RSAC – Distributed Power (DP) Train Braking Modernization Task Group

U.S. Department of Transportation
Federal Railroad Administration

March 27, 2024

DP Task Group Charter

Opportunity Statement:

Identify potential modifications of train brake equipment and brake-related processes and procedures to improve train braking effectiveness employing technological advancements of a DP system.

Description:

The Task Group (TG) will review the braking effectiveness of trains with different combinations of DP and various train lengths to determine if braking effectiveness can be improved.

Revised Objectives:

1. Perform study/analysis of conventional vs. distributed power train operations:
    a. Evaluate train braking effectiveness of conventional vs. DP trains.
    b. Research the effect of DP position in train consist.
    c. Evaluate DP impact on drawbar forces.
    d. Evaluate asynchronous DP operation.
2. LXA impact on Comm Loss.
3. How DP train braking measures against ECP (ref. AAR statement from 2018).
4. Any other issues related to train brake performance associated with DP.
5. Communicate findings/recommendations with OP TG.
6. Generate preliminary report by March 1st, 2024.

TG Team Members:

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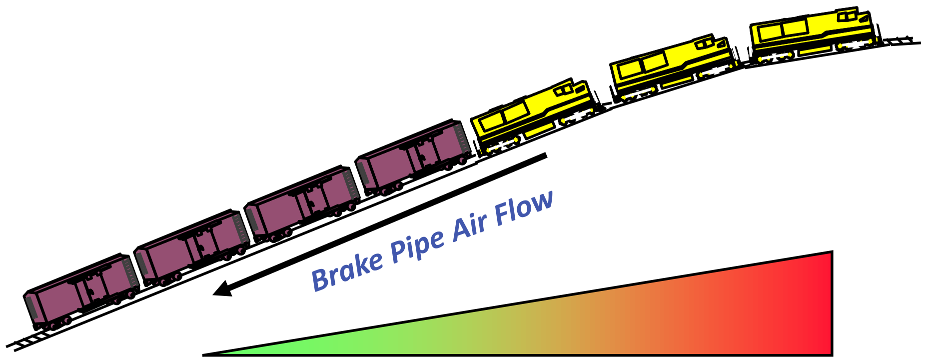
What is Distributed Power ?

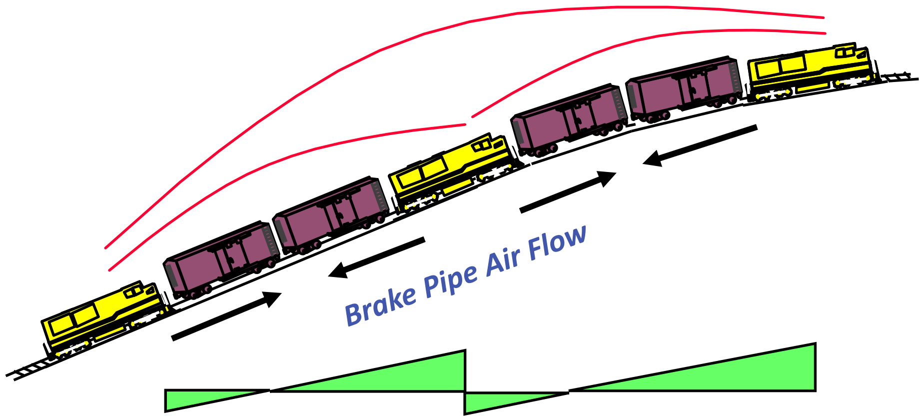
- Distributed Power (DP) technology enables up to 5 locomotives consists to be distributed in a single train.
- The train engineer resides in the leading loco (DP Lead) and controls the remote locos (DP Remotes).
- Distributed Power reduces draw bar forces and improves braking control.

Conventional Train



Draw Bar Force highest behind Trail locomotive

Distributed Power Train



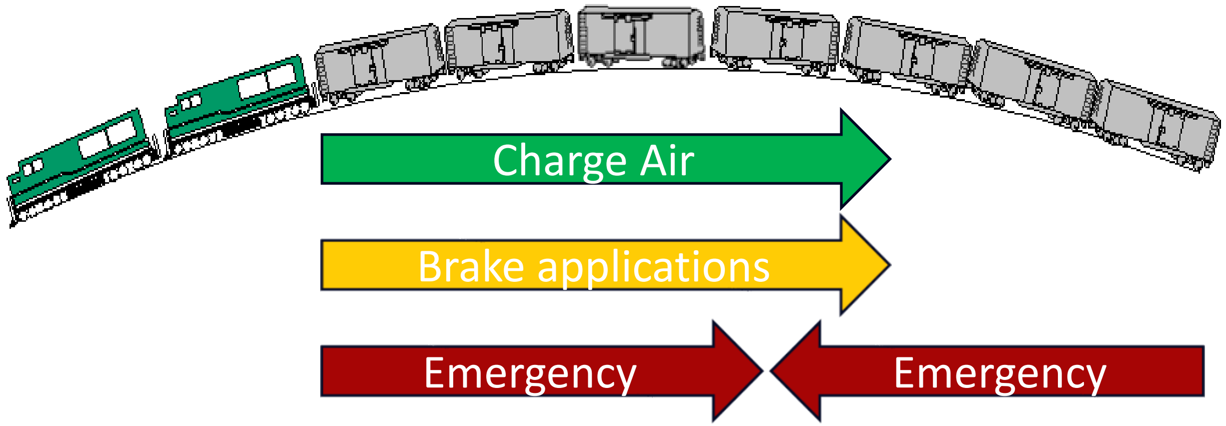
Draw Bar Forces reduced when locomotive power and braking is distributed throughout the train

