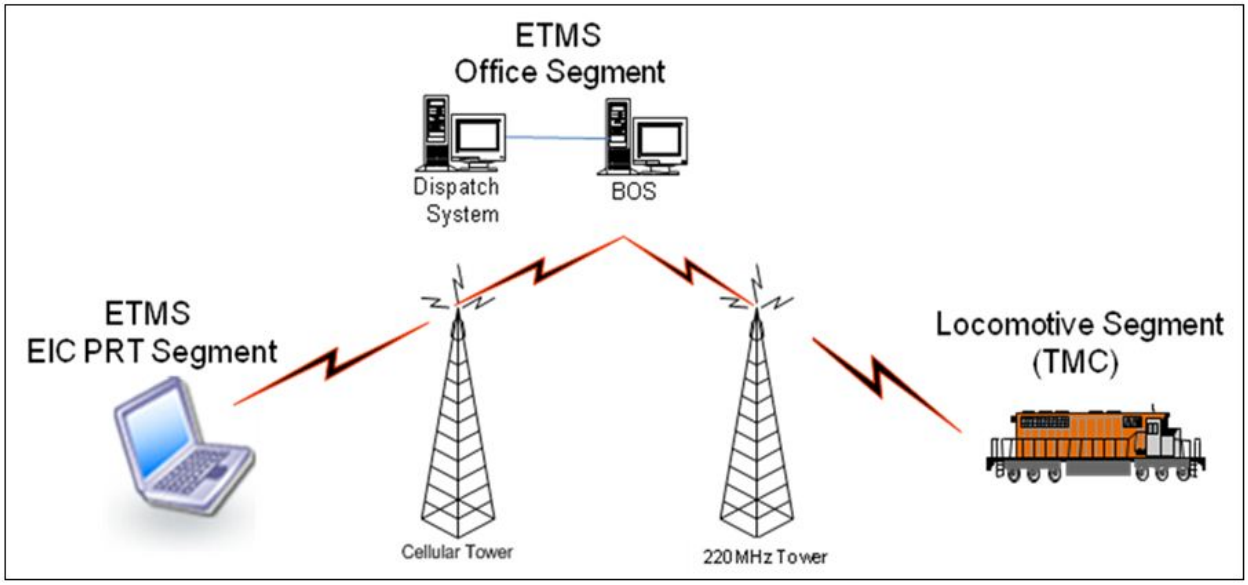
U.S. Department of Transportation

Federal Railroad Administration

Employee-In-Charge Portable Remote Terminal Phases 3 and 4 Summary Report

Office of Research,
Development,
and Technology
Washington, DC 20590



NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof. Any opinions, findings and conclusions, or recommendations expressed in this material do not necessarily reflect the views or policies of the United States Government, nor does mention of trade names, commercial products, or organizations imply endorsement by the United States Government. The United States Government assumes no liability for the content or use of the material contained in this document.

NOTICE

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objective of this report.

NOTICE

The documents referenced in the Appendices are superseded by documents to be published from current research effort.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	May 2016	Technical Report – January 2014

4. TITLE AND SUBTITLE
Employee-In-Charge Portable Remote Terminal Phases 3 and 4 Summary Report

5. FUNDING NUMBERS
DTFR53-C-00012,
Task Order 257

6. AUTHOR(S)
Thomas Nast

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Transportation Technology Center, Inc.
A subsidiary of Association of American Railroads
PO Box 11130
Pueblo, CO 81001

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
Federal Railroad Administration
Office of Railroad Policy and Development
Office of Research, Development, and Technology
Washington, DC 20590

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
DOT/FRA/ORD-16/11

11. SUPPLEMENTARY NOTES
COTR: Jared Withers and Ken Orr

12a. DISTRIBUTION/AVAILABILITY STATEMENT
This document is available to the public through the FRA Web site at http://www.fra.dot.gov.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
Under Federal Railroad Administration Task Order 257, Transportation Technology Center, Inc. partnered with BNSF Railway Company to complete Builds 1 and 2 of the Employee-In-Charge (EIC) portable remote control (PRT) application software and to successfully integrate and test the EIC PRT Build 2 application with Electronic Train Management System. The EIC PRT system provides an EIC of maintenance of way workers with an interface to the host Positive Train Control (PTC) system to enforce the train entry into protected work areas and speed of trains operating within work areas. The EIC PRT Build 1 application, completed in Phase 3, implemented a minimum set of functions. EIC PRT Build 2, completed in project Phase 4a of the project, expanded the function set to improve usability by roadway workers. Project Phases 3 and 4a included systems engineering, safety engineering, and software engineering tasks.

14. SUBJECT TERMS
Employee-in-charge, portable remote control, personal data assistant, Positive Train Control, Interoperable Train Control, Electronic Train Management System

15. NUMBER OF PAGES
24

16. PRICE CODE

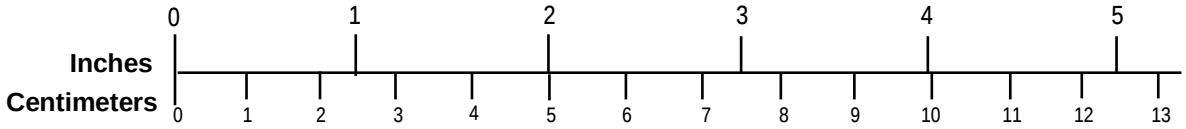
17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

NSN 7540-01-280-5500
Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18
298-102

