METROLINK

Southern California Regional Rail Authority

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Methodology for Cost Apportionment for a Shared 220MHz RF Network in a Multi-railroad, Dense Traffic Area

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1.1	July 25, 2013	Revised based on Dr. Hartong's review comments

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Sponsorship of Report

This report has been prepared as a part of Grant No. FR-TEC-0004-11-01-00 issued by the Federal Railroad Administration (FRA) to the Southern California Regional Railroad Authority (SCRRA), a.k.a. Metrolink, under the Railroad Safety Technology Grant Program.

Focus of Report

This report will provide a methodology for determining an equitable distribution of costs for the development and long term maintenance of a 220MHz RF network for the handling of Positive Train Control (PTC) messaging in a multi-railroad, dense traffic area. This will be accomplished by examining the type of costs incurred by a typical host railroad in developing and maintaining its systems as a part of the regional radio frequency (RF) network and by examining alternate methods available to apportion costs among each of the host and tenant railroads that will operate under a common RF umbrella. Among the factors to be considered in making the assessment will be: spectrum contribution, shared wayside and base station assets, backhaul connectivity, message utilization, and annual licensing and maintenance costs.

The 220MHz radio network is intended to service the needs of the PTC systems being deployed concurrently by multiple railroads in accordance with the requirements of the Rail Safety Improvement Act (RSIA) of 2008, and the corresponding implementing rules issued by the Federal Railroad Administration (FRA). The methodologies examined herein are intended to assist railroad entities in developing their own PTC radio network cost apportionment strategies for multi-railroads in dense urban areas.

Though communications, and more specifically the 220MHz radio network, is the primary operationally shared asset related to PTC, there are other railroad owned assets that will need to be shared by the host railroad with all tenant users of the PTC system. These include, but are not limited to, back-office systems, back-haul networks, and wayside signaling and communications systems.

Format of the Report

This report follows a sequential process that can be used in performing the initial assessment for the costs of providing and maintaining a PTC system and then equitably distributing these costs among the system users of the shared infrastructure.

The reader is reminded that this report provides a roadmap for steps that can lead to a formal host/tenant agreement for identifying cost parameters and equitably proportioning the costs among the various users of the RF network. However, the methodology addressed herein is not the only possible cost sharing approach. Each operating area and group of user railroads will have its own unique set of conditions, requirements and

restrictions that will need to be factored in to the cost allocation process. These unique conditions can be driven by technical constraints, business necessities, or both. No one cost sharing approach will be applicable in all urban areas.

While this report attempts to provide actual costs incurred by Metrolink, many of the capital and license/maintenance costs for the RF network components are not currently available, or cannot be disclosed for purposes of business security. Therefore, the values used in the accompanying calculation worksheets are for illustration purposes only. Each user railroad will need to tailor the worksheets to meet their own needs and those of the other area railroads.

For additional information, a companion report titled, "Methodology for Initial Assessment of Spectrum Requirements and Required Numbers of Base Stations in a Multi-railroad, Dense Traffic Area," was issued September 10, 2012, providing a methodology for development of an RF network in a multi-railroad, urban environment.[1]

Background

In accordance with the requirements of the Rail Safety Improvement Act (RSIA) of 2008, passenger railroads and most freight railroads, shall install and have operational an interoperable Positive Train Control System (PTC) by no later than December 2015.

PTC is a predictive collision avoidance system that shall provide a first warning to train operators and then intervene and stop a train before a collision or other hazardous train movement can occur through use of an "integrated command, control, communications, and information system. The four (4) core requirements of a PTC System that it shall reliably and functionally prevent are:

- Train-to-train collisions
- Over speed derailment
- Incursions into established work zone limits
- Movement of a train through a main line switch in an improper position

In order to comply with the federal mandate for interoperability[2], the PTC system must be configured so that all trains can operate over trackage owned and operated by various host railroads. A key factor in assuring interoperability is development of a coordinated communications network where all operating railroads can reliably send and receive compatible PTC control and status messages over the single communication network,

[1] The Report titled "Methodology for Initial Assessment of Spectrum Requirements and Required Numbers of Base Stations in a Multi-railroad, Dense Traffic Area" examines the factors involved in apportioning cost sharing among the host and tenant railroads that will operate under the RF umbrella. Among the factors to be considered in making the apportionment will be spectrum contribution, shared base station assets, backhaul connectivity, message utilization, and maintenance.