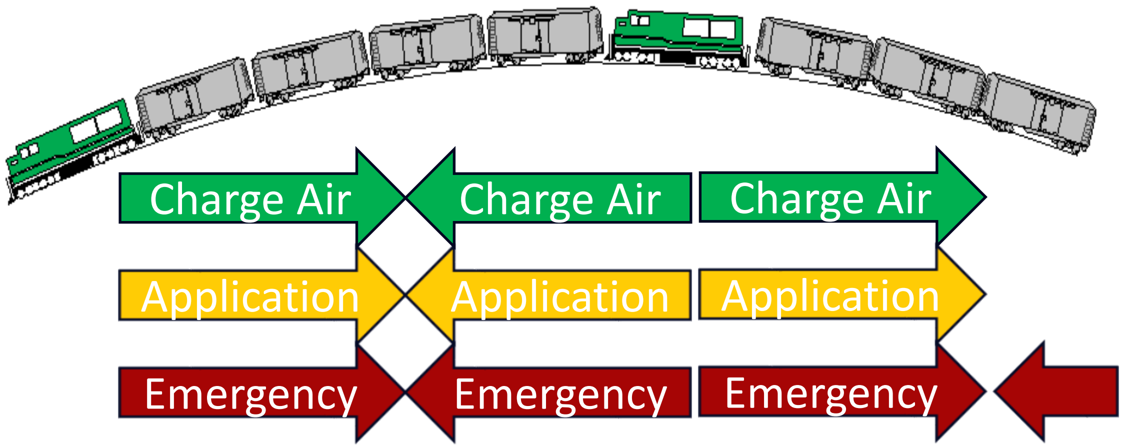
Objective 1a: Train Braking Effectiveness: Conventional vs. DP Trains

DP Remote consist(s) provide additional locations for air brake control in a train. This provides the following benefits compared to conventional trains:

- Provides a supply of air at the various points in the train from each remote consist reducing charge times.
- Brake pipe reductions are affected simultaneously from each remote consist reducing propagation times.
- Emergency applications are affected simultaneously from each remote consist. Trainline initiated emergencies are sensed and transmitted from closest consist.

Regardless of Synchronous or Asynchronous modes for power and dynamic brake, the commands from the air brake systems of the remote consist(s) are always synchronized to the lead locomotive. This is true anytime train is operating with BV In (normal operation).





Conclusions

Based on simulation studies at one Class I railway for a 200-car train in head-end and DP (75% length placement) configurations compared to conventional head end only power, the DP Task Group determined the following DP benefits in key brake performance areas:

- Full brake set - 2.8x faster
- Recovery time - 3.6x faster
- Max brake pipe gradient - 9.6x less
  - Measured after release and at steady state (0.25 PSI DP vs 2.4 PSI Conventional)
  - Simulation assumed a 2.0 lb leak

*Preliminary results from the FRA long train study also show performance improvements.

Objective 1b: DP Position Effect In Train Consists

Location of DP units or consists in trains is driven by:

- Effective distance to ensure reliable communication between controlling and DP locomotives
- Weight distribution/train make-up (train origination)
- Planned set-outs and pick-ups (train make-up change)
- Type of the cars in train consist (length, draft system, etc.)
- Cumulative length of brake pipe trainline (air propagation)
- Planned and/or alternate train route (terrain, ruling grade, etc.)
- Compliance with foreign road DP trains rules (if interchanged)

Typical DP Train Configurations

Class I railroads use 5 configuration mappings in DP trains, which includes Head and Remote Consists

- Remote Consist DP train configuration
  - Capability: up to 4 Remote Consists, designated A through D may be utilized
  - Most typical operations:
    - Single remote consist
      - Position: Head/Mid (1x1x0, 2x1x0, 1x2x0, 2x3x0, 3x2x0)
      - Position: Head/Rear (1x0x1, 2x0x1, 3x0x1)
    - Two remote consists
      - Position: Head/Mid/Rear (1x1x1, 2x1x1, 2x2x2, 2x3x2)
  - Three remote units are used very rarely

*Locomotives can be positioned in up to 5 configurations in a train, a Head Consist and Remote Consists A, B, C, and D.
Operators may control Remote Consists by placing a “fence” between them, thereby designating a “Lead” control group and a “Remote” control group.

DP Node(s) Position in Train Consist Is Driven by Computer Simulations

Generally, TOES software is used to determine the DP placement and adjusted by data collected and analyzed during factual train performance.

The following factors are considered:

- Ability of remote consists to generate buff forces.
    - The effect of buff / draft at remote consists locations
    - Light/long car placement restrictions near locomotive consists.
- Distance from lead based on geography, generation of software.
- Tonnage trailing remote DP consists.
- Braking effectiveness.
- Car placement (including hazmat) next to DP consist(s).
- Placement or EOCC cars ahead of remote consists.
    - Many restrictions are territory specific.
- Comm loss idle down considerations.
- Alleviation of trailing tonnage restrictions on cars ahead of DP consist(s).

Conclusions

DP Task Group determined:

- ~ 66% of Brake Pipe for Head/Mid operation is typical.

- Trailing tonnage consist distribution defines DP consist(s) location in consist.

- Segmentation: 7,400' – 10,000' predicated on DP Comm system type, brake pipe air propagation requirements and route characteristics

- Interchange of the DP trains are coordinated between handling railroads to ensure compliance with the subject railroads' operating rules and train makeup guidelines.

- Maximum braking effectiveness is achieved through compliance with all the best practices, such as, train make-up, compliance with the OP rules, etc.

