Long Train Coupler Forces

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Research & Tests
Norfolk Southern

60W eastbound at Waterloo IN, 7 Aug 2015

Presentation Outline

- 100+ car coil steel trains
  - 80-car practical limit
  - Alternative powering possibilities
- Mixed train – Multilevels and Doublestacks
  - The speed wave, and
  - How to minimize it

Coil Steel Train 60W

- Conventional Consist: three (3) head-end units
- 100 loads; 0 mtys; 12-13,000 tons; 5500-5700 ft
- Undulating grade in east central Ohio (Alliance)
- Frequent broken knuckles near the rear of the train
- Limit train to 80 cars → no knuckles
- Why? Is there a better solution?


RD70
RD71
RD72
RD73
RD74
RD75
5281'
5267'
5274'
5279'
5286'
TRACK LAYOUT #1 #2
CURVATURE #1
1.2R
1.1L
1.3L
1.3R
ALIGNMENT #2
ELEVATION
2.50
2.00
3.00
3.00
MAINTENANCE SPEED (CURVE)
60
60
GRADE
+0.16
+0.69
-0.55
+0.59
East bound trains …
get knuckles here

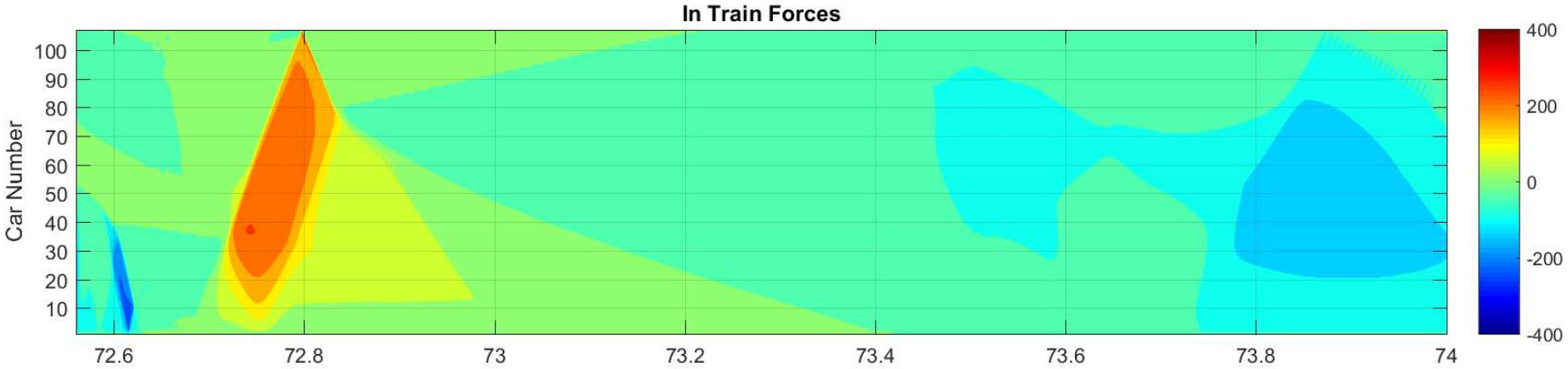
Consist: EOCC-equipped trough cars

- Three head-end units
- 103 lds, 0 mtys, 12500 tons, 5500 ft

15” EOCC units

100 cars yields 250-275 ft
of slack (>5 carlengths)

