TEI INNOVATIVE SOLUTIONS

TRANSPORTATION,
ECONOMIC/MANAGEMENT, AND
INFORMATION TECHNOLOGY CONSULTANTS

Final Report

Research, Validation, and Normalization of Railroad Operational Data

Federal Railroad Administration, U. S. Department of Transportation

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EXECUTIVE SUMMARY

TEI Innovative Solutions (TEI) approached this research project as a two-part assignment. The first part was to determine what sources the FRA could use to validate the integrity of operational data submitted to it by the railroads. The second part was to determine how to better measure Remote Control Locomotive (RCL) operations and how to compare RCL switching operations with conventional yard switching operations with respect to safety considerations.

In Part I, TEI found that the railroads produce a plethora of data using the latest technology for their own use in improving railroad performance. The railroads provide some of these data to industry trade groups and, as required by law, to various government agencies. The operational data reported to the FRA's sister agencies, the Surface Transportation Board (STB) and Federal Transit Administration, are not directly comparable to data reported to the FRA. The primary reason for this is that the definitions for these operational data categories (Freight Train Miles, Yard Switching Miles, Other Train Miles, Railroad Worker Hours, Passenger Train Miles, Passenger Miles Operated, and Number of Passengers) are not identical among agencies. For example, FRA's Yard Switching Miles do not include a locomotive factor while the STB's Yard Switching Miles do include a locomotive factor.

TEI also found variation among railroads as to what exactly was required to be reported for each of these operational data categories. This does not reflect any nefariousness on the part of the railroads but a genuine difference in understanding of what the FRA actually expects in these operational metrics.

While our research found no facile and directly comparable data sources that FRA could employ to monitor the integrity of the data it receives, we believe that these data sources can still be helpful as proxy measures to ensure consistency in data reporting. As long as differences in data reported to the STB and FRA remain relatively constant, it is unlikely that something substantive has changed in the railroads' reporting of that figure. To maintain and enhance this approach to validating the data received, we make several recommendations.

We recommend a periodic review of reporting requirements through seminars or training sessions. The quality of the data for all purposes would be enhanced by consistency among railroads. Consistency among agencies with respect to the content of reporting categories would also benefit all users of the data. Thus, TEI also recommends closer coordination with the STB in terms of the data collected and as data collection requirements are changed, coordination with the STB to ensure that both agencies retain/provide a valuable data crosscheck source.

With regard to proxies, we further recommend that FRA continue and expand its efforts to check and crosscheck the considerable data resources it maintains as well as the data resources of its sister agencies. These efforts should include the development of proxies by class and/or size of railroad to better fit the proxies to the data being monitored.

Finally, TEI suggests that the FRA conduct a methodical review of its data reporting requirements leading to an updating of the data collection regime. The railroad industry has changed remarkably over the past 25 years. Data collection is not the same task as it was even 25 years ago, the burden associated with generating additional data is not what it used to be – and the power and potential for the FRA to improve safety through an enhanced data collection regime would be extremely valuable.

In Part II, TEI reviewed the available evidence on the use and performance of RCL in switching service and how best to measure and compare the safety performance of RCL and conventional switching operations. In addition, we conducted our own analysis using data from FRA's Final Report on Safety of Remote Control Locomotive (RCL) Operations dated March 2006. In this analysis, we isolated ten human causal factors in which there were actual differences in the type of switching (eight involved operators physical positioning and two involved communication).

On balance, our review and analysis suggest that RCL switching operations are less safe than conventional switching operations. For the ten causal factors that we analyzed, in four factors RCL operations were safer than conventional operations. Furthermore, we note that RCL operations are supposedly far safer than conventional operations in Canada. This could be due a number of factors, such as, the Canadian railroads having more experience with the technology or it could simply reflect the inadequacies of current measures for comparing RCL and conventional switching operations.

Our review of existing analyses and our own analysis highlight the need for a better metric for evaluating the safety of RCL operations. In particular, a proper analysis should only compare those accidents where there are actual differences in switching operations. For example, a bad ordered car that derails should not count against an RCL switching crew nor a conventional switching crew.

To identify a better metric to measure RCL and conventional switching operations we began by assuming away data limitations. We then narrowed down a list of locomotive-based, labor-based, operation-based, and economic-based metrics to four measures – (two labor-based and two operation-based). We concluded that using worker hours for measuring safety performance is the most appropriate method for measuring safety. We also note that the railroads currently maintain the data required for this measure. Based on the efforts described above, we developed several recommendations that are summarized here.

TEI found confusion in the industry with what should be included in switching miles/hours. FRA should define and communicate what types of switching activity should be considered for measurement i.e., yard switching, industrial switching, switching of shop tracks, etc.

Second, FRA should define new Job Codes that are to be included for RCL and conventional operations and require compliance. Moreover, the FRA should request that the STB add codes 630 and 631 for RCL operations as defined in FRA's Guide for Preparing Accident/Incident Reports to their Classification of Job Titles.

Third, in our research we found variation in conclusions reach by various studies. This suggests that a longer time horizon with a greater amount of data and appropriate metrics are required to truly assess the safety record of RCL versus conventional switching operations.

PART I – ANALYSIS OF DATA SOURCES

The purpose of this part of the research project is to determine if the Federal Railroad Administration can use other data sources to validate or normalize operational data it receives. The metrics that TEI focused on for this research are Freight Train Miles, Yard Switching Miles, Other Train Miles, Passenger Train Miles, Railroad Worker Hours, Passenger Miles Operated, and Number of Passengers Transported. Details for each category follow.

While the ultimate sources of railroad data are the railroads themselves, a number of government agencies and other organizations collect and make railroad data available. In the course of regulation, both economic and safety, the railroads collect and submit data regarding their operations to the Surface Transportation Board (the economic regulator) and the Federal Railroad Administration (the safety regulator). In addition, the railroads submit data to the Bureau of Labor Statistics regarding their use of various types of labor. Railroads are also required to submit financial data to the Securities Exchange Commission and State Corporation Commissions and to publish an annual corporate report. Lastly, the railroads submit data to their industry association group, the Association of American Railroads or the American Short Line and Regional Railroad Association. From these primary sources, many other groups, both public and private, gather information to publish reports regarding the railroad industry with respect to their particular concerns or interests.

In general, railroads collect data for two purposes, responding to regulatory requirements and improving railroad operations. For the first purpose, railroads report safety related data to the Federal Railroad Administration (FRA). The FRA primarily receives data on accidents and incidents involving railroad property, third party private property, and employees. The FRA also receives limited operational data. Primarily, this information is railroad, incident, and accident specific and is focused on ensuring safe operations and identifying any changes in trends in the operation of the railroad. The STB in its data collection role focuses on the economic aspect of railroading. Its focus is on collecting information about unit-costs, service-units, financial health, and shipper's costs. The FTA collects data about the use of federal funds in state and local transit programs. They focus, generally, on financial measures and levels of service (passenger linked trips, passenger revenue miles, etc). Clearly, each regulatory report is tailored by the railroad to the agency to which they are responding. Hence, the purpose of reporting reflects the need for that data and is provided at the level i.e. industry versus firm or financial versus operational, etc.

Of the thirteen data series published by the Surface Transportation Board (STB), only the Class I Railroad Annual R-1 Reports and the Quarterly Condensed Balance Sheet could potentially be used to validate and/or normalize data reported to the FRA. None of the four Bureau of Labor Statistics (BLS) data sets examined contain operational data that could be used to validate and/or normalize data reported to the FRA. The Bureau of Transportation Statistics' website has links to a host of data resources but is primarily a clearinghouse. As such, it is not a direct source of data that could be used to validate and/or normalize data reported to the FRA. The Federal Transit Administration's National Transit Database contains some operational data and employment statistics that could be used to validate and/or normalize data reported to the FRA for passenger railroads, though not for Amtrak.

The Association of American Railroads' (AAR) annual report contains aggregated data that, if it were available in disaggregated form, could be used to validate and/or normalize data reported to the FRA. However, such data has never been published because AAR has traditionally only provided industry-wide data and reports. The American Short Line and Regional Railroad Association (ASLRRA) produces data that is too aggregated to be used to validate and/or normalize data reported to the FRA. However, such data has never been published because ASLRRA has traditionally only provided short-line industry-wide data and reports. Railroad Corporate Annual Report contain data about various operational and safety statistics. In this case, most are sourced from the STB, FRA, or their own informational databases. These reports, however, being primarily financial in nature, do not provide in any uniform way, data about operations. Moreover, these data are not submitted to any federal agency for auditing. Local, state, and Eno Foundation data are sourced from the STB, FRA, and other primary sources. Therefore, local and state sources are not useful because they are driven by their own revenue generation concerns only and do not contain operational data. The Eno Foundation is a secondary source of information and simply repackages data from other sources.

