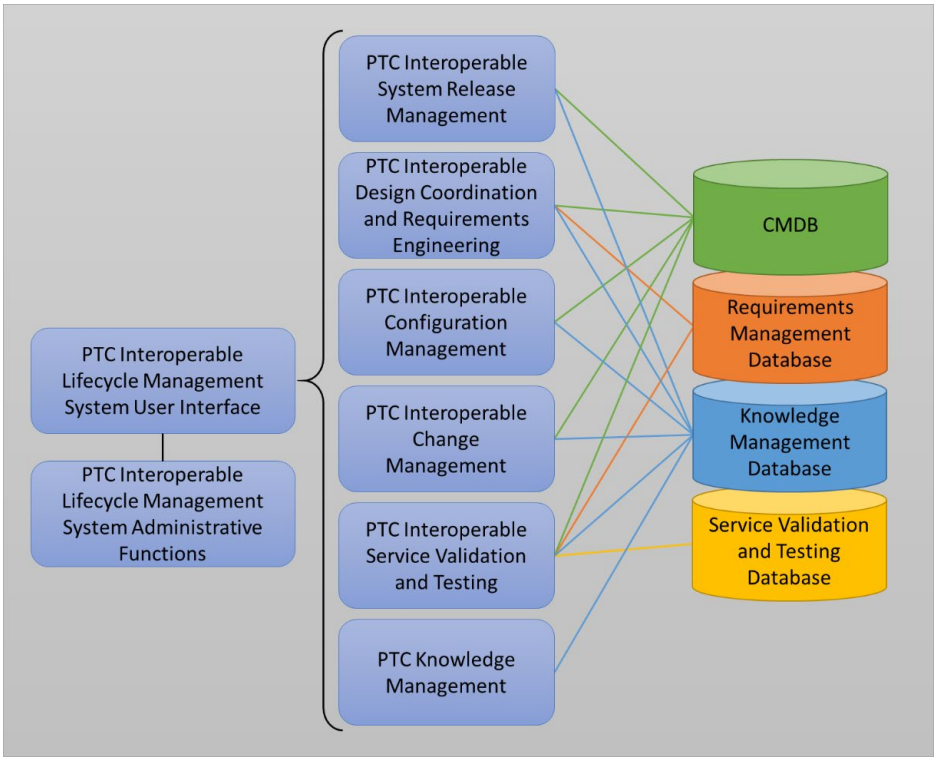
U.S. Department of Transportation

Federal Railroad Administration

Concepts for a Positive Train Control (PTC) Interoperable Lifecycle Management System

Office of Research,
Development
and Technology
Washington, DC 20590



DOT/FRA/ORD-20/19

Final Report
May 2020

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 2020	Technical Report, March 2017-March 2019

4. TITLE AND SUBTITLE

Concepts for Interoperable Lifecycle Management of Positive Train Control (PTC)

5. FUNDING NUMBERS

DTFR53-11-D-00008

Task Order 30

6. AUTHOR(S)

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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-20/19

11. SUPPLEMENTARY NOTES

COR: Richard Orcutt

12a. DISTRIBUTION/AVAILABILITY STATEMENT

This document is available to the public through the FRA eLibrary.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Transportation Technology Center, Inc. (TTCI) developed initial concepts for a Positive Train Control (PTC) Interoperable Lifecycle Management (ILM) system to support established and evolving industry processes to manage, coordinate, and document changes to PTC throughout its lifecycle. As part of the project, TTCI engaged industry groups established to support PTC ILM activities to support the established and evolving processes, gaining insights into the needs for the PTC ILM system. In addition to the initial concepts, TTCI developed initial high-level requirements for the interoperable change and configuration management aspects of the system and evaluated existing commercially available tools to determine applicability to the PTC ILM system.

14. SUBJECT TERMS

Positive Train Control, PTC, change and configuration management, interoperability, lifecycle management, information technology infrastructure library, ITIL, information technology service management, ITSM

15. NUMBER OF PAGES

134

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

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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
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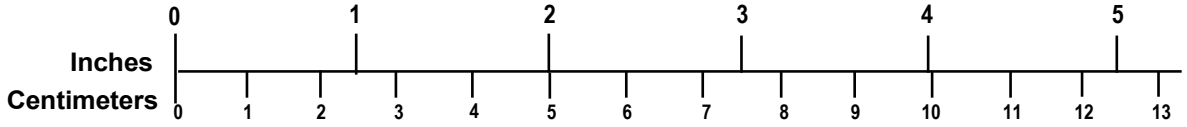

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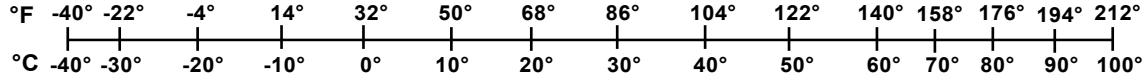

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286 Updated 6/17/98

Acknowledgments

The project team would like to thank the members of the following industry groups for their leadership, input, guidance, support, and feedback related to this project:

- Association of American Railroads (AAR) Train Control, Communications and Operations Committee
- AAR Positive Train Control Interoperability Committee
- Interoperable Train Control, Change and Configuration Management team

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Executive Summary

Transportation Technology Center, Inc. (TTCI) developed initial concepts for a Positive Train Control (PTC) Interoperable Lifecycle Management (ILM) system to support established and evolving industry processes to manage, coordinate, and document changes to one of the primary PTC systems implemented by many of the freight railroads (Interoperable Train Control (ITC)) throughout its lifecycle. TTCI researchers derived initial high-level requirements for the PTC ILM system interoperable change and configuration management (CCM) processes from the concepts, and they identified and reviewed existing commercially available tools to determine if they could be implemented to support industry needs. The research team determined that none of the identified commercially available tools identified are likely capable of performing all of the needed functions. In particular, the specific application of Information Technology Service Management (ITSM) processes to PTC ILM suggested that a custom application may be preferable to adapting an existing tool, and a separate project has been initiated to develop the highest-priority capabilities of the PTC ILM system. However, it may be possible to incorporate commercially available system requirements and test management software into the PTC ILM system, and this study recommends this approach be considered further as the PTC ILM system development efforts progress.

PTC is a complex technology that will continue to evolve over time to support advancements in technology as well as new functionality needs. Successful operation of such a system requires a disciplined systems management program which includes processes to coordinate and document aspects of the system as it changes throughout its lifecycle. While each railroad deploying the one primary PTC system must address these lifecycle management challenges to support continued compliance with the PTC statute and regulations, operations and business needs, there are aspects of lifecycle management that also must be addressed amongst the railroads implementing the PTC system to continue to ensure interoperability between railroads.

As part of this project, TTCI engaged the industry groups that have been established to support PTC ILM activities. Specifically, TTCI worked with the following committees that support the ITC PTC system, specifically PTC Interoperability Committee (PTC IC), Interoperable Train Control (ITC) subcommittee, members of the ITC Change and Configuration Management (CCM) team, and the Interoperable Change Approval Board (ICAB) to understand current and evolving processes related to PTC ILM, support and enhance these processes, and get input and feedback on the draft concepts and requirements for the PTC ILM system. The work performed during this project helped to support the evolution of the processes established by the ITC CCM Team, and the coordination with their continued efforts in turn supported the development of the draft concepts for the PTC ILM system.

Lessons learned from the execution and support of current ITC railroad processes, along with input from members of the industry groups, were used to develop the rationale and needs of the PTC ILM system. To develop the draft PTC ILM system concepts, TTCI reviewed established best practices for ITSM and determined their applicability to PTC ILM. The research team documented the draft concepts for the PTC ILM system in a System Description and Operational Concept document. High-level requirements for PTC ILM system functions to support interoperable CCM capabilities were derived from the PTC ILM System Description and

Operational Concept document, industry policies and procedures established for interoperable CCM, and lessons learned from supporting the interoperable CCM processes. The project team and supporting industry representatives recognized that these concepts and requirements will continue to be refined reflecting lessons learned from existing industry processes and as the PTC ILM system development effort progresses. As a result, the documents included as appendices to this report represent the current understanding of the project team, based on the experience gained through the efforts described and input from members of the associated industry groups, but are considered living documents.

In parallel with this project, the industry has begun development of the PTC ILM system with the capabilities to support interoperable change, configuration, and release management. The development project is being executed as a joint effort involving the railroads (primarily through the ITC CCM team), TTCI, and Railinc, with the Federal Railroad Administration supporting aspects of the continued design and testing activities. As these efforts continue, this study recommends that the design of the PTC ILM system continue to leverage from best practices in ITSM. Additionally, researchers recommend developing the requirements for interoperable design coordination and requirements management and industry test management along with a more thorough investigation of the available tools to support these aspects, including the potential for integration with the PTC ILM system currently being developed.

1. Introduction

Positive Train Control (PTC) is a system that is designed to prevent train-to-train collisions, over-speed derailments, incursions into established work zone limits, and the movement of a train through a mainline switch left in the wrong position. There are five (5) primary PTC systems that are being implemented throughout the United States. Several of these PTC systems involve complex technology, which will continue to evolve to support advancements in technology as well as new functionality needs. Successful operation of a system of this nature requires a disciplined systems management program which includes processes to coordinate and document aspects of the system as it changes throughout its lifecycle. This is the case for the Interoperable Train Control PTC system. While each railroad deploying a PTC system must address these lifecycle management challenges to ensure continued compliance with the PTC statute and regulations, and support its operation and business needs, there are aspects of lifecycle management that also must be addressed at an industry level to support interoperability between railroads. This project was funded by the Federal Railroad Administration (FRA) and executed by Transportation Technology Center, Inc. (TTCI) in coordination with railroad industry representatives, to support the development of processes and tools that can be used for PTC Interoperable Lifecycle Management (ILM). The intent is for the results of this and future efforts to support coordinated efforts among all PTC railroads, including Class I freight, passenger, commuter, and shortline rail carriers, for the successful ongoing operation of interoperable PTC.

1.1 Background

PTC is a system that is designed to prevent train-to-train collisions, over-speed derailments, incursions into established work zone limits, and the movement of a train through a mainline switch left in the wrong position. The Interoperable Train Control (ITC) PTC system is a form of communications-based train control technology designed to enforce operating rules to prevent certain types of accidents from occurring. The ITC PTC system is designed to monitor and enforce the established authority and speed limits for each train by means of an automatic penalty brake application if the train is predicted to exceed any such limits.

The Rail Safety Improvement Act of 2008 (RSIA ’08) [1] mandates, among other things, that each Class I railroad carrier and each entity providing regularly scheduled intercity or commuter rail passenger transportation develop and execute a plan for implementing a PTC system on mainlines over which passenger transportation is regularly provided and over which poison- or toxic-by-inhalation hazardous materials are transported. RSIA ’08 defines PTC as a system designed to prevent train-to-train collisions, over-speed derailments, incursions into established work zone limits, and the movement of a train through a mainline switch left in the wrong position. It also specifies that each PTC system must provide for interoperability of the system with movements of trains of other railroad carriers over its lines.

The mandate to implement PTC requires equipping approximately 16,000 locomotives and approximately 54,000 route miles by the U.S. Class I railroads alone [2]. Amtrak, U.S. commuter rail providers, and many U.S. shortline railroads also are required to implement PTC, in addition to the U.S. Class I railroads. As a result of the scope of the PTC mandate, the largest Class I

railroads implemented one of the five primary PTC systems (ITC) and have developed standards to ensure interoperability for all railroads implementing the ITC PTC system, which must be maintained as the system evolves, demanding continued close coordination among affected railroads.

ITC PTC systems are designed to include the following four segments:

- Back Office Segment: Connects to dispatching and ancillary systems
- Wayside Segment: Connects to field systems, such as signals and switches
- Locomotive Onboard Segment: Receives input from other segments to track the position of the train relative to authority, speed, and other limits and enforce these limits; also includes interface for train operators, as applicable
- Communications Segment: Provides data communication between the other three segments. PTC systems currently are designed as overlays of existing train control systems such as Centralized Traffic Control (CTC), Track Warrant Control (TWC) or Direct Traffic Control (DTC). PTC, in its current form, enforces operating rules and procedures that are associated with these underlying systems.

The ITC PTC system being implemented across the U.S. was borne out of an agreement among the largest U.S. Class I freight railroads, known as the Interoperable Train Control (ITC) agreement, to jointly develop and implement standards for the interoperable aspects of a PTC system. Other examples of PTC solutions include the Advanced Civil Speed Enforcement System (ACSES), being implemented by Amtrak and commuter railroads operating on and around the Northeast Corridor (NEC); the Incremental Train Control System (ITCS); the Enhanced Automatic Train Control (E-ATC) system and the Communications Based Train Control (CBTC) system. The varying PTC solutions are not interoperable with each other.

The term “ITC-compliant system” refers to the implementation of a system that complies with the set of ITC standards and specifications designed to support interoperability among participating railroads. The intent of these standards is to define the elements of the system necessary to allow for interoperability while leaving railroad-specific implementation and design details up to the individual implementing railroad. Though the focus of this project is on supporting ILM for the ITC-compliant systems, the expectation is that the research conducted can apply to other interoperable PTC solutions, and the draft system concepts developed may expand to support ILM for these systems.

Most railroad track miles are owned and maintained by 7 Class I railroads, 21 regional railroads, and 510 local railroads. The remainder is owned by Amtrak and some of the commuter operators; however, not all passenger routes operate exclusively on Amtrak or commuter agency lines. Most of the routes into urban centers were owned by the freight railroads long before the passenger agencies came into being. In addition, some urban lines taken over by commuter operators for operational and management convenience still maintain some residual freight operation by freight railroads.

The net result is that the PTC systems installed on Amtrak and commuter trains must be compatible or interoperable with the system installed on the host railroad, and interoperability is

also required for freight trains operating on Amtrak or commuter lines. Similarly, freight railroads operate on each other's lines under running right agreements for reasons of convenience or economy, and therefore their PTC systems also must be interoperable. Further, freight railroads lease locomotives from each other or from leasing companies in times of traffic imbalance or seasonal traffic peaks.

One of the key elements of the RSIA '08 is that the PTC system must "provide for interoperability of the system with movements of trains of other railroad carriers over its lines." Interoperability is further defined as "the ability to control locomotives of the host railroad and tenant railroad to communicate with and respond to the positive train control system, including uninterrupted movements over property boundaries." [1] For PTC systems to be interoperable, trains must be able to traverse from territory operated by one railroad to territory operated by another railroad at track speed (that is, without having to stop to reinitialize a different system) without loss of PTC function or safety. Resolving issues associated with interoperability is critical to the successful implementation of PTC and achieving the associated safety benefits.

The system defined by the ITC standards was designed with interoperability in mind. For those railroads operating an ITC-compliant system, coordination and testing between host and tenant railroads is necessary to ensure that the tenant can operate according to the host railroad's PTC operating procedures. Once the system is implemented and tested, maintaining interoperability will require close coordination among the railroads as the interoperable elements of the system change and evolve.

Interoperability between railroads using different PTC systems (such as ITC and ACSES) is required. A variety of means are used to achieve interoperability, such as duplicate wayside systems, duplicate onboard systems, or translators. These also need to be verified through testing to ensure that the correct system response is achieved.

The complexity in the number of configurable items and interactions, combined with the continuous rapid rate of change of these configurable items presents a significant challenge to maintaining fully compatible, functional, and interoperable PTC systems within and between railroads. This requires disciplined lifecycle management processes and tools that can support the tracking of supported versions of configurable items, traceability of requirements, and coordinated schedules for the change-out of system elements as new features are tested and commissioned for operation.

1.2 Objectives

The objectives of this project were to:

- Organize and coordinate an advisory group (AG) with railroad industry representatives to provide input and feedback on the work conducted.
- Engage in industry interoperable change and configuration management activities to develop an understanding of the industry needs, capabilities, and constraints.

- Document the concepts for a system designed to support industry PTC ILM and key requirements for the system to support interoperable change and configuration management processes.
- Research existing tools and identify systems that may provide sufficient capability to meet the defined functionality and key requirements.
- Review the potential alternatives and develop a recommended approach for development and implementation of the PTC ILM system, with the support of the AG.

1.3 Overall Approach

To achieve the objectives of the project, TTCI engaged the industry groups that have been established to support PTC ILM activities. Specifically, TTCI worked with the PTC Interoperability Committee ITC subcommittee, members of the ITC Change and Configuration Management (CCM) team, and the Interoperable Change Approval Board (ICAB) to understand current and evolving processes related to PTC ILM, support and enhance these processes, and get input and feedback on the draft concepts and requirements for the PTC ILM system.

Through engagement with these industry groups, TTCI helped transition the interoperable CCM activities that were initiated to support interoperable PTC operations in Southern California to the broader industry. As part of this transition, TTCI took on the role of the Interoperable Change Manager, which involved chairing the ICAB and managing the activities and documentation associated with interoperable CCM. While providing support to the industry, invaluable lessons on the intricacies of PTC ILM were learned, informing the efforts to enhance the processes and develop the draft concepts for the PTC ILM system.

To develop the draft PTC ILM system concepts, TTCI drew from established processes including Information Technology Service Management (ITSM) per the Information Technology Infrastructure Library (ITIL) core volumes [3] and Institute of Electrical and Electronics Engineers (IEEE) standards. The applicability of these established processes to PTC ILM was evaluated based on the needs and constraints associated with PTC ILM, which were based on the existing industry processes for interoperable CCM, input and feedback from the industry groups, and experiences of the project team. The draft concepts for the PTC ILM system were documented in a System Description and Operational Concept document.

High-level requirements for PTC ILM system functions to support interoperable CCM capabilities were derived from the PTC ILM System Description and Operational Concept document, policies and procedures established for interoperable CCM, and lessons learned from supporting the interoperable CCM processes.

Commercially available tools for supporting ITSM and other lifecycle management processes were identified through internet searches and discussions with railroad and vendor representatives. Information on the tools identified was extracted from available marketing information to provide an indication of the types of functions and capabilities provided as well as the flexibility of the tools for customization to support PTC ILM. This information can be used in future efforts to determine if one or more tools could be incorporated into the overall PTC ILM system to meet industry needs.

1.4 Scope

The initial focus of this project was on PTC ILM within a single PTC solution, specifically for that defined by the ITC standards. Future functionality and capability to support additional PTC solutions may be considered as future extensibility.

The scope of the PTC ILM system concept development included the areas of PTC ILM identified as most critical to support interoperability, recognizing that additional processes may be incorporated in the future as needs arise.

Documentation of key requirements to support the operational concepts developed was included within the scope for existing industry processes, including interoperable release management, interoperable change management, and interoperable configuration management. The expectation is that requirements for additional areas of the PTC ILM system will be developed in parallel with the initial development to support these initial processes.

Additionally, the requirements developed were limited to high-level requirements, with the intent of providing enough detail to identify and analyze existing products, potential solutions, and alternatives. Detailed software requirements specifications and similar design documentation was not part of the scope of the work defined in this phase.

1.5 Organization of the Report

This report is organized into five primary sections:

- Section 2 describes current PTC ILM activities, including established industry groups, activities to support interoperable CCM, and current efforts related to additional PTC ILM activities, as well as describing TTCI's engagement with these groups and lessons learned from these engagements.
- Section 3 provides an overview of the efforts to develop the draft concepts for the PTC ILM system and to develop high-level requirements for the interoperable CCM functions of the system.
- Section 4 describes commercially available tools related to lifecycle management that were identified and provides a summary of their applicability to PTC ILM system concepts and requirements.
- Section 5 provides a brief conclusion and recommendations for further efforts.

2. Current PTC Interoperable Lifecycle Management Activities

The initial industry focus, with regard to PTC, has been on implementation of the technology to meet congressionally mandated functionality. A number of joint industry efforts have been established to support activities such as agreement on functionality of common components, standardization of common interfaces, development of safety analyses, and drafting of industry best practices. While these efforts have gone a long way toward ensuring successful interoperable operations, only recently have truly interoperable operations become a reality.

Similarly, railroads have established internal processes to support the ongoing operation and maintenance of PTC, including areas such as asset configuration management, data management, incident management, requirements analysis, system testing, change management, and others. Each railroad has a responsibility to develop and execute these processes to meet their safety, operational, and business needs. However, certain aspects of these processes also must be coordinated at the industry level to support interoperability.

The industry has made significant progress in establishing the principles, processes, capabilities, and committees to support PTC ILM. This section describes these activities, including the role TTCI has taken on as part of this project, and describes key lessons learned that influenced the development of the draft PTC ILM system concepts and requirements.

2.1 Interoperable PTC System Releases and Interoperable PTC Change and Configuration Management

There are two primary industry groups responsible for the current industry efforts relating to PTC ILM – the PTC Interoperability Committee (PTC IC) and the ITC CCM team. Independent of this project, the industry created the PTC Interchange Agreement, which binds each signatory to agreed-upon standards that support safe and efficient interoperable PTC operations. A standing committee was created through the Association of American Railroads (AAR), known as the PTC IC, responsible for adopting PTC interchange standards. For railroads implementing ITC-compliant PTC systems, the ITC CCM team is responsible for development and oversight of the execution of PTC CCM policies and procedures.

Interoperable PTC CCM deals with minimizing risk associated with changes to PTC that can impact railroads that interoperate with each other. Coordination of changes to PTC deployments that have the potential to impact PTC operations on other railroads must be coordinated and maintaining a record of the configuration items that can affect interoperability, their relationships, and the versions deployed over time, further supports this objective.

The ITC CCM team made significant progress in the development and implementation of interoperable CCM policies and procedures prior to the involvement of TTCI through this project. The ITC CCM team developed the Interoperable Configuration Item Management Preliminary Approach white paper [4], which documents many of the guiding principles for interoperable CCM and advances an approach for documentation and communication of configuration items that must be managed to support interoperability. In this white paper, the term industry configuration item (ICI) was introduced to differentiate from the Configuration Item (CI) term used in more traditional CCM applications. Additionally, a spreadsheet was

developed to accompany the white paper that included the initial ICIs proposed for interoperable CCM and the initial attributes of those ICIs that were proposed to be managed, including the type (e.g., software release, specification, safety artifact, etc.), the interoperable compliance scope (i.e., to which railroads compliance with the version of the ICI applies), and the allowable versions of the ICI. This spreadsheet was used as the starting point for both the documentation of PTC Interoperable System Release definitions as well as the PTC Interoperable Configuration Management Database (CMDB).

The initial version of the Interoperable Change and Configuration Management Policies and Procedures Manual (PPM) was developed to define the industry processes for interoperable change management of ICIs to support interoperable operations in Southern California. This was later modified and adopted as the PPM for supporting all interoperable PTC operations, eventually being separated into Interoperable Change Management PPM [5] and Interoperable Configuration Management PPM [6]. The PPMs outline the processes for CCM, including the definition and requirements for an Interoperable Change Request (ICR), the stages of documentation and approval for an ICR, the roles and responsibilities to support the interoperable CCM processes, the system used to manage the ICRs and related documentation, and the methods for updating the interoperable CMDB.

The concept of Interoperable PTC System Releases was introduced within the industry to address issues related to the number of versions of ICIs deployed in interoperable service at a given time. As this number increases, so does the risk of encountering scenarios where interoperability could be affected, as well as the level of testing required to verify interoperability can be maintained when operating in an environment with this number of versions deployed. Additionally, railroads choosing not to deploy new versions consistent with the broader industry could create issues relating to deployment of new functions and features that the industry is looking to take advantage of. As a result, the industry agreed, through the PTC IC, to defining Interoperable PTC System Releases for railroads implementing ITC-compliant PTC systems. Interoperable PTC System Releases currently define the minimum deployable version of each ICI in interoperable service after a specified date.

As part of this project, TTCI worked directly with members of the PTC IC and the ITC CCM team to support ongoing industry efforts and to gather input and feedback for development of the PTC ILM system. Figure 1 shows an overview of the current processes for PTC ILM, specifically for interoperable CCM and definition of PTC Interoperable System Releases, how they relate, and the entity responsible for each of the key components of the processes. The processes are described in further detail in the following subsections. The work performed during this project helped to support the evolution of the processes established by the PTC IC and the ITC CCM team, and the coordination with their continued efforts, in turn, supported the development of the draft concepts for the PTC ILM system.

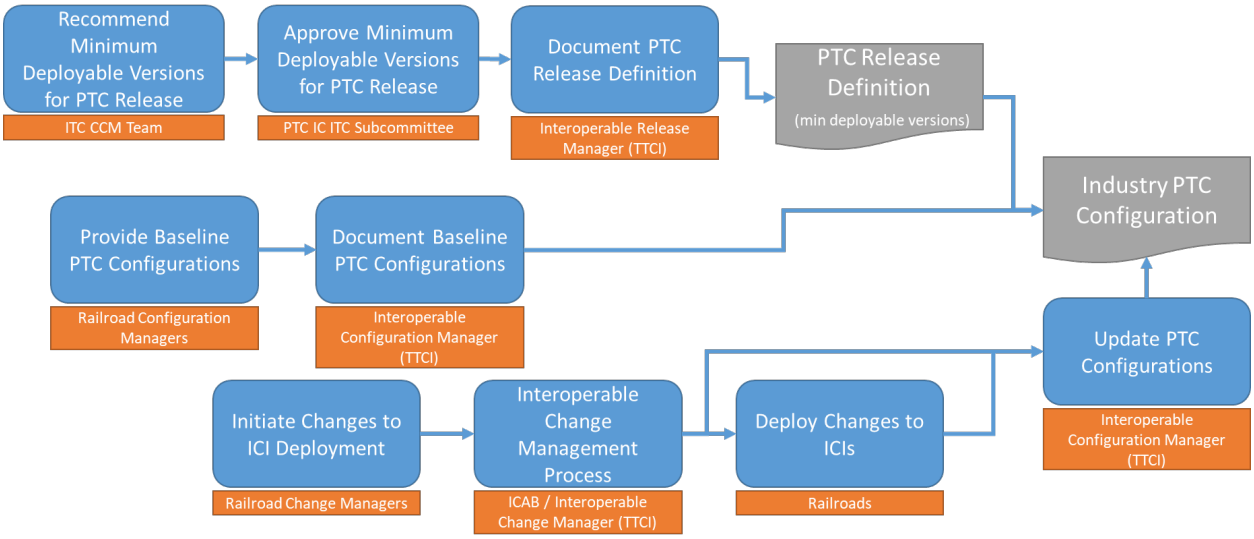

Figure 1. Overview of Current PTC ILM Processes

2.1.1 Interoperable Change Management

At the outset of this project, the processes outlined in the Interoperable Change and Configuration Management PPM recently were put into practice to support interoperable PTC operations in Southern California. To support that effort, templates for ICR forms were developed and an interoperable change management SharePoint site was established to manage the change management workflow and store the required change management documentation. An ICAB was established, made up of representatives of the participating interoperable railroads authorized to approve ICRs on behalf of their railroad. With the necessary systems and documentation in place, the interoperable change management processes were initiated.

Figure 2 shows an overview of the interoperable change management process in the currently established process, as documented in the Interoperable Change Management PPM [5].