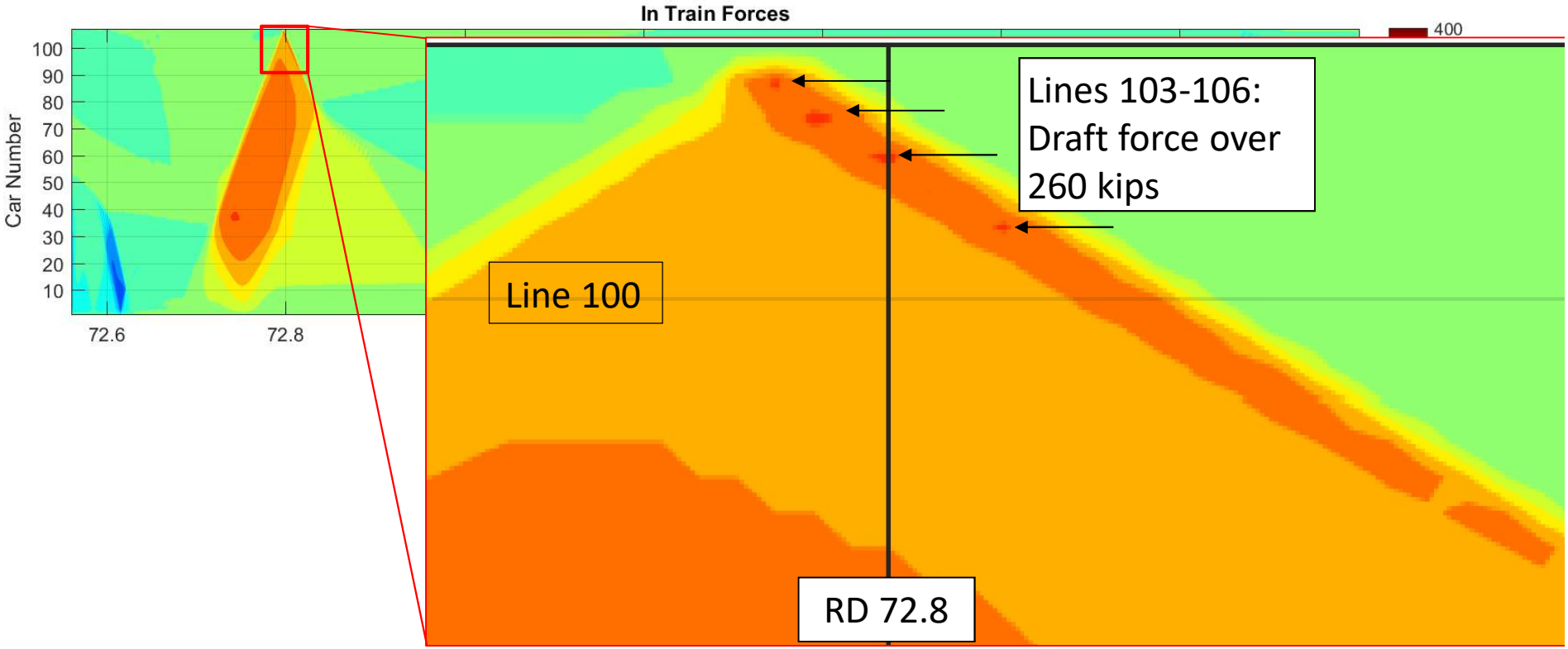
TOES simulation: 103-car train



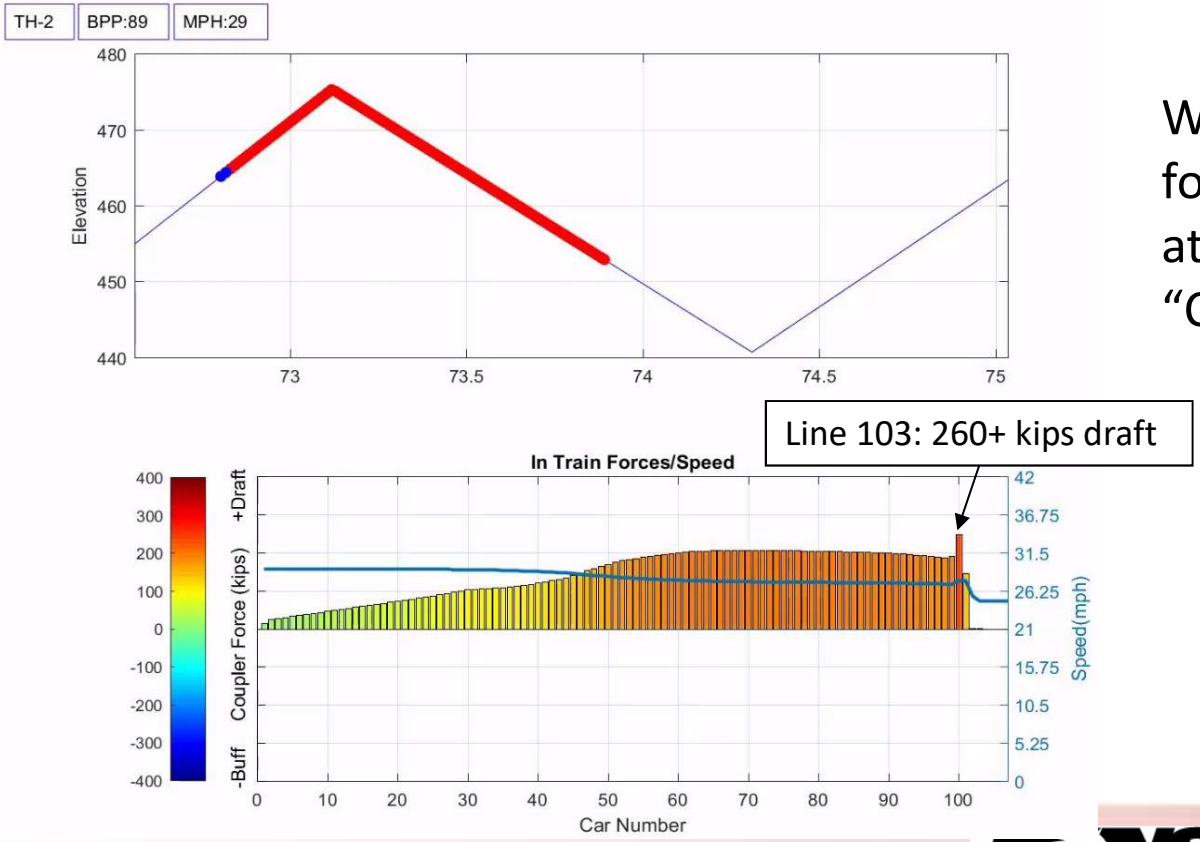
- X axis – head-end mile post
- Y axis – position in train (left) and coupler force (color)

To read graph: Select head-end mile post, then read vertically to determine coupler forces throughout train at that location.

TOES simulation: 103-car train

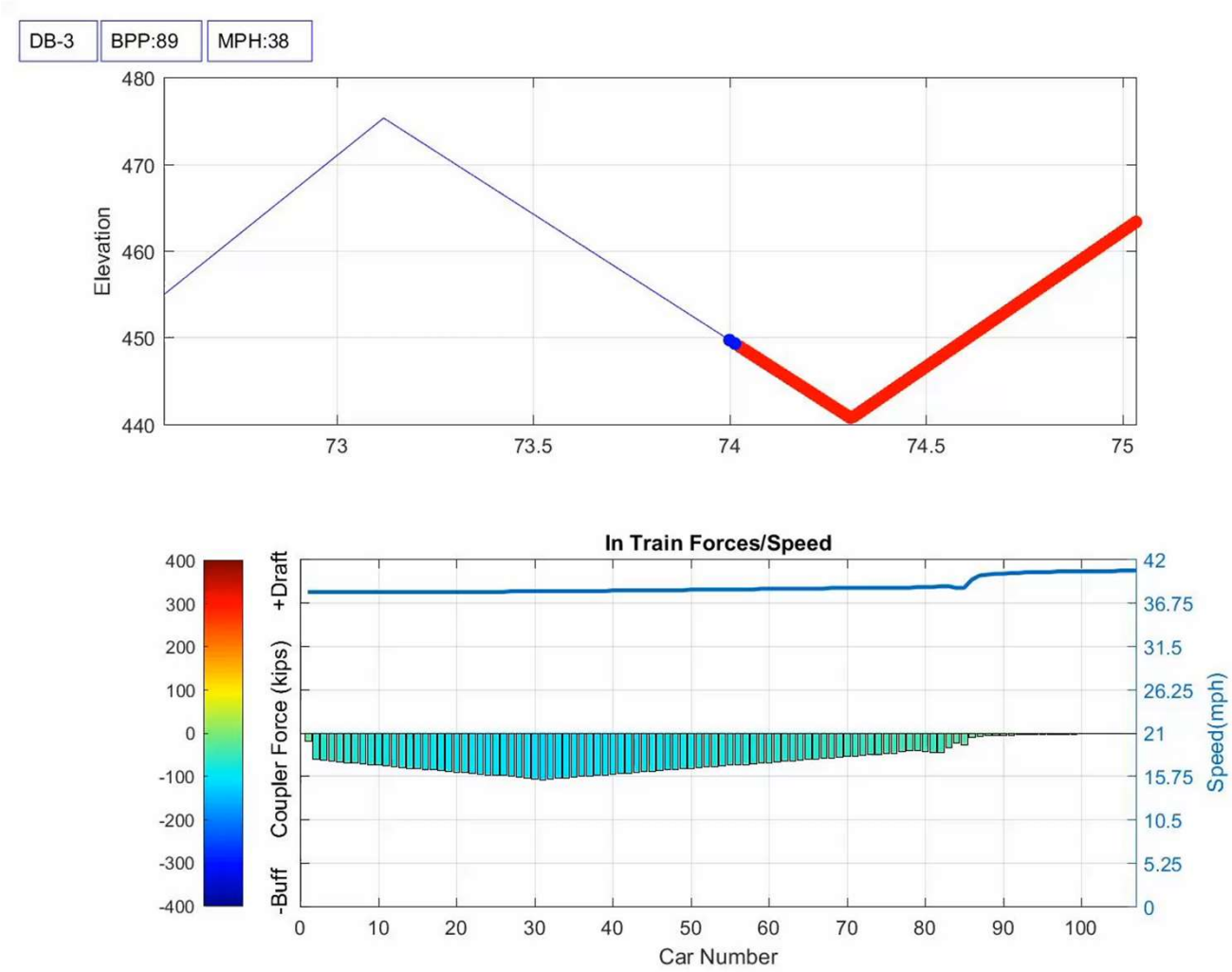


TOES simulation: 103-car train



We found peak draft forces occurred suddenly at the rear of the train: "Cracking the whip."

