The Physics of Railroading

An Introduction to the Science of Track Train Dynamics

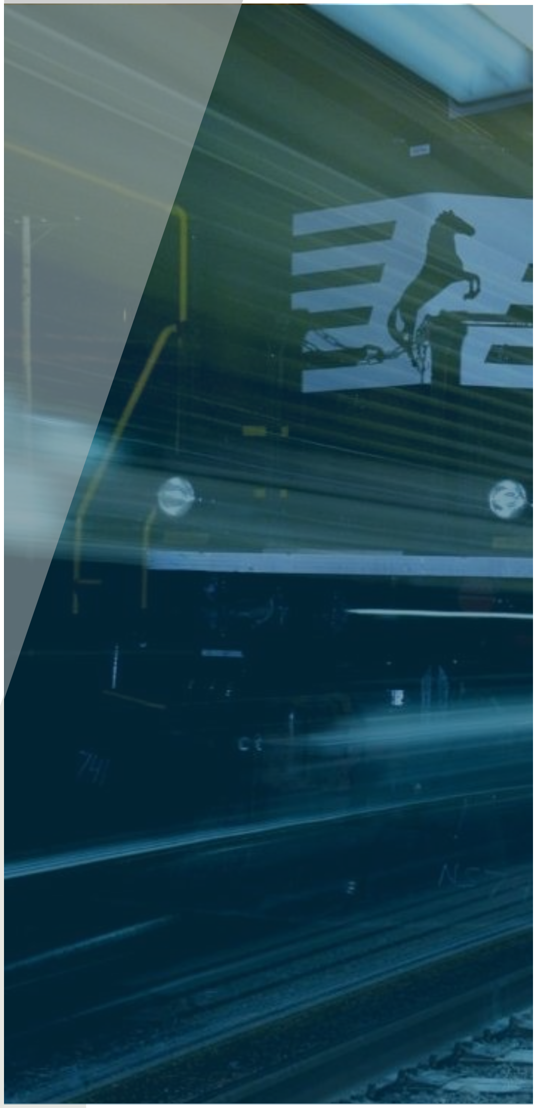
Jesse Lambert
Labor Relations Officer
Norfolk Southern

