Electronically Controlled Pneumatic Brake Systems

Final Rulemaking

Regulatory Analysis

Federal Railroad Administration

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I. EXECUTIVE SUMMARY

The Federal Railroad Administration (FRA) is responsible for the safe and secure movement of rail traffic on the Nation's railroads. Electronically controlled pneumatic (ECP) brakes are a tested technology that offers major benefits in freight train handling, car maintenance, fuel savings, and network capacity. Their use could significantly enhance rail safety and efficiency. With the present system (developed in the 1870s), freight train cars brake individually at the speed of the compressed air pressure moving from car to car in trains that are often well over a mile long. Compared with the potential performance of ECP brakes, this conventional braking system contributes to greater in-train forces, more complex train handling, longer stopping distances, and safety risks of prematurely depleting air brake reservoirs. Current train-handling procedures require anticipating draft (pulling) and buff (compressive) forces within the train, particularly on hilly terrain; and any misstep can result in derailment. Current brake systems are very complex and subject to failure, which is a maintenance challenge and a safety concern. These systems are prone to causing undesired emergency applications (UDEs), which can result in delays or even derailments. Current brakes can also stop functioning on individual cars en route without the locomotive engineer being aware of it.

These challenges and concerns are greatly reduced in the ECP brake mode of operation, during which all cars brake simultaneously by way of an electronic signal. ECP brake systems simultaneously apply and release freight car air brakes through a hardwired electronic pathway down the length of the train, and allow the engineer to "back off" or reduce the braking effort to match the track grade and curvature, without having to completely release the brakes. ECP brakes have the potential to save fuel and reduce emissions, reduce wear and stress on wheels and brake shoes, and greatly reduce the risk of runaway trains. ECP brakes provide shorter stopping distances, in the range of 40 to 60 percent, and greater control on the braking characteristics of trains. The safety benefits of ECP brakes include: fewer and less-severe collisions with obstacles on the railroad, including vehicles stuck on grade crossings; fewer and less-severe train-to-train collisions; reduced chances of runaway trains; and fewer train-handling accidents, including derailments. ECP brake wiring also provides the train a platform for the gradual addition of other train-performance monitoring devices using sensor-based technology to maintain a continuous feedback loop on the train's condition for the train crew.

Trains operating with ECP brakes have not been extensively implemented in the United States for various reasons. Primarily, many requirements of existing regulations are inapplicable to ECP brake-equipped trains, which is why FRA is pursuing this rulemaking. In addition to the regulatory challenges, ECP brakes represent a very extensive investment. Cost-effective applications will require "standalone" ECP brakes, which will have only limited compatibility with conventional brake systems. With more than 1 million freight cars and almost 30,000 locomotives that operate in the United States, the logistics of converting brake systems are challenging. ECP brakes are a major capital investment (approximately $7.4 billion[1] for all locomotives and cars). The majority of costs fall on rail car owners (most cars are privately owned by shippers or leasing companies); however, the majority of benefits are gained by railroads. This rule does not mandate a conversion to ECP brakes; it applies to railroads and car owners who voluntarily decide to implement this technology. Moving from conventional to ECP brakes will be logistically difficult. Eventually, all North American freight railroads will need to convert.

In the interest of safety, FRA commissioned a report by Booz Allen Hamilton (BAH) to describe a path to ECP brake implementation. A copy of this report has been placed in the public docket to this rulemaking at Docket Number FRA-2006-26175. The report suggests that ECP brake technology can return substantial private and public safety benefits. As applied to western coal service, the business case appears to be substantial, and ECP brake implementation in other market sectors appears plausible as the industry gains confidence. Significant capacity savings are associated with ECP brake-equipped trains because of their increased velocity. More than 90 percent of the total noncapacity-related savings from ECP brakes lie in three areas: fuel costs,

[1] Calculation: 22,779 locomotives ($48,000) = $ 1,093,392,000 locomotive costs. 1,312,245 freight cars ($4,800) = $ 6,298,776,000. $1,093,392,000 + $6,298,776,000 = $ 7,392,168,000.

wheel wear, and intermediate brake test elimination (regulatory adaptation). Preliminary financial analyses for the Powder River Basin (PRB) Implementation Plan (unit trains in dedicated service) indicate a 3-year payback, an internal rate of return of 47 percent, and a net present value of almost $700 million. ECP brakes have previously been tested and demonstrated in the United States, and they are currently used in revenue service by railroads in Canada, Australia, and South Africa. South Africa's Transnet Freight Rail (formerly Spoornet) has embraced ECP brake systems for its huge export coal operations, reporting a 23 percent savings in train energy consumption. Electronic monitoring on Transnet Freight Rail's ECP brake-equipped trains has increased capacity, reducing turn times by 9 percent. Growth in demand for United States coal and imported goods, coupled with motor carriers' limited ability to expand due to driver shortages and other factors, indicate that North American rail network congestion will be a major concern for the foreseeable future. ECP brake-equipped trains will move more efficiently with increased velocity, resulting in greater network capacity. Increased braking efficiency supports reduced train spacing and increased train speed.

To make ECP brake system implementation viable, the FRA rule provides the regulatory relief necessary to initiate investment in this technology. FRA believes that ECP brake system implementation would start where the benefits are clearest, on train sets that are usually kept together in operations, namely, unit and "unit-like"[2] trains. High-mileage, dedicated trains that produce a high percentage of traffic lend themselves to early conversion to ECP brakes. Once confidence is established, a transition by market sector should begin. Both the rail industry and FRA have studied ECP brake safety issues, and a substantial body of standards and analysis is already available.

FRA's rulemaking prescribes safety requirements for ECP brake-equipped trains and regulates the operation of ECP brake-equipped trains. As mentioned above, many existing regulatory requirements are inapplicable to these trains. The rule addresses acceptance of electronic systems using a performance-based approach. FRA is working with shippers and railroads to acquire data from initial implementations and validate the business case. Shippers will need reassurance that service will remain stable through the carrier's provision of ECP brake-equipped locomotives. Train crewmembers need training and experience to optimize use of this technology. The adoption of industry interchange standards that make new equipment ECP brake-ready (i.e., more easily and inexpensively converted) is critical. The Association of American Railroads (AAR) has already developed and adopted standards for ECP brake systems (AAR S-4200 Series Standards). FRA developed this regulatory analysis in accordance with Executive Order 12866. This document estimates the costs and consequences of the rulemaking, as well as its anticipated economic and safety benefits. A copy of this document has been placed in Docket Number FRA-2006-26175 for this rulemaking. The following is a summary of our findings.

FRA estimates that ECP brakes will be installed on cars and locomotives in unit and unit-like train service over a 10-year period. As noted previously, this rule is voluntary and does not mandate the use of ECP brakes. The time frame for this analysis is 20 years. Both costs and benefits are presented as totals and discounted at both 3 percent and 7 percent. The table below presents the estimated 20-year monetary costs associated with unit and unit-like train conversion

[2] Unit and unit-like train service is based on commodity groups and contains the same commodity.

to ECP brakes on unit trains. Unit and unit-like train traffic represents approximately 61 percent of carloads that originate in the United States.[3] This service provides the best rate of return and will most likely convert to ECP brakes.

Table 1: 20-Year Monetary Costs Associated with Unit and Unit-Like Conversion to ECP Brakes

Total 20-Year Costs and Discounted Costs (at 3% and 7%)			
	Costs	3% Discount	**7% Discount**
Freight Car Costs	$ 1,746,326,400	$ 1,467,957,882	**$ 1,186,425,904**
Locomotive Costs	$ 582,624,000	$ 489,752,370	**$ 395,825,320**
Employee Training	$ 231,470,835	$ 165,421,968	**$ 111,016,540**
Total Costs	$ 2,560,421,235	$ 2,123,132,220	**$ 1,693,267,764**

FRA's analysis determines that over a 20-year period, the discounted costs at 7 percent would be approximately $1.7 billion. The annualized costs are $142.7 million discounted at 3 percent and $159.8 million discounted at 7 percent.[4]

The parties that benefit from ECP brakes include: railroads, through more efficient operations; rail shippers and car owners, through improved asset utilization and service; railroad employees and the public, through improved safety on the railroad and by keeping shipments on the rails that would otherwise burden congested highways; and the national economy and the environment, through better utilization of fossil fuels and contributing to transportation capacity.

A major benefit of ECP brake use is improved velocity.[5] Because FRA estimates that only a portion of the fleet will be converted, velocity benefits may accrue on a corridor basis, not a network basis. It is reasonable to expect that a 1 mph gain in network velocity will be realized from avoidance of brake tests and the associated delays incurred by trains waiting for these tests. This analysis assumes ECP brake implementation on both the slowest (coal) and fastest (intermodal) trains on the system. This important network velocity benefit was noted in the analysis of the proposed rule, but was not previously included in the total benefit calculation.

The benefits resulting from the provisions of this rule are related to the regulatory relief provided in this rulemaking, enhanced safety, and business efficiencies. FRA specifically requested public comments on these benefits, and has responded to received comments, where appropriate, in this analysis. FRA intends to further quantify and verify benefits in a followup study of ECP brake implementation. FRA expects technology adopted under this rule to reduce fatalities, injuries, property and environmental damage, and associated train delays resulting from brake-related rail accidents. FRA calculated safety benefits in terms of the decline in the risk of certain accidents and their consequences based on our analysis of accident data. The following table summarizes the benefits associated with the implementation of ECP brakes.

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[3] "Freight Commodity Statistics," 2005, Association of American Railroads.

[4] Annualized estimates were determined using the following Office of Management and Budget's Excel formula: -PMT (discount rate, number of years, total present value estimate).

[5] According to the BAH report, an industrywide equipment savings of $2.5 billion may be realized from a 1 mph gain in network velocity. "Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry," Booz Allen Hamilton, August 2006, p. III-5.

Table 2: 20-Year Benefits Associated with Implementation of ECP Brakes

Total 20-Year Benefits and Discounted Benefits (at 3% and 7%)			
	Benefits	3% Discount	**7% Discount**
Highway-Rail Accident Risk Reduction	$ 25,802,114	$ 17,897,484	**$ 11,513,191**
Rail Equipment Accident Risk Reduction	$ 286,687,494	$ 198,859,081	**$ 127,923,151**
Environmental Cleanup Savings	$ 113,296,427	$ 78,587,395	**$ 50,554,127**
Track Out-of-Service Costs for Accidents	$10,825,104,763	$ 7,508,769,780	**$ 4,830,282,231**
Regulatory Relief	$ 2,283,662,829	$ 1,586,425,219	**$ 1,022,855,259**
Fuel Savings	$ 2,745,000,000	$ 1,904,052,986	**$ 1,224,849,552**
Wheel Replacement Savings	$ 1,601,250,000	$ 1,110,697,575	**$ 714,495,572**
Network Velocity Improvement of 1 mph	$ 2,500,000,000	$ 2,101,494,145	**$ 1,698,459,555**
Total Benefits	$ 20,380,803,627	$14,506,783,665	**$ 9,680,932,638**

FRA's analysis determines that over a 20-year period, the discounted benefits at 7 percent would be approximately $9.7 billion. The annualized benefits are $975.1 million discounted at 3 percent and $913.8 million discounted at 7 percent.[6]

Benefits were estimated by applying effectiveness rates to accident causation codes that may be affected by ECP brake technology. Probabilities based on accident histories were used to estimate the potential safety benefits of ECP brakes. The risk of an accident is assessed from a quantitative standpoint by valuing property damage and fatality and injury rates. The accident probability reduction is also associated with the reduction of environmental cleanup costs and track out-of-service costs.

FRA recognizes that the effectiveness of and, therefore, the benefits to be gained from the use of ECP brakes will vary by circumstances (e.g., train speed and length, track geometry, grade crossings, etc.). Benefit estimates were based on the reduction in risks of historical accidents recurring in the future. Forecasting the benefits that would likely result from the rule requires the exercise of judgment and necessarily includes subjective elements. The costs and benefits shown in the tables above represent our best estimate of the costs and benefits to be realized under the targeted application of ECP brakes to unit and unit-like trains.

[6] Annualized estimates were determined using the following Office of Management and Budget's Excel formula: -PMT(discount rate, number of years, total present value estimate).

The rule is estimated to cost approximately $1.7 billion present value (discounted at 7 percent) over the next 20 years ($2.1 billion discounted at 3 percent). The largest portion of these costs, $1.2 billion, is the cost to convert freight cars to ECP brake-equipped freight cars. This cost is followed by locomotive conversion costs of $396 million. The total benefits of the rule are approximately $9.7 billion present value (discounted at 7 percent) over the next 20 years ($14.5 billion discounted at 3 percent). The regulatory relief benefits of $1 billion and the fuel savings estimated at $1.2 billion more than pay the costs. The benefits of track out-of-service time reduction and velocity improvements make the overall case very strong. The expected benefits of ECP braking technology appear to justify the investment, based on the assumption that the high-mileage, unit and unit-like train services that would be the first to take advantage of the rulemaking since they would most benefit from its use. Any further implementation beyond this portion of the fleet is likely to have less impressive net benefits than the scenario analyzed; however, FRA believes that the case is likely to be strong for continued further implementation, especially as ECP brake manufacturers achieve economies of scale and the railroads gain experience with the new braking systems.

II. SUMMARY OF RULE

The rule provides regulatory relief; it does not mandate that railroads adopt ECP brake technology. Railroads that implement this technology are required to train their employees on the safe operation and maintenance of ECP brake equipment. Due to the logistical challenges of implementing this technology, regulatory relief is provided from current regulations so that ECP brake-equipped cars and locomotives can be brought into and out of service. The rule provides for movement of ECP brake equipment in non-ECP brake-equipped trains and non-ECP brake equipment in ECP brake-equipped trains.

The key features of the rule are:

- Relief from certain Class I (Title 49 Code of Federal Regulations (CFR) §§ 232.205(a) and (b)), Class IA (§ 232.207), and Class II (§ 232.209) required brake inspections when the train is equipped with an ECP brake system and operating in ECP brake mode.
- Allowing more flexibility regarding the addition of cars to a train, including the ability to dispatch trains with only 95 percent operative brakes and increasing the time a car can be off air before another brake test has to be performed from 4 hours to 24 hours.
- Flexibility in the handling and tagging of defective equipment with ECP brakes.

The railroad industry in the United States consists of more than 500 companies. Of these, 39 are Class I and Class II (regional) rail carriers.[7] Seven privately owned, major freight railroad systems are referred to as Class I railroads. These Class I railroads account for 71 percent of the industry's mileage operated, 89 percent of its employees, and 93 percent of the industry's total freight revenue.[8] The remainder of the privately owned rail system is comprised of 32 regional

[7] Class I railroads, as designated by the Surface Transportation Board, are those railroads with operating revenues of $272 million or more. Regional railroads, referred to as Class II, are those with at least 350 route-miles and/or revenue of between $40 million and the Class I threshold.
[8] "Overview of United States Freight Railroads," AAR Policy and Economics Department, February 2005, p.1.

and more than 500 local (shortline or switching and terminal) railroads. For the purpose of this analysis, the regional railroads are referred to as Class II, and all smaller railroads are referred to as Class III. All rail carriers are eligible for regulatory relief in the rule; however, the base assumption for this analysis is that only four Class I carriers will initially implement ECP brake technology.

Table 3: Rail Carriers Eligible for Regulatory Relief in the Rule

Number of Rail Carriers by Size
39 large entities
520 small entities
559 total

A. Background

The AAR first investigated advanced braking concepts for freight railroads in 1990. Over the past 18 years, ECP brake technology has progressed rapidly and has been field tested on revenue freight trains since 1995 on various railroads.

FRA has been an active and consistent advocate of ECP brake system implementation. In 1997, FRA participated in an AAR initiative to develop ECP brake standards. In 1999, FRA funded, through the Transportation Technology Center, Inc. (TTCI), "Failure Modes, Effects, and Criticality Analysis" of ECP brake systems based on the AAR standards. FRA also participated in programs to develop and enhance advanced components for ECP brake systems.

During this period, however, FRA did not initiate regulatory actions affecting ECP brake technology. The development and application of ECP brake technology remained the sole responsibility of the brake suppliers and the railroads. Railroad industry progress in implementing ECP brake technology slowed down due to difficulties in identifying an optimal implementation strategy and justifying the required investment.

In 2005, FRA identified the need for regulatory support to reenergize ECP brake technology interest and implementation. FRA moved to assess industry readiness and the effectiveness of ECP brake technology. It contracted with BAH, a major consulting firm, to assess the ECP brake technology costs, benefits, and implementation strategies. BAH identified and estimated the costs and benefits from ECP brake implementation. While the cost of implementation was $40,000 per locomotive and $4,000 to retrofit a car[9], BAH noted that brake manufacturers currently do not expect there to be any significant difference in maintenance costs between ECP brake systems and non-ECP brake systems. BAH also identified benefits that were realized by Quebec Cartier Mining and Transnet Freight Rail following ECP brake implementation on their respective rail systems. These included: 1) reduced fuel consumption, 2) reduced annual

[9] These costs were used in the Booz Allen Hamilton ECP brake report. The costs used in this analysis are $48,000 per locomotive and $4,800 per car.

expenditures for wheel replacement and brake shoes, and 3) increased capacity resulting from improved train velocity and better asset utilization. While implementation on a United States railroad would include the same benefits, BAH also identified benefits that could come if FRA adopted some form of regulatory relief for ECP brake-equipped trains. Most notably, the study identified the elimination of the 1,000-mile intermediate terminal brake test (1,500 miles for extended haul) as a regulation that could be relaxed to afford relief without compromising safety. FRA agreed with this conclusion. As BAH discussed, such relief would improve train transit times, but it could also improve rail reliability, thereby reducing shipper logistical costs. The BAH study[10] released in 2006 identified and quantified significant business benefits that could be realized with this technology through greater operational efficiencies, and suggested a migration plan that would start with unit train operations, logistically focused initially on the PRB coal service. Since then, FRA has been working with the AAR, railroads, vendors, and the coal sector to generate momentum toward implementing this cost-saving, and potentially life-saving, technology.

After a thorough analysis of the current state of ECP brake technology and the results of the numerous studies and initiatives mentioned above, FRA concluded that the industry is ready to implement ECP brake technology. Therefore, FRA is proceeding with this rulemaking to regulate and support industry conversion to ECP brakes. FRA's current ECP brake rulemaking activity is a timely and adequate response to the industry's needs and should facilitate the introduction and widespread application of ECP brake technology.

B. Comments and Changes on the Analysis of Proposed Rule

FRA received comments in response to its initial ECP Brake Regulatory Analysis, but did not make any changes to this final regulatory analysis in response to comments relating to training, scope, fuel savings, wheels, and train accident costs and benefits. Despite a labor union's claim that the estimated training costs were too high, they were, in fact, substantiated by one railroad's 3-day training session. While the scope of FRA's analysis includes all unit trains, AAR opined that the scope should include only the subset of PRB coal cars and locomotives. However, the existing analysis remains, since FRA is aware of at least one intermodal operation likely to use ECP brakes in 2008 and six non-PRB coal trains that are currently using ECP brakes.

Additionally, comments were received regarding the estimate of unit commodities traffic. After reviewing the comments and the data, FRA determined that the proposed estimate was only for originating traffic. In an effort to determine the percentage of traffic that is unit train traffic, FRA included returning empty trains in its estimate. For example, coal trains operate with empty cars on the outgoing trip from a power plant to pick up coal and then with loaded cars on the return trip to deliver the coal to the power plant. Potential safety risks are not changed if the train is empty or loaded; exposure remains the same. While AAR estimates a 3 percent fuel savings, FRA retains the 5 percent fuel savings estimate since it is conservative and was developed in light of overseas experience. Relying on a TTCI report from the 1990s, AAR also suggests a 20 percent wheels savings and a 10–30 percent train accidents savings. However, FRA has utilized the unbiased BAH report and in-house experts to reach the estimates in the

[10] "ECP Brake System for Freight Service," Booz Allen Hamilton, August, 2006.

initial regulatory analysis and FRA continues to rely on that more up-to-date and substantiated information.

FRA made changes to this final regulatory analysis based on comments relating to "set-out" benefits. The analysis of the proposed rule used a 50 percent estimate for the number of times a car must be set out en route for the purpose of repair. FRA estimated that for ECP brake-equipped trains that travel 3,500 miles, 50 percent of them would not have to set out cars for repair. (Under the rule, cars with defective brakes may continue in the train to destination for repairs.) The logic used for the analysis of the proposed rule was that the trains will go almost five times the distance (5 x 750 miles = 3,750 miles) and the 10 percent set-out frequency was multiplied by five to get 50 percent. The former estimate was based solely on distance, but based on the number of train starts, the AAR estimates 0.5 percent. Extending crew starts over the maximum 3,500 miles between ECP brake inspections would suggest that about 10 percent, not 50 percent, of such long-haul trains may experience an equipment set-out.[11] However, FRA finds that because ECP brake-operated trains travel longer distances (up to 3,500 miles) than non-ECP brake-operated trains (750 mile average), a 20 percent set-out rate is appropriate for brake-related defects in this final analysis. The 20 percent set-out rate captures not only the 10 percent for train starts, but also an additional 10 percent for the increased mileage that ECP brake-operated trains are allowed to travel. The total reduction in regulatory relief benefits is $90 million.[12]

The largest change in the benefits is the inclusion of track out-of-service time benefits. This time savings occurs when an accident that blocks the track is avoided. FRA requested comments on track out-of-service time savings and noted its intent to include such benefits in the analysis of the final rule; however, no comments were received. FRA has estimated the value of track out-of-service time due to an accident using methodology explained in Appendix C. The new value of track out-of-service time was added to the benefits, which significantly increased the safety benefits by $4.8 billion.

Another significant change in the analysis is the inclusion of velocity benefits. These benefits were presented in the analysis of the proposed rule, but not included in the total amount of benefits because forecasts were not available at that time. These estimates were calculated by an independent party,[13] presented with the benefits in the analysis of the proposed rule, and FRA did not receive comments or evidence indicating anything to the contrary. Initial ECP brake implementation on limited routes has demonstrated velocity improvements on ECP brake operated trains. Velocity benefits are calculated in terms of equipment savings (i.e., improved asset utilization); less equipment is needed to haul the same amount of commodities when moved faster. The slowest moving commodity by train is coal, which makes up 23.6 percent of carloads originated by commodity. The only commodity with more carloads originated than coal is intermodal traffic, which accounts for 26.9 percent of carloads originated by commodity. The coal and intermodal commodity groups together account for half of the total carloads

[11] "AAR Comments on FRA Regulatory Impact Analysis Electronically Controlled Pneumatic Brake Systems," Docket Number FRA-2006-26175, November 5, 2007, p.3.
[12] Calculation: $192,834,490 - $102,845,035 = $ 89,989,455.
[13] "ECP Brake System for Freight Service," Booz Allen Hamilton, August 2006.

originated.[14] Both coal and intermodal trains are assumed to implement ECP brakes in this analysis, in addition to other commodities.

Initial implementation suggests a reduction in cycle times for coal trains to move coal from the mine to load coal and back to the power plant to deliver the coal. These cycle times can be reduced by 10–20 percent with ECP brakes. Coal and intermodal trains benefit from increases to average train speed. This is possible because of the time savings gained by the reduction of brake tests and the associated queue time waiting for the brake tests, time spent placing a train in a siding or a yard to perform the test, wait time for employees to arrive to perform the test, time spent with no sets, time spent waiting for new train crews to arrive, yard and facility capacity issues and delays, and the reduction in coal loading times. The average train speed for coal trains by railroad ranges from 15.5 mph to 19.6 mph, the slowest of all commodities. The fastest of all commodities is intermodal, whose speed ranges from 25.7 mph to 33.7 mph. This analysis assumes implementation on trains transporting both of these commodities. If both the slowest and the highest speeds are increased, the average velocity will also increase, if all else remains equal. The train speed for all trains ranges from 20.4 mph to 23.2 mph. Based on the above, FRA conservatively estimates a 1 mph increase in average system velocity, and the resulting benefits of $2.5 billion, or $1.7 billion once discounted by 7 percent.[15]

The U.S. Department of Transportation (DOT) has adjusted the value of a statistical life from $3 million to $5.8 million, with appropriate alternatives presented in the sensitivity analysis. The value of injuries is directly related to the value of life and has increased accordingly. This has increased safety benefits used in the NPRM by approximately $31 million present value (PV). Similarly, FRA has updated the hourly wage burden on wages from 40 to 75 percent to better reflect current industry practice after careful consideration of industry comments submitted prior to this rulemaking. The burdened labor rate used in the proposed rule analysis was $35.95 ($25.68 X 1.4 = $35.95), and the labor rates used in this final analysis are $40.40 for maintenance employees and $44.04 for engineers. The labor rate increase affects the training costs in this analysis. Accordingly, the training costs have increased from $96,152,211 in the proposed rule analysis to $111,018,983 in this final analysis (both discounted 7 percent), an increase of approximately $15 million. Initial ECP brake implementation indicated that the locomotive and car costs were too low. The previous cost per car was $4,000 and the new cost per car used in this analysis is $4,800. This increases the costs of freight cars from $1,022,122,156 to $1,186,425,904 (both discounted at 7 percent), an increase of approximately $164 million. The previous cost per locomotive was $40,000 and the new cost per locomotive

[14] "Railroad Facts," 2007 edition, pp.25, 29. Calculations: coal: 7,574,000 carloads / 32,114,000 total 2006 carloads = 23.6%; intermodal: 8,636,000 carloads / 32,114,000 total 2006 carloads = 26.9%. Coal carloads (23.6%) + intermodal carloads (26.9%) = 50.5%.

