Baltimore LRV Case Study
Braking Functionality and Operator Vigilance System Improvements

What do these four things have in common?

25 Years

Old

Rail Conference

APTA

Baltimore LRV Case Study
Braking Functionality and Operator Vigilance System Improvements

(Author #1)

Michael Wiedecker

MDOT-MTA, Director of Training and Development

Baltimore, MD USA

Key Presentation Take-Aways

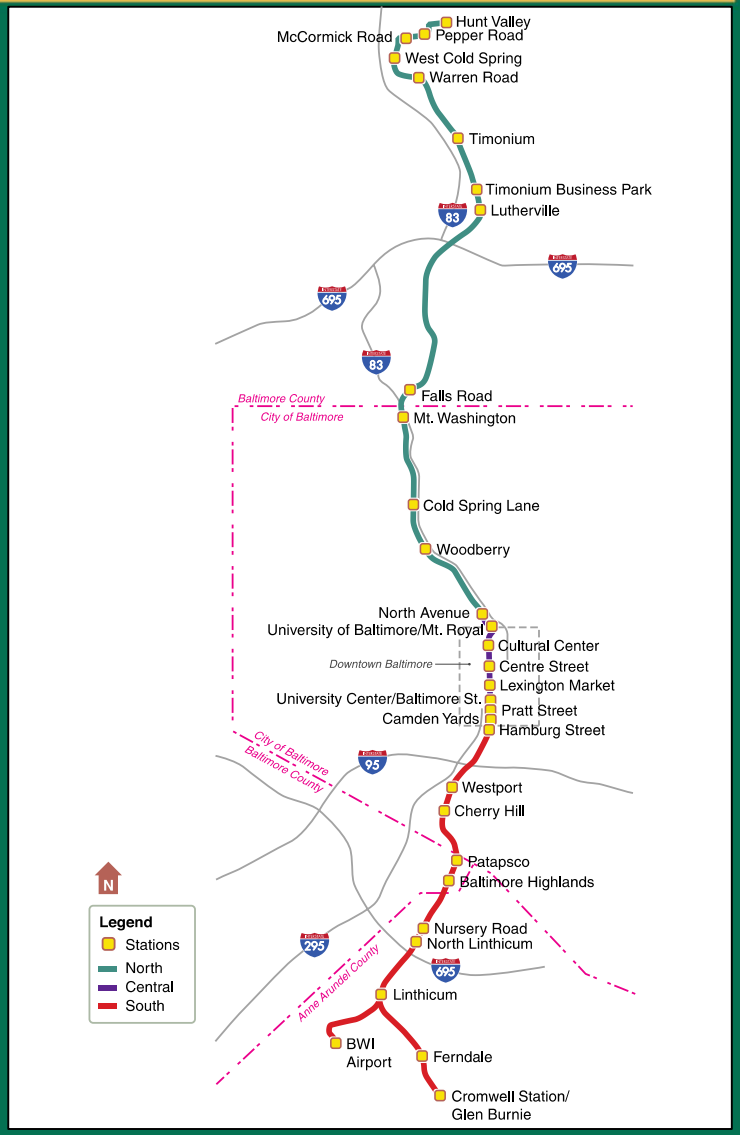
- Describe the MDOT-MTA Light Rail System.
- Describe the Light Rail Vehicle (LRV).
- Operational and safety enhancing features.

History of the Light Rail System

- Proud History.