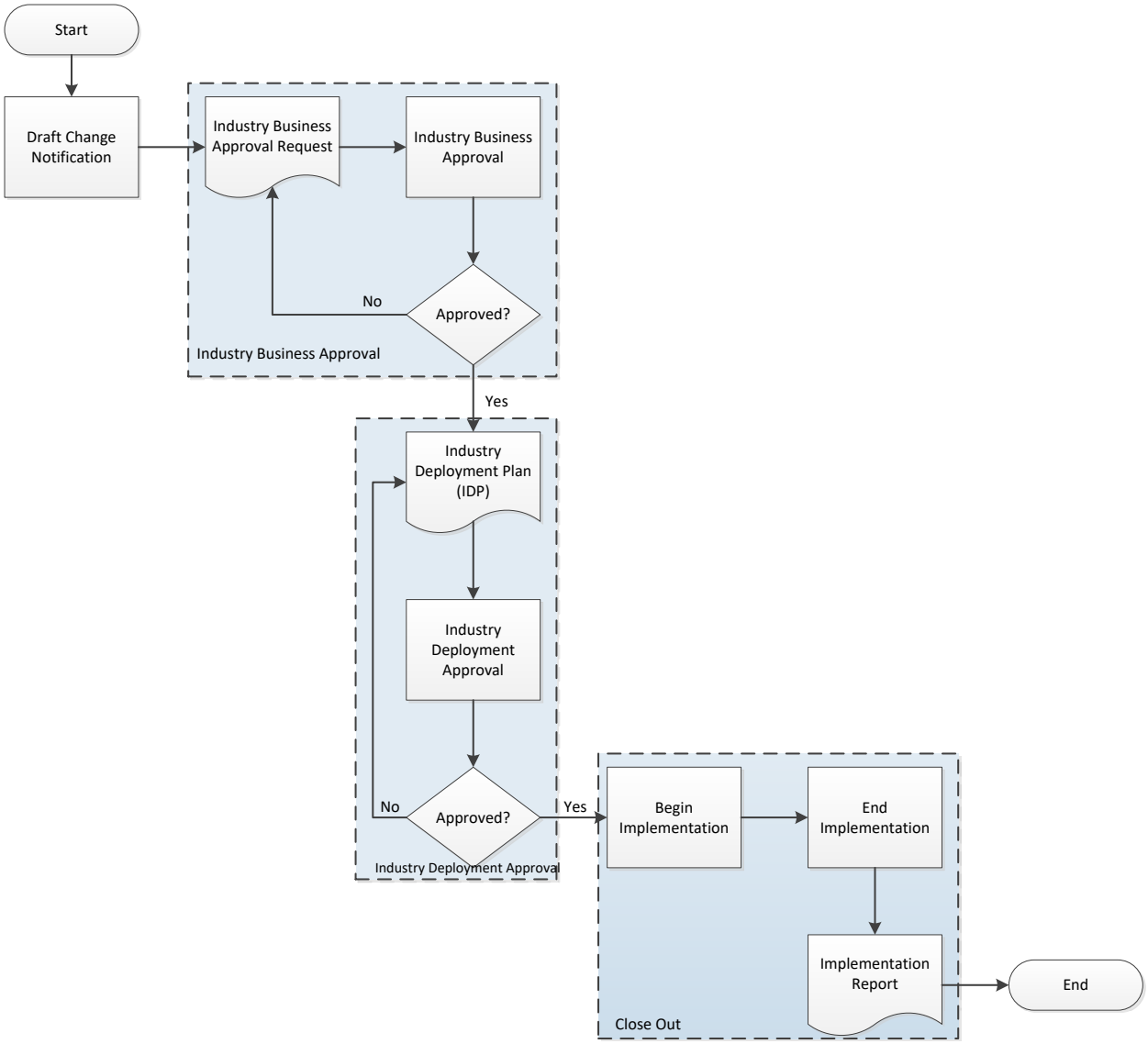

Figure 2. Interoperable Change Management Process

The first stage in the interoperable change management process is change notification, which begins with a railroad indicating that they are planning to make a change to an ICI by creating an ICR and completing a change notification form. The change notification is emailed to the interoperable change management community, allowing other railroads an opportunity to discuss the ICR with their subject matter experts, identify if the change will impact their PTC operations, and respond to the change notification, including any information pertinent to the change for their railroad. The ICR is discussed with the ICAB, where items are clarified, concerns are addressed, and inconsistencies are resolved, as necessary.

The second stage in the interoperable change management process is business approval, which generally coincides with the release of the new version of the ICI indicated in the ICR. The business approval stage is triggered by the railroad submitting a business approval request, which updates the information from the change notification with information such as the railroad's

planned testing duration and deployment date, versions of the ICI that are planned to be decommissioned as a result of the change, etc. The business approval request is emailed to the interoperable change community, and each railroad enters their response, including details regarding their deployment of the ICI, as appropriate. The ICAB then votes to grant business approval for the ICR.

The third stage in the interoperable change management process is deployment approval. Before deployment approval can be granted, each railroad must have completed its testing of the new version of the ICI and solidified its deployment plans. The deployment approval stage is triggered by the railroad submitting a deployment approval request, which provides any issues identified during testing, more formalized deployment plans, etc. An email with the deployment approval request is sent to the interoperable change community and each railroad submits its response, including any issues it may have found during testing and the more formalized deployment plans for its railroad, as appropriate. The ICAB votes to grant deployment approval, after which deployment of the new version of the ICI in interoperable service can commence.

The final stage of the change is the Close Out, which involves the completion of an implementation report by each railroad, following the completion of the deployment of the change. ICRs also can be expedited, for justifiable reasons, in which an ICR can advance through multiple stages simultaneously.

As part of this project, TTCI worked with members of the ITC CCM team and the ICAB to understand the details of the processes and how they were being executed, both to prepare for taking on a more involved support role and to inform the efforts to develop draft concepts for the PTC ILM system. This involved meetings with the leaders of these efforts within the industry, participation in the ICAB calls, and review of the SharePoint site and ICAB documentation, to develop a solid understanding of the processes, capabilities, constraints, as well as integration with individual railroad processes.

As interoperable operations were expanded to include additional railroads and geographic regions, a transition from the initial ICAB to the broader industry was required. As part of this project, TTCI supported the transition by taking a more active role in the industry process, which included responsibility for chairing the ICAB, managing the interoperable change management documentation, and supporting efforts to engage more of the industry in the processes.

ICAB chair responsibilities include the following:

- Managing the flow and content of the ICAB
- Facilitating the approval stages for ICRs by working with all railroads to gather the necessary change requirement information.
- Encouraging communication of stakeholders for each change
- Verifying that updates are communicated through documentation
- Leading the process to ensure that unanimous approvals are gained and captured for each ICR through the change cycle, including working through any issues or exceptions.

The ICAB initially met via teleconference every other week, with additional calls as necessary for expedited ICRs. However, during the course of this project, it was decided by the community to shift to weekly teleconferences, to facilitate the level of change being experienced, manage the number of ICRs discussed at each ICAB, and reduce the number of expedited ICRs required.

To prepare for each ICAB call, TTCI reviewed the active ICRs to determine (a) if the documentation was complete and up-to-date, (b) if all railroads had responded (following up with those who had not), (c) if there was an approval pending for the ICR, and/or (d) if the ICR needed to be discussed at the upcoming call for any other reason. From this information, TTCI prepared an agenda for each call. During each ICAB call, TTCI reviewed each ICR with the ICAB, requesting the ICR sponsor to brief the group on the change and encouraging other ICAB participants to ask questions or provide feedback relating to the ICR. For those ICRs requiring approval, TTCI collected and recorded the approvals from the impacted railroads for inclusion in the minutes.

Throughout the course of this project, the Interoperable Change and Configuration Management PPM and the processes outlined within it evolved and matured as TTCI and the industry worked to improve their efficiency and effectiveness, while utilizing them in the production environment. It was recognized that a number of improvements to the process and the tools to support the process would be required to support the longer-term needs of the industry.

Several limitations of the interoperable change management process in place at the time were related to the SharePoint site used to manage documentation and the interoperable change management work flow. The processes using this tool required a great deal of manual effort, which proved to be inefficient and had a relatively high potential for error. Further, the system was limited in the number of railroads it could realistically support and would not support interoperable change management across the broader industry. The tools have since been enhanced to resolve some of these initial limitations, but the lessons learned were helpful in understanding the needs of the PTC ILM system.

Communication is a critical component of the interoperable change management process and several of the lessons learned during the initial interoperable change management efforts were related to use of the system to enhance communication. Initially, the process required email notifications to be sent to the ICAB members whenever a new ICR was created, an approval of an ICR was requested, a close out of an ICR was requested, or a response to an ICR was submitted. The process of ensuring email notifications were sent to the correct individuals was acceptable for the initial efforts, but the benefit of automation of the communications were clearly realized. The ITC CCM team agreed to have all ICAB communications sent through agreed-upon, well-known email addresses using a common format, wherein each railroad can manage the distribution of the emails internally. Additionally, the benefit of a system that can automatically generate and send emails to the appropriate recipients at the appropriate stages in the process was recognized.

Certain aspects of interoperable change management that have been identified through the execution of the existing process are related to the scope of interoperable change management and are likely to continue to be discussed as the processes evolve and mature. For example, certain deployment details are recognized as required to support the processes, such as deployment dates, while others are less clear, such as configuration changes to existing system

components required to support the change. Similarly, handling deployment of new versions of ICIs at significantly different times by different railroads must be addressed through the process.

Flexibility within both the process and the tools also was identified as being a requirement moving forward. Changes to the ICR forms and responses completed at each stage were reviewed and discussed periodically throughout the project, with some changes being made as the process matured. It was apparent that new fields may be needed, existing fields may become obsolete, and the purpose of fields may change over time.

A number of improvements to the process were identified through scenarios and conditions that were not initially anticipated. Initially, railroads responding to a change indicated whether they were impacted (meaning action is required on their part to support the ICR) or not. As the process matured, a third option was recognized and the process was updated such that a responding railroad could indicate they were impacted, applicable (meaning they are not directly impacted, but share common interest of being within scope), or not applicable (meaning the ICR is considered out of scope).

Improvements relating to the scope and different types of ICRs also were identified. This included ICRs containing changes to multiple ICIs (e.g., for cases with absolute dependencies between the ICIs), ICRs for communication of changes to deployments of ICIs that had previously been approved for interoperable service, and ICRs to document the decommissioning of existing version(s) of ICIs not in conjunction with the introduction of a new version. There also was recognition that latent changes (i.e., a change that was deployed without following the normal interoperable change management process), must be handled by the process and the system, including conditions under which a latent change would be acceptable and the process for communicating or otherwise handling a latent change.

Finally, it was observed during the project that, while the process supported communication and traceability of the interoperable change management process, the most challenging aspect of the process was in understanding the potential impact of an ICR on each railroad. Enhancing the tools from a standpoint of helping to understand these impacts to a practical degree would be valuable. Adding more information about relationships and attributes of ICIs to the CMDB that could be accessed easily during the interoperable change management process could assist in this way.

It has been recognized that the scope of interoperable change management differs significantly from the scope of change management within a single organization. These differences, highlighted by some of the lessons learned that were discussed above, were not always obvious until observed through the execution of the process and through the use of the initial tools, but were instrumental in developing the draft concepts for the PTC ILM system.

2.1.2 Interoperable Configuration Management

The processes for interoperable change and configuration management were initially defined in a single PPM and the interoperable configuration process was initiated jointly with the initiation of the interoperable change management process discussed previously. To support interoperable configuration management, the participating railroads baselined their deployed versions of the

ICIs previously identified by the ITC CCM team in the spreadsheet version of the CMDB that had been created.

TTCI again worked with members of the ITC CCM team and the ICAB to understand the details of the interoperable configuration management processes and how they were being executed. This involved a thorough review of the CMDB, including how it was organized, the classifications and categorization of ICIs, and the documentation of the versions deployed by each railroad. At the time, there were approximately 150 ICIs included in the CMDB (that number has since grown to more than 200, driven by a combination of the identification of additional ICIs as well as the expansion of the number of interoperable railroads).

As part of the industry support TTCI provided through this project, industry configuration management responsibilities included:

- Updating the CMDB as ICIs are identified for addition, removal, or modification.
- Updating the CMDB according to changes in deployments through ICRs

After each ICR reached the deployment approval stage, TTCI was responsible for adding the version of the ICI included in the ICR to the CMDB for each railroad that was indicated to be deploying.

Throughout the course of this project, the Interoperable Change and Configuration Management PPM and the processes outlined within it evolved and matured as TTCI and the industry worked to improve their efficiency and effectiveness, while utilizing them in the production environment. It was recognized that a number of improvements to the process and the tools to support the process would be required to support the longer-term needs of the industry.

Several ICIs were adopted for interoperable change and configuration management during the course of the project, while others were removed for various reasons. There also were many discussions on whether certain CIs met the criteria to be considered an ICI. Many of these discussions related to the fact that certain components of the system are not standardized across the industry but include some functions or behaviors that can impact the operation of another interoperable railroad. While the industry continues to mature in these areas, the CCM team agreed on methods for addressing these in the interim, to maintain the objective of supporting interoperable operations.

As the processes were implemented, changes to multiple dimensions of the CMDB were observed. For example, addition or removal of ICIs, reorganization of the ICIs within the CMDB, changes to the deployed versions of the ICIs by each railroad, and baselining of the versions deployed by a new interoperable railroad could all occur in parallel. A versioning system for the CMDB was developed and implemented, but it was clear that a system with a relational database that could be searched, modified, and maintained in a controlled manner through a separate user interface will be necessary from a practical standpoint. This enhancement also will improve traceability of the changes to the CMDB over time and support visualization by the community, e.g., to view the deployment history of an ICI over time, or the versions deployed by a railroad at a specific point in time.

Development of a CMDB that can support more attributes and relationships between ICIs and versions of ICIs, including dynamically creating these attributes and relationships would be valuable in supporting the assessment of potential changes. Additionally, as interoperable PTC system release management and other aspects of PTC ILM are developed and enhanced, this flexibility to create, store and relate information will be invaluable, as well as the capability to generate customizable reports on any of the information contained within the CMDB.

It also was observed during the project that the CMDB could contain errors at a given time, due not only to the manual processes used but also as a result of the broad scope of PTC implementation, the number of railroads and personnel at those railroads involved, and the rapid rate of changes within the community. As a result, an audit process for the CMDB was determined to be required and development of the process was initiated.

2.1.3 Definition of Interoperable PTC System Releases

Limiting the number of versions of each ICI deployed in interoperable service through Interoperable PTC System Releases reduces the operational risk associated with potential incompatibilities between versions, minimizes the amount of interoperable testing required throughout the industry, and encourages continued advancement of the technology. During this project, the PTC IC began working with the ITC CCM team and TTCI to agree on the ICIs that would be included in the Interoperable PTC System Release, as well as which versions of those ICIs should be included in the first Interoperable System Release. Currently, new Interoperable PTC System Releases are planned to be adopted every six months, recognizing that minor changes within the six-month period also may be necessary.

The process for defining the initial PTC Interoperable System Release was for the group to work through each previously identified ICI, discussing which versions currently were deployed, and giving the participating railroads an opportunity to suggest a minimum deployable version based on their business needs. Through this process, recommendations for the minimum deployable versions of each ICI were compiled. A spreadsheet was developed by TTCI to document the recommended minimum deployable versions for each ICI that was derivative of the CMDB spreadsheet used for interoperable PTC CCM. The recommendations developed through this process were provided to the participating railroads for review with their subject matter experts and follow-on discussions in subsequent meetings resulted in a finalized recommendation for adoption, which was ultimately approved.

For definition of subsequent PTC Interoperable System Releases, the process began to evolve, with the majority of the discussion focusing on changes to the minimum deployable versions occurring between the ITC CCM team and the railroad subject matter experts. Through these discussions, a draft recommendation was discussed with the PTC IC prior to developing the final recommendation for approval. Additionally, the documentation of the recommendations was improved, including the development of a versioning system for the PTC Interoperable System Release definition spreadsheet to improve traceability and communication.

Throughout the course of this project, and through the experience of defining the first PTC Interoperable System Releases, a number of observations and potential improvements were identified. As with the interoperable CMDB, it was determined that the documentation of PTC

Interoperable System Releases would benefit greatly from a centralized system that allowed railroads to easily visualize or obtain information relevant to a given release, as well as understand the changes associated with an upcoming release.

While the process for defining the minimum deployable versions of each ICI has been sufficient for the current maturity of the PTC ILM processes, it was recognized that evolving to a definition of PTC Interoperable System Releases which includes the specific versions of each ICI (as opposed to just the minimum) included in each release eventually will be needed.

2.2 Additional Industry Activities Related to PTC ILM

In addition to the interoperable CCM efforts and definition of PTC Interoperable System Releases described in the preceding section, other activities have been recognized as being necessary to support successful ongoing interoperable PTC operations and relate to the activities described above. To achieve interoperability, standards for interoperable functions and interfaces must be agreed to, processes and tools must be established for required sharing data, requirements for level of service of shared components must be created, targets for system availability and capacity and the interrelationships between railroads' PTC deployments to achieve those targets must be understood, processes relating to interoperable troubleshooting must be developed, and testing within and between interoperable railroads must be performed.

The industry has been diligent in addressing each of these areas throughout the development and implementation of interoperable PTC. The development of the ITC system was the result of an agreement by the major Class I railroads operating in the U.S. to establish and maintain standards for interoperable PTC. A number of formalized structures and processes were established at the industry level for those railroads implementing ITC-compliant systems. Additionally, each railroad implementing an ITC-compliant system developed internal structures and processes for those aspects of system development, testing and lifecycle management that are particular to their individual railroad. The ITC agreement led to the establishment of a structure of technical working committees, each responsible for developing ITC standards for, and guiding development of, a particular interoperable aspect of the PTC system, including the areas described above.

The standards developed by these committees are typically submitted to AAR to be published as interchange standards in the AAR Manual of Standards and Recommended Practices (MSRP). Although the ITC committees are responsible for ensuring that the PTC system is interoperable, not all elements are published as industry standards, due in part to the incorporation of components with vendor proprietary requirements. In these cases, the ITC committee is responsible for working with the vendor(s) to ensure that the product provided will satisfy the needs of all users by agreeing on implementation of common functions and defining functions that must be railroad-configurable.

The structures and processes described above were instrumental in the initial development and implementation of interoperable PTC and many of the functions will be required throughout the lifecycle of the technology. As the deployment of the technology nears completion and interoperable operations continue to expand, the focus of these efforts, and the establishment of new structures and processes, are shifting to address the ongoing implications of the operation and maintenance of the technology. As described previously, the AAR PTCIC is responsible for

establishing and maintaining PTC interchange standards to achieve the interoperability requirement of PTC. The PTCIC includes a number of working subcommittees to develop and recommend new standards and changes to existing standards, and is intended to provide the structure for ongoing industry governance of PTC, as the system and concepts evolve.

It is well-understood that the requirements and interfaces for PTC will continue to evolve as new functions and features are identified, integration with other technologies is advanced, and operational needs change. The current PTC ILM processes include identification of new versions of ICIs, which includes both interoperable standards as well as software and configuration releases. However, the responsibility of understanding the changes to the ICIs to determine the impact of deploying a new version, both internally to the railroad as well as on interoperable operations, is on each individual railroad. This means that each railroad must review the updated requirements or changes to the interfaces, identify changes from prior versions, determine the impact of the changes within their deployment (e.g., impact on related ICIs), and assess how the changes will affect their operations, including interoperable operations. The relationship between the management of the interoperable requirements and interfaces of the system and the interoperable change management processes is apparent. Industry traceability of versions of interoperable standard requirements and interfaces across time is a key area of PTC ILM.

In addition to managing the interoperable requirements and interfaces, there is clear value in coordinating between defining changes to these requirements and interfaces, developing new versions of software and configuration releases to support the changes, and including these new versions in upcoming Interoperable PTC System Releases. In particular, as more railroads become interoperable, especially those that are not intimately involved in the design process, the need to communicate upcoming changes to the allowable versions of ICIs in future Interoperable PTC System Releases and the implications of those changes will greatly enhance the success of advancing the new developments through the interoperable CCM processes.

PTC system testing is another area related to PTC ILM and the coordination of new requirements, interfaces, and versions of ICIs in particular. The high-level structure for testing of the ITC system is defined with the ITC Master Test Strategy, which is published as a recommended practice in the AAR MSRP [7]. The Master Test Strategy describes the levels of testing to be conducted, the high-level test processes to be followed, and the management of defects identified during testing. At this time, the specific test plans and procedures used to verify that implementation of the ITC system meets both the interoperable standards, as well as any individual railroad requirements, are defined individually by each railroad implementing an ITC-compliant system. Testing to verify interoperable operations currently is coordinated between individual railroads that interoperate with one another.

As interoperable operations continue to expand, including the number of railroads that are interoperable with each given railroad, the level of testing required to verify interoperable operations between each of these individual railroads will continue to grow considerably. Supporting traceability of interoperable test cases to the evolving requirements across time at an industry level has the potential to improve the coordination, consistency, and overall success of this testing. Identifying testing that is common to all interoperable railroads and conducting this testing in a joint manner can provide further improvements, as well as reducing the redundancy of this testing across the industry.

3. Development of Draft PTC ILM System Concepts and High-Level PTC ILM System CCM Requirements

The industry focus on addressing the lifecycle implications of operating and maintaining interoperable PTC led to the recognition that a common system to support and enhance the current and evolving processes was necessary. Through this project, TTCI was tasked with working with the appropriate industry groups to define and document the concepts and develop a description and key requirements for a PTC ILM system to meet this need. Many of the processes associated with PTC ILM can be derived from well-established system engineering and ITSM concepts. However, there also are a number of differences, relating primarily to the relationship between individual railroad PTC lifecycle management and lifecycle management at the interoperable level. Additionally, the scope of PTC ILM must be considered in relation to the industry structures and processes already in place. This section describes the development of the draft PTC ILM system concepts and the high-level PTC ILMS system requirements relating to interoperable CCM.

3.1 Established Best Practices Related to Lifecycle Management

As the efforts to develop draft concepts and requirements for the PTC ILM system were initiated, it was recognized by FRA, TTCI, and the industry groups that supported the project that technology lifecycle management was not a new field, and that processes and best practices in the fields of systems and software engineering and ITSM could be leveraged for PTC ILM. It also was recognized that adoption and strict adherence to these processes and best practices would not be appropriate, given the differences between the lifecycle management of a product, the lifecycle management of an IT system, and PTC ILM. Lifecycle management of a product involves the management of the detailed requirements, designs, source code, etc., as the product evolves. Lifecycle management of an IT system involves defining the organizational needs, designing and implementing the IT services, and maintaining those services as the organizational needs evolve. PTC ILM is focused on processes to address lifecycle implications of a technology implemented by individual organizations that must coordinate to support interoperability, but also individually manage their specific implementation of the technology according to their own business needs and objectives. As a result, it was recognized that there was value in referencing established processes and best practices and using them as guidelines in the development of the draft PTC ILM system concepts, without being constrained by them.

With regard to lifecycle management of IT systems, the field of ITSM has evolved considerably as IT services now play a vital role in almost any organization. In the context of ILM, PTC can be considered a service provided internally by each railroad, but requiring coordination with other interoperable railroads, to support safe and efficient operations in the areas it is implemented. Consideration of PTC as a service allows for the use of best practices that have been established for other information technology services, as they are determined to be applicable.

ITIL is a widely accepted approach to ITSM and provides a useful foundation for defining the applicable aspects of PTC ILM and the scope and functions of the PTC ILM system. As described in the ITIL core volumes that document the established best practices, “ITIL is part of a suite of best practices publications for IT Service management. ITIL provides guidance to

service providers on the provision of quality IT services, and on the processes, functions and other capabilities needed to support them. ITIL is the most widely recognized framework for ITSM in the world" [3].

The ITIL Service Lifecycle provides a systematic workflow that can be applied to most businesses that provide a service. A high-level view of ITIL shows the five stages of the Service Lifecycle that are the foundation of the ITIL framework. The ITIL Service Lifecycle approach considers the strategy, design, transition, operation, and continuous improvement of IT services. The ITIL core consists of these five lifecycle stages, with each containing a group of processes under them:

- ITIL Service Strategy – Defines the perspective, position, plans and patterns that a service provider needs to be able to execute.
- ITIL Service Design – Defines the IT service, together with the governing IT practices, processes and policies.
- ITIL Service Transition – Ensures that new, modified or retired services meet the expectations of the business.
- ITIL Service Operation – Coordinates and carries out the activities and processes required to deliver and manage services.
- ITIL Continual Service Improvement – Aligns IT services with changing business needs by identifying and implementing improvement to IT services that support business processes.

The 5 core stages within ITIL contain 26 defined processes found in a fully established business or IT operation. Figure 3 outlines the processes within each of the core stages.

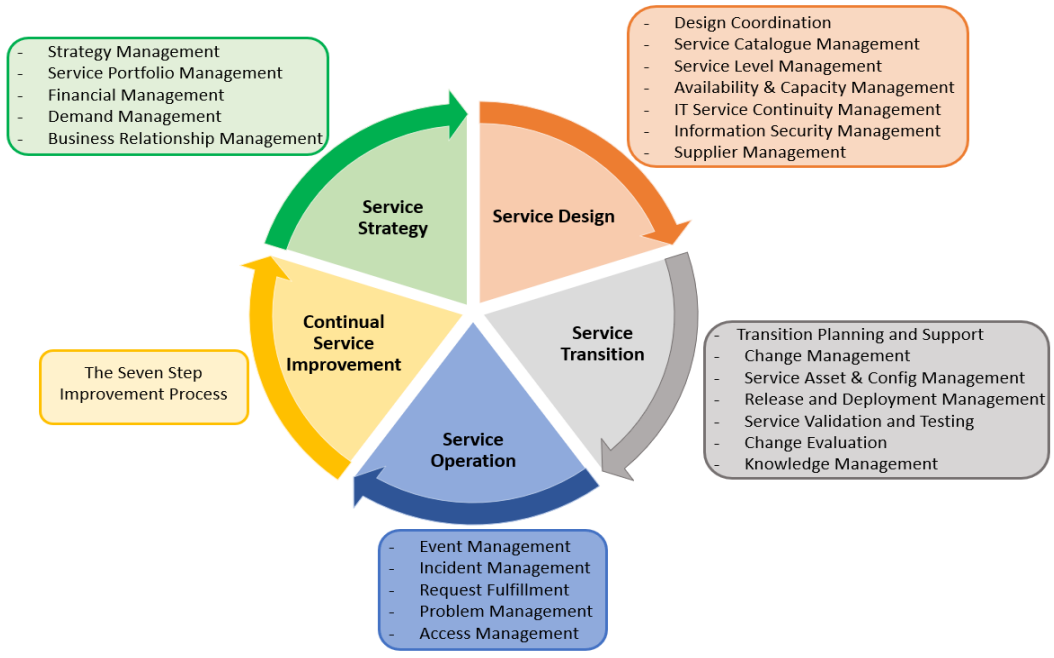

Figure 3. The Five Stages of the Service Lifecycle and Underlying Processes

The ITIL processes were reviewed and used in the development of the draft PTC ILM system concepts, in particular those processes that were most closely related to the initial scope of the PTC ILM system.

With regard to lifecycle management activities associated with a system or software product, there are a number of IEEE standards that apply, including IEEE Std 828 (IEEE Standard for Configuration Management in Systems and Software Engineering) [8], IEEE Std 1220 (IEEE Standard for Application and Management of the Systems Engineering Process) [9], IEEE 15288 (Systems and Software Engineering – System Life Cycle Processes) [10]. These standards were reviewed and considered in developing the draft PTC ILM system concepts, but are expected to be used more directly as some of the future functions of the PTC ILM system are further defined.