[15] Increases in system velocity will derive from two general effects. As explained, ECP brake unit trains will experience shorter periods en route as a result of avoiding unnecessary tests and inspections, translating into better utilization of ECP brake-equipped rolling stock and reducing the investment required to transport the same amount of lading. In addition, in some cases the superior braking characteristics of ECP brake trains will permit railroads to assign them higher maximum authorized speeds within existing signal blocks. To the extent the trains in question would otherwise be the slowest trains over the corridor, as is often the case with unit coal trains, the differential between the actual achieved speeds of the various train types will be reduced, and traffic flows over the corridor should increase in velocity. This second benefit will accrue to both ECP braked *and conventionally-braked trains* as ECP brake trains become more common in the traffic mix on capacity-constrained corridors. FRA has considered both effects in conservatively estimating a 1 mph increase in overall system velocity.

used in this analysis is $48,000. The cost of locomotives has increased $55 million from $341,008,931 to $395,825,320. Total increased costs in this final analysis are approximately $234 million ($15m training + $164m freight cars + $55m locomotives).

Final Rule vs. NPRM Total 20-Year Discounted Benefits (at7%)		
	Final 7% Discount	**NPRM 7% Discount**
Highway-Rail Accident Risk Reduction	$ 11,513,191	$ 6,263,034
Rail Equipment Accident Risk Reduction	$ 127,923,151	$ 101,783,196
Environmental Cleanup Savings	$ 50,554,127	Not included
Track Out-of-Service Time	$ 4,830,282,231	Not included
Regulatory Relief	$ 1,022,855,259	$ 1,112,844,715
Fuel Savings	$ 1,224,849,552	$ 1,224,849,552
Wheel Replacement Savings	$ 714,495,572	$ 714,495,572
Velocity Benefits	$ 1,698,459,555	Not included
Total Benefits	$ 9,680,932,638	$ 3,160,236,069

Final Rule vs. NPRM Total 20-Year Discounted Costs (at 7%)		
	Final 7% Discount	**NPRM 7% Discount**
Freight Car Costs	$1,186,425,904	$ 1,022,122,156
Locomotive Costs	$395,825,320	$ 341,008,931
Employee Training	$111,016,540	$ 96,152,211
Total Costs	$1,693,267,764	$ 1,459,283,298

C. Assumptions

This analysis has a foundation based on certain data, estimates, and assumptions. Unless otherwise noted, the following assumptions apply to this analysis and all attached documents.

- An initial 10-year implementation will occur only on unit and unit-like train service.
- Unit and unit-like train service includes the following commodities: coal, grain, intermodal[16] containers, motor vehicle parts, ore, and nonmetallic minerals.
- The unit-like commodities represent 62 percent of freight carloads originated (including empty unit train back hauls) on U.S. Class I railroads and 61 percent of all U.S. carloads originated. This data is based on "Freight Commodity Statistics 2005," an annual publication identifying gross freight revenues, tonnage, and carloads up to the 5-digit Standard Transportation Commodity Code (STCC) level for Class I railroads.
- Only four U.S. Class I railroads currently operate extended haul trains. Both the private and social net benefits appear to be greatest on unit and unit-like trains operating over

[16] Intermodal is freight traffic that moves over more than one transportation mode between shipper and consignee. The miscellaneous mixed shipments category (STCC 46) is mostly intermodal traffic. Some intermodal traffic is also included in commodity-specific categories.

longer distances. The statistics are for these railroads only, which account for the majority of U.S. rail freight activity.

- FRA estimates that approximately 1,312,245 freight rail cars are in service in the United States. Of this group, 363,818 potentially operate in unit and unit-like consists.
- FRA estimates that after the final rule is effective, all new cars in unit and unit-like train service will be "ECP ready," thus reducing the cost to retrofit cars.
- FRA estimates that there are 21,125 locomotives in service on U.S. Class I railroads, of which approximately 38 percent, or 8,092,[17] are used in unit and unit-like service.
- The time horizon for the analysis is 20 years.
- All dollars are estimated for the year 2005, unless otherwise noted.
- All findings in this analysis are rounded to the nearest dollar.
- Because costs and benefits accrue in different years, discount rates are applied to future benefits and costs. Two discount rates are used, 3 percent and 7 percent. The discount rate of 7 percent represents the before-tax rate of return to private capital in the U.S. economy, and is emphasized in this analysis.

D. Need for Regulatory Action

In order to take full advantage of the unique characteristics of ECP brake systems, the rule requires railroads using freight trains and cars equipped with ECP brake technology to amend their current operating rules and training programs accordingly for inspection and operating personnel. Additionally, the rule provides regulatory relief from various existing inspection, testing, and maintenance requirements while providing alternative inspection, testing, and maintenance requirements more applicable to ECP brake systems. The regulatory relief provides an incentive for the private sector to invest in ECP brake technology, while simultaneously maintaining safety. A Federal regulation is needed to provide this regulatory relief. While portions of the current regulations would still apply to ECP brake technology, the current Federal regulations governing brake systems were put in place without fully developing provisions related to ECP braking technology. Therefore, the advancement in technology requires the formation of new policies.

1. Market Failure and Regulatory Incompatibility

Executive Order 12866 requires that all new Federal regulations specify the market failure or other specific problem that is addressed by the rulemaking. A market failure occurs when the market fails to allocate scarce resources to their highest-valued uses.

This can occur for several reasons, such as market power, externality, or information problems. (Office of Management and Budget Circular A-4 describes each of these in detail. See http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf). Normally in competitive markets,

[17] Costs are estimated using 12,138 locomotives, which equals 1.5 times 8,092 locomotives. Minor differences in calculations may occur because of rounding.

exchanges between self-interested buyers and sellers allocate resources to their highest-valued uses. To a certain extent, the market for railroad safety is working. In the absence of Federal regulation, railroads certainly have a private incentive to develop and maintain robust braking systems, as they would suffer the majority of the consequences of any safety accident or incident. In the case of ECP braking systems, where the business case and safety benefits appear to be substantially greater than the costs for the types of unit services studied in this analysis, one might expect fleet penetration to eventually rise to near 100 percent, absent some market failure. If, however, a substantial share of those benefits accrue to individuals other than the owners of ECP brake equipment, then it is conceivable that the purchaser of the equipment might (correctly) not expect private benefits sufficient to justify the expense, especially in the types of services where the business case for these systems is less clear. For example, some of the benefits of avoiding derailments or other accidents, or avoiding time delays due to accidents, are conferred on other trains, motor vehicles, or other individuals. These would constitute “external” benefits that would not be felt by the owner of the equipment. Under such circumstances, the market could yield fewer than the optimal number of ECP brake-equipped trains, and regulation could be justified.

In addition, as discussed previously and in more detail below, current regulations are somewhat incompatible with the widespread deployment of ECP braking systems. FRA has recognized this incompatibility and is therefore proposing regulatory relief as part of this rulemaking.

Although railroad safety has generally improved in recent years, brake-related accidents continue to be a source of fatalities, injuries, hazardous material releases, evacuations, and significant property damage and delays. These accidents have been caused by a variety of factors, including the blockage of train brake pipe lines, worn or broken brake components, insufficient or inaccurate train-handling information, and improper inspection and maintenance.

One particular area where the safety externalities may be of significant concern is coal transportation. The demand for coal in the United States has recently increased. When there is a delay in coal delivery to power plants, the plants must increase the sizes of their inventories and, therefore, increase their costs. If a delay is not anticipated and the reserve coal inventory runs out, power plants must, if they are able, switch to higher priced gas to generate electricity. These higher prices are passed directly to the consumer in higher electric bills. The seasonal demands of electric utility customers and the manufactured products are what drive the demand for coal nationwide. Coal production in the United States is driven by the PRB, which is the largest coal-producing region, accounting for approximately 40 percent of all coal mined in the country.[18] The PRB is the source of reasonably priced, low-sulfur coal for all electric utilities. In the United States today, coal demand is driven by the electric power sector, which accounts for 90 percent of consumption, compared with the 19 percent it represented in 1950. As demand for electricity grew, demand for coal to generate it rose and resulted in increasing coal production.[19] Many electric utilities are located far from the mine and receive several hundred cars of coal a week by train. The increased coal demand, however, has not been met by the railroads in a robust, low-cost way. Currently, major rail lines are near full capacity; therefore, the external

[18] Data are based on Energy Information Administration data.
[19] “Coal Production in the United States – An Historical Overview,” Energy Information Administration, October 2006.

costs of an accident, especially in terms of delay on these crowded lines, may be substantial in coal transportation. If an accident occurs on a major route, the delay may cost millions. Owners of the equipment are not necessarily fully burdened by the delay costs, so they don't have incentive to warrant any voluntary change on their part.

The majority of coal in the United States is moved by railroads exclusively or in multimodal service with another method of transportation. The recurring problems that the coal industry typically deals with had varying impacts on coal production in 2005. Although many of these issues were related to weather, environmental issues, legal challenges, and global economics, the overriding issue for the U.S. coal industry in 2005 was the transportation of coal from mines to consumers. The one transportation issue that most affected the coal industry in 2005 was the disruption of rail traffic from the PRB due to track maintenance. In mid-May 2005, there were two train derailments on the southern PRB joint line, caused in part by severe weather and coal dust on the rails. This resulted in an extensive program of track repair and replacement that affected the ability of mines in the area to ship coal to consumers throughout the country. After the train derailments in May 2005, PRB coal production in Wyoming and Montana was curtailed for approximately 2 months, returning to prederailment levels by July 2005. Although production began increasing after this date, electric utilities in the Midwest continued to experience problems with deliveries through spring 2006.[20] These derailments reverberated throughout all aspects of the coal industry. Several consumers experienced major disruptions in coal shipments, which then resulted in precariously low stock levels and led to a major scramble to find other sources of coal to help ease the situation. The Union Pacific Railroad (UP) instituted an embargo on new southern PRB business and the spot market price of PRB coal hit record levels in the latter part of 2005. The electric power sector (electric utilities and independent power producers) is the driving force for all coal consumption, accounting for about 92 percent of all coal consumed in the United States[21] Coal continues to be the largest source of power generation in the United States.

Limited rail capacity serving the PRB market is causing railroads to fail to deliver the contracted amount of coal to some consumers. In 2005, PRB coal was delivered to electric utilities and independent power producers in 36 states, including Wyoming. The challenges of getting coal to all consumers exist even when there are no disruptions in the production and distribution systems. Changes in velocity or average train speed indicate whether or not railroads are improving their capability to meet expected delivery schedules. Delays in coal distribution have been a significant source of concern. Arch Coal, Inc., the second largest U.S. coal producer, reported that railroad delays and missed shipments, along with curtailed production due to flooding in Central Appalachia, cost the company $8 million in the second quarter of 2004.[22]

One of the potentially most significant benefits of conversion of main-line corridors to all-ECP brake service is enhanced capacity without the need for major new equipment or infrastructure investment. According to the BAH report on the ECP brake system for freight service, focusing

[20] "Deliveries of Coal From the Powder River Basin: Recent Events and Trends," Infrastructure Security and Energy Restoration, Office of Electricity Delivery and Energy Reliability, United States Department of Energy, 2006.
[21] United States Coal Supply and Demand 2005 Review, Fred Freme, Energy Information Administration, United States Department of Energy.
[22] Coal News and Markets, Week of September 26, 2004, Energy Information Administration.

ECP brake system implementation in the PRB makes both economic and practical sense. PRB coal represented an estimated 26 percent of total Class I revenue ton-miles in 2004, more than a quarter of all rail traffic.[23]

The following chart summarizes the report's quantifiable costs and benefits for the PRB.[24]

Preliminary financials for the PRB Implementation Plan indicate a 3-year payback, an IRR of 47%, and an NPV of almost $700 million

One-Time Costs	Amount ($ million)	Annual Benefits	Amount ($ million)
Locomotive Conversion @ $40,000 per unit	112	Fuel Savings	78
Freight Car Conversion @ $4,000 per car	320	Reduced Wheel Defects	45
		Brake Inspection Savings	45
		Brake Shoe Savings	2
Total	**432**	**Total**	**170**

Source: Booz Allen analysis, using a discount rate of 12%

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This regulation improves market efficiency by providing reliable and suitable standards and procedures that support investments in ECP brake technology. The efficiencies gained through this technology improve the efficiency of the entire market. ECP brakes can improve the overall capacity and relieve congestion in the PRB market. The additional safety improvements[25] achieved through the use of ECP brakes reduces the risk of future derailments that place additional constraints on the coal market.

a. ECP Brake Technology Market Maturity

The U.S. market for ECP brake systems is mature enough to begin implementation of ECP brake technology. The equipment manufacturers have already made a significant investment in the technology and have completed the preliminary design work and field testing of ECP brakes. A commitment by the railroad industry to change over to ECP brakes is necessary to inspire additional technological initiatives by the manufacturers.

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[23] Based on 1.66 trillion revenue ton-miles in 2004.

[24] This analysis uses 3 and 7 percent discount rates, while the costs and benefits shown for the PRB use a 12 percent discount rate. The costs used in the Booz Allen Hamilton ECP brake report were $40,000 per locomotive and $4,000 per car. The costs used in this analysis are $48,000 per locomotive and $4,800 per car.

[25] The additional train-handling benefits of ECP brakes are discussed further in section II. D. Safety Advantages of ECP Brakes, and the Benefit Estimates section (V. E. 2. b. Rail Equipment Accident/Incident Safety Benefits).

The ECP brake systems available from two U.S. suppliers can be characterized as being built with the intention of compliance with AAR standards, proven safe through field testing, designed using fail-safe principles, and accommodating the industry's need for different implementation schemes. The ECP brake systems manufactured by both suppliers have been tested in revenue service. There is no evidence of a malfunctioning ECP brake system that resulted in a catastrophic or critical event.

The suppliers' equipment relies on the conventional pneumatic emergency brake system as a backup in case of failure of the ECP brake control. Therefore, the ECP brake system does not diminish safety compared to the current safety level of conventional pneumatic brakes. In most cases, ECP brake systems support enhanced safety even if the electronics fail, because continuous recharging of the brake pipe ensures availability of an emergency application.

2. Improve the Safety of the Public

a. Technological Safety Advantages of ECP Brakes vs. Conventional Pneumatic Brakes

The technical concept of ECP brakes is significantly more advanced than that of conventional pneumatic brakes and offers significant improvement in the safety of train operation. Research and deployment experience has shown that ECP brake systems that comply with AAR Standard S-4200 are significantly safer than conventional pneumatic brakes. The main advantage that ECP brake systems have over conventional pneumatic brake systems is that ECP brakes do not use the brake pipe as a signaling medium for commanding a brake application or release. ECP brake systems use an independent electrical communication cable to control the brakes on each car in the train. Such control command configuration is technologically superior to the brake pipe command signal. The ECP brake electrical communication cable can provide accurate and instantaneous brake commands throughout the train, whereas the conventional pneumatic brake pipe signal is slow to propagate from the front of the train to the rear car. However, the two-way end-of-train (EOT) device used as part of the conventional brake system allows for an emergency brake application to be implemented from the rear of the train.

The ECP brake cable-based brake system design concept provides significant safety advantages:

- Instantaneous application of the brakes results in shorter stopping distances, lower in-train forces, and overall improved train handling.
- The stability of the electrical command signal supports graduated application and release of the brakes, which leads to improved train handling and better train operations on grades.
- Continuous brake pipe charging ensures that full brake capacity is available at all times.
- Continuous self-diagnostics of the car-mounted brake system provides real-time brake fault indication to the locomotive engineer.
- The electric communications cable can be multiplexed to provide a platform for establishing additional train management controls including distributed power management, activation and release of handbrakes, hot box detection, etc.; all of these potential features increase the reliability and safety of freight train operation.

ECP brake systems also eliminate some of the undesirable characteristics of conventional pneumatic brake systems that can lead to accidents, including depletion of air from the brake pipe, undesired emergency applications, and sticking brakes. Air pressure reduction in a brake pipe, as a means of initiating braking, was a good concept when air brakes were first developed in the 19th century. Today, however, propagating a brake command signal through the brake pipe is the main limitation of conventional pneumatic brakes. The same brake pipe air used to propagate brake commands also charges reservoirs on each freight car. The brake pipe must be fully charged to restore full braking capacity. Partially depleted air from the brake pipe, which occurs during initial braking, prohibits repeat applications of brakes until the brake pipe can be fully recharged. The brake pipe can only be charged when the brakes are fully released. This characteristic of conventional pneumatic brakes can jeopardize the safe stopping of a train, particularly on steep grades. Constant charging of brake reservoirs is possible using ECP brakes because, under normal conditions, the brake pipe acts exclusively as the brake reservoir supply pipe. The brake application is signaled electrically, and not by reducing brake pipe pressure. Therefore, the brake pipe can continuously supply the reservoirs. Conventional air brakes cannot be charged unless they are released. This causes operational issues when traversing a heavy grade where brakes cannot be released without losing control of the train. In the case of ECP brakes, reservoirs are always charged regardless of whether the air brakes are applied or released.

Improved train handling due to brakes being applied evenly and simultaneously, reduces the risk of derailments caused by in-train forces, also referred to as “draft” (stretching) forces and “buff” (compressive) forces within the train. With conventional brake technology, the first cars in the train (the cars at the head of the train) begin to brake first, then braking is initiated progressively back through the train. If braking is not performed carefully, the cars in the rear of the train run in as the slack adjusts (compressing the train). This condition could cause excessive forces that could cause a car to derail. Starting or stopping trains too fast can also cause excessive in-train forces. Excessive train forces can cause a train to separate, cause a rail to turn over, or cause a car to climb over the head of the rail. For example, trains operating in territory with rolling hills can experience significant draft and buff force peaks at virtually any point in the train, which, if they become high enough to overcome the forces holding the train on the track, can lead to derailments.[26] ECP brake systems also control the brake application rate. Once the car receives the brake signal, air pressure is applied to the cylinder at a controlled rate so that all cars in the train have the same brake cylinder pressure at any point in time during the buildup. This further reduces in-train forces caused by differences in braking effort during cylinder pressure buildup.

Train braking is accomplished by dynamic braking, by use of the automatic brake, and by use of the independent brake. Dynamic braking is a process by which the traction motors are electrically converted to generators. The current they develop is then dissipated through resistor grids. Because dynamic brakes are only present on locomotives, the retarding force usually starts from the head end of a train.[27] Steady state forces are those that are applied for a relatively long period of time such as the pull up of a grade or the compressive forces of descending a grade under dynamic braking. The automatic brake is applied by the operation of a brake valve in the locomotive and controls the application and release of brake shoes against the wheels of a train. Once automatic brakes are applied, retardation is applied to each individual car and there is no steady state concentration of braking forces in the train.[28] The independent brake controls brake applications on the locomotive only. As with dynamic braking, use of the independent brake causes retardation forces to concentrate at the front of the train.

High steady state forces can cause three problems. One problem is train separation when the train breaks in two. Another problem is "stringlining," where the pull of the locomotive through a curve combined with the resistance of heavy trailing tonnage (cars) stretches the train into a straight line and derails on the inside of the curve. A third is buckling (the opposite of string-lining), which occurs when a braking locomotive, combined with the push of momentum from heavy trailing tonnage rail cars, causes the cars to jackknife and derail. ECP brake-equipped cars practically eliminate this risk by braking simultaneously so that slack run-in is minimized or eliminated.

ECP brakes are also easier to operate than conventional brakes, and therefore reduce the chance of engineer error. Operating a train with conventional brake technology is a complex task, requiring extensive knowledge and experiences with various types of trains, knowledge of the rail line over which the train is running, and constant preplanning of train speed and braking options several miles ahead. Because of the slow application and release times for conventional braking, engineers must plan their moves well in advance. On grades, the locomotive engineer is constantly watching gauges, monitoring speed, air brake pressure, and dynamic brake effort, to control train speed. On level track, the locomotive engineer must use proper train-handling techniques to ensure that the train can stop short of a red signal before entering a track that

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[26] 'Safe Placement of Train Cars: A Report,' United States Department of Transportation, Federal Railroad Administration, June 2005, pp. 4-8.

[27] Where midtrain auxiliary power is used, the forces from dynamic braking will "spike" behind each set of locomotives and where a rear pusher locomotive stays on a train as it moves down the crest of a hill, the effect of its braking action, whether dynamic or not, will tend to slack ahead of the locomotive.

[28] Brake application is not instantaneous throughout the train because the air "signal" that moves down the brake pipe travels at the speed of sound, rather than the speed of light (the way an electric signal does). The signal can take more than 1 minute to travel the length of a 100-car train. While the brakes are applying, forces tend to concentrate at the head of the train, although midtrain power, helper engines, and two-way EOT brake devices, each of which can initiate a brake application from its location, are able to establish steady-state braking significantly faster than with head-end power alone.

another train is occupying. The engineer is constantly making judgments on how much brake pressure to apply. The brake application process is simplified with ECP brakes because ECP brake effort can be decreased at will with graduated release. The engineer does not need to worry about applying too much braking effort, because he can partially reduce the brake effort at any time.

Graduated release is an important feature for long freight trains using ECP brakes. Graduated release is the ability to reduce the brakes to a lower braking level after making a brake application. Graduated release makes it possible to adjust the braking effort to the exact level required to follow the safe speed limits. When using conventional brakes, the locomotive engineer cannot reduce the braking level without completely releasing and resetting the brakes, which can only be done safely at very low speeds. In many cases, this leads to a forced stop. The characteristics of the conventional brake system may lead to the locomotive engineer making less of a brake application than needed because it is always possible to add more brake cylinder pressure, but not to reduce it once applied.[29]

Reduction of undesired emergency applications (UDEs) is another significant benefit of ECP brake technology. UDEs can occur randomly, forcing the braking system into emergency. When the system goes into emergency, engineers have no control over the situation and in-train forces can cause derailments. Even when UDEs do not result in derailment, they can introduce significant delays in train operations on capacity-constrained lines, as the crew walks the train to inspect for damage and recharges the brake pipe. UDEs are virtually eliminated using ECP brakes. Conventional pneumatic brake valves rely on the use of springs and diaphragms against air pressure to move the internal valves of their seats and/or move brass slide valves to control and initiate brake functions, whether it be a desired brake application/release or an undesired brake application. Movement of the internal valves within the pneumatic brake valve can occur because of weak springs, train dynamics, or the inertia of gravity and in-train forces. Valve movement can cause an undesired emergency brake application. In-train forces can also cause the brake pipe pressure to vary enough to move the springs and valves off the valve seat, thus resulting in an undesired emergency. The ECP system uses pressure transducers to regulate and modulate the air pressure to the car's brake cylinder, thereby eliminating the springs and diaphragms that contribute to UDEs. Also, because the ECP system does not use the brake pipe pressure as the means to transmit the signal for brake functions, that variable is also eliminated as a cause for UDEs.

b. Safety Advantages of ECP Brakes

The associated safety advantages of ECP brakes are:

Shorter stopping distances: Instantaneous application of brakes on all cars of the train leads to a significant reduction in brake stopping distances (from 40 percent to 60 percent for the longest trains). The locomotive engineer is able to operate the train with more brake control. Simultaneous braking of all cars reduces the in-train forces and avoids damage or premature wear of brake system elements and car components. Lower in-train forces reduce lading

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[29] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006.

damage. Also, the consequences of a collision or derailment are reduced because the brake system can potentially reduce the collision speed or slow the nonderailed portion of the train.

Graduated brake release: ECP brake systems overcome a major conventional pneumatic brake deficiency by allowing the engineer to reduce braking effort to a lower level after making an initial application. Conventional pneumatic air brakes can only be operated in direct release. Direct release means that after a brake application, brake effort can be increased but not decreased without fully releasing the brakes. ECP brake systems operate in graduated release and have the ability to decrease the brake application level without the necessity of fully releasing the brakes. This feature enables the engineer to accurately adjust the braking level to operate at speed limits. Graduated release is especially important when operating on steep grades or undulating terrain. It eliminates the need to bring a train to a full stop if the engineer has made too much brake application.

Continuous brake pipe charging: Since ECP brakes do not use the brake pipe as a brake command medium, the brake pipe is constantly being charged. This feature allows the locomotive engineer to operate the brake system without concern for the state of charge of the brake pipe. Full brake capacity is available at all times, which enhances brake performance and avoids the danger of depleted air, which can occur with conventional pneumatic brakes. With ECP brake systems, there is no need to apply hand brakes on steep grades to recharge the brake pipe.

Diagnostics and self-tests: The use of an electrical communication cable allows real-time self-diagnostic functions to be incorporated in the brake system. The initial check of brake system conditions on each car, and continuous monitoring of each car's braking functions, provides the locomotive engineer immediate notice of any brake failure. 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.

Additional train management controls: The electrical communication cable network can also serve as a platform for additional train management controls, including: distributed power locomotive control, automatic activation of hand brakes, hot bearing detection, and truck oscillation and vibration.

These and other train management features increase the reliability and safety of train operations.

c. Combining Other Technologies with ECP Brakes

This analysis necessarily omits potential benefits that might be generated by a combination of ECP brakes and other technologies. Industry technology leaders understand the synergies that could be achieved by combining ECP brakes, Positive Train Control systems, enhanced traffic planning software, and on-board computing functions that are designed to limit fuel use to only that necessary to achieve a target arrival time at the next point where conflicting traffic may be met or passed. All of the major railroads have active efforts to design and test PTC systems, and two or more vendors are already offering fuel-saving software capable of taking into consideration exact route conditions. Major railroads and vendors are continuing efforts to develop sophisticated traffic planners.

