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Examining the Effects of Precision Scheduled Railroading on Intercity Passenger and High-Speed Rail Service

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EXAMINING THE EFFECTS OF PRECISION SCHEDULED RAILROADING ON INTERCITY PASSENGER AND HIGH-SPEED RAIL SERVICE

John G. Green, PhD, PE
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16. Abstract
More than just scheduling terminal-to-terminal trips for trains, "Precision Scheduled Railroading" (PSR) creates entire point-to-point trip plans for individual railroad shipments. Since precision execution was first put into practice, the benefits to shipment arrival reliability and to freight railroads' profitability have been demonstrated by its use in several Class One freight railroads. However, the effects of the PSR operating strategy on passenger railway operations in shared freight/passenger corridors has not been studied in detail. This research examines the effects of PSR railroad operations on passenger railways, including measuring "Host Railroad Minutes of Delay per 10,000 Train-Miles" and "On-Time Performance" of individual passenger railways, both intercity and high-speed.

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EXECUTIVE SUMMARY

"Precision Scheduled Railroading" (PSR) is a concept that has been closely associated with the late railway magnate E. Hunter Harrison. More than just scheduling terminal-to-terminal trips for trains, PSR creates entire point-to-point trip plans for individual railroad shipments. Service failures can result if there is a mismatch between demand and the amount of capacity provided. Prior research suggests that "precision execution" of freight trains is a necessary, but not sufficient condition for achieving service reliability. Since the concept was first put into practice, the benefits to shipment arrival reliability and to freight railroads' profitability has been demonstrated by several Class One freight railroads where it has been implemented. However, the effects of the "Precision Scheduled Railroad" operating strategy to passenger railway operations in shared freight/passenger corridors has not been studied in detail.

This paper researches the effects of the PSR approach in the context of passenger railways. The key measures examined are "Host Railroad Minutes of Delay per 10,000 Train-Miles" and "On-Time Performance" of individual passenger railways for both intercity passenger railways and high-speed rail.

The results concerning "Host Railroad Minutes of Delay per 10,000 Train-Miles" suggest that PSR may be able to reduce delays of the Amtrak passenger trains that it hosts. However, the "On-Time Performance" results suggest that PSR strategies have the potential to worsen a host railroad's performance. Taken together, the results of the study suggest that if implemented properly, PSR strategies will have no effect on a freight railroad's ability to host Amtrak intercity and high-speed rail passenger railway service, but that if implemented incorrectly, the host railroad can negatively affect Amtrak's train performance.

I. INTRODUCTION

Since 1971, intercity passenger railway service in the United States has been provided almost entirely by Amtrak, including North America's one high-speed rail line, Acela. Unlike passenger railways in most nations, Amtrak rents its tracks from freight railway owners, paying annually roughly $142 million to these "Host Railroads," who dispatch the trains that run on their tracks. (1) Because who controls the dispatching of trains determines which trains have priority over others on a line, the operating strategies of the host freight railroads have a significant impact on the on-time performance of Amtrak's passenger trains. For years, Amtrak officials have been dissatisfied with the excessive delays in its passenger railway service that were caused by the host railroads. (2) So, in March of 2020, the Federal Railroad Administration (FRA) met with stakeholders and proposed a new minimum performance standard for its host railroads of 80% on-time trains. (3) Some key statistics of Amtrak's operations on the Class One freight railroads are shown in **Table 1**.

Table 1. Data for Class One Freight Railroads Hosting Amtrak Intercity Passenger Railway Service

Freight Railroad Name	Total Miles of Track (2020)	Uses PSR (yes or no)	Year Started PSR	Miles of Amtrak Service
BNSF Railway	32,500	No	N/A	7,014
Canadian National Railway	20,400	Yes	1998	1,539
Canadian Pacific Railway	12,400	Yes	2012	675
CSX	21,000	Yes	2017	7,057
Norfolk Southern Railway	19,420	Yes	2018	3,056
Union Pacific Railroad	32,000	Yes	2018	6,460
TOTAL	137,720			25,801

NOTE: The Kansas City Southern Railway does not host Amtrak trains

Clearly Amtrak and the freight railways disagree on how to best run passenger and freight trains on the same tracks in the shared railroading environment of the United States, but with a new operating strategy that has gradually been adopted by most of the largest freight railways in the United States over the past several years, "Precision Scheduled Railroading" (PSR), there is potential for change.

II. BACKGROUND AND HISTORY

In 1982, at its lowest point in market share of the US freight transportation market (4,010,592 million-ton-miles), railroads only transported 20.2% (810,000 million-ton-miles) of the freight, while trucks transported 32.4% (1,300,863 million-ton-miles) of the freight. ***(4)*** Since that low point for the railroads in the USA, academics and railroad managers have meticulously studied how freight railroads operate, with the goal of developing the most efficient railroad operations possible, in order to increase market share and keep it against competition from trucks. One area where it was thought improvement could be made to return more freight to railroads was improving on-time performance. In research by Edwin Kraft, a railroad network simulation model was built to test the effect of various operating strategies on transit (freight travel) time reliability. The study indicated that "precision execution of railroad shipments is a necessary condition for achieving service reliability," and "carriers have a financial incentive to figure out how to schedule sufficient capacity to handle demand peaking." The study then concluded that "railroads must improve reliability, particularly on single railcar shipments, if they hope to remain competitive with trucks in the future." ***(5)***

The natural next question is therefore, "what is the appropriate amount of railroad track, other railway infrastructure, and railway equipment to provide sufficient capacity"? First, a definition of railway line capacity is needed. One definition is that railway capacity is the maximum number of trains that would be able to operate on a given railway infrastructure, during a specific time interval, subject to the railway operating plan. Capacity analyses are key to efficient train operations and have been calculated since the inception of the railway industry. The goal of a capacity analysis is to determine the maximum number of trains that can safely operate on a railway's tracks and yards, over a certain pre-defined length of time, given the operating conditions of that railroad. ***(5)*** In Kraft's research, the authors demonstrated that railway capacity is not constant, but rather it depends on how the railway infrastructure is utilized. For example, the "Infrastructure Parameters," the signaling system's block section lengths, whether a section of the route has single or double tracks, and the condition the ties, rails, and ballast of the track structure, all have major effects on maximum train speeds allowed and therefore the number and size of trains run daily. "Traffic Parameters," such as the mix of trains running on a line, the percentage of trains that run according to regular timetables, and the prioritization and the total number of train priority classes affect capacity in a significant manner. (Because high-priority trains are given preferential treatment over lower priority trains, the total system delays increase; therefore the greater number of priority classes, the less capacity is available.) Additionally, "Operating Parameters" such as train stop time, time spent in yards and terminals, and the reliability of service plans affect a railway line's capacity. ***(6)***