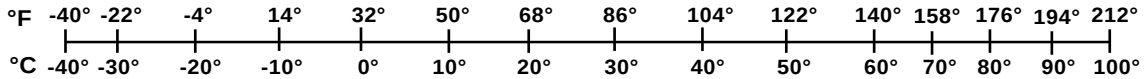
METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC	METRIC TO ENGLISH
LENGTH (APPROXIMATE)	**LENGTH (APPROXIMATE)**
1 inch (in) = 2.5 centimeters (cm)	1 millimeter (mm) = 0.04 inch (in)
1 foot (ft) = 30 centimeters (cm)	1 centimeter (cm) = 0.4 inch (in)
1 yard (yd) = 0.9 meter (m)	1 meter (m) = 3.3 feet (ft)
1 mile (mi) = 1.6 kilometers (km)	1 meter (m) = 1.1 yards (yd)
	1 kilometer (km) = 0.6 mile (mi)
AREA (APPROXIMATE)	**AREA (APPROXIMATE)**
1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)	1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)	1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)	1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)	10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres
1 acre = 0.4 hectare (he) = 4,000 square meters (m^2)	
MASS - WEIGHT (APPROXIMATE)	**MASS - WEIGHT (APPROXIMATE)**
1 ounce (oz) = 28 grams (gm)	1 gram (gm) = 0.036 ounce (oz)
1 pound (lb) = 0.45 kilogram (kg)	1 kilogram (kg) = 2.2 pounds (lb)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)	1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons
VOLUME (APPROXIMATE)	**VOLUME (APPROXIMATE)**
1 teaspoon (tsp) = 5 milliliters (ml)	1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 tablespoon (tbsp) = 15 milliliters (ml)	1 liter (l) = 2.1 pints (pt)
1 fluid ounce (fl oz) = 30 milliliters (ml)	1 liter (l) = 1.06 quarts (qt)
1 cup (c) = 0.24 liter (l)	1 liter (l) = 0.26 gallon (gal)
1 pint (pt) = 0.47 liter (l)	
1 quart (qt) = 0.96 liter (l)	
1 gallon (gal) = 3.8 liters (l)	
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)	1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)	1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT)	**TEMPERATURE (EXACT)**
[(x-32)(5/9)] °F = y °C	[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSIO



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

Updated 6/17/98

Contents

Illustrations

Tables

Executive Summary

Under Federal Railroad Administration (FRA) Task Order 257, Transportation Technology Center, Inc. (TTCI) partnered with BNSF Railway Company (BNSF) to complete Builds 1 and 2 of the employee-in-charge (EIC) portable remote control (PRT) application software and to successfully integrate and test the EIC PRT Build 2 application with Electronic Train Management System (ETMS). The EIC PRT system provides an EIC of maintenance of way workers with an interface to the host Positive Train Control (PTC) system to enforce the train entry into protected work areas and speed of trains operating within work areas. The EIC PRT Build 1 application, completed in Phase 3, implemented a minimum set of functions. EIC PRT Build 2, completed in project Phase 4a of the project, expanded the function set to improve usability by roadway workers. Project Phases 3 and 4a included systems engineering, safety engineering, and software engineering tasks.

1. Introduction

FRA contracted TTCI to develop an EIC PRT.

An outcome of the design portion of the North American Joint Positive Train Control Project was recognition of the need for an EIC of a maintenance of way (MOW) work gang to communicate directly with a PTC system via an easily portable terminal, such as a commercial off-the-shelf personal data assistant (PDA), laptop computer, or cellular smart phone. Generally, the EIC is supervising the MOW work gang(s) and cannot be close enough to his or her vehicle, which may be in communication with the larger PTC network. The portable terminal will allow the EIC to interact with the PTC system without returning to the vehicle. The improved communication between the EIC and the PTC system has the potential to improve both the safety and productivity of work crews under supervision of the EIC.

1.1 Background

The EIC PRT is a handheld portable computer terminal application for use by the roadway worker who establishes on-track safety for others in roadway work groups and lone workers who establish their own protection. For the purposes of this document, these two types of individuals are called EIC. This EIC PRT system provides a remote, wireless, functional link to a PTC system. Through interaction with a train control system, the EIC PRT allows the EIC to transmit entry permission and speed limits to trains requesting entry into maintenance of way protection (MWP).

Functions of the EIC PRT that provide protection to roadway workers are safety-related, and as such, comply with the performance standards as stated in 49 Code of Federal Regulations (CFR) Part 236 — "Rules, Standards, and Instructions Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Appliances." This rule requires that the introduction of a new product/system "not result in a risk that exceeds the previous condition." In the case of the EIC PRT system, the previous condition is roadway work protection mechanisms and procedures as described in the General Code of Operating Rules or equivalent railroad safety rules.

The EIC PRT project has been conducted in four phases to date.

Phase 1 and Phase 2 of the EIC PRT project were conducted from 2004 through 2007. These two phases produced and tested software that supports the following EIC PRT system functions:

- Receive MWP information from the PTC Back Office Server (BOS)
- Display MWP information to the EIC
- Allow EIC to directly authorize train entry via PTC system into MWP where Stop is required
- EIC defines speed limits for train through MWP limits

During these two phases, no specific target PTC system for the EIC PRT system was identified. Accordingly, TTCI designed and developed the EIC PRT software using a modular approach to maximize its adaptability to any PTC system. TTCI selected a representative hardware platform, operating system, and development environment. The development team performed system testing using simulated office and locomotive segments. Safety documentation for Phases 1 and 2 was developed on the basis of 49 CFR Part 236 Subpart H requirements.