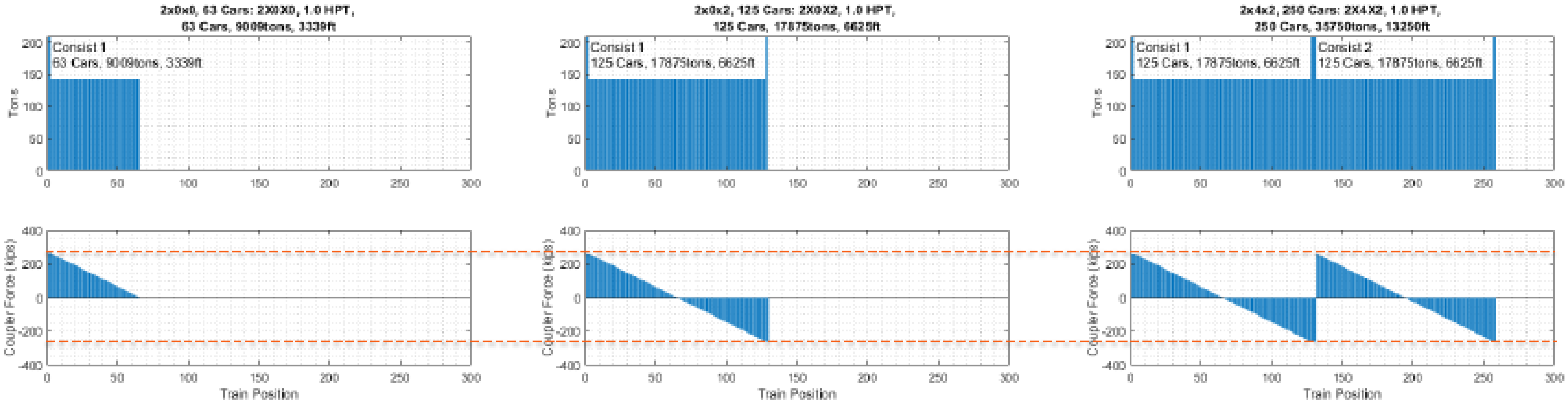
Objective 1c: DP Impact on Coupler Forces

In-train forces analysis is based on collected data during the study of the bulk commodity trains.
Scope:

- Single to double coal trains comparison
  - Static in-train forces (steady pull or braking)
  - Mountain grade operation
  - Cresting a hill operation
  - Undulating track operation
- Type E Coupler capacity – 390,000 lbs. (390 kips)

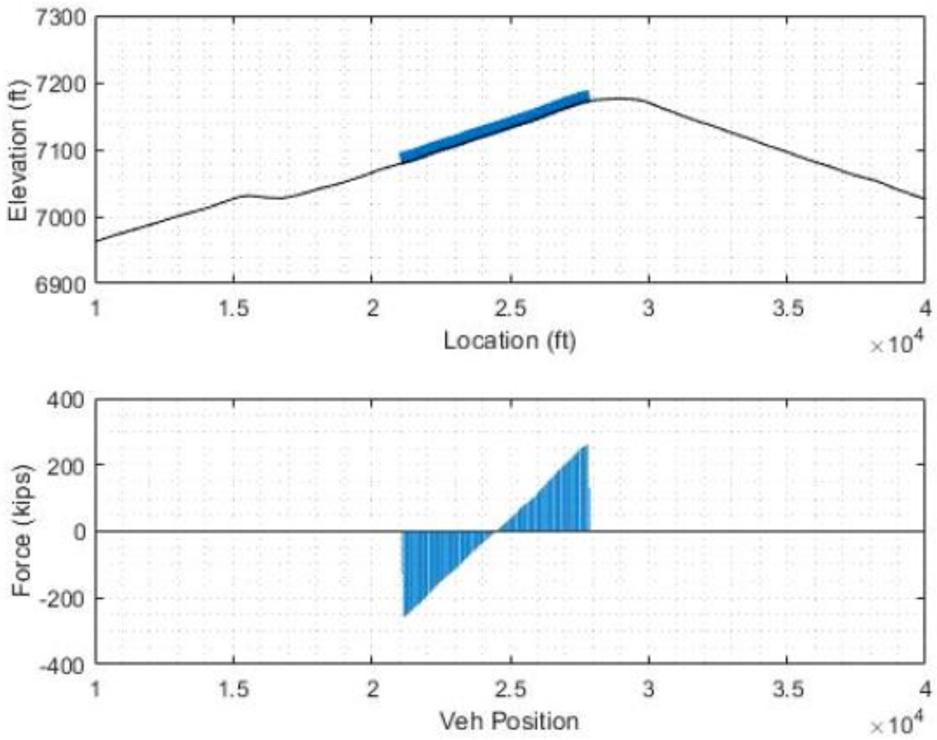
Static In-Train Forces

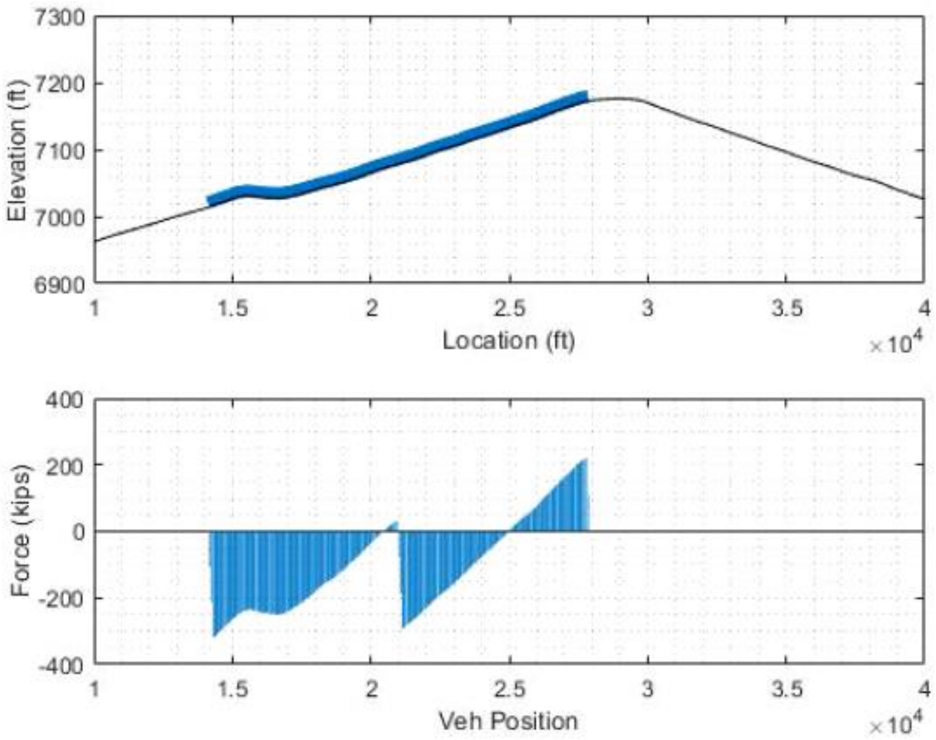
- Train power configurations:
  - 2x0
  - 2x0x2
  - 2x4x2
- Same HPT maintained on all trains in study
- Draft forces represented by positive values and buff forces by negative values
- Draft and buff forces are virtually corresponding in steady operation



