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Breakthrough In-Train Data

How Longitudinal Force Affects

Wheel/Rail Wear

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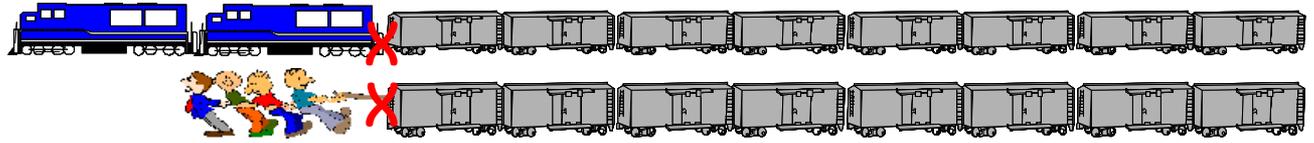
WRI 2013

Product 1: LOCOTROL Distributed Power

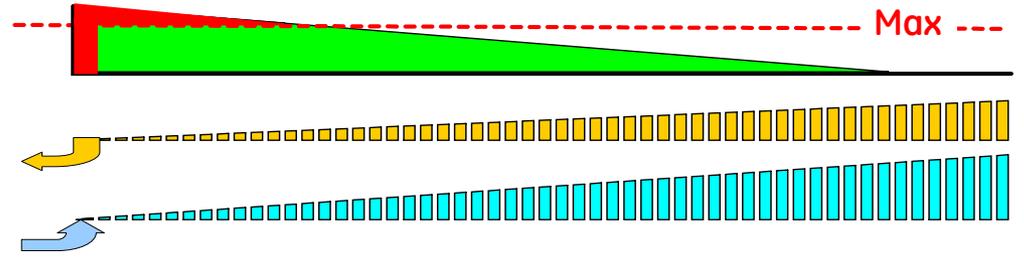
Basic Concept:

Distribute Locomotives to improve performance

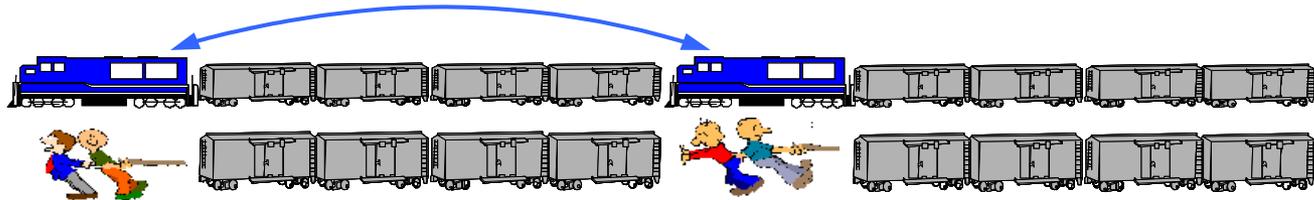
Head-End:



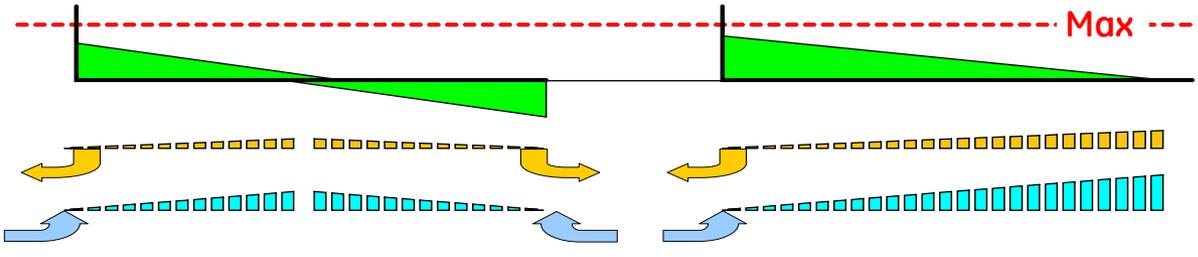
- High Forces:
(Coupler, Curve friction, slack action)
- Slow Brakes:
Air Vented at lead only
- Slow Release:
Air filled at lead only



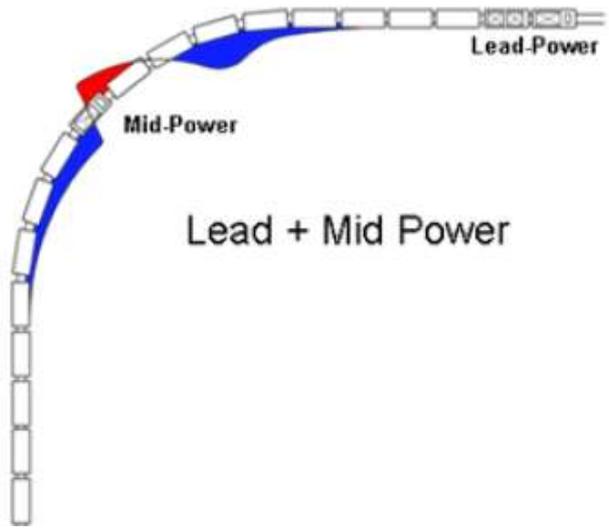
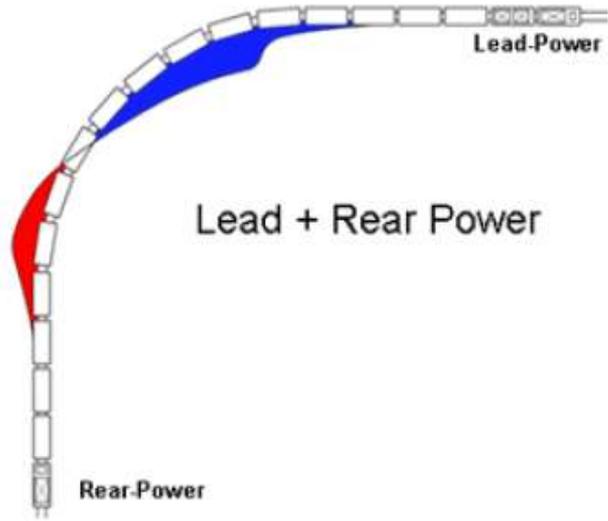
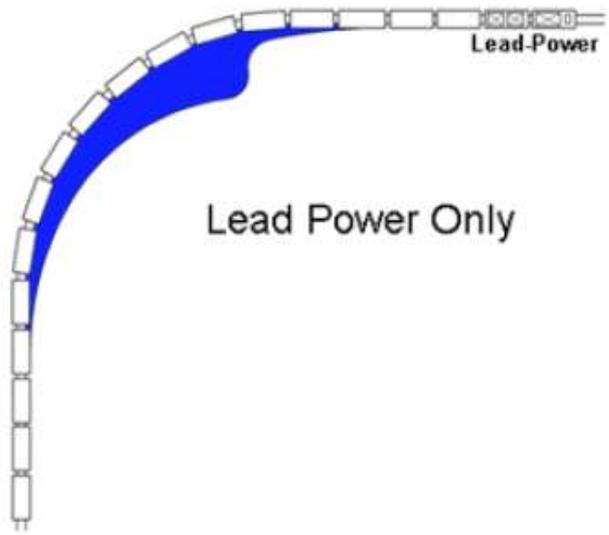
LOCOTROL DP:



- Low Coupler Force:
- Fast Brakes:
Air Vented at multiple places
- Fast Release:
Air filled at multiple places



Less Longitudinal Force, less Lateral Force



Source: Progressive Railroading Webcast, 28 July 2010

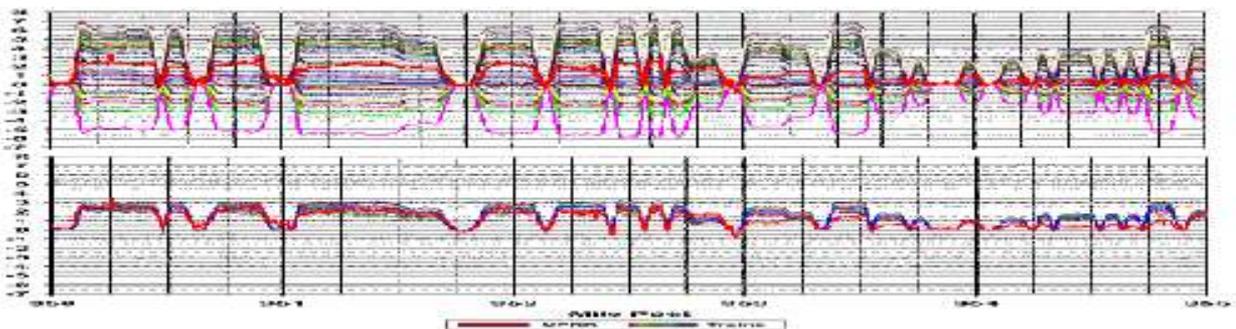
Information on Slide from ARRT



DP and Wheel/Rail Wear

Super elevation range without DP

Super elevation range with DP



Results of Changes @ MP 342



Before

The rail installed in Oct. 2004 and replaced in May 2005.

- The extreme rail wear was seen after only 7 months.

Source: Progressive Railroading webcast , 28 July 2010



After

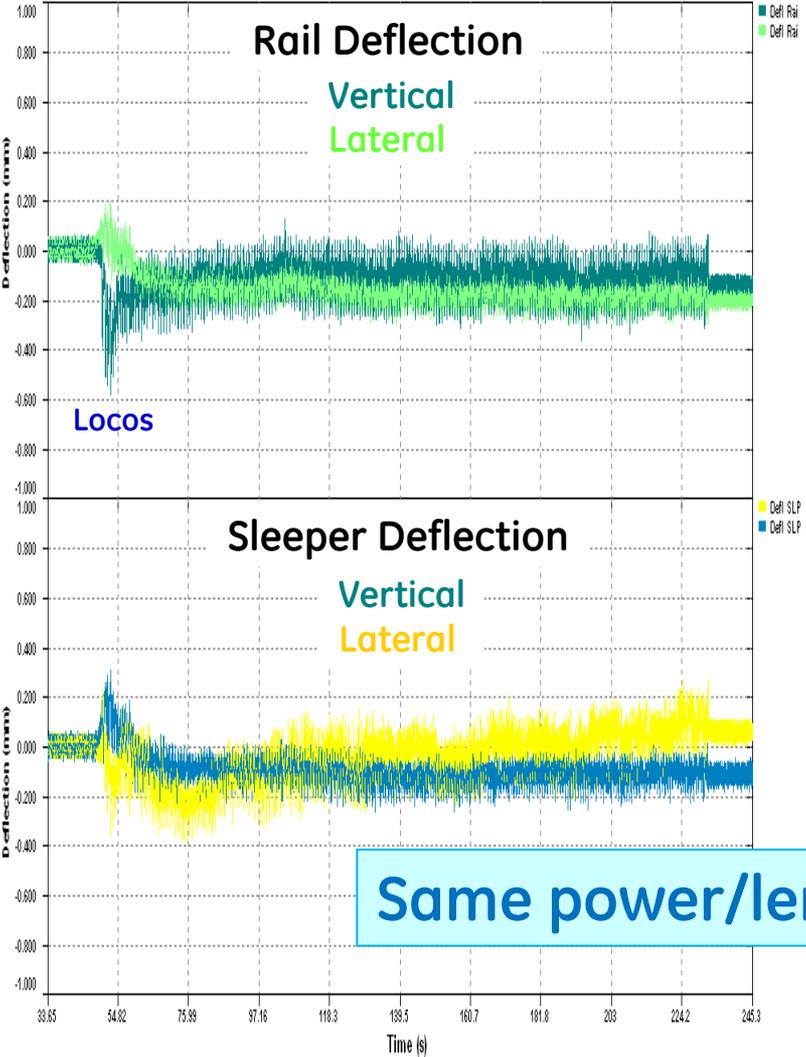
After installation in May of 2005, which is 7 months, the curve rail wear was between 1/32 to 2/32.

- This is a major improvement.
- Rail Life extended from one year to five years.

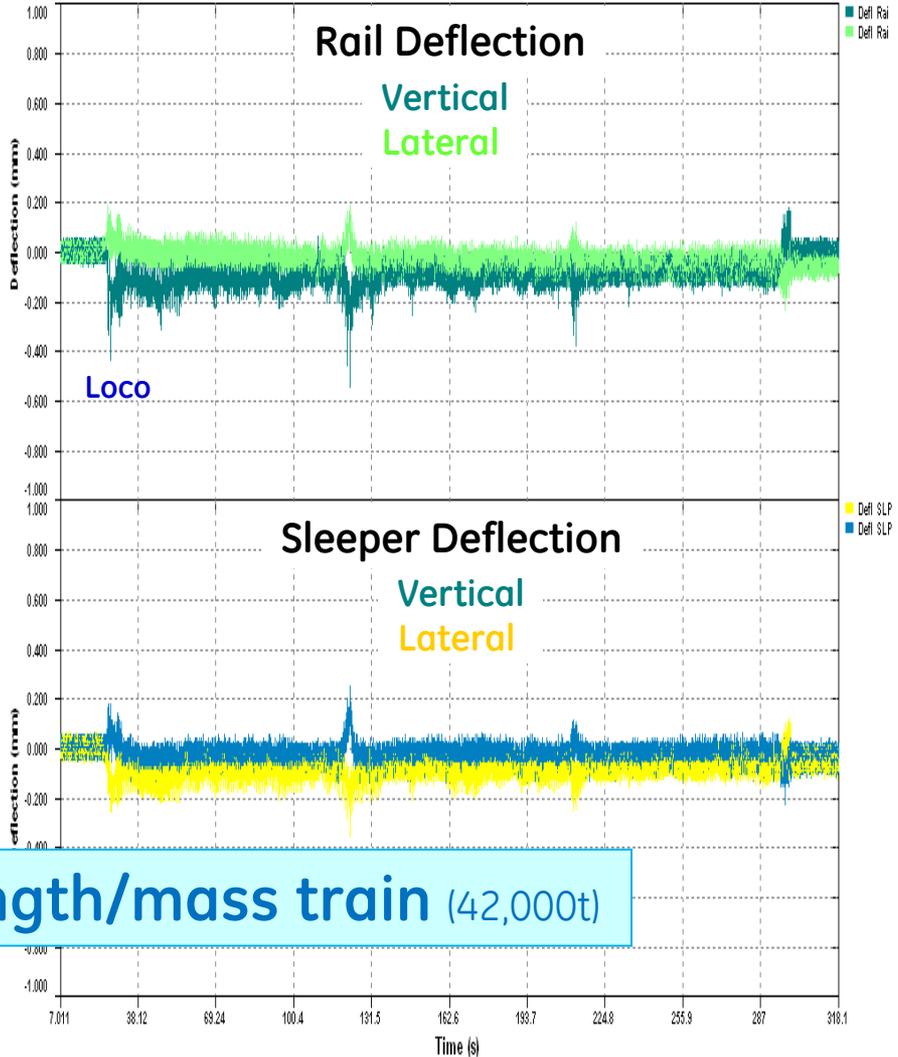


DP: Less Infrastructure Damage

Head-end Train



DP Train



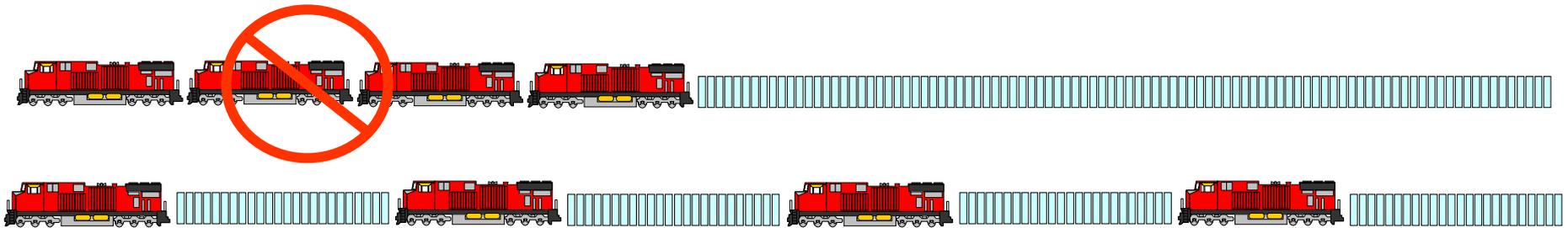
Same power/length/mass train (42,000t)



