David L. Freeman
Sr. Vice President
Transportation

BNSF Railway
2600 Lou Menk Drive
Fort Worth, TX 76131
[redacted]

July 28, 2015

Mr. Richard Hipskind
Railroad Accident Investigator
National Transportation Safety Board
490 L'Enfant Plaza SW
Washington DC 20024

Dear Mr. Hipskind:

I write to clarify the position of BNSF Railway Company (BNSF) regarding the July 20, 2015 "Train Braking Simulation Study" (the Study) related to Electronic Controlled Pneumatic (ECP) brakes which the National Transportation Safety Board (NTSB) undertook as part of the party investigation process related to the December 30, 2013 Casselton, ND accident (NTSB Number DCA14MR004).

BNSF Clarifications

The NTSB requested BNSF's input regarding the matters addressed in the Study which BNSF provided as part of the NTSB's docketed investigation of the Casselton incident. BNSF was allowed to review the text of the report before it was finalized. BNSF appreciates that in response to BNSF's review, the NTSB modified its approach in the Study to include a comparison of Distributed Power (DP) versus conventional braking (CONV). However, despite the change made by the NTSB, BNSF takes issue with several assertions in the Study as well as the scope of the methodology which are briefly detailed in Exhibit 1, attached.

BNSF believes that the Study is more useful than FRA's computer simulation studies of stopping distance because it recognizes the significance of DP. However, BNSF believes that the Study's inquiry and findings should not be taken to imply that increased Net Braking Ratio (NBR), as well as reduced braking distance, are the most important elements in considering the role of braking systems in reducing risk in derailments of crude and ethanol unit trains since most mainline derailments are not attributable to braking. Rather, BNSF believes that the more significant safety question is whether a braking system can dissipate energy in derailment scenarios and, consequently, reduce the number of cars with the potential of releasing material following a derailment.

Although we do not wish to prejudge the NTSB's final incident report for the Casselton accident, BNSF does not believe that a shorter stopping distance which may have resulted from different braking technology would have prevented this incident. The NTSB notes that the results of the Study are not intended for use in evaluating this incident. BNSF modeled the potential effects of ECP on the Casselton incident, as well as the two other crude-by-rail incidents experienced on the BNSF network over the last two years, at the Transportation Technology Center Inc. in Pueblo, Colorado (TTCI). The TTCI modeling shows that utilization of ECP in these BNSF incidents would not have significantly impacted their outcomes. Attached as Exhibit 2 is TTCI modeling of the 'derailment mitigation impact' that ECP brakes would have had on the total number of cars derailing and releasing in these three crude oil train derailments:

- December 30, 2013 - Casselton, ND
- March 5, 2015 - Galena, IL
- May 6, 2015 - Heimdal, ND

While the modeling shows that, if these trains were equipped with ECP, the total number of cars reaching the Point of Derailment (POD) would have been modestly reduced (3.3 fewer cars reaching the POD at Casselton; 2.4 fewer cars at Galena; and 0.4 fewer cars at Heimdal), the analysis must go beyond just the number of cars reaching the POD to achieve a full understanding of the total risk. Analyzing the total potential for risk requires overlay of the initial energy dissipation analysis with the actual reduction in the potential for a release. As our submissions indicate, the most significant reductions in the Conditional Probability of Release (CPR) come from transition to the Next Generation Tank Car recently required by the Department of Transportation, rather than a mandate for ECP brakes.

Limitations of ECP Braking Technology

Railroad industry experience and analysis of ECP brakes was provided to the FRA in the attached expert report prepared by Oliver Wyman for the Association of American Railroads entitled, "Assessment of the Enhanced Braking Requirements in the Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains Final Rule of May 1, 2015," Exhibit 3. BNSF has tested ECP brakes widely since 1998 in a number of services. The last BNSF ECP set was retired in 2014 (BNSF continues to support ECP testing on a Norfolk Southern coal set through 2015). BNSF's two decade experience shows that ECP-equipped trains have a failure rate, including service interruptions due to unplanned braking events, of more than three times that of a standard train.

There are several important points to consider when analyzing ECP implementation. First, connectors and software pose considerable problems in ECP utilization and, most troubling, any loose connector, software mismatch between locomotives, or depleted ECP battery can cause unexpected, undesired, and unplanned emergency brake applications. Second, brake shoe consumption remains considerably higher than comparable conventional train sets. Third, due to increased braking, BNSF's ECP testing wheel consumption is equal to or slightly higher than otherwise experienced. Finally, overall reliability of current ECP technology is a significant concern. Each of these events consume additional manpower, including mechanical responders, train crews, mechanical desk support, and OEM technicians and introduce new and additional work events and exposures to BNSF's operations which ripple across BNSF's entire network.

Given the ECP failure rate, BNSF has never had to address the issue of how to deploy ECP brake technology more broadly across unit train fleets. This is complex, in and of itself, since locomotive and car fleets are not discreet but flow across different business units, train services, and geography. ECP failure rates make implementation significantly more impactful and costly as a braking technology. Last year and in 2013, when BNSF had widespread congestion on its network, maintaining a segregated ECP-High Hazard Flammable Train (HHFT) fleet would have further degraded network operations for all customers.

As units of all types grow on the U.S. freight rail network, complexity and the need for interoperability and reliability become increasingly important. Far from a discreet fleet, North American crude oil and ethanol trains move across 70 percent of BNSF track but represent only five percent of BNSF shipments. These products move between multiple origins and destinations, and tank cars and locomotive frequently shift between manifest and unit train operations. At destination, cars and their locomotives may move back to the same location, but have a high likelihood of being diffused throughout the system as needed. Even for crude or ethanol unit trains, where cars and locomotives stay together, ECP reliability issues will require broader deployment and maintenance of redundant braking systems in order to anticipate failure rates and to ensure additional equipment for operational flexibility.

Conclusion

BNSF wishes to emphasize that in operating a modern freight railroad, achieving overall safety outcomes is an exercise in addressing the multiple risks present in the real-world operations of railroading. With respect to transportation of crude-by-rail, this multi-layered approach to risk reduction includes safer tank cars, related speed restrictions, Positive Train Control, HHFT operating and train handling practices, enhanced equipment and rail inspection and detection technology, as well as significant on-going maintenance investment. BNSF submits that ECP's marginal additional efficacy over DP in preventing and reducing the consequences of tank car breaches must be weighed in this overall safety context. As such, BNSF believes:

- The overall net improvement in safety from ECP brakes relative to DP is small;
- Deploying ECP brakes will significantly impact overall network operations due to their failure rates;
- Fluidity and operational concerns will hurt other rail customers, potentially forcing more freight to the highway (including hazardous materials), where exposure to risk is increased;

BNSF's experience with ECP is not theoretical. Unlike PTC, which BNSF confidently initiated while aware of its ambitiousness and difficulty, BNSF does not have the same belief that ECP will be network-ready over time, nor result in significant benefits given potential impacts to the overall health of the freight rail network.

Sincerely,

[redacted]

David L. Freeman
Senior Vice President, Transportation

Exhibit 1: BNSF comments, "Train Braking Simulation Study"

(NTSB Number DCA14MR004)

The NTSB concludes that *"Under conventional braking, unplanned service or emergency pneumatic brake signal propagation through the length of the train can result in notable run-in forces on cars at the head-end of the train. Heavy buff and run-in forces may result in 1) derailment of lightly-loaded cars, depending in part on their geometry, track curvature, and local rail conditions or 2) sliding of heavily-braked and/or lightly-loaded wheels (wheel longitudinal motion with low/zero angular velocity), depending in part on actual track contamination and/or environmental conditions."*

- BNSF disagrees with the statement that these forces are sufficiently high enough to cause derailment. In a review of FRA data on reportable mainline derailments, to support inclusion of emergency braking as a safe option in the PTC braking calculations, no derailments were found for which the primary cause was attributed to emergency brake application. BNSF and other railroads employ train make-up policies designed in part to mitigate derailment risk associated with excessive slack run-in events.

- The assertion of wheel sliding during automatic brake application, service or emergency, does not appear to be a matter established by research or experience. BNSF is not aware of any test data that suggests wheel slippage occurs during braking with automatic brakes under normal conditions.

- BNSF does not believe wheels of ECP trains will slide any less than wheels of DP trains, or conventional pneumatic trains, for that matter. Additionally, under conditions of severe deceleration, such as collision or inordinately high speed switching impact, it is possible for slippage of a wheel to occur due to its angular momentum relative to the sudden change of car body linear velocity, but not from slack changes caused by normal braking.

  At best, "micro-slippage" of wheels may possibly occur during braking. BNSF is not aware of any test data that suggests wheel slippage occurs during braking with automatic brakes under normal conditions. We do not believe wheels of ECP trains will slide any less than wheels of DP trains, or conventional pneumatic trains.

- Increasing Net Braking Ratio (NBR) can reduce braking distance, but also can impact wheel performance. The NTSB report makes a reference to this, but this safety trade-off should be carefully reviewed. Operating with average NBR closer to the allowable upper limit may not be something railroads should or will want to do. The effect of additional thermal input into tread-braked wheels from higher NBRs must be evaluated.

The industry made design changes to freight car wheels several years ago to mitigate wheel failures caused by thermal overload. BNSF, and likely other roads, also instituted operational procedures requiring use of dynamic brake to minimize thermal input into freight car wheels. It is likely BNSF would not change this practice even if ECP brake systems are used. More background and research into the costs and benefits of a higher average NBR is needed before arriving at conclusions regarding its use.

- BNSF notes that the NTSB Train Braking Simulation Study is limited to scenarios with train line emergencies initiated at the head-end locomotive on uniform grade, tangent track with clean, dry rail. The trains are assumed to have no inoperative locomotives, no inoperative brakes, no wheel or car derailments, no collisions among cars or with other obstacles, and no loss of communications among applicable electronic devices. The very narrow range of conditions upon which the study is based may be useful for simulation comparison, but does not reflect real-world railroad operating conditions, which could have a significant impact on conclusions.

Conclusion: BNSF believes that additional efforts are needed to confirm that increased NBR operations deliver safe and effective train performance, and additional review of NBR increases should be undertaken under broader operating parameters.

EXHIBIT 2: TTCI MODELING

The analysis performed previously in response to the PHMSA NPRM was applied to the Casselton, ND derailment. The table below summarizes the results:

	Casselton, ND
Reduction in stopping distance (feet) with ECP	275 feet
*Reduction in energy dissipated in derailment (%) with ECP**	30%*
Reduction in cars reaching point of derailment (#) with ECP	3.3 cars

*In the Casselton derailment, the engineer initiated the emergency brake application 10 seconds prior to the collision. This provided the brake system additional opportunity to dissipate energy before the blockage force had an impact, compared to other derailments that have been considered in this type of analysis which had trainline, not engineer-induced emergency brake application. The table below shows the amount of energy dissipated by the brake system prior to and during the derailment:

	Energy dissipated prior to derailment (ft-lb)	*Energy dissipated during derailment (ft-lb)*
DP	189.8M (11.6% of total)	1,452M (88.4% of total)
ECP	389.7M (23.7% of total)	1,252M (76.3% of total)
Difference	199.9M (105% more than DP)	-199.9M (13.7% less than DP)

The additional 10 seconds of braking prior to the derailment resulted in 13.7% less energy in the train at the time of derailment with ECP brakes, compared to DP. This additional reduction in energy prior to the derailment had a significant impact on the reduction in energy dissipated in the derailment with ECP. Had the emergency application occurred at the time of derailment, the reduction in % energy dissipated in the derailment with ECP would have been approximately 18%, instead of 30%.

EXHIBIT 2: TTCI MODELING

The analysis performed previously in response to the PHMSA NPRM was applied to the Galena, IL and Heimdal, ND derailments to identify the potential benefit of ECP brakes in these cases. The table below summarizes the results:

	Galena, IL[1]	*Heimdal, ND*[2]
Reduction in stopping distance (feet) with ECP	140 feet	25 feet
Reduction in energy dissipated in derailment (%) with ECP	28%	8%
Reduction in cars reaching point of derailment (#) with ECP	2.4 cars	0.4 cars

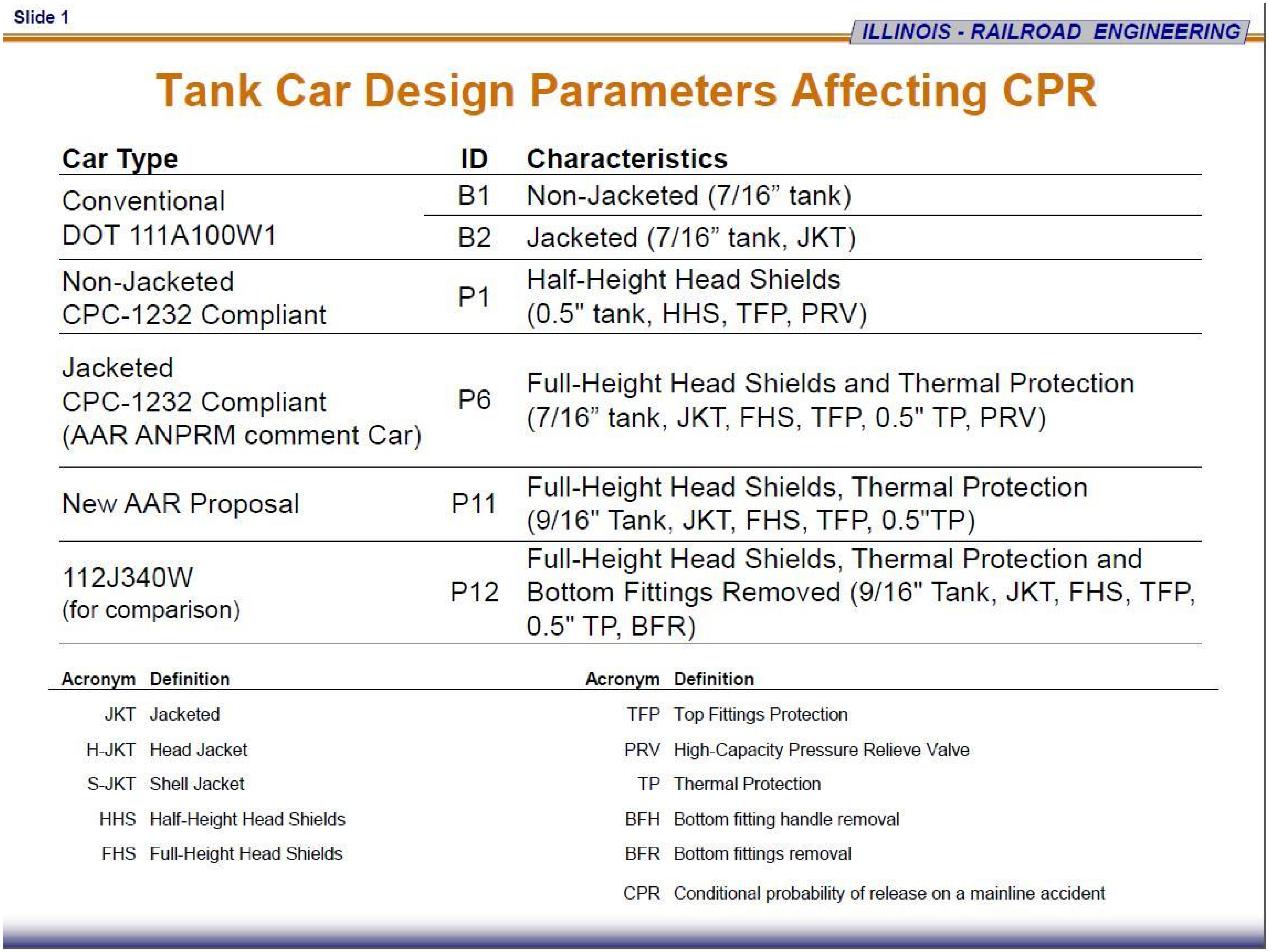
Notes 1 – DP, end of train
2 – Conventional head end power with 2-way EOT

In both cases, the trains were traveling 24 mph when the derailments occurred. However, two particular factors contributed to the significantly different number of cars derailed (20 at Galena, 6 at Heimdal) and different potential benefits from ECP brakes:

- The mass of train trailing the point of derailment:
    - At Galena, 99 cars trailed the first car derailed (13,857 tons, 97% of total)
    - At Heimdal, 28 cars trailed the first car derailed (3859 tons, 26% of total)
- The response of the cars involved in the derailment:
    - At Galena, the first three derailed cars were pulled away from the pile by the head end of the train. Many of the following cars rolled down an embankment and out of the way of cars approaching the derailment. This resulted in a reduced derailment blockage force and more kinetic energy extracted by the brake system.
    - At Heimdal, the initial derailing cars separated from the head end of the train and quickly jackknifed, resulting in a large blockage force, reducing the contribution of the brake system in stopping the train.

These results are consistent with the previously published report:

- The potential benefit of ECP brakes is greater for derailments occurring near the head of a train.
- The reduction in number of cars reaching the point of derailment with ECP brakes is marginal.



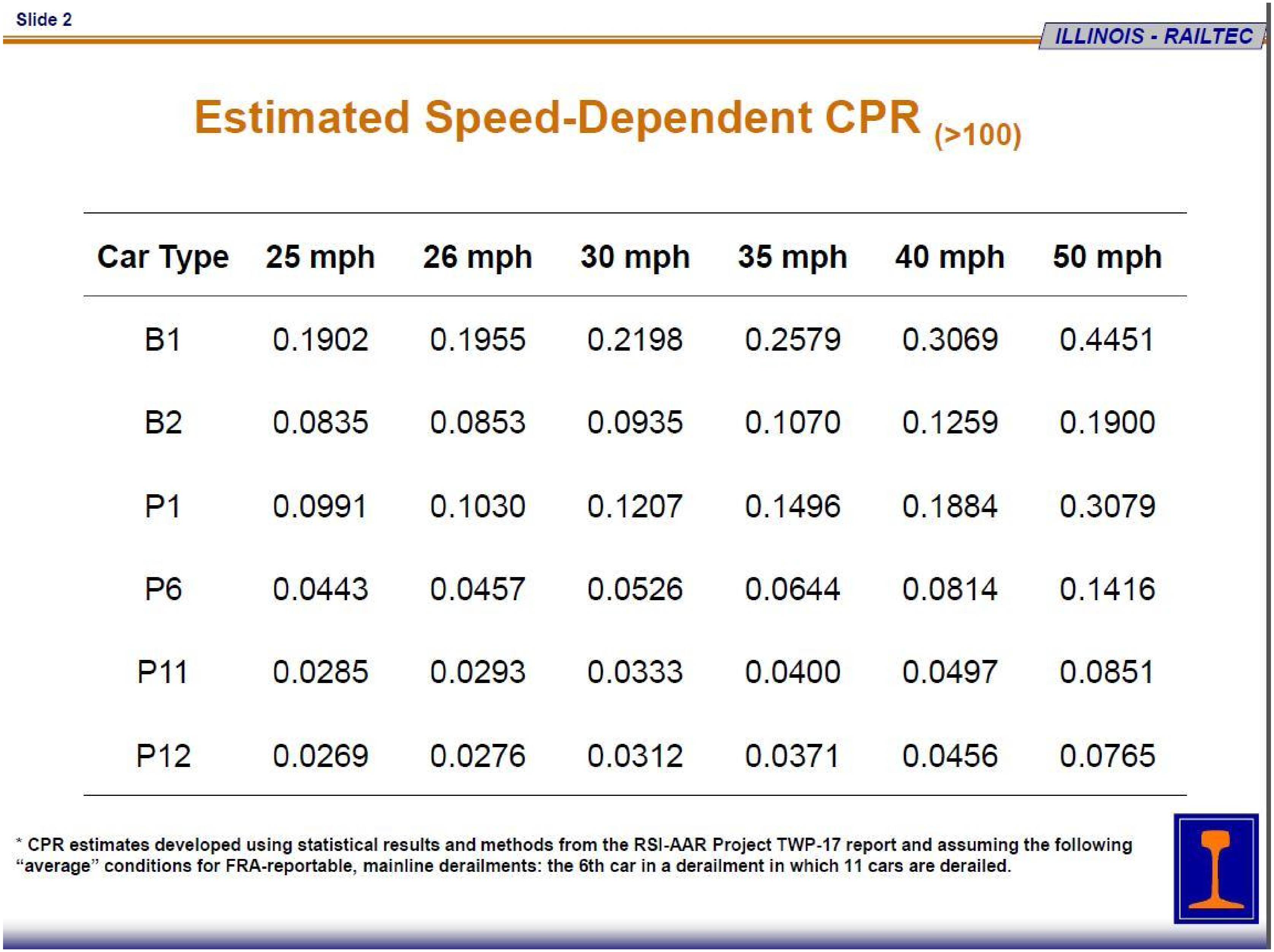
Slide 1

ILLINOIS - RAILROAD ENGINEERING

Tank Car Design Parameters Affecting CPR

Car Type	ID	Characteristics
Conventional DOT 111A100W1	B1	Non-Jacketed (7/16" tank)
	B2	Jacketed (7/16" tank, JKT)
Non-Jacketed CPC-1232 Compliant	P1	Half-Height Head Shields (0.5" tank, HHS, TFP, PRV)
Jacketed CPC-1232 Compliant (AAR ANPRM comment Car)	P6	Full-Height Head Shields and Thermal Protection (7/16" tank, JKT, FHS, TFP, 0.5" TP, PRV)
New AAR Proposal	P11	Full-Height Head Shields, Thermal Protection (9/16" Tank, JKT, FHS, TFP, 0.5"TP)
112J340W (for comparison)	P12	Full-Height Head Shields, Thermal Protection and Bottom Fittings Removed (9/16" Tank, JKT, FHS, TFP, 0.5" TP, BFR)

Acronym	Definition	Acronym	Definition
JKT	Jacketed	TFP	Top Fittings Protection
H-JKT	Head Jacket	PRV	High-Capacity Pressure Relieve Valve
S-JKT	Shell Jacket	TP	Thermal Protection
HHS	Half-Height Head Shields	BFH	Bottom fitting handle removal
FHS	Full-Height Head Shields	BFR	Bottom fittings removal
		CPR	Conditional probability of release on a mainline accident



ILLINOIS - RAILTEC

Estimated Speed-Dependent CPR (>100)

Car Type	25 mph	26 mph	30 mph	35 mph	40 mph	50 mph
B1	0.1902	0.1955	0.2198	0.2579	0.3069	0.4451
B2	0.0835	0.0853	0.0935	0.1070	0.1259	0.1900
P1	0.0991	0.1030	0.1207	0.1496	0.1884	0.3079
P6	0.0443	0.0457	0.0526	0.0644	0.0814	0.1416
P11	0.0285	0.0293	0.0333	0.0400	0.0497	0.0851
P12	0.0269	0.0276	0.0312	0.0371	0.0456	0.0765

* CPR estimates developed using statistical results and methods from the RSI-AAR Project TWP-17 report and assuming the following "average" conditions for FRA-reportable, mainline derailments: the 6th car in a derailment in which 11 cars are derailed.

National Transportation Safety Board

Exhibit 3

Expert Report Prepared for:

The Association of American Railroads

Assessment of the Enhanced Braking Requirements in the Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains Final Rule of May 1, 2015

By:

OLIVER WYMAN

1166 Avenue of the Americas
New York, NY 10036

June 12, 2015

Contents

I. Introduction and summary of findings

A. Introduction

On May 1, 2015, the Pipeline and Hazardous Materials Safety Administration (PHMSA), in coordination with the Federal Railroad Administration (FRA), issued the "Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains Final Rule." Key provisions of the Final Rule involve enhanced braking requirements, specifically:

- The Final Rule will require any high-hazard flammable unit train (HHFUT) – defined as a train comprising 70 or more loaded tank cars containing Class 3 flammable liquids – to be operated with an electronically controlled pneumatic (ECP) braking system by January 1, 2021 when transporting one or more cars loaded with a Packing Group I flammable liquid and traveling at a speed exceeding 30 mph.[1]
- The Final Rule will require all other HHFUTs to be operated with an ECP braking system by May 1, 2023 when traveling at a speed exceeding 30 mph.[2]

The thesis of the ECP braking requirement is that ECP brakes, being quicker to apply, will reduce the number of cars entering a derailment pile-up, and therefore reduce the severity of a derailment. PHMSA, FRA, and third-party contractors have conducted various analyses of ECP braking. In response to these studies, Oliver Wyman was asked to provide an independent

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[1] Final Rule: Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, Docket No. PHMSA-2012-0082 (HM-251), Pipeline and Hazardous Materials Safety Administration, May 1, 2015, 80 Fed. Reg. 26732.

[2] Final Rule: Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, Docket No. PHMSA-2012-0082 (HM-251), 80 Fed. Reg. 26732, op. cit.

evaluation of the ECP braking Final Rule in terms of rail industry costs, benefits, and risks. Oliver Wyman also specifically examined PHMSA's "Final Regulatory Impact Analysis" (RIA) of May 2015 and other documentation upon which PHMSA and FRA relied, including "ECP Brake System for Freight Service," a report by Booz Allen Hamilton from August 2006.

Oliver Wyman is an international management consulting company, with one of the largest consultancies in the world dedicated to the rail industry. Oliver Wyman has carried out major strategic, operational, and financial planning and evaluation assignments for leading railroads worldwide. Recognized experts in rail operations and equipment optimization and network planning from Oliver Wyman's North American rail practice prepared this paper (see Appendix C for Oliver Wyman's qualifications).

Oliver Wyman developed its evaluation using currently available information on ECP braking, including public and private research and data, and interviews with industry experts and railroad representatives (including from all seven Class I freight railroads in the United States and Canada).

In this report, Oliver Wyman examines where PHMSA disregarded evidence, failed to consider substantially important questions, or did not conduct relevant analyses with regard to ECP braking costs/risks and railroad operational/financial benefits, resulting in an understatement of costs and overstatement of benefits. Oliver Wyman examined the actual results of ECP brake testing by North American railroads and the use of ECP braking by foreign railroads, and determined what assumptions and calculations of costs and benefits would be most appropriate based on real-world rail operations and experience with ECP braking. Our findings are summarized in Section I.B and discussed in detail in Sections II-IV.

B. Summary of findings

Oliver Wyman's key findings include the following:

- PHMSA ignored the experience of North American railroads that have actually run ECP brakes in test operations. These test operations demonstrated that ECP brakes are unreliable and produce results not materially better than conventional trains equipped with Distributed Power (DP) or an End-of-Train Device (EOTD). This experience from actual test operations was made available to PHMSA and the Office of Management and Budget (OMB) through formal comments and presentations from railroads and shippers. Despite the fact that FRA provided waivers to conduct some of these test operations and committed to collecting and analyzing the data these tests generated during the past eight years, neither FRA nor PHMSA discussed the actual North American results with the railroad technical experts who conducted these test operations since at least 2010, and did not utilize the information they had gathered in earlier discussions as part of the rulemaking.
- PHMSA instead relied heavily upon experience with ECP brakes on railroads in Australia. Its knowledge of this experience appears to be based solely on a brief report by a consultant at a conference, and PHMSA mischaracterized some of the findings from that single source. The fact is that ECP brakes in Australia are used on closed-loop mining railroads owned by shippers operating primarily in remote areas of the Australian Outback that do not interact with, or disrupt, regular railroad freight operations. These operations in no way resemble the complex operations of North American railroads. In addition, where North American-style operations do exist in Australia, they do not employ ECP brakes.

- PHMSA also relied on benefits of ECP braking predicted in a 2006 report by Booz Allen Hamilton (BAH). The agency did not verify whether subsequent test operations in North America, or experience in other countries, validated the predictions. In fact, the benefits predicted by BAH nine years ago did not materialize in subsequent test operations in North America and operations in foreign countries.
- PHMSA's cost estimate vastly understates the costs of implementing ECP braking. The actual cost of implementing ECP braking will be nearly six times PHMSA's estimate (Exhibit I-1). PHMSA underestimates the costs of mandating ECP brakes because it assumes that ECP brake-equipped tank cars will run mostly in isolated unit trains with dedicated locomotives. In fact, that equipment is likely to be co-mingled with the other one million-plus freight cars and 20,000-plus locomotives that operate in North America, and they will operate over the majority of the transcontinental North American network. PHMSA underestimates the costs to install ECP braking equipment, to train crews and maintenance personnel, and to manage ECP braking-equipped assets by more than $2.3 billion.

Exhibit I-1: Cost by Category for ECP Braking, as Estimated by PHMSA and Oliver Wyman

$ millions (present-day dollars), six-year installation plus 20 year maintenance, using a 7 percent discount rate

Cost Category	PHMSA	Oliver Wyman
Tank Cars	345.0	996.0
Locomotives	79.5	1,552.4
Training	39.9	245.6
Buffer Cars	1.0	11.7
Maintenance	27.2	68.3
Asset Management	0.4	Not estimated
Total Costs	**493**	**2,874**

- PHMSA ignored the fact that essentially all of the tank car fleet in North America is privately owned by shippers, and the implications of this fact. Whether any given shipper or car owner equips a set of cars with ECP brakes will dictate how the railroads will transport those cars. Conversely, how railroads operate their networks (specifically, whether they can keep an ECP brake-equipped train set together) likely will influence whether car owners invest in ECP brakes.

- PHMSA did not consider the significant collateral damage that will be caused by mandating ECP brakes. Because they have been shown to be unreliable when operated in the North American railroad environment, it is likely that deployment of ECP brakes will disrupt major arteries along the national railroad network and will degrade the performance and capacity of the network. In addition, ECP brake deployment could further complicate the mandated implementation of positive train control (PTC), which FRA has defined as a safety-critical system.

The sum of our findings is that the decision to mandate ECP brakes on certain trains is based on a seriously flawed record. PHMSA has vastly understated both the cost of implementing this mandate and the collateral damage to the national railroad network that this mandate will cause. It is telling that both the FRA in the United States (in 2008) and Transport Canada (in 2015) looked at essentially the same fact set and declined to mandate ECP braking technology.

II. In its analysis of ECP braking costs and railroad operational/financial benefits, PHMSA disregarded evidence, did not consider substantial questions, and did not conduct relevant analyses.

PHMSA uses a flawed rationale and analysis in its Final Regulatory Impact Analysis (RIA) to support the Final Rule, which would mandate electronically controlled pneumatic (ECP) brakes for high-hazard flammable unit trains (HHFUTs). The PHMSA analysis is flawed for a variety of reasons:

- PHMSA did not consider the outcome of real-world test operations of ECP brakes conducted by railroads in North America.
- PHMSA relied upon experience with ECP brakes on foreign railroads with operations that are not analogous to rail operations in North America, and ignored the problems these railroads encountered with ECP brakes.
- PHMSA relied upon theoretical findings concerning the business benefits of ECP braking from an outdated consulting study by Booz Allen Hamilton, and did not verify whether subsequent experience with ECP brakes on North American railroads validated the predictions of the study.

Each of these issues is described in greater detail below.

A. PHMSA ignored the North American rail industry’s actual, accumulated experience with ECP brakes.

In a 2008 rulemaking on ECP brakes – in which it declined to mandate their use – FRA modified 49 CFR Part 232 to allow trains equipped with ECP brakes to travel up to 3,500 miles between brake inspections, rather than the interval of 1,000 miles (or 1,500 miles permitted in "extended haul" service.)[3] A waiver was subsequently granted to permit travel up to 5,000 miles between brake inspections on a specific route.[4] The purpose of these measures was to give the railroads an incentive to experiment with ECP braking systems, and some did. The results are informative:

- Union Pacific (UP) paid TTX to install ECP brakes on a set of 40-foot intermodal well cars. These cars were operated between Long Beach, CA and Dallas, TX from October 2008 to July 2009 and between Oakland, CA and Seattle/Tacoma, WA between July 2009 and August 2009. At the conclusion of the test operations, UP paid TTX to uninstall the ECP brakes, and has said it has no plans for further test operations.[5] UP reported the results of this experiment to PHMSA.[6] The railroad discontinued the use of ECP brakes after encountering "considerable compatibility and reliability issues with ECP brakes that make them a less effective option for Union Pacific. For example, Union Pacific experienced multiple power failures, voltage issues with the electrical system, and both hardware and software issues."[7] It also reported that the test operations showed that Distributed Power (DP), a proven and widely used operating practice in which additional locomotives are placed in the train or at the end of the train, "has essentially the same stopping performance as ECP."

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[3] Electronically Controlled Pneumatic Brake Systems, Final Rulemaking, Regulatory Analysis, Federal Railroad Administration, June 2008, p. 22. Prior to this, FRA had granted BNSF Railway (BNSF) and Norfolk Southern (NS) a waiver permitting operation of trains equipped with ECP brakes for up to 3,500 without a brake test. See letter from Grady C. Cothen, Jr., Deputy Associate Administrator for Safety Standards and Program Development, dated March 21, 2007 in FRA Docket No. FRA-2006-26435.

[4] Final Regulatory Impact Analysis, Docket No. PHMSA-2012-0082, Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High Hazard Flammable Trains, Final Rule, May 2015, p. 223.

[5] Interview with General Director, Car and Locomotive Engineering, Union Pacific (UP), May 19, 2015.

[6] Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, Docket No. PHMSA 2012-0082 (HM-251), Comment Request. Comments of Union Pacific Railroad Company, pp. 17-18.

[7] Interview with General Director, Car and Locomotive Engineering, UP, op. cit.