[2] Interoperability as defined under 49 Code of Federal Regulations (CFR) Part 236.1003: Definitions as "the ability of a controlling locomotive to communicate with and respond to the PTC railroad's positive train control system, including uninterrupted movements over property boundaries".

parts of which were are constructed/operated by different railroads. The 220MHz RF communications system is structured to handle the four significant distributors and consumers of data traffic:

1. The on-board PTC equipment
2. The interface to the wayside signal equipment
3. The radio base stations including backhaul
4. The individual railroad back office systems

A core requirement for PTC to be interoperable is that all participating railroads in an area be able to communicate seamlessly between the on-board PTC system and the wayside signal system (this also requires seamless access to up-to-date geographic data bases and directives through the governing Back Office Server (BOS)).

This means that the interoperable communications network (which has been agreed to be the 220MHZ spectrum) needs to be designed to be seamless as a train from any participating railroad traverses the entire area, including when it transitions from one host railroad's territory to another host railroad's territory.

Spectrum is a finite resource which must be managed so that the PTC messages reach the intended train, and only the intended train. A significant portion of the design effort for PTC implementation is centered upon the establishment of criteria for PTC data handling. Much of this work is being undertaken by the Interoperable Train Control (ITC) committee. The ITC is an industry consortium of "Class I" railroads which are installing interoperable PTC systems and have developed the standards and principles of governance for interoperable PTC. However, additional significant effort by each host railroad is required to design, deliver and test the databases and communications networks that will process the message streams.

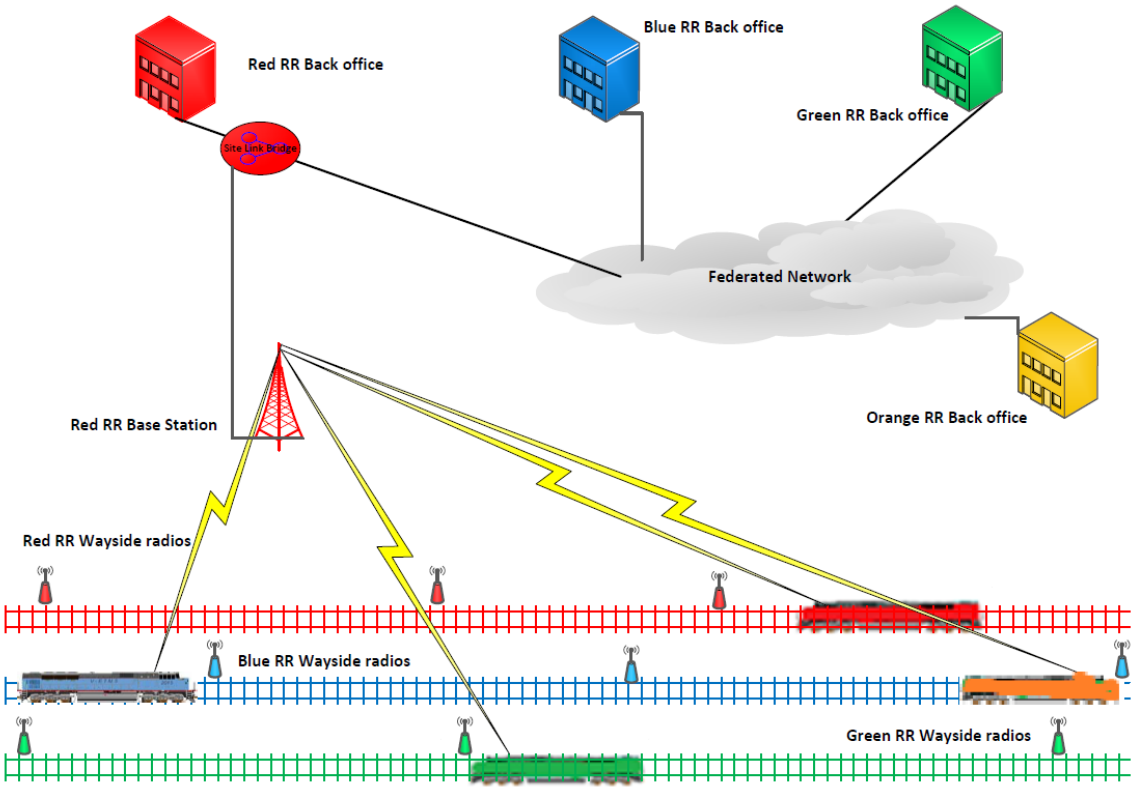
Organizational Relationships

The first step in approaching the assessment for cost sharing of an area wide PTC RF network is to identify the key participants in the process that will either share the cost, or generate the cost (such as cost associated with licensing fees). This includes the system development partners, each of the host railroads, and any 2nd tier PTC users and vendors. By this is meant identification of all railroad entities that are host railroads within the immediate RF coverage area and any other railroads that operate as tenants on one or more of these host railroad properties. Also to be identified are any organizations that have either direct ownership or control of potential assets and any entities that may exercise governance over the assets.