17 years at NS

Hired out 2006 as a Conductor

2008 went into Management; Craft in 2016

Locomotive Engineer 2017 until 2021

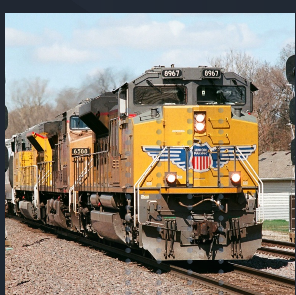


Doug Davidson

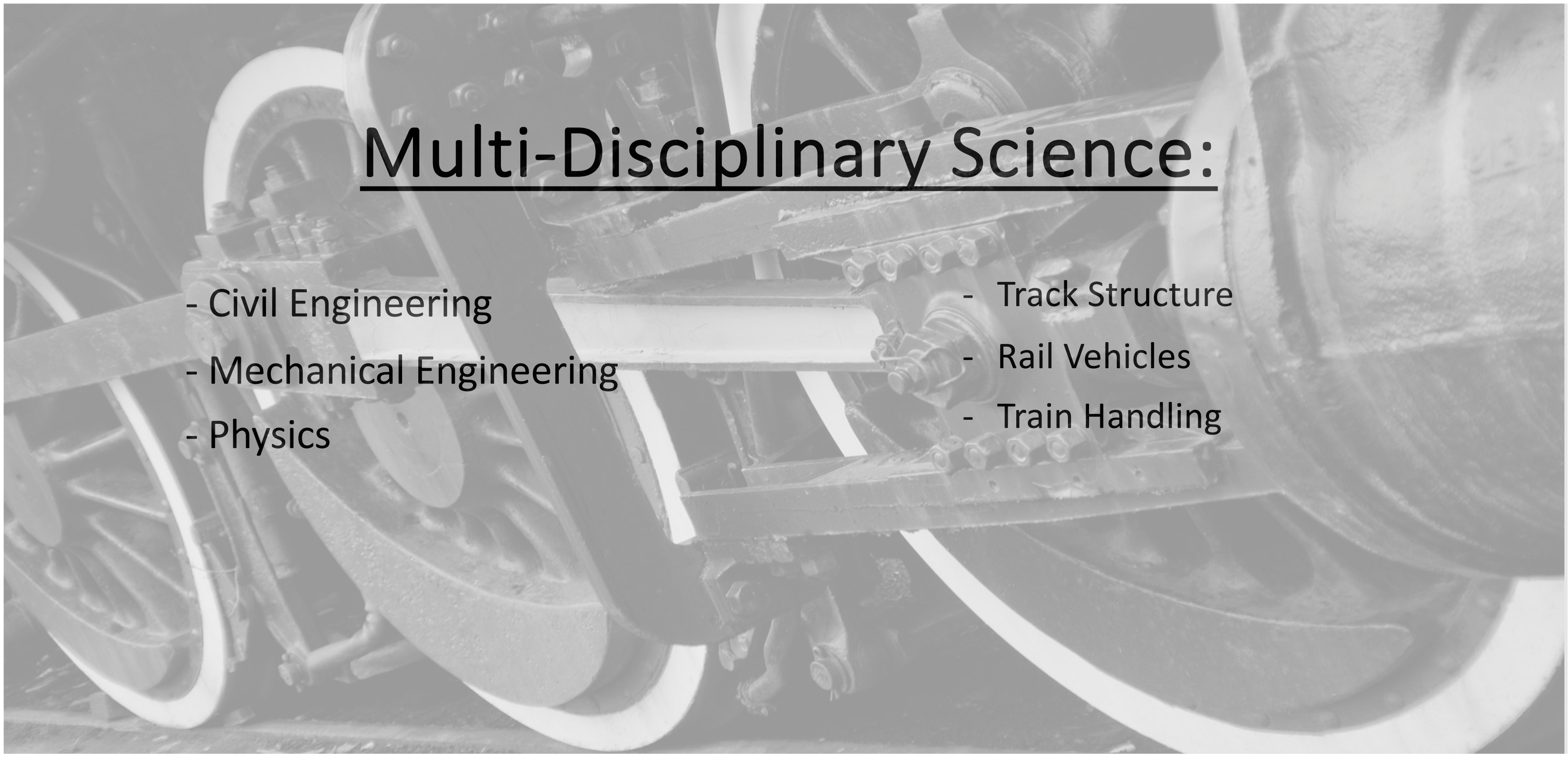
Locomotive Engineer
August 22, 1978

BLE-T Director of Arbitration

Vice Chairman NRAB



What Is Track Train Dynamics?