- Canadian Pacific (CP) installed ECP brakes on two unit coal trains operating between a mine in British Columbia and the West Coast of Canada. After multiple breakdowns, the railroad reported that "The manufacturer was told it had one opportunity to make it right, they went through the train with a fine tooth comb and on the return trip there were nine brake penalty applications that blocked the mainline. That was the end – we can't have these trains blocking our main lines."[8] The railroad reported its findings to OMB but no one from PHMSA or FRA contacted the railroad after that meeting to understand the nature of the issues it had encountered with ECP.[9]
- BNSF Railway has experimented with ECP braking systems for two decades in a number of services, including an experimental joint service with Norfolk Southern under a waiver granted by FRA that allowed for the operation of a coal train between the Powder River Basin, WY and a Georgia power plant. While FRA gathered data generated by early experimental operations with ECP brakes, it has not done so in recent years. Railroads involved in experimental operations report that PHMSA and FRA did not collect updated data that would have documented problems with ECP brakes prior to publication of the regulation.
  - BNSF reports that the failure rate of ECP brake-equipped trains is three times the rate for standard trains. If the technology provided any of the stated benefits identified two decades ago, BNSF's ongoing testing would have supported and confirmed the anticipated benefits and ECP would be deployed broadly on BNSF's unit train fleet.

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[8] Interview with Vice President, Safety, Environment & Regulatory, and Chief Mechanical Engineer, Canadian Pacific (CP), May 19, 2015.
[9] Interview with Vice President, Safety, Environment & Regulatory, and Chief Mechanical Engineer, CP , op. cit.

Unfortunately, the technology does not currently deliver as had been hoped for and theorized over the past decade. Even today, any loose connector, software mismatch between locomotives, or a dead ECP battery can cause an undesired emergency or penalty brake application that cannot be cleared, leading to an event that blocks all of the capacity on the mainline and requiring significant time and effort for the railroad and the OEM to troubleshoot and resolve.

- Starting in 1998, BNSF operated ECP brake-equipped trains in coal, intermodal, and taconite service. “All were an abysmal failure,” according to BNSF. In 2007, BNSF and Southern Companies assembled two ECP brake-equipped train sets to run coal from the Powder River Basin, WY to an Alabama power plant; one of these sets was retired in 2012 because of a very high failure rate, the other had every ECP connector and battery replaced in 2014 as a “last chance opportunity” for the technology to prove itself. The only other operational set on BNSF is the joint BNSF/Norfolk Southern (NS) train. Likewise, this joint BNSF/NS set continues to experience significant service interruptions; for example, on one run it experienced 53 hours of service interruptions, delaying numerous other trains. “Each of these ECP equipped sets has performed well below the standard when compared to all other trains in the same service for the entire six-month test period. In fact, in our experience, brake shoe usage remains substantially higher on the ECP brake-equipped sets, as train crews use the brakes more often, and wheel wear has been equal to or slightly higher than that of the conventional train sets.”[10]

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[10] Interview with Shop Superintendent, BNSF Railway (BNSF), May 18, 2015. Note: In general brake wear should be similar between ECP and conventional, but in some cases, carriers operating ECP trains reported higher brake wear.

- Norfolk Southern (NS) stated that it began limited experiments with ECP brake-equipped trains in 2007.[11] It has not equipped any additional cars with ECP brakes since 2008, due in part to reliability problems, including trains with failures that took multiple days to diagnose and correct. Any new services introduced since that time, including the waiver train with BNSF, were simply the redeployment of existing cars from one service to another rather than an expansion of service, contrary to PHMSA's claims.[12] NS also reported a number of "real world" problems:
  - While NS did not add any additional cars equipped with ECP brakes, it did have to retrofit additional locomotives because of the difficulties of operating a fleet in which ECP brake-equipped locomotives must be available to operate ECP brake-equipped trains.
  - Because crews are called by seniority and the next crew up is assigned when a train is ready, the railroad had to train 100 train crews for a train that operated only twice a month.
- CSX installed ECP brakes on a coal train in a test operation starting in November 2000 in conjunction with Southern Company and Wabco (TMS at the time). Originally conceived as a Powder River Basin to southeast US run, the team realized that 2,000 miles and 14 crew change points was too large of an investment, and the test operation was scaled back to a 95-mile run from Corbin, KY to Stilesboro, GA.[13]

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[11] Interview with Operations Engineer and Manager Car Administration, Norfolk Southern (NS), May 18, 2015.

[12] Final Regulatory Impact Analysis, op. cit., p. 35.

[13] ECP Brake System for Freight Service, Booz Allen Hamilton, August 2006, p. D-8.

- Even this short run required 4,000 cars to be equipped with a Wabco developed overlay braking system and over 50 crews be trained and qualified.[14]
- Due to the problems encountered with the equipment's reliability, this test operation was "quickly abandoned," and CSX has not attempted to operate any additional ECP brake-equipped trains.[15]

FRA also stated in its 2008 rulemaking that it would collect and analyze data gained from the test operations of ECP brakes, and as the experiments above illustrate, a wealth of such data has been available for years.[16] Interviews with the key railroad personnel involved in the test operations verified that FRA did not contact them in recent years with respect to the results. The fact is that five of the seven Class I freight railroads in North America have tried ECP brakes, and all of them declined to expand their use of the technology beyond their initial test operations. This is the opposite of the result FRA had anticipated, and calls into serious question the basis for mandating ECP braking.

In addition to the data from test operations that PHMSA and FRA did not analyze, the Association of American Railroads (AAR), five of its Class I member railroads, the American Short Line and Regional Railroad Association (ASLRRA), and at least four dozen railroad shippers from a variety of different industries presented statements to PHMSA concerning the costs and significant real-world problems associated with ECP brakes in the United States and Canada. In addition, the railroad industry presented such information to the Office of

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[14] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. D-9.

[15] Interview with CSX personnel, May 20, 2015.

[16] Electronically Controlled Pneumatic Brake Systems, Federal Railroad Administration, June 2008, op. cit., pp.. 3, 5, 23-24.

Management and Budget (OMB) in March 2015.[17] There is no evidence in the RIA that PHMSA seriously considered any of this information.

Oliver Wyman interviewed the ECP braking experts at each of the seven Class I freight railroads in the United States and Canada, and none had been contacted by PHMSA or FRA concerning their recent experiences with ECP braking since 2010 (if at all). Instead, PHMSA relied on outdated information and theoretical findings, as well as opinions (not data) provided by manufacturers, who might not have a fully objective perspective, since they are seeking to convince PHMSA to impose a federal mandate that would force the sale of equipment that has thus far failed in the market because it is unreliable and provides no better results than existing technology.[18] Exhibit II-1 compares statements in the RIA with updates and clarification obtained through recent interviews with senior railroad personnel involved in the test operations of ECP brakes.

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[17] Impact of Potential ECP Requirement on the Railroad Industry, Railroad/OMB Meeting, March 6, 2015.
[18] Final Regulatory Impact Analysis, op. cit., pp. 223-24.

Exhibit II-1: Comparison of RIA Statements and Railroad Updated Information

Page #	RIA Statements	RR	Railroad Updated Information[19]
35 and footnote 42	NS has extended its ECP brake service within the past three years: "NS added a train that operates using ECP brakes in 2014. This train travels round trip between the Powder River Basin and Macon, GA."	NS	NS did begin operating a Powder River Basin to Georgia ECP brake-equipped test train in October 2014 in conjunction with BNSF; however, it is not correct to claim that NS extended its ECP brake service. First, NS has not equipped any coal hoppers/gondolas with ECP brakes since 2008; the equipment on this test operation was sitting out of service unutilized. Second, it is not fair to characterize it as a service. It was a test train conducted in conjunction with BNSF. Finally, the test operation is proving unsuccessful due to numerous service failures and delays caused by the ECP brakes. The test was temporarily suspended in May 2015 due to excessive delays, but was resumed once the manufacturer had corrected problems with the ECP brake equipment.
217	"PHMSA and FRA estimate that the use of dynamic braking in conjunction with ECP brakes would reduce dynamic brake-induced rail wear by at least 25 percent, based on CP experience. Further, in spite of initial increases in thermal mechanical shelling due to heavy 'experimenting' by train crews during the familiarization phase, CP found a four percent improvement in average wheel life. Once operations 'settle in,' improvements in wheel life may reach ten percent, thus reducing the estimated wheel wear benefit by 75 percent instead of the 85 percent estimated by AAR."	CP	The 25 percent savings in wheel wear and four percent improvement in wheel life are based on CP's experience with heavy coal trains on a downhill section of the Rocky Mountains, which contains several flat areas. With conventional air brakes, CP is unable to release and reapply the brakes through these flat areas, so coal trains are "dragged across" the flat spots with the brakes on (a practice known as "power braking"). ECP allowed CP to release the brakes on the flat areas and then reapply them on the downhill. By eliminating this power braking, CP was able to reduce wheel wear. But this downhill terrain is unique and comprises only a small portion of the CP network. Other terrain would not be able to realize the same savings in reduced wheel wear. Additionally, BNSF has questioned ECP wheel wear claims, by stating that it has seen "way too many wheel issues" on the most recent tests conducted in 2014/2015.
223 and repeated on 225	"In 2014, BNSF and Norfolk Southern (NS) began moving forward with a pilot program waiver that allowed the carriers to jointly operate an ECP-equipped train that is permitted to travel up to 5,000	NS and BNSF	BNSF and NS both stated that the 3,500 and the 5,000 mile inspection limits were not a reflection of their confidence in the reliability of ECP brakes, but incentives offered by FRA to test the brakes. Furthermore, this program, begun in October 2014, has demonstrated the problems

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[19] Interviews with relevant personnel at all seven Class I railroads and follow-up correspondence, May 18-June 10, 2015.

Page #	RIA Statements	RR	Railroad Updated Information[19]
	miles between brake inspections. Setting aside AAR's alternative assertions, the carriers' pursuit of this waiver is evidence that they consider ECP brake systems reliable. Otherwise, they would not be pursuing a regime that would allow for fewer inspections of ECP-equipped trains, which would need to be justified with data from the pilot program. FRA has granted this waiver and is currently assessing the efficacy of extending the interval between brake inspections to 5,000 miles on ECP-equipped trains. The success of these pilot programs indicates that this technology is working well, and is ready for further deployment. If ECP braking was not a success, these pilot programs would end, and no additional carriers would seek waivers."		with ECP. For example, in May 2015, the delays caused by the unreliability of the ECP brakes led to a suspension of the test operation. Nor is it true that the "technology is working well." The railroads have data comparing ECP and conventional brakes on this route showing the additional delays caused by ECP (see Section III.A). PHMSA did not request this information for the RIA.
226	"Once railroads have incorporated the software updates, they will be able to operate more efficiently by avoiding delays related to crosstalk."	Various	While the Association of American Railroads (AAR) has incorporated the software updates into its new standard established in 2014, there are still issues with crosstalk. Updates cause interoperability problems because updated locomotives and/or cars can become incompatible with non-updated cars and locomotives. Also, installation of new software is not simple. It takes about two hours per locomotive, and must be done in a shop. Taking locomotives out of service for a software update that accounts for a small percentage of traffic on a rail network is an expensive proposition.
234	"NS and BNSF currently operate under a pilot waiver an ECP-equipped unit coal train that permits brake inspections every 5,000 miles instead of the 3,500 miles permitted by 49 CFR § 232.607. If the safety data collected from this pilot waiver is positive, it is reasonable to assume that other railroads would apply to extend ECP brake inspections to every 5,000 miles as well. This could further increase the utilization rates of ECP brake operated unit trains."	NS and BNSF	There is no data collected from the ECP pilot test operations that would indicate that ECP brakes are safer than conventional air brakes.

Page #	RIA Statements	RR	Railroad Updated Information[19]
236	"In a BNSF analysis of its coal operations, it was reported that it experienced a 5-10 percent reduction in its car fleet on trains equipped with ECP brakes."	BNSF	Neither PHMSA nor FRA asked BNSF for information explaining or updating this prediction made in 2008. This estimate of a 5-10 percent fleet reduction was a theoretical calculation based on reduced cycle times from a 3,500 mile inspection waiver. BNSF never realized these savings, due to delays caused by reliability issues with actual ECP brake-equipped trains.
236	"Another report from 1999 noted that the Quebec Cartier Mining Company had seen an increase of 14 percent in the average tonnage per train compared to conventional trains with the same horsepower of locomotives."	Arcelor Mittal	According to ArcelorMittal (the successor to Quebec Cartier), "We don't increase our capacity with ECP on tonnage. Locomotive capacity and couplers (260,000 lbs.) dictate our tonnage. ECP and conventional run 160 to 240 car iron ore trains."[20]
236	"In a public hearing on October 19, 2007, Mike Iden, a general director for the Union Pacific Railroad, presented a graphic example of the potential efficiencies of ECP brakes. In this example he cited a UPS test train that traversed the country from New Jersey to California. In order to meet the schedule with conventional brakes, a special 75 mph speed limit was required. Mr. Iden pointed out that with the regulatory relief from inspections a minimum of two hours could be saved from each origin to destination. ECP would allow UPS to meet the same transportation time from origin to destination traveling at a 70 mph speed limit which would not only save fuel, but also reduce congestion caused by overtaking slower trains."	UP	This UPS train never ran using ECP brakes. The intermodal railcars that UP tested were constructed for a different intermodal service: double stack "marine" containers. The two-hour savings was hypothetical for UP's Chicago to West Coast intermodal trains and based on the anticipated savings from using 3,500 mile rather than 1,500-mile inspection distances for "extended haul" trains. The projected savings did not anticipate the real-world difficulties of maintaining consistent operations, which became clear during the test operation and affected the potential time saved as a result of fewer inspections.
236-237	"On June 15, 2010, Jim Forrester, Manager Equipment Planning and Business Development for Norfolk Southern's Coal Business Group, presented a paper to the National Coal Transportation Association to update it on NS's ECP brake pilot	NS	These results were from the early stages of test operations using ECP braked equipment in 2007-2009, and were optimistic. They were based on one test train set. These results are not achievable where rail operations are very dense, since a train's cycle time is not just determined by its own performance, but by the performance of trains

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[20] Correspondence from Spécialiste Règlementation Ferroviaire, ArcelorMittal, May 25, 2015.

Page #	RIA Statements	RR	Railroad Updated Information[19]
	project. In this report he concluded that through direct testing comparing conventional trains and ECP-equipped trains (both would have dynamic braking) that ECP-equipped trains experienced a reduction in dwell time, ECP-equipped trains operated at track speed for longer periods of time, ECP-equipped trains were able to better control their speed, and ECP-equipped trains had faster loading processes and better car loading performances. On moderate grades, ECP-equipped trains stopped 33 percent faster and returned back to track speed 25 percent sooner. On heavy grades ECP-equipped trains stopped 50 percent faster and returned to track speed 97 percent sooner (as the hand brakes did not need to be applied to recharge the air brakes on the train)."		ahead of and behind it, and by the customer. Trains with conventional air brakes could run faster and reduce cycle times, just as claimed for ECP brake-equipped trains; however, all trains are constrained by network congestion. Also, customer processes plays a large role in cycle times, since the length of time a car is held by the customer is a large portion of a car's total cycle time.
263 and page 266, footnote 215	"Canadian Pacific achieved a fuel savings of 5.4 percent from ECP brakes used in conjunction with dynamic brakes during testing in Golden, British Columbia, a route which has particularly advantageous terrain for maximizing the fuel benefits associated with ECP braking. Because not all terrain will be as advantageous as this test region, PHMSA is reducing estimated fuel efficiency benefits by 50 percent, corresponding to a fuel improvement rate of 2.5 percent. However, this estimate is conservative and likely understates the fuel efficiency benefits."	CP	PHMSA correctly noted the "advantageous terrain," but understates just how advantageous. The 5.4 percent fuel savings was realized on a downhill section of the Rocky Mountains, which as noted above contained several flat areas. CP is unable to release and reapply conventional air brakes through these flat areas, meaning heavy coal trains must use power braking in these areas. ECP allowed CP to release the brakes on the flat areas and then reapply them on the downhill. By eliminating power braking, CP was able to achieve 5.4 percent fuel savings. This type of downhill terrain is unique and comprises only a small portion of the North American network. PHMSA's arbitrary selection of 2.5 percent fuel improvement is not justified, and certainly not conservative. CP stated that on uphill grades, downhill grades that do not include segments with level grade, and across the plains there would be no reason that ECP brakes should achieve better fuel usage than conventional brakes. If these fuel savings were real, CP would have expanded the use of ECP brakes. CP has instead discontinued all ECP brake test operations and removed the ECP components from its test train in 2012. CP has no plans to conduct future testing.

As the comments above demonstrate, the real world is not a laboratory or a computer model, and test operations amply demonstrate that ECP brakes do not work well in the real-world operating environment of North American railroads. This has been true even in experimental settings in which extraordinary technical resources from the manufacturer and the railroad were available to maintain and troubleshoot the equipment.

B. PHMSA relied on non-analogous experiences of foreign railroads to support its decision and failed to investigate claims regarding ECP braking thoroughly.

PHMSA describes the implementation of ECP braking in Australia at length in the RIA and presents this as evidence that such systems could be deployed successfully in the United States.[21] Yet PHMSA apparently did not research and understand Australian railroads' actual experience with ECP brakes or the nature of the railroad operations on which they are employed. Instead, PHMSA relied upon a single presentation by a consulting firm at a conference.[22] The quotations from the presentation PHMSA included in the RIA do not represent the full range of comments contained in the presentation. In particular, they do not include comments on the problems with ECP brakes in Australia.

Indeed, the railroad operations on which ECP brakes are deployed in Australia have nothing in common with railroad operations in the United States – and even in Australia, ECP braking operations have not been proven to provide any benefits.

For example, PHMSA postulates in the RIA that a major factor leading to the adoption of ECP brakes in Australia, but not the United States, is that railroads rather than shippers own the

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[21] Final Regulatory Impact Analysis, op. cit., pp. 33-36.

[22] Final Regulatory Impact Analysis, op. cit., p. 35.

cars in Australia.[23] It offers as an example the Genesee & Wyoming (G&W) operation in Australia, stating that it "is more like a Class I railroad, and it provides an example of the benefits a carrier can attain from using ECP brakes when there is a seamless operation of a single unit going from the originating location to the delivery location *while also owning the cars*" (italics added).[24] But in fact, G&W does not own the cars in the operation equipped with ECP brakes in Australia. G&W officials stated that they do not see any benefit in ECP brakes and are operating ECP brakes on a train set owned by its customer solely because it is a condition of the contract.[25]

Experience in Australia does demonstrate that ECP brakes may be more appropriate in closed loop services, in which unit trains do not need to mix with other freight or be broken up for loading and unloading. All of the Australian railroads using ECP brakes fit this description. However, crude oil and ethanol trains in North America do not. While they may function as unit trains for the long haul part of their journey, crude oil and ethanol cars can be gathered by a railroad from several different points to make up a unit train, and the trains often are broken into smaller blocks at both origin and destination, due to limitations at loading/unloading terminals. If tank cars are equipped with ECP brakes, the process of gathering them or breaking them into smaller blocks can quickly lead to inefficiencies and damage, due to multiple handlings of the connecting electrical cables. Additionally, in North America, crude oil and ethanol unit trains

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[23] Final Regulatory Impact Analysis, op. cit., p. 34.
[24] Final Regulatory Impact Analysis, op. cit., p. 35
[25] Interview with Chief Operating Officer, Genesee & Wyoming (G&W), May 21, 2015.

share a complex network of mainline rail segments and terminals with many other types of unit and intermodal trains and 25.7 million carloads of general freight traffic.[26]

The report prepared by Booz Allen Hamilton (BAH) for the FRA in 2006 makes exactly this point. It states that "The experimenting railroads or car owners can be split into two groups. There are those that must operate in the North American rail system, with all of its interchange requirements and locomotive assignment problems. And there are those that operate independently on their own track, whose interest in standardized AAR systems is for the purpose of ensuring future competitive supply."[27]

The BAH report goes on to describe two types of ECP experiments: general railroad experiments and private line experiments. The former, by BNSF, Conrail, Southern Company, and CP "involved the conversion of a few trains out of massive fleets. Those trains were assembled for testing of ECP brake benefits. Supply of ECP-equipped locomotives was essential to operating the train in ECP mode. The difficulty in supplying locomotives different from the fleet became more evident as the experiments proceeded. The disruption caused by trying to split a fleet of common equipment, such as a coal fleet or intermodal fleet, into ECP and non-ECP cars and locomotives discourages continuation of the few experimental ECP trains after the experimentation is complete. As a result, these trains have either been converted back or are being used only in pneumatic brake mode."[28]

The private line experiment the BAH report describes is that of the railway operated by ArcelorMittal (formerly Quebec Cartier Railway) between Mont-Wright and Port-Cartier,

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[26] Surface Transportation Board 2013 Public Use Carload Waybill Sample. The 25.7 million merchandise carloads is based on records in which the number of unexpanded cars in the sample equaled 60 or less (i.e., block size of 60 or less cars.)

[27] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. D-12.

[28] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit.

Quebec. Like the Australian railroads that use ECP brakes, this is a railway wholly owned by a shipper, ArcelorMittal. The railway moves iron ore from the company's mine to a port, and is completely isolated from the rest of the North American rail network. The railroad experimented with one train and then converted three of the eight trains in its iron ore fleet, and it described having a mixed fleet even on a small, non-interchange railroad as "a pain."[29] The BAH report also notes that the Mont-Wright to Port-Cartier operation "differs from most of the rest of the railroad network in North America in that it operates on private lines, has control over its entire fleet, and has equipped a significant portion of its fleet with ECP brakes. Nevertheless, it still has problems blending the ECP cars into a larger fleet or different equipment."[30] The point is that there is no similarity between:

- On the one hand, a single-purpose railroad with no existing fleet of cars equipped with conventional brakes (or a small fleet composed primarily of one type of railcar, e.g., gondolas) that can gradually equip all of its cars and locomotives with ECP braking and seldom has to touch the electrical connections between cars.
- And on the other, major North American railroads on which crude oil and ethanol are a minor portion of total traffic, there is a large existing fleet of cars equipped with conventional brakes in which ECP brake-equipped cars will operate in ECP mode only a portion of the time, and where ECP cars will frequently be coupled and uncoupled.

It is telling that the portions of the Australian railway system that actually do resemble North America and carry a mix of freight operate without ECP brakes.

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[29] Interiew with Spécialiste Règlementation Ferroviaire, ArcelorMittal, May 20, 2015.
[30] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit.

Similarly, another foreign railroad cited by PHMSA, South Africa's Transnet freight railroad, operates ECP brake-equipped trains only on one dedicated coal line. As PHMSA acknowledges, this service is completely segregated from the railroad's mixed freight service, which operates with other braking systems.[31]

PHMSA cited specific findings from a 2014 Australian presentation by Interfleet Technology, a rail technology consultancy, to justify its conclusion that ECP braking could be implemented by US railroads, but omitted major performance observations in the report.[32] Indeed, the report describes concerns regarding ECP brakes even on simple closed loop, single-purpose railroads in Australia that are far from the positive comments on benefits that the PHMSA reports. Some of these issues are listed in Exhibit II-2.

Exhibit II-2: PHMSA-Cited Benefits Versus Interfleet Technology Cautions

Expected Benefits Cited by PHMSA in the RIA, Based on the Booz Allen Hamilton Report	Findings of Interfleet Technology[33]
Fuel Savings	"Fuel savings are difficult to quantify even for those operators that run ECP and PCP fleets."
Wheel Savings	"This is an area where real savings should be able to be made and some operators have seen wheel temperatures spread evenly across whole trains, resulting in reduced risk of wheel spalling. However, for other operators the results to date have been disappointing."
Brake Inspection	"Savings have not been forthcoming."[34]
Brake Shoe Savings	"This has not been realized for some operators."[35] (Note: BNSF data shows that ECP brake-equipped trains are operated in airbrake-only mode four times as long as non-ECP brake-equipped trains on every trip (47.29 minutes vs. 11.2 minutes), leading to much heavier brake shoe

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[31] Final Regulatory Impact Analysis, op. cit., p. 33, footnote 39.

[32] Final Regulatory Impact Analysis, op. cit., p. 34 and footnote 40.

[33] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. 226.

[34] The report attributes part of the lack of savings to the fact that Australian inspection regulations are less restrictive than those in the United States. Given that in Australia and Canada systems operate safely with much less restrictive regulations, FRA may be able to capture this benefit through reforming brake inspection requirements overall, rather than mandating ECP.

[35] The report did note "anecdotal" evidence of longer brake shoe life on ECP trains. However, the savings were attributed to growing expertise among locomotive drivers with the ECP system, which is much easier to develop on a closed system using only ECP brakes than on the mixed North American system, where locomotive engineers will operate ECP brakes infrequently.

Expected Benefits Cited by PHMSA in the RIA, Based on the Booz Allen Hamilton Report	Findings of Interfleet Technology[33]
	wear and wheel thermal activity, reducing the life of the wheels.)
Network Capacity	"In most cases, any network capacity benefits are a long way off."
Safety Benefits	"Safety benefits are nebulous"

In addition, the Australian, ArcelorMittal (Quebec), and South African experiences suggest a number of problems that have occurred but appear not to have been considered by PHMSA, including:

- Difficulties in managing a mixed ECP-braked and traditionally braked fleet on even single-commodity railroads
- Difficulties in connecting inter-car jumper connectors properly because of the force required
- Infiltration of moisture and contaminants into connectors and junction boxes
- A need for better methods of diagnosing train line conditions and ground faults
- Crosstalk issues leading to undesired emergency (brake) applications
- Car Control Device battery replacement being required earlier than planned
- Increased electrical fault-finding knowledge and skillset requirements for car maintainers
- Poor inter-car cable connector reliability

One of the major problems identified by Interfleet Technology touched on a problem that has arisen in North America: the severe delays that can occur when a train equipped with ECP brakes fails on a high-density main line. The report states that "ECP braked trains have not been viewed kindly by some track owners. Severe delays and capacity loss have occurred on some networks primarily due to ‘crosstalk’.”[36] (Crosstalk is a problem caused when ECP brake-equipped trains pass and interfere with each other electrically, causing unwanted emergency brake applications that are difficult and time consuming to correct.) This and other reliability problems have occurred in North America, and (despite claims to the contrary by PHMSA) as of this writing have yet to be fully resolved.[37] One Australian track owner told the report authors that it was “almost at the point of banning ECP trains from the network.”[38] Those North American railroads that have tried ECP brakes and given up on them appear to have reached about the same conclusion.

All of these operating and equipment problems occurred on single-purpose railroads operating ECP-only brake systems, rather than the more complex overlay systems that will likely be used in the United States to meet the federal mandate. Every one of these critical issues also have been identified and communicated to PHMSA by North American railroads. The problems on a mixed system such as exists in North America, where even cars operating in unit trains for large portions of their time in transit must be regularly connected and disconnected due to switching at origin and destination, can be expected to be worse.

For these reasons, it is inappropriate to rely upon experience in Australia and other countries when analyzing the practicality of mandating ECP brakes in the United States.

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[36] The ECP Brake – Now It’s Arrived, What’s the Consensus? Bruce Sismey and Lindsay Day, Interfleet Technology, Conference on Railway Excellence (CORE), May 5-7, 2014, p. 225.
[37] Correspondence from Manager Car Administration, NS, May 24, 2015.
[38] The ECP Brake – Now It’s Arrived, What’s the Consensus? op. cit., p. 225.

C. PHMSA relied on outdated information for its business benefits case.

1. PHMSA utilized information on anticipated benefits from a 2006 report and did not validate this information using recent real-world experience.

In August 2006, Booz Allen Hamilton (BAH) provided the FRA with a report entitled “ECP Brake System for Freight Service,” as noted previously. This report provided a cost-benefit analysis of ECP brakes and claimed that “The expected benefits of ECP braking technology appear to justify the investment.”[39] The BAH report was essentially a forward-looking document designed to envision circumstances under which ECP brakes might come into more widespread use. It relied upon an assessment by an industry expert panel using very limited and incomplete data from ECP brake test operations to that point.

PHMSA relied on this outdated report in 2015 but apparently did not compare the potential benefits it predicted with the actual experience gained in the past nine years through test operations of ECP brakes on North American railroads and the use of ECP brakes on Australian and other international heavy haul railroads in closed-loop operations. These real-world applications show that the benefits anticipated nearly a decade ago were overly optimistic and do not appear to be achievable.

In Australia, which has the most operational experience with ECP brakes, the Interfleet Technology report assigned only one of the seven BAH benefit categories – fuel savings – a positive grade, although even this was based on a “general feeling” rather than any actual evidence.[40] Four of the BAH benefit categories were rated neutral by Interfleet Technology, including brake inspections, brake shoe savings, network capacity, and safety. Finally, based on

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[39] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. I-1.

[40] The ECP Brake – Now It’s Arrived, What’s the Consensus? op. cit., Section 5.

actual operational experience in Australia, Interfleet Technology rated savings due to wheels and the "other" category as negative.

Test operations of ECP brakes throughout North America have confirmed the lack of measurable benefits seen in Australia. And as discussed previously, ECP brakes in Australia are used on dedicated heavy haul trains in closed loop operations, while in North America, ECP-equipped trains have been tested on lines used by a mix of trains. The frequent brake penalties and failures of ECP brakes during test operations in North America blocked mainlines and proved to be so detrimental to operations that nearly all of the test operations have been halted. Exhibit II-3 provides a comparison of BAH's 2006 projected benefits and real-world experience through May 2015.

Exhibit II-3: Comparison of BAH Projected Benefits versus Australian Operations and North American Test Operations

Benefit	BAH Projected Benefits (2006)[41]	International Operating Experience (through May 2015)	North American Test Operations (through May 2015)
Fuel Savings	BAH claimed savings of 5-10 percent, and based on 5 percent a potential savings of $300 million in fuel costs annually (at $2.10/ gallon non-hedged fuel price). These anticipated savings are due to graduated brake release, elimination of power braking, and unnecessary train stops and starts (Section III.4)	▪ Likely some small savings, but not validated ▪ Interfleet Technology report: Fuel savings is the only category from the BAH report graded as positive; the report states that "The general feeling was that there may be some fuel savings with ECP braked trains but no one would hazard a guess on the magnitude."[42] ▪ G&W Australia stated that fuel savings are determined more by how the train engineer operates the locomotive than by the type of brakes.[43] ▪ ArcelorMittal stated that it has observed no difference in fuel consumption between ECP brake-equipped and conventional train sets; it continues to monitor fuel consumption.[44] ▪ PHMSA states in the RIA that "Anecdotally, it appears that expectations related to fuel savings in Australia have not matched the estimates used in our analysis."[45]	▪ North American test operations using ECP brakes have not shown improved fuel usage, except in special circumstances. ▪ As reported in the RIA, "Canadian Pacific achieved a fuel savings of 5.4 percent from ECP brakes used in conjunction with dynamic brakes during test operations in Golden, British Columbia, a route which has particularly advantageous terrain for maximizing the fuel benefits associated with ECP braking. Because not all terrain will be as advantageous as this test region, PHMSA is reducing estimated fuel efficiency benefits by 50 percent, corresponding to a fuel improvement rate of 2.5 percent."[46] PHMSA's claim of 2.5 percent fuel savings is not supportable because: – As described previously, CP identified the nature of the "advantageous terrain" as a very small percentage of its network. CP stated that over most of its network, it did not expect fuel savings from ECP brakes.[47] – No railroad has been able to quantify fuel savings from ECP brakes, not even the 2.5 percent savings assumed by PHMSA. This is clearly an arbitrary number without any scientific basis or actual experience as evidence.

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[41] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., relevant report sections are listed in the table above.
[42] The ECP Brake – Now It's Arrived, What's the Consensus? op. cit., Section 5.
[43] Interview with Chief Operating Officer, G&W, op. cit.
[44] Interview with Spécialiste Règlementation Ferroviaire, ArcelorMittal, op. cit.
[45] Final Regulatory Impact Analysis, op. cit., p. 36.

Benefit	BAH Projected Benefits (2006)[41]	International Operating Experience (through May 2015)	North American Test Operations (through May 2015)
Wheel Savings	BHA cited a TTCI study of coal gondolas, where brake-related failures were found to reduce the life of wheelsets by more than 50 percent. The expert panel assembled for the BAH study did not want to assume ECP would eliminate all brake-related wheel defects, so an annual savings of $175 million was assumed. (Section III.5)	▪ Interfleet Technology report: Wheel savings are given a negative grade: "This is an area where real savings should be able to be made and some operators have seen wheel temperatures spread evenly across whole trains... However, for other operators the results to date have been disappointing."[48] ▪ ArcelorMittal has stated that there are no wheel savings in using ECP brakes versus conventional brakes.[49]	▪ As discussed previously, PHMSA estimated based on CP's experience that the "use of dynamic braking in conjunction with ECP brakes would reduce dynamic brake induced rail wear by at least 25 percent" and that improvements in wheel life could reach ten percent.[50] ▪ Test operations by North American railroads show that wheel savings from ECP may not be that clear cut, however: – Wheel impact load detectors (WILD) have found wheels on ECP brake-equipped trains with defects such as tread build up, flat spots, and wheel shelling. In the current ECP brake operation, these trains are handled as unit trains and are less subject to switching operations, therefore it appears, from BNSF's ECP experience, that higher brake usage is leading to increased wear and stress on wheels than might otherwise be seen on conventional air brake equivalent trains.[51] – One railroad mechanical officer stated that ECP was expected to create more uniform wheel wear, but that test operations have not borne this out for coal train sets; there were "way too many wheel issues" with the test trains.[52]

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[46] Final Regulatory Impact Analysis, op. cit., p. 263.

[47] Interview with AVP Environmental Risk and Chief Mechanical Engineer, CP, op. cit. The advantageous terrain and descriptions of the fuel savings over this terrain are also described in Wachs, Aronian, Bell, Carriere, and Gallagher, "Electronically-Controlled Pneumatic (ECP) Brake Experience at Canadian Pacific." This paper does not report any fuel savings due to ECP brakes on CP trains under different types of terrain.

[48] The ECP Brake – Now It's Arrived, What's the Consensus? op. cit., Section 5.