DP Controls Longitudinal Force and therefore Lateral Force:

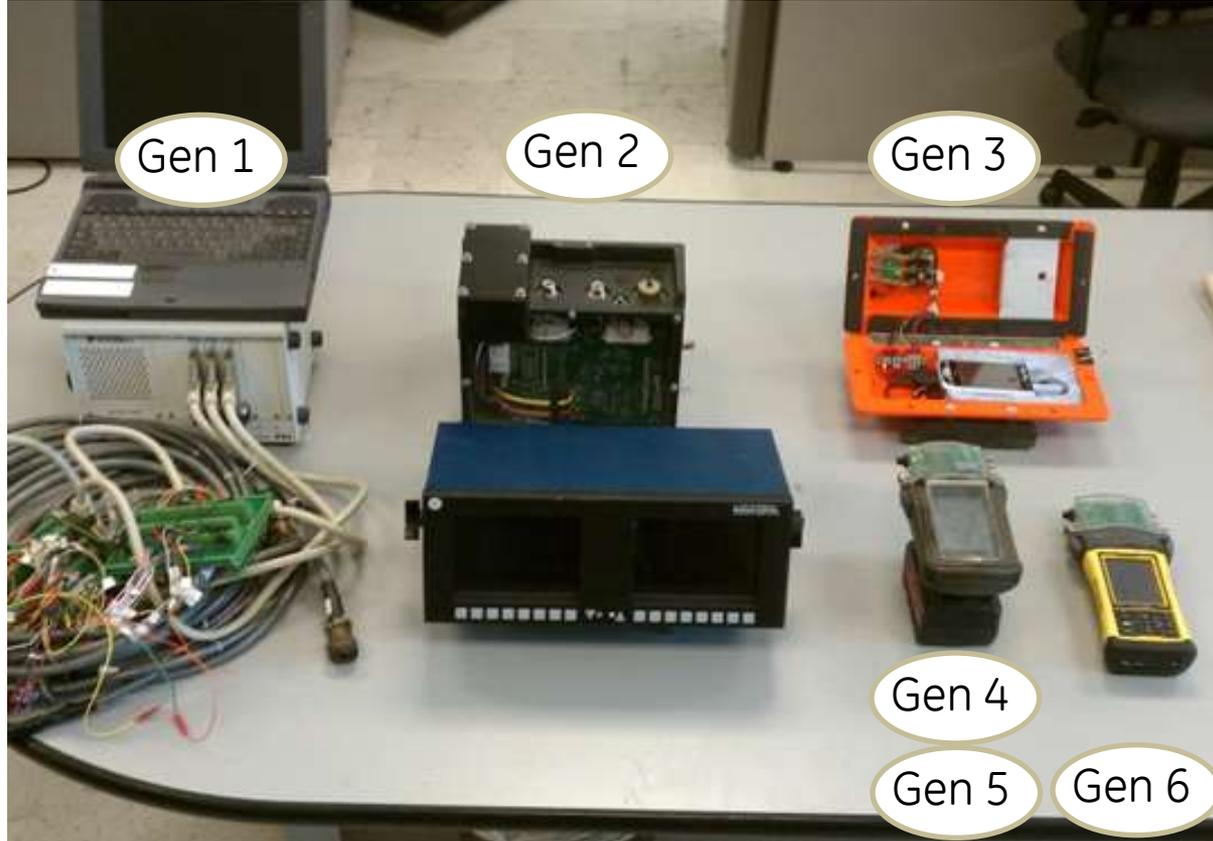
Minimizes damage to train and infrastructure

- Couplers, wheels, boggies
- Rail, sleepers, road-bed



Every Locomotive should be Distributed

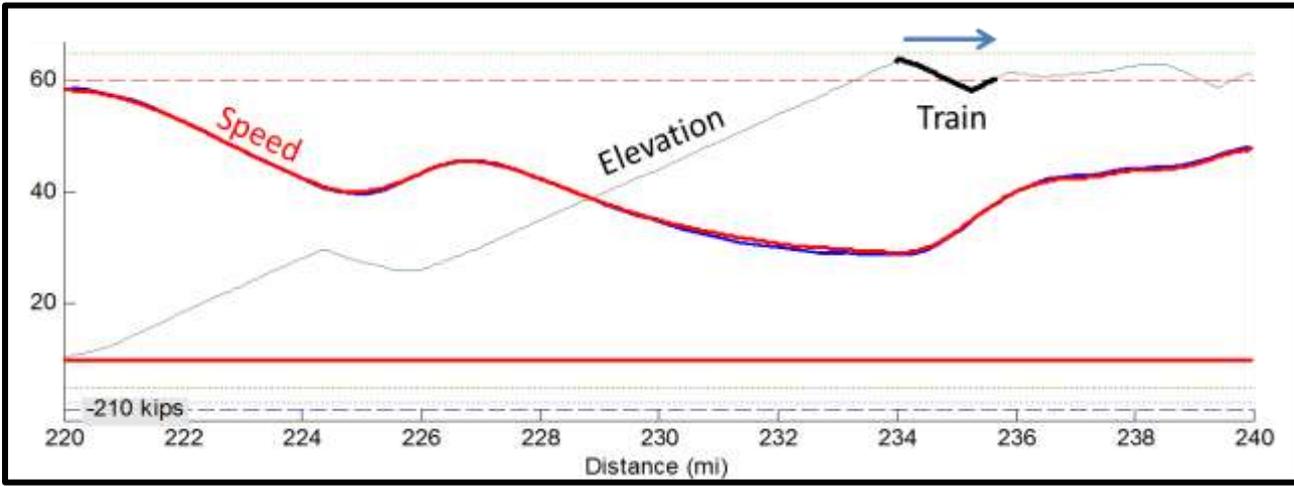
In-Train Instrumentation



- Gen 1:** Single location
8ch, 100 S/sec, 8hrs, 15lb
- Gen 2:** Multi (radio) locations
4ch, 0.5 S/sec, 4hr, 30lb
- Gen 3:** Multi locations
4ch, 10 S/sec, 6hr, 15lb
- Gen 4:** Multi location waterproof
4ch, 10 S/sec, 10hr, 8lb
- Gen 5:** Multi location waterproof
4ch, 50 S/sec, 8hr, 8lb
- Gen 6:** Multi Location waterproof
4ch, 100 S/sec, 96hr 9lb

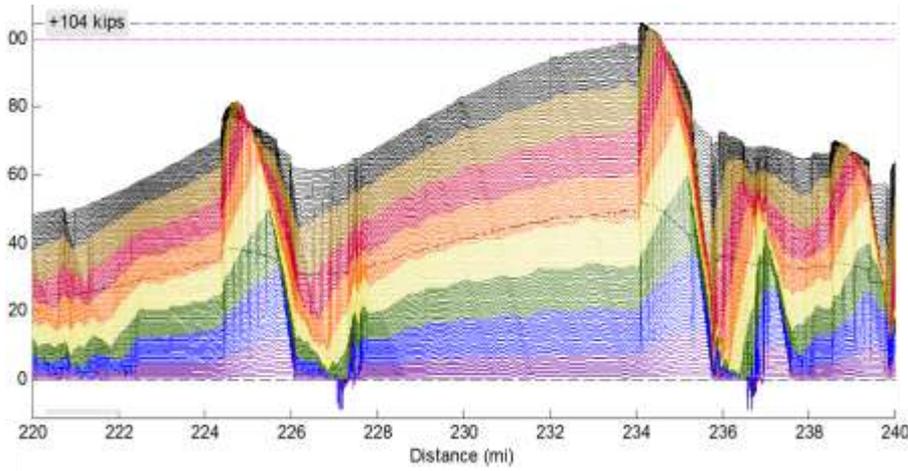
Innovation and system Improvement can only be as good as the visibility into the situation..

DP In-Train Force Modeling:

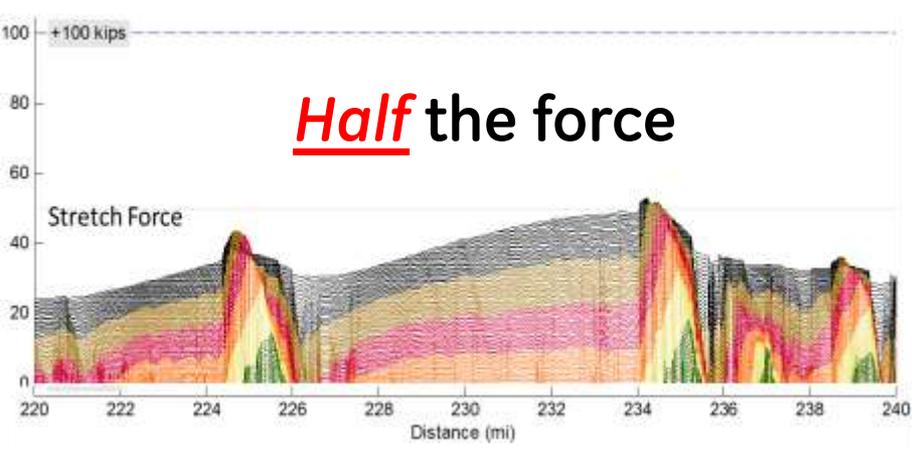


Same 10,000' - 10Kton - 2 Locomotive Train modeled as:

Conventional Head-End Power



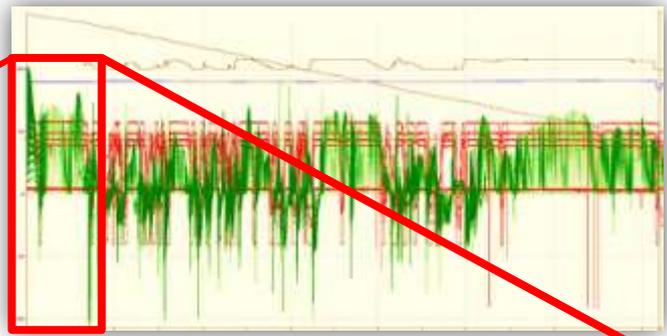
Distributed Power



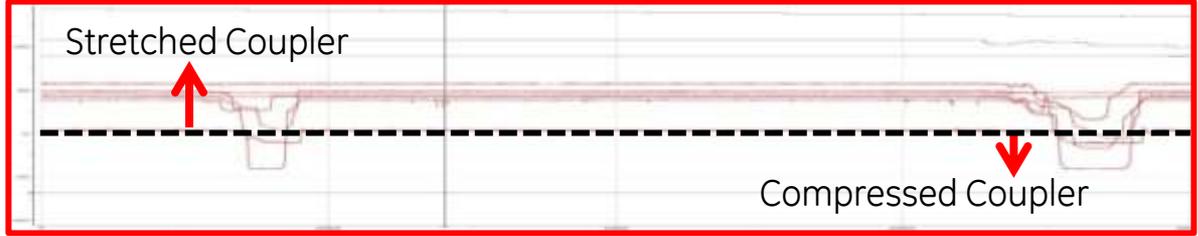
DP In-Train Force Model Validation:



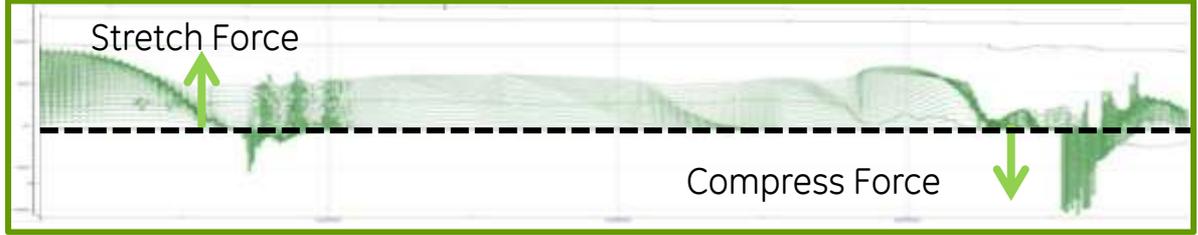
Slack detection:
Data systems every 11 cars
100 Sample/Sec
0.1" Resolution



