POSITIVE TRAIN CONTROL (PTC) RADIO SPECTRUM PLANNING FOR PASSENGER COMMUTER RAIL OPERATORS IN THE UNITED STATES

Prepared for:

American Public Transportation Association

Federal Transit Administration

Final Report, Revision 1

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SPECIAL NOTE: This report **IS NOT** an official publication of the Transit Cooperative Research Program, Transportation Research Board, National Research Council, or The National Academies.

Acknowledgements

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Disclaimer

The opinions and conclusions expressed or implied are those of the research agency that performed the research and are not necessarily those of the Transportation Research Board or its sponsoring agencies. This report has not been reviewed or accepted by the Transportation Research Board Executive Committee or the Governing Board of the National Research Council.

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Abbreviations

AAR	Association of American Railroads
ACSES	Advanced Civil Speed Enforcement System
AGL	Above Ground Level
AMTS	Automated Maritime Telecommunications System
APTA	American Public Transportation Association
BEA	Bureau of Economic Analysis
CEA	Component Economic Area
CFR	Code of Federal Regulations
CMA	Cellular Market Area
DOC	Department of Commerce
EA	Economic Area
ETMS	Electronic Train Management System
FCC	Federal Communications Commission
FIPS	Federal Information Processing Standard
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GAO	Government Accountability Office
GPS	Global Positioning System
I-ETMS	Interoperable – Electronic Train Management System
ITC	Interoperable Train Control
ITCS	Incremental Train Control System
ITM	Irregular Terrain Model
IVDS	Interactive Video Data Services
PTC	Positive Train Control
RF	Radio Frequency
RSIA	Rail Safety Improvement Act
SDR	Software Defined Radio
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
US	United States
USA	United States of America

REVISION HISTORY

Revision No.	Date	Description	Author
0	10/17/11	Draft Submittal	KW
1	11/18/11	Final Submittal (Addressed Review Panel Comments)	KW

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1.0 SUMMARY OF FINDINGS

This section provides a brief summary of findings from this study. For a description of the scope and methodology used to develop these findings, see Sections 2.0 through 5.0 and the Appendices of this report.

1.1 PURPOSE OF REPORT

The purpose of this report is to provide an assessment of the spectrum needed within the identified commuter rail corridors to implement Positive Train Control (PTC) systems and provide data for planning and acquisition of suitable spectrum for PTC systems. The results contained herein are preliminary in the sense that the data provided is not based on a final design, but rather on a conceptual design to develop a conservative estimate of the amount of spectrum that could be deployed based on industry standard RF engineering frequency re-use principals and RF specifications provided by the manufacturer of the radio equipment. From this analysis, an order of magnitude of PTC spectrum needed for each commuter rail operator was established.

Should the quantity of spectrum indicated in this study be applied to each passenger rail corridor, the PTC spectrum needs of each commuter rail operator would be accommodated. While this study used the ITC radio technology to develop a PTC spectrum estimate, this assumption was not intended in any way to specify what technology can be used or limit the use of other radio technologies.

1.2 ECONOMIC AREA FINDINGS

The following table lists each commuter rail entity and the associated Economic Area (EA). See Appendices for a detailed listing of EAs in which commuter rail lines are located. In total 19 out of 172 economic areas (11%) need spectrum for PTC applications.

Table 1 - Economic Area Listing

Item	State	Agency	1995 EA Code
1	NY	MTA Long Island Rail Road (MTA LIRR)	10
2	NJ	New Jersey Transit Corporation (NJ TRANSIT)	10
3	NY	Metro-North Commuter Railroad Company, dba: MTA Metro-North Railroad (MTA-MNCR)	10
4	IL	Northeast Illinois Regional Commuter Railroad Corporation (Metra)	64
5	MA	Massachusetts Bay Transportation Authority (MBTA)	3
6	PA	Southeastern Pennsylvania Transportation Authority (SEPTA)	12
7	CA	Southern California Regional Rail Authority (Metrolink)	160
8	CA	Peninsula Corridor Joint Powers Board (PCJPB)	163
9	MD	Maryland Transit Administration (MTA) - Brunswick and Camden Lines Only	13
10	FL	South Florida Regional Transportation Authority (TRI-Rail)	31
11	IN	Northern Indiana Commuter Transportation District (NICTD)	64 & 65
12	VA	Virginia Railway Express (VRE)	13
13	WA	Central Puget Sound Regional Transit Authority (ST)	170
14	TX	Dallas Area Rapid Transit (DART) (TRE LINE)	127

Item	State	Agency	1995 EA Code
15	CA	North County Transit District (NCTD)	161
16	UT	Utah Transit Authority (UTA)	152
17	TX	Fort Worth Transportation Authority (The T) [Planned Cottonbelt line]	127
18	NM	Rio Metro Regional Transit District (RTD) (NM Rail Runner Express)	156
19	CA	Altamont Commuter Express (ACE)	163
20	CT	Connecticut Department of Transportation (CDOT) (East shore line)	10
21	PA	Pennsylvania Department of Transportation (PENNDOT)	12
22	ME	Northern New England Passenger Rail Authority (NNEPRA)	2 & 3
23	TN	Regional Transportation Authority (RTA)	71
24	OR	Tri-County Metropolitan Transportation District of Oregon (TriMet)	167
25	MN	Metro Transit	107
26	AK	Alaska Railroad Corporation (ARRC) [PTC Not Required]	171
27	TX	Denton County Transit Authority (DCTA)	127

1.3 PTC SPECTRUM NEEDS SUMMARY

The following table aggregates the PTC spectrum needed within each EA and represents the total quantity of spectrum anticipated for all passenger rail agencies/operators with trackage or operations within the EA (or multiple EAs), based on the general assumptions listed in Section 2.0 and the technical assumptions listed in Section 5.0. See Appendix A for additional detail.

A key assumption used for the purposes of estimating spectrum (see Section 2.7), was that all commuter rail lines were modeled using the ITC 220 MHz technology and the associate RF parameters. However, we were informed by Amtrak that several of the commuter rail lines listed above are operated by Amtrak and will be using a technology called Advanced Civil Speed Enforcement System (ACSES) for their PTC deployments. See Appendix E for information regarding their deployment plans. The use of ACSES rather than ITC technology will affect the spectrum needs within those economic areas in which these Amtrak rail lines operate. As indicated in Section 1.5 below, further analysis is suggested to refine the spectrum needs base on the RF parameters associated with ACSES.

Table 2 – PTC Spectrum Needs by Economic Area

Item	1995 EA Code	Total Spectrum (kHz)
1	2	140
2	3	660
3	10	1,825
4	12	1,025
5	13	800
6	31	325
7	64	740
8	65	210
9	71	250
10	107	275

Item	1995 EA Code	Total Spectrum (kHz)
11	127	825
12	152	300
13	156	375
14	160	500
15	161	325
16	163	675
17	167	250
18	170	425
19	171	425

1.4 KEY FINDINGS

The following are the key findings from this study.

- Deployment of PTC system in the USA is located within 19 economic areas out of a total of 172. See Section 3.0 for additional detail. Accordingly, initiatives to find or obtain spectrum for PTC purposes can be focused within these areas.
- As indicated in the following table, the 218-219 MHz band (formerly IVDS band) appears to have adequate quantities of spectrum that could be used for PTC applications. See Appendices and Section 5.0 for additional detail. It is noted that waiver of existing FCC service rules (e.g. power and antenna elevation) may be needed in order for licenses to be issued for PTC use.

Table 3 - 218-218 Service Spectrum Block Availability

Item	1995 EA Code	Total Available in EA (kHz)	Total EA Spectrum Need (kHz)	Net EA Available (Avail - Needed)
1	2	4,000	140	3,860
2	3	12,000	660	11,340
3	10	25,000	1,825	23,175
4	12	6,000	1,025	4,975
5	13	12,000	800	11,200
6	31	5,500	325	5,175
7	64	10,500	740	9,760
8	65	6,000	210	5,790
9	71	11,000	250	10,750
10	107	6,907	275	6,632
11	127	18,000	825	17,175
12	152	8,000	300	7,700
13	156	5,000	375	4,625
14	160	6,000	500	5,500
15	161	1,000	325	675
16	163	12,000	675	11,325
17	167	8,000	250	7,750
18	170	7,000	425	6,575
19	171	4,000	425	3,575

1.5 RECOMMENDATIONS FOR FURTHER STUDY

This study is preliminary and conceptual; therefore the following recommendations for additional study are suggested, but not limited to the following.

- For those rail corridors that will not be using ITC technology, the spectrum estimate should be refined based on the actual technology deployed.
- Assess the PTC spectrum needs of the National Amtrak rail network where applicable.
- As PTC radio technology is new and developing, suggest frequency coordination models be studied that would be best suited to PTC applications.
- It is recommended that where commuter rail operations substantially overlap (typically in dense urban areas) within a given corridor/area/region that additional coordinated re-use analysis be performed between operators to optimize the use of spectrum.

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2.0 INTRODUCTION

2.1 BACKGROUND

The Rail Safety Improvement Act (RSIA) of 2008[1] enacted by congress required that freight and commuter rail passenger operators in the continental USA implement PTC systems to prevent train related accidents and improve rail safety by December 31, 2015. Positive Train Control is a term of the industry intended to encapsulate various train control concepts, such as enforcing "positive" separation between trains and operation within authorized speed limits. The FRA in response to the RSIA issued specific regulations in [2]49 CFR, § 236.1005 (and other sections) in 2010 that PTC systems specifically provide the following functions:

- Prevention of Train-to Train Collisions.
- Prevention of over speed derailments (e.g., speed limit enforcement).
- Prevention of incursion into established work zone limits without proper authority. This is intended to provide improved protection for wayside and track workers.
- Prevention of movement across misaligned switches.

PTC systems being developed use GPS and/or fixed transponder-based train tracking technology and mobile data radio communications to verify the movement authority given to the a train, the current location of the train, the status of the next signal and the position of switches.

As a mobile data radio system is an integral component of most of the planned PTC implementations, suitable radio spectrum is required to implement PTC systems. In anticipation of complying with the FRA regulations, the Class 1 freight railroads have acquired spectrum in the 220 MHz band (defined as 220 to 222 MHz) for PTC use throughout their nationwide rail networks. The Class 1 railroads have also begun the development of communications and messaging protocols for their use and for interoperability with other freight railroads and with commuter/passenger railroads where tracks are shared. The 220 MHz band was selected primarily for two general reasons:

- It has favorable propagation characteristic to cover large areas.
- Channels were available for purchase on a nation-wide basis.

To allow other spectrum adjacent to the 220 – 222 MHz band to also be used, mobile data radio equipment is being developed that operates in a wider frequency range. This range has been specified by the freight railroads to be 217.6125 MHz to 221.9875 MHz.

On June 9th, 2010, the FCC issued Auction Notice Number 89 for spectrum between 218 and 219 MHz[3]. Auction 89 was scheduled for Dec. 7th 2010, but was suspended by the FCC[4] based on feedback from the industry and to allow time for the issue to be studied. This spectrum band is within the frequency range of the mobile data radio equipment being developed for PTC applications. As this spectrum band has not been fully utilized since its creation, spectrum within this band is available in many economic areas of the US. Refer to Section 5.0 for analysis details.

[1] See 9 U.S.C § 20157
[2] FRA final rule 49 CFR Parts 229, 234, 235 and 236 Docket No. FRA-2008-0132, Notice No. 3 issued March, 2010.
[3] FCC AU Docket 10-107; DA 10-849, Federal Register Vol. 75, No. 110, June 9, 2010
[4] FCC Public Notice DA 10-1630 dated 8/26/2010, AU Docket No. 10-107

2.2 OBJECTIVE

The following is the stated objective for this study:

"Assess the spectrum needs for implementation of PTC systems by commuter rail providers and providing useful analysis, and the development of spectrum options."[5]

2.3 SCOPE OF STUDY

2.3.1 Task Description

The following are the stated Tasks that define the scope of this study:

1. Research, identify and define commuter rail corridors to be studied.
2. Correlate study corridors identified with Economic Areas as defined by the FCC
3. Collect prior relevant traffic studies and train control studies that may have been performed previously in particular corridors.
4. Research appropriate radio protocols, technology and develop RF analysis metrics, such as frequency re-use criteria.
5. Coordinate activities with freight railroads and the American Association of Railroads as needed.
6. Search the FCC database for available and suitable spectrum between 217 and 222 MHz in the identified corridors.
7. Perform conceptual frequency re-use analysis to estimate the quantity of spectrum needed in each commuter rail corridor.
8. Prepare a draft report describing and summarizing all research, analysis and developing spectrum options for implementation of PTC radio base systems.
9. Prepare a revised report and response to panel comments on the draft report.

2.3.2 Commuter Rail Corridors Studied

The following table lists the US commuter rail operators considered in this study.

Table 4 - US Commuter Rail Operators[6]

Item	State	Agency	City	UZA Name	Mode
1	NY	MTA Long Island Rail Road(MTA LIRR)	Jamaica	New York-Newark, NY-NJ-CT	CR
2	NJ	New Jersey Transit Corporation(NJ TRANSIT)	Newark	New York-Newark, NY-NJ-CT	CR
3	NY	Metro-North Commuter Railroad Company, dba: MTA Metro-North Railroad(MTA-MNCR)	New York	New York-Newark, NY-NJ-CT	CR
4	IL	Northeast Illinois Regional Commuter Railroad Corporation(Metra)	Chicago	Chicago, IL-IN	CR
5	MA	Massachusetts Bay Transportation Authority(MBTA)	Boston	Boston, MA-NH-RI	CR
6	PA	Southeastern Pennsylvania Transportation Authority(SEPTA)	Philadelphia	Philadelphia, PA-NJ-DE-MD	CR
7	CA	Southern California Regional Rail Authority(Metrolink)	Los Angeles	Los Angeles-Long Beach-Santa Ana, CA	CR

[5] TCRP Project J6-079, Attachment A Scope of Work dated 6/2/2011
[6] APTA 2011 Fact Book, Appendix B

Item	State	Agency	City	UZA Name	Mode
8	CA	Peninsula Corridor Joint Powers Board(PCJPB)	San Carlos	San Francisco-Oakland, CA	CR
9	MD	Maryland Transit Administration(MTA)	Baltimore	Baltimore, MD	CR
10	FL	South Florida Regional Transportation Authority(TRI-Rail)	Pompano Beach	Miami, FL	CR
11	IN	Northern Indiana Commuter Transportation District(NICTD)	Chesterton	Chicago, IL-IN	CR
12	VA	Virginia Railway Express(VRE)	Alexandria	Washington, DC-VA-MD	CR
13	WA	Central Puget Sound Regional Transit Authority(ST)	Seattle	Seattle, WA	CR
14	TX	Dallas Area Rapid Transit(DART)	Dallas	Dallas-Fort Worth-Arlington, TX	CR
15	CA	North County Transit District(NCTD)	Oceanside	San Diego, CA	CR
16	UT	Utah Transit Authority(UTA)	Salt Lake City	Salt Lake City, UT	CR
17	TX	Fort Worth Transportation Authority(The T)	Fort Worth	Dallas-Fort Worth-Arlington, TX	CR
18	NM	Rio Metro Regional Transit District(RMRTD)	Albuquerque	Albuquerque, NM	CR
19	CA	Altamont Commuter Express(ACE)	Stockton	Stockton, CA	CR
20	CT	Connecticut Department of Transportation(CDOT)	Newington	Hartford, CT	CR
21	PA	Pennsylvania Department of Transportation(PENNDOT)	Harrisburg	Philadelphia, PA-NJ-DE-MD	CR
22	ME	Northern New England Passenger Rail Authority(NNEPRA)	Portland	Boston, MA-NH-RI	CR
23	TN	Regional Transportation Authority(RTA)	Nashville	Nashville-Davidson, TN	CR
24	OR	Tri-County Metropolitan Transportation District of Oregon(TriMet)	Portland	Portland, OR-WA	CR
25	MN	Metro Transit	Minneapolis	Minneapolis-St. Paul, MN	CR
26	AK	Alaska Railroad Corporation(ARRC)	Anchorage	Anchorage, AK	AR
27	TX	Denton County Transit Authority (DCTA)	Lewisville	Not yet assigned	CR

2.4 PURPOSE OF REPORT

The purpose of this report is to provide an assessment of the spectrum needed within the identified commuter rail corridors to implement Positive Train Control (PTC) systems and provide data for planning and acquisition of suitable spectrum for PTC systems. The results contained herein are preliminary in the sense that the data provided is not based on a final design, but rather on a conceptual design to develop a conservative estimate of the amount of spectrum that could be deployed based on industry standard RF engineering frequency re-use principals and RF specifications provided by the manufacturer of the radio equipment. From this analysis, an order of magnitude of PTC spectrum needed for each commuter rail operator was established.

Should the quantity of spectrum indicated in this study be applied to each passenger rail corridor, the PTC spectrum needs of each commuter rail operator would be accommodated. While this study used the ITC radio technology to develop a PTC spectrum estimate, this

assumption was not intended in any way to dictate what technology can be used or limit the use of other radio technologies.

2.5 REPORT ORGANIZATION

The report is organized into sections by topic for convenience and clarity as follows:

- Introduction
- Economic Area Analysis
- Review of Prior Studies and PTC technology survey
- Spectrum Analysis
- Appendices
- Addenda

2.6 COORDINATION OF ACTIVITIES

To ensure the approach used to develop this study is coordinated with the industry, the following organizations were contacted and their suggestions and feedback considered as needed. Their efforts towards the development of this study are appreciated and thank them for their efforts.

2.6.1 Association of American Railroads

Representatives from the Association of American Railroads (AAR) were contacted and advised regarding the scope of this study. Their request was that they would appreciate a briefing to the Wireless Communications Committee (WCC) at a future meeting to be scheduled following substantial completion of the study. A briefing date is to be determined.

2.6.2 Freight Railroads

The Class 1 railroads created a new company called PTC-220, LLC in 2008 with the primary purpose of acquiring spectrum in the 220 – 222 MHZ band nationwide and managing the use of that spectrum amongst the freight railroads. The chair of the PTC-220 spectrum use committee was contacted and the scope of this study discussed. The technical approach used in this study was also discussed and validated.

Additionally, Meteorcomm LLC, a wholly owned subsidiary by the Class 1 railroads was contacted via a non-disclosure agreement to obtain technical data used for frequency analysis performed[7].

2.6.3 Interoperable Train Control Committee

The Class 1 freight railroads formed an organization in 2008 called the Interoperable Train Control (ITC) committee with the purpose of developing hardware and software standards for PTC applications for use primarily by freight operators. The ITC is organized into various sub-committees and technical teams, one of which is the communications team which handles among other things, wireless/radio issues including the development of data radios by Meteorcomm LLC compatible with the 220 MHz spectrum acquired. Meteorcomm was contacted to obtain technical data regarding their product for the purposes of defining various metrics and parameters used for modeling radio coverage and frequency re-use.

[7] PTC-220 Network Design Principals dated 5/10/2011

2.6.4 The Joint Council on Transit Wireless Communications

To assist in the development of this study, the Joint Council was contacted to coordinate the development of general assumptions and advise the commuter rail members regarding status and scope of this study.

2.6.5 APTA

To assist in the development of this study, APTA was contacted to obtain commuter rail corridor information regarding the limits of service and validate track alignment data obtained from the FRA.

APTA also organized a meeting with the FCC to obtain their feedback on the approach used for this study and discuss preliminary results. This meeting was held on September 7, 2011 under Ex Parte rules at FCC offices[8].

2.7 GENERAL ASSUMPTIONS

The following constraints and general assumptions were used for this study.