[49] Correspondence from Spécialiste Règlementation Ferroviaire, ArcelorMittal, June 2, 2015.

[50] Final Regulatory Impact Analysis, op. cit., p. 217.

[51] Interview with Shop Superintendent, BNSF, May 22, 2015.

[52] Interview with Shop Superintendent, BNSF, op. cit.

Benefit	BAH Projected Benefits (2006)[41]	International Operating Experience (through May 2015)	North American Test Operations (through May 2015)
			– CP noted that most of the savings from wheel wear was over the same "advantageous terrain" that also led to the fuel savings, but that there is little such terrain in its network. – Another interviewee pointed out that some of the operations in foreign countries were "laboratory operations." Besides being on a closed loop with minimal switching, the railroad in some cases owns both the track and the railcars and can match maintenance to achieve maximum longevity.[53] This is in contrast to US operations, where rail renewal is not necessarily timed to when the car owner maintains the wheels, so newly maintained or replaced track may be subjected to flat spots and other wheel defects that increase the load impact.

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[53] Interview with General Director, Car and Locomotive Engineering, UP, op. cit.

Benefit	BAH Projected Benefits (2006)[41]	International Operating Experience (through May 2015)	North American Test Operations (through May 2015)
Brake Inspections	Two kinds of savings related to brake inspections are claimed in the BAH report: ▪ $125 million annually due to the elimination of the 1,000-mile intermediate terminal brake test, since the constant wire-based monitoring eliminates the need to “pull over” and physically inspect the brakes. ▪ $48 million annually due to the elimination of the periodic single car air brake test (SCABT). (Section III.6)	▪ The Interfleet Technology report gives brake inspections a neutral rating. “Savings have not been forthcoming mainly because when compared to North American practices, train and brake inspections in Australia are not prescriptive. Train operators propose their own train and brake inspections practices justified on a risk-based approach. Typically a unit train in Australia (ECP or PCP [pneumatically controlled pneumatic or automatic air brake]) will operate up to 28 days without a brake inspection.”[54]	▪ North American operations have produced no data that supports PHMSA’s claim that the overall tank car fleet size can be reduced because cycle times will improve due to longer intervals between brake inspection stops with ECP equipment.[55] ▪ The railroads do see advantages to increasing the current 1,000 mile inspection distance to 3,500 miles. The longer inspection distance waivers were offered by FRA as an incentive to the railroads to test ECP equipment. When the 3,500 mile incentive proved insufficient to justify the costs of ECP brakes, the FRA increased it to 5,000 miles. This allowed NS and BNSF to conduct test operations using an ECP-equipped train from the Powder River Basin to Georgia with only one brake inspection per trip.[56] ▪ PHMSA’s claims for reduced cycle times and reductions in car fleet size are overstated. – Trains still are required to stop for regular servicing events, e.g., refueling and sanding; the removal and addition of locomotives is often scheduled to coincide with these servicing events. – Trains must typically stop every 150-300 miles to change crews. – The speed of a single train is influenced by the train in front and the train behind. Just because a train can skip inspections does not mean that it will not experience congestion on the network, thus eroding any time savings.

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[54] The ECP Brake – Now It’s Arrived, What’s the Consensus? op. cit., Section 5.

[55] Final Regulatory Impact Analysis, op. cit., p. 122.

[56] Interviews with Shop Superintendent, BNSF, and Manager Car Administration, NS, op. cit.

Benefit	BAH Projected Benefits (2006)[41]	International Operating Experience (through May 2015)	North American Test Operations (through May 2015)
Brake Shoe Savings	Citing the experience of the Quebec Cartier Mining Railroad (now ArcelorMittal), the BAH report claims a 20 to 25 percent prolonged brake shoe life. At 20 percent, this would lead to an annual savings of $9 million. (Section III.7)	▪ ArcelorMittal has stated that there are no brake shoe savings using ECP brakes versus conventional brakes and that the use of dynamic brakes is preferred.[57] ▪ Brake shoe savings are given a neutral rating by Interfleet Technology. "This has not been realised for some operators. Almost all indicated that initial brake block wear was higher for ECP trains compared to PCP trains due to drivers 'practicing' using ECP. Once the novelty wore off, the brake shoe wear decreased. One comment made was that the shoe wear on ECP trains was very even when compared to PCP trains."[58]	▪ The RIA states that "Brake shoe wear can also be reduced by 20 to 25 percent." During interviews, most railroads had no data to support a brake wear claim, since it is not carefully tracked. ▪ One mechanical expert said he "doubted" any brake shoe savings would be possible for ECP compared to conventionally braked trains.[59] This is because all Class I railroads have changed their operating practices to support dynamic braking as a standard method for train control, a fact acknowledged, but not accounted for, by PHMSA. Dynamic braking is like downshifting in a car, and it reduces the physical action of a brake shoe being applied to the wheel. The less time the shoe and wheel come into contact, the smaller any potential savings in brake shoe wear will become.

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[57] Correspondence from Spécialiste Règlementation Ferroviaire, ArcelorMittal, op. cit.
[58] The ECP Brake – Now It's Arrived, What's the Consensus? op. cit., Section 5.
[59] Interview with Shop Superintendent, BNSF, op. cit.

Benefit	BAH Projected Benefits (2006)[41]	International Operating Experience (through May 2015)	North American Test Operations (through May 2015)
Network Capacity	The BAH report cites Spoornet (now Transnet Freight Railroad) as being able to reduce the cycle time on its coal line by 9 percent due to ECP brakes. The report estimates an industry-wide savings in the US of $2.5 billion for every 1 mph increase in average train speed. Since no systematic studies have been done on this topic, the BAH report does not claim network capacity savings. (Section III.8)	▪ Network capacity is given a neutral rating in the Interfleet Technology report: "Any network capacity benefits are a long way off," even though Australia has been operating trains with ECP brakes for 10 years. Part of the issue is that the signaling systems are set for the "worst" class of trains, so in operations with a mixture of train types it is not possible to re-signal to improve network capacity. Another issue is that there are "many factors such as traffic density, age of signaling equipment, etc. that would influence decisions in this direction [strategies to improve network capacity]."[60]	▪ It is stated in the RIA that "FRA found that ECP brakes offered major benefits in train handling, car maintenance, fuel savings, and increased capacity under the operating conditions present."[61] Since FRA has not publically reported on any data collection and analysis from North American railroad test operations using ECP brakes, it is unclear what information is being used on which to base this claim. ▪ Theoretical cycle time improvements from ECP brakes can be shown, however field testing has proven that these savings are difficult to achieve: – Even if ECP were to offer superior train handling and reduced inspections, all trains are restricted by other trains on the network, by the signal systems, by the length of time the customer holds the car, and by the time a customer takes to order the train into its terminal.[62] It is difficult for a train to make significant cycle time improvements through equipment changes alone. – Every interviewee from the Class Is reiterated concerns about the reliability of ECP brakes and the disruptions they could cause on the rail network. – One Class I railroad reported that the average time to repair an ECP train failure was 6.91 hours, versus 1.85 hours for a train with conventional brakes.[63] – Another Class I railroad reported that between October 13, 2014 and May 7, 2015, conventionally braked trains saw 13 percent fewer average train delay hours per trip than ECP brake-equipped trains. This increase in average delay hours translates to a reduction in train velocity.[64]

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[60] The ECP Brake – Now It's Arrived, What's the Consensus? op. cit., Section 5.
[61] Final Regulatory Impact Analysis, op. cit., pp. 251-252.
[62] Interview with Manager Car Administration, NS, op. cit.
[63] Impact of Potential ECP Requirement on the Railroad Industry, op. cit., p. 8.
[64] "BNSF 14 Run Overview 2014," provided by BNSF.

Benefit	BAH Projected Benefits (2006)[41]	International Operating Experience (through May 2015)	North American Test Operations (through May 2015)
Other Cost Savings	Other non-quantifiable savings reported by BAH include: ▪ Reduction in cost of EOT device purchases ▪ Reduced damage to couplers ▪ Reduced premature rail wear (Section III.9)	▪ Interfleet Technology gives "other savings" a negative grade. Regarding EOT devices: "In Australia most operators would view this as a negative benefit. There is no legislative requirement to have 2-way EOTs on trains….The weight and cost of ECP EOT devices are not positive attributes."[65] ▪ None of the foreign railroads gave any indication that ECP brakes reduce rail wear. ▪ ArcelorMittal stated that there are no savings with couplers when using ECP brakes versus conventional brakes.[66]	▪ EOTDs: The Final Rule will mandate two-way EOTDs on any train comprising 20 or more tank carloads of a Class 3 flammable liquid in a continuous block or 35 or more tank carloads of a Class 3 flammable liquid across the entire train.[67] For the most part, railroads adopted two-way EOTDs for these and other services long ago. ▪ Reducing damage to couplers and lading damage: The RIA does not directly address improvements to couplers through the use of ECP brakes, only train handling, which impacts coupler wear and lading damage. "FRA found that ECP brakes offered major benefits in train handling, car maintenance, fuel savings, and increased capacity under the operating conditions present."[68] – Train handling has more to do with how the engineer operates the train, not which brake system is used on cars. – In test operations of intermodal equipment hauling consumer goods, UP found that braking and train handling with DP was "virtually as good as the ECP test train."[69] – BNSF has achieved improved train handling through DP: "With DP, the engineer can manipulate the relative power outputs to minimize coupler slack throughout the train."[70] ▪ Reduced premature rail wear: None of the seven Class I railroads interviewed gave any indication that ECP brakes reduce rail wear, with the exception of CP, in the one specific instance described previously of heavy coal trains operating over uniquely advantageous terrain.

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[65] The ECP Brake – Now It's Arrived, What's the Consensus? op. cit., Section 5.

[66] Correspondence from Spécialiste Règlementation Ferroviaire, ArcelorMittal, op. cit.

[67] Final Regulatory Impact Analysis, op. cit., p. 238.

[68] Final Regulatory Impact Analysis, op. cit., p. 251.

[69] Verified Statement of Michael E. Iden, Union Pacific Railroad Company Before the Department of Transportation Pipeline and Hazardous Materials Safety Administration, Docket No. PHMSA 2012-0082 (HM-251): Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains; Comment Request, September 30, 2014, p. 17.

[70] Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, Docket No. PHMSA 2012-0082 (HM-251), Comment Request. Comments of BNSF Railway Company, p.4.

Benefit	BAH Projected Benefits (2006)[41]	International Operating Experience (through May 2015)	North American Test Operations (through May 2015)
Safety Benefits	No dollar value is assumed for safety benefits, due to "many quantitative unknowns about the safety benefits of ECP brake systems." Any claimed savings would come from FRA accident codes related to conventional brake failures or human error associated with brake-related train handling. These categories accounted for $40 million in reportable damage and 18 non-fatal injuries in 2004. BAH also mentions the potential for reducing accident severity if the train is able to slow down faster before a collision. (Section III.10)	▪ Safety, even though ECP trains have been operated in Australia since 2005, is only given a neutral rating by Interfleet Technology, and the benefits are described as "nebulous." The report goes on to state that "Clearly ECP trains can stop in shorter distances, which is a good thing, but as the signaling system is set for the 'worst' train it is difficult to quantify any safety benefit."[71] ▪ Interfleet Technology also notes in its report that train handling-related derailments, incidence of train break-in-two events, and derailment risk in emergency stops are all rare events, and there is no evidence that ECP brakes offers any safety benefits in these three categories (a neutral rating is given to all three).[72] ▪ The COO of G&W (Australia) stated that ECP brakes "make no difference from a safety viewpoint."[73]	▪ Because there is very limited experience operating ECP brake-equipped trains in North America, and none have derailed to date, PHMSA had to rely on a simulation model to try to predict the savings.[74] ▪ If "an ECP brake mandate resulted in shipments forced off of the safest mode, rail, and back to the highway, the overall safety of the surface transportation system could be degraded rather than enhanced by a mandate."[75] ▪ The diversion of funds to ECP brakes also could impact investments in projects with potentially greater and better proven safety benefits. The railroads are continually investing to improve rail safety for their employees and the public. "The safety measures currently in place have resulted in considerable progress towards preventing catastrophic crude oil incidents from occurring."[76] ▪ Finally, electricity on tank cars could pose an additional safety hazard to railroad employees. Carmen, engineers and mechanics will need to be trained in the use of new equipment, and proper techniques for grounding and prevention of arcing. The ECP brake manufacturer instruction manuals are filled with warnings about electrocution and other dangers associated with the handling of ECP brake components.[77]

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[71] The ECP Brake – Now It's Arrived, What's the Consensus? op. cit., Section 5.

[72] The ECP Brake – Now It's Arrived, What's the Consensus? op. cit., Section 6.

[73] Interview with Chief Operating Officer, G&W, op. cit.

[74] Final Regulatory Impact Analysis, p. 64.

[75] Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, Comments of BNSF Railway Company, op. cit., p.8.

[76] Union Pacific Railroad Company Before the Department of Transportation Pipeline and Hazardous Materials Safety Administration, Docket No. PHMSA 2012-0082 (HM-251): Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains; Comment Request, September 30, 2014, p. 22.

[77] ECP- S4200 Electronically Controlled Pneumatic Braking System Operations and Maintenance Manual, Wabtec.

2. Real-world usage of brakes explains the lack of ECP brake benefits.

a. Both ECP and conventional air brakes are only used for approximately 2 percent of a train's trip time.

As trains move from origin to destination, they brake less than 10 percent of total trip time. When the brakes are applied, the engineer is three times more likely to engage dynamic braking than "shoe-on-wheel" conventional air or ECP brakes.[78] A data sample provided by several Class I railroads showed that conventional air brakes were engaged, either on their own or in conjunction with dynamic braking, only 2.16 percent of trip time on average and that ECP brakes were engaged only 1.37 percent of trip time on average (see Exhibits II-4 and II-5).[79] This means that for every 24 hours a train was in transit, ECP brakes were used for less than 20 minutes and conventional air brakes were used for approximately 31 minutes, based on the sample data.

Given the predominance of dynamic braking, and the relatively small time that "shoe-on-wheel" brakes are used, it is not surprising that the benefits promised by ECP brakes have failed to materialize, even after years of testing in North America. The lack of benefits is not confined to the United States. In Australia, where ECP braking has been used on closed loop, single-commodity mining railroads, the report that PHMSA relies upon notes "disappointing" wheel savings, that savings have "not been realized" for brake shoes, that savings are "difficult to quantify" for fuel, and that safety improvements have been "nebulous."[80]

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[78] Dynamic braking uses the traction motors on locomotives as generators, with the power generated being dissipated through brake grid resistors. The effect is to slow the train without applying brake shoes to the wheels.

[79] Data on conventional air brakes was provided by BNSF, CSX, KCS, and UP. Data on ECP brakes was provided by BNSF and NS. Details of the trains and dates included in the sample are provided in Appendix B.

[80] The ECP Brake – Now It's Arrived, What's the Consensus? op. cit., Section 5.

Exhibit II-4: Use of Brakes on Trains with Conventional Air Brakes[81]

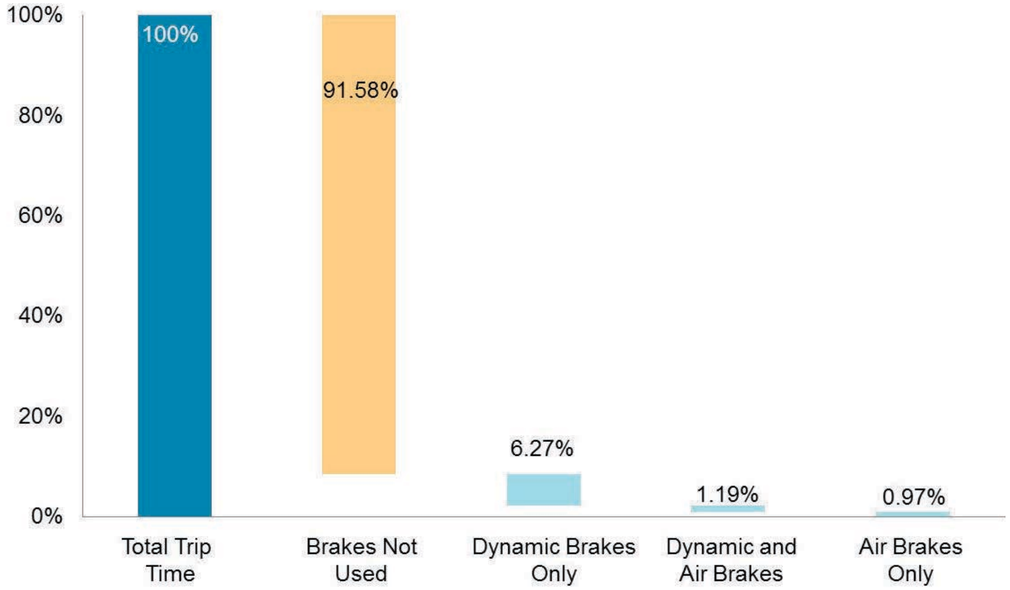
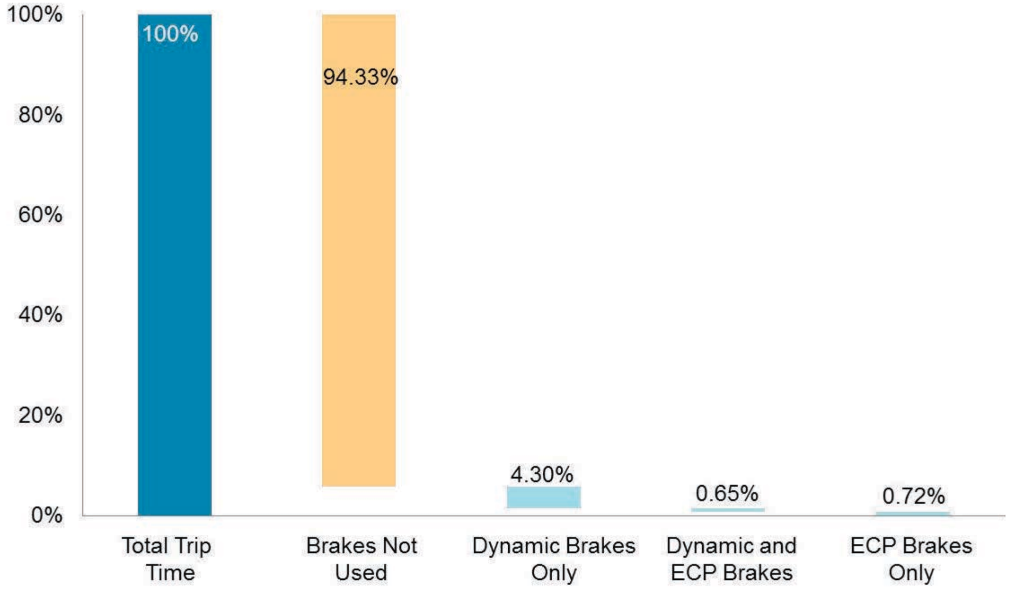


Exhibit II-5: Use of Brakes on Trains with ECP Brakes[82]



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[81] Data provided by BNSF, CSX, KCS, NS and UP. Details are provided in Appendix B.
[82] Data provided by BNSF and NS. Details are provided in Appendix B.

b. Use of ECP and conventional air brakes is statistically the same.

Statistical analysis of the data also demonstrates that there is no meaningful difference between the time conventional brakes and ECP brakes are applied.[83] BNSF provided data for six trains with ECP brakes and six trains with conventional air brakes. A statistical test was constructed with a null hypothesis that the use of the two braking systems was the same. The null hypothesis could not be rejected (i.e., the hypothesis was confirmed), which means that based on this sample of data, there was no statistical difference between the amount of time ECP brakes were engaged and the amount of time conventional air brakes were engaged.[84] The statistical analysis was run again using NS-provided data on 27 trains with conventional air brakes and 18 trains with ECP brakes. This test, like that of the BNSF data, also showed that there was no statistical difference in the average amount of time that ECP brakes and conventional air brakes were applied.[85]

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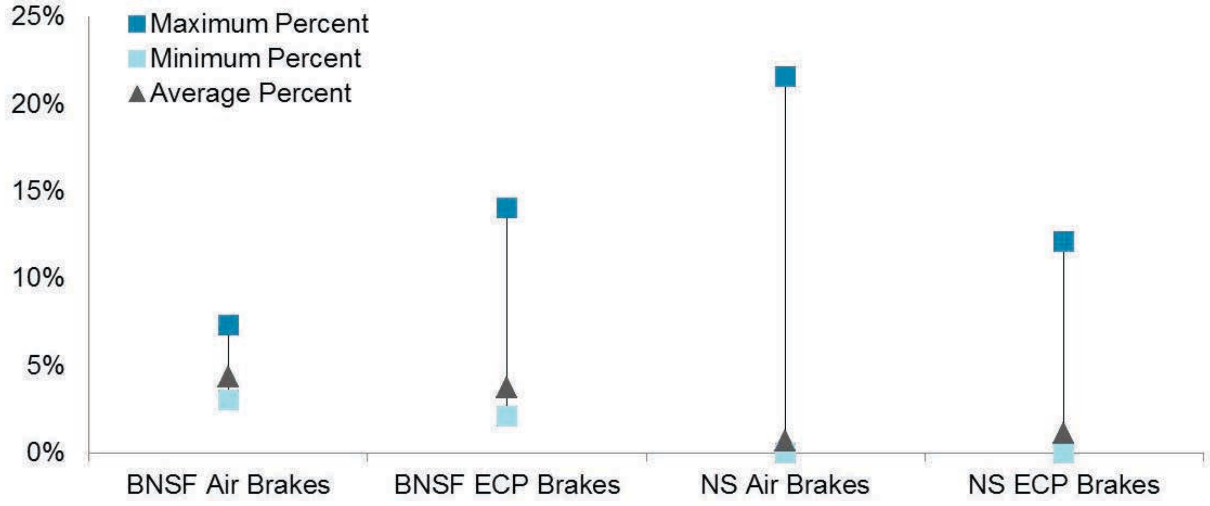
[83] Anecdotal evidence from BNSF indicates that in some services, it has observed that on ECP brake-equipped trains the brakes are applied more frequently than on conventional trains, leading to brake shoe and wheel wear.

[84] BNSF results: a two sample t-test assuming unequal variances was run using Microsoft Excel. The t static of -0.579 was less than the critical t value for the two-tailed test of 2.571, and therefore the null hypotheses that these samples were drawn from different distributions with different means was rejected.

[85] NS results: a two sample t-test assuming unequal variances was run using Microsoft Excel. The t static of 0.400 was less than the critical t value for the two-tailed test of 2.020, and therefore the null hypotheses that these samples were drawn from different distributions with different means was rejected.

Exhibit II-6: Statistical Comparison of ECP and Conventional Air Brake Use[86]
Percent of time brakes are used, either on their own or in conjunction with dynamic braking.



3. PHMSA did not update the case studies presented in the BAH report.

a. BNSF Railway[87]

BNSF has been a pioneer in testing ECP brakes in North America. As reported by BAH, BNSF has conducted test operations using ECP brakes on double-stack trains (Los Angeles to Chicago), taconite trains (Hibbing, MN to Allouez, WI), coal trains (Powder River Basin to Becker, MN), and grain trains (Kansas City to Galveston).[88] It has not tested them on tank cars.

Most recently, BNSF has been conducting a test operation of an ECP brake-equipped train jointly with NS. The train operates from the Powder River Basin to a utility plant in Georgia. FRA granted a 5,000 mile inspection waiver for this service as an incentive to test the train, so NS and BNSF redeployed locomotives and railcars they had previously purchased to this route. Operation of this train has been plagued with service delays.

BAH reports the benefits of ECP braking from BNSF test operations prior to August 2006 as:

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[86] Oliver Wyman statistical analysis of BNSF and NS data.
[87] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., pp. D-2 – D-6.
[88] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. D-2.

- Wheel replacement showed a significant decrease with ECP braking on intermodal trains[89]
- For taconite trains, brake shoe replacement and wheel replacement were better than with conventional brakes, except during periods of low ECP brake use. No values were provided on the claimed reductions. (Note however that brake shoe replacement was much higher with ECP braking on intermodal trains, though this was attributed to engineers being unfamiliar with the brakes.)
- For coal trains, both brake shoe replacement and wheel replacement on ECP cars were cited as less frequent than replacements for conventional brakes, though again no values were provided.

When asked about the benefits of ECP brakes in a recent interview, BNSF stated that the failure rate of ECP trains on the BNSF is three times the rate for standard trains. BNSF is currently running two ECP trains: The 3,500-mile inspection train has been running for eight years and the joint BNSF/NS 5,000-mile train has been running for six months. The railroad reports that each of these trains has substantially higher brake usage than conventional trains, by a factor of four. This increase in usage directly equates to higher brake shoe usage and wear on ECP trains and higher thermal forces being induced into wheels, impacting wheel life. In its experience, BNSF has not seen any reduction in wheel usage and, in fact, has seen a slightly higher wheel usage on ECP trains sets. However, from BNSF's experience, the biggest outstanding concern with ECP remains the continued frequency of interruptions caused by ECP failure, requiring significant resources to investigate and resolve; resulting in significant

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[89] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. D-4.

increases in train delay and cycle times. Unfortunately, two decades into this project, the technology is still working out simple communications, durability, and reliability issues.[90]

BNSF provided the results of recent tests that highlight the issues:[91]

- **5,000-mile NS ECP brake-equipped train versus conventional air brake-equipped train (past six months of service):** For the joint NS-BNSF coal train from the Powder River Basin to Marion, GA using the 5,000-mile inspection waiver, a comparison between ECP-equipped trains and the trains with conventional air brakes operating in the same service showed that:
  - ECP brake-equipped trains experienced a 12 percent longer cycle time (even though these trains begin with a base theoretical improvement of three hours, due to the reduction of two inspections per cycle).
  - ECP brake-equipped trains experienced 28 percent more delay due to equipment failure.
  - ECP brake-equipped trains suffered from some 40 known delays, each which consumed additional manpower, including rapid responders, extra train crews, mechanical desk support, and New York Air Brake (NYAB) technicians to resolve.
  - Sixty-two additional trains (non-ECP) were delayed due to ECP brake-equipped trains causing service interruptions.
- **3,500-mile BNSF ECP brake-equipped train versus conventional air brake-equipped train:** For coal trains operating in the same service into Palos, AL, a comparison between the ECP brake-equipped trains (subject to the 3,500 mile inspection rule) and the trains with conventional air brakes (subject to the 1,500 mile extended haul inspection rule) showed that:
  - ECP trains experienced a 5 percent longer cycle time.

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[90] BNSF team interview, May 18-20, 2015.
[91] "ECP Brake Overview, Joint BNSF/NS 5000 Mile Waiver," PowerPoint provided by BNSF, March 2015.

  - ECP trains experienced 6 percent more delay.
  - ECP brake-equipped trains suffered from some 65 known delays, each of which consumed additional manpower, including rapid responders, extra train crews, mechanical desk support, and NYAB technicians.
  - An additional 227 trains (non-ECP) were delayed due to ECP brake-equipped trains causing service interruptions.

Based on these experiences over the past eight years, BNSF projects that it would actually take 5-12 percent more freight cars and locomotives to operate with ECP brakes, as opposed to the theoretical 5-10 percent cycle time/fleet reduction projected in the nearly decade-old BAH report.

Additionally, major interoperability issues still hamper ECP operations at BNSF:

- ECP systems from various vendors do not work together as assumed in the RIA:
  - NYAB system and Wabtec ECP controllers do not currently work together.
  - When used with multiple locomotives, the software versions, even within one vendor system, must be exactly the same on each locomotive.
  - BNSF’s version of the NYAB ECP system cannot be linked to any NS NYAB ECP locomotive. Likewise, many NS ECP locomotives do not link to one another due to software configuration issues. Locomotive software is continually upgraded on the ECP locomotive fleet in an effort to keep it functional. For example, NYAB installed new software on four of the 150 NS ECP locomotives specifically to operate the joint BNSF/NS train on May 26, 2015. (And BNSF reports that on June 10, 2015 – two days

before this filing – it had to park its ECP train due to incompatible software versions within the locomotive consist, which it is now waiting for the supplier to fix.)[92]

- The ECP single-car interconnector continues to experience ongoing failures, leading to continuous OEM replacement as failures occur.
  - The design of this interconnector lacks the necessary reliability to function predictably in the freight railroad environment and is prone to corrosion and other failures; when these connections fail in the field, the result is an undesired emergency or penalty braking event. Reliability of this connection, due to the failure modes and the unplanned braking events, is a significant cause for concern, both in the current pilot and in considering any expanded use of ECP. Current ECP piloting experience is with unit train operations that in this instance are infrequently disconnected, and yet BNSF is unable to maintain connection reliability. If equipped on cars which are more frequently connected and disconnected, BNSF expects that reliability will be further negatively compromised, leading to even greater impacts.
  - On the fleet operating under the 3,500 mile rule, BNSF had to replace every connector and battery within the first five years of the program.
  - Although ECP is understood to be self-diagnostic, when BNSF experiences failures in the field, it must manually inspect and check each and every connector on that train to ensure connectivity; that means on a 135-car coal train, all 270 connectors must be manually inspected. This process is both very tedious and time consuming when the train is stalled on the mainline.

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[92] Correspondence from Shop Superintendent, BNSF, June 11, 2015.

- The diagnostics for failures are primitive and in most cases do not pinpoint the exact nature and location of a failure. Thus all failures require significant manual inspection, investigation, and troubleshooting, involving railroad mechanical employees and vendor technical experts.

b. Southern Company, CSX, Wabco[93]

The BAH report describes a test operation conducted by Southern Company, CSX, and Wabco to operate a coal train equipped with ECP brakes. The original plan, to operate 2,000 miles from the Powder River Basin, WY to the southeastern US, proved to be too much of an investment in crew training, so the test operation was changed to a 95-mile route from Corbin, KY to Stilesboro, GA. The predicted benefits from this test operation were:

- Better train handling and corresponding reduced fuel usage
- Reduced wheel damage and wheel replacement
- Reduced overall trip time and increased equipment utilization

The testing began in November 2000 and was stopped in July 2001. Reasons for stopping this test operation included:

- Getting equipped locomotives and keeping them dedicated to this service
- Training and qualifying over 50 crews for ECP operations for just a 95-mile trip
- Keeping up with changing technology, specifically train-line transceivers

This test operation was considered a failure and did not yield sufficient benefits to justify additional testing. CSX has not tested ECP brakes since halting this test operation.[94]

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[93] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., pp. D-8-D-9.

[94] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. D-9. See also correspondence from CSX, dated June 1, 2015 stating that the test operaton was abandoned in July 2001 due to “Multiple reliability issues were cited, including

c. ArcelorMittal (formerly Quebec Cartier Railway)[95]

As noted previously, ArcelorMittal hauls iron ore from Mount Wright, Quebec to Port Cartier on the St. Lawrence River. The railroad does not connect to other railroads, and runs an isolated mine-to-port operation. The train sets are kept intact from mine to water and back, with the exception of removing cars for planned maintenance or "bad order" condition. Currently, three of eight trains are equipped with ECP brakes; the other five use conventional air brakes. ArcelorMittal is planning to standardize the fleet to either conventional or ECP brakes for operational uniformity.

Quoting reports from 1998, 1999, and 2000, the BAH report lists a series of benefits associated with the use of ECP brakes at ArcelorMittal. Interviews were conducted with ArcelorMittal to obtain an update. The differences are shown in Exhibit II-7 below.[96]

Exhibit II-7: ArcelorMittal: Original BAH Benefits Reported and Interview Updates

Benefit	Original BAH Report Findings (2006)	Interview Updates (May 2015)[97]
Train Delays	31% better	Some savings from shorter braking distance, ability to release and reapply brakes without losing air, and easier handling on steep hills
Fuel Consumption	4.9% better. BAH states that the potential fuel savings resulting from ECP brakes was due to the ability to change train handling procedures and run longer trains.	"Same as conventional"
Wheel Mileage	7% worse	"Same as conventional"
Brake Shoe Mileage	27% better	"Same as conventional (dynamic braking preferred)"
Undesired Emergencies per Train (UDE's)	100% better	"None"

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repeated incorrect brake cylinder pressure alarms, issues with junction boxes, issues with the software, excessive repair times, and EOT failures."

[95] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., pp. D-6-D-8.

[96] Interview with Spécialiste Règlementation Ferroviaire, ArcelorMittal, op. cit.

[97] Interview with Spécialiste Règlementation Ferroviaire, ArcelorMittal, op. cit., and follow-up correspondence on May 31, 2015.

Benefit	**Original BAH Report Findings (2006)**	**Interview Updates (May 2015)**[97]
Car Miles per Coupler Knuckle Failure	7% worse	"Same as conventional"
Train Length	17% better	"Same as conventional"

d. Transnet Freight Railroad (formerly Spoornet)

Transnet Freight Railroad (TFR) operates coal trains on a dedicated line in South Africa, downhill from Ermelo to Richards Bay. The trains are 200 or more cars long and they operate with ECP brakes. TRF's objectives in using ECP brakes, as reported by BAH, were to:

- Reduce derailments and train break-in-twos
- Reduce wheel wear (distribute thermal loads on wheels)
- Increase line capacity (by increasing average trip speed)
- Save energy (by eliminating power braking)
- Eliminate the need for a separate brake-holding pneumatic line
- Provide a new standard for locomotive multiple-unit lines, allowing mixing of different types
- Stay with a standard technology (i.e., AAR standards) for long-term competitive supply of components

The benefits reported by BAH included shorter stopping distance, reduction in wheel temperatures on long descending grades, and reduction in trip time. Reduction in trip time was the only one of the TFR goals that created measureable benefits. A ten percent trip time reduction was attributed to:

- Full use of dynamic brakes
- 30-minute savings due to saved restart time (did not have to stop at signals for recharging of brake reservoirs)

- 45-minute savings from reduced use of holding brake on descending grades

In actuality, there were no reported benefits in reduced derailments, energy savings, or reduced wheel wear. Perhaps most telling in terms of the value of the benefits realized by TFR is that ECP brakes have not been expanded to the heavy haul dedicated iron ore lines or any other services on the Transnet network.