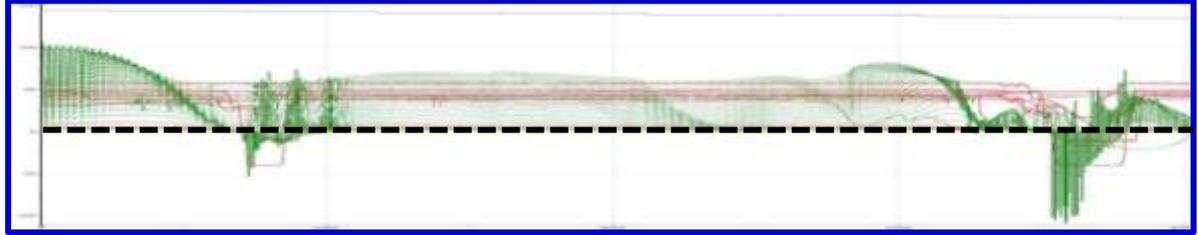
**Measured slack data
from MP143-135:**



**GE Simulation force
data for MP143-135:**



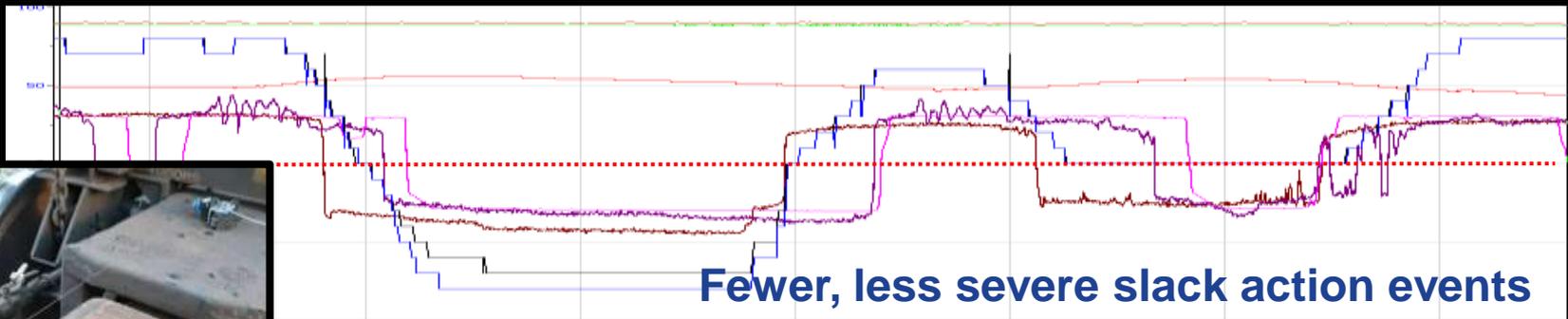
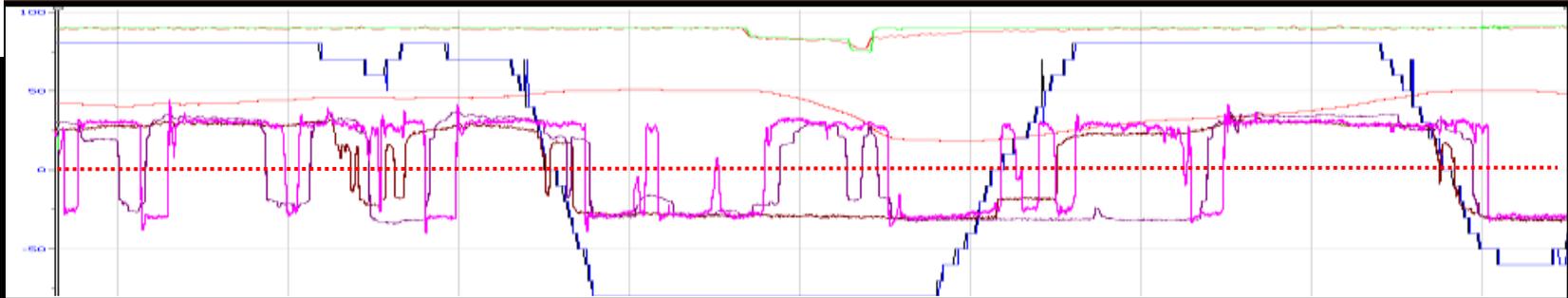
**Combined data:
Excellent Correlation**



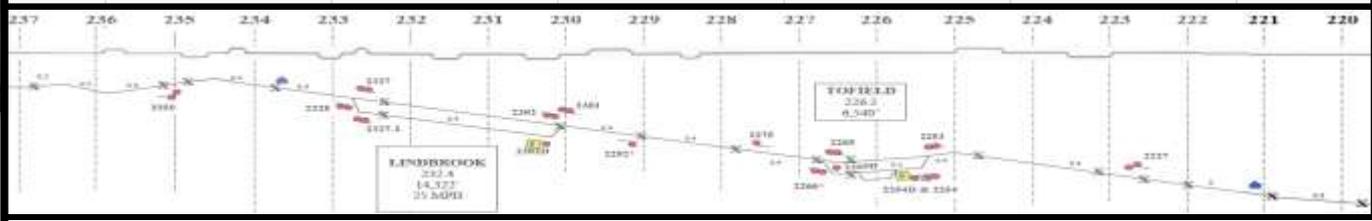
DP Elements: Independent Control

Minimizes in-train forces:

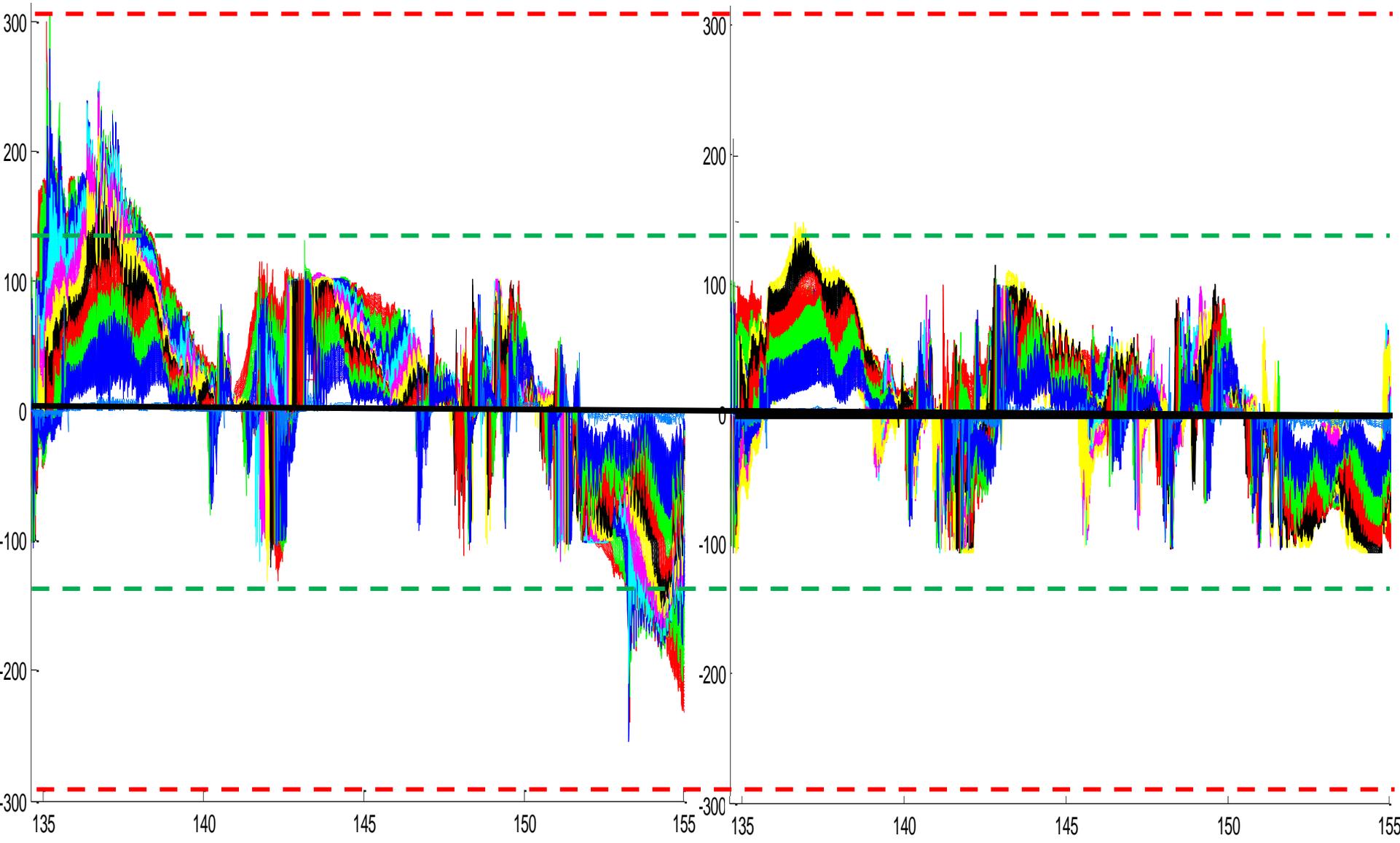
Remote:
Throttle



Slack data from real train



Longitudinal Force Sim: DP Synch vs. Independent



Product 2: Trip Optimizer Train Energy Management

TO Currently Controls Throttle/DB on:

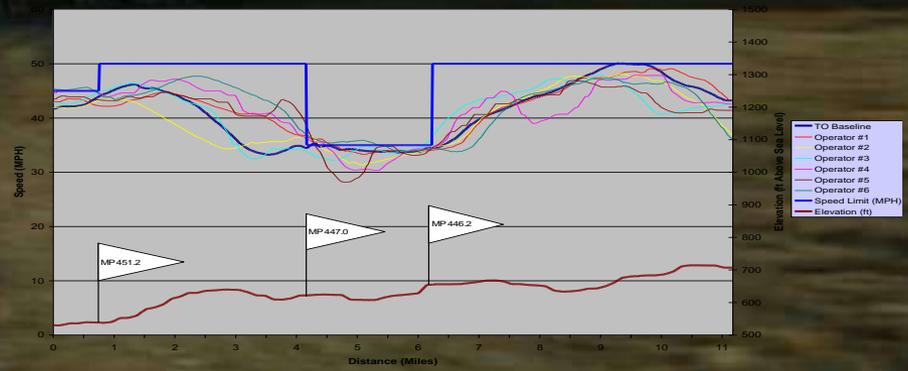
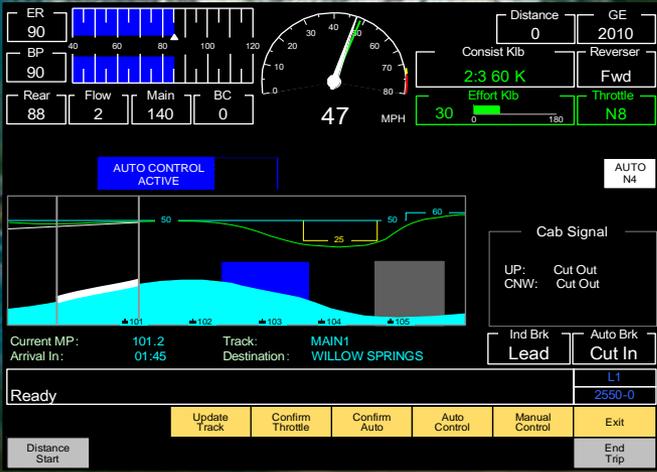
- Head-end trains
- DP Synchronous trains
- DP Independent trains

TO will Soon Control:

- Air Brake Prompting
- Automatic Air Brake

TO will Eventually Control:

- Full ATO train Ops



State of the Art Train Data Equipment



PPC-Daq R7

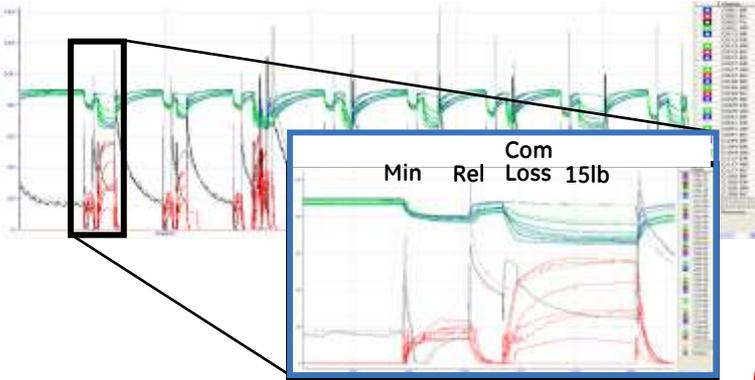
4 Channel + GPS

Pressure/0-5V selectable

100 Sample/Sec

86hr logging max (12hr/battery)

0.01 psi, 0.01", 0.01CFM



Pressure Interfaces

3/32" tubing/valve quick disconnects

- Glad-hand gasket
- Single Car Test Port
- Service Portion Gasket



0-5V Interfaces

- 0 to 200 CFM high precision flow meter
- 36" travel string pot for slack measure



NEW!

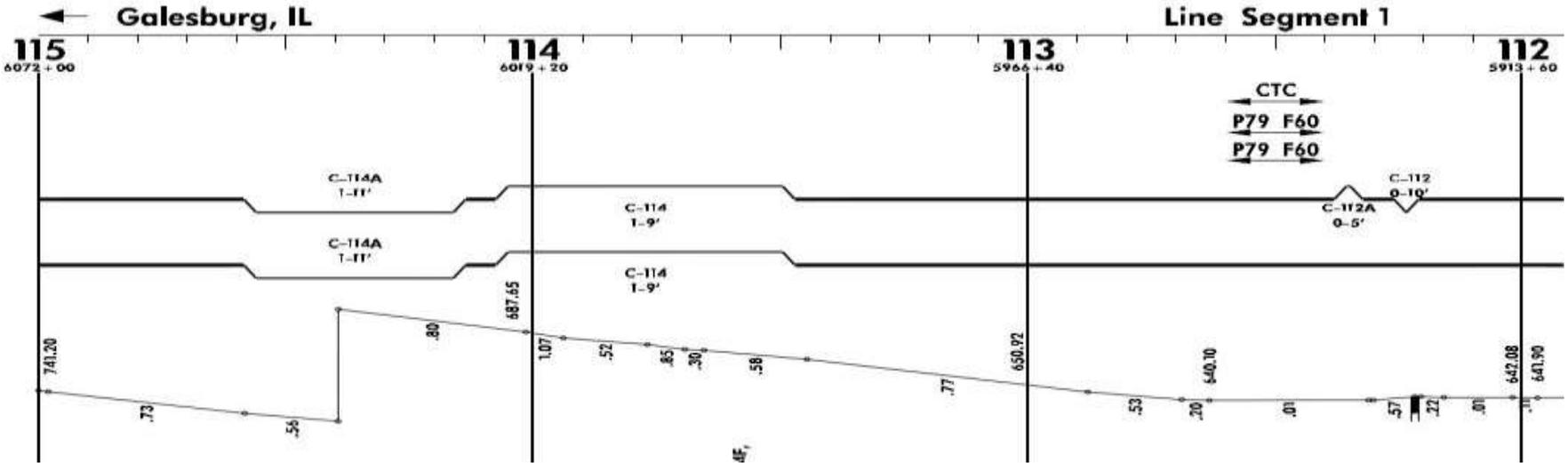
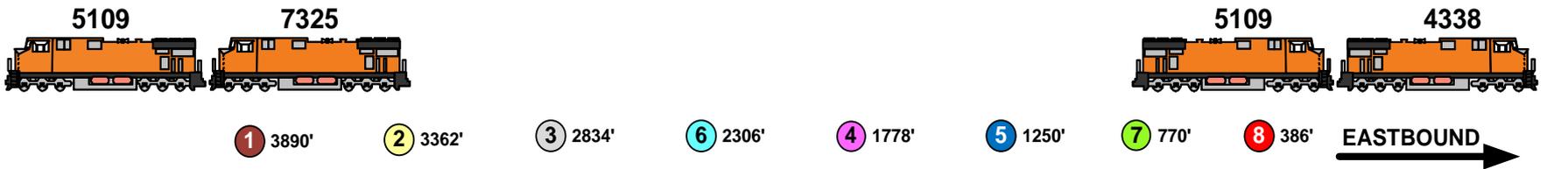
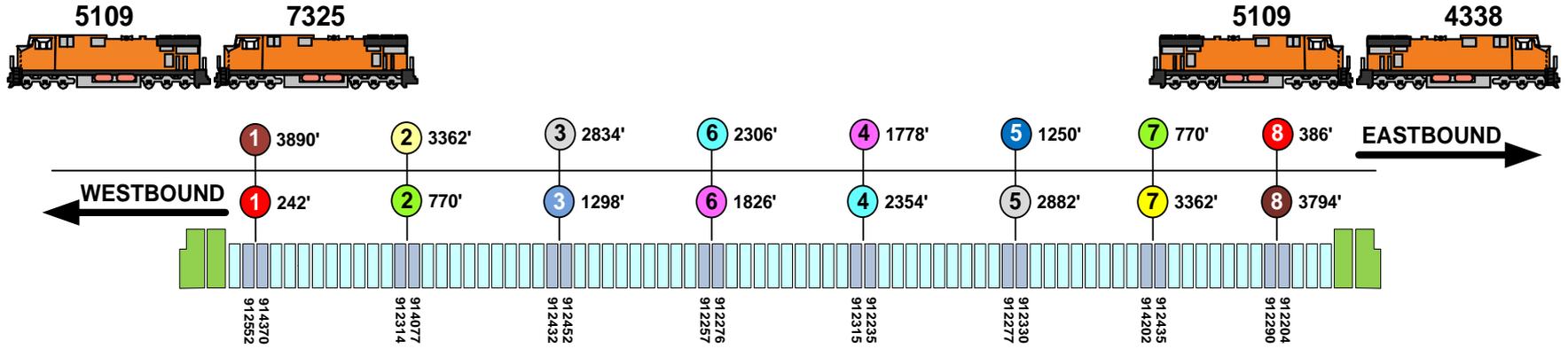
- Temp: 0.1 Degree f, 100s/s