Mountain Grade Operation

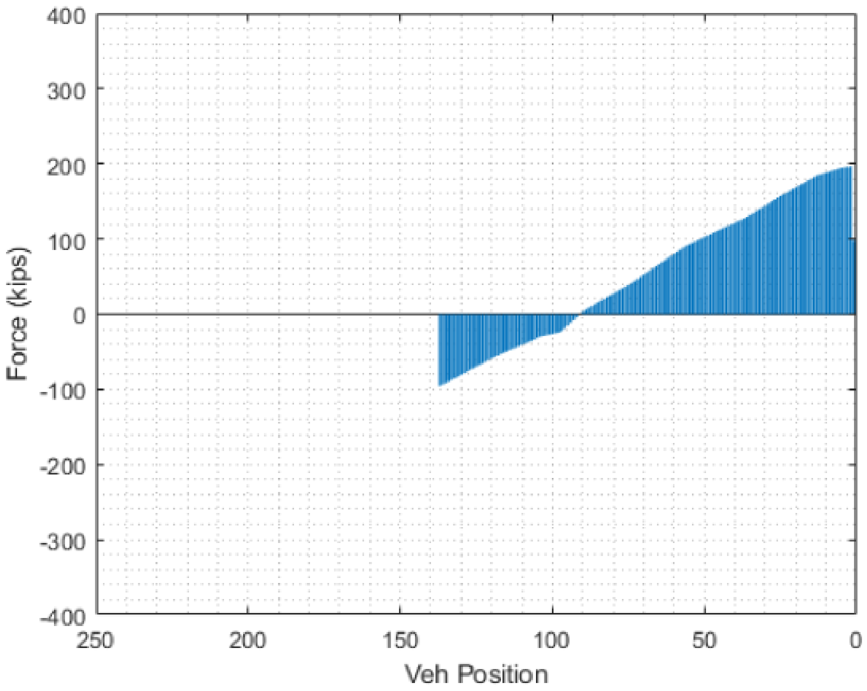
- Train power configuration comparison: 2x2 vs. 2x4x3
- Peak draft force on single train of 260 kips, concentrated near the head-end of the train
- Peak draft force on doubled train of 370 kips, concentrated near the middle of the train

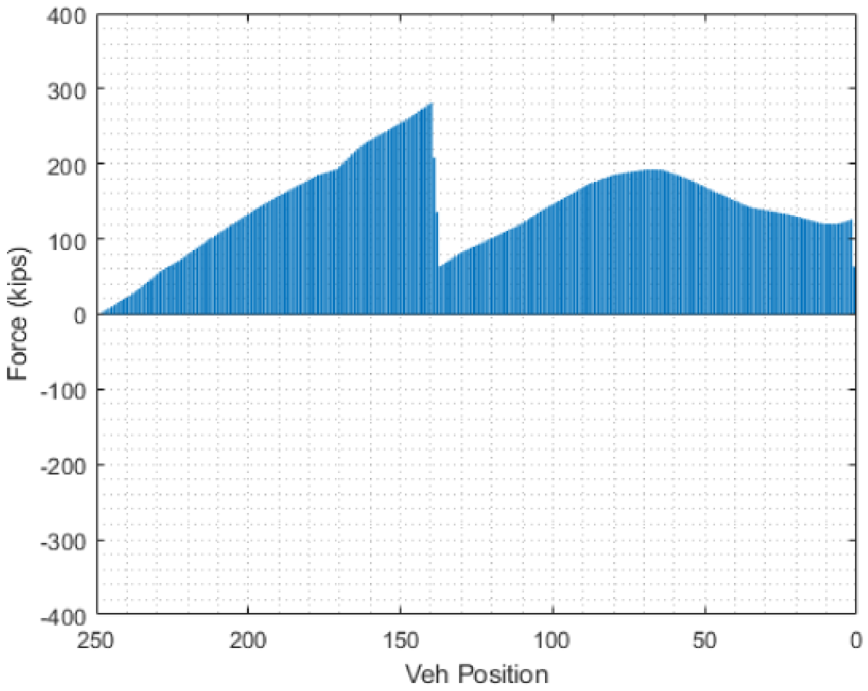




Cresting a Hill Operation

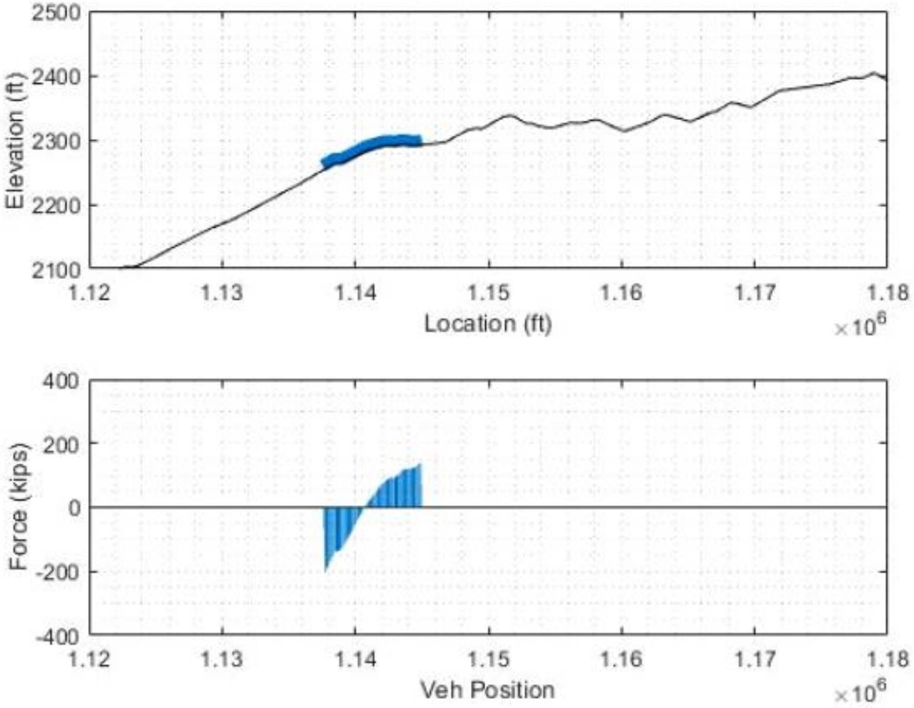
- Train power configuration comparison 2x0x1 vs. 2x3x1
- Peak draft force on single train of 200 kips, concentrated near the head-end of the train.
- Peak draft force on doubled train of 290 kips, concentrated near the middle of the train.