3. Review of the BAH cost-benefit analysis

BAH commented in its report that there were three possible implementation alternatives for testing ECP braking in the United States. It called these the "Powder River Basin (PRB) Implementation Plan," "One Railroad Implementation Plan," and "New Equipment Implementation Plan." A cost-benefit study was provided only for the first test plan, so the comments herein are limited to that case.

BAH believed that installing ECP brakes on coal trains operating out of the PRB had "potential benefits most likely to exceed their implementation costs and in which a practical migration plan can be fashioned."[98] The BAH report lists a number of characteristics that made the PRB attractive for testing ECP brakes at that time:[99]

- Heavy-haul, high mileage (loads in excess of 100 tons/car and an average of 1,100 mile trips)
- Freight cars and locomotives that remain together in dedicated train sets (i.e., that remain intact and circulate continuously)
- Concentration of trains on selected rail corridors (130 trains per day over the 95-mile BNSF-UP joint line in Wyoming)

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[98] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. IV-1.
[99] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. IV-1.

- PRB traffic accounts for a significant percentage of rail traffic (26 percent of Class I revenue in 2004)
- Relatively few stakeholder participants in these movements (train sets are often owned by the utilities)
- Stakeholders that are familiar with and interested in ECP braking issues (several stakeholders participated on the BAH report expert panel)

BAH did mention other potential services where ECP brakes could be tested, such as unit train grain traffic or West Coast intermodal movements. BAH noted however that "These services have operating or commercial complexities beyond those of PRB coal, which make them better intermediate stage conversion candidates than first tier ones."[100] Grain, for example, has an extensive gathering network more geographically dispersed than the PRB coal mining area, and grain tends to move based more on market prices, rather than throughout the year like utility coal. Intermodal traffic is more commercially complex than PRB coal, with numerous parties to bring to the table to discuss the dynamics of ECP brake conversion.

Crude oil resembles the rail services BAH believed were not suitable for initial installation or that would not realize maximum benefit from ECP brakes. Crude oil is geographically diverse, with loading terminals scattered through production areas in West Texas, the Bakken region, the Edmonton area, etc. (see Exhibit III-3). As noted previously, the trains do not remain intact from origin to destination in a "ring" cycle – they are instead typically switched at origin and/or destination. This traffic accounts for only about 2 percent of US rail traffic and travels over many of the mostly heavily used rail lines in the country. Finally, there are many different stakeholders

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[100] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. IV-2.

involved, including railroads, car owners, loading terminal operators, unloading terminal operators, and oil companies.

BAH claimed that the payback for the PRB plan would be three years, with an internal rate of return (IRR) of 47 percent and a net present value (NPV) of almost $700 million over 15 years. Experimental operations with ECP brakes since the BAH report was issued have disclosed numerous problems with the brakes that have altered the payback calculation and, as a result, no North American railroad has chosen to adopt ECP brakes.[101]

Exhibit II-8 recreates the BAH cost-benefit results, which total $432 million in one-time costs and $170 million in annual savings. However, as noted in the comments field, the costs appear to be understated and the benefits overstated.

Exhibit II-8: BAH Cost-Benefit Analysis for PRB Implementation Plan[102]

Cost/Benefit	BAH Amount	Comments
One-Time Costs		
Locomotive Conversion	$112 million	▪ BAH estimated 2,800 locomotives at $40,000 per locomotive to install ECP. As discussed in this report, it is not possible to install ECP only on a subset of locomotives. Even unit coal trains can be broken apart and the locomotives reassigned to another service. ▪ The cost of equipping a locomotive with ECP has more than doubled, to $88,300, since release of the BAH report.
Freight Car Conversion	$320 million	▪ BAH estimated 80,000 coal gondolas at $4,000 per gondola to install ECP. ▪ If only PRB coal cars were to be equipped with ECP, then this estimate would have been reasonable in 2006. However, the cost to install ECP on tank cars in 2015 is more than double the cost to install ECP on gondolas in 2006 ($9,600 instead of $4,000).
Training	Not included	▪ Although significant, not included as a cost in the BAH analysis.
Maintenance	Not included	▪ Although significant, not included as a cost in the BAH analysis.
Annual Benefits		
Fuel savings	$78 million	▪ BAH claimed a “conservative” figure of 5 percent savings. This is higher than the PHMSA estimate of 2.5 percent, which is higher than any measurable results other than on “advantageous terrain.”

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[101] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit., p. IV-3.
[102] ECP Brake System for Freight Service, Booz Allen Hamilton, op. cit.

Cost/Benefit	BAH Amount	Comments
Reduced Wheel Defects	$45 million	▪ BAH assumed that ECP brakes would reduce 50 percent of all brake-related wheel defects. There is no evidence or justification for this 50 percent value. ▪ There have been no savings in wheel defects identified during operations in Canada or Australia, or during the operational tests conducted in the US. Railroads have reported that increased use of dynamic braking has led to improved wheel wear.
Brake Inspection Savings	$45 million	▪ BAH based savings on the elimination of the 1,000-mile brake inspection, at $500 per train. ▪ There is no indication that brake inspections will be eliminated, but there may be some savings from extending brake inspection distances. However, the BAH estimate still seems to be overstated for the following reasons: – The waiver distance had to be increased from 3,500 miles to 5,000 miles to provide sufficient incentive to run the Power River Basin to southeast US coal train. – As described in this report, it is likely that the time necessary to inspect ECP brakes could add 50 minutes or more to the inspection process, increasing the cost of inspections. – Trains must still stop for crew changes, refueling, and other train services, so it is not as if the train can go 5,000 miles without stopping.
Brake Shoe Savings	$2 million	▪ BAH reports that the Quebec Cartier Railway saved 20 to 25 percent on brake shoe life, and this value was used as the basis for the estimated savings. ▪ There have been no savings in brake shoes identified during operations in Canada or Australia, or during the operational tests conducted in the US. Railroads have reported that increased use of dynamic braking has led to brake shoe savings. ▪ Recent conversations with Cartier Railway (ArcelorMittal) have indicated that under real-world operating conditions, there have been no savings in brake shoe life resulting from ECP brakes.

In summary, the 2006 BAH cost-benefit analysis is based on a single segment of the North American rail industry, misses several large cost categories, and overstates the benefits of ECP braking relative to what has been observed during test operations in North America and operations in Australia and elsewhere.

III. PHMSA significantly understated the cost of installing ECP brakes and overstated the benefits.

The introduction of ECP brakes will generate higher costs than estimated by PHMSA for car owners and lessees, railroads, and ultimately, customers. There is a significant difference between PHMSA and rail industry estimates for the cost to implement and operate under the provisions of the ECP brake mandate as specified in the Final Rule (Exhibit III-1).

Exhibit III-1: Comparison of Rail Industry to PHMSA Cost Estimates for ECP Brake Implementation and Operation

$ millions, over 20 years, discounted at 7 percent

	Rail Industry[103]	PHMSA	Multiple That PHMSA is Below Industry Estimate
Locomotives	$1,766	$80[104]	22.1x
Tank Cars	$1,037	$373[105]	2.8x
Training	$239	$40[106]	6.0x
Operating Costs	Not reported, but moderate if most locomotives are equipped and cars have ECP overlay system	Not reported, but large if the railroads attempt to manage segregated ECP fleets	N/A
Total Costs	**$3,042**	**$492**[107]	**6.2x**

The largest difference between PHMSA and the railroad industry is on the cost to equip locomotives with ECP brakes (the railroad estimate is 22.1 times higher), and there are smaller, yet still significant, differences over the cost to equip tank cars (the railroad industry estimate is 2.8 times higher) and provide training (the railroad industry estimate is 6.0 times higher). There are two primary sources for the difference between the estimates:

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[103] Impact of Potential ECP Requirements on the Railroad Industry, op. cit., p. 12.
[104] Final Regulatory Impact Analysis, op. cit., p. 241.
[105] Final Regulatory Impact Analysis, op. cit., p. 240.
[106] Final Regulatory Impact Analysis, op. cit., p. 244.
[107] Final Regulatory Impact Analysis, op. cit., p. 245.

- PHMSA incorrectly assumes that the ECP equipment can be segregated from the rest of the rail fleet, ignoring the complexities and necessary interoperability of US rail operations.
- PHMSA appears to be using incorrect cost data for some of its estimates.

In addition, PHMSA significantly overstates the cost of crude oil and ethanol spills, which results in an incorrect calculation of the benefits attributed to the use of ECP brakes in unit trains carrying crude oil and ethanol.

A. PHMSA incorrectly assumed that the ECP equipment can be segregated from the rest of the rail fleet, ignoring the complexities and necessary interoperability of US rail operations.

PHMSA states that “Not all locomotives would need to be retrofit since the equipment with ECP brakes is part of a captive fleet, and therefore the locomotives would be part of that captive fleet.”[108] No such captive fleet actually exists today, and PHMSA’s simplifying assumptions overlook the complexities of US railroad operations and the critical need for interoperability, which make such segmentation impossible. Instead, the railroad industry will need to pay upfront to equip a large percentage of locomotives and cars for possible use in ECP brake-mandated service, and teach a broad spectrum of employees how to operate, maintain, and repair ECP brakes.

PHMSA, by making a highly simplifying assumption, has come up with unrealistic minimal installation costs for ECP brakes on a much smaller fleet of ECP equipment, with minimal training for employees. The PHMSA adoption of a cost basis with dedicated locomotives and cars is likely a result of improperly drawing conclusions on ECP braking from single-purpose, one-commodity foreign railroads, as discussed at length in Section II of this report. As noted in

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[108] Final Regulatory Impact Analysis, op. cit., p. 219.

Section II, the railroads upon which PHMSA bases its cost estimates are not comparable to the complex multi-commodity, multi-route North American rail system. Furthermore, PHMSA only considered the limited capital costs to install dedicated equipment, and overlooked the substantial increase in operating costs that would be needed to support segregated fleets in a system as complex as North America.

PHMSA believes a network as complex as the US railroad system could successfully support the operation and maintenance of a captive fleet for crude and ethanol unit trains, particularly when a small, single-commodity fleet like ArcelorMittal's, operated in isolation in Northern Canada (see Exhibit III-2) has difficulties dealing with two different braking systems on a single iron ore car type. Three out of eight of ArcelorMittal's train sets are equipped with ECP brakes, while the other five use conventional air brakes. Interoperability problems are severe, including complexity when sending out a train to pick up bad order cars, where half of the bad order cars use ECP and the other half use conventional air brakes. The difficulties of maintaining both braking systems even on this small fleet are so complex that ArcelorMittal is considering whether to standardize on ECP or conventional brakes to simplify operations.[109] The ArcelorMittal example demonstrates that dedicated systems with dedicated equipment cannot be co-located even on a single-commodity iron ore railroad. The appropriate costs then are all of the costs to the system to equip and staff in support of interoperability.

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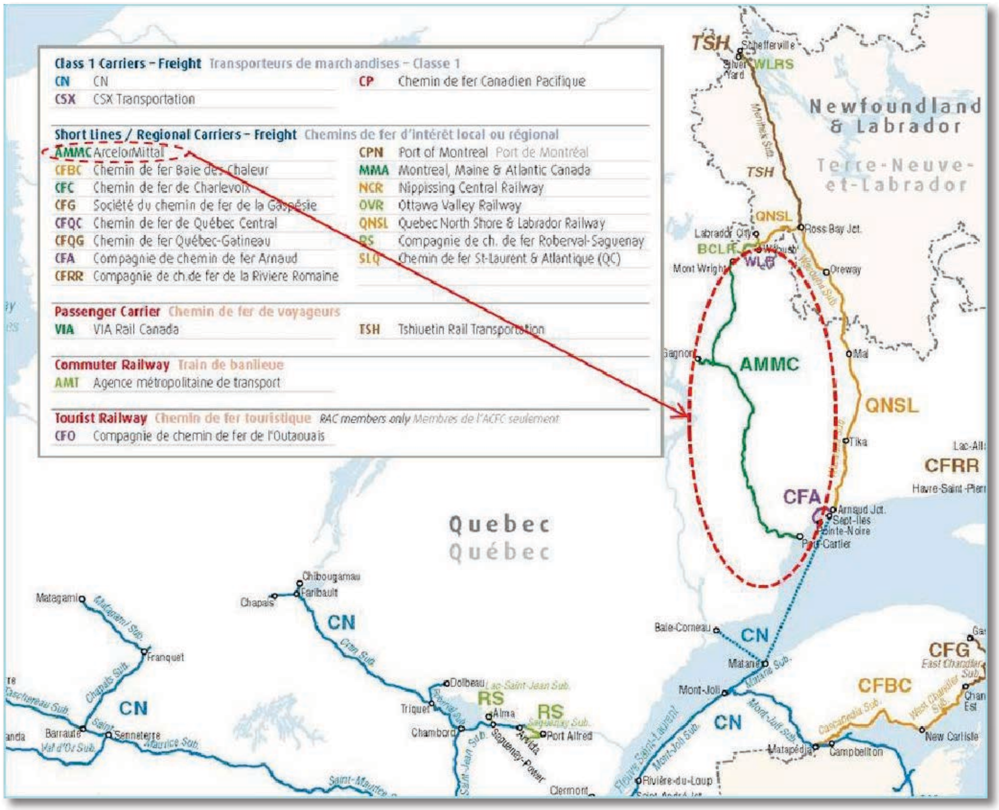
[109] Interview with Spécialiste Règlementation Ferroviaire, ArcelorMittal, op. cit.

Exhibit III-2: ArcelorMittal Rail Network (AMMC green line)[110]



North American unit trains equipped with ECP brakes cannot operate like dedicated unit coal trains in South Africa or dedicated ore trains in Australia, both of which remain intact in isolated operations. In North America, crude oil and ethanol trains move between multiple origins and destinations, and tank cars and locomotives frequently shift between manifest and unit trains operations. Many of the origin or support terminals that handle trains moving crude oil and ethanol also provide support for trains hauling a full range of other rail commodities. It is rare to find major terminal or support locations that only serve crude oil, ethanol, or any other commodity. Crude tank cars must be flexible to move along many different paths and in differing services. Upon reaching their destinations, they "diffuse throughout the system" as they move to

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[110] Railway Association of Canada, used with permission.

the most logical next destination for each car, rather than all moving back to the same location; "once you let the cars go, they will never come back together."[111] Some of these cars and locomotives will end up in another ECP brake-equipped unit train service, but others will end up in manifest service with conventional air brakes. The movement of locomotives and empty tank cars is often governed by complex computer algorithms designed to minimize empty mileage. Forcing the train to remain intact and return to a single origin will reduce fleet utilization, leading to increases in cycle times, empty train miles, and fleet size – all of which adds congestion to the network.

An example of the breadth of crude/ethanol movements is illustrated by the fact that while accounting for only five percent of BNSF's shipments, crude/ethanol traffic moves over 70 percent of BNSF's network.[112] Similarly, CSX has reported that locomotives assigned to ethanol unit train service traverse nearly 100 percent of the CSX core network.[113]

In addition, not all loading and receiving facilities in North America are unit train-capable or even designed to accommodate a common train size, meaning that blocks of cars must be continually built and reassembled. Nor are all facilities loop track capable, particularly for unloading, resulting in the need to split apart trains that may not be reassembled with the same cars or return to the same loading point. Exhibit III-3, for example, shows that loading terminals in the Bakken region are geographically dispersed, with different capacities and train loading capabilities, multiple owners, and are served by different railroads traveling to refineries

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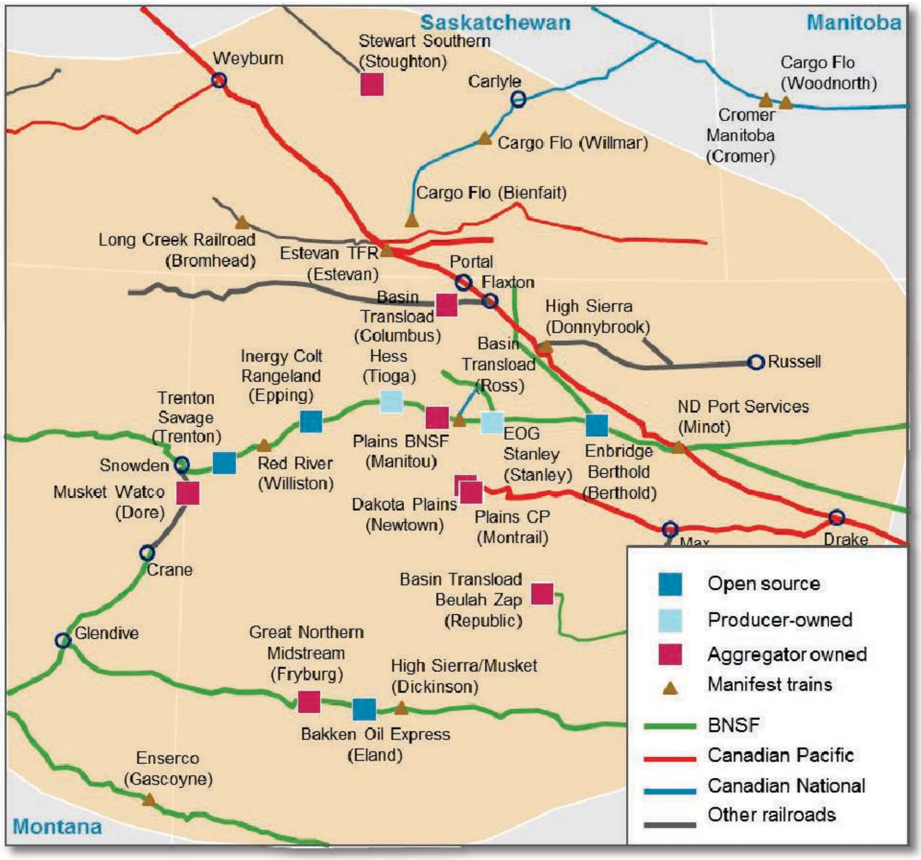
[111] Interview with Operations Engineer, NS, op. cit.

[112] Interview with Shop Superintendent, BNSF, op. cit.

[113] Impact of Potential ECP Requirements on the Railroad Industry, op. cit., p. 6.

throughout the US and Canada, making it extremely impractical to keep equipment in captive trains.[114]

Exhibit III-3: Loading Terminals in the Bakken Region



The bottom line is that the railroads will incur large capital costs upfront to equip a large portion of the North American fleet with ECP brakes and train a large number of employees in their use. If the railroads were to choose an alternative strategy, they would incur major, ongoing operating costs, face increased operational complexity, and suffer additional congestion and delays on the North American rail network.

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[114] North Dakota Pipeline Authority (April 2013), Oliver Wyman interviews and research.

B. PHMSA costs estimates are based on flawed assumptions.

To develop a deeper understanding of the total costs associated with ECP brakes, and the differences between the PHMSA and AAR cost estimates, it is necessary to break down the PHMSA and the rail industry estimates item by item.

Assumptions and values provided by PHMSA and the rail industry were reviewed and an estimated range developed for the cost of ECP braking as mandated by the Final Rule. The PHMSA total estimate was $493 million, while the rail industry estimate was $3,042 million. Further analysis by Oliver Wyman arrived at a cost estimate of $2.7 billion to $3.0 billion. The Oliver Wyman installation cost estimated values were amortized over a six year phase-in period, weighted toward the first three years, plus 20 years of maintenance beginning in year one.

Exhibit III-4: Cost by Category for ECP Braking, as Estimated by PHMSA, Rail Industry, and Oliver Wyman[115]

$ millions (present day dollars), six-year installation plus 20 year maintenance, using a 7 percent discount rate

	PHMSA	Rail Industry[116]	Oliver Wyman
Tank Cars	345.0	1,037.0	996.0
Locomotives	79.5	1,766.0	1,552.4
Training	39.9	239.3	245.6
Buffer Cars	1.0	Not estimated	11.7
Maintenance	27.2	Not estimated	68.3
Asset Management	0.4	Not estimated	Not estimated
Total Costs	**493.0**	**3,042**	**2,874**

To provide a basis for comparison, all dollar values discussed below are reported over 20 years using a 7 percent discount factor, unless otherwise noted.

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[115] See Appendix A for references.

[116] These figures were presented to OMB (Impact of Potential ECP Requirements on the Railroad Industry, op. cit., p. 12) and were intended to highlight major underestimates by PHMSA. The presentation notes that additional costs exist but were not included.

1. Installation of ECP braking on tank cars

PHMSA estimates a total of $345 million to equipment the tank car fleet with ECP brakes. The rail industry estimates $1,037 million and Oliver Wyman's estimate closely approximates this, at nearly $1 billion. The differences in estimates are largely due to how many tank cars are assumed to require ECP brakes, and the unit cost to install ECP as an overlay system.

Exhibit III-5: Comparison of Tank Car ECP Braking Installation Cost Estimates[117]

	PHMSA	Rail Industry	Oliver Wyman
Number of tank cars	93,379	132,605	119,000
Number of cars requiring ECP	60,231	132,605	119,000
Cost per tank car to install ECP ($)	7,633	9,665	9,665
Cost for ECP installation ($ millions)	459.7	1,281.6	1150.1
Adjustment for ECP unit train productivity ($ millions)	-14.5	0	0
Total 20 year cost (undiscounted) ($ million)	445.2	1,281.6	1,150.1
Total 20 year cost (discounted @ 7 %) ($ million)	345.0	1,037.0	996.0

PHMSA's estimate includes the costs of installing the ECP brakes as an overlay to existing air brakes and an adjustment for assumed improvements in car utilization caused by the ECP brakes.[118] PHMSA assumes that tank cars used in unit train service for flammable liquids will be managed as a separate pool, segregated from those used in manifest service. PHMSA states that "the PHMSA and FRA analysis assumes that shippers have the ability to predict or control whether a given tank car will be used in manifest train service or unit train service."[119] As a result, PHMSA separates tank cars into two groups and assumes that only those in dedicated unit

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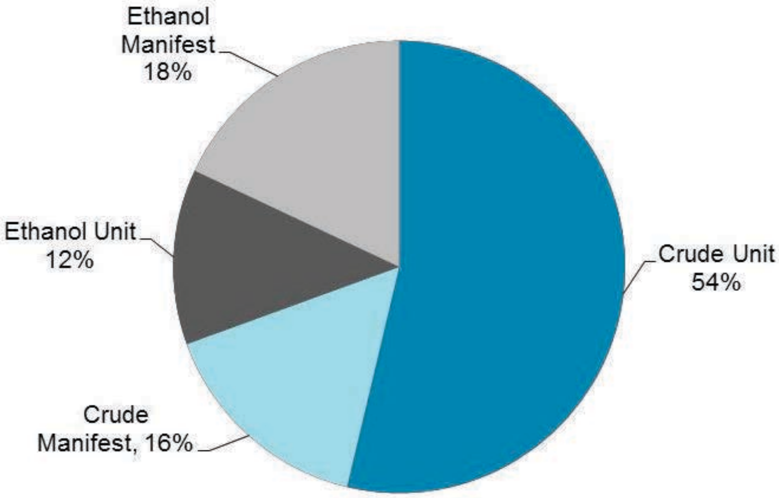
[117] See Appendix A for references.

[118] Final Regulatory Impact Analysis, op. cit., pp. 239-240. For this discussion, the cost of bypass cables for buffer cars and periodic scheduled maintenance is described in a later section.

[119] Final Regulatory Impact Analysis, op. cit., p. 221.

train service will need to be ECP brake-equipped, totaling 66 percent of crude oil/ethanol tank cars (Exhibit III-6).[120]

Exhibit III-6: PHMSA Estimate of Tank Cars Moving in Unit Train or Manifest Service



PHMSA further adjusts the tank cars required by assuming that unit trains with ECP brakes will be more productive in miles per day than trains with conventional brakes, thereby improving tank car utilization and reducing the total number of cars needed. This adjustment reduces tank cars requiring ECP brakes from 65,066 to 60,231, leading to a $36.9 million reduction in installation costs.[121] The concept of improved efficiency of ECP brake-equipped trains is questionable, however, given that ECP brake-equipped trains experienced mechanical delays 3.2 times higher than conventional trains in North American test operations, and each delay was for a longer duration.[122]

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[120] Final Regulatory Impact Analysis, op. cit., p. 232.
[121] Final Regulatory Impact Analysis, op. cit., p. 240. Note: 4,835 cars * $7,633 per car = $36.9 million.
[122] Impact of Potential ECP Requirements on the Railroad Industry, op. cit., pp. 8-9.

Using an assumption of one-third new construction and two-thirds retrofit, PHMSA developed a weighted ECP installation cost of $7,633 per car for parts and labor.[123]

As noted previously, PHMSA's simplifying assumptions do not account for the complexities of US railroad operations and the critical need for interoperability, which make any such segmentation of tank cars impossible. All tank cars hauling high-hazard flammable liquids will have to be ECP brake-equipped, since railroads and shippers must be able to utilize the fleet for both unit train and manifest train origins and destinations as needed. Today, a shipper can load a tank car without consideration of the type of train service that will be used to haul the car to destination. With a segregated fleet, the shipper and railroad would need to coordinate the type of service, and the shipper would be forced to match tank car brake systems with train services, adding complexity and possibly additional car switching at the loading terminal. For example, ExxonMobil, which is one of the nation's largest petroleum products producers, supports this view in its comments to PHMSA by indicating that any requirement for ECP braking would mean that all tank cars carrying flammable products would need to be equipped with dual braking systems.[124]

The rail industry estimates that 132,605 tank cars would need to be equipped with ECP brakes, at an installation cost of $9,655 per car for a total of $1,037 million.[125] The $692 million cost difference between PHMSA and the rail industry is based on differences in both the number of cars requiring ECP brakes and the cost of installation. The rail industry uses an installation

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[123] Final Regulatory Impact Analysis, op. cit., p. 239.

[124] Notes from 12866 Meeting with ExxonMobil Regarding Notice of Proposed Rule Making (HM-251) RIN 2137-AE91; April 8, 2015.

[125] Impact of Potential ECP Requirements on the Railroad Industry, op. cit., backup spreadsheet.

cost of $9,665 per tank car,[126] as compared to the blended new car/retrofit car rate of $7,633 used by PHMSA,[127] a $2,032 per car difference. The difference of 72,374 tank cars between the PHMSA and the rail industry estimates is based on both the unit train service separation and the total cars required for tank car service. In generating the total tank car fleet size, PHMSA effectively assumes a car utilization rate of 15.3 trips per year per car.[128] This compares to the reported 2013 utilization of 11.2 trips per year for crude oil cars and 10.8 trips per year for ethanol cars reported by PHMSA.[129] While PHMSA comments that "these two utilization estimates are likely too low"[130] due to cars with partial year service, there will always be cars with partial year service that will need to be equipped with ECP brakes under the regulations.

Using a conservative utilization rate of 12 trips per year, Oliver Wyman estimated the size of the tank car fleet needing to be equipped with ECP brakes to be approximately 119,000 cars.[131] Based on interviews with rail industry experts, Oliver Wyman identified the cost of an ECP overlay kit to be $7,000 per tank car, and the labor cost for installation to be approximately $2,000 per tank car.[132] The labor involved in the installation of an ECP overlay system on an existing car is extensive. First, an overlay manifold must be mounted on the air brake bracket to provide pneumatic control and sensor functions. A car control junction box must then be installed, including running and mounting conduit for wiring. Next, the ECP train line cable must be run and the ECP end of car connectors must be installed. Finally, labor is required for testing the installation and troubleshooting any issues. Oliver Wyman therefore accepts the rail industry

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[126] Impact of Potential ECP Requirements on the Railroad Industry, op. cit., backup spreadsheet.
[127] Final Regulatory Impact Analysis, op. cit., p. 218.
[128] Calculated as 1,428,852 tank car loads/93,379 tank cars = 15.3 trip per year. Denominator of 93,379 is 98,314 fleet size adjusted for assumed 4,835 car savings due to increased ECP brake-equipped unit train productivity.
[129] Final Regulatory Impact Analysis, op. cit., p. 231.
[130] Final Regulatory Impact Analysis, op. cit., p. 231.
[131] 1,428,852 tank car loads/12.0 trips per year = 119,071.
[132] Interviews with personnel at NS and ArcelorMittal, op. cit.

value of $9,665 per tank car for labor and parts as a more accurate estimate than the PHMSA value. Furthermore, Oliver Wyman rejects the PHMSA assumption that there will be $14.5 million in savings due to improved performance of ECP brakes. As discussed previously herein, a review of literature and discussions with rail industry experts indicate that there has been no performance savings from the use of ECP brakes. Therefore, the total Oliver Wyman estimate for the installation of ECP brakes as an overlay system is approximately $1 billion. This estimate is $650 million higher than the PHMSA estimate and $40 million lower than the rail industry estimate.

2. Installation of ECP braking on locomotives

PHMSA estimates a total of $80 million to equip the locomotive fleet with ECP brakes, the rail industry estimates $1.77 billion, and Oliver Wyman estimates $1.55 billion. Locomotives represent the largest cost difference between PHMSA and the rail industry, largely due to differing assumptions about how many locomotives will need to be ECP brake-equipped and also how rapidly locomotives will be converted. Neither PHMSA nor the rail industry estimated the additional maintenance costs associated with ECP brakes on locomotives.

Exhibit III-7: Comparison of Locomotive ECP Braking Installation Cost Estimates[133]

	PHMSA	Rail Industry	Oliver Wyman
Number of locomotives	2,532	20,000	20,000
Cost to equip current locomotive	79,000 (not used)	88,300	88,300
Cost to equip a new locomotive	40,000	N/A	88,300
% of locomotives that are new	100%	N/A	25%
Cost to upgrade locomotives ($ million)	101.3	1,766.0	1,766.0
Number of locomotive bypass cables	2,532	0	20,000
Cost per bypass cable ($)	1,000	N/A	1,000
Total cost of bypass cables ($ million)	2.5	0	20.0

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[133] See Appendix A for references.

	PHMSA	**Rail Industry**	**Oliver Wyman**
Total 20 year cost (undiscounted) ($ million)	103.8	1,766.0	1,786.0
Total 20 year cost (discounted @ 7 %) ($ million)	79.5	1,766.0[134]	1,552.4[135]

As is the case for tank cars, PHMSA assumes that HHFUT service will be managed as a separate pool and therefore estimates that only 2,532 locomotives will be required to transport 633 dedicated unit train tank car sets; in other words, four locomotives per train.[136] Furthermore, PHMSA assumes that all of the locomotives in HHFUT service will be provided through the purchase of new equipment, thus lowering the per-unit cost of adding ECP braking from the PHMSA estimate of $79,000 per locomotive for a current locomotive to $40,000 per locomotive for a new locomotive.[137] PHMSA assumes that the Class I railroads will buy 6,000 new locomotives over the next six years and that a portion of these locomotives will be equipped with ECP brakes. For these new locomotives, it assumes only the $40,000 per locomotive for ECP brakes as an added cost.

PHMSA further assumes that each of the new locomotives will be equipped with a $1,000 bypass cable, for use in providing safe braking in the event that a non- ECP brake-equipped locomotive is placed on an ECP brake-equipped train. While the concept of including bypass cables on locomotives is a good idea for emergency situations, every Class I railroad interviewed said that bypass cables are only for temporary emergency use and should not be used on a

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[134] The rail industry estimate is based on all locomotives being equipped with ECP in year 1, therefore the discounted and undiscounted values are the same.

[135] Oliver Wyman assumed that locomotives would be equipped with ECP brakes on the same schedule as tank cars, i.e., over a six year period, but weighted toward the first three years.

[136] Final Regulatory Impact Analysis, op. cit., p. 240.

[137] Final Regulatory Impact Analysis, op. cit., p. 219.

regular basis.[138] These cables can require up to an hour to install each time they are used, and they must be properly secured to prevent tripping hazards, whether they are being applied in a yard to isolate a non-ECP brake equipped locomotive or in the field to isolate a locomotive or car that has failed en route. In addition, the bypass cables carry 230 volts of electricity and create hazards for crew members who must install them in a yard or in the field, often at night or under adverse weather conditions.

By assuming that ECP brake-equipped locomotives will be managed as a separate pool, PHMSA greatly reduces the number of locomotives that must be equipped with ECP brakes and the cost of the program. However, Class I locomotives are not managed in fixed pools. Locomotives are the railroads' most important asset for maintaining network fluidity and flexibility. To maintain service levels and minimize disruptions, most of the mainline locomotives in the North American fleet would have to be equipped with ECP brakes. Dedicating locomotives to a specific commodity or geographic service is not possible, as it would severely limit both locomotive utilization and distribution flexibility.

For example, UP reports that it "does not have a 'captive' flammable liquids locomotive fleet." Thus to ensure network fluidity and customer service, UP, like all railroads, would need to equip every locomotive that is likely to be part of a train covered by the rule, as locomotives move around the country and are not assigned to a dedicated area (and must be interoperable with other railroads).[139] To demonstrate this point, UP mapped the movements of a single locomotive over a 60-day period, showing that the locomotive traveled over a large portion of the national rail network, and over multiple railroads. UP concluded that "Because a

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[138] Interviews with all seven of the Class I freight railroads operating in the United States and Canada, May 18-22, 2015.