It should be noted that whereas the wayside interface units (WIUs) which process the wayside signaling and switch status information for transmission to the on-board system are owned and maintained by the host railroad, the PTC radio network itself may often transcend property boundaries. The base station(s) servicing all or part of a host railroad by transmitting PTC messaging between the back office and on-board systems may be

owned and maintained by an adjoining railroad. This overlapped coverage will need to be factored into the cost sharing allocation agreement. See Figure 1 below for a visual example of the shared network resources.

Figure 1: Shared Network Resources



In Figure 1 above, Green, Red and Blue are the owning (Host) railroads. Orange is a tenant operating on the Blue Railroad. The trains operating in this region are all communicating through Red Railroad's base station which carries the message traffic. Each train must communicate to the back office of the railroad that it is operating on and less frequently to the back office of the railroad which owns and operates the train. Each railroad's wayside radios in that region are also relaying messages to their respective back offices' through the Red Railroad's base station. Over-air message traffic, whether it is from a locomotive or wayside device, is routed via the Red Railroad base station to the appropriate back office. A federated network is utilized to route the traffic to and from the wayside devices and locomotives through base stations to the applicable back offices.

> ***Case Study #1:*** *In the case of the LA Basin Area, the three host railroads are SCRRA, Burlington Northern Santa Fe (BNSF) and Union Pacific Railroad (UPRR) that have mutual host/tenant relationships. A fourth railroad, San Diego's North County Transit District (NCTD), also owns and operates trackage in the Southern California*

area for commuter passenger service. However, NCTD is not on the same accelerated PTC implementation schedule as the other LA Basin area service providers so their network relationships will be factored into the area network allocation process at a time in the future when NCTD is closer to implementation.

Amtrak is a tenant on various portions of the trackage owned by either SCRRA, BNSF or UPRR. Though not a host railroad in Southern California, Amtrak's level of service was factored into the overall traffic density calculations when developing the RF requirements list for the area.

Other important participants in the area RF design process are PTC-220, LLC and MeteorComm LLC (MCC). PTC-220, LLC is an entity created by four of the major Class 1 railroads (BNSF, CSX, NS and UPRR) to manage shared spectrum consisting of eighteen frequency blocks in the 220MHz Bandwidth area. MCC, a designer/vendor wholly owned by the four (4) Class 1 railroads, was tasked with development, design and licensing of the 220MHz PTC compliant radios. MCC has established the protocols that will be used for over-the-air interoperable data messaging transmission between the on-board, wayside and base stations.[3]

Though not direct participants in the RF design process, it is important to factor the roles of the FRA and the Federal Communications Commission (FCC) into the development of RF network. The FRA holds governance over the final PTC deployment. SCRRA has chosen to engage the local and national FRA representatives throughout the RF design process to assure them that their statute requirements are being factored into the design. The FCC also holds governance over the final RF design and its statute requirements were factored into the design.

Finally, the secondary spectrum market was also an indirect participant in the RF design process. This part of the equation will be addressed in more detail when we explore the spectrum acquisition portion of the RF process.

Formal Agreement for RF Network Cost Sharing Among User Railroads

The railroad industry, through the Association of American Railroads (AAR) and American Railroad Engineering and Maintenance-of-Way Association (AREMA) have established a methodology for identifying and allocating cost for shared use of signaling systems. This methodology is captured in Parts 1.3.1 and 1.3.2 of the "American Railway Engineering and Maintenance-Of-Way Association (AREMA) Communications & Signals Manual of Recommended Practices for 2012".

This established methodology is a good starting place for quantifying costs and for allocating these costs across the PTC RF network user base.

[3] Alternate over-the-air messaging utilizing the ITC messaging protocol can be realized via Wi-Fi, commercial cellular or commercial satellite systems. However, the 220MHz band will be the primary message carrier for PTC data traffic.

Part 1.3.1: Recommended Joint Signal Facility Agreement, as the title indicates, is a listing of the elements that are recommended for inclusion in a formal cost allocation agreement between railroads. Though specifically targeted toward cost sharing for Signaling Systems, most of the elements included in this listing are equally applicable to developing a new agreement between railroads for allocating costs of a shared PTC RF network or for amending an existing agreement between railroads.