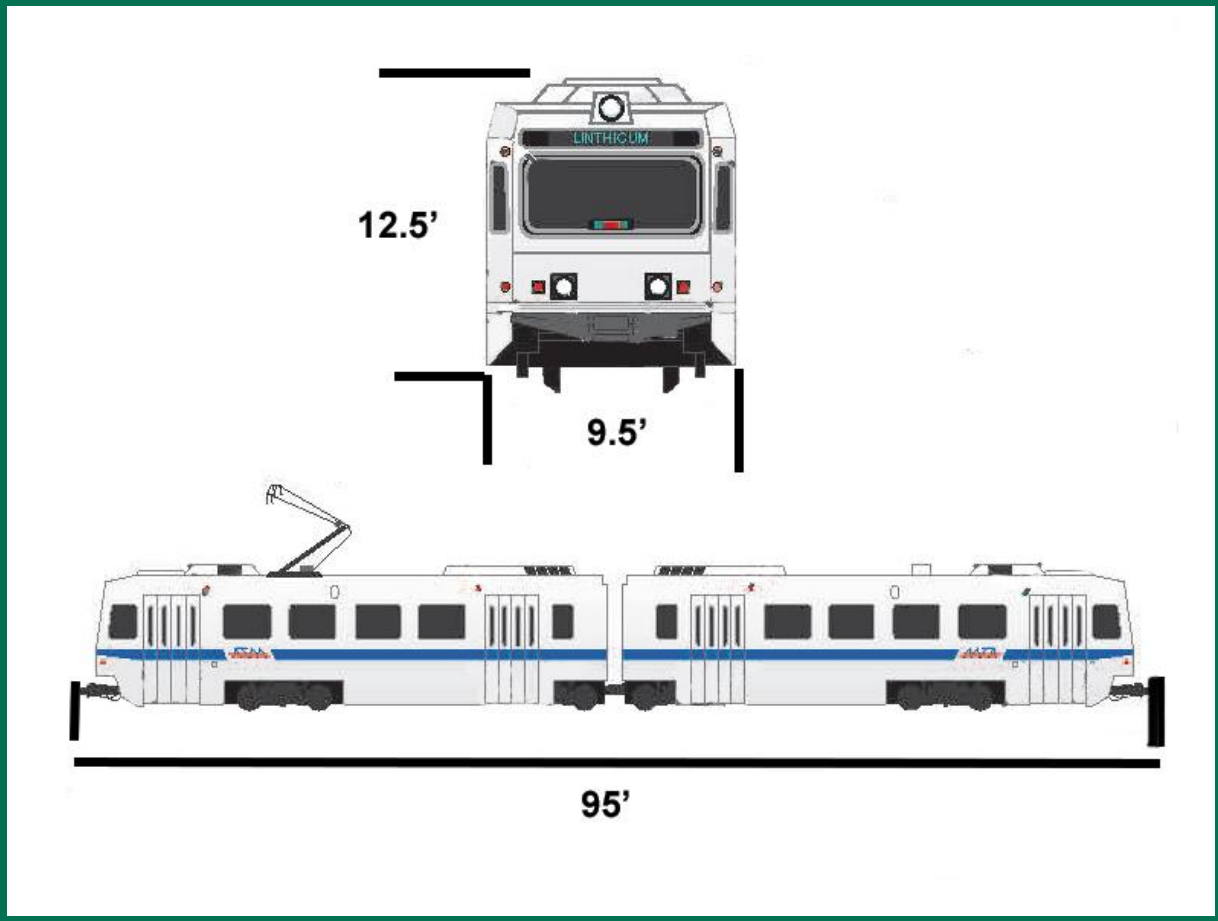
Overview of the Light Rail System

- Divided into three geographic sections:
  - North
  - Central
  - South
- 2003-2006
  - Double Track project



Overview of the Light Rail Vehicle

- Dimensions
- Capacity
  - 84
  - 177
  - 260



Overview of the Light Rail Vehicle

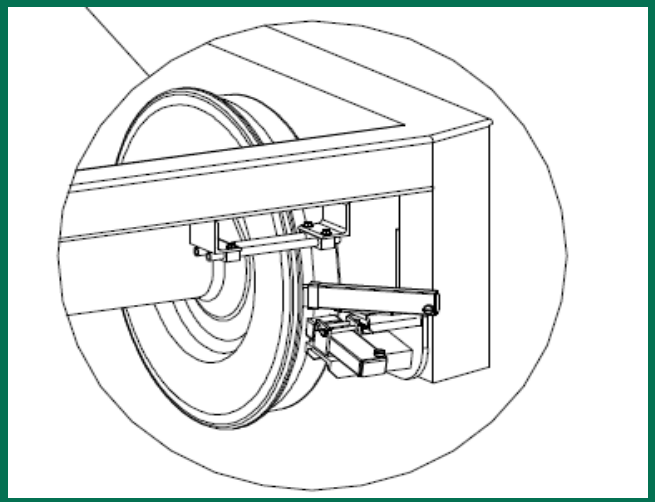
- Cab layout
- Operational Characteristics

Operational Features, 1993 and 1996

- Deadman feature disabled 1993

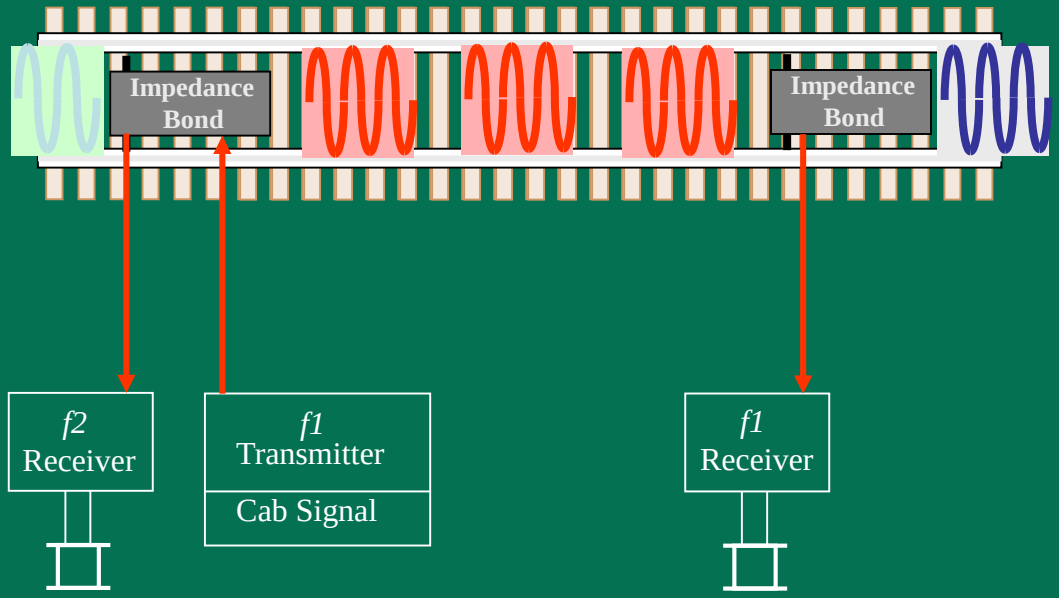
The handle must be in its “depressed” state. If released for five (5) seconds, irrecoverable Full Service brake application.