For Freight Train Miles, Yard Switching Miles, Other Train Miles, Railroad Worker Hours, and Passenger Train Miles we evaluate the usefulness of some of the data sources identified in our research. This effort has highlighted some apparent anomalies in the data reported to the FRA. Our analysis is discussed next followed by our conclusions and recommendations. Appendix A contains a brief description of the various data sources reviewed in the course of this research. Appendix B presents examples of the data available from most of these sources. Sources with copyrights, such as those from the AAR, ASLRRA, and others are not provided in Appendix B.

Freight Train Miles

To assess Freight Train Miles, we compared Total Train Miles[1] reported to the FRA with those reported to the STB in the Class I Railroad Annual R1 Reports. However, for reporting purposes the definitions used by the FRA and STB vary. From our research, it is clear that the Total Train Miles reported to the FRA include Yard Switching Miles while those reported to the STB do not. This causes a non-negligible difference between the two measures. Table I-1 below shows the values for the major Class I carriers from 2003-2007 without adjusting for the difference in Yard Switching Miles. Table I-2 below shows the values for the major Class I carriers from 2003-2007 after subtracting Yard Switching Miles from the FRA Total Train Miles figure.

[1] The FRA defines Total Train Miles as equal to Freight Train Miles plus Yard Switching Miles plus Other Train Miles.

TABLE I-1 – FRA Total Train Miles compared to STB R1 Miles

Railroad	FRA	STB	FRA % Difference
BNSF			
2003	173,448,392	153,181,805	11.685%
2004	186,458,968	164,829,672	11.600%
2005	193,486,771	166,802,023	13.792%
2006	200,210,260	174,802,720	12.690%
2007	193,504,107	170,896,735	11.683%
CSX			
2003	107,613,819	94,226,482	12.440%
2004	110,285,062	96,449,384	12.545%
2005	108,459,091	96,542,213	10.987%
2006	108,362,974	97,268,835	10.238%
2007	109,015,883	92,910,709	14.773%
KCS			
2003	8,606,605	6,970,511	19.010%
2004	8,666,298	7,262,953	16.193%
2005	8,740,394	8,397,774	3.920%
2006	11,616,923	9,234,335	20.510%
2007	11,393,344	8,725,280	23.418%
NS			
2003	93,044,745	73,913,145	20.562%
2004	96,872,856	77,666,184	19.827%
2005	101,731,375	81,150,220	20.231%
2006	105,234,463	84,159,673	20.027%
2007	102,362,845	81,855,099	20.034%
UP			
2003	190,164,939	162,738,091	14.423%
2004	193,130,457	163,176,514	15.510%
2005	199,103,551	167,737,139	15.754%
2006	203,283,356	172,380,606	15.202%
2007	194,228,915	165,153,510	14.970%

TABLE I-2 – FRA Total Train Miles-YSM compared to STB R1 Miles

Railroad	FRA Total	FRA Yard	FRA Less Yard	STB R-1	FRA % Difference
BNSF					
2003	173,448,392	13,032,426	160,415,966	153,181,805	4.510%
2004	186,458,968	13,644,403	172,814,565	164,829,672	4.620%
2005	193,486,771	14,562,362	178,924,409	166,802,023	6.775%
2006	200,210,260	15,088,443	185,121,817	174,802,720	5.574%
2007	193,504,107	15,149,543	178,354,564	170,896,735	4.181%
CSX					
2003	107,613,819	12,789,407	94,824,412	94,226,482	0.631%
2004	110,285,062	12,038,633	98,246,429	96,449,384	1.829%
2005	108,459,091	11,916,964	96,542,127	96,542,213	0.000%
2006	108,362,974	11,244,951	97,118,023	97,268,835	-0.155%
2007	109,015,883	15,687,446	93,328,437	92,910,709	0.448%
KCS					
2003	8,606,605	1,484,312	7,122,293	6,970,511	2.131%
2004	8,666,298	1,403,346	7,262,952	7,262,953	0.000%
2005	8,740,394	1,158,812	7,581,582	8,397,774	-10.765%
2006	11,616,923	2,432,306	9,184,617	9,234,335	-0.541%
2007	11,393,344	2,503,800	8,889,544	8,725,280	1.848%
NS					
2003	93,044,745	12,978,158	80,066,587	73,913,145	7.685%
2004	96,872,856	12,929,856	83,943,000	77,666,184	7.477%
2005	101,731,375	14,049,414	87,681,961	81,150,220	7.449%
2006	105,234,463	14,234,622	90,999,841	84,159,673	7.517%
2007	102,362,845	14,419,734	87,943,111	81,855,099	6.923%
UP					
2003	190,164,939	14,765,910	175,399,029	162,738,091	7.218%
2004	193,130,457	15,672,510	177,457,947	163,176,514	8.048%
2005	199,103,551	15,902,358	183,201,193	167,737,139	8.441%
2006	203,283,356	15,789,241	187,494,115	172,380,606	8.061%
2007	194,228,915	26,434,733	167,794,182	165,153,510	1.574%

Shown in the two Tables above, the treatment of yard miles is a major difference in the reported figures. The magnitude of the difference is reduced when Yard Switching Miles are subtracted from FRA Total Train Miles figure. Furthermore, the difference between the two figures is relatively consistent over time for each railroad. When outliers such as the UP 2007 figure are eliminated the largest difference for UP between 2003 and 2006 is only 1.2 percentage points. The largest variation in differences for any railroad (removing the outlier KCS 2005 figure) over the five year period is 2.7 percentage points.

Another point to note here is that the railroads, when reporting the aggregate level of miles, as in Table I-1, are relatively consistent in their reporting. More precisely, even though the railroads reported data to the FRA includes Yard Switching Miles, it is consistently greater by approximately the same magnitude reported to the STB in the R1 report. At an aggregate level for each railroad, this consistent difference in reports to the FRA and STB could be used as a proxy to determine if there are any substantive changes in operations or data reported to each agency.

Furthermore, we noticed that after removing Yard Switching Miles from the FRA Total Train Miles figure, UP, whose data ranged about 1 percentage point had a range of nearly 7 percentage points when adjusting for Yard Switching Miles. KCS had a range of 20 percentage points before removing Yard Switching Miles from the FRA Total Train Miles figure and a range of 10 percentage points after making the Yard Switching Miles adjustment. The difference between the reporting of the railroads indicates a misunderstanding of what data items are included in each category. Among themselves, the railroads are not consistent in the reporting to the FRA of Total Train Miles and for some reason the amount of the overstatement varies even among the railroads. Though not exactly comparable railroad-to-railroad, these figures could be monitored for changes that would warrant further investigation. This highlights a problem in the understanding of reporting requirements. We address this issue further below.

Yard Switching Miles

There are two sources of Yard Switching Miles. FRA's Yard Switching Miles are computed by multiplying "actual switching hours" by 6 MPH. The STB's R1 Yard Switching Locomotive Miles are also computed by multiplying "actual switching hours" by 6 MPH but then are multiplied by the number of locomotives used in the switching service. This includes miles calculated for locomotives in switching service in yards where regular switching service is maintained and in terminal switching and transfer service. Due to the STB's "locomotive" factor, we would expect to see a difference in the two numbers, especially where more than one locomotive is used. However, we would expect to see relative consistency in the magnitude of differences. Here again the data reported to the STB and FRA do not match well. As shown in Table I-3, BNSF and CSX Yard Switching Miles generally differ consistently through the analysis period, with only one outlier value for CSX 2004. The comparison is more erratic for KCS' and NS' reporting of this metric. Differences in this category for these two carriers range from negative 58 to positive 16 percentage points.

Data reported by the UP for Yard Switching Miles exhibits additional anomalies. While there is no clear difference in yard operations between railroads across the nation, or even between railroads in the same region, UP reports roughly double the R1 Yard Switching Locomotive Miles compared with the other railroads analyzed or with FRA

Yard Switching Miles. Moreover, a sudden change occurs in 2007 resulting in over 10 million more FRA Yard Switching Miles than in previous years. These data suggest that there is a misunderstanding of what miles should be included in this category. In principle, there should be consistency in the variance in the data reported to the FRA and STB. We address this issue further below.

TABLE I-3 - FRA YSM and STB R1 Yard Switching Locomotive Miles

Railroad	FRA	STB R-1	FRA % Difference
BNSF			
2003	13,032,426	12,495,456	4.120%
2004	13,644,403	13,047,696	4.373%
2005	14,562,362	13,944,240	4.245%
2006	15,088,443	13,944,240	7.583%
2007	15,149,543	16,106,508	-6.317%
CSX			
2003	12,789,407	12,805,407	-0.125%
2004	12,038,633	14,292,271	-18.720%
2005	11,916,964	11,894,269	0.190%
2006	11,244,951	11,243,785	0.010%
2007	15,687,446	15,662,307	0.160%
KCS			
2003	1,484,312	1,264,488	14.810%
2004	1,403,346	1,175,016	16.270%
2005	1,158,812	1,836,972	-58.522%
2006	2,432,306	2,368,230	2.634%
2007	2,503,800	2,469,180	1.383%
NS			
2003	12,978,158	14,526,876	-11.933%
2004	12,929,856	13,243,542	-2.426%
2005	14,049,414	12,468,281	11.254%
2006	14,234,622	13,725,165	3.579%
2007	14,419,734	12,856,258	10.843%
UP			
2003	14,765,910	29,310,060	-98.498%
2004	15,672,510	35,516,292	-126.615%
2005	15,902,358	35,235,810	-121.576%
2006	15,789,241	32,911,343	-108.442%
2007	26,434,733	29,388,569	-11.174%

Other Train Miles

In our research, we found that the UP reported the following miles shown in Table I-4 below to the FRA in the "Other Miles" category.