These technologies together will foster highly precise, safe and efficient use of existing infrastructure, adding to effective capacity and offering enormous societal benefits as total transportation-related fossil fuel emissions are reduced. However, it is impossible to know the sequence in which these technologies will be introduced or the manner in which potential benefits will be claimed (e.g., in velocity, which reduces required investment in rolling stock or in optimum use of fuel, which holds down freight rates and also reduces the severity of remaining rail accidents). Any analysis of these potential synergies would be enormously complex, require data not currently available, and significantly delay the introduction of ECP brakes. This final rule provides latitude for use of ECP brakes among other beneficial technologies that will describe the future of North American railroading.[30]

E. Major Provisions of Rule

- Requires ECP brake-equipped systems to comply with AAR standards incorporated by reference and receive AAR approval prior to use.
- Requires the amendment of current operating rules and training programs for inspection and operating personnel to reflect the unique characteristics of ECP brake systems.
- Regulatory relief from various existing inspection, testing, and maintenance requirements and alternative inspection, testing, and maintenance requirements more appropriately applicable to ECP brake systems.
- Requires ECP brake-equipped trains to receive Class I brake inspections by a qualified mechanical inspector and full mechanical inspection (under 49 CFR Part 215) at their initial terminal (similar to existing extended haul trains) and allows such trains to travel to destination, not to exceed 3,500 miles, between brake inspections.
    - Currently, extended haul trains are limited to 1,500 miles between brake inspections and all other trains are limited to no more than 1,000 miles between brake inspections. Thus, the proposal would eliminate at least one Class I brake test or two Class IA brake tests on each long distance train, depending on how it currently operates.
- Extends the period that a train or car equipped with ECP brakes could be disconnected from a source of compressed air without being re-inspected to 24 hours, or to 80 hours for those left in an extended off-air facility. The current rule only permits cars to be off air for 4 hours before needing to be re-inspected.
- Modifies all brake pipe service reductions for all brake tests and piston travel limit adjustments for applicable brake tests so they are consistent with how ECP brake systems operate.

[30] "Benefits and Costs of Positive Train Control: Report in Response to Request of Appropriations Committees," U.S. Department of Transportation, Federal Railroad Administration, August 2004, pp. B-1-B-3.

- Allows freight trains operating in ECP brake mode to depart from an initial terminal with 95 percent operative and effective brakes, instead of the currently required 100 percent operative and effective brakes. Also permits cars with defective ECP brakes to be moved to a train's destination and permits defective non-brake and conventional pneumatic brake equipment to be hauled to the nearest, or nearest forward, repair location.
  - In order to provide this flexibility, FRA is utilizing the statutory exemption provision contained in 49 U.S.C. 20306. This provision permits FRA to exempt equipment from the specific statutory safety appliance requirements if the requirements preclude the development or implementation of technological improvements.
- Contains requirements related to the movement of ECP brake-equipped cars in conventional pneumatic brake-equipped trains.
- Requires the tagging of defective equipment and contains procedures for handling ECP brake system repairs. Recognizes the ability of ECP brake systems to continuously monitor and identify defective equipment. Thus, the rule accepts electronic tagging via the ECP brake system if certain retention and access criteria are met.
- Modifies periodic maintenance requirements, including single car brake tests tailored specifically for ECP brake systems. This will reduce the number of single car tests that must be performed on cars equipped with ECP brakes.

F. General Benefits of Rule

As stated earlier, the parties that benefit from ECP brakes include: railroads, through more efficient operations; rail shippers and car owners, through improved asset utilization and service; railroad employees and the public, through improved safety on the railroad and by keeping shipments on the rails that would otherwise burden congested highways; and the national economy and the environment, through better utilization of fossil fuels and contributing to transportation capacity. The rail carriers benefit from clearer expectations, minimum performance standards, enhanced planning, and better guidance and direction. ECP brakes apply uniformly and virtually instantaneously throughout the train, provide health status information on the condition of brakes on each car, respond to commands for graduated releases, and avoid runaway accidents caused by depletion of trainline air pressure. ECP brakes shorten stopping distances on the order of 40 percent to 60 percent, depending on train length and route conditions.[31] In turn, shortened stopping distances mean that some accidents that occur today may be avoided entirely, and some others may be less severe. However, safety analysis confirms that most grade crossing accidents, in particular, could not be avoided with ECP brakes because motorist actions become manifest only seconds before the collision.

The safety benefits of regulatory changes can frequently be estimated with some degree of precision. Incident and accident history often provide a basis for estimating fatality, injury, property damage, environmental damage, and similar costs to society that can be avoided by the

[31] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006.

implementation of new requirements. Models can even estimate the costs to society of high-consequence, low-probability accidents. Benefit estimates can then be balanced against the estimated costs of new requirements to determine whether the changes are justified. In the end, when safety measures are evaluated, an element of judgment is required to determine whether the costs of the measures are justified by the benefits that accrue. The benefit discussion can be found in Section V, Evaluation of the Benefits and Costs.

FRA has funded and initiated a followup study on the initial ECP brake-equipped trains. The objective of the followup study is to verify the business benefits following ECP brake implementation. As part of the study, the relevant data items will be collected to compare ECP brake-equipped trains and conventional brake-equipped trains, and develop supportable conclusions for the business case validation. The study will compare the costs of operating unit and unit-like train sets over the same origination/destination pairs with conventional brakes versus those operating with ECP brakes. Pending issuance of this final rule, carriers intending to operate ECP brake-equipped trains have required waivers before commencement of operations.

G. Benefit Estimates

The primary source of safety benefits would result from the avoidance of a portion of the fatalities, injuries, and property damage that result from accidents. Accidents often result in fatal or very serious injuries, evacuations, railroad equipment damage, and environmental damage.

The safety benefits of the rule are measured in terms of the reduction in the risk of an accident. The number of potential accidents is a function of exposure. The greater the traffic volume, the greater the likelihood of exposure and number of potential accidents. Potential benefits, which have not been quantified in this analysis due to a lack of data, may equal or substantially exceed the benefits that have been quantified. A qualitative description of these benefits is provided below. And although these benefits cannot be quantified, they are significant.

1. Benefits that cannot be Quantified

a. Effects of Accidents on Communities

Train accidents affect the surrounding areas in which they occur and can affect whole communities. Local emergency response personnel and equipment bear the expense associated with an accident. The costs of medical treatment for those near the accident site could be substantial, and associated road closures also produce significant economic impact to travelers and the communities nearby. The potential for hazardous materials releases can significantly exacerbate these accidents. This benefit to communities may be high in the case of a hazardous materials release, or modest if there is no release. Should a hazardous materials release impact a river or stream, the consequences to wildlife in the area could also be severe and lasting. The costs associated with these types of accidents could be extremely high and, as these types of costs (potential benefits) have not been calculated in this analysis, the benefit estimations are conservative. However, it should also be noted that, absent involvement of a second train carrying different commodities, events involving unit trains will tend to be less serious because the commodities transported are generally not bulk hazardous materials. Accordingly, omission of a specific analysis of these impacts does not radically understate the benefits quantified in this analysis.

b. Additional Time "Off Air" for ECP Brake-Equipped Cars/Trains

An additional benefit that cannot be quantified is the flexibility provided in the relief to the current regulation by proposing a performance standard. Flexibility can be extremely beneficial to the regulated community. Under current regulations, when a car or train is "off air" (not connected to a source of compressed air) for more than 4 hours, a new Class I inspection is required. With ECP brakes, that car or train could be disconnected from a source of compressed air for 24 hours before requiring reinspection (and up to 80 hours at a shipper/consignee location where loading or unloading occurs). This regulatory change could potentially change operations. FRA anticipates that the savings could be substantial, but without data, this benefit cannot be quantified. FRA requested comments and information on this potential impact, but did not receive any information that would have allowed us to develop a quantitative estimate of this potential benefit. Trains frequently idle their engines to avoid being "off air." Idling not only increases fuel consumption, but contributes to both noise and air pollution. The additional fuel and pollution savings cannot be quantified due to lack of data. This benefit, although it cannot be quantified, can be quite large, especially in environmentally sensitive areas in the U.S.

c. Platform for Monitoring

As mentioned previously as a safety advantage of ECP brakes, wiring the train provides a platform for the gradual addition of other train-performance monitoring devices using sensor-based technology to maintain a continuous feedback loop on train condition for the crew and any centralized monitoring. Although adding sensors results in additional costs, the platform provided by ECP brakes permits additional options to the owners and operators of rail equipment. Some examples of monitoring sensors are: hand-brake indicators, hot bearing detectors, vibration monitoring, etc. Furthermore, the potential exists to add a device that would apply and release the cars' hand brakes with a push of a button from the cab of the locomotive. This important benefit of ECP brakes could be substantial, but is not possible to quantify at this time.

d. Reduction in Percent Operative Brake Requirement at Initial Terminal

Another benefit that cannot be quantified is allowing freight trains operating in ECP brake mode to depart from an initial terminal with 95 percent operative brakes compared with conventional trains that are required to have 100 percent operative brakes. This time-saving benefit is substantial because when a conventional train is put together, and a car with inoperable brakes is found, the train must be taken apart to remove the defective car and then reassembled. Reassembling a train can be an extremely time-consuming process and, therefore, very costly. The loss in efficiency can be substantial if it causes a domino effect and delays other trains. FRA does not have sufficient train reassembling data in the absence of FRA motive power and equipment inspectors, and cannot quantify this benefit; but, the industry does see the potential for savings and did request an increase from 5 percent inoperative bakes to 15 percent inoperative brakes at initial terminal. However, the industry did not provide any data to support its request, and therefore we are not able to provide a basis for such a decrease in the percent of operative brakes in these regulations.

e. Improved Train Handling

Improved train handling is also possible with ECP brakes because of continuous monitoring and the automatic stopping of the train if operative brakes fall below 85 percent. If a brake application is incorrect, the engineer can immediately correct the brake pressure because of the ECP brake feature of graduated release. While no definitive data have yet been compiled, ECP brake-equipped trains are far easier to operate. They do not require the engineer to closely monitor the train brake-system pressure level, as the system is always fully charged. Thus, the engineer can safely and efficiently brake the train. The engineer can concentrate on the operating environment in which the train is located, rather than also having to prepare for likely brake pressure levels miles ahead.[32] When an engineer makes too much of a brake pipe reduction while on a descending grade, or when the grade moderates as the train progresses down a grade punctuated by undulating terrain, he/she can simply use the gradual release feature of ECP brakes to make the required adjustment. If the same requirement arises with a conventional train, the engineer's option to safely control the train is to make a complete stop. Then, the engineer must apply a sufficient number of hand brakes to hold the train while the pneumatic brakes are released to recharge the air pressure; or (more likely) to move to a higher throttle notch and drag the train over the terrain, which consumes fuel and potentially overheats the wheels.

f. Movement of Equipment with a Non-Brake Safety Appliance Defect

[32] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006.

An additional benefit of the rule that cannot be quantified is allowing cars with non-brake safety appliance defects to be moved to the nearest or nearest forward location where necessary repairs can be performed. Currently, defective equipment must be hauled to the nearest repair facility, which may be in the opposite direction of the train's movement. The benefits of this relief are likely to be great. However, FRA lacks data regarding how often these situations occur and, therefore, cannot quantify this benefit. FRA requested comments on this issue; none were received.

g. Electronic Tagging of Defective Equipment

The rule recognizes the ability of the ECP brake system to identify defective equipment and to accept electronic tagging via the ECP brake system, if certain criteria are met. This benefit allows the train to continue moving; whereas, currently, the crew must stop and walk the length of the train to identify the car that has the defective condition. The crew must then inspect the defective car(s) and properly fill out and apply the appropriate defect tags on each side of the car(s). Because trains can be more than a mile long, this is time consuming. By not having to leave the locomotive cab, electronic tagging saves time and reduces safety risks associated with walking the length of the train, especially during inclement weather. FRA does not have sufficient data to quantify this important benefit.

h. ECP Brake EOT Device Calibration, Battery, and Communication Speed Savings

Under the existing regulations, the conventional pneumatic brake system's EOT device can lose communication for 16 minutes and 30 seconds before the locomotive engineer is alerted. After the message is displayed, the engineer must restrict the speed of the train to 30 mph or stop the train if a defined heavy grade is involved. Per the current regulations, railroads must calibrate conventional two-way EOT devices every 365 days and incur additional maintenance and cost expenses while replacing batteries. Also, conventional EOT devices are heavy and often present problems when applied to the rear of the train. Blue signal worker protection (lock out track switches and place appropriate signage) is required for mechanical employees to apply or maintain the EOT on the rear of the train. This protection is required to reduce the risk to employees associated with performing these tasks. This protection has the potential to delay traffic.

By contrast, an ECP brake EOT device uniquely monitors both brake pipe pressure and operating voltages and sends an EOT beacon every second from its rear unit to its head end unit (HEU) on the controlling locomotive. The HEU will initiate a full service brake application if brake pipe pressure falls below 50 psi, or an emergency brake application if a communication loss occurs for 5 consecutive seconds, or the electrical connection breaks. An ECP brake EOT device does not require an annual calibration. The EOT battery, only a backup for the computer, is charged by the train-line cable and is much lighter in weight than the conventional EOT device battery. Physically, the last network node in the train, the ECP brake EOT device also contains an electronic train-line cable circuit, a 50 ohm resistor in series with 0.47 micro-farad capacitor, and must be connected to the network and transmit status messages to the HEU before the train-line cable can be powered continuously, resulting in a shorter interval where there is potential to lose the brake signal. This ensures that the brake system is much quicker than the conventionally-braked train, thus guaranteeing that the train will stop before a minor problem becomes a significant one. FRA requested comments on these savings, but did not receive any comments or data.

2. Effectiveness

a. The Effectiveness Metric for Public Health and Safety Rulemakings

The public safety effectiveness metrics used include the number of lives saved and the rule's impact on morbidity (in this case, nonfatal injury).

b. Number of Lives Saved (Fatality Risks)

Measurements of willingness to pay for reductions in the risk of premature death are used in the calculation of the value for the projected reduction in the risk of premature mortality. The U.S. DOT recently revised guidance raising to $5.8 million the value of a statistical life to be used by analysts in the DOT when assessing the benefit of preventing fatalities. This "willingness to pay" estimate is based on the amount individuals are willing to pay to avoid small changes in risk; this method does not assign a value to an actual life, but rather sums up a large number of valuations of small changes in risk to the point where the expected number of lives saved is equal to one. This value incorporates all aspects of well being, including forgone labor and nonlabor income, leisure time, and pain and suffering of relatives and friends. This amount has no application to an identifiable individual or to very large reductions in individual risks. This does not suggest that any individual's life can be expressed in monetary terms. Alternative values of a statistical life of $3.2 million and $8.4 million are used in the sensitivity analysis.

c. Potential Injuries Averted (Nonfatal Health and Safety Risks), Impact on Morbidity

A traumatic injury that can be treated effectively in the emergency room without hospitalization or long-term care is different from a traumatic injury resulting in paraplegia. Severity and duration of an impaired health state is necessary before the task of monetization can be performed. Data on the severity of injuries resulting from brake-related accidents suggest these injuries are typically quite severe. The value of an injury is calculated using the Abbreviated Injury Scale (AIS) developed by the Association for the Advancement of Automotive Medicine. The AIS categorizes injuries into the six levels of severity presented below. The AIS also assigns values to these categories based on the "willingness to pay" approach discussed above.

Fraction of AIS Level	**Value**	**Value of Life**	**Example of Injury**
AIS 1 - Minor	$11,600	0.0020	Superficial abrasion or laceration of skin, digit sprain, first-degree burn, head trauma with headache or dizziness (no other neurological signs).

An AIS 1 injury is simple, and may not require professional medical treatment. Recovery is usually rapid and complete.

AIS 2 - Moderate	$89,900	0.0155	Major abrasion or laceration of skin, cerebral concussion (unconscious less than 15 min.), finger or toe crush/amputation, closed pelvic fracture with or without dislocation.

An AIS 2 injury almost always requires treatment, but is not ordinarily life-threatening or permanently disabling.

AIS 3 - Serious	$333,500	0.0575	Major nerve laceration; multiple rib fracture (without a flail chest); abdominal organ contusion; hand, foot, or arm crush/ amputation.

An AIS 3 injury has the potential for major hospitalization and long-term disability, but is not generally life threatening.

AIS 4 - Severe	$1,087,500	0.1875	Spleen ruptures, leg crushes, chest wall perforations, and cerebral concussions with other neurological signs (unconscious less than 24 hrs.).

An AIS 4 injury is often permanently disabling, but survival is probable.

AIS 5 - Critical	$4,422,500	0.7625	Spinal cord injury, extensive/deep laceration of kidney or liver, extensive second- or third-degree burns, cerebral concussions with severe neurological signs.

An AIS 5 injury usually requires intensive medical care. Survival is uncertain.

AIS 6 - Fatal	$5,800,000	1.0000	An injury that will probably eventually lead to death, massive destruction of the cranium, skull, and brain.

3. Distributional Effects

The rail equipment owners and operators bear the immediate costs of this rule. The majority of the direct costs fall on car owners (most cars are privately owed by shippers or leasing companies); however, the majority of benefits fall on the railroads (locomotive operators). FRA expects that car owners will likely spread the cost of ECP brake implementation via higher prices. The primary benefit of reduced risk accrues to railroad employees and the general public. Benefits of risk reductions depend on the degree of exposure to risk. Historical accident data is used to estimate safety benefits. These benefits are substantial.

H. Methods for Estimating Benefits

Safety benefits are addressed using recent railroad accidents. To address the benefits, the cost of an accident is estimated based on standard DOT estimates for the value of a statistical life set at $5.8 million. The AIS scale is used in conjunction with the statistical value of life to determine the value of injuries. This analysis uses the midpoint of the AIS scale for rail equipment accident/incident injuries ($710,500),[33] and AIS Level 2, moderate injury ($89,900) for highway-rail grade crossing accident/incident injuries. The result is the benefit value of avoiding the risk of a similar accident. The benefits of avoiding some accidents also accrue to railroads. These benefits include the reduction in railroad property damages (locomotives, cars, and track), which are normally paid for by the railroad. These amounts are reported to FRA on accident/incident reports and are included in accident/incident benefits.

Other benefits are estimated per accident, including environmental cleanup costs and the elimination of track out-of-service expenses. These out-of-service expenses include costs associated with the track being out of service or blocked, the resulting train delays, and the domino effects these delays incur on the rail system. Additional benefits estimated include the value of regulatory relief, fuel savings, wheel savings, and velocity benefits.

1. Historical Accident Data

An example of a brake-related accident is a 1996 accident in Cajon Pass in California. An out-of-control train coming down a hill killed two people, injured 32 more, and released hazardous materials causing the evacuation of the surrounding area. A 20-mile segment of a main highway was closed for 5 days, requiring approximately 89,000 vehicles a day to find alternative routes. This example is illustrative, and was not used to calculate ECP brake benefits.

While FRA has taken other specific actions to prevent a repeat of this particular accident, and has therefore not included the reduction in risk of this accident reoccurring in the estimated benefits for this rule, this accident illustrates the type of danger posed by an out-of-control train. Whether caused by a brake system failure or other reasons, a train that loses its ability to control its speed poses a tremendous risk to life and property. The rule being analyzed at this time will help to prevent this type of accident (out-of-control train) because ECP brakes do not depend on the brake pipe to transmit the brake command.[34]

ECP brake system safety benefits are calculated using both highway-rail grade crossing accidents (Form F 6180.57) and rail equipment accidents/incidents (Form F 6180.54) from the 5-year period from 2001 to 2005. FRA specifically used recent data to account for regulatory changes and changes in crossing characteristics, including the upgrading of crossing warning devices.

The number of potential accidents is a function of exposure (rail and highway traffic volume at grade crossings and freight traffic). Greater traffic volume can lead to greater exposure and an increase in the number of accidents. Although growth in traffic may increase the benefits of the rulemaking by increasing the number of trains that are safer to operate, volumes may at some

[33] Calculation: ($333,500 + $1,087,500)/2 = $710,500.

[34] See ‘Safety Advantages of ECP Brakes’ earlier in this analysis for a more technical explanation.

point increase to the point where congestion becomes a larger issue, offsetting a portion of the business benefits of this rule. The magnitude of the impact of the probability of accidents as a result of ECP brake utilization depends on the effectiveness of ECP brakes in reducing accident probability and the number of accidents expected absent ECP brake utilization. Absent the regulatory relief, FRA assumes that accidents in the future will be similar to accidents in the past, resulting in similar levels of safety risks. The frequency and type of fatalities, injuries, and vehicle damages in the future will mirror the past, all other factors being equal.

2. Benefit Summary

Brake systems are a key component for controlling train speed. Train accidents caused by a loss of control are often the most serious accidents, and often have severe consequences for both the train crew and the surrounding communities. Not only does derailed railroad equipment itself pose a significant hazard, but fires and the release of hazardous materials can also threaten lives and property near the accident site. When a brake system loses the ability to control train speed or stop the train, the results can be truly catastrophic. ECP brakes significantly improve train handling, stopping distance, throughput, efficiency, and safety. The safety benefits include reduction in the risk of fatalities and injuries and the reduction in the risk of property damage. Additional benefits of avoiding both highway-rail and rail equipment accidents include the associated reductions in environmental cleanup costs and track out-of-service time. Business benefits of ECP brakes include the operational latitude provided to implement ECP brakes. This latitude is provided in the form of regulatory relief. Additional business savings include the reduction in fuel consumption and resulting reduction in emissions, the reduction in wheel costs for car owners, and increased velocity benefits.

a. Highway-Rail Grade Crossing Accident/Incident Benefits

FRA separately estimated the potential benefits of ECP brake technology in reducing highway-rail grade crossing accidents. These are collisions between the train and motor vehicles, physical obstructions, and other highway users on the roadway, sidewalks, and other paths at the crossing. While many variables may determine whether a grade crossing accident occurs, the most significant factor affecting the decrease in these accidents from using ECP brakes is the reduction in the required stopping distance, compared to a non-ECP brake-equipped train. In general, the faster application of brakes on an ECP brake-equipped train decreases the stopping distance of the train. Therefore, ECP brakes will likely avoid some accidents. Given the large mass of the train relative to the object it collides with, however, there will likely be little effect on reducing the severity of accidents. Even at low speeds, the large mass of the train results in considerable force in a collision.

ECP brakes will change the incentives facing the locomotive engineer who approaches an obstruction at a grade crossing. With conventional brakes, an engineer who makes an emergency brake application in an attempt to avoid a collision risks derailing the train because of the resulting in-train forces. After an emergency brake application, the engineer will also have to stop and check the train, adding to the trip time. Knowledge of the risk of derailment, in combination with the delay and need to check the train, may influence or delay the decision to apply the brakes. With ECP brakes, the electronic signal permits all the train cars to brake simultaneously, reducing in-train forces and the chance of a derailment. By not having to physically check the train after an emergency brake application, the amount of time lost will also be reduced. ECP brakes will also add the ability of graduated brake release, permitting the engineer to reduce the brake pressure without having to fully release the brakes first. With graduated release, the engineer can lessen the stopping effort without a time penalty to reset the brakes. The primary benefit of graduated release will be improved train handling, by being able to follow slow orders and other track speed limits more easily and closely, but it may also affect grade crossing accidents. Given the variety of operating conditions and the relative youth of this technology, it is difficult to predict at this time the manner in which graduated release may affect grade crossing accidents.

One of the factors that determine the time the locomotive engineer has to react to a motor vehicle or other obstruction is the sight distance approaching a grade crossing. ECP brakes will have limited effectiveness in locations that lack enough distance to allow the engineer sufficient reaction time. Curved track, for example, will limit sight distance and reduce the time the engineer has to react if he/she spots an obstruction blocking the crossing. High train speeds will also limit reaction time. FRA feels that at speeds greater than those on class 1 track (maximum train speed of 10 mph) or track class 2 (maximum speed 25 mph), the engineer will not have enough reaction time to prevent a collision, even with ECP brakes. For estimating benefits, only selecting accidents that occur on track classes 1 and 2 will account for the engineer's lack of reaction time at higher train speeds. These selection criteria should reduce the potentially preventable set of accidents enough to account for the decreased reaction time on curved track as well.

Another fundamental factor affecting grade crossing accidents is motorists' behavior. Especially in urban areas with much vehicle and train traffic, impatient drivers are sometimes tempted to try to beat the train as it approaches a crossing. This behavior is usually unpredictable and happens suddenly, providing little time for the engineer to apply the brakes. ECP brakes will not offer any advantage over conventional brakes in these types of accidents because of the limited reaction time available.

To estimate the safety benefits of ECP brakes in potentially preventing grade crossing collisions, a set of relevant past accidents is selected. Assuming that accidents in the past are a good predictor of the type of accidents that will happen in the future, this accident pool is extrapolated over a standard 20-year period of analysis to estimate the number of potentially preventable accidents in the future. ECP brakes will likely only prevent some portion of these accidents. To estimate the effectiveness of ECP brakes in preventing accidents, the advantage of shorter stopping distances is used as an effectiveness measure. In order to monetize the potential benefits, fatalities are accounted for at the standard DOT value of a statistical life, and injuries are accounted for using AIS.

Grade Crossing Accident Data

This analysis uses grade crossing accidents reported on FRA Form F 6180.57 from 2001 through 2005 as the starting point to determine accidents that are potentially preventable with ECP brakes (Access FRA data at http://safetydata.fra.dot.gov/officeofsafety/). From this initial data set, several categories of accidents were deleted because ECP brakes would not be effective in some types of accidents. For example, accidents where the rail equipment was struck by the highway user, identified by the field “typacc” of value 2, were deleted.