- The PTC spectrum needs for freight rail corridors is addressed separately by others and not estimated in this study.
- The Amtrak inter-city passenger rail network was not considered in this study.
- All commuter rail corridors would use technology similar to the PTC SDR radio being developed by the freight ITC committee. While this may not be the case for some commuter rail operators, it was assumed for the purposes of developing a preliminary spectrum estimate.
- Only spectrum in the 217 – 222 MHz range was considered in this study.
- Each commuter rail corridor was specifically defined per published agency rail system maps which indicate the rail lines they operate. Rail systems maps were obtained from agency websites or via agency staff.

[8] Ex Parte filling dated 9/13/2011 by Alan S. Tilles, Esquire available from the FCC's website.

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3.0 ECONOMIC AREA ANALYSIS

3.1 BACKGROUND

The term Economic Area (EA) is defined by the US Department of Commerce (DOC) and the Bureau of Economic Analysis using census data of individual and business income and statistically aggregated into geographic areas and regions. These areas are based on existing county boundaries (or groups of counties), drawn on a map and assigned a number from 1 to 172. Economic output of the US is tracked within these areas and then aggregated nationally to calculate the Gross Domestic Product of the USA.

The FCC uses this EA definition for auctions of spectrum to define spectrum pricing and other items. As this study seeks to suggest spectrum option for PTC, we present those options and spectrum estimates within the EA construct used by the FCC for those options. Accordingly this study presents the commuter rail spectrum needs within economic area boundaries.

3.2 APPROACH

The maps included in this study were developed using the following approach.

- Rail network GIS data was derived from the FRA database available at the time the study was performed.
- Economic Area boundaries are defined base on electronic GIS files obtained from the DOC. Since the FCC has used the 1995 definition of economic areas (based on the 1990 census) to make spectrum regulation, the 1995 definition is used for this study.
- The Amtrak inter-city passenger rail lines were intentionally not shown except in cases where Amtrak service shares track with a commuter rail line. In either case Amtrak service is not specifically identified.

3.3 NATIONAL MAP

The following map depicts all 27 commuter rail lines (indicated in **red**) overlaid with US state boundaries. For reference Amtrak lines are also indicated (in black). This defines the scope and scale of the study from a USA national view. From this map one can see that commuter rail lines (Amtrak excluded) are only located in particular regions within certain states.

Figure 1 - US Commuter Rail Lines

PCJPB/ACE

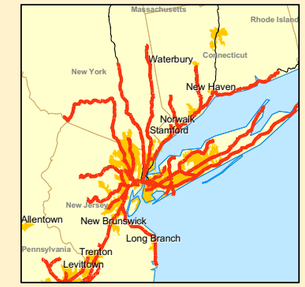
Metrolink/NCTD

ARR

TRI-Rail

MTA/VRE

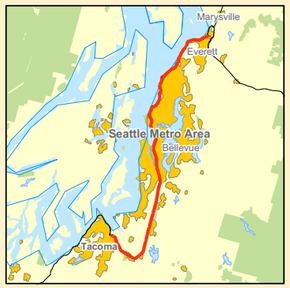
SEPTA/PENNDOT



MTA LIRR/NJ Transit/MTA MNCR/CDOT

MBTA/NNEPRA

TriMet



ST

UTA

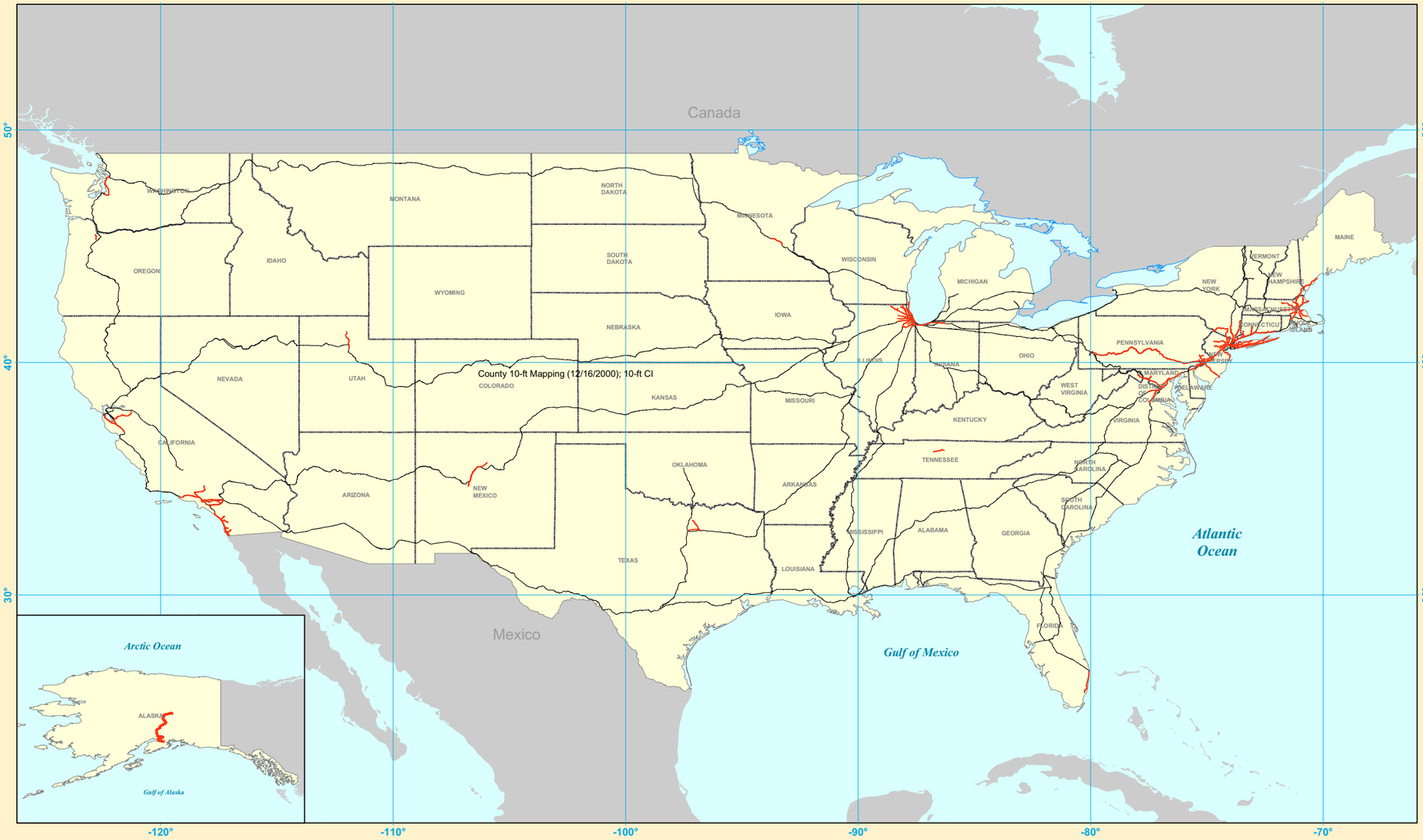
RMRTD

DART/The T/DCTA

Metro Transit

Metra/NICTD

RTA



United States Commuter Rail Lines

Stantec
Stantec Consulting Inc.
8211 S. 48th Street
Phoenix, AZ U.S.A. 85044

3.4 ECONOMIC AREA CORRELATION

The following figure is a map that depicts all 27 commuter rail lines overlaid with EA boundaries (as defined by the BEA).

Figure 2 - US Commuter Rail Line Economic Areas

PCJPB/ACE

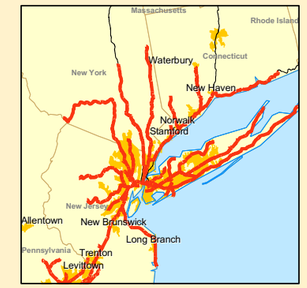
Metrolink/NCTD

ARR

TRI-Rail

MTA/VRE

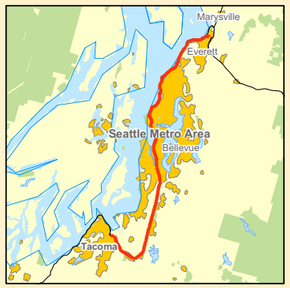
SEPTA/PENNDOT



MTA LIRR/NJ Transit/MTA MNCR/CDOT

MBTA/NNEPRA

TriMet



ST

UTA

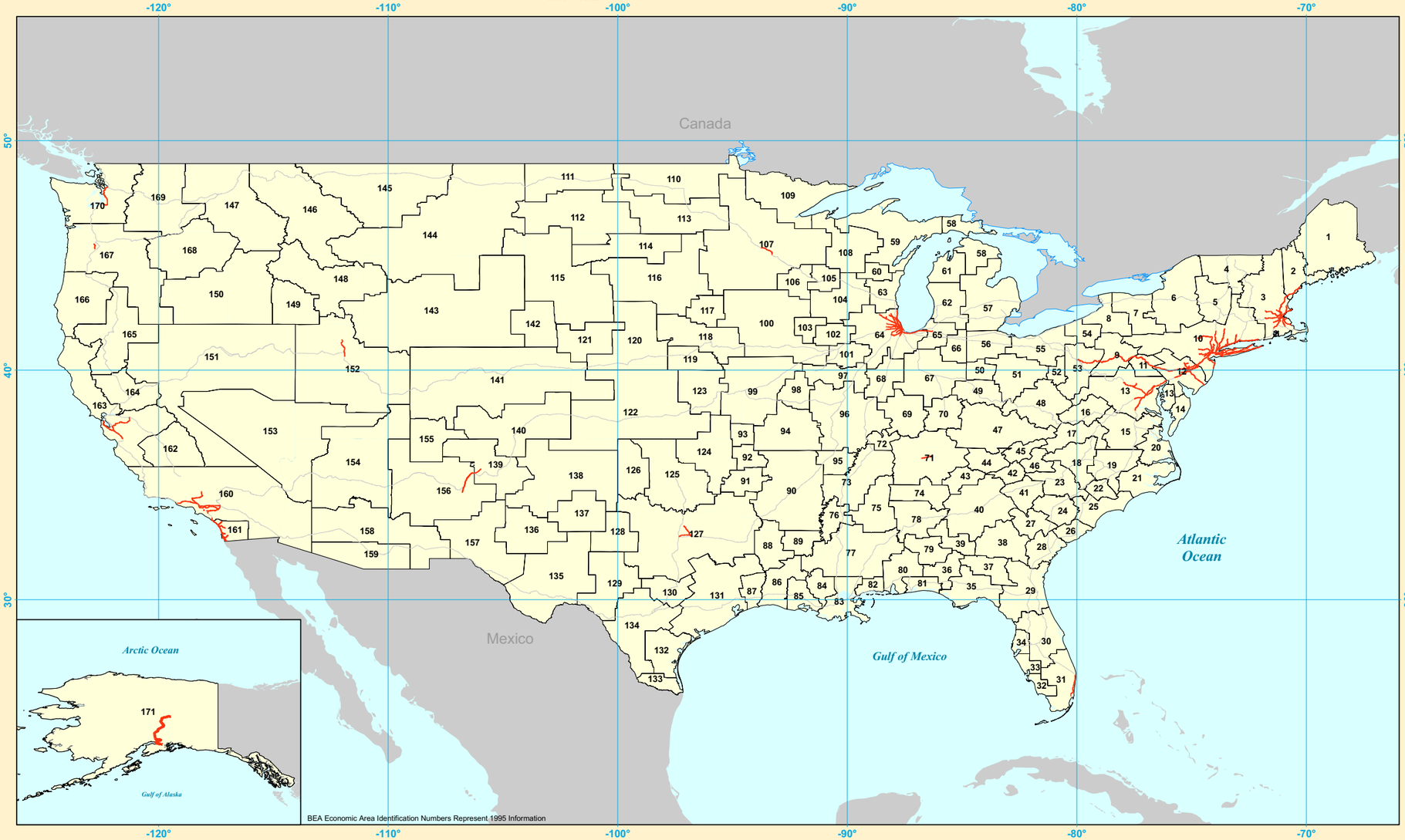
RMRTD

DART/The T/DCTA

Metro Transit

Metra/NICTD

RTA



Commuter Rail Lines & BEA Economic Areas

Stantec
Stantec Consulting Inc.
8211 S. 48th Street
Phoenix, AZ U.S.A. 85044

From this map, the particular EA's associated with each commuter rail line were determined. The following table lists each commuter rail entity and the associated EA. See Appendices for a detailed listing of EA's in which commuter rail lines are located. In total 19 out of 172 economic areas need spectrum, or 11%.

Table 5 - Commuter Rail Economic Areas

Item	State	Agency	City	1995 EA Code
1	NY	MTA Long Island Rail Road (MTA LIRR)	Jamaica	10
2	NJ	New Jersey Transit Corporation (NJ TRANSIT)	Newark	10
3	NY	Metro-North Commuter Railroad Company, dba: MTA Metro-North Railroad (MTA-MNCR)	New York	10
4	IL	Northeast Illinois Regional Commuter Railroad Corporation (Metra)	Chicago	64
5	MA	Massachusetts Bay Transportation Authority (MBTA)	Boston	3
6	PA	Southeastern Pennsylvania Transportation Authority (SEPTA)	Philadelphia	12
7	CA	Southern California Regional Rail Authority (Metrolink)	Los Angeles	160
8	CA	Peninsula Corridor Joint Powers Board (PCJPB)	San Carlos	163
9	MD	Maryland Transit Administration (MTA) [Brunswick and Camden lines Only]	Baltimore	13
10	FL	South Florida Regional Transportation Authority (TRI-Rail)	Pompano Beach	31
11	IN	Northern Indiana Commuter Transportation District (NICTD)	Chesterton	64 & 65
12	VA	Virginia Railway Express (VRE)	Alexandria	13
13	WA	Central Puget Sound Regional Transit Authority (ST)	Seattle	170
14	TX	Dallas Area Rapid Transit (DART) (TRE LINE)	Dallas	127
15	CA	North County Transit District (NCTD)	Oceanside	161
16	UT	Utah Transit Authority (UTA)	Salt Lake City	152
17	TX	Fort Worth Transportation Authority (The T) [Planned Cottonbelt line]	Fort Worth	127
18	NM	Rio Metro Regional Transit District (RTD) (NM Rail Runner Express)	Albuquerque	156
19	CA	Altamont Commuter Express (ACE)	Stockton	163
20	CT	Connecticut Department of Transportation (CDOT) (East shore line)	Newington	10
21	PA	Pennsylvania Department of Transportation (PENNDOT)	Harrisburg	12
22	ME	Northern New England Passenger Rail Authority (NNEPRA)	Portland	2 & 3
23	TN	Regional Transportation Authority (RTA)	Nashville	71
24	OR	Tri-County Metropolitan Transportation District of Oregon (TriMet)	Portland	167
25	MN	Metro Transit	Minneapolis	107
26	AK	Alaska Railroad Corporation (ARRC) [PTC Not Required]	Anchorage	171
27	TX	Denton County Transit Authority (DCTA)	Lewisville	127

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4.0 REVIEW OF PRIOR STUDIES and PTC TECHNOLOGY SURVEY

4.1 REVIEW OF PRIOR TRAIN CONTROL STUDIES

This section provides a brief summary of published PTC related studies that were available at the time this report was prepared with the purpose of gleaning any spectrum related information that may be useful for this study.

An internet search of relevant train control studies was greatly facilitated by a similar activity conducted in 2009 for the Washington State Department of Transportation, Positive Train Control: Synthesis prepared by Aaron Poor, TRAC Synthesis Editor, Kathy Lindquist, WSDOT Research Office and Michel Wendt, WSDOT Library, July 27, 2009. Following are summaries considered relevant:

1. **Communications Based Positive Train Control Systems Architecture in the USA**
   M. Hartong et al, May 2006, Vehicular Technology Conference 2006, IEEE 63rd, Vol. 6: 2987-2991, Melbourne, INSPEC Accession No. 9121350

   This paper summarizes the recent regulatory change that supports the implementation of PTC in the United States. This paper describes basic PTC architectures and functionality being adopted in the railroad environment, and closes by highlighting two different implementations of the same basic PTC architecture.

2. **Two New Technologies Ready to Roll**
   William C. Vantuono, April 2008, Intl. Railway J. 48(4): 26-28, Accession No. 01099761

   Abstract: Positive train control (PTC) and electronically-controlled pneumatic (ECP) braking are two technologies that, after almost two decades of development, are finally poised to change North American heavy-haul freight railroading's character dramatically. Existing brake cylinders and rigging are used in ECP-actuated braking, but the brake pipe functions only as a reservoir charging pipe. PTC is designed to protect track workers, enforce permanent and temporary speed restrictions, and prevent train collisions. The two technologies allow the opportunity for "intelligent" trains with intelligent control centers to be created, and pave the way for virtually unlimited opportunities for North American railways. Implementation challenges are discussed. An insert describes several North American PTC projects.
   This article lists current projects:

   - Advanced Civil Speed Enforcement System (ACSES) used by Amtrak
   - Collision Avoidance System (CAS) used by Alaska Railroad, supplied by Union Switch & Signal
   - Communications-Based Train Management (CBTM) used on CSXT track under Direct Traffic Control rules, supplied by Wabtec Railway Electronics. Received FRA extension approval to adapt to signaled territory.
   - Electronic Train Management System (ETMS) used by BNSF, a CBTM-based system supplied by Wabtec. Received FRA deployment approval.
   - Incremental Train Control System (ITCS) used on Amtrak's Chicago-Detroit line, supplied by GE
   - Vital Train Management System (V-TMS) being tested in the Powder River Basin and Washington state, an ETMS derivative supplied by Wabtec

- Optimized Train Control (OTC) used by Norfolk Southern, an ETMS derivative supplied by Wabtec
- Train Sentinel used on Panama Canal Railroad and being installed on Ohio Central Railroad, supplied by Quantum Engineering
- North American Joint Positive Train Control Project (NAJPTC) developed by AAR, FRA, Amtrak, Union Pacific, and Illinois DOT to produce an interoperable industry standard, tested by the Transportation Technology Center

3. **Creating Capacity: Growth Capital is a Priority at UP, and the Payoff is Impressive**
   William C. Vantuono, August 2008, Railway Age 209(8): 21-29, Accession No. 01111613

   Abstract: This article explains why Union Pacific railroad is spending $3.1 billion in capital improvements in 2008. One way UP expects to create capacity is through its Positive Train Control (PTC) system known as Vital Train Management System (V-TMS). UP will be evaluating interoperability with BNSF's PTC system, as interoperability remains one of the biggest hurdles to deploying PTC across North America.

4. **Practical Positive Train Control in the Northeast Corridor and in an Emerging Corridors**
   Lawrence E. Light, 2007, TRB 86th Annual Meeting 2007, Report No. 07-2798, Accession No. 01045987

   Abstract: The purpose of this paper is to review some practical principles emerging from Amtrak's successful development of new train control systems over the past fifteen years. The paper will note the importance of keeping the functionality as simple as possible, the advantage of modular architecture utilizing well-proven technologies when available, and the importance of early involvement of all disciplines affected by the new system to ensure timely acceptance for revenue service. Amtrak's experience has come out of the search for enhanced safety while reducing passenger trip times in the Northeast Corridor and in the emerging corridors. In the Northeast Corridor, the Acela Express required full Positive Train Control (PTC) to raise speeds from 110 and 125 MPH to 150 MPH in December 2000. This system is now in operation on 430 track miles of the Northeast Corridor. In the "emerging" Chicago-Detroit Corridor, a 45-mile "new start" PTC system has achieved sufficient maturity to support revenue service speed increases from 79 MPH to 95 MPH, with the design speed of 110 MPH expected in 2007. This system will also be extended another 20 miles in 2007. The paper will walk through the development of these two vital failsafe train control systems. Both systems meet the basic requirements of PTC as defined by the Federal Railroad Administration. These systems, though different technologies in different service environments, have some common elements worth reviewing.