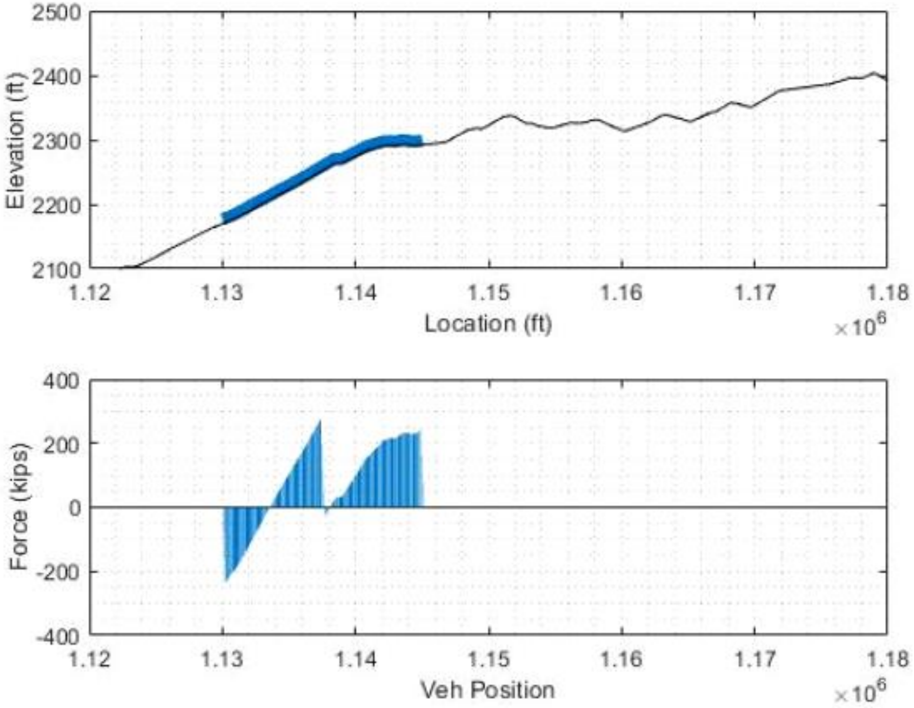




Undulating Track Operation

- Train power configuration comparison 2x0x3 vs. 3x4x3
- Peak draft force on single train of 240 kips
- Peak draft force on doubled train of 300 kips





Conclusions

DP Task Group determined:

- Doubled bulk trains (coal in study) stay below maximum E-type coupler capacity in all scenarios
- DP consist position ensures doubled bulk and single train forces can be maintained to equivalent levels
- Cresting or traversing on undulating track may generate higher in train forces in doubled trains

Objective 1d: What Is The Difference Between Synchronous And Asynchronous DP Modes Of Operation?

- Synchronous DP Operation: All Distributed Power Consists* apply the same power and dynamic braking commands as input by the operator on the lead locomotive control stand.