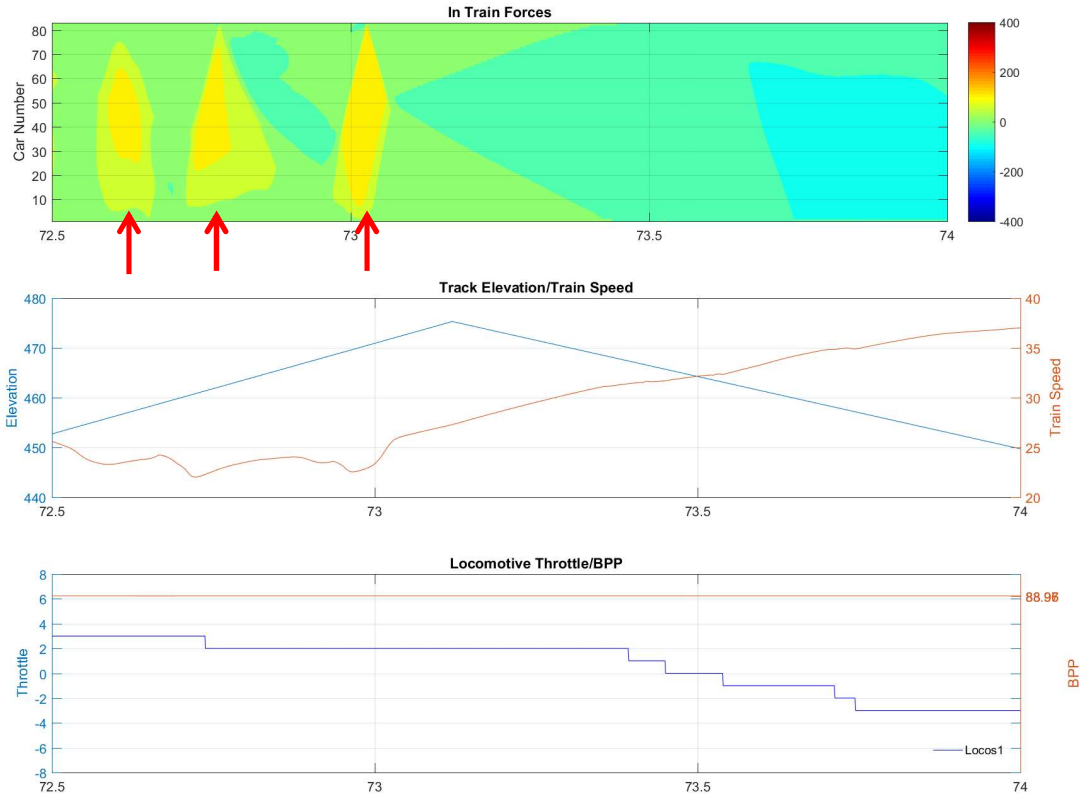
103-car train



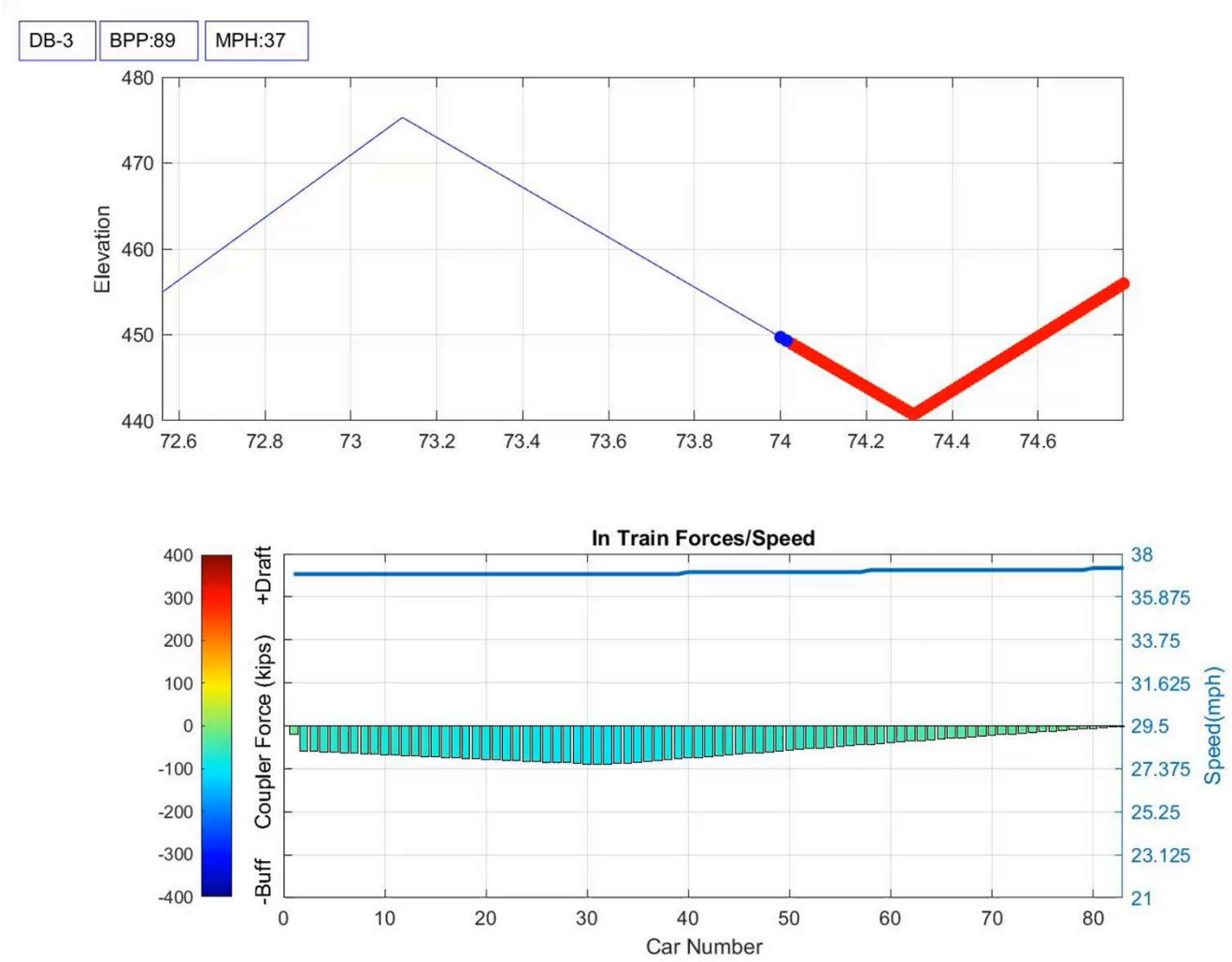
TOES simulation: 80-car train

Three moderate, but abrupt, run-out events

Throttle handling similar to 100-car case



80-car train

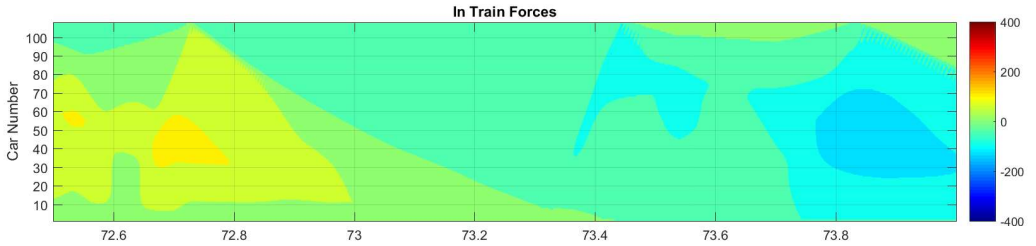

DB-3
BPP:89
MPH:37
Elevation
480
470
460
450
440
72.6
72.8
73
73.2
73.4
73.6
73.8
74
74.2
74.4
74.6
In Train Forces/Speed
+Draft
-Buff
Coupler Force (kips)
400