Phase 3 of the EIC PRT project was developed; Phase 4 was initiated under FRA Task Order 257; and Phase 4 is being continued (as Phase 4B) under FRA Task Order 330.

In these phases, TTCI partnered with Burlington Northern Santa Fe Railway Company (BNSF) and developed an EIC PRT to be integrated with BNSF ETMS. The Phase 3 scope was expanded in Phase 4 to extend the utility and value of the project to the roadway worker.

1.2 Objectives

The objectives of the EIC PRT Phase 3 project are as follows:

- Integrate the EIC PRT with the BNSF ETMS system. This task requires modification of the prototype to fit BNSF operating rules and procedures, desired user interface characteristics, and the ETMS architecture.
- Implement the EIC PRT safety-related functions on the hardware and software platform defined by BNSF.
- Revise EIC PRT system requirements and system safety documentation to reflect system changes related to integration with ETMS.
- Provide EIC PRT system documentation according to 49 CFR Part 236 Subpart I requirements.
- Perform integration testing between the EIC PRT and ETMS. This integration testing was deferred to Phase 4 to allow for the inclusion of the expanded function set in the testing.

The objectives of EIC PRT Phase 4 are:

- Expand EIC PRT functions to include:
  - Form B track bulletin assignment at user login or at user request
  - Mechanisms to allow the EIC to issue multipart instructions to trains requesting entry into protected work areas
- Implement the EIC PRT safety-related functions on the hardware and software platform defined by BNSF
- Revise EIC PRT system requirements and system safety documentation to reflect the additional functions
- Conduct integration testing between the EIC PRT and ETMS to include Phase 4 functions

1.3 Overall Approach

The approach for EIC PRT Phase 3 and 4 was broken into the following tasks:

1. Conduct a requirements analysis for the integration of the EIC PRT into ETMS. This analysis includes identification of additional functionality needed to ensure the EIC PRT is operationally viable for use with ETMS.
2. Conduct safety assessment of the addition of EIC PRT to ETMS.

3. Develop EIC PRT software for integration with ETMS.
4. Conduct integration testing of EIC PRT with ETMS.

1.4 Scope

EIC PRT Phases 3 and 4 focused on integration of EIC PRT with ETMS and expansion of functions to promote the utility of the EIC PRT to BNSF. This process included systems engineering and software engineering tasks such as development of documentation (system requirements, system safety documentation, and test plan documentation) and test execution.

1.5 Organization of the Report

This is a summary report that highlights activities of the EIC PRT project conducted under FRA Task Order 257. Sections 2 and 3 of the report describe the work activities of Phase 3 and Phase 4, respectively. Each of those sections contains a summary of the work activities associated with the respective phases.

Appendix A and Appendix B contain the EIC PRT Phase 3 Document Library and EIC PRT Phase 4 Document Library, respectively. The EIC PRT Document Libraries accompanying this report provide more detailed information on the EIC PRT system project approach and implementation. Rather than reiterate information provided in the EIC PRT Document Library, this report provides an overview of project activities and refers to the appended EIC PRT documentation as appropriate. Note that the documents contained in the appendices represent works in progress and therefore are not finalized at this time because of development currently underway and various changes in project requirements. As such, the reader will find some TBDs, highlighted statements to be further assessed, and comments.

2. EIC PRT Phase 3 Overview

Phase 3 of the EIC PRT Project focused on integrating the EIC PRT safety-related functions with a host railroad's PTC system as an overlay. BNSF agreed to be the host railroad and partnered with TTCI to integrate the EIC PRT into ETMS.

EIC PRT Phase 3 consisted of the following tasks:

- ETMS Integration Analysis
- EIC PRT System Development
- Documentation of EIC PRT System Requirements and Design
- Critical Design Review (CDR)
- System Test
- Development of User Manuals and Training Materials

Activities associated with each of these tasks are described in the following sections.

2.1 ETMS Integration Analysis

The ETMS Integration Analysis was a collaborative effort between TTCI and BNSF. The analysis involved reviewing how the EIC PRT is expected to operate within the ETMS architecture and identifying modifications to the EIC PRT system created in Phase 2. Table 1 provides a list of significant differences between the Phase 2 prototype EIC PRT and the EIC PRT to be integrated into ETMS (Phase 3).

Table 1. Differences Between Phase 2 EIC PRT and EIC PRT for ETMS

EIC PRT System Feature	EIC PRT Phase 2 Prototype	EIC PRT for ETMS
EIC PRT Hardware Platform	EIC PRT deployed on a Pocket PC or Smartphone hardware platform.	EIC PRT deployed on laptop computer as defined by BNSF.
EIC PRT Operating System	EIC PRT deployed on a Windows Mobile operating system.	EIC PRT deployed on a Windows XP, Windows Vista, or Windows 7 operating system.
EIC PRT Data Radio	The EIC PRT equipped with a 802.11 Wireless Local Area Network (WLAN) data radio.	EIC PRT equipped with cellular data radio.
WLAN to WWAN Gateway	A WLAN to WWAN gateway provides the EIC PRT with an interface to the railroad VHF radio WWAN.	WLAN to WWAN Gateway not needed.
EIC PRT – BOS Message Routing	Messaging between the EIC PRT and the PTC BOS via railroad Very High Frequency (VHF) radio Wireless Wide Area Network (WWAN) routed through a base station.	Messaging between the EIC PRT and ETMS BOS via cellular network.
EIC PRT – Locomotive Message Routing	Messages between EIC PRT- and PTC-equipped Locomotive addressed directly to one another (i.e., peer-to-peer communication).	Messages between EIC PRT- and PTC-equipped Locomotive routed through ETMS BOS. ETMS BOS performs integrity checks on messages.
Time Synchronization	EIC PRT operating system obtains time synchronization from a Global Positioning System (GPS) clock.	EIC PRT operating system obtains time synchronization from cellular network.
Message Definition and Messaging Protocols	Defined in TTCI-EICPRT-011 Interface Requirements Specification and Design Document	Provided by BNSF.