3.2 Justification for and Scope of the PTC ILM System

As part of developing the draft concepts for the PTC ILM system, it was necessary to document the primary reasons or justification for the system, which in turn helped to define the scope of the system. In developing the justification for the system, TTCI drew primarily from the lessons learned in executing the current processes for interoperable PTC CCM and definition of Interoperable PTC System Releases, described in Section 2.1. However, it also was recognized that other industry activities associated with PTC ILM, described in Section 2.2, relate closely to these processes and would benefit from a system to support them. Based on these inputs, TTCI documented the current understanding of the primary rationale for development of the PTC ILM system.

Using the rationale for development of the PTC ILM system as a guide, TTCI reviewed the ITIL processes to determine the applicability to PTC ILM. As the ITIL processes were reviewed in the context of PTC ILM, a key difference was observed. While the ITIL processes are intended to apply to any organization and not necessarily bound to a single company, there is a basic assumption that the service provided by the organization is designed, deployed, maintained, and operated by that organization. In the case of PTC, each individual railroad represents an organization that provides a PTC service within its operation, but to support interoperability, there are certain aspects of the service that also must be coordinated at an industry level. The goal of PTC ILM is to support the processes required for this coordination, while maintaining individual railroad responsibility to implement the processes and tools necessary for managing the PTC deployment on their railroad. This creates a constraint for PTC ILM, in that the processes only apply to the extent they are required to be coordinated at an industry level. As a result, PTC ILM supports only certain aspects of the processes described in the ITIL core volumes. This critical difference would drive a somewhat distinct interpretation of the processes in their application to PTC ILM.

Each of the 26 processes defined in the ITIL core volumes were reviewed in terms of their applicability to PTC ILM. Some processes likely have applicability to PTC lifecycle management at the individual railroad level, but not at the interoperable level. A number of other processes were identified as having applicability to PTC ILM, but currently are being addressed through other coordinated industry efforts and, while related, were considered out of scope for the PTC ILM system. An example is availability management, which has applicability at the industry level as a result of the potential for aspects of one railroad's PTC deployment to affect availability of PTC operations on another. However, there are independent, ongoing industry

efforts to analyze PTC reliability, availability, and maintainability, establish appropriate industry metrics and targets, and develop appropriate growth plans. These activities may drive new requirements and new versions of ICIs, which will then be reflected in the activities supported by the PTC ILM system, but at this time, the availability management activities will continue to be conducted independently.

After considering all of the ITIL processes, the current industry needs with respect to the PTC ILM system, and the scope of PTC ILM as opposed to individual railroad PTC lifecycle management, the following six ITIL processes were determined as having aspects within the initial scope of the PTC ILM system:

- Change Management
- Service Asset and Configuration Management (SACM)
- Design Coordination (in particular, requirements engineering)
- Service Validation and Testing (in particular, test case management)
- Release and Deployment Management
- Knowledge Management

In some cases, the interpretation of the ITIL core process in the context of PTC ILM resulted in only a loose relationship with the process as described in the ITIL core volumes. As a result, the following terms were used to describe the PTC ILM processes to be supported:

- Interoperable Change Management
- Interoperable Configuration Management
- Interoperable Design Coordination and Requirements Management
- Industry Test Management
- Interoperable Release Management
- Knowledge Management

3.3 Development of Draft PTC ILM System Description and Operational Concept

The purpose of the PTC ILM System Description and Operational Concept is to document the needs and envisioned capabilities of the PTC ILM System. The objective is to use the document to support development of an industry consensus on the primary system capabilities, and also to be used as a guide in efforts to develop and validate the system. Because the PTC ILM activities are evolving and maturing beyond this project, the industry continues to discuss and comment on the concepts and capabilities described in the document. Further, as the development effort progresses, certain aspects of the system described may be added, removed, or modified as the design details are worked through. As a result, the PTC ILM System Description and Operational Concept developed during this project is considered an initial draft and represents the current

understanding of the project team, based on the experience gained through the efforts described and input from members of the associated industry groups.

The development of the draft PTC ILM System Description and Operational Concept involved documentation of the current processes related to PTC ILM, the tools currently used to support these processes, and the rationale for development of the PTC ILM system, per the project activities described in the preceding sections. The foundational concepts, including the ITIL processes and their application to PTC ILM, as well as a high-level description of the relationships between the PTC ILM processes, also were included.

Each of the six primary PTC ILM processes was then considered in terms of the PTC ILM system capabilities required to support them. Care was taken to avoid documenting the industry processes associated with these capabilities to the extent possible, recognizing that the system must support the processes, the details of which may evolve over time. Also, for this reason, flexibility was a key factor in describing the capabilities. As the system capabilities to support each of the processes were identified, it became necessary to define system user classes. The intent was not to define roles within the industry processes but rather to define system user roles. In many cases, an individual may take on multiple user roles within the system, and this level of abstraction was intentionally maintained.

Certain user access and administrative aspects of the system also were considered. The intent was not to be comprehensive in this regard but rather to address some of the capabilities required to ensure controlled access to the system and to allow user configuration of various aspects of the system. Finally, a brief description of the priorities from a development standpoint was included, recognizing the potential extensibility beyond the capabilities described. The Draft PTC ILM System Description and Operational Concept is included as Appendix A.

3.4 Development of Draft High-Level PTC ILM System Requirements for Interoperable CCM

The PTC ILM System CCM Requirements document captures the high-level requirements for the interoperable release management, interoperable change management, and interoperable configuration management capabilities of the PTC ILM system, based on the description of these capabilities from the Draft PTC ILM System Description and Operational Concept. The scope of the requirements was limited to these capabilities, as they support the industry processes that are currently better defined, recognizing that requirements for the other capabilities will need to be developed in a future effort. As with the PTC ILM System Description and Operational Concept, the PTC ILM System CCM Requirements are considered an initial draft, as a result of the state of the developing and maturing processes and continued industry discussions and comments. The intent is to provide documentation that represents the current understanding of the project team, with the goal of using this documentation to support discussions toward an industry consensus as the development of the system progresses.

The PTC ILM System CCM Requirements were developed by reviewing the capabilities described with the PTC ILM System Description and Operational Concept, as well as the capabilities of the tools currently used to support interoperable CCM. The high-level requirements for each of the capabilities were documented in a format from which lower-level requirements and/or system design details can be developed and traced. The objective was to

capture the basic requirements in this form without specifying details on how the system may achieve the requirements. The documentation is not intended as a formal software requirements specification. The draft PTC ILM System CCM Requirements are included as Appendix B.

4. Identification and Review of Commercially Available Lifecycle Management Systems

One of the objectives of PTC ILM is to leverage from existing best practices where possible, and part of the scope of this project included a high-level review of commercially available tools that may support some or all of the defined PTC ILM system capabilities. This section explores some of the commercially available tools that were identified as having the potential to satisfy one or more capabilities of the PTC ILM system.

4.1 ITSM System

Given the similarities between ITSM and PTC ILM, TTCI initially focused the review of commercially available products on systems designed to support ITSM. ITSM refers to the entirety of activities, directed by policies, and organized and structured in process and procedures that are performed by an organization. These processes and procedures help an organization design, plan, deliver, operate, and control IT services offered. Most commercial ITSM products deliver similar solutions packaged in a single tool that supports a set of common applications, such as change management, configuration or asset management, and incident or problem management. Typically, commercial ITSM products provide a cloud-based package that can be accessed through a network.

It was determined during this task that numerous ITSM solutions exist, all providing similar capabilities. The objective was not to identify and compare the advantages and disadvantages of specific products, but rather to determine if the products available satisfy the needs, after which a more detailed assessment of individual products could be conducted to select the preferred option. Below is a sample list of some of the more popular commercial off-the-shelf (COTS) ITSM products, with a brief overview of key features gleaned from publicly available marketing information that were identified during the review and could be considered to support one or more of the PTC ILM processes:

- **Samanage® Service Platform** is one of many ITSM tools on the market, and provides a unified, cloud-based IT service desk and asset management platform with the following features related to PTC ILM:
  - Change Management – allows changes to be created, documentation to be added, and supports a change approval process.
  - Release and Deployment Management – supports managing, planning, and scheduling the rollout of IT services within an organization.
  - IT Asset Management – designed to manage an organization's physical assets.
  - CMDB – supports tracking of configuration items and relationships between assets, users, and other configuration items to understand impacts of changes and incidents.
  - Knowledge Base – allows for documentation of best practices and recommended solutions.

- Reporting – provides capability to view and manage status of configurations, changes, and deployments.
- Dashboards – provides real-time snap shot into various aspects of the business' current state.
- Integrations – supports linking to other COTS software to enhance the application.

Other features offered by the Samanage Service Platform include Incident Management, Problem Management, Service Catalog, Service Level Management, Procurement Tools and Mobile Compatibility.

- **Cherwell® Service Management** is a configurable, scalable, service desk solution based on ITSM best practices and the ITIL framework. The system supports eleven ITIL processes, codeless configuration, flexible portals, and dashboards to enable IT organizations to improve service delivery and support more effective operations.

Cherwell Service Management provides a variety of configurable service desk features, including Business Objects, Dashboards, Actions, Searching, Reporting, and Knowledge. Cherwell Service Management also provides a number of administrative features, such as Blueprints (for configuring and test-driving system definitions), comprehensive Security, automation tools, and integrations.

Cherwell Service Management provides multiple configurable processes to help log and manage service desk records, including Incident/Service Request Management, Service Portfolio/Service Catalog Management, Problem Management, Service Asset and Configuration Management (CMDB), Change Management, and Knowledge Management. In addition to the core processes, Cherwell Service Management also offers the ability to quickly merge and integrate additional processes through Cherwell mergeable applications and integrations.

- **BMC Helix Remedy 9** is an ITSM solution that includes the following key features:
  - Incident and Problem Management – supports creation and resolution of incidents through integration with other IT service support functions.
  - Knowledge Management – built-in knowledge centered service to support delivery of fast and accurate service and support.
  - Smart Reporting – includes capability to create custom reports and dashboards.
  - Change Management – has the ability to document and coordinate changes.
  - Release Management – supports combining multiple change requests into a single release as well as notification and tracking of deployment activities.
  - Asset management – documents and tracks individual assets.
  - Configuration Management (CMDB) – provides a single source reference for infrastructure and service and supports understanding of dependencies between configuration items.

BMC Helix Remedy 9 also features capabilities to track and report service levels across the organization.

The commercially available ITSM products could be configured to support some of the PTC ILM processes, in particular the CMDB capabilities associated with interoperable configuration management. These tools offer significant customization in the configuration of the CMDB, which likely could satisfy the capability and flexibility required for the PTC ILM system. Other aspects of these tools, such as change management and release management capabilities, address some of the needs of the PTC ILM system but may not directly support the existing processes. For example, the change management capabilities would need to be customized to support the current interoperable change management forms and processes. Similarly, the release and deployment management capabilities could potentially support the definition of Interoperable PTC System Releases but are more geared toward tracking and reporting on the deployment of new IT services. Many of the features of the commercially available ITSM tools are designed to support tracking of assets and infrastructure as well as incident and problem management within an organization. These features may be useful for individual railroad lifecycle management of PTC but are not the focus of PTC ILM. This is a result of the somewhat distinct application of ITSM concepts in PTC ILM, wherein only the aspects related to interoperability are relevant, as noted at the beginning of Section 3.1.

Additionally, none of the ITSM tools identified address all of the processes included in the draft PTC ILM concepts and requirements, most notably interoperable design coordination and requirements management or industry test management. One potential option would be to utilize different tools to satisfy the overall needs of the PTC ILM system, either individually or through integration with other software packages, to create a multi-platform solution.

4.2 Requirements and Test Case Management Systems

Because the ITSM tools identified did not generally support the PTC ILM capabilities associated with interoperable design coordination and requirements management or industry test management, TTCI also investigated commercially available software with features that could potentially support these capabilities. Similar to the market for ITSM products, there were a number of products identified that support requirements and test case management functions. Again, the objective was not to compare specific products, but rather to identify if products exist that support the needs identified. Below is a sample list of some of the identified COTS requirements and test case management products, with a brief overview of key features gleaned from publicly available marketing information that were identified during the review and could be considered to support these PTC ILM processes:

- **IBM® Rational® DOORS® Next Generation** is a scalable solution that supports communication, collaboration, and verification of requirements, including capabilities to capture, trace, analyze, and manage changes to requirements. DOORS Next Generation supports navigation between projects and artifacts within multiple projects, and supports collaboration with comments and concurrent editing. Each artifact represents a piece of information, such as a requirements document or an individual requirement, and relationships between artifacts can be captured for traceability across the project

lifecycle. Standard or customizable templates are supported as well as importing of documents of various file types.

- **IBM Rational Quality Manager™** is a web-based quality management solution that supports test planning and test asset management. Rational Quality Manager can integrate with DOORS Next Generation or other requirements management tools to link test cases to requirements and also supports integration with many test automation tools. Rational Quality Manager also supports development of comprehensive test plans, and recording of test results.
- **TestRail™** is a web-based test case management software system that supports management of test cases, test plans, and test runs. TestRail supports creation and organization of test cases for easy navigation as well as recording of test results and comments, including images and screenshots. TestRail also can integrate with requirements management and defect management tools.
- **Case Complete** is one of many agile requirements management applications based on the Unified Modeling Language (UML). Case Complete supports creation and management of use cases and software requirements, using both visual UML diagrams and declarative requirements, and also supports addition of test scenarios. Case Complete supports collaborative development through tracking of changes and comments.

The list above represents a sample of the types of commercially available requirements and test case management systems that could support some of the PTC ILM system capabilities. Many of the requirements and test case management solutions are geared toward software development teams working in an agile software development environment. As a result, development of user stories, use cases, and UML diagrams are commonly featured. While these tools may support some of the interoperable design coordination and requirements management and industry test management capabilities, they are designed to support development of software products and may not be easily set up for management of interoperable system requirements and test case management.

However, requirements and test case management solutions designed to support more traditional system requirements and test case management processes may be better suited for the interoperable design coordination and requirements management and industry test management PTC ILM processes. These tools likely will not support the interoperable change management, configuration management, release management, and knowledge management capabilities. However, they potentially could be used in a multi-platform solution, as described above.

4.3 Overall Review of Potential Alternatives

Through this task, a number of commercially available tools were identified that support processes related to PTC ILM. However, there were no commercially available tools identified that are likely capable of performing all of the functions described in the Draft PTC ILM System Description and Operational Concept.

In general, the tools available on the market are designed to support either ITSM within an organization or requirements and test case management for a system or product, but not both. For the identified tools designed to support ITSM, the customizable CMDB features likely are the

most applicable features for use in the PTC ILM system, while many of the other functions are designed for management of assets, configurations, and infrastructure within the IT environment of an organization. For the identified tools designed to support requirements and test case analysis, many are designed to support agile software development, but there also were tools identified that have the potential to satisfy many of the needs for interoperable design coordination and requirements management and industry test management. However, a more thorough review of some of the specific tools, including potential to integrate with tools to support the other PTC ILM processes, needs to be conducted.

Based on the draft concepts and high-level requirements, and the review of available ITSM solutions, a system designed specifically to support the ITSM/ITIL concepts as adapted and modified to address the distinct aspects of PTC ILM would be preferable to adapting an existing tool. In parallel with this project, an effort was kicked off to develop components of the PTC ILM system, beginning with the capabilities to support interoperable change, configuration, and release management. The development project is being executed as a joint effort involving the railroads (primarily through the ITC CCM team), TTCI, and Railinc, with FRA supporting aspects of the continued design and testing activities. Given the potential applicability of the requirements and test management tools available, TTCI recommends developing the requirements for interoperable design coordination and requirements management and industry test management, followed by a more thorough investigation of the available tools, including potential for integration with the system currently being developed.

5. Conclusion

To provide for interoperable PTC operations, the industry has implemented organizational structures and policies and procedures to address, among other aspects, changes to the technology as it evolves throughout its lifecycle. While the entirety of activities required to support the ongoing evolution of interoperable PTC is broad in scope, through this project the concepts for PTC ILM were established to address the following:

- Interoperable Change Management
- Interoperable Configuration Management
- Interoperable Design Coordination and Requirements Management
- Industry Test Management
- Interoperable Release Management
- Knowledge Management

As part of this project, TTCI supported the execution and continued development of the previously established processes, including interoperable CCM and definition of minimum deployable versions for Interoperable PTC System Releases. Through these efforts, it was recognized that, while there are aspects of conventional ITSM that relate closely to PTC ILM, the focus of PTC ILM solely on those aspects that affect interoperability requires a somewhat unique adaptation of the concepts.

Through the support of the current processes related to PTC ILM, along with input and guidance from the ITC CCM team and the PTC IC, the rationale for the development of a centralized system to support PTC ILM was established and documented. Based on the identified needs, the initial concepts for the PTC ILM system were developed and documented. High-level requirements for interoperable change, configuration, and release management, derived from the draft concepts for these processes, also were developed. It has been recognized by the project team and supporting industry representatives that these concepts and requirements will continue to be refined as the industry processes continue to mature and the PTC ILM system development effort progresses. As a result, the documents included as appendices to this report represent the current understanding of the project team, based on the experience gained through the efforts described and input from members of the associated industry groups, but are considered living documents.

A number of commercially available tools with the potential to support some or all of the PTC ILM system capabilities were identified and reviewed. The intent of the review was to determine if the types of tools that currently exist support the documented needs. Through this review, it was determined that no commercially available tools identified likely are capable of performing all of the needed functions. In particular, the specific application of the ITSM processes to PTC ILM suggest that a custom application may be preferable to adapting an existing tool.

In parallel with this project, the industry has begun development of the PTC ILM system with the capabilities to support interoperable change, configuration, and release management. The development project is being executed as a joint effort involving the railroads (primarily through

the ITC CCM team), TTCI, and Railinc, with FRA supporting aspects of the continued design and testing activities. As these efforts continue, it is recommended that the design of the PTC ILM system continue to leverage from best practices in ITSM. Additionally, TTCI recommends developing the requirements for interoperable design coordination and requirements management and industry test management along with a more thorough investigation of the available tools to support these aspects, including potential for integration with the PTC ILM system currently being developed.

6. References

1. Rail Safety Improvement Act of 2008, Implementation of Positive Train Control Systems. (2010). 49 U.S.C. §20157.
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3. Information Technology Infrastructure Library (ITIL) Lifecycle Suite. (2011). London: The Stationary Office.
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7. Association of American Railroads. (2012). RP-9457 Positive Train Control Master Test Strategy Recommended Practice.
8. Institute of Electrical and Electronics Engineers. (2012). Std 828 IEEE Standard for Configuration Management in Systems and Software Engineering.
9. Institute of Electrical and Electronics Engineers. (2015). Std 1220 IEEE Standard for Application and Management of the Systems Engineering Process.
10. Institute of Electrical and Electronics Engineers. (2015). Std 15288 Systems and Software Engineering – System Life Cycle Processes.

Appendix A.
PTC Interoperable Lifecycle Management System

Revision History

Date	Revision	Description	Author
1/13/2019	0.1	Initial Draft	Joe Brosseau, Paul Martinez, Sri Atluri
2/2/2019	0.2	Updated definitions, acronyms, and references. Added text to section 5.4.6.1, 5.4.6.3, and 5.6.4 regarding latent changes, ICRs for documenting decommissioned versions and ICRs for deployment of previously approved ICIs. Added text to sections 5.4.6.1 and 5.4.6.7 regarding ICRs advancing to the close out stage. Other minor edits for consistency of terminology.	Joe Brosseau
5/9/2019	0.2.1	Changes to background	Joe Brosseau

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1 Scope

This document describes operational concepts for a system conceived to support industry lifecycle management activities for interoperable Positive Train Control (PTC) systems. The concepts described within are designed initially to support users of PTC systems that comply with the Interoperable Train Control (ITC) standards but may be expanded upon in the future to support other types of PTC systems, as well as other train control and operations technology.

1.1 Purpose

The purpose of this document is to provide a conceptual description of the envisioned system to document an industry consensus on the overall needs of the PTC Interoperable Lifecycle Management (ILM) system. The intent is that this document will be used in generating system requirements as well as providing a high-level description and context for those involved with development, testing, implementation, and use of the envisioned system.

PTC is a U.S. Government-mandated technology being implemented by the North American railroads which functions to prevent train-to-train collisions, overspeed derailments, unauthorized incursions into established work zones, and movement of a train through a mainline switch in the wrong position. PTC is designed to be interoperable, allowing a PTC locomotive from one railroad to (a) operate on territory owned and managed by another railroad, (b) be operated by a crew from another railroad, and/or (c) communicate with PTC assets owned by another railroad.

ILM, in the context of this document, refers to the management of PTC Interoperable System Releases throughout the lifecycle of the technology, including management of all interoperable configuration items (ICIs). The PTC ILM system will support these processes with a focus on combining best practices with established industry procedures to promote interoperability between railroads.

1.2 Document Overview

This document is organized into five major sections:

1. Section 1 provides an introduction and overview of the conceived PTC ILM system.
2. Section 2 is a list of external documents referenced within the text of this document.
3. Section 3 describes the current situation with regard to PTC ILM, including a brief background on PTC, basic PTC ILM concepts, and the Interoperable Train Control (ITC) agreement and associated structures and processes.
4. Section 4 enumerates the primary justification for enhancement of the tools currently used to support PTC ILM.
5. Section 5 documents the concepts for the PTC ILM system, including objectives, foundational concepts and process relationships, system user classes, descriptions of the primary PTC ILM system capabilities, and priorities among those capabilities.

1.3 System Overview

The PTC ILM system is conceived to provide a centralized software platform for supporting the primary lifecycle management activities related to interoperable operations of PTC. The system is intended to support industry-defined policies and procedures relating to these activities with customization and flexibility in mind, to support continuous improvement of the processes supported and future extensibility of the capabilities of the system. The U.S. railroad industry has developed a number of structures and processes to support PTC interoperability, following the U.S. government mandate to implement the technology on a broad scale. These structures and processes continue to mature and, as deployment of the technology nears completion and more interoperable operations get underway, are becoming increasingly critical to the successful implementation of PTC. The PTC ILM system will help enable successful execution of these critical processes moving forward.

The PTC ILM system incorporates a web-based service management tool allowing for industry access and management of the ICIs that comprise the interoperable aspects of the system throughout their lifecycle. The system concepts were developed by leveraging best practices and general concepts from well-established Information Technology Service Management (ITSM) documentation, such as the Information Technology Infrastructure Library (ITIL) core volumes and combining them with existing and developing PTC ILM processes and concepts.

The system will initially focus on six functional areas that are of most critical importance:

1. PTC Interoperable Release Management
2. PTC Interoperable Design Coordination and Requirements Management
3. PTC Interoperable Configuration Management
4. PTC Interoperable Change Management
5. PTC Industry Test Management
6. PTC Knowledge Management

Each of these functional areas is accessible by users of the system according to user access levels defined by assigned user classes. The functional areas are not intended as isolated functions; rather, they interact and support each other in the overall PTC ILM process. Data is stored in four logical system databases, which are accessed by each of the functional areas of the system:

1. Configuration Management Database (CMDB) – stores data relating to ICIs and their versions, interoperable change requests (ICRs), and PTC Interoperable System Releases.
2. Requirements Management Database – stores data relating to PTC requirements specifications and interface documentation.
3. Industry Testing Database – stores data relating to PTC industry test cases, test results, and test artifacts.

4. Knowledge Management Database – stores data relating to knowledge management artifacts.

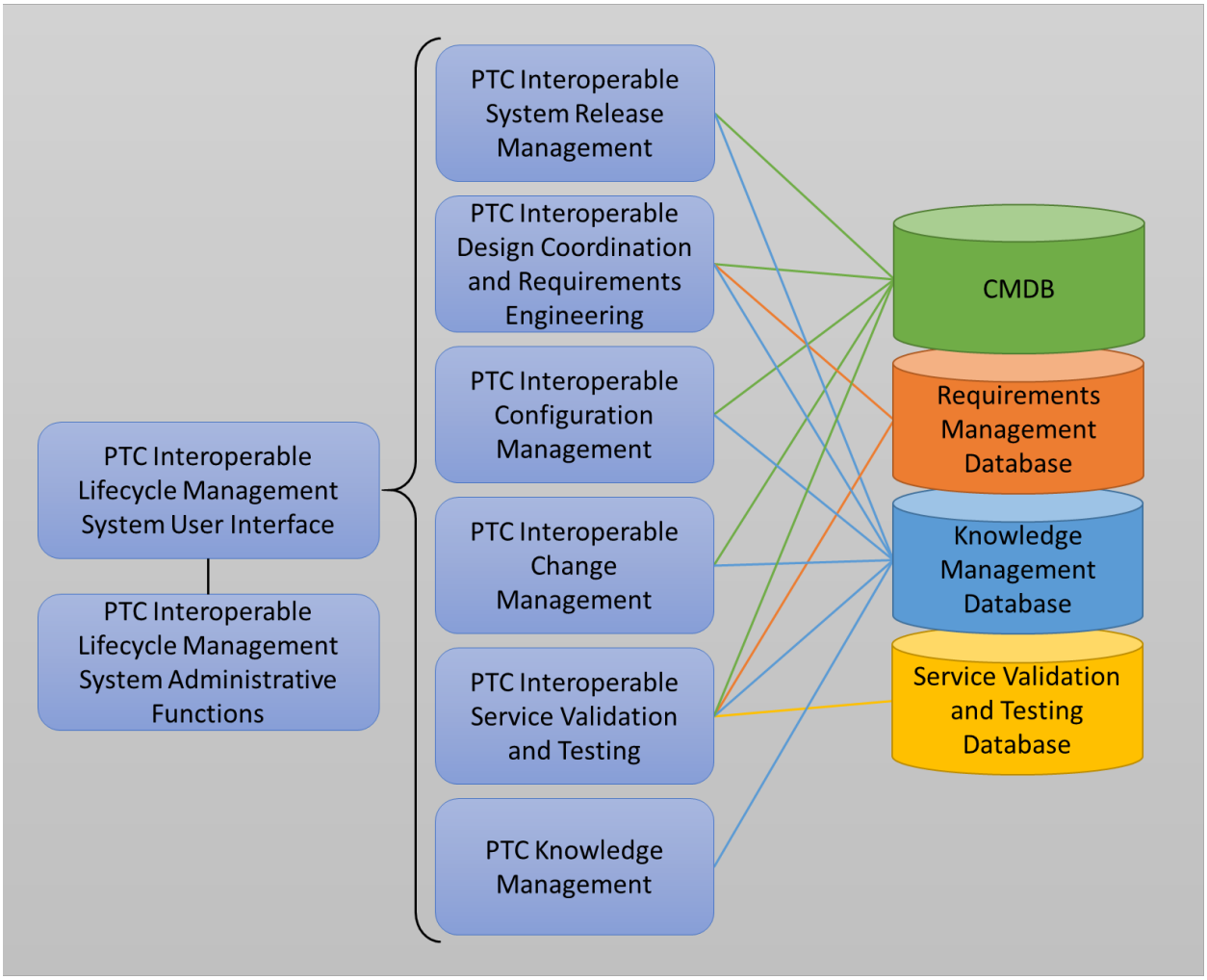

Figure 1: Interoperable Lifecycle Management System Overview

As shown in Figure 1, all functional areas of the system are accessible through the PTC ILM system user interface. The functional areas store and retrieve data from the four databases, as shown in the diagram.