These accident selection criteria are listed in the table below with the corresponding fields and values from the Form 6180.57 database.

Grade Crossing Accident Deselecting Criteria		
Field Name	**Definition**	**Deleted Values**
Typacc	circumstance of accident	2=rail equipment struck by highway user
Position	position of highway user	3=moving over crossing
Typeq	type of consist	2=passenger train, 3=commuter train, 5=single car, 6=cut of cars, 7=yard/switching, 8=light loco’s, 9=maint/inspec car, A=special MoW equipment
Typtrk	type of track	4=industry
Rrequip	RR equipment involved	2=train (units pushing), 3=train (standing), 4=cars moving, 5=cars standing, 6=light loco’s (moving), 7=light loco’s (standing), 8=other, A=train pulling (RCL), B=train pushing (RCL), C=train standing (RCL)
Trkclas	FRA track class	track classes 3 to 9, X

The remaining accident pool was further qualified to focus on unit and unit-like train traffic. BAH identified long-haul, high-mileage trains as the most likely candidates for conversion to ECP brakes. FRA estimates that 61 percent of all freight traffic is unit and unit-like train traffic (using freight commodity data). Thus the accident pool is reduced by an additional 39 percent.

The resulting counts of accidents, fatalities, injuries, and vehicle damages are shown below.

Qualified Grade Crossing Accidents for Unit-Like Trains, 2001 - 2005				
Track Class	**Accidents**	**Fatalities**	**Injuries**	**Vehicle Damage**
Track Class 1	75.03	0	12.20	$150,000
Track Class 2	240.95	1.83	46.97	$770,000
Total	315.98	1.83	59.17	$920,000

To extrapolate these safety measures to a 20-year period, sample average annual counts are first calculated by simply dividing by 5 years, e.g., average annual accidents for track class 1 are 15.006 (75.03 accidents ÷ 5 years = 15.006 accidents per year). Other average annual amounts are calculated in the same way. For amounts over a 20-year period, the average annual count is multiplied by 20. For track class 1 accidents, the equivalent number of accidents is 300.12 (15.006 accidents per year x 20 years = 300.12 accidents over 20 years).

FRA does not expect that using ECP brakes will entirely prevent these qualified grade crossing accidents. In instances where the engineer has a chance to apply the brakes before a potential collision, ECP brakes will help reduce accidents by reducing stopping distances. This decrease in stopping distance, in comparison to conventional brakes, is used as an estimate of the effectiveness of ECP brakes in preventing collisions. The effectiveness rate is defined as the rate at which ECP brakes will reduce non-ECP brake accidents and ranges between 0 and 1, with 0 being not effective at all and 1 being totally effective (i.e., accidents with ECP brakes = (1-effectiveness rate) x accidents without ECP brakes). To find the number of *prevented* accidents with ECP brakes, the accidents with ECP brakes is subtracted from the accidents without ECP brakes (prevented accidents = accidents without ECP brakes - accidents with ECP brakes). Stop-distance simulation data provided by New York Air Brake Corp. shows that the effectiveness rate for loaded trains at 10 mph is 0.564 or 56.4 percent, and for empty trains is 61.5 percent. For trains traveling at 25 mph, the effectiveness rates are 45.1 percent loaded and 55.7 percent empty. These rates are for full service brake applications on 100-car trains. As the grade crossing accident data is not categorized by loaded or empty, FRA assumes that half of the trains will be loaded and half will be empty. Using 100-car trains seems appropriate, as the effectiveness rate will be applied to unit-like trains. Continuing the example with track class 1 accidents, the 300.12 accidents are divided in half to represent loaded and empty trains (300.12 ÷ 2 = 150.06). Applying the effectiveness rate for loaded trains yields 65.426 accidents with ECP brakes [65.426 = (1- 0.564) x 150.06]. Finally, the number of prevented accidents is 84.634, the difference between accidents without ECP brakes and accidents with ECP brakes (150.06 - 65.426 = 84.634).

The table below lists the number of prevented accidents and resulting consequences that can be expected over 20 years, after applying effectiveness rates for loaded and empty trains.

ECP Brake-Prevented Grade Crossing Accidents, 20-Year Period				
Track Class	**Accidents**	**Fatalities**	**Injuries**	**Vehicle Damage**
1. Track Class 1	176.920	0	28.768	$ 353,700
1a. Loaded	84.634	0	13.762	$ 169,200
1b. Empty	92.287	0	15.006	$ 184,500
2. Track Class 2	485.756	3.690	94.692	$1,552,320
2a. Loaded	217.337	1.651	42.367	$ 694,540
2b. Empty	268.418	2.039	52.325	$ 857,780
Total	662.676	3.690	123.460	$1,906,020

For benefit estimating purposes, this approach to estimate grade crossing accidents preventable with ECP brakes assumes that the speed of the train at the time of collision is evenly or uniformly distributed among the population of accidents. For example, for accidents on track class 1, it is assumed that the same number of accidents occur at a train speed of 10 mph, 9 mph, or 8 ,ph and so on until a train speed of 1 mph. Similarly, on track class 2 an equal number of accidents are assumed to occur at a train speed of 25 mph down to 1 mph. The assumption for track class 2 may be less accurate, as the range of speeds is not as "tight" as for track class 1, and the variance in train speeds at impact may be higher.

Monetized ECP Brake-Prevented Grade Crossing Accidents

Absent the regulatory change, FRA expects that the accidents in the future will approximate accidents in the past, resulting in similar levels of safety risks. The frequency and type of fatalities, injuries, and vehicle damages in the future will mirror the past, all other factors being equal.

For scheduling benefits, FRA does not have data regarding which of the particular trains involved in grade crossing accidents are long-haul, high-mileage trains that the BAH report identified as candidates for early conversion to ECP brakes. These trains are used, for example, in coal and intermodal movements. Over time, other market sectors will convert to ECP brakes as the rate of conversion to ECP brakes increases in the industry. FRA estimates that a reasonable timeline for conversion of unit-like trains to ECP brakes is 10 years. Thus, partial benefits from prevented accidents will accrue from years 1 to 10, with full benefits starting at year 11. Benefits are assumed to increase at a constant rate, but will occur with a time lag following implementation of ECP brakes. Over the course of a year, trains that are equipped with ECP brakes early in the year will supply close to full benefits by the end of the year. Trains that are equipped with ECP brakes toward the end of the year will only supply benefits for part of the year (although the cost of conversion will be incurred immediately). Recognizing that some benefits will be gained for only part of the year, the midpoint, or 5 percent of the benefits are accounted for in a year, rather than 10 percent as the 10-year implementation period might suggest. Each subsequent year will account for 5 percent of the benefits for trains equipped in that year, plus 10 percent of the benefits for the cars equipped in the previous year (which would be providing full benefits after the year of conversion).

The schedule of annual accident data, calculated by dividing the 20-year accidents by 20 and applying the ECP brake conversion rates, is presented in the following table:

Schedule of ECP Brake-Prevented Grade Crossing Accidents							
	Accidents		**Fatalities**		**Injuries**		
Rule Year	**Track Class 1**	**Track Class 2**	**Track Class 1**	**Track Class 2**	**Track Class 1**	**Track Class 2**	**Convert Rate**
1	0.442	1.214	0	0.009	0.072	0.237	0.05
2	1.327	3.643	0	0.028	0.216	0.710	0.15
3	2.212	6.072	0	0.046	0.360	1.184	0.25
4	3.096	8.501	0	0.065	0.503	1.657	0.35
5	3.981	10.930	0	0.083	0.647	2.131	0.45

6	4.865	13.358	0	0.101	0.791	2.604	0.55
7	5.750	15.787	0	0.120	0.935	3.077	0.65
8	6.635	18.216	0	0.138	1.079	3.551	0.75
9	7.520	20.645	0	0.157	1.223	4.024	0.85
10	8.404	23.073	0	0.175	1.366	4.500	0.95
11	8.846	24.288	0	0.184	1.438	4.735	1.00
12–20	8.846	24.288	0	0.184	1.438	4.735	1.00
Total	132.691	364.316	0	2.767	21.576	71.019	1.00

In order to monetize the accident data presented above, fatalities are accounted for at the DOT value of a statistical life (VSL) of $5.8 million, generally used in DOT analyses.[35] Injuries are accounted for following the assignment in FRA's "Use of Locomotive Horns at Highway-Rail Grade Crossings" rule. As that rule concerned grade crossing accidents, it seems an appropriate guide to use for valuing grade crossing injuries. The locomotive train horn rule used the AIS scale, which accounts for different levels of bodily harm as percentages of the value of a statistical life. For train speeds less than or equal to 25 mph, injuries were valued at AIS Level 2, moderate injury, representing 1.55 percent of the value of a life, or $89,900. For train speeds greater than 25 mph, injuries were valued at AIS Level 5 at $4,422,500. For ECP brakes, the data was limited to track classes 1 and 2, and no injuries were found to occur at speeds greater than 25 mph. Thus all injuries are valued at AIS Level 2 ($89,900). For estimating monetary benefits, these life and injury values are multiplied by the annual accident data above. Vehicle damages are scheduled using the conversion rate.

Monetized Schedule of ECP Brake-Prevented Grade Crossing Accidents							
	Vehicle Damages		**Fatalities**		**Injuries**		
Rule Year	**Track Class 1**	**Track Class 2**	**Track Class 1**	**Track Class 2**	**Track Class 1**	**Track Class 2**	**Total**
1	$884	$3,881	0	$53,495	$6,466	$21,282	$86,007
2	2,653	11,642	0	160,484	19,397	63,846	258,021
3	4,421	19,404	0	267,473	32,328	106,410	430,035
4	6,190	27,166	0	374,462	45,259	148,973	602,049
5	7,958	34,927	0	481,451	58,190	191,537	774,063
6	9,727	42,689	0	588,440	71,121	234,101	946,078

[35] DOT recently revised the value of statistical life from $3 million to $5.8 million.

7	11,495	50,450	0	695,429	84,052	276,665	1,118,092
8	13,264	58,212	0	802,418	96,983	319,229	1,290,106
9	15,032	65,974	0	909,408	109,914	361,793	1,462,120
10	16,801	73,735	0	1,016,397	122,845	404,356	1,634,134
11	17,685	77,616	0	1,069,891	129,310	425,638	1,720,141
12–20	17,685	77,616	0	1,069,891	129,310	425,638	1,720,141
Total	265,275	1,164,240	0	16,048,368	1,939,655	6,384,576	25,802,114
Total PV 7%	118,369	519,497	0	7,160,960	865,496	2,848,869	11,513,191
Total PV 3%	184,006	807,568	0	11,131,855	1,345,430	4,428,623	17,897,484

Total safety benefits are over $11 million when discounted at a 7 percent discount rate, and about $18 million if discounted at 3 percent. Nominal 20-year benefits are about $26 million.

In addition to the stopping distance benefits that lend themselves to quantification, ECP brakes may aid in preventing grade crossing accidents in several other ways. The advantages of easier train handling may lead to less engineer fatigue, improved confidence, and other human factors type of improvements that are difficult to quantify. More experience with ECP brakes will help describe these types of benefits.

In brief, the monetized safety benefits from potentially prevented accidents are displayed below:

Summary of Monetized ECP Brake-Prevented Grade Crossing Accidents					
	Highway Vehicle Damages	**Fatalities**	**Injuries**	**Fatalities & Injuries**	**Total**
Total	$1,429,515	$16,048,368	$8,324,231	$24,372,599	$25,802,114
Total, PV at 7%	$637,866	$7,160,960	$3,714,365	$10,875,325	$11,513,191
Total, PV at 3%	$991,575	$11,131,855	$5,774,054	$16,905,909	$17,897,484

b. Non-Grade Crossing Rail Equipment Accident/Incident Safety Benefits

As noted above, ECP brakes have a significant positive impact on rail safety by reducing stopping distances, improving train handling, allowing continuous charging of brake reservoirs, and supporting the graduated release of brakes. Improved train handling and the graduated release feature of the brakes reduces the chances of runaway trains and resulting derailments. Continuous charging of brake reservoirs provides the ability to stop the train at all times, removing the threat of premature depletion of air from the system. Reduction of UDEs is another significant benefit of ECP brake technology. UDEs are virtually eliminated using ECP brakes.

It is clear that the stopping distance of the longest, heaviest trains with ECP brakes would be reduced by as much as 40–60 percent, compared to conventional brakes. For a long coal train with a current stopping distance of almost 2 miles,[36] that reduction represents a material improvement in safety and potential avoidance, or reduction in severity of collisions with other trains, obstructions, or, in limited circumstances, users of highway-rail grade crossings.

One measure of the safety benefits of ECP brakes, albeit incomplete, is the reported damage and injuries from rail accidents in FRA's database that have cause codes associated with conventional brake failures or human error associated with brake-related train handling.[37] FRA determined that the risk of some rail equipment accidents/incidents would be reduced by the use of ECP brakes. FRA's internal experts identified accidents described by 50 cause codes (see Appendix A) that will potentially be reduced by ECP brakes.

These experts also assigned effectiveness rates for each cause code. Each cause code was assigned three effectiveness rates: a minimum, maximum, and best estimate effectiveness rate. For the 5-year period ending in December 2005, there were a total of 20,401 accident reports.[38] However, there can be more than one report for the same accident. The National Inspection Plan data (see Appendix B) was used to avoid duplicate reports for the same accident and for increased accuracy. According to this data, there were over 16,000 separate rail **e**quipment accidents. A data sort using the "Type" field (type of accident) was conducted and all highway-rail grade crossing accident types were deleted because highway-rail accidents are handled separately in this analysis.[39] The remaining accidents were sorted by the "Type Q" field (type of consist) to delete accidents that involved any of the following: passenger trains, commuter trains, a single car, a cut of cars, light locomotives, maintenance/inspections cars, and specialty maintenance-of-way equipment. The remaining accident pool was further qualified to focus on unit and unit-like train traffic. BAH identified long-haul, high-mileage trains as the most likely candidates for conversion to ECP brakes. FRA estimates that 61 percent of all freight traffic is unit and unit-like train traffic (using freight commodity data). Thus the accident pool is reduced by an additional 39 percent. The final accident pool consisted of 2,189 accidents where the accident cause was attributed to one of the 50 cause codes listed in Appendix A. The annual

[36] The coal train is operating at top speed.
[37] Data are based on Booz Allen Hamilton analysis of FRA's Office of Safety Analysis Accident/Incident Web site.
[38] Data are from the Rail Equipment Accident/Incident (Form F 6180.54) reports from the 5-year period of 2001-2005.
[39] 16,434 accidents – 1,066 highway-rail grade crossing accidents = 15,368 accidents.

average number of accidents was determined by dividing the 2,189 accidents by five for the 5-year period.

The information available to FRA on the value of property damage significantly understates the true value of the damages resulting from railroad accidents. The property damage estimates provided by the railroad(s) in the aftermath of an accident are only for "railroad property damage" (equipment, track, and structures). Although FRA has increased those figures to account for chronic underreporting of these damages, the figures used in this analysis still do not include the costs of individual or community health expenses, the closure of adjacent roads, or any of the other potential costs that are often borne by society after a railroad accident.[40] FRA has no information on the extent of these expenses, and has no data upon which to reliably make an estimate, but it is clear that these expenses are often substantial. The benefits included in this regulatory analysis underestimate the true benefits because of this exclusion.

The effectiveness rates represent a minimum, maximum, and best estimate of potential risk reduction of a similar accident occurring in the future with ECP brakes. The three effectiveness rates for each cause code were multiplied by each of the 2,189 accidents to derive values for accident damage and fatality and injury rates.

This produced the following values per accident:

Rail Equipment Accident/Incident Values			
	Minimum Estimate	**Best Estimate**	**Maximum Estimate**
Accident Damage[41]	$34,167	$41,258	$47,685
Fatality Rate (at $5,800,000)[42]	0.0010	0.0015	0.0020
Injury Rate (at $710,500)[43]	0.0211	0.0304	0.0395
Total Accident Value	$54,998	$71,582	$87,439

The annual average number of accidents multiplied by 61 percent equals 267.06[44] accidents per year. Benefits accrue with installation at a rate of the average installations per year. Year 1 is the first year that the rule becomes effective. FRA estimates that a reasonable timeline for conversion of unit-like trains to ECP brakes is 10 years. Thus, partial benefits from prevented accidents will accrue from years 1 to 10, with full benefits starting at year 11. Benefits are assumed to increase at a constant rate, but will occur with a time lag following implementation of ECP brakes. Over the course of a year, trains that are equipped with ECP brakes early in the year will supply nearly full benefits by the end of the year. Trains that are equipped with ECP brakes toward the end of the year will only supply benefits for part of the year (although the cost

[40] The damage estimates were multiplied by 1.5 for consistency with previous FRA brake related accident analysis work.
[41] A multiplication factor of 1.5 is included to compensate for underreporting and for consistency with FRA's Regulatory Evaluation of Power Brake Regulations, November 22, 2000.
[42] The Department of Transportation set the statistical value of a life at $5,800,000.
[43] The midpoint of the AIS scale is used to value injuries absent more data regarding the severity of injuries in the accidents. Calculation: AIS 3 $333,500 + AIS 4 $1,087,500 = $1,421,000 / 2 = $710,500.
[44] The accidents are rounded to 267 per year.

of conversion will be incurred immediately). Recognizing that some benefits will be gained for only part of the year, the midpoint, or 5 percent of the benefits are accounted for in a year, rather than 10 percent as the 10-year implementation period might suggest. Each subsequent year will account for 5 percent of the benefits for trains equipped in that year, plus 10 percent of the benefits for the cars equipped in the previous year (which would be providing full benefits after the year of conversion).

The following table summarizes the benefits that will accrue in a 20-year period:

Rail Equipment Accident / Incident Benefits					
Year	Rate	Accidents per Year	Accidents * Min. Accident Value	Accidents * Best Estimate Accident Value	Accidents * Maximum Accident Value
1	0.05	13.35	$ 734,219	$ 955,625	$ 1,167,305
2	0.15	40.05	$ 2,202,656	$ 2,866,875	$ 3,501,915
3	0.25	66.75	$ 3,671,094	$ 4,778,125	$ 5,836,525
4	0.35	93.45	$ 5,139,531	$ 6,689,375	$ 8,171,135
5	0.45	120.15	$ 6,607,969	$ 8,600,625	$ 10,505,745
6	0.55	146.85	$ 8,076,406	$ 10,511,875	$ 12,840,355
7	0.65	173.55	$ 9,544,843	$ 12,423,125	$ 15,174,965
8	0.75	200.25	$ 11,013,281	$ 14,334,375	$ 17,509,575
9	0.85	226.95	$ 12,481,718	$ 16,245,625	$ 19,844,185
10	0.95	253.65	$ 13,950,156	$ 18,156,875	$ 22,178,795
11	1	267	$ 14,684,375	$ 19,112,500	$ 23,346,100
12	1	267	$ 14,684,375	$ 19,112,500	$ 23,346,100
13	1	267	$ 14,684,375	$ 19,112,500	$ 23,346,100
14	1	267	$ 14,684,375	$ 19,112,500	$ 23,346,100
15	1	267	$ 14,684,375	$ 19,112,500	$ 23,346,100
16	1	267	$ 14,684,375	$ 19,112,500	$ 23,346,100
17	1	267	$ 14,684,375	$ 19,112,500	$ 23,346,100
18	1	267	$ 14,684,375	$ 19,112,500	$ 23,346,100
19	1	267	$ 14,684,375	$ 19,112,500	$ 23,346,100
20	1	267	$ 14,684,375	$ 19,112,500	$ 23,346,100
Sums		4005	$ 220,265,619	**$ 286,687,494**	$ 350,191,501
PV (3%)			$ 152,785,941	**$ 198,859,081**	$ 242,908,260
PV (7%)			$ 98,284,971	**$ 127,923,151**	$ 156,259,345

The resulting benefits of a 20-year reduction in the occurrence of non-grade crossing rail equipment accidents/incidents from reoccurring are expected to total $98 million to $156 million at a present value of 7 percent. The best estimate value of $127,923,151 will be used in the calculation of total benefits. In addition to preventable accidents, reductions in accident severity are an important benefit of ECP brakes. If a train with ECP brakes can significantly reduce its speed prior to an otherwise unavoidable collision, this could reduce the level of injuries and property damage compared to current outcomes with conventional brakes. Initial implementation experience showed a reduction in property damages in one accident.

c. Environmental Cleanup

The environmental cleanup portion of the benefit assessment covers the determination of environmental cleanup costs resulting from locomotive fuel tank spills. FRA Accident/Data Analysis and Benefit Assessment Task Force reviewed accidents occurring in 1995, 1996, and 1997. This task force reviewed accidents, which were assessed, and a data set was established. Then the accidents were assessed as to the potential benefit the improved features would provide in the same scenario. Each accident was assessed as "maximum" potential benefit, "medium" potential benefit, "minimum" potential benefit, or "no" potential benefit. The final data set included 286 accidents and 46 of these had fuel tank breaches. In addition, 22 other accidents, which were not included in the data set, had fuel tank breaches. Out of the accidents where data was provided or noted, an average of 1.5 locomotives per accident (for the 68 accidents with breached fuel tanks) had fuel tank spills, and the average number of gallons spilled was 1,836. Based on environmental cleanup costs, which were found in the review of some accidents that involved fuel spills, FRA found that the average cleanup cost of a fuel spill was $129,260. This amount adjusted to 2005 dollars[45] is equal to $157,286. FRA solicited comments on environmental cleanup costs in the analysis of the proposed rule, but did not receive any data or comments. The benefit of avoiding these costs was not included in the analysis for the proposed rule, but it is included in this analysis of the final rule. FRA assumes that 16 percent[46] of rail accidents have fuel spills and assigns a "per accident" value of $157,286 to 16 percent of ECP brake-preventable accidents. The highway-rail and rail equipment (nonhighway-rail) preventable accidents from the previous sections are multiplied by the 16 percent fuel spill rate; the result is multiplied by $157,286, the value of the cleanup costs. The result is a 20-year benefit of $113,296,427, or a 7 percent discounted benefit of $50 million.

The following chart summarizes the findings:

Reduction in Train Delay Associated With Preventable Accidents

Year	Rate	Highway-Rail Accident Reduction	Highway-Rail Accidents * 2 Hour Delay	Rail Equip. (non highway-rail) Accident Reduction	Rail Equip. Accidents * 77% (derailments)	Rail Equip. Accidents (derailments) * 24 Hour Delay	Rail Equip. Accidents * 23% (non-derailments)	Rail Equip. Accidents (non-derailments) * 5 Hour Delay
1	0.05	1.65669	$ 360,424	13.35	10.28	$ 26,836,501.51	3.07	$ 1,670,020
2	0.15	4.97007	$ 1,081,272	40.05	30.84	$ 80,509,504.52	9.21	$ 5,010,061
3	0.25	8.283449	$ 1,802,121	66.75	51.40	$ 134,182,507.54	15.35	$ 8,350,102
4	0.35	11.59683	$ 2,522,969	93.45	71.96	$ 187,855,510.55	21.49	$ 11,690,143
5	0.45	14.91021	$ 3,243,817	120.15	92.52	$ 241,528,513.56	27.63	$ 15,030,183
6	0.55	18.22359	$ 3,964,666	146.85	113.07	$ 295,201,516.58	33.78	$ 18,370,224
7	0.65	21.53697	$ 4,685,514	173.55	133.63	$ 348,874,519.59	39.92	$ 21,710,265
8	0.75	24.85035	$ 5,406,362	200.25	154.19	$ 402,547,522.61	46.06	$ 25,050,306
9	0.85	28.16373	$ 6,127,210	226.95	174.75	$ 456,220,525.62	52.20	$ 28,390,347
10	0.95	31.47711	$ 6,848,059	253.65	195.31	$ 509,893,528.64	58.34	$ 31,730,387
11	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408
12	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408
13	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408
14	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408
15	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408
16	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408
17	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408
18	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408
19	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408
20	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408
Sums		497.007	$ 108,127,243	4005.00	3,083.85	$ 8,050,950,452.16	921.15	$ 501,006,116
PV (3%)			$ 75,001,821			$ 5,584,494,079		$ 347,519,924
PV (7%)			**$ 48,247,579**			**$ 3,592,423,700**		**$ 223,554,505**

d. Train Delay, Yard Delay, and Associated Track Out-of-Service Expenses

The costs associated with main-line track out of service are generally very high. All traffic must be rerouted over other track. If the company does not have trackage rights over alternate track, rerouting distances can be large. Larger distances have higher associated costs. If trackage

[45] Calculation made with the CPI inflation calculator located at www.bls.gov.
[46] This number was derived from the study data set that had 46 fuel tank breaches of 286 accidents. Calculation: 46/286= 0.160839.

rights do exist, the company has to pay the equivalent of a toll to use track it does not own. Alternate track may not be available at any price and railroads must lay track around some accident sites. Track utilization in the United States is extremely high; it is estimated at over 90 percent. When traffic is rerouted, it slows up other traffic and has far-reaching effects on the system. Industry estimates that blocking a single main line for 1 hour costs approximately $1 million. Obviously, this amount depends on numerous factors. FRA requested comments on the value of track out-of-service time for ECP brake trains and did not receive any comments. For purposes of estimating this impact associated with this rulemaking, FRA used a methodology described in Appendix C for estimating track out-of-service time costs associated with a train accident. The cost of track out-of-service time associated with a train accident includes the domino effects that this accident has on other trains and congestion in yards that develops as a result of the accident. Terminal dwell is the average time a car resides at the specified terminal location expressed in hours.[47] Based on this methodology, the value of $135,973 per hour of out-of-service time is used in this analysis to calculate these benefits. While this number is substantially less than the $1 million estimate, the data available to FRA suggests this represents the average cost per hour for track out-of-service time associated with a train accident.