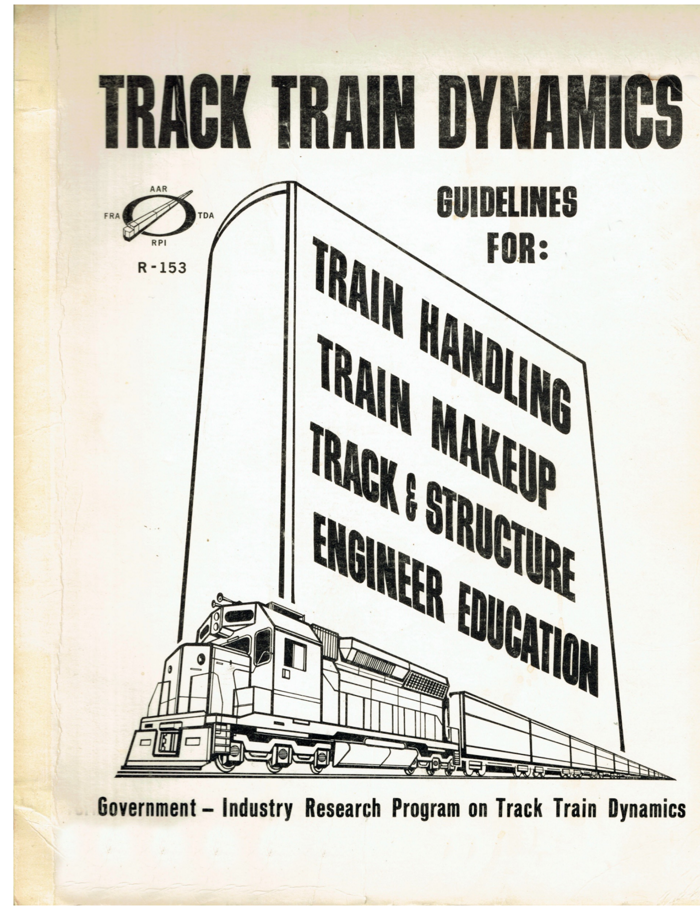

Multi-Disciplinary Science:
- Civil Engineering
- Mechanical Engineering
- Physics
- Track Structure
- Rail Vehicles
- Train Handling