[139] Verified Statement of Michael E. Iden, Docket No. PHMSA 2012-0082 (HM-251), op. cit., p. 6.

locomotive's location or ultimate destination is not predictable, and locomotives are required wherever power is needed, there is no feasible way to dedicate a locomotive to a single commodity or designated geographical area."[140]

Similarly, CSX reviewed the activity of its locomotives used in ethanol unit train service and found that while only 15 percent of miles were in ethanol unit service, those locomotives traversed nearly 100 percent of the core CSX network.[141]

The fact that the railroads are equipping entire locomotive fleets with positive train control (PTC) – even though PTC will be used only on a subset of rail lines – clearly illustrates that PHMSA's assumptions that a subset of the locomotive fleet can remain captive to HHFUT trains is not possible given the realities of rail operations.

The rail industry estimated the demand for ECP brake-equipped locomotives to be 20,000 units – almost eight times the number of locomotives estimated by PHMSA. Furthermore, the estimate for upgrading a current locomotive with ECP is $88,300 per unit, which is $9,300 higher than the PHMSA estimate for existing locomotives and $48,300 higher than the PHMSA estimate for a new locomotive. The rail industry assumes that existing locomotives would be equipped with ECP brakes. The total rail industry cost estimate for equipping road locomotives with ECP brakes is $1.77 billion.[142]

Oliver Wyman estimated the cost of equipping locomotives with ECP to be $1.55 billion, based on 20,000 locomotives at $88,300 per locomotive and discounted at 7 percent. The 20,000 road locomotives to be equipped with ECP braking systems represents 80 percent of the overall

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[140] Verified Statement of Michael E. Iden, op. cit., p. 7 for all quotes in this paragraph.

[141] Impact of Potential ECP Requirements on the Railroad Industry, op. cit., p. 6.

[142] Comments of the Association of American Railroads, Docket No. PHMSA-2012-0082 (HM-251), op. cit., Attachment C, Exhibit 2-B – "AAR Other Cost Estimates."

US Class I railroad fleet, which totals 25,033 locomotives.[143] This total includes locomotives used in both road and switching service. Locomotives that are not used as road locomotives will likely not require ECP braking equipment. The unit cost of $88,300 to equip each locomotive with ECP braking technology may still be conservative, especially for retrofitting existing locomotives (which could exceed $100,000 per locomotive,) but appears to be closer to the actual cost than the PHMSA estimate of $79,000 per locomotive.[144]

The issue that PHMSA raises about ECP brake-equipped locomotives carrying bypass cables so non-ECP locomotives can be used as backup would be necessary if only a small portion of the fleet is equipped with ECP brakes, as is the case in the PHMSA assumptions.[145] However, even when the entire road locomotive fleet has ECP brakes, every ECP brake-equipped locomotive will need to have bypass cables for use in emergency situations. Since locomotive consists change, railroads cannot run the risk of having a locomotive consist that is not equipped with bypass cables in the event of an ECP brake failure.

The total Oliver Wyman estimate of $1.55 billion is $214 million lower than the rail industry estimate to equip locomotives with ECP, and $1,473 million higher than the PHMSA estimate. The primary difference between the Oliver Wyman and PHMSA estimated cost for locomotives is due to the different assumptions about the percentage of the road locomotive fleet requiring ECP brakes. Oliver Wyman agrees with the rail industry that it is not possible to maintain a separate fleet of locomotives for hauling HHFUTs.

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[143] Railroad Facts, 2014 Edition, Association of American Railroads, p. 51.

[144] Comments of Amsted Rail Company, Inc. Before the Department of Transportation, Pipeline and Hazardous Materials Administration, Docket No. PHMSA-2012-0082 (HM-251) Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, September 20, 2014, p. 5.

[145] Final Regulatory Impact Analysis, op. cit., p. 219.

3. Training costs for ECP braking

PHMSA estimates a total of $39.9 million to train engineers, conductors, carmen, and selected supervisors, while the rail industry estimates $239 million and Oliver Wyman estimates $246 million. The differences among the estimates revolve around assumptions on the number of employees to be trained, the number of training days required by employee type, and the hourly wage rate.

Exhibit III-8: Comparison of ECP Braking Training Cost Estimates[146]

	PHMSA	Rail Industry	Oliver Wyman
# of Engineers to be trained	18,000	27,143	26,500
# of Conductors to be trained	27,000	41,015	39,700
# of Carmen to be trained	6,500	9,849	9,600
Hours of training – Engineers	16	80	80
Hours of training – Conductors	8	16	40
Hours of training – Carmen	56	80	80
Wage Rate – Engineers	50.56	73.10	73.10
Wage Rate – Conductors	50.56	62.16	62.16
Wage Rate – Carmen	50.56	42.60	46.60
# of Supervisors to be trained	292	200	292
Cost per supervisor of training	7,147.80	7,090.00	7147.80
Total 20 year cost (undiscounted) ($ million)	48.5	239.3	291.6
Total 20 year cost (discounted @ 7 %) ($ million)	39.9	239.3[147]	245.6

PHMSA used historical patterns for crude oil and ethanol unit trains to calculate that 68 percent of engineers, conductors, and carmen required training.[148] Given the dynamic nature of the crude oil and ethanol by rail markets and the conclusion that most road service locomotives needed to be equipped with ECP, the rail industry concludes that most of the employees in these

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[146] See Appendix A for references.

[147] Note: the rail industry estimate includes all training in year one, therefore the undiscounted and discounted values are the same.

[148] Final Regulatory Impact Analysis, op. cit., p. 224.

categories will require training on ECP braking technology.[149] Failure to train the appropriate number of employees would likely lead to increased time out of service for ECP trains and possible network delay impacts. The Oliver Wyman estimate assumes that most employees in these categories will require training. The number of total employees to be trained is based on scaling the PHMSA estimates to 100 percent. Comparison of the calculated engineer and conductor totals to train and engine (T&E) employment for 2013 provided a validation of this methodology.

A second source of variation in the estimates involves wage rates. Oliver Wyman reviewed T&E wages for 2013 and determined that the rail industry estimates appeared most consistent with the reported numbers.[150]

The most significant difference in the estimates involves the number of days of training required. PHMSA cut the number of days of training for engineers from 10 in the draft RIA to just two in the final RIA.[151] The two days of training includes one day of on-the-job training. Conductor training was cut from two days to one. The estimates from the railroad industry maintain 80 hours for engineers (10 days), 16 hours for conductors (two days), and 80 hours for carmen (10 days). The Oliver Wyman estimate recognizes that since training is scheduled over a five-year period, engineers may need more than a one-time training class as ECP braking operations are more fully implemented. Therefore, the Oliver Wyman estimate maintains the original rail industry 80-hour estimate for engineers. The Oliver Wyman estimate increases the conductor estimate to 40 hours, based on comments from industry representatives. The inclusion of the electrical systems required by the ECP brakes effectively means that a conductor must be

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[149] Impact of Potential ECP Requirements on the Railroad Industry, op. cit., backup spreadsheet.
[150] Analysis of Class I Railroads, 2013, Association of American Railroads.
[151] Final Regulatory Impact Analysis, op. cit., p. 243.

trained more like a car mechanic with regard to level of understanding. The conductor training for ECP would require at least 1 to 1.5 weeks, as conductors would now need to understand grounding, arcing, and other electrical precautions.[152]

In addition, railroads involved in operating experiments with ECP brakes found that the success or failure of getting a train that failed en route moving often hinged on the training of front line supervisors, including Road Foremen of Engines and General Foremen. PHMSA has not accounted for either the training of these supervisors or the possibility that additional supervisors will be required to cope with en route failures should ECP brake-equipped trains enter widespread use.

4. Buffer car requirements

PHMSA concluded that buffer cars do not have to be equipped with ECP brakes and instead estimates a total of $1 million to equip buffer cars with bypass cables.[153] The rail industry did not provide an estimate for the costs of ECP installation on buffer cars. Oliver Wyman estimates $10 million for the installation of ECP brakes on buffer cars.

Exhibit III-9: Comparison of ECP Brake-Equipped Buffer Car Cost Estimates[154]

	PHMSA	Rail Industry	Oliver Wyman
Number of buffer cars to be equipped with ECP brakes	0	Not estimated	1,393
Cost to equip buffer cars with ECP brakes ($)	7,800	N/A	9,655
Number of bypass cables	1,266	Not estimated	0
Unit cost of bypass cables ($)	1,000	N/A	1,000
Total 20 year cost (undiscounted) ($ million)	1.3	Not estimated	13.5
Total 20 year cost (discounted @ 7 %) ($ million)	1.0	Note Estimated	11.7

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[152] Interviews with CSX railroad personnel, op. cit.
[153] Final Regulatory Impact Analysis, op. cit., p. 239.
[154] See Appendix A for references.

In the final RIA, PHMSA states that "PHMSA and FRA believe that it is not cost beneficial to retrofit buffer cars with ECP brakes; however, PHMSA and FRA believe that each car would be equipped with cables that would connect the locomotives to the first tank car. This would allow the trains to operate in ECP brake mode. FRA's ECP braking systems regulation allows for only 95% of the train to be operating with ECP brakes, therefore the buffer cars would not have to operate with ECP brakes."[155] PHMSA estimates that two buffer cars per train will be used. Interviews with all seven of the Class I railroads however identified a strong consensus that bypass cables would not be a solution for normal operations; bypass cables are only designed to be used for emergency situations, such as moving a train to a yard for repairs.[156]

In addition, railroads position a buffer car at the end of a train when a "helper" locomotive is used to assist on a grade. The buffer car separates the last tank car from the locomotive, which is coupled to the rear of the train. Critically, the last car of any train must have operable brakes – ECP or otherwise – for safety reasons in case it becomes uncoupled from the train, as required by FRA regulations. Only in theory could a railroad have a buffer car without ECP brakes on the rear of an ECP train. A railroad would have to test the brakes on the buffer car separately from a Class I brake test, for example, because when conducting a Class I brake test on a train in ECP mode the railroad would not know whether the buffer car's brakes were operable. Therefore, railroads will need to build, maintain, and manage a fleet of ECP-equipped buffer cars for use at the end of trains. PHMSA has not considered the cost of this requirement.

PHMSA estimates that 1,266 bypass cables would be required. Oliver Wyman estimates that instead 1,266 buffer cars would be needed, which equates to two per train, plus a 10 percent

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[155] Final Regulatory Impact Analysis, op. cit., p. 239.
[156] Interviews conducted with each of the seven North American Class I freight railroads, May 18-22, 2015.

spare rate for a total of 1,393 buffer cars requiring ECP brakes. Oliver Wyman applied the same installation charge of $9,665 per buffer car that was used to estimate the cost of adding ECP brakes to tank cars.

5. Regular maintenance for ECP brakes on railcars

The PHMSA estimate for regularly scheduled parts replacement for ECP brakes is $27.2 million[157] while Oliver Wyman estimated similar maintenance costs at $68.3 million. The railroad industry cost estimate did not include maintenance of ECP equipment.

Exhibit III-10: Comparison of ECP Braking Regular Maintenance Cost Estimates[158]

	PHMSA	Rail Industry	Oliver Wyman
Number of tank cars requiring maintenance	60,231	Not estimated	119,000
Number of buffer cars requiring maintenance	0	Not estimated	1,393
Unit cost of battery ($)	87	N/A	87
Unit cost of cables ($)	300	N/A	300
Replacement cycle (years)	5	N/A	5
Total 20 year cost (undiscounted) ($ million)	64.7	Not estimated	139.4
Total 20 year cost (discounted @ 7 %) ($ million)	27.2	Not estimated	68.3

This estimate is for regularly scheduled parts replacement and does not consider maintenance for mechanical failures or other unscheduled maintenance. The difference in costs is due to the difference in the estimated number of tank cars requiring ECP brakes, as discussed in the tank car section. Additionally, the Oliver Wyman estimate includes maintenance for the buffer cars identified in the buffer car section.

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[157] Final Regulatory Impact Analysis, op. cit., p. 239.

[158] See Appendix A for references.

6. Asset management for ECP braking

PHMSA estimated the cost of the extra burden of managing the new assets associated with ECP brakes to be $0.4 million, all attributable in the first year of operation.

Exhibit III-11: Comparison of ECP Braking Asset Management Cost Estimates[159]

	PHMSA	Rail Industry	Oliver Wyman
Number of labor-hours for asset management	8,000	Not estimated	Not estimated
Wage rate ($ per hour)	62.30	N/A	N/A
Total 20 year cost (undiscounted) ($ million)	0.5	Not estimated	Not estimated
Total 20 year cost (discounted @ 7 %) ($ million)	0.4	Not estimated	Not estimated

The RIA states that “The railroads and shippers may currently have employees who already manage the crude oil and ethanol fleets. The additional cost would be attributed to determining the best way to manage these fleets in the first year of operation. PHMSA and FRA estimate that an additional 8,000 labor-hours would be sufficient to manage all assists [assets] for the stakeholders involved. After the initial year of the management of these assets, further management would be included in the regular duties of the current asset managers.”[160]

PHMSA expects that the combined railroads, car owners, and lessees will need the equivalent of only four people, across all stakeholders, to manage the implementation of ECP brakes. PHMSA gives no consideration to the opportunity costs associated with current asset managers taking on these responsibilities. Oliver Wyman did not attempt to estimate these costs, but believes that substantially more staff would be required to handle these associated tasks over a multiple year time frame.

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[159] See Appendix A for references.

[160] Final Regulatory Impact Analysis, op. cit., p. 241.

C. PHMSA significantly overstated the cost of crude oil and ethanol spills.

PHMSA incorrectly calculates benefits attributed to the use of ECP brakes in unit trains carrying crude oil and ethanol. The RIA uses a total rail accident cost of $200 per gallon of ethanol or crude oil released. [161] The AAR reports however that this cost is 10 to 18 times higher than total costs per gallon spilled as calculated from reports by its member railroads and the National Transportation Safety Board.[162] While it is possible that the railroads may have failed to include certain costs in their initial reports, especially environmental cleanup costs that may go on for months or years, the PHMSA finding in this case can be considered to be extreme.

AAR recently requested detailed, updated costs from those of its members who had mainline ethanol and crude oil release accidents of over 100,000 gallons in the period 2006-2014. Updates were made available from these railroads for five accidents (out of a total of seven). These updates indicate that total costs were notably higher than in initial reports – one was ten times the original estimate – but still far below PHMSA's assumption of $200 per gallon spilled. The updated cost per gallon for these accidents ranged from $12 to $67, with an unweighted average of $35 per gallon – less than one-fifth of the PHMSA assumption. The updated total costs of the accidents ranged from $10 million to $22 million. For PHMSA's $200 per gallon spilled derailment total cost to be valid, that range of total costs would instead have to be $48 million to $157 million.

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[161] Final Regulatory Impact Analysis, op. cit., pp. 86-89. Note: Total costs include railroad track and equipment damage costs, the material loss, the property damage, the response costs, the evacuation costs, the remediation and cleanup costs, and other costs.

[162] NTSB reports on spills at New Brighton, Cherry Valley, Tiskilwa, and Casselton, cited in the Final Regulatory Impact Analysis, op. cit., p. 88.

PHMSA's assumption in the RIA of $200 per gallon spilled is based to a significant degree on pipeline crude oil spill data and costs.[163] A more thorough analysis of the pipeline release costs from the PHMSA database is provided in Exhibit III-12, which expands on Table EB4 on page 86 of the RIA.

Exhibit 12: Hazardous Liquid Pipeline Crude Oil Releases, January 2010-May 2015[164]

Pipeline Spills Included	Number of Spills	Gallons Released	Total Cost	Pipeline Cost per Gallon
All	1,018	7,072,977	$1,523,540,178	$215
All (Excluding 1 High-Consequence Event – HCE)	1,017	6,229,536	$683,014,060	$110
All Underground	379	4,854,922	$1,412,658,591	$291
All Underground (Excl. 1 HCE)	378	4,011,480	$572,132,473	$143
All Underground on Rights-of-Way	173	3,917,547	$1,317,535,743	$336
All Underground on Rights-of-Way (Excl. 1 HCE)	172	3,074,106	$477,009,625	$155
All Above Ground	528	793,326	$59,318,943	$75
All Above Ground on Rights-of-Way	11	46,081	$1,843,998	$40
All > 100,000 Gallons	15	4,594,464	$1,059,658,418	$231
All > 100,000 Gallons (Excl. 1 HCE)	14	3,751,020	$219,132,300	$58
All Underground > 100,000 Gallons	10	3,292,506	$1,028,394,158	$312
All Underground > 100,000 Gallons (Excl. 1 HCE)	9	2,449,062	$187,868,040	$77
All Underground on Rights-of-Way >100,000 Gallons	8	2,936,346	$1,017,338,682	$346
All Underground on Rights-of-Way >100,000 Gallons (Excl. 1 HCE)	7	2,092,902	$176,812,564	$84
All Above Ground >100,000 Gallons	1	147,000	$515,800	$4
All Above Ground on Rights-of-Way > 100,000 Gallons	0	0	$0	$0

Exhibit III-12 offers three insights into the costs of pipeline oil spills in comparison with rail oil spills. First, for all of the 1,018 crude oil pipeline spills during 2010-2015, the average total cost did indeed exceed $200 per gallon. But this number is skewed due to a single "High Consequence Event" (HCE) pipeline spill, in July 2010, for which costs totaled over $840

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[163] See Final Regulatory Impact Analysis, op. cit., pp. 85-90, especially pp. 86-87.

[164] PHMSA Hazardous Liquid Pipeline Database.

million and the average cost per gallon was just under $1,000. Thus, this one HCE spill accounted for 55 percent of the total cost for all pipeline spills in the United States in this five-year period. Such HCE's are rare and arguably should be considered separately from more typical oil spills. In any event, it should not be used to determine the cost of low-consequence events. Thus, if this single HCE incident were removed from the database, the average cost per gallon of the 1,017 remaining pipeline spills would fall to around $110.

Second, the exhibit shows a large difference between the costs of below ground pipeline spills ($143 per gallon, excluding the HCE) and above ground pipeline oil spills ($75 per gallon). Above ground pipeline spills are detected and located much more quickly and easily and require little or no excavation to find and repair the leak. In these respects, they are more like releases from railroad tank cars in accidents than they are like underground pipeline spills. Focusing on just the few above ground spills that occur on pipeline rights-of-way (which would be most similar to railroad right-of-way spills) produces an even lower average cost of $40 per gallon.[165]

Third, the average total accident cost per gallon is much lower for large pipeline spills, i.e., those over 100,000 gallons (and excluding the HCE), at $58 per gallon, than for smaller spills ($187 per gallon). This is because spill costs tend to be non-linear: doubling the size of a spill increases total costs, but does not double them.

Overall, a more thorough analysis of recent PHMSA pipeline accident data, particularly the finding that above ground spills on pipeline rights-of-way average $40 per gallon, results in a more reasonable basis of comparison to the oil spill costs reported by the railroads than PHMSA's $200 per gallon estimate.

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[165] Above ground pipeline oil spills also occur on pipeline property at pumping stations, tanks, and other facilities.

Another source of the RIA $200 per gallon estimate is PHMSA's review of a single incident in Lynchburg, VA, in which a rail tank car released approximately 30,000 gallons of crude oil. The total cost of the accident was estimated at $9 million, resulting in a cost per gallon released of about $300.[166] Despite the attention this accident received, however, the amount spilled was less than half of what PHMSA claims is the average release per accident (83,600 gallons) in its list of mainline accidents.[167] As noted, costs do not scale, so a $300 cost per gallon spilled is possible for some smaller accidents. If we assume that the crude oil and ethanol release accidents exceeding 100,000 gallons had average total costs per gallon of $35 but that all of the smaller release accidents had PHMSA's assumed average total cost of $200 per gallon, the overall average total accident cost per gallon spilled would have been about $58. If the RIA had assumed an average cost per rail gallon spilled of $58 rather than $200, the calculated overall ECP net benefit (present value at 7 percent discount rate) would have declined from +$121 million to negative $18 million, all other values in the RIA remaining the same.

Furthermore, PHMSA has overstated the future derailment rate for crude oil and ethanol trains by overlooking the historical decline in derailment rates the rail industry has been able to achieve through a continued focus on and investment in safety. The RIA states that "For the estimation of benefits during the final rule stage, the PHMSA no longer uses the approach of estimating a derailment trend for all trains/carloads or any subset of carloads." [168] It is explained in the RIA how the NPRM did assume a declining rate of derailments based on analysis of all rail commodities, but several industry and environmental groups "suggested that we should consider only

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[166] Final Regulatory Impact Analysis, op. cit., p. 87.
[167] Final Regulatory Impact Analysis, op. cit., p. 84 and Appendix B, pp. 299-301.
[168] Final Regulatory Impact Analysis, op. cit., p. 78.

crude and ethanol rail incidents rather than attempting to forecast them indirectly based on a trend that involves other commodities."[169]

This argument is flawed for three reasons:

First, although there are extra safety measures for selected commodities, especially hazardous materials, most investments in safety made by the railroad industry apply equally to all commodities. Investments made to better detect rail or wheel defects, for example, provide safety benefits to all trains.

Second, railroads have a remarkable record of delivering 99.997 percent of all hazardous materials safely; hazmat derailments can seem more frequent because they tend to be reported in the news.[170] Therefore, by basing the 20-year trend in crude oil and ethanol train derailments on a small subset of derailment observations, rather than on all derailments, PHMSA has introduced a large statistical error in the forecast. The larger the sample size, the more accurate a forecast is likely to be.

Third, and most importantly, the derailment rate for crude oil and ethanol trains also has been declining. The forecast of derailments from 2015 through 2034 contained in the RIA assumes growth in the number of crude and ethanol carloads, but a constant derailment rate.[171] The average derailment rate for crude oil and ethanol trains from 2009 to 2013 was assumed for the next 20 years, according to PHMSA, "because we found derailment rates for crude and ethanol to be nearly constant over time," and so "we have eliminated the declining trend used in the NPRM to predict future derailment rates."[172] Since the historical data is not provided in the RIA,

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[169] Final Regulatory Impact Analysis, op. cit., p. 78.

[170] "Requiring ECP Brakes is Unjustified, Provides Minimal Safety Benefits," Association of American Railroads statement, undated.

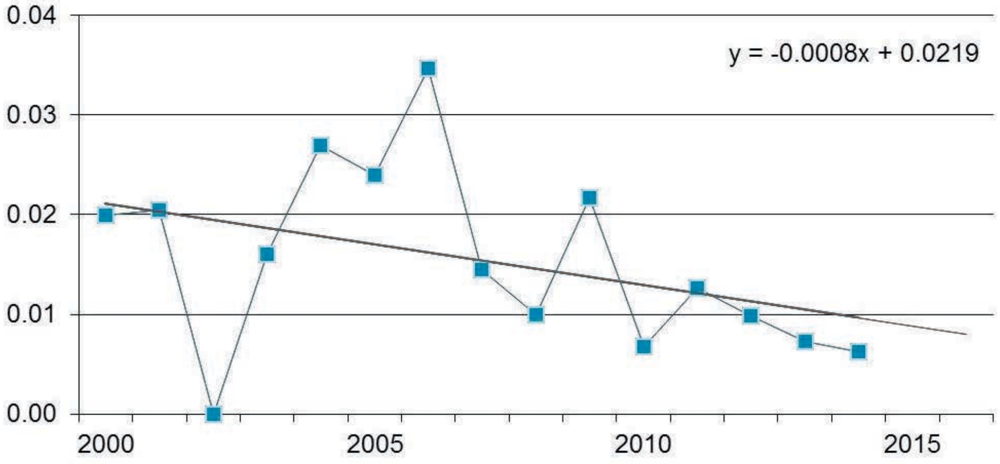
[171] Final Regulatory Impact Analysis, op. cit., Table EB3, p. 82.

[172] Final Regulatory Impact Analysis, op. cit., p. 78.

it is unclear what is meant by "nearly constant," particularly as a graph of derailment rates for crude oil and ethanol trains from 2000 through 2014 clearly illustrates a declining derailment rate and the success of the rail industry's constant focus on safety improvements (Exhibit III-13).

Exhibit III-13: Rates of Main/Siding Track Derailments Resulting in Releases of Crude Oil or Ethanol on US Freight Railroads[173]

Derailment rate per 1,000 carloads of crude oil or ethanol



The assumption in the RIA of static derailment rates is based on a very small sample, i.e., five years of data on a total of 29 mainline accidents that resulted in a release of ethanol or crude oil. The focus appears to have been on the raw number of such accidents, six each per year in 2011, 2012, and 2013. But when compared to the dramatic increase in the number of carloads of crude oil and ethanol during this period, the derailment rate per carload even for this small sample actually declined, dropping by 20 percent per year for 2011 through 2014.

The RIA assumption of a constant derailment rate significantly inflates the avoided derailment damage costs claimed for ECP brakes in the later years of the analysis. This in turn

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[173] PHMSA Hazmat Incident Database and Final Regulatory Impact Analysis, op. cit., pp. 19, 22, 253-254 and Appendix B, pp. 299-301. Compiled by the Association of American Railroads.

inflates claimed benefits. If the declining derailment trend is assumed to be 6 percent per year, as was achieved for all main track derailments on US Class I freight railroads during 2000-2014, and if the decline starts from the already low 2014 value (see Exhibit III-13 above), the calculated ECP net benefit would decline from the + $121 million claimed in the RIA to about negative $13 million, assuming a present value at 7 percent and that all other values in the RIA remain the same.

This calculation does not even take into account a further consideration: that logically, “High Consequence Events” (HCEs) should decline proportionally as mainline train accidents decline. As a result, HCE costs would decline by $99 million and thus the ECP net benefit would decline in total from + $121 million to negative $112 million, assuming a present value at 7 percent and that all other values in the RIA remain the same.

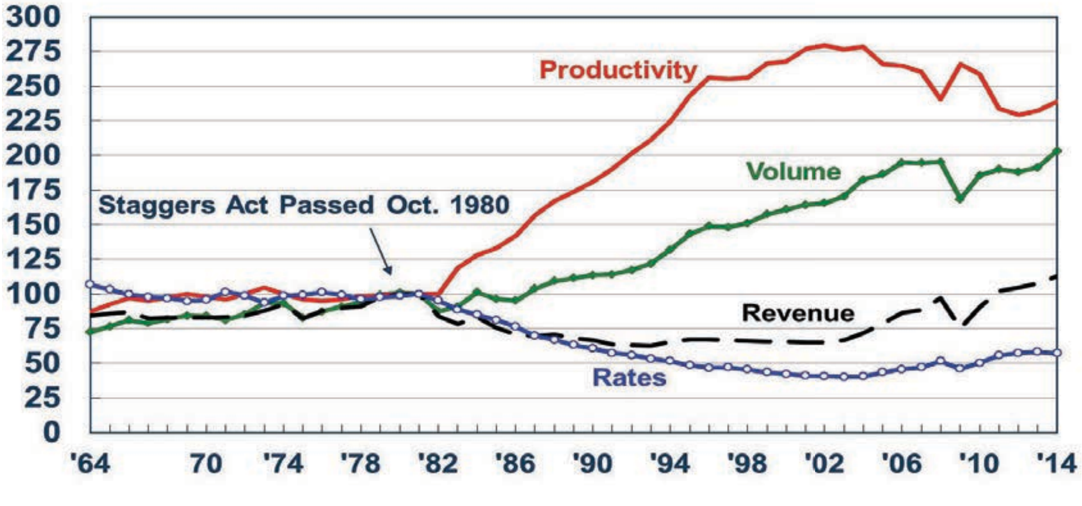
IV. PHMSA also did not consider the impact of the ECP braking mandate in terms of other costs/risks.

A. PHMSA did not consider that mandating ECP braking will decrease railroad productivity and service performance.

The ECP braking mandate carries high risks, offers limited benefits, and has the potential to broadly and adversely impact the national rail network.

Since passage of the Staggers Rail Act of 1980, the productivity of the railroad industry in the United States has improved dramatically, and these productivity gains have been shared with shippers in the form of lower rates (Exhibit IV-1). This productivity improvement has been achieved largely through a concerted effort to simplify the operation of the national freight rail system, supported by regulatory policy that has been, for the most part, aligned with this effort.

Exhibit IV-1: Class I Railroad Metrics, 1964-2014[174]
1981 = 100



In mandating the overlay of ECP brakes on a portion of the railcar and locomotive fleet, PHMSA did not consider the impact of reversing the process of simplification and

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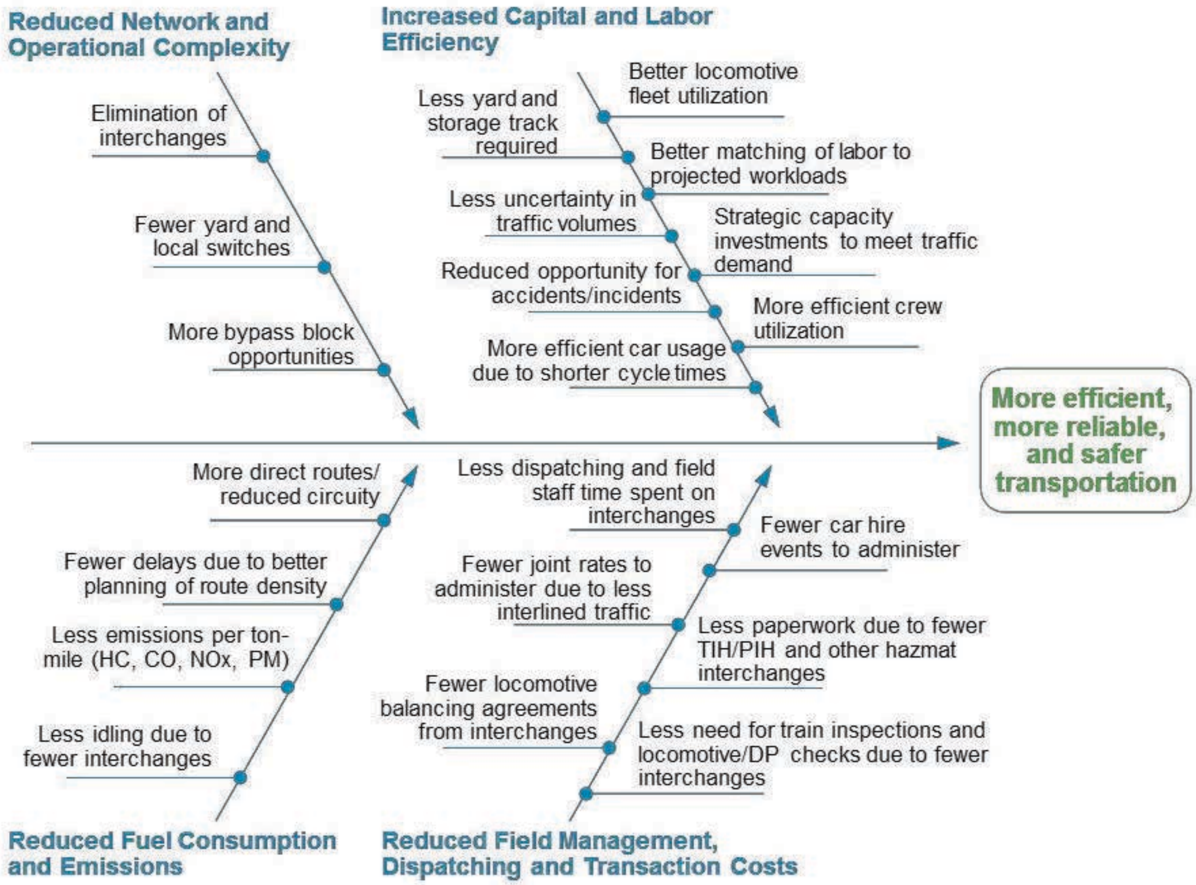
[174] Association of American Railroads.

standardization that has been a cornerstone of railroad productivity and service improvements. Adding a second braking technology to a large portion of the North American rolling stock fleet will materially increase the operational complexity of the railroad industry, and will reverse gains in productivity achieved over the past 35 years. PHMSA does not appear to have analyzed the degree to which railroad shippers across a wide range of industries will be affected by this change – shippers that in many cases rely on low railroad costs to be competitive internationally. PHMSA also does not appear to have analyzed or considered how this change could affect the US economy, which relies on an efficient and financially viable national rail network for the efficient and cost effective transport of goods.

B. PHMSA did not consider that mandating ECP brake-equipped trains will reduce the capacity of the national railroad network, due to the unreliability and high failure rate of this technology in real-world operation.

