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of Transportation
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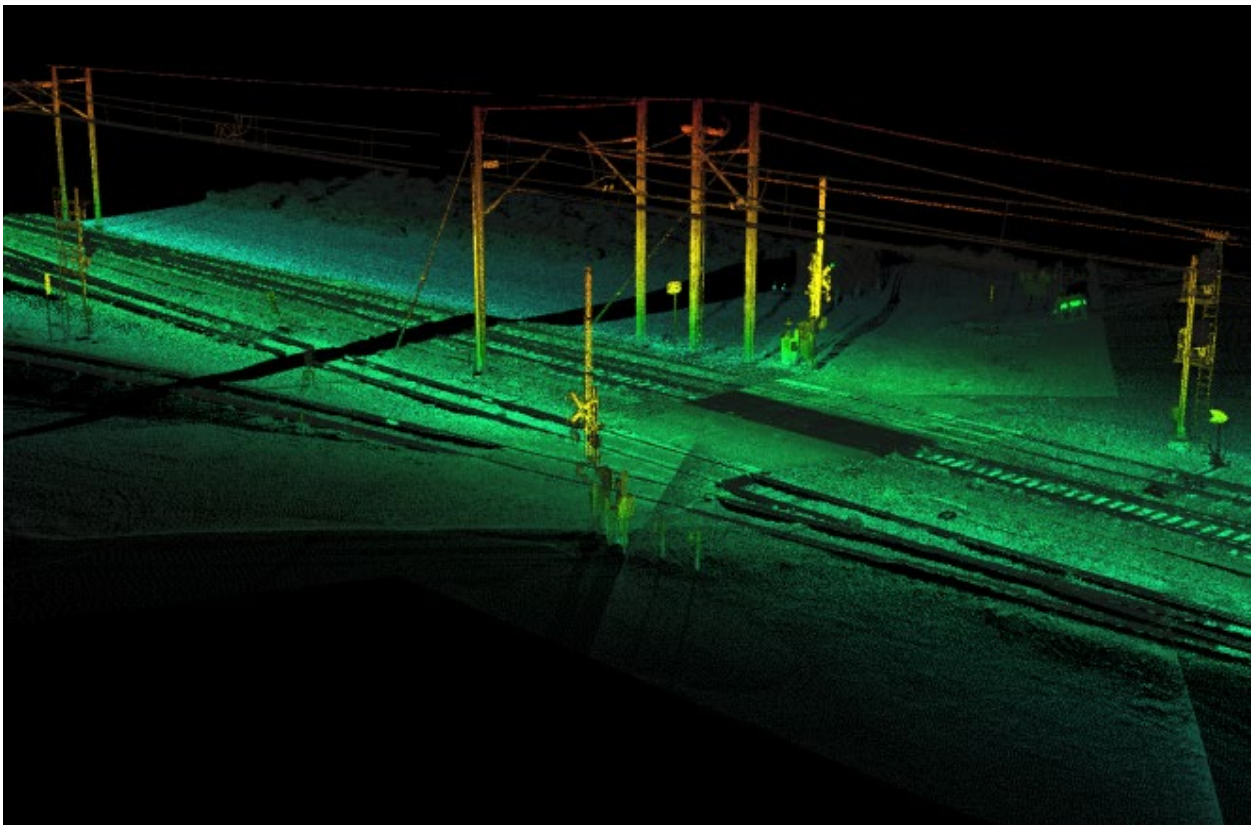
Administration

Office of Research,
Development and Technology
Washington, DC 20590

Positive Train Control
Critical Asset Track Database Auditing System (TDAS): Phase II



DOT/FRA/ORD-21/06

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14. ABSTRACT

Phase II of the Track Database Auditing System (TDAS) program sought to produce a system development and implementation plan with a more comprehensive outline of the project approach and goals, as well as further refine the Concept of Operations (ConOps) and system requirements developed in the first phase. The refined system requirements were then further decomposed into subsystem requirement documents that established functions and capabilities for each subsystem, as well as Interface Control Documents (ICDs) to describe communication requirements between each subsystem, and between TDAS subsystems and other railroad subsystems. Finally, TTCI and the technical advisory group (TAG) generated and submitted a request for proposal (RFP) to vendors to establish candidates for development of testable prototypes for Phase III. TTCI evaluated responses to this RFP with the TAG, identifying a need for a modified approach to the prototype development and testing, and expansion of the pool of potential vendors.