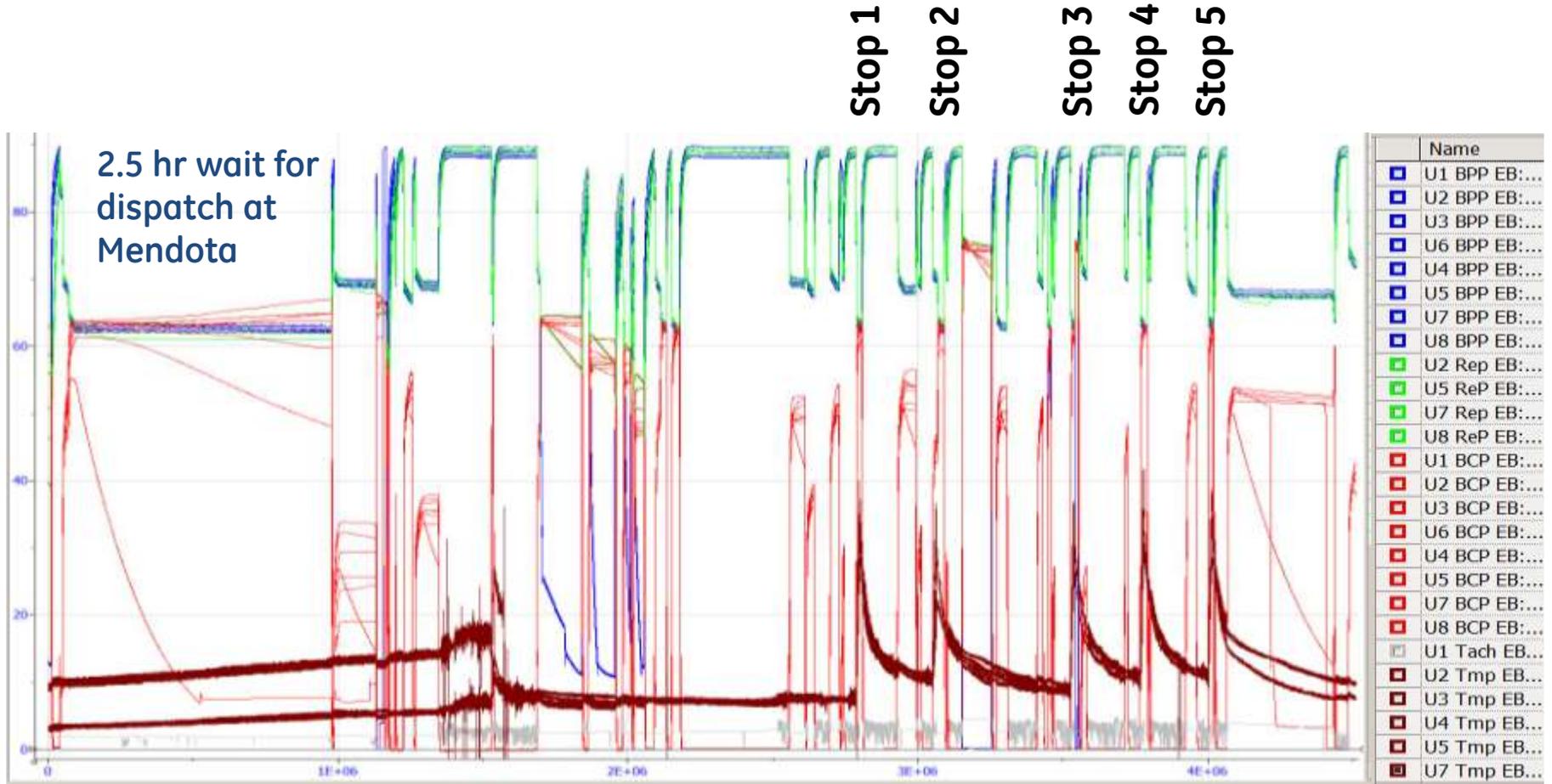
MU 27 pin connector
Converts throttle TLs to stepped voltage for capture of Notch Commands

BNSF, Mendota: Wheel Heat Stop Tests

train configurations:

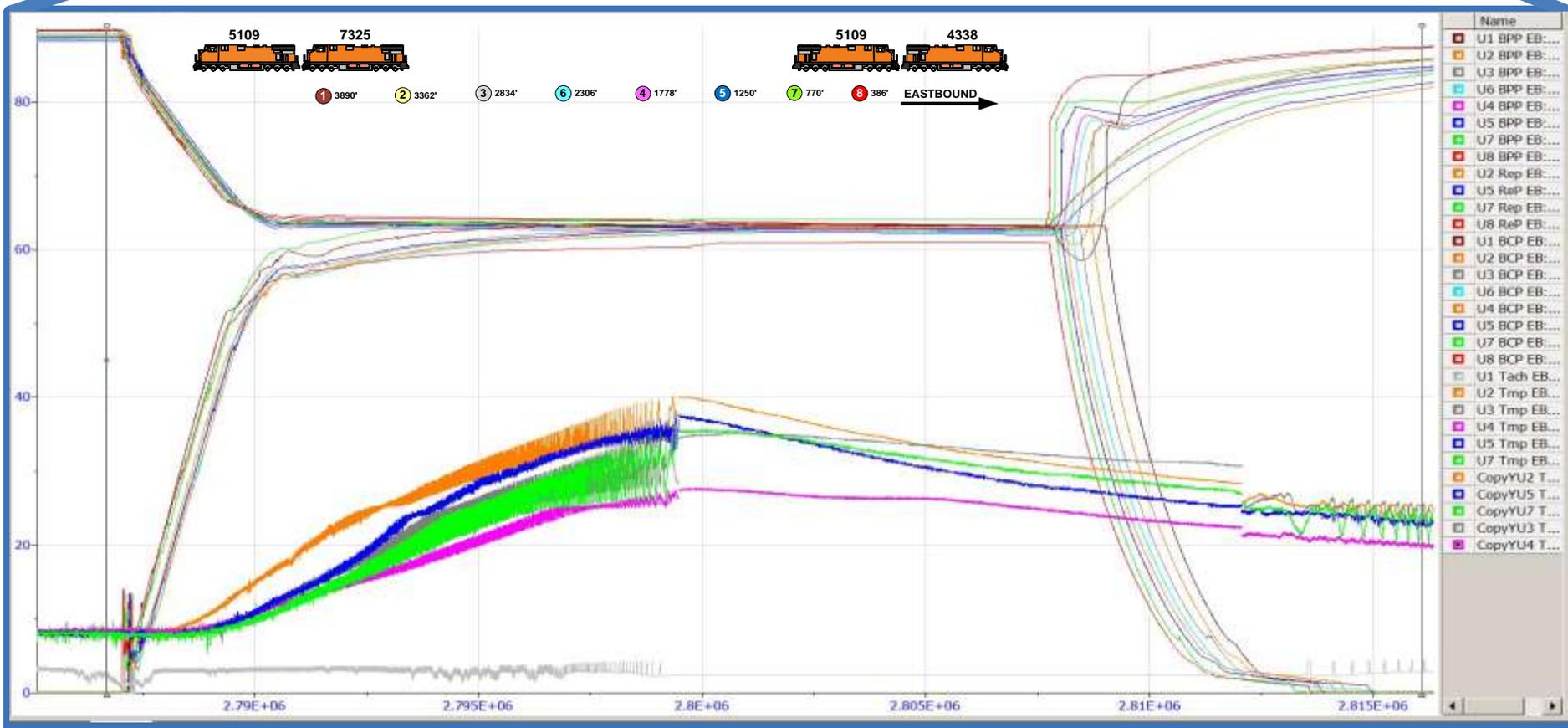
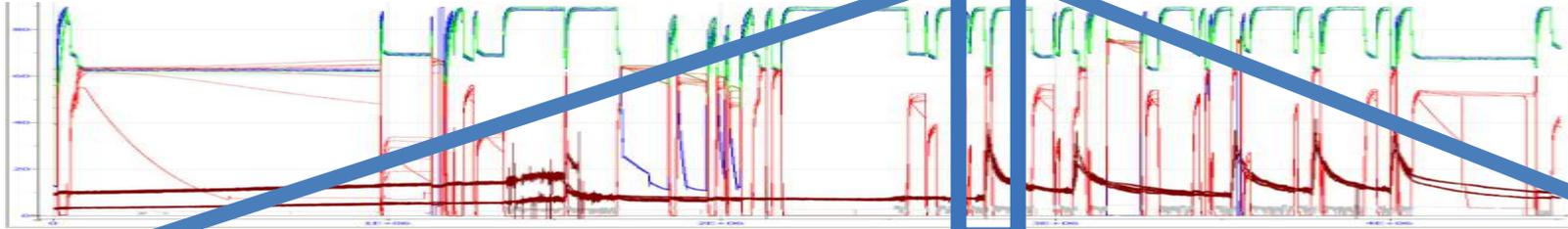


Day 3 Stop tests

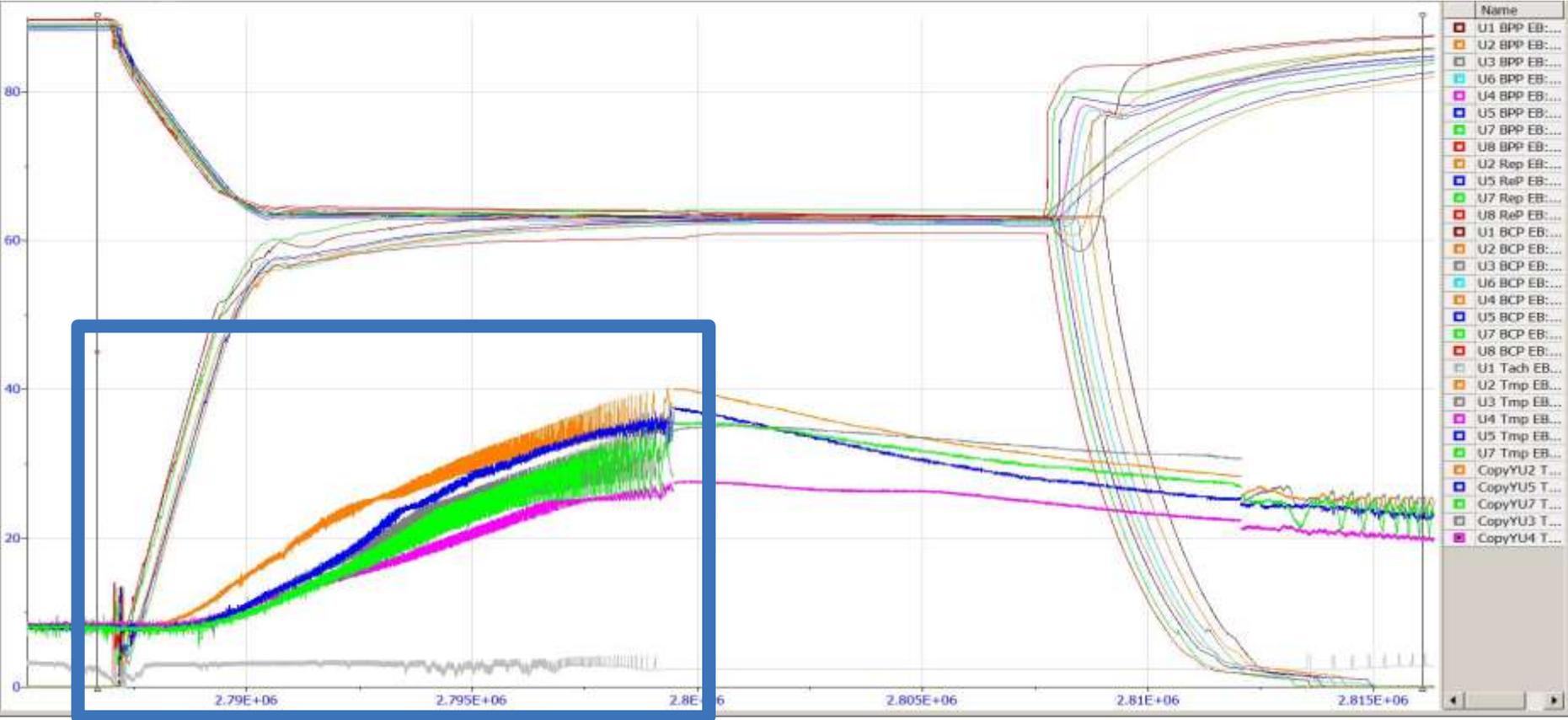
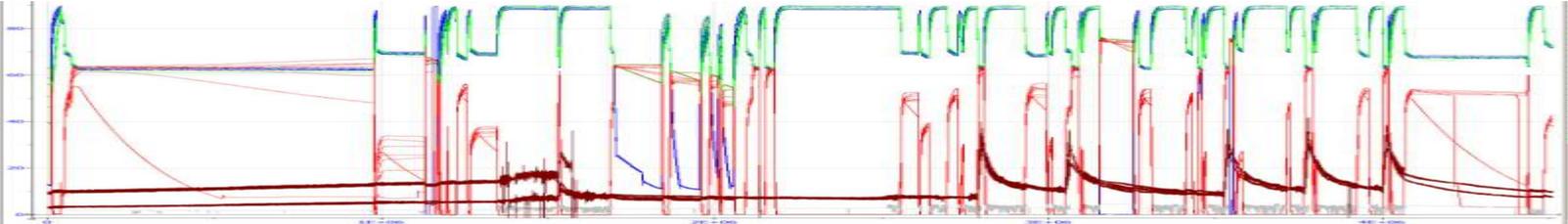