TABLE I-4 – UP "Other" Train Miles reported to FRA

	Total	Freight	Yard	Other
2003	190,164,939	164,522,334	14,765,910	10,876,695
2004	193,130,457	165,332,523	15,672,510	12,125,424
2005	199,103,551	170,250,470	15,902,358	12,950,723
2006	203,283,356	184,308,553	15,789,241	3,185,562
2007	194,228,915	164,552,435	26,434,733	3,241,747

This is significant because all of the other Class I railroads report zero miles in this category. And even within UP's reported figures, there was a major change between 2005 and 2006 resulting in markedly fewer miles in this category. The fact that only UP reports miles in the other category indicates that UP's understanding of what is to be included here differs from that of the other railroads or that UP has operations that the other railroads do not have. Further, it appears that UP's understanding of this category of operations changed rather significantly between 2005 and 2007.

We have researched this issue further and find that in this instance UP might be properly including miles in this category. When we review data included in each of the mileage categories, clearly there were special trains, inspection trains, etc. that are not supposed to be included in the Train and Yard Switching Miles categories. We do not imply any nefarious intent on UP or other railroads in reporting or not reporting data in this category. However, we conclude from this concrete evidence that the understanding of the reporting requirements has morphed over time. We address this issue further below.

Railroad Worker Hours

Employee hours, as defined in Sec. 245.5(a) of FRA's Guide for Preparing Accident/Incident, includes the number of hours worked during the calendar year for all occupational codes in Appendix D of the Guide. We verified that the major classifications codes for the STB Annual Wage Forms A and B were the same as that for the FRA. Precisely, the classifications are: Executives, Officials, and Staff Assistants; Professional and Administrative; Maintenance of Way and Structures; Maintenance of Equipment and Stores; Transportation (Other than Train and Engine); and Transportation (Train and Engine). However, there is a significant difference in the hours reported to the FRA and STB as well as a lack of consistency in some cases, as shown in Table I-5 below.

TABLE I-5 – FRA Employee Work Hours and STB Annual Wage Forms A&B

Road	FRA Work Hours	Wage Forms A&B	FRA % Difference
BNSF			
2003	73,650,604	64,768,208	12.060%
2004	77,821,155	64,931,218	16.564%
2005	82,010,039	64,876,488	20.892%
2006	86,394,018	66,414,950	23.126%
2007	84,255,691	65,858,558	21.835%
CSX			
2003	63,667,250	57,761,348	9.276%
2004	60,236,240	53,778,230	10.721%
2005	67,206,910	57,259,139	14.802%
2006	67,874,578	57,262,642	15.635%
2007	65,859,501	56,486,873	14.231%
KCS			
2003	5,992,553	4,715,560	21.310%
2004	6,470,219	5,107,143	21.067%
2005	7,165,233	5,681,094	20.713%
2006	6,760,749	5,873,366	13.126%
2007	6,957,324	5,821,713	16.323%
NS			
2003	58,768,180	53,694,069	8.634%
2004	59,162,395	53,347,090	9.829%
2005	64,371,222	58,003,318	9.892%
2006	63,707,375	57,120,308	10.340%
2007	63,854,617	57,186,685	10.442%
UP			
2003	89,623,306	83,817,889	6.478%
2004	94,511,265	88,826,086	6.015%
2005	97,540,553	89,920,455	7.812%
2006	100,702,269	94,025,542	6.630%
2007	101,040,810	94,646,121	6.329%

Our research discovered that FRA Employee Hours Worked included overtime while the Wage Form A and B figure we cite in Table I-5 did not. FRA's report includes straight time and overtime "actual hours worked". The STB's Wage Form A and B includes Straight Time Actually Worked, Straight Time Paid For, Overtime Paid and Constructive Allowance/Vacation/etc. hours paid.

We then adjusted the Wage Form A and B data to include overtime. This change reduced the difference between the FRA and STB figures and is shown in Table I-6 below. Without adding overtime hours to the Wage Forms A and B figures, the FRA hours were greater than the STB figures, UP figures were typically greater by 6 to 7 percentage points and NS figures by 9 to 10 percent. Differences were in the double digits for BNSF, CSX, and KCS. By adding in overtime data, both UP and NS moved to negligible differences between data sources and the other railroads exhibited significant differences ranging from 4.2 to 13.6 percent. It is unclear why such data deviations continue to exist among railroads and why the figures reported to the STB and FRA do not match, given they are from the same source (railroads) and the major job classifications match exactly.

TABLE I-6 – FRA Employee Work Hours and STB Annual Wage Forms A&B+OT

Road	FRA	Wage Forms A&B	Wage Forms A&B OT	Wage Forms A&B Total	FRA % Difference
BNSF					
2003	73,650,604	64,768,208	5,779,276	70,547,484	4.213%
2004	77,821,155	64,931,218	7,136,252	72,067,470	7.393%
2005	82,010,039	64,876,488	7,948,132	72,824,620	11.200%
2006	86,394,018	66,414,950	8,919,035	75,333,985	12.802%
2007	84,255,691	65,858,558	8,747,181	74,605,739	11.453%
CSX					
2003	63,667,250	57,761,348	6,130,937	63,892,285	-0.353%
2004	60,236,240	53,778,230	6,229,014	60,007,244	0.380%
2005	67,206,910	57,259,139	6,493,136	63,752,275	5.140%
2006	67,874,578	57,262,642	6,766,664	64,029,306	5.665%
2007	65,859,501	56,486,873	6,508,228	62,995,101	4.349%
KCS					
2003	5,992,553	4,715,560	463,214	5,178,774	13.580%
2004	6,470,219	5,107,143	482,722	5,589,865	13.606%
2005	7,165,233	5,681,094	572,399	6,253,493	12.724%
2006	6,760,749	5,873,366	561,286	6,434,652	4.823%
2007	6,957,324	5,821,713	609,311	6,431,024	7.565%
NS					
2003	58,768,180	53,694,069	5,157,295	58,851,364	-0.142%
2004	59,162,395	53,347,090	5,896,093	59,243,183	-0.137%
2005	64,371,222	58,003,318	6,441,660	64,444,978	-0.115%
2006	63,707,375	57,120,308	6,651,513	63,771,821	-0.101%
2007	63,854,617	57,186,685	6,736,277	63,922,962	-0.107%
UP					
2003	89,623,306	83,817,889	8,041,785	91,859,674	-2.495%
2004	94,511,265	88,826,086	9,419,927	98,246,013	-3.952%
2005	97,540,553	89,920,455	10,065,938	99,986,393	-2.508%
2006	100,702,269	94,025,542	10,212,106	104,237,648	-3.511%
2007	101,040,810	94,646,121	9,866,336	104,512,457	-3.436%

Passenger Train Miles

The Federal Transit Agency's National Transit Database (NTD) contains information on passenger miles for transit systems that use federal funding and are above a certain operational threshold. The NTD defines Passenger Train Miles as the cumulative sum of the distances ridden by each passenger. The FRA defines a passenger-mile as the movement of a passenger for a distance of one mile. Hence, by definition, Passenger Train Miles from the NTD and FRA should be identical for rail transit operators. This does not seem to be the case. As Table I-7 shows only the figures for the Long Island Rail Road and Port Authority Trans-Hudson are anywhere near the same. Moreover, our sampling of other transit railroads showed large variations in reported data comparable to those for the MARC, MBTA, and NIRC systems as show in Table I-7 below. At first, we thought that this difference was due to a misallocation of service among modes, but this was not the case. In fact, while checking websites of individual services as a cross check we found that even those did not agree in all instances with data submitted to the FTA or FRA.

We also checked for data on Amtrak in the NTD and were unable to locate any data regarding their operations. In speaking with NTD representatives, we discovered that Amtrak does not file data or operating statistics with the FTA. Amtrak only files operational data with the FRA and does not publicly disseminate this information to other sources.