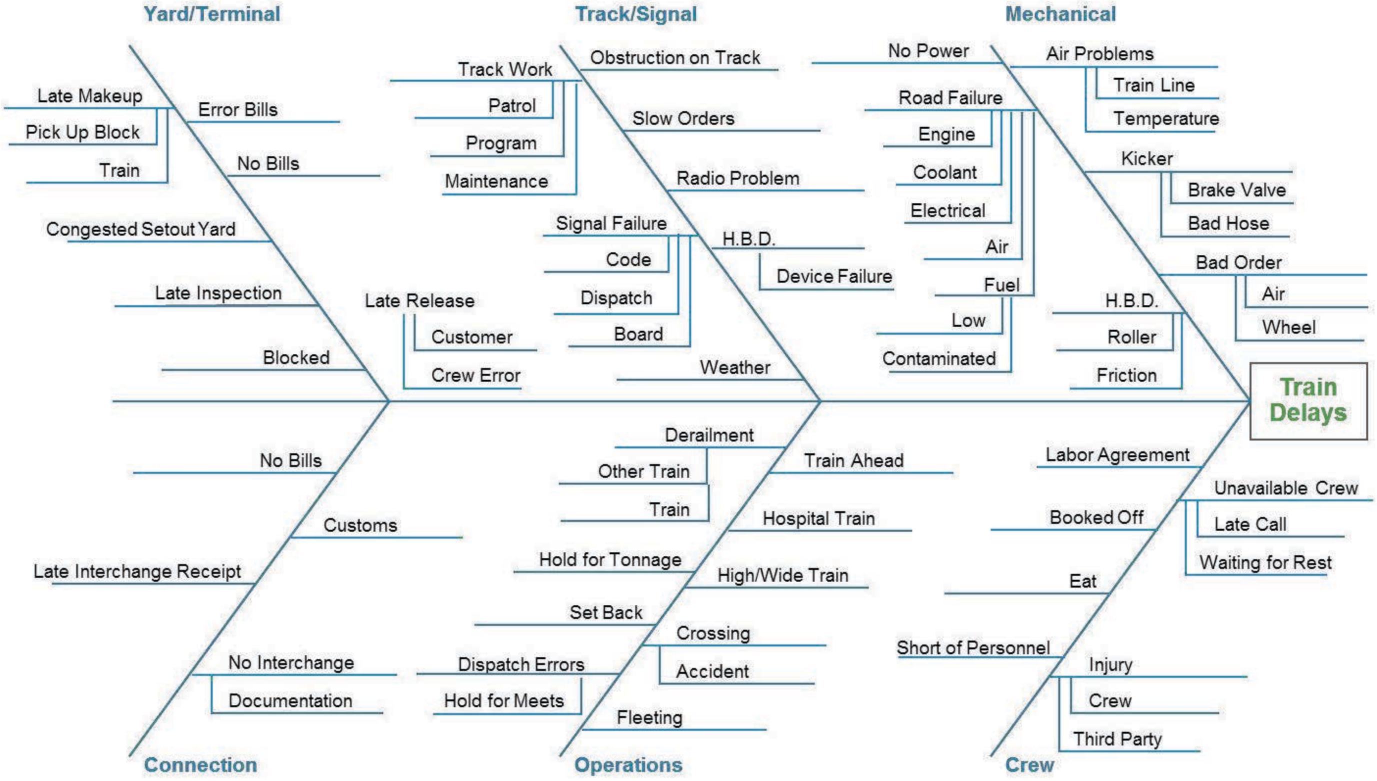
Even after 30 years of streamlining and simplification, the North American railroad network is still a complex system. As Exhibit IV-2 demonstrates, the railroad network is comprised of a large number of interdependent components, and the productivity of the network is dependent upon all of these components working together. A failure in one component very quickly affects other components.

Exhibit IV-2: Sources of Railroad Performance Improvement



While performance improvements have been increasing in the railroad industry for the past 35 years, the sources of train delay have remained constant. Operating trains in a reliable fashion requires discipline and perseverance on a daily basis, since there are still many contributors to train delay that must be addressed. PHMSA does not appear to have considered or analyzed how the addition of a second train connection line and braking system could lead to yet more unforeseen sources of train delay that will need to be addressed.

Exhibit IV-3: Sources of Railroad Train Delays



The byproduct of the balance between productivity improvements and train delay reductions within the railroad network is its capacity, which measures its ability to carry trains without reaching gridlock. Capacity is critical because, given the rapid growth of rail traffic over the past 30 years (see Exhibit IV-1) some portions of the network are capacity constrained. These constraints have occurred despite large and growing investment by railroads in their infrastructure (Exhibit IV-4). The US DOT estimates that *without capacity-destroying events such as the mandate for ECP brakes,* US railroads will need to add 37 percent more capacity by 2040.[175]

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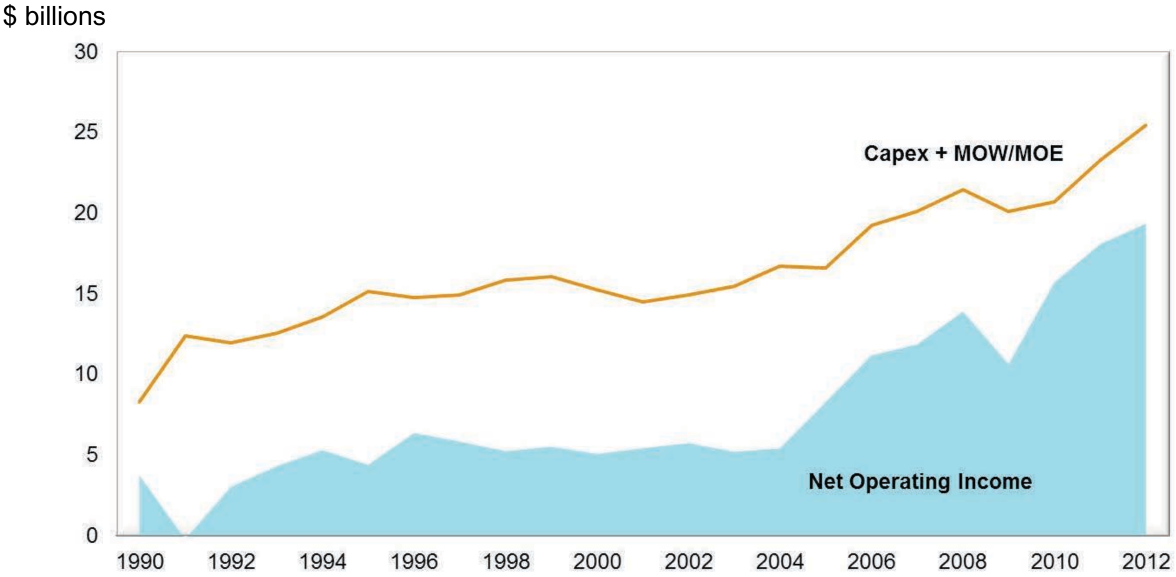
[175] Freight Facts and Figures 2013, US Department of Transportation.

Exhibit IV-4: Railroad Capital Investment versus Net Operating Income, 1990-2012[176]



Network capacity is, in large part, a function of net velocity. The faster trains move over the system, the more freight can be moved with a given amount of infrastructure and equipment. PHMSA does not appear to have recognized that if network velocity slows as a result of ongoing problems with ECP brakes, more infrastructure and equipment will be required to move the same amount of freight, reducing both infrastructure and equipment productivity and reversing at least some of the gains made by the railroads over the past five decades (Exhibit IV-5).

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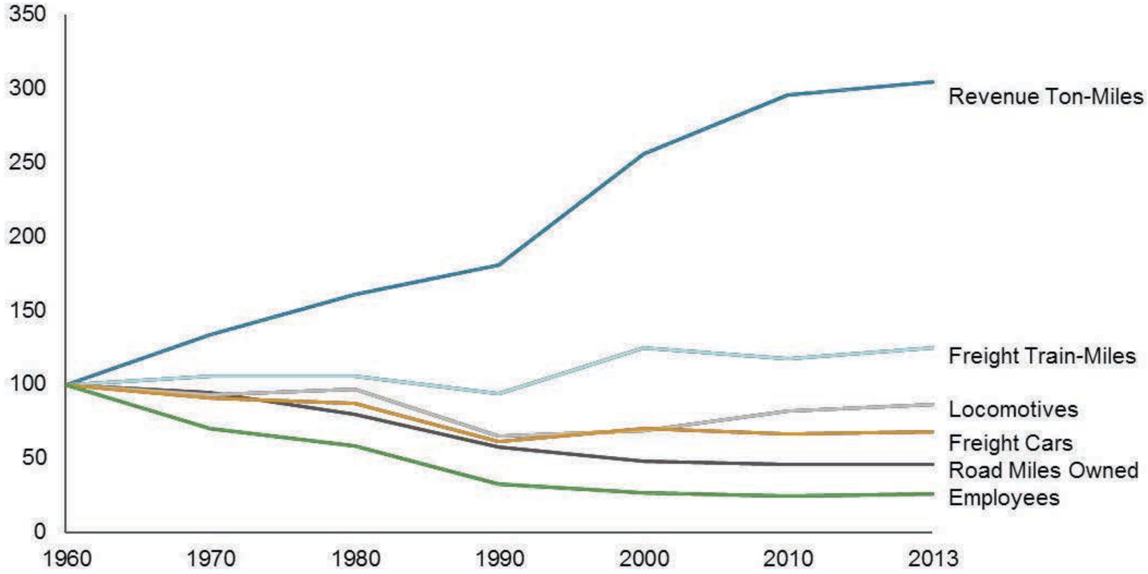
[176] Analysis of Class I Railroads, Association of American Railroads.

Exhibit IV-5: Indexed Changes in Class I Railroad Productivity, 1960-2013[177]



And network velocity is likely to slow, given that ECP brakes have proven unreliable in North American test operations and in real-world operation elsewhere, and appear highly likely to fail frequently. As discussed in Section II, PHMSA does not appear to have taken into consideration the test operations of ECP brakes conducted by Class I railroads in North America. The railroads participating in the ECP brake experiments spent capital to equip cars and locomotives for testing and invested in the training and certification of train crews and mechanical staff to deal with this completely new system. The experiments consumed thousands of hours of mid to senior level management time, first to evaluate the technological options, then to plan a test operation and finally to deal with the significant daily equipment and service failures that occurred on every single railroad during the test operations.

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[177] Rail Fact Book, 2014 edition, Association of American Railroads.

1. Key ECP brake reliability issues

Far from being a reliable technology, as PHMSA claims in the RIA, real-world testing of ECP brakes by the Class I railroads revealed that problems with ECP are severe and ongoing. This is true even when trains have been run for some time – i.e., well past the initial learning curve – and in a test operating environment in which they have enjoyed levels of technical support from ECP brake equipment manufacturers and railroad experts that would be impossible to replicate if ECP brakes were required for use nationwide in regular train service.

To determine the most relevant and up-to-date status of ECP braking equipment actually in use, interviews were conducted during the week of May 18, 2015 with railroad managers responsible for the maintenance and operation of installed ECP braking equipment in North America. Exhibit IV-6 presents representative findings from interviews with Class I mechanical and operational personnel involved in the test operations using ECP braking equipment, and performance and delay data provided by the railroads.[178] The findings illustrate that PHMSA did not consider all available evidence concerning the reliability of ECP brakes in real-world operations.

Exhibit IV-6: Results of Test Operations of ECP Brakes by Class I Railroads[179]

Category	Typical Impact	Root Cause After Troubleshooting
ECP Cable Issues	Train stopping unexpectedly and remaining stationary until the problem can be diagnosed and corrected	▪ ECP loose cable connections ▪ ECP bent pins / other cable integrity issues ▪ Battery issues / connectivity
Issues with ECP Brake-Equipped Locomotives	Train stopping unexpectedly and remaining stationary until the problem can be diagnosed and corrected	▪ Locomotive cannot lead due to unknown systems issue – will not sync with the train ▪ Insufficient locomotive electrical

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[178] Interviews with Class I railroad personnel, May 18-20, 2015.
[179] "ECP PB Chief Log 2014.xls," provided by NS; interviews with Class I railroad personnel, May 18-20, 2015; "BNSF 14 Run Overview 2014," provided by BNSF.

Category	Typical Impact	Root Cause After Troubleshooting
		power ▪ Undiagnosed issues with locomotive air brake integrity ▪ Locomotive supplied to power the train not equipped with a working ECP system
ECP Car Component Issues	Train stopping unexpectedly and remaining stationary until the problem can be diagnosed and corrected	▪ Car Communication Device (CCD) failures ▪ Battery issues / connectivity ▪ Other electrical issues (typically junction box) ▪ Improper brake cylinder pressure
Cross Talk Issues Between Two ECP Trains When Passing Each Other	One or both trains stopping unexpectedly and remaining stationary until the problem can be diagnosed and corrected	▪ Cross talk, which is the electronic “noise” that occurs when one ECP brake-equipped train passes another ECP brake-equipped train on an adjacent track
Wheel Issues	Train stopping unexpectedly and remaining stationary until it is inspected; then proceeding at slow speed to set out the car with a bad wheel	▪ WILD (Wheel Impact Load Detector) defective wheel detection ▪ Built up tread ▪ Flat spots ▪ Wheel shelling
Other	Train stopping unexpectedly and remaining stationary until the problem can be diagnosed and repaired	▪ Undiagnosed issues that fix themselves with multiple ECP system reset attempts

a. ECP cable issues

PHMSA assumed that electrical cables will be replaced every five years.[180] But the most frequent failure experienced during test operations involved the electrical integrity of the entire train. Electrical cables run through the train from the locomotive to the last car. Cables at the end of each car must be connected to provide a continuous circuit. Like electrical cords in the home, these cables become damaged from wear and tear, since they must be unplugged and plugged each time a train is assembled and broken down. One railroad mechanical official stated that they

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[180] Final Regulatory Impact Analysis, op. cit., p. 239.

are "not hardened for railway use."[181] Additionally, one railroad reported important issues with the electrical connectors between cars, stating that "The issue was mainly with intermittent train-line connections, which are pronounced during a train movement. These poor connections are difficult to find with a naked eye when the train is stationary and being inspected in the yard. We have an ECP Trail Line Test that MS [mechanical services] runs from the head-end as per following procedure to detect the poor cable connections. This test can only be run when the train is stationary, so the intermittent cable issues will be difficult to identify."[182]

This statement illustrates two key points. Visual inspection of a train standing in a yard, even when augmented by electronic tests, cannot locate problems with the ECP brake electronics that manifest themselves only when the train is moving and under load. Second, another railroad reported the same observations concerning the harsh effect of actual railroad operations on these electric cables. Once these ECP brake-equipped trains are moving, train dynamics further stretch the physical properties of these cables and their associated hardware, reducing their reliability. The photographs below document common ECP connecting cable issues experienced by one of the Class I railroads conducting test operations in North America.

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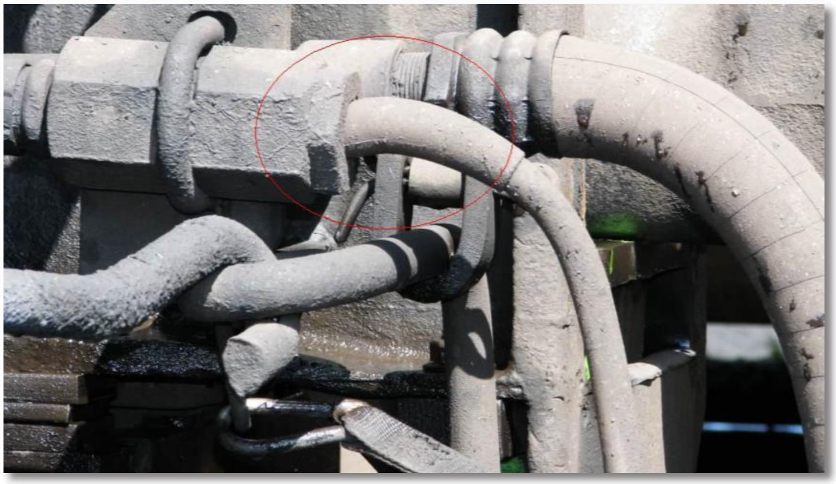
[181] BNSF team interview, May 18, 2015.
[182] CP email, November 13, 2012.

Exhibit IV-7: Examples of Common ECP Connecting Cable Problems

Excessive cable droop – likely will be bent

Cable bent upwards



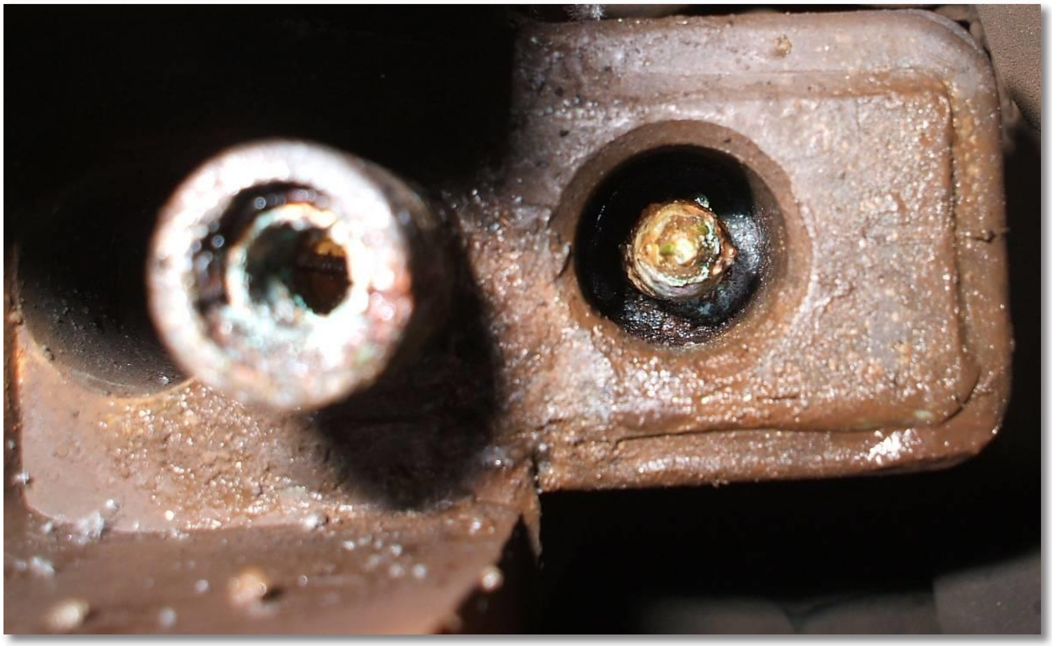
Pins bent upwards

Pins twisted, caused by a seized jam nut (can happen when installing or removing cables)

Pins pulled out ¼" and bent up

As an example, within a year of commencing ECP brake operations on its Shelocta, PA service, NS began to experience significant inter-car cable connector problems. They became so serious that the trains were parked temporarily in February 2009. The problem was traced to expulsion of zinc corrosion products from the brass connector pins, exacerbated by scraping with metal tiles and a calcium chloride freeze release agent. One example from January 2009 is shown in Exhibit IV-8.

Exhibit IV-8: Example of Corrosion on Connector Pins



Prohibiting the use of metal objects on the connector pins, as well as improved pin metallurgy, has reduced the corrosion problem. However, connectors still fail, sometimes catastrophically, for reasons not completely known (Exhibit IV-9). And as shown in Exhibit IV-10, on February 3, 2013, a train experienced an ECP issue and penalty application – the wire between two units had melted, possibly due to shorting caused by water. Exhibit IV-11 shows water intrusion into a locomotive junction box, eventually causing the car identification module to fail.

Exhibit IV-9: Example of a Connector with Catastrophic Failure

Exhibit IV-10: Water Intrusion into a Locomotive Junction Box Burned the Cable Connection to the Car Identification Module

Exhibit IV-11: Water Intrusion into a Locomotive Junction Box

b. Locomotive issues with the ECP braking system

PHMSA claims that "The railroad industry has effectively addressed crosstalk and interoperability issues and has updated AAR Standard S-4200 accordingly."[183] Crosstalk and interoperability are two separate issues. Crosstalk involves problems arising from unintended communications between two trains. Interoperability involves problems that can occur between equipment from different manufacturers or different versions of the same software program.

The correction that PHMSA assumes has been achieved concerning crosstalk has not been experienced during actual test operations. While the standard and the software for railroad locomotives have been updated, the software has just been released for testing; it has not been released for production and it is not backward compatible with other software.

Crosstalk occurs when one ECP brake-equipped train operates in close proximity to another ECP brake-equipped train. While this generally occurs when trains pass on main lines, it also has occurred when a train is switching ECP brake-equipped cars next to another group of ECP brake-equipped cars. Crosstalk events cause an ECP brake-equipped train to apply penalty braking when it receives ECP data signals from the other train or active CCDs that are not recognized in its consist. PHMSA claims that "The ECP brake manufacturers were able to resolve this (the crosstalk issue) by updating the ECP brake software program."[184] However, PHMSA has not independently verified the claim. NS continues to experience crosstalk problems, and the newest software was installed for testing only beginning May 25, 2015.[185]

Crosstalk occurrences during test operations on CP had a more severe effect on operations than a single train failure effect, because they occurred when one train was passing another on a

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[183] Final Rule: Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, op. cit., p. 6697.

[184] Final Regulatory Impact Analysis, op. cit., p. 225.

[185] Correspondence from Manager Car Administration, NS, May 25, 2015.

two-track mainline, or one train was on a mainline and the other was on a siding (NS reports also seeing the same issue on the mainline).[186] Both trains were effectively locked in place and could not move until both trains' ECP systems were powered down, then one train's system was powered up so the train could be moved away from the other train with an inactive ECP system. The total delay incurred was 1.5 hours.[187]

Locomotive issues with the ECP system have been frequent and problematic. The biggest problem occurs when trains are delayed for a lead locomotive that cannot lead due to a brake systems issue. Typically, the train will have a penalty application, and during troubleshooting a locomotive systems problem will be found, requiring the ECP system to be shut down and repowered. Sometimes a breaker switch needs to be cycled. In some cases, the locomotive that was leading could no longer lead because one part of the locomotive's ECP system would no longer function correctly. For example, the New York Air Brake ECP system is integrated with the cab control device (CCD), so if the CCD fails, then the entire unit needs to be replaced, which impacts the braking system.

c. ECP braking car component issues

PHMSA claims that ECP brake-equipped trains have "higher utilization rates."[188] This has not been the case during test operations. The utilization of ECP brake-equipped trains is poorer than conventional trains.[189] This should not be surprising, since ECP brake-equipped cars have a layer of complexity not found on conventional railcars.[190] As noted previously, problems found

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[186] Interview with Vice President, Safety, Environment & Regulatory, and Chief Mechanical Engineer, CP, op. cit.; direct communication from NS.

[187] Interview with Vice President, Safety, Environment & Regulatory, and Chief Mechanical Engineer, CP, op. cit., plus follow-up clarification emails.

[188] Final Rule, op. cit., p. 182.

[189] "BNSF MHE PAE Cycle Time.ppt," provided by BNSF, May 2015.

[190] Interviews with Class I railroad personnel, May 18-20, 2015.

by the railroads included Car Communication Device (CCD) failures, a need to replace batteries more frequently and battery integrity problems, junction box problems, and improper brake cylinder pressures. During testing within the most recent 140 days, BNSF had to replace CCDs on two ECP brake-equipped coal hoppers.[191] These replacements required the cars to be taken out of service for a shop event.[192] A conventional car would not experience this sort of failure, so this caused a lower utilization rate for the ECP brake-equipped car.

d. Wheel issues

PHMSA claims that "ECP brakes have the potential to … reduce wear and stress on wheels."[193] Test operations by North American railroads however show that this is not the case. WILD defect detectors on the railroads have found wheels on ECP brake-equipped trains with defects such as tread build up, flat spots, and wheel shelling. One railroad mechanical officer mentioned that ECP documentation has stated there would be more uniform wheel wear, but real-world test operations have not borne this out for coal train sets; he stated that there were "way too many wheel issues" with the test trains.[194] During a 140-day period, one railroad reported 14 separate wheel exceptions on one train of coal hoppers, each one of them requiring the railroad either to set the car out on a siding or set out the car at a shop. Wheel-related failure events represented the largest category of ECP brake-equipped car exceptions during the test period.[195]

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[191] "BNSF 14 Run Overview 2014," provided by BNSF.

[192] "BNSF 14 Run Overview 2014," provided by BNSF.

[193] Final Regulatory Impact Analysis, op. cit., p. 252.

[194] Interview with Shop Superintendent, BNSF, op. cit.

[195] "BNSF, 14 Run Overview 2014," provided by BNSF.

According to PHMSA, “UDEs [undesired emergencies] are virtually eliminated using ECP brakes.”[196] However, as the experience during the test operations indicates, this is simply not the case. Many of the problems discussed above result in unintended emergency brake application or a “penalty brake” application, both resulting in significant delay. ECP cable problems, locomotive system and connectivity problems, car component problems, and crosstalk all have caused unintended emergency brakes applications on ECP brake-equipped trains. Real-world test operations, dispatch center delay reports, and comments from railroad managers who were responsible for ECP test operations demonstrate that such incidents are frequent. Once the ECP brake system stops a train, it is frequently impossible to move the train to a convenient location for repair. One interviewee equated ECP brake failures to “being like a bridge outage” because “it has taken up to 36 hours to move a stopped train.”[197] Once the issue is fixed, the ECP system needs to be put through an initiation sequence, which is another step that is not present with conventional trains. Therefore, even in test operations in which ample technical support from ECP brake equipment manufacturers and railroad technical personnel was available, broken-down ECP brake-equipped trains blocked main lines for extended periods, in extreme cases exceeding two days. Such blockages play havoc with railroad dispatch centers and yard managers, and also impact railroad terminals and customer load/unload sites.[198]

2. Effects of a line-of-road breakdown

It is not just the frequency at which ECP brake-equipped trains break down, but also the duration of each incident that is so damaging to train operations. In real-world test operations, breakdowns are complex and difficult to resolve. On NS, the three train sets operating on the

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[196] Electronically Controlled Pneumatic Brake Systems, FRA, June 2008, op. cit.
[197] BNSF mechanical employees, team interview, May 18, 2015.
[198] “ECP PB Chief Log 2014.xls,” provided by NS.

Pittsburgh Division between January and June 2013 encountered 19 delays totaling 64 hours (3.4 hours per delay) and required at least six re-crews.[199] PHMSA appears not to have considered or analyzed the following:

Effect on train crew: The engineer must inspect the locomotive and its cable, while the conductor must walk along the train and check each connector until the train is able to go into "run" mode and initialize. A 110-car train is more than a mile long, so the conductor may need to walk that distance and then return to the locomotive. Even if only a single defect is found and the conductor is able to correct it, the process typically consumes at least an hour. If the conductor is unable to correct a defect, or if he or she is unable to locate the defect, the crew must call for mechanical personnel, or in some cases the manufacturer's representatives, who may be located a considerable distance away. These personnel can utilize a Trainline Integrity and Locomotive Test Device (TILT) to try to locate the problem. In many cases, manufacturer's representatives will download the Trainline Communications Controller (TCC) and send the information back to headquarters for analysis. In the real world, ECP brake failures do not always occur near grade crossings where mechanical personnel traveling in trucks can easily reach them, and this causes further delay. Finally, once the train is ready to move again, the engineer must re-initialize the ECP system, check for faults, and then try to resume the journey. During ECP test operations, however, many times the train would fail a second or third time.[200]

Effect on equipment manufacturers: In a number of cases in which ECP brake-equipped test trains failed, technical experts from the railroad's mechanical department were unable to diagnose or correct the problem and a representative from the ECP brake equipment

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[199] "ECP Delay Analysis for Pittsburgh Division – 2008-2012," provided by NS, December 20, 2012.

[200] "ECP PB Chief Log 2014.xls," provided by NS; interviews with Class I railroads, May 18-20, 2015.

manufacturer had to be summoned to help with troubleshooting. Reflecting the urgency of getting these trains moving, there were cases where OEM representatives flew to the train's location. Needless to say, while this solution was feasible in a test operation – if costly and time consuming – it would quickly become infeasible if ECP brake-equipped trains are required to operate throughout the US rail system in regular train service.

Train delays: One Class I railroad reported that the average time to repair an ECP train failure was 6.91 hours, versus 1.85 hours for a train with conventional brakes.[201] As with any average, there were cases in which the delays were much longer. As described earlier, the adverse effects of a lengthy delay quickly cascade through the complex railroad operating system, creating problems for:

- Locomotive schedulers, who then must locate ECP-equipped locomotives to replace the locomotives on the stranded train
- Train dispatchers, who must guess when the stranded train might be able to move and make way for other trains
- Yard managers, who then must adjust plans for other trains and for car deliveries, since the cars on the stranded train will arrive late and at variance with their trip plans
- Customers, who are waiting for cars that have missed their connections

Need to replace crews: Railroads closely schedule trains and crews, and try to ensure that the crew can traverse the crew district within its service hours. (Regulations require that a train crew cannot remain on duty for more than 12 hours.) If an ECP brake-equipped train breaks

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[201] Impact of Potential ECP Requirements on the Railroad Industry, op. cit., p. 8.

down and its crew's duty limit has been reached, the railroad must replace the expired crew with a rested, available, and ECP-trained crew. Finding a crew trained to operate ECP brake-equipped trains will likely be a problem, since unless the railroad trains all of its crews so that they are available for occasional duty on ECP trains, a qualified crew may not be available at the nearest crew point. This leads to a significant portion of the crew's duty time being consumed reaching the train, especially if the breakdown occurs at a location remote from a grade crossing. In a lengthy delay, this process may be repeated several times.

Effect on train inspection times: PHMSA has stated that "Real-time diagnostics may eliminate the need for some physical inspections of the train and supports the reduced regulatory requirements for brake inspections and for operating cars with nonfunctioning brakes in the initial terminal consist."[202] While the head end unit in a locomotive can "display condition and fault data to the driver by means of the on board display,"[203] the railroad environment means that trackside train inspections, whether physical or automated, are still necessary. One of the railroad officers stated that they expect ECP inspections will take an additional 30 seconds more per car to inspect cables, lanyards, inter-car connectors, and CCD status lights.[204] Conservatively assuming that the average train is composed of 100 cars, that is 50 extra minutes per train. While saving inspection time is laudable, to suggest that crude oil or ethanol trains might save time without physical inspections is not in alignment with the needs of a 24-7 rail environment.

Therefore, ECP brakes will save nothing on inspection times and may actually increase the time needed for personnel to inspect a train with these extra components. This additional inspection time could be mitigated if the FRA permanently adopts the inspection waiver of 5,000

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[202] Electronically Controlled Pneumatic Brake Systems, FRA, June 2008, op. cit., p. 21.
[203] ECP-S4200 Electronically Controlled Pneumatic Braking Systems Operations and Maintenance Manual, Wabtec, p. 9.
[204] Interview with Shop Superintendent, BNSF, op. cit.

miles or another appropriate distance that will maintain an acceptable safety level. Increasing the distance between brake inspections however still does not eliminate the need to stop for crew changes (which require time to conduct an initial brake test), refueling, and other operating requirements, all of which reduce the benefits of the brake inspection waiver.

Unknown length of time to troubleshoot an ECP problem: Train delays typically have a sequence of root causes to follow, as indicated in Exhibit III-3. ECP technology, however, introduces a host of unknown issues. As one Class I railroad mechanical expert noted, "Finding a defective car or locomotive in an ECP brake-equipped train has proven to be very time consuming on many occasions, with or without the on-scene assistance of manufacturer's field engineers."[205] The cars are not the only place to look. Because the problems to troubleshoot are within a complex electrical system, the problem can be located physically anywhere from the lead locomotive cab to the EOTD at the rear of the train. How much time and how many people might be required to solve a problem were clearly demonstrated to be unpredictable factors during testing of ECP brake-equipped trains. For example, in 2012, NS's Pittsburgh Division had delays that averaged 4.54 hours per delay, including one delay of 18 hours.[206]

Disruption caused by ECP brake-equipped railcars: PHMSA has stated that "ECP brake-equipped trains are not required to stop and set out a defective car."[207] This statement is not always true. As noted above, wheel defects can occur on line of road that are related to ECP brakes, and the railroads have had to set out those cars.[208] The train still had to be stopped, and then inspection and troubleshooting had to occur. If the car could proceed with the train and not

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[205] Interview with Superintendent Air Brakes, NS, May 18, 2015.
[206] "ECP Delay Analysis for Pittsburgh Division – 2008-2012," op. cit.
[207] Final Regulatory Impact Analysis, op. cit., p. 254.
[208] "BNSF 14 Run Overview 2014," provided by BNSF; interview with Shop Superintendent, BNSF, op. cit.

be set out, a bypass cable had to be used to get the car to a railroad location where it then could be set out.[209]

Velocity is negatively impacted: PHMSA has stated that train velocity is a benefit of ECP, however, real-world test operations have proven that not to be true.[210] One Class I railroad has summarized the delay hours experienced by conventional and ECP coal trains, both operating in the same cycle. Between October 13, 2014 and May 7, 2015, conventional-brake-equipped trains saw fewer average train delay hours per trip than ECP trains did, a difference of 13 percent. This increase in average delay hours translates to a reduction in train velocity.[211]

The results of ECP experiments at each railroad in North America yielded essentially similar results: Line-of-road failures of ECP trains became too disruptive to operations and in all but one case were discontinued.[212] Yet PHMSA accepts the representations of the ECP brake equipment manufacturers that the problem is not theirs but rather occurs because the railroads have not trained a sufficient number of personnel.[213] The fact is that even the ECP brake equipment manufacturers have had difficulty keeping their own equipment running.[214]

Practical operating problems: Locomotives and freight cars with conventional brakes are designed to uncouple without involvement of the crew. The couplers separate and the pneumatic train lines automatically disconnect. This is not the case with ECP brake-equipped locomotives

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[209] ECP PB Chief Log 2014.xls," provided by NS; interviews with Class I railroad personnel, May 18-20, 2015; "BNSF 14 Run Overview 2014," provided by BNSF.
[210] Electronically Controlled Pneumatic Brake Systems, FRA, June 2008, op. cit., p. 53.
[211] "BNSF 14 Run Overview 2014," provided by BNSF.
[212] Interviews with NS, UP, CP, BNSF, May 18-20, 2015.
[213] Interviews with railroad staff actually involved in the ECP brake test operations found no attempt by PHMSA or FRA to understand the root cause of the ECP brake equipment failures or to understand whether the repeated failures were caused by faulty equipment or an insufficient railroad mechanical force.
[214] Interviews with NS, UP, CP, BNSF, May 18-20, 2015.

and freight cars, where a crew member must manually disconnect the electrical connections between the locomotive and the train and between cars.

The effect of this aspect of ECP brakes on productivity is illustrated by a routine operation at NS: "Currently on 'the mountain' west of Altoona, we use HelperLink, which allows attachment of the pusher with nothing more than the coupler. The train line is 'connected' via radio link from the EOT to the HelperLink on the pusher. Thus, conventional pushers can uncouple on the fly. ECP will require the train to stop, drop train line power, disconnect the ECP cables from the helper, connect to the ECP EOT on the last car, and re-establish train line power. Whenever you drop train line power, go to Switch Mode, or end ECP, there is a significant risk that the ECP system will not come back up (into Run Mode). Stopping a train also entails more risk overall than keeping it moving (analogous to takeoff and landing in an airplane being riskier than cruising at altitude)."[215]

3. Additional impacts of breakdowns

In addition to problems with the reliability of ECP brake-equipped railcars and locomotives leading to breakdowns on rail lines, railroad test operations revealed three other concerns.