15. SUBJECT TERMS

Track Data Auditing System, TDAS, Process Management subsystem, Data Collection subsystem, Data Comparison subsystem, Positive Train Control, PTC, PTC critical asset audit, track data audit

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
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 yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

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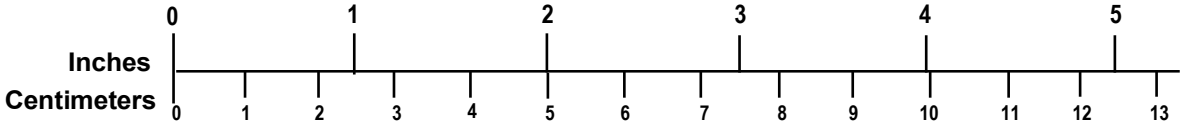
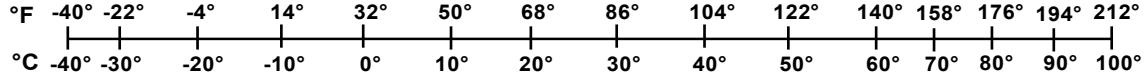
QUICK INCH - CENTIMETER LENGTH CONVERSION



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

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Contents

Illustrations

Executive Summary

From August 16, 2017, to February 29, 2020, Transportation Technology Center, Inc. (TTCI), through a program sponsored by the Federal Railroad Administration (FRA), developed the architecture and core requirements for a Positive Train Control (PTC) Track Database Auditing System (TDAS) at the Transportation Technology Center (TTC), including system, subsystem, and interface requirements that can be used to develop and test prototype solutions in future phases of the program. TDAS aims to support the development of specifications, in the form of standards and/or best practices, for subsystems of an auditing system designed to support flexible implementation and increased automation of auditing functions. The standards and/or best practices and capabilities defined by TDAS are intended to be available for all railroads to utilize. The deliverables produced in this phase include:

1. System Development and Implementation Plan
2. Update of TDAS Concept of Operations (ConOps)
3. TDAS System Requirements
4. TDAS Subsystem Requirements
5. TDAS Interface Requirements
6. Request for Proposal (RFP) and review of proposals received for evaluation in future phases

TDAS is a set of defined capabilities and standardized architecture intended to support the ongoing management of PTC track data to meet the requirements of the Interoperable Train Control (ITC) system. Key objectives of TDAS include flexibility of implementation, supporting increased automation of auditing capabilities, and standardization or definition of best practices for audit management, audit prioritization and scheduling, and recordkeeping processes.

The TDAS concept is intended to support the ongoing management of PTC track data to meet the requirements of the ITC PTC system. The system manages auditing of railroad track data for PTC systems that use the ITC PTC data model definition. TDAS manages the track data auditing functions for an organization's entire railway network, including audit data collection, audit data storage, audit data comparison, generation of audit reports, and audit prioritization and scheduling.

To function safely and effectively, PTC systems rely on accurate track data. Although processes exist to document and update PTC track databases following changes made to the track or other PTC critical assets, the potential exists for changes to occur without the track database being updated. Auditing of the PTC track databases is necessary to verify that the track data used by the PTC system accurately represents the actual track and PTC critical assets in place. Depending on the approach used, auditing can be a labor-intensive process that can reduce track availability and consume resources. Additionally, the processes are typically manually managed, which can introduce the potential for irregular audit periods. A system and standards and/or recommended practices that support a more automated process for scanning the locations and critical attributes of PTC critical assets and auditing PTC track databases could reduce the resource requirements and improve management of the PTC track data auditing processes.