TABLE I-7 – FTA NTD Passenger Miles and FRA Passenger Miles

ID/Year	FTA Psgr. Miles	FRA Psgr. Miles	% Difference
MTA Long Island Rail Road (LI)			
2003	2,147,141,349	2,180,038,414	-1.532%
2004	1,994,484,822	2,145,681,089	-7.581%
2005	1,925,735,613	2,155,432,949	-11.928%
2006	2,207,016,596	2,205,755,962	0.057%
Maryland Transit Administration (MARC/MCAZ)			
2003	297,831,894	204,796,485	31.238%
2004	297,788,822	179,563,572	39.701%
2005	311,334,887	214,040,053	31.251%
2006	329,596,941	224,718,087	31.820%
Massachusetts Bay Transportation Authority (MBTA)			
2003	710,932,501	439,403,498	38.193%
2004	760,002,384	405,935,760	46.588%
2005	684,039,476	409,812,824	40.089%
2006	767,345,511	434,662,988	43.355%
Northeast Illinois Regional Commuter Railroad Corporation (NIRC)			
2003	1,506,371,044	768,302,632	48.996%
2004	1,518,710,223	761,516,700	49.858%
2005	1,548,276,634	791,423,569	48.884%
2006	1,636,188,833	850,296,950	48.032%
Port Authority Trans-Hudson Corporation (PATH)			
2003	254,002,693	253,545,114	0.180%
2004	288,071,462	323,453,768	-12.282%
2005	301,282,483	301,282,464	0.000%
2006	332,894,111	332,512,866	0.115%

Passenger Miles Operated and Number of Passengers Transported

FRA's number of passengers transported and passenger miles by railroad are not comparable with similar statistics in the NTD service data. The NTD measures unlinked passenger trips, which counts some passenger trips more than once (unlinked passenger trips), producing a larger number than passengers transported. The NTD passenger miles traveled is also derived from the unlinked passenger trips and is therefore larger than passenger miles. The underlying data is not publicly available and it is unclear if the NTD receives this data with its components parts or pre-processed from the various data sources.

RESEARCH FINDINGS

TEI's goal for this part of the project was to identify sources for railroad data and determine if these sources could be used to validate and normalize operational data reported to the FRA. We conclude the following sources may be helpful.

STB Class I Railroad Annual R1 Reports

We found that the STB's Class I Railroad Annual R1 Reports does indeed have data on operational metrics such as Freight Train Miles and Yard Switching Locomotive Miles that the FRA could use. Moreover, the definitions of Freight Train Miles are similar given one change.[2] However, after a detailed analysis we found that the data reported to the STB in the R1 was different numerically from that reported to the FRA. Therefore, while the R1 cannot be used to determine if the same figures are being reported to the FRA as are being reported to the STB, we can use the R1 information to develop proxies to alert the FRA of any significant changes in what is reported. For example, in aggregate, BNSF's the FRA Freight Train Miles have been 11.6 to 13.8 percentage points (see Table I-1) greater than R1 Freight Train Miles. If the FRA continues to monitor the R1 reports and notes any changes (positive or negative) from this range this would imply a closer review of the data is warranted. Yard Switching Miles can be treated in a similar fashion.

[2] FRA's definition of Freight Train Miles includes Yard Switching Miles while the R1 definition does not.

STB Wage Forms A and B

In our inspection of Wage Forms A and B, we found that the STB and FRA major classification codes were identical. In theory, figures reported to the STB and FRA should be directly comparable (and very close if not identical). Alas, again this is not the case, though NS is closest to being identical for both the FRA and STB with a less than one-tenth percent difference. Yet, the other carriers are off by negative three to positive 13 percentage points with a range of 16 percentage points. For recent years, though, the percentage point difference has been relatively consistent and again this could be used a proxy to cross check if employee hours data were being reported in a consistent manner.

FTA National Transit Database

In our review of the voluminous NTD, we found that database did contain information about Passenger Miles for select railroads. We do know that not all of the railroads that report Passenger Miles to the FRA report data to the NTD. Here, much more than in the previous two STB sources, the difference in figures reported to the FRA and FTA are completely inconsistent. We researched and dissected what possible causes for these huge differences could be, but were unable to identify any solid factors. Without detailed queries to the respective railroads that report Passenger Miles to the FRA and FTA, it is doubtful that this source can be useful for vetting FRA data.

RECOMMENDATIONS

After having conducted a detailed review of railroad operational metrics and the various data sources, TEI has developed the following five recommendations for the FRA with respect to data considerations.

First, TEI feels that both the FRA and railroad industry would benefit from a periodic review of reporting requirements. This could be accomplished by conducting training seminars at the FRA headquarters or by an independent contractor in each region. We base this recommendation on the fact the only UP reports miles in the Other Miles category. According to their explanation of the miles included in this category, we agree that those miles are rightfully classified. This implies an industry-wide misunderstanding of what miles should be included under the Other Miles category. With training sessions or seminars, any questions that railroad representatives might have could be addressed and the FRA could ensure that each railroad was reporting not what they thought the FRA wanted in terms of data but what is actually expected by the FRA. We note here that railroads want to comply with rules and regulations – any differences that have developed are not through any tacit attempt to deceive. Providing review/training sessions will improve the quality of the data that the FRA collects.

Second, TEI suggests closer coordination with the STB in terms of the data collected. It is commendable that the FRA is concerned about validating and normalizing data. We know that the STB, like the FRA, audits the data submissions. Closer coordination between the STB and FRA may make the comparison of data items uniform. Furthermore, as the FRA considers changes in data collection requirements, coordination with the STB could ensure that such changes are reported to both agencies retaining/providing a valuable data cross check source.

Third, TEI suggest that the FRA develop annual check of the proxies that we have identified in this report. We also suggest that these sources as well as data checks within the FRA data continue, to ensure consistency of the data. We recommend that informational dashboards be created for those responsible for data vetting. With limited resources in terms of auditing, informational dashboards will allow the FRA to quickly identify changes in data and industry performance that should be acknowledged, quantified, and addressed. Informational dashboard technology can allow the FRA to monitor all of relevant data points and metrics on daily, weekly, monthly, quarterly, or any other time increment the FRA desires.

Fourth, the railroad industry has changed remarkably over the past 25 years since the passage of the Staggers Act. Though basic railroading is essentially the same, other parts have modernized. To this end, TEI suggest that the FRA conduct a methodical review of its data reporting requirements leading to an updating of the data collection regime. Changes, additional reporting requirements, and elimination of archaic reports as ascertained by the review should be adopted. Data collection is not the same task as it was even 25 years ago, most every railroad (Class I, II, and III) all have sophisticated IT systems and gather information on myriad factors. The burden associated with generating additional data is not what it use to be – and the power and potential for the FRA to improve safety through an enhanced data collection regime would be extremely valuable.

Fifth, the volume of data that the FRA has warehoused impresses us. We suggest that the FRA use this data for an internal crosscheck of data (perhaps even coordinated with our third suggestion above). This way the FRA could make sure that railroads within classes are functioning within a specified range with respect to various parameters. For example, if a Class III railroad started reporting significantly more Train Miles while no changes in miles of track operated or in classification level, further scrutiny would be necessary. Data mining the existing safety database is a key to improving FRA's monitoring capability.

PART II – MEASURING REMOTE CONTROL LOCOMOTIVE OPERATIONS

The purpose of this part of the research project is to determine if the FRA can better measure and manage the safety requirements of yard switching operations, particularly remote control locomotives (RCL) yard switching operations *vis-à-vis* conventional yard switching operations. In the remaining part of this section, we discuss the need for a better exposure metric for yard switching safety performance.

RCL have existed for nearly three decades but only in the most recent decade have RCL operations been increasingly adopted by the railroad industry in regular operations. The use of RCL has been, to date, limited to yard and industrial operations. The increased use of RCL has occurred for manifold reasons. One key driver has been the increased economy of RCL operations through a reduction in labor requirements. Conventional yard switching consists of one engineer in the locomotive cab, and two crewmembers on the ground directing the engineer's locomotive movements, setting switches, and coupling and uncoupling railcars.

RCL operations have eliminated the engineer's position in the cab and reduced communication channels from three down to two crewmembers. The RCL is controlled by one or both (one at a time) of the crewmembers using a computer on the locomotive and a remote control unit. The RCL has multiple built-in fail-safe features that require operations within certain parameters on behalf of the RCL operator. Thus, in aggregate, the costs associated with switching are reduced due to fewer crewmembers required for switching activities and the potential of a miscommunication occurring is also reduced.

Approximately 9 years ago, as RCL operations became more frequently employed in switching and industry service in the railroad industry, the FRA held a Technical

Conference on July 19, 2000, to allow interested and concerned parties an opportunity to share their opinions on RCL operations. Since the FRA's primary mandate is as the safety regulator of railroad operations, FRA initiated a Technical Conference to ensure that RCL operations posed no increased or changed threat to railroad workers or the public at large. The conference examined the following safety aspects of RCL operations:

1. Design standards
2. Employee training
3. Operating practices and procedures
4. Test and inspection procedures
5. Security and accident/incident reporting procedure

In addition to FRA staff, approximately sixty representatives attended the conference from railroads, industry associations, labor organizations, technology suppliers, consultants, and other government agencies.