Problems introducing new ECP brake-equipped locomotives into existing consists: The only railroads that have attempted to interchange ECP brake-equipped railcars and locomotives are BNSF and NS. PHMSA has stated: "Some commenters also have raised the issue of interoperability between the ECP equipment of various manufacturers. This argument is misplaced regarding ECP equipment in full interchange service. The issue of interoperability between varying manufacturers has been addressed by AAR's ECP standards since 2008."[216]

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[215] Correspondence from Operations Engineer, NS, June 10, 2015.
[216] Final Regulatory Impact Analysis, p. 226.

Adopting standards, while helpful, does not automatically resolve problems in the field. A mechanical expert at one of these railroads said that during test operations they experienced problems when making any change to the locomotive consist.[217] The problems generally occurred when a locomotive that had not been used in ECP service, or had not been operated in that service for an extended period, was introduced. It was noted that when a set of three or four locomotives was working well with an ECP train, the mechanical and operating personnel disliked taking even one locomotive from the set because it introduced the potential for reliability issues and degradation of the ECP braking system when not being operated in ECP brake-equipped service.

Railroad managers believe that locomotive problems compound the car problems and introduce new unknowns and train delay. The same mechanical expert described the changing of ECP locomotives between railroads or on any single railroad due to routine maintenance or mechanical failure as “like playing Russian Roulette.”[218] Recent practical experience has proven that swapping of ECP brake-equipped locomotive power from one trip to the next can create havoc on the performance of the entire train. The reliability of these replacement units has proven unpredictable.[219]

Problems with ECP brake-equipped trains moving from line of road to sidings: As noted previously, online locomotive failures for ECP trains have been cited during test operations. If a locomotive systems issue was found during breakdown troubleshooting, sometimes the locomotive that was leading could no longer lead. This meant that the train would need to travel to a side track, while consuming mainline capacity, in order to switch the sequence

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[217] “ECP PB Chief Log 2014.xls,” provided by NS.
[218] Interview with Superintendent Air Brakes, NS, op. cit.
[219] Interview with Superintendent Air Brakes, NS, op. cit.

of the locomotives, assuming that another locomotive in the consist had a functional lead-qualified ECP control systems and was facing nose-forward.[220]

Problems with ECP locomotive management: PHMSA has claimed that the issue of not having an ECP locomotive available for ECP trains can be easily solved. "One of the major railroads currently operating an ECP-equipped subset of their fleet has purchased additional runaround cables used to bypass a locomotive that may not be equipped for ECP. These cables cost $1,000. PHMSA and FRA believe that other railroads would follow this business practice, and purchase one set for each locomotive in service. This would prevent any bottlenecks or slowdowns from occurring in the eventuality of an ECP-equipped locomotive that was not available."[221] There are several real-world situations that contradict this logic, however. Most crude oil and ethanol trains operate with two to four locomotives. If there is a problem with a trailing locomotive, it may be possible to utilize bypass cables, although ECP bypass cables are not easy to apply securely and may encumber safety appliances such as grab irons, cut levers, and steps if not installed correctly.

A lead locomotive, however, must have an operating ECP system. In some real-world test operations, there are cases where there was an ECP system but it did not function correctly or "sync/initialize" with the train.[222] One Class I railroad mechanical officer questioned the interoperability point and stated that the lead locomotive must have the same brand of ECP system as the cars.[223]

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[220] "ECP PB Chief Log 2014 xls," provided by NS.
[221] Final Regulatory Impact Analysis, op. cit., p. 240.
[222] "ECP PB Chief Log 2014.xls," provided by NS.
[223] Interview with General Director, Car and Locomotive Engineering, UP, op. cit.

Finally, PHMSA is advocating the position that only a small percentage of the road locomotive fleet will need to be outfitted with ECP.[224] The above examples, as well as all of the other examples cited in this paper and in rail industry regulatory response filings, highlight that this is not the case. As one railroad stated, "not having the right ECP brake-equipped locomotive at the right time could mean even more trains holding for power and even more capacity consumed."[225] The railroads are experts at managing their locomotive supply. The many intricacies of locomotive restrictions present in real-world railroad operations have been overlooked by PHMSA.

Problems with ECP brake-equipped buffer cars. Another of the many complications that will be involved in mandating ECP brakes is the conversion of buffer cars. At least one buffer car must be inserted between a locomotive and loaded placarded cars carrying crude oil and ethanol.[226] Since none of the ECP brake test operations in North America to date have involved trains requiring buffer cars, no ECP brake-equipped buffer cars have been created.

There is no information apparent in the RIA or Final Rule that covers the creation of a fleet of buffer cars to be employed on each ECP train. There has been some speculation that ultimately PHMSA expects the railroads to build, maintain, and manage a fleet of buffer cars, since alternatives such as expecting the railroads to make extensive use of jerry-rigged bypass cables around the buffer car have been described as infeasible as a long-term solution; they "represent a failure."[227] The storage, installation, positioning, and then operation of the bypass

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[224] Final Regulatory Impact Analysis, op. cit., p. 240.

[225] Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, Comments of BNSF Railway Company, op. cit., p.7.

[226] Safe Placement of Train Cars: A Report, US Department of Transportation, June 2005.

[227] Interview with Operations Engineer, NS, op. cit.

cables would introduce a major operating complexity, and cable availability has been cited as a problem.[228]

C. PHMSA did not consider that mandating ECP brake-equipped equipment will adversely impact the rail supply industry and increase maintenance and inventory complexity for the railroads.

PHMSA has underestimated the impacts of ECP braking on the supply industry, as well as on the railroads that maintain a portion of car fleets and handle emergency repairs. The ECP brake component supply industry has only two primary suppliers. The supply of components with only two suppliers available could be a concern. The American Petroleum Institute for example notes that: "The inclusion of a requirement for electronically controlled pneumatic (ECP) brakes will add to the artificial constraints created by a timeline for retrofitting the existing tank car fleet that does not fully account for limited shop capacity available to complete the work." [229] In addition, the Independent Petroleum Association of America noted that "These providers do not have the capacity to provide the needed number of ECP brakes for implementation."[230] Although PHMSA has done some rudimentary math on what it perceives to be the demand for ECP brake components,[231] production capabilities are unknown, and installing ECP braking components as an overlay system will add time and complexity. Ultimately, this will impact both railroads and shippers: While car owners will attempt to coordinate ECP brake retrofits with other required maintenance, this may not be possible in many instances. The result will be cars incurring lease or ownership costs, while sitting idle and earning no revenue.

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[228] Interview with Operations Engineer, NS, op. cit.

[229] "API welcomes release of U.S. & Canadian rail rules," American Petroleum Institute press release, May 1, 2015.

[230] Docket Number: PHMSA-2012-0082-HM-251, Independent Petroleum Association of America (IPAA), North Dakota Petroleum Council (NDPC) joint comment on rulemaking, undated, p. 3.

[231] Final Regulatory Impact Analysis, op. cit., pp. 226-227.

Additionally, railroads will be affected by ECP braking component inventory requirements over the long term. The roving mechanical trucks – and railroad car repair facilities – will need more capacity to deliver and store components for the entirely new ECP braking system. They will actually need to manage three entire sets of braking system components, since ECP systems rely on replacement of components from the same brand on a “like for like” basis. Thus both conventional braking components and components from each of the two ECP braking suppliers will need to be maintained. According to the Railway Supply Institute: “If one tank car has components from Supplier A, and one tank car has components from Supplier B… the components themselves are not physically interchangeable, as is the case with traditional pneumatic control valves. Therefore, once a car owner or manufacturer equips a tank car with one vendor’s componentry, it must continue to use that vendor for as long as the equipment is applied to the tank car. Effectively, repair shops will be required to stock ECP parts inventory and test equipment for multiple brake systems because they are not interchangeable.” [232]

PHMSA also does not appear to have considered the learning curve required for mechanical staff to diagnose and repair locomotive and car ECP braking systems. The skillset required to understand the electrical requirements will require significant investments to hire additional employees.[233] “What BNSF has found is that the ECP braking equipment is more expensive to maintain, (and) requires specialized skills and shopping capabilities.”[234]

Finally, PHMSA does not appear to have recognized that railroads also will need to purchase and manage test equipment that is used only to diagnose problems with ECP brakes. Test

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[232] “Follow up Information Related to Questions Raised at the December 2, 2014 Meeting between the RSI-CTC and PHMSA, FRA, and DOT Personnel,” Railway Supply Institute letter dated December 19, 2014, p. 3.

[233] Interviews with Operations Engineer and Manager Car Administration, NS, op. cit.

[234] Hazardous Materials: Enhanced Tank Car Standards and Operational Controls, Comments of BNSF Railway Company, op. cit., p.6.

equipment also will be doubled – as the railroads will need to test components from each of the two manufacturers.

D. PHMSA did not consider that mandating ECP braking will congest rail main lines.

Crude oil/ethanol unit trains generally load in the Midwest and Plains areas of the US and Canada, and bring their commodities to coastal refineries, operating over some of the highest-density main lines in the country. FRA has acknowledged that in the RIA, stating "FRA estimated that each type of train is on a transcontinental corridor for five-sevenths, or 71 percent, of each trip."[235] Many of these high-density mainlines already are operating near capacity, which provides limited opportunities for recovery when things do not go according to plan. Exhibit IV-12 shows the principal crude oil routes (ethanol not included) within the rail network.

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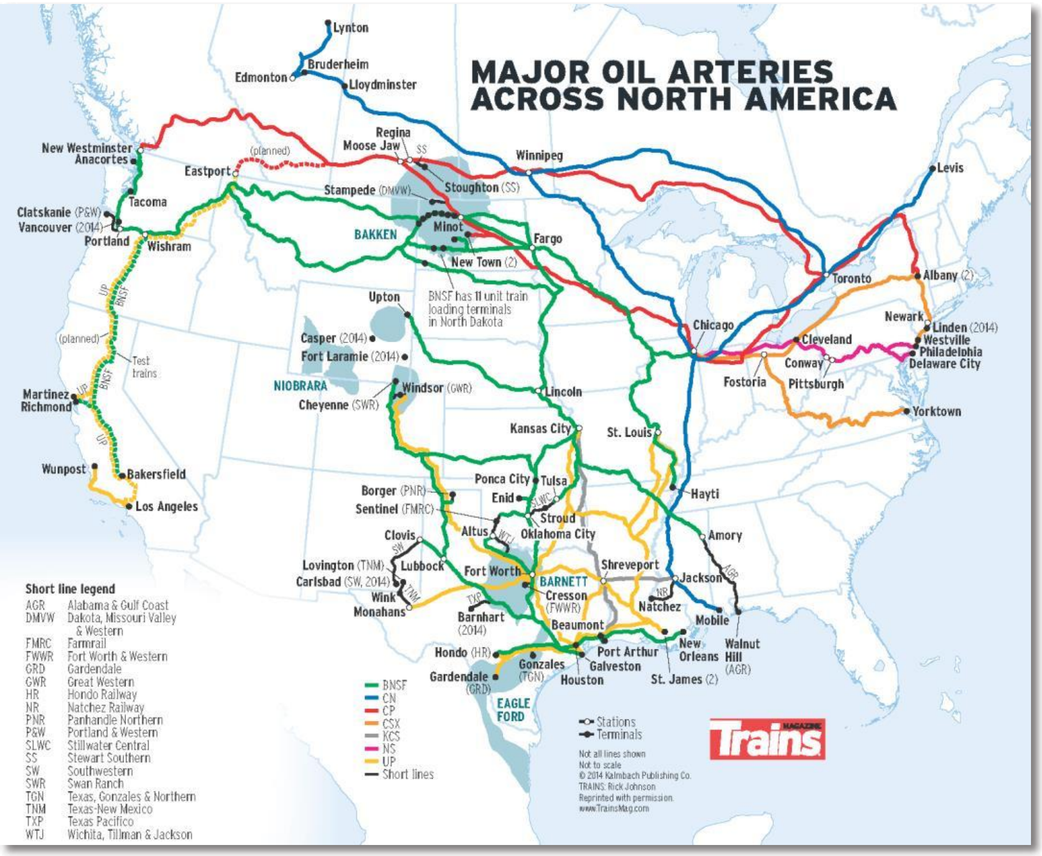
[235] Final Regulatory Impact Analysis, op. cit., p. 202.

Exhibit IV-12: Major Crude Oil Train Routes[236]



PHMSA does not appear to have considered that ECP brake equipment will be operating over (and breaking down on) some of the country's most important mainlines.

E. PHMSA did not consider that mandating ECP braking may further complicate PTC implementation.

The RIA makes only passing reference to the effects of ECP brake-equipped trains on the current positive train control (PTC) mandate, claiming that "PTC and ECP brake systems should work together seamlessly to provide faster braking and enhanced train handling."[237] PHMSA does not appear to have conducted any fact gathering or analysis on which to base this assertion.

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[236] Used with the permission of *Trains* magazine.

[237] Final Regulatory Impact Analysis, op. cit., p. 271.

There has been no analysis or testing performed to understand the inevitable challenges involved in successfully implementing these two complex technologies on the same rail system, although past work to integrate other complex systems strongly suggests that the obstacles will be significant. In particular, the safety risks involved in such integration are unknown, as are the time, effort, and costs involved in remediating these risks.

PTC and ECP are both designed to be safety-critical systems, yet neither is a mature or even fully tested technology in actual operating use. Mandated PTC is an immense undertaking on the part of the railroads, which must add new technology to 60,000 miles of the rail network, as well as to the majority of the Class I locomotive fleet. The railroads are expected to spend in excess of $9 billion dollars on PTC in the initial investment phase (plus more in future years), a significant financial risk, since implementing PTC represents an "unprecedented technical and operational challenge."[238] ECP braking will add yet another layer of new technology, which will increase the risk of operational disruption and failures that compromise safety.

PHMSA presents no research concerning the net effect on safety of mandating ECP brakes. PHMSA research claims that ECP brakes could reduce the number of tank cars entering a pileup in a derailment. But as documented in test operations by North American railroads, and described elsewhere in this paper, ECP brakes by themselves may increase the number of unwanted emergency brake applications. Moreover, PHMSA has not researched whether interactions between ECP brakes and PTC will lead to additional unwanted brake applications.

This is an important question, since emergency brake applications can cause a derailment; such as by causing a wheel to leave the track, a drawbar to fail and drop in the path of a wheel, or

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[238] "Positive Train Control," Association of American Railroads website (https://www.aar.org/policy/positive-train-control).

putting stresses on the rail that cause it to break. Therefore, PHMSA does not know whether introducing ECP brakes, or introducing ECP brakes simultaneously with the rollout of PTC, will lead to further derailments that could outweigh any marginal benefits ECP brakes might provide in reducing the number of cars in a pileup.

Two other areas of immediate concern are the effects of the ECP braking mandate on PTC braking algorithms and on PTC-equipped locomotives.

PTC braking algorithms: PHMSA has provided no analysis of the cost, time, and technical difficulty involved to account for ECP braking in PTC braking algorithms. Braking algorithms will need to be modified to determine the distance necessary to stop an ECP train, since that distance will be different than the braking distance of a conventional train. Because of the technological differences in the application of the brakes between ECP and conventional, the logic behind the calculations will be different, e.g., how much time is required to actuate the brakes, and what degree of braking is required.[239]

First, there will be the issue of how to create train profiles within the PTC system that will allow for the accurate calculation of stopping distances for ECP brake-equipped trains. Since ECP brake-equipped tank car trains are not in regular operation, there is no real-world experience to use in validating the braking calculations. Setting up PTC to work with ECP brake-equipped trains will thus involve a complicated and time-consuming implementation phase, as the various ECP train types, corridors, environmental conditions, etc. will all need real-world testing to validate the algorithm predictions. The result likely will be very conservative braking

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[239] Interview with General Director, Car and Locomotive Engineering, UP, op. cit.

estimates until this work is completed and will only reinforce previous findings that PTC will likely reduce capacity and certainly will not provide any capacity benefits.[240]

Further complicating implementation is the need to account for only a subset of the railcar fleet being equipped with ECP brakes. For example, operational variants such as ECP trains having to run in a conventional mode when experiencing issues will represent significant challenges in terms of warning, enforcement and automation within the PTC system. If the braking performance of ECP brakes under PTC will indeed be more aggressive than the current braking system, as asserted in the RIA, then the failure to properly track ECP brake status could create a critical safety failure risk on PTC corridors and disrupt scheduled train movements. For example, if ECP brakes fail and the PTC system does not detect the reversion to conventional brakes, the train could overshoot a stopping point. Conversely, if the PTC system does not account for an active ECP system, the shorter stopping distance could unintentionally leave a train occupying a crossing with another railroad or lead to extended blockage of a highway crossing. [241]

ECP on PTC locomotives: PHHMSA has not recognized that installation of ECP controls in the locomotive fleet will have a very high overlap with the same locomotives targeted for PTC installation. These locomotives already must go to a shop multiple times – as many as three on some railroads – for installation and upgrading of PTC equipment. Mandated ECP brakes will force locomotives back into the shop for yet another system installation, again increasing the costs and time for PTC implementation, a process which is already experiencing substantial delays.

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[240] Assessment of the Commercial Benefits of Positive Train Control; Oliver Wyman Inc. April 23, 2010, p. 29.
[241] Interview with General Director, Car and Locomotive Engineering, UP, op. cit.

Installation of ECP subsystems in the same locomotive as the PTC subsystems also will increase the electronic complexity of the locomotive. How will the two systems work together to verify that ECP brakes are in operation? What will be the operational and maintenance impacts of an additional new and immature subsystem within the same locomotive? The answers to these questions are unknown. Considering this scenario, one railroad executive experienced in the difficulties of simultaneously integrating multiple technical changes on locomotives said, "I don't believe that the integration will be seamless, I don't believe it will be easy, and I don't believe it will be quick."[242]

PHMSA claims in the RIA that PTC and ECP should work together seamlessly and dismisses the topic in a single sentence. But it is difficult to understand how PHMSA reached this conclusion, given that there is no field experience in using the two systems together or even evidence of the change in design criteria that will be required to handle the variation in braking algorithms. Just as ECP braking doubles the types of trains in the system, it also will double the characteristics of the types of trains managed by PTC. Indeed, there are significant unresolved and untested issues between these subsystems. The fact that the PTC and ECP subsystems must be integrated at some level means that the same PTC experts, technicians, and assets will have to be drawn on to support both implementations. This can only further slow the complete implementation of PTC, given the new complexities that ECP will introduce and competition for the same specific resources. Implementing one new technology is difficult enough; implementing two simultaneously will exacerbate capacity, scheduling, and cost issues, adversely affecting the North American rail network and shippers.

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[242] Discussion with General Director, Car and Locomotive Engineering, UP, June 10, 2015.

Appendix A. References for Cost Estimate Tables

Sources	Citation Code
Association of American Railroads, "Impact of Potential ECP Requirements on the Railroad Industry," presentation for Railroad/OMB Meeting, March 6, 2015	Presentation
Association of American Railroads, Support Spreadsheet for OMB Meeting presentation, "Regulatory Impact Analysis ECP March2015_v2.xlsx"	Spreadsheet
Comments of the Association of American Railroads Before the Pipeline and Hazardous Materials Safety Administration, Docket No. PHMSA-2012-0082 (HM-251): Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains, September 30, 2014. Attachment C, Exhibit 2B – "AAR Other Cost Estimates"	Comments
US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Hazardous Material Safety, "Final Regulatory Impact Analysis - Docket No. PPHMSA-2012-0082 (HM-251), Final Rule, May 2015	Final RIA

Exhibit	Field	PHMSA	PHMSA Source - Page Number From Final RIA	Rail Industry	Rail Industry Source
III-4	Tank cars	345	calculated using data from pages 239 & 240	1,037	Presentation - Page 12
III-4	Locomotives	79.5	241 - asset management in separate category	1,766	Presentation - Page 12
III-4	Training	39.9	244	239	Presentation - Page 12
III-4	Buffer cars	1	239	Not Estimated	
III-4	Maintenance	27.2	239	Not Estimated	
III-4	Asset management	0.4	241	Not Estimated	
III-4	Total costs	493	245	2,911.2	Calculated
III-5	Number of tank cars	93,379	calculated using data from pages 237 & 237	132,605	Spreadsheet - Tab: NPV Model
III-5	Number of cars requiring ECP	60,231	239	132,605	Spreadsheet - Tab: NPV Model
III-5	Cost per tank car to install	7,633	218	9,665	Spreadsheet - Tab: NPV Model

Exhibit	Field	PHMSA	PHMSA Source - Page Number From Final RIA	Rail Industry	Rail Industry Source
	ECP ($)				
III-5	Cost for ECP installation ($ millions)	459.7	calculated	1,281.6	calculated
III-5	Adjustment for ECP unit train productivity ($ millions)	-14.5	237	N/A	
III-5	Total 20 year cost (undiscounted) ($ million)	445.2	240 - maintenance in separate category	1,281.6	Spreadsheet - Tab: NPV Model
III-5	Total 20 year cost (discounted @ 7 %) ($ million)	345	240	1,037	Presentation - Page 12
III-7	Number of locomotives	2,532	219	20,000	Spreadsheet - Tab: ECP Costs
III-7	Cost to equip current locomotive	79,000 (not used)	219	88,300	Spreadsheet - Tab: ECP Costs
III-7	Cost to equip a new locomotive	40,000	219	N/A	
III-7	% of locomotives that are new	100%	240	N/A	
III-7	Cost to upgrade locomotives ($ million)	101.3	calculated, excludes asset management and bypass cables	1,766	calculated
III-7	Number of locomotive bypass cables	2,532	219	Not Estimated	
III-7	Cost per bypass cable ($)	1,000	239	N/A	
III-7	Total cost of bypass cables ($ million)	2.5	239	Not Estimated	
III-7	Total 20 year cost (undiscounted) ($ million)	103.8	241 - asset management in separate category	1,766.0	Spreadsheet - Tab: ECP Costs
III-7	Total 20 year cost (discounted @ 7 %) ($ million)	79.5	241.00	1,766.0	Presentation - Page 12
III-8	# of Engineers to be trained	18,000	227	27,143	Spreadsheet - Tab: ECP Costs
III-8	# of Conductors to be trained	27,000	227	41,015	Spreadsheet - Tab: ECP Costs

Exhibit	Field	PHMSA	PHMSA Source - Page Number From Final RIA	Rail Industry	Rail Industry Source
III-8	# of Carmen to be trained	6,500	227	9,849	Spreadsheet - Tab: ECP Costs
III-8	Hours of training – Engineers	16	243	80	Spreadsheet - Tab: ECP Costs
III-8	Hours of training – Conductors	8	244	16	Spreadsheet - Tab: ECP Costs
III-8	Hours of training - Carmen	56	244	80	Spreadsheet - Tab: ECP Costs
III-8	Wage Rate - Engineers	50.56	243	73.1	Spreadsheet - Tab: ECP Costs
III-8	Wage Rate – Conductors	50.56	244	62.16	Spreadsheet - Tab: ECP Costs
III-8	Wage Rate – Carmen	50.56	244	42.6	Spreadsheet - Tab: ECP Costs
III-8	# of Supervisors to be trained	292	242 & 243	200	Spreadsheet - Tab: ECP Costs
III-8	Cost per supervisor of training	7,147.8	243	7,090	Spreadsheet - Tab: ECP Costs
III-8	Total 20 year cost (undiscounted) ($ million)	48.5	244	239.3	Comments
III-8	Total 20 year cost (discounted @ 7 %) ($ million)	39.9	244	239.3	Comments
III-9	Number of bypass cables	1,266	239	Not Estimated	
III-9	Unite cost of bypass cables ($)	1,000	239	Not Estimated	
III-9	Total 20 year cost (undiscounted) ($ million)	1.3	239	Not Estimated	
III-9	Total 20 year cost (discounted @ 7 %) ($ million)	1	239	Not Estimated	
III-10	Number of tank cars requiring maintenance	60,231	239	Not Estimated	
III-10	Unit cost of battery ($)	87	239	Not Estimated	
III-10	Unit cost of cables ($)	300	239	Not Estimated	
III-10	Replacement cycle (years)	5	239	Not Estimated	
III-10	Total 20 year cost (undiscounted) ($ million)	64.7	239	Not Estimated	
III-10	Total 20 year cost (discounted @ 7 %) ($ million)	27.2	239	Not Estimated	

Exhibit	Field	PHMSA	PHMSA Source - Page Number From Final RIA	Rail Industry	Rail Industry Source
III-11	Number of labor-hours for asset management	8,000	222	Not Estimated	
III-11	Wage rate ($ per hour)	62.30	222	Not Estimated	
III-11	Total 20 year cost (undiscounted) ($ million)	0.5	241	Not Estimated	
III-11	Total 20 year cost (discounted @ 7 %) ($ million)	0.4	241	Not Estimated	

Appendix B. Data on Railroad Brake Use

Carrier	Type	Train ID	Trip Begin Date	Trip Time (Hrs)	DB Only (Hrs)	AB/ECP Only (Hrs)	AB/ECP + DB (Hrs)	Total Braking (Hrs)
BNSF	Conventional Air Brake	C BKMMHS0 56	04/02/15	52.967	6.100	0.633	1.97	8.70
BNSF	Conventional Air Brake	C BKMMHS0 57	04/04/15	80.600	11.000	0.050	2.80	13.85
BNSF	Conventional Air Brake	C BKMMHS0 58	04/07/15	33.350	5.833	0.017	0.98	6.83
BNSF	Conventional Air Brake	C BKMMHS0 61	04/12/15	90.083	10.150	0.167	3.20	13.52
BNSF	Conventional Air Brake	C BKMMHS0 62	04/15/15	93.467	15.967	0.150	3.50	19.62
BNSF	Conventional Air Brake	C BKMMHS0 63	04/18/15	57.133	17.017	0.117	4.07	21.20
CSX	Conventional Air Brake	K04015	05/16/15	41.829	6.178	0.016	0.31	6.51
CSX	Conventional Air Brake	K04616	05/16/15	42.000	2.961	-	0.06	3.02
CSX	Conventional Air Brake	K63412	05/13/15	55.000	6.298	-	0.09	6.39
CSX	Conventional Air Brake	K13817	05/17/15	49.000	6.122	0.039	0.25	6.41
KCS	Conventional Air Brake	QKCNL18	05/18/15	27.111	2.775	1.794	0.96	5.53
KCS	Conventional Air Brake	GKCMXS17	05/17/15	33.396	2.188	1.563	0.06	3.81
KCS	Conventional Air Brake	HKCSH14	05/15/15	48.700	2.467	0.810	0.14	3.42
KCS	Conventional Air Brake	GKCMYS16	05/17/15	44.081	4.301	2.261	1.14	7.70
KCS	Conventional Air Brake	QSHKC16	05/10/15	34.167	2.469	1.118	0.63	4.22
KCS	Conventional Air Brake	MSHDA15	05/16/15	8.350	0.963	0.061	0.05	1.07
KCS	Conventional Air Brake	MDASH14	05/14/15	14.717	1.784	0.095	0.08	1.96
KCS	Conventional Air Brake	MSHAR17	05/17/15	26.024	2.100	0.368	0.06	2.52
KCS	Conventional Air Brake	MSHAR18	05/18/15	22.946	1.678	0.099	0.08	1.85
KCS	Conventional Air Brake	MJASH19	05/19/15	10.667	0.786	0.149	0.08	1.01
NS	Conventional Air Brake	561C209	12/13/11	681.515	5.054	0.009	0.01	5.08
NS	Conventional Air Brake	64EH412	11/07/14	268.363	11.298	0.452	1.47	13.22
NS	Conventional Air Brake	64EH415	05/16/15	24.482	1.815	0.033	0.63	2.48
NS	Conventional Air Brake	64EH417	04/08/15	317.028	11.869	1.707	1.13	14.70

Carrier	Type	Train ID	Trip Begin Date	Trip Time (Hrs)	DB Only (Hrs)	AB/ECP Only (Hrs)	AB/ECP + DB (Hrs)	Total Braking (Hrs)
NS	Conventional Air Brake	64VC312	05/06/15	171.444	12.883	0.151	0.56	13.60
NS	Conventional Air Brake	64WH405	05/15/15	72.468	1.666	0.051	0.56	2.28
NS	Conventional Air Brake	65KH517	05/13/15	120.231	2.727	0.051	-	2.78
NS	Conventional Air Brake	65KH517	05/15/15	73.182	2.324	0.062	0.72	3.11
NS	Conventional Air Brake	66WC317	05/17/15	24.382	3.584	-	0.10	3.69
NS	Conventional Air Brake	66WH409	05/09/15	120.154	2.208	0.001	0.02	2.22
NS	Conventional Air Brake	66WH409	05/09/15	120.054	2.253	0.001	0.81	3.07
NS	Conventional Air Brake	66WH410	05/12/15	51.694	2.791	0.256	0.21	3.25
NS	Conventional Air Brake	66ZC112	05/18/15	2.982	0.548	-	0.07	0.61
NS	Conventional Air Brake	66ZC112	05/16/15	48.050	2.327	0.014	0.02	2.36
NS	Conventional Air Brake	66ZC615	05/17/15	25.094	1.950	4.300	1.12	7.37
NS	Conventional Air Brake	66ZH410	05/09/15	120.284	5.256	0.059	0.97	6.28
NS	Conventional Air Brake	66ZH411	05/12/15	120.799	3.519	0.146	0.61	4.28
NS	Conventional Air Brake	N11C415	04/22/15	651.284	13.119	0.565	1.60	15.28
NS	Conventional Air Brake	67WC129	04/30/15	24.184	2.471	0.009	0.12	2.60
NS	Conventional Air Brake	66ZH412	05/17/15	25.022	0.503	-	0.03	0.53
NS	Conventional Air Brake	64EH403	02/25/14	280.826	5.099	1.467	0.69	7.25
NS	Conventional Air Brake	64EH412	11/07/14	288.333	11.298	0.452	1.47	13.22
NS	Conventional Air Brake	64EH431	10/27/14	173.817	10.383	0.398	1.78	12.56
NS	Conventional Air Brake	64EH429	09/26/14	158.520	2.430	0.780	0.05	3.26
NS	Conventional Air Brake	64VC312	05/06/15	171.444	12.883	0.151	0.56	13.60
NS	Conventional Air Brake	66ZC112	05/18/15	2.982	0.548	-	0.07	0.61
NS	Conventional Air Brake	66WH420	04/19/15	136.267	7.558	1.309	0.55	9.42
UP	Conventional Air Brake	OWKSJ 11	05/07/15	261.076	6.404	0.301	0.80	7.51
UP	Conventional Air Brake	OWPDO 03	02/23/15	326.777	9.421	0.010	1.86	11.29
UP	Conventional Air Brake	OWDPG 27	02/25/15	189.490	7.528	0.125	0.39	8.04

Carrier	Type	Train ID	Trip Begin Date	Trip Time (Hrs)	DB Only (Hrs)	AB/ECP Only (Hrs)	AB/ECP + DB (Hrs)	Total Braking (Hrs)
UP	Conventional Air Brake	OWDPG 14	02/14/15	97.549	11.336	0.458	0.58	12.37
UP	Conventional Air Brake	OACCA 07	02/04/15	204.307	8.329	27.267	2.28	37.87
UP	Conventional Air Brake	OWDPG 22	04/15/15	291.727	1.361	0.411	0.41	2.18
UP	Conventional Air Brake	OGONU 24	04/27/15	7.999	0.163	0.034	0.03	0.23
UP	Conventional Air Brake	OEHSJ 12	05/12/15	7.999	0.640	0.105	0.03	0.77
UP	Conventional Air Brake	OPWKN 26	01/30/15	7.999	0.353	0.338	0.12	0.81
UP	Conventional Air Brake	OSRKB 21	01/23/15	155.404	2.997	0.078	0.29	3.37
BNSF	ECP	C ATMPAE05	03/23/15	104.217	11.036	0.408	1.75	13.19
BNSF	ECP	C ATMPAE06	04/07/15	31.067	7.093	0.375	0.89	8.35
BNSF	ECP	C ATMPAE07	04/14/15	108.383	12.706	1.608	2.87	17.18
BNSF	ECP	C ATMPAE08	04/25/15	66.250	17.267	0.224	1.58	19.07
BNSF	ECP	C ATMPAE09	05/04/15	67.867	10.561	0.906	1.20	12.67
BNSF	ECP	C ATMPAE10	05/17/15	22.383	5.301	1.226	1.92	8.44
NS	ECP	561C211	04/18/15	585.068	0.482	0.001	-	0.48
NS	ECP	561C212	05/10/15	74.498	0.376	-	0.00	0.38
NS	ECP	77ZAA14	01/27/15	447.896	26.139	51.183	3.18	80.50
NS	ECP	77ZAA15	10/01/14	1,106.696	20.053	1.463	3.16	24.67
NS	ECP	77ZAA18	03/01/15	478.296	24.182	0.766	3.74	28.69
NS	ECP	77ZAA27	10/08/14	505.027	21.790	1.180	5.57	28.54
NS	ECP	77ZAA28	02/11/15	437.196	30.236	1.093	3.17	34.50
NS	ECP	77ZAA29	12/12/14	435.903	29.625	0.446	3.49	33.56
NS	ECP	77ZAA30	11/14/14	423.109	28.525	0.744	3.86	33.13
NS	ECP	77ZAA31	01/12/15	477.195	24.812	0.691	3.98	29.48
NS	ECP	77ZAB11	10/25/14	1,148.461	30.024	1.094	4.75	35.87
NS	ECP	561C215	04/21/15	587.941	0.894	0.017	-	0.91
NS	ECP	561C220	05/18/15	73.113	0.428	-	-	0.43

Carrier	Type	Train ID	Trip Begin Date	Trip Time (Hrs)	DB Only (Hrs)	AB/ECP Only (Hrs)	AB/ECP + DB (Hrs)	Total Braking (Hrs)
NS	ECP	562C420	05/18/15	61.203	1.106	0.010	0.01	1.13
NS	ECP	64ZH206	05/09/15	49.851	2.938	-	-	2.94
NS	ECP	66WC116	05/17/15	72.162	2.454	-	-	2.45
NS	ECP	732AB13	08/22/14	1,998.612	14.251	1.416	2.73	18.40
NS	ECP	77ZAB12	12/23/14	499.566	7.921	2.332	1.48	11.73

Appendix C. Oliver Wyman Qualifications and Experience

Oliver Wyman is a global leader in management consulting. With offices in 50+ cities across 26 countries, Oliver Wyman combines deep industry knowledge with specialized expertise in strategy, operations, risk management, and organization transformation. The firm's 3,700 professionals help clients optimize their business, improve their operations and risk profile, and accelerate their organizational performance to seize the most attractive opportunities.