Industry and railroad change managers, configuration managers, release managers, system engineers, and test engineers, as well as other interested railroad users, can access the system to share information; communicate and approve interoperable releases, deployment changes and system configuration details; and access requirements and testing information, including requirements traceability and testing results and artifacts. The user interface is conceived to be highly interactive and user contextual, making it easy for a user to access the most critical information for their role, and navigate easily between the PTC ILM system functional areas.

1.4 Terms & Acronyms

1.4.1 Terms

The following defined terms are used within this document:

Automatic Train Control (ATC)	A system designed to initiate an automatic penalty brake application when a train exceeds a maximum speed or exceeds the limit of a signal-based speed restriction it is operating under.
Track Bulletin	A notice of conditions affecting train movement.
Cab Signaling	A system that displays signal block status to the train crew inside the cab of the locomotive.
Computer-Aided Dispatch (CAD) System	A computer-based system that allows a train dispatcher to interact with the train control system to issue train routes, mandatory directives, track warrants, and bulletins – and receive information from the field devices including switch positions and signal block status.
Centralized Traffic Control (CTC)	A form of train control that uses block signaling and allows for control of interlockings and control blocks by a dispatcher from a centralized location.
Direct Traffic Control (DTC)	A form of train control wherein the dispatcher authorizes a train to occupy predefined blocks of track.
Global Positioning System (GPS)	A global navigation satellite system (GNSS), owned by the U.S Government, that provides geolocation and time information to receivers.
Information Technology Infrastructure Library (ITIL)	Per the ITIL core volumes, ITIL is part of a suite of best practices publications for IT Service management. ITIL provides guidance to service providers on the provision of quality IT services, and on the processes, functions and other capabilities needed to support them.
Information Technology Service Management (ITSM)	The organizational and management functions and activities required to provide information technology services to an organization.
Institute of Electrical and Electronics Engineers (IEEE)	A professional association composed of engineers, scientists, and students that develops standards for electronics and computer science applications.

Automatic Train Control (ATC)	A system designed to initiate an automatic penalty brake application when a train exceeds a maximum speed or exceeds the limit of a signal-based speed restriction it is operating under.
Interoperability	Per 49CFR236.1003, the ability of a controlling locomotive to communicate with and respond to the PTC railroad's positive train control system, including uninterrupted movements over property boundaries.
Interoperable Change Approval Board (ICAB)	The group of railroad representatives responsible for submitting, reviewing, communicating and approving changes to PTC ICIs that affect interoperable PTC operations.
Interoperable Change Request (ICR)	A request to deploy a version of a PTC ICI that may impact interoperable PTC operations and which is not currently deployed.
Interoperable Configuration Item (ICI)	A PTC artifact that needs to be managed at an industry level to support PTC interoperability.
Interoperable Lifecycle Management (ILM)	The set of activities related to and supporting the management of industry-level PTC system releases to support interoperability throughout the lifecycle of the technology, including management of all interoperable configuration items (ICIs).
Interoperable Train Control (ITC)	(a) A collaboration agreement among the BNSF Railway Company (BNSF), CSX Transportation, Inc. (CSXT), Norfolk Southern Railway Company (NS), and Union Pacific Railroad (UP) – and the organizational structure to support this agreement. (b) A set of standards, specifications, recommended practices, and related documentation defining a system designed to meet the regulatory requirements of PTC
Interoperable Train Control Messaging (ITCM) System	A messaging solution designed for interoperable train control applications to exchange messages over a variety of potential communications paths.
Location Determination System (LDS)	A system that determines the location of a locomotive for use by the PTC onboard application.

Automatic Train Control (ATC)	A system designed to initiate an automatic penalty brake application when a train exceeds a maximum speed or exceeds the limit of a signal-based speed restriction it is operating under.
Management Information Systems (MIS)	Railroad back-office systems that contain data and information used by the railroad for business and operational purposes.
Mandatory Directive	Any movement authority or speed restriction that affects a railroad operation.
Manual of Standards and Recommended Practices (MSRP)	A collection of standards, specifications, and recommended practices adopted by the Association of American Railroads (AAR).
Northeast Corridor (NEC)	A rail line operated by Amtrak that runs from Washington, DC to Boston over which a number of intercity passenger, commuter, and freight trains operate, most notably the high-speed Acela Express, which operates at speeds up to 150 mph.
Positive Train Control (PTC)	Per 49CFR236.1005, a system designed to prevent train-to-train collisions, overspeed derailments, unauthorized incursions into established work zones and movement of a train through a mainline switch in the improper position
PTC Artifact	PTC work product designated for change and configuration management.
PTC Interoperable System Release	An agreed upon list of required versions of ICIs that are approved for interoperable operations across a specific date range.
PTC Interoperability Committee (PTC IC)	A committee of the Association of American Railroads (AAR) responsible for adopting PTC interchange standards.
PTC Radio Frequency (RF) Network Design Plans	Plans that specify channel assignments and other design parameters for the railroad-owned 220 MHz radio frequency (RF) spectrum in each of the Major Trading Areas (MTAs) where interoperable PTC is deployed.
Railroad Configuration Item (RCI)	A PTC artifact that needs to be managed by each individual railroad to support the operation of PTC on or by that railroad, but that does not impact interoperability.

Automatic Train Control (ATC)	A system designed to initiate an automatic penalty brake application when a train exceeds a maximum speed or exceeds the limit of a signal-based speed restriction it is operating under.
Rail Safety Improvement Act of 2008 (RSIA '08)	A federal law enacted by the United States congress with provisions for enhancing safety on the United States rail network, including a mandate for the implementation of PTC.
Service Level Agreement (SLA)	A contractual agreement between a service provider and a consumer of that service specifying the agreed-upon level of service expected of the service provider.
Standard Carrier Alpha Code (SCAC)	A code used to identify freight carriers, including railways and private car owners.
Track Database	A database used by the PTC onboard application to determine the location of the locomotive on the track and the location of track features required to support PTC functions.
Track Warrant Control (TWC)	A method of operation where track access is controlled through the issuance of track warrants that specify the location(s), time(s), direction of movement and similar aspects related to occupancy of the track.
Wayside Interface Unit (WIU)	A device that interfaces with field signal equipment and similar devices to provide information to the PTC system regarding the status of the field device it monitors.
Wayside Status Relay Service (WSRS)	A capability of the PTC system to relay the status reported by a WIU via a path other than direct broadcast from a WIU radio.

1.4.2 Acronyms

The following acronyms are used throughout this document:

Acronym	Name
AAR	Association of American Railroads
ACSES	Advanced Civil Speed Enforcement System
ATC	Automatic Train Control
ATCS	Advanced Train Control System
BOS	Back Office Server

Acronym	Name
CAD	Computer-Aided Dispatch
CCM	Change and Configuration Management
CI	Configuration Item
CMDB	Configuration Management Data Base
COTS	Commercial Off-the-shelf
CTC	Centralized Train Control
DTC	Direct Traffic Control
E-ATC	Enhanced Automatic Train Control
ETMS	Electronic Train Management System
ICAB	Interoperable Change Approval Board
ICD	Interface Control Document
ICI	Interoperable Configuration Item
ICR	Interoperable Change Request
IEEE	Institute of Electrical and Electronics Engineers
IETMS	Interoperable Electronic Train Management System
ILM	Interoperable Lifecycle Management
ITC	Interoperable Train Control
ITCM	Interoperable Train Control Messaging
ITCS	Incremental Train Control System
ITIL	Information Technology Infrastructure Library
ITSM	Information Technology Service Management
LDS	Location Determination System
LDU	Locomotive Display Unit
MIS	Management Information System
MSRP	Manual of Standards and Recommended Practices
NEC	Northeast Corridor

Acronym	Name
PTC	Positive Train Control
PTCIC	Positive Train Control Interoperability Committee
RCI	Railroad Configuration Item
RF	Radio Frequency
RSIA ‘08	Rail Safety Improvement Act of 2008
SACM	Service Asset and Configuration Management
SCAC	Standard Carrier Alpha Code
SKMS	Service Management Knowledge System
SLA	Service Level Agreement
TMC	Train Management Computer
TWC	Track Warrant Control
WIU	Wayside Interface Units
WSRS	Wayside Status Relay Service

2 Referenced Documents

The following are referenced within this document:

- Rail Safety Improvement Act of 2008 (2010). Implementation of Positive Train Control Systems. 49 U.S.C. §20157.
- Positive Train Control Systems. (2010). 49 C.F.R. §236 Subpart I.
- Information Technology Infrastructure Library (ITIL) Lifecycle Suite. (2011). London: The Stationary Office.
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- Industry Configuration Item Management – Preliminary Approach, v0.01. (2015). Interoperable Train Control Change and Configuration Management Team.

3 Current Processes and Tools

The initial industry focus with regard to PTC is on implementation of the technology to meet the congressionally-mandated functionality. A number of joint industry efforts have been established to support activities such as agreement on functionality of common components, standardization of common interfaces, development of safety analyses, and drafting of industry best practices. While these efforts have gone a long way toward ensuring successful interoperable operations, only recently have truly interoperable operations become a reality. As such, interoperable change and configuration management (CCM) and other ILM processes have been limited in terms of scope and number of participating railroads. However, this landscape is changing rapidly, as the mandated deadline for implementation of PTC approaches and more railroads begin interoperable operations. This section provides background on PTC, an overview of some of the joint industry efforts associated with ITC, and a description of the current interoperable CCM processes.

3.1 Background

PTC is a form of communications-based train control technology designed to enforce operating rules to prevent certain types of accidents from occurring. It is designed to monitor and enforce the authorized limits and established speed limits for each train by means of an automatic penalty brake application if the train is predicted to exceed any such limits. The Rail Safety Improvement Act of 2008 (RSIA ’08) mandates installation of interoperable PTC on a large percentage of the U.S. rail network, resulting in one of the most focused investments in technology improvement in the history of the railroad industry.

PTC is a new and complex technological development which will continue to evolve and change as requirements change, unanticipated conditions are encountered, and new supporting technologies become available. The complexity in the number of configurable items and interactions, combined with the continuous rapid rate of change of these configurable items, presents a significant challenge to maintaining fully compatible, functional and interoperable PTC systems within and between railroads. This requires disciplined lifecycle management processes and tools that can support tracking of supported versions of configurable items, traceability of requirements, and coordinated schedules for change-out of system elements as new features are tested and commissioned for operation.

There are currently several PTC solutions being developed and implemented, resulting from the varying requirements, constraints, and existing technologies of each individual railroad. The predominant PTC system being implemented across the U.S. is the ITC system, based on standards developed for the interoperable aspects of the system. Other examples of PTC solutions include the Advanced Civil Speed Enforcement System (ACSES), being implemented by Amtrak and commuter railroads operating on and around the Northeast Corridor (NEC), the Incremental Train Control System (ITCS), and the Enhanced Automatic Train Control (E-ATC) system. While the initial focus of the PTC ILM system is on supporting ILM for the ITC-compliant systems, it is helpful to understand that other PTC solutions exist, and the PTC ILM system may expand to support these systems.

Most railroad track-miles are owned and maintained by 7 Class I railroads, 21 regional railroads, and 510 local railroads. The remainder is owned by Amtrak and some of the commuter operators; however, not all passenger routes operate exclusively on Amtrak or commuter agency

lines. Most of the routes into urban centers were owned by the freight railroads long before the passenger agencies came into being. In addition, some urban lines taken over by commuter operators for operational and management convenience still maintain some residual freight operation by freight railroads.

The net result is that the PTC systems installed on Amtrak and commuter trains must be compatible or interoperable with the system installed on the host railroad, and interoperability is also required for freight trains operating on Amtrak or commuter lines. Similarly, freight railroads operate on each other's lines under running right agreements for reasons of convenience or economy, and therefore their PTC systems must also be interoperable. Further, freight railroads lease locomotives from each other or from leasing companies in times of traffic imbalance or seasonal traffic peaks.

For PTC systems to be interoperable, trains must be able to traverse from territory operated by one railroad to territory operated by another railroad at track speed (that is, without having to stop to reinitialize a different system) without loss of PTC function.

The system defined by the ITC standards was designed for interoperability. For those railroads operating an ITC-compliant system, coordination and testing between railroads that have an interoperable relationship is necessary to ensure that each railroad can operate according to applicable PTC operating procedures. Once the system is implemented and tested, maintaining interoperability will require close coordination among the railroads as the interoperable elements of the system change and evolve.

3.2 PTC Interoperable Lifecycle Management Concepts

Many of the concepts, processes, tools, and knowledgebase surrounding system lifecycle management is well established. As examples, the Institute of Electrical and Electronics Engineers (IEEE) and the ITIL provide good references on these topics. The goal of the railroad industry is not to redefine nor reinvent what currently exists. However, PTC interoperability requirements do lead to a need to further define and clarify certain concepts for application to PTC ILM.

3.2.1 PTC Configuration Items

This section expands on the conventional definitions of a Configuration Item (CI) and identifies the types of CIs associated with PTC.

3.2.1.1 Definition of Configuration Item (CI)

For reference, two examples of traditional definitions for a CI are provided below:

- The IEEE definition of a CI is:

  > An aggregation of work products designated for configuration management and treated as a single entity in the configuration management process.

- The ITIL definition of a CI is:

  > A service asset that needs to be managed in order to deliver an IT service. Every CI must be under the control of change management.

These definitions follow a consistent theme and are useful for purposes of defining a CI for PTC ILM. The ITIL definition is focused on assets, while the IEEE definition is broader, applying to work products, in general. For purposes of PTC ILM, the industry has used the term artifact to apply to the work products designated for CCM.

To help differentiate between conventional CIs as defined above and those required for PTC, the terms Interoperable Configuration Item (ICI) and Railroad Configuration Item (RCI) are used within this document. When a configuration item is required to be managed by the industry as a whole to support interoperability, the term ICI is used. When a configuration item is railroad-specific and does not impact interoperability, the term RCI is used. This leads to the following definitions:

- PTC Interoperable Configuration Item (ICI): A PTC artifact that needs to be managed at an industry level to support PTC interoperability.
- PTC Railroad Configuration Item (RCI): A PTC artifact that needs to be managed by each individual railroad to support the operation of PTC on or by that railroad, but that does not impact interoperability.

It is understood that lifecycle management activities associated with RCIs and certain railroad-specific activities associated with ICIs are the responsibility of each individual railroad and are not considered part of the PTC ILM process.

3.2.1.2 Types of Configuration Items

Within the PTC system, there are different types of CIs, each of which must be managed differently. There are four general categories of PTC CIs:

- **Documentation** – System, segment, and component documentation, including:
  - Specifications – Requirements specifications for specific instances of individual segments or components
  - Standards – Published open standards, including system requirements specifications, interface control documents (ICDs), and similar documentation
  - Recommended Practices – Published documentation of generally accepted methods, but which are not required.
  - Safety Artifacts – Documentation relating to safety analysis for the system.

- **Hardware** – Physical components
- **Software Release** – Software applications
- **Configuration Release** – Configurable settings or plans, including:
    - Common component configuration files
    - Railroad component configuration files
    - Radio frequency (RF) network design plans
    - Track databases

While each individual railroad is free to use their own definitions for RCIs, the following are the agreed-upon types of ICIs:

- Specifications
- Standards
- Recommended Practices
- Safety Artifacts
- Software Releases
- Configuration Releases

3.2.2 Railroad Lifecycle Management vs. Interoperable Lifecycle Management

Similar to the definitions for ICIs and RCIs provided above, there is a need to distinguish between railroad PTC lifecycle management and PTC ILM. It is understood within the industry that there are many activities associated with the management of an individual railroad's PTC implementation that do not affect interoperable operations. These activities include things such as management of a railroad's individual PTC assets. Many of the traditional lifecycle management processes and tools are designed for management of a system that is overseen by a single controlling entity, and railroads are free to implement these processes and tools as they see fit for their particular organization, subject to the constraints of what is required for interoperable operations.

PTC ILM is constrained to management of ICIs and considers only those activities required to support interoperable operations. As such, many of the traditional lifecycle management concepts cannot be strictly applied. The ITC railroads have worked jointly to identify the activities that must be managed at an industry level to promote interoperability from a system development and operation standpoint and these are described in the subsections that follow.

3.2.3 Complexities of PTC ILM

The system lifecycle management process helps to ensure functionality and consistency of a system throughout its lifecycle. It is essentially a method of organizing and controlling changes within large, complex systems. It is therefore targeted at systems, such as PTC, that:

- Contain a large number of configuration items that are expected to change as the system evolves over time.

- Comprise a number of components and interfaces between components
- Are widely deployed
- Require a high level of performance and availability

However, PTC is somewhat unique in its level of complexity with regard to lifecycle management. In particular, the interoperability requirement of the RSIA ’08, along with the general nature of railroad operations and interchange, and the pace at which PTC is evolving, result in additional complexity that must be considered. The PTC application involves:

- Multiple PTC systems, all of which do not necessarily interoperate at a system functionality level.[1]
- Multiple railroads, most of which have their own unique implementation of PTC, due to differences in operating rules and business practices.
- Multiple system segments, each made up of a number of system components.
- Multiple back office systems, without comprehensive standard interoperable behavior definitions
- Multiple system component suppliers
- A combination of industry standard and vendor proprietary requirements
- Shared assets between railroads, for certain components
- A combination of components, some of which can have multiple versions deployed at any given time, while others can only have a single version at any given time.

In addition to the general complexities listed above, the scope of the deployment of PTC (i.e., the number of physical components and interfaces to existing systems such as wayside devices and locomotives) adds significantly to the complexity of the lifecycle management process.

3.3 Current Structures and Processes

As a result of RSIA ’08, the development and implementation of PTC has involved many parallel efforts. The processes established to support definition, standardization, development, implementation, testing, and certification are different for each of the different systems and each of the different railroads implementing those systems. The following sections summarize these processes as they apply to ITC-compliant PTC systems.

[1] Many railroads are choosing to achieve interoperability at an operational level, as opposed to at a system level, by either (a) equipping their locomotives with onboard hardware for each system installed on track over which the locomotive will be required to operate, or (b) equipping their track with wayside hardware for each system installed on locomotives that will operate over it.

3.3.1 PTC ILM Stakeholder Groups

At a high level, there are four primary stakeholder groups associated with the implementation and ongoing lifecycle management of PTC:

Railroad – The primary PTC stakeholder, the railroad is ultimately responsible for ensuring their PTC system meets federal requirements and their individual business objectives. The railroad is generally focused on achieving these objectives for their operations. The railroad is responsible for definition of the individual requirements of their PTC system; implementation, operation, and maintenance of their PTC system; and maintenance of their PTC shared assets according to service level agreements (SLAs).

System Integrator – The system integrator is responsible for installation, integration, testing, maintenance, deployment, and ongoing management of an individual railroad's PTC system, according to that railroad's requirements. In many cases, the railroad acts as its own system integrator, but in other cases, the railroad will contract a system integrator to perform these functions. The focus of the system integrator is on ensuring the PTC system meets the requirements of the railroad.

Industry – Stakeholders at the industry level are generally railroad or system integrator stakeholders acting on behalf of the industry to support interoperability goals. The industry is generally focused on ensuring interoperability between the railroad PTC systems. The industry is responsible for defining ITC standards and recommended practices and supporting the ongoing PTC ILM processes.

Vendor – Vendor stakeholders develop one or more individual components of the overall PTC system implemented by a railroad. The vendor focus is on developing a competitive product. The vendor is responsible for developing its product(s) to meet the needs of railroad customers. This may include design, manufacturing, software development, and similar activities, but also include maintaining version control and change management for its individual product(s).

Current ITC lifecycle management processes involve all of the above stakeholders.

3.3.2 Current ITC Structures and Processes

The development of the ITC system is the result of an agreement by the major Class I railroads operating in the U.S. to establish and maintain standards for interoperable PTC. As a result, a number of formalized structures and processes have been established at the industry level for those railroads implementing the ITC system. Additionally, each railroad implementing the ITC system has developed internal structures and processes for those aspects of system development, testing, and lifecycle management that are particular to its individual railroad.

The ITC agreement led to the establishment of a structure of technical working committees, each responsible for developing ITC standards for, and guiding development of, a particular interoperable aspect of the PTC system. This includes aspects such as:

Applications

Architecture

Communications

Data Management

Messaging

Wayside

Security

Systems Management

CCM

The standards developed by these committees are generally submitted to AAR to be published as interchange standards in the AAR Manual of Standards and Recommended Practices (MSRP). Although the ITC committees are responsible for ensuring that the PTC system is interoperable, not all elements are published as industry standards, due in part to the incorporation of components with vendor proprietary requirements. In these cases, the ITC committee is responsible for working with the vendor to ensure that the product provided will satisfy the needs of all users by agreeing on implementation of common functions and defining functions that must be railroad-configurable.

Recently, AAR established a standing PTC Interoperability Committee (PTCIC), responsible for establishing and maintaining PTC interchange standards to achieve the interoperability requirement of PTC. This includes, among other items, standards for PTC ILM. The PTCIC includes a number of working subcommittees to develop and recommend new standards and changes to existing standards, and is intended to provide the structure for ongoing industry governance of PTC, as the systems and concepts evolve throughout their lifecycles.

The high-level structure for testing of the ITC system is defined with the ITC Master Test Strategy, which is published as a recommended practice in the AAR MSRP. The Master Test Strategy describes the levels of testing to be conducted, the high-level test processes to be followed, and the management of defects identified during testing. At this time, the specific test plans and procedures used to ensure that implementation of the ITC system meets both the interoperable standards, as well as any individual railroad requirements, are defined individually by each railroad implementing an ITC-compliant system.

3.3.3 Status of ITC Documentation

The development path for PTC has been complex due to the evolution of the concepts; the changing state of the art of the technology; impacts on operations and other existing systems; the implementation and migration challenges; the changing operational, business, economic, and political landscape; and other factors. As a result, implementation of the ITC system is currently comprised of products that comply with a combination of AAR standards (adopted formally by the industry at large), ITC standards (adopted by the ITC railroads), and vendor proprietary requirements (owned and managed by the vendor). Management of the system requirements and traceability must be accomplished to support interoperability but must also be done in such a way so as to protect vendor IP.

3.3.4 Current Structure and Process for ITC Interoperable Change and Configuration Management

As part of the ITC committee structure, there is a subcommittee responsible for interoperable CCM. The current processes, which are being implemented across the industry, were initially documented in the Interoperable Configuration Item Management Preliminary Approach. The

processes were intended to provide a comprehensive list of ICIs and versions required for interoperable operation of the ITC system at the current point in time, as well as manage the deployment of new ICIs and versions and retirement of obsolete ICIs and versions.

While acknowledging the anticipated evolution to a more sophisticated method of interoperable CCM in the future, a spreadsheet was developed as a starting point for configuration management. The spreadsheet was intended to document and communicate the accepted versions of each ICI and the specific versions in use by each railroad at a given time. Within the spreadsheet, each agreed-upon ICI is defined and categorized, along with the versions of each ICI that are deployed or planned to be deployed by one or more railroads.

More recently, as interoperable PTC operations have been tested and implemented across the country, these processes have been more formalized by the affected railroads and documented in the Interoperable Change Management and Interoperable Configuration Management Policies and Procedures Manuals. These manuals document the agreed upon Interoperable CCM processes, which are focused on assessing, approving, and managing PTC Interoperable Change Requests (ICRs) that affect interoperability and maintaining the list of ICIs and deployment of these ICIs by each railroad.

The current process defines Interoperable Change Management documentation, including change requests, approvals, and process documentation, which is stored on an Interoperable Change Management SharePoint site. An Interoperable Change Approval Board (ICAB) was established and meets on a weekly basis to review and approve upcoming ICRs. Figure 2 shows an overview of the interoperable change lifecycle phases in the currently established process.

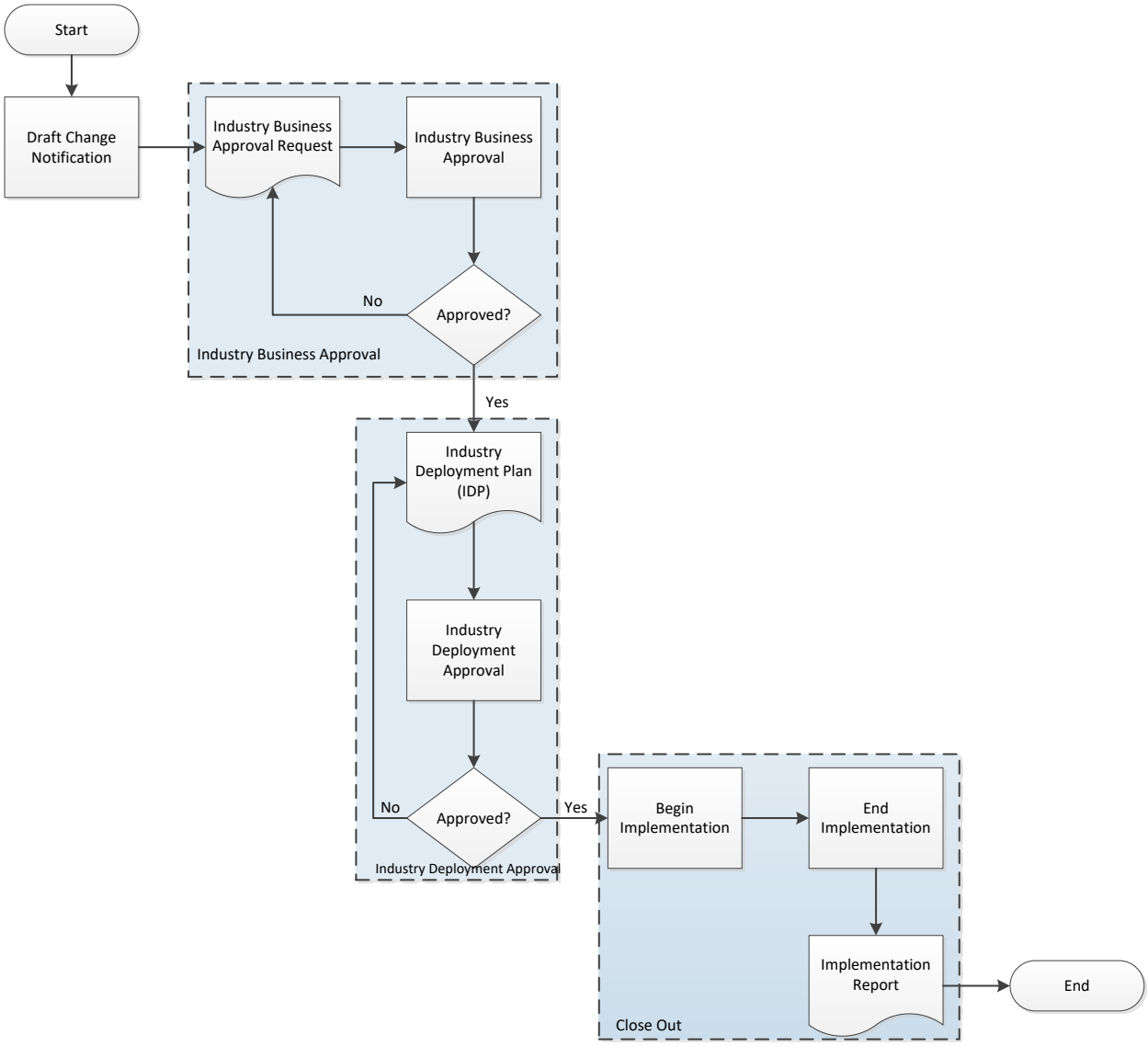

Figure 2: Interoperable Change Lifecycle Phases

When a railroad first determines that they are planning to make a change to an ICI within its system configuration, a change notification form is completed and submitted. The other participating railroads then have 7 days to discuss with their subject matter experts to identify if the change will impact their PTC operations and, if so, complete the information pertinent to the change for their railroad. The change is discussed at the next ICAB meeting, where items are clarified, concerns are addressed, and inconsistencies are resolved, as necessary.