On February 14, 2001, approximately eight months after the Technical Conference, the FRA published Notice of Safety Advisory 2001-01. In reviewing the materials and comments presented at the Technical Conference, the FRA noted that:

> ...several commenters stated that RCL operations have enhanced safety performance. Some of the suggested enhancements included better visual contact with the leading end of rail movements, the elimination of communication error between the locomotive engineer and ground crew, and the reduction of yard accidents and injuries. Several commentors submitted data that indicate accidents and incidents dropped dramatically as RCL operations increased. Although FRA commends these commentors for their efforts in gathering such data, FRA notes that the data used were obtained without equal exposure metrics to allow valid comparisons between remote control and manual operations (i.e., comparisons were not equalized for the number of labor hours and number of employees). Normalizing safety data is necessary to clarify our understanding of the potential safety risks.

The FRA went on to note:

> ...FRA recommends that railroads maintain appropriate exposure measures, including total number of labor hours and total number of employees by location for both RCL operations and manual locomotive operations. Together these measures will allow FRA to accurately measure accident and incident rates of both types of operations and make valid comparisons between RCL operations and manual operations...FRA will then use these data when considering any future policies on these operations.

The Notice of Safety Advisory 2001-01 clearly identified the need for data to compare RCL and conventional switching operations.

On September 2, 2003, the Senate Committee on Commerce, Science, and Transportation (Committee) requested that the FRA assess the impact of RCL operations on safety. Included in this request was a comparison of the rate of accidents, injuries, and fatalities involving RCL and conventional switching operations.

FRA's May 2004 Interim Report to the Committee found that the aggregate accident rate for RCL versus conventional yard switching operations was 21.00 and 24.28 per million yard switched miles (MYSM), respectively. This conclusion was reversed in the March 2006 Final Report to the Committee. The Final Report noted that in aggregate, RCL yard switching accident rates were 22.42 per MYSM and conventional yard switching accidents rates were 17.89 per MYSM. The final report also concluded that the Employee Injury rates were 6.49 per MYSM for RCL operations and 8.14 per MYSM for conventional operations. Though the FRA developed a rationale for this different result and presented reasoning for the variant conclusion, this highlighted the fact that a better metric was required to ascertain RCL yard switching operational safety.

To state this more precisely, a measure is needed that will accurately capture the variables and considerations in yard switching operations so that RCL and conventional activities can be compared without caveats. The Final Report acknowledged this point in a note on page nine as follows:

> All of the data presented in this report was provided to the Operating Rules Working Group of the RSAC (Railroad Safety Advisory Committee) during the summer of 2005 for its consideration. One party to that discussion has called attention to the fact that injury data is typically normalized by 200,000 work hours, rather than by using MYSM. FRA agrees that use of 200,000 work hours is preferable; however, during the period this report was prepared FRA did not have access to work hour data disaggregated in the manner that would have been required to perform this analysis. FRA is exploring options for pursuing work hour data that would be more suitable for this purpose.

Review of these previous results and our own analysis that follows show that the MYSM metric is inadequate when used to compare RCL yard switching operations with conventional switching operations to measure safety performance.

ANALYSIS OF ACCIDENTS PER MYSM

To facilitate our analysis, we reproduce data from the Interim Report to the Committee in Table II-1 below.

TABLE II-1 – Data Replicated from Interim Report on Safety of RCL Operations

	Accidents				YSM				Accident Rates per MYSM		
Railroad	RCL	Conv.	Total	% RCL	RCL	Conv.	Total	% RCL	RCL	Conv.	Total
All Railroads	181	687	868	20.9	8,620,986	28,295,583	36,916,569	23.4	21	24.28	23.51
All Class I Railroads	171	632	803	21.3	8,051,433	25,618,574	33,670,007	23.9	21.24	24.67	23.85
All Class II Railroads	9	43	52	17.3	507,666	2,627,580	3,135,246	16.2	17.73	16.36	16.59
All Class III Railroads	1	12	13	7.7	61,887	49,429	111,316	55.6	16.16	242.8	116.8
Alton & Southern Rwy [ALS]	4	3	7	57.1	217,564	333,903	551,467	39.5	18.39	8.98	12.69
Belt Rwy Co. of Chicago [BRC]	3	7	10	30	77,537	171,688	249,225	31.1	38.69	40.77	40.12
Birmingham Southern [BS] *	0	1	1	0	0	9,835	9,835	0	0	101.7	101.7
BNSF Rwy Co. [BNSF]	39	149	188	20.7	2,080,873	5,585,742	7,666,615	27.1	18.74	26.68	24.52
California Northern RR Co. [CFNR]	0	1	1	0	3,623	2,963	6,586	55	0	337.5	151.8
Cleveland Works Railway (CWRO) *	0	7	7	0	0	4,622	4,622	0	0	1515	1515
Consolidated Grain & Barge Co. [CGBX]	0	0	0	0	9,002	0	9,002	100	0	0	0
Consolidated Rail Corp. [CRSH]	1	20	21	4.8	24,528	1,046,154	1,070,682	2.3	40.77	19.12	19.61
CSX Transportation [CSX]	27	147	174	15.5	2,070,967	5,272,965	7,343,932	28.2	13.04	27.88	23.69
Florida East Coast Rwy Co. [FEC]	0	3	3	0	5,900	241,718	247,618	2.4	0	12.41	12.12
Illinois Central RR Co. [IC]	0	24	24	0	4,770	1,478,104	1,482,874	0.3	0	16.24	16.18
Indiana Rail Road Co. [INRD]	0	2	2	0	5,945	17,825	23,770	25	0	112.2	84.14
Jefferson Warrior RR [JEFW]	0	0	0	0	4,942	266	5,208	94.9	0	0	0
Kansas City Southern Rwy Co. [KCS]	3	29	32	9.4	212,022	526,238	738,260	28.7	14.15	55.11	43.35
McKeesport Connecting RR Co. [MKC] *	0	0	0	0	0	5416	5,416	0	0	0	0
Montana Rail Link [MRL]	1	2	3	33.3	155,293	113,250	268,543	57.8	6.44	17.66	11.17
Norfolk Southern Corp. [NS]	5	91	96	5.2	431,750	7,104,466	7,536,216	5.7	11.58	12.81	12.74
Pennsylvania Southwestern RR, Inc. [PSWR]	0	0	0	0	36,216	3,354	39,570	91.5	0	0	0
Puget Sound & Pacific RR Co. [PSAP]	0	1	1	0	1462	1,648	3,110	47	0	606.8	321.5
San Luis & Rio Grande RR [SLRG]	1	0	1	100	697	3,500	4,197	16.6	1435	0	238.3
Union Pacific RR Co. [UP]	97	192	289	33.6	3,251,051	5,651,059	8,902,110	36.5	29.84	33.98	32.46
Wheeling & Lake Erie Rwy Co. [WE]	0	6	6	0	1,212	109,235	110,447	1.1	0	54.93	54.32
Wisconsin Central Ltd. [WC]	0	2	2	0	25,632	611,632	637,264	4	0	3.27	3.14

As shown in the Table above, railroads such as Birmingham Southern and California Northern each had one incident on their yard tracks and each involved conventional switching. Using this example, the conclusion would be that RCL operations are safer, even though only the California Northern logged RCL yard switching miles. It would be incorrect to say that RCL yard switching has or had no risk for the California Northern.

As the FRA noted in the Final Report, three railroads (UP, CSX, and BNSF) were responsible for 85 percent of yard switching miles and had a rate of 24.09 per MYSM for RCL operations and 24.52 per MYSM for conventional operations. Injury rates for these three railroads were 6.58 per MYSM and 9.54 per MYSM, respectively for RCL and conventional yard switching operations.

It seems clear that more and possibly different information is required to make an adequate and unbiased judgment with respect to the safety of either method of switching. Depending on the metric employed, the fact that RCL operations employ fewer workers than conventional switching operations must be taken into consideration.

MICRO-LEVEL ANALYSIS

As we researched and analyzed how best to measure yard switching operations, we also developed a micro-level analysis for comparing RCL and conventional yard switching. To do this, we first reviewed the claimed benefits of RCL operations over conventional operations. We determined that the primary differences were: fewer crewmembers resulting in a reduced chance of miscommunication and better physical positioning with regard to switching movements. We then revisited the accident data used by the FRA in preparing its Final Report.[3] Reviewing Table 1-4 in Appendix 1, we found five major classifications of specific causes: human factors, track defects, miscellaneous, equipment defects, and signal and train control.

Our analysis assumed that regardless of the type of switching operation, track defects, miscellaneous, equipment defects, and signal and train control factors would affect RCL and conventional switching operations equally. The implication being that it would be difficult to ascertain if indeed RCL operations or conventional operations were meaningful contributors to the accident. Stated differently, a track defect will cause a conventional or RCL yard switching job to result in the same end scenario with equal probabilities. Therefore, it would not add to our knowledge of the safety performance of RCL yard switching operations by studying or attempting to attribute performance related assertions based on data from these types of accidents.