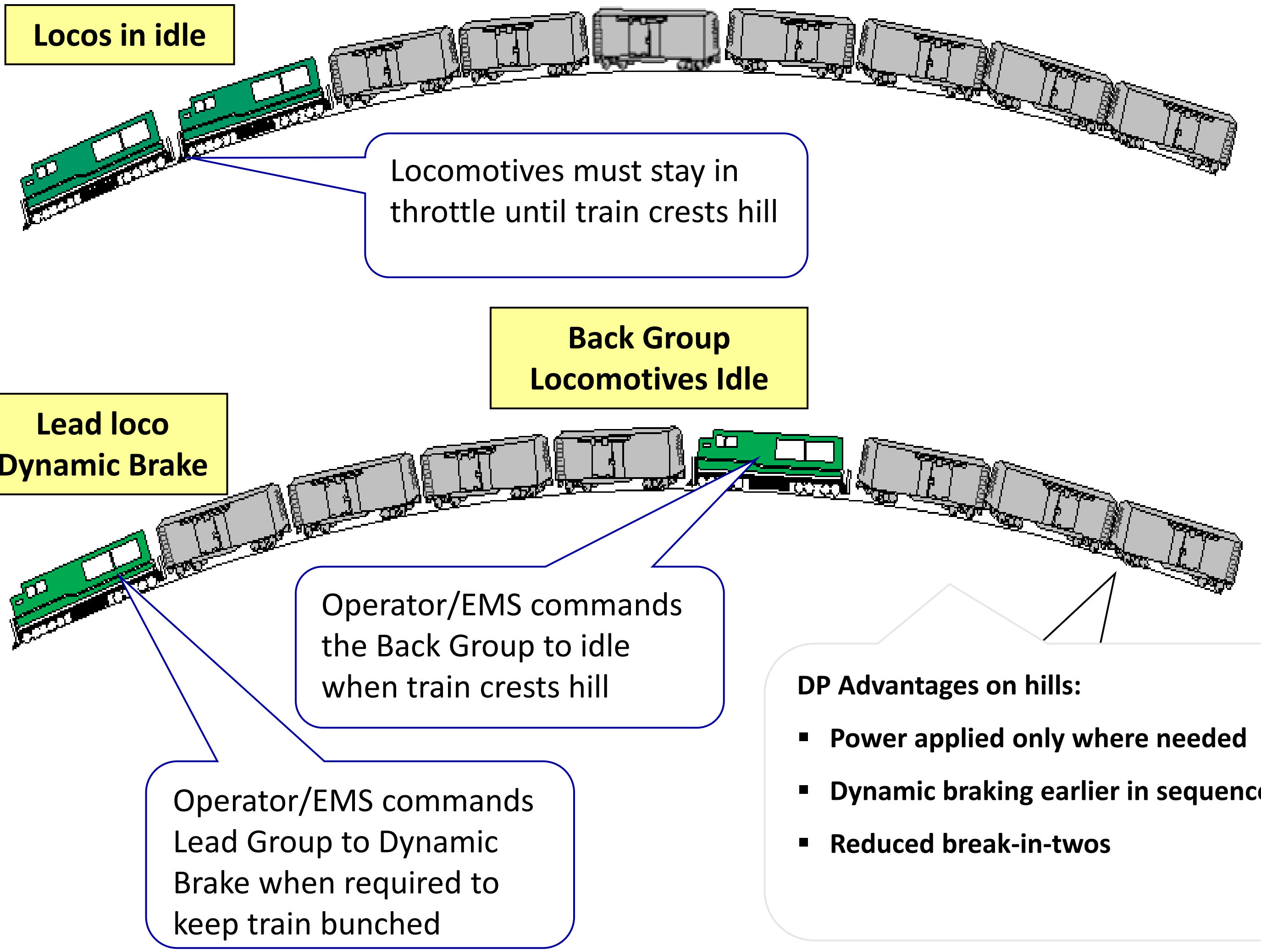
- Asynchronous DP Operation: The practice of commanding the power and dynamic braking functions of Remote Distributed Power Consists* in a freight train independent of the controlling or lead locomotive group utilizing the locomotive display screens.

*Locomotives can be positioned in up to 5 configurations in a train, a Head Consist and Remote Consists A, B, C, and D.
Operators may control Remote Consists by placing a “fence” between them, thereby designating a “Lead” control group and a “Remote” control group.

Asynchronous DP Feature Aimed to Improve Safety Through Control Of In-train Forces

Conventional Train

DP Train



DP Advantages on hills:

- **Power applied only where needed**
- **Dynamic braking earlier in sequence**
- **Reduced break-in-twos**

What is identical?

- Air Brake systems in DP operation are always synchronous and controlled from the brake valve of the controlling locomotive.

- Asynchronous operation has no effect on air propagation or air brake effectiveness of DP operation.

Practical Application And Benefits

- Asynchronous operation is recognized by the Class I's as the preferred method of DP operation for the purposes of controlling and mitigating in-train forces by means of real-time variation of the locomotive consists.

- Short-line railroads consider synchronous DP operation as a standard mode of operation.

- Energy Management systems utilize asynchronous operation as their default method of DP "Auto" control.

- Operator's decision on "fence" location is dependent on Remote Consist placement in train, trailing tonnage, train makeup rules and other route-specific requirements.

- Fencing is subject to change due to the train consist adjustments and environmental conditions.

- Use of Asynchronous DP feature benefits the engineer when traversing over undulating territory.

Asynchronous DP Operation – Conclusions

DP Task Group determined:

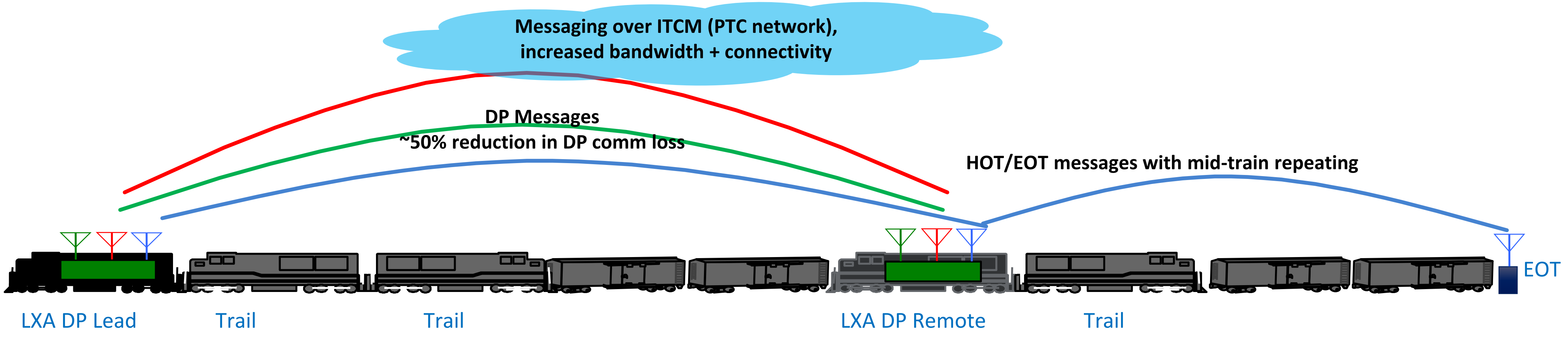
- Train simulations suggest reduction in in-train forces when asynchronous mode of DP operation is utilized decreasing potential for UDE/break-in-two events.

- Asynchronous mode of DP operation helps control the train in a manner that allows consistent control of the train in various challenging terrain scenarios thereby avoiding the need to use the automatic air brake in some cases.

- Locomotive operator additional task to manually control DP consists is minimized as EM systems control the mode of operation automatically.