As explained previously in highway-rail grade crossing and rail equipment accident/incident safety benefits, the numbers of ECP brake-preventable accidents were determined. The rail equipment accident (FRA Form F 6180.54) pool consisted of 2,189 accidents where the accident cause was attributed to one of the 50 cause codes listed in Appendix A. For a derailment, a track may be out of service and blocked typically for 24 to 48 hours, depending on accident damage. If there is no derailment, it would be a matter of just a couple hours that the track is blocked. Of the accidents in the rail equipment accident pool, 77 percent were derailments and are assigned an average track delay of about 24 hours. The remaining 23 percent had a different 'type' of accident listed and are assigned a track delay of 5 hours. Highway-rail grade crossing accidents incur train delay time associated with waiting for local police to arrive on the scene and any reports that need to be taken or cleanup that needs to be done before the train is allowed to move. Grade crossing accidents have an average delay of 2 hours per accident.[48] The benefits of avoiding the resulting track delay of ECP brake-preventable accidents are estimated using the number of preventable accidents (both highway-rail grade crossing and rail equipment accidents) per year and multiplying the accidents by the associated average train delay. The result is the number of hours of delay, which is then multiplied by the hourly rate for train delay to obtain the value for track out-of-service time. The 20-year value of this benefit is $10.8 billion, or $4.8 billion discounted at 7 percent and $7.5 billion discounted at 3 percent.

[47] The measurement begins with a customer release, received interchange, or train arrival event and ends with a customer placement (actual or constructive), delivered or offered in interchange, or train departure event. Cars that move through a terminal on a run-through train are excluded, as are stored, bad ordered, and maintenance of way cars.

[48] A 2-hour delay is consistent with previous FRA analysis of highway-rail grade crossing accidents.

The following table summarizes these benefits:

Reduction in Train Delay Associated With Preventable Accidents									
Year	Rate	Highway-Rail Accident Reduction	Highway-Rail Accidents * 2 Hour Delay	Rail Equip. (non highway-rail) Accident Reduction	Rail Equip. Accidents * 77% (derailments)	Rail Equip. Accidents (derailments) * 24 Hour Delay	Rail Equip. Accidents * 23% (non-derailments)	Rail Equip. Accidents (non-derailments) * 5 Hour Delay	Total Value of Train Delay Reduction
1	0.05	1.65669	$ 450,530	13.35	10.28	$ 33,545,626.88	3.07	$ 2,087,525	$ 36,083,683
2	0.15	4.97007	$ 1,351,591	40.05	30.84	$ 100,636,880.65	9.21	$ 6,262,576	$ 108,251,048
3	0.25	8.283449	$ 2,252,651	66.75	51.40	$ 167,728,134.42	15.35	$ 10,437,627	$ 180,418,413
4	0.35	11.59683	$ 3,153,711	93.45	71.96	$ 234,819,388.19	21.49	$ 14,612,678	$ 252,585,778
5	0.45	14.91021	$ 4,054,772	120.15	92.52	$ 301,910,641.96	27.63	$ 18,787,729	$ 324,753,143
6	0.55	18.22359	$ 4,955,832	146.85	113.07	$ 369,001,895.72	33.78	$ 22,962,780	$ 396,920,508
7	0.65	21.53697	$ 5,856,892	173.55	133.63	$ 436,093,149.49	39.92	$ 27,137,831	$ 469,087,873
8	0.75	24.85035	$ 6,757,953	200.25	154.19	$ 503,184,403.26	46.06	$ 31,312,882	$ 541,255,238
9	0.85	28.16373	$ 7,659,013	226.95	174.75	$ 570,275,657.03	52.20	$ 35,487,933	$ 613,422,603
10	0.95	31.47711	$ 8,560,073	253.65	195.31	$ 637,366,910.80	58.34	$ 39,662,984	$ 685,589,968
11	1	33.1338	$ 9,010,604	267	205.59	$ 670,912,537.68	61.41	$ 41,750,510	$ 721,673,651
12	1	33.1338	$ 9,010,604	267	205.59	$ 670,912,537.68	61.41	$ 41,750,510	$ 721,673,651
13	1	33.1338	$ 9,010,604	267	205.59	$ 670,912,537.68	61.41	$ 41,750,510	$ 721,673,651
14	1	33.1338	$ 9,010,604	267	205.59	$ 670,912,537.68	61.41	$ 41,750,510	$ 721,673,651
15	1	33.1338	$ 9,010,604	267	205.59	$ 670,912,537.68	61.41	$ 41,750,510	$ 721,673,651
16	1	33.1338	$ 9,010,604	267	205.59	$ 670,912,537.68	61.41	$ 41,750,510	$ 721,673,651
17	1	33.1338	$ 9,010,604	267	205.59	$ 670,912,537.68	61.41	$ 41,750,510	$ 721,673,651
18	1	33.1338	$ 9,010,604	267	205.59	$ 670,912,537.68	61.41	$ 41,750,510	$ 721,673,651
19	1	33.1338	$ 9,010,604	267	205.59	$ 670,912,537.68	61.41	$ 41,750,510	$ 721,673,651
20	1	33.1338	$ 9,010,604	267	205.59	$ 670,912,537.68	61.41	$ 41,750,510	$ 721,673,651
Sums		497.007	$135,159,053	4005.00	3,083.85	$ 10,063,688,065.20	921.15	$ 626,257,645	$ 10,825,104,763
PV (3%)			$ 93,752,277			$ 6,980,617,599		$ 434,399,905	$ 7,508,769,780
PV (7%)			**$ 60,309,474**			**$ 4,490,529,625**		**$ 279,443,131**	**$ 4,830,282,231**

e. Regulatory Relief Benefits

The rule revises brake regulations in 49 CFR Part 232 to accommodate ECP brake technologies. The rule provides regulatory relief from various existing inspection, testing, and maintenance requirements and provides alternative inspection, testing, and maintenance requirements more appropriately applicable to ECP brake systems. Installation of ECP brake systems will reduce automatic brake inspection costs.

Single Car Air Brake Test (SCABT) Relief

The rule also modifies periodic maintenance requirements, including certain SCABTs, in order to tailor the requirements more specifically for ECP brake systems. Due to the ECP brake system's ability to continuously monitor the condition of a car's air brakes, FRA believes that less frequent SCABTs are justified on ECP brake equipment. Railroads may retrofit ECP brake systems on existing cars equipped with conventional pneumatic brake systems. Accordingly, the performance of a SCABT is required prior to returning the car to revenue service after the application of the ECP brake system. This is already required when installing a new brake system, thus the cost of this test is not avoided with ECP brake systems. However, the self-monitoring capabilities of ECP brake systems may extend the time period to perform SCABTs. This would reduce the number of single car tests that must be performed on cars equipped with

ECP brakes. Freight cars with conventional brakes receive a SCABT every time they are on the repair track if they haven't received one within the past 12 months. It has been estimated by the AAR that more than 99 percent of cars are on a repair track every 2 years. FRA estimates the benefits of SCABT avoidance once at the beginning of a five year period coinciding with the ECP brake installation rate, and once every 5 years thereafter. This estimate is conservative, and it is possible that these cars may avoid up to 2.5 SCABTs every 5-year period. Because this estimate is so conservative, this benefit is taken at the beginning of the 5-year period. The cost of the SCABT is either $89.22 for a manual test or $100.85 for an instrument test. FRA used the average value of these two tests, $95.04, to calculate this benefit.

The following table summarizes the SCABT benefits:

Benefits of Avoiding One Single Car Air Brake Test at Installation, Then Once Every 5 Years After Installation

Year	Rate	Car Installation	Single Car Air Brake Tests Avoided	Total Annual Benefits
1	0.05	18191	18191	$ 1,728,863
2	0.15	54573	36382	$ 3,457,726
3	0.25	90955	36382	$ 3,457,726
4	0.35	127336	36382	$ 3,457,726
5	0.45	163718	36382	$ 3,457,726
6	0.55	200100	54573	$ 5,186,589
7	0.65	236482	72764	$ 6,915,453
8	0.75	272864	72764	$ 6,915,453
9	0.85	309245	72764	$ 6,915,453
10	0.95	345627	72764	$ 6,915,453
11	1	363818	72764	$ 6,915,453
12	1	363818	72764	$ 6,915,453
13	1	363818	72764	$ 6,915,453
14	1	363818	72764	$ 6,915,453
15	1	363818	72764	$ 6,915,453
16	1	363818	72764	$ 6,915,453
17	1	363818	72764	$ 6,915,453
18	1	363818	72764	$ 6,915,453
19	1	363818	72764	$ 6,915,453
20	1	363818	72764	$ 6,915,453
Sums				$ 117,562,693
PV 3%				$ 83,922,694
PV 7%				**$ 56,317,268**

Class I and Class IA Brake Test Relief

The rule allows ECP brake-equipped trains to travel to their destination, not to exceed 3,500 miles. Extended haul and other trains are currently limited to 1,500 miles and 1,000 miles, respectively, between brake inspections. Thus, the rule will eliminate, conservatively, at least one Class I brake test or two Class IA brake tests on a long distance train equipped with ECP brakes, depending on current operations. The long-haul, unit, and unit-like trains are assumed to convert to ECP brake systems. Trains with conventional brakes that meet FRA's extended haul requirements are given 1,500 miles between intermediate terminal brake inspections. These requirements limit the number of times an extended haul train on extended haul can pick up or set out cars en route, and impose additional recordkeeping. Many long-haul unit trains are extended haul trains. FRA estimates that there are 40,000 extended haul trains that operate each year.

The single largest cost savings in the brake inspection category is expected to be the elimination of the 1,000-mile intermediate terminal brake test (Class IA test) for trains operating in the ECP brake mode. Under current regulations, conventionally-braked trains are required to stop at a terminal for inspection every 1,000 miles, where the brakes on each car are inspected to determine whether they are fully functioning.

With ECP brake systems, there is constant wire-based monitoring of the brake condition on all cars and hence a reduced need to stop and physically inspect the brakes every 1,000 miles after initial terminal departure. More than 10 years ago, the AAR calculated the cost of the intermediate brake test (Class IA) to be $450 per train, including both the direct cost of the inspection and delay costs of setting out or repairing defective equipment when identified.[49] To reflect current costs as confirmed in the BAH report, FRA assumes that this cost is at least 10 percent greater 10 years later, or $500 per train.[50] The Class I test is substantially more involved than the Class IA test and is estimated to cost $1,000 per train. Trains operating under the extended haul provisions, estimated at 40,000 trains each year, must receive a Class I test at the beginning of the extended haul segment and a Class I test at the end of the Class I segment if the train goes further than 1,500 miles. Thus, a train that travels more than 1,500 miles and uses the extended haul provision would receive two Class I tests ($2,000). With ECP brakes, the same train would only receive a Class I test at initial terminal, which would permit it to travel to 3,500 miles, or to its destination. A cycle train is a train that operates in a continuous loop(s), without a specific destination, that requires a Class IA test at a location not to exceed 1,000 miles. Every 3,000 miles, a cycle train must receive a Class I test. Many cycle trains are used in coal service, which will implement ECP brakes. With ECP brakes, the Class I test is still required, but two Class I A tests are eliminated. There are approximately 14,000 cycle trains that operate each year that are estimated to receive relief from two Class IA brake tests ($1,000).

Using the AAR Fact Book, the Freight Commodity Statistics, waybill data, and information provided by one Class I carrier, FRA estimates that approximately 178,071 trains travel more than 1,000 miles to destination and 88,045 (including the 40,000 extended haul trains) travel more than 1,500 miles to destination each year. Of these trains, approximately 25 percent operate over 2,000 miles and thus will receive relief from two Class IA brakes tests (2 X $500 = $1,000). Since extended haul trains are not required to have any Class IA brake tests they would not benefit from this relief.

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[49] "Economic Analysis of Braking Systems," Thomas S. Guins, November 1994 (TD94-021).
[50] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006, p. III-4.

The following table summarizes regulatory relief benefits for the Class I and Class IA brake tests:

Class I and Class IA Brake Test Relief												
Year	Rate	Cycle Trains	Cycle Train Relief	Extended Haul Trains	Extended Haul Relief	Trains > 2,000 Miles	>2,000 Miles Relief	Trains 1,500 < 2,000 Miles	1,500-2,000 Mile Train Relief	1,000-1,500 Miles Trains	1,000-1,500 Miles Relief	Class I & IA Annual Relief
1	0.05	700	$ 700,000	2000	$ 2,000,000	601	$ 600,550	1802	$ 900,850	4501	$ 2,250,650	$ 6,452,050
2	0.15	2100	$ 2,100,000	6000	$ 6,000,000	1802	$ 1,801,650	5405	$ 2,702,550	13504	$ 6,751,950	$ 19,356,150
3	0.25	3500	$ 3,500,000	10000	$ 10,000,000	3003	$ 3,002,750	9009	$ 4,504,250	22507	$ 11,253,250	$ 32,260,250
4	0.35	4900	$ 4,900,000	14000	$ 14,000,000	4204	$ 4,203,850	12612	$ 6,305,950	31509	$ 15,754,550	$ 45,164,350
5	0.45	6300	$ 6,300,000	18000	$ 18,000,000	5405	$ 5,404,950	16215	$ 8,107,650	40512	$ 20,255,850	$ 58,068,450
6	0.55	7700	$ 7,700,000	22000	$ 22,000,000	6606	$ 6,606,050	19819	$ 9,909,350	49514	$ 24,757,150	$ 70,972,550
7	0.65	9100	$ 9,100,000	26000	$ 26,000,000	7807	$ 7,807,150	23422	$ 11,711,050	58517	$ 29,258,450	$ 83,876,650
8	0.75	10500	$ 10,500,000	30000	$ 30,000,000	9008	$ 9,008,250	27026	$ 13,512,750	67520	$ 33,759,750	$ 96,780,750
9	0.85	11900	$ 11,900,000	34000	$ 34,000,000	10209	$ 10,209,350	30629	$ 15,314,450	76522	$ 38,261,050	$ 109,684,850
10	0.95	13300	$ 13,300,000	38000	$ 38,000,000	11410	$ 11,410,450	34232	$ 17,116,150	85525	$ 42,762,350	$ 122,588,950
11	1	14000	$ 14,000,000	40000	$ 40,000,000	12011	$ 12,011,000	36034	$ 18,017,000	90026	$ 45,013,000	$ 129,041,000
12	1	14000	$ 14,000,000	40000	$ 40,000,000	12011	$ 12,011,000	36034	$ 18,017,000	90026	$ 45,013,000	$ 129,041,000
13	1	14000	$ 14,000,000	40000	$ 40,000,000	12011	$ 12,011,000	36034	$ 18,017,000	90026	$ 45,013,000	$ 129,041,000
14	1	14000	$ 14,000,000	40000	$ 40,000,000	12011	$ 12,011,000	36034	$ 18,017,000	90026	$ 45,013,000	$ 129,041,000
15	1	14000	$ 14,000,000	40000	$ 40,000,000	12011	$ 12,011,000	36034	$ 18,017,000	90026	$ 45,013,000	$ 129,041,000
16	1	14000	$ 14,000,000	40000	$ 40,000,000	12011	$ 12,011,000	36034	$ 18,017,000	90026	$ 45,013,000	$ 129,041,000
17	1	14000	$ 14,000,000	40000	$ 40,000,000	12011	$ 12,011,000	36034	$ 18,017,000	90026	$ 45,013,000	$ 129,041,000
18	1	14000	$ 14,000,000	40000	$ 40,000,000	12011	$ 12,011,000	36034	$ 18,017,000	90026	$ 45,013,000	$ 129,041,000
19	1	14000	$ 14,000,000	40000	$ 40,000,000	12011	$ 12,011,000	36034	$ 18,017,000	90026	$ 45,013,000	$ 129,041,000
20	1	14000	$ 14,000,000	40000	$ 40,000,000	12011	$ 12,011,000	36034	$ 18,017,000	90026	$ 45,013,000	$ 129,041,000
sums												$ 1,935,615,000
PV 3%												$ 1,342,627,876
PV 7%												**$ 863,692,957**

Set-Out Relief

Additional regulatory flexibility is provided by the rule. The removal of equipment with defective or inoperative brakes en route, known as set-outs,[51] is eliminated. The defective equipment is permitted to remain in the train consist to destination, not to exceed 3,500 miles. ECP brake systems monitor in real time the health of the train's brake system, thus eliminating the safety concern that exists in conventionally-braked trains. Locomotive engineers operating trains equipped with ECP brakes have the ability to monitor the condition and the location of defective or inoperable brakes. ECP brake-equipped trains are not required to stop and set out a defective car. FRA requested and received comments and information on the cost per set-out. The AAR provided comments on the cost per set-out ($400) and the quantity of set-outs (10 percent). While FRA agrees that the original set-out percentage was high, the 10 percent long-haul train figure offered by AAR is too low. This figure does not address the extended mileage that the rule permits ECP brake trains to travel (3,500 miles versus 1,000 miles). FRA estimates, on average, 20 percent of trains must stop en route for one set-out due to the increased length of haul of ECP brake trains. FRA accepts the $400 figure provided by the AAR for the cost of a set-out. The number of ECP brake-equipped trains annually, as estimated above, is 178,071 + 14,000 unit trains = 192,071 trains per year. Approximately, half of these trains will likely avoid one set-out valued at $400 each.

[51] A set-out is removing a defective car(s) from the train consist before it reaches destination.

The following table summarizes these en route set-out benefits:

Regulatory Flexibility Benefits for Set-Outs				
Year	Rate	Unit-like' Trains	Number of Set-Outs	Cost of Set-Outs
1	0.05	9604	1921	$ 768,284
2	0.15	28811	5762	$ 2,304,852
3	0.25	48018	9604	$ 3,841,440
4	0.35	67225	13445	$ 5,378,000
5	0.45	86432	17286	$ 6,914,560
6	0.55	105639	21128	$ 8,451,120
7	0.65	124846	24969	$ 9,987,680
8	0.75	144053	28811	$ 11,524,240
9	0.85	163260	32652	$ 13,060,800
10	0.95	182467	36493	$ 14,597,360
11	1	192071	38414	$ 15,365,680
12	1	192071	38414	$ 15,365,680
13	1	192071	38414	$ 15,365,680
14	1	192071	38414	$ 15,365,680
15	1	192071	38414	$ 15,365,680
16	1	192071	38414	$ 15,365,680
17	1	192071	38414	$ 15,365,680
18	1	192071	38414	$ 15,365,680
19	1	192071	38414	$ 15,365,680
20	1	192071	38414	$ 15,365,680
Sums				$ 230,485,136
PV3%				$ 159,874,649
PV7%				**$ 102,845,035**

Total regulatory relief benefits for the 20-year period of this analysis, conservatively estimated, equal $2,283,662,829. The present value of the total regulatory relief benefits, discounted at 7 percent, equals $1,022,855,259.

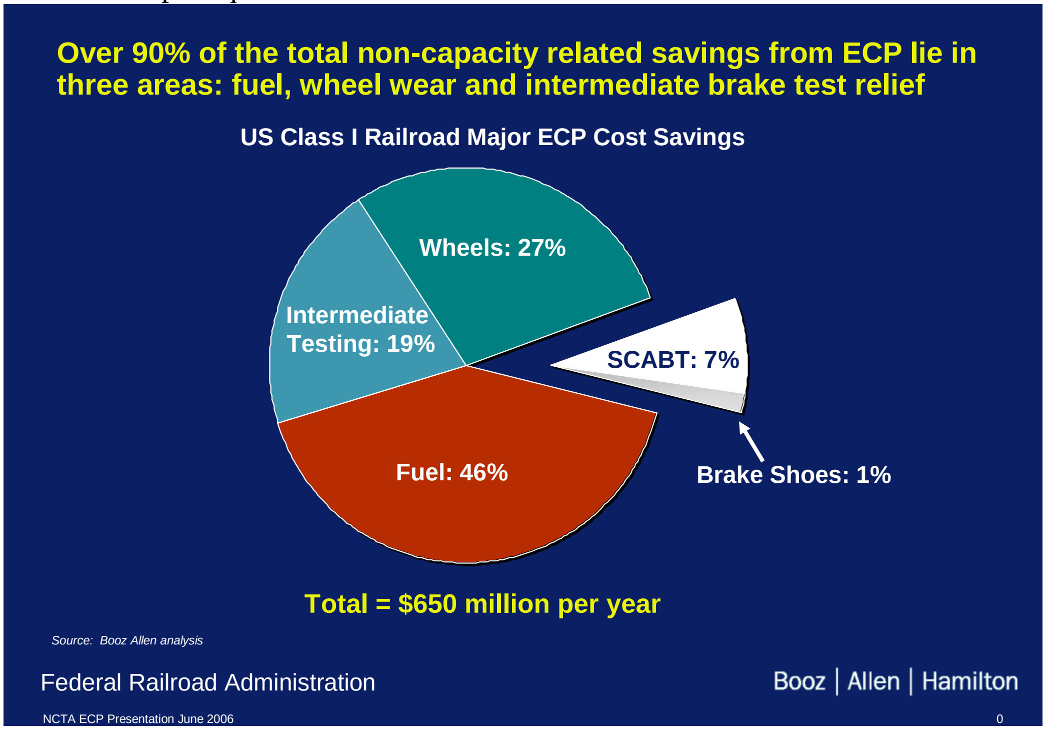
The following chart summarizes the annual benefits for each aspect of monetized regulatory relief for the 20-year period:

Regulatory Relief Benefits					
Year	Rate	Set-Out Relief	Single Car Air Brake Test Relief	Class IA & Class I Relief	Total Regulatory Relief
1	0.05	$ 768,284	$ 1,728,863	$ 6,452,050	$ 8,949,197
2	0.15	$ 2,304,852	$ 3,457,726	$ 19,356,150	$ 25,118,728
3	0.25	$ 3,841,440	$ 3,457,726	$ 32,260,250	$ 39,559,416
4	0.35	$ 5,378,000	$ 3,457,726	$ 45,164,350	$ 54,000,076
5	0.45	$ 6,914,560	$ 3,457,726	$ 58,068,450	$ 68,440,736
6	0.55	$ 8,451,120	$ 5,186,589	$ 70,972,550	$ 84,610,259
7	0.65	$ 9,987,680	$ 6,915,453	$ 83,876,650	$ 100,779,783
8	0.75	$ 11,524,240	$ 6,915,453	$ 96,780,750	$ 115,220,443
9	0.85	$ 13,060,800	$ 6,915,453	$ 109,684,850	$ 129,661,103
10	0.95	$ 14,597,360	$ 6,915,453	$ 122,588,950	$ 144,101,763
11	1	$ 15,365,680	$ 6,915,453	$ 129,041,000	$ 151,322,133
12	1	$ 15,365,680	$ 6,915,453	$ 129,041,000	$ 151,322,133
13	1	$ 15,365,680	$ 6,915,453	$ 129,041,000	$ 151,322,133
14	1	$ 15,365,680	$ 6,915,453	$ 129,041,000	$ 151,322,133
15	1	$ 15,365,680	$ 6,915,453	$ 129,041,000	$ 151,322,133
16	1	$ 15,365,680	$ 6,915,453	$ 129,041,000	$ 151,322,133
17	1	$ 15,365,680	$ 6,915,453	$ 129,041,000	$ 151,322,133
18	1	$ 15,365,680	$ 6,915,453	$ 129,041,000	$ 151,322,133
19	1	$ 15,365,680	$ 6,915,453	$ 129,041,000	$ 151,322,133
20	1	$ 15,365,680	$ 6,915,453	$ 129,041,000	$ 151,322,133
Sums		$ 230,485,136	$ 117,562,693	$ 1,935,615,000	$ 2,283,662,829
PV 3%		$ 159,874,649	$ 83,922,694	$ 1,342,627,876	$ 1,586,425,219
PV 7%		**$ 102,845,035**	**$ 56,317,268**	**$ 863,692,957**	**$ 1,022,855,259**

Business Benefits

Growth in demand for U.S. coal and for Asian imported goods, coupled with limits on motor carriers' ability to expand domestic service due to driver shortages and hours-of-service rules, suggest that North American rail network congestion will be a major concern for the foreseeable future. An example of growing North American capacity demand is the PRB, where BNSF Railway (BNSF) and UP serve over a joint line with a capacity of 130 trains per day, each approaching 2 miles in length. The BAH report broke out the major benefits of ECP brake use into a few main categories. Two of the benefit categories are quantified above as regulatory relief benefits (intermediate air brake test relief and SCABT relief). These benefits are significant and will greatly assist the industry in the implementation of ECP brake technology.

The BAH report quantifies these business benefits for Class I railroads as follows:



f. Fuel Savings

The diverse operating benefits of ECP brake systems discussed previously in the rail equipment accident/incident benefits section, such as graduated brake release and elimination of power braking and unnecessary train stops and starts, are expected to yield sizeable dollar benefits in reduced fuel consumption and associated reduction in emissions. Fuel savings are derived from reductions in train energy use. ECP does allow for higher train speeds. However, there is no incentive to increase speed to get through the signal faster if the train must wait at the end of the signal block for other trains ahead. There have been no increases in train speed during initial implementation. Railroads have implemented new technology and operational changes to save fuel. The Class I railroads spent more than $6 billion on diesel fuel in 2005.[52] Quarterly fuel expenses became the Class I railroads' largest expense category for the first time in 2008. ECP brakes are estimated to save 5 percent of fuel spending, which is consistent with the experience of Quebec Cartier Mining's ECP brake operations in Canada.[53] According to the Freight Commodity Statistics report, ECP brake unit-like commodity revenue freight originated carloads on the four Class I railroads account for 61 percent of all U.S. carloads originated. Therefore, approximately 61 percent of fuel spending is consumed hauling these unit and unit-like commodities.