Once the new version of the ICI is released, the change notification information will be updated, as necessary, with information such as railroads' planned testing duration and deployment date, versions of the ICI that may be obsolete as a result of the change, etc. The ICAB representative for each railroad will then vote to grant business approval for the change.

The next stage in the interoperable change process is deployment approval. Before deployment approval can be granted, each railroad must have completed its testing of the new version of the

ICI and solidified its deployment plans. The ICAB representatives for each railroad again will vote to grant deployment approval, after which deployment of the new version of the ICI can commence.

The final stage of the change is close out, which involves the completion of an implementation report following the completion of the deployment of the change. Once the change is complete for each railroad, the configuration management spreadsheet is updated with the new configuration of each railroad.

4 Rationale for Developing New System

As the industry transitions from PTC development, testing, and implementation to the ongoing operation, maintenance, and management of the technology, and particularly as more railroads begin interoperable PTC operations with other railroads, the capability of the current tools and processes will need to be expanded. This section provides justification for enhancement of the tools used. A description of the capabilities needed in the new tools and the priorities of these capabilities is explored in Section 5.

The following subsections enumerate the needs for the PTC ILM system.

4.1 Common Industry Platform for Visibility of PTC Configurations and Changes

There are a number of industry committees and teams involved in the deployment and operation of PTC, and the organizational structure supports industry discussion and decision-making on topics related to interoperability. However, the broad scope of the technology and rapid pace of change makes it challenging for all railroads operating ITC-compliant systems to be coordinated on current configurations and upcoming changes. One of the most fundamental needs is to provide a common, centralized platform for all railroads to visualize current and upcoming configurations of the interoperable aspects of PTC.

4.2 Support PTC Interoperable Change and Configuration Management on a Broad Scale

The processes and tools currently used for PTC interoperable CCM were designed specifically to address the immediate needs of the railroads entering into interoperable operations in a single region of the country. These processes and tools have been instrumental in supporting interoperable operations in this region and have also provided an important incremental capability for the industry. These processes and tools are limited in their ability to support the broader industry. As more railroads become interoperable, the tools will need to be expanded to support the broader industry.

4.3 Enhance Efficiency and Traceability of the PTC Interoperable Change and Configuration Management Process

In addition to the limitations in scalability of the current PTC interoperable CCM processes and tools, there are also limitations in their efficiency. The current processes and tools require a significant number of manual tasks to organize, visualize, and track PTC changes and configurations. These will not be practically supportable as the process scales but also create opportunities for human error. Additionally, the tools must support traceability of decision making and approvals which is currently performed manually.

4.4 Support PTC Interoperable System Release Management

Interoperable CCM supports notification, analysis, and approval of changes to the defined ICIs of any railroad that have the potential to impact other railroads. As the number of interoperable railroads increases, the need to limit the allowable combinations of ICIs will become more critical, in order to limit the amount of analysis and testing to verify the proper operation of the system in all possible configurations. PTC Interoperable System Releases will be defined by the PTCIC, which will contain the specific configuration of all ICIs for that release. The PTCIC will also produce a schedule of allowable PTC Interoperable System Releases, including planned allowable deployment dates for new releases and retirement dates of old releases.

4.5 Support PTC System Requirements Management

Each individual railroad is responsible for verifying its PTC system implementation remains functional and interoperable throughout its lifecycle. To do so, each railroad must be able to identify what has changed from one PTC Interoperable System Release to the next. Currently, management of ITC system, segment, and component requirements is distributed among industry committees, railroads, and system component vendors. The method, quality, completeness, and visibility of traceability of requirements between versions of an ICI is inconsistent and dependent on the entity managing the requirements. While individual vendors must retain responsibility for management of their product releases, visibility of changes to the railroad users is necessary to support verification of the interoperability of PTCIC-approved PTC Interoperable System Releases. To practically manage the railroad PTC system testing efforts as the system evolves, the ability to identify the requirements that changed between each release is critical.

Additionally, to support interoperability between systems that utilize different vendor products, traceability between requirements of these products is necessary to identify inconsistencies with potential to result in practical incompatibilities. Therefore, there is need to trace requirements from system-level down to component-level as well as between components that are designed to be functionally equivalent, from an interoperability standpoint, at the same level.

4.6 Support Potential Future Industry Joint PTC System Test Management

Currently, each railroad is responsible for testing its implementation of PTC to verify that it functions as designed. Each railroad maintains a test case management system that allows it to design test cases, trace them to system requirements, and track test results and progress. Although each railroad has developed its own approach to testing, it is recognized that there is potentially a great deal of overlap, given the similarities in the systems designed to support interoperability. As a result, there is potential for joint industry testing of the common elements of the system, which can reduce the redundancy of testing in the future. The capability to manage joint industry test cases, as they evolve along with the system requirements, will be needed to support this capability in the future.

5 PTC ILM System Concepts

As the industry continues in the deployment and begins operation of interoperable PTC, ILM activities are being defined and introduced within the industry. As described previously, the processes and tools are being introduced as required to support the current objectives but will benefit from a centralized system to support these activities. This section provides the concepts for the PTC ILM system, including definition of the objectives, foundational principles, user classes, key capabilities of the system, and priorities among the described capabilities.

5.1 PTC ILM System Objective

The primary objective of the PTC ILM system is to support execution of industry agreed-upon procedures and methods for managing changes to PTC that impact interoperability throughout the lifecycle of the technology. Creating a centralized platform allows for better communication among railroads and uniformity in process which increases efficiency in testing and deployment activities and reduces risk of negative impacts to interoperable PTC operations.

5.2 PTC ILM Foundational Concepts

To define the scope and functions of the PTC ILM system, several foundational concepts have been established. This section describes these foundational concepts, which have been used to derive the applicable aspects of PTC ILM and the scope and functions of the PTC ILM system.

5.2.1 PTC as a Service

In the context of ILM, PTC can be considered a service provided internally by each railroad, but requiring coordination with other interoperable railroads, to support safe and efficient operations in the areas in which it is implemented. The consideration of PTC as a service allows for the use of best practices that have been established for other information technology services, as they are determined to be applicable.

ITIL is a widely accepted approach to ITSM and provides a useful foundation for defining the applicable aspects of PTC ILM and the scope and functions of the PTC ILM system. As described in the ITIL core volumes that document the established best practices:
“ITIL is part of a suite of best practice publications for IT Service management. ITIL provides guidance to service providers on the provision of quality IT services, and on the processes, functions and other capabilities needed to support them. ITIL is the most widely recognized framework for ITSM in the world.” ITIL is used as a guideline in development of the foundational concepts for PTC ILM.

5.2.2 Overview of ITIL

The ITIL Service Lifecycle provides a systematic workflow that can be applied to most businesses that provide a service. A high-level view of ITIL shows the five stages of the Service Lifecycle that are the foundation of the ITIL framework. The ITIL Service Lifecycle approach considers the strategy, design, transition, operation, and continuous improvement of IT services. The ITIL core consists of these five lifecycle stages, with each containing a group of processes under them:

ITIL Service Strategy – Defines the perspective, position, plans, and patterns that a service provider needs to be able to execute.

ITIL Service Design – Defines the IT service, together with the governing IT practices, processes, and policies.

ITIL Service Transition – Ensures that new, modified, or retired services meet the expectations of the business.

ITIL Service Operation – Coordinates and carries out the activities and processes required to deliver and manage services.

ITIL Continual Service Improvement – Aligns IT services with changing business needs by identifying and implementing improvement to IT services that support business processes.

Figure 3 was taken directly from the ITIL core publications and shows how the five stages work together as inputs, outputs and feedback connect each of the stages together. This workflow follows a service from concept to the day-to-day operations after it has been fully implemented.

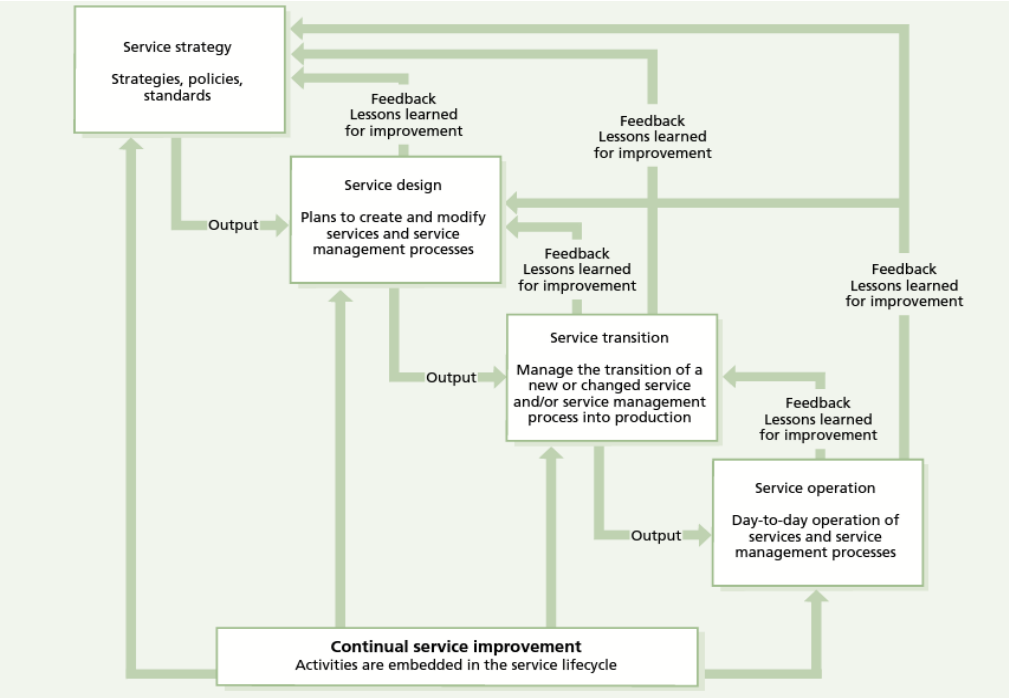

Figure 3. ITIL Service Lifecycle

The 5 core stages within ITIL contain 26 defined processes found in a fully established business or IT operation. Figure 4 outlines the processes within each of the core stages.

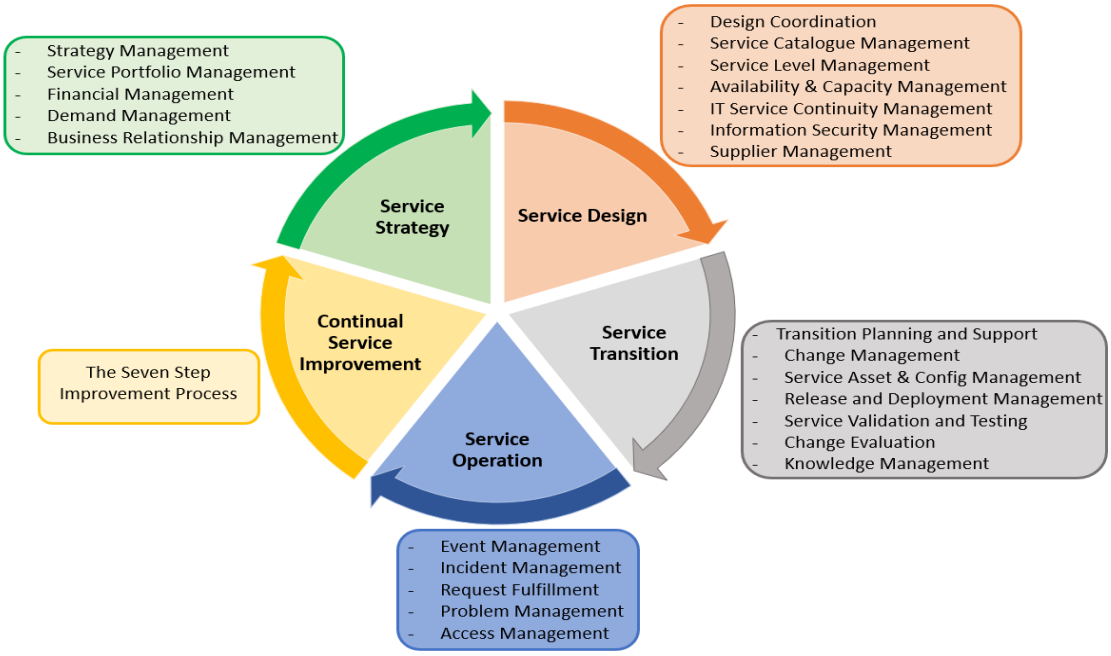

Figure 4. The Five Stages of the Service Lifecycle and Underlying Processes

5.2.3 Application of ITIL to PTC ILM

Using the model of the ITIL Service Lifecycle as a foundation, the core stages can be applied to PTC ILM to provide context for the use of ITIL concepts in defining the core aspects of PTC ILM. Figure 5 shows the definitions for each of the core stages replaced with descriptions that apply to PTC ILM, demonstrating how the industry processes associated with PTC and the core stages of ITIL parallel each other.

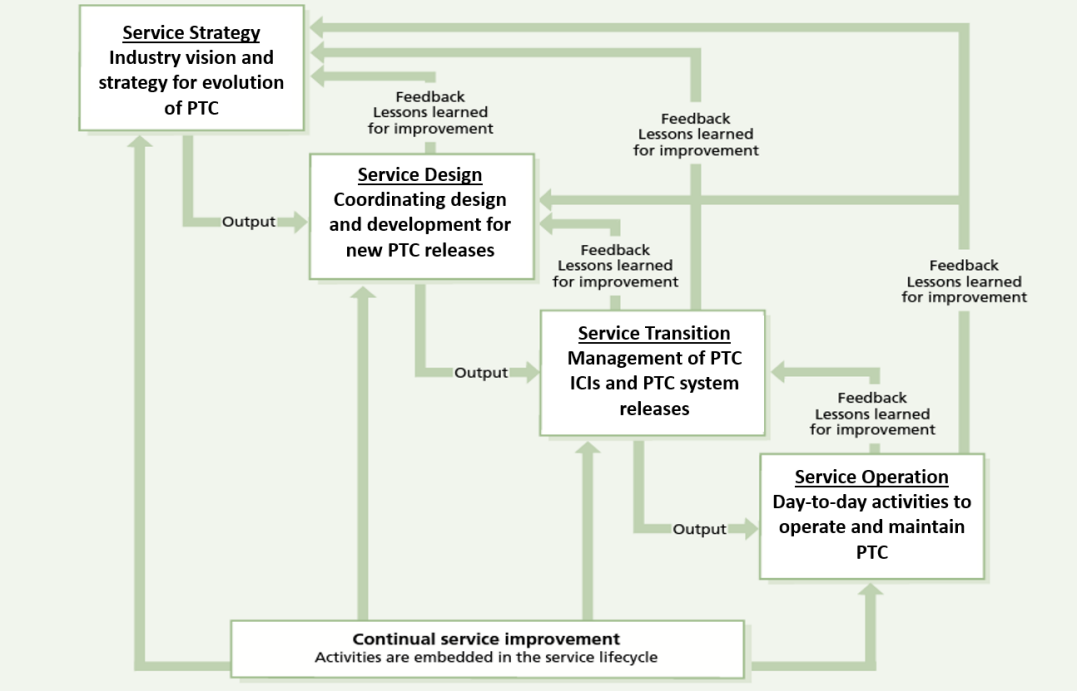

Figure 5. PTC ILM Service Lifecycle

5.2.4 PTC ILM Core Processes

Applying the concept of PTC as a service provided by the railroads, each of the established processes within the ITIL framework can be examined to determine its applicability to PTC at the industry interoperable level. Note that each individual railroad that provides PTC as a service on its railroad may choose to incorporate additional processes or aspects of processes that do not apply at the industry interoperable level. Additionally, there are industry initiatives and existing tools (or tools under development) that support processes that do apply at the interoperable level but are not considered part of PTC ILM in the context of the PTC ILM system described in this document. These include, as examples, systems to support Incident Management in an interoperable environment and systems to support Availability Management of the interoperable PTC system. In the future, the PTC ILM system may expand to interface or otherwise encompass these systems but are not part of the initial scope of the system.

The PTC ILM system is intended to initially support the most critical processes that support interoperability, with the ability to expand later. The initial ITIL processes to help establish ILM are defined below. As the process matures, there will be opportunity, in future stages, to add support for additional ITIL processes. The initial six ITIL processes to be supported are:

Change Management

Service Asset and Configuration Management (SACM)

Design Coordination (in particular, requirements engineering)

Service Validation and Testing (in particular, test case management)

Release and Deployment Management

Knowledge Management

Each of these ITIL processes is described in further detail below, with further definition of how they apply to PTC ILM.

Change Management – Change Management is a function of the ITIL Service Lifecycle under Service Transition. Change is defined as, "the addition, modification or removal of anything that could have an effect on IT services." In the context of PTC ILM, this is defined as anything that could have an effect on interoperable operations.

Interoperable Change Management is the foundation of the PTC ILM system, as it allows for management of individual changes, updates or modifications to ICIs in a central location. Interoperability requires the industry to manage these changes through documentation and communication of every step to encourage traceability throughout the change lifecycle.

The Interoperable Change Management component of the PTC ILM system allows interoperable railroads to share details of changes to ICIs, analyze the impact of the changes, and coordinate testing and deployment, to reduce the risk of unanticipated effects of the changes. Management of change can happen proactively to improve services or reactively when resolving errors or adapting to changing circumstances. The PTC ILM system also helps to ensure that all stakeholders receive appropriate and timely communication.

Service Asset and Configuration Management – SACM is a function of the ITIL Service Lifecycle under Service Transition. SACM ensures that ICIs are identified, baselined, and maintained, and that changes are controlled and documented. In the context of PTC ILM, this applies to identification, baselining, and maintenance of PTC ICIs by the industry groups that are responsible for interoperable PTC CCM.

Another major component of the PTC ILM system, Interoperable Configuration Management, introduces a database for all ICIs. As railroads complete the deployment of a new version of an ICI, the ICR is documented within the Interoperable Change Management component, which links to the ICI database. This linkage helps ensure the database remains updated and accurate. Each ICI has a configuration record listing a set of attributes and relationships for that ICI. The relationships to other ICIs defined in the database support the Interoperable Change Management process by identifying potential impacts of changes to an ICI. Configuration records also contain historical records listing version updates, ICR identifiers and railroads that deployed each change.

Design Coordination – Design Coordination is a function of the ITIL Service Lifecycle under Service Design. The purpose of Design Coordination is to coordinate all design activities, resources, and capabilities required to design new or changed services. Related to Design Coordination, and within the Service Design stage of the ITIL Service Lifecycle, are Service Design Technology-Related Activities, most notably (in the context of PTC ILM) Requirements Engineering. Requirements Engineering is the process of defining new or modifying existing system requirements and analyzing changes to requirements in terms of traceability to other requirements and decomposition of those requirements into lower-level segment- and/or component-level requirements. In the context of PTC ILM, Interoperable Design Coordination and Requirements Management supports visibility across the industry of new versions of ICIs, as well as the Requirements Engineering effort to maintain the versions of the requirements across time and produce a list of changes from one version to the next.

There are many reasons a new version of an ICI may be developed and released, ranging from resolution of identified defects, modifications to optimize functions within the software, updates to support hardware changes, etc. In many cases, these changes will not be the result of changed requirements. However, in many cases (for example, when new features or functions are added) a new version of an ICI does require modifications to requirements. Existing processes for industry groups and vendors associated with each ICI are in place to discuss and plan activities around changes to each ICI. The PTC ILM system supports these activities by allowing requirements to be updated and analyzed within the PTC ILM system as well as planned ICI version development and release timelines. The system produces information that each PTC railroad can use in their PTC planning process.

Service Validation and Testing – Service Validation and Testing is a function of the ITIL Service Lifecycle under Service Transition. The purpose of Service Validation and Testing is to ensure that a new or changed service matches its design specification and will meet the needs of the business.

In the context of PTC ILM, Industry Test Management supports industry processes for evaluating new PTC releases and/or versions of ICIs prior to deployment. Industry Test Management within the PTC ILM system is supported by the Interoperable Design Coordination and Requirements Management process, which provides information for updating industry test cases within the system. The PTC ILM system also can be used for tracking test progress and results, as well as maintaining test artifacts, as part of the Industry Test Management process.

Release and Deployment Management – Release and Deployment Management is a function of the ITIL Service Lifecycle under Service Transition. The purpose of Release and Deployment Management is to plan, schedule, and control the build, test and deployment of releases and to deliver new functionality required by the business while protecting the integrity of existing services.

In the context of PTC ILM, a PTC Interoperable System Release is a scheduled release package of specific versions of ICIs, defined and approved by the responsible industry committees. Each PTC Interoperable System Release has a defined earliest deployment date and end-of-life date. The PTC ILM system provides visibility to the industry for each PTC Interoperable System Release, allowable deployment dates, and details of what is contained within each PTC Interoperable System Release.

Knowledge Management – Knowledge Management is a function of the ITIL Service Lifecycle under Service Transition. The purpose of Knowledge Management is to share perspectives, ideas, experience, and information to support informed decisions, and to improve efficiency by reducing the need to rediscover knowledge.

Sometimes referred to as service management knowledge system (SKMS), this database gathers, analyzes, stores, uses, and maintains knowledge such as “lessons learned” from prior changes that help increase efficiency with future decisions on changes.

The Knowledge system eventually becomes a reference tool that is only as valuable as the information that is placed in it. Test results, findings, errors, faults, or workarounds collected and shared help the industry manage projects and risk more efficiently. People gain knowledge both from their own and from their peers’ expertise, as well as from the analysis of information (data).

5.2.5 PTC ILM Process Relationships

The six core PTC ILM processes are interconnected in their execution throughout the lifecycle of PTC as it evolves through new Interoperable System Releases and ICRs. PTC is and will continue to be an ever-changing technology, with a number of potential factors driving the change. New functions, improved efficiency, reduction of risk, changes to operations, obsolescence of hardware, and addressing defects drive the continued need for design, development, testing, and deployment of changes to the system. The identification of the need for a change as a result of one of these potential factors is the initiator of the core PTC ILM processes, but these processes are not executed serially. Rather, they are executed in a coordinated fashion, with information from each passing to the others, enabling communication between the various processes and entities executing those processes.

Figure 6 shows a high-level conceptual breakdown of the key elements of the core PTC ILM processes and how they interact with each other.

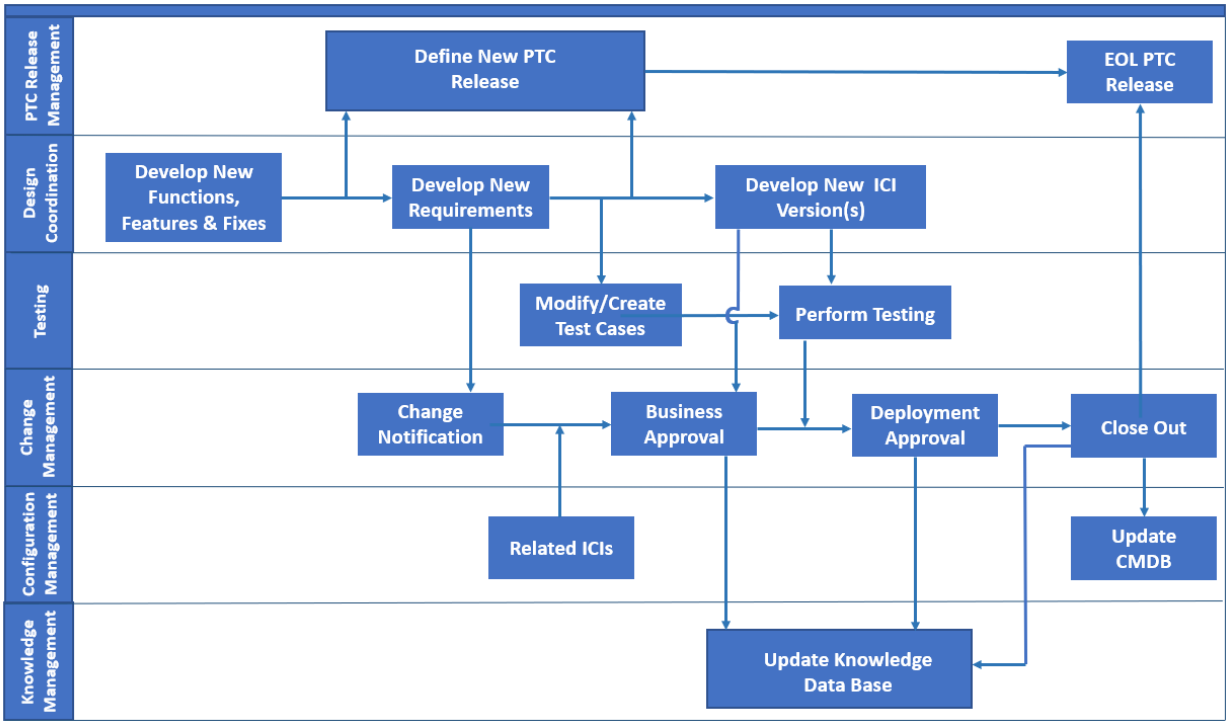

Figure 6. Relationships Between Core PTC ILM Processes

New system-level features and functions, as well as fixes to identified defects or other issues, are depicted on the left side of the diagram, kicking off the PTC ILM processes. Although not depicted in the figure, this is not meant to indicate a single event, but rather a constant stream of new concepts that drive the process continuously. Discussion initiated at various levels between railroad stakeholders concerning these changes may lead to development of new or modified requirements, which drive development of new versions of ICIs, all as part of the Interoperable Design Coordination and Requirements Management process. Prioritization of the development

efforts, as well as coordination of the design and development work on new versions of ICIs, is also handled as part of the Interoperable Design Coordination and Requirements Management process. Additionally, as part of the requirements engineering effort, any changes to requirements are traced through, informing potential impacts of the change on other ICIs.
As the Interoperable Design Coordination and Requirements Management process takes place, initial discussions for defining a new PTC Interoperable System Release are ongoing as part of the PTC Interoperable Release Management process. New PTC Interoperable System Releases generally include new versions of some ICIs, along with versions of other ICIs that have not changed from a prior PTC Interoperable System Release. As details of new versions of ICIs under development and their release schedules take shape, the definition of the specific versions of each ICI contained in the next PTC Interoperable System Release, as well as initial planned dates for the release, are established.

In addition to driving the PTC Interoperable Release Management process, the definition of a new version of an ICI also initiates the first step in the Interoperable Change Management process, an initial Change Notification. A Change Notification is a formal indication of the intent of a railroad to deploy a change to an ICI. A Change Notification initiates a traceable ICR that provides all pertinent information for review and response by the change community. Railroads document their intentions to schedule, test and deploy the new ICI in the ICR.