5. **North American Joint Positive Train Control System Four-Quadrant Gate Reliability Assessment**
   Federal Railroad Administration, October 2008, Research Results RR08-10, Accession No. 01115334

   Abstract: The implementation of high-speed rail (HSR) technology, at speeds of 80 to 110 miles per hour (mph) on corridors with pre-existing conventional rail service (up to 79 mph), requires upgrading the crossing activation technology with additional emphasis on safety by adding four-quadrant gates. Frequently, these crossings cannot be closed

or grade-separated, and they are equipped with insufficient warning devices to support HSR operations. One solution, four-quadrant gates with inductive loop vehicle detection, was installed at 69 grade crossings on a 120.7-mile segment of the future 280-mile HSR corridor between Chicago and St. Louis. This segment will carry passenger trains at speeds up to 110 mph, including at many of the highway-rail grade crossings. These and other infrastructure improvements were completed to reduce the Chicago to St. Louis travel time from 5.5 hours to 3.5 hours and increase the number of daily round trips in each direction from three to five. [Note: this proposed project has not been implemented as of the writing of this report]

6. **Interoperable Communications-Based Signaling Project**
   Federal Railroad Administration, June 2009, Report No. DOT/FRA/ORD-09/12

   Abstract: Interoperable Communication-Based Signaling (ICBS) refers to an implementation of a train control system based on signaling principles whose system architecture and interface are documented as Recommended Practices (from the AREMA Manual of Recommended Practices for Communications and Signaling) by the Association of Railroad Engineering and Maintenance-of-Way Association (AREMA). This project demonstrated that existing suppliers of vital (fail-safe) train control equipment can modify their products to support the system architecture and interfaces as specified. ICBS is capable of satisfying the requirements of a positive train control system.

7. **Wired For Progress: ECP Braking is Just One of Norfolk Southern's Ground-Breaking Technology Initiatives**
   William C. Vantuono, June 2008, Railway Age 209(6): 20-29, Accession No. 01105498

   Abstract: This article describes some of the various technological advancements adopted and planned by Norfolk Southern Railway, as well as the positive financial results of these advancements. Focus is on the electronically controlled pneumatic brakes (ECP) adopted by the company. ECP braking provide the engineers with more control while loading and going downhill, while also reducing fuel consumption and wear on the train and rails. In addition to ECP, the railway is incorporating advanced technologies such as Unified Traffic Control System (UTCS) dispatching and Optimized Train Control (OCS), which will allow trains to go faster and more safely.

8. **Communications-Based Signaling (CBS) – Vital PTC**
   Bill Petit—Safetran Systems, May 2007, AREMA C&S Technical Conference

   Abstract: This paper describes a Positive Train Control system based on using new technologies to evolve proven signaling principles and safety-critical architectures to achieve the safety, cost and performance benefits of positive train control systems. In addition, it describes the process for developing interoperability manual parts through AREMA Committee 37.

4.1.1 GAO Report

The following GAO report was prepared for the FRA regarding PTC.

- GAO Report to Congressional Committees, December 2010. Rail Safety FRA Report on Risks to the Successful Implementation of Mandated Safety Technology. *www.gao.gov/new.items/d**11133**.pdf*. A key finding of this study is found in

Appendix III, Part 6 survey question No. 46. Issue "c" indicates that: acquisition of adequate spectrum in the 220 MHz band particularly in dense, metropolitan areas is a major issue.

4.2 RELEVANT TRAIN TRAFFIC STUDIES

The internet search of relevant train traffic studies and information yielded many commuter rail corridor studies such as:

- North Carolina Railroad Company Shared Corridor Commuter Rail Capacity Study, October 9, 2008, which primarily presents the case for commuter rail.
- The Pacific Surfliner Corridor Los Angeles to San Diego, Service Development Plan, California Department of Transportation, August 2010 is indicative of rail capacity studies based on simulation and assumption of future freight and commuter traffic. In general the studies underpin the need for infrastructure investment.
- The National Rail Freight Infrastructure Capacity and Investment Study prepared for the Association of American Railroads by Cambridge Systematics, Inc. September 2007 is a comprehensive assessment of the long-term capacity expansion needs of the continental U.S. freight railroads. It provides a first approximation of the rail freight infrastructure improvements and investments needed to meet the U.S. Department of Transportation's (U.S. DOT) projected demand for rail freight transportation in 2035.

The research yielded one study of particular value to commuter and freight common corridor traffic. The Catalog of "Common Use" Rail Corridors, Final Report, April 2003, DOT/FRA/ORD-03/16 is a FRA study to determine how many miles of common corridors exist in which light or heavy rail transit facilities are parallel to, and within 200 feet or less of, active freight rail lines. This report includes the results of a survey of rail transit properties to determine:

- The extent of "common corridors" in terms of route mileage;
- The types of protections between transit and freight railroad tracks (signal control, fencing, emergency response);
- Any shared "minor" facilities (bridges, highway-rail grade crossings); and
- Locations where level crossings or track connections exist.

The FRA has defined three types of common corridors:

1. Shared track, in which the heavy or light rail vehicles operate on the same tracks used by freight trains. FRA has written regulations governing this type of operation, in which temporal separation (no simultaneous operation) is required in most cases.
2. Shared right-of-way. In this case the transit vehicles run on separate tracks, but track centers are less than 25 feet (that is, separation between the centerline of the freight track and the centerline of the passenger track is less than 25 feet). Tracks separated by less than 25 feet are defined as "adjacent" by FRA, and certain roadway worker protection rules apply on adjacent tracks. FRA also defines "less than 30 feet" as the distance at which tracks are "non-insular" and operators are therefore subject to certain railroad regulations.
3. Shared corridor. Transit and freight operators share a transportation corridor, but tracks are separated by at least 25 feet and no more than 200 feet. FRA believes that intrusion by derailed freight or transit cars onto a parallel railroad track is unlikely beyond 200 feet.

The table below is provided by the FRA study and is modified to remove light rail information and edits relevant to this research.

Table 6 - FRA Shared Corridor Analysis

City	Agency	Route Mileage			Notes
		Shared Track	Shared ROW	Shared Corridor	
Anchorage, AK	Alaska Railroad Corporation (ARRC)				
Baltimore, MD	Maryland Transit Administration(MTA)	10.9		7.2	Shared corridor with CSX Hanover Sub, heavy rail. Track spacing all > 25 ft.
Boston, MA	Massachusetts Bay Transportation Authority(MBTA)		21.6		Two segments of shared ROW on Orange Line; one on Red Line. See text
Chicago, IL	Northeast Illinois Reg. Commuter Railroad Corp.(Metra)				
Chicago, IL	Northern Indiana Commuter Transportation District(NICTD)				
Dallas, TX	Dallas Area Rapid Transit(DART)	28.4	4.2	0.9	Lines to Farmer's Branch, Pleasant Grove will use shared ROW. Both are funded - 2002. Track at Dallas Union Station > 25 feet. Planned: 28.4 miles shared ROW
Dallas, TX	Fort Worth Transportation Authority(The T)				
Hartford, CT	Connecticut Department of Transportation(CDOT)				
Los Angeles, CA	Southern California Regional Rail Authority(Metrolink)				
Miami, FL	South Florida Regional Transportation Authority(TRI-Rail)				
Nashville, TN	Regional Transportation Authority(RTA)				
New York	MTA Long Island Rail Road(MTA LIRR)				
New York/Newark	New Jersey Transit Corporation(NJ TRANSIT)	0.2	0.8		Shared with freight spur; freight trains must use light rail track to reach customer
New York	Metro-North Commuter Railroad Company (MTA-MNCR)				

City	Agency	Route Mileage			Notes
		Shared Track	Shared ROW	Shared Corridor	
Philadelphia, PA	Southeastern Pennsylvania Transp. Authority (SEPTA)				Diamond in street, protected by standard highway crossing warning devices
Philadelphia, PA	Pennsylvania Department of Transportation(PENNDOT)				
Portland, ME	Northern New England Passenger Rail Auth.(NNEPRA)				
San Diego, CA	North County Transit District(NCTD)				
San Francisco, CA	Peninsula Corridor Joint Powers Board(PCJPB)				
Seattle, WA	Central Puget Sound Regional Transit Authority(ST)				
Stockton, CA	Altamont Commuter Express(ACE)				
Trenton NJ	New Jersey Transit Corporation(NJ TRANSIT)	33.0			Shared track with Conrail Shared Assets
Washington, DC	Virginia Railway Express(VRE)				

4.3 PTC RADIO TRAFFIC STUDIES

No PTC data radio traffic (or capacity) studies were available for review. However it is noted that several PTC system capacity studies are in progress and planned to be completed by the end of 2011.

4.4 PTC TECHNOLOGY SURVEY

The following radio protocols were identified as being pertinent to PTC systems.

4.4.1 ITC/AAR RADIO PROTOCOLS

The ITC (Interoperable Train Control) committee, in collaboration with the AAR, is developing a suite of over-the air radio protocols and technical standards to facilitate interoperability between all freight operations in the US and also between commuter rail operations on shared tracks. This has been referred to as I-ETMS or Interoperable – Electronic Train Management System. For more information contact the AAR http://www.aar.org. The radio equipment being deployed using this protocol is the model ITC 220, developed by CalAmp Wireless Networks and MeteorComm LLC and is available in mobile, base and wayside configurations. For additional details, please refer to the following URL links http://www.calamp.com and http://www.meteorcom.com.

4.4.2 ACSES® System

The Advanced Civil Speed Enforcement System (ACSES) is a product line developed by the Alstom Corporation for AMTRAK and is currently one of the two PTC technologies to be granted PTC safety certification by the FRA. This technology uses cab signaling, track mounted

transponders and a data radio to provide PTC functionality. For information regarding ACSES, please refer to the following URL http://www.alstom.com.

4.4.3 GE MDS TD220®

The GE Digital Energy Division has developed a mobile data radio for PTC applications based on TDMA technology and compatible with the spectrum bands discussed in this study. Their product operates within a 12.5 KHz channel and is currently being used for ACSES deployments as the wireless data link between the train and fixed radio locations. Additional details on this product can be obtained via the following URL ftp://ftp.microwavedata.com/OUTGOING/TD220X/

4.4.4 ITCS® System

The Incremental Train Control System (ITCS) is a product line developed and manufactured by GE Transportation, a General Electric Company. ITCS is one of the two PTC technologies currently approved by the FRA. ITCS uses GPS, data radio equipment, an on-board computer and display to monitor and ensure compliance with all operating instructions. Using existing signals or virtual signals, ITCS wirelessly communicates train movement authority as though the territory was operating under centralized traffic control. ITCS is design to be a vital system intended to increase the maximum velocity of all trains on the network, both passenger and freight. For information regarding ITCS, please refer to the following URL http://www.getransportation.com/rail/rail-products/signaling-a-communication/signaling-a-train-control/incremental-train-control-system-itcs.html

4.4.5 ETMS® System

The Electronic Train Management System (ETMS) is a product line developed and manufactured by the Wabtec Corporation. This system is primarily used by the BNSF freight railroad and is a precursor to I-ETMS technology. ETMS uses GPS, data radio equipment, an on-board computer and display to monitor and ensure compliance with all operating instructions. As the train moves down the track, ETMS calculates warning and braking curves based on relevant train and track information, including speed, location, movement authority, speed restrictions, work zones and consist restrictions. ETMS also queries wayside devices for broken rails, proper switch alignment and signal aspects. For additional information regarding ETMS, please refer to the following URL http://www.wabtec.com/railroad/etms.asp.

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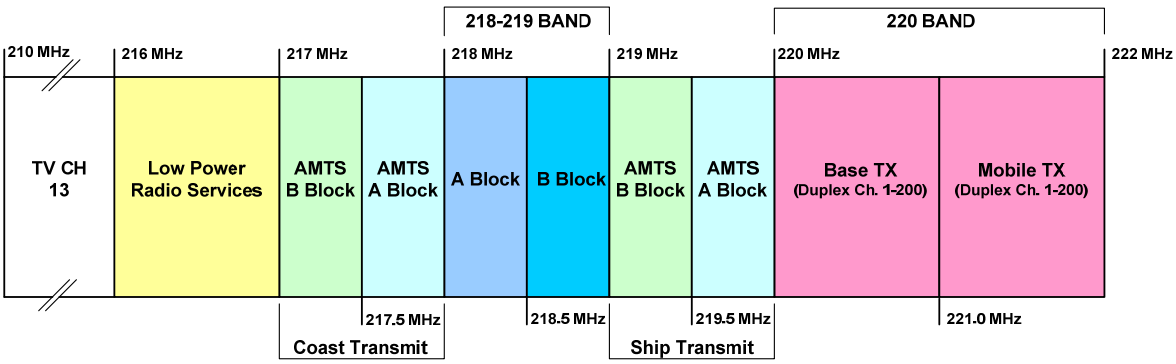
5.0 SPECTRUM ANALYSIS

This section provides an overview of the spectrum bands identified as suitable for PTC wireless applications and the conceptual spectrum analysis performed.

5.1 SPECTRUM BANDS

Radio equipment being developed for PTC applications are using RF bandwidths of approximately 5 MHz between 217.000 to 222.000 MHz[9]. This frequency range is divided into bands by FCC regulations as indicated in the following figure. Each band represents a different radio service, each with unique service rules. It is noted that as PTC technology is new, existing service rules were not specifically written to enable deployment of PTC applications.

Figure 3 - 217 to 222 MHz Spectrum Bands



The following three bands have been identified by the industry as being potentially suitable for radio equipment manufactured for PTC applications.

- AMTS
- 218-219
- 220

These three bands are of interest because of their favorable propagation characteristic to cover larger areas than higher frequency bands, and availability of spectrum in many needed areas.

5.1.1 AMTS Band

This AMTS (Automated Maritime Telecommunications System) band consists of two 1 MHz blocks of spectrum with each block divided into two 500 kHz blocks (A & B), two for ship transmit, and two for coast transmit with twenty 25 kHz duplex channel pairs spaced 2 MHz apart from each other in each block.

Regulatory Background[10]

The AMTS service was originally intended to authorize specialized systems of coast stations providing integrated and interconnected marine voice and data communications[11]. In 1997, the

[9] Specifications for the ITC 220 radio (published by Meteorcomm/CalAmp) indicate an operating range between 217.6125 – 221.9875 MHz, which excludes the use of frequencies in the lower portion of the AMTS band (217.0000 – 217.6000 MHz). Specifications published for the GE MDS TD220 radio indicated an operating range between 217 – 225 MHz.

[10] Source URL http://wireless.fcc.gov/encyclopedia

[11] See Amendment of Parts 2 and 80 of the Commission's Rules Applicable to Automated Maritime Telecommunications Systems (AMTS), First Report and Order, RM-5712, 6 FCC Rcd 437 (1991).

Commission amended its rules to permit AMTS licensees to provide commercial service to fixed and mobile units on land, under certain conditions.[12] In 2002, the Commission adopted a geographic area licensing approach for AMTS stations.[13] In 2007, the Commission further amended its rules to permit AMTS licensees to provide private mobile radio service, as well as commercial service, to units on land.[14]

Licensing

The AMTS service is regulated under 47 CFR Part 80. It is noted that within the upper AMTS block between 219 - 220 MHz, amateur radio operators are allowed to transmit on a secondary basis.

In order to obtain a license in this band for PTC use, waivers of various FCC service rules are typically needed to account for differences in transmit power, antenna height and other technical or procedural issues with respect to the existing rules. Due to this, various licensing applications and associated waivers are pending before the FCC at this time

Availability

A search of available of spectrum within the AMTS band was not performed in this study.

5.1.2 218-219 Band

The 218-219 MHz Service (formerly known as the Interactive Video and Data Service (IVDS)) is a 1 MHz contiguous block of spectrum intended for low power wireless applications.

Regulatory Background[15]

The 218-219 MHz service is configured for fixed or mobile services and dates back to 1989 when the FCC received a petition for rulemaking that proposed interactive capabilities for television viewers. In 1992, the FCC announced service rules[16] for the 218 – 219 MHz Service. In 1999, the FCC revised[17] many of the 218 – 219 MHz rules to increase flexibility for how licensees use the spectrum. In 2010, the FCC proposed[18] to move the service rules for the 218 – 219 MHz Service from Part 95 to Part 27, recognizing that the service may fit within the other Part 27 services more than Part 95 services. This proposal is still pending.

Licensing

The FCC uses an auctions process[19] to issue initial 218 – 219 MHz Service licenses. Previously, licenses were issued by lottery[20]. This band was licensed under Auction 2 which was completed on 7/29/1994.The FCC service rules for the 218 – 219 MHz Service are located in 47 CFR Part 95[21].

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[12] See Amendment of the Commission's Rules Concerning Maritime Communications, Second Report and Order and Second Further Notice of Proposed Rule Making, PR Docket No. 92-257, 12 FCC Rcd 16949, 16965 24 (1997)

[13] See Amendment of the Commission's Rules Concerning Maritime Communications, Second Memorandum Opinion and Order and Fifth Report and Order, PR Docket No. 92-257, 17 FCC Rcd 6685, 6696 24 (2002)

[14] Maritel, Inc. and Mobex Network Services, LLC, Report and Order, WT Docket No. 04-257, 22 FCC Rcd 8971 (2007) (Flexibility Order), aff'd, 25 FCC Rcd 533 (2010), aff'd, 26 FCC Rcd 2491 (2011), review pending.

[15] Source URL http://wireless.fcc.gov/encyclopedia/218-219-mhz-service

[16] http://wireless.fcc.gov/services/218-219MHz/Svs_established%20_%20Lottery_Filing_Procedures_1992.pdf

[17] http://transition.fcc.gov/Bureaus/Wireless/Orders/1999/fcc99239.txt

[18] http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-10-106A1.pdf

[19] http://wireless.fcc.gov/auctions/default.htm?job=auction_summary&id=2

[20] http://wireless.fcc.gov/services/218-219MHz/PN_3_30_94%20First_18_licenses.pdf

[21] http://wireless.fcc.gov/index.htm?job=rules_and_regulations

Market Areas and Channel Blocks

218 – 219 MHz Service block licenses are issued by the FCC within Cellular Market Areas (CMAs) with each market area consisting of one, or combination of two or more counties. There are 734 CMAs defined in the US. Channel blocks are groups of frequencies within the 218 – 219 MHz band and are assigned as indicated in the following table:

Table 7 - 218-219 MHz Service Channel Blocks

Channel Blocks	Spectrum Amount (kHz)	Market Areas
A	500	CMA
B	500	CMA

Availability

Attachment A included with the Auction 89 notice issued by the FCC provided a listing of 500 kHz CMA blocks to be auctioned (Note: Auction 89 has not yet occurred). From the EA correlation analysis performed in Appendix C, there were 177 CMAs associated with the 19 EAs. This information was used to aggregate the spectrum available within each EA. Refer to Appendix D for details.

The following table summarizes the findings in Appendix D. This analysis indicates that adequate spectrum could be available in the 218-219 MHz band.