1. Introduction

From August 16, 2017, to February 29, 2020, the Federal Railroad Administration (FRA) contracted Transportation Technology Center, Inc. (TTCI) to review and modify design documentation from the prior phase of the Track Data Auditing System (TDAS) program, as well as develop design documentation for two of the TDAS subsystems. This document describes the work performed and recommendations for a path forward for development of a TDAS capable of meeting the existing and future needs of the railroad industry.

1.1 Background

The Rail Safety Improvement Act of 2008 (RSIA '08) requires the implementation of interoperable Positive Train Control (PTC) on rail lines over which intercity passenger or commuter transportation is regularly provided, poisonous or toxic-by-inhalation hazardous materials are transported, and any additional lines identified by the U.S. Secretary of Transportation. PTC is defined within RSIA '08 as a system designed to prevent:

1. Train-to-train collisions
2. Overspeed derailments
3. Unauthorized incursions into established work zones
4. Movement of a train through a mainline switch in the improper position

The scope of PTC implementation covers approximately 60,000 miles of the national railroad network.

To achieve interoperability, the largest Class I freight railroads established Interoperable Train Control (ITC) standards, which specify requirements for an interoperable PTC system, including subsystem requirements, interface requirements, human-machine interface (HMI) standards, messaging standards, as well as standards for track data and track database format.

The system defined by the ITC standards is currently designed as an overlay system, providing enforcement of movement authorities and speed limits defined by an underlying method of operation, such as centralized traffic control (CTC) or track warrant control (TWC). In the ITC PTC system, movement authorities and speed limits are transmitted digitally to a computer on board the locomotive. The onboard computer tracks the train speed and location relative to the defined authority and speed limits and calculates the estimated stopping distance of the train on a periodic basis. The system alerts the train crew of any impending speed or authority violations and automatically initiates a penalty brake application if the train is predicted to exceed the limits of its authority or allowable speed.

The onboard computer of an ITC PTC-equipped locomotive tracks locomotive position and speed using a Global Navigation Satellite System (GNSS), the locomotive tachometer, and a track database defining the characteristics of the track and the locations and critical attributes of all PTC critical assets. Track databases are unique for each rail line; however, to support the ITC PTC system, each railroad must define its track database according to the ITC database format. A PTC track database is a collection of geographical information that specifies track layout information such as track geometry, as well as locations and critical attributes of PTC critical

assets. For a PTC system to function properly, the information contained in the track database must accurately represent the characteristics of each asset in the field.

The purpose of the TDAS program is to establish standards and/or best practices for requirements relating to the auditing of PTC critical assets from both the perspective of audit process management, data collection, and verification. PTC critical asset locations and attributes within PTC track databases can change because of various factors. Therefore, track databases require regular management and timely updates to support safe rail operations. Auditing PTC track databases can be a manual, time consuming process. In some currently used track database auditing processes, PTC critical assets are visually inspected, surveyed, and documentation is submitted and verified. Development of technology to increase the level of automation and support open standards and/or best practices is valuable to the industry in enhancing the PTC track data audit process accuracy and efficiency.

Phase I of the TDAS program established the initial framework for the system and goals for the program, based on stakeholder feedback (Federal Railroad Administration, May 2018). Researchers developed a Concept of Operations (ConOps) document in this phase as well as a system requirements specification. Additionally, multiple vendors received a Request for Information (RFI) to establish capabilities of existing technologies and identify gaps between those capabilities and the system requirements.