300
200
100
0
-100
-200
-300
-400
38
35.875
33.75
31.625
29.5
27.375
25.25
23.125
21
Speed(mph)
0
10
20
30
40
50
60
70
80
Car Number

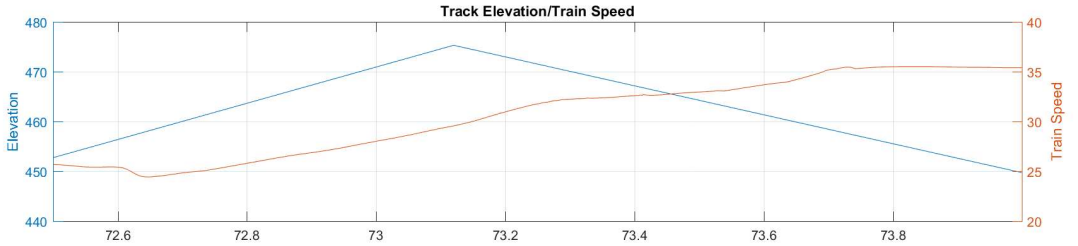
TOES simulation: DP synchronous mode

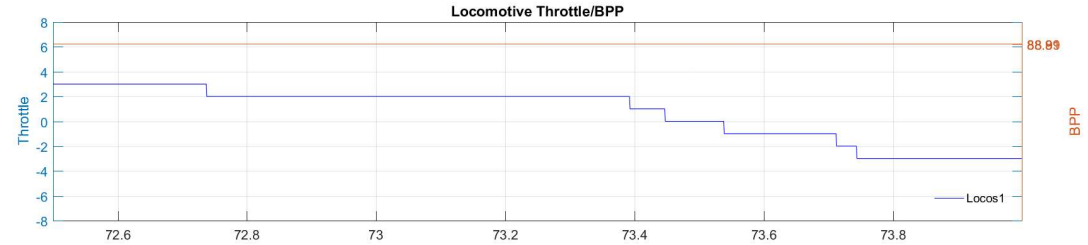
104 loads,
13180 tons, 5700 ft

Note smooth transition from light buff to light draft

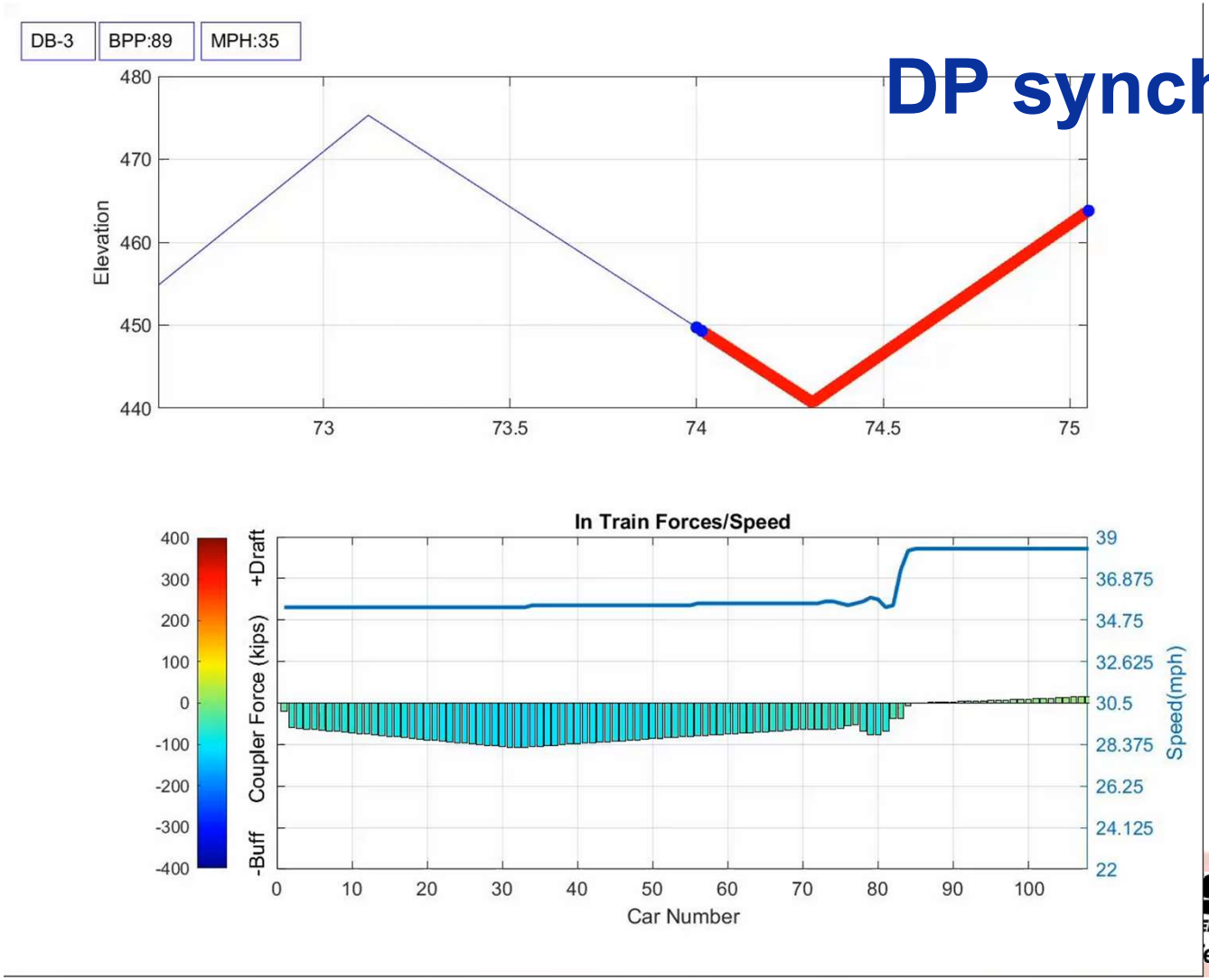
Same throttle handling as conventional case