The following is a paraphrased rendering of the key elements in the Part 1.3.1 list, to structure a cost allocation agreement for a shared PTC RF network.

A recommended Joint Use PTC RF Network Agreement should:

1. Define clearly the limits of the joint facilities. Plans showing the shared use facilities should be a part of the agreement
2. Provide for division of costs for facilities used jointly, including those not in the agreement, such as pole line, etc.
3. Provide for revision as required to account for changes in physical, economic or operating conditions
4. Provide, as far as practicable, the basis and reasoning to be followed when revisions, major replacements or improvements are to be made.
5. Quantify the minimum quality of service and availability requirements
6. Include appropriate liability clauses
7. Include the right of each party to request the removal of unsatisfactory employees for good and sufficient cause
8. Clearly define maintenance and testing responsibilities
9. Provide for division of costs on a PTC communications unit, or other mutually agreed basis[4]. Refer to AREMA Communications and Signal (C&S) Manual Part 1.3.2 "Recommended Table of Signal and Interlocking Units and Interpretations" as an example of how units may be defined
10. Define wayside communications, base station, back office messaging and other work, and designate how both the capital and the operating costs of each shall be borne.
    - Designate as wayside communications material; PTC data radio(s), wayside message server, wayside interface unit, wayside antenna and antenna support structure, and the other wayside PTC related communications material used in the construction and maintenance of the wayside PTC installation, in addition to labor used to install and maintain such material.
    - Designate as base station material; PTC base station radio(s), router and communications appurtenances, and other communications material used in the construction and maintenance of the PTC RF system, in addition to labor used to install and maintain such material.

[4] Refer to Section **Basis for Identifying Utilization of Shared Assets** (page 8) for a discussion of using train-miles, train mile-tonnage or RF Messaging as a basis for establishing a railroad's cost of a shared RF asset.

- Designate as back office messaging material; PTC messaging server(s), router and communications appurtenances, and other communications material used in the construction and maintenance of the PTC back office messaging system, in addition to labor used to install and maintain such material.

11. Provide for different apportionment for construction, maintenance, operation and operating costs and should define these terms.
12. Divides construction, maintenance and operation costs on a fixed unit basis or may properly divide operating costs in a different manner.
13. Provide a uniform procedure to be followed in allowing credits for salvaged material and for making charges for used, repaired or reconditioned material. Agreement may include language such as:
    - Communications material removed from service for re-use should be salvaged at ___ percent of current new price, and when used again charged out at same percentage; communications material such as ____ or other electrical apparatus which must be repaired or rebuilt should be salvaged at ___ percent, and when used again after being repaired, charged out at ___ percent of current new price. These percentages may be varied with mutual approval of the parties.
14. Specify in detail the corporate ownership of the respective facilities involved. When physical changes (either additions, betterment's or retirements) affect ownership, the agreement should be amended to cover the changes.

Basis for Identifying Cost of PTC Infrastructure

As noted above, the railroads, through AAR and AREMA Part 1.3.2, have established a point system for quantifying the relative values of common signaling devices with the intent of using these values to assign user fees. No such cost assignment or allocation agreement has yet been established for railroad related communications systems. The line between communications and signaling devices has always been imprecise. Many railroads have a combined Communications and Signals departments, and indeed, the AREMA manual is the AREMA Communications and Signals Manual. In general, the transport medium is the purview of communications whereas the equipment which operates the train control system is the signal element. At a wayside installation, the WIU is clearly a signal device. An integrated WIU is often a single module within a controller chassis. The wayside status message then may travel to a Wayside Message Server (WMS) where it then may be relayed over a PTC radio, or in some cases, a cellular telephone or fiber optic line. The radio, cell connection and fiber optic systems are obviously communications devices. The WMS could arguably be considered either a signal device or a communications device. Since all are software driven devices and connected, the same technician may be responsible for diagnosing and configuring either of the three. The above list for the joint use PTC RF Network Agreement captures these items. Therefore, until the costs for PTC related RF and messaging systems can be better quantified on an industry wide basis, railroads which share an area wide network will need to negotiate the relative costs of developing and maintaining the network on a one-to-one basis.