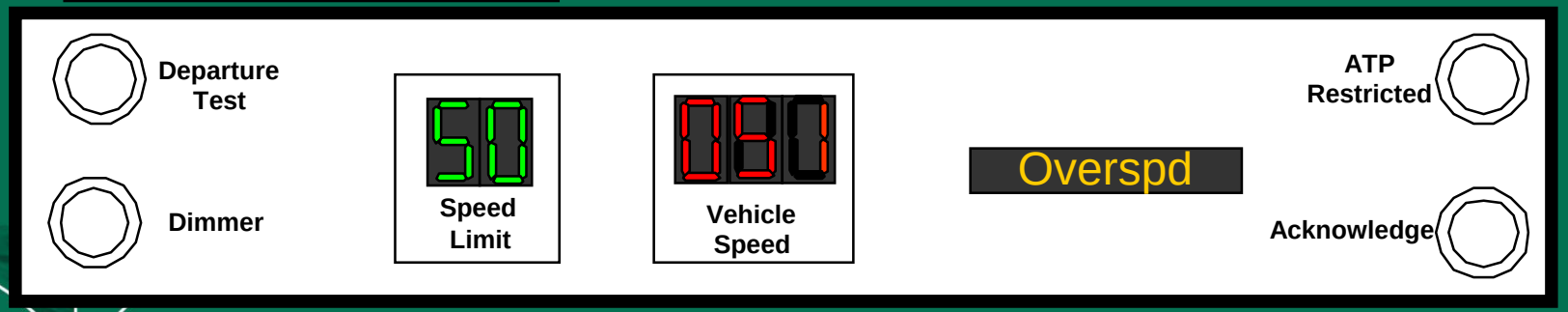
- Removed truck mounted lubricators 1996



Operational Features – ATP 2001-2002

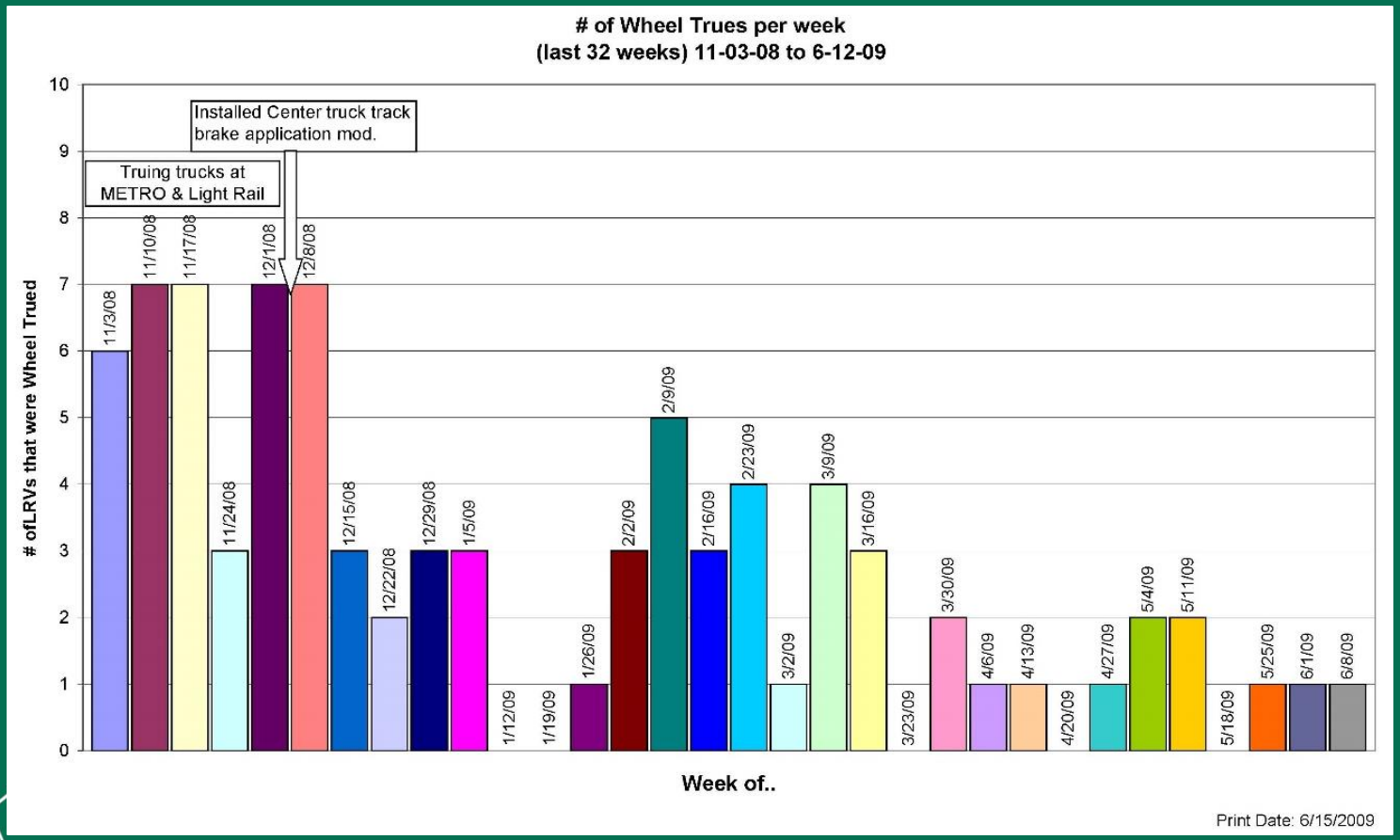
- Automatic Train Protection (ATP) added in 2001 - 2002