The track and yard infrastructure and the railway signaling system are both somewhat straightforward elements to determine, but the railway equipment utilization can be more difficult to assess. William Vantuono pointed out that equipment utilization has many facets and covers everything from railcar design to the scheduling of trains, and train scheduling is the most important part. ***(7)***

The modern era of railroad scheduling started in the mid-1970s, when the Association of American Railroads (AAR), the Federal Railroad Administration (FRA), and the

Massachusetts Institute of Technology (MIT) worked together to create an "operations/ service planning" computer model that would focus on service quality and make freight railroad operations more efficient. The data inputs for the model were "origin-destination traffic volumes," throughput numbers for railyards, train schedules, and unit costs. The outputs of the computer model were predictions of shipment "origin-destination trip times" and transportation costs for a particular operating plan. ***(7)*** Several railroads took a strong interest in the project and its lessons learned, including the BNSF, the Southern Pacific Railroad, and the Illinois Central Railroad (where Hunter Harrison first became a Chief Executive Officer).

PRECISION SCHEDULING RAILROADING DEFINED

Railroads have long desired to improve the reliability of delivery dates and times for their customers' shipments. Railway operations managers worked on developing sorting concepts for railyards that would allow "time definite" service with a guaranteed delivery date and time. By changing the way in which railcars were assigned to outgoing trains, from "first-come-first-served" to ensuring connections of particular cars to specific trains, it was postulated that service reliability could be improved. **(8*)*** What was needed was for a Class One (major) freight railroad to put the various ideas and concepts together and implement it as an operating strategy.

In 1998, the Canadian National Railway (CN) was deep in debt, and steadily losing market share of the freight transportation business to the trucking industry. In that year, the CN acquired the Illinois Central Railroad (IC), and with it, the IC's CEO, E. Hunter Harrison, who had already implemented the strategy of point-to-point trip plans for individual railcars, now called Precision Scheduled Railroading, or PSR. After seeing the results of PSR at the IC, the CEO of the CN at the time, Paul Tellier, made Harrison the Chief Operating Officer of the CN, and PSR was begun at the CN. ***(9)*** PSR consists of seven principles that allow a railroad to move the same amount of freight as with traditional methods, but with fewer people and less equipment. PSR consists of seven principles: (1) minimizing railcar dwell times in yards; (2) reducing railcar classifications; (3) using multiple traffic outlets; (4) running fewer specialized and more "general purpose" trains, (5) balancing train movements by direction; (6) minimizing locomotive power requirements; and (7) striving for more smoothed-out, steady work. ***(10)***

A goal of implementing PSR is to streamline operations using departure scheduling and point-to-point delivery methods in order to improve service to customers. Before PSR, most railroads used a "hub-and-spoke-system," in which railcars enter a hub or terminal, where they are placed on different trains and redirected to their respective destinations. Railway operating strategy focused on moving long trains, maximizing capacity to yield the efficiency of labor and motive power. Railroads would operate both unit (a single commodity) and manifest (a variety of commodities) trains with unit trains being the preferred method. This approach did not always achieve the best outcomes for the railroad and its customers, because the strategy meant that if a train service headed to a specific destination city did not meet specific length requirements for its scheduled day of departure, it could be cancelled—the result being that railcars often sat for long periods of time in railyards, thereby reducing the yards' capacities.

The Precision Scheduled Railroading concept replaced the "terminal-to-terminal" shipment strategy with "loading-dock-to-loading-dock." By employing such an operating method, and sticking to its schedules, a railroad eliminates much railcar switching within its yards, and hauls freight from origin to destination more quickly, thereby reducing dwell time of equipment, which improves its asset utilization. ***(11)*** Departure scheduling requires trains to leave on-time, regardless of whether a customer's railcars are ready to depart with their scheduled train or not. The combination of the departure scheduling and point-to-point delivery is intended to allow railroads to maximize running time at lower operating costs. Railroads using PSR strategies lower their operating costs through the elimination of jobs thought to be not needed, and through sale of extra locomotives and railcars, as fewer trains are run. Additionally, most of the major railroads running PSR have expanded upon its cost-cutting efficiencies by eliminating many of their less profitable rail lines.

EXPERIENCES OF THE OTHER CLASS ONE RAILROADS

CP Railway

The Canadian Pacific Railway implemented Precision Scheduled Railroading in 2012, when the Pershing Square Capital Management hedge fund, owners of a 14% share of the railroad, replaced the CEO and Chairman of the Board with Hunter Harrison. ***(12)*** Harrison instituted his PSR strategy and the operating ratio of the CP decreased from roughly 80% to 70% in just one year's time. Harrison's asset utilization point of view was stated directly in the book *How We Work and Why* when he said, "An asset is not an asset until it is put to use. Until then it is a liability. Assets have to earn their keep." ***(13)*** To get to that point, Harrison let go 4,800 of the 19,500 employees who worked for CP when he joined the company, sold 400 locomotives and 11,000 railcars, and closed numerous terminals. ***(14)*** Since Hunter Harrison left CP in 2017, the railroad has continued with the PSR strategy for railroads, having Keith Creel, Harrison's protégé, succeeding him as the CP's CEO.

CSX Railway

In 2017, Hunter Harrison left the CP Railway and joined CSX, becoming its CEO. One of his first steps was to start consolidating trains into fewer, longer trains. Then three other aspects of Precision Scheduled Railroading followed—roughly one-third of CSX's 31,000 employees were let go, 900 locomotives and 26,000 railcars were done away with, and less profitable rail lines were sold by the second quarter of the year 2017. ***(15)*** Hunter Harrison passed away when he was only a few months on the job at CSX, and the railroad is still working to find the best balance of PSR strategies. ***(16)***

NS Railway

NS began developing its "Top21" PSR program in late 2018 as part of a strategy called "Reimagine Possible." This began with streamlining of terminal operations and in order to speed the flow of rail cars from origins to customers. In mid-2019, NS launched TOP21, a new operating plan that changed the way NS runs trains across the network, basically running fewer, heavier trains, reducing railcar switching, and increasing network velocity. When the program started, NS owned roughly 4,100 locomotives and employed 26,000 people. ***(15)*** In a filing to the Securities and Exchange Commission (SEC) on April 9, 2020, NS stated that it had recently sold 300 locomotives, and intended to put another 400 locomotives up for sale. Also, as part of the "Reimagine Possible" initiative of PSR, NS let go 3,500 of its 26,000 employees in the year of 2019-2020. ***(17)*** The company attributed its decision to the introduction of precision scheduled railroading (PSR) in 2019, which "continues to provide significant benefits to the network operations and has resulted in excess capacity." ***(18)***