Table 8 - 218-219 Service Block Totals by EA

Item	1995 EA Code	Total Available in EA (kHz)	Total EA Spectrum Need (kHz)	Net EA Available (Avail - Needed)
1	2	4,000	140	3,860
2	3	12,000	660	11,340
3	10	25,000	1,825	23,175
4	12	6,000	1,025	4,975
5	13	12,000	800	11,200
6	31	5,500	325	5,175
7	64	10,500	740	9,760
8	65	6,000	210	5,790
9	71	11,000	250	10,750
10	107	6,907	275	6,632
11	127	18,000	825	17,175
12	152	8,000	300	7,700
13	156	5,000	375	4,625
14	160	6,000	500	5,500
15	161	1,000	325	675
16	163	12,000	675	11,325
17	167	8,000	250	7,750
18	170	7,000	425	6,575
19	171	4,000	425	3,575

5.1.3 220 Band[22]

The 220 band consists of 2 MHz of contiguous spectrum between 220-222 MHz. The spectrum is divided into 200 channel pairs, each channel's center frequency is spaced 5 KHz apart, with mobile frequencies 1 MHz higher than the corresponding base frequencies. 10 channel pairs are available exclusively for Government operations and 15 channel pairs are available exclusively for Public Safety. Accordingly, there are a total of 175 channel pairs available for use by commercial, business, or other eligible entities (see Rule 90.703).

Regulatory Background

In Phase I, the channels were organized functionally into radio service groups: QT, NC, QO, QD, and QM [QT= Phase I Trunked service, QD = Phase I Data service, QO = Phase I Other service, QM = Public Safety licenses, NC = Phase I Nationwide Commercial service and QA = Phase II auctioned service].

In the QT radio service, channels were initially required to be trunked. To account for trunked radio technologies, the channels for each trunked radio license maintained a separation of 150 KHz. These trunked channels were assigned in groups of 5 channel pairs per license (trunked channel groups). The non-trunked channel pairs (NC, QO, QD, and QM) were divided so that they would be licensed in contiguous channel groups. In total for the 220-222 MHz band, there are 100 QT channel pairs, 20 Nationwide Commercial (NC) channel pairs, 10 Other (QO) channel pairs, 15 Data (QD) channel pairs, and 15 Public Safety (QM) channel pairs. 10 channels are for Government Nationwide use and 30 channels did not become available until Phase II.

In Phase II, QT radio service trunked channel groups or contiguous single channel pairs were combined to create channel blocks for auction. Each block, A through E, includes 10 channel pairs (100 KHz) for each Economic License (EA) license area. Each block, F through J, includes 15 channel pairs (150 KHz) for each Regional Economic Area Group (REAG) license area. And each block, K through M, includes 10 channel pairs (100 KHz) for each nationwide license.

[22] See http://wireless.fcc.gov/services

Market Areas and Channel Blocks
220 licenses are assigned by EAs and Economic Area Groupings (EAGs). There are 175 EAs in the USA and territories. Channel blocks are groups of frequencies assigned as indicated in the following table.

Table 9 – 220-222 MHz Service Channel Blocks (Phase II)

Block	Spectrum Amount (kHz)	Channel Pairing (Auction 89 Block Pairing)	Geographic Area Type	Service Area
A	100	10 X 5 kHz (2 X 50 kHz)	EA	Regional
B	100	10 X 5 kHz (2 X 50 kHz)	EA	Regional
C	100	10 X 5 kHz (2 X 50 kHz)	EA	Regional
D	100	10 X 5 kHz (2 X 50 kHz)	EA	Regional
E	100	10 X 5 kHz (2 X 50 kHz)	EA	Regional
F	150	15 X 5 kHz (2 X 75 kHz)	EAG	Regional
G	150	15 X 5 kHz (2 X 75 kHz)	EAG	Regional
H	150	15 X 5 kHz (2 X 75 kHz)	EAG	Regional
I	150	15 X 5 kHz (2 X 75 kHz)	EAG	Regional
J	150	15 X 5 kHz (2 X 75 kHz)	EAG	Regional
K	100	10 X 5 kHz (2 X 50 kHz)	EA	Nationwide
L	100	10 X 5 kHz (2 X 50 kHz)	EA	Nationwide
M	100	10 X 5 kHz (2 X 50 kHz)	EA	Nationwide

Licensing
220 band channels are licensed under 47 CFR Part 90.

Availability
A search of available of spectrum within the 220 band was not performed in this study.

It is noted that the freight railroads via an organization called PTC-220 LLC has acquired various nationwide and regional channels in the 220 band for PTC use along their freight rail lines, however they have also indicated sharing of these frequencies is possible in shared freight/passenger service rail corridors.

5.2 SPECTRUM ESTIMATE METHODOLOGY

The engineering methodology to develop the spectrum estimate was to first place base sites with antennas at 60 AGL along the track alignment of each corridor, 5 to 10 miles apart as needed so that radio coverage was provided for 100% of the track. Secondly, once coverage was modeled, C/I+N (Carrier to Interference plus Noise ratio) analysis was performed to determine how many base frequencies would be needed in a re-use pattern. The RF propagation modeling software[23] automatically makes this determination based on the metrics indicated below. Thirdly, the common channel and wayside channels were added to develop a total number of channels.

5.2.1 PTC Radio System Configuration

For the purposes of developing a conceptual mobile data radio system design, the following assumptions were made in consultation with PTC-220 LLC.

[23] ComSite Design© RF Software by RCC Consultants Inc., http://www.rcc.com/comsite.shtml

- All radio sites were assumed to be identical low level 60 foot towers, located wayside rail lines to cover the track mileage associated with each rail corridor. Wayside was assumed to be within each operator's right-of-way. This height was chosen as this represents a standard height for a telescoping or tilt-down tower.
- Mountain top radio sites would not be used.
- Wayside devices would use an OMNI antenna placed at 20 to 40 foot maximum AGL.
- Each radio would use all 8 simplex frequencies, which is the maximum capacity of the radio.
    - One common simplex frequency (identical to all sites)
    - A control frequency assigned to each base in a re-use pattern.
    - Six wayside frequencies assigned as needed to wayside devices in a re-use pattern to be determined.
- 25 kHz bandwidth channels.
- The back-haul communications link from base sites to a dispatch center could be any method (i.e. microwave, fiber, radio link, etc.) and spectrum for this purpose was not considered in this study.

5.2.2 Propagation Settings

Consistent with recommendations by PTC-220 LLC, and the developer of the RF engineering software used, the following settings were used for this analysis.

- Longley-Rice ITM model (non-adaptive) at 220 MHz nominal frequency.
- Land-use data not used (only terrain was considered).
- 30 meter terrain data used in all corridors
- 720 radials were calculated for each site.
- 90% reliability
- 90% Lognormal fading
- Only wayside Base to Train mobile transmissions were modeled to estimate a frequency re-use pattern.
- Frequency re-use parameters per MeteorComm guidelines.
- Nominal 6 dBd gain OMNI antennas at 60 feet AGL.
- Base radio power output: 37.5 Watts (average power)
- ERP calculated between 100 and 150 watts
- Receive sensitivity and C/N+I (Carrier to Noise plus Interference ratio) modeled to achieve a maximum of a 10% PER (packet error rate) per MeteorComm guidelines.

5.3 SPECTRUM ESTIMATE

From the analysis above, a spreadsheet was developed indicating the spectrum needs. The following table is a summary of the spectrum estimate and the associated EA. The total spectrum indicated is the aggregate amount needed to allow a design to be developed by others.

For more detail, refer to Appendix A.

Table 10 - Spectrum Estimate Totals by Passenger Rail Line

Item	State	Agency	Total Spectrum (kHz)	1995 EA Code
1	NY	MTA Long Island Rail Road (MTA LIRR)	**475**	10
2	NJ	New Jersey Transit Corporation (NJ TRANSIT)	**500**	10
3	NY	Metro-North Commuter Railroad Company	**550**	10
4	IL	Northeast Illinois Regional Commuter Railroad Corporation (Metra)	**600**	64
5	MA	Massachusetts Bay Transportation Authority (MBTA)	**475**	3
6	PA	Southeastern Pennsylvania Transportation Authority (SEPTA)	**450**	12
7	CA	Southern California Regional Rail Authority (Metrolink)	**500**	160
8	CA	Peninsula Corridor Joint Powers Board (PCJPB)	**325**	163
9	MD	Maryland Transit Administration (MTA) [Brunswick and Camden lines Only]	**475**	13
10	FL	South Florida Regional Transportation Authority (TRI-Rail)	**325**	31
11	IN	Northern Indiana Commuter Transportation District (NICTD)	**350**	64 & 65
12	VA	Virginia Railway Express (VRE)	**325**	13
13	WA	Central Puget Sound Regional Transit Authority (ST)	**425**	170
14	TX	Dallas Area Rapid Transit (DART) (TRE LINE)	**275**	127
15	CA	North County Transit District (NCTD)	**325**	161
16	UT	Utah Transit Authority (UTA)	**300**	152
17	TX	Fort Worth Transportation Authority (The T) (Planned Cottonbelt line)	**300**	127
18	NM	Rio Metro Regional Transit District (RTD) (NM Rail Runner Express)	**375**	156
19	CA	Altamont Commuter Express (ACE)	**350**	163
20	CT	Connecticut Department of Transportation (CDOT) (East shore line)	**300**	10
21	PA	Pennsylvania Department of Transportation (PENNDOT)	**575**	12
22	ME	Northern New England Passenger Rail Authority (NNEPRA)	**350**	2 & 3
23	TN	Regional Transportation Authority (RTA)	**250**	71
24	OR	Tri-County Metropolitan Transportation District of Oregon (TriMet)	**250**	167
25	MN	Metro Transit	**275**	107
26	AK	Alaska Railroad Corporation (ARRC)	**425**	171
27	TX	Denton County Transit Authority (DCTA)	**250**	127

The following table aggregates the spectrum to each EA and represents the total quantity of spectrum needed in each economic area.

Table 11 - EA Spectrum Totals

Item	1995 EA Code	Total Spectrum (kHz)
1	2	140
2	3	660
3	10	1,825
4	12	1,025
5	13	800
6	31	325
7	64	740
8	65	210
9	71	250
10	107	275
11	127	825
12	152	300
13	156	375
14	160	500
15	161	325
16	163	675
17	167	250
18	170	425
19	171	425

As discussed in Section 5.1.2, each of these 19 EAs were correlated with 177 CMAs (see Appendix C).

6.0 APPENDICES

6.1 APPENDIX A – SPECTRUM ESTIMATE DETAILS

United States Commuter Rail Lines
Preliminary PTC Spectrum Estimate

Item	State	Agency	City	UZA Name	Mode	Base Local Ch	Common Channel	Wayside Channels	Total Channels (25 kHz)	Total Spectrum (kHz)	1995 EA Code
1	NY	MTA Long Island Rail Road (MTA LIRR)	Jamaica	New York-Newark, NY-NJ-CT	CR	12	1	6	19	**475**	10
2	NJ	New Jersey Transit Corporation (NJ TRANSIT)	Newark	New York-Newark, NY-NJ-CT	CR	13	1	6	20	**500**	10
3	NY	Metro-North Commuter Railroad Company, dba: MTA Metro-North Railroad (MTA-MNCR)	New York	New York-Newark, NY-NJ-CT	CR	15	1	6	22	**550**	10
4	IL	Northeast Illinois Regional Commuter Railroad Corporation (Metra)	Chicago	Chicago, IL-IN	CR	17	1	6	24	**600**	64
5	MA	Massachusetts Bay Transportation Authority (MBTA)	Boston	Boston, MA-NH-RI	CR	12	1	6	19	**475**	3
6	PA	Southeastern Pennsylvania Transportation Authority (SEPTA)	Philadelphia	Philadelphia, PA-NJ-DE-MD	CR	11	1	6	18	**450**	12
7	CA	Southern California Regional Rail Authority (Metrolink)	Los Angeles	Los Angeles-Long Beach-Santa Ana, CA	CR	13	1	6	20	**500**	160
8	CA	Peninsula Corridor Joint Powers Board (PCJPB)	San Carlos	San Francisco-Oakland, CA	CR	6	1	6	13	**325**	163
9	MD	Maryland Transit Administration (MTA) [Brunswick and Camden lines Only]	Baltimore	Baltimore, MD	CR	12	1	6	19	**475**	13
10	FL	South Florida Regional Transportation Authority (TRI-Rail)	Pompano Beach	Miami, FL	CR	6	1	6	13	**325**	31
11	IN	Northern Indiana Commuter Transportation District (NICTD)	Chesterton	Chicago, IL-IN	CR	7	1	6	14	**350**	64 & 65
12	VA	Virginia Railway Express (VRE)	Alexandria	Washington, DC-VA-MD	CR	6	1	6	13	**325**	13
13	WA	Central Puget Sound Regional Transit Authority (ST)	Seattle	Seattle, WA	CR	10	1	6	17	**425**	170
14	TX	Dallas Area Rapid Transit (DART) (TRE LINE)	Dallas	Dallas-Fort Worth-Arlington, TX	CR	4	1	6	11	**275**	127
15	CA	North County Transit District (NCTD)	Oceanside	San Diego, CA	CR	6	1	6	13	**325**	161
16	UT	Utah Transit Authority (UTA)	Salt Lake City	Salt Lake City, UT	CR	5	1	6	12	**300**	152
17	TX	Fort Worth Transportation Authority (The T) (Planned Cottonbelt line)	Fort Worth	Dallas-Fort Worth-Arlington, TX	CR	5	1	6	12	**300**	127
18	NM	Rio Metro Regional Transit District (RTD) (NM Rail Runner Express)	Albuquerque	Albuquerque, NM	CR	8	1	6	15	**375**	156
19	CA	Altamont Commuter Express (ACE)	Stockton	Stockton, CA	CR	7	1	6	14	**350**	163
20	CT	Connecticut Department of Transportation (CDOT) (East shore line)	Newington	Hartford, CT	CR	5	1	6	12	**300**	10
21	PA	Pennsylvania Department of Transportation (PENNDOT)	Harrisburg	Philadelphia, PA-NJ-DE-MD	CR	16	1	6	23	**575**	12
22	ME	Northern New England Passenger Rail Authority (NNEPRA)	Portland	Boston, MA-NH-RI	CR	7	1	6	14	**350**	2 & 3
23	TN	Regional Transportation Authority (RTA)	Nashville	Nashville-Davidson, TN	CR	3	1	6	10	**250**	71
24	OR	Tri-County Metropolitan Transportation District of Oregon (TriMet)	Portland	Portland, OR-WA	CR	3	1	6	10	**250**	167
25	MN	Metro Transit	Minneapolis	Minneapolis-St. Paul, MN	CR	4	1	6	11	**275**	107
26	AK	Alaska Railroad Corporation (ARRC) [PTC Not Required]	Anchorage	Anchorage, AK	AR	10	1	6	17	**425**	171
27	TX	Denton County Transit Authority (DCTA)	Lewisville	Dallas-Denton, TX	CR	3	1	6	10	**250**	127

6.2 APPENDIX B – ECONOMIC AREA CORRELATION DETAIL

EA Code	CEA Code	County fips	see * (end)	CEA Count	County Count	NAME (EA if D=9; CEA if D=8; County if D is 10 or more)
2	0	0	9	2	8	Portland, ME
2	4243	0	8	1	3	Lewiston-Auburn, ME
2	4243	23007	40	0	1	Franklin County, ME
2	4243	23001	10	0	1	Androscoggin County, ME
2	4243	23017	40	0	1	Oxford County, ME
2	6403	0	8	1	5	Portland, ME
2	6403	23023	40	0	1	Sagadahoc County, ME
2	6403	23031	40	0	1	York County, ME
2	6403	23013	40	0	1	Knox County, ME
2	6403	23015	40	0	1	Lincoln County, ME
2	6403	23005	10	0	1	Cumberland County, ME
3	0	0	9	4	29	Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-V
3	743	0	8	1	1	Barnstable-Yarmouth, MA
3	743	25001	10	0	1	Barnstable County, MA
3	1123	0	8	1	18	Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-V
3	1123	25007	40	0	1	Dukes County, MA
3	1123	25005	10	0	1	Bristol County, MA
3	1123	25009	10	0	1	Essex County, MA
3	1123	25017	10	0	1	Middlesex County, MA
3	1123	25025	10	0	1	Suffolk County, MA
3	1123	25019	40	0	1	Nantucket County, MA
3	1123	25021	10	0	1	Norfolk County, MA
3	1123	25023	10	0	1	Plymouth County, MA
3	1123	25027	10	0	1	Worcester County, MA
3	1123	33003	40	0	1	Carroll County, NH
3	1123	33013	40	0	1	Merrimack County, NH
3	1123	33001	40	0	1	Belknap County, NH
3	1123	33011	10	0	1	Hillsborough County, NH
3	1123	33005	31	0	1	Cheshire County, NH
3	1123	33017	10	0	1	Strafford County, NH
3	1123	33015	10	0	1	Rockingham County, NH
3	1123	44005	40	0	1	Newport County, RI
3	1123	50025	41	0	1	Windham County, VT
3	6483	0	8	1	4	Providence-Warwick-Pawtucket, RI
3	6483	44003	10	0	1	Kent County, RI
3	6483	44001	10	0	1	Bristol County, RI

3	6483	44009	10	0	1	Washington County, RI
3	6483	44007	10	0	1	Providence County, RI
3	9537	0	8	1	6	*Lebanon, NH-VT
3	9537	33007	40	0	1	Coos County, NH
3	9537	33019	40	0	1	Sullivan County, NH
3	9537	33009	30	0	1	Grafton County, NH
3	9537	50027	40	0	1	Windsor County, VT
3	9537	50009	40	0	1	Essex County, VT
3	9537	50017	41	0	1	Orange County, VT
10	0	0	9	18	58	@New York-No. New Jer.-Long Island, NY-NJ-CT-PA-MA-\
10	240	0	8	1	3	Allentown-Bethlehem-Easton, PA
10	240	42095	10	0	1	Northampton County, PA
10	240	42025	10	0	1	Carbon County, PA
10	240	42077	10	0	1	Lehigh County, PA
10	875	0	8	1	2	#Bergen-Passaic, NJ
10	875	34003	20	0	1	Bergen County, NJ
10	875	34031	20	0	1	Passaic County, NJ
10	2281	0	8	1	2	#Dutchess County, NY
10	2281	36027	20	0	1	Dutchess County, NY
10	2281	36111	40	0	1	Ulster County, NY
10	3283	0	8	1	4	Hartford-New Britain-Middletown-Bristol, CT
10	3283	9007	10	0	1	Middlesex County, CT
10	3283	9015	41	0	1	Windham County, CT
10	3283	9013	10	0	1	Tolland County, CT
10	3283	9003	10	0	1	Hartford County, CT
10	3640	0	8	1	1	#Jersey City, NJ
10	3640	34017	20	0	1	Hudson County, NJ
10	5015	0	8	1	3	#Middlesex-Somerset-Hunterdon, NJ
10	5015	34035	20	0	1	Somerset County, NJ
10	5015	34019	20	0	1	Hunterdon County, NJ
10	5015	34023	20	0	1	Middlesex County, NJ
10	5190	0	8	1	2	#Monmouth-Ocean, NJ
10	5190	34029	20	0	1	Ocean County, NJ
10	5190	34025	20	0	1	Monmouth County, NJ
10	5380	0	8	1	2	#Nassau-Suffolk, NY
10	5380	36059	20	0	1	Nassau County, NY
10	5380	36103	20	0	1	Suffolk County, NY