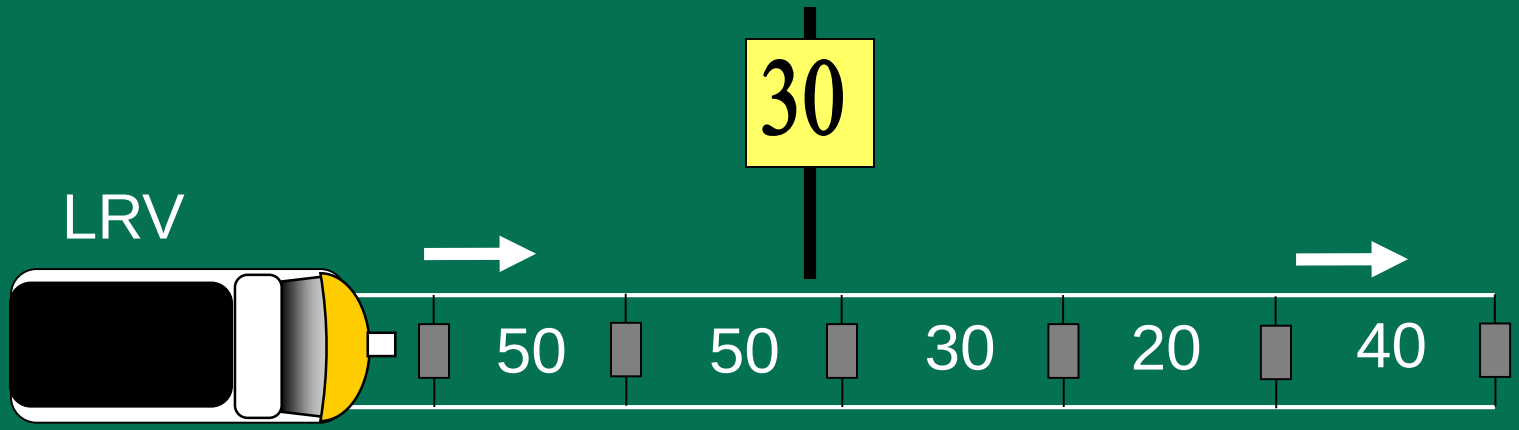
Operational Features - Track Brake 2008 - 2010

- Automatic Train Protection (ATP) Control Mods in 2008 thru 2010



Training Light Rail Operators to Anticipate Speed Reductions - 2009

- The speed of the LRV should be reduced to match the approaching cab code change in speed.



Baltimore LRV Case Study
Braking Functionality and Operator Vigilance System Improvements

(Author #2)

Patrick Albright

Omni Strategy, Project Manager, Senior Vehicle/Systems Engineer

Baltimore, MD USA

Rail Conference APTA

LRV Sanding Mitigation Efforts - 2009

- Sanding tubes on the trucks were made to reduce the original distance of the tube from the wheel to rail interface of 12 inches.

Track/Wayside Issues Pertaining to Wheel Flats - 2009

- Based on a study of wheel flat occurrences, three mainline locations were identified as significant offenders. They were:
  1. Chain Marker 397 North, Falls Road
  2. Chain Marker 711 North, Texas Road
  3. Chain Marker 373 South, Camp Meade Junction

Track/Wayside Issues Pertaining to Wheel Flats - 2009

- Inspections of these track areas and tests of their track signals highlighted the following issues:
  1. Rail lubrication grease and crushed leaves on rail head for an extended distance.
  2. LRV receives cab code for Restricted 8 mph to NO CODE, when in a normal 30 mph code area, causing an immediate Emergency Brake application.
  3. Missing or Incorrect cab code signals.

Top of Rail (TOR) Friction Modifiers - 2009

- Evaluated in an effort to ensure that the application of grease, along with the correct type of grease, is made in the appropriate places and amounts and at appropriate time intervals.

MOW VAC Truck Modified to Clean Top-of-Rail - 2009

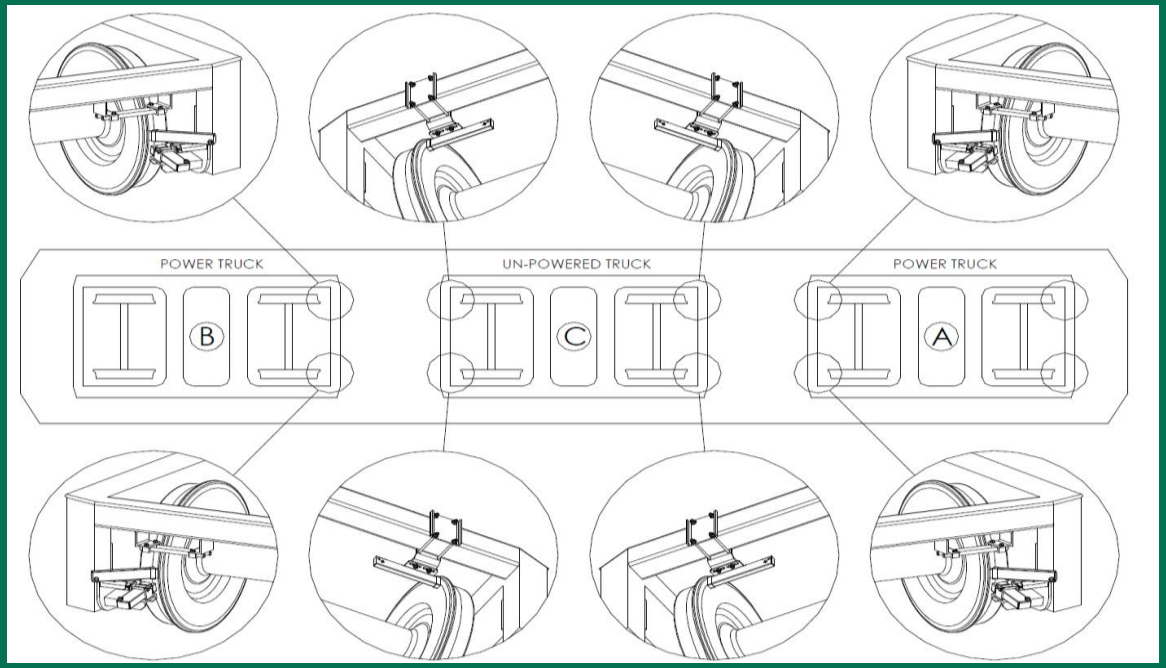
- During the “leaf season” MOW personnel would clean the top of rail to remove leaf residue. This effort enhanced wheel-to-rail adhesion.