The overall system architecture of the EIC PRT was modified per BNSF wireless communication requirements for interaction between the EIC PRT and the ETMS BOS and trains operating within the ETMS system. To illustrate these architecture changes, Figure 1 shows the overall architecture of the EIC PRT system as developed in Phase 2, and Figure 2 shows the EIC PRT for ETMS system architecture.

High level architecture definitions and concepts of how the Phase 3 EIC PRT is to operate within the ETMS system were documented in *BNSF-EICPRT-101 Concept of Operations (CONOPS).* This document is included in Appendix A.

The high level EIC PRT Phase 3 requirements described in the CONOPS were expanded into a set of detailed system requirements in *BNSF-EICPRT-102-Phase-3 System Requirements Specification*. This document is included in Appendix A.

The requirements defined in the EIC PRT System Requirements document focuses on the EIC PRT application. In order to perform its defined functions, the EIC PRT application interacts with other elements of ETMS, specifically the ETMS BOS and the Train Management Computer (TMC) of trains operating with ETMS. *BNSF-EICPRT-026 Critical Assumptions* documents the

set of functions that must be implemented in the ETMS BOS and TMC in order to support EIC PRT functionality. This document is included in Appendix A.

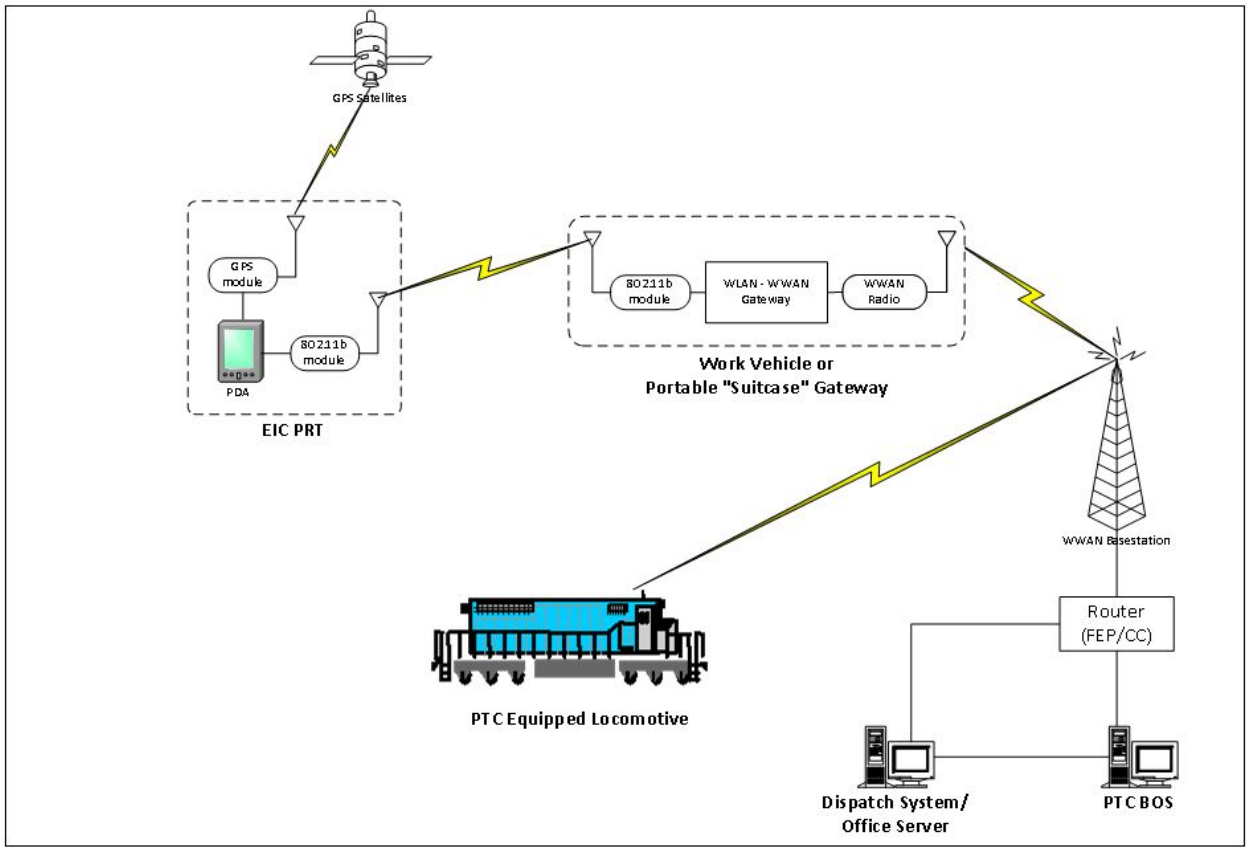


Figure 1. EIC PRT Phase 2 System Architecture (from *EIC PRT CONOPS Rev. 6.0*)