Union Pacific Railroad

As part of the PSR wave flowing through the industry, in 2018 the Union Pacific Railroad instituted its "Unified Plan 2020," which aims to cut the railroad's operating ratio to 60% in the course of two years by adopting PSR principles. Using a similar strategy to the CN, the CP, and CSX, the Union Pacific plan focused on moving individual railcars rather than whole trains, on minimizing car classification yard handling and dwell time, on balancing train movements on their network to improve asset utilization, on running more general purpose trains, and on increasing efficiencies by running longer trains with fewer locomotives and employees. ***(19)*** In practice, this has meant that since August of 2018, the Union Pacific has removed 1,500 locomotives and 30,000 railcars from service and eliminated the jobs of 1,000 people. The primary reason for implementing PSR is to enable more efficient train operations (thereby making more profit by doing less), but in early 2020, UP reversed course and started re-establishing some services it had cut. ***(20)***

Kansas City Southern Railway

In 2018, the Kansas City Southern Railway had its best year in terms of revenues and earnings per share, but senior management thought the railroad could do better with a different operating strategy. Additionally, KCS CEO Patrick Ottensmeyer has explained that with its major interchange partner the Union Pacific Railroad now running PSR operating strategies, it made business sense to match their way of operating. So, KCS decided to implement their own brand of PSR in 2019. The KCS form of PSR aims for operational excellence and is intended to drive the following improvements: to improve and sustain consistency and reliability of customer service; to facilitating growth by providing additional capacity to pursue new opportunities; to improve asset utilization; and to improve the profitability of the company. In one year's time, the length of trains was increased from an average of 5,741 feet in 2018 to 6,008 feet in 2019. Additionally, 175 locomotives and 2,000 railcars were removed from service, and the KCS reduced its total number of employees from 2018 to 2019 by 160 people. ***(21)*** However, as the Kansas City Southern Railway does not host Amtrak trains, it is included in the paper only to provide background information on Class One freight railroad experience with PSR.

BNSF Railway

The BNSF Railway is the lone holdout of the Class One railroads not to implement Precision Scheduled Railroading. The former CEO of the BNSF, Matt Rose, has said,

> A PSR method that seeks about $125 million in cost savings from every thousand

> employees cut isn't thinking long-term, as it often ignores service disruptions to customers. Disengaging from our customers to change internal cost savings is not a good long-term business strategy. De-marketing tactics can result in unanticipated, but logical bad publicity outcomes. There is nothing wrong with being a low-cost supplier, but ignoring your customers until you hit a wall on costs can have understandable longer-term consequences. ***(15)***

Counter to other railroads' downsizing strategy, the BNSF is building its railroad network with new facilities, e.g., recently adding a new logistics center outside of Denver, in order to grow the company.

POTENTIAL FOR PSR TO AFFECT PERFORMANCE OF INTERCITY PASSENGER AND HIGH-SPEED RAIL SERVICE

History suggests that the implementation of PSR operating strategies at major freight railroads may significantly affect the performance of intercity passenger and high-speed rail service. When Congress enacted the Rail Passenger Service Act (RPSA), the law that relieved freight railways of their public obligation to provide passenger rail service through the creation of Amtrak, the freight railroads agreed legally to "grant Amtrak trains preference over their own freight trains." However, shortly after the agreement was put in place, the major freight railroads began selling off their less profitable lines, consolidating their trains onto more congested main lines, selling equipment, and terminating employees in order to increase their profits. ***(1)*** All of these actions are happening again today as part of PSR. Interestingly enough, when freight railroads have had to explain the reason for Amtrak train delays on their system, the host railroads have cited "freight train congestion" as the major reason for delaying Amtrak trains. ***(1)***

There are two potentially positive effects of PSR operating strategies on the performance of intercity passenger rail train services. The first is that with PSR bringing more schedule discipline to the host railroad's operations, intercity passenger rail service trains should have better, more reliable access to the host freight railroad's tracks when scheduled. Also, as the host railroad runs fewer, longer trains, and moves away from specialized-purpose unit trains towards mixed-consist, general service trains, there are less delays for all trains operating on the PSR railroad's tracks overall, due to trains not having to wait to use tracks until higher-priority trains pass through the section of track. Therefore, due to the positive effects of PSR, it can be postulated that intercity passenger rail trains will experience better on-time performance.

Conversely, there are potentially three negative effects of PSR on intercity passenger railway service. The first is that PSR creates much longer trains than what was previously the normal length of long freight trains. Many freight railroad sidings were built to handle one-mile long trains, but PSR means that three-mile long trains are common today. These trains cannot fit in most sidings, so this may mean that passenger trains need to wait in sidings a greater percent of the time, because they can fit in the sidings, while the up to three-mile long freight trains cannot. The second potentially negative aspect of PSR is that due to having fewer employees and fewer repair facilities, any freight train mechanical failure may mean key tracks are blocked for longer periods of time, resulting in passenger trains waiting longer than previously for the blockages to eventually clear and allow the passenger trains to continue on their journeys. The third way that PSRT could potentially negatively affect intercity passenger railway service is that with PSR operating strategies railroads try to do more with less, including less trackage. While freight trains may have been running spread out across somewhat parallel routes in the past, with PSR, better asset utilization means more densely packed mainlines, often mainlines where intercity passenger trains are operated. As stated in the paper "An Assessment of Railway Capacity," **(6)** whether a section of railroad has a single or double tracks has a major impact on capacity. When a railroad downsizes a main line track from a double track to a single track with sidings in order to reduce track maintenance costs, its capacity is not reduced by half, its capacity is reduced by roughly 75%. Whether PSR freight railroad operating strategies have a positive effect, negative effect, or no significant effect on intercity passenger and high-speed rail train on-time performance can be determined from the performance data of the passenger trains.