Oliver Wyman's thought leadership is evident in our agenda-setting books, white papers, research reports, and articles in the business press. To that end, the Oliver Wyman Institute connects the firm with prominent leaders of the academic community for joint research on frontier issues. The firm's Global Risk Center analyzes the increasingly complex risks that are reshaping industries, governments, and societies.

The firm's capabilities and intellectual capital are enhanced by our deep industry expertise, geographic range, analytical rigor, and hands-on, collaborative approach. Our professionals see what others don't, challenge conventional thinking, and consistently deliver innovative, customized solutions. We also work side by side with senior executives to accelerate execution through a blend of behavioral and management approaches. As a result, we have a tangible impact on clients' top and bottom lines.

Oliver Wyman is a wholly owned subsidiary of Marsh & McLennan Companies [NYSE: MMC], a global team of professional services companies offering clients advice and solutions in the areas of risk, strategy and human capital. With over 5,0700 employees worldwide and annual revenue exceeding $12 billion, Marsh & McLennan Companies is also the parent company of Marsh, a global leader in insurance broking and risk management; Guy Carpenter, a global leader in providing risk and reinsurance intermediary services; and Mercer, a global leader in talent, health, retirement and investment consulting. For more information, visit www.oliverwyman.com. Follow Oliver Wyman on [redacted].

Transportation Consulting

Oliver Wyman's Transportation Group, with a professional staff of more than 100 in Europe and North America, is one of the largest consultancies in the world dedicated to the transportation industry. It provides a comprehensive set of services and capabilities to transportation carriers, and to the users and regulators of transportation services, across the full range of the transportation sector, including:

- Air freight
- Air passenger
- Airports
- Equipment supply
- Financial services
- Freight forwarding and customs brokerage
- Inland waterways
- Intermodal services
- Motor carriers
- Ocean shipping (liner, tanker, bulk)
- Parcel and express delivery
- Ports
- Rail freight
- Rail passenger (commuter and intercity)
- Third-party logistics
- Toll roads and highways
- Travel and tourism
- Urban transportation and transit
- Warehousing and distribution

The Transportation Group also offers capabilities in international market research, evaluating new business opportunities, developing strategic plans and specific marketing plans, designing organizational structures to manage businesses, and implementing transportation services. Oliver Wyman's transportation clients include national and regional governments on six continents as well as many of the world's largest railroads, motor carriers, leasing companies, and industrial and consumer manufacturing firms.

Oliver Wyman's Rail Practice

Oliver Wyman's Rail Practice employs the largest and most experienced staff in the world dedicated to the rail industry and is widely recognized as the premier management consultancy to state-owned and private freight and passenger railroads. It has carried out major strategic, operational, and financial planning and evaluation assignments for nearly all major railroads in North America and for state-owned railways in Europe, South America, Africa, and the Pacific Rim.

Oliver Wyman is known for its innovation and creativity. Oliver Wyman staff was heavily involved in the restructuring of the bankrupt north-eastern US railroads into Conrail, both as consultants and as senior managers at Conrail. Oliver Wyman also spearheaded the regional railroad movement following deregulation, and has led the development of unique public-private partnerships and operating agreements that have helped railroads recover from bankruptcy and compete effectively in a deregulated environment.

Oliver Wyman's Multimodal Practice

Oliver Wyman's Multimodal Practice is a global leader in applied operations research and the development of simulation and optimization software tools. The Multimodal Practice leverages its deep rail expertise and industry leading software development to create industry specific tools for the global rail industry. Tools created by this practice are in active use by railways on five continents and are recognized as the global industry standard.

The Multimodal Practice is the world leader in the analysis of freight rail operational efficiencies. Through the application of Oliver Wyman's proprietary MultiRail Enterprise

Edition software, the operating plans of freight railroads throughout the world have been optimized to yield new benchmarks in productivity and service. These levels of improvement are achieved through the optimization of the network at the shipment level, allowing for hidden costs to be revealed and eliminated.

Oliver Wyman's services cover several key areas of rail management

- *Rail System Restructuring, Commercialization, and Privatization.* Oliver Wyman's key rail staff have been deeply involved in rail restructuring, commercialization, and privatization projects worldwide – including in Canada, Mexico, the Czech Republic, Hungary, Poland, Argentina, Chile, Colombia, Uruguay, Australia, New Zealand, the United Kingdom, and the United States. Oliver Wyman engagements have ranged from commercializing internal rail functions, such as engineering, construction, and workshop activities, to privatizing rail segments or entire railways. Oliver Wyman has developed privatization strategies to return maximum value to the shareholders, identified interested parties, and helped negotiate asset sales.
- *Transportation Cost and Financial Analysis*. Oliver Wyman has been active in rail costing and financial analysis for two decades. For such clients as VIA, Amtrak, National Railway Labour Conference, major financial institutions and equipment leasing companies, British Rail, SNCF, Deutsche Bahn, Class I and regional railroads, major commuter rail authorities, and state departments of transportation, Oliver Wyman has assessed operating costs of rail operations, allocated costs between freight and passenger operations, analyzed joint costs of public and private rail operations, and determined the degree to which costs are fixed or variable. Oliver Wyman has presented its findings in legal proceedings, public hearings, and other public or regulatory forums.
- *Market and Revenue Analysis for Rail Passenger and Freight Transportation Services*. About one-third of the Practice's major projects involve analysis of the market for transportation services. Clients include international transportation companies, leasing companies and financial institutions, major European and Asian railways, and North American Class I and regional railroads. Oliver Wyman provides critical insights into the transportation marketplace that serve as the basis for strategic planning, new business assessment, organizational realignment, and acquisition and divestiture planning. Oliver Wyman is experienced in analyzing the markets for most major commodities carried in freight service, as well as for intercity and commuter passenger services.
- *Operational Strategies for Freight and Passenger Railroads.* The Oliver Wyman rail practice brings together professionals who, as both consultants and senior railroad managers, have planned and executed a wide range of operating strategies, including a number of organizational transitions. Collectively, they possess a high degree of management and technical expertise in all the disciplines related to rail operations.
- *Organizational Assessment of Public and Private Sector Clients*. Since its founding, Oliver Wyman has conducted several dozen organizational and operational analyses of public and private sector service providers. For example, Oliver Wyman has analyzed the organization, operations, and deployment of funds for several state rail programs, and has evaluated the

entire management structure of the PKP (the Polish State Railways) in Europe and the Port Authority of New York and New Jersey in North America.

- *Commercial Strategy, Customer Service, Sales/Marketing Process Reengineering.* Oliver Wyman has assisted leading railway clients and rail industry suppliers in the design and execution of their commercial strategies. Oliver Wyman provides clients with reorganization assistance, formulation of integrated sales and marketing planning processes and techniques, channel management strategy development, preparation and installation of decision support tools (modal costing, total logistics analysis), design and development of customer service center activities, and training.
- *Asset Valuation and Line of Business Assessment.* Oliver Wyman has extensive experience valuing assets of transportation companies, using approaches including net liquidation value, going concern value, original cost less depreciation value, and comparable sales value. In addition, Oliver Wyman has analyzed transportation companies not only as single entities, but also as a collection of "unbundled" assets and rights. Because the value of the parts often differs from the value of the whole, this innovative approach has proven extremely useful in some cases. Oliver Wyman has been involved in freight and passenger service evaluations and in helping government and railways agree on equitable subsidy levels for unremunerative services.
- *Intermodal Strategy and Implementation.* Oliver Wyman has been closely involved in developing breakthrough intermodal strategies. For example, in Russia Oliver Wyman developed the Moscow/St. Petersburg intermodal strategy; in the UK it helped develop British Rail's Channel Tunnel intermodal strategy; and in North America it advised American President Companies and CSX/Sea-Land, among others, in the early development of doublestack container intermodal network strategies.

Senior Team Resumes

William J. Rennicke

William J. Rennicke, a Partner in Oliver Wyman's Manufacturing, Transportation, and Energy Group, specializes in transportation strategic planning, management, marketing, economics, and operations. He has particular expertise in restructuring, organizational redesign, and transactions to improve financial and operating performance of transport operators around the world.

Mr. Rennicke's career in the transportation industry spans four decades, including senior management and operating positions at Class I railways. He has been in the forefront of restructuring and transaction-related activities for both private and government-owned transport operators. He has also managed the development of strategic and financial planning, simulation, and control models for transportation companies. Mr. Rennicke has worked closely with service providers and operating companies; commercial and investment banks; large investors and investment fund firms; operators; equipment manufacturers and leasing companies; construction and engineering companies; and government transportation entities in many countries.

Drawing on his extensive experience, Mr. Rennicke has served as an expert witness in litigation, regulatory and arbitration cases, and he has provided expert testimony before the Canadian and US legislatures. His relevant experience includes the following:

<table>
<tr><th>Testimony on Behalf of or Before</th><th>Subject</th><th>Year</th></tr>
<tr><td>Minnesota Public Utilities Commission</td><td>Application of the North Dakota Pipeline Company for a Certificate of Need for the Sandpiper Expansion and Extension Project (PL-6668/CN-13-473)</td><td>08/2014</td></tr>
<tr><td colspan="3"><i>Provided an expert witness report on likely crude-by-rail transportation routes in the event of non-approval of the project, and the potential impact on other freight and passenger traffic on these routes of additional crude-by-rail traffic.</i></td></tr>
<tr><td>US State Department</td><td>Review of Enbridge Energy's Application for Amendment of the August 2009 Presidential Permit for Line 67, Supplemental Environmental Report on "No Action" Alternatives</td><td>04/2014</td></tr>
<tr><td colspan="3"><i>Provided an expert report identifying "no action" transportation options (i.e., if permit amendment were denied). This assessment included detailed route descriptions, capacity constraints, and capital investment requirements for the most feasible "no action" options.</i></td></tr>
<tr><td>Federal Energy Regulatory Commission</td><td>Petition for Declaratory Order, North Dakota Pipeline Company LLC (OR14-21-00)</td><td>04/2014</td></tr>
<tr><td colspan="3"><i>Provided an expert witness statement on the nature of railroad-shipper contracts, the characteristics of rail network capacity, and the multi-commodity nature of rail operations.</i></td></tr>
<tr><td>Minnesota Public Utilities Commission</td><td>Application of Enbridge Energy for a Certificate of Need for the Line 67 Station Upgrade Project, Phase 2 (Pl-9/Cn 13-153)</td><td>03/2014</td></tr>
<tr><td colspan="3"><i>Provided expert witness testimony on the potential impact of the "no action" alternative (i.e., non-approval of the upgrade project) on freight and passenger rail capacity and services in the State of Minnesota.</i></td></tr>
<tr><td>US Surface Transportation Board</td><td>Ex Parte No. 711, Petition for Rulemaking to Adopt Revised Competitive Switching Rules</td><td>03/2014</td></tr>
<tr><td colspan="3"><i>Provided expert witness testimony concerning the operation of railroad interchanges and the potential service and cost impacts of a proposed change to switching rules</i></td></tr>
<tr><td>US Surface Transportation Board</td><td>Finance Docket No. 27590/4, TTX Company Application for Approval of Pooling of Car Service with Respect to Flatcars</td><td>01/2014</td></tr>
<tr><td colspan="3"><i>Provided an expert report assessing the benefits provided by TTX's flatcar pooling activities and the potential consequences for the railroad industry if TTX were no longer authorized to engage in</i></td></tr>
</table>

Testimony on Behalf of or Before	Subject	Year
pooling.		
US District Court for the District of Columbia	Civil Action MDL No. 1869 (confidential client)	01/2013
Provided expert witness testimony on surface freight modal competition and rail freight network operations		
US Surface Transportation Board	Genesee & Wyoming Application for Control of RailAmerica, FD 35654	8/2012
Provided an expert report on the impact of G&W's acquisition of RailAmerica on competition in the North American rail industry		
Department of Commerce and Consumer Affairs, State of Hawaii	Evidentiary Hearing in the Matter of Sumitomo Corporation of America vs. City and County of Honolulu and Ansaldo Honolulu JV (PCX-2011-5)	07/2011
Provided expert witness testimony on price realism and past performance as a criterion in bid evaluations		
US Surface Transportation Board	Ex Parte No. 705, Competition in the Railroad Industry	04/2011
Provided expert witness testimony concerning the current state of competition in the freight railroad industry and proposals to change the current regulatory structure		
Confidential North American client	Confidential arbitration proceeding	05/2010
Provided expert witness testimony on rail costs and rates for an arbitration between a company-owned bulk railroad and a major shipper		
Confidential North American client	Confidential arbitration proceeding	03/2010
Advised on approaches and analytic techniques to more accurately attribute variable and fixed costs in a volatile volume environment. Built a dynamic tool that captured all direct cost for a commodity's movement to calculate the true cost to serve at various volume levels		
US Surface Transportation Board	Standalone rate case, NOR 42110 (confidential client)	01/2010
Provided expert witness testimony on railroad general and administrative costs in a standalone rate case between a North American Class I railroad and a major shipper		
US District Court for the California Eastern District	Civil Action No. 08-CV-1086-AWI (confidential client)	09/2009
Provided expert witness testimony with regard to the appropriate rate divisions and escalation of revenue shared between two railroads, and estimated damages for the client		

Testimony on Behalf of or Before	**Subject**	**Year**
US House of Representatives Committee on Transportation & Infrastructure	Hearing on Rail Competition and Service	09/2007
Provided expert witness testimony evaluating the current performance of the US freight rail industry, the challenges it will face, and the potential for differential pricing to support a sound US rail network		
US House of Representatives Committee on Transportation & Infrastructure	Congressional Forum on High-Speed Rail	03/2007
Provided a perspective on the role high-speed rail could play in the United States, potential high-speed rail markets, structural reform options, and options for public-private development of high-speed rail		
US Bankruptcy Court, Southern District of Texas	Confidential bankruptcy proceeding	02/2007
Provided expert witness testimony that a copper refining mill satisfied the criteria to be considered a going concern and the appropriate methods for valuing such an operation		
Confidential North American client	Confidential arbitration proceeding	10/2006
Provided expert witness testimony on 1) trends in the North American surface transportation and logistics market, with a focus on motor carriers, and 2) third-party logistics contracting processes and risk mitigation strategies for an arbitration between a major consumer products company and a third-party logistics provider		
Confidential Canadian client	Confidential arbitration proceeding	09/2006
Provided expert witness testimony on the North American rail wheel market and rail wheel supply and demand for an arbitration between a railroad equipment distributor and a European manufacturer		
US District Court of New Jersey	Civil Action No. 05-4010 (confidential client)	12/2005
Provided expert witness testimony on the interface between rail and intermodal facilities for litigation involving a Class II railroad and state environmental agency		
Confidential Canadian client	Confidential arbitration proceeding	08/2005
Provided expert witness testimony on rail costs and rates for an arbitration between a company-owned bulk railroad and a major shipper		
Confidential Canadian client	Confidential arbitration proceeding	05/2005
Provided expert witness testimony on rail costs and rates for an arbitration between a company-owned bulk railroad and a major shipper		
Confidential Canadian client	Confidential arbitration proceeding	04/2005

Testimony on Behalf of or Before	Subject	Year
Provided expert witness testimony on rail costs and rates for an arbitration between a company-owned bulk railroad and a major shipper		
US Surface Transportation Board	Standalone rate case, NOR 41191 (confidential client)	05/2004
Provided expert witness testimony analyzing the construction schedule and cost estimates for a standalone railroad in a dispute between a utility and railroad over common carrier rates		
Confidential Canadian client	Confidential arbitration proceeding	2004
Provided expert witness testimony on rail costs and rates for an arbitration between a company-owned bulk railroad and a major shipper		
US Surface Transportation Board	Ex Parte No. 646, Rail Rate Challenges in Small Cases	2004
Submitted a statement that identified key issues and challenges facing the rail industry (in particular long-term capital funding needs) and explained how the risk of increasing the regulatory exposure of significant portions of railroad revenue would adversely affect the financial condition of the industry and its ability to meet the challenges it faces.		
US House of Representatives Committee on Transportation and Infrastructure, Subcommittee on Railroads	Hearing on the Status of the Surface Transportation Board and Railroad Economic Regulation	2004
Testified regarding Oliver Wyman's perspective on the state of the railroad industry, including its current financial conditions and transformation since enactment of the Staggers Rail Act of 1980		
US Surface Transportation Board	Arbitration (confidential client)	2003
Submitted a statement analyzing the economic and business conditions faced by the railroad industry and by a Class I railroad preceding its decision to furlough certain MOE and MOW employees		
US House of Representatives Committee on Transportation and Infrastructure, Subcommittee on Railroads	Hearing on Passenger Rail Service in America	2002
Testified regarding worldwide trends in private sector involvement in passenger railroad restructuring and privatization, and potential public policy changes and restructuring options for the US passenger rail system		
US Senate Commerce Committee	Hearing on S. 1991, the National Defense Rail Act	2002
Testified as to worldwide trends toward private sector involvement in passenger railroad restructuring and privatization over the past 10 years		
Canadian Transportation Agency	In the matter of an application by the Ferroequus	2002

Testimony on Behalf of or Before	Subject	Year
	Railway Co. Ltd. pursuant to sections 93 and 138 of the *Canada Transportation Act*, seeking third-party running rights over CN infrastructure	
Testified as to the adverse impacts on CN and the Canadian rail system of granting FE, a "virtual railroad," forced access to CN's privately owned infrastructure		
Canadian Transportation Agency	In the matter of complaints filed by Naber Seed and Grain Co. Ltd. pursuant to section 116 of the *Canada Transportation Act,* alleging CN's failure to fulfill its level of service obligations	2002
Testified as to the adverse impacts on CN and the Canadian rail system of Naber's requested remedy of granting a third-party carrier access to CN's network		
US District Court for the Northern District of Maryland	In the matter of Allfirst Bank vs. Progress Rail Services Corp. and Railcar Ltd.	2002
Submitted a statement assessing the market demand for certain railcar equipment sold by PRSC and RL to Allfirst Bank		
US District Court for the Eastern District of Virginia, Alexandria Division	Civil Action No. 00-1489-A (confidential client)	2001
Expert witness in a major service dispute between one of the six North American Class I railroads and a major bulk shipper. Submitted a statement analyzing the actual service performance of the carriers and the underlying causes of transit time and reliability performance issues		
US Senate Subcommittee on Surface Transportation and Merchant Marine	Hearing on the State of the Rail Industry	2001
Testified as to the current financial conditions and transformation of the US rail industry since enactment of the Staggers Rail Act of 1980, infrastructure capacity and its impact on rail service, and long-term capital funding needs		
United States District Court for the District of Nebraska	Case No. 8:98CV 34 (confidential client)	2000
Expert witness in a major service dispute between one of the six North American Class I railroads and a major coal shipper. Analyzed the actual service performance of the carriers and the underlying causes of transit time and reliability performance issues as well as the impact of the logistics practices of the rail customer		
Canada Transportation Act Review Panel	Review of the Canada Transportation Act	2000
Submitted a statement regarding the state of the Canadian rail industry and the application of differential pricing and efficient component pricing theory relative to the industry's financial		

Testimony on Behalf of or Before	Subject	Year
needs		
US Surface Transportation Board	Ex Parte No. 582, Public Views on Major Rail Consolidations	2000
Assisted in preparation of Oliver Wyman's testimony with respect to Oliver Wyman's views on major railroad consolidations and the future structure of the North American railroad industry		
US Surface Transportation Board, on behalf of Assoc. of American Railroads	Ex Parte No. 575, Review of Rail Access and Competition Issues:	1998
Testified as to why open access or forced access is not required for the US freight rail network and the likely impacts if it were instituted		
US Senate Subcommittee on Surface Transportation and Merchant Marine	Hearing on the Financial Viability of Amtrak	1997
Assisted in the preparation of Oliver Wyman's testimony on the financial viability of Amtrak (US intercity passenger rail)		
Connecticut Department of Transportation	In the Matter of Arbitration Between the Connecticut Department of Transportation and the Metropolitan Transportation Authority (NY)	1996
Testified regarding Oliver Wyman's assessment of the economics of the New Haven commuter rail line and the fair and equitable allocation of operating deficit and shared capital costs between the two states that share the line		
Canadian National Railway	Before the Interstate Commerce Commission: FD 32640 – Contract to Operate Grand Trunk Western Railroad Inc. and Duluth, Winnipeg and Pacific Railway Co.	1994
Testified before the ICC concerning a restructuring of the GTW and DWP to enhance operational efficiency and overall profitability		
General Electric	For the Department of Justice and Federal Trade Commission: In the Matter of Chrysler Rail Transit	1993
Statement to the DOJ and FTC concerning the level of competition relative to the ownership of rail boxcars and the impact of the proposed acquisition on competition		
Consolidated Rail Corp.	President's Emergency Board No. 221: Dispute Between Consolidated Rail Corp. and Its Employees Represented by the Brotherhood of Maintenance of Way Employees	1992
Testified regarding the outlook for Conrail in the context of the financial condition and prospects		

Testimony on Behalf of or Before	Subject	Year
of the Class I railroad industry		
Wisconsin Central	Before the Interstate Commerce Commission: FD 32036 – Wisconsin Central Transportation Corp. et al. – Continuance in Control – Fox Valley & Western Ltd.	1992
Testified before the ICC regarding the effect on competition of Wisconsin Central's proposed acquisition of the Fox Valley & Western Railroad		
National Carriers Conference Committee	Before Presidential Emergency Board No. 219, Financial Condition and Prospects for the Class I Railroad Industry	1990
Testified concerning the financial challenges facing the US freight rail industry, as part of the process of government intervention to resolve a labor dispute over wages and benefits		
Citicorp	Before the Federal Bankruptcy Court re: Chicago and Missouri Western Railway	1988
Testified on behalf of a major institutional creditor of the CM&W concerning the outlook for profitable operation of the railway		
Santa Fe Southern Pacific Corporation	Before the Interstate Commerce Commission: Docket Nos. 30400, 30400 (Sub No. 1) et al. – Santa Fe Southern Pacific Corp. – Control – Southern Pacific Transportation Company	1984-85
Testified on behalf of the Applicants regarding the effect on competition of the proposed merger of the Santa Fe and Southern Pacific railroads		
Confidential investor in rail equipment	Confidential lawsuit	1980s
Assessed overall demand for rail equipment in the late 1970's and early 1980's to determine the validity of long-term equipment plans		
Boston & Maine Railroad	Before a Federal Arbitration Panel re: Crew Consist Issues on the B&M	1980s
Was a key witness for the B&M in the first crew consist arbitration case in the United States. Result was the creation of single brakeman and conductor only crews, ten years before the rest of the industry		
Boston & Maine Railroad	Before the Federal Bankruptcy Court re: Boston & Maine Railroad	1980s
Testified numerous times on a wide variety of subjects related to the future of the B&M and the validity of the reorganization plan		

Before joining Oliver Wyman, Mr. Rennicke held various senior positions at the Boston and Maine Railroad. He is a member of the Transportation Research Forum and the Council of Supply Chain Management Professionals.

Mr. Rennicke holds a B.S.B.A. in accounting from the School of Business Administration at Georgetown University and an M.B.A. with a concentration in transportation and logistics from the University of Minnesota.

Rodney Case

Mr. Case is a Partner in Oliver Wyman's Global Surface Transportation Practice. He is an international expert in transportation operations planning, infrastructure design and maintenance, strategy development, and performance management, dominantly for the rail freight industry.

Mr. Case's recent North American rail work has included work in the bulk train markets and benchmarking of key mechanical and engineering functions.

Mr. Case's recent case work with European and Asian freight railways has focused on helping clients adapt to the new competitive realities of open access by reducing overall costs while increasing flexibility and service levels. Oliver Wyman's approach of moving from train-centered to shipment-centered strategies is increasing profitability in this short haul market. The transfer of industry-leading practices between European and North American railways continues to generate new value capture strategies for the industry on both sides of the Atlantic.

Prior to joining Oliver Wyman, Mr. Case led a team in the redesign and installation of the operating plan at SNCF, the French national railway. Key deliverables included redefining the carload and trainload network to reduce its complexity by over half, increasing frequency in key lanes to meet both financial and service targets, and developing mixed train operations to stabilize service quality and increase product options while reducing overall operating costs.

Mr. Case was the Director of Service Design at Canadian Pacific Railway. He led the preparation of the Integrated Operating Plan (IOP). Key elements of the IOP included service level impacts, system cost analysis, train path planning, train schedule creation, crew and locomotive resource requirements, railcar fleet velocity impacts, rail yard and intermodal terminal workloads, port terminal schedules, connections to foreign railway services, and implementation into daily operations.

At Canadian Pacific Railway, Mr. Case was also a Project Manager for the Executive Team of Field Operations. Key projects included railcar acquisition, national labor contract negotiations, and interline railway coordination.

Mr. Case received a Bachelor of Engineering Science – civil engineering from the University of Western Ontario and an M.S. in logistics and supply chain management from Cranfield University.

David T. Hunt

Mr. Hunt is a Manager in Oliver Wyman's Manufacturing, Transport, and Energy Group and has 30 years of experience in the areas of transportation operations and strategic planning, national and regional transportation policy and planning, and network modeling and operations research. Mr. Hunt focuses on projects that provide fact based policy analysis, and projects that improve operating efficiencies for his clients. Recent projects include:

- Developed "No Action" scenarios in several proceedings to support the approval of pipeline expansion and/or construction on behalf of an international energy company.
- Worked on behalf of an industry trade association to provide support as part of a federal proceeding addressing proposed changes in US transportation regulatory policy.
- Worked on behalf of a railcar owner to identify the benefits of operating a national railcar pool.
- Developed a network design strategy for a nationwide truckload carrier.
- Developed two network models as part of an Environment Impact Statement for the proposed New York City Cross Harbor Freight Tunnel: a choice model to estimate the amount of freight traffic diverting to the new tunnel; and, a rail capacity model to predict the likely network chokepoints created by different scenarios.
- Analyzed potential locations for a new rail terminal, and evaluated competitive operating strategies for a nationwide transporter of fresh fruits and vegetables.
- Worked with senior IT staff at a Class I railroad to develop a multi-year roadmap for prioritizing software funding and development.
- Managed the development of an open source software product for visualizing large quantities of network-based data in a geographical information system (GIS) environment.
- For the national freight railroad of South Africa, applied a locomotive optimization model developed by Oliver Wyman to identify more efficient strategies for utilizing the existing locomotive fleet.
- For the national freight railroad of Kazakhstan, assisted in developing strategies to improve current operations, with a goal of migrating from a tonnage-based railway to a schedule-based railway.

Prior to joining Oliver Wyman, Mr. Hunt was a Senior Associate at Cambridge Systematics (CS) where he focused on transportation policy and planning, including management of the first ever nationwide rail capacity study. Mr. Hunt was also a Vice President at ALK Associates, where he developed decision support systems and worked with senior rail management to assess merger and acquisition opportunities.

Mr. Hunt is active in the Institute for Operations Research and Management Science (INFORMS), where he is currently on the Board of Directors as Vice President of Chapters & Fora, and has served as the Chair of the Railway Applications Section, Council Member of the Transportation Science and Logistics Section, and Chair of the New Jersey Chapter. He is also a member of the Transportation Research Board's Network Modeling Committee and Railroad Operating Technology Committee.

Mr. Hunt earned a B.S. in civil engineering from West Virginia University and a M.S.E. from the Civil Engineering and Operations Research Department at Princeton University.

David Lehlbach

Mr. Lehlbach, a Senior Specialist in Oliver Wyman's Transportation Group, specializes in railroad operational analysis and modeling, transportation planning, and performance management.

Mr. Lehlbach's recent assignments for Oliver Wyman involved optimization planning for three key freight railroads in Europe and Asia. The first case involved the modeling and analysis of several key corridors with a goal to improve service and asset utilization. The second and third cases utilized Oliver Wyman's MultiRail Enterprise Edition software to model the railroad's operating plan to understand network operating costs and streamline operations.
Other recent casework involved performance of line capacity simulation and analysis for a major Class 1 railroad in North America, Locomotive MRO practices and associated technology tradeoffs for a major railroad in Asia, and miscellaneous "new technology" analyses for Oliver Wyman customers.

Prior to joining Oliver Wyman, Mr. Lehlbach worked independently on rail projects. For a US container facility, he analyzed port to rail operations of Class I railroads with a focus on blocking between ports and inland terminals. For a Class I railroad, he analyzed car movement, fleet management, and customer facility utilization.

Mr. Lehlbach worked for US Class I railroad Union Pacific. Key accountabilities during his tenure in the Service Design group included schedule creation, local operations, crew/locomotive/path utilization, railcar velocity impacts, terminal workload analysis, block handling, and connecting railroad services. He was chief planner for Texas and Louisiana, the most complicated rail infrastructure in North America. He was then assigned to the "zero-based" network redesign team, with a primary goal to evaluate terminal capabilities, car flows, and blocking using MultiRail software.

During his tenure in UP's Network Planning group, Mr. Lehlbach worked in metrics, line capacity, resource planning, and industrial engineering. His primary contribution was providing operating analysis and service metrics to senior executives and field staff, diagnosing relationships between current and historical performance, isolating geography that required capital improvement, and recognizing repetitive failures. Mr. Lehlbach was selected for UP's Leadership Development Program, a long-term planning process for high-potential employees.

Mr. Lehlbach has a B.A. degree from Beloit College and an M.B.A. from the University of Tennessee (with honors).

J. Phillip Rowe

Mr. Rowe is a Senior Specialist with Oliver Wyman based in the Princeton, New Jersey Office. Mr. Rowe specializes in operational planning and analysis in the surface transportation industry with a focus on the railway industry. His transportation career spans 25 years, including holding analytical and management positions at railway, airline, and air freight companies.

Mr. Rowe's area of expertise centers on using analytical methods and planning systems to support decision-making. Typical transportation assignments have included the following:

- Application of planning methods and analysis tools to identify improvements in network operations for transportation companies including railroads in North America, Europe, and South Africa
- Analysis of network flows to identify options for terminal realignments
- Design and installation of operational planning and automated decision support tools for use by railroads in North and South America, Europe, and South Africa.
- Participation on merger teams for railways to analyze network impacts
- Development and installation of performance measurement systems
- Unit and revenue forecasting for transportation companies

Before joining Oliver Wyman, Mr. Rowe held positions at Southern Pacific Railways, Lynden Air Freight, United Airlines, and the University of Alaska.

Mr. Rowe holds a B.A. degree in political science from California State University, Long Beach. He also holds an M.C.R.P. degree in city and regional planning from Harvard University and a M.S. degree in transportation from Northwestern University.

Phil C. Ireland

Mr. Ireland is a Senior Advisor to Oliver Wyman. He was a railroad executive with the Canadian Pacific Railroad (CP) for more than 29 years before retiring in January 2013. His last position at CP was Vice President Service Design & Asset Optimization, with responsibility for managing the execution of the operating plan for Canada and the United States. In this position, he directed all aspects of the railroad operating plan, including delivering on customer commitments, sizing the mobile and capital assets required to execute the plan, and driving continuous improvement in operations.

Prior to becoming Vice President Service Design & Asset Optimization, Mr. Ireland held a variety of management positions in mechanical services, internal audit/consulting services, marketing, and interline management, and worked with senior executives at all of the major North American railroads.

Mr. Ireland has a Bachelor of Applied Science in mechanical engineering from Queen's University and a M.B.A. with a concentration in strategy from McGill University.
Mr. Ireland is a registered Professional Engineer with Professional Engineers of Ontario (PEO) and the Association of Professional Engineers and Geoscientists of Alberta (APEGA). He is also a member of the Institute of Corporate Directors and holds an ICD.D certification.

Rebekah E. Bartlett

Ms. Bartlett is a Senior Editor in the Manufacturing, Transport, and Energy Group at Oliver Wyman. She has 25 years of experience in editing, writing, research, and project management and is the editor of Oliver Wyman's annual *Transport and Logistics* journal.

Ms. Bartlett is experienced in developing content around issues of public and government transportation policy (e.g., competition, deregulation, privatization, PPPs), legal/regulatory testimony, and transportation industry market studies. Recent relevant projects in which she has been extensively involved include:

- Expert witness testimony on the impacts of rail versus pipeline transport of crude oil for a state utility commission and FERC
- Testimony before the Surface Transportation Board on railroad competition, expanded switching, and potential railroad regulatory rate changes
- Regulatory comment paper on the impact of positive train control systems on US freight railroads
- White paper on international rail regulatory regimes for a major railroad facing potential re-regulation
- Expert witness testimony before the US Congress and Canadian government on rail competitive access issues and development of passenger rail services

Ms. Bartlett has a B.A. from Florida Atlantic University and an M.A. from the University of Massachusetts, with additional graduate work at Oxford University.