The portions of the PTC infrastructure that may be subject to construction, operation and maintenance related cost sharing among the host and tenant users of the system consist of:

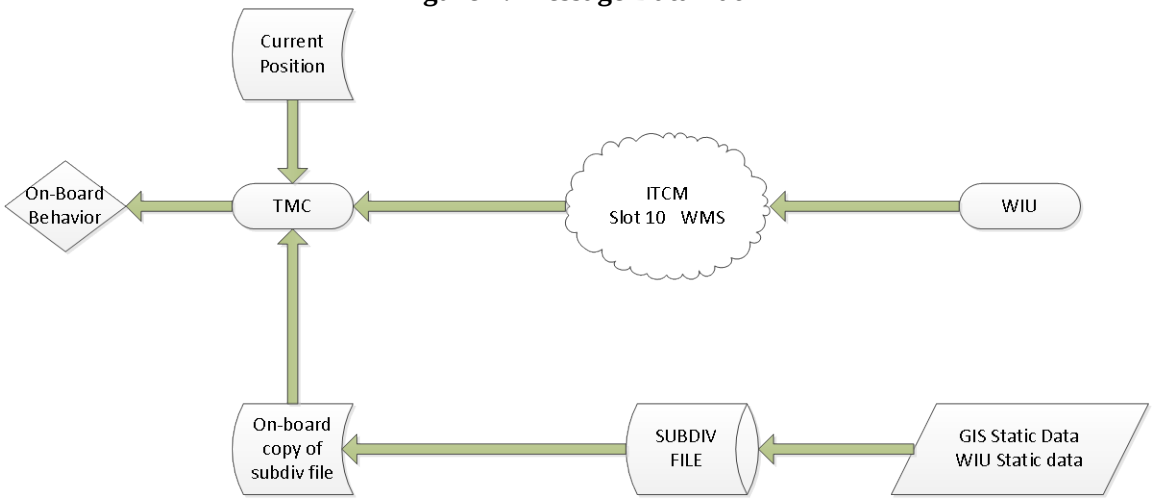
- Back office: including the BOS, Interoperable Train Control Messaging (ITCM) system, federated links[5] to other railroads, and PTC related upgrades to the computer-aided dispatch (CAD) system;
- Communications: including cost of spectrum acquisition or lease, and base station backhaul connections;
- Wayside locations: including wayside interface units (WIUs), wayside message servers (WMSs), wayside radios and antennas, and backhaul interconnections to the Operations Control Center; and,
- Licensing fees for radios and messaging software products.

There are additional costs associated with implementation of a PTC system, such as update of the various subsystem databases[6] that may be considered for inclusion into the calculation for shared cost components. In Figure 2 below, the data associated with the Subdiv file, including that pertaining to the wayside interface units (WIU) may be a candidate for cost sharing. Cost sharing may be relevant in areas of joint track, or where the need for PTC on a line segment is driven by a tenant.

[5] Federated links are the secure telecommunication connections between railroad operators within a shared network which route the message traffic to and from the wayside devices and locomotives through base stations to the applicable back offices. A group of users (nodes) connected together form a network. Each railroad has its own communications network. When the networks are connected together so that communications can take place between nodes of one network and the nodes or central server of another network, the networks are termed federated. The connection from a railroad office to the federated network is the federated link.

[6] There are a number of databases that must be maintained in order to assure the functionality of PTC. These databases include: geographic databases that capture the location and status of the wayside critical features such as switches, signals, clearance points, speed zone limits, highway-rail grade crossing boundaries, and track profile information. These data points are utilized to generate the subdivision descriptive SubDiv files; rolling stock parameter database is used to capture the weight, length, horsepower and other physical features of the locomotives and cab cars, plus the physical features of passenger coaches. This information is used to populate the consist message that is in turn used in determining a train's predictive braking performance; employee identification and PIN codes are used to verify that only qualified individuals can access the on-board system during the initialization process. The database for wayside signals also includes the unique addressing for each location, signal and switch status and signal enforcement groups.

Figure 2: Message Data Path



The capital costs associated with the initial design, procurement and installation of the joint use RF network may or may not be considered as a part of the shared cost depending upon the policies and funding sources of the individual railroads. This is especially true for commuter railroads where a portion of the capital cost may have been provided through local, state or federal grants. Detailed consideration of capital costs would involve issues such as ownership rights and funding sources that may be best left to a case-by-case agreement between railroads.

There are a number of non-shared infrastructure assets that are railroad specific costs and should, therefore, not be included in the calculation for shared cost components. Examples of these non-shared asset costs include: on-board PTC equipment; private cellular, satellite or wireless local area network (WLAN) services; and, business related applications tied into the CAD system.

Given the competitive nature of the railroad industry, it may not be possible to obtain a breakdown of construction, maintenance and licensing costs from all rail entities that fall under a shared RF network. In this instance, a bottom line cost for RF network maintenance and licensing may be the best that can be obtained.