PSR AND AMTRAK

Amtrak is the nation's intercity passenger rail service and its current high-speed rail operator. Their principal business is to provide rail passenger service in the major intercity travel markets of the United States. Amtrak operates a national rail network of more than 21,400 route miles serving more than 500 destinations in 46 states, the District of Columbia, and three Canadian provinces. The Acela Express, Amtrak's high-speed rail service, travels on the northeast corridor (NEC) between Washington, D.C., and Boston, Massachusetts. It travels at a maximum speed of 150 mph on sections of its route between Boston and New Haven, Connecticut that Amtrak owns. However, its top speed between New York City and Washington, D.C., is 135 mph, which is also on publicly-owned tracks. Amtrak is the only railroad in North America to maintain right-of-way for service at speeds more than 125 mph and their engineering forces maintain more than 350 route-miles of track for 100+ mph service.

The NEC is the busiest railroad segment in North America with approximately 2,200 trains operating daily over some portion of the Washington, D.C., to Boston route. In Fiscal Year 2018, customers made 18.3 million trips on the NEC. In addition, nine commuter rail services operate on the NEC. Amtrak serves 526 stations in the United States and Canada. In addition, there are 59 stations in the United States where Amtrak owns one or more station components (i.e., station structure, platform, parking facility) but does not serve the station. Amtrak owns 18 tunnels consisting of 24 miles of track and 1,414 bridges.

In FY2018, 15.1 million trips were taken on Amtrak's state-supported services routes, which each had ridership of one million or more passengers in FY2018:

- Pacific Surfliner service (San Diego–Los Angeles–San Luis Obispo) at 2.9 million;
- Capitol Corridor service (San Jose–Oakland–Sacramento–Auburn) at 1.7 million;
- Keystone service (Harrisburg–Philadelphia) at 1.5 million;
- Empire service (New York–Albany–Buffalo–Toronto) at 1.5 million and
- San Joaquins service (Oakland/Sacramento–Bakersfield) at 1.1 million.

Four other state supported corridors had ridership greater than 500,000 in FY2018:

- Hiawatha service (Chicago–Milwaukee) at 0.8 million;
- Amtrak Cascades service (Eugene–Portland–Seattle–Vancouver, BC) at 0.8 million;
- Lincoln service (Chicago–St. Louis) at 0.6 million; and
- Downeaster service (Boston–Portland–Brunswick) at 0.5 million.

Amtrak operates 15 long-distance (LD) train routes (more than 750 miles), which accounted for 14% of ridership (4.5 million trips) in FY2018, with 18% of customers traveling to and/or from a rural station.

Amtrak is the only intercity passenger transportation service in an increasing number of communities that lack intercity bus and airline service. Their long-distance trains provide the only rail service at nearly half of the stations in the Amtrak system and are the only trains in 23 of the 46 states in the network. Most train-miles traveled by Amtrak on these routes are on the host railroad tracks owned by freight and commuter railroads. On-time performance (OTP) on the long-distance routes is the weakest in their network. Customer OTP (measured as the number of customers arriving on time compared to total customers traveling by Amtrak train) for LD routes for FY2018 was 43.0%, a decline of 1.7% from 44.7% for FY2017. The primary reason for the delays on most of the LD routes was freight train interference. Amtrak-owned and/or -maintained property includes:

- NEC: 363 miles of the 457-mile NEC spine which connects Washington, D.C., Philadelphia, New York City, and Boston. The NEC is the busiest passenger line in the country, with trains regularly reaching speeds of 125–150 mph. Two sections of the NEC are owned by others: (1) the New York Metropolitan Transportation Authority (10 miles) and Connecticut Department of Transportation (46 miles) own 56 miles on Metro-North Railroad between New Rochelle, New York, and New Haven, CT; and (2) the Commonwealth of Massachusetts owns 38 miles between the Massachusetts/ Rhode Island border and Boston that is operated and maintained by Amtrak;
- Springfield Line: A 60.5-mile track segment from New Haven, Connecticut, to Springfield, Massachusetts;
- Harrisburg Line (also known as the Keystone Corridor): The 104.2 miles of track in Pennsylvania between Philadelphia and Harrisburg rated at speeds up to 110 mph (177 kph);
- Michigan Line: A 95.6-mile segment of 110 mph (177 kph) track from Porter, Indiana, to Kalamazoo, Michigan;
- Michigan Right-of-Way: Amtrak also operates, maintains, and dispatches a 135-mile right of way between Kalamazoo and Dearborn purchased by the state of Michigan in December 2012; and

- Hudson Line: Amtrak leases, operates, maintains and dispatches approximately 94 miles of the CSXT Hudson Line, also known as the Empire Corridor, in New York state between Poughkeepsie and Hoffmans (near Schenectady).

Outside of the NEC, Amtrak contracts with other railroads for the use of their tracks and other resources required to operate trains, with incentives for on-time performance. These host railroads are responsible for the condition of their tracks and for the dispatching on their tracks. Approximately 72 percent of Amtrak's train miles are run on tracks owned by the host railroads. The six largest host railroads for intercity passenger trains in FY2018, by train-miles traveled, were:

- BNSF Railway with 6.9 million train-miles;
- Union Pacific Railroad with 6.2 million train-miles;
- CSX Transportation with 5.0 million train-miles;
- Norfolk Southern Railway with 2.3 million train-miles;
- Canadian National Railway with 1.4 million train-miles; and
- Metro-North Railroad (not a Class One freight railroad) with 1.3 million train-miles.

EFFECT ON AMTRAK

The authors contacted and participated in meetings and discussions with numerous Amtrak staff at various levels within Operations, Engineering, and Maintenance departments, plus their counterparts at New Jersey Transit (NJT) and the Long Island Railroad (LIRR), where the three agencies share operations along the Northeast Corridor and through the Penn Station Complex into Queens. Unanimously, all three agencies reported that they did not believe that the implementation of the PSR operating strategy by host railroads has had a significant effect on their ability to operate trains. However, Amtrak stated that many of their trains are delayed by freight carriers for various reasons.

As mentioned above, Amtrak's network consists of tracks owned, maintained, and dispatched by freight railroads who "host" Amtrak trains using their tracks. The freight railroads control the dispatching and decisions on what trains have priority. Federal law requires that Amtrak trains receive preference over freight trains and that the largest cause of Amtrak delays is due to freight train interference (Figure 3) causing Amtrak to wait until the freight trains operate first. Amtrak reports that the host railroads typically achieve good Amtrak performance especially on the Northeast Corridor where freight movements are more prevalent at night, however a recent past study revealed that Amtrak could realize a one-time savings of $336 million, and annual savings of approximately $42 million if the railroad were permitted to operate reliably despite the financial incentives they offered. Therefore, the performance of Amtrak is greatly dependent upon it freight host railroads.