Related ICIs that may be impacted by the change are identified through links stored in the CMDB. This information can be used by railroads in analyzing impacts of the change, along with information provided through the requirements engineering aspect of the Interoperable Design Coordination and Requirements Management process.

The definition of new requirements in the Interoperable Design Coordination and Requirements Management process also drives analysis and potentially new or modified test cases as part of the Industry Test Management process. New or modified requirements, as well as any test cases traced to new, modified, or removed requirements, are identified, leading to development of new test cases or modification of existing test cases, as applicable.

Once the new version of the ICI is released, the next stage of the Interoperable Change Management process is initiated, the Business Approval stage. As part of this stage, railroads update their plans for testing the new versions of the ICI, as well as their intent and plans for deployment. Also, at this point, railroads will begin testing the new version of the ICI according to their test plans and the updated test cases. Knowledge and lessons learned from this stage of the lifecycle management process are documented in the knowledge management database as part of the Knowledge Management process.

As part of the Interoperable Release Management process, knowledge gained through the development, release and testing of new versions of ICIs may result in changes to definitions of upcoming PTC Interoperable System Releases. Versions of ICIs may be added, removed, or moved to various planned PTC Interoperable System Releases. As details of new versions of ICIs, including changes incorporated and release dates, are firmed up, upcoming PTC Interoperable System Releases that contain those new versions are finalized and communicated to the industry, including a schedule for earliest deployment of the new PTC Interoperable System Release. At this point, end-of-life plans for older PTC Interoperable System Releases are also developed and communicated.

Following successful testing of the new version of the ICI, the change advances to the Deployment Approval stage of the Interoperable Change Management process, wherein railroads update and confirm final details of their deployment plans and the change proceeds through the review and approval process. At this point, railroads proceed with deployment of the change, documenting knowledge and lessons learned in the knowledge management database as part of the Knowledge Management process as the deployment proceeds. Following successful deployment of the new version of the ICI, the change is closed and the knowledge management database is updated with any final lessons learned from the deployment. As changes are formally closed through the Interoperable Change Management process, older PTC Interoperable System Releases containing versions of ICIs that have been decommissioned throughout the industry are formally moved to an end-of-life release stage.

The description of the processes and their relationships provided in this section provide an overview of the general progression of events as the technology proceeds through each stage of the lifecycle. There are many potential deviations from the description that are possible. For example, if testing of a new version of an ICI identifies a critical defect in the new version, the change may progress directly to the closed stage of the Interoperable Change Management processes, and the PTC Interoperable System Release would require updating to remove this version. The description is therefore intended to provide a general understanding of how the processes relate, and not to comprehensively describe every potential outcome at each stage.

5.3 PTC ILM System User Classes

User Classes define the various types of users of the PTC ILM system. The areas of the system that can be accessed and the actions that can be taken by a user are defined by their assigned User Class. It is possible for a user to be assigned to multiple User Classes if they must act in multiple roles within the PTC ILM system. Note that the PTC ILM system User Classes are not intended to define all roles within the PTC ILM processes, which include representatives of the industry and individual railroads, as well as a number of industry committees, performing a number of support functions. Industry policies and procedures define these types of roles and functions. The purpose of the PTC ILM system User Classes is solely to define the roles within the context of the system itself. Below is a list of User Classes within the PTC ILM system:

- PTC ILM System Administrator – Users within this User Class can perform administrative functions, such as adding new railroads, adding and managing users, and user roles, and can access any area of the system.
- Standard User – Users within this User Class can only access the system for purposes of viewing information and creating, running, and viewing/exporting reports for the following areas: Interoperable System Releases, ICI version development tracking, CMDB, ICRs, and ICR impact assessment.
- Industry Release Manager – Users within this class User Class can initiate new PTC Interoperable System Releases, update PTC Interoperable System Releases, and enter approvals for PTC Interoperable System Releases.
- Industry Requirements Manager – Users within this User Class can create new versions of requirements specifications, authorize users for access as a System Engineer for a requirements specification ICI, plus perform all functions of a System Engineer for all requirements specification ICIs.

- System Engineer – Users given access by the Industry Requirements Manager for a requirements specification ICI can perform the following actions on the requirements specification ICIs for which they have been given access:
    - Develop and modify drafts or works-in-progress.
    - Initialize requirements from prior versions.
    - Import requirements.
    - Create/edit tracing links between requirements.
    - Initialize links from prior versions of requirements specifications.

Users authorized as System Engineers can also perform all functions of a Read-Only System Engineer for the requirements specification ICIs for which they have been given access:

- Read-Only System Engineer – Users given access by the Industry Requirements Manager for a requirements specification ICI can view requirements specifications, compare versions of requirements specifications, view tracing between requirements, and run/view/export traceability reports for the requirements specification ICIs for which they have been given access.
- ICI Version Manager – Users within this User Class can input/modify ICI development tracking information for ICIs for which they have been given access.
- Industry Configuration Manager – Users within this User Class can select new versions of ICIs for development tracking, authorize users as ICI Version Manager for development tracking for a particular ICI, archive ICIs for development tracking, add new ICIs to the CMDB, remove ICIs from Interoperable Configuration Management, change the attributes of an ICI, add new versions of ICIs, and enter/modify ICI version attributes and relationships.
- Railroad Configuration Manager – Users within this User Class can baseline their railroad configuration of ICIs, enter ICI version attributes of new ICI versions they enter through baselining, and update versions of ICIs deployed as a result of a CMDB audit.
- Industry Change Manager – Users within this User Class can enter approvals for ICRs, close ICRs, reassign Change Sponsors. They are responsible for configuring the standard number of days to respond to changes and the customizable fields within ICR forms.
- Railroad Change Manager – Users within this User Class can respond to ICRs, complete ICR close out forms, initiate new ICRs, and advance ICRs for which they have been assigned the Change Sponsor.
- Industry Test Case Manager – Users within this User Class can import new or modified test cases, create new test cases, create and modify links between test cases and requirements, modify draft cases, enter approvals of draft test cases, archive old test cases, and authorize users to view test cases and test results – plus perform all functions of an Industry Test Support User.
- Industry Test Support User – Users within this User Class can enter/import test results, upload test artifacts, and perform all functions of a Read-Only Test Support User.

- Read-Only Test Support User – Users within this User Class can view test cases, view links between test cases and requirements, create/run/view/export test case traceability reports, create/run/view/export test result reports, and view test artifacts.

5.4 PTC ILM System Capabilities

The PTC ILM system is conceived as a tool to support the ILM processes described in the preceding sections. Because of the unique aspects of PTC ILM, as compared to traditional ITSM, implementation of a single, commercial, off-the-shelf (COTS) product that could satisfy all the needs is likely not practical, although integration of customized applications with COTS products may be possible. The key differences between traditional ITSM and PTC ILM include, most notably, the following:

- Not all aspects of PTC are managed at the interoperable level. In traditional IT Service Management, there is complete visibility and traceability throughout the ITIL core stages and the processes that support them. In PTC ILM, certain aspects are managed at the interoperable level, while others are managed at the individual railroad level.
- There is a mix of industry-standard and non-standard ICIs, which creates complexity in deterministically tracing requirements and assessing impacts of changes. In some cases, railroads use different ICIs to fulfill the same functionality within the overall PTC system.
- PTC ILM considers aspects outside of traditional ITSM, including requirements management and test case management, in includes only certain aspects within traditional ITSM (those that affect interoperability).

The subsections that follow outline the key capabilities of the PTCILM system.

5.4.1 User Access

The PTC ILM system is intended to be accessible by users employed by different organizations in various geographic locations. As a result, the system must be accessible through a network, either via web application or user client application.

The system requires user login and verifies user credentials before allowing system access.

5.4.2 Dashboard (Home Page)

The PTC ILM system will provide an interactive dashboard (home page), viewable by all users, with content specific to the user logged in. The dashboard is intended to be accessible to the user at any time, from any other area of the system. The dashboard provides the following:

Links to the core subsystems of the PTC ILM system:

- PTC Interoperable Release Management Subsystem
- PTC Interoperable Design Coordination and Requirements Management Subsystem
- PTC Interoperable Configuration Management Subsystem
- PTC Interoperable Change Management Subsystem
- PTC Industry Test Management Subsystem

- PTC Knowledge Management Subsystem
- Interactive snapshot of the current industry PTC Interoperable System Release schedule
- Action items for pending items, as applicable to the user
- Other content specific to user

The dashboard is intended to provide a combination of high-level information and information most relevant to the user, and also to help the user navigate quickly to the various PTC ILM system functions.

The interactive PTC Interoperable System Release schedule allows the user to visualize the PTC Interoperable System Releases across time, from the high-level PTC Interoperable System Releases down to the details of a specific version of a specific ICI. The interactive PTC Interoperable System Release schedule can assist the user in comparing different PTC Interoperable System Releases to see which ICIs were changed from the previous PTC Interoperable System Release. The PTC Interoperable System Release schedule shows past, present and future PTC Interoperable System Releases on a timeline that shows when they were (or are planned to be) authorized for deployment and when they were (or are planned to be) moved to an end-of-life state.

Figure 7 shows a conceptual mockup of the interactive PTC Interoperable System Release schedule, showing a timeline with past (red), present (green) and future (grey) PTC Interoperable System Releases. In this mockup example, the user has selected a past release, “PTC Release 4.0” (note: the large gray arrow indicates where the user selected the PTC Interoperable System Release to drill down on). A window provides the user a deeper look at the selected PTC Interoperable System Release by showing individual ICI versions that were changed with this release. In this mockup example, the user has then selected an individual ICI, “AAR: S-9356 Class D Messaging” (note: the large green arrow indicates where the user selected the ICI to drill down on). Another window provides information specific to this version of the ICI, as applicable.

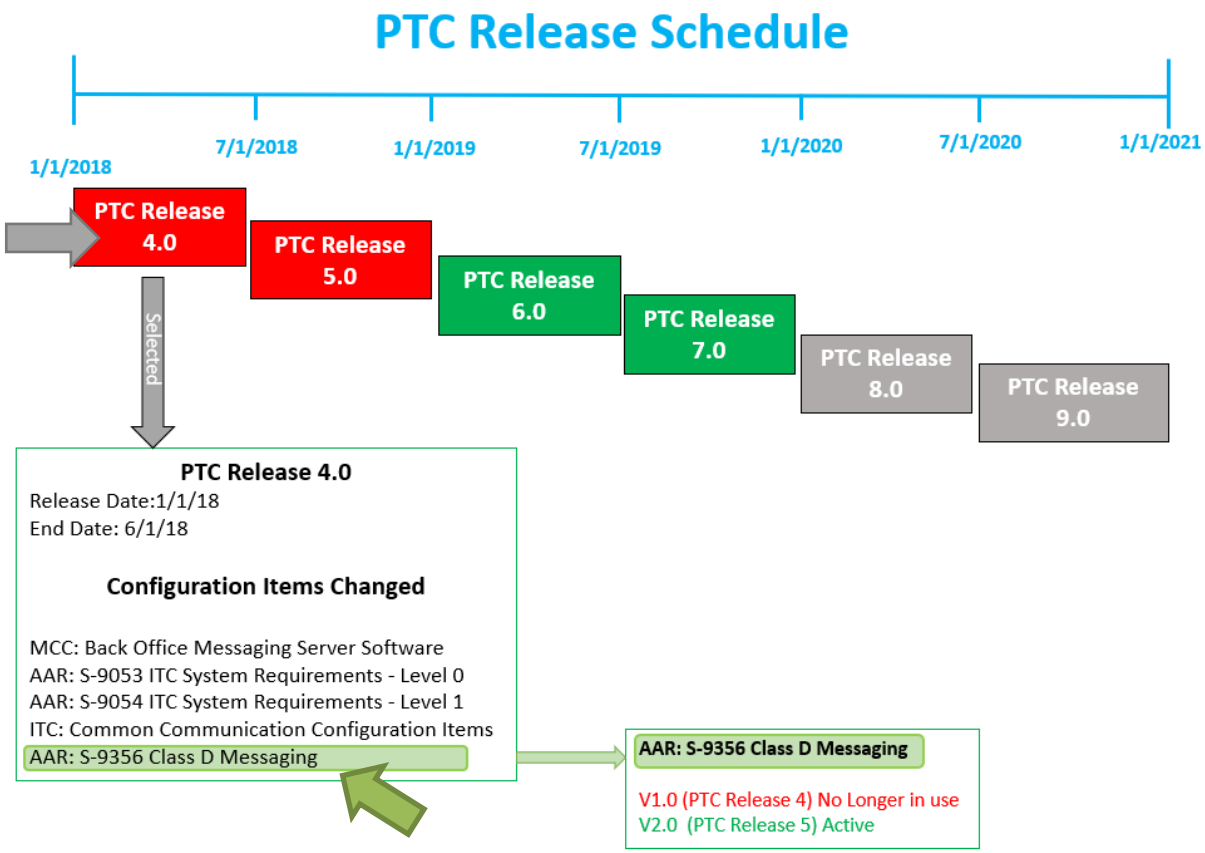

Figure 7. Conceptual Mockup of PTC Release Schedule Snapshot

5.4.3 PTC Interoperable Release Management

In the context of PTC ILM, Interoperable Release Management is the process by which the industry defines (a) the required versions of individual ICIs approved for inclusion in a defined PTC Interoperable System Release and (b) the date range for which each defined PTC Interoperable System Release is approved. This section describes the PTC ILM system capabilities associated with the PTC ILM Interoperable Release Management process.

5.4.3.1 PTC Interoperable System Release

A PTC Interoperable System Release is an agreed-upon list of required versions of ICIs that are approved for interoperable operations across a specific date range. The purpose of defining PTC Interoperable System Releases is to control the number of approved versions of ICIs to a practical, manageable number to support continued advancement of the PTC technology while maintaining interoperability, and to provide visibility to all railroads on expectations for interoperable deployments.

A PTC Interoperable System Release has the following characteristics, within the context of the PTC ILM System:

- A defined Release Date, before which the PTC Interoperable System Release is not approved for interoperable operations.
- The Release Date could be, but does not have to be, tied to the Retirement Date of another PTC Interoperable System Release.
- A defined Retirement Date, beyond which the PTC Interoperable System Release is not approved for interoperable operations.
- The Retirement Date could be, but does not have to be, tied to the Release Date of another PTC Interoperable System Release.

One or more versions of each ICI, any of which are approved for interoperable operations within the date range defined by the Release and Retirement dates.

A version of an ICI could belong to multiple PTC Interoperable System Releases.

Comments that apply to the PTC Interoperable System Release and comments that apply to each ICI. The comments can be used to document any information that the industry feels are appropriate to support understanding of the information contained within the PTC Interoperable System Release.

Note that industry policy may further constrain the definitions of a PTC Interoperable System Release (e.g., to control the number of versions of ICIs or to control the number of active PTC Interoperable System Releases), but the PTC ILM System will allow the flexibility as described above.

Figure 8 provides a visual representation of how PTC Interoperable System Releases may look over time, considering the above characteristics. As shown in Figure 8, the PTC Interoperable System Releases can, but do not necessarily have to, overlap in time. Additionally, from one PTC Interoperable System Release to the next, allowable versions of each ICI can be added removed – or remain the same.

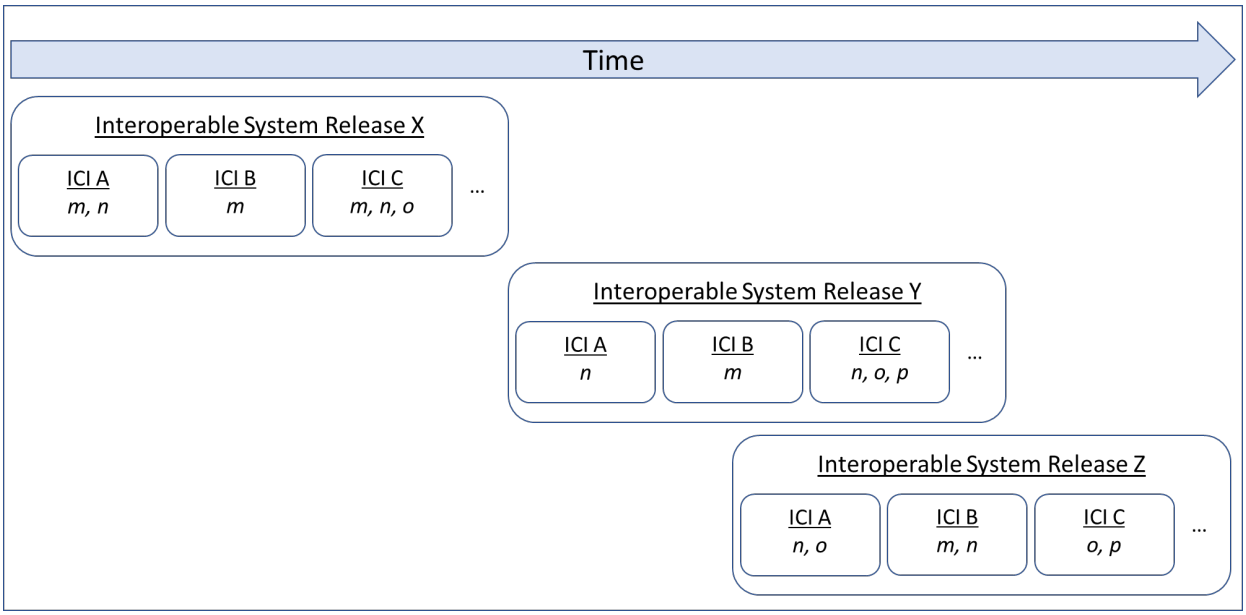

Figure 8. Example of PTC Interoperable System Release Definitions

5.4.3.2 PTC Interoperable System Release Status and Versioning

The lifecycle of a PTC Interoperable System Release includes four stages:

- Draft – A PTC Interoperable System Release is in the draft stage after it has been created within the PTC ILM System but has not yet been finalized and approved by the appropriate industry committee.
- Approved – A PTC Interoperable System Release is in the approved stage after it has been finalized and approved by the appropriate industry committee, but the release date has not yet been reached.
- Active – A PTC Interoperable System Release is in the active stage when it has been finalized and approved by the appropriate industry committee, and the current date is between the release and retirement dates.
- Retired – A PTC Interoperable System Release is in the retired stage after the retirement date has been reached.

Approved and Active PTC Interoperable System Releases are versioned using an x.y.z format, as follows:

- X is incremented for each new PTC Interoperable System Release.
- Y is incremented when there is a change to the allowable versions of an ICI while the PTC Interoperable System Release is approved or active (e.g., if a critical defect is identified and the allowable versions of an ICI have to be changed) or if the release date or retirement date is changed.
- Z is incremented when there are any other changes to the PTC Interoperable System Release that do not affect the allowable versions of ICIs or the release date or retirement date (e.g., changes to comments).

Draft PTC Interoperable System Releases are versioned using only the PTC Interoperable System Release number and a draft version, which is incremented with any change. Once the draft PTC Interoperable System Release is approved, the version will be set to X.0.0 and begin following the versioning for approved and active releases described above.

Retired PTC Interoperable System Releases maintain the last version number prior to retirement and are not incremented.

5.4.3.3 Defining PTC Interoperable System Releases

PTC Interoperable System Releases are defined, scheduled, and approved in advance of the release date, providing the railroads ample time to prepare for the decommissioning of ICI versions that will not be allowed in an upcoming PTC Interoperable System Release. The process of defining a new PTC Interoperable System Release may take many iterations, as the industry considers how the system should evolve over the course of the next one or more releases.

The PTC ILM System allows for the definition of future PTC Interoperable System Releases as drafts prior to approval by the appropriate industry committee. Once the desire to begin definition of a new PTC Interoperable System Release is established, the Industry Release Manager can start a new draft release within the PTC ILM System, providing the major release

version, the targeted release date, and the targeted retirement date. The PTC ILM System creates the new release as draft 1 and includes all current ICIs with the allowable versions defined as null.

While in the draft stage, the Industry Release Manager can update the allowable versions of each of the ICIs or the targeted release and retirement dates at any time and the system will automatically save a new draft version of the PTC Interoperable System Release, increment the draft version number, and prompt the Industry Release Manager to enter a description of the changes made. The system will log the draft version number and the description of the changes made in a change log in the CMDB.

When the industry approves the draft release, the Industry Release Manager will indicate to the PTC ILM System that the draft has been approved and the system will change the state to approved and apply the appropriate versioning. Once the approved release date is reached, the system will change the state to active.

5.4.3.4 Changes to Approved and Active PTC Interoperable System Releases

Following an approved decision by the appropriate industry committee, the Industry Release Manager can make changes to any of the following while the PTC Interoperable System Release is in the approved or active stage:

- The approved release date (Note that this can only be changed while in the approved stage and cannot be changed once the release is in the active stage.)
- The approved retirement date
- Any allowable version of any ICI
- Any comments associated with the release or any ICI

When any of these changes are made by the industry release manager, the PTC ILM System will automatically save a new version of the PTC Interoperable System Release, increment the release version according to the versioning system described in Section 5.4.3.2, and prompt the Industry Release Manager to enter a description of the changes made. The system will log the version number and the description of the changes made in a change log in the CMDB.

5.4.3.5 Retirement of PTC Interoperable System Releases

Once the approved retirement date is reached, the PTC ILM System will change the PTC Interoperable System Release to the retired stage. Once in the retired stage, the PTC ILM System will no longer allow changes to the PTC Interoperable System Release.

5.4.3.6 Viewing PTC Interoperable System Releases

All users will be able to view information on PTC Interoperable System Releases. The PTC ILM System will provide visualization of PTC Interoperable System Releases across time, as described in Section 5.4.2. Additionally, the system will allow users to view or export a table of all allowable versions of each ICI in a selected PTC Interoperable System Release. This table includes the following information from the CMDB for each ICI in the PTC Interoperable System Release (see Section 5.4.5.1 for more information on these fields):

- ICI Category
- ICI Type

- Interoperable Compliance Scope
- ICI Name
- Allowable Versions of ICI
- Comments

The system will also allow users to view or export the information listed above in a table for prior versions (and draft versions) of the PTC Interoperable System Release as well as view the change log associated with the selected PTC Interoperable System Release.

The user can also choose to view or export a report on changes between PTC Interoperable System Releases. The system will allow the user to select two versions of PTC Interoperable System Releases, which could be two versions of the same PTC Interoperable System Release or a single version of two different PTC Interoperable System Releases. The system will then generate a report that includes the following information from the CMDB:

- The two PTC Interoperable System Release versions (or draft versions) selected, along with the approved or targeted Release Date and Retirement Date and comments associated each
- Differences in the ICIs included in each version of PTC Interoperable System Release
- Differences in the ICI Category associated with an ICI between each version of PTC Interoperable System Release
- Differences in the ICI Type associated with an ICI between each version of PTC Interoperable System Release
- Differences in the Interoperable Compliance Scope associated with an ICI between each version of PTC Interoperable System Release
- Differences in the allowable versions of an ICI between each version of PTC Interoperable System Release
- Differences in the comments associated with an ICI between each version of PTC Interoperable System Release

5.4.4 Interoperable Design Coordination and Requirements Management

Interoperable Design Coordination and Requirements Management supports PTC ILM by providing visibility across the industry of planned and upcoming changes to the design of industry-common components and providing traceability of these design changes from one version to the next. To achieve interoperability, railroads must understand changes in the design of the interoperable aspects of the system so that the impact of these changes can be analyzed, the changes can be tested, and it can be verified that interoperable operations can be maintained. While individual railroads are responsible for these activities, industry coordination reduces the risk associated with interoperable components and requirements that are common throughout the industry. This section describes the PTC ILM system capabilities associated with the Interoperable Design Coordination and Requirements Management process.

5.4.4.1 Requirements Management Database

The PTC ILM system will contain a requirements management database that can be populated with the requirements contained within any version or draft version of a requirements specification ICI. The requirements management database will contain the following information:

- Requirements specification ICI name
- Version of the requirements specification ICI
- Indication of whether the version is a work in progress, draft, or published version
- Section number and title
- Paragraph ID and indication of whether the paragraph is a requirement or supplemental text
- Requirement ID, if the paragraph is a requirement
- Paragraph (requirement) text
- Links to parent requirements (upward traceability), including parent requirements specification ICI name, version, and requirement ID
- Links to child requirements (downward traceability), including child requirements specification ICI name, version, and requirement ID
- Links to parallel requirements (parallel traceability), including parallel requirements specification ICI name, version, and requirement ID
- Other configurable attributes

5.4.4.2 Creating New Versions of Requirements Specifications

The Industry Requirements Manager can create a new version of a requirements specification through the Interoperable Design Coordination and Requirements Management component of the PTC ILM system. When creating a new version of a requirements specification, the Industry Requirements Manager will select the requirements specification ICI from the list of available requirements specification ICIs in the CMDB. The Industry Requirements Manager will indicate whether the new version of the requirements specification ICI is a work in progress, a draft, or a published version. The PTC ILM system will support various methods of creation or modification of requirements documentation both within the system or outside of the system:

- Development of new version within the PTC ILM system – A new version can be created as a work in progress within the PTC ILM system and authorized System Engineers can develop the requirements directly within the system. When the version is ready for industry review, it can be set as a draft and reviewed by the interested parties (either within the system or exported and distributed). When it is published, it can be set in the system accordingly and no further edits can be made.
- Review of draft version within the PTC ILM system – A new version can be generated external to the PTC ILM system and entered into the system when ready for industry review. The version can be created within the system as a draft and reviewed by the

interested parties (either within the system or exported and distributed). When it is published, it can be set in the system accordingly and no further edits can be made.

- Published version entered directly into the PTC ILM system – A new version can be generated, reviewed and published external to the PTC ILM system and entered in the system directly as a published version without allowing any edits.

The Industry Requirements Manager will also enter the version of the requirements specification ICI that is being created. The PTC ILM system will allow the version to be changed by an authorized user at any time and will also save revisions of the version with a date/time stamp and the user that made the revisions for cases where the version is being developed or revised within the system.

Once the Industry Requirements Manager enters the required information, the PTC ILM system will store the new requirements specification version information in the requirements management database. The Industry Requirements Manager will also enter the PTC ILM system users that will have access to modify this version of the requirements specification ICI. For requirements specifications that are in the work in progress or draft state, there may be multiple users authorized to make changes to the version of the requirements specification as it is developed, reviewed, and edited. For requirements specifications that are approved and published, there may be no users authorized to make changes. Industry policies and procedures will establish the guidelines concerning authorized users, and the PTC ILM system will be flexible to support these decisions.

Once the new version of the requirements specification ICI is created within the requirements management database, any user authorized to modify the new version of the requirements specification ICI can initialize the requirements within that version. Requirements can be initialized either by copying requirements from another version of the requirements specification ICI or importing requirements from an external document. Requirements initialization is not required (i.e., requirements can be manually entered), but can be used to reduce the time required to begin managing a new requirements specification.

5.4.4.3 Importing Requirements

Versions of requirements specifications can be imported into the PTC ILM system requirements management database, either when initializing the requirements for a new version or when a new revision of an existing version is generated outside of the system. The system will support importing from a document, spreadsheet, or external database.

When importing a version of a requirements specification document, the PTC ILM system will parse the individual paragraphs within the requirements specification document and store them in the requirements management database according to the section of the document they appear in. For each paragraph that specifies a requirement, the PTC ILM system will identify it and store it as a requirement, based on the unique identifier. The PTC ILM system will support both the user entering the unique identifier format or automatic identification of the unique identifier format.