> ***Case Study #2:*** *In the case of the Los Angeles Basin Area, each of the railroads are in the process of developing the PTC system components, and as stated above, no cost assignment or allocation agreement has yet been established for the operations, maintenance or other costs related to railroad related communications systems. One of the first substantial shared assets to be addressed is the radio spectrum. Since early 2010, SCRRA has been in the process of acquiring spectrum through the purchase spectrum from a seller on the secondary market. SCRRA entered into a contract and deposited funds in escrow for the purchase of one MHz of bandwidth (40 separate 25 KHz broadband channels) in the upper ATMS bands of spectrum at a price of approximately $7 million. It was assumed that this spectrum would be available to meet SCRRA's*

spectrum needs and would be made available to others as SCRRA's contribution to a shared "spectrum pool" for the LA Basin Area. As that spectrum acquisition has remained mired in years of legal challenges and a protracted FCC license process, SCRRA needed to pursue an alternative interim short term solution to meeting the agency's interim spectrum needs until the AMTS Band can be acquired, especially the more immediate radio spectrum needs to conduct PTC system testing.

In July 2012, SCRRA staff received Board approval to enter into a five-year lease with PTC 220 LLC for use of its spectrum. PTC 220 LLC is a spectrum holding company formed by the major freight railroads – BNSF, UPRR, NS and CSX – to support their spectrum needs for PTC. SCRRA was the first agency outside of the four partner railroads to utilize the corporation's spectrum, which consists of 18 broadband 25 KHz channels in the 220 to 222 MHz frequency range. The cost of the agreement was $250,000 (or $50,000 per year), based on fixed costs of $10,000 per year plus $39,000 for the agency's 24 base stations. These costs may be modified in the future depending on factors, such as accounting for SCRRA's contribution to the spectrum pool once its AMTS spectrum acquisition is complete. As stated previously, other costs related to PTC governance and maintenance of the spectrum are not available at this time.

Basis for Identifying Utilization of Shared Assets

Most railroads currently operating in a high density, multi-railroad area already have operating agreements in place with their neighbor host/tenant railroads for cost sharing of track and signaling assets. These costs are typically quantified and distributed in accordance with the provisions of AREMA Parts 1.3.1 and 1.3.2. It is reasonable to expect that any sharing of PTC asset costs would follow this established track and signaling model.

There are two main options in determining the distribution of agreed shared asset costs. These are either based upon train-mile-tonnage or on train miles. In either instance, each host railroad is responsible for recording and quantifying its own utilization and that of each tenant railroad for the given time period. However, each railroad that is a tenant on another railroad's property will want to independently track its own utilization metric when on the other railroad(s) just as a crosscheck of the host railroad's calculations. A typical time period being used for measuring utilization is the calendar month. Of these two utilization measurement methods, the opinion of the author is that the train-mile basis is a better metric for determining relative PTC RF utilization than the train-mile-tonnage metric.

The designer of the RF radio being used in many of the PTC systems currently being implemented has indicated that there will be a method of automatically capturing the actual levels of messaging traffic between specific locomotives and wayside, base stations and back offices. This message traffic measurement information could be mined

to provide a per-railroad messaging utilization report that would provide an accurate breakdown for determining proportional utilization of the RF network. Unfortunately much of the messaging traffic measurement information related to data gathering is still in the developmental stage and/or is covered by various non-disclosure agreements[7]. Therefore, the messaging traffic measurement methodology for quantifying cost sharing is not being pursued further for the purposes of this Report.

RF Cost and Utilization Calculator

A companion to this report is a workbook calculator that systematically organizes the railroad specific costs for the maintenance and licensing of the RF network components and then distributes these costs on a train-mile utilization basis.

The PTC RF Messaging Cost Allocation Calculator[8] is based upon having up to five (5) railroads operating in various host/tenant relationships under the same RF umbrella. If a railroad chooses to utilize the worksheet, it will likely need to modify the Calculator to accommodate the specific area requirements.

The Calculator consists of four (4) worksheets:

1. ***Mileage Breakdown:*** this is a breakdown of the actual train miles traveled by each user railroad on each of its own subdivisions and on each subdivision for which it is a tenant. The mileage information is typically available as a report generated from the host railroad's CAD system.

(See Figure 3 on next page)

[7] Anyone currently involved in the design, procurement or implementation of a PTC system will be required to enter into a number of non-disclosure agreements. These agreements are in place for both protection of business interests and operation security. NDAs will typically be required between: designer of the 220MHz radio and the railroad/customer; the railroad and its contractor/vendor; the railroad and its engineering service provider; the railroad and its tenant/host railroads; the railroad and the PTC220,LLC;

[8] The RF Messaging Cost Allocation Calculator was created using Microsoft Excel 2010, version 14.0.6129.5(32 bit). The Cost Allocation Calculator may be available by contacting the FRA's Office of Research and Development.