Deadman Feature Re-enabled and Modified - 2009

- Momentarily release and re-depress (cycle) the Deadman every 20 seconds
- If the LRV operator fails to release the Deadman every 20 seconds, LRV executes an irrecoverable Full Service brake application.

Reinstall Truck Mounted Lubricators & Install Traction Enhancers - 2010

- After several test runs, it was decided to install truck mounted lubricators on all 53 LRVs.
- As of the writing of this paper, all LRVs remain equipped with functioning truck mounted lubricators.



Baltimore LRV Case Study
Braking Functionality and Operator Vigilance System Improvements

(Author #3)

Glenn D. Gardner

CH2M, Senior Systems Engineer

Southampton, PA USA

Key Presentation Take-Aways

- Control criteria need to be consistent with performance capabilities (vehicle and wayside).
- Beware of the possible “Domino Effect”.
- Ergonomics matter.
- The term “good enough” has little value where Safety is concerned.

Mid-Life Overhaul
Goals Related to Braking Operation and Performance

1) Enable wheel slip-slide correction during Emergency Brake.
2) Improve wheel slip-slide correction performance.
3) Satisfy maximum allowable GEBR stop distance requirements.
4) Improve braking performance during failure and cutout conditions.

Mid-Life Overhaul
Equipment / Functional Upgrades

- Replace “Deadman” feature with friendly computerized Operator Vigilance system.
- Remove the ATP Emergency Magnet Valves and utilize the existing Emergency Brake loop circuit.
- Add another Brake Control Unit and associated Electronic Control Unit.
- Replace original “on/off” wheel slip-slide control valves with “on/hold/off” valves.

Mid-Life Overhaul
Equipment / Functional Upgrades

- Provide both Friction Brake and Propulsion wheel slip-slide correction control software.
- Replace the original Sanding control system with an “intelligent” control system.
- Convert the existing single Emergency Brake mode into two (2) Emergency Brake modes
  1. EM-1 (WS disabled)
  2. EM-2 (WS enabled)

Mid-Life Overhaul
"Conventional" vs. "Aggressive" Wheel Slip-Slide Correction

- The "**conventional**" wheel slip-slide control and associated performance originally provided by the vehicles utilizes a percentage of the "**available**" wheel-to-rail adhesion that was termed "**efficiency**".