When importing a version of a requirements specification contained within a spreadsheet or external database, the PTC ILM system will allow the user to map the fields from the spreadsheet or database to the fields required within the PTC ILM system requirements management database.

5.4.4.4 Viewing and Editing Requirements

The Interoperable Design Coordination and Requirements Management component of the PTC ILM system will allow the user to view and, if authorized, edit any version of a requirements specification stored within the requirements management database. The user interface will allow the user to view and select from the requirements specification ICIs and the versions of a selected ICI contained within the requirements management database.

The requirements management viewer will display the entire selected requirements specification, organized by section and paragraph, as stored in the requirements management database. The user interface will allow the user to quickly navigate to any section or paragraph of the requirements specification.

The PTC ILM system will allow an authorized user to add, modify, or remove sections and the text of any paragraph within the requirements specification. While the user is editing the document, the PTC ILM system will save a temporary version of the changes until the user saves the changes as a new revision. When the user saves the changes as a new revision, the system will update the requirements management database accordingly.

5.4.4.5 Comparing Versions of Requirements Specification ICIs

The PTC ILM system will provide users the capability to compare versions of a requirements specification ICI contained within the requirements management database. The system will allow the user to select the requirements specification ICI and the two versions to compare. The system will scan each section and paragraph of the selected versions of the requirements specification and identify any that differ between the two versions. A version comparison viewer will allow the user to view the two versions side-by-side, with each difference highlighted in the viewer. The viewer will also allow the user to navigate directly to each section or paragraph where a difference between the two versions exists.

5.4.4.6 Creating, Editing, and Viewing Links between Requirements

The PTC ILM system allows authorized users to create and edit links between requirements for traceability purposes as well as allowing users to view established links between requirements. For new versions of existing requirements specification ICIs for which links have already been established, the user can have the PTC ILM system initialize the links in the new version according to those established from a previous version.

When initializing tracing links for a new version of a requirements specification ICI from a prior version, the user can select which prior version to initialize from. The system will scan each requirement in the selected prior version and determine if it is the same in the new version. If so, the links from the prior version for that requirement will be established in the new version. After completing the initialization from the prior version, the system will provide a report to the user of all links in the prior version that were unable to be established in the new version, and all requirements in the new version for which links were not established from the old version, due to changes in the requirements between the two versions.

The PTC ILM system will allow authorized users to establish links between requirements documents within the requirements management viewer. The user interface will allow the user to select a requirement to be linked from one document, select the requirement it is to be linked to in another document, and specify the type of link:

- Parent – A parent link establishes the first selected requirement as a parent of the second selected requirement (i.e., the first selected requirement traces down to the second selected requirement). The system will automatically create a child link from the second selected requirement to the first selected requirement.
- Child – A child link establishes the first selected requirement as a child of the second selected requirement (i.e., the first selected requirement traces up to the second selected requirement). The system will automatically create a parent link from the second selected requirement to the first selected requirement.
- Parallel – A parallel link establishes the two requirements as being equivalent between two different requirements specification ICIs. This type of linking can be used to verify compatibility when there are two ICIs intended to be functionally interchangeable at an interoperable level but built to two different requirements specifications.

The PTC ILM system will maintain all links between all versions of requirements specification ICIs within the requirements management database. When a user is viewing a version of a requirements specification ICI in the requirements management viewer, the system will allow them to visualize parent, child, and parallel links to other requirements as well as navigate to the requirements and requirements specification ICIs that they are linked to. Additionally, the system will allow them to visualize test cases linked to each requirement, as specified in the Industry Testing database, as well as navigate to the test case viewer in the Industry Test Management component to view the test cases they are linked to (see Section 5.4.7).

5.4.4.7 Analyzing Traceability of Requirements Specification ICI Versions

The PTC ILM system will provide functions for supporting analysis of requirements traceability between versions of requirements specification ICIs. When introducing a new version of a requirements specification ICI, the user will be able to run customizable requirements traceability reports that will help in the analysis of potential impacts of the new version. As examples, the user may choose to run the following reports:

- A report of any requirements with no parent links and/or no child links
- A report showing the complete traceability of a selected requirement, both upward and downward.
- A report showing all requirements that have been modified and the requirements to which they are linked, to help the user verify that the changes do not affect the links or the linked requirements.

These are intended as examples that a user may wish to report on. The user interface for the Interoperable Design Coordination and Requirements Management component will allow development of any customized report from the requirements management database. The reports can be viewed in the user interface or exported to standard formats, such as pdf or Excel workbooks.

The PTC ILM system also provides similar functionality to support parallel requirements tractability. Parallel requirements traceability is used when comparing requirements specification ICIs that specify different ICIs intended to be interchangeable, from a functionality standpoint, at the interoperable level. Parallel requirements are established as described in Section 5.4.4.6. When a new version of one of the parallel requirements specification ICIs is introduced, the user

can run a report to identify any requirements changes that may have affected the parallel links and any new requirements that do not have parallel links. This report can be used by the user to identify any requirements that would affect the ability to interchange the two ICIs at a functional, interoperable level.

5.4.4.8 ICI Version Development Tracking

The PTC ILM system Interoperable Design Coordination and Requirements Management component will also support the tracking of development of new versions of ICIs for visibility by the industry. Versions of ICIs are stored in the CMDB and new versions of ICIs can be entered into the PTC ILM system through the Interoperable Change Management process (see Section 5.4.6), the Interoperable Configuration Management process (see Section 5.4.5), or the Interoperable Design Coordination and Requirements Management process. Through the Interoperable Design Coordination and Requirements Management component, the Industry Configuration Manager can select a version of an ICI that was entered in the CMDB through the Interoperable Change Management or Interoperable Configuration Management processes for development tracking. Alternatively, the Industry Configuration Manager can select an ICI from the CMDB and enter a new version for development tracking.

When the Industry Configuration Manager identifies a version of an ICI for development tracking, they will also enter the users that are authorized to update the development tracking information. The system will notify those users that development tracking has been enabled for the selected version of the selected ICI.

A user authorized to update development tracking for a version of an ICI will be able to input or modify any of the following information through the Interoperable Design Coordination and Requirements Management component:

- Development start date – The date development on the new version began or is planned to begin.
- Planned release date – The date when the version of the ICI is planned to be release.
- Comments – Any information regarding the development of the new version of the ICI
- Other configurable attributes

Any new versions of ICIs being tracked can be viewed by any user through the Interoperable Design Coordination and Requirements Management component.

When an ICR that contains the new version of the ICI being tracked is granted Business Approval (meaning the version of the ICI has been released), the system will archive the development tracking information. The Industry Configuration Manager can also manually archive the development tracking information in the event the new version is never included in an ICR for deployment.

5.4.5 Interoperable Configuration Management

Interoperable Configuration Management for PTC ILM involves the management of the versions, relationships, and attributes associated with ICIs, as well as the deployment of ICIs by individual railroads over time, in the PTC ILM CMDB. This section describes the PTC ILM system capabilities associated with the PTC ILM Interoperable Configuration Management process.

5.4.5.1 PTC ILM Configuration Management Database (CMDB)

The PTC ILM CMDB contains all of the data and relationships associated with the defined ICIs used in the PTC ILM process. This includes the following:

- ICIs and associated attributes:
    - ICI Identifier – A descriptive title, uniquely identifying the ICI
    - ICI Description – A more verbose description of the ICI
    - Indication of whether the ICI is proposed, adopted, or retired
    - ICI Category – The category within which the ICI belongs; the PTC ILM System will allow for configurable ICI Categories, but generally include:
        - Vendor Proprietary ICIs
        - AAR Published Standards
        - ITC Configuration Items
        - PTC220 Configuration Items
    - ICI Type – One of a defined type that applies to the ICI; the PTC ILM System will allow for configurable ICI Types, but generally include:
        - Software Release
        - Configuration Release
        - Specification
        - Safety Artifact
        - Standard
        - Recommended Practice
    - Interoperable Compliance Scope – The applicable compliance scope areas that define the railroads to which the ICI applies in terms of interoperable operations; the PTC ILM System will allow for configurable Interoperable Compliance Scope areas, but generally include:
        - All Railroads
        - Railroads with Locomotives
        - Railroads with PTC Back Office Systems
        - Railroads with 220 MHz Base Stations
        - Railroads with WIUs
        - Railroads Deploying the ICI
    - Adoption Date – The date the ICI was adopted for Interoperable Configuration Management.
    - Retirement Date – The date the ICI was retired from Interoperable Configuration Management (if applicable).

    - Retirement Comments – Comments associated with the retirement of the ICI from Interoperable Configuration Management (if applicable)
    - Other configurable attributes – The PTC ILM system will support configurable attributes for each ICI that will be stored in the PTC ILM CMDB.
- ICI Relationships:
    - Dependent ICIs – ICIs that are explicitly related in their definition, e.g., a specification and the software release that it specifies.
    - Related ICIs – ICIs that may be impacted by a change to the specified ICI.
    - Other Relationships – The PTC ILM system will support configurable relationships between ICIs that will be stored in the PTC ILM CMDB.
- Versions of ICIs and associated attributes:
    - Version number – The unique version number
    - Release date – The date the version of the ICI was released (if applicable).
    - Comments – Comments and other information associated with this version of the ICI, e.g., release notes
    - Other configurable attributes – The PTC ILM system will support configurable attributes for each ICI version that will be stored in the PTC ILM CMDB.
- ICI Version Relationships – Version of another ICI that applies to the specified version of the specified ICI, e.g., the specific version of a specification ICI that is implemented by a specific version of a software release.

The PTC ILM CMDB also contains the deployment status of every ICI on every participating railroad across time. This includes, for each railroad, ICI, and version of ICI, the following information:

- Deployment Date – The date the version of the ICI was deployed by the railroad (if applicable).
- Decommission Date – The date the version of the ICI was decommissioned from interoperable service by the railroad (if applicable).
- Comments – Any comments applying to the version of the ICI from railroad.

5.4.5.2 Management of ICI Data

As the technology evolves and as the PTC ILM processes mature, there will be a need to add, modify, and remove ICIs. Although the decision to add, modify, or remove an ICI will largely be governed by the appropriate industry committee, the Industry Configuration Manager will be the only user with access to make these changes within the PTC ILM CMDB.

When the Industry Configuration Manager adds a new ICI to the CMDB, the PTC ILM system will prompt the Industry Configuration Manager to enter the required information for the ICI, as described in Section 5.4.5.1. The Industry Configuration Manager can select the ICI to be adopted on the date entered or any date in the future. The adoption date does not need to be entered if it has not yet been established at the time the new ICI is added. Prior to the adoption

date, the new ICI will be marked as “proposed” within the CMDB. Once the adoption date for the new ICI is reached, the system will mark the ICI as “adopted,” notify all Railroad Configuration Managers, and request them to baseline their deployed version(s) of the newly adopted ICI. The baseline will include all of the required information for the deployed version of the ICI, as described in Section 5.4.5.1. Additionally, if the Railroad Configuration Manager enters a version of the ICI that had not previously been entered, the system will prompt them to enter the required attributes of that version of the ICI, as described in Section 5.4.5.1.

When a new ICI is added for Interoperable Configuration Management, the system will also include it in any active, approved, or draft PTC Interoperable System Releases, as described in Section 5.4.3. The system will notify the industry release manager, so that the appropriate versions can be added to each of these PTC Interoperable System Releases.

When removing an ICI from Interoperable Configuration Management, the Industry Configuration Manager must specify the retirement date and comments associated with the retirement for record-keeping purposes. A notification will be sent to Railroad Configuration Managers, indicating removal from Interoperable Configuration Management on the specified date. The system will archive all information associated with the ICI and will no longer include the ICI in any active, approved, or draft PTC Interoperable System Releases.

The Industry Configuration Manager can make changes to any of the attributes of an ICI in Interoperable Configuration Management at any time, aside from adoption and retirement information. The system will notify the Railroad Configuration Managers of the change.

5.4.5.3 Management of ICI Version Data

New versions of ICIs can be entered into the system in several ways:

- A new version of an ICI can be specified to be included in a PTC Interoperable System Release, as described in Section 5.4.3.
- A new version of an ICI can be identified in the Interoperable Design Coordination and Requirements Management process, as described in Section 5.4.4.
- A new version of an ICI can be added by a Railroad Configuration Manager when baselining a newly adopted ICI, as described in Section 5.4.5.2.
- A new version of an ICI can be added directly to the CMDB by the Industry Configuration Manager.

When a new version of an ICI is entered through the PTC Interoperable Release Management process or the Interoperable Design Coordination and Requirements Management process, or when a new version of an ICI is entered by a Railroad Configuration Manager as part of baselining a newly adopted ICI, the system will alert the Industry Configuration Manager and request that the version attributes and relationships be entered. When a new version is directly added by the Industry Configuration Manager, the attributes and relationships are entered at the time the new version is entered. The Industry Configuration Manager can make changes to the attributes and relationships associated with a version of an ICI at any time. Note that the release date of a version of an ICI is defined through the Interoperable Change Management process, as described in Section 5.4.6, and cannot be changed through any of the above described processes.

5.4.5.4 Management of ICI Deployment Record

Railroads are responsible for maintaining their own asset list and deployment records for their railroad. PTC ILM supports communication of what version(s) of each ICI each interoperable railroad has deployed in interoperable service. When a new railroad is added to the PTC ILM system, as described in Section 5.4.9, the Railroad Configuration Manager for that railroad will be responsible for baselining their interoperable service deployment record. The PTC ILM system will prompt the Railroad Configuration Manager to enter version(s) deployed by their railroad for each ICI, along with deployment dates and any applicable comments or other attributes, as described in Section 5.4.5.1. This information will be stored in the CMDB.

The Interoperable Configuration Management component is linked directly to the changes that are managed in the Interoperable Change Management component of the PTC ILM system. Each ICR contains information about which railroads are deploying a new version of an ICI, which railroads are decommissioning a version of an ICI, and any comments or other railroad-specific attributes associated with the versions of the ICI in the ICR. As new versions of ICIs are introduced via the Interoperable Change Management component, changes to the deployment status for each railroad associated with each ICR are updated in the CMDB, as described in Section 5.4.6.7.

Although baselining and updating of the deployment record for each railroad through the Interoperable Change Management process is intended to keep a complete, up-to-date record of the deployment status of each ICI by each railroad, it is expected that periodic audits of the interoperable configuration record stored in the CMDB of the PTC ILM system against the deployment records maintained by each individual railroad will be conducted. If, as a result of such an audit, it is identified that there are errors in the deployment record for a railroad, the Railroad Configuration Manager can address the error in one of two ways: the Railroad Configuration Manager can request that the change manager for their railroad initiate an ICR or the Railroad Configuration Manager can make a change to their deployment record directly.

If the Railroad Configuration Manager determines the deployment record should be updated with an ICR, the change manager for that railroad can initiate the ICR according to the normal process, described in Section 5.4.6.3. If the Railroad Configuration Manager determines the deployment record should be updated directly, they will enter the change through the PTC ILM Interoperable Configuration Management user interface. At this point, the update will go into a pending status until acknowledged by the Industry Configuration Manager, at which point the CMDB will be updated. It is expected that industry policy will dictate the conditions under which an ICR must be submitted and when the update can be made directly by the Railroad Configuration Manager.

5.4.5.5 Interoperable Configuration Management Viewing and Reporting

The Interoperable Configuration Management component of the PTC ILM system will allow users to run and view custom reports from the CMDB on ICIs, ICI attributes, ICI relationships, ICI versions, ICI version attributes, ICI version relationships, and railroad deployment status through a reporting function.

The Interoperable Configuration Management reporting function will allow the user to create and save custom reports that can be run on demand or run automatically and sent to the user at predetermined times. As examples, the user may choose to run the following reports:

- A report on the deployment record for an ICI, showing the versions deployed by each railroad over a specified date range
- A report on the relationships between all ICIs
- A report on the attributes and relationships for a specified ICI

These are intended as examples that a user may wish to report on. The user interface for the Interoperable Configuration Management component will allow development of any customized report from the CMDB. The reports can be viewed in the user interface or exported to standard formats, such as pdf or Excel workbooks.

5.4.6 Interoperable Change Management

Interoperable Change Management is the process by which all changes to ICIs deployed for interoperable service by a railroad are documented, communicated, approved, and recorded in the CMDB. This section describes the PTC ILM system capabilities associated with the Interoperable Change Management process.

5.4.6.1 Interoperable Change Request (ICR)

An ICR is a collection of data associated with a change to the deployment of one or more ICIs by one or more railroads. ICRs may be initiated for any of the following purposes:

- To introduce a new version of one or more ICIs into interoperable service. (These ICRs can also include decommissioning of one or more versions of the ICIs for which new versions are being introduced.)
- To seek approval to deploy a new version of one or more ICIs that were previously approved and deployed by one or more railroads in interoperable service. (These ICRs can also include decommissioning of one or more versions of the ICIs for which new versions are being deployed.)
- To document the decommissioning of existing version(s) of one or more ICIs.
- To document a change that was previously deployed but did not follow the normal Interoperable Change Management process, referred to as a latent change. Industry policies and procedures will dictate when latent changes are appropriate, and the PTC ILM system is intended to support these policies and procedures.

When an ICR is initiated to introduce a new version of one or more ICIs (including those that also include the decommissioning of one or more versions of ICIs for which new versions are being deployed), it can be initiated as a normal change or as an expedited change. A normal ICR will typically advance through the following stages of the Interoperable Change Management process (unless expedited during the process):

- Change Notification
- Business Approval
- Deployment Approval
- Close Out
- Closed

An expedited ICR can be advanced directly to Business Approval or Deployment approval. Figure 9 illustrates how the PTC ILM system supports the management of an ICR through the process. The shapes represent each step in the process with the user class that executes each step indicated in parentheses. Note that industry policies and procedures may dictate parties outside of those indicated to be involved in each step, but the user class in parentheses indicates who executes the step within the PTC ILM system. The stage of the process that each step is a part of is indicated by the color of highlight.

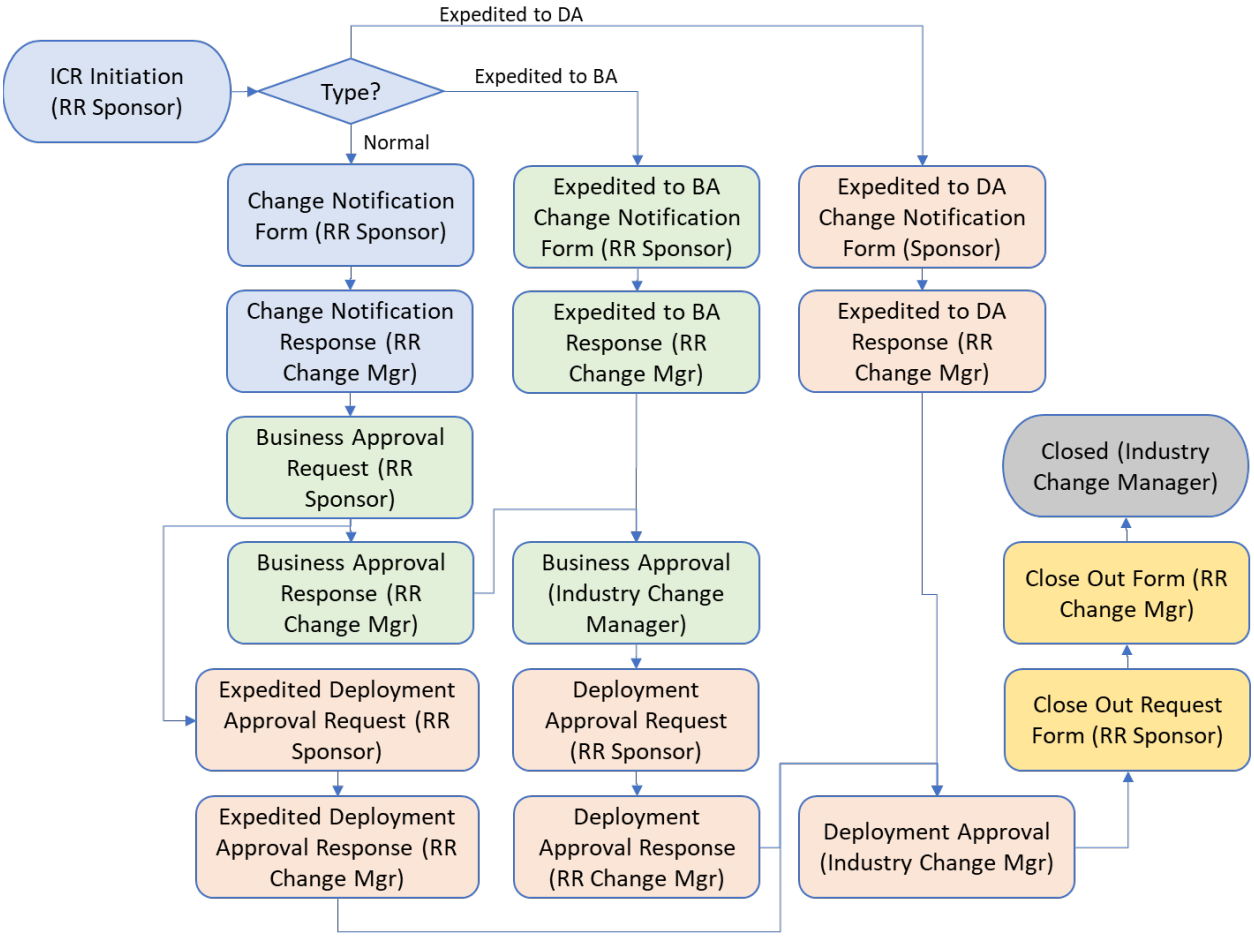

Figure 9. Interoperable Change Management Process

Although an ICR can include multiple railroads all making the same change to their interoperable deployment, each ICR has a defined change sponsor. The initiating railroad will generally be the change sponsor throughout the change, but another railroad can take over for various reasons, such as when the initiating railroad has decided they will no longer proceed with the change.

Figure 9 shows the paths of an ICR advancing through the stages until it is completed. Although not shown in the figure, a change can also be advanced to the Close Out stage by the change sponsor from any other stage if circumstances arise during the Interoperable Change Management process that result in the change not being completed (for example, an issue found during testing, prior to deployment approval).

To control the time that an ICR is in progress, the industry may determine a defined time period for deployment or decommissioning of the version(s) of ICI(s) specified in an ICR, outside of which a separate ICR will be required. Railroads planning to deploy or decommission the version(s) of ICI(s) specified in the original ICR can initiate a separate ICR, with reference to the original ICR, at the time they are prepared to deploy or decommission the version(s) of ICI(s) specified.

When an ICR is initiated to seek approval for the deployment of a new version of one or more ICIs that were previously approved and deployed by one or more railroads in interoperable service, it will be initialized with a reference to the original approved ICR and expedited to deployment approval. The Interoperable Change Management process will proceed as any other ICR that is expedited to Deployment Approval, maintaining the reference to the original approved ICR.

When an ICR is initiated to document the decommissioning of one or more versions of one or more ICIs (i.e., does not include the introduction of any new versions of any ICIs), the ICR is sent directly to the Close Out stage. Other railroads who may also be decommissioning old versions of the same ICI(s) can add close out information for their railroad and then the ICR is closed, triggering an update to the CMDB.

When an ICR is initiated to document a latent change, it is indicated in the ICR that it is a latent change and the change is expedited to deployment approval. The Interoperable Change Management process will proceed as any other ICR that is expedited to Deployment Approval, maintaining the indication that the ICR is a latent change.

Within the PTC ILM system, the information that applies to each ICR is maintained in a database and can be viewed by the users of the system. The user interface for each ICR displays information pertaining to each stage of the process that the ICR has been through. This information includes summary information for the ICR, general information for the ICR entered by the sponsoring railroad at each stage, as well as the individual railroad responses by each railroad at each stage.

5.4.6.2 Interoperable Change Management Dashboard

The PTC ILM system Interoperable Change Management component will have a dashboard that allows the user to quickly navigate through this component of the system. The dashboard is customized by the user class and railroad. The dashboard for all railroad users will contain the following:

- Active ICRs that apply to the user's railroad
- Search panel

The active ICRs that apply to the user's railroad can be accessed through the dashboard and will open the details of the ICR to be viewed or modified by the user, according to their user class. The search panel allows the user to search all ICRs in the system according to:

- ICR identifier – The ICR specified with the unique identifier entered/selected.
- Initiating railroad – Any ICRs initiated by the railroad entered/selected.
- ICR status – Any ICRs in the selected stage of the Interoperable Change Management process; also includes an option for all active ICRs.

- ICI identifier – Any ICRs that pertain to the ICI entered/selected.
- Date range – Any ICRs that were modified within the date range entered.

A search will display all ICRs in the system that meet the criteria of the search, along with which railroad initiated the ICR, which ICIs are being changed, which versions of the ICIs pertain to the ICR, the current status of the ICR, and if the ICR is normal or expedited. Any ICI returned from the search results can then be accessed by the user to view or modify, depending on their user class.

In addition to the above, the dashboard for railroad change managers will also contain the following:

- Capability to create a new ICR.
- ICRs currently awaiting action by the user's railroad.

The Railroad Change Manager can choose to create a new ICR, which will trigger the PTC ILM system to create the new ICR and allow the user to enter the information associated with the Change Notification for the new ICR.

The ICRs currently awaiting action will list all ICRs that require a response from the Railroad Change Manager's railroad. When the Railroad Change Manager accesses one of these ICRs, the system will open the details of the ICR and allow the Railroad Change Manager to enter the required response for the ICR.

5.4.6.3 Change Sponsor and ICR Initiation

When a Railroad Change Manager initiates an ICR, their railroad is defined as the change sponsor, and the system will prompt them to enter the type of change: Normal, Expedited to Business Approval, Expedited to Deployment Approval, Decommissioning of Old Versions, or a Latent Change. Upon entering this information, the ICR is created within the system and the user is prompted to enter details of the change associated with the Change Notification process.

The PTC ILM system will allow the Industry Change Manager to reassign the change sponsor of an ICR to a different railroad at any time during the Interoperable Change Management process. This allows the change to proceed for instances where the previously defined change sponsor decides that they will no longer proceed with the change, but other interoperable railroads still do plan to proceed with the change.

The PTC ILM system will also support initiation of an ICR based on a prior ICR. This would typically be done when a railroad is preparing to deploy a version of an ICI that was previously approved for deployment by another railroad. In this case, the railroad preparing to make the change can indicate to the system the prior ICR they are preparing to deploy, and the system will create a new ICR with a reference to the prior ICR. The new ICR will be expedited to deployment approval and follow the Interoperable Change Management process associated with that type of change, described below.

5.4.6.4 Change Notification

The Interoperable Change Management process begins with Change Notification, which requires information to be entered by the sponsor of the ICR, followed by each railroad responding with information pertaining to their planned involvement in the change.

For a normal (not expedited) change, the ICR sponsor will enter general information pertaining to the ICR in a Change Notification form that contains the following fields:

- ICI(s) Affected – The ICI(s) that will be changed as a result of the ICR (either introduced to, or decommissioned from, interoperable service).
- Version(s) of affected ICI(s) – The specific version(s) of the ICI(s) that pertain to the ICR.
- Proposed Change Summary – A summary of the ICR
- Other configurable fields – The PTC ILM system will support configurable general information fields for the Change Notification form.

