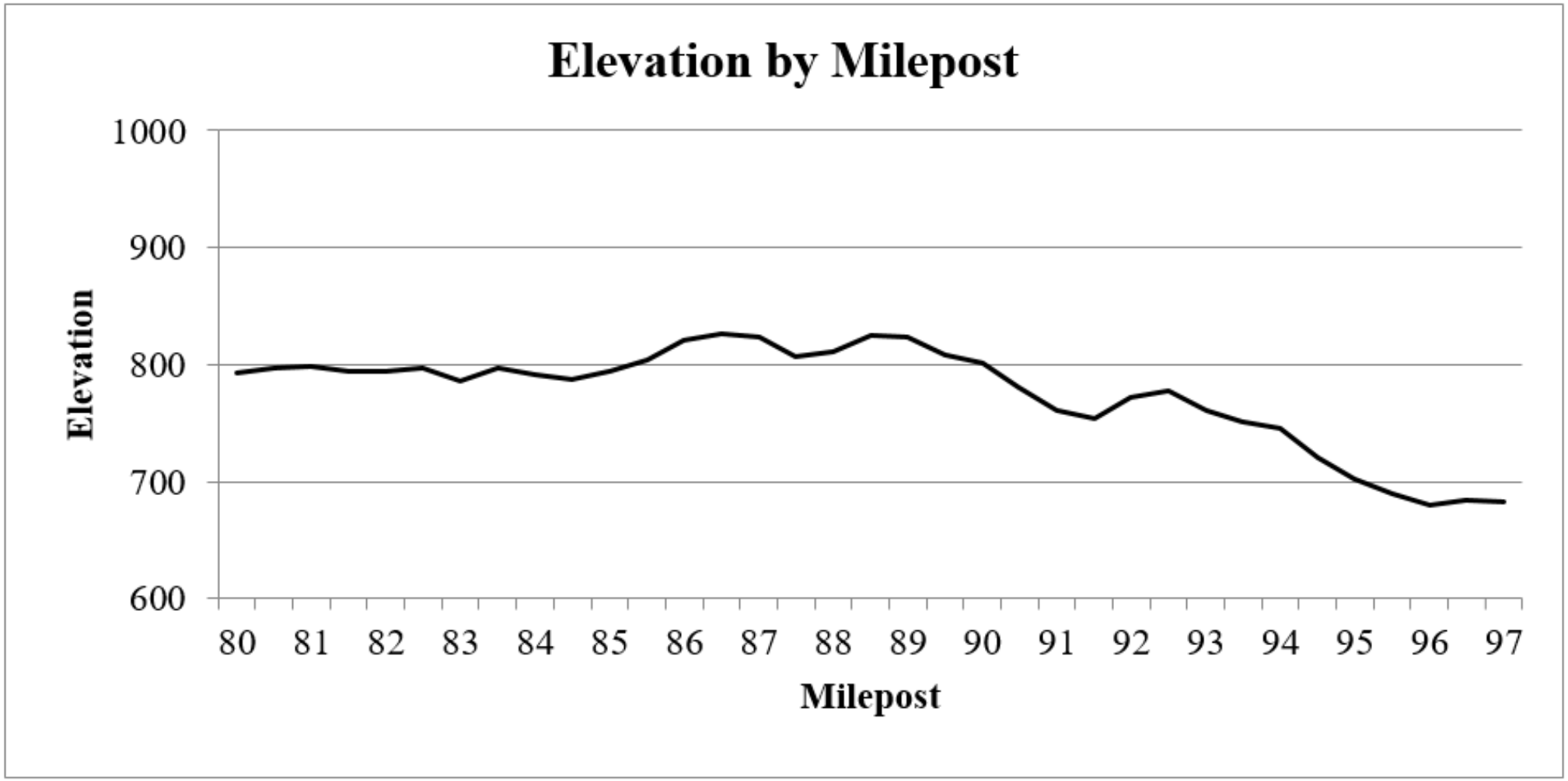
- Manual Operation / Familiarization
- Simple (Low Workload) Scenario with automation (PTC or TO)
- Complex (High Workload) Scenario with automation (PTC or TO)
- Complex (High Workload) PTC ***and*** TO Scenario

https://usdotblog.typepad.com/secretarysblog/2012/03/volpe-rail-simulator.html#.XhUh2HdFxPY