III. RESULTS

To determine the effects of PSR on Amtrak's Intercity passenger rail service, it is necessary to understand the host railroads. It is important to consider the total minutes of delay that the host freight railroads cause Amtrak, as well as the percentage of Amtrak trains that are on-time, viewed over time. PSR was gradually accepted by the major freight railroads, so knowing the year when PSR was first implemented at a railroad helps with the understanding of any significant changes to the performance of passenger service over time.

"HOST-RESPONSIBLE DELAY MINUTES PER 10,000 TRAIN-MILES"

Historically Amtrak evaluates host performance based on "host responsible delay minutes per 10,000 train-miles" which is the measure of delay caused to Amtrak trains. This measurement is normalized (means and standard deviation) of the number of miles traveled by each train so that different routes and hosts are compared. Then Amtrak assigns letter grades of A, B, C, D, or F for each host railroad based on these delays, and reports these grades on its website. For this research, Amtrak provided data for the years 2000 to 2019 concerning the performance of each of the five Class One freight railroads that host Amtrak passenger services. The key performance data listed in **Table 2** was provided by Amtrak.

Table 2. Amtrak Train Data, Listing Total Number of Train Departures, Total Train-Miles Traveled and Total Minutes of Amtrak Train Delay, Differentiated by Each Host Freight Railroad

	2019 Train Departs	2019 Train Miles	2019 Delay per 10K Train-Miles	2015 Train Departs	2015 Train Miles	2015 Delay per 10K Train-Miles	2014 Train Departs	2014 Train Miles	2014 Delay per 10K Train-Miles	2013 Train Departs	2013 Train Miles	2013 Delay per 10K Train-Miles	2012 Train Departs	2012 Train Miles	2012 Delay per 10K Train-Miles
BNSF	24,092	6,926,689	1,057	22,695	6,788,929	1,116	22,602	6,793,217	1,269	22,791	6,808,873	881	22,745	6,816,617	873
CN RWY	9,698	1,395,454	5,298	9,770	1,451,126	4,660	9,710	1,444,207	2,954	10,208	1,456,862	2,894	10,071	1,439,042	3,382
CP	7,095	710,317	1,209	7,156	715,854	2,129	7,140	718,754	3,134	7,140	711,646	3,450	7,188	718,823	3,496
CSX	14,070	5,048,477	989	14,527	5,149,394	1,348	15,000	5,116,267	1,379	15,904	5,235,378	1,167	21,263	5,943,524	1,067
NS	12,444	2,502,672	1,658	11,702	2,342,669	1,540	11,666	2,342,208	1,504	11,502	2,450,854	975	10,932	2,590,197	1,109
UP	27,478	6,144,936	1,160	27,000	6,146,785	1,159	26,965	6,147,893	1,114	27,015	6,184,607	871	27,123	6,096,197	1,006
TOTAL	94,877	22,728,544	11,370	92,850	22,594,757	11,952	93,083	22,562,545	11,353	94,560	22,848,219	10,237	99,322	23,604,400	10,934

	2011 Train Departs	2011 Train Miles	2011 Delay per 10K Train-Miles	2010 Train Departs	2010 Train Miles	2010 Delay per 10K Train-Miles	2009 Train Departs	2009 Train Miles	2009 Delay per 10K Train-Miles	2008 Train Departs	2008 Train Miles	2008 Delay per 10K Train-Miles	2007 Train Departs	2007 Train Miles	2007 Delay per 10K Train-Miles
BNSF	22,619	6,513,719	937	22,958	6,800,666	716	23,028	6,757,185	776	22,673	6,692,761	986	22,830	6,735,123	1,061
CN RWY	10,128	1,425,094	4,938	10,461	1,461,543	5,787	10,397	1,430,918	5,449	10,399	1,457,299	4,850	10,255	1,454,010	5,837
CP	7,093	710,972	3,560	7,141	715,965	2,866	7,100	710,097	3,890	7,139	707,459	3,891	7,128	706,231	4,247
CSX	20,713	5,926,581	1,076	20,431	5,907,343	1,096	19,679	5,925,431	1,143	19,788	5,849,855	1,425	19,690	5,713,787	1,699
NS	10,778	2,555,651	1,253	10,368	2,502,581	897	9,399	2,350,013	921	9,421	2,360,263	1,533	9,429	2,366,787	1,877
UP	27,126	6,008,338	1,086	27,471	6,195,251	951	27,315	6,164,753	4,200	27,449	6,089,617	2,005	27,066	6,147,030	2,444
TOTAL	98,457	23,140,355	12,850	98,830	23,583,348	12,312	96,918	23,338,396	16,379	96,869	23,157,254	14,689	96,398	23,122,969	17,165

	2006 Train Departs	2006 Train Miles	2006 Delay per 10K Train-Miles	2005 Train Departs	2005 Train Miles	2005 Delay per 10K Train-Miles	2004 Train Departs	2004 Train Miles	2004 Delay per 10K Train-Miles	2003 Train Departs	2003 Train Miles	2003 Delay per 10K Train-Miles	2002 Train Departs	2002 Train Miles	2002 Delay per 10K Train-Miles
BNSF	22,049	6,450,230	1,087	22,491	6,425,237	922	22,675	6,426,660	956	22,612	6,463,327	812	22,350	6,393,840	689
CN RWY	8,268	1,200,543	5,644	8,257	1,184,010	4,882	8,307	1,201,344	3,999	8,311	1,185,327	3,938	8,486	1,180,662	3,298
CP	7,150	711,924	3,708	7,127	710,092	2,936	7,159	709,692	2,788	7,123	710,256	2,269	6,648	686,971	2,867
CSX	19,600	5,625,401	1,760	20,610	6,044,692	1,714	20,824	6,345,993	1,478	21,233	6,608,769	1,279	22,157	6,809,133	1,158
NS	9,431	2,343,567	1,961	9,730	2,390,378	1,528	10,397	2,616,585	1,314	10,386	2,707,980	1,265	10,659	2,953,714	1,290
UP	23,556	5,554,531	2,670	22,148	5,406,938	2,218	22,386	5,445,884	2,108	22,059	5,405,722	2,045	20,830	5,298,226	1,993
TOTAL	90,054	21,886,197	16,829	90,363	22,161,347	14,201	91,748	22,746,159	12,642	91,724	23,081,380	11,608	91,130	23,322,546	11,295