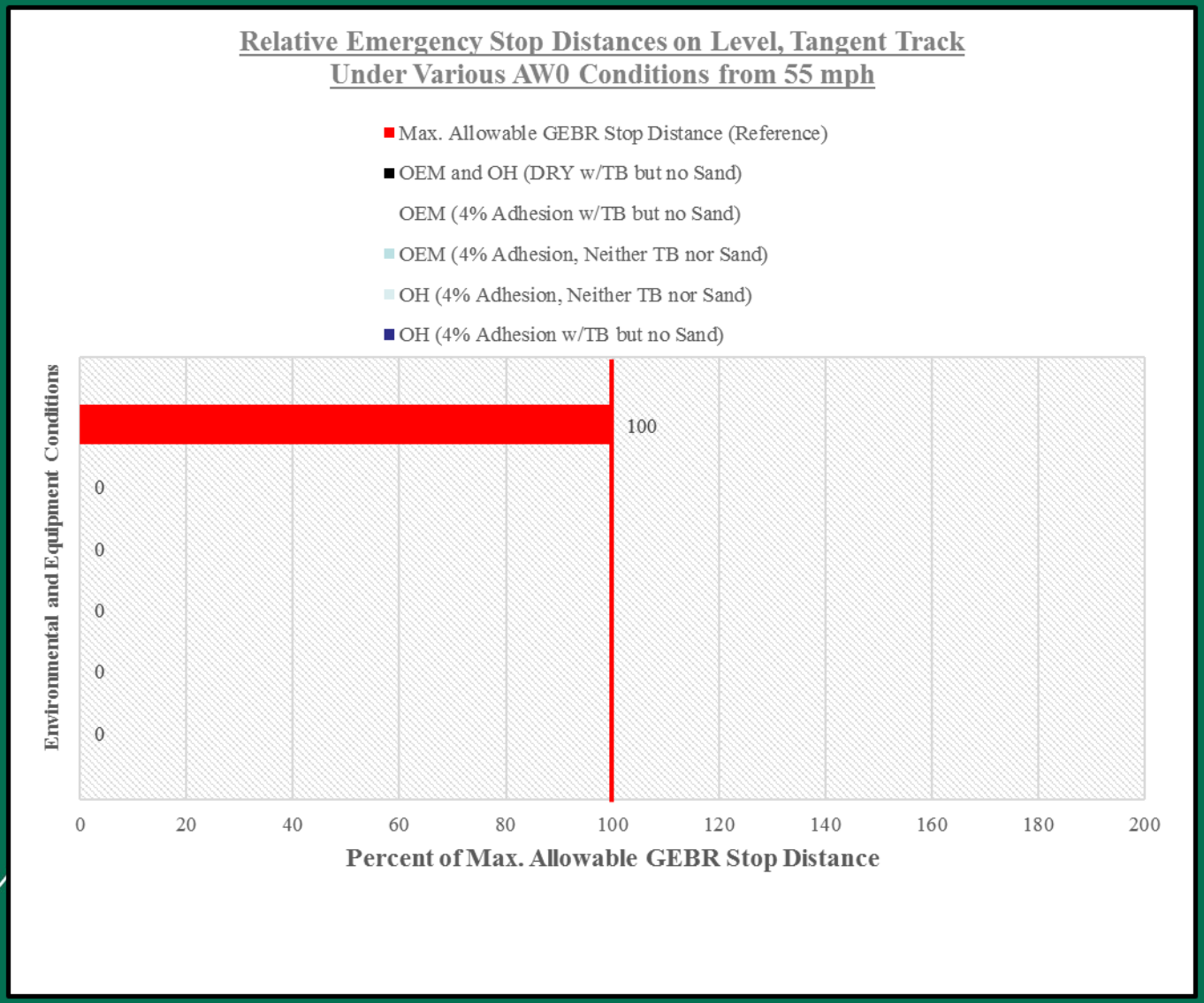
Speed (mph)	Wet Leaves		Damp Rail (Lower Limit)		Dry Rail (Lower Limit)		Dry Rail (Upper Limit)	
	% Adhesion	AWO Decel. (mphps)	% Adhesion	AWO Decel. (mphps)	% Adhesion	AWO Decel. (mphps)	% Adhesion	AWO Decel. (mphps)
10	3.5	0.77	8.0	1.76	11.0	2.41	21.5	4.72
30	3.0	0.66	7.0	1.54	9.5	2.09	18.0	3.95
50	2.5	0.55	6.0	1.32	9.0	1.98	15.5	3.40

Note: The table is derived from information presented by Harry G. P. Burt and E. Saumweber at the IEEE/ASME Joint Railroad Conference, 1985. The AW0 Deceleration figures assume an evenly distributed load and that all wheels in the train (or vehicle) are doing equal amounts of work.

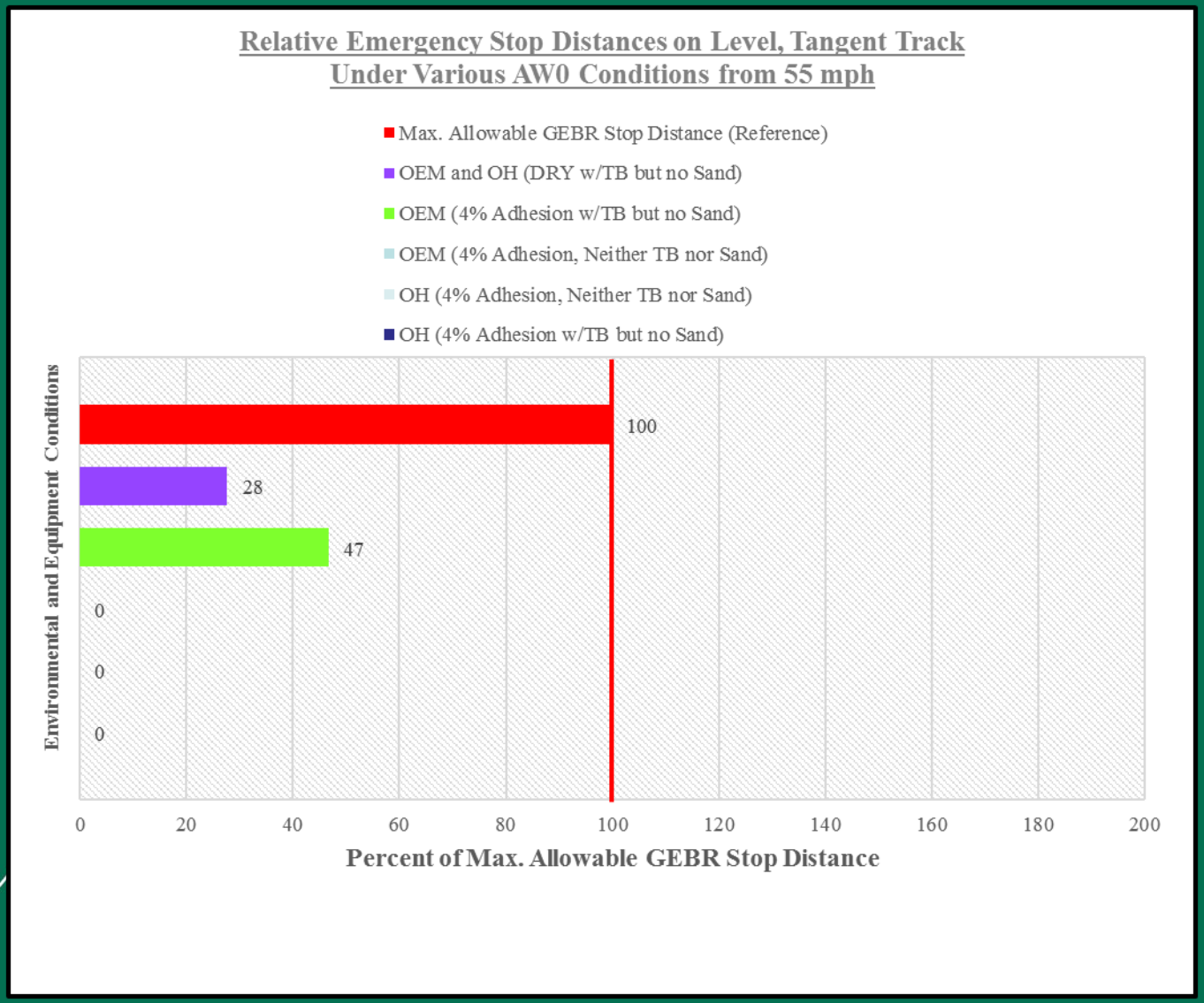
Mid-Life Overhaul
"Conventional" vs. "Aggressive" Wheel Slip-Slide Correction