Phase II sought to produce a system development and implementation plan with a more comprehensive outline of the project approach and goals, as well as further refine the ConOps and system requirements developed in the first phase. The refined system requirements were then further decomposed into subsystem requirement documents that established functions and capabilities for each subsystem, as well as Interface Control Documents (ICD) to describe communication requirements between each subsystem, and between TDAS subsystems and other railroad subsystems. Finally, TTCI and the technical advisory group (TAG) generated and submitted an RFP to vendors to establish candidates for development of testable prototypes for Phase III. The TAG evaluated responses to this RFP with select vendors for developing prototypes.

1.2 Objectives

The objectives of Phase II of this project were to:

1. Document a system development and implementation plan, based on findings from Phase I
2. Refine design documentation from Phase I
3. Develop open standard specifications for individual system subsystems
4. Develop open standard interfaces between individual system subsystems
5. Generate RFPs for development of the audit management software and proof-of-concept data collection system subsystems and develop recommendations for the next project phase

1.3 Overall Approach

To achieve the stated objectives, TTCI began by documenting the industry strategic plan for development, implementation, testing, and expansion of the TDAS, using the findings from

Phase I and input and feedback from the industry TAG. During the development of this plan, face-to-face meetings occurred with members of the TAG to evaluate the project progress and deliverables in terms of applicability to the industry and alignment with individual railroad programs. These meetings resulted in adjusting project deliverables for the current phase of the program to remain applicable and provide the intended benefits that FRA and the industry are seeking.

Researchers updated the ConOps and System Requirements documentation developed in the first phase by using feedback received in Phase I and collaboration with the TAG. TTCI facilitated consensus with the TAG on the subsystem-level requirements and ICDs for the TDAS subsystems. TTCI prepared RFPs for the Audit Management subsystem and Data Collection subsystem that included these documents and the updated ConOps and System Requirements. The distribution of Data Collection subsystem RFP to vendors resulted in an analysis of responses to select potential vendor(s) to develop and test proof-of-concept Data Collection subsystems in the next phase of the program.

1.4 Scope

The scope of work included:

- Preparation of a document that defined the industry plan for initial and ongoing development and implementation of TDAS
- Refining documentation from the first phase, including the ConOps and System Requirements, using findings from Phase I and the development and implementation plan
- Definition of open standard subsystem-level requirements for the Audit Management subsystem and subsystem-level requirements for the Data Collection subsystem
- Development of ICDs between TDAS subsystems, and between TDAS subsystems and external systems
- Development of an RFP for the for future development of an Audit Management subsystem, and Data Collection subsystem, as well as distribution of the latter RFP and recommendations for a vendor(s) to develop a prototype(s) for testing in the next phase
- Preparation of a final report documenting the findings from Phase II

1.5 Organization of the Report

This report is organized into the following sections:

Section 1 provides background information on the project.

Section 2 details the project documentation, including updates to documents from the previous phase, and the development of new design documentation.

Section 3 describes the RFP produced for development of TDAS subsystem prototypes.

Section 4 summarizes the work performed and the results.

Appendices A Through M includes the following: the System Development and Implementation Plan; the revised Concept of Operations (ConOps) document from Phase I; an updated System Requirements Specification document from Phase I; the development of

subsystem-level requirements for the Process Management and Data Collection subsystems; a data Comparison subsystem and Data Collection subsystem ICD; information on Process Management subsystem and Data Collection subsystem ICD; Process Management subsystem and railroad back office ICD; and Process Management subsystem and Data Comparison subsystem ICD. The appendices also include a trade table developed to assist in the selection of a vendor from the responses received.

2. Project Documentation

2.1 System Development and Implementation Plan

The purpose of the System Development and Implementation Plan (Appendix A) is to document an industry plan for development and implementation of industry-common standards and/or recommended practices relating to PTC track database auditing processes and associated technology solutions by the railroads that use an ITC PTC system.