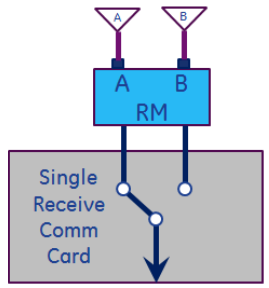
Objective 2: LXA DP Feature Impact on Communication Losses

- Distributed Power (DP) technology has evolved over the last 50 years.
- The most recent generation of DP technology is called Locotrol eXpanded Architecture (LXA) DP.
- LXA DP is a proven solution with +8,000 LXA DP systems installed on various locomotive models at +10 customers.
- LXA DP feature enhancements include
  - DP radio diversity (results in improved DP communications)
  - DP communication over ITCM (results in improved DP communications)
  - Integrated HOT with mid-train HOT/EOT repeating (improved reliability of 2-way transmission, and emergency brake application)
  - Over the Air updates/downloads
  - Improved diagnostics
- Improved DP communications (with LXA DP) between the DP Lead and DP Remote leads to improved train braking.

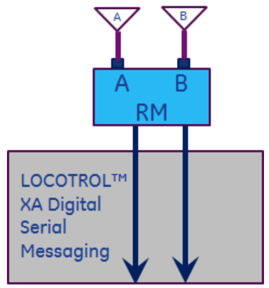


Objective 2: LXA DP Feature Impact on Communication Losses – DP Radio Diversity

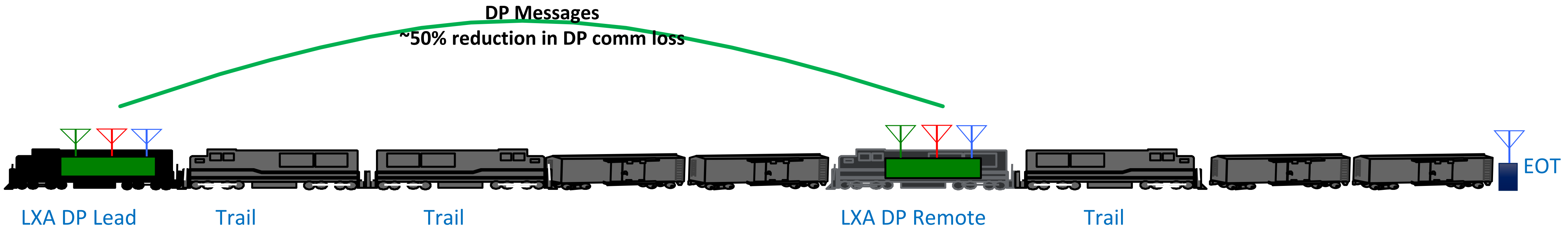
- The LXA DP system continuously listens on both radios and provides full radio diversity. Due to this feature, LXA reduces DP communication interruptions by 50%.



Standard DP radio communications
- switch between radios



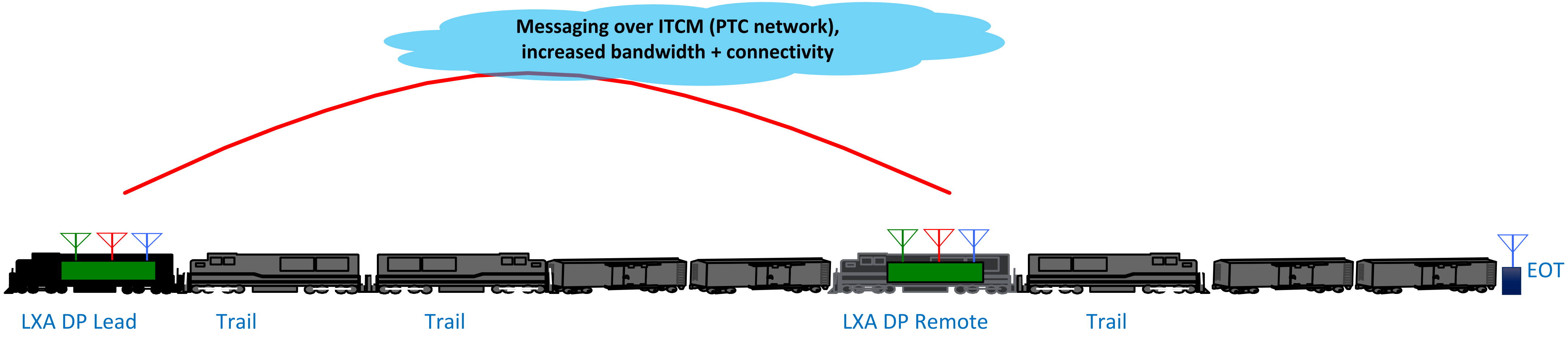
LXA DP radio communications
- full radio diversity



Objective 2: LXA DP Feature Impact on Communication Losses – DP communication over the ITCM network

- The LXA DP system can utilize ITCM network to improve DP communication.
- DP communication over ITCM has two communications pathways:
  1. Utilize standard DP radios (450 MHz) << primary communication pathway >>
  2. Utilize ITCM network (220 MHz, Cell, WiFi) << secondary communication pathway >>

Field tests indicate DP communication interruptions are reduced further due to the dual communication path.



Analysis of the Collected Field Tests Data

LXA DP Radio Diversity

- Results from multiple train tests = 16% to 84% improvement (i.e. reduction in DP comm losses), with most test results showing > 50% improvement
- Result from Transcontinental test train:
  - LXA run vs. IPM DP runs = 77% improvement
  - In Train Remote Repeating (ITRR) was active 56 min on LXA run → improvement due to ITRR = 26%
  - Balance of the improvement due to LXA radio receive diversity = **51%**

Train Runs	Comm Loss Time in Transit
LXA Run (S-LPCSCO2-09T, 8/9 - 8/13 11,850 ft, 2 Remotes)	**49 minutes***
IPM-based DP Run 1 (S-LPCSCO2-13T, 9/13 – 9/16 11,950 ft, 2 Remotes)	**215 minutes***
IPM-based DP Run 2 (S-LPCSCO2-20T, 9/20 – 9/24 11,895 ft, 2 Remotes)	**209 minutes***

*Note: Removed from analysis all comm loss while train is stopped

LXA DP communication over the ITCM network

- DP comm interruptions further reduced with DP communication over ITCM as a backup secondary communication path (minutes of Comm Loss are aggregate)