- The "aggressive" approach to wheel slip-slide control is to maintain the wheel in a controlled slip condition (known as, "creep") once wheel slip-slide correction is required.
- Typically, wheel slip-slide correction control uses a "creep" range of 10% - 35% off rail speed.
- An "aggressive" wheel slip-slide correction control can potentially improve an extremely low available wheel-to-rail adhesion by a conservative 4.5%.

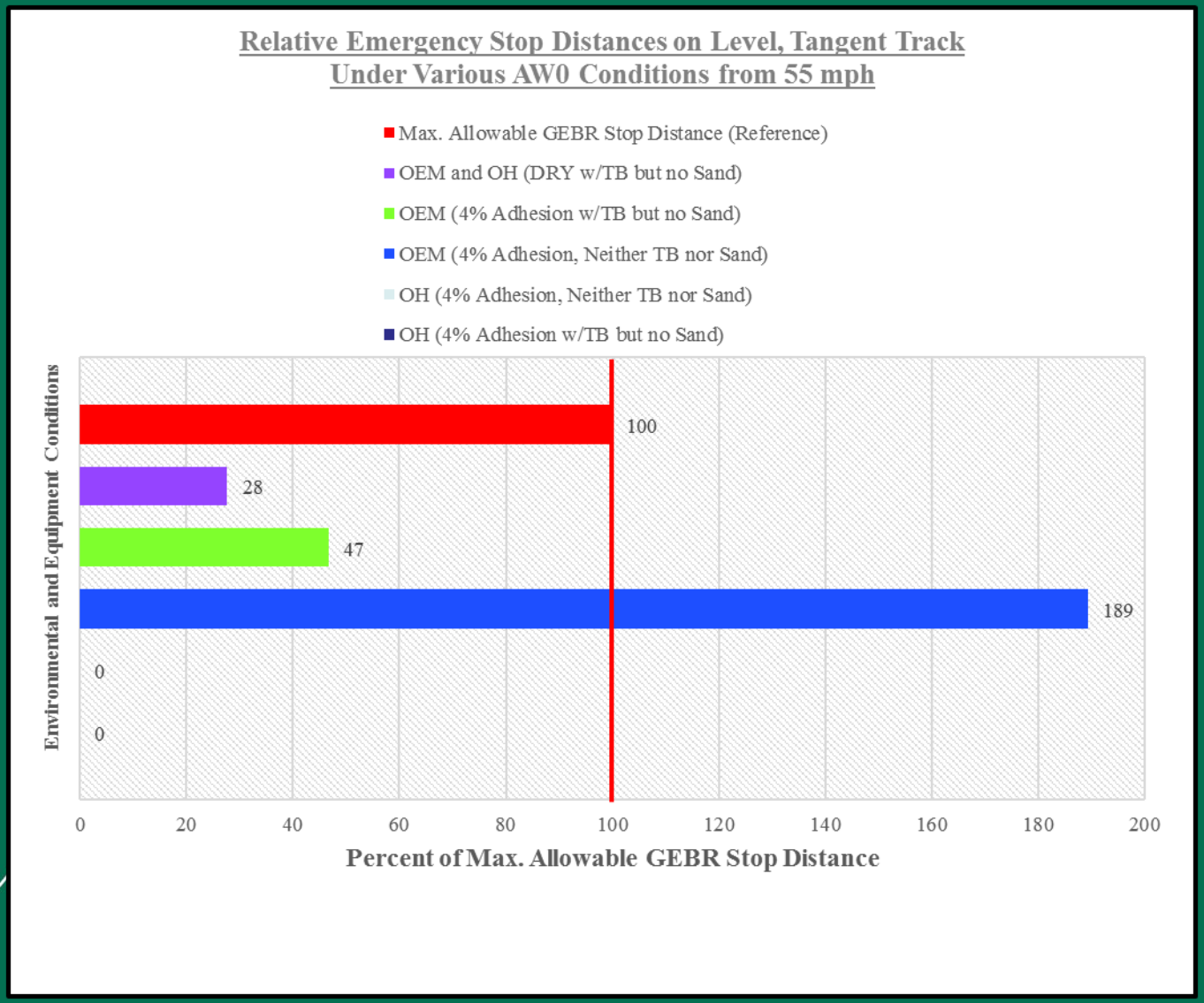
Mid-Life Overhaul
Preliminary Brake Performance Results