Figure 3: Mileage Breakdown

Usage During August 2012

RR	SUBDIVISION	Route Miles	Monthly Train Miles of Each Tenant Railroad						Total Miles per Sub.
			RR-A	RR-B	RR-C	RR-D	RR-E		
RR-A	SubA1	73	16,656		4,192				20,848
	SubA2	36	14,599	5,688	13,430				33,717
	SubA3	11	6,825		20		1,650		8,495
	SubA4	55	60,555		317				60,872
	SubA5	42	48,342		2,898		12,600		63,840
	SubA6	6	2,430		414				2,844
	SubA7	2	138	276					414
RR-B	SubB1	23	1,587						1,587
	SubB2	54	26,082						26,082
RR-C	SubC1	66	22,970						22,970
RR-D	SubD1	20	9,640	750	1,500	12,000	3,000		26,890
	SubD2	40	-	2,000	4,000	24,000	8,000		38,000
	SubD3	30	-	1,500	3,000	18,000	6,000		28,500
RR-E	Tenant Only	0	-						-

PTC RF Messaging Cost Allocation Calculator Mileage Breakdown

2. ***Cost Railroad-A Worksheet***: this is a tabulation of the monthly cost for the various PTC RF related costs that are covered in the Cost Sharing Agreement between railroads.

Figure 4: Cost Railroad-A Worksheet

PTC Related Costs for Railroad A

Cost Item	Annual Cost	Monthly Cost
Annual Maintenance Budget for Wayside PTC	$ 1,200,000	$ 100,000
Annual Unit Cost for Wayside Radio/WMS Licenses & Warranties	$ 900	$ 75
Annual Maint. Budget for PTC Basestation Locations	$ 600,000	$ 50,000
Annual Unit Cost for Base Station Radio Licenses & Warranties	$ 6,000	$ 500
Annual Cost of Back Office Maint. Support Services Cost	$ 1,200,000	$ 100,000
Annual Cost of Back Office PTC Licenses	$ 300,000	$ 25,000
Annual Cost of Spectrum Lease	$ 60,000	$ 5,000
[Insert Additional Cost Items, Carry-over to "Cost per RR-A Sub"]		$ -

COSTS SHOWN ABOVE ARE EXAMPLES USED FOR POPULATING THE SPREADSHEET AND DO NOT REFLECT ACTUAL COSTS THAT MAY BE APPLIED TO ANY GIVEN RAILROAD.

PTC RF Messaging Cost Allocation Calculator Cost RR-A Worksheet

The Additional Cost Items noted on Figure 4 may include an allocation of system development (i.e. in-house engineering) costs and/or procurement and construction costs. These capital related costs will need to be amortized on an annual basis over the useful life of the component and further divided on a calculated monthly cost for insertion into the Calculator.

3. ***Cost per Railroad-A Subdivision***: this is a breakdown of the monthly costs captured in the "Cost Railroad-A Worksheet" and distributed on a subdivision specific basis (for items such as wayside radio costs) or on a percentage bases (for items such as back office costs).