[52] Total fuel spending will continue to escalate. Indeed, if the recent hedged fuel price of one major Class I of $1.70 per gallon, 40 cents below the non-hedged price, is applied to the 2004 level of Class I fuel consumption of 4.1 billion gallons, the resulting fuel bill approaches $7 billion.

[53] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006, p. III-2.

2005 Fuel Spending	$6,000,000,000
ECP Brake Commodity Usage	x .61
	$3,660,000,000
5 percent Fuel Savings	x .05
Annual Savings	**$183,000,000**

The following chart shows the 20-year fuel savings for ECP brakes:

Fuel Savings		
Year	Rate	Fuel Savings
1	0.05	$ 9,150,000
2	0.15	$ 27,450,000
3	0.25	$ 45,750,000
4	0.35	$ 64,050,000
5	0.45	$ 82,350,000
6	0.55	$ 100,650,000
7	0.65	$ 118,950,000
8	0.75	$ 137,250,000
9	0.85	$ 155,550,000
10	0.95	$ 173,850,000
11	1	$ 183,000,000
12	1	$ 183,000,000
13	1	$ 183,000,000
14	1	$ 183,000,000
15	1	$ 183,000,000
16	1	$ 183,000,000
17	1	$ 183,000,000
18	1	$ 183,000,000
19	1	$ 183,000,000
20	1	$ 183,000,000
Sum		$ 2,745,000,000
PV 3%		$ 1,904,052,986
PV 7%		**$ 1,224,849,552**

g. Wheel Savings

Wheels are but one component of a freight car that could provide maintenance savings under ECP brake operation. Wheel damage is reduced due to more uniform braking and better train handling. One of the ways in which ECP brakes contribute to a reduction in premature wheel wear is by lowering the average brake friction temperature on the wheels through more consistent braking. Excessive buildup of heat in the wheels is a major contributor to wheel failure. The sheer magnitude of industry expenditure on wheel replacements warrants singling them out as a significant benefit of conversion to ECP brake systems. A recent study by the TTCI found that the rail freight industry spends 37 percent of its annual freight car repair cost of $1.5 billion on wheel replacements—representing $555 million. These data are for calendar year

(CY) 2000, and the costs are undoubtedly higher now.[54] Wheelsets need to be replaced because they are either worn out or damaged. Brake-related failures were found to reduce the life of wheelsets by more than 50 percent.

Per wheelset replacement costs are now at least $1,250 and could range as high as $1,500. Using the lower end of this range ($1,250), the resulting 25 percent increase in per unit wheel replacement costs translates into a conservative estimate of $700 million in annual wheel repair expenditures, when applied to the CY 2000 data. Assuming that ECP brakes would eliminate half of all brake-related wheel defects, this would translate into $175 million annually for the entire freight car fleet. Heavy-haul, high-mileage cars would account for a disproportionately high share of these savings.[55] Using the same adjustment of 61 percent for ECP brake-related savings, the annual savings for the entire fleet of $175 million (.61) = $106,750,000. The 20-year wheel savings discounted at 7 percent equals $714,495,572.

The following table summarizes these benefits:

Wheel Replacement Savings		
Year	Rate	Wheel Replacement Savings
1	0.05	$ 5,337,500
2	0.15	$ 16,012,500
3	0.25	$ 26,687,500
4	0.35	$ 37,362,500
5	0.45	$ 48,037,500
6	0.55	$ 58,712,500
7	0.65	$ 69,387,500
8	0.75	$ 80,062,500
9	0.85	$ 90,737,500
10	0.95	$ 101,412,500
11	1	$ 106,750,000
12	1	$ 106,750,000
13	1	$ 106,750,000
14	1	$ 106,750,000
15	1	$ 106,750,000
16	1	$ 106,750,000
17	1	$ 106,750,000
18	1	$ 106,750,000
19	1	$ 106,750,000
20	1	$ 106,750,000
Sum		$ 1,601,250,000
PV 3%		$ 1,110,697,575
PV 7%		**$ 714,495,572**

[54] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006, p. III-3.
[55] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006, p. III-3.

h. Velocity Benefits/Less Equipment Needed

A significant ECP brake benefit is the potential for increased train velocity and capacity gains. These gains are possible because with ECP brakes higher average train speeds are possible, restarting times after train stops are shorter, train-handling issues are significantly reduced, and train brake system recharge times are practically eliminated. The rail network capacity and operational benefits of ECP brakes will impact a broad range of onboard locomotive and dispatch operations. Better braking performance will provide railroads the opportunity to increase consist lengths. Train dispatchers can decrease the spacing between consists due to increased braking efficiency and locomotive engineers can operate their trains more effectively knowing that their air supply will not need as frequent charging and that their stopping distances will be reduced. Increased braking efficiency will afford dispatchers new operational efficiencies that will impact rail network capacity. Increased braking efficiency will allow engineers to maintain speed for longer distances within blocks, and particularly in double-track territory where trains are “fleeted”, in many cases this will contribute to reduced trip time as signals upgrade prior to the point where action must be taken. This increased speed will reduce route time, allowing an increase in the number of trains that can be scheduled for a given day.

On capacity-constrained lines equipped with traffic control systems, the more favorable braking curves offered by ECP trains may permit coal and other tonnage unit trains to operate at higher speed than now permitted, reducing the speed differential between those trains and priority trains (intermodal, manifest) and contributing to overall system velocity.

FRA presented these velocity benefits and requested comments in the regulatory analysis of the proposed rule, but did not receive any comments or data. Velocity benefits were not included in total benefits of the proposed rule due to lack of ECP brakes in-service experience. However, since the proposed rule was issued, the industry has benefited from initial implementation following the guidelines of the FRA waiver. Initial implementation has shown that the average speed of ECP brake trains has increased.

Increases in velocity, or higher average train speeds, are possible with the use of ECP brakes. Average train speeds increase in some cases due to higher maximum speeds, but in all cases due to better ability to follow the safe speed limitations. Although increased speeds require more fuel, most large railroads have implemented fuel saving techniques to reduce fuel consumption. There is no reason to increase speed when traffic congestion necessitates waits at signals. ECP brake systems permit more rapid over-the-road movement because trains do not have to be artificially slowed or stopped to meet the recharging and lack of graduated release limitations of conventional air brakes. Greater throughput is achieved even within existing signal block configurations. ECP brakes will also reduce or eliminate train delays associated with undesired emergency applications and break-aparts caused by brake-related train handling.

BAH’s ECP Brake System for Freight Service final report to FRA suggests that significant industrywide equipment savings from a 1 mph gain in network velocity may be reasonable to expect. Often trains must wait for a brake test to be performed. In congested areas this wait can be from 12 to 24 hours for each test. Not all coal trains operate on congested corridors where there are long waiting periods for brake tests. However, there are other time savings that ECP brake trains experience. Capacity benefits from ECP brakes have been documented in the preliminary business case developed in South Africa by Transnet Freight Rail and similar benefits for North America can be expected and were estimated in the BAH study. Electronic monitoring on Transnet Freight Rail's ECP brake-equipped cars and locomotives increased capacity, reducing turn times by 9 percent. Initial implementation showed time savings loading coal into ECP brake-equipped cars. Because ECP brakes provide graduated brake release, there is no longer a need to apply handbrakes on individual cars. At some locations, there is a 50-precent reduction in loading times.

South Africa's Transnet Freight Rail has embraced ECP brakes for its huge export coal operations, reporting savings in train energy consumption of 23 percent. A decrease in the use of fuel, and the resulting emissions savings, also reduces the number of times a train has to stop for refueling. These time savings also increase average train speed.

Velocity takes into account diminishing the turn time of trains. It also takes into account the number of times equipment is handled and how long freight remains stationary. This analysis assumes ECP brake conversion will be focused first on the high-mileage unit and unit-like train services that would most benefit from its use. Longer trains are possible with ECP brakes. The use of electrical signals instead of air pressure for brake applications allows the brake pipe to be maintained at full pressure at all times. The uniform braking and constant pressure reduces end-of-train pressure problems and in-train forces that restrict current train lengths.

Higher average train speeds are possible due to better ability to follow the safe speed limitations. The ability to perform a graduated release allows the engineer to reduce the brake application whenever it is too severe. Thus, there is no need to travel any distance at too slow a speed because of the inability to make a brake release.[56]

The information currently available from ECP brake pilot train implementation suggests that velocity benefits will be realized. This is possible because of the time savings gained by the reduction of brake tests and the associated queue time waiting for the brake tests[57], time spent placing a train in a siding or a yard to perform the test, wait time for employees to arrive to perform the test, time spent with no sets, time spent waiting for new train crew to arrive, yard and facility capacity issues and delays, and the reduction in coal loading times. The most significant benefit of conversion of main-line corridors to all ECP brake service is enhanced capacity, without the need for major new equipment or infrastructure investment.

For instance, with the current brake technology, the auxiliary reservoirs on each car of the train must be recharged, and the brakes reset before starting the train, if braking will soon be required. Thus, in areas of known descending grades there is a waiting period before the train can proceed after stopping en route.[58] With ECP brakes, the brake pipe pressure is not lowered to signal a brake application. Instead, electric signal transmitted down the train on a wire indicates the brake application. The brake pipe remains charged at 90 psi and continues to supply the

[56] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006, p. II-6.
[57] In congested areas this wait can be from 12 to 24 hours for each test.
[58] Ibid.

reservoirs during braking. Hence, there is no downtime needed for recharge after braking.[59] FRA believes that the adoption of ECP brake technology will increase train speed and this hypothesis is supported by both the BAH analysis and initial ECP brake implementation experience. In addition, the BAH report cites a UP estimate that for each 1 mph (or 5 percent) improvement in its overall system average velocity UP saves 250 locomotives and 5,000 freight cars that would otherwise be required. At a cost of $2 million per locomotive and an average of $50,000 per freight car, this savings represents $750 million for UP alone. The UP fleet is representative of the industry's Class I railroads and comprises approximately a third of all Class I railroad-owned locomotives and a fourth of all Class I railroad-owned freight cars. Assuming that other Class I railroads have similar equipment utilization rates, it could be possible to extrapolate the $750 million in UP savings to the other Class I railroads, which could result in a $2.5 billion in savings from a 1 mph increase in network velocity. Any savings realized would increase accordingly with speed gains of greater than 1 mph.

The unit and unit-like trains covered by this analysis are used to transport coal, ores, motor vehicles, and miscellaneous (intermodal) commodities. The slowest moving commodity by train is coal, which makes up 43 percent of the total tons originated by Class I railroads. Initial implementation suggests a reduction in cycle time for a coal train to move from the power plant to the mine to load coal and back to the power plant to deliver the coal can be achieved with ECP brakes. Reductions in cycle times are primarily achieved through the reduction of brake tests. This, in combination with the reduced wait time discussed above has reduced cycle time experienced during ECP brake domestic initial implementation ranges from a low of 14 percent to a high of 33 percent.

Coal trains, which are the slowest moving trains on any given network, are the largest source of tons originated and make up a substantial portion of rail traffic. Coal trains could experience velocity gains significantly greater than 1 mph and all Class I railroads transport a significant amount of coal on their main lines. By commodity, the highest percentage of carloads originated is 26.9 percent, which is intermodal. This is followed closely by coal that accounts for 23.6 percent of all carloads originated.[60] Both of these commodities, in addition to grain, motor vehicle parts, ore, and nonmetallic minerals are assumed to implement ECP brakes in this analysis.

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[59] Ibid.

[60] 'Railroad Facts', 2007 edition, p.25.

The following chart details reported average train speeds by railroad and by commodity: [61]

Train Speed (Miles per Hour) by Commodity and Railroad[62]

Commodity:	BNSF	CSX Transportation	Norfolk Southern	Union Pacific
Intermodal	33.7	28.8	27.5	25.7
Multilevel	28.2	22.1	21.0	22.2
Grain Unit	23.6	18.6	18.0	20.6
Manifest	21.7	19.5	20.2	20.5
Coal Unit	18.5	16.0	15.5	19.6
All Trains	23.2	20.4	21.3	21.6

One railroad's performance metrics cannot meaningfully be compared to another railroad's, due to differences in the carriers' calculation methodologies, operational strategies, network characteristics, terrain, traffic mix and volume, length of haul, extent of passenger operations, and other factors such as weather.

This analysis assumes implementation on the fastest commodity, intermodal, and the slowest commodity, coal. The fastest average train speed of all commodities is intermodal, ranging from 25.7 mph to 33.7 mph. The average train speed for coal ranges from is 15.5 mph to 19.6 mph. These two commodities account for over half of all carloads originated and contribute substantially to the average train speed for all trains. If the slowest speed is increased and the highest speed is increased, the average velocity will increase, all else being equal. FRA estimates a minimum 1 mph improvement in velocity. Given that unit coal trains, which are among the slowest moving trains on any given network, could experience velocity gains significantly greater than 1 mph and that all Class I railroads transport a significant amount of coal on their main lines, this estimate is likely a lower bound estimate. Lower bound estimate benefits are included in the total benefits because of the number and variability of factors that would determine the actual level of savings realized due to network velocity improvements. FRA is confident that from the initial implementation assumed in this analysis, a minimum of 1 mph in velocity will be achieved. These benefits will accrue with ECP brake implementation over a 10-year period.

[61] Average train speed is calculated by dividing train miles by hours operated on main lines between terminals.

[62] Source: Union Pacific Railroad, Norfolk Southern, CSX Transportation, BNSF Railway Company, Railroad Performance Measures, www.railroadpm.org, 4/21/2008 4:18 PM EST.

The following chart details velocity benefits:

Velocity Benefits (1 mph Improvement)		
Year	Implementation Rate	Total
1	0.05	$125,000,000
2	0.15	$250,000,000
3	0.25	$250,000,000
4	0.35	$250,000,000
5	0.45	$250,000,000
6	0.55	$250,000,000
7	0.65	$250,000,000
8	0.75	$250,000,000
9	0.85	$250,000,000
10	0.95	$250,000,000
11	1	$125,000,000
12	1	
13	1	
14	1	
15	1	
16	1	
17	1	
18	1	
19	1	
20	1	
Sums		$2,500,000,000
PV 3%		$2,101,494,145
PV 7%		**$1,698,459,555**

III. ALTERNATIVE REGULATORY APPROACHES

The primary alternative to the regulation would be to adopt a mandatory requirement to adopt ECP brakes. This alternative is analyzed in more detail below. OMB Circular A-4 recommends that agencies consider other alternative regulatory approaches. Here, a few areas are highlighted where FRA believes it has adopted flexibilities reflective of the approaches OMB recommends.

A. Different Enforcement Methods

Onsite inspections are the most economically efficient method of enforcement for this regulation. The review and approval of hundreds of brake systems by DOT personnel on an annual basis would be extremely resource-intensive and time-consuming. Enforcement of this rule would be conducted in the same manner of enforcement as other brake requirements. During the course of their regular inspections, DOT inspectors will review the technology, physical parts present, and paperwork for compliance with the regulations. As with other regulations, inspectors have the discretion to issue notices of noncompliance, or to recommend civil penalties for probable violation of the regulations. This rulemaking has considered different methods of enforcing safety requirements, and in fact a significant part of the regulatory relief offered is due to decreased inspection frequency.

B. Different Requirements for Different Sized Firms

FRA is proposing facilitating the voluntary adoption of ECP braking systems. Although the requirements do not differ by the size of the firm, FRA believes the costs imposed by this regulation will be more proportionate to the benefits through this voluntary approach. An important assumption in this analysis is that only four U.S. Class I railroads will initially implement ECP brake technology. This assumption is reasonable given the cost of conversion. In practice, FRA believes the largest Class I carriers will take advantage of this opportunity to adopt ECP brakes; therefore, FRA believes it has adequately considered firm size when designing these regulations.

C. Informational Measures Rather than Regulation

Standards and regulations are essential to ensure that all carriers work to improve the safety and security of their operating environment. An alternative might be a guidance document published in the Federal Register, which would be instructive to the carriers but would fail to ensure an improvement in safety or efficiency. The scheme is flexible, allowing each rail carrier to have the same regulatory relief opportunities. Informational measures may also be used in addition to the rule. Such informational measures include tools to assist carriers in predicting the business benefits of ECP brake technology, and guidance documents detailing best practices throughout the industry. It is anticipated that the ECP brake manufacturers will assist their customers with best practices regarding conversion and training acquired through their overseas experiences.

IV. AN EXAMINATION OF ALTERNATIVE APPROACHES

A. Evaluation of Alternative Regulatory Approaches

Analyzing all possible combinations of provisions is impractical. FRA is not mandating the use of ECP brakes. ECP brakes are a major capital investment (on the order of $7 billion for all locomotives and cars). This analysis assumes only four U.S. Class I railroads will implement this technology on the portion of their operations where it produces the greatest returns, although it is possible that additional carriers adopt the technology within the time period of analysis. The rule provides reliable and suitable standards and procedures that can support investments in ECP brake technology for revenue service.

B. Different Levels of Stringency

The benefits and costs associated with a regulation will increase with the level of stringency. Alternative levels of stringency are presented to further describe the relationship between stringency options and the benefits and costs. The costs and resulting benefits are proportionate with the number of cars and locomotives converted to ECP brakes. If the regulation were mandatory (i.e., more stringent) all cars and locomotives in the United States would require conversion to ECP brakes. The more stringent, mandatory rule would require a percentage of the entire locomotive and freight car fleets would have to be converted to ECP brake technology each year on a gradual basis. There are approximately 22,779 freight locomotives in the U.S. fleet, and approximately 1,312,245 freight cars in service.[63] Equipping this entire fleet with ECP brakes at a cost of $48,000 per locomotive and $4,800 per freight car would total approximately $7.4 billion.[64] To put this number in context, it is more than the combined annual capital expenditures of all the Class I railroads.[65] The operating realities of the rail industry are such that, for a significant number of freight cars, overlay operation will be unavoidable for some time. Overlay is defined here as the capability of a freight car to operate in either conventional or ECP brake service.[66]

Even if the investment were spread over 20 years, at a rate of $350 million per year, it would require $42 million in annual net benefits over 20 years for each investment installment to achieve even a relatively modest return of 12 percent. Realizing such sizeable benefit streams from an undifferentiated approach to ECP brake system installation is highly unlikely, as the operational difficulties of making ECP brake-equipped locomotives available for ECP brake-converted cars, and vice versa, means that few trains would actually operate in the ECP brake

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[63] "Railroad Facts," 2006 edition, pp.50-51. Canadian-owned U.S. Railroads are excluded from these numbers.
[64] Calculation: 22,779 locomotives ($48,000) = $ 1,093,392,000 locomotive costs. 1,312,245 freight cars ($4,800) = $ 6,298,776,000. $1,093,392,000 + $6,298,776,000 = $ 7,392,168,000. This is before making three adjustments: 1) for inflation, 2) for economies of ECP manufacturing scale and implementation experience not yet factored into the per-unit costs used here, and 3) to reflect that some portion of road locomotives, perhaps as high as 20–25 percent, operate as permanent trailing locomotives, and require only an ECP run-through cable at minimal cost, not full cab conversion.
[65] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006, p. I-9.
[66] Ibid.

mode until the majority of the fleet was converted. Thus, near-term costs may outstrip more distant benefits, especially in the absence of regulatory relief.[67] Additionally, all 559 railroads and hundreds of car owners would incur conversion costs. The expected benefits of ECP braking technology appear to justify the investment, provided that the conversion is focused first on the high mileage, unit and unit-like train services that would most benefit from its use, and that subsequent conversions incorporate lessons learned.

An example of a less stringent alternative would involve the granting of waivers in lieu of a rule. This alternative may not spur investment in ECP brake technology. Waivers would not afford the regulatory certainty the rule provides. Waivers are not permanent and can be rescinded. Companies are not likely to make significant investments in ECP brakes with the additional uncertainty and increase in risks that would be present absent a regulation.

C. Status Quo (Do Nothing)

The baseline continues the status quo. This is a "no action" baseline and the benefits and costs are compared with this alternative. If the rule is not adopted, rail carriers are not provided regulatory relief. This may also occur if the railroads decide not to implement this technology. The railroads have limited resources and numerous competing technologies that may result in the adoption of other technologies in lieu of ECP brakes.

V. EVALUATION OF THE COSTS

A. Scope of Analysis

This analysis focuses on benefits and costs accruing to citizens and residents of the United States. The time frame of this analysis is 20 years, a sufficient time frame to encompass all the important benefits and costs likely to result from this rule. The rule may also affect Mexican and Canadian rail carriers, should they choose to adopt ECP brakes, although we believe the best estimate of the impacts of the rule, at least in the early stages of adoption, is that 4 Class I railroads will adopt ECP brakes. This regulation may affect the same rail carriers already required to comply with all existing regulations because they operate within the United States. The costs associated with the regulation are based on shipments within the United States and associated carriers. No additional carriers are affected by this regulation.

As stated earlier, this analysis assumes implementation on unit and "unit-like" trains. There are two distinct types of train freight operations: carload freight and unit train operations. For the purposes of this analysis, "unit-like" operations is used to describe current extended haul trains allowed to have one pickup and set-out en route, and unit train operations that lend themselves to unit train service but may have more pickups and set-outs. Carload freight is handled in multiple

[67] Keeping ECP locomotives available for ECP freight cars has been one of the chief obstacles in railroad experiments to date with ECP. In addition, one study estimated that, even after 99 percent of all freight cars were equipped with ECP, the probability of randomly assembling a 100-car all-ECP train would be only 37 percent. (Study by New York Air Brake as cited in Leonard McLean's paper to the September 2001 Chicago meeting of the Air Brake Association.)

trains en route, possibly with three to four handlings between pickup and delivery. Carload freight is switched through classification yards and usually travels through multiple yards per trip. Pickup and delivery occurs as individual cars or small blocks of cars. These commodities are often priced, marketed, and managed as individual carload lots. Empty carload freight cars are unlikely to return to the original loading customer. The following chart from the BAH report explains the differences between unit train operations and carload freight operations.

Carload freight lacks many of the operational efficiencies that unit trains possess, resulting in more equipment to deliver fewer revenue train miles[68]

	Unit Train Operations	Carload Freight
Requirements	Scheduled long-haul mainline movement	Extensive gathering, sorting, delivery, storage
Pricing	Sophisticated yield management to maximize revenue contribution from each contract	Blizzard of contracts, tariffs, spot quotations requiring extensive marketing and administrative support
Turnaround	Scheduled cycle times, as for coal moving to utilities in dedicated train sets	Complicated train makeup, power assignment, crew calling and intermediate terminal burdens
Network Performance	Generally maximizes overall system fluidity	Can lead to reduced velocity, increased terminal dwell times, greater numbers of cars on line
Customer Service	Large, sophisticated customers operating under long-term contracts	Diverse customer base requiring extensive marketing, operating and administrative support
Overall Complexity	Maximizes what the network does best – predictable line-haul movement of large, scheduled trains	Maximizes what the network is least suited to – last-mile type gathering, delivery and enroute sorting of diverse loose carloads

Coal, grain, intermodal containers, motor vehicle parts, nonmetallic minerals, and ore are all market segments that have characteristics suitable for unit and unit-like train operations described in the table above. Typical coal traffic operations transport high volumes of coal from a mine source to a power plant. Grain operations carry the commodity from grain elevator or other storage facilities to processing plants. Motor vehicle parts are transported from manufacturer or port to receiving facilities. Nonmetallic minerals and ore (e.g. rock) are transported from quarry to processing plant. All of these traffic movements involve one commodity transported in repetitive high volume operations.

FRA does not know which of the trains involved in the historical accidents are long-haul, high-mileage trains that the BAH report identified as candidates for early conversion to ECP brakes. However, by using the 2005 Freight Commodity Statistics published by the AAR, approximately 61 percent of all train traffic in the United States is unit-like train service. The following commodities were used to calculate unit-like trains: coal, intermodal, grain, ore, nonmetallic minerals, and motor vehicle parts.[69] Because these commodities account for 61 percent of

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[68] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006.

[69] Freight Commodity Statistics, Association of American Railroads, 2005.

traffic, the accident pool (2001–2005 accidents) is multiplied by 61 percent in an effort to capture the portion of those selected accidents that may have ECP brake-equipped trains. Over time, other market sectors will convert to ECP brakes as the number of cars with ECP brakes increases in the industry. FRA estimates that a reasonable timeline for conversion of unit-like train movements to ECP brakes is 10 years. Thus, partial safety benefits will accrue up to a period of 10 years, with full benefits accruing from years 11 to 20 for unit-like train service. As mentioned, during the first 10 years of conversion, the rate of conversion will likely increase as more trains are converted; however, FRA does not have information to determine what that rate of conversion will be. Thus, benefits are increased at a constant rate for the first 10 years.

B. Baseline

The best assessment of the way the world would look absent the regulation will resemble the present. The baseline assumes no change in the regulatory program. Although railroads work toward safety and efficiency improvements, the development of this technology may take place more slowly and less consistently absent this regulation.

C. Discounting

The benefits and costs of the regulation occur in different time periods; therefore, discounting is used to account for the fact that resources available in a given year are worth more than the identical resources in a later year. The discount rates currently used are 3 percent and 7 percent in real terms. The discount rate of 7 percent is emphasized because it is an estimate of the average before-tax rate of return to private capital in the U.S. economy. It is a broad measure that reflects the returns to real estate and small business capital as well as corporate capital. It approximates the opportunity cost of capital, and it is the appropriate discount rate whenever the main effect of a regulation is to displace or alter the use of capital in the private sector.