DP synchronous mode



60W Conclusions

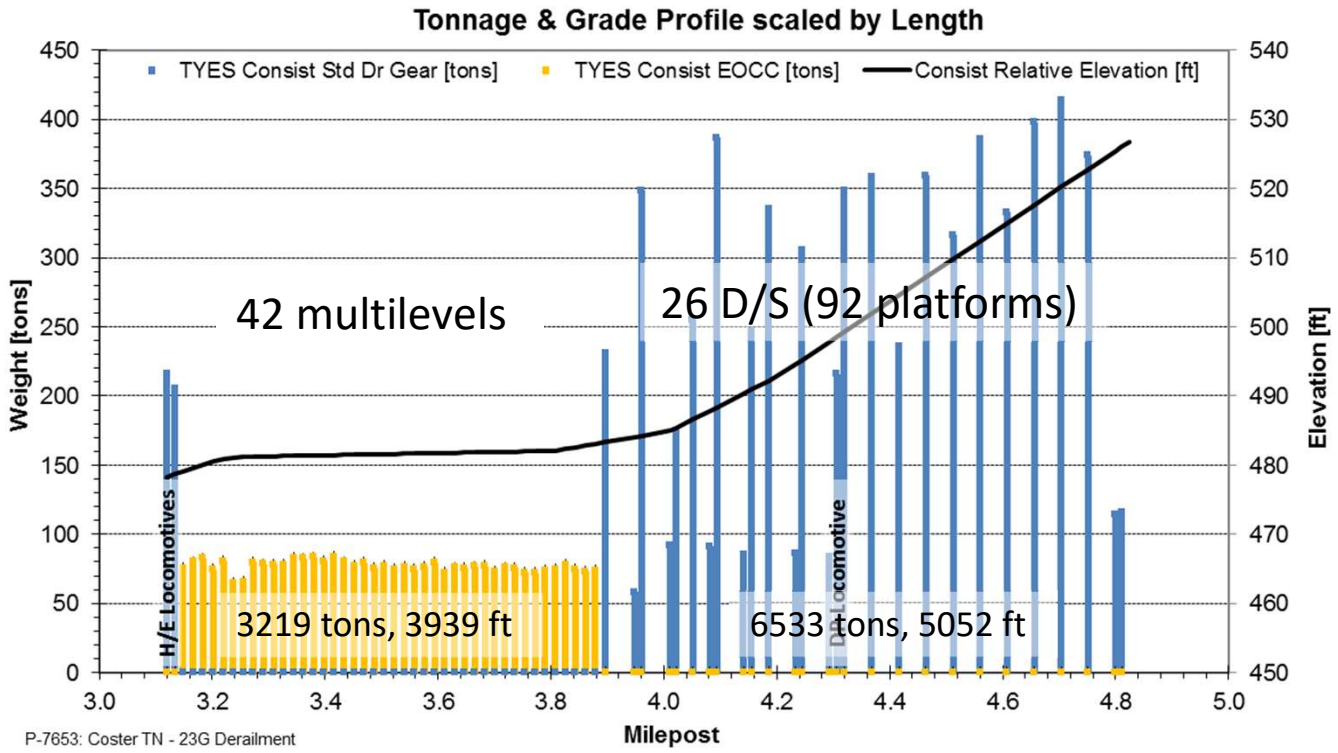
- We verified the draft forces breaking the knuckles.
- We verified 80-car trains avoid getting knuckles.
- We showed that we could use DP to manage coupler forces, and still run full-sized trains.

23G Derailment at Coster

23G Derailment at Coster

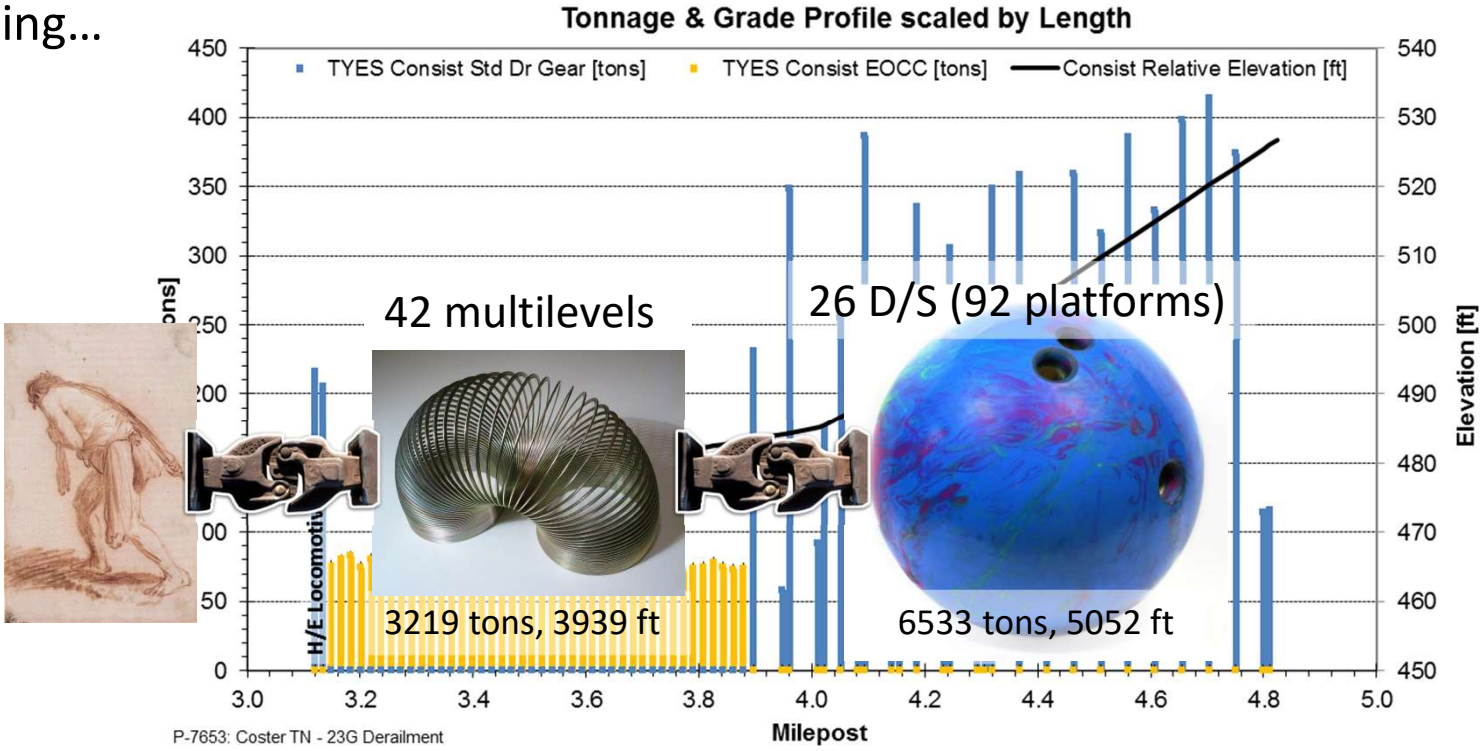
- 2x1 mid-train DP
- 68 lds, 0 mtys, 9752 tons, 9211 ft
- 42 multilevels leading 26 doublestacks
- Undulating grade in east Tennessee
- Gage ruptured under last M/L and first D/S