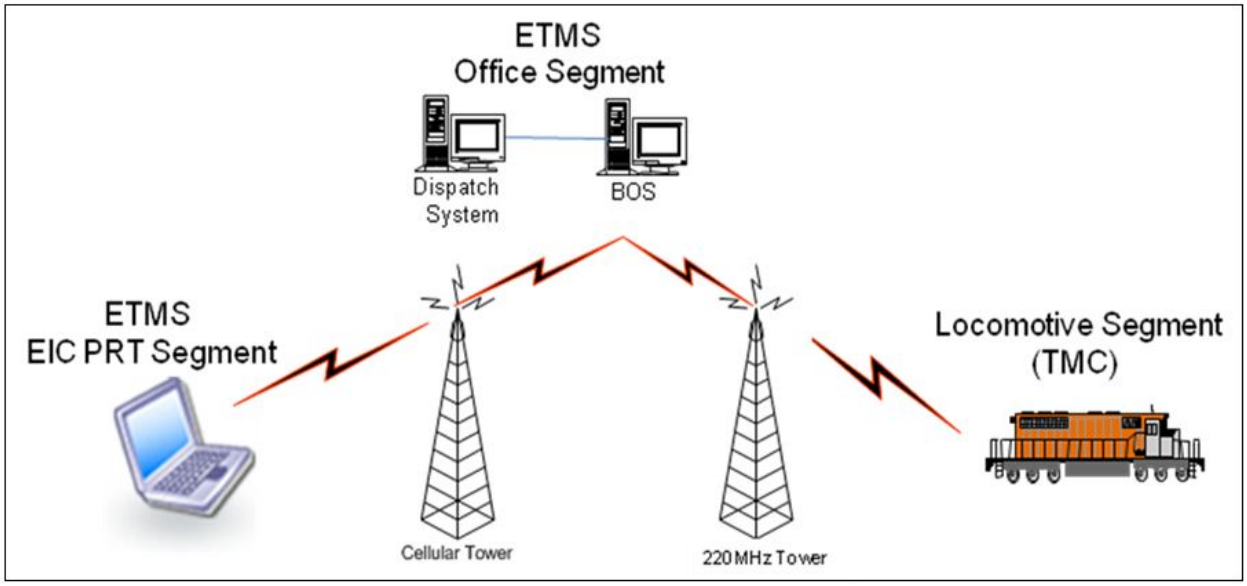


Figure 2. EIC PRT for ETMS System Architecture (from *BNSF-EICPRT-101 CONOPS*)

In addition to identifying architectural and functional changes needed in the EIC PRT, the EIC PRT system safety analysis was reviewed and revised to support the integration of EIC PRT into ETMS. During the integration analysis process, the EIC PRT safety analysis was revised for integration into the ETMS PTC Safety Plan (PTCSP) and PTC Development Plan (PTCDP) (e.g., the EIC PRT fault trees were modified to be compatible and consistent with the ETMS fault trees so that they could be imported and linked). *BNSF-EIC PRT-006 System Safety Program Plan* details the approach to system safety in the EIC PRT project. *BNSF-EICPRT-024 Safety Assessment and Verification & Validation Processes* details the overall approach to conducting the EIC PRT system safety assessment. Both of these documents are included in Appendix A.

Additionally, the following documents were developed during the course of the safety assessment, as required by the Safety Assessment Process:

- *BNSF-EICPRT-008 Hazard Log*
- *BNSF-EICPRT-021 Safety Assurance Concepts*
- *BNSF-EICPRT-022 Human Factors Analysis*
- *BNSF-EICPRT-024 Safety Assessment and Verification & Validation Process*
- *BNSF-EICPRT-027 System Architecture Satisfaction of Safety Requirements*

Each of these documents is included in Appendix A.

2.2 EIC PRT System Development

In Phase 2, TTCI developed and delivered the EIC PRT software for a PDA device running the Windows Mobile operating system. In Phase 3, TTCI's development team ported the EIC PRT application to a laptop platform with a Windows XP operating system. The graphical user interface was redesigned and updated to meet the needs of BNSF. The application was also updated to support BNSF requirements identified during the ETMS Integration Analysis.

The EIC PRT requirements defined in *BNSF-EICPRT-102* were allocated to the EIC PRT hardware platform, operating system, and software. For example, time synchronization functions were allocated to hardware (e.g., data radio) that remains synchronized to radio network system time, as well as to the operating system that is responsible for maintaining the system clock. The complete allocation of the EIC PRT requirements is documented in *BNS-EICPRT-015 Requirements Allocation Matrix*, which is included in Appendix A.

EIC PRT requirements allocated to software were expanded into a set of detailed requirements that specified the operation, function, and performance of the EIC PRT application. *BNSF-EICPRT-014 Software Requirements Specification* contains these requirements. The *Safety Assurance Concepts BNSF-EICPRT-021* document describes software assertion processes, such as data storage in multiple locations within the hardware memory and comparison of that data before its use by the application, which result in additional requirements that must be met by the software. These software assertions to be implemented in the EIC PRT application are also documented in the *BNSF-EICPRT-014 Software Requirements Specification*. This document is included in Appendix A.

Datatraks, a software development subcontractor to TTCI, developed *BNSF-EICPRT-014 Software Design Document*. The *Software Design Document* provides a detailed description of the EIC PRT software implementation. A software development firm contracted by TTCI implemented the EIC PRT application prototype as defined in the *Software Design Document* and in accordance with the methods and processes defined in *BNSF-EICPRT-010 Software Development Plan*.