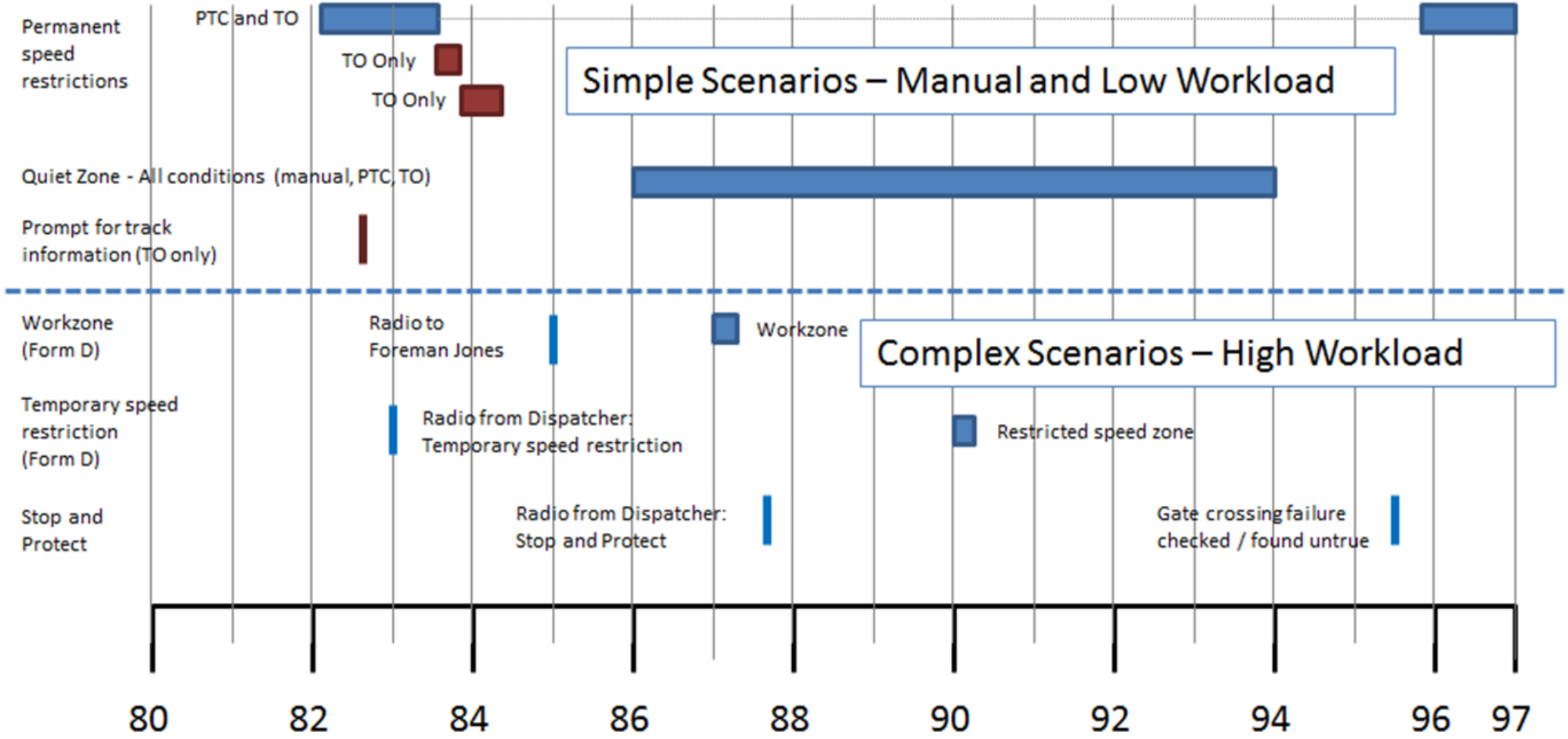
PARTICIPANTS AND SCENARIOS

	Session 1: Manual	**Session 2: TO *or* PTC support, low workload**	**Session 3: TO *or* PTC support, high workload**	**S4: TO *and* PTC support, high workload (P3 only)**
P1 (RR1)	Manual	TO	TO	N/A
P2 (RR1)	Manual	TO	TO	N/A
P3 (RR2)	Manual	PTC	PTC	TO and PTC