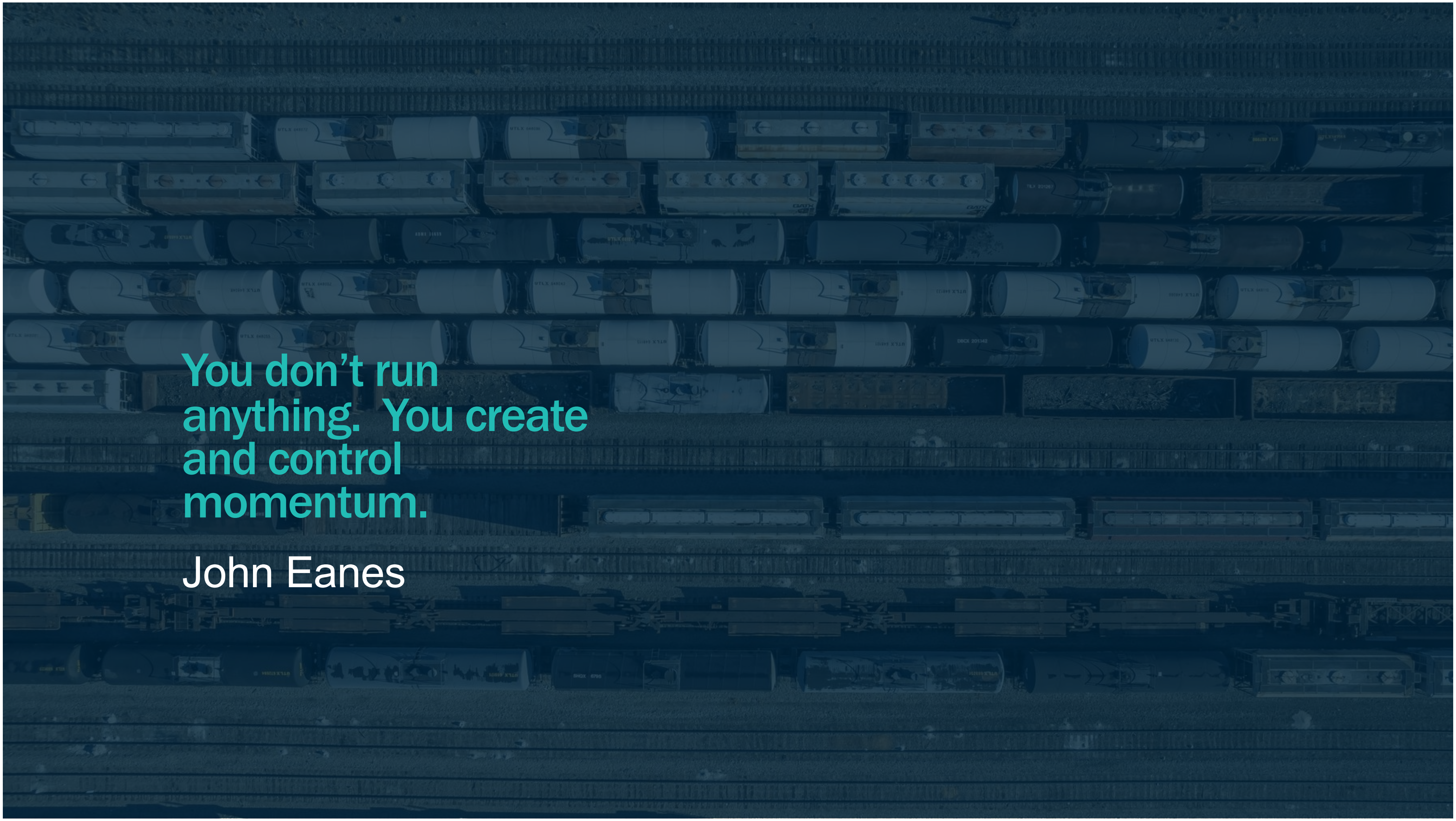
A Brief History

- October 1966 Congress Authorized the US Department of Transportation and Federal Railroad Administration
- US DOT and FRA launched on April 1, 1967
- FRA – Dual Mission to Regulate and Promote Rail Transportation
- DOT created the John Volpe National Transportation Center 1970
- To conduct research, the Volpe Center established rail testing grounds on 30,000 acres near Pueblo, Colorado.

A Brief History

- A Government / Industry research program involving FRA, the AAR and the Railway Progress Institute was established to improve freight train performance .
- Research resulted in 1973 Track Train Dynamics Report that offered best practices for track & structure, train makeup, train handling and engineer education.
- Since 1973, the science of Track Train Dynamics continues to evolve to understand and improve the performance of freight train operation.




You don’t run anything. You create and control momentum.