	2001 Train Departs	2001 Train Miles	2001 Delay per 10K Train-Miles	2000 Train Departs	2000 Train Miles	2000 Delay per 10K Train-Miles
BNSF	21,153	6,179,127	779	19,858	5,968,203	614
CN RWY	7,964	1,156,837	3,039	7,731	1,136,725	2,265
CP	6,718	688,151	2,259	6,563	672,831	2,189
CSX	22,265	6,773,321	1,120	21,696	6,585,197	1,208
NS	10,482	2,904,967	1,147	10,305	2,863,715	1,126
UP	18,650	4,720,668	1,655	16,057	4,123,709	1,127
TOTAL	87,232	22,423,070	9,999	82,210	21,350,379	8,530

This information is also presented in Figure 1 in order to show a comparison of the performances of each Class One freight host railroad host over the time period of 2000 through 2019. Note that BNSF has never instituted PSR, and also that the railroad has the least number of minutes of Amtrak train delay per 10,000 train-miles over the course of the past twenty years. The BNSF service level has remained relatively constant during the period studied, with a minimum delay rate of 614 minutes and a maximum rate of only 1,269 minutes. Also, the BNSF has had the most consistently good service with the smallest standard deviation for the rate of delay for the railroads, as shown in Table 3.

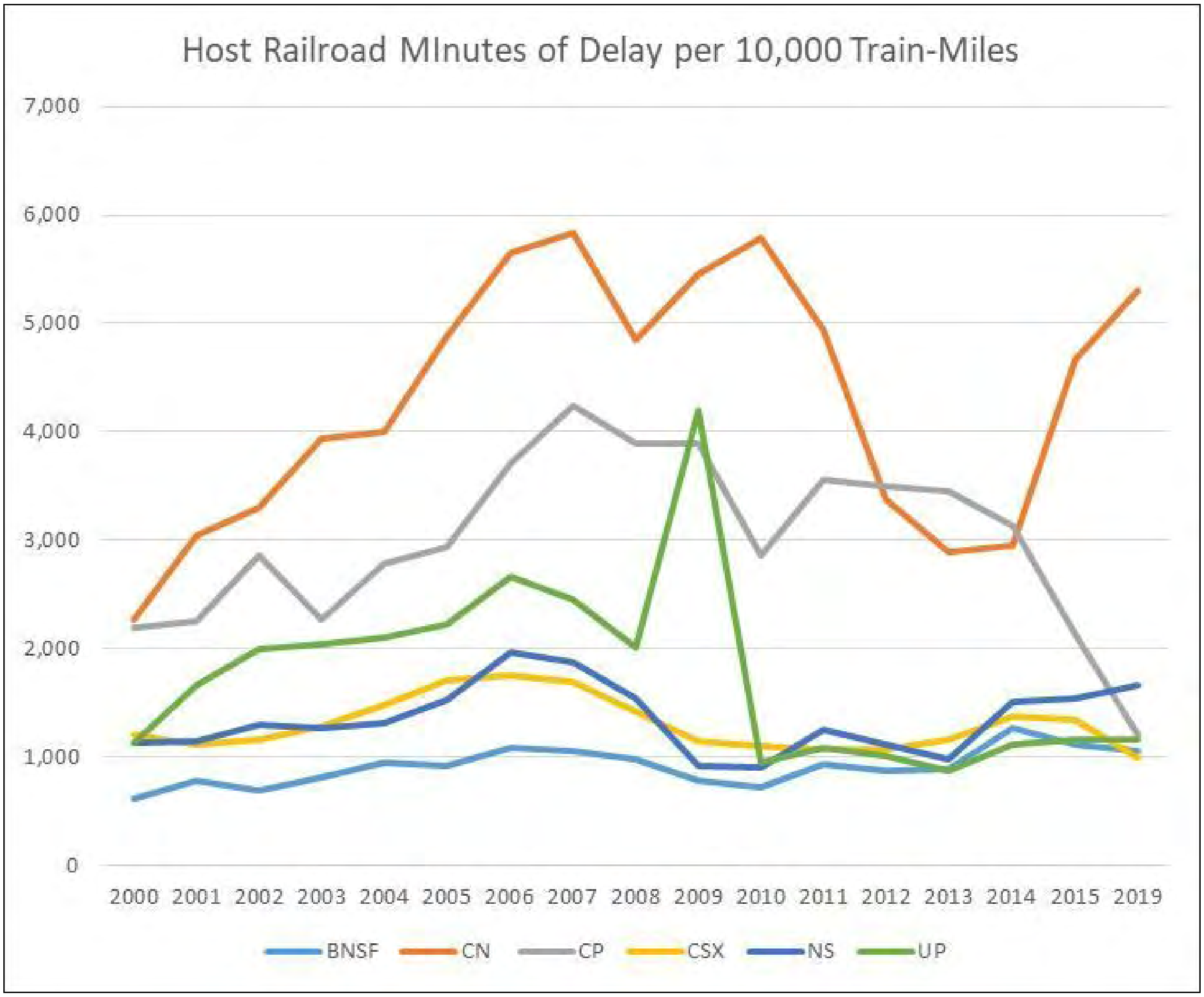

Figure 1. Delay of Amtrak's Trains Measured in Minutes per 10,000 Train-Miles for Each Class One Host Railroad

Table 3. Comparison of Host Delay Rates for Each Class One Freight Railroad Host of Amtrak

Host Railroad Minutes of Delay per 10,000 Train-Miles					
	min	max	range	variance	std. dev.
BNSF	614	1,269	655	29,776	167.41
CN	2,265	5,837	3,572	1,341,416	1123.61
CP	1,209	4,247	3,038	638,435	775.16
CSX	989	1,760	771	58,999	235.64
NS	897	1,961	1,065	98,257	304.10
UP	871	4,200	3,329	737,156	832.94

The Amtrak data allows a comparison of the host railroad's performance in the years before its implementation of PSR and its performance afterwards using PSR. The Canadian National Railway was the first railroad to adopt PSR in 1998, but data was not available for the years prior to 2000, so a before-and-after comparison is not possible. The next railroad to institute PSR was the CP in 2012. Examining the data for the CP, prior to implementing PSR the railroad had reached a maximum of 4,247 minutes of delay, but after PSR was implemented, the CP's minutes of delay rate has shrunk significantly, down to 1,209 minutes in 2019. The CSX implemented PSR in 2017, and it has experienced a significant decrease in minutes of delay, decreasing from a rate of 1,348 minutes in 2015 down to 989 in 2019, the best amongst the Class One freight railroads. The NS put PSR into effect in 2018. Before that time NS had a its minutes of delay rate has held steady since then, without a significant increase or decrease. Finally, the UP instituted PSR also in 2018. While over the course of 20 years, the UPS has had times of poor performance delaying Amtrak's trains, since 2010, UP's delay rate has held somewhat steady, being 1,160 minutes last year, the third best of the group of railroads.