163 Million samples taken in 10 hours

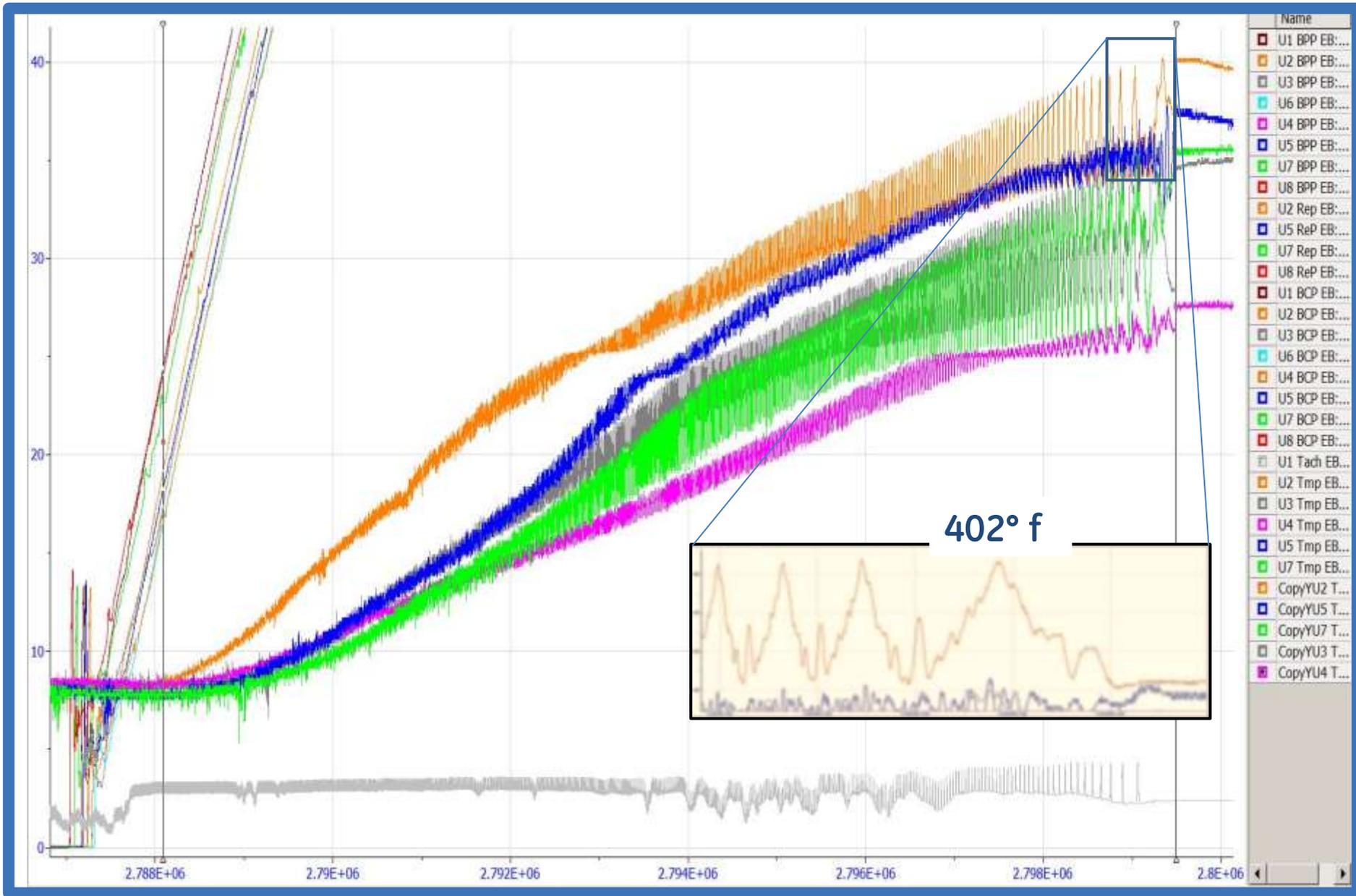
First PTC Penalty Stop (colored by unit)

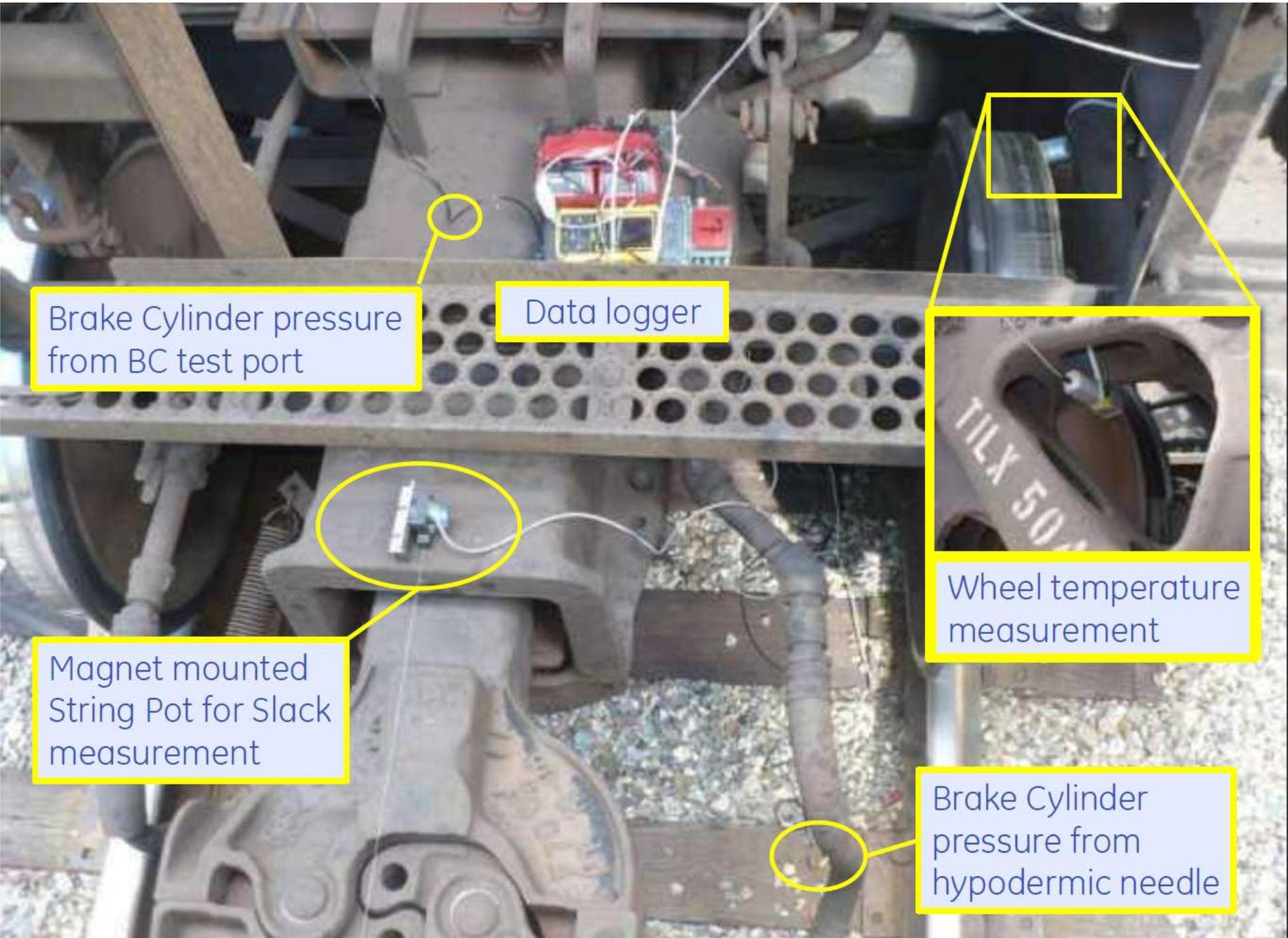


PTC Penalty Stop 1



Stop 1: 114s to stop, Max temp 402f





Brake Cylinder pressure from BC test port

Data logger

Magnet mounted String Pot for Slack measurement

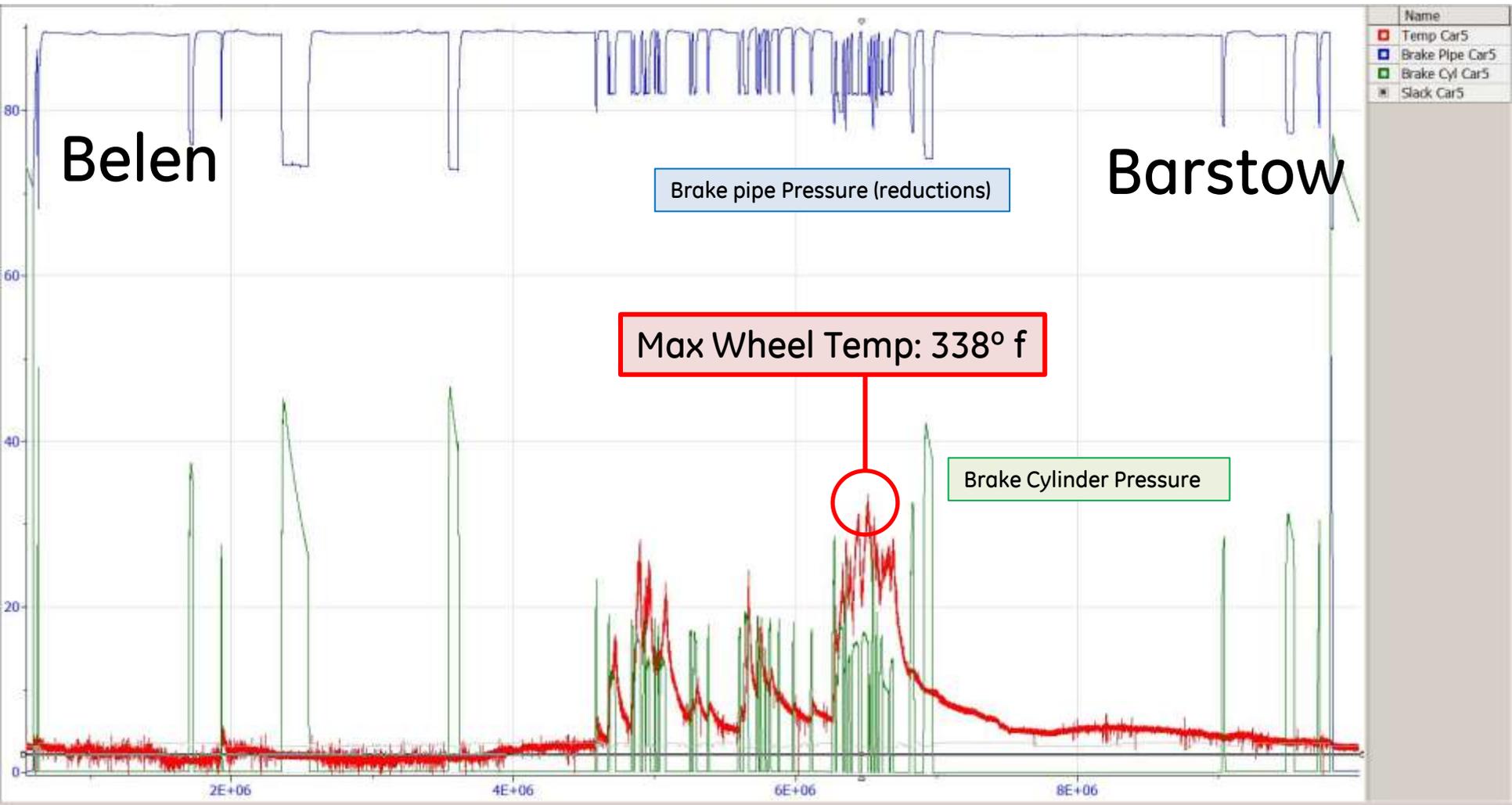
Wheel temperature measurement

Brake Cylinder pressure from hypodermic needle

BNSF, Seligman Dec '12 Long Downhill

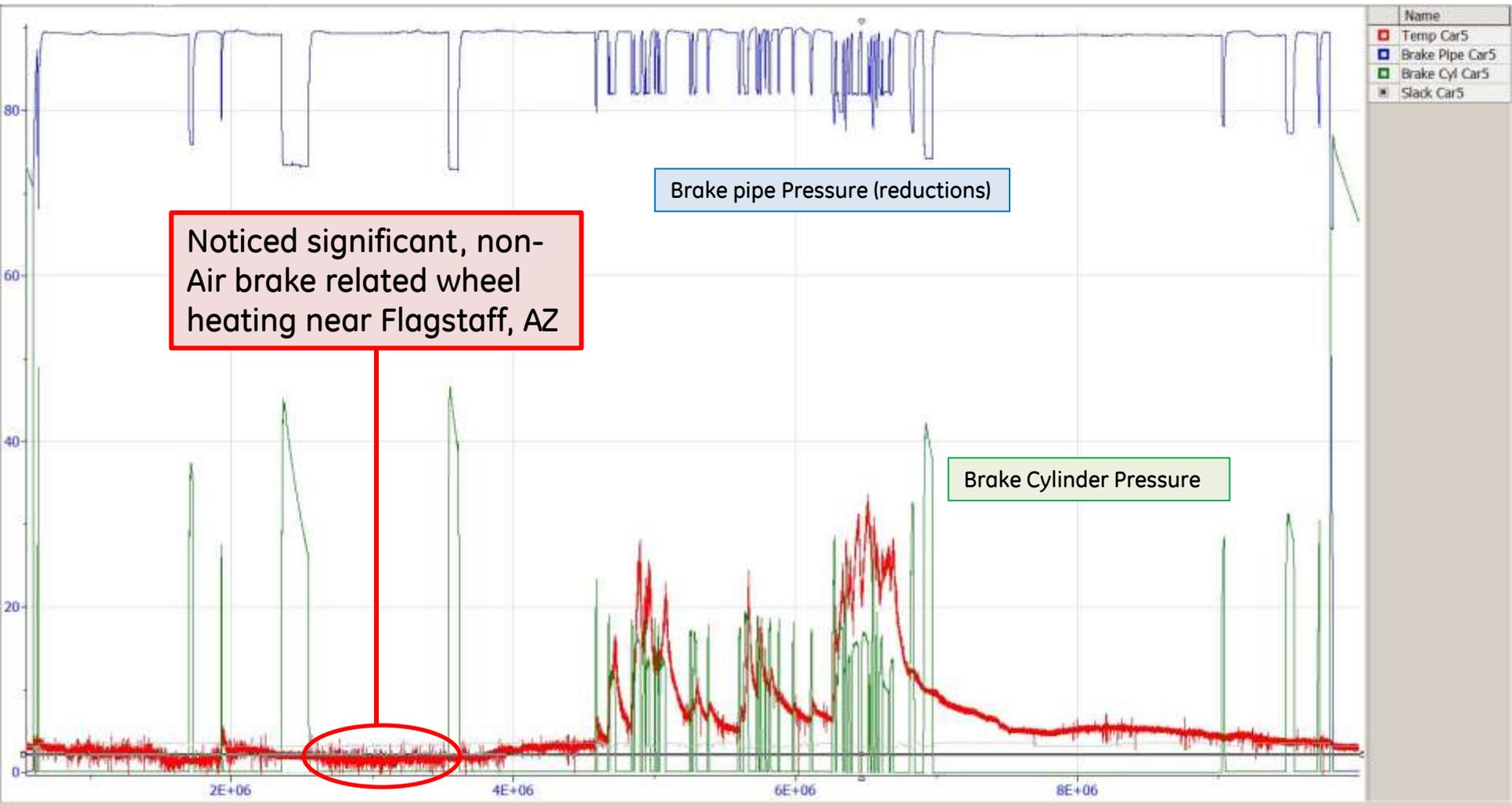
Investigation: Repetitive braking was not causing excessive wheel heating

Goal Met: wheel heating characterized, no brake-Fade Risk



BNSF, Seligman Dec '12 Long Downhill

New Investigation: Look at Areas of "interesting" data...