Figure 5: Cost per Railroad-A Subdivision

Railroad A

		Total Monthly System Cost Where Applicable	*SubA1*	*SubA2*	*SubA3*	*SubA4*	*SubA5*	*SubA6*	*SubA7*	*Totals*
	Sub Total Route Miles		73	36	11	55	42	6	2	225
	% of Total Route Miles		32.4%	16.0%	4.9%	24.4%	18.7%	2.7%	0.9%	1.00
Monthly Per Subdivision Costs										
	Wayside Maint Budget/Mo.	$ 100,000.00	$ 32,444.44	$ 16,000.00	$ 4,888.89	$ 24,444.44	$ 18,666.67	$ 2,666.67	$ 888.89	$ 100,000.00
	Wayside Equip License Fee	$ 12,900.00	$ 3,525.00	$ 1,800.00	$ 1,650.00	$ 3,000.00	$ 2,625.00	$ 225.00	$ 75.00	$ 12,900.00
	Basestation Maint Budget/Mo	$ 50,000.00	$ 16,222.22	$ 8,000.00	$ 2,444.44	$ 12,222.22	$ 9,333.33	$ 1,333.33	$ 444.44	$ 50,000.00
	Basestation Radio License Fee	$ 11,000.00	$ 3,568.89	$ 1,760.00	$ 537.78	$ 2,688.89	$ 2,053.33	$ 293.33	$ 97.78	$ 11,000.00
	Back Office Maint Budget/Mo.	$ 100,000.00	$ 32,444.44	$ 16,000.00	$ 4,888.89	$ 24,444.44	$ 18,666.67	$ 2,666.67	$ 888.89	$ 100,000.00
	BOS/ITCM License Fee	$ 25,000.00	$ 8,111.11	$ 4,000.00	$ 1,222.22	$ 6,111.11	$ 4,666.67	$ 666.67	$ 222.22	$ 25,000.00
	Spectrum Cost	$ 5,000.00	$ 1,622.22	$ 800.00	$ 244.44	$ 1,222.22	$ 933.33	$ 133.33	$ 44.44	$ 5,000.00
	[Insert Additional Cost Items from "Cost RR-A Worksheet"]	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Monthly cost of PTC per Sub	$ 303,900.00	$ 97,938.33	$ 48,360.00	$ 15,876.67	$ 74,133.33	$ 56,945.00	$ 7,985.00	$ 2,661.67	$ 303,900.00
	Wayside Radio/WMS per Sub	172	47	24	22	40	35	3	1	

COSTS AND QUANTITIES SHOWN ABOVE ARE EXAMPLES USED FOR POPULATING THE SPREADSHEET AND DO NOT REFLECT ACTUAL COSTS THAT MAY BE APPLIED TO ANY GIVEN RAILROAD.

PTC RF Messaging Cost Allocation Calculator Cost per RR-A Subdivision

4. ***Cost Mileage Basis***: this is a breakdown of the host railroad's costs and each of the tenant railroad' costs based upon the train-mile distribution captured in the "Mileage Breakdown" worksheet.

Figure 6: Cost Mileage Basis

Distribution of RF Costs

Railroad A

	SubA1	SubA2	SubA3	SubA4	SubA5	SubA6	SubA7		Totals
Sub Total Route Miles	73	36	11	55	42	6	2		225
% of Total Route Miles	32.4%	16.0%	4.9%	24.4%	18.7%	2.7%	0.9%		1.00
Train Miles RR-A	16,656	14,599	6,825	60,555	48,342	2,430	138		149,545
Train Miles RR-B	-	5,688	-	-	-	-	276		5,964
Train Miles RR-C	4,192	13,430	20	317	2,898	414	-		21,271
Train Miles RR-D	-	-	-	-	-	-	-		-
Train Miles RR-E	-	-	1,650	-	12,600	-	-		14,250
Total Train Miles/Sub	20,848	33,717	8,495	60,872	63,840	2,844	414		191,030
% Train Miles RR-A	79.9%	43.3%	80.3%	99.5%	75.7%	85.4%	33.3%		
% Train Miles RR-B	0.0%	16.9%	0.0%	0.0%	0.0%	0.0%	66.7%		
% Train Miles RR-C	20.1%	39.8%	0.2%	0.5%	4.5%	14.6%	0.0%		
% Train Miles RR-D	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
% Train Miles RR-E	0.0%	0.0%	19.4%	0.0%	19.7%	0.0%	0.0%		
Cost per Subdivision	$ 97,938.33	$ 48,360.00	$ 15,876.67	$ 74,133.33	$ 56,945.00	$ 7,985.00	$ 2,661.67		$ 303,900.00
Cost Split RR-A	$ 78,245.44	$ 20,939.22	$ 12,755.53	$ 73,747.27	$ 43,120.85	$ 6,822.63	$ 887.22		$ 236,518.16
Cost Split RR-B	$ -	$ 8,158.25	$ -	$ -	$ -	$ -	$ 1,774.44		$ 9,932.69
Cost Split RR-C	$ 19,692.90	$ 19,262.53	$ 37.38	$ 386.06	$ 2,585.00	$ 1,162.37	$ -		$ 43,126.24
Cost Split RR-D	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -
Cost Split RR-E	$ -	$ -	$ 3,083.76	$ -	$ 11,239.14	$ -	$ -		$ 14,322.90
							Total =		$ 303,900.00

PTC RF Messaging Cost Allocation Calculator Cost Mileage Basis

Conclusion

The development and deployment of PTC among the national railroad network is still a work in progress and to-date, the technical challenges have captured most of the attention. However, eventually the commercial issues, such as cost allocation of shared assets will be addressed in the national forum as was done for the cost allocation for track and signaling. It is expected that cost allocation for the shared PTC RF and messaging systems will follow the precedents established for railroad signaling.