D. Cost Estimate of Regulation

Implementing new ECP braking technology will be financially expensive and logistically challenging. This analysis addresses the costs of implementing this new technology on the most likely implementation course the rail industry will pursue. A car operating with ECP brakes must be in a train consist that not only has an ECP brake locomotive, but also has almost all rail cars equipped with ECP brakes. Some trains operate in unit service where the train and locomotives stay together for most of the train operation. The most practicable way to implement ECP brakes initially is in unit and unit-like train operations. This analysis assumes that initial implementation will occur on unit and unit-like train service. The time frame for this analysis is 20 years. As noted above, 10-year implementation on unit and unit-like train service is a primary assumption in this analysis. There are 7 Class I railroads, 32 regional railroads, and 523 local railroads.[70] Only four U.S. Class I railroads are assumed in this analysis to take advantage of this technology. It is not anticipated that any other U.S. railroads will initially take advantage of this technology because of the high level of initial costs; although costs are proportional to size of fleets. The large railroads are estimated to have more equipment per

[70] 'Railroad Facts,' Association of American Railroads, 2006, p.3.

carrier than the smaller railroads. The majority of local railroads do not interchange with unit-like trains. For the purposes of this analysis, it is assumed that no other railroads will take advantage of this rule, even though all railroads would enjoy the same regulatory relief the rule provides were they to decide to convert to ECP brakes.

An important determinate of costs is the amount of equipment that must be converted. It is assumed that in year 1, the year the final rule is effective; all new equipment coming into the fleet—both locomotives and cars—is ECP brake-compatible. There will be a sustained rate of introduction of ECP brake-compatible equipment into the fleet—without incurring the cost of retrofitting existing equipment—until conversion is complete. Both locomotives and cars are estimated to have 10-year implementation schedules. The costs used in this analysis are $4,800 per freight car and $48,000 per locomotive. The $4,800/$48,000 cost estimates are 20 percent higher than the estimates used in the analysis of the proposed rule ($4,000/$40,000). These estimates better reflect costs observed from initial ECP brake implementation experience. The costs used include installation labor. When the decision is made to begin phased implementation, and railroads place orders accordingly, production will ramp up and more formalized installation arrangements will be initiated. Such volume-based conversion can be expected to reduce ECP brake costs for both freight cars and locomotives. All other things being equal, the expected decline in conversion costs due to economies of scale and experience will cause the net benefits in this analysis to be understated. While the direction of the anticipated change in costs is clear, it is impossible to project with accuracy the magnitude of the cost decline under large-scale implementation. FRA specifically requested comments on this issue in the analysis of the proposed rule, but none were received. Due to the competitive nature of the market, neither supplier could provide comments without revealing its competitive position.

In terms of maintenance, brake manufacturers do not presently expect any significant long term difference in maintenance costs between ECP brake and non-ECP brake systems, thus the cost issue is primarily a one-time installation cost consideration. BAH discussions with Quebec Cartier Mining, which has been running heavy-haul ECP brake-equipped trains of up to 180 cars in North America since 1998—including in harsh winter conditions—confirm this conclusion.[71]

1. Freight Car Conversion Costs

The potential freight car fleet (units) to be converted to ECP brake technology dwarfs by nearly 25 to 1 the locomotive pool needing conversion.[72] For freight car conversion, an average of $4,800 per car is estimated for total conversion costs. Certain types of freight cars will cost more to convert and certain cars will cost less. Using a combination of the “Freight Car Commodity Statistics” report, and information from one of the four U.S. Class I railroads assumed to implement ECP brakes, it is estimated that approximately 363,818 cars will be converted to ECP brakes for unit-like service. The total costs for freight car conversion is $1,746,326,400. The 20-year present value of this cost discounted at 7 percent is $1,186,425,904 and at 3 percent is $1,467,957,882.

[71] ‘Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,’ Booz Allen Hamilton, August 2006, p. III-3.
[72] The number of locomotives that will need conversion to ECP is 8,092 (38 percent of United States Class I railroad locomotive fleet) times 1.5, equals 12,139 (12,138 rounded up for ‘partial locomotive’) locomotives.

The following table summarizes these costs:

Freight Car Conversion Costs				
Year	Rate	Cars Equipped	Cars Equipped Annually	Costs per Year
1	0.05	18,191	18,191	$ 87,316,320
2	0.15	54,573	36,382	$ 174,632,640
3	0.25	90,955	36,382	$ 174,632,640
4	0.35	127,336	36,382	$ 174,632,640
5	0.45	163,718	36,382	$ 174,632,640
6	0.55	200,100	36,382	$ 174,632,640
7	0.65	236,482	36,382	$ 174,632,640
8	0.75	272,864	36,382	$ 174,632,640
9	0.85	309,245	36,382	$ 174,632,640
10	0.95	345,627	36,382	$ 174,632,640
11	1	363,818	18,191	$ 87,316,320
12	1	363,818		
13	1	363,818		
14	1	363,818		
15	1	363,818		
16	1	363,818		
17	1	363,818		
18	1	363,818		
19	1	363,818		
20	1	363,818		
Sums			363,818	$ 1,746,326,400
PV 3%				$ 1,467,957,882
PV 7%				**$ 1,186,425,904**

2. Locomotive Conversion Costs

An important determinant of costs is the number of locomotives that must be converted. Approximately 38 percent of locomotives are used in the movement of unit-like commodities.[73] Most locomotive pools have a relatively free-running nature in which realizing high levels of locomotive utilization is more important than dedicating expensive power to specific trains or corridors. Railroads must equip more locomotives with ECP brakes than just the normal number of locomotives used on a particular route or in a particular service. Locomotives are taken out of service in regular intervals for required tests. For locomotive ECP brake conversion, additional ECP brake-equipped locomotives must be equipped than the corresponding number for freight cars conversion. Although dedicating power to specific ECP brake corridors is possible, this analysis estimates that the locomotives needed are 1.5 times the number of locomotives used in unit-like service. Therefore, the number of locomotives that will need conversion to ECP brakes is 8,092 (38 percent of U.S. Class I railroad locomotive fleet) multiplied by 1.5, which equals 12,139 (rounded up because cannot cost for a ‘partial locomotive’) locomotives. As stated

[73] Data extrapolated from information received from ‘Railroad Facts,’ 2006 Edition and one United States Class I railroad, and the ‘2005 Freight Commodity Statistics’ report.

earlier, the average cost per locomotive is estimated at $48,000.[74] The total cost of conversion, not including maintenance, is $582,624,000, or discounted at 7 percent is $395,825,320.

The following chart summarizes the locomotive conversion costs:

Locomotive Conversion Costs				
Year	Rate	Locomotives Equipped	Locomotives Equipped Annually	Costs per Year
1	0.05	607	607	$ 29,131,200
2	0.15	1,821	1,214	$ 58,262,400
3	0.25	3,035	1,214	$ 58,262,400
4	0.35	4,248	1,214	$ 58,262,400
5	0.45	5,462	1,214	$ 58,262,400
6	0.55	6,676	1,214	$ 58,262,400
7	0.65	7,890	1,214	$ 58,262,400
8	0.75	9,104	1,214	$ 58,262,400
9	0.85	10,317	1,214	$ 58,262,400
10	0.95	11,531	1,214	$ 58,262,400
11	1	12,138	607	$ 29,131,200
12	1	12,138		
13	1	12,138		
14	1	12,138		
15	1	12,138		
16	1	12,138		
17	1	12,138		
18	1	12,138		
19	1	12,138		
20	1	12,138		
Sums			12,138	$ 582,624,000
PV 3%				$ 489,752,370
PV 7%				**$ 395,825,320**

3. Training Costs

FRA estimates that the Class I carriers will incorporate ECP brake training into existing locomotive engineer and inspector training programs. An initial training template that all of the railroads can modify to suit their individual operations will be needed. In accordance with other freight brake regulations, a template is being developed among the railroads. This initial template is estimated to cost approximately $300,000. This estimate is consistent with previous freight rail brake training estimates. FRA assumes all inspectors need training as well as half of the engineers and conductors. There are 29,940 inspectors (maintenance of equipment and stores employee group) and 68,307 engineers and conductors (transportation, train, and engine employee group), according to the 2006 edition of “Railroad Facts.” Assuming only half of train crews will need training; the total number of people needing training is 64,094. The average wages per employee hour are $25.68, according to the 2006 edition of “Railroad Facts.”

[74] Different locomotive configurations can have different costs. Because it is not known exactly which locomotives will be converted, the estimate of $48,000 is used in this analysis.

Multiplying this hourly wage by 1.75 to load the rate derives hourly loaded rates of $40.40 for maintenance employees and $44.04 for engineers. Training is proportional to the fleet conversion rate for the first 10 years, and training will occur on an annual basis for years 11–20. Inspectors will require 8 hours of initial training followed by 1-hour annual training. Train crews will require 24 hours of initial training and 8 hours of annual training. The total 20-year cost of initial and recurring training is $231,470,835, or discounted at 7 percent is equal to $111,016,540.

The following chart summarizes these training costs:

Total 20-Year Training Costs

Year	Rate	Inspectors Initially Trained per Year	Aggregate Total Inspectors Trained	Inspectors' Initial Training Costs	Engineers and Conductors Trained Initially per Year	Cumulative Engineers and Conductors Trained	Engineer and Conductor's Initial Training Costs	Sum of Initial Training Costs	Annual Inspector Training	Annual Engineer and Conductor Training	Sum of Initial and Reccurring Training Costs
1	0.05	1497	1497	$ 483,830	1708	1708	$ 1,805,288	$ 2,289,118			$ 2,589,118
2	0.15	2994	4491	$ 967,661	3415	5123	$ 3,609,518	$ 4,577,179	$ 60,479	$ 601,657	$ 5,239,315
3	0.25	2994	7485	$ 967,661	3415	8539	$ 3,609,518	$ 4,577,179	$ 181,436	$ 1,804,971	$ 6,563,586
4	0.35	2994	10479	$ 967,661	3415	11954	$ 3,609,518	$ 4,577,179	$ 302,394	$ 3,008,284	$ 7,887,858
5	0.45	2994	13473	$ 967,661	3415	15369	$ 3,609,518	$ 4,577,179	$ 423,352	$ 4,211,598	$ 9,212,129
6	0.55	2994	16467	$ 967,661	3415	18785	$ 3,609,518	$ 4,577,179	$ 544,309	$ 5,414,912	$ 10,536,400
7	0.65	2994	19461	$ 967,661	3415	22200	$ 3,609,518	$ 4,577,179	$ 665,267	$ 6,618,226	$ 11,860,672
8	0.75	2994	22455	$ 967,661	3415	25616	$ 3,609,518	$ 4,577,179	$ 786,224	$ 7,821,539	$ 13,184,943
9	0.85	2994	25449	$ 967,661	3415	29031	$ 3,609,518	$ 4,577,179	$ 907,182	$ 9,024,853	$ 14,509,214
10	0.95	2994	28443	$ 967,661	3415	32446	$ 3,609,518	$ 4,577,179	$ 1,028,140	$ 10,228,167	$ 15,833,485
11	1	1497	29940	$ 483,830	1708	34154	$ 1,805,288	$ 2,289,118	$ 1,149,097	$ 11,431,480	$ 14,869,696
12	1		29940			34154			$ 1,209,576	$ 12,033,137	$ 13,242,713
13	1		29940			34154			$ 1,209,576	$ 12,033,137	$ 13,242,713
14	1		29940			34154			$ 1,209,576	$ 12,033,137	$ 13,242,713
15	1		29940			34154			$ 1,209,576	$ 12,033,137	$ 13,242,713
16	1		29940			34154			$ 1,209,576	$ 12,033,137	$ 13,242,713
17	1		29940			34154			$ 1,209,576	$ 12,033,137	$ 13,242,713
18	1		29940			34154			$ 1,209,576	$ 12,033,137	$ 13,242,713
19	1		29940			34154			$ 1,209,576	$ 12,033,137	$ 13,242,713
20	1		29940			34154			$ 1,209,576	$ 12,033,137	$ 13,242,713
Sums		29940		$9,676,608	34151		$36,096,241	$45,772,849	$16,934,064	$168,463,922	$ 231,470,835
PV 3%				$8,134,134			$30,342,422	$38,476,556	$11,915,515	$118,538,259	$ 165,421,968
PV 7%				$6,574,131			$24,523,229	$31,097,360	$ 7,783,317	$ 77,430,205	**$ 111,016,540**

4. Total 20-Year Costs

The total 20-year costs are summarized in the following table:

ECP Brake Total COSTS					
Year	Rate	Freight Car Costs	Locomotive Costs	Training Costs	Total Costs
1	0.05	$87,316,320	$29,131,200	$2,589,118	$119,036,638
2	0.15	$174,632,640	$58,262,400	$5,239,315	$238,134,355
3	0.25	$174,632,640	$58,262,400	$6,563,586	$239,458,626
4	0.35	$174,632,640	$58,262,400	$7,887,858	$240,782,898
5	0.45	$174,632,640	$58,262,400	$9,212,129	$242,107,169
6	0.55	$174,632,640	$58,262,400	$10,536,400	$243,431,440
7	0.65	$174,632,640	$58,262,400	$11,860,672	$244,755,712
8	0.75	$174,632,640	$58,262,400	$13,184,943	$246,079,983
9	0.85	$174,632,640	$58,262,400	$14,509,214	$247,404,254
10	0.95	$174,632,640	$58,262,400	$15,833,485	$248,728,525
11	1	$87,316,320	$29,131,200	$14,869,696	$131,317,216
12	1			$13,242,713	$13,242,713
13	1			$13,242,713	$13,242,713
14	1			$13,242,713	$13,242,713
15	1			$13,242,713	$13,242,713
16	1			$13,242,713	$13,242,713
17	1			$13,242,713	$13,242,713
18	1			$13,242,713	$13,242,713
19	1			$13,242,713	$13,242,713
20	1			$13,242,713	$13,242,713
Sums		$1,746,326,400	$582,624,000	$231,470,835	$2,560,421,235
PV (3%)		$1,467,957,882	$489,752,370	$165,421,968	$2,123,132,221
PV (7%)		$1,186,425,904	$395,825,320	$111,016,540	**$1,693,267,764**

E. Sensitivity Analysis

The purpose of sensitivity analysis is to acknowledge the underlying uncertainty of estimates and the impact of assuming alternative values. Sensitivity analysis conveys how sensitive predicted costs and benefits are to changes in assumptions. Partial sensitivity analysis shows how costs change when a single assumption is varied while holding all others constant.

1. Alternative Values for a Statistical Life

Highway-Rail Grade Crossing Accident Risk Reduction Benefits

The benefits from reduced grade crossing accidents are also estimated using different values of the VSL. Per DOT guidance, VSL values of $3.2 million and $8.4 million are used to compare how the benefits vary with the choice of VSL.

The following table summarizes the resulting discounted benefit estimates, using 3 and 7 percent discount rates:

Using Alternate VSL Values to Monetize ECP Brake-Prevented Highway-Rail Grade Crossing Accidents (PV at 3% and 7%)			
	VSL $3.2 M	VSL $5.8 M	VSL $8.4 M
Total	$ 14,876,466	$ 25,802,114	$ 36,727,762
Discounted at 3%	$ 10,318,973	$ 17,897,484	$ 25,475,995
Discounted at 7%	$ 6,638,045	$ 11,513,191	$ 16,388,336

The total safety benefits from fewer expected grade crossing accidents range from about $6.6 million to $16.4 million with a median analysis estimate of $11.5 million.[75] The table demonstrates that benefits vary significantly depending on the VSL.

Rail Equipment Accident Risk Reduction Benefits

The benefits of reduced rail equipment (non-grade crossing) accidents are also estimated using different values of the VSL.

The following table shows the total and results discounted at 3 percent and 7 percent:

Using Alternate VSL Values to Monetize ECP Brake-Prevented Rail Equipment Accidents (PV at 7%)			
	VSL $3.2 M	VSL $5.8 M	VSL $8.4 M
Total	$ 232,243,891	$ 286,687,494	$ 341,131,096
Discounted at 3%	$ 161,094,599	$ 198,859,081	$ 236,623,563
Discounted at 7%	$ 103,629,809	$ 127,923,151	$ 152,216,492

The total safety benefits from fewer expected rail equipment accidents range from about $104 million to $152 million with a median analysis estimate of $128 million.[76]

2. Fifteen-Year Implementation Period

Benefits and costs will vary by how fast or slow the industry implements ECP brake technology. FRA assumes that a 10-year implementation period is reasonable, but the implementation period could vary and therefore affect the rate at which costs accrue. As explained previously, railroads have many technological advances and improvements to choose from when investing money. Railroads may spread investment in this technology over a longer period. Costs are estimated with a15-year implementation period and compared to the 10 year cost schedule used in the analysis.

Several factors could affect the rate of implementation. A railroad's availability of funds for investing in ECP brake technology will determine whether it can purchase ECP brakes. A railroad may also select to place its funds in alternative investments. Thus, a railroad's finances and resource decisions will determine how fast or slow it employs ECP brakes; the rate will vary by

[75] Results were estimated with a 7 percent discount rate.
[76] Results were estimated with a 7 percent discount rate.

railroad. Future demand for train operations that will benefit from using ECP brakes is another factor that will determine the rate of conversion to ECP brakes. As mentioned, coal, intermodal, and other unit-like train operations are the best candidates for using ECP brakes. As demand for these operations increase, the demand for ECP brakes will likely rise as well. However, in the past, the industry has shown some hesitation to adopting ECP brake technology. Until additional experience with the technology helps to verify the operational benefits of ECP brakes, the industry may be slow to adopt ECP brakes. It is assumed that as field experience with ECP brakes increases, the rate of implementation will increase. If a decision is made to implement ECP brakes at a slower rate of 15 years, the costs will accrue at a slower rate. Benefits would also accrue at a slower rate, but still exceed the costs. To determine how changing the implementation period affects the costs, the following additional cost schedule is presented. The overall method is the same as used for the 10-year implementation period. When the costs accrue at this slower rate there is a reduction of $200 million, from $1.7 billion to $1.5 billion (PV 7 percent).

All costs are calculated at this slower implementation rate and appear in the following table:

ECP Brake COSTS With 15-Year Implementation

Year	Rate	Freight Car Costs	Locomotive Costs	Training Costs	Total Costs
1	0.0667	$ 116,421,760	$ 38,841,600	$ 3,351,735	$ 158,615,095
2	0.1333	$ 116,421,760	$ 38,841,600	$ 3,934,582	$ 159,197,942
3	0.2000	$ 116,421,760	$ 38,841,600	$ 4,817,430	$ 160,080,790
4	0.2667	$ 116,421,760	$ 38,841,600	$ 5,700,277	$ 160,963,637
5	0.3333	$ 116,421,760	$ 38,841,600	$ 6,583,125	$ 161,846,485
6	0.4000	$ 116,421,760	$ 38,841,600	$ 7,465,972	$ 162,729,332
7	0.4667	$ 116,421,760	$ 38,841,600	$ 8,348,820	$ 163,612,180
8	0.5333	$ 116,421,760	$ 38,841,600	$ 9,231,668	$ 164,495,028
9	0.6000	$ 116,421,760	$ 38,841,600	$ 10,114,515	$ 165,377,875
10	0.6667	$ 116,421,760	$ 38,841,600	$ 10,997,363	$ 166,260,723
11	0.7333	$ 116,421,760	$ 38,841,600	$ 11,880,210	$ 167,143,570
12	0.8000	$ 116,421,760	$ 38,841,600	$ 12,763,058	$ 168,026,418
13	0.8667	$ 116,421,760	$ 38,841,600	$ 13,645,905	$ 168,909,265
14	0.9333	$ 116,421,760	$ 38,841,600	$ 14,528,753	$ 169,792,113
15	1.0000	$ 116,421,760	$ 38,841,600	$ 15,411,600	$ 170,674,960
16	1.0000			$ 13,242,713	$ 13,242,713
17	1.0000			$ 13,242,713	$ 13,242,713
18	1.0000			$ 13,242,713	$ 13,242,713
19	1.0000			$ 13,242,713	$ 13,242,713
20	1.0000			$ 13,242,713	$ 13,242,713
Sums		$ 1,746,326,400	$ 582,624,000	$ 204,988,579	$ 2,533,938,979
PV (3%)		$ 1,389,835,414	$ 463,688,499	$ 143,629,589	$ 1,997,153,502
PV (7%)		**$1,060,359,378**	**$353,765,953**	**$94,057,180**	**$1,508,182,511**

3. Alternative Costs and Savings Assumption Estimates for Fuel Cost Savings

FRA received comments on the analysis of the proposed rule that the fuel savings may be 3 percent, not 5 percent as assumed in this analysis. This benefit is also sensitive to the price of fuel. Both the lower fuel savings rate assumption and the higher price of fuel assumptions are quantified in the tables below. To estimate the fuel savings at 3 percent, all other assumptions are unchanged. The Class I railroads spent more than $6 billion on diesel fuel in 2005.[77] The difference in fuel savings benefits from a 5 percent savings rate to a 3 percent savings rate is $1.1 billion, or $490 million discounted at 7 percent.[78]

The following table summarizes these results:

5% Fuel Savings vs. 3% Fuel Savings			
Year	Rate	5% Fuel Savings	3% Fuel Savings
1	0.05	$ 9,150,000	$ 5,490,000
2	0.15	$ 27,450,000	$ 16,470,000
3	0.25	$ 45,750,000	$ 27,450,000
4	0.35	$ 64,050,000	$ 38,430,000
5	0.45	$ 82,350,000	$ 49,410,000
6	0.55	$ 100,650,000	$ 60,390,000
7	0.65	$ 118,950,000	$ 71,370,000
8	0.75	$ 137,250,000	$ 82,350,000
9	0.85	$ 155,550,000	$ 93,330,000
10	0.95	$ 173,850,000	$ 104,310,000
11	1	$ 183,000,000	$ 109,800,000
12	1	$ 183,000,000	$ 109,800,000
13	1	$ 183,000,000	$ 109,800,000
14	1	$ 183,000,000	$ 109,800,000
15	1	$ 183,000,000	$ 109,800,000
16	1	$ 183,000,000	$ 109,800,000
17	1	$ 183,000,000	$ 109,800,000
18	1	$ 183,000,000	$ 109,800,000
19	1	$ 183,000,000	$ 109,800,000
20	1	$ 183,000,000	$ 109,800,000
Sum		$ 2,745,000,000	$ 1,647,000,000
PV 3 %		$ 1,904,052,986	$ 1,142,431,792
PV 7%		**$ 1,224,849,552**	**$ 734,909,731**

This benefit is also sensitive to the price of fuel. Recently the price of fuel has increased. Quarterly fuel expenses surpassed $1 billion and fuel became the Class I railroads' largest expense category for the first time in 2008. Despite this recent increase, it is uncertain what future rail fuel cost levels will be. There are no forecasts available, and the FRA does not have sufficient information to reliably forecast future rail fuel cost levels. The fuel consumption in 2007[79] for four U.S. Class I railroads presumed to implement ECP brake technology, was 3.8 billion gallons at a cost of $7.9 billion.[80]

77 Total fuel spending will continue to escalate. Indeed, if the recent hedged fuel price of one major Class I of $1.70 per gallon, 40 cents below the non-hedged price, is applied to the 2004 level of Class I fuel consumption of 4.1 billion gallons, the resulting fuel bill approaches $7 billion.

78 Calculations: $2,745,000,000 - $1,647,000,000 = $1,098,000,000, and $1,224,849,552 - $734,909,731 = $489,939,821.

79 2007 estimates were converted to 2005 dollars to be consistent with constant dollars used in this analysis. The conversion tool used was the BLS calculator located at: http://www.bls.gov/data/inflation_calculator.htm.

80 Fuel data are from 2007 R1 reports and annual reports.

2007 Fuel Consumption		
	Gallons	Cost (2005 dollars)
Union Pacific	1,338,300,581	$ 2,801,232,820
BNSF	1,441,587,000	$ 3,008,659,100
Norfolk Southern	497,623,614	$ 983,687,810
CSX Transportation	569,000,000	$ 1,141,581,260
Totals	3,846,511,195	$ 7,938,219,440
ECP Commodity Usage	2,346,371,829	$ 4,842,313,858
Annual 5% Fuel Savings	117,318,591	$ 242,115,693

A 5 percent annual fuel cost savings of $242,115,693 over 20 years is $3.6 billion, or $1.6 billion discounted at 7 percent. The fuel cost savings benefits increase from $1.2 billion by $400 million to $1.6 billion using 2007 consumption and fuel costs. The following table summarizes the fuel cost savings benefits using 2007 consumption and fuel cost data.[81]

5% Fuel Savings Using 2007 Consumption and Price		
Year	Rate	Fuel Savings
1	0.05	$ 12,105,785
2	0.15	$ 36,317,354
3	0.25	$ 60,528,923
4	0.35	$ 84,740,493
5	0.45	$ 108,952,062
6	0.55	$ 133,163,631
7	0.65	$ 157,375,200
8	0.75	$ 181,586,770
9	0.85	$ 205,798,339
10	0.95	$ 230,009,908
11	1	$ 242,115,693
12	1	$ 242,115,693
13	1	$ 242,115,693
14	1	$ 242,115,693
15	1	$ 242,115,693
16	1	$ 242,115,693
17	1	$ 242,115,693
18	1	$ 242,115,693
19	1	$ 242,115,693
20	1	$ 242,115,693
Sum		$ 3,631,735,395
PV 3%		$ 2,519,131,739
PV 7%		**$ 1,620,520,755**

Of note is that, so far in 2008, diesel fuel prices for the railroads have already almost doubled from an industry average price of $2.19 per gallon in 2007 to over $4.00 per gallon as of June

[81] 2007 estimates were converted to 2005 dollars to be consistent with constant dollars used in this analysis. The conversion tool used was the BLS calculator located at: http://www.bls.gov/data/inflation_calculator.htm.