2.3 Critical Design Review (CDR)

The EIC PRT for ETMS CDR was conducted on June 17, 2011, in Ft. Worth, TX, and was hosted by BNSF. The CDR topics included:

- Overview of Project Scope
- Human Machine Interface Concepts
- System Safety
- System Security
- Software Design
- Failure Handling
- Requirements Traceability
- System Maintenance
- System Testing
- Future Functional Expansion

The main objective of the CDR was to confirm that TTCI's proposed changes to the EIC PRT system satisfied BNSF requirements in terms of system functionality, performance, safety, and integration into the ETMS system.

The CDR addressed the entire EIC PRT system as it is expected to operate within ETMS. Key operating scenarios under normal conditions and exceptional conditions, such as communication coverage gaps, were discussed.

The prototype EIC PRT application, as implemented by Datatraks, was demonstrated during CDR. ETMS BOS and TMC simulators were used during the demonstration to show the overall functionality of the EIC PRT in operation within ETMS.

The EIC PRT CDR was attended by representatives from FRA, TTCI, and each of the Class 1 Railroads involved with the development of Interoperable Train Control (ITC) standards.

The key outcomes of the CDR were:

- BNSF approval of the design and implementation approach of the EIC PRT
- BNSF decision to begin implementation of EIC PRT-related functions for ETMS BOS
- Attendee consensus that development of the EIC PRT should continue
- Definition of the set of functions to be implemented in EIC PRT Project Phase 4

2.4 System Testing

Phase 3 EIC PRT integration was deferred until the Phase 4 EIC PRT functions could be implemented.

3. EIC PRT Phase 4

The EIC PRT project Phase 4 is an extension of the Phase 3 EIC PRT. Phase 4 of this project expanded the EIC PRT function set to improve utility and value of the EIC PRT for the roadway worker.

EIC PRT Phase 4 included the following tasks:

- Develop Concept of Operations for Phase 4 Functions
- Develop System Requirements and Design Documentation for Phase 4 Functions
- Develop Prototype
- Preliminary Design Review (PDR)
- System Testing

Activities associated with each of these tasks are described in the following sections.

3.1 Develop Concept of Operations for Phase 4 Functions

During the EIC PRT Phase 3 CDR, TTCI reviewed potential Phase 4 functions with the CDR attendees. At that time, the group identified the following functions as potential candidates for EIC PRT Phase 4:

- Provide mechanism to allow the EIC to define multiple speed restrictions within a Form B (e.g., 20 mph to milepost 356, then maximum allowable speed after that).
- Provide mechanism to allow the EIC to require a train to stop at a designated location within the Form B limits and then wait for further instructions.
- Provide mechanism for Form Bs to be selected by the EIC and assigned to the EIC by the BOS at login time or as needed by the EIC.
- Provide a mechanism to support the transfer of control of a Form B from one EIC to another as needed.

With the agreement of FRA, the EIC PRT function set was expanded to include these functions in Phase 4.

TTCI expanded *BNSF-EICPRT-101 Concept of Operations* for EIC PRT for ETMS under this task. This document is included in Appendix B, The EIC PRT Phase 4 Document Library.

3.2 Develop System Requirements and Design Documentation for Phase 4 Functions

The EIC PRT system requirements were expanded to include definitions of the requirements for the Phase 4 functions. In addition to defining the functional requirements, this document defines performance requirements, maintainability requirements, security requirements, extendibility requirements, etc. TTCI expanded the *BNSF-EICPRT-102 System Requirements* for EIC PRT for ETMS under this task. This document is included in Appendix B, The EIC PRT Phase 4 Document Library.

The following systems engineering documents were also revised and expanded during this task:

- *BNSF-EICPRT-012 Software Requirements Specification*
- *BNSF-EICPRT-014 Software Design Document*
- *BNSF-EICPRT-015 Requirements Allocation Matrix*
- *BNSF-EICPRT-026 Critical Assumptions*

Each of these documents is included in Appendix B, The EIC PRT Phase 4 Document Library.

During the EIC PRT Phase 4 requirements analysis and system design, the safety assessment was performed on the EIC PRT with the expanded function set. The following documents were revised and expanded during the safety assessment:

- *BNSF-EICPRT-008 Hazard Log*
- *BNSF-EICPRT-016 Risk Assessment*
- *BNSF-EICPRT-021 Safety Assurance Concepts*
- *BNSF-EICPRT-022Human Factors Analysis*
- *BNSF-EICPRT-023 Hazard Mitigation Analysis*
- *BNSF-EICPRT-025 Target Safety Levels & Backup Methods of Operation*
- *BNSF-EICPRT-027 System Architecture Satisfaction of Safety Requirements*
- *BNSF-EICPRT-028 System Safety Case*

Each of these documents is included in Appendix B, The EIC PRT Phase 4 Document Library.

3.3 Prototype Development

In this task, a prototype EIC PRT system that implements the expanded Phase 4 functions was developed on the basis of requirements and design documentation developed by TTCI in cooperation with BNSF. As in Phase 3, the EIC PRT application was developed by Datatraks in accordance with the principals defined in *BNSF-EICPRT-010 Software Development Plan*.