John Eanes

- How many feet in a mile?

    5,280 feet

- How many pounds in a ton?

    2,000 lbs

    10,000 tons = 20,000,000 lbs

- How fast must you travel to cover a mile a minute?

    60mph = 60 seconds

    50mph = 72 seconds

    45mph = 80 seconds

RESPONSIBILITIES

SAFE

A to B

RUN

ON-TIME

Throttle

Dynamic

Automatic

Independent

The 3 Innovations

Steel Rail

Steel Flanged Wheel

Coupling System

Track Structure

- SUB GRADE
- BALLAST
- RAILS, TIES & FASTENERS
- TURNOUT & SWITCHES

The Flanged Steel Wheel

Cast or Forged

1” Flange

Thermal Load

150K – 250K

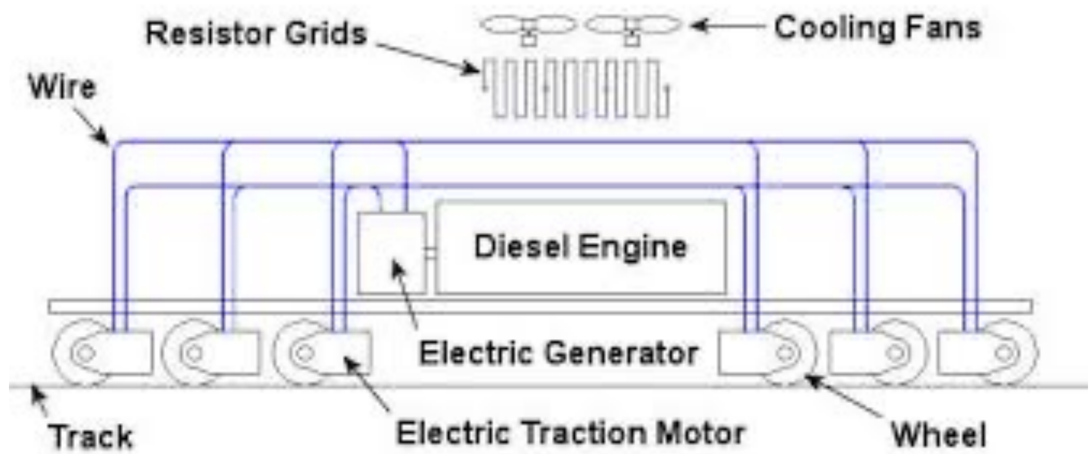
Fuel Efficiency
- 500 miles



The Coupler System

- Essential to the business model
- Federal Safety Appliance Act of 1893
- Janney Coupler
- Draft Gear

Locomotive Propulsion



layshaft → generator → electricity → traction motors → wheels

Train Brake Systems

Pressurized Air:

- Independent
- Automatic

Electric Regenerative:

-Dynamic

- Locomotive Only
- Bail-Off Feature
- Switching

- Entire Train
- Train Line
- Individual Brake Systems

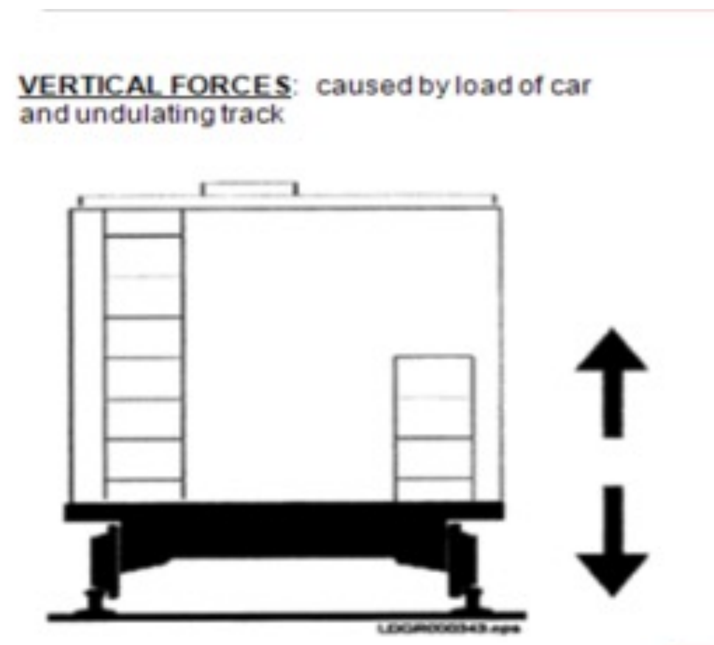
- Reverse Polarity
- 10 seconds
- 8 notches for desired amperage

Train Forces

- Always Present
- Free Force
- Drawbar Force

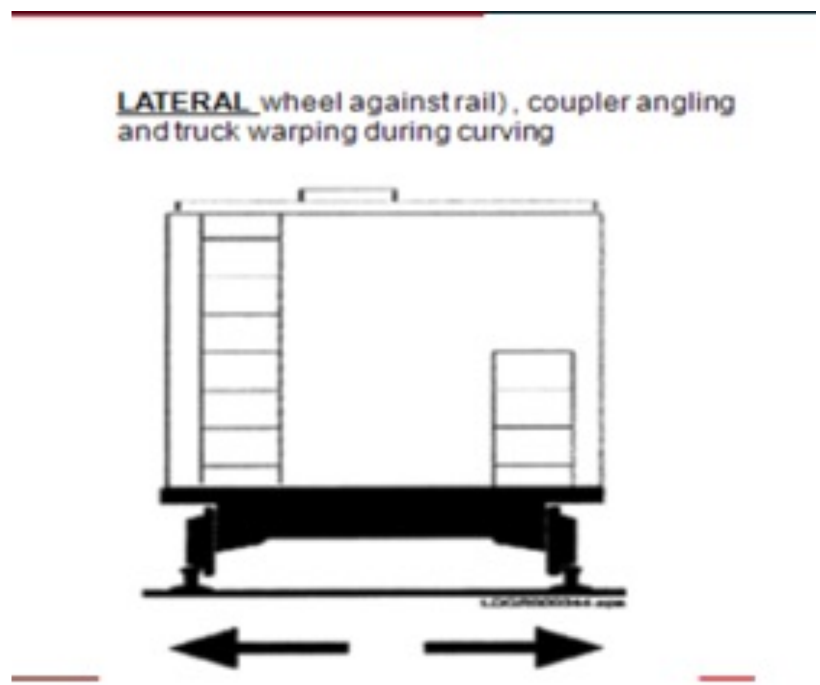
Vertical Force

- Gravity & Weight
- Wheel Tread to Ball of Rail
- Expressed in pounds per wheel
- 100 ton has a vertical force of 25,000l bs per wheel



Lateral Force

- Necessary Evil
- Negotiate Curves and switches
- Outer Flange to Ball of rail
- Many contributors; centrifugal