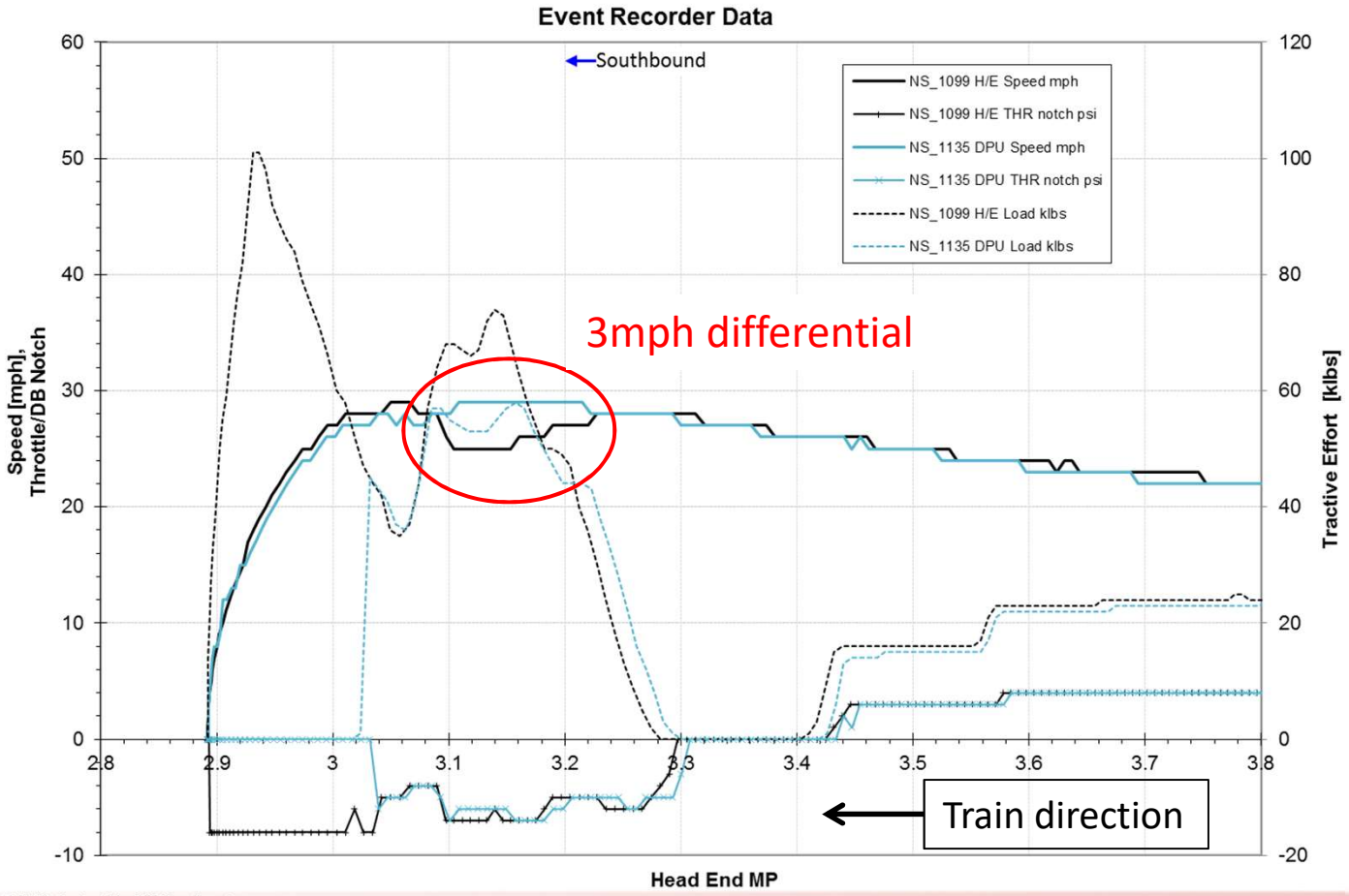
23G Coster Derailment



23G Coster Derailment

Metaphorically speaking…

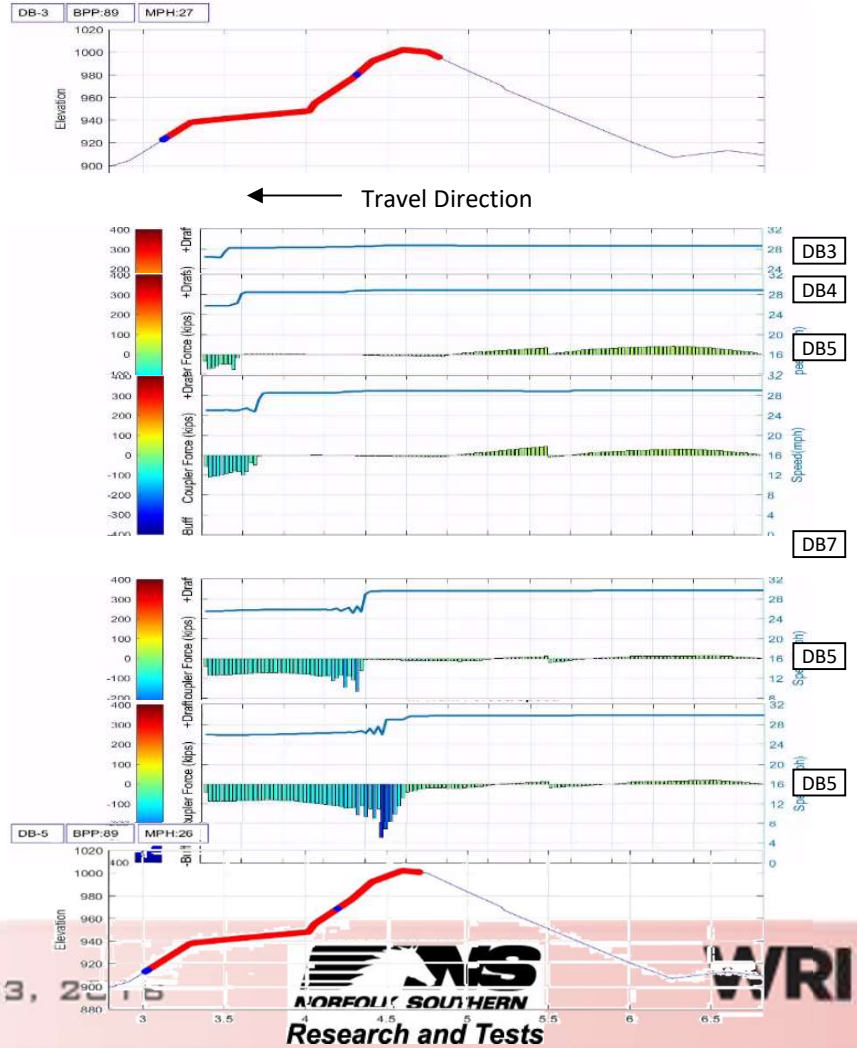




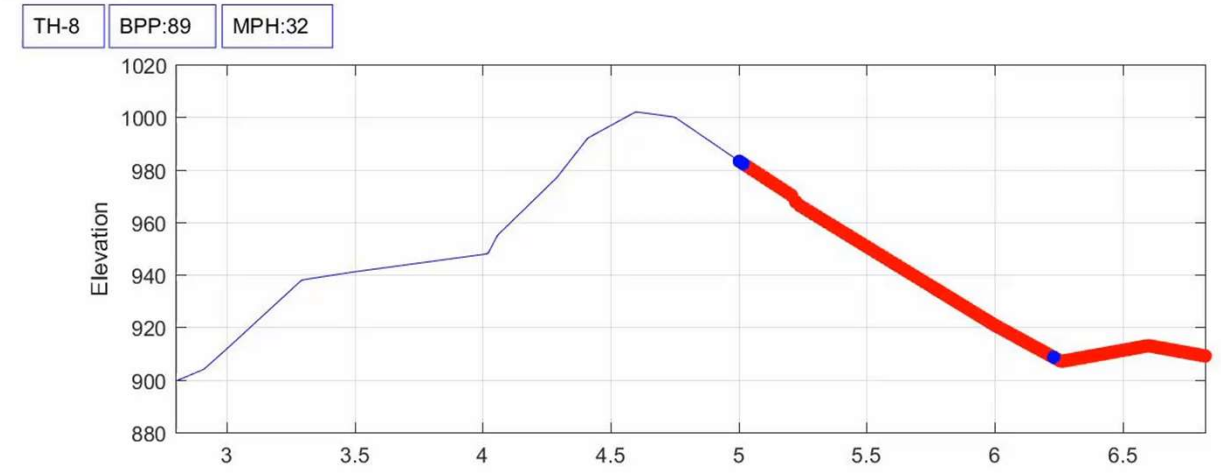
P-7653: Coster TN - 23G Derailment

TOES simulation actual conditions

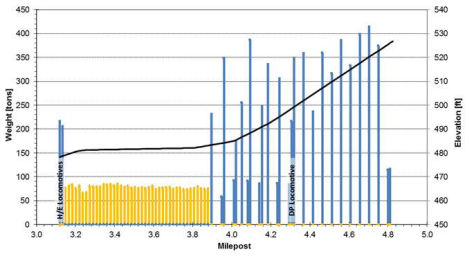
- 2x1 mid-train DP synchronous mode
- Head end decelerated 3 mph, DP accelerated 1 mph until run-in occurred