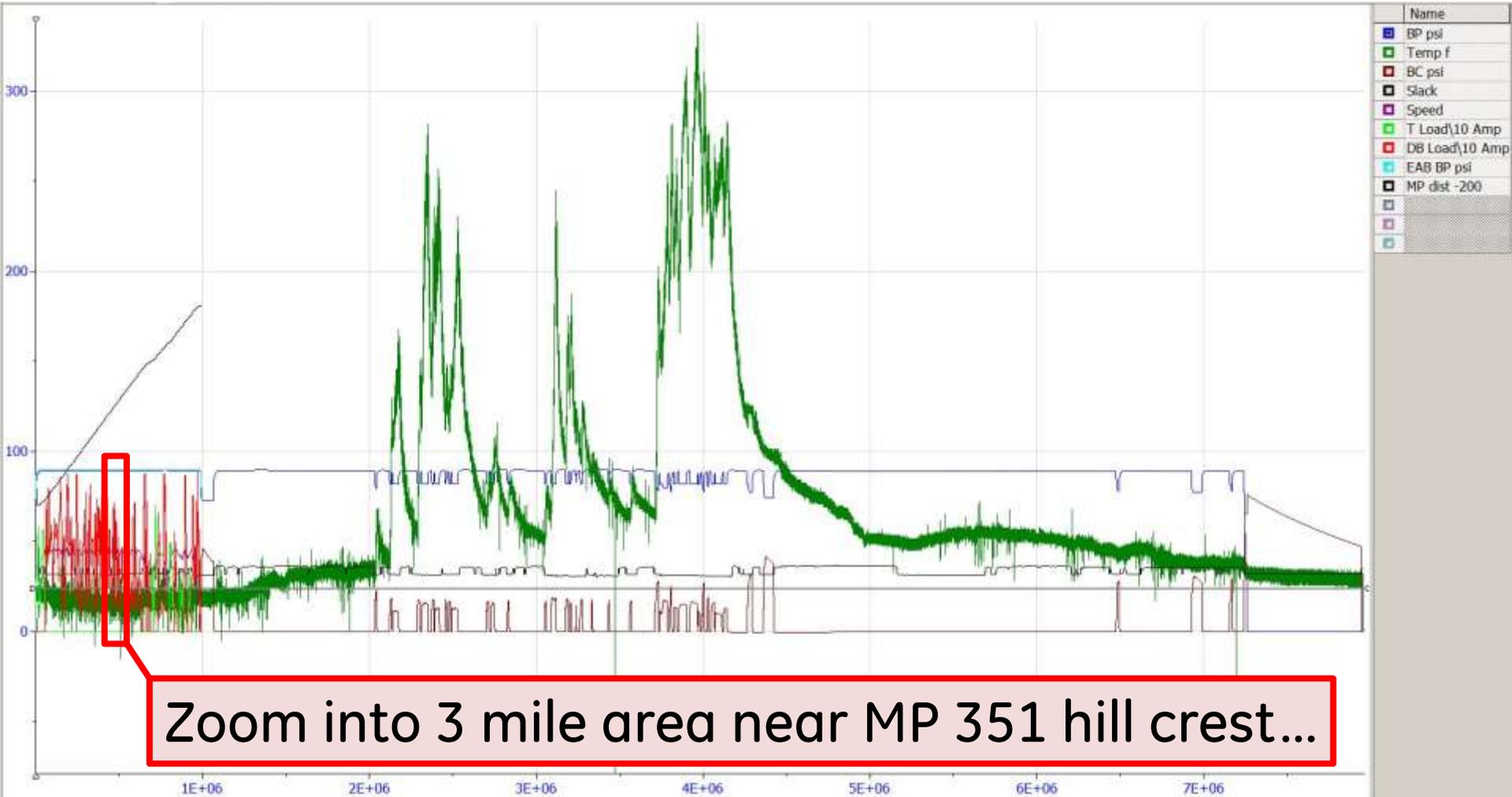


BNSF, Seligman Dec 2012 Long Downhill

New Investigation: "Interesting" data...



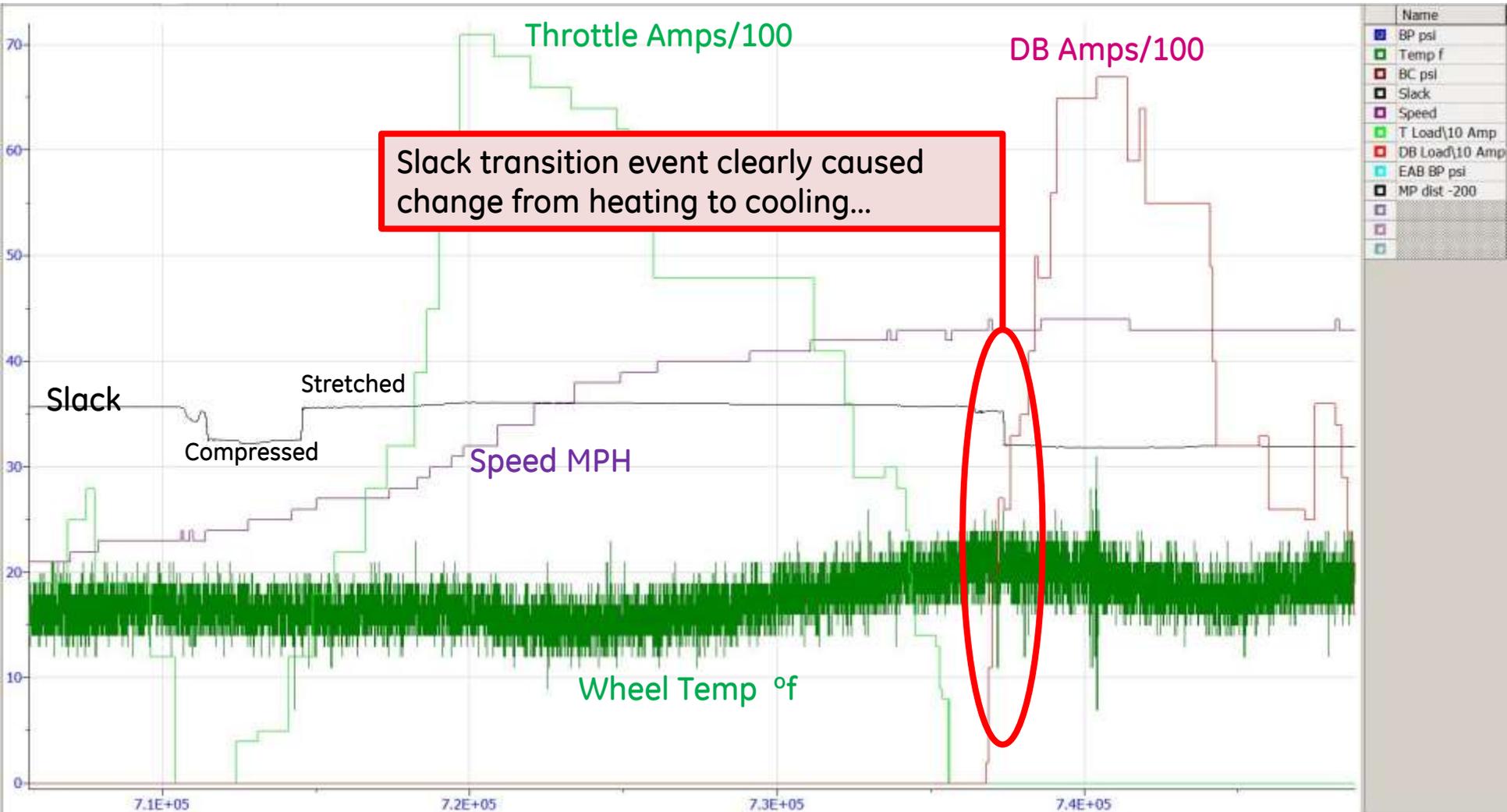
BNSF, Seligman Dec 2012 Long Downhill



Wheel temp Changes with no Brake Apps:

Found: Longitudinal Force causing Wheel heating or cooling...

Cause: Longitudinal force in curves causes Lateral force, which, when high enough, causes wheel flanging or un-loading causing heating/cooling.



Hypothesis test:

Need to correlate:

- Longitudinal Force Factors
 - Grade
 - TE/DB
- Lateral Force Factors
 - Curvature
- Train (Temp Sensor) Location
 - Mile Post

With:

- Measured indication of Force
 - Slack State
- Indication of lateral wear force
 - Temperature

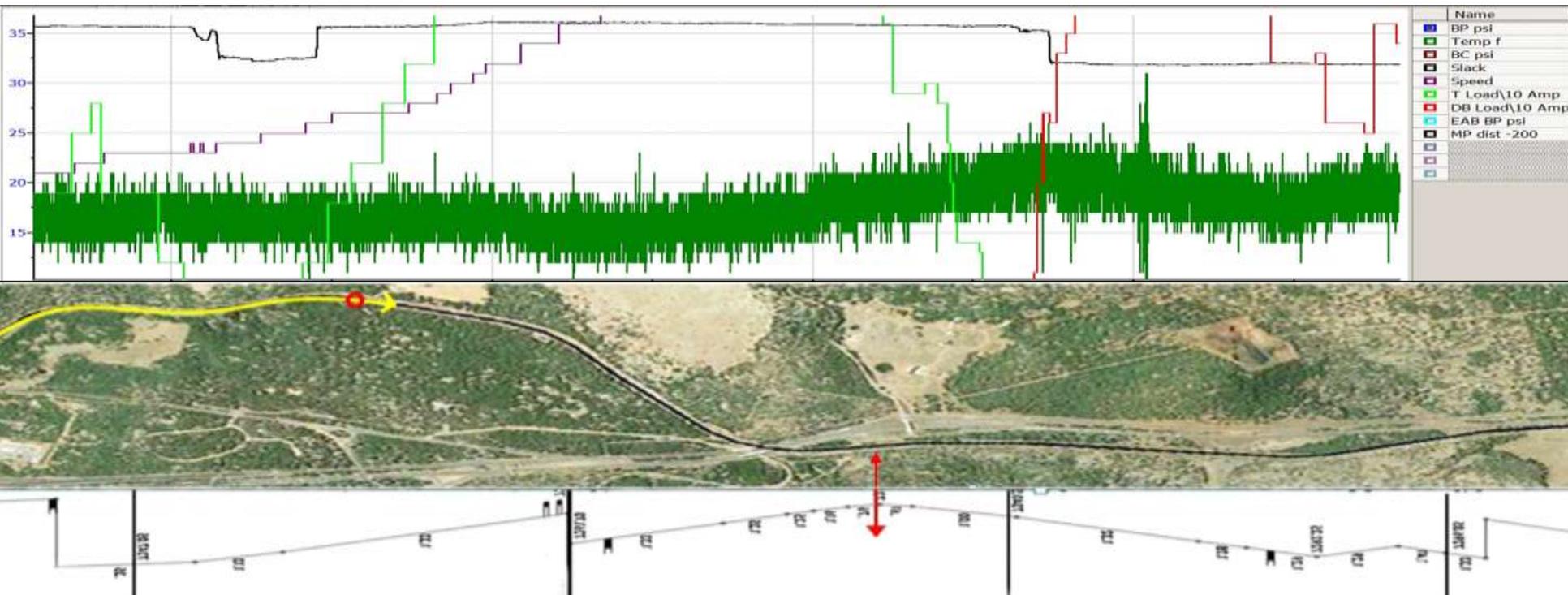
Hypothesis test:

Need to correlate:

- Longitudinal Force Factors
 - Grade (**Track Map**)
 - TE/DB (**Event Recorder**)
- Lateral Force Factors
 - Curvature (**Google Earth**)
- Train (Temp Sensor) Location
 - Mile Post (**Event Recorder**)

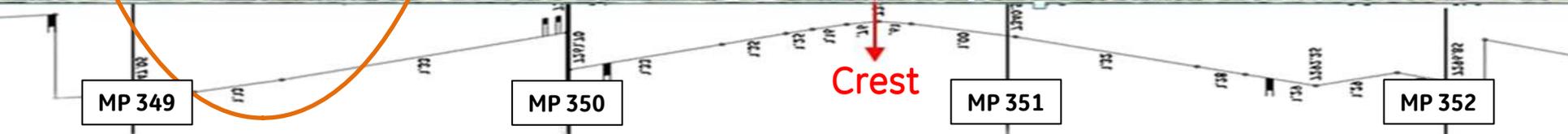
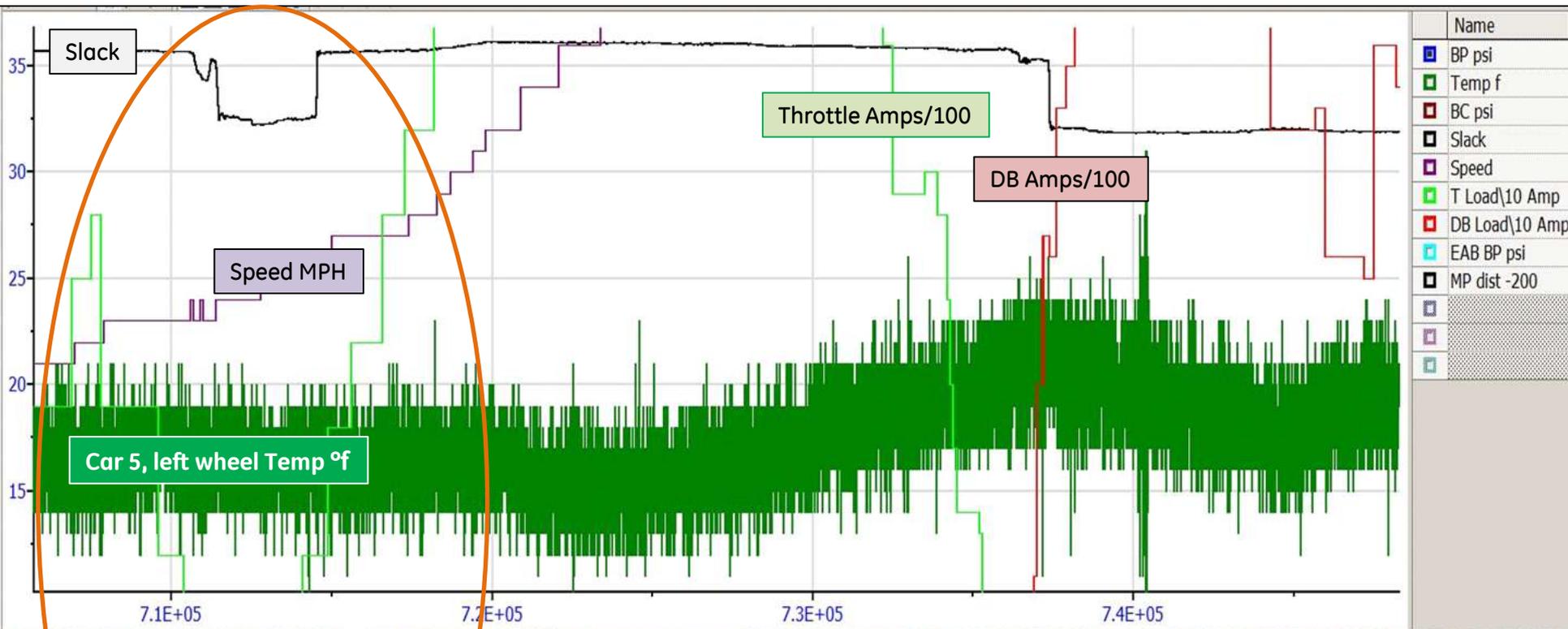
With:

- Measured indication of Force
 - Slack State (**Test String-Pots**)
- Indication of lateral wear force
 - Temperature (**Test Temp Sensors**)



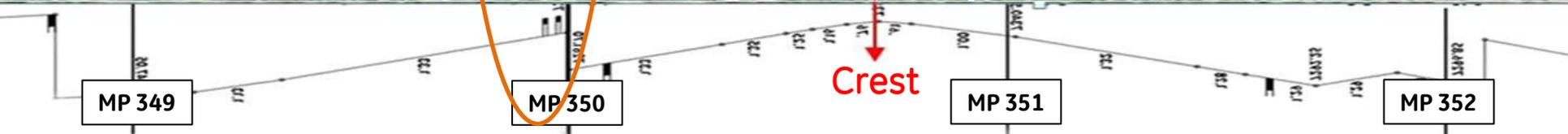
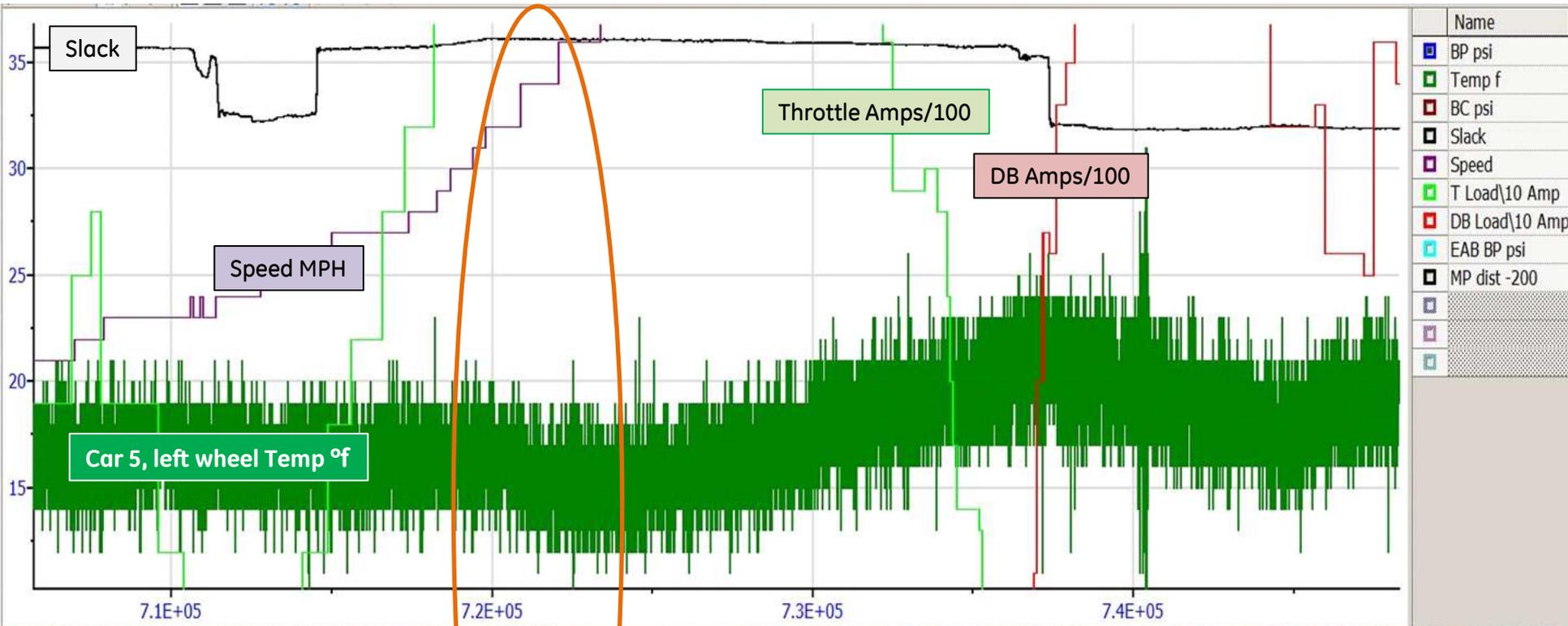
Investigation:

Low Longitudinal force area MP 349-350: low/reducing throttle effort, Low speed, Slack state shows “floating” coupler.
Results: Car 5 left wheel – no/little change in rolling temp



Investigation:

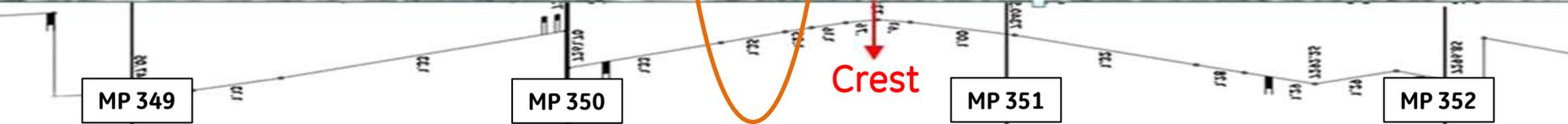
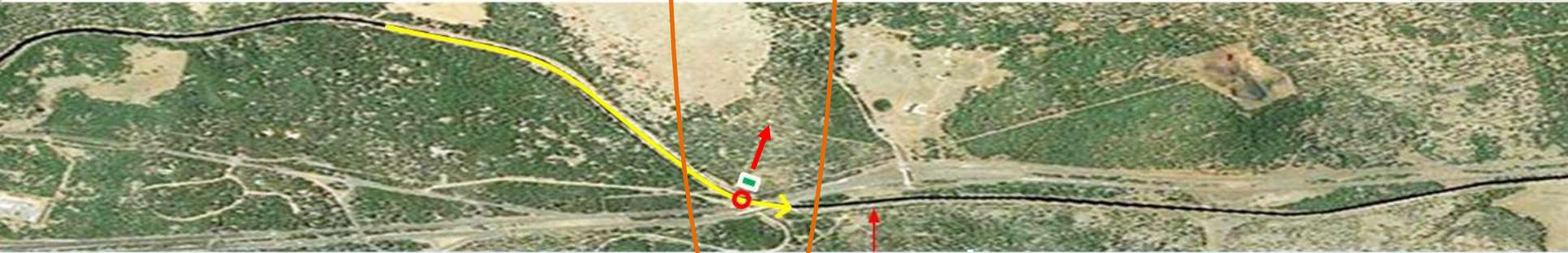
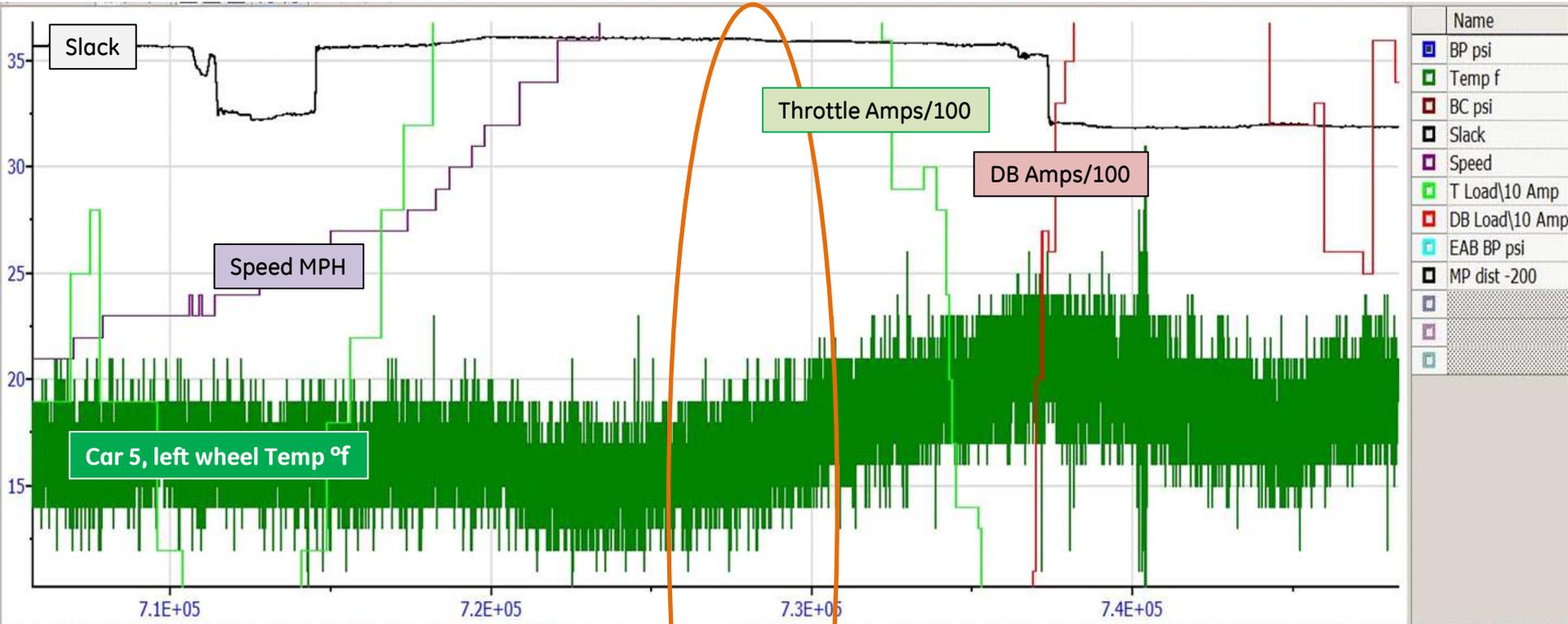
High Longitudinal stretch force area MP 350: High/increasing throttle effort, acceleration, Slack state shows high stretch, medium right curve **Results: Car 5 left wheel - stingline unloading - cooling**



Investigation:

Extremely high Longitudinal stretch force area MP 350. 3: Max throttle effort, acceleration, tight left curve, Slack state high stretch.

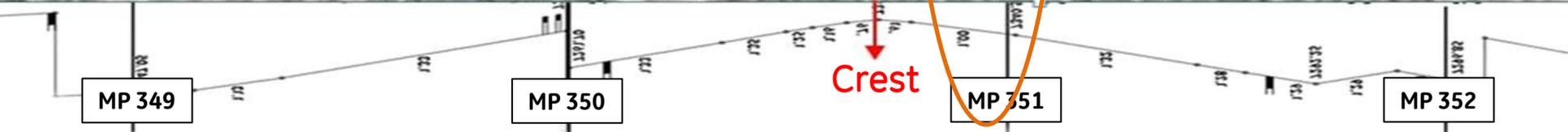
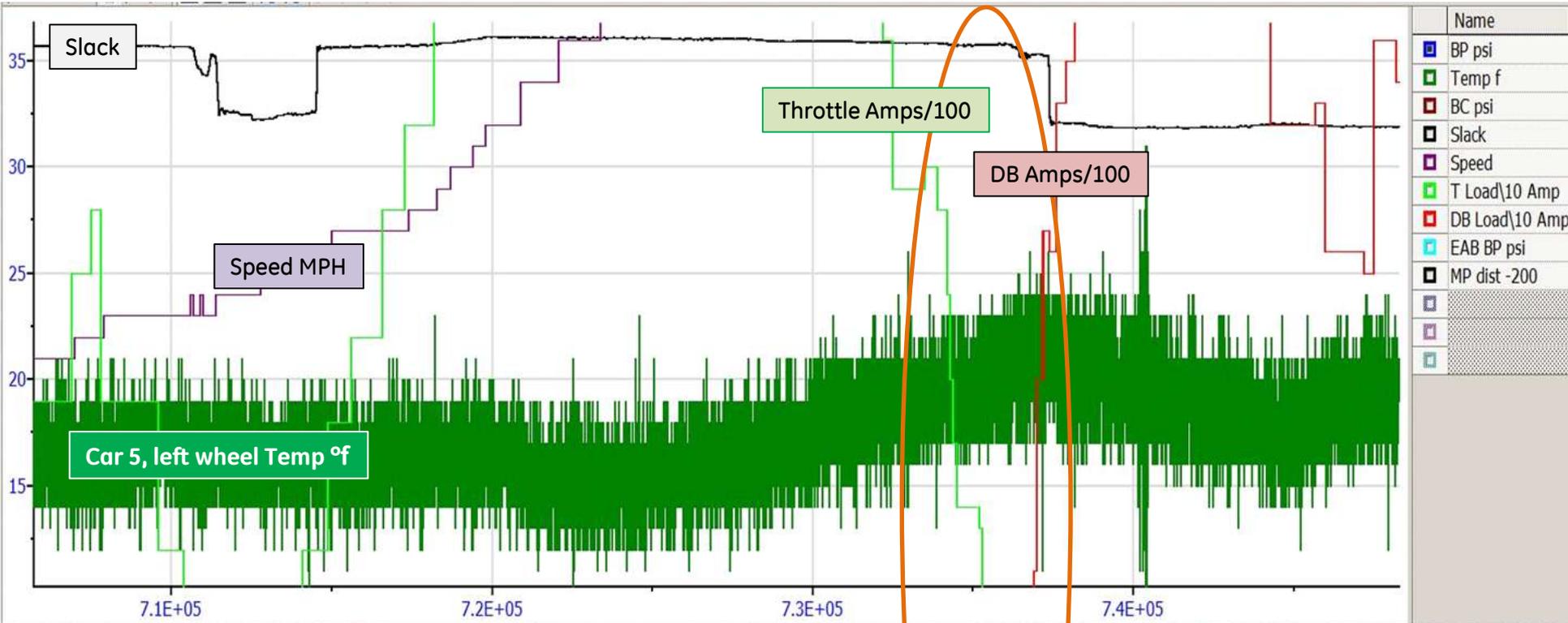
Results: Car 5 left wheel - stingline flanging - heating



Investigation:

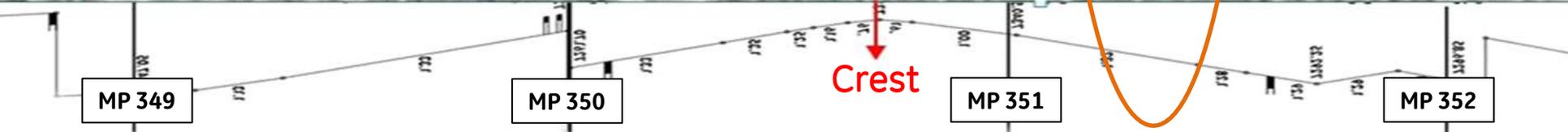
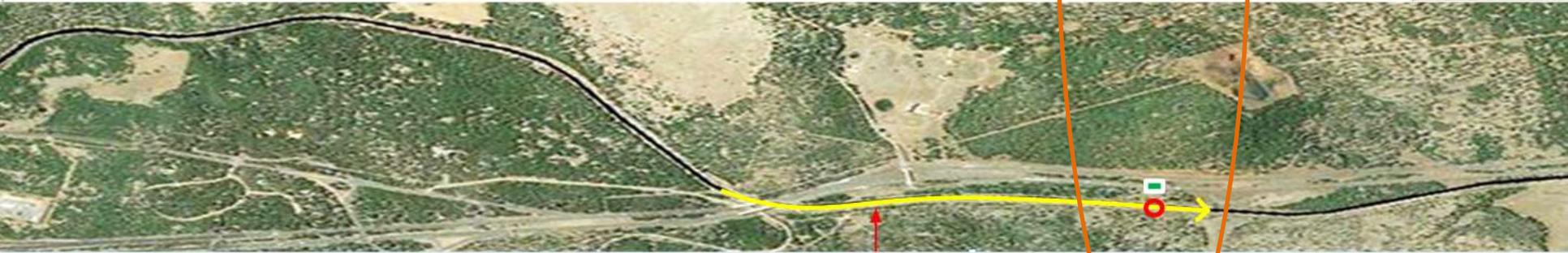
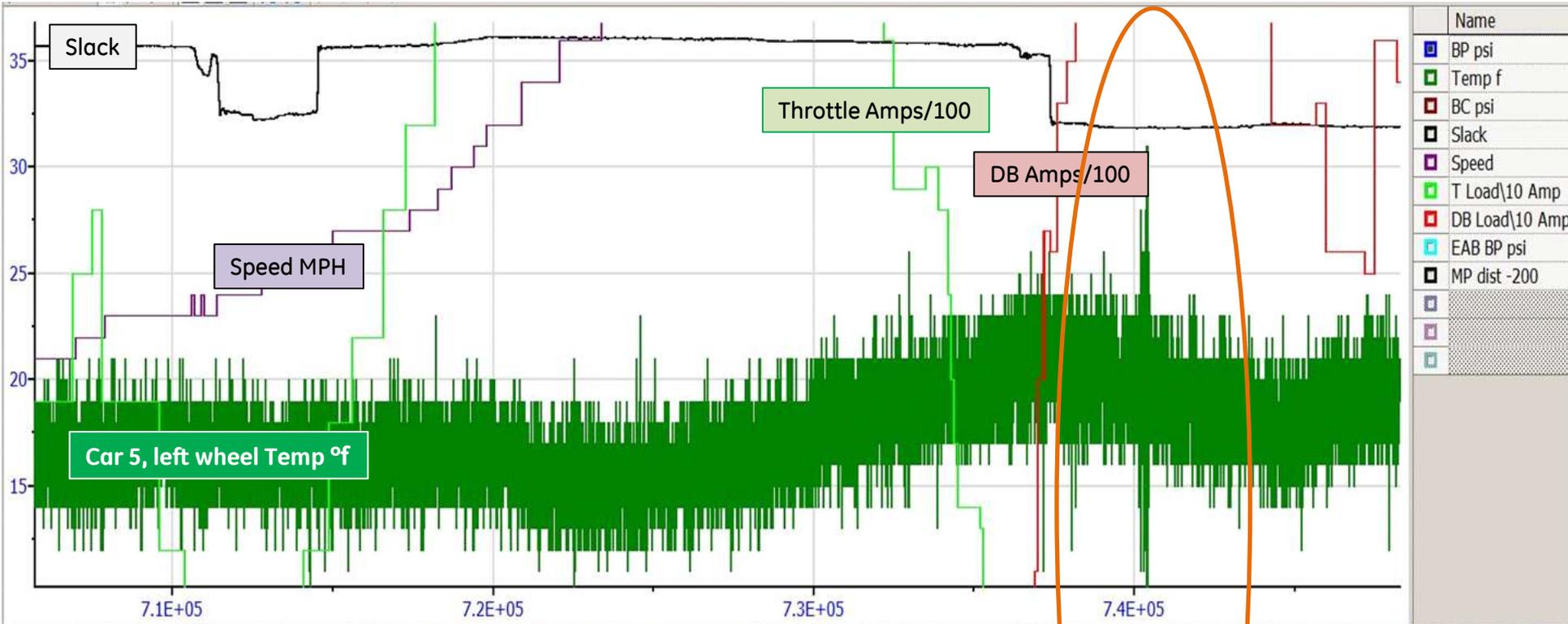
Extremely high Longitudinal compress force MP 351.0: Rapid change from Throttle to DB, mild right curve, Slack state - high compress.

Results: Car 5 left wheel - Jackknife flanging - still heating

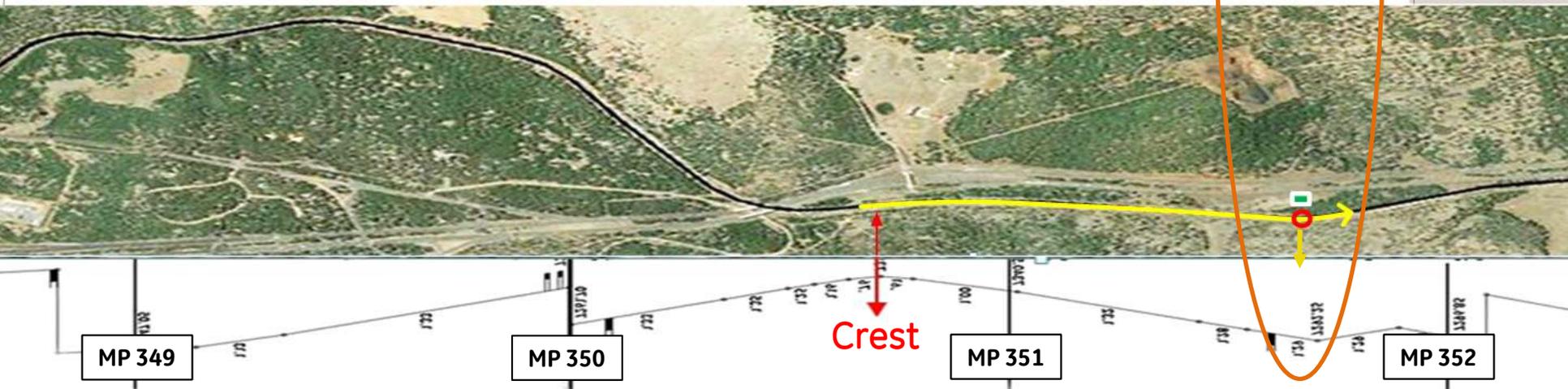
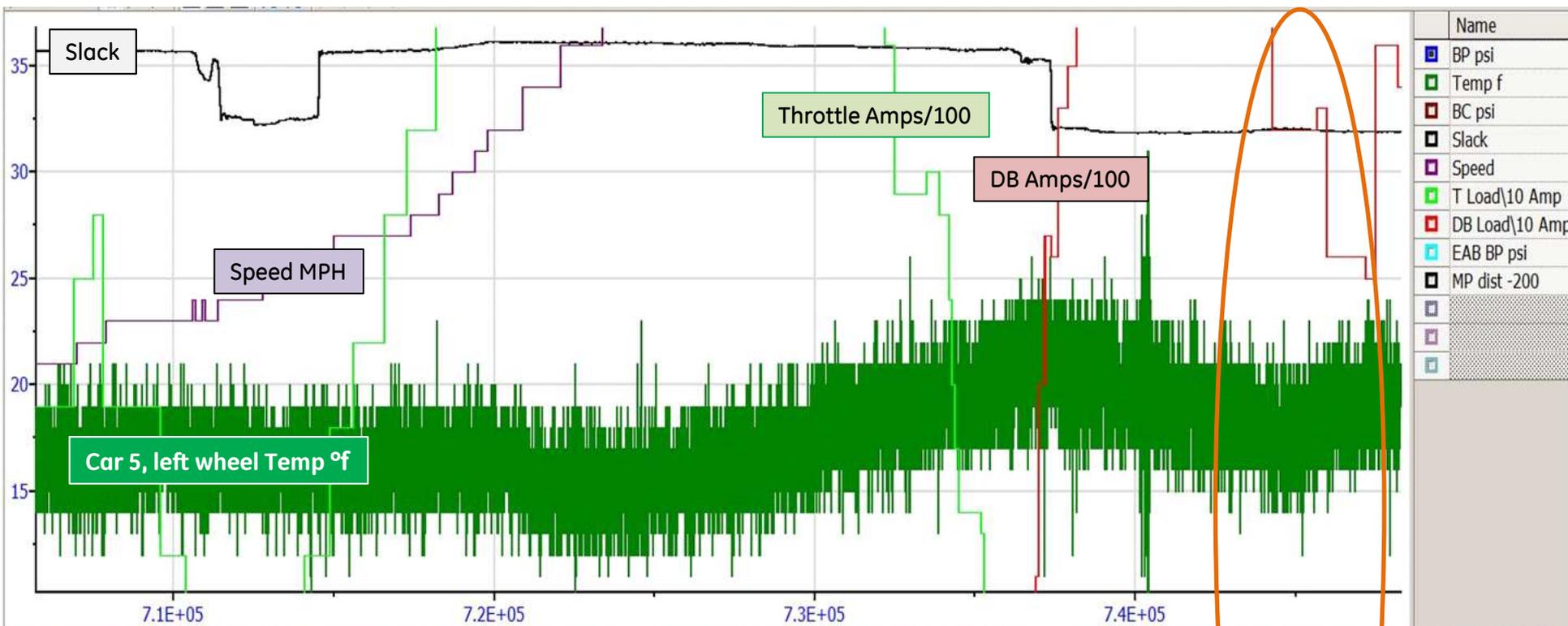


Investigation:

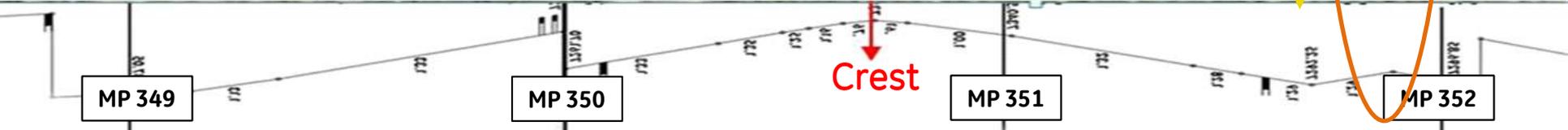
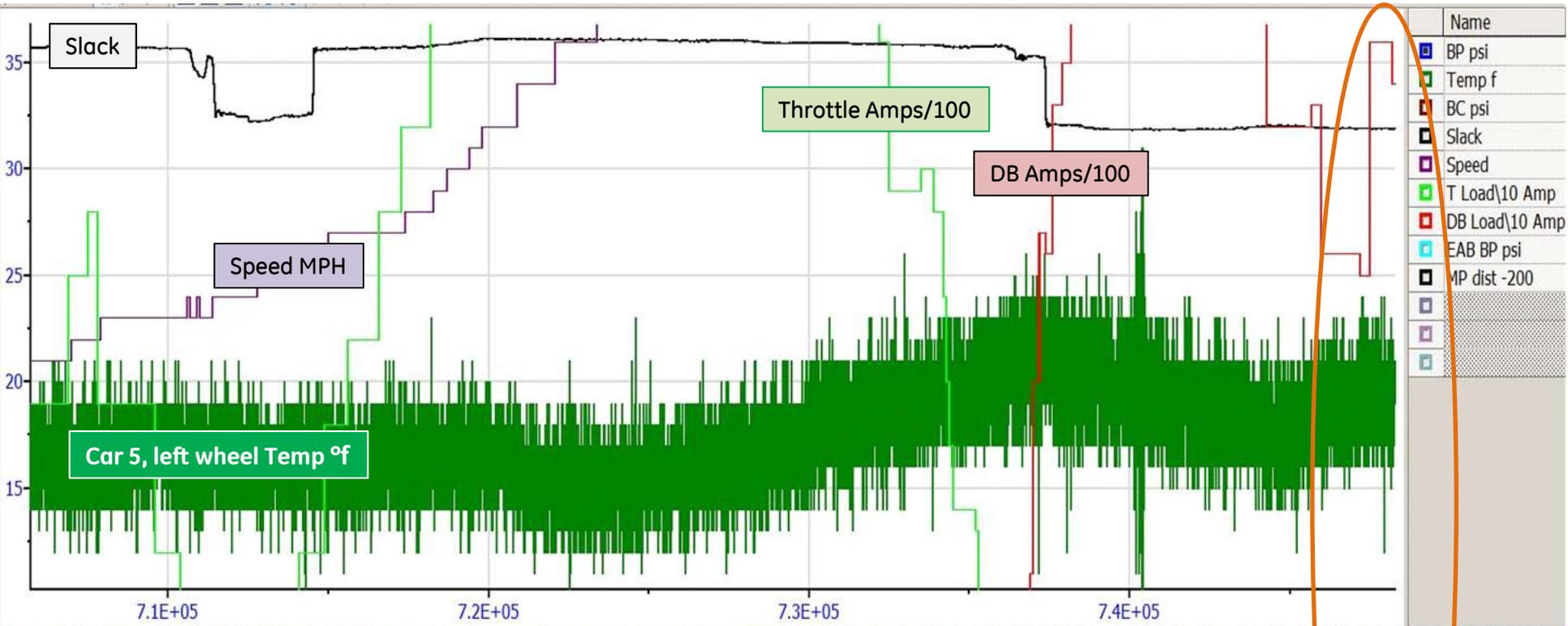
High high Longitudinal compress force MP 351-351.5: Max DB effort, straight track, Slack state - high compress, but car 5 centered on straight track. **Results: Car 5 left wheel - nominal state - Cooling**



Investigation: High Longitudinal compress force MP 351.7: Decreasing DB effort, mild left curve, Slack state - high compress. **Results: Car 5 left wheel - Jackknife unloading - still cooling**



Investigation: High Longitudinal compress force MP 351.7: Decreasing DB effort, mild left curve, Slack state - high compress. Results: Car 5 left wheel - Jackknife Flanging - heating



Next Steps:

- Determine wear
 - Calculate friction due from temperature rise
 - Use Grade, Curvature, speed, wagon mass, Tribology.
 - Determine wear from friction
 - Determine rail replacement cost
- Investigate use of DP, different ops
- Compare Value

- **BREAKTHROUGH:** Can measure wear due to [train operations](#)

- **What Next:** Run more validation tests !

- Contact me: david.peltz@ge.com

Cooperation/Coordination Between Operations and Maintenance