10	5483	0	8	1	3	#New Haven-Bridgeport-Stamford-Danbury-Waterbury, CT
10	5483	9009	20	0	1	New Haven County, CT
10	5483	9001	20	0	1	Fairfield County, CT
10	5483	9005	41	0	1	Litchfield County, CT
10	5523	0	8	1	1	New London-Norwich, CT
10	5523	9011	10	0	1	New London County, CT
10	5600	0	8	1	8	#New York, NY
10	5600	36079	20	0	1	Putnam County, NY
10	5600	36005	20	0	1	Bronx County, NY
10	5600	36061	20	0	1	New York County, NY
10	5600	36047	20	0	1	Kings County, NY
10	5600	36081	20	0	1	Queens County, NY
10	5600	36085	20	0	1	Richmond County, NY
10	5600	36087	20	0	1	Rockland County, NY
10	5600	36119	20	0	1	Westchester County, NY
10	5640	0	8	1	6	#Newark, NJ-PA
10	5640	34039	20	0	1	Union County, NJ
10	5640	34041	20	0	1	Warren County, NJ
10	5640	34027	20	0	1	Morris County, NJ
10	5640	34013	20	0	1	Essex County, NJ
10	5640	34037	20	0	1	Sussex County, NJ
10	5640	42089	40	0	1	Monroe County, PA
10	5660	0	8	1	3	#Newburgh, NY-PA
10	5660	36071	20	0	1	Orange County, NY
10	5660	36105	40	0	1	Sullivan County, NY
10	5660	42103	20	0	1	Pike County, PA
10	6323	0	8	1	2	Pittsfield, MA-VT
10	6323	25003	10	0	1	Berkshire County, MA
10	6323	50003	40	0	1	Bennington County, VT
10	7560	0	8	1	5	Scranton-Wilkes-Barre-Hazleton, PA
10	7560	42037	10	0	1	Columbia County, PA
10	7560	42079	10	0	1	Luzerne County, PA
10	7560	42069	10	0	1	Lackawanna County, PA
10	7560	42127	40	0	1	Wayne County, PA
10	7560	42131	10	0	1	Wyoming County, PA
10	8003	0	8	1	3	Springfield, MA
10	8003	25013	10	0	1	Hampden County, MA

10	8003	25015	10	0	1	Hampshire County, MA
10	8003	25011	40	0	1	Franklin County, MA
10	8480	0	8	1	1	#Trenton, NJ
10	8480	34021	20	0	1	Mercer County, NJ
10	9140	0	8	1	7	Williamsport, PA
10	9140	42093	41	0	1	Montour County, PA
10	9140	42081	10	0	1	Lycoming County, PA
10	9140	42035	40	0	1	Clinton County, PA
10	9140	42097	31	0	1	Northumberland County, PA
10	9140	42113	40	0	1	Sullivan County, PA
10	9140	42119	41	0	1	Union County, PA
10	9140	42109	41	0	1	Snyder County, PA
12	0	0	9	7	18	@Philadelphia-Wilmington-Atl. City, PA-NJ-DE-MD
12	560	0	8	1	2	#Atlantic-Cape May, NJ
12	560	34009	20	0	1	Cape May County, NJ
12	560	34001	20	0	1	Atlantic County, NJ
12	2190	0	8	1	1	Dover, DE
12	2190	10001	10	0	1	Kent County, DE
12	4000	0	8	1	1	Lancaster, PA
12	4000	42071	10	0	1	Lancaster County, PA
12	6160	0	8	1	9	#Philadelphia, PA-NJ
12	6160	34005	20	0	1	Burlington County, NJ
12	6160	34015	20	0	1	Gloucester County, NJ
12	6160	34007	20	0	1	Camden County, NJ
12	6160	34033	20	0	1	Salem County, NJ
12	6160	42029	20	0	1	Chester County, PA
12	6160	42017	20	0	1	Bucks County, PA
12	6160	42045	20	0	1	Delaware County, PA
12	6160	42091	20	0	1	Montgomery County, PA
12	6160	42101	20	0	1	Philadelphia County, PA
12	6680	0	8	1	2	Reading, PA
12	6680	42011	10	0	1	Berks County, PA
12	6680	42107	40	0	1	Schuylkill County, PA
12	8760	0	8	1	1	#Vineland-Millville-Bridgeton, NJ
12	8760	34011	20	0	1	Cumberland County, NJ
12	9160	0	8	1	2	#Wilmington-Newark, DE-MD
12	9160	10003	20	0	1	New Castle County, DE

12	9160	24015	20	0	1	Cecil County, MD
13	0	0	9	4	58	@Washington-Baltimore, DC-MD-VA-WV-PA
13	720	0	8	1	11	#Baltimore, MD
13	720	24035	20	0	1	Queen Anne's County, MD
13	720	24019	40	0	1	Dorchester County, MD
13	720	24005	20	0	1	Baltimore County, MD
13	720	24011	40	0	1	Caroline County, MD
13	720	24003	20	0	1	Anne Arundel County, MD
13	720	24041	40	0	1	Talbot County, MD
13	720	24025	20	0	1	Harford County, MD
13	720	24013	20	0	1	Carroll County, MD
13	720	24029	40	0	1	Kent County, MD
13	720	24027	20	0	1	Howard County, MD
13	720	24510	20	0	1	Baltimore city, MD
13	1900	0	8	1	3	Cumberland, MD-WV
13	1900	24023	40	0	1	Garrett County, MD
13	1900	24001	10	0	1	Allegany County, MD
13	1900	54057	10	0	1	Mineral County, WV
13	3180	0	8	1	3	#Hagerstown, MD-PA
13	3180	24043	20	0	1	Washington County, MD
13	3180	42057	40	0	1	Fulton County, PA
13	3180	42055	40	0	1	Franklin County, PA
13	8840	0	8	1	41	#Washington, DC-MD-VA-WV
13	8840	11001	20	0	1	District of Columbia, DC
13	8840	24017	20	0	1	Charles County, MD
13	8840	24037	40	0	1	St. Mary's County, MD
13	8840	24033	20	0	1	Prince George's County, MD
13	8840	24031	20	0	1	Montgomery County, MD
13	8840	24021	20	0	1	Frederick County, MD
13	8840	24009	20	0	1	Calvert County, MD
13	8840	51069	70	0	1	Frederick County, VA
13	8840	51061	20	0	1	Fauquier County, VA
13	8840	51043	20	0	1	Clarke County, VA
13	8840	51047	20	0	1	Culpeper County, VA
13	8840	51059	20	0	1	Fairfax County, VA
13	8840	51013	20	0	1	Arlington County, VA
13	8840	51099	20	0	1	King George County, VA

13	8840	51033	41	0	1	Caroline County, VA
13	8840	51157	40	0	1	Rappahannock County, VA
13	8840	51113	40	0	1	Madison County, VA
13	8840	51137	40	0	1	Orange County, VA
13	8840	51139	41	0	1	Page County, VA
13	8840	51153	20	0	1	Prince William County, VA
13	8840	51179	20	0	1	Stafford County, VA
13	8840	51171	70	0	1	Shenandoah County, VA
13	8840	51177	20	0	1	Spotsylvania County, VA
13	8840	51107	20	0	1	Loudoun County, VA
13	8840	51187	20	0	1	Warren County, VA
13	8840	51193	40	0	1	Westmoreland County, VA
13	8840	51510	20	0	1	Alexandria city, VA
13	8840	51610	20	0	1	Falls Church city, VA
13	8840	51685	20	0	1	Manassas Park city, VA
13	8840	51630	20	0	1	Fredericksburg city, VA
13	8840	51600	20	0	1	Fairfax city, VA
13	8840	51683	20	0	1	Manassas city, VA
13	8840	51840	70	0	1	Winchester city, VA
13	8840	54065	41	0	1	Morgan County, WV
13	8840	54023	41	0	1	Grant County, WV
13	8840	54027	51	0	1	Hampshire County, WV
13	8840	54031	41	0	1	Hardy County, WV
13	8840	54003	20	0	1	Berkeley County, WV
13	8840	54037	20	0	1	Jefferson County, WV
13	8840	54083	61	0	1	Randolph County, WV
13	8840	54093	41	0	1	Tucker County, WV
31	0	0	9	4	10	@Miami-Fort Lauderdale, FL
31	2680	0	8	1	1	#Fort Lauderdale, FL
31	2680	12011	20	0	1	Broward County, FL
31	2710	0	8	1	4	Fort Pierce-Port St. Lucie, FL
31	2710	12085	10	0	1	Martin County, FL
31	2710	12061	40	0	1	Indian River County, FL
31	2710	12093	41	0	1	Okeechobee County, FL
31	2710	12111	10	0	1	St. Lucie County, FL
31	5000	12086	8	1	2	#Miami, FL
31	5000	12025	20	0	1	Dade County, FL

31	5000	12087	40	0	1	Monroe County, FL
31	8960	0	8	1	3	West Palm Beach-Boca Raton, FL
31	8960	12043	40	0	1	Glades County, FL
31	8960	12099	10	0	1	Palm Beach County, FL
31	8960	12051	40	0	1	Hendry County, FL
64	0	0	9	7	30	@Chicago-Gary-Kenosha, IL-IN-WI
64	1040	0	8	1	2	Bloomington-Normal, IL
64	1040	17039	40	0	1	De Witt County, IL
64	1040	17113	10	0	1	McLean County, IL
64	1600	0	8	1	13	#Chicago, IL
64	1600	17043	20	0	1	DuPage County, IL
64	1600	17031	20	0	1	Cook County, IL
64	1600	17093	20	0	1	Kendall County, IL
64	1600	17089	20	0	1	Kane County, IL
64	1600	17097	20	0	1	Lake County, IL
64	1600	17037	20	0	1	DeKalb County, IL
64	1600	17011	40	0	1	Bureau County, IL
64	1600	17063	20	0	1	Grundy County, IL
64	1600	17099	40	0	1	La Salle County, IL
64	1600	17111	20	0	1	McHenry County, IL
64	1600	17105	40	0	1	Livingston County, IL
64	1600	17155	40	0	1	Putnam County, IL
64	1600	17197	20	0	1	Will County, IL
64	2960	0	8	1	5	#Gary, IN
64	2960	18091	40	0	1	La Porte County, IN
64	2960	18089	20	0	1	Lake County, IN
64	2960	18073	40	0	1	Jasper County, IN
64	2960	18111	40	0	1	Newton County, IN
64	2960	18127	20	0	1	Porter County, IN
64	3620	0	8	1	1	Janesville-Beloit, WI
64	3620	55105	10	0	1	Rock County, WI
64	3740	0	8	1	2	#Kankakee, IL
64	3740	17091	20	0	1	Kankakee County, IL
64	3740	17075	40	0	1	Iroquois County, IL
64	3800	0	8	1	1	#Kenosha, WI
64	3800	55059	20	0	1	Kenosha County, WI
64	6880	0	8	1	6	Rockford, IL

64	6880	17007	10	0	1	Boone County, IL
64	6880	17015	40	0	1	Carroll County, IL
64	6880	17141	10	0	1	Ogle County, IL
64	6880	17103	40	0	1	Lee County, IL
64	6880	17177	40	0	1	Stephenson County, IL
64	6880	17201	10	0	1	Winnebago County, IL
65	0	0	9	3	11	Elkhart-Goshen, IN-MI
65	870	0	8	1	1	Benton Harbor, MI
65	870	26021	10	0	1	Berrien County, MI
65	2330	0	8	1	5	Elkhart-Goshen, IN-MI
65	2330	18039	10	0	1	Elkhart County, IN
65	2330	18085	40	0	1	Kosciusko County, IN
65	2330	18087	40	0	1	Lagrange County, IN
65	2330	26027	40	0	1	Cass County, MI
65	2330	26149	40	0	1	St. Joseph County, MI
65	7800	0	8	1	5	South Bend, IN
65	7800	18049	40	0	1	Fulton County, IN
65	7800	18099	40	0	1	Marshall County, IN
65	7800	18149	40	0	1	Starke County, IN
65	7800	18131	40	0	1	Pulaski County, IN
65	7800	18141	10	0	1	St. Joseph County, IN
71	0	0	9	4	54	Nashville, TN-KY
71	1660	0	8	1	5	Clarksville-Hopkinsville, TN-KY
71	1660	21047	10	0	1	Christian County, KY
71	1660	21219	40	0	1	Todd County, KY
71	1660	21221	40	0	1	Trigg County, KY
71	1660	47161	40	0	1	Stewart County, TN
71	1660	47125	10	0	1	Montgomery County, TN
71	5360	0	8	1	36	Nashville, TN-KY
71	5360	21057	40	0	1	Cumberland County, KY
71	5360	21003	41	0	1	Allen County, KY
71	5360	21141	41	0	1	Logan County, KY
71	5360	21171	41	0	1	Monroe County, KY
71	5360	21213	41	0	1	Simpson County, KY
71	5360	47085	40	0	1	Humphreys County, TN
71	5360	47051	40	0	1	Franklin County, TN
71	5360	47055	40	0	1	Giles County, TN

71	5360	47061	41	0	1	Grundy County, TN
71	5360	47041	40	0	1	DeKalb County, TN
71	5360	47003	40	0	1	Bedford County, TN
71	5360	47021	10	0	1	Cheatham County, TN
71	5360	47099	40	0	1	Lawrence County, TN
71	5360	47081	40	0	1	Hickman County, TN
71	5360	47031	40	0	1	Coffee County, TN
71	5360	47037	10	0	1	Davidson County, TN
71	5360	47043	10	0	1	Dickson County, TN
71	5360	47015	40	0	1	Cannon County, TN
71	5360	47027	40	0	1	Clay County, TN
71	5360	47083	41	0	1	Houston County, TN
71	5360	47111	40	0	1	Macon County, TN
71	5360	47165	10	0	1	Sumner County, TN
71	5360	47119	40	0	1	Maury County, TN
71	5360	47127	40	0	1	Moore County, TN
71	5360	47149	10	0	1	Rutherford County, TN
71	5360	47159	40	0	1	Smith County, TN
71	5360	47189	10	0	1	Wilson County, TN
71	5360	47169	40	0	1	Trousdale County, TN
71	5360	47175	40	0	1	Van Buren County, TN
71	5360	47135	41	0	1	Perry County, TN
71	5360	47147	10	0	1	Robertson County, TN
71	5360	47181	40	0	1	Wayne County, TN
71	5360	47101	40	0	1	Lewis County, TN
71	5360	47187	10	0	1	Williamson County, TN
71	5360	47117	40	0	1	Marshall County, TN
71	5360	47177	40	0	1	Warren County, TN
71	9516	0	8	1	6	*Bowling Green, KY
71	9516	21009	40	0	1	Barren County, KY
71	9516	21061	40	0	1	Edmonson County, KY
71	9516	21099	40	0	1	Hart County, KY
71	9516	21031	40	0	1	Butler County, KY
71	9516	21169	40	0	1	Metcalfe County, KY
71	9516	21227	30	0	1	Warren County, KY
71	9558	0	8	1	7	*Cookeville, TN
71	9558	47087	40	0	1	Jackson County, TN

71	9558	47049	40	0	1	Fentress County, TN
71	9558	47035	40	0	1	Cumberland County, TN
71	9558	47137	40	0	1	Pickett County, TN
71	9558	47133	40	0	1	Overton County, TN
71	9558	47185	40	0	1	White County, TN
71	9558	47141	30	0	1	Putnam County, TN
107	0	0	9	5	70	Minneapolis-St. Paul, MN-WI-IA
107	2290	0	8	1	2	Eau Claire, WI
107	2290	55017	10	0	1	Chippewa County, WI
107	2290	55035	10	0	1	Eau Claire County, WI
107	5120	0	8	1	52	Minneapolis-St. Paul, MN-WI
107	5120	27051	51	0	1	Grant County, MN
107	5120	27053	10	0	1	Hennepin County, MN
107	5120	27057	50	0	1	Hubbard County, MN
107	5120	27059	10	0	1	Isanti County, MN
107	5120	27065	40	0	1	Kanabec County, MN
107	5120	27067	41	0	1	Kandiyohi County, MN
107	5120	27035	50	0	1	Crow Wing County, MN
107	5120	27073	50	0	1	Lac qui Parle County, MN
107	5120	27079	40	0	1	Le Sueur County, MN
107	5120	27081	70	0	1	Lincoln County, MN
107	5120	27049	41	0	1	Goodhue County, MN
107	5120	27093	40	0	1	Meeker County, MN
107	5120	27029	50	0	1	Clearwater County, MN
107	5120	27001	50	0	1	Aitkin County, MN
107	5120	27003	10	0	1	Anoka County, MN
107	5120	27007	50	0	1	Beltrami County, MN
107	5120	27019	10	0	1	Carver County, MN
107	5120	27021	50	0	1	Cass County, MN
107	5120	27023	50	0	1	Chippewa County, MN
107	5120	27025	10	0	1	Chisago County, MN
107	5120	27083	70	0	1	Lyon County, MN
107	5120	27085	40	0	1	McLeod County, MN
107	5120	27041	50	0	1	Douglas County, MN
107	5120	27047	41	0	1	Freeborn County, MN
107	5120	27037	10	0	1	Dakota County, MN
107	5120	27095	40	0	1	Mille Lacs County, MN

107	5120	27121	50	0	1	Pope County, MN
107	5120	27149	50	0	1	Stevens County, MN
107	5120	27115	41	0	1	Pine County, MN
107	5120	27129	50	0	1	Renville County, MN
107	5120	27123	10	0	1	Ramsey County, MN
107	5120	27127	50	0	1	Redwood County, MN
107	5120	27141	10	0	1	Sherburne County, MN
107	5120	27143	40	0	1	Sibley County, MN
107	5120	27147	40	0	1	Steele County, MN
107	5120	27163	10	0	1	Washington County, MN
107	5120	27151	41	0	1	Swift County, MN
107	5120	27131	40	0	1	Rice County, MN
107	5120	27139	10	0	1	Scott County, MN
107	5120	27161	41	0	1	Waseca County, MN
107	5120	27173	70	0	1	Yellow Medicine County, MN
107	5120	27171	10	0	1	Wright County, MN
107	5120	55005	40	0	1	Barron County, WI
107	5120	55095	40	0	1	Polk County, WI
107	5120	55091	41	0	1	Pepin County, WI
107	5120	55033	41	0	1	Dunn County, WI
107	5120	55093	10	0	1	Pierce County, WI
107	5120	55013	40	0	1	Burnett County, WI
107	5120	55129	40	0	1	Washburn County, WI
107	5120	55113	50	0	1	Sawyer County, WI
107	5120	55107	40	0	1	Rusk County, WI
107	5120	55109	10	0	1	St. Croix County, WI
107	6980	0	8	1	5	St. Cloud, MN
107	6980	27097	40	0	1	Morrison County, MN
107	6980	27009	10	0	1	Benton County, MN
107	6980	27153	40	0	1	Todd County, MN
107	6980	27159	40	0	1	Wadena County, MN
107	6980	27145	10	0	1	Stearns County, MN
107	9522	0	8	1	6	*Mankato, MN
107	9522	27013	30	0	1	Blue Earth County, MN
107	9522	27015	40	0	1	Brown County, MN
107	9522	27091	40	0	1	Martin County, MN
107	9522	27043	40	0	1	Faribault County, MN