We then focused on human causal factors. From the data reported in Appendix 1 Table 1-4 of the Final Report, we developed a list of causes that should result in fewer accidents for RCL operations when compared to conventional operations. This is listed

[3] Because of data limitations, we were unable to conduct a similar analysis of employee injuries by causal incidents.

in Table II-2 below along with the number of accidents for each type of operation. Ideally, better positioning of the RCL operator should be reflected in Causes 1 through 8 and a reduction in communication channels should be reflected in Causes 9 and 10.

TABLE II-2 – Human Causal Factors Favoring RCL Operations

Cause	Description	RCL	Conventional	Total
1	Shoving movement, failure to control	28	17	45
2	Kicking or dropping cars, inadequate precautions	4	18	22
3	Buff/slack action excess, train handling	6	11	17
4	Car(s) shoved out & left out of clear	2	11	13
5	Coupling speed excessive	2	6	8
6	Buff/slack action excess, train make-up	4	3	7
7	Switch movement, excessive speed	5	2	7
8	Failure to stop train in clear	3	2	5
9	Radio communication, failure to comply	1	4	5
10	Instruction to train/yard crew improper	7	8	15
	Total RCL Advantage	62	82	144

It would be improper to draw any conclusion from the raw data as presented above, so we weighted the number of accidents with MYSM for each type of yard switching operation as shown in Table II-3 below.[4] For this part of the analysis, the metric was not important, as each would provide the same order of magnitude difference because any other calculated metric would have been developed from the same source data.[5] We also present the same analysis but include all human factor related causes in the last line of Table II-3.

[4] This is the same metric used by CN its report to the FRA, which is cited industry-wide for radically safer RCL operations. See FRA Docket No. FRA 2000-7325 "Canadian National Experience with Locomotive Remote Control Technology" November 16, 2000.

[5] Namely, the Final Report to the Committee.

TABLE II-3 – Human Causal Factors and RCL Operations per MYSM

Cause	RCL Acc.	Conv. Acc.	RCL Acc. Rate/MYSM	Conv. Acc. Rate/MYSM
1	28	17	1.327	0.343
2	4	18	0.190	0.364
3	6	11	0.284	0.222
4	2	11	0.095	0.222
5	2	6	0.095	0.121
6	4	3	0.190	0.061
7	5	2	0.237	0.040
8	3	2	0.142	0.040
9	1	4	0.047	0.081
10	7	8	0.332	0.162
Total 1-10	62	82	2.939	1.656
All HF	285	466	13.509	9.411

What these results imply is that US carriers have not garnered the same, nor even near the same level of improvements in safer yard switching operations, as Canadian railroads claim to have achieved from the adoption of RCL operations. For example, Canadian National (CN) claimed 56 percent fewer incidents then conventional operations. However, the CN study included all incidents regardless of size as the base dataset not FRA reportable accidents and incidents. As another example, Canadian Pacific Railway (CPR) reported that its FRA reportable incidents went from 176 in 1994 to 50 in 1999.[6] Still, given data limitations in our micro-level analysis, it is difficult to jibe the results of the Canadian operations with the results from our micro-level analysis and also the analysis conducted for the Final Report.

Because we were unable to acquire the underlying data for these studies, we hypothesize at least two factors that could be contributing to differences in the US versus Canada. First, because the CN study includes all accidents in the calculations, it could

[6] See FRA Docket No. FRA 2000-7325-2 "Remote Control Locomotive System" Canadian Pacific Railway July 19, 2000.

well be that RCL operations result in significantly fewer minor accidents. This data is not captured in either of the two FRA RCL safety studies to allow comparison.

While the CPR study only uses data from accidents that are FRA reportable a "learning by doing" effect could be masking the difference in this instance. When new operational techniques (RCL) are adopted as a driver for improvement in productivity (and profitability) they must also result in an improvement of safety.[7] This phenomenon arises from a long-recognized factor that was formalized by the Nobel laureate Kenneth Arrow in his seminal paper "The Economic Implications of Learning by Doing."[8] Productivity and safety improves over time because the firm experiments and learns which techniques are most efficient.

Numerous empirical studies have confirmed the learning by doing phenomenon across a wide array of industries. For example, Armen Alchian explored the implications of learning by doing in the production of airframes;[9] he found that productivity improved as workers gained additional experience building airframes. Paul Joskow and George Rozanski documented the relevance of learning by doing to the nuclear power industry.[10] Joskow and Rozanski show that "technical progress due to learning by doing plays an important role in determining the productivity of nuclear power plants." Rosenberg notes that interactions between products and their use environments are sometimes too complex

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[7] Firms will not adopt technologies that improve productivity, while reducing safety more than marginally, as this would directly affect profitability.

[8] Arrow, Kenneth. "The Economic Implications of Learning by Doing." *Review of Economic Studies*, Vol. 29, No.3 (June, 1962), pp. 155-173.

[9] Alchian, Armen. "Reliability of Progress Curves in Airframe Production." *Econometrica*, Vol. 31, No. 4 (October, 1963), pp. 679-693.

[10] Joskow, Paul L. and George A. Rozanski. "The Effects of Learning by Doing on Nuclear Plant Operating Reliability." *The Review of Economics and Statistics*, Vol 61, No. 2 (October, 1979), pp. 161-168.

to be predicted and so improvements occur over time.[11] Byong-Hyong Bahk and Michael Gort decompose the learning by doing effect into three categories – labor learning, capital learning, and organization learning.[12] Moreover, that labor and organizational learning can begin almost immediately and continue for upwards of ten years after the adoption of new technologies.

We note that railroads make large intangible investments that improve productivity and safety over time. Workers must be trained and retrained, organizations must discover the best way of employing new and existing technologies. In this instance, Canadian railroads have had RCL operations for nearly a decade longer then those in the US resulting in a higher safety performance. Moreover, only three railroads in the US have adopted and employed RCL technology intensively. These factors may point to future improvements in RCL operational safety.

[11] Rosenberg, Nathan. Inside the Black Box: Technology and Economics. New York: Cambridge University Press (1982).

[12] Bahk, Byong-Hyong and Gort, Michael. "Decomposing Learning by Doing in New Plants." *The Journal of Political Economy*, Vol. 101, No. 4 (Aug., 1993), pp. 561-583.

DEVELOPING AND REFINING ALTERNATIVE METRICS

The railroads did not furnish worker hours for the analysis in the Final Report. Therefore, TEI constructed worker hours for RCL and conventional switching jobs from the YSM provided for both operations. In this effort, TEI divided YSM by six miles per hour and then divided that result by eight hours per switching shift.[13] The results of these calculations provide the number of crew starts for each type of yard switching operation. TEI then multiplied the crew starts times 16 hours for RCL and 20 hours for conventional yard jobs.[14] The component calculations and a comparison of the Accident Rate using the study MYSM and the "Converted Worker Hours" are shown below in Table II-4 and Table II-5.

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[13] FRA Guide for Preparing Accident/Incident Reports states that Yard Switching Train-Miles may be computed at the rate of 6 mph for the time actually engaged in yard switching service (or any other method that will yield a more accurate count) if actual mileage is not known.

[14] TEI used the 6180.54 – Rail Equipment Accident/Incident Report database to calculate the average crewmembers for RCL and conventional switching operations for 2004. Accidents that occurred on yard and/or industrial tracks in switching operations were used and provided an average of **2.00** crew members (16 hours) for RCL operations and **2.51** crew members (20 hours) for conventional switching operations.

TABLE II-4 – Conversion of Switching Miles to Hours to Worker Hours

	Switching Miles		Crew Starts [MYSM/6mph/8Sw.Hrs]		Conversion to Hours		Hours/200,000	
Railroads	RCL	Conv.	RCL	Conv.	RCL (16 Hours)	Conv. (20hours)	RCL	Conv.
ALL	21,097,583.00	49,513,963.00	439,532.98	1,031,540.90	7,032,527.67	20,630,817.92	35.16	103.15
BNSF	5,026,175.00	9,708,587.00	104,711.98	202,262.23	1,675,391.67	4,045,244.58	8.38	20.23
CSX	4,851,944.00	8,127,775.00	101,082.17	169,328.65	1,617,314.67	3,386,572.92	8.09	16.93
KCS	339,451.00	934,253.00	7,071.90	19,463.60	113,150.33	389,272.08	0.57	1.95
NS	866,592.00	13,070,316.00	18,054.00	272,298.25	288,864.00	5,445,965.00	1.44	27.23
UP	8,040,837.00	8,875,851.00	167,517.44	184,913.56	2,680,279.00	3,698,271.25	13.40	18.49
ALL RR-NS	20,230,991.00	36,443,647.00	421,478.98	759,242.65	6,743,663.67	15,184,852.92	33.72	75.92

TABLE II-5 – Accident Rates Comparing MYSM and Worker Hours

	Accidents		Accident Rate (MYSM)		Accident Rate (Worker Hours/200,000)	
Railroads	RCL	Conv.	RCL	Conv.	RCL	Conv.
ALL	473	886	22.42	17.89	13.45	8.59
BNSF	116	175	23.08	18.03	13.85	8.65
CSX	67	160	13.81	19.69	8.29	9.45
KCS	12	32	35.35	34.25	21.21	16.44
NS	11	125	12.69	9.56	7.62	4.59
UP	227	320	28.23	36.05	16.94	17.31
ALL RR-NS	462	761	22.84	20.88	13.70	10.02

We conducted this exercise to develop alternative "types" of data and to see how we could use these data to develop alternative metrics. In essence, what we did was attempt to bring to yard switching operations a similar metric used for employee on duty cases. With the above background information, we examine several measurement alternatives in the next section.