SIMULATED SCENARIO - SECTION OF TRACK



SCENARIO EVENTS

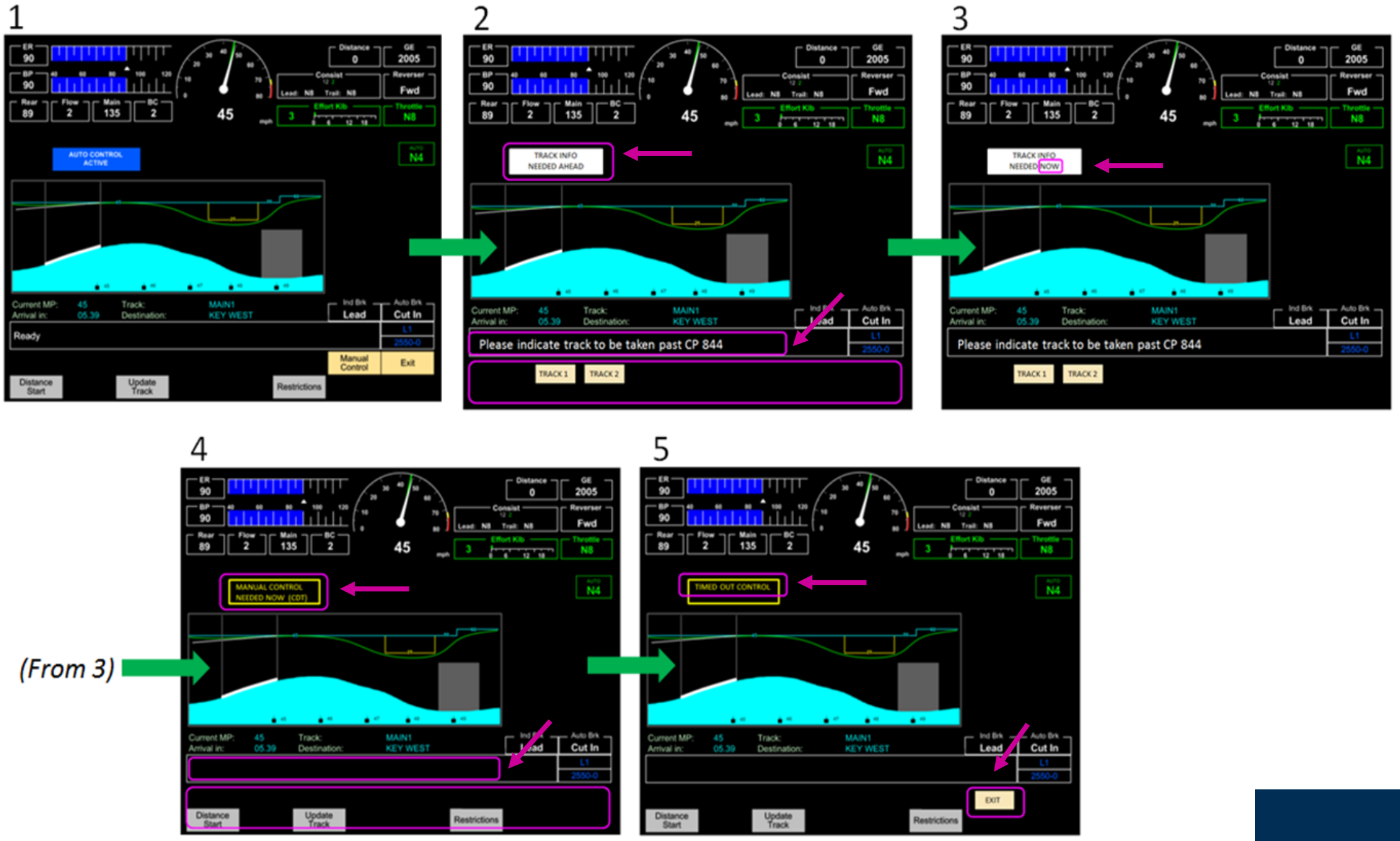


OBSERVATIONS

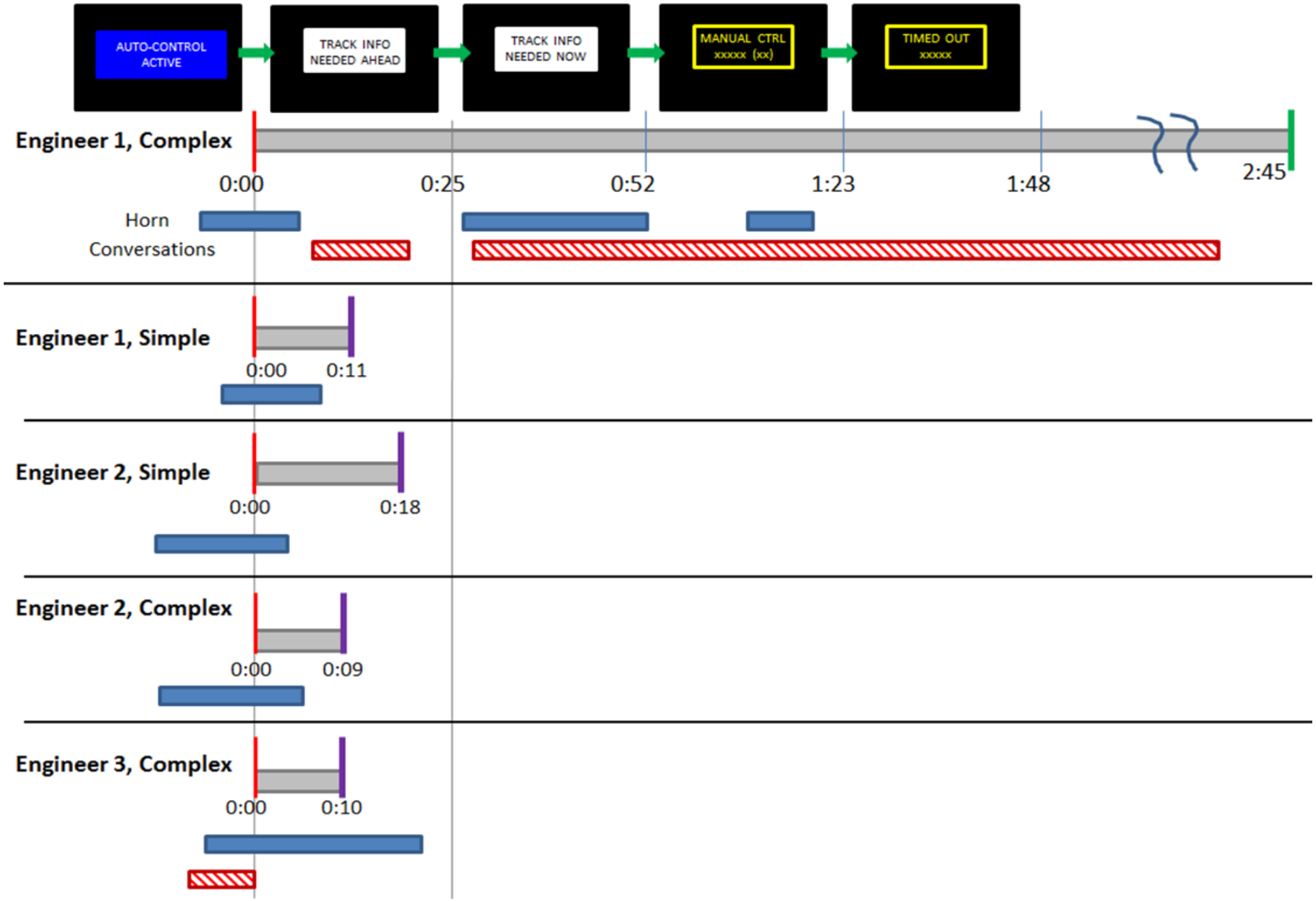
Three key errors

1. Failure to detect automation mode change
2. Failure to stop at a stop and protect
3. Overspeed

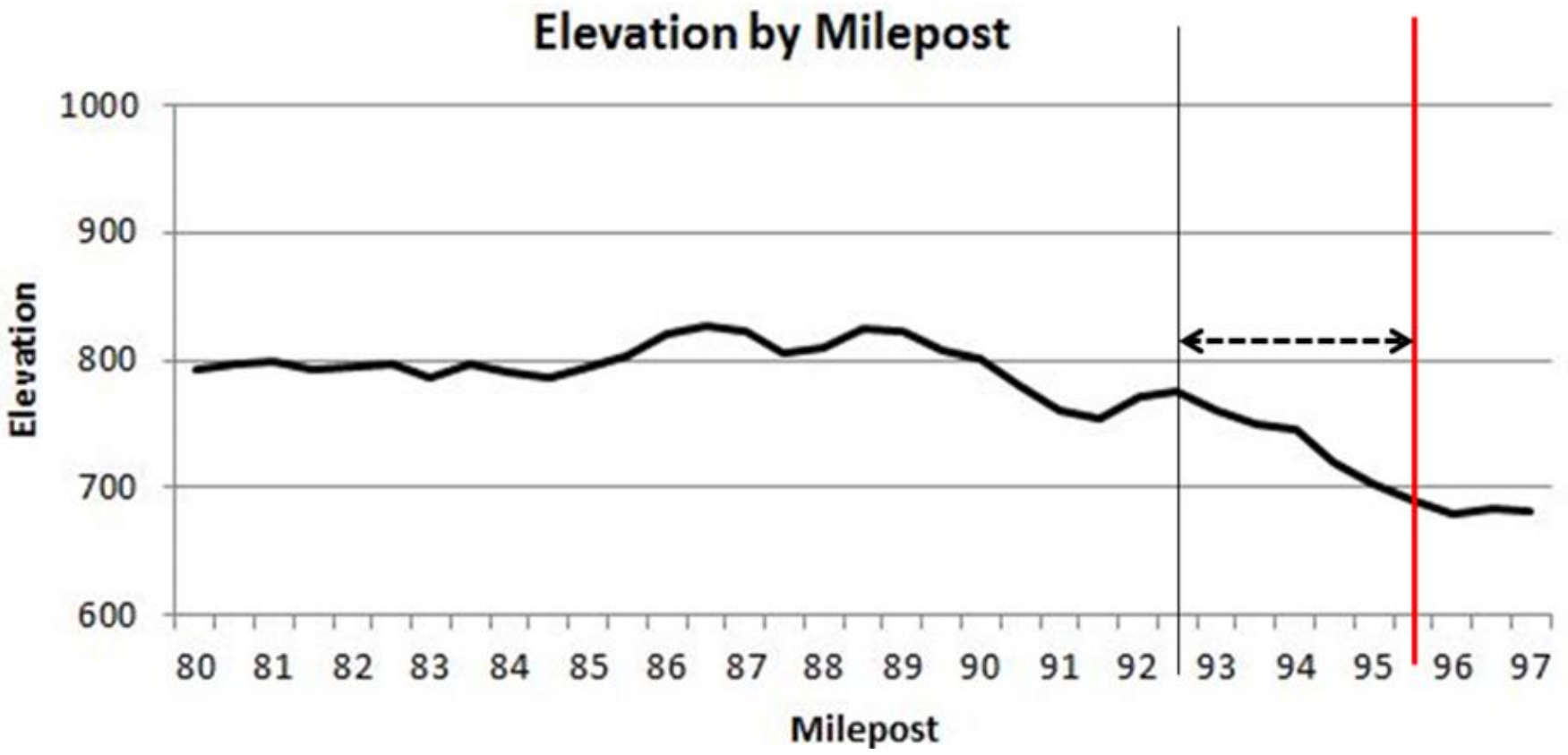
FAILURE TO DETECT MODE CHANGE



FAILURE TO DETECT MODE CHANGE



FAILURE TO STOP AT A GRADE CROSSING



OVERSPEED

Part	Scenario	Maximum Speed Observed (mph)	Average Overspeed (mph)	Speed Restriction (mph)	Percent of Overspeed (max allowed) / allowed	Overspeed Distance (miles)	Overspeed Duration (seconds)	Scenario Duration (seconds)	Percent of Scenario Time	TO (or PTC) Active?	Related to a Change in Speed Zone?
1	2 TO Low WL	40.12	40.07	40	0.3%	0.03	3	1,317	0.2%	No	No
1	2 TO Low WL	36.18	35.62	35	3.4%	0.08	8	1,317	0.6%	Yes	Yes (40 > 35)
1	2 TO Low WL	60.68	60.47	60	1.1%	0.4	24	1,317	1.8%	Yes	No
1	2 TO Low WL	60.32	60.22	60	0.5%	0.25	15	1,317	1.1%	Yes	No
1	2 TO Low WL	63.36	62.21	60	5.6%	0.49	28	1,317	2.1%	No	No
1	2 TO Low WL	63.32	58.42	45	40.7%	1.2	74	1,317	5.6%	No	Yes (60 > 45)
1	3 TO High WL	40.09	40.06	40	0.2%	0.09	8	1,632	0.5%	Yes	No
1	3 TO High WL	35.39	35.25	35	1.1%	0.04	2	1,632	0.1%	No	Yes (40 > 35)
1	3 TO High WL	60.54	60.31	60	0.9%	0.15	9	1,632	0.6%	No	No
2	2 TO Low WL	35.55	35.29	35	1.6%	0.05	3	1,361	0.2%	Yes	Yes (40 > 35)
2	2 TO Low WL	60.80	60.55	60	1.3%	0.46	27	1,361	2.0%	Yes	No
2	2 TO Low WL	62.53	61.32	60	4.2%	0.96	56	1,361	4.1%	Yes > *No*	No
2	2 TO Low WL	45.09	45.06	45	0.2%	0.15	12	1,361	0.9%	Yes	No
2	3 TO High WL	35.83	35.42	35	2.4%	0.05	5	1,662	0.3%	Yes	Yes (40 > 35)
2	3 TO High WL	63.06	61.73	60	5.1%	0.94	55	1,662	3.3%	No	No
2	3 TO High WL	45.16	45.09	45	0.4%	0.09	7	1,662	0.4%	Yes	No
3	2 PTC Low WL	60.61	60.43	60	1.0%	0.40	24	1,346	1.8%	PTC	No
3	3 PTC High WL	N/A	N/A	N/A	N/A	N/A	N/A	1,668	N/A	PTC	N/A
3	4 PTC & TO High WL	N/A	N/A	N/A	N/A	N/A	N/A	1,593	N/A	Yes, both	N/A
Average for all Scenarios					4.12%	0.34	21		1.51%		
Average without the 40.7% overspeed					1.83%	0.29	18		1.25%		