107	9522	27103	40	0	1	Nicollet County, MN
107	9522	27165	40	0	1	Watonwan County, MN
107	9523	0	8	1	5	*Worthington, MN-IA
107	9523	19143	40	0	1	Osceola County, IA
107	9523	27063	40	0	1	Jackson County, MN
107	9523	27033	40	0	1	Cottonwood County, MN
107	9523	27105	30	0	1	Nobles County, MN
107	9523	27101	40	0	1	Murray County, MN
127	0	0	9	9	77	@Dallas-Fort Worth, TX-AR-OK
127	1920	0	8	1	24	#Dallas, TX-OK
127	1920	40023	60	0	1	Choctaw County, OK
127	1920	40127	60	0	1	Pushmataha County, OK
127	1920	48085	20	0	1	Collin County, TX
127	1920	48097	40	0	1	Cooke County, TX
127	1920	48063	50	0	1	Camp County, TX
127	1920	48119	40	0	1	Delta County, TX
127	1920	48147	41	0	1	Fannin County, TX
127	1920	48121	20	0	1	Denton County, TX
127	1920	48113	20	0	1	Dallas County, TX
127	1920	48139	20	0	1	Ellis County, TX
127	1920	48159	50	0	1	Franklin County, TX
127	1920	48231	20	0	1	Hunt County, TX
127	1920	48213	20	0	1	Henderson County, TX
127	1920	48257	20	0	1	Kaufman County, TX
127	1920	48277	50	0	1	Lamar County, TX
127	1920	48223	40	0	1	Hopkins County, TX
127	1920	48343	51	0	1	Morris County, TX
127	1920	48349	40	0	1	Navarro County, TX
127	1920	48379	40	0	1	Rains County, TX
127	1920	48387	50	0	1	Red River County, TX
127	1920	48397	20	0	1	Rockwall County, TX
127	1920	48467	40	0	1	Van Zandt County, TX
127	1920	48499	41	0	1	Wood County, TX
127	1920	48449	50	0	1	Titus County, TX
127	2800	0	8	1	20	#Fort Worth-Arlington, TX
127	2800	48093	40	0	1	Comanche County, TX
127	2800	48049	51	0	1	Brown County, TX

127	2800	48083	51	0	1	Coleman County, TX
127	2800	48133	40	0	1	Eastland County, TX
127	2800	48143	40	0	1	Erath County, TX
127	2800	48193	41	0	1	Hamilton County, TX
127	2800	48221	20	0	1	Hood County, TX
127	2800	48237	50	0	1	Jack County, TX
127	2800	48251	20	0	1	Johnson County, TX
127	2800	48337	40	0	1	Montague County, TX
127	2800	48363	40	0	1	Palo Pinto County, TX
127	2800	48367	20	0	1	Parker County, TX
127	2800	48333	51	0	1	Mills County, TX
127	2800	48447	51	0	1	Throckmorton County, TX
127	2800	48497	40	0	1	Wise County, TX
127	2800	48425	40	0	1	Somervell County, TX
127	2800	48411	51	0	1	San Saba County, TX
127	2800	48439	20	0	1	Tarrant County, TX
127	2800	48429	40	0	1	Stephens County, TX
127	2800	48503	51	0	1	Young County, TX
127	3810	0	8	1	3	Killeen-Temple, TX
127	3810	48099	10	0	1	Coryell County, TX
127	3810	48027	10	0	1	Bell County, TX
127	3810	48281	40	0	1	Lampasas County, TX
127	4420	0	8	1	6	Longview-Marshall, TX
127	4420	48183	10	0	1	Gregg County, TX
127	4420	48203	10	0	1	Harrison County, TX
127	4420	48365	40	0	1	Panola County, TX
127	4420	48315	40	0	1	Marion County, TX
127	4420	48401	40	0	1	Rusk County, TX
127	4420	48459	10	0	1	Upshur County, TX
127	7640	0	8	1	2	Sherman-Denison, TX-OK
127	7640	40013	40	0	1	Bryan County, OK
127	7640	48181	10	0	1	Grayson County, TX
127	8360	0	8	1	7	Texarkana, TX-Texarkana, AR-AR-OK
127	8360	5081	40	0	1	Little River County, AR
127	8360	5091	10	0	1	Miller County, AR
127	8360	5113	51	0	1	Polk County, AR
127	8360	5133	50	0	1	Sevier County, AR

127	8360	40089	60	0	1	McCurtain County, OK
127	8360	48067	40	0	1	Cass County, TX
127	8360	48037	10	0	1	Bowie County, TX
127	8640	0	8	1	3	Tyler, TX
127	8640	48001	40	0	1	Anderson County, TX
127	8640	48073	40	0	1	Cherokee County, TX
127	8640	48423	10	0	1	Smith County, TX
127	8800	0	8	1	4	Waco, TX
127	8800	48035	40	0	1	Bosque County, TX
127	8800	48145	40	0	1	Falls County, TX
127	8800	48217	40	0	1	Hill County, TX
127	8800	48309	10	0	1	McLennan County, TX
127	9080	0	8	1	8	Wichita Falls, TX-OK
127	9080	40141	40	0	1	Tillman County, OK
127	9080	48077	40	0	1	Clay County, TX
127	9080	48009	10	0	1	Archer County, TX
127	9080	48023	50	0	1	Baylor County, TX
127	9080	48155	40	0	1	Foard County, TX
127	9080	48197	40	0	1	Hardeman County, TX
127	9080	48487	40	0	1	Wilbarger County, TX
127	9080	48485	10	0	1	Wichita County, TX
152	0	0	9	2	22	Salt Lake City-Ogden, UT-ID
152	6520	0	8	1	1	Provo-Orem, UT
152	6520	49049	10	0	1	Utah County, UT
152	7160	0	8	1	21	Salt Lake City-Ogden, UT-ID
152	7160	16041	40	0	1	Franklin County, ID
152	7160	16071	40	0	1	Oneida County, ID
152	7160	49007	50	0	1	Carbon County, UT
152	7160	49029	40	0	1	Morgan County, UT
152	7160	49035	10	0	1	Salt Lake County, UT
152	7160	49039	50	0	1	Sanpete County, UT
152	7160	49003	40	0	1	Box Elder County, UT
152	7160	49043	40	0	1	Summit County, UT
152	7160	49045	40	0	1	Tooele County, UT
152	7160	49047	50	0	1	Uintah County, UT
152	7160	49011	10	0	1	Davis County, UT
152	7160	49051	40	0	1	Wasatch County, UT

152	7160	49055	60	0	1	Wayne County, UT
152	7160	49019	51	0	1	Grand County, UT
152	7160	49041	50	0	1	Sevier County, UT
152	7160	49057	10	0	1	Weber County, UT
152	7160	49023	41	0	1	Juab County, UT
152	7160	49027	50	0	1	Millard County, UT
152	7160	49005	40	0	1	Cache County, UT
152	7160	49013	50	0	1	Duchesne County, UT
152	7160	49015	60	0	1	Emery County, UT
156	0	0	9	1	9	Albuquerque, NM-AZ
156	200	0	8	1	9	Albuquerque, NM-AZ
156	200	4001	41	0	1	Apache County, AZ
156	200	35053	40	0	1	Socorro County, NM
156	200	35061	10	0	1	Valencia County, NM
156	200	35003	41	0	1	Catron County, NM
156	200	35006	40	0	1	Cibola County, NM
156	200	35031	31	0	1	McKinley County, NM
156	200	35043	10	0	1	Sandoval County, NM
156	200	35057	40	0	1	Torrance County, NM
156	200	35001	10	0	1	Bernalillo County, NM
160	0	0	9	8	11	@Los Angeles-Riverside-Orange County, CA-AZ
160	680	0	8	1	1	Bakersfield, CA
160	680	6029	10	0	1	Kern County, CA
160	4480	0	8	1	1	#Los Angeles-Long Beach, CA
160	4480	6037	20	0	1	Los Angeles County, CA
160	5945	0	8	1	1	#Orange County, CA
160	5945	6059	20	0	1	Orange County, CA
160	6780	0	8	1	4	#Riverside-San Bernardino, CA-AZ
160	6780	4012	40	0	1	La Paz County, AZ
160	6780	6065	20	0	1	Riverside County, CA
160	6780	6025	40	0	1	Imperial County, CA
160	6780	6071	20	0	1	San Bernardino County, CA
160	7460	0	8	1	1	San Luis Obispo-Atascadero-Pasa Robles, CA
160	7460	6079	10	0	1	San Luis Obispo County, CA
160	7480	0	8	1	1	Santa Barbara-Santa Maria-Lompoc, CA
160	7480	6083	10	0	1	Santa Barbara County, CA
160	8735	0	8	1	1	#Ventura, CA

160	8735	6111	20	0	1	Ventura County, CA
160	9360	0	8	1	1	Yuma, AZ
160	9360	4027	10	0	1	Yuma County, AZ
161	0	0	9	1	1	San Diego, CA
161	7320	0	8	1	1	San Diego, CA
161	7320	6073	10	0	1	San Diego County, CA
163	0	0	9	10	22	@San Francisco-Oakland-San Jose, CA
163	4940	0	8	1	1	Merced, CA
163	4940	6047	10	0	1	Merced County, CA
163	5170	0	8	1	3	Modesto, CA
163	5170	6043	41	0	1	Mariposa County, CA
163	5170	6099	10	0	1	Stanislaus County, CA
163	5170	6109	40	0	1	Tuolumne County, CA
163	5775	0	8	1	2	#Oakland, CA
163	5775	6013	20	0	1	Contra Costa County, CA
163	5775	6001	20	0	1	Alameda County, CA
163	7120	0	8	1	1	Salinas, CA
163	7120	6053	10	0	1	Monterey County, CA
163	7360	0	8	1	3	#San Francisco, CA
163	7360	6081	20	0	1	San Mateo County, CA
163	7360	6041	20	0	1	Marin County, CA
163	7360	6075	20	0	1	San Francisco County, CA
163	7400	0	8	1	2	#San Jose, CA
163	7400	6069	40	0	1	San Benito County, CA
163	7400	6085	20	0	1	Santa Clara County, CA
163	7485	0	8	1	1	#Santa Cruz-Watsonville, CA
163	7485	6087	20	0	1	Santa Cruz County, CA
163	7500	0	8	1	5	#Santa Rosa, CA
163	7500	6097	20	0	1	Sonoma County, CA
163	7500	6033	40	0	1	Lake County, CA
163	7500	6023	40	0	1	Humboldt County, CA
163	7500	6045	40	0	1	Mendocino County, CA
163	7500	6105	40	0	1	Trinity County, CA
163	8120	0	8	1	2	Stockton-Lodi, CA
163	8120	6077	10	0	1	San Joaquin County, CA
163	8120	6009	40	0	1	Calaveras County, CA
163	8720	0	8	1	2	#Vallejo-Fairfield-Napa, CA

163	8720	6055	20	0	1	Napa County, CA
163	8720	6095	20	0	1	Solano County, CA
167	0	0	9	2	24	@Portland-Salem, OR-WA
167	6440	0	8	1	19	#Portland-Vancouver, OR-WA
167	6440	41009	20	0	1	Columbia County, OR
167	6440	41005	20	0	1	Clackamas County, OR
167	6440	41007	40	0	1	Clatsop County, OR
167	6440	41055	50	0	1	Sherman County, OR
167	6440	41057	41	0	1	Tillamook County, OR
167	6440	41013	41	0	1	Crook County, OR
167	6440	41017	31	0	1	Deschutes County, OR
167	6440	41027	50	0	1	Hood River County, OR
167	6440	41031	41	0	1	Jefferson County, OR
167	6440	41037	41	0	1	Lake County, OR
167	6440	41051	20	0	1	Multnomah County, OR
167	6440	41071	20	0	1	Yamhill County, OR
167	6440	41065	50	0	1	Wasco County, OR
167	6440	41067	20	0	1	Washington County, OR
167	6440	53039	50	0	1	Klickitat County, WA
167	6440	53011	20	0	1	Clark County, WA
167	6440	53015	40	0	1	Cowlitz County, WA
167	6440	53059	40	0	1	Skamania County, WA
167	6440	53069	41	0	1	Wahkiakum County, WA
167	7080	0	8	1	5	#Salem, OR
167	7080	41053	20	0	1	Polk County, OR
167	7080	41003	31	0	1	Benton County, OR
167	7080	41041	41	0	1	Lincoln County, OR
167	7080	41043	41	0	1	Linn County, OR
167	7080	41047	20	0	1	Marion County, OR
170	0	0	9	5	15	@Seattle-Tacoma-Bremerton, WA
170	860	0	8	1	1	Bellingham, WA
170	860	53073	10	0	1	Whatcom County, WA
170	1150	0	8	1	4	#Bremerton, WA
170	1150	53045	40	0	1	Mason County, WA
170	1150	53009	40	0	1	Clallam County, WA
170	1150	53035	20	0	1	Kitsap County, WA
170	1150	53031	40	0	1	Jefferson County, WA

170	5910	0	8	1	4	#Olympia, WA
170	5910	53049	40	0	1	Pacific County, WA
170	5910	53027	40	0	1	Grays Harbor County, WA
170	5910	53041	40	0	1	Lewis County, WA
170	5910	53067	20	0	1	Thurston County, WA
170	7600	0	8	1	5	#Seattle-Bellevue-Everett, WA
170	7600	53033	20	0	1	King County, WA
170	7600	53055	40	0	1	San Juan County, WA
170	7600	53029	20	0	1	Island County, WA
170	7600	53057	40	0	1	Skagit County, WA
170	7600	53061	20	0	1	Snohomish County, WA
170	8200	0	8	1	1	#Tacoma, WA
170	8200	53053	20	0	1	Pierce County, WA
171	0	0	9	2	25	Anchorage, AK
171	380	0	8	1	18	Anchorage, AK
171	380	2050	50	0	1	Bethel Census Area, AK
171	380	2060	50	0	1	Bristol Bay Borough, AK
171	380	2016	70	0	1	Aleutians West Census Area, AK
171	380	2020	10	0	1	Anchorage Borough, AK
171	380	2013	70	0	1	Aleutians East Borough, AK
171	380	2070	50	0	1	Dillingham Census Area, AK
171	380	2090	31	0	1	Fairbanks North Star Borough, AK
171	380	2185	70	0	1	North Slope Borough, AK
171	380	2122	50	0	1	Kenai Peninsula Borough, AK
171	380	2188	70	0	1	Northwest Arctic Borough, AK
171	380	2150	50	0	1	Kodiak Island Borough, AK
171	380	2164	60	0	1	Lake and Peninsula Borough, AK
171	380	2170	40	0	1	Matanuska-Susitna Borough, AK
171	380	2180	70	0	1	Nome Census Area, AK
171	380	2240	51	0	1	Southeast Fairbanks Census Area, AK
171	380	2270	60	0	1	Wade Hampton Census Area, AK
171	380	2261	40	0	1	Valdez-Cordova Census Area, AK
171	380	2290	51	0	1	Yukon-Koyukuk Census Area, AK
171	9569	0	8	1	7	*Alaska Panhandle, AK
171	9569	2100	40	0	1	Haines Borough, AK
171	9569	2110	30	0	1	Juneau Borough, AK
171	9569	2130	40	0	1	Ketchikan Gateway Borough, AK

171	9569	2231	40	0	1	Skagway-Yakutat-Angoon Census Area, AK
171	9569	2280	40	0	1	Wrangell-Petersburg Census Area, AK
171	9569	2220	40	0	1	Sitka Borough, AK
171	9569	2201	40	0	1	Prince of Wales-Outer Ketchikan Census Area, AK

DETAILED CODE FILE FOR DEFINITIONS OF BEA COMPONENT ECONOMIC AREAS
AND THE FINAL REDEFINITIONS OF THE BEA ECONOMIC AREAS

February, 1995

This file includes 3,661 lines of data. These records include codes, names, and other information for 3,141 counties (all those summarized from the 1990 Census of Population), for 348 Component Economic Areas (CEA's), and for the 172 BEA Economic Areas. The file is sorted by economic area code (a geographic ordering), by CEA (alphabetically) within each economic area, and by county (alphabetically) within each CEA. Each record has six numerical fields followed by a 58-character area name. The numerical fields, in order, are:

the 3-digit economic-area code,
the 4-digit CEA code,
the 5-digit State/County FIPS code,
the 2-digit area-type code*,
the count of the number of CEA's included (3-digit field), and
a count of the number of counties included (3-digit field).

The 3-digit economic area code was assigned after the areas were defined, beginning with 1 in northern Maine, continuing south to Florida, then north to the Great Lakes, continuing in a serpentine pattern to the west coast, and ending with Alaska (EA#171) and Hawaii (EA#172).

The 4-digit CEA code generally is the FIPS code for the metropolitan area serving as the CEA's node. Codes for the 38 nonmetropolitan nodes (areas) were assigned and are distinguished by having "95" in the first two positions.

The 5-digit county code is simply the 2-digit State FIPS code followed by the 3-digit county FIPS code.

*The area-type code is "8" for records related to CEA's and is "9" for records related to economic areas. All county records have a code of 10 or more. The 1st digit indicates the initial assignment status of the county in the economic area redefinition process; the second digit in the county type code is "0" if the initial assignment was not changed, it is "1" in cases where the assignment was changed during the analytical refinement processes, and it is "2" for the two cases where the CEA assignments of counties were changed following public comment on their preliminary assignments. Initial assignment status codes (the ten's digit) are:

Code	Meaning
1	A CEA's nodal county within an MSA or NECMA
2	A CEA's nodal county within a PMSA
3	A CEA's nonmetropolitan node
4	Part of the Main Labor Hinterlands for a CEA node
5	Part of the Newspaper-Readership Hinterlands for a CEA node
6	Part of the Secondary Labor Hinterlands for a CEA Node
7	One of 68 counties requiring special assignment processes

Note: Lamar and Forrest counties in Mississippi were declared in late 1994 by OMB to constitute the new Hattiesburg MSA. County codes for these counties do not reflect this change. They would each be given an assignment code of 10 to reflect their current status. This change did not affect the development of the Hattiesburg Component Economic Area.

Hinterland assignments are made only if a candidate county is contiguous to at least one county already assigned to a CEA. Subject to that constraint: The main labor hinterlands are nonnodal counties whose main commuting flow is (1) directly to a CEA node, or (2) to another nonnodal county whose main flow is directly to a CEA node, or (3) to another nonnodal county whose main flow is to another nonnodal county whose main flow is directly to a CEA node. Newspaper-readership hinterlands are nonnodal counties, not in the main labor hinterlands, whose main source of newspapers is within a CEA

node or the main labor hinterlands. Secondary labor hinterlands are counties that require the newspaper-readership hinterlands in order to establish contiguity or a main commuting flow to a county in one of the emerging CEA's.

The count fields provide the number of subordinate areas within each larger area. They are not meaningful in all records. The count of CEA's is meaningful only for economic area records (type code 9) and the count of counties is meaningful only for economic area and CEA records (type codes 9 and 8).

The name on each county record reflects that used in the reports of county data from the 1990 census; CEA and economic area names reflect the metropolitan area names used in OMB announcements and the nonmetropolitan node names--usually the largest cities within the associated CEA's.

Economic areas including a CMSA are always named for the CMSA and this name is preceded by the @ symbol in the file. The names of CEA's that have PMSA's as their nodes are preceded by the # symbol. The names of economic areas or CEA's that are named after nonmetropolitan nodes are preceded by the * symbol. All other CEA's have MSA's or NECMA's as their nodes.

This files were prepared by:

U.S. Department of Commerce
Bureau of Economic Analysis
Regional Economic Analysis Division
Washington, DC 20230

Additional discussion of the BEA economic areas and a two-page map of the areas may be found in "Redefinition of the BEA Economic Areas," Survey of Current Business, 70 (February, 1995).

Contact Kenneth Johnson at (202) 606-9219 if any questions arise regarding the use of this information.