3.4 Preliminary Design Review (PDR)

The EIC PRT Phase 4 PDR was conducted June 19, 2012, in Minneapolis, MN, and was hosted by the Canadian Pacific Railroad. The EIC PRT PDR was attended by representatives from FRA, TTCI, and each of the Class 1 railroads involved in the development of ITC standards. The PDR topics included:

- Overview of Project Scope
- Review of EIC PRT Phase 3
- EIC PRT Phase 4 Functional Overview
- EIC PRT Phase 4 Critical Assumptions
- EIC PRT Safety Assessment
- EIC PRT Demonstration
- Next Steps in the Project

The EIC PRT Phase 4 PDR provided project stakeholders and other interested parties an opportunity to obtain an overview of the design and development of the system at a time when changes in implementation, scope, and functionality could be made at minimal cost.

Key outcomes of the EIC PRT Phase 4 PDR were:

- EIC PRT should not be used to manage transfers of Form Bs between EICs. Failure mode analysis of the Form B transfer function revealed that if a Form B is transferred to the PRT for an EIC who is out of radio communication, the BOS cannot confirm which EIC controls the Form B. It was therefore decided that the Form B transfer function should not be implemented.
- The EIC PRT development should proceed.
- BNSF committed to work with TTCI to conduct EIC PRT integration tests with ETMS as ETMS functions to support EIC PRT are implemented.

3.5 System Testing

Laboratory Integration Nearest Neighbor (LINN) testing was the focus of this portion of the project. System testing tasks included:

- Development of EIC PRT for ETMS LINN test plans
- Development of EIC PRT for ETMS LINN test procedures
- Test readiness review
- Execution of LINN tests

LINN testing between the EIC PRT and the ETMS BOS began July 16, 2012, and continued through December 28, 2012.

4. Future Work

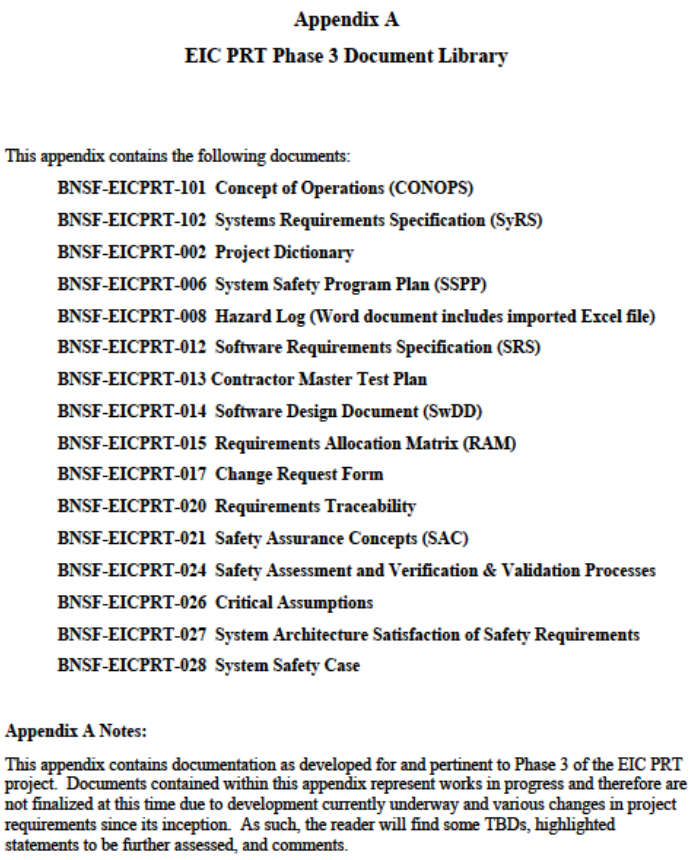
FRA has funded the continuation of EIC PRT Phase 4 (as Phase 4B) under Task Order 330. Under Task Order 330, TTCI and BNSF will continue the partnership to integrate the EIC PRT prototype system with BNSF's ETMS train control system. EIC PRT Phase 4B will extend the utility and value of the EIC PRT to the roadway worker by adding the following functionality:

- EIC Modification and Revision of Instructions to Train — Provides the capability for an EIC to modify an instruction sent to a train entering or within the Form B Limits. In most cases, this will be a modification to a more restrictive instruction.
- Nonverbal Overlay Operation — Provides the capability to negotiate train entry into Form B limits, as well as set speed restrictions within those limits; the setting of those speed restrictions will be done entirely through digital messages and without verbal dialog between the EIC and the train crew.
- EIC Notification of Train Occupancy of Form B — Provides notification to the EIC when a train is no longer within Form B limits. This function will either operate in conjunction with Positive Train Location, or use conservative train length.

EIC PRT Phase 4B will include EIC PRT systems engineering, safety assessment, and software development and will test the EIC PRT system with the expanded functionality.

Appendix A.
EIC PRT Phase 3 Document Library

Click Appendix A page image below to open PDF document binder.