2008. This, of course has the potential to nearly double the benefit of these projected fuel savings should the fuel consumption of railroads remain constant.

4. Alternative Density Assumption Estimates for Train Delay, Yard Delay, and Associated Track Out-of-Service Benefits

Over half of the total benefits of ECP brakes result from track out-of-service costs for accidents. The major determinate of these benefits is track density. There is a high level of uncertainty associated with this estimate. The higher the track density, the more trains are delayed when an accident occurs. Thus, the hourly train delay costs are higher when more trains are delayed. Track density is measured using Waybill data that has a three percent expansion factor when estimated for the year. Yearly Waybill estimates were used to determine density. Most rail traffic occurs on major corridors. Estimates for a lower traffic density are presented to address the uncertainty surrounding this estimate. It would not be unreasonable for the average traffic density to be closer to 40% of the "dense corridor" selected. The following table summarizes the results using this alternative assumption for train delay, yard delay, and associated track out-of-service benefits:

Reduction in Train Delay Associated With Preventable Accidents									
Year	Rate	Highway-Rail Accident Reduction	Highway-Rail Accidents * 2 Hour Delay	Rail Equip. (non highway-rail) Accident Reduction	Rail Equip. Accidents * 77% (derailments)	Rail Equip. Accidents (derailments) * 24 Hour Delay	Rail Equip. Accidents * 23% (non-derailments)	Rail Equip. Accidents (non-derailments) * 5 Hour Delay	Total Value of Train Delay Reduction
1	0.05	1.65669	$ 360,424	13.35	10.28	$ 26,836,501.51	3.07	$ 1,670,020	$ 28,866,946
2	0.15	4.97007	$ 1,081,272	40.05	30.84	$ 80,509,504.52	9.21	$ 5,010,061	$ 86,600,838
3	0.25	8.283449	$ 1,802,121	66.75	51.40	$ 134,182,507.54	15.35	$ 8,350,102	$ 144,334,730
4	0.35	11.59683	$ 2,522,969	93.45	71.96	$ 187,855,510.55	21.49	$ 11,690,143	$ 202,068,622
5	0.45	14.91021	$ 3,243,817	120.15	92.52	$ 241,528,513.56	27.63	$ 15,030,183	$ 259,802,514
6	0.55	18.22359	$ 3,964,666	146.85	113.07	$ 295,201,516.58	33.78	$ 18,370,224	$ 317,536,406
7	0.65	21.53697	$ 4,685,514	173.55	133.63	$ 348,874,519.59	39.92	$ 21,710,265	$ 375,270,298
8	0.75	24.85035	$ 5,406,362	200.25	154.19	$ 402,547,522.61	46.06	$ 25,050,306	$ 433,004,191
9	0.85	28.16373	$ 6,127,210	226.95	174.75	$ 456,220,525.62	52.20	$ 28,390,347	$ 490,738,083
10	0.95	31.47711	$ 6,848,059	253.65	195.31	$ 509,893,528.64	58.34	$ 31,730,387	$ 548,471,975
11	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408	$ 577,338,921
12	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408	$ 577,338,921
13	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408	$ 577,338,921
14	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408	$ 577,338,921
15	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408	$ 577,338,921
16	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408	$ 577,338,921
17	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408	$ 577,338,921
18	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408	$ 577,338,921
19	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408	$ 577,338,921
20	1	33.1338	$ 7,208,483	267	205.59	$ 536,730,030.14	61.41	$ 33,400,408	$ 577,338,921
Sums		497.007	$ 108,127,243	4005.00	3,083.85	$ 8,050,950,452.16	921.15	$ 501,006,116	$ 8,660,083,811
PV (3%)			$ 75,001,821			$ 5,584,494,079		$ 347,519,924	$ 6,007,015,824
PV (7%)			**$ 48,247,579**			**$ 3,592,423,700**		**$ 223,554,505**	**$ 3,864,225,784**

The reduction in traffic density reduces the discounted, present value benefit from $4,830,282,231 to $3,864,225,784, or approximately $1 billion.

VI. SPECIALIZED ANALYTICAL REQUIREMENTS

A. Analysis of Impacts on Small Entities

The purpose of this section is to provide information and further detail on the assessment of the impacts on small entities by the ECP brake system requirements. This section is also intended to fulfill the requirements found in the Regulatory Flexibility Act (the Act).[82] Further, this document illuminates the thought processes of FRA during the rulemaking and its efforts to minimize the adverse economic impact on small entities and to ensure sufficient outreach to these entities.

The initial analysis of impacts on small entities concluded that this rule would not have a significant economic impact on a substantial number of small entities. In order to determine the significance of the economic impact for the final rule's Regulatory Flexibility Act requirements, FRA invited comments from all interested parties concerning data and information regarding the potential economic impact caused by this proposed rule. FRA did not receive any comments or data.

The *factual basis* for the certification that the rule will not have a significant economic impact on a substantial number of small entities is that the rule is voluntary. Therefore, the rulemaking does not impose direct costs on small railroads and the analytical requirements of the Act do not apply. Even given the voluntary nature of the rulemaking, FRA estimates that only four Class I railroads will take advantage of the rule. The rule will more than likely not affect any small railroads. As will be explained in greater detail later in this document, all of the 523 small railroads will have no economic impact from the rule.

In addition to its conclusion that this rule will not have a significant economic impact on a substantial number of small entities, FRA further concludes that the rule will not have a noticeable impact on the *competitive position* of small entities, or on the small entity segment of the railroad industry as a whole.

The small entity segment of the railroad industry faces little in the way of intramodal competition. Small railroads generally serve as "feeders" to the larger railroads, collecting carloads in smaller numbers and at lower densities than would be economical for the larger railroads. Smaller railroads that carry unit and unit-like commodities often operate the train with the locomotives and cars without ownership of the equipment. They transport those cars over relatively short distances and then turn them over to the larger systems, which transport them relatively long distances to their ultimate destination, or for handoff back to a smaller railroad for final delivery. Although there are situations in which the relative interests of large and small railroads may not always coincide, the relationships between the large and small entity segments of the railroad industry are more supportive and co-dependent than competitive.

It is also extremely rare for small railroads to compete with each other. As mentioned above, small railroads generally serve smaller, lower density markets and customers. They exist, and

[82] 5 U.S.C. § 601, et seq.

often thrive, doing business in markets where there is not enough traffic to attract the larger carriers that are designed to handle large volumes over distance at a profit. As there is usually not enough traffic to attract service by a large carrier, there is also not enough traffic to sustain more than one smaller carrier. In combination with the huge barriers to entry in the railroad industry (need to own right-of-way, build track, purchase fleet, etc.), small railroads rarely find themselves in competition with each other. Thus, even to the extent that the rule may have an economic impact, it should have no impact on the intramodal competitive position of small railroads.

FRA does recognize that small entities may in some cases, be involved in specific route segments for trains that originate or terminate on a Class I railroad. In these cases, the cars involved are more likely than not to be shipper owned or provided from the Class I fleet. Mutual support arrangements and shared power practices are likely to ensure that the smaller railroad will not require ECP brake-equipped locomotives for this service.

To the extent FRA has included grain unit train service in these estimates, and to the extent doing so is not warranted by the practicalities of particular shipping practices (as where carloads are collected at grain elevators on branch lines), FRA anticipates that ECP brakes will not be used in that service. Since grain cars are used heavily only during certain seasons of the year (in contrast to year-round services), removing any portion of grain service from the analysis would tend, at worst, to reduce costs more than benefits.

Additionally, the suppliers of conventional and ECP brakes are not small entities.

1. Rationale for Choosing Regulatory Action

In an effort to understand why ECP brake systems were not implemented in the industry, FRA commissioned a report and performed research on ECP brakes. The report, title "Benefit Cost Analysis an Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry," dated August 2006, elaborates the results of these studies. The report found that it is not cost effective to implement this technology on smaller railroads. Most of the potential benefits have a higher rate of return on unit and unit-like service. Smaller railroads primarily handle mixed freight which does not lend itself to being transported in unit or unit-like trains.

2. Small Entities Affected

The United States Small Business Administration (SBA) stipulates in its "size standards" a for-profit railroad business firm may not have more than 1,500 employees for line-haul operating railroads, and 500 employees for switching and terminal establishments to be considered a small entity.[83] "Small entity" is defined in 5 U.S.C. § 601 as a small business concern that is independently owned and operated and is not dominant in its field of operation. SBA's size standards may be altered by Federal agencies upon consultation with SBA, and in conjunction with public comment.

[83] Public Law 102-365, September 3, 1992.

Pursuant to that authority, FRA has published a final policy that classifies "small entities" as being railroads that meet the line haulage revenue requirements of a Class III railroad.[84] Currently, the revenue requirements are $20 million or less in annual operating revenue. The $20-million limit is based on the Surface Transportation Board's threshold of a Class III railroad carrier, which is adjusted by applying the railroad revenue deflator adjustment.[85] The same dollar limit on revenues is established to determine whether a railroad shipper or contractor is a small entity. FRA is using this definition of "small entity" for regulatory flexibility purposes in this rulemaking.

For this rulemaking, there are approximately 523 small railroads that could potentially receive regulatory relief.[86] However, railroads are not mandated to convert to ECP brake technology. Regulatory relief provides an incentive for most long-haul services to convert. Smaller railroads do not operate over 1,000 miles or 1,500 miles and would not benefit economically by converting to this technology. Hence, FRA does not expect this regulation to impact any small railroads. FRA estimates that in aggregate, small railroads own approximately 2,500 locomotives.

The only nonrailroad businesses that potentially could be impacted by the requirements in this rule are ECP brake manufacturers, i.e., original equipment manufacturers (OEM) and re-manufacturers. The primary OEMs of ECP brakes are large corporations that are already in the air brake market and are not considered small entities. FRA requested comments, information and data that would substantiate that there either are or are not secondary equipment manufacturers that would be considered small entities and impacted by this proposed regulation. No comments, information, or data were received.

3. Reporting, Recordkeeping, and Other Compliance Requirements

The major reporting or recordkeeping requirements in this rulemaking are for ECP brake manufacturers. Railroads are required to identify repair locations for ECP brake trains. Locomotive engineer training on ECP brake equipment requires records and certifications. However, since no small railroads are anticipated to purchase ECP brake technology, these requirements are not anticipated to impact any small entities.

4. Impacts

The impacts from this regulation are primarily a result of the cost to convert to ECP brake technology. These costs include locomotive crew and inspector training, freight car conversion costs, and locomotive conversion costs. Again, since no small railroads are expected to convert to ECP brake technology, these impacts are not anticipated to impact any small entities.

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[84] RSAC was established to provide advice and recommendations to the FRA on railroad safety matters. The Committee consists of 48 representatives, drawn from among 27 organizations representing various railroad industry interests, including both the AAR, which represents large railroads, and the ASLRRA that represents the small and medium railroads.

[85] "Table of Size Standards," United States Small Business Administration, January 31, 1996, 13 CFR Part 221.

[86] See 68 FR 24891 (May 9, 2003).

The regulatory analysis for this rulemaking estimates that the total nondiscounted costs over 20 years are $2.6 billion. The present value (7 percent, PV) for this cost total is $1.7 billion for the 20-year period. FRA estimates there will be no impact to the small railroads for the time period of this analysis. As noted above, the regulatory analysis contains more details on the individual impacts of each section of the rule.

5. Alternative Treatment for Small Entities

Since FRA does not anticipate that this rule would impose any burdens on small entities, there is no alternative treatment for small entities.

6. Outreach to Small Entities

On September 21, 2006, FRA had a meeting of its Rail Safety Advisory Committee (RSAC), which includes the American Short Line and Regional Railroad Association (ASLRRA), where BAH provided a briefing on their report.[87] FRA indicated at the RSAC meeting its intention to issue a proposed rule on ECP brakes. Since that RSAC meeting, there have been numerous opportunities for small entities to raise concerns. None have been raised. FRA assumed that the regulatory relief benefits would not apply to railroads that operate fewer than 1,000 miles. FRA solicited comments from small entities that would be interested in implementing this technology, but none were received.

7. Conclusion

FRA's ECP brake requirements are intended to improve the safety and efficiency of railroad operations. This small entity impact assessment and evaluation concludes that this rule would not have an economic impact on any small entities. In order to determine the significance of the economic impact for the final rule's regulatory flexibility assessment, FRA invited comments from all interested parties concerning the potential economic impact on small entities caused by this rule. The Agency did not receive comments or data.

Executive Order No. 13272, "Proper Consideration of Small Entities in Agency Rulemaking," requires a Federal agency, inter alia, to notify the Chief Counsel for Advocacy of the SBA of any of its draft rules that would have a significant economic impact on a substantial number of small entities, to consider any comments provided by the SBA, and to include in the preamble to the rule the agency's response to any written comments by the SBA unless the agency head certifies that including such material would not serve the public interest.[88] Since FRA has determined that this rule would not have significant impact on a substantial number of small entities, no notification to SBA has been provided for this purpose.

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[87] RSAC was established to provide advice and recommendations to the FRA on railroad safety matters. The Committee consists of 48 representatives, drawn from among 27 organizations representing various railroad industry interests, including both the AAR, which represents large railroads, and the ASLRRA that represents the small and medium railroads.

[88] See 67 FR 53461 (August 16, 2002).

B. Analysis of Unfunded Mandates

Pursuant to Section 201 of the Unfunded Mandates Reform Act of 1995 (Pub. L. 104-4, 2 U.S.C. § 1531), each Federal agency "shall, unless otherwise prohibited by law, assess the effects of Federal regulatory actions on State, local, and tribal governments, and the private sector (other than to the extent that such regulations incorporate requirements specifically set forth in law)." Section 202 of the act (2 U.S.C. § 1532) further requires that "before promulgating any general notice of proposed rulemaking that is likely to result in the promulgation of any rule that includes any Federal mandate that may result in expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100,000,000 or more (adjusted annually for inflation) in any one year, and before promulgating any final rule for which a general notice of proposed rulemaking was published, the agency shall prepare a written statement" detailing the effect on State, local, and tribal governments and the private sector. The rule may result in the expenditure, in the aggregate of $100,000,000 or more in any one year. The value equivalent of $100,000,000 in CY 1995, adjusted for inflation to CY 2008 levels by the Consumer Price Index for All Urban Consumers (CPI-U) as published by the Bureau of Labor Statistics, is $141,000,000. In accordance with DOT guidance, when applying this test, the costs in any year of voluntary compliance with this rule do exceed $141,000,000. However, those costs are not mandated and would only be incurred by the private sector if it wishes to take advantage of the regulatory relief provided by the rule. The analytical requirements under Executive Order 12866 are similar to the analytical requirements under the Unfunded Mandates Reform Act of 1995 and, thus, the same analysis complies with both analytical requirements.

Appendix A

ECP BRAKE CAUSE CODES				
Cause Code	DESCRIPTION	Minimum	Best Estimate	Maximum
E00C	Knuckle Broken or Defective	**34%**	**40%**	**46%**
E03C	Obstructed brake pipe or connections (closed angle cock, ice, etc.)	**74%**	**87%**	**100%**
E03L	Obstructed brake pipe or connections (closed angle cock, ice, etc.) (Locomotive)	**74%**	**87%**	**100%**
E04C	Other brake components damaged, worn,broken, or disconnected	**26%**	**30%**	**35%**
E05C	Brake valve malfunction (undesired emergency)	**74%**	**87%**	**100%**
E06C	Brake valve malfunction (stuck brake, etc.)	**74%**	**87%**	**100%**
E08C	Hand brake (including gear) broken or defective	**10%**	**15%**	**20%**
E09C	Other brake defects, cars (Provide detailed description in narrative)	**26%**	**30%**	**35%**
E66C	Damaged flange or tread (flat)	**43%**	**50%**	**58%**
E67C	Damaged flange or tread (build up)	**81%**	**90%**	**95%**
E6AC	Thermal crack flange or tread	**10%**	**15%**	**20%**
E69C	Other wheel defect (CAR) (Provide detailed description in narrative)	**10%**	**15%**	**20%**
E99C	Other mechanical and electrical failures, (Car) (Provide detailed description in narrative)	**10%**	**15%**	**20%**
H008	Improper operation of train line air connections (bottling the air)	**74%**	**87%**	**100%**
H019	Failure to release hand brake on car(s) (railroad employee)	**10%**	**15%**	**20%**
H099	Use of brakes, other (Provide detailed description in narrative)	**26%**	**30%**	**35%**
H401	Failure to stop train in clear	**10%**	**15%**	**20%**
H499	Other main track authority causes (Provide detailed description in narrative)	**10%**	**15%**	**20%**
H501	Improper train makeup at intitial terminal	**68%**	**80%**	**92%**
H503	Buffing or slack action excessive, train handling	**81%**	**90%**	**95%**
H504	Buffing or slack action excessive, train make-up	**81%**	**90%**	**95%**
H505	Lateral drawbar force on curve excessive, train handling	**81%**	**90%**	**95%**
H506	Lateral drawbar force on curve excessive, train make-up	**68%**	**80%**	**92%**
H507	Lateral drawbar force on curve excessive, car geometry (short car/long car combination)	**26%**	**30%**	**35%**
H508	Improper train make-up	**68%**	**80%**	**92%**
H509	Improper train inspection	**43%**	**50%**	**58%**
H510	Automatic brake insufficient (H001)	**74%**	**87%**	**100%**
H511	Automatic brake excessive (H002)	**81%**	**90%**	**95%**
H512	Automatic brake, failure to use split reduction (H003)	**81%**	**90%**	**95%**
H513	Automatic brake, other improper use (H004)	**81%**	**90%**	**95%**
H514	Failure to allow air brakes to fully release before proceeding (H005)	**74%**	**87%**	**100%**
H517	Dynamic brake insufficient (H009)	**10%**	**15%**	**20%**
H518	Dynamic brake excessive (H010)	**10%**	**15%**	**20%**
H519	Dynamic brake, too rapid adjustment (H011)	**43%**	**50%**	**58%**
H520	Dynamic brake, excessive axles (H012)	**43%**	**50%**	**58%**
H521	Dynamic brake, other improper use (H013)	**43%**	**50%**	**58%**
H522	Throttle (power) improper use (H014)	**43%**	**50%**	**58%**
H523	Throttle (power) too rapid adjustment (H015)	**15%**	**20%**	**25%**
H525	Independent (engine) brake, improper use (except actuation) (H023)	**43%**	**50%**	**58%**
H526	Failure to actuate off independent brake (H024)	**43%**	**50%**	**58%**
H599	Other causes relating to train handling or makeup (Provide detailed description in narrative)	**10%**	**15%**	**20%**
H699	Speed, other (Provide detailed description in narrative)	**10%**	**15%**	**20%**
H702	Switch improperly lined	**10%**	**15%**	**20%**
H999	Other train operation/human factors (Provide detailed description in narrative)	**10%**	**15%**	**20%**
M308	Highway user deliberately disregarded crossing warning devices	**10%**	**15%**	**20%**
M399	Other causes (Provide detailed description in narrative)	**10%**	**15%**	**20%**
M401	Emergency brake application to avoid accident	**10%**	**15%**	**20%**
M402	Object or equipment on or fouling track (motor vehicle - other than highway-rail crossing)	**10%**	**15%**	**20%**
M404	Object or equipment on or fouling track - other than above (for vandalism, see code M503)	**10%**	**15%**	**20%**
M599	Other miscellaneous causes (Provide detailed description in narrative)	**10%**	**15%**	**20%**

Appendix B

ACCIDENT/INCIDENT RECORD EXTRACTION PROCESS USED TO SUPPORT NATIONAL INSPECTION PLAN (NIP) ANALYSES

1. Because the FRA Accident/Incident file for a calendar year contains multiple records for a number of its entries, it is desirable to find an identifier for each accident, and apply that identifier to its records. The identifier used in this record extraction process is the concatenation of the following file fields:
    a. IYR3
    b. IMO3
    c. RR3
    d. INCDTNO3
2. The process used to support NIP analyses begins by appending together the incident files for a user specified range of years. Before appending them together, the annual files are processed to insert the accident keys into a newly created key field inserted into each file. The appended year incident file is sorted in ascending order by record key and descending order by JointCD field values.
3. A second file containing distinct accident keys is then extracted from the appended year incident file, and is sorted in ascending key order.
4. The record extraction process begins by selecting the appended year incident file records that contain the first accident key file entry.
5. If there is only one record associated with the first key, and the RR2 field is empty, that record will represent the key's accident in the extraction process output file.
6. If there is only one record associated with the first key, the RR2 field is not blank, and the RAILROAD and RR3 field entries are equal, the record will still be used, but the value in the RAILROAD field will be changed to the value in the RR2 field, the RR2 field will be made blank, and the JointCD entry will be set to zero (0).
7. When the number of appended file records associated with the accident key exceeds one, they will be screened by the following criteria applied sequentially.
8. If incident cause is equipment related, and the RAILROAD field entry does not equal its RR3 counterpart, the record will be selected to represent the key's accident.
9. If the incident cause is equipment related, the RAILROAD and RR3 field entries match, and the RR2 field is blank, the record will again be selected.
10. If the incident cause is related to human factors, and the RAILROAD and RR3 entries do not match, the record will be selected.
11. If the incident cause is related to human factors, the RAILROAD and RR3 entries do match, and the RR2 field entry is blank, the record will be selected.
12. If incident cause is track or signal related, and the RAILROAD and RR3 entries match, the record will be selected.
13. If incident cause falls in the FRA's Miscellaneous Cause category, and the record's JointCD entry equals 1, the record will be selected.
14. If multiple records have been extracted for the accident key, and the first record is not selected to represent the key's accident, process the next extracted record through the

criteria appearing in steps 7 through 14. Continue with succeeding records until one of the records is selected, or until the last record is reached.

15. The final record, if reached, will be subjected to further screening but, except for limited editing of certain of its fields that may occur, will be used to represent the accident. It should be noted that that record would have a JointCD entry equal to 1.
16. Processing of the first accident key is now complete. Returning to step 5, the process will then be repeated for each entry in the accident key file until a record is selected for each key and its related accident.

Appendix C

Methodology to Determine Train Delay/Track Out-of-Service Time Benefits

The United States was divided into several primary dense corridors. The corridors are main-line track and operate the majority of rail traffic for the country. The track class of the corridor was used to determine the average speed of trains. Data from the Surface Transportation Board Carload Waybill Sample were used to determine the expanded tons, expanded cars on the corridor, develop train sets, and determine the percentage of traffic for that corridor out of the representative carrier's total system traffic. Development of train sets also included annual cars for unit trains and thru trains from the Analysis of Class I Railroads. This information included the number of cars for each train type (unit trains and thru trains). Finally, the number of trains of each train type was based on average train length.

After the traffic was determined for the corridor, with the corresponding number of train sets, railroad transportation costs could be applied on a per train per day basis. A point on the corridor was chosen for an accident that blocked traffic in both directions. A determination was made with regard to the number of trains held in a 24-hour period with the associated cost of delay for those trains. Due to the network effects, costs for trains held increase as more and more trains must stop on the corridor. These costs are then added for the 24-hour period and then assessed as a per hour cost.

Assuming that average corridor density is one-half of the "dense corridor" selected, the results were divided in half. This application may not necessarily be the case for all railroads; considerations should be given to the number of corridors, corridor length, and the density on those corridors. The sensitivity analysis section includes estimates for a lower traffic density to address the uncertainty surrounding this estimate. It would not be unreasonable for the average traffic density to be closer to 40% of the "dense corridor" selected.

The work steps for any railroad to estimate the cost of track out-of–service time were as follows:

1. Determine the number of unit and mixed train loaded cars for the railroad whose corridor was selected (AAR: *Analysis of Class I Railroads*, Lines 718 & 720);
2. Make assumptions of the number of cars per unit train (115 cars) and the number of cars per merchandise train based upon AAR statistics (East - 60 cars; West - 75 cars);
3. Double the number of unit trains to account for empty returns;[89]
4. Select a U.S. Class I railroad corridor;
5. Determine the number of loaded freight trains on that corridor based upon annual waybill data;
6. Separate trains on the corridor into categories of unit, mixed freight, and empty unit trains;
7. Derive the number of trains per day by category operating on the corridor;

[89] Empty cars were included in the mixed freight trains. To account for empty unit trains, reverse routing is assumed.

8. Determine headways and train spacing (assumption: trains have 20-mile spacing, 45 mph speed, and 2-mile signal spacing), picking one point on that corridor where the accident occurs;
9. Determine total train operating costs for the selected carrier (AAR: *Analysis of Class I Railroads*, Line 159; Transportation – Train Operations) for that corridor per day based upon percent of transportation costs for train operations;
10. Assign train costs on a per train per hour basis;
11. For derailments, determine the number of trains on the corridor delayed during a 24-hour period and the associated delay costs;
12. Use transportation costs for yard operations (AAR: *Analysis of Class I Railroads*, Line 160; Transportation – Yard Operations);
13. Determine average transportation and yard costs per hour for accident;
14. Costs are multiplied by hours of delay per accident in the accident reduction benefit pool.