6.3 APPENDIX C – 218-219 MHZ SERVICE, SPECTRUM BLOCK EA CORRELATION

Data from FCC Auction 89, Attachment A

License	Market Name	Market	EA Code	Frequency Block	Bandwidth (kHz)
ZV-CMA006-A	Boston-Brockton-Lowell, MA-NH	CMA006	3	A	500
ZV-CMA006-B	Boston-Brockton-Lowell, MA-NH	CMA006	3	B	500
ZV-CMA007-A	San Francisco-Oakland, CA	CMA007	163	A	500
ZV-CMA007-B	San Francisco-Oakland, CA	CMA007	163	B	500
ZV-CMA012-A	Miami-Fort Lauderdale, FL	CMA012	31	A	500
ZV-CMA014-A	Baltimore, MD	CMA014	13	A	500
ZV-CMA014-B	Baltimore, MD	CMA014	13	B	500
ZV-CMA015-A	Minneapolis-St. Paul, MN-WI	CMA015	107	A	500
ZV-CMA015-B	Minneapolis-St. Paul, MN-WI	CMA015	107	B	500
ZV-CMA018-A	San Diego, CA	CMA018	161	A	500
ZV-CMA018-B	San Diego, CA	CMA018	161	B	500
ZV-CMA020-A	Seattle-Everett, WA	CMA020	170	A	500
ZV-CMA020-B	Seattle-Everett, WA	CMA020	170	B	500
ZV-CMA027-A	San Jose, CA	CMA027	163	A	500
ZV-CMA027-B	San Jose, CA	CMA027	163	B	500
ZV-CMA030-A	Portland, OR-WA	CMA030	167	A	500
ZV-CMA030-B	Portland, OR-WA	CMA030	167	B	500
ZV-CMA032-A	Hartford-Bristol, CT	CMA032	10	A	500
ZV-CMA032-B	Hartford-Bristol, CT	CMA032	10	B	500
ZV-CMA038-A	Providence-Warwick, RI	CMA038	3	A	500
ZV-CMA038-B	Providence-Warwick, RI	CMA038	3	B	500
ZV-CMA039-A	Salt Lake City-Ogden, UT	CMA039	152	A	500
ZV-CMA039-B	Salt Lake City-Ogden, UT	CMA039	152	B	500
ZV-CMA042-A	Bridgeport-Stamford-Danbury CT	CMA042	10	A	500
ZV-CMA042-B	Bridgeport-Stamford-Danbury CT	CMA042	10	B	500
ZV-CMA046-A	Nashville-Davidson, TN	CMA046	71	A	500
ZV-CMA046-B	Nashville-Davidson, TN	CMA046	71	B	500
ZV-CMA049-A	New Haven-Waterbury-Meriden CT	CMA049	10	A	500
ZV-CMA049-B	New Haven-Waterbury-Meriden CT	CMA049	10	B	500
ZV-CMA054-B	Gary-Hammond-East Chicago, IN	CMA054	64	B	500
ZV-CMA055-A	Worchester-Leominster, MA	CMA055	3	A	500
ZV-CMA055-B	Worchester-Leominster, MA	CMA055	3	B	500
ZV-CMA056-A	Northeast Pennsylvania, PA	CMA056	10	A	500
ZV-CMA056-B	Northeast Pennsylvania, PA	CMA056	10	B	500
ZV-CMA058-A	Allentown-Bethlehem, PA-NJ	CMA058	10	A	500
ZV-CMA058-B	Allentown-Bethlehem, PA-NJ	CMA058	10	B	500
ZV-CMA062-A	New Brunswick-Perth Amboy, NJ	CMA062	10	A	500
ZV-CMA062-B	New Brunswick-Perth Amboy, NJ	CMA062	10	B	500
ZV-CMA063-A	Springfield-Holyoke, MA	CMA063	10	A	500
ZV-CMA063-B	Springfield-Holyoke, MA	CMA063	10	B	500
ZV-CMA069-A	Wilmington, DE-NJ-MD	CMA069	12	A	500
ZV-CMA069-B	Wilmington, DE-NJ-MD	CMA069	12	B	500
ZV-CMA070-A	Long Branch-Asbury Park, NJ	CMA070	10	A	500
ZV-CMA070-B	Long Branch-Asbury Park, NJ	CMA070	10	B	500
ZV-CMA072-A	West Palm Beach-Boca Raton, FL	CMA072	31	A	500
ZV-CMA072-B	West Palm Beach-Boca Raton, FL	CMA072	31	B	500
ZV-CMA073-A	Oxnard-Simi Valley-Ventura, CA	CMA073	160	A	500
ZV-CMA073-B	Oxnard-Simi Valley-Ventura, CA	CMA073	160	B	500
ZV-CMA076-A	New Bedford-Fall River, MA	CMA076	3	A	500
ZV-CMA076-B	New Bedford-Fall River, MA	CMA076	3	B	500
ZV-CMA082-A	Tacoma, WA	CMA082	170	A	500
ZV-CMA082-B	Tacoma, WA	CMA082	170	B	500
ZV-CMA086-A	Albuquerque, NM	CMA086	156	A	500
ZV-CMA086-B	Albuquerque, NM	CMA086	156	B	500
ZV-CMA097-A	Bakersfield, CA	CMA097	160	A	500
ZV-CMA097-B	Bakersfield, CA	CMA097	160	B	500
ZV-CMA105-A	Lancaster, PA	CMA105	12	A	500
ZV-CMA105-B	Lancaster, PA	CMA105	12	B	500
ZV-CMA107-A	Stockton, CA	CMA107	163	A	500

License	Market Name	Market	EA Code	Frequency Block	Bandwidth (kHz)
ZV-CMA107-B	Stockton, CA	CMA107	163	B	500
ZV-CMA111-A	Vallejo-Fairfield-Napa, CA	CMA111	163	A	500
ZV-CMA111-B	Vallejo-Fairfield-Napa, CA	CMA111	163	B	500
ZV-CMA118-A	Reading, PA	CMA118	12	A	500
ZV-CMA118-B	Reading, PA	CMA118	12	B	500
ZV-CMA121-A	Trenton, NJ	CMA121	10	A	500
ZV-CMA121-B	Trenton, NJ	CMA121	10	B	500
ZV-CMA123-A	Santa Rosa-Petaluma, CA	CMA123	163	A	500
ZV-CMA123-B	Santa Rosa-Petaluma, CA	CMA123	163	B	500
ZV-CMA124-A	Santa Barbara, CA	CMA124	160	A	500
ZV-CMA124-B	Santa Barbara, CA	CMA124	160	B	500
ZV-CMA126-A	Salinas-Seaside-Monterey, CA	CMA126	163	A	500
ZV-CMA126-B	Salinas-Seaside-Monterey, CA	CMA126	163	B	500
ZV-CMA129-A	South Bend-Mishawaka, IN	CMA129	65	A	500
ZV-CMA129-B	South Bend-Mishawaka, IN	CMA129	65	B	500
ZV-CMA131-A	Rockford, IL	CMA131	64	A	500
ZV-CMA131-B	Rockford, IL	CMA131	64	B	500
ZV-CMA133-A	Manchester-Nashua, NH	CMA133	3	A	500
ZV-CMA133-B	Manchester-Nashua, NH	CMA133	3	B	500
ZV-CMA134-A	Atlantic City, NJ	CMA134	12	A	500
ZV-CMA134-B	Atlantic City, NJ	CMA134	12	B	500
ZV-CMA142-A	Modesto, CA	CMA142	163	A	500
ZV-CMA142-B	Modesto, CA	CMA142	163	B	500
ZV-CMA144-A	Orange County, NY	CMA144	10	A	500
ZV-CMA144-B	Orange County, NY	CMA144	10	B	500
ZV-CMA148-A	Salem, OR	CMA148	167	A	500
ZV-CMA148-B	Salem, OR	CMA148	167	B	500
ZV-CMA151-A	Poughkeepsie, NY	CMA151	10	A	500
ZV-CMA151-B	Poughkeepsie, NY	CMA151	10	B	500
ZV-CMA152-A	Portland, ME	CMA152	2	A	500
ZV-CMA152-B	Portland, ME	CMA152	2	B	500
ZV-CMA154-A	New London-Norwich, CT	CMA154	10	A	500
ZV-CMA154-B	New London-Norwich, CT	CMA154	10	B	500
ZV-CMA156-A	Portsmouth-Rochester, NH-ME	CMA156	3	A	500
ZV-CMA156-B	Portsmouth-Rochester, NH-ME	CMA156	3	B	500
ZV-CMA159-A	Provo-Orem, UT	CMA159	152	A	500
ZV-CMA159-B	Provo-Orem, UT	CMA159	152	B	500
ZV-CMA160-A	Killeen-Temple, TX	CMA160	127	A	500
ZV-CMA160-B	Killeen-Temple, TX	CMA160	127	B	500
ZV-CMA175-A	Santa Cruz, CA	CMA175	163	A	500
ZV-CMA175-B	Santa Cruz, CA	CMA175	163	B	500
ZV-CMA187-A	Anchorage, AK	CMA187	171	A	500
ZV-CMA187-B	Anchorage, AK	CMA187	171	B	500
ZV-CMA193-A	Benton Harbor, MI	CMA193	65	A	500
ZV-CMA193-B	Benton Harbor, MI	CMA193	65	B	500
ZV-CMA194-A	Waco, TX	CMA194	127	A	500
ZV-CMA194-B	Waco, TX	CMA194	127	B	500
ZV-CMA198-A	St. Cloud, MN	CMA198	107	A	500
ZV-CMA198-B	St. Cloud, MN	CMA198	107	B	500
ZV-CMA206-A	Longview-Marshall, TX	CMA206	127	A	500
ZV-CMA206-B	Longview-Marshall, TX	CMA206	127	B	500
ZV-CMA208-A	Fort Pierce, FL	CMA208	31	A	500
ZV-CMA208-B	Fort Pierce, FL	CMA208	31	B	500
ZV-CMA209-A	Clarksville-Hopkinsville TN-KY	CMA209	71	A	500
ZV-CMA209-B	Clarksville-Hopkinsville TN-KY	CMA209	71	B	500
ZV-CMA212-A	Bremerton, WA	CMA212	170	A	500
ZV-CMA212-B	Bremerton, WA	CMA212	170	B	500
ZV-CMA213-A	Pittsfield, MA	CMA213	10	A	500
ZV-CMA213-B	Pittsfield, MA	CMA213	10	B	500
ZV-CMA216-A	Janesville-Beloit, WI	CMA216	64	A	500
ZV-CMA216-B	Janesville-Beloit, WI	CMA216	64	B	500

License	Market Name	Market	EA Code	Frequency Block	Bandwidth (kHz)
ZV-CMA223-A	Elkhart-Goshen, IN	CMA223	65	A	500
ZV-CMA223-B	Elkhart-Goshen, IN	CMA223	65	B	500
ZV-CMA228-A	Vineland-Millville, NJ	CMA228	12	A	500
ZV-CMA228-B	Vineland-Millville, NJ	CMA228	12	B	500
ZV-CMA232-A	Eau Claire, WI	CMA232	107	A	500
ZV-CMA232-B	Eau Claire, WI	CMA232	107	B	500
ZV-CMA233-A	Wichita Falls, TX	CMA233	127	A	500
ZV-CMA233-B	Wichita Falls, TX	CMA233	127	B	500
ZV-CMA237-A	Tyler, TX	CMA237	127	A	500
ZV-CMA237-B	Tyler, TX	CMA237	127	B	500
ZV-CMA240-A	Texarkana, AR-TX	CMA240	127	A	500
ZV-CMA240-B	Texarkana, AR-TX	CMA240	127	B	500
ZV-CMA242-A	Olympia, WA	CMA242	170	A	500
ZV-CMA242-B	Olympia, WA	CMA242	170	B	500
ZV-CMA244-A	Kenosha, WI	CMA244	64	A	500
ZV-CMA244-B	Kenosha, WI	CMA244	64	B	500
ZV-CMA250-A	Bloomington-Normal, IL	CMA250	64	A	500
ZV-CMA250-B	Bloomington-Normal, IL	CMA250	64	B	500
ZV-CMA251-A	Williamsport, PA	CMA251	10	A	500
ZV-CMA251-B	Williamsport, PA	CMA251	10	B	500
ZV-CMA257-A	Hagerstown, MD	CMA257	13	A	500
ZV-CMA257-B	Hagerstown, MD	CMA257	13	B	500
ZV-CMA269-A	Cumberland, MD-WV	CMA269	13	A	500
ZV-CMA269-B	Cumberland, MD-WV	CMA269	13	B	500
ZV-CMA270-A	Bellingham, WA	CMA270	170	A	500
ZV-CMA270-B	Bellingham, WA	CMA270	170	B	500
ZV-CMA273-A	Kankakee, IL	CMA273	64	A	500
ZV-CMA273-B	Kankakee, IL	CMA273	64	B	500
ZV-CMA279-B	Lewiston-Auburn, ME	CMA279	2	B	500
ZV-CMA292-A	Sherman-Denison, TX	CMA292	127	A	500
ZV-CMA292-B	Sherman-Denison, TX	CMA292	127	B	500
ZV-CMA303-A	Aurora-Elgin, IL	CMA303	64	A	500
ZV-CMA303-B	Aurora-Elgin, IL	CMA303	64	B	500
ZV-CMA315-A	Alaska 1 - Wade Hampton	CMA315	171	A	500
ZV-CMA315-B	Alaska 1 - Wade Hampton	CMA315	171	B	500
ZV-CMA316-A	Alaska 2 - Bethel	CMA316	171	A	500
ZV-CMA316-B	Alaska 2 - Bethel	CMA316	171	B	500
ZV-CMA317-A	Alaska 3 - Haines	CMA317	171	A	500
ZV-CMA317-B	Alaska 3 - Haines	CMA317	171	B	500
ZV-CMA320-A	Arizona 3 - Navajo	CMA320	156	A	500
ZV-CMA320-B	Arizona 3 - Navajo	CMA320	156	B	500
ZV-CMA321-A	Arizona 4 - Yuma	CMA321	160	A	500
ZV-CMA321-B	Arizona 4 - Yuma	CMA321	160	B	500
ZV-CMA332-A	Arkansas 9 - Polk	CMA332	127	A	500
ZV-CMA332-B	Arkansas 9 - Polk	CMA332	127	B	500
ZV-CMA336-A	California 1 - Del Norte	CMA336	163	A	500
ZV-CMA336-B	California 1 - Del Norte	CMA336	163	B	500
ZV-CMA338-A	California 3 - Alpine	CMA338	163	A	500
ZV-CMA338-B	California 3 - Alpine	CMA338	163	B	500
ZV-CMA339-A	California 4 - Madera	CMA339	163	A	500
ZV-CMA339-B	California 4 - Madera	CMA339	163	B	500
ZV-CMA340-A	California 5 - San Luis Obispo	CMA340	160	A	500
ZV-CMA340-B	California 5 - San Luis Obispo	CMA340	160	B	500
ZV-CMA342-A	California 7 - Imperial	CMA342	160	A	500
ZV-CMA342-B	California 7 - Imperial	CMA342	160	B	500
ZV-CMA344-A	California 9 - Mendocino	CMA344	163	A	500
ZV-CMA344-B	California 9 - Mendocino	CMA344	163	B	500
ZV-CMA357-A	Connecticut 1 - Litchfield	CMA357	10	A	500
ZV-CMA357-B	Connecticut 1 - Litchfield	CMA357	10	B	500
ZV-CMA358-A	Connecticut 2 - Windham	CMA358	10	A	500
ZV-CMA358-B	Connecticut 2 - Windham	CMA358	10	B	500

License	Market Name	Market	EA Code	Frequency Block	Bandwidth (kHz)
ZV-CMA359-A	Delaware 1 - Kent	CMA359	12	A	500
ZV-CMA359-B	Delaware 1 - Kent	CMA359	12	B	500
ZV-CMA360-A	Florida 1 - Collier	CMA360	31	A	500
ZV-CMA360-B	Florida 1 - Collier	CMA360	31	B	500
ZV-CMA361-A	Florida 2 - Glades	CMA361	31	A	500
ZV-CMA361-B	Florida 2 - Glades	CMA361	31	B	500
ZV-CMA370-A	Florida 11 - Monroe	CMA370	31	A	500
ZV-CMA370-B	Florida 11 - Monroe	CMA370	31	B	500
ZV-CMA393-A	Idaho 6 - Clark	CMA393	152	A	500
ZV-CMA393-B	Idaho 6 - Clark	CMA393	152	B	500
ZV-CMA394-A	Illinois 1 - Jo Daviess	CMA394	64	A	500
ZV-CMA394-B	Illinois 1 - Jo Daviess	CMA394	64	B	500
ZV-CMA395-A	Illinois 2 - Bureau	CMA395	64	A	500
ZV-CMA395-B	Illinois 2 - Bureau	CMA395	64	B	500
ZV-CMA398-A	Illinois 5 - Mason	CMA398	64	A	500
ZV-CMA398-B	Illinois 5 - Mason	CMA398	64	B	500
ZV-CMA403-A	Indiana 1 - Newton	CMA403	64	A	500
ZV-CMA403-B	Indiana 1 - Newton	CMA403	64	B	500
ZV-CMA404-A	Indiana 2 - Kosciusko	CMA404	65	A	500
ZV-CMA404-B	Indiana 2 - Kosciusko	CMA404	65	B	500
ZV-CMA406-A	Indiana 4 - Miami	CMA406	65	A	500
ZV-CMA406-B	Indiana 4 - Miami	CMA406	65	B	500
ZV-CMA427-A	Iowa 16 - Lyon	CMA427	107	A	500
ZV-CMA427-B	Iowa 16 - Lyon	CMA427	107	B	500
ZV-CMA444-A	Kentucky 2 - Union	CMA444	71	A	500
ZV-CMA444-B	Kentucky 2 - Union	CMA444	71	B	500
ZV-CMA445-A	Kentucky 3 - Meade	CMA445	71	A	500
ZV-CMA445-B	Kentucky 3 - Meade	CMA445	71	B	500
ZV-CMA447-A	Kentucky 5 - Barren	CMA447	71	A	500
ZV-CMA447-B	Kentucky 5 - Barren	CMA447	71	B	500
ZV-CMA463-A	Maine 1 - Oxford	CMA463	2	A	500
ZV-CMA463-B	Maine 1 - Oxford	CMA463	2	B	500
ZV-CMA465-A	Maine 3 - Kennebec	CMA465	2	A	500
ZV-CMA465-B	Maine 3 - Kennebec	CMA465	2	B	500
ZV-CMA467-A	Maryland 1 - Garrett	CMA467	13	A	500
ZV-CMA467-B	Maryland 1 - Garrett	CMA467	13	B	500
ZV-CMA468-A	Maryland 2 - Kent	CMA468	13	A	500
ZV-CMA468-B	Maryland 2 - Kent	CMA468	13	B	500
ZV-CMA469-A	Maryland 3 - Frederick	CMA469	13	A	500
ZV-CMA469-B	Maryland 3 - Frederick	CMA469	13	B	500
ZV-CMA470-A	Massachusetts 1 - Franklin	CMA470	10	A	500
ZV-CMA470-B	Massachusetts 1 - Franklin	CMA470	10	B	500
ZV-CMA471-A	Massachusetts 2 - Barnstable	CMA471	3	A	500
ZV-CMA471-B	Massachusetts 2 - Barnstable	CMA471	3	B	500
ZV-CMA480-A	Michigan 9 - Cass	CMA480	65	A	500
ZV-CMA480-B	Michigan 9 - Cass	CMA480	65	B	500
ZV-CMA483-A	Minnesota 2 - Lake of the Woods	CMA483	107	A	500
ZV-CMA483-B	Minnesota 2 - Lake of the Woods	CMA483	107	B	500
ZV-CMA486-A	Minnesota 5 - Wilkin	CMA486	107	A	500
ZV-CMA486-B	Minnesota 5 - Wilkin	CMA486	107	B	500
ZV-CMA487-A	Minnesota 6 - Hubbard	CMA487	107	A	500
ZV-CMA487-B	Minnesota 6 - Hubbard	CMA487	107	B	500
ZV-CMA488-A	Minnesota 7 - Chippewa	CMA488	107	A	500
ZV-CMA488-B	Minnesota 7 - Chippewa	CMA488	107	B	500
ZV-CMA489-A	Minnesota 8 - Lac qui Parle	CMA489	107	A	500
ZV-CMA489-B	Minnesota 8 - Lac qui Parle	CMA489	107	B	500
ZV-CMA490-A	Minnesota 9 - Pipestone	CMA490	107	A	500
ZV-CMA490-B	Minnesota 9 - Pipestone	CMA490	107	B	500
ZV-CMA491-A	Minnesota 10 - Le Sueur	CMA491	107	A	500
ZV-CMA491-B	Minnesota 10 - Le Sueur	CMA491	107	B	500
ZV-CMA492-A	Minnesota 11 - Goodhue	CMA492	107	A	500