DRAFT FORCES

- Stretched
- Inward force on curve
- String-Lining

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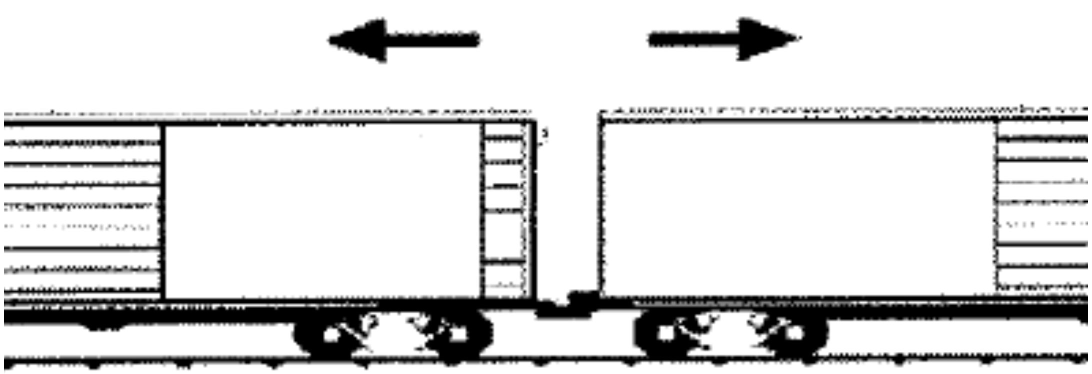
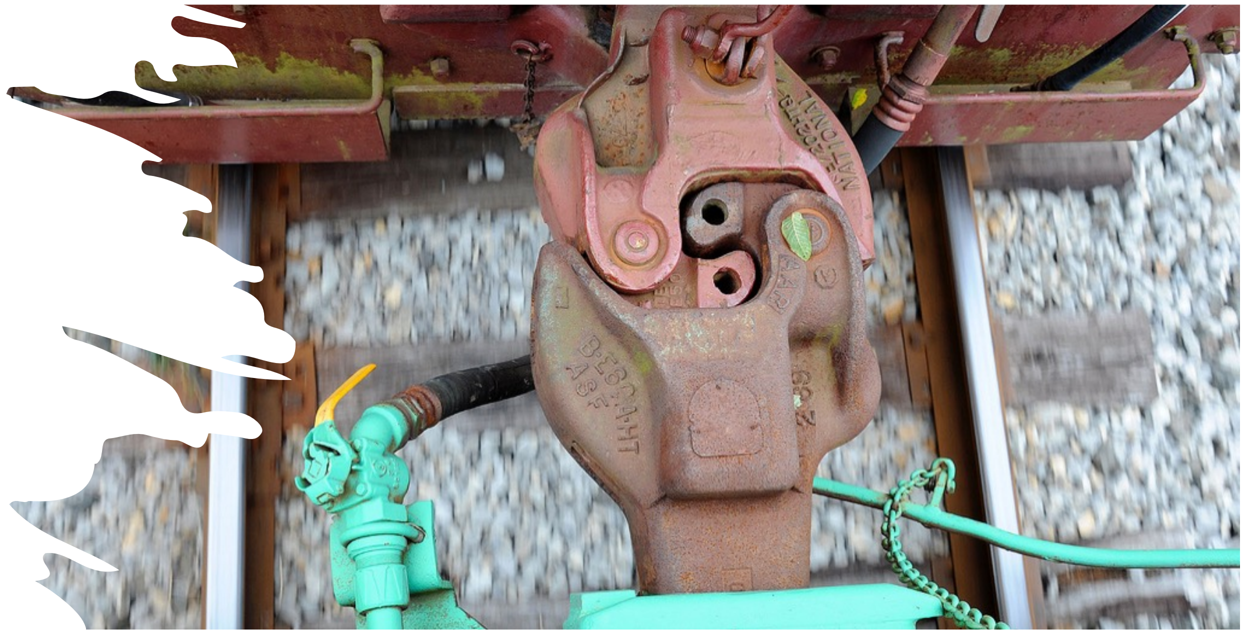
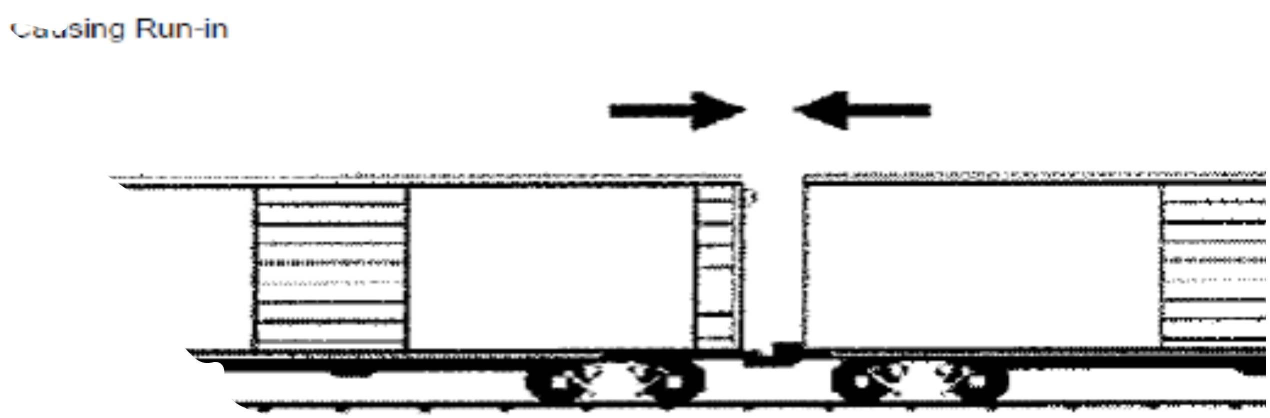