ON-TIME PERFORMANCE

Another measure of the quality of intercity passenger railway service is "On-Time Performance." Table 4 shows each route of Amtrak that is hosted by one or more Class One freight railroads, the host railroad or railroads, and the percentage of trains on each route that are considered to have arrived within 15 minutes of their scheduled arrival times, for the years 2002 to 2019. For the routes where BNSF is the primary railroad by mileage—Cascades, Empire Builder, Heartland Flyer, San Joaquins, and Southwest Chief—the performance has held somewhat steady and currently averages 56.8% of trains on-time.

When the CN is the sole host, such as with of the City of New Orleans (73%) service the results are acceptable. When the CN is the secondary or tertiary host, such as with the Michigan Wolverine (27%), and the Texas Eagle (27%), the on-time performance of trains suffers. However poor the performance, the CN has been operating with PSR since before the first year of data examined, so it is hard to draw conclusions as to whether or not PSR is the cause of their poor performance.

The CP is the sole host for the Hiawatha (92%), and it is the secondary host of the Empire

Builder (47%), averaging 69.5%, but for the Empire Builder, the CP operates less than one-sixth of its route miles. However, the performance of the Hiawatha averaged 93.5% prior to the CP's implementation of PSR in 2012, and has averaged 93.6% with PSR, suggesting that PSR has had no effect on passenger train service.

CSX is the primary or sole host of eight routes—the Cardinal (55%), Carolinian (64%), Lake Shore Ltd (48%), Silver Star (34%), Auto Train (54%), Empire / New York (66%), Palmetto (63%), and Silver Meteor (44%)—averaging out to 53.5% for 2019. CSX is the secondary host on the Capitol Limited with an on-time performance of 31% in 2019, and on that route, it operates about two-fifths of the total route miles. Considering the five immediate years prior to the year 2017, when CSX started using PSR concepts, and the data since then, the rates did not significantly change for five routes: the Palmetto (63%), Silver Meteor (44%), the Cardinal (55%), the Carolinian (64%), and the New York route to Albany (66%). However, for three routes—Lake Shore Limited (48%), Silver Star (34%), and the Auto Train (54%)—there has been a small decrease in on-time performance.

The Norfolk Southern is the primary or sole host railroad for five routes: the Michigan / Wolverine (27%), Capitol Limited (31%), Crescent (31%), Pennsylvanian (70%), and Piedmont (75%). On all five routes the NS has seen on-time performance significantly worsen since their start of PSR in 2018. NS is also the secondary host on four routes—the Cardinal (55%), Carolinian (64%), Lake Shore Ltd (48%), and Silver Star (34%), where each has held steady—with the exception being the Silver Star, of which NS is a very small part.

Lastly, the Union Pacific Railroad is the sole or primary host for seven routes: California Zephyr (33%), Coast Starlight (51%), Pacific Surfliner (73%), Sunset Ltd (21%), Texas Eagle (27%), Capitol Corridor (87%), and Missouri / River Runner (63%). The year of implementation of PSR at UP was 2018. Considering the range of the five years prior to 2018 through the present, the on-time performance of every one of those routes has decreased significantly. Also, the UP is the secondary host for the Cascades (63%) and the San Joaquins (64%) routes, and on both of those routes the on-time performance has significantly decreased.

Table 4. Amtrak Routes Hosted by Class One Freight Railroads On-Time Performance Measurements, Showing Percentage On-Time Within 15 Minutes of Scheduled Arrival Time, Between the Years 2002 and 2019