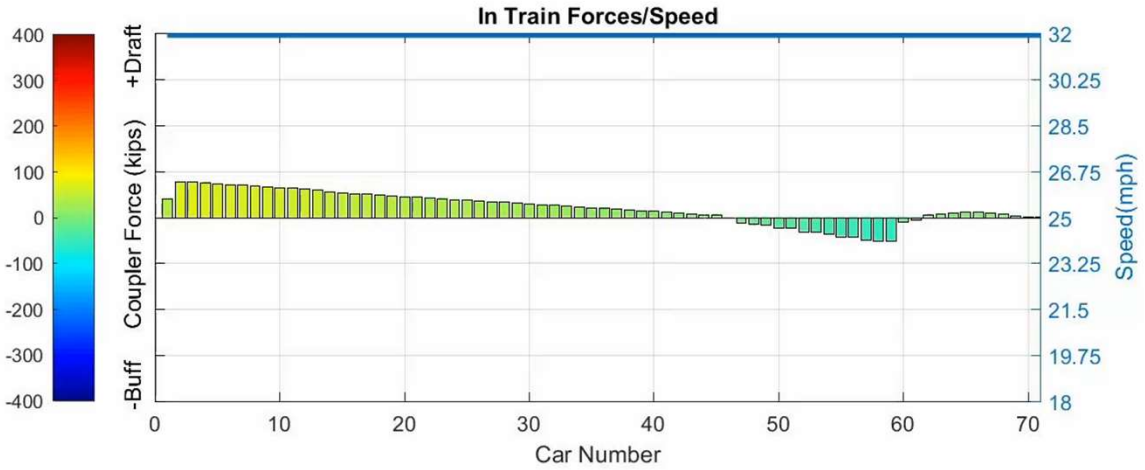


Actual conditions



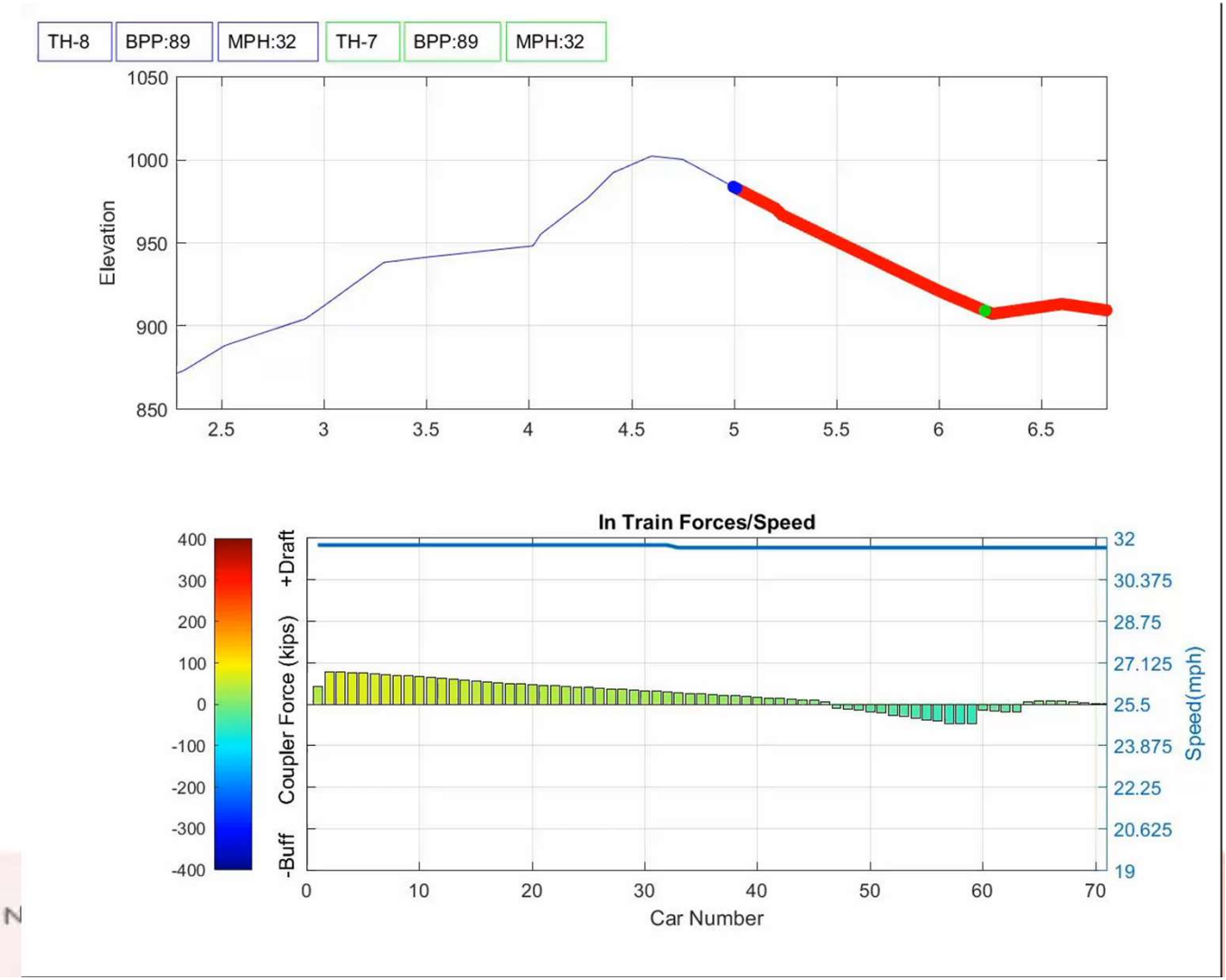
Consist



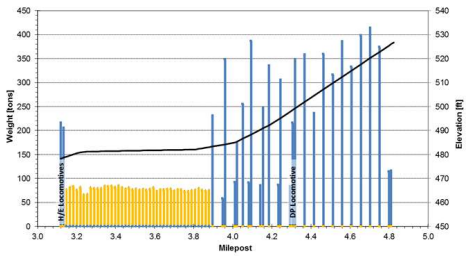


HEAVY HAUL SEMIN

Actual consist, fenced DP



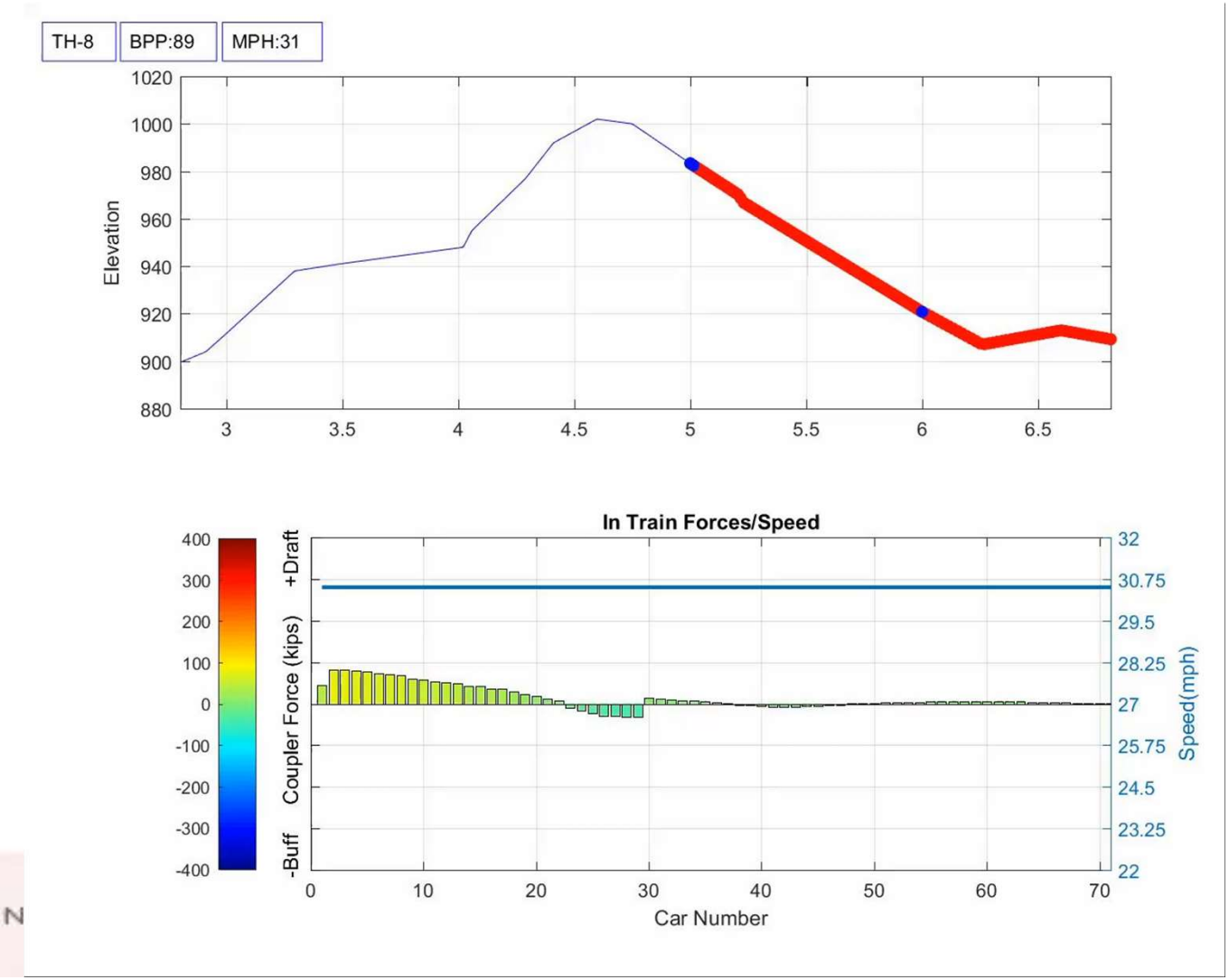
Consist



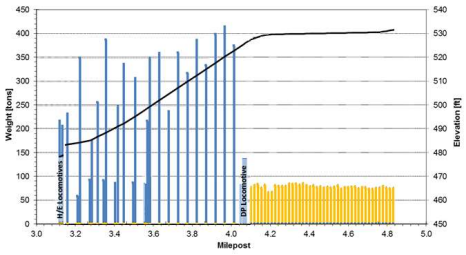
Improved train makeup

Synchronous mode

Train handling similar to original case



Consist



HEAVY HAUL SEMIN

23G Conclusions

- Significant velocity differentials can exist in large blocks of EOCC cars.
- Very large coupler forces can arise at the coupling between EOCC and conventional cars.
- DP can help, but only so much.
- Address the root problem: EOCC block position.

Conclusions

- Buff forces are more likely to result in track damage and derailment than draft forces.
- Large coupler forces tend to result from type of equipment (EOCC blocks) and tonnage (not necessarily length).

Questions, Comments, Discussion