Appendix A

EIC PRT Phase 3 Document Library

This appendix contains the following documents:

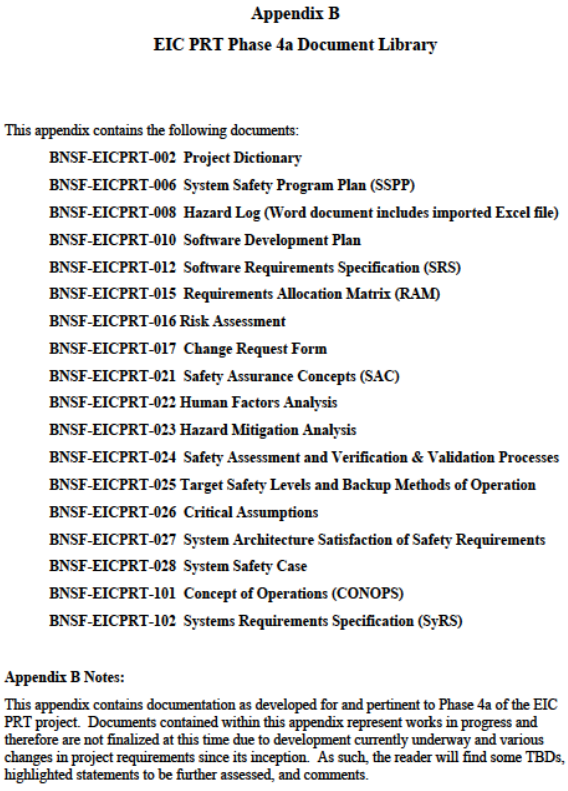
- **BNSF-EICPRT-101 Concept of Operations (CONOPS)**
- **BNSF-EICPRT-102 Systems Requirements Specification (SyRS)**
- **BNSF-EICPRT-002 Project Dictionary**
- **BNSF-EICPRT-006 System Safety Program Plan (SSPP)**
- **BNSF-EICPRT-008 Hazard Log (Word document includes imported Excel file)**
- **BNSF-EICPRT-012 Software Requirements Specification (SRS)**
- **BNSF-EICPRT-013 Contractor Master Test Plan**
- **BNSF-EICPRT-014 Software Design Document (SwDD)**
- **BNSF-EICPRT-015 Requirements Allocation Matrix (RAM)**
- **BNSF-EICPRT-017 Change Request Form**
- **BNSF-EICPRT-020 Requirements Traceability**
- **BNSF-EICPRT-021 Safety Assurance Concepts (SAC)**
- **BNSF-EICPRT-024 Safety Assessment and Verification & Validation Processes**
- **BNSF-EICPRT-026 Critical Assumptions**
- **BNSF-EICPRT-027 System Architecture Satisfaction of Safety Requirements**
- **BNSF-EICPRT-028 System Safety Case**

Appendix A Notes:

This appendix contains documentation as developed for and pertinent to Phase 3 of the EIC PRT project. Documents contained within this appendix represent works in progress and therefore are not finalized at this time due to development currently underway and various changes in project requirements since its inception. As such, the reader will find some TBDs, highlighted statements to be further assessed, and comments.

Appendix B.
EIC PRT Phase 4 Document Library

Click Appendix B page image below to open PDF document binder.



Appendix B

EIC PRT Phase 4a Document Library

This appendix contains the following documents:

- **BNSF-EICPRT-002 Project Dictionary**
- **BNSF-EICPRT-006 System Safety Program Plan (SSPP)**
- **BNSF-EICPRT-008 Hazard Log (Word document includes imported Excel file)**
- **BNSF-EICPRT-010 Software Development Plan**
- **BNSF-EICPRT-012 Software Requirements Specification (SRS)**
- **BNSF-EICPRT-015 Requirements Allocation Matrix (RAM)**
- **BNSF-EICPRT-016 Risk Assessment**
- **BNSF-EICPRT-017 Change Request Form**
- **BNSF-EICPRT-021 Safety Assurance Concepts (SAC)**
- **BNSF-EICPRT-022 Human Factors Analysis**
- **BNSF-EICPRT-023 Hazard Mitigation Analysis**
- **BNSF-EICPRT-024 Safety Assessment and Verification & Validation Processes**
- **BNSF-EICPRT-025 Target Safety Levels and Backup Methods of Operation**
- **BNSF-EICPRT-026 Critical Assumptions**
- **BNSF-EICPRT-027 System Architecture Satisfaction of Safety Requirements**
- **BNSF-EICPRT-028 System Safety Case**
- **BNSF-EICPRT-101 Concept of Operations (CONOPS)**
- **BNSF-EICPRT-102 Systems Requirements Specification (SyRS)**

Appendix B Notes:

This appendix contains documentation as developed for and pertinent to Phase 4a of the EIC PRT project. Documents contained within this appendix represent works in progress and therefore are not finalized at this time due to development currently underway and various changes in project requirements since its inception. As such, the reader will find some TBDs, highlighted statements to be further assessed, and comments.

Abbreviations and Acronyms

BNSF	Burlington Northern Santa Fe Railway Company
BOS	back office server
CDR	critical design review
CFR	Code of Federal Regulations
CONOPS	Concept of Operations
EIC	employee-in-charge
ETMS	Electronic Train Management System—BNSF's PTC system
FRA	Federal Railroad Administration
GCOR	General Code of Operating Rules
ITC	Interoperable Train Control
LINN	Laboratory Integration Nearest Neighbor
MOW	maintenance of way
MWP	maintenance of way protection
PDA	personal data assistant
PDR	preliminary design review
PRT	portable remote control
PTC	Positive Train Control
PTCDP	Positive Train Control Development Plan
PTCSP	Positive Train Control Safety Plan
RAM	Requirements Allocation Matrix
SAC	Safety Assurance Concepts
SRS	Software Requirements Specification
SSPP	System Safety Program Plan
SwDD	Software Design Document
SyRS	Systems Requirements Specification
TBD	to be determined
TMC	Train Management Computer
TTCI	Transportation Technology Center, Inc. (the company)
VHF	very high frequency
WLAN	wireless local area network
WWAN	wireless wide area network