Services	Host Rwy 1	Rwy 1 Miles	Host Rwy 2	Rwy 2 Miles	Host Rwy 3	Rwy 3 Miles	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19
Acela Express							76.9%	73.1%	73.8%	76.5%	87.4%	87.8%	86.2%	86.4%	82.7%	85.5%	87.5%	84.3%	82.4%	80.2%	83.1%		-	
Auto Train	CSX	898					69.0%	69.1%	62.2%	56.2%	44.5%	71.5%	84.7%	90.4%	85.6%	90.4%	88.4%	83.6%	75.5%	77.2%	68.0%		72.0%	54.0%
California Zephyr	BNSF	1027	UP	1381			25.8%	30.2%	25.3%	27.4%	19.7%	19.0%	28.1%	48.9%	47.1%	37.9%	45.7%	56.6%	33.1%	42.3%	56.1%		48.0%	33.0%
Capitol Corridor	UP	171					52.1%	61.2%	80.5%	60.8%	56.9%	71.3%	78.4%	84.0%	85.8%	95.2%	93.9%	94.9%	95.3%	94.5%	95.7%		89.0%	87.0%
Capitol Limited	NS	481	CSX	307			35.5%	37.7%	27.4%	26.9%	20.6%	25.9%	30.3%	60.1%	56.0%	42.7%	51.9%	56.5%	35.6%	34.4%	58.7%		36.0%	31.0%
Cardinal	NS	79	CSX	703			23.6%	24.9%	32.7%	33.9%	33.1%	27.4%	29.5%	40.9%	39.0%	33.6%	38.7%	47.4%	39.2%	40.2%	50.3%	50.0%	53.0%	55.0%
Carolinian	CSX	295	NS	202			47.2%	44.1%	43.0%	39.7%	37.6%	39.3%	46.2%	53.0%	51.8%	60.6%	66.8%	64.6%	57.8%	54.5%	50.2%		51.0%	64.0%
Cascades	BNSF	343	UP	125			54.2%	57.2%	51.9%	52.6%	44.2%	48.5%	50.9%	54.8%	60.2%	71.6%	77.1%	78.5%	69.7%	70.0%	76.4%		64.0%	63.0%
City of New Orleans	CN	930					36.5%	35.5%	45.8%	63.4%	64.4%	67.8%	49.0%	58.0%	61.7%	52.6%	63.7%	70.7%	52.2%	53.4%	62.6%		51.0%	73.0%
Coast Starlight	BNSF	186	UP	1162			25.0%	24.6%	18.5%	19.1%	14.1%	21.6%	35.2%	56.0%	69.0%	58.6%	60.4%	62.3%	55.0%	56.9%	60.4%	57.0%	55.0%	51.0%
Crescent	NS	1141					49.4%	53.3%	52.2%	51.9%	33.4%	44.9%	59.5%	73.3%	66.2%	62.8%	72.1%	66.0%	54.5%	50.1%	52.4%	33.0%	29.0%	31.0%
Empire / New York	CSX	296					56.6%	48.7%	46.8%	43.5%	58.5%	61.7%	66.2%	72.4%	77.0%	71.6%	80.2%	73.9%	67.5%	63.7%	73.4%		70.0%	66.0%
Empire Builder	BNSF	2147	CP	384			53.2%	60.9%	42.2%	47.6%	46.6%	54.4%	47.5%	53.4%	59.9%	26.9%	43.5%	38.8%	19.7%	33.9%	71.6%		44.0%	47.0%
Heartland Flyer	BNSF	236					59.7%	77.7%	73.3%	69.2%	57.2%	45.6%	60.0%	83.2%	84.3%	81.3%	76.4%	72.4%	71.1%	65.6%	82.8%		58.0%	53.0%
Hiawatha	CP	53					94.3%	96.1%	95.3%	92.9%	93.2%	91.6%	92.9%	92.2%	93.8%	92.8%	95.0%	92.7%	92.8%	92.5%	97.4%	90.0%	96.0%	92.0%
Hoosier	CSX	175					-	-	58.5%	58.5%	57.5%	54.4%	55.9%	62.9%	81.3%	70.2%	76.1%	80.9%	61.9%	70.8%	82.3%		80.0%	-
Lake Shore Ltd	CSX	741	NS	339			23.4%	31.3%	27.7%	30.2%	27.3%	31.0%	45.8%	58.3%	57.6%	39.0%	51.6%	47.8%	25.5%	34.4%	53.1%		41.0%	48.0%
Michigan / Wolverine	NS	39	CN	27			40.9%	53.6%	57.6%	55.6%	56.8%	51.1%	47.7%	58.6%	70.0%	50.2%	62.6%	57.8%	51.0%	57.9%	75.2%		60.0%	27.0%
Missouri / River Runner	UP	271					-	-	-	-	41.8%	37.1%	39.4%	73.2%	88.1%	83.6%	87.5%	92.7%	80.1%	83.9%	86.8%		83.0%	63.0%
Pacific Surfliner	BNSF	22	UP	174			68.0%	65.7%	64.4%	56.7%	57.8%	58.1%	63.4%	69.6%	72.6%	84.8%	82.9%	88.9%	84.9%	87.1%	87.6%		78.0%	73.0%
Palmetto	CSX	659					-	-	-	-	-	-	52.1%	66.1%	60.2%	66.6%	71.7%	68.2%	61.4%	64.0%	62.1%		59.0%	63.0%
Pennsylvanian	NS	249					43.1%	56.5%	44.1%	56.1%	62.7%	57.8%	64.7%	77.5%	79.5%	73.8%	86.7%	87.6%	83.5%	80.7%	85.1%		71.0%	70.0%
Piedmont	NS	173					72.8%	76.3%	83.7%	80.7%	81.3%	87.5%	84.2%	88.0%	87.5%	88.4%	88.6%	89.6%	85.1%	81.9%	79.7%		74.0%	75.0%
San Joaquins	BNSF	284	UP	88			45.5%	39.8%	38.2%	47.5%	49.1%	53.3%	64.1%	70.7%	78.3%	87.7%	86.7%	77.0%	80.8%	75.9%	84.7%		73.0%	64.0%
Silver Meteor	CSX	1152					-	-	-	-	-	-	58.0%	62.4%	64.8%	64.2%	55.8%	47.1%	44.1%	50.1%	45.4%		47.0%	44.0%
Silver Star	CSX	1209	NS	28			-	-	-	-	-	-	48.1%	63.7%	67.8%	62.1%	58.8%	52.5%	47.6%	47.7%	43.3%		36.0%	34.0%
Southwest Chief	BNSF	2206					34.7%	49.4%	39.1%	50.5%	53.4%	50.1%	50.1%	70.2%	67.8%	54.6%	54.3%	60.2%	44.5%	34.4%	55.9%		43.0%	33.0%
Sunset Ltd	BNSF	190	UP	1784			12.5%	20.0%	11.7%	7.7%	12.7%	11.8%	16.8%	43.1%	44.3%	39.3%	33.4%	40.5%	34.0%	31.6%	51.5%		26.0%	21.0%
Texas Eagle	BNSF	116	UP	1073	CN	35	18.8%	31.1%	43.6%	43.0%	25.5%	22.7%	19.4%	60.7%	59.5%	47.0%	49.2%	50.2%	31.3%	26.9%	41.4%		37.0%	27.0%

IV. SUMMARY & CONCLUSIONS

The results are mixed but when considering the measure of “Host Railroad Minutes of Delay per 10,000 Train-Miles” suggests that PSR may be able to improve a railroad’s ability to reduce delays of the Amtrak passenger trains that it hosts. Of the five railroads that implemented PSR, one has worsened its minutes of delay rate, two railroads have experienced no significant changes, and two railroads have experienced significant improvements. Alternatively, considering “On-Time Performance” measures suggests that PSR strategies have the potential to worsen a host railroad’s performance. Setting aside the CN, which began PSR prior to the earliest year of data, of the other five railroads, the BNSF, CP, and CSX metrics showed no significant difference. However, after PSR strategies were initiated at the Union Pacific and the Norfolk Southern, the two railroads’ on-time performance worsened noticeably.

Therefore, the results of the study suggest that if implemented properly, PSR strategies will have no effect on a freight railroad’s ability to host Amtrak intercity and high-speed rail passenger railway service, but that if implemented incorrectly, the host railroad can negatively affect Amtrak’s train performance.

Furthermore, if PSR-related double track removals are found to have reduced capacity in a section of mainline to the point that on-time performance of passenger trains suffers significantly, restoring the second main track may alleviate the problem. A potential source of funding for such double track restorations would be the Federal Railroad Administration’s Consolidated Rail Infrastructure and Safety Improvements (CRISI) Program.

However, if there are already two or more tracks in a section of main line, there are diminishing returns as additional tracks are added, and therefore building more tracks alone may not solve the on-time performance problem. For example, research has shown that a four-track main line section only has a capacity that is roughly 50% better than two tracks. (6) In such a case, the only solution may be to raise the penalties paid by the host freight railroad for late passenger trains to ensure that passenger trains truly do receive the highest priority from the freight railroad’s dispatcher, as is required by law.

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