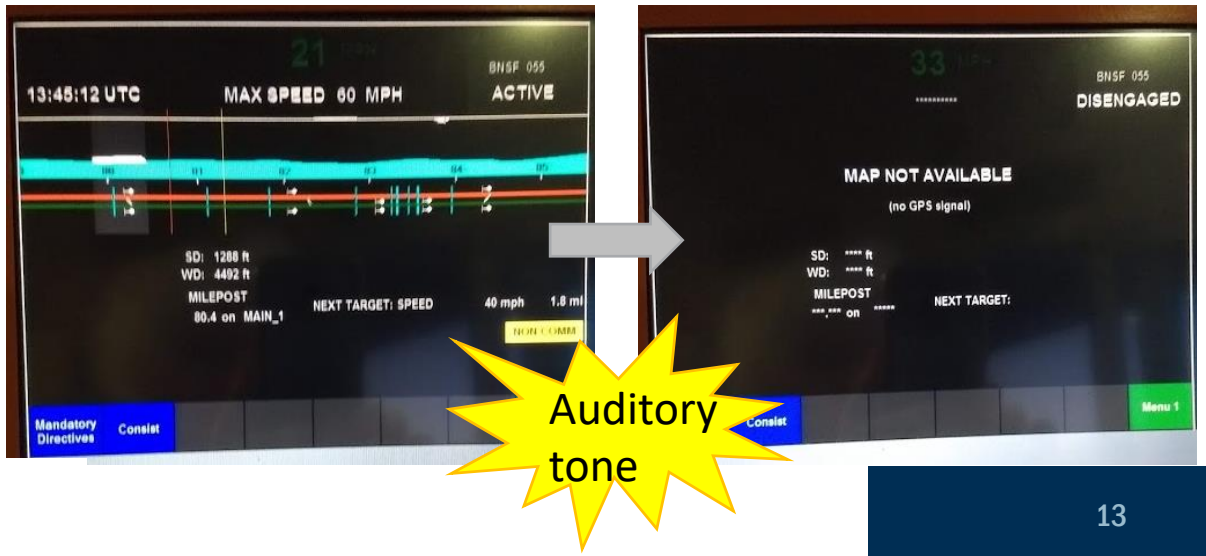
OVERSPEED


84
83
63
1
2
3
4
5
Fwd
Value Fail
Not Fwd
Ind Brk Lead
Auto Brk Freight

DESIGN RECOMMENDATIONS

- Improve the presentation of information, particularly on the TO:
  - Provide a clear indication of overspeed, even when the TO is in manual mode
  - Sound an auditory alert whenever the system requires input from the Engineer or when a mode change occurs
- Electronically sense maintenance-of-way personnel on tracks and create an engineering-based indication for “person or equipment on track.” Present on PTC and TO.

TO – Automated control versus Manual control



WORK PROCESS RECOMMENDATIONS

- Include pre-trip check to verify the correctness of data entered
- Before a trip begins, the engineer and the conductor should review the train and trip information in the PTC and TO systems
- Duplicate the PTC and TO displays at the conductor's workstation.
  - This allows the conductor to analyze the performance of automation, notice mode changes, and review requests for input from the system
  - Offer the ability for the conductor to make programming changes if information has not been entered into the PTC system, the TO system, or both

TRAINING RECOMMENDATIONS

- Train the engineers, conductors, and dispatchers to verify the data in the PTC and the TO systems
- Provide engineers with the ability to identify errors that might have been made by dispatchers (e.g., provide maintenance-of-way work zone data directly to the engineers)
- Inform personnel about known automation concerns (e.g., TO switching to manual mode without the engineer being aware of it)
- Conduct simulator based training in which engineers experience automation failures, so they get exposure to and experience with the possible failures

FEEDBACK

- Do these findings resonate?
- What comments do you have on the recommendations?
- Are there additional recommendations?
- What challenges do you envision in implementing those recommendations?
- What workarounds could get around these challenges?
- How can we use / expand on these ideas to improve rail safety?