License	Market Name	Market	EA Code	Frequency Block	Bandwidth (kHz)
ZV-CMA492-B	Minnesota 11 - Goodhue	CMA492	107	B	500
ZV-CMA548-A	New Hampshire 1 - Coos	CMA548	3	A	500
ZV-CMA548-B	New Hampshire 1 - Coos	CMA548	3	B	500
ZV-CMA549-A	New Hampshire 2 - Carroll	CMA549	3	A	500
ZV-CMA549-B	New Hampshire 2 - Carroll	CMA549	3	B	500
ZV-CMA550-A	New Jersey 1 - Hunterdon	CMA550	10	A	500
ZV-CMA550-B	New Jersey 1 - Hunterdon	CMA550	10	B	500
ZV-CMA551-A	New Jersey 2 - Ocean	CMA551	10	A	500
ZV-CMA551-B	New Jersey 2 - Ocean	CMA551	10	B	500
ZV-CMA552-A	New Jersey 3 - Sussex	CMA552	10	A	500
ZV-CMA552-B	New Jersey 3 - Sussex	CMA552	10	B	500
ZV-CMA553-A	New Mexico 1 - San Juan	CMA553	156	A	500
ZV-CMA553-B	New Mexico 1 - San Juan	CMA553	156	B	500
ZV-CMA555-A	New Mexico 3 - Catron	CMA555	156	A	500
ZV-CMA555-B	New Mexico 3 - Catron	CMA555	156	B	500
ZV-CMA556-A	New Mexico 4 - Santa Fe	CMA556	156	A	500
ZV-CMA556-B	New Mexico 4 - Santa Fe	CMA556	156	B	500
ZV-CMA563-A	New York 5 - Otsego	CMA563	10	A	500
ZV-CMA563-B	New York 5 - Otsego	CMA563	10	B	500
ZV-CMA603-A	Oklahoma 8 - Jackson	CMA603	127	A	500
ZV-CMA603-B	Oklahoma 8 - Jackson	CMA603	127	B	500
ZV-CMA604-A	Oklahoma 9 - Garvin	CMA604	127	A	500
ZV-CMA604-B	Oklahoma 9 - Garvin	CMA604	127	B	500
ZV-CMA605-A	Oklahoma 10 - Haskell	CMA605	127	A	500
ZV-CMA605-B	Oklahoma 10 - Haskell	CMA605	127	B	500
ZV-CMA606-A	Oregon 1 - Clatsop	CMA606	167	A	500
ZV-CMA606-B	Oregon 1 - Clatsop	CMA606	167	B	500
ZV-CMA607-A	Oregon 2 - Hood River	CMA607	167	A	500
ZV-CMA607-B	Oregon 2 - Hood River	CMA607	167	B	500
ZV-CMA609-A	Oregon 4 - Lincoln	CMA609	167	A	500
ZV-CMA609-B	Oregon 4 - Lincoln	CMA609	167	B	500
ZV-CMA611-A	Oregon 6 - Crook	CMA611	167	A	500
ZV-CMA611-B	Oregon 6 - Crook	CMA611	167	B	500
ZV-CMA614-A	Pennsylvania 3 - Potter	CMA614	10	A	500
ZV-CMA614-B	Pennsylvania 3 - Potter	CMA614	10	B	500
ZV-CMA615-A	Pennsylvania 4 - Bradford	CMA615	10	A	500
ZV-CMA615-B	Pennsylvania 4 - Bradford	CMA615	10	B	500
ZV-CMA616-A	Pennsylvania 5 - Wayne	CMA616	10	A	500
ZV-CMA616-B	Pennsylvania 5 - Wayne	CMA616	10	B	500
ZV-CMA619-A	Pennsylvania 8 - Union	CMA619	10	A	500
ZV-CMA619-B	Pennsylvania 8 - Union	CMA619	10	B	500
ZV-CMA621-A	Pennsylvania 10 - Bedford	CMA621	13	A	500
ZV-CMA621-B	Pennsylvania 10 - Bedford	CMA621	13	B	500
ZV-CMA624-A	Rhode Island 1 - Newport	CMA624	3	A	500
ZV-CMA624-B	Rhode Island 1 - Newport	CMA624	3	B	500
ZV-CMA643-A	Tennessee 1 - Lake	CMA643	71	A	500
ZV-CMA643-B	Tennessee 1 - Lake	CMA643	71	B	500
ZV-CMA644-A	Tennessee 2 - Cannon	CMA644	71	A	500
ZV-CMA644-B	Tennessee 2 - Cannon	CMA644	71	B	500
ZV-CMA645-A	Tennessee 3 - Macon	CMA645	71	A	500
ZV-CMA645-B	Tennessee 3 - Macon	CMA645	71	B	500
ZV-CMA647-A	Tennessee 5 - Fayette	CMA647	71	A	500
ZV-CMA647-B	Tennessee 5 - Fayette	CMA647	71	B	500
ZV-CMA648-A	Tennessee 6 - Giles	CMA648	71	A	500
ZV-CMA648-B	Tennessee 6 - Giles	CMA648	71	B	500
ZV-CMA651-A	Tennessee 9 - Maury	CMA651	71	A	500
ZV-CMA651-B	Tennessee 9 - Maury	CMA651	71	B	500
ZV-CMA656-A	Texas 5 - Hardeman	CMA656	127	A	500
ZV-CMA656-B	Texas 5 - Hardeman	CMA656	127	B	500
ZV-CMA657-A	Texas 6 - Jack	CMA657	127	A	500
ZV-CMA657-B	Texas 6 - Jack	CMA657	127	B	500

License	Market Name	Market	EA Code	Frequency Block	Bandwidth (kHz)
ZV-CMA658-A	Texas 7 - Fannin	CMA658	127	A	500
ZV-CMA658-B	Texas 7 - Fannin	CMA658	127	B	500
ZV-CMA660-A	Texas 9 - Runnels	CMA660	127	A	500
ZV-CMA660-B	Texas 9 - Runnels	CMA660	127	B	500
ZV-CMA661-A	Texas 10 - Navarro	CMA661	127	A	500
ZV-CMA661-B	Texas 10 - Navarro	CMA661	127	B	500
ZV-CMA662-A	Texas 11 - Cherokee	CMA662	127	A	500
ZV-CMA662-B	Texas 11 - Cherokee	CMA662	127	B	500
ZV-CMA666-A	Texas 15 - Concho	CMA666	127	A	500
ZV-CMA666-B	Texas 15 - Concho	CMA666	127	B	500
ZV-CMA673-A	Utah 1 - Box Elder	CMA673	152	A	500
ZV-CMA673-B	Utah 1 - Box Elder	CMA673	152	B	500
ZV-CMA674-A	Utah 2 - Morgan	CMA674	152	A	500
ZV-CMA674-B	Utah 2 - Morgan	CMA674	152	B	500
ZV-CMA675-A	Utah 3 - Juab	CMA675	152	A	500
ZV-CMA675-B	Utah 3 - Juab	CMA675	152	B	500
ZV-CMA677-A	Utah 5 - Carbon	CMA677	152	A	500
ZV-CMA677-B	Utah 5 - Carbon	CMA677	152	B	500
ZV-CMA678-A	Utah 6 - Piute	CMA678	152	A	500
ZV-CMA678-B	Utah 6 - Piute	CMA678	152	B	500
ZV-CMA679-A	Vermont 1 - Franklin	CMA679	3	A	500
ZV-CMA679-B	Vermont 1 - Franklin	CMA679	3	B	500
ZV-CMA680-A	Vermont 2 - Addison	CMA680	3	A	500
ZV-CMA680-B	Vermont 2 - Addison	CMA680	3	B	500
ZV-CMA690-A	Virginia 10 - Frederick	CMA690	13	A	500
ZV-CMA690-B	Virginia 10 - Frederick	CMA690	13	B	500
ZV-CMA691-A	Virginia 11 - Madison	CMA691	13	A	500
ZV-CMA691-B	Virginia 11 - Madison	CMA691	13	B	500
ZV-CMA692-A	Virginia 12 - Caroline	CMA692	13	A	500
ZV-CMA692-B	Virginia 12 - Caroline	CMA692	13	B	500
ZV-CMA693-A	Washington 1 - Clallam	CMA693	170	A	500
ZV-CMA693-B	Washington 1 - Clallam	CMA693	170	B	500
ZV-CMA696-A	Washington 4 - Grays Harbor	CMA696	170	A	500
ZV-CMA696-B	Washington 4 - Grays Harbor	CMA696	170	B	500
ZV-CMA698-A	Washington 6 - Pacific	CMA698	167	A	500
ZV-CMA698-B	Washington 6 - Pacific	CMA698	167	B	500
ZV-CMA699-A	Washington 7 - Skamania	CMA699	167	A	500
ZV-CMA699-B	Washington 7 - Skamania	CMA699	167	B	500
ZV-CMA704-A	West Virginia 4 - Grant	CMA704	13	A	500
ZV-CMA704-B	West Virginia 4 - Grant	CMA704	13	B	500
ZV-CMA705-A	West Virginia 5 - Tucker	CMA705	13	A	500
ZV-CMA705-B	West Virginia 5 - Tucker	CMA705	13	B	500
ZV-CMA708-A	Wisconsin 1 - Burnett	CMA708	107	A	500
ZV-CMA708-B	Wisconsin 1 - Burnett	CMA708	107	B	500
ZV-CMA709-A	Wisconsin 2 - Bayfield	CMA709	107	A	500
ZV-CMA709-B	Wisconsin 2 - Bayfield	CMA709	107	B	500
ZV-CMA712-A	Wisconsin 5 - Pierce	CMA712	107	A	500
ZV-CMA712-B	Wisconsin 5 - Pierce	CMA712	107	B	500

6.4 APPENDIX D – 218-219 MHZ BLOCK AVAILABILITY CORRELATION

218-219 Service Spectrum Block Availabilty Correlation

Item	1995 EA Code	CMA Code(s)	CMA Available BW (kHz)	Total Available in EA (kHz)	Total EA Spectrum Need (kHz)	Net EA Available (Avail - Needed)
1	2	152	1,000	4,000	140	3,860
2	2	279	1,000			
3	2	463	1,000			
4	2	465	1,000			
5	3	6	1,000	12,000	660	11,340
6	3	38	1,000			
7	3	55	1,000			
8	3	76	1,000			
9	3	133	1,000			
10	3	156	1,000			
11	3	471	1,000			
12	3	548	1,000			
13	3	549	1,000			
14	3	624	1,000			
15	3	679	1,000			
16	3	680	1,000			
17	10	32	1,000	25,000	1,825	23,175
18	10	42	1,000			
19	10	49	1,000			
20	10	56	1,000			
21	10	58	1,000			
22	10	62	1,000			
23	10	63	1,000			
24	10	70	1,000			
25	10	121	1,000			
26	10	144	1,000			
27	10	151	1,000			
28	10	154	1,000			
29	10	213	1,000			
30	10	251	1,000			
31	10	357	1,000			
32	10	358	1,000			
33	10	470	1,000			
34	10	550	1,000			
35	10	551	1,000			
36	10	552	1,000			
37	10	563	1,000			
38	10	614	1,000			
39	10	615	1,000			
40	10	616	1,000			
41	10	619	1,000			
42	12	69	1,000	6,000	1,025	4,975
43	12	105	1,000			

218-219 Service Spectrum Block
Availabilty Correlation

44	12	118	1,000			
45	12	134	1,000			
46	12	228	1,000			
47	12	359	1,000			
48	13	14	1,000	12,000	800	11,200
49	13	257	1,000			
50	13	269	1,000			
51	13	467	1,000			
52	13	468	1,000			
53	13	469	1,000			
54	13	621	1,000			
55	13	690	1,000			
56	13	691	1,000			
57	13	692	1,000			
58	13	704	1,000			
59	13	705	1,000			
60	31	12	500	5,500	325	5,175
61	31	72	1,000			
62	31	208	1,000			
63	31	360	1,000			
64	31	361	1,000			
65	31	370	1,000			
66	64	54	500	10,500	740	9,760
67	64	131	1,000			
68	64	216	1,000			
69	64	244	1,000			
70	64	250	1,000			
71	64	273	1,000			
72	64	303	1,000			
73	64	394	1,000			
74	64	395	1,000			
75	64	398	1,000			
76	64	403	1,000			
77	65	129	1,000	6,000	210	5,790
78	65	193	1,000			
79	65	223	1,000			
80	65	404	1,000			
81	65	406	1,000			
82	65	480	1,000			
83	71	46	1,000	11,000	250	10,750
84	71	209	1,000			
85	71	444	1,000			
86	71	445	1,000			
87	71	447	1,000			
88	71	643	1,000			
89	71	644	1,000			
90	71	645	1,000			

218-219 Service Spectrum Block
Availabilty Correlation

91	71	647	1,000			
92	71	648	1,000			
93	71	651	1,000			
94	107	15	1,000	6,907	275	6,632
95	107	198	1,000			
96	107	232	1,000			
97	107	427	1,000			
98	107	483	1,000			
99	107	486	1,000			
100	107	487	1,000			
101	107	488	1,000			
102	107	489	1,000			
103	107	490	1,000			
104	107	491	1,000			
105	107	492	1,000			
106	107	708	1,000			
107	107	709	1,000			
108	107	712	1,000			
109	127	160	1,000	18,000	825	17,175
110	127	194	1,000			
111	127	206	1,000			
112	127	233	1,000			
113	127	237	1,000			
114	127	240	1,000			
115	127	292	1,000			
116	127	332	1,000			
117	127	603	1,000			
118	127	604	1,000			
119	127	605	1,000			
120	127	656	1,000			
121	127	657	1,000			
122	127	658	1,000			
123	127	660	1,000			
124	127	661	1,000			
125	127	662	1,000			
126	127	666	1,000			
127	152	39	1,000	8,000	300	7,700
128	152	159	1,000			
129	152	393	1,000			
130	152	673	1,000			
131	152	674	1,000			
132	152	675	1,000			
133	152	677	1,000			
134	152	678	1,000			
135	156	86	1,000	5,000	375	4,625
136	156	320	1,000			
137	156	553	1,000			

218-219 Service Spectrum Block
Availabilty Correlation

138	156	555	1,000			
139	156	556	1,000			
140	160	73	1,000	6,000	500	5,500
141	160	97	1,000			
142	160	124	1,000			
143	160	321	1,000			
144	160	340	1,000			
145	160	342	1,000			
146	161	18	1,000	1,000	325	675
147	163	7	1,000	12,000	675	11,325
148	163	27	1,000			
149	163	107	1,000			
150	163	111	1,000			
151	163	123	1,000			
152	163	126	1,000			
153	163	142	1,000			
154	163	175	1,000			
155	163	336	1,000			
156	163	338	1,000			
157	163	339	1,000			
158	163	344	1,000			
159	167	30	1,000	8,000	250	7,750
160	167	148	1,000			
161	167	606	1,000			
162	167	607	1,000			
163	167	609	1,000			
164	167	611	1,000			
165	167	698	1,000			
166	167	699	1,000			
167	170	20	1,000	7,000	425	6,575
168	170	82	1,000			
169	170	212	1,000			
170	170	242	1,000			
171	170	270	1,000			
172	170	693	1,000			
173	170	696	1,000			
174	171	187	1,000	4,000	425	3,575
175	171	315	1,000			
176	171	316	1,000			
177	171	317	1,000			

6.5 APPENDIX E – AMTRAK PTC DEPLOYMENT PLAN INFORMATION

The following information in this appendix was provided by Amtrak and is included for informational purposes only, and has not been independently reviewed or verified.

APPENDIX ~~A~~E

Item	State	Agency	NOTES
1	NY	MTA Long Island Rail Road (MTA LIRR)	MTA LIRR will use ACSES
2	NJ	New Jersey Transit Corporation (NJ TRANSIT)	NJT will use ACSES
3	NY	Metro-North Commuter Railroad Company, dba: MTA Metro-North Railroad (MTA-MNCR)	MTA Metro North will use ACSES
5	MA	Massachusetts Bay Transportation Authority (MBTA)	MBTA will use ACSES
6	PA	Southeastern Pennsylvania Transportation Authority (SEPTA)	SEPTA will use ACSES
9	MD	Maryland Transit Administration (MTA) [Brunswick and Camden lines Only]	Brunswick and Camden lines are owned by CSX
12	VA	Virginia Railway Express (VRE)	VRE owns no track, it operates on CSX and NS
20	CT	Connecticut Department of Transportation (CDOT) (East shore line)	Shore Line East operates on Amtrak and Metro North
21	PA	Pennsylvania Department of Transportation (PENNDOT)	This is Amtrak's Harrisburg Line (Philadelphia – Harrisburg)
22	ME	Northern New England Passenger Rail Authority (NNEPRA)	NNEPRA owns no track it operates on MBTA and Pan Am

Notes:

Item 1 - MTA LIRR will use ACSES and significantly less spectrum than the 475 KHz forecast in the report

Item 2 – NJ Transit will use ACSES and significantly less spectrum than the 500 KHz forecast in the report. Current estimates indicate approximately eight 12.5 KHZ channels (100 KHz)

Item 3 – MTA Metro North will use ACSES and significantly less spectrum than the 500 KHz forecast in the report.

Item 5 – MBTA will use ACSES and significantly less spectrum than the 475 KHz forecast in the report. Current estimates indicate approximately eight 12.5 KHZ channels (100 KHz)

Item 6 – SEPTA will use ACSES and significantly less spectrum than the 450 KHz forecast in the report. SEPTA has obtained their spectrum; eight 12.5 KHz channels (100 KHz)

Item 9 –MTA [Brunswick and Camden lines only] operate on CSX and the host, CSX, should supply the required spectrum

Item 12 – VRE doesn't own any track it operates on host railroads CSX and NS, the host railroads should supply the required spectrum

Item 20 – CDOT (Shore Line East) operates on Amtrak and Metro North ROW and will use the ACSES spectrum supplied by Amtrak and Metro North

Item 21 – PENNDOT doesn't own any ROW Philadelphia to Harrisburg; this is Amtrak ROW and as such will be ACSES equipped. Current estimates indicate approximately six 12.5 KHZ channels (75 KHz)

Item 22 – NNEPRA doesn't own any ROW it operates on MBTA and Pan Am and will use spectrum supplied by MBTA and Pan Am