The railroads indicated that a complete set of standards and requirements would not be beneficial, as many already have auditing systems in various stages of design and development. Instead, the railroads determined that the project should produce the following two sets of documents, each with their own specific purpose:

1. The definition of high-level concepts and system-level requirements to be used as standards or best practices for all interoperable railroads, without being overly restrictive or requiring significant change to existing or developing systems.
2. The development of more detailed system and subsystem requirements for a specific implementation of TDAS providing railroads with the option to (a) use this more complete design as defined, (b) use it as a basis to design their own specification, or (c) use their own detailed design specification, providing flexibility to modify their implementation within the higher-level system standards or best practices.

It was recognized that an incremental approach to automation of track data auditing provides the most immediate benefit to the railroads, while subsequently providing a path forward for increased automation. Specifying implementations of TDAS at various levels of automation allows railroads to implement versions of TDAS that conform to the standards and best practices, but do not necessarily immediately require the significant development and investment of a fully automated auditing system.

A high-level architecture (illustrated in Figure 1), specifying basic TDAS subsystems and the organization of TDAS capabilities, was also developed to allow railroads and their vendors more flexibility in implementation, and to encourage continued advancement in state-of-the-art technology that can be used, without locking into a specific technology or product.

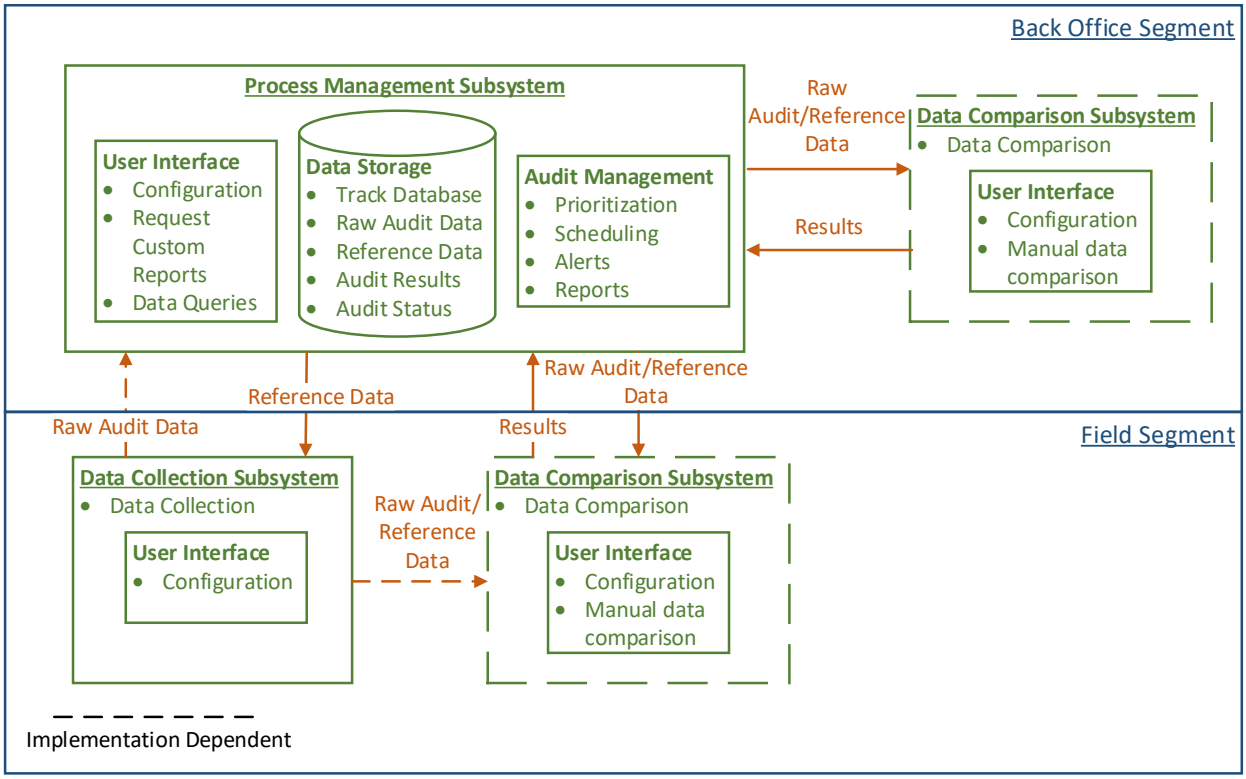

Figure 1. TDAS Architecture

Feedback received from meetings with the railroads informed much of the content and the path forward described in the System Development and Implementation Plan.