BUFF FORCES

- Compressed
- Outward force on curve
- Jack-knifing





L/V Ratio

L/V Ratio is a calculation to determine the relative forces present in the train at a particular moment to explain certain incidents such as derailments or damage to track.

Expressed as a fraction:

L = Lateral force is the numerator

V = Vertical force is the denominator

When lateral force overcomes vertical force, there is the risk of a derailment or track damage.

L/V Ratio – A Working Example

An empty flatcar in the middle of a long train that has heavy loads at the rear of train is negotiating a switch when a heavy independent brake application occurs.

The vertical force of the empty flat car is 12K lbs.

The lateral force of the track geometry is 4K lbs.

The lateral force of the independent brake application is 9K lbs.

The L/V Ratio is 13K/12K.

Lateral exceeding vertical = OOPS!

TECHNOLOGY

FUEL CONSERVATION SOFTWARE

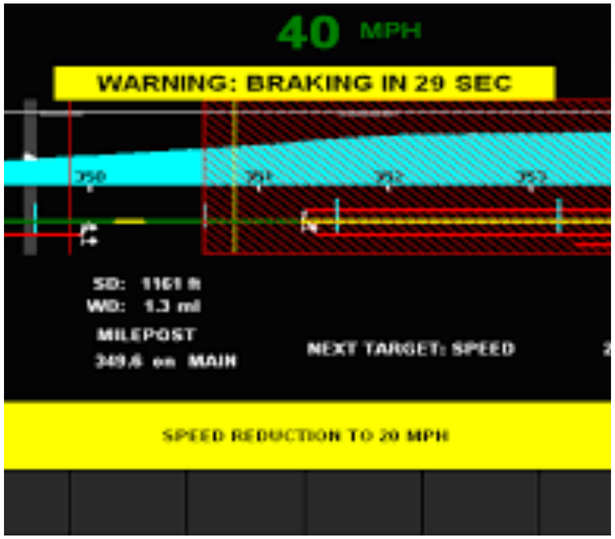
TRIP OPTIMIZER

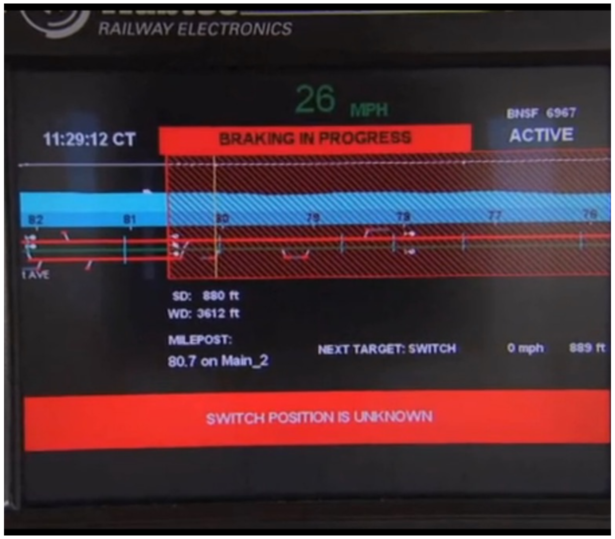
LEADER

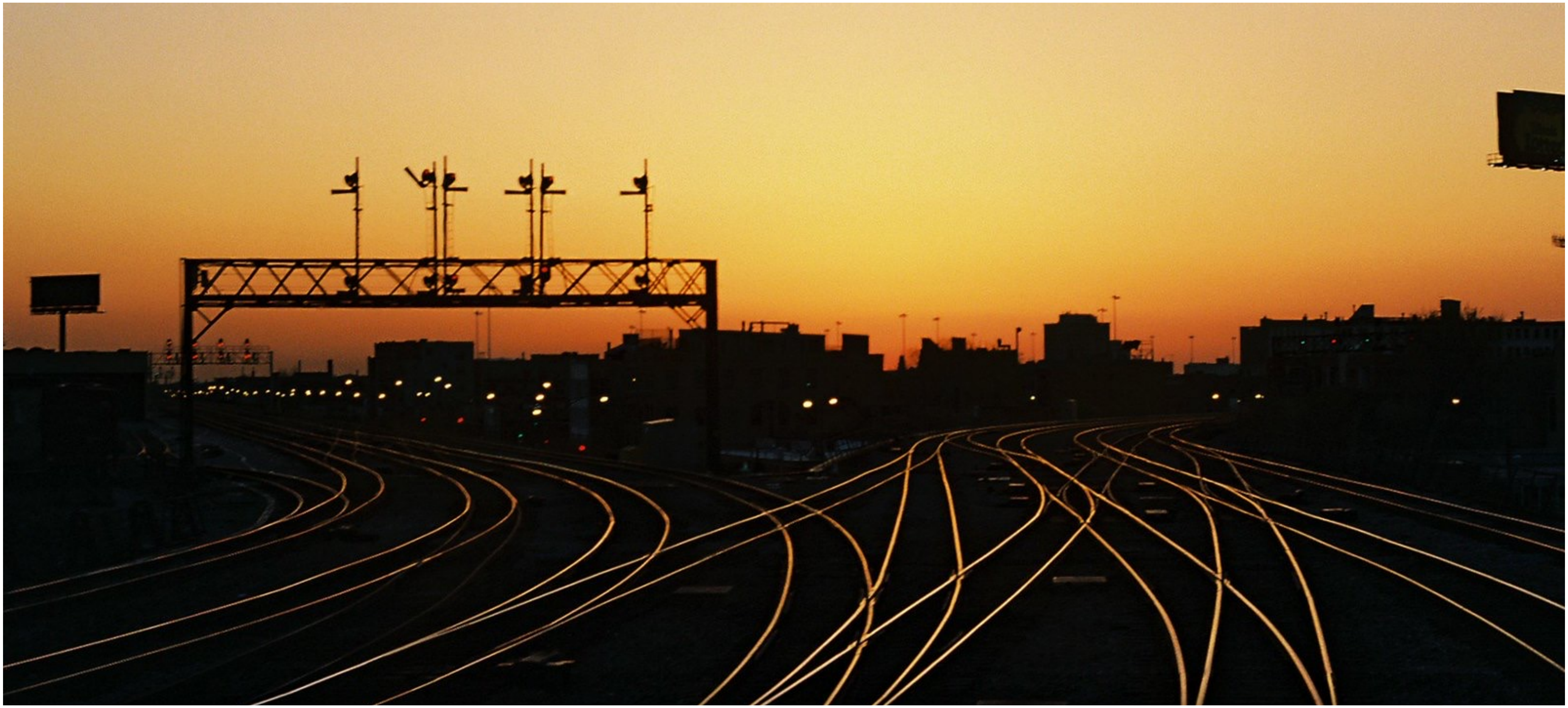
POSITIVE TRAIN CONTROL

DP: Distributed Power

PTC: Positive Train Control







Conclusion