MEASUREMENT ALTERNATIVES FOR YARD SWITCHING OPERATIONS

As noted earlier in this report, most[15] conventional yard switching requires three crewmembers one engineer in the locomotive cab and two crewmembers on the ground performing switching tasks. RCL yard switching eliminates the engineer's position by giving control of the locomotive to the two remaining crewmembers.

TEI began its research by developing a list of metrics and methods for assessing safety in yard switching operations. To ensure that we accounted for all of the aspects of yard switching operations and in order not to limit the analysis we disregarded any data limitations in this initial stage. Thereafter, we examined all of the possible metrics and then addressed data requirements or limitations.

The analysis in the Interim and Final Reports to the Committee relied on yard switching miles data provided by the railroads for each type of switching activity. The FRA does not collect this data in the course of its normal data collection activities. Thus, there is no way to ascertain if the results from these two reports are representative of the actual trend in RCL and conventional yard switching operations or if the study period for the Final Report was an exceptional year. Moreover, the Final Report reverses the trend given in the Interim Report on an industry-wide basis, which makes unclear the direction of safety with respect to RCL and conventional yard switching operations. Even if no changes were made in the metric used to measure yard switching operations (accidents per MYSM), a multi-year study would provide more rigorous results from which to draw conclusions about yard switching operations.

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[15] As explained further below, the average crew size for conventional yard switching was 2.5 implying that some crews had three crewmembers and others had two crewmembers.

In order to capture yard switching activity, we developed four categories of measures as follows:

1. Locomotive-based
    a. Switch Engine Minutes
    b. Locomotive Hours
    c. Yard Switching Locomotive Unit Miles
    d. Yard Switching Locomotive Hours
2. Labor-based
    a. Crew Starts
    b. Employee Hours Worked
    c. Crew Size
3. Operation-based
    a. Origination and Termination of Cars
    b. Cars Switched per Crew Start
    c. Cars Switched
    d. Yard Switching Miles
4. Economic-based
    a. Revenue Hours
    b. Revenue Ton-miles Switched
    c. Revenue Train Miles

We determined that economic-based measures would be inappropriate for measuring safety performance. Use of revenues introduces variations that are not necessarily related to physical activity. We also determined that using locomotive-based measures would incorporate an unneeded double count where switching operations required or used more than one locomotive. Moreover, this would add another dimension to calculating switching activities where Car Control RCL was in use. That left us with labor-based and operation-based measures. We further determined that origination and termination of cars and cars switched would not meaningfully add to the understanding of safety considerations in yard switching operations. Thus, we determined the remaining two operation-based measures and three labor-based measures were best suited for a detailed analysis. However, in the labor-based measures we implicitly include crew size in our analysis as the key difference in RCL and conventional yard switching activities.

Though we step back and approach this task from a yard switching perspective in general, we acknowledge that measuring RCL and conventional yard switching safety drive our analysis.

We present and evaluate four candidates for measuring yard switching activity below.

Candidate Measure # 1 – Yard Switching Crew Starts

Most railroads have a payroll and/or crew management system that maintains a record of job/crew starts. A job/crew start is defined as one or more individuals assigned to a specific train or switching job. For instance, a first shift switching crew of three individuals is classified as a single crew start and a first shift switching crew of two individuals would also be classified as a single crew start.

Each crew works as a team and generally performs a job/safety briefing at the onset of their shift to discuss how to safely complete the work planned and any safety issues/bulletins presented to them. This may include how to work due to excessive heat/cold, watch for slipping hazards due to weather, etc.

In order to determine this 'safety percentage' for RCL and Conventional Yard Switching Operations by "crew start", it is necessary to identify the total population of yard switching jobs by type (RCL and Conventional) and the accidents for each. The FRA database provides information on the actual incidents by RCL and Conventional operations; however, the total population of yard switching jobs is not currently reported to the FRA. In order to make this calculation TEI used the Yard Switching Mile data from the FRA's Final Report on Safety of Remote Control Locomotive (RCL) Operations dated March 2006, Appendix 1 to create "crew starts".[16]

The study data in the March 2006 Final Report indicated that for the thirty-eight (38) railroads involved, RCL operations had an accident rate of 22.42 while Conventional operations had an accident rate of 17.89 per MYSM.

Using this Crew Start method, RCL operations have a failure percentage of .107 while Conventional Operations have a failure percentage of .086 per 100 crew starts.

Using yard switching Crew Starts does have benefits. For example, it assumes a functional equivalence between what a conventional crew should accomplish and compares it to a smaller RCL yard switching crew. However, while theoretically the Crew Start method could provide a straight failure percentage, we do not think it provides enough penetration into the actual switching activities. Moreover, with respect to other activities measured on a labor-based metric it does not fit well either. Therefore, we do not see this as a good practical measure for Yard Switching Safety Performance.

Candidate Measure # 2 – Cars Switched

Foster-Miller, Inc., in its "Recommendations for Improved Analysis of Worker Safety" stated that:

> More in-depth analysis of yard injury and accident data requires additional injury and accident exposure measures. Number of cars switched per month is a candidate exposure measure for both injuries and accidents. This metric, in

[16] TEI developed total crew starts by dividing RCL and Conventional Switching miles by 6 (6 MPH) and then 8 (8 switching hours per shift). Although railroads are requested to report time actually engaged in yard switching service, it is not known how or if actual switching time is maintained. One would have to consider the time the switching job is blocked by incoming or outgoing trains, waiting for signals, mealtime, etc. It is thought that railroads report actual on duty hours/minutes, which are thought to normally be 8 hours per shift. Although this method may not produce precise switching hours, it does not favor RCL or conventional switching operations in creating crew starts.

contrast to the currently reported "yard switching miles," would be a measure of actual operations rather than an estimated measure, which may be the case for number of switching miles.[17]

Most, if not all, major railroads provide automated printouts (switch lists) to their yard switching crews that outlines which tracks to switch cars into as well as any hazardous information for the cars. Most railroads have "yard printers" stationed at strategic locations in their major yards as well as "computers" for the yard crews to report their "execution" (cars switched as outlined or exceptions) of the switch list. When these switch movements are reported via computer, an electronic record of cars switched is available.

Some railroads that have computerized Yard Management Systems maintain the detail track-to-track switch movement records for one or two weeks only. These internal yard track-to-track movements are not communicated to the AAR's database for future crosschecking potential and are also not maintained at the yard job assignment level by the railroad which could be used for reporting Cars Switched and auditing/crosschecking purposes. It is not known how all of the non-major class railroads record and/or maintain records on cars switched. However, the availability of cars switched at the yard job assignment level would produce a good productivity exposure measure. However, it appears that not all of the railroads, if any, maintain the desired data at levels needed to produce this exposure measure. For these reasons, Cars Switched is not recommended as an exposure measure for Yard Switching Safety Performance.

[17] See FRA An Examination of Railroad Yard Worker Safety. Final Report. July 2001. Online: http://www.fra.dot.gov/downloads/Research/ord0120.pdf

Candidate Measure # 3 – Yard Switching Miles (YSM)

Yard Switching Miles along with Freight Train Miles, Other Train Miles and Passenger Train Miles comprises Total Train Miles which, after being divided by one million miles, are used as the denominator in calculating the frequency rate for overall accidents/incidents.

The FRA Guide for Preparing Accident/Incident Reports, effective May 1, 2003, states that a Yard Switching Train-Mile may be computed at the rate of 6 mph for the time actually engaged in yard switching service (or any other method that will yield a more accurate count) if actual mileage is not known.

The Canadian Transportation Agency[18] states that Yard Switching Miles are measured as time spent in yard switching (yard switching minutes) and converted to miles at six miles per hour. A yard switching minute is one minute's work in switching service by a yard crew. For the purpose of this statistic "switching service" includes transfer train operations.

It is thought that the current method of using 6 mph with the time actually engaged in yard switching service was developed in a 1954 ICC Yard Switching Study. TEI was unable to obtain a copy of the 1954 Yard Switching Study for analysis. It is not clear what the criteria were used for selecting this measure or selecting 6 mph and not a higher or lower number. However, even if the mph rate changed, the magnitude between the accident rates of RCL and conventional yard switching jobs would remain constant, *ceterus paribus*.