The System Development and Implementation Plan includes:

- Identification of industry needs, and how TDAS is structured to support developing solutions to satisfy those needs
- Prioritization of the objectives of TDAS based on feedback from the TAG
- Identification of the data collection technologies to be initially supported
- Demonstration how the basic system architecture will be applied to each of the identified operational scenarios
- Delineation of the individual TDAS subsystems
- Documentation of the industry plan for development and implementation of each TDAS subsystem to support open standards, vendor engagement, and evolution of automated data processing over time

TTCI worked with the TAG to gain agreement on the System Development and Implementation Plan to represent the industry consensus path for incrementally increasing the level of automation of the TDAS to support each railroad's individual objectives and requirements, while maintaining standardization to the extent possible.

2.2 Update of Design Documentation

2.2.1 ConOps

Phase I included the development of a ConOps as part of the initial system design documentation. The purpose of the ConOps is to highlight major objectives and goals for the system; identify the system users, primary functions, and high-level architecture; and describe the role the system plays in meeting the railroad industry's PTC track data auditing needs. The definition of and relationships among key system components are discussed along with capabilities and constraints. The document outlines and describes the environment in which the system will operate and the operational scenarios that detail how the system impacts different users under differing conditions.

Based on feedback from Phase I of the project, as well as feedback received during visits to the railroads, the ConOps was revised (Appendix B) to better reflect the goals of the participant railroads. Major changes to the ConOps included the following:

1. Focus on updating the specification of standards for all aspects of TDAS and removing as appropriate, to better align with the focus on high-level standards or best practices agreed upon with the railroads.
2. Detailed system requirements and system processes that were more appropriate in the system requirement documentation were abstracted to high-level system concepts.
3. Restrictive, detailed design concepts were abstracted to more generalized system goals. In addition to being more appropriate for lower-level specifications, these design concepts did not completely align with railroad technical approaches, and unnecessarily restricted the technological approach without specifying meaningful standards for system performance.

2.2.2 System Requirements

Similar to the ConOps, the development of a System Requirements Specification occurred in Phase I. The purpose of the System Requirements document is to specify the minimum high-level requirements for TDAS, including:

- System architecture:
  - Required subsystems
  - Subsystem interfaces
- Audit management requirements:
  - Data management requirements
  - Audit prioritization and scheduling requirements
- Data collection requirements
- Data comparison requirements

This document was updated (Appendix C) to match the narrative of the revised ConOps, with respect to TDAS capabilities. Additionally, improving the organization of the document to aid in better distinguishing between system-level and subsystem-level requirements, which were

moved to the appropriate documents. Major changes to the system requirements included the following:

- Requirements were reorganized by level of specification. It was found that many of the requirements specified in the original document were specified at a subsystem level. These requirements were added to the new subsystem requirement documents, and equivalent system requirements were created from abstractions of these requirements.
- Requirements no longer in alignment with railroad goals were removed, and new requirements were added as appropriate.

2.3 Subsystem Requirements and ICDs

2.3.1 Subsystem Requirements

Appendices D and E contain the subsystem-level requirements developed for the Process Management and Data Collection subsystems. These documents, along with the RFPs were written with sufficient detail for development of working implementations in a follow-on phase.