Traversal (Origin – Destination)	Comm Loss Radio (Minutes)	Comm Loss Radio + ITCM (Minutes)	Improvement
Los Angeles – Chicago	111.0	61.0	**45%**
Memphis – Birmingham	28.0	2.0	**93%**
Cincinnati – Waycross	39.3	14.0	**64%**
Pittsburg – Heavener	26.3	5.0	**81%**
Birmingham – Burnside	49.1	11.0	**87%**
Chicago – Los Angeles	13.0	1.5	**88%**
Granger – Hinkle	60.0	20.0	**66%**

Conclusions

DP Task Group determined:

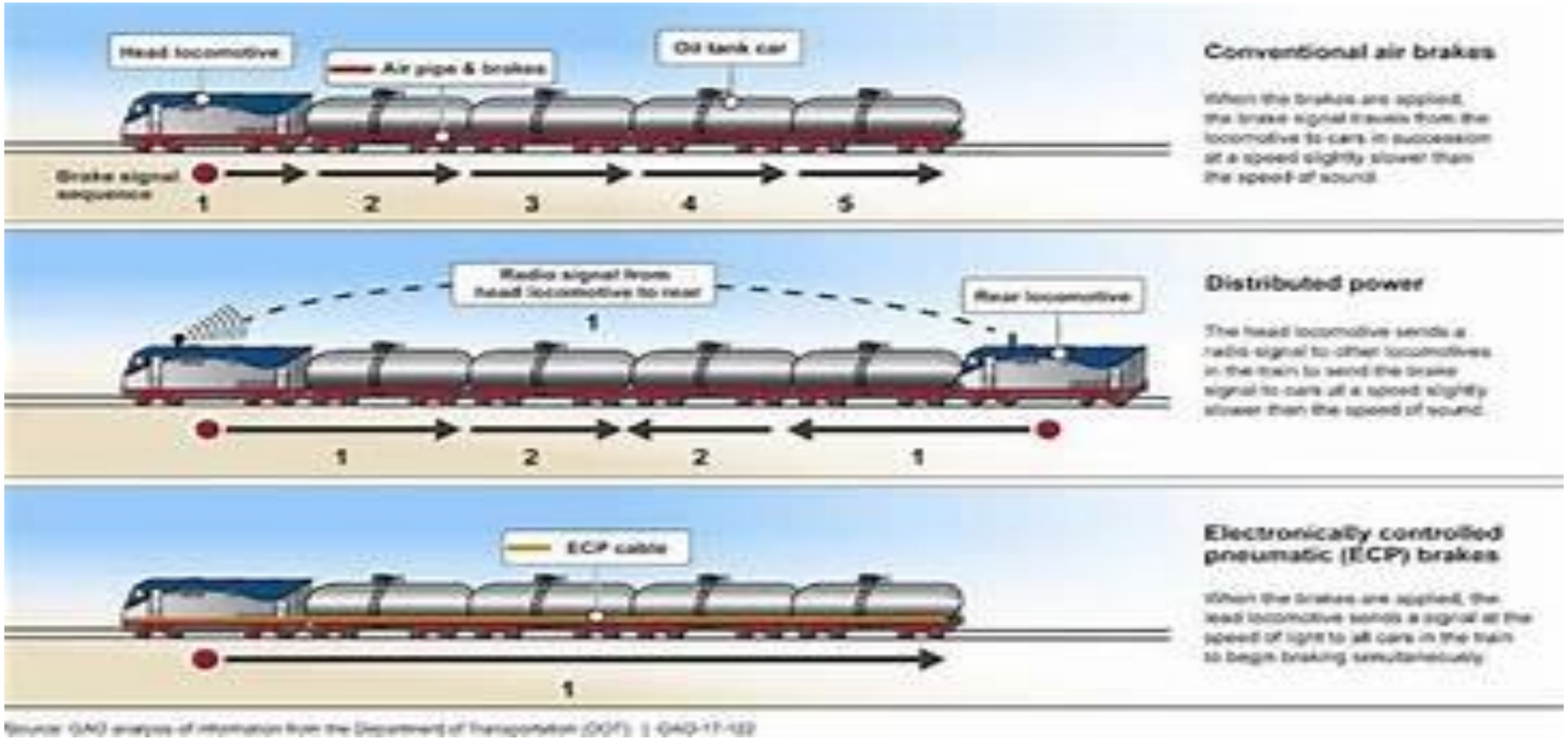
- LXA DP radio diversity reduces DP communication losses by 50%.

- Utilization of ITCM network for DP communications further reduces comm losses, between 45% to ~90%.

- Improved DP communications (with LXA DP) between the DP Lead and DP Remote leads to improved train braking.

Objective 3: Train Braking Effectiveness: DP vs. ECP

DP vs. ECP comparison:



Objective 3: Train Braking Effectiveness: DP vs. ECP

DP vs. ECP comparison:

- Not an either or, ECP and DP can be used at the same time.
  - Radio DP essentially propagates the brake command from 2 or more points instead of 1
  - Allows extending train length while keeping brake performance like a shorter train (dependent on how long segment between remotes is)
  - Adds a layer of redundancy (from a safety perspective)

- DP adds additional source of air supply
- ECP essentially brakes the train like a single vehicle (no matter what length is)
  - Adds graduated release
  - Adds continual charging
  - Adds brake cylinder maintaining and consistent NBR (each car will maintain against leakage and go to the same proportionate brake as the car next to it)
  - Adds faster consistent service application and release (all cars go to same brake level at the same time) how this measures to 1x1x0 and 1x1x1 DP configuration
  - Adds brake condition monitoring
  - Adds a layer of redundancy (from a safety perspective)

Conclusions

DP Task Group determined:

- Train braking in emergency is similar between Radio DP and ECP
- DP adds a source of air supply
- ECP adds the following benefits
  - Enhanced service braking performance
  - Train brake condition monitoring

Open Discussion and Questions