Although railroads are requested to report time actually engaged in yard switching service to be used in calculating yard switching miles, it is not known how or if actual

[18] Canadian Transportation Agency. "1800 Chart of Operating Statistics – 1804 Yard Operating Statistics". Online: http://www.cta-otc.gc.ca/rail-ferro/finance/uca/1800_e.html

switching time is maintained. One would have to consider the time the switching job is blocked by incoming or outgoing trains, waiting for signals, mealtime, etc. It is thought that railroads report actual on duty hours/minutes. The FRA instructions allow a railroad to use "any other method that will yield a more accurate count"; however, it is not clear that the railroads have to or do notify the FRA when these "other methods" are used.

Yard switching is a complicated activity with numerous opportunities for accidents and incidents. Thus, it appears that the probability for a train accident is much greater than for through freight train movements. Measuring these two activities with the same metric does not capture the inherent difference between the two activities. For example, if a yard job spends their entire shift (8 hours) switching, they tally 48 miles (8 hours times 6 mph). In contrast, a through freight train that has only one crew change and travels 150 miles in 4 hours tallies 300 miles.

There also appears to be some confusion on what train class of service to place train mileage in as there have been some recent major swings in Yard Switching Miles by some railroads.[19]

Since the results of "switching hours" times 6 mph is used in the denominator when calculating the "frequency rate", a railroad that reports 'actual hours worked' has an apparent advantage in their "frequency rate" over a railroad that may be capable of accurately measuring "actual switching time" in that "actual switching time" will always be less than "actual hours worked" and thereby the miles produced will also be less than those produced using "actual hours worked".

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[19] This is evidenced by a 4,442495 mile increase in CSX's Yard Switching Miles from 2006 to 2007 with a decrease in Freight Train Miles of 3,789,586 for the same period and a 10,645,492 increase in Yard Switching Miles by UP in 2007 with a decrease of 19,756,118 Freight Train Miles for the same period.

TEI identified a major difference in definition between Freight Train Running Miles as defined by the STB and Freight Train Miles as defined and used by the FRA. The STB's measure of this statistic does not include Yard Switching Miles. This causes a significant difference in the statistics ranging from 11-20 percent. TEI further researched this by subtracting Yard Switching Miles from FRA's statistic Freight Train Miles and still the STB's R-1 figures and Freight Train Miles do not match. Again, the difference is significant: FRA miles ranged from 1.3 percent lower to 7.4 percent higher for Class I railroads.

TEI believes that Train Miles continue to be a good measure for creating the Overall Accidents/Incidents, Total Train Accidents, number of Accidents on Yard Track, Highway-Rail Incidents, and Other Incidents. We believe that reporting requirements with respect to the above measures should not be changed. However for the reasons stated above and the fact that the current use of "mph" produces an "estimated" measure rather than a measure of "actual operations" TEI believes YSM is not the best exposure measure to compare the difference in Yard Switching Safety Performance between RCL and conventional operations.

Candidate Measure # 4 – Worker Hours for RCL and Conventional Assignments

In our analysis, TEI discovered two candidate measures that rose above the others in using actual yard operations as an exposure measure for yard switching performance. We have discussed one of these above (Candidate Measure # 2 – Cars Switched), and the difficulty in capturing the required data. The second measure, Worker Hours, is a good measure of actual yard operations because it is a report of the actual hours worked by a given crew and is a measure on which the railroads maintain data.

FRA's Form F6180.55 (Railroad Injury and Illness Summary) requires the reporting of Railroad Worker Hours as a total for all job codes. However, FRA's Guide for Preparing Accident/Incidents Reports, Appendix D provides Employee Job Codes that allow the differentiation between Remote Control Locomotive (RCL) and conventional switching jobs. TEI is very confident that through their Payroll and Crew Management systems, railroads have the capacity to furnish actual hours worked by the employee job codes provided in Appendix D of the FRA Guide.

We have previously discussed the weakness in establishing YSM as an exposure measure as it is not known if a railroad reports actual yard switching time or actual hours worked. A railroad that reports 'actual hours worked" has an apparent advantage in their "frequency rate" over a railroad that may be capable of accurately measuring "actual switching time" in that "actual switching time" will always be less than "actual hours worked". Therefore, unless a standard guideline was established, the same imbalance in reporting could continue.

STB's Wage Form A & B provides total hours for each major numerical group (i.e., 400,500,600, etc.). However under 49CFR 1245.5 Classification of Railroad Employees, the STB does not require codes 630 (Remote Control Locomotive Operator – Operating) or 631 (Remote Control Locomotive Operator – Not Operating). Therefore, a direct validation of RCL and conventional yard switching worker hours between the STB and FRA is not possible unless the FRA were to require the reporting of this activity by job code and the STB were to add the same RCL job codes and provide data by those job codes.

The railroads and labor unions have already accepted the use of "actual hours worked" in the calculation of injuries for "Employees on Duty". Here the frequency rate is developed by dividing the "actual hours worked" by 200,000 with the result being divided into the number of "employee on duty cases". These resulting measures are being used in selecting winners for the annual Harriman Safety Award.

It is TEI's opinion that the use of "actual hours worked" is currently the best exposure measure available in understanding the difference between the safety of operations for RCL and Conventional yard switching activity because it is a measure of actual operations and is supported by data currently maintained by the railroads.

CONCLUSIONS

TEI has reviewed the issues associated with assessing the safety of RCL and conventional yard switching operations. This entailed a detailed review of the background studies and measurement attempts. From there, we examined the usefulness of the current measure, examined RCL and conventional yard switching at the micro level, then calculated accident rates using an estimate of hours worked. Next, we presented and evaluated a number of alternative measures. From this, we derived the following general and specific conclusions and recommendations.

When noting yard switching operations in aggregate, using MYSM is not an inappropriate measure to judge overall safety in the railroad industry. However, as noted by the FRA, it is also TEI's belief that the difference in the methods of Yard Switching Operations performed by RCL and conventional yard crews, calls for and justifies the need for measurements that are specific to the safety of these types of operations. It is TEI's opinion that the use of "actual hours worked", as in Candidate Measure # 4, is the best metric available to understanding the differences in safety performance between RCL and conventional yard switching activity. This is because actual hours worked is a measure of actual operations and functions and is supported by data currently maintained by the railroads.

In both FRA's Interim Study dated May 2004 and the Final Report dated March 2006, the railroads provided Yard Switching Miles (YSM) as an exposure measure and did not furnish any data on actual hours worked or actual switching time specific to RCL and conventional yard switching assignments. However, the definition of Yard Switching Miles is "actual switching time" times 6 MPH. As noted above, it is known that some if not all railroads use "actual hours worked" rather than "actual switching time" in the calculation of YSM. Therefore, it is known that the railroads have both the knowledge of which yard switching assignments are either RCL or conventional and the actual hours worked.

TEI recommends that a new measurement specifically designed to compare the safety of RCL and conventional yard operations be constructed and added as a new section on all applicable "pre-set" reports generated using FRA's Office of Safety Analysis Web Site. This new measure should also include the Primary Causes (similar to those of Employee On-Duty Cases) for both RCL and conventional yard switching operations.

RECOMMENDATIONS

First, the FRA should define what type of switching activity should be considered for measurement i.e., yard switching, industrial switching, switching of shop tracks, switching of bad order, switching at intermodal facilities, yard transfer movements, etc. Hopefully this will reflect what is currently being included in Yard Switching Miles. Then clearly communicate these results to all involved parties.

Second, the FRA should define the Job Codes that are to be included for RCL and conventional operations. Potential codes for RCL operations are: 630 (Remote control Locomotive Operator – Operating) and 631 (Remote Control Locomotive Operator – Not Operating). Potential codes for "conventional operations": 614 (Yard Conductors and Yard Foremen), 615 (Yard Brakemen and Yard Helpers), 619 (Yard Engineers), and 623 (Yard Firemen and Helpers).

Third, the FRA should require railroads to report "Railroad Worker Hours" as defined above and grouped by RCL and conventional yard switching operations. The FRA should establish a standard of requiring "actual hours worked" to be reported.

Fourth, the FRA should modify form FRA F 6180.55 to include the recording of "Yard Switching Worker Hours – RCL operations" and "Yard Switching Worker Hours – conventional operations". Include these requirements in FRA's Guide for Preparing Accident/Incident Reports. The requirement for the reporting of current Railroad Worker Hours should remain unchanged.

Fifth, the FRA should modify the description for job codes 630 and 631 in FRA's Guide for Preparing Accident/Incident Reports to say "incident/injury" instead of the current "injury".

Sixth, the FRA should include a section for "Yard Switching Safety Performance", similar to "Employee On-Duty Cases", on all applicable "pre-set" reports generated using FRA's Office of Safety Analysis Web Site to compare the difference between RCL and conventional yard switching operations.

Seventh, the FRA should request that the STB add codes 630 and 631 for RCL operations as defined in FRA's Guide for Preparing Accident/Incident Reports to their Classification of Job Titles. This may provide a valid crosschecking method for yard switching hours reported.

Eighth and last, in our research we found variation in conclusions reach by various studies. This suggests that a longer time horizon with a greater amount of data and appropriate metrics are required to truly assess the safety record of RCL versus conventional switching operations.