The Data Collection subsystem provides TDAS with raw audit data used to perform audits. Raw audit data is either collected opportunistically via data collection hardware mounted on revenue service vehicles or targeted by collection vehicles which provided data collection locations from the Process Management subsystem. The Data Collection subsystem interfaces with the Process Management subsystem to exchange raw audit data, reference data, and data collection locations. The Data Collection subsystem also interfaces with the Data Comparison subsystem to exchange reference data and raw audit data, in implementations where the Data Comparison subsystem is on board the collection vehicle. The Data Collection subsystem requirements documentation specifies the requirements for a TDAS Data Collection subsystem, including:

- Data quality
- Hardware support requirements
- Subsystem interface requirements

Performance requirements for the Data Collection subsystem were, in part, tied to the Data Comparison subsystem. The total error budget for TDAS is specified to include error in the track database, from the Data Collection subsystem, and from the Data Comparison subsystem. Since there was no basis for assigning portions of the error budget to either subsystem, it was agreed that the full budget should be set as the minimum for each subsystem.

The Process Management subsystem provides capabilities for TDAS to:

- Manage prioritization and scheduling of audits
- Manage data stored and transferred between the back office and TDAS subsystems
- Allow configuration of audit management capabilities and audit parameters by users
- Provide alerts and reports
- Provide custom reports and data upon user request

To support the raw audit data collection process, the Process Management subsystem provides the required reference data to the Data Collection subsystem and facilitates transfer of audit data

from the Data Collection subsystem into the data storage component. The Process Management subsystem also provides the raw audit data and associated reference data to the Data Comparison subsystem to support the data comparison process and saves the audit results to the data storage component. An interface to the back office is included as a means of obtaining track database files and providing alerts and reports. The Process Management subsystem requirements documentation specified the requirements for a TDAS Process Management subsystem, including:

- Audit management, including:
  - Alerting and report generation
  - Prioritization and scheduling
- Data collection support
- Data comparison support
- Subsystem interface requirements

Requirements specified in these documents were provided as guidelines for Data Collection and Process Management subsystem implementations should the railroad choose to utilize them, and to support development of the associated RFPs.

2.3.2 ICDs

The ICDs (appendices F through I) were developed for each interface illustrated in Figure 1. The purpose of the ICDs is to provide a description of the messages between each subsystem and identify the content of those messages. Non-standard requirements such as messaging protocols and security requirements were left to be specified by individual railroads in an included appendix of each ICD.

- The Data Comparison subsystem and Data Collection subsystem ICD (Appendix F) includes specifications for messages related to transfer of reference data and raw audit data from the Data Collection subsystem to the Data Comparison subsystem for implementations of TDAS where the Data Comparison subsystem is collocated with the Data Collection subsystem onboard the data collection vehicle.
- The Process Management subsystem and Data Collection subsystem ICD (Appendix G) includes specifications for messages related to transfer of data collection locations and reference data from the Process Management subsystem to the Data Collection subsystem, and transfer of raw audit data and data collection asset locations from the Data Collection subsystem to the Process Management subsystem.
- The Process Management subsystem and railroad back office ICD (Appendix H) includes specifications for messages related to transfer of reference data from the back office to the Process Management subsystem, and for the Process Management subsystem to provide alerts and reports to the railroad back office.
- The Process Management subsystem and Data Comparison subsystem ICD (Appendix I) includes specifications for messages related to exchange of reference data, raw audit data, and audit results between these two subsystems.

Using feedback from the TAG, requirements related to messaging specifications and protocols were removed to avoid being overly restrictive. Message specifications only included the minimum message payload, with details regarding the messaging protocols left to be specified by the individual railroads. An appendix was added to each ICD to provide a template for railroads to specify these details for their implementation. For purposes of the RFP, the appendices of the relevant ICDs were populated with the details needed to develop a prototype.

3. RFP and Follow-on Subsystem Testing

The follow-on phase of this project aims to support the development and testing of a Data Collection subsystem prototype. The authors prepared and distributed an RFP to several vendors selected by TTCI and the TAG, and an evaluation of responses ensued. The RFP included design documentation sufficient for a vendor to develop a prototype Data Collection subsystem, as well as details for the testing to occur in the follow-on phase of the program. Testing planned for the follow-on phase includes laboratory evaluation of the subsystem to verify adherence to interface and messaging specifications, and field evaluation to verify the system adheres to all functional and performance requirements when collecting raw audit data.