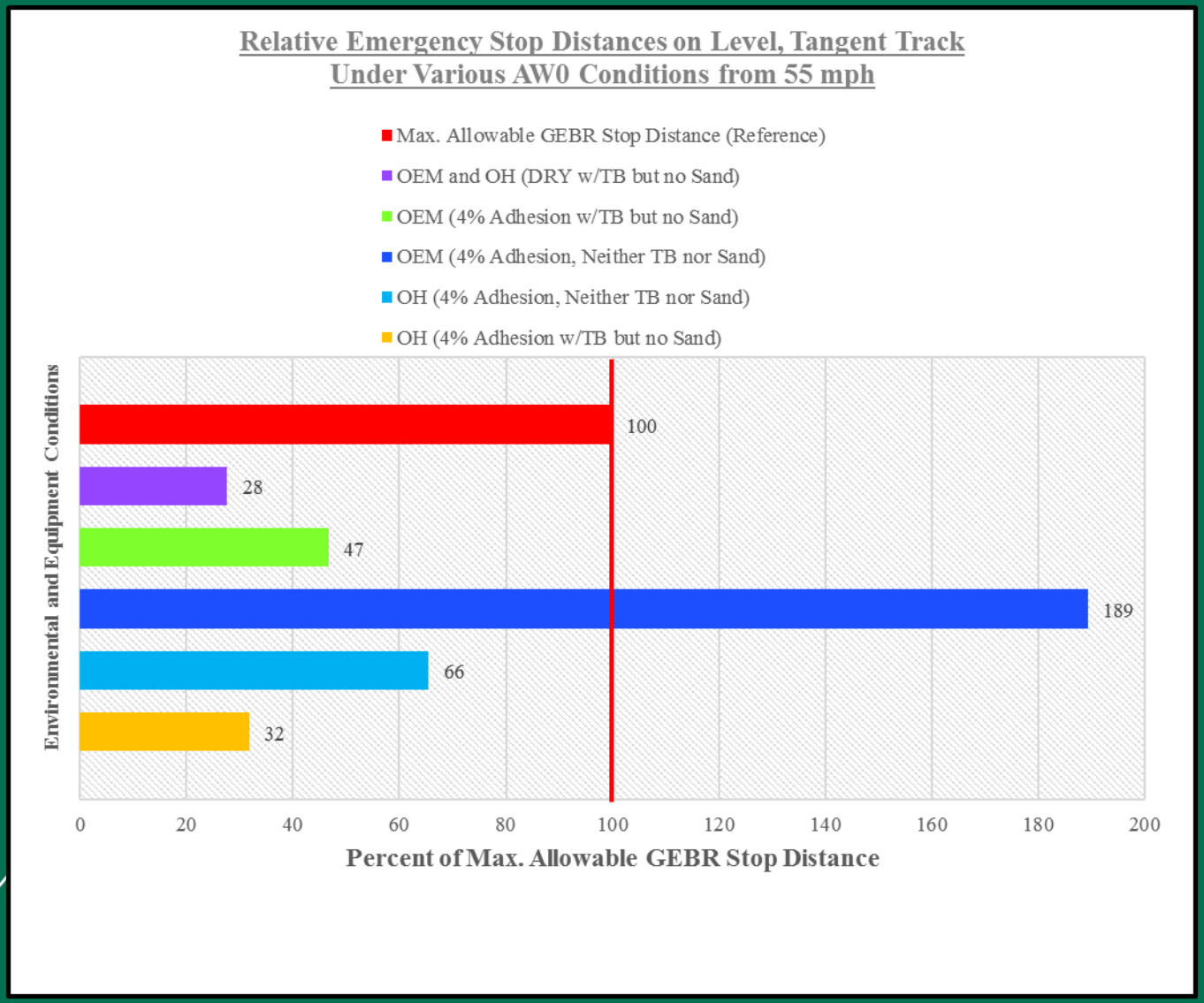
Mid-Life Overhaul
Preliminary Brake Performance Results



Mid-Life Overhaul
Preliminary Brake Performance Results



Mid-Life Overhaul
Preliminary Brake Performance Results



Mid-Life Overhaul
Have Goals Related to Braking Operation and Performance Been Fulfilled?

- ✓ Enable wheel slip-slide correction during Emergency Brake requests by ATP and Vigilance systems to mitigate wheel flats.

Mid-Life Overhaul
Have Goals Related to Braking Operation and Performance Been Fulfilled?

- ✓ Enable wheel slip-slide correction during Emergency Brake requests by ATP and Vigilance systems to mitigate wheel flats.
- ✓ Improve wheel slip-slide correction performance to mitigate nuisance Emergency Brake applications during ATP Overspeed correction activities without requiring Track Brake activation.

Mid-Life Overhaul
Have Goals Related to Braking Operation and Performance Been Fulfilled?

- ✓ Enable wheel slip-slide correction during Emergency Brake requests by ATP and Vigilance systems to mitigate wheel flats.
- ✓ Improve wheel slip-slide correction performance to mitigate nuisance Emergency Brake applications during ATP Overspeed correction activities without requiring Track Brake activation.
- ✓ Satisfy maximum allowable GEBR stop distance requirement when wheel slip-slide correction is active during Emergency Braking.

Question and Answer