Responses to the RFP contributed to the TAG's selection of one or more vendors for development of prototype Data Collection subsystems. A trade table was also developed to assist in the selection of a vendor from the responses received (Appendix M).

The TAG expressed concern that the number of responses received was potentially insufficient to provide a robust selection pool. Additional responses were desired to ensure the selection of a vendor capable of meeting the requirements set forth by the associated requirements documents.

Evaluation of the RFP responses also highlighted several concerns regarding the testing approach, and limitations it may create when developing the subsystem prototype. Many vendors already had commercial off the shelf systems capable of being evaluated against the Data Collection subsystem's core performance requirements. The TAG agreed that testing several existing systems and choosing a single vendor from that evaluation to develop a full prototype would be more effective. A decision came to pass to update and redistribute the RFP to account for these necessary changes, and because of time and funding limitations for this phase, these tasks would be pushed into the next phase.

An RFP was also produced for the Process Management subsystem, though due to updates in the System Development and Implementation Plan, no follow-on phase for development of a Process Management subsystem prototype is planned. The documentation stands to be utilized at a later time, should a future phase include the development of such a prototype.

4. Conclusion

From August 16, 2017, to February 29, 2020, FRA sponsored TTCI to develop the architecture and core requirements for a PTC TDAS, including system, subsystem, and interface requirements that can be used to develop and test prototype solutions in future phases of the program. Several individual efforts are currently underway within the railroad industry to address various issues with existing change management and track validation processes. This also includes efforts aimed at evaluating future capabilities for track data auditing. The goal of the TDAS program is to support collaboration between the railroads for development of industry standards and/or best practices related to track data auditing and technology to support automation of these processes. The System Development and Implementation Plan defines the proposed structure of the TDAS program as well as a roadmap to incrementally increase the level of automation of the audit process. The ConOps and System Requirements Document updated in this phase of the program provide a framework for fundamental capabilities that any implementation of the TDAS should include, and the Subsystem Requirements and ICDs detail requirements and specifications necessary to develop prototypes of two of the three subsystems.

An analysis of the RFP responses received in this phase highlighted the need to modify the envisioned test structure and vendor selection process in Phase III. Phase III goals are:

- To update the prototype development and testing process
- The initial development of the Data Comparison subsystem requirements and PTC critical asset library

Phase IV goals will be:

- The development and testing of a Data Comparison subsystem utilizing the requirements developed in Phase III
- Analyzing results of testing on the Data Collection subsystem

5. References

Federal Railroad Administration. (May 2018, May). *Positive Train Control Track Data Auditing System*. Transportation Technology Center, Inc. Technical Report No. DOT/FRA/ORD-18/16. Washington, DC: U.S. Department of Transportation.

Appendix

Federal Railroad Administration. *Positive Train Control Critical Asset Track Database Auditing System (TDAS): Phase II Appendices A Through M*. DOT/FRA/ORD-21/06. Washington, DC: U.S. Department of Transportation. 2021.

Abbreviations and Acronyms

ACRONYM	EXPLANATION
CTC	Centralized Traffic Control
ConOps	Concept of Operations
FRA	Federal Railroad Administration
GNSS	Global Navigation Satellite System
HMI	Human-Machine Interface
ICD	Interface Control Document
ITC	Interoperable Train Control
LiDAR	Light Detection and Ranging
PTC	Positive Train Control
RSIA ‘08	Rail Safety Improvement Act of 2008
RFI	Request for Information
RFP	Request for Proposal
TAG	Technical Advisory Group
TDAS	Track Data Auditing System
TTCI	Transportation Technology Center, Inc.
TWC	Track Warrant Control