The sponsoring railroad will also enter the following information pertaining to the ICR that is specific to its railroad:

- Impact Level – The sponsoring railroad is impacted by default, but responding railroads can select from the following options, defined within the Interoperable Change Management Policies and Procedures Manual:
  - Impacted
  - Applicable
  - Not Applicable
- Comments – Any additional information pertaining to the ICR specific to the railroad
- Other configurable fields – The PTC ILM system will support configurable railroad-specific information fields for the Change Notification form.

The railroad can also attach supplemental material, such as support documentation pertaining to the ICR.

After submission of the Change Notification form by the sponsoring railroad, an auto-generated email will notify other railroads of an action to review and respond. The number of days to respond will be provided to the other railroads in the email and indicated on their dashboard. The number of days to respond to a Change Notification for a normal change will be configurable by the Industry Change Manager.

The responding user from each railroad can then navigate to the ICR and enter whether they are Impacted, Applicable, or Not Applicable to the ICR. If the responding railroad indicates to the system that they are Impacted or Applicable, they will proceed to enter the other railroad-specific information fields on the Change Notification form. Supplemental documentation can be added to the request at this time. If the responding railroad indicates to the system it is Not Applicable, it will be prompted to enter comments.

Once all railroads have responded, the ICR will remain in the Change Notification stage until a request for Business Approval is made by the ICR sponsor.

When a change is in Change Notification, the system will allow a user to navigate from the ICR to the development tracking in the Interoperable Design Coordination and Requirements Management component, if development track has been enabled for the new version(s) of the ICI(s) (see Section 5.4.4).

If the ICR is for a change that is to be expedited to Business Approval, the ICR sponsor will enter general information pertaining to the ICR in an Expedited to Business Approval Change Notification form that contains the following fields:

- Response Due Date – The date by which all railroads need to respond to meet the timing requirements of the expedited request.
- ICI(s) Affected – The ICI(s) that will be changed as a result of the ICR (either introduced to, or decommissioned from interoperable service).
- Version(s) of affected ICI(s) – The specific version(s) of the ICI(s) that pertain to the ICR.
- Proposed Change Summary – A summary of the ICR
- Other configurable fields – The PTC ILM system will support configurable general information fields for the Expedited to Business Approval Change Notification form.

The sponsoring railroad will also enter the following information pertaining to the ICR that is specific to their railroad:

- Impact Level – The sponsoring railroad is impacted by default, but responding railroads can select from the following options, which are defined within the Interoperable Change Management Policies and Procedures Manual:
  - Impacted
  - Applicable
  - Not Applicable
- Comments – Any additional information pertaining to the ICR specific to the railroad
- Other configurable fields – The PTC ILM system will support configurable railroad-specific information fields for the Expedited to Business Approval Change Notification form.

The railroad can also attach supplemental material such as support documentation pertaining to the ICR.

After submission of the Expedited to Business Approval Change Notification form by the sponsoring railroad, the ICR will advance to the Business Approval-Pending stage and an auto-generated email will notify other railroads of an action to review and respond. The number of days to respond will be provided to the other railroads in the email and indicated on their dashboard, according to the due date specified by the sponsor of the ICR.

The responding user from each railroad can then navigate to the ICR and enter whether they are Impacted, Applicable, or Not Applicable to the ICR. If the responding railroad indicates to the system that they are Impacted or Applicable, they will proceed to enter the other railroad-specific information fields on the Expedited to Business Approval Change Notification form. Supplemental documentation can be added to the request at this time. If the responding railroad indicates to the system it is Not Applicable, it will be prompted to enter comments.

Changes that are expedited to Deployment Approval include changes that need to be expedited according to criteria defined by the industry policy, changes involving deployment of versions of

ICIs that were previously approved and deployed by other railroads through a prior ICR, and latent changes. If the ICR is for a change that is to be expedited to Deployment Approval for one of these reasons, the ICR sponsor will enter general information pertaining to the ICR in an Expedited to Deployment Approval Change Notification form that contains the following fields:

- Response Due Date – The date by which all railroads need to respond to meet the timing requirements of the expedited request.
- ICI(s) Affected – The ICI(s) that will be changed as a result of the ICR (either introduced to, or decommissioned from interoperable service); note that these will be prepopulated if the ICR is for deployment of versions of ICIs that were previously approved and deployed by other railroads through a prior ICR.
- Version(s) of affected ICI(s) – The specific version(s) of the ICI(s) that pertain to the ICR; note that these will be prepopulated if the ICR is for deployment of versions of ICIs that were previously approved and deployed by other railroads through a prior ICR.
- Proposed Change Summary – A summary of the ICR
- Other configurable fields – The PTC ILM system will support configurable general information fields for the Expedited to Deployment Approval Change Notification form.

The sponsoring railroad will also enter the following information pertaining to the ICR that is specific to their railroad:

- Impact Level – The sponsoring railroad is impacted by default, but responding railroads can select from the following options, defined within the Interoperable Change Management Policies and Procedures Manual:
  - Impacted
  - Applicable
  - Not Applicable
- Comments – Any additional information pertaining to the ICR specific to the railroad
- Other configurable fields – The PTC ILM system will support configurable railroad-specific information fields for the Expedited to Deployment Approval Change Notification form.

The railroad can also attach supplemental material such as support documentation pertaining to the ICR.

After submission of the Expedited to Deployment Approval Change Notification form by the sponsoring railroad, the ICR will advance to the Deployment Approval stage and an auto-generated email will notify other railroads of an action to review and respond. The number of days to respond will be provided to the other railroads in the email and indicated on their dashboard, according to the due date specified by the sponsor of the ICR.

The responding user from each railroad can then navigate to the ICR and enter whether they are Impacted, Applicable, or Not Applicable to the ICR. If the responding railroad indicates to the system that it is Impacted or Applicable, it proceed to enter the other railroad-specific information fields on the Expedited to Deployment Approval Change Notification form.

Supplemental documentation can be added to the request at this time. If the responding railroad indicates to the system they are Not Applicable, they will be prompted to enter comments.

For an ICR that is initiated to document the decommissioning of one or more versions of one or more ICIs (i.e., does not include the introduction of any new versions of any ICIs), the ICR sponsor will enter general information pertaining to the ICR in a Decommissioning Old Versions Change Notification form that contains the following fields:

- ICI(s) Affected – The ICI(s) that will be decommissioned as a result of the ICR.
- Version(s) of affected ICI(s) – The specific version(s) of the ICI(s) that will be decommissioned as a result of the ICR.
- Proposed Change Summary – A summary of the ICR
- Other configurable fields – The PTC ILM system will support configurable general information fields for the Decommissioning Old Versions Change Notification form.

The sponsoring railroad will also enter information as required for ICR close out. The specific fields required for ICR close out are configurable by the Industry Change Manager. The railroad can also attach supplemental material such as support documentation pertaining to the ICR.

After submission of the Decommissioning Old Versions Change Notification form by the sponsoring railroad, the ICR will advance to the Close Out stage and an auto-generated email will notify other railroads of an action to review and respond. The number of days to respond will be provided to the other railroads in the email and indicated on their dashboard. The number of days to respond to a Change Notification for an ICR initiated for decommissioning of old versions will be configurable by the Industry Change Manager.

The responding user from each railroad can then navigate to the ICR and enter any applicable railroad-specific information fields on the Close Out form if they plan to decommission versions of the same ICI(s). Supplemental documentation can also be added to the ICR at this time.

5.4.6.5 Business Approval

For a normal (not expedited) ICR, the Business Approval process is initiated through a request for Business Approval by the ICR sponsor. When an ICR is in the Change Notification stage, the PTC ILM system will allow the sponsor of the ICR to submit a request for Business Approval. When this occurs, the system will require general information to be entered by the sponsor in a Business Approval form. The general information fields for the Business Approval form can be customized by the Industry Change Manager.

The sponsoring railroad will also enter the following information pertaining to the ICR that is specific to their railroad:

- Impact Level – The sponsoring railroad is impacted by default, but responding railroads can select from the following options, defined within the Interoperable Change Management Policies and Procedures Manual:
    - Impacted
    - Applicable
    - Not Applicable

- Comments – Any additional information pertaining to the ICR specific to the railroad
- Other configurable fields – The PTC ILM system will support configurable railroad-specific information fields for the Business Approval form.

The railroad can also attach supplemental material such as support documentation pertaining to the ICR.

After submission of the Business Approval form by the sponsoring railroad, the PTC ILM system will advance the ICR to the Business Approval-Pending stage and an auto-generated email will notify other railroads of an action to review and respond. The number of days to respond will be provided to the other railroads in the email and indicated on their dashboard. The number of days to respond to a Request for Business Approval for a normal change will be configurable by the Industry Change Manager.

The responding user from each railroad can then navigate to the ICR and enter whether they are Impacted, Applicable, or Not Applicable to the ICR. The system will default to the impact level entered by the railroad during the Change Notification stage but can be updated during the Business Approval stage if anything has changed. If the responding railroad indicates to the system that it is Impacted or Applicable, it will proceed to enter the other railroad-specific information fields on the Business Approval form. Supplemental documentation can be added to the request at this time. If the responding railroad indicates to the system it is Not Applicable, it will be prompted to enter comments.

For an Expedited to Business Approval ICR, the ICR is advanced to the Business Approval-Pending stage as soon as the Expedited to Business Approval Change Notification form is submitted, as described in Section 5.4.6.4.

Whenever an ICR is in the Business Approval-Pending stage, the Industry Change Manager can advance the ICR to the Business Approval-Approved stage. Upon doing so, the PTC ILM system will require the Industry Change Manager to include comments that will be stored in the CMDB. Industry approved policies and procedures will dictate the process for obtaining Business Approval, but the Industry Change Manager is responsible for advancing the change within the PTC ILM system.

5.4.6.6 Deployment Approval

For a normal (not expedited) ICR, the Deployment Approval process is initiated through a request for Deployment Approval by the ICR sponsor. When an ICR is in the Business Approval stage, the PTC ILM system will allow the sponsor of the ICR to submit a request for Deployment Approval. When this occurs, the system will require general information to be entered by the sponsor in a Deployment Approval form. The general information fields for the Deployment Approval form can be customized by the Industry Change Manager.

The sponsoring railroad will also enter the following information pertaining to the ICR that is specific to their railroad:

- Impact Level – The sponsoring railroad is impacted by default, but responding railroads can select from the following options, defined within the Interoperable Change Management Policies and Procedures Manual:
    - Impacted

    - Applicable
    - Not Applicable
- Deployment Start Date – The date the railroad plans to begin their deployment of the ICR.
- Comments – Any additional information pertaining to the ICR specific to the railroad
- Other configurable fields – The PTC ILM system will support configurable railroad-specific information fields for the Deployment Approval form.

The railroad can also attach supplemental material such as support documentation pertaining to the ICR.

After submission of the Deployment Approval form by the sponsoring railroad, the PTC ILM system will advance the ICR to the Deployment Approval-Pending stage and an auto-generated email will notify other railroads of an action to review and respond. The number of days to respond will be provided to the other railroads in the email and indicated on their dashboard. The number of days to respond to a Request for Deployment Approval for a normal change will be configurable by the Industry Change Manager.

The responding user from each railroad can then navigate to the ICR and enter whether they are Impacted, Applicable, or Not Applicable to the ICR. The system will default to the impact level entered by the railroad during the Business Approval stage but can be updated during the Business Approval stage if anything has changed. If the responding railroad indicates to the system that it is Impacted or Applicable, it will proceed to enter the other railroad-specific information fields on the Deployment Approval form. Supplemental documentation can be added to the request at this time. If the responding railroad indicates to the system it is Not Applicable, it will be prompted to enter comments.

The Deployment Approval process can also be initiated through a request for Expedited Deployment Approval during the Change Notification stage by the ICR sponsor. When an ICR is in the Change Notification stage, the PTC ILM system will allow the sponsor of the ICR to submit a request for Expedited Deployment Approval. When this occurs, the system will require general information to be entered by the sponsor in an Expedited to Deployment Approval form. The Expedited to Deployment Approval form will include a response due date indicating the date by which all railroads need to respond to meet the timing requirements of the expedited request. The other general information fields for the Expedited to Deployment Approval form can be customized by the Industry Change Manager.

The sponsoring railroad will also enter the following information pertaining to the ICR that is specific to their railroad:

- Impact Level – The sponsoring railroad is impacted by default, but responding railroads can select from the following options, which are defined within the Interoperable Change Management Policies and Procedures Manual:
    - Impacted
    - Applicable
    - Not Applicable

- Deployment Start Date – The date the railroad plans to begin their deployment of the ICR.
- Comments – Any additional information pertaining to the ICR specific to the railroad
- Other configurable fields – The PTC ILM system will support configurable railroad-specific information fields for the Expedited to Deployment Approval form.

The railroad can also attach supplemental material such as support documentation pertaining to the ICR.

After submission of the Expedited to Deployment Approval form by the sponsoring railroad, the PTC ILM system will advance the ICR to the Deployment Approval-Pending stage and an auto-generated email will notify other railroads of an action to review and respond. The number of days to respond will be provided to the other railroads in the email and indicated on their dashboard, according to the due date specified by the sponsor of the ICR.

The responding user from each railroad can then navigate to the ICR and enter whether they are Impacted, Applicable, or Not Applicable to the ICR. The system will default to the impact level entered by the railroad during the Change Notification stage but can be updated during the Deployment Approval stage if anything has changed. If the responding railroad indicates to the system that it is Impacted or Applicable, it will proceed to enter the other railroad-specific information fields on the Expedited to Deployment Approval form. Supplemental documentation can be added to the request at this time. If the responding railroad indicates to the system it is Not Applicable, it will be prompted to enter comments.

For an ICR that was initiated as an Expedited to Deployment Approval ICR, the ICR is advanced to the Deployment Approval-Pending stage as soon as the Expedited to Deployment Approval Change Notification form is submitted, as described in Section 5.4.6.4.

Whenever an ICR is in the Deployment Approval-Pending stage, the Industry Change Manager can advance the ICR to the Deployment Approval-Approved stage. Upon doing so, the PTC ILM system will require the Industry Change Manager to include comments that will be stored in the CMDB. Industry approved policies and procedures will dictate the process for obtaining Deployment Approval, but the Industry Change Manager is responsible for advancing the change within the PTC ILM system.

For any versions of any ICIs deployed as part of the ICR, the PTC ILM system will automatically update the CMDB for each railroad deploying the new ICI(s). For each railroad that has indicated they are impacted, when the deployment start date specified by that railroad is reached, the PTC ILM system will add the new version(s) of the ICI(s) to that railroad's deployment record in the CMDB. Updating the CMDB with retirement of old versions are handled during the close out phase, as described in Section 5.4.6.7.

5.4.6.7 Close Out

The Close Out process is initiated by the sponsor of the ICR once they have completed the change on their railroad. When an ICR is in the Deployment Approval stage, the PTC ILM system will allow the sponsor of the ICR to submit a request for Close Out. Alternatively, the Close Out process can be initiated from other stages by the sponsor of the ICR if circumstances arise during the Interoperable Change Management process that result in the railroad deciding not to complete the change.

When the Close Out process is initiated, the system will require the sponsoring railroad to indicate whether the change was completed or not. If so, the system will prompt the change sponsor to enter information pertaining to the ICR that is specific to their deployment of the change. If not, the system will prompt the change sponsor to enter information pertaining to their decision not to complete the change. The specific fields that are required are configurable by the Industry Change Manager. The railroad can also attach supplemental material such as support documentation pertaining to the ICR. For changes that were completed, the PTC ILM system will automatically update the deployment record in the CMDB for the sponsoring railroad when the Close Out form is submitted, removing any versions of any ICIs indicated as removed from interoperable service as part of the ICR.

After submission of the Close Out form by the sponsoring railroad, the PTC ILM system will advance the ICR to the Close Out stage and an auto-generated email will notify other railroads. The responding user from each railroad can then navigate to the ICR and enter the information pertaining to their deployment of the change, once completed. When each railroad completes and submits its Close Out form, the PTC ILM system will automatically update the deployment record in the CMDB for the responding railroad, removing any versions of any ICIs indicated as removed from interoperable service as part of the ICR.

When all impacted railroads have completed their deployment, the Industry Change Manager can advance the ICR to the Closed stage.

5.4.6.8 Assessing the Impact of an ICR

At any point in the Interoperable Change Management process, a user can generate an ICR impact assessment report. The report will include information that can help the user assess the impact of the ICR on their railroad, including the following:

- ICI(s) included in the ICR.
- Versions of ICI(s) included in the ICR (both new and being removed from interoperable service).
- ICI(s) that are related to an ICI included in the ICR and the type of relationship.
- Versions of ICI(s) that are related to the versions of ICI(s) included in the ICR and the type of relationship.

5.4.7 Industry Test Management

Industry Test Management, in the context of PTC ILM, includes the management of industry common test cases, tracing of industry common test cases to system requirements, tracking of industry testing progress, documentation of industry common test results, and storage of industry common test artifacts. This section describes the PTC ILM system capabilities associated with the Industry Test Management process.

5.4.7.1 Industry Testing Database

The PTC ILM system will contain an Industry Testing database, which contains all of the data related to the Industry Test Management process. This includes data related to industry test cases, industry test results, and industry test artifacts. Industry test case data includes the following:

- Test case ID – A unique identifier for each test case
- Test case title – A short descriptive title describing the test case
- Test case description – A more verbose description of the test case
- Test case status – An indication of whether the test case is a draft test case, approved test case, or archived test case.
- Test case details, including:
    - Test case level – Level of testing the test case corresponds to, e.g., unit test, segment test, nearest neighbor test, end-to-end test, etc.
    - Preconditions – Details of configuration and state of system and test components
    - Equipment required – System and test equipment required to execute the test case.
    - Test setup – Details of setup of the test case and test equipment
    - Test procedures – Detailed steps to be executed.
    - Analysis/expected results – Description of how test results will be recorded and analyzed and the expected system behavior.
    - Pass/fail criteria – Quantitative criteria that describes test results that would result in a pass or fail.
    - Other configurable parameters – The PTC ILM will be configurable to include other parameters associated with each test case, as needed.
- Links to requirement(s) – A link establishing a requirement that is evaluated by the test case.

Industry test result data includes the following:

- Test case – ID of the test case the result applies to
- Test execution details, including:
    - Date/time test was conducted.
    - Party responsible for test execution
    - Versions of system software or other system configuration details
    - Versions of test software or other test configuration details
    - Other configurable parameters
- Test result – Pass/fail result of the test case executed.

Industry test artifact data includes any information produced from the execution of the test and could include artifacts such as completed test books, logs, screen shots, etc. Industry test artifacts will be referenced to the test result data in the database.

5.4.7.2 Importing Test Cases

New or modified test cases can be imported by the Industry Test Case Manager into the PTC ILM system Industry Testing database, either from a document, spreadsheet, or external

database. When importing test cases from a document, the PTC ILM system will parse the individual test cases and test case data within the document, based on unique test case IDs, and store them in the database.

The PTC ILM system will allow the user to map the formatting of the elements from each test case in the document to the appropriate fields within the database. When importing test cases contained within a spreadsheet or external database, the PTC ILM system will allow the user to map the fields from the spreadsheet or database to the fields required within the PTC ILM system database.

When importing test cases, the Industry Test Case Manager will indicate the status (either draft or approved) to the PTC ILM system.

5.4.7.3 Creating Test Cases

The Industry Test Case Manager can create new test cases through the Industry Test Management component of the PTC ILM system. When creating a new test case, the Industry Test Case Manager will enter the necessary information associated with the test case through the PTC ILM Industry Test Management user interface. The PTC ILM system will store the new test case information in the database. When creating new test cases, the PTC ILM system will default the new test cases to a draft status.

New test cases can also be created by copying existing test cases and making changes within the PTC ILM system. The system will allow the Industry Test Case Manager to select an existing test case to be copied and enter a new title for the test case, at which point the system will generate a new test case with a new identifier, using the new title and copying all other test case data from the source test case. The new test case status will be set to draft and the Industry Test Case Manager can then edit any of the data associated with the copied test case, as appropriate.

5.4.7.4 Creating, Editing, and Viewing Links between Test Cases and Requirements

The PTC ILM system allows authorized users to create and edit links from test cases to related requirements in the requirements management database for traceability purposes, as well as allowing users to view established links between test cases and requirements. The PTC ILM system will allow authorized users to establish links between test cases and requirements, either by entering the requirement ID or through the test case viewer. The user interface will allow the user to select a test case from the test case viewer, then select the requirement it is to be linked to in a requirements specification from the requirements management database. Authorized users can edit links in a similar manner.

When new versions of existing requirements specification ICIs are released, if links have already been established between existing test cases and the prior version of the requirements specification ICI, the user can have the PTC ILM system automatically create links from the existing test cases to the new version of the requirements specification ICI, according to those established from the previous version. When initializing links between test cases and requirements for a new version of a requirements specification ICI from a prior version, the user can select which prior version to initialize from. The system will scan each requirement in the selected prior version and determine if it is the same in the new version. If so, the links from the prior version for that requirement will be established in the new version. After completing the initialization from the prior version, the system will provide a report to the user of all

requirements in the new version for which links were not established from the old version due to changes in the requirements between the two versions, and all test cases linked to requirements in the previous version that are no longer linked due to changes in the requirements between the two versions. The user can then work through these items to establish new links or create new test cases, as appropriate.

The PTC ILM system will maintain all links between test cases and all versions of requirements specification ICIs within the Industry Testing database. When a user is viewing a test case, the system will allow them to visualize the links to requirements in the requirements management database, as well as navigate to the requirements and requirements specification ICIs that they are linked to.

5.4.7.5 Viewing and Editing Test Cases

Railroad Test Case Managers can view any of the test cases within the database. The user interface for the Industry Test Management component will include the ability to search for test cases according to search criteria specified by the user. The test case viewer will allow the user to view any or all elements of the test case in customizable windows allowing for the information to be presented according to the user's needs.

The Industry Test Case Manager will have the ability to edit any element of test cases that are in the draft status. This allows the industry to review the details of draft test cases and the Industry Test Case Manager to make changes prior to the industry approving them for interoperable testing. The Industry Test Case Manager can set a test case to the approved status, at which point the only changes the system will allow to be made to the test case are to the links to requirements and to change the status to archived. When the Industry Test Case Manager changes the status to archived, the system will no longer allow the test case to be editable.

5.4.7.6 Analyzing Traceability of Test Cases to Requirements

The PTC ILM system will provide functions for supporting analysis of test case traceability to versions of requirements specification ICIs. The user will be able to run customizable test case to requirements traceability reports that will help in the analysis of test coverage and potential modifications to test cases as a result of new versions of requirements specification ICIs. As examples, the user may choose to run the following reports:

- A report of any requirements in a requirements specification with no links to test cases
- A report showing the traceability of a selected test case, showing all requirements it is traced to
- A report showing all test cases traced to a version of a requirements specification ICI, to be compared with a similar report to a different version of the same requirements specification ICI.

These are intended as examples that a user may wish to report on. The user interface for the Industry Test Management component will allow development of any customized report from the test case database. The reports can be viewed in the user interface or exported to standard formats, such as pdf or Excel workbooks.

5.4.7.7 Entering, Importing, and Viewing Test Results

The PTC ILM system will allow Industry Test Support Users to enter or import test results into the system through a test results user interface. When entering test results, the PTC ILM system will provide a user interface allowing the Industry Test Support User to directly enter the required information, which the system will then store in the Industry Test Management database.

Test results can also be imported by the Industry Test Support User into the database, either from a document, spreadsheet, or external database. When importing test results from a document, the PTC ILM system will parse the individual tests and test case data result data within the document and store them in the database. The PTC ILM system will allow the user to map the formatting of the elements from the test results in the document to the appropriate fields within the database. When importing test results contained within a spreadsheet or external database, the PTC ILM system will allow the user to map the fields from the spreadsheet or database to the fields required within the PTC ILM system database.

Test results can be viewed by any authorized user through the Industry Test Management user interface, which will include the ability to search for test results according to search criteria specified by the user. The test result viewer will allow the user to view any or all elements of the test results in customizable windows allowing for the information to be presented according to the user's needs.

In addition to viewing test results through the user interface, authorized users will be able to run customizable test result reports. As examples, the user may choose to run the following reports:

- A report of the results of all tests relating to a particular version of an ICI
- A report of the results from every time a particular test case was executed over time.
- A report of the tests that failed for all test cases related to a railroad's current configuration, as documented in the CMDB.

These are intended as examples that a user may wish to report on. The user interface for the Industry Test Management component will allow development of any customized report from the test results database. The reports can be viewed in the user interface or exported to standard formats, such as pdf or Excel workbooks.

5.4.7.8 Uploading, Viewing, and Downloading Test Artifacts

The PTC ILM system will allow Industry Test Support Users to upload test artifacts into the system through the test results user interface. When uploading test artifacts, the Industry Test Support User will enter the required information through the user interface, including the test result record(s) the artifact(s) apply to and select the artifact to be uploaded. The PTC ILM system will then store the artifacts and associated references in the Industry Testing database.

Authorized users can search for test artifacts stored in the database through the test results user interface. The user can select the test artifact and either view it through the user interface or download it for external use.

5.4.8 Knowledge Management

Knowledge Management provides a method of keeping records of knowledge artifacts that may be useful to the industry in various ways, such as lessons learned in deploying a version of an ICI

that other railroads may find useful in their own deployment, notes regarding the execution of a test case that may be useful in future execution of that test case, or information justifying a change to a requirement that may be helpful in determining whether to deploy the version of the ICI with the changed requirement – to name a few possible examples. This section describes the PTC ILM system capabilities associated with the Knowledge Management process.

5.4.8.1 Knowledge Management Database

The PTC ILM system will provide a repository for knowledge artifacts (lessons learned, potential issues, etc.) to be stored in a Knowledge Management database. The Knowledge Management Database will include the following data:

- Knowledge artifact ID – A unique identifier for the knowledge artifact
- Knowledge artifact title – A brief descriptive title of the knowledge artifact
- Knowledge artifact reference – A reference to the data element in the PTC ILM system databases to which the knowledge artifact applies, such as a PTC Interoperable System Release, a requirement, an ICI, a version of an ICI, an ICR, a test case, a test result, a test artifact, etc.
- Knowledge artifact user reference – The user that entered the knowledge artifact.
- Knowledge artifact date/time – The date/time stamp for when the knowledge artifact was entered.
- Knowledge artifact – Knowledge artifacts could be freeform text fields, documents, or other data files.
- Other configurable parameters

5.4.8.2 Entering Knowledge Artifacts

Any authorized user will have the ability to enter knowledge artifacts, either directly through the Knowledge Management component user interface or through a link in any other area of the PTC ILM system. When entering a knowledge artifact through the Knowledge Management component user interface, the PTC ILM system will allow the user to enter the required information for the knowledge artifact, including a reference for linking the new artifact to an ICI, test case, requirement, etc. The PTC ILM system will store the information entered in the Knowledge Management database.

Alternatively, users can enter knowledge artifacts through a link in any other area of the PTC ILM system. The PTC ILM system user interface will include a link on every screen to add a knowledge artifact, making it simple for the user to enter artifacts when working in any component of the system. When entering a knowledge artifact through one such link, the PTC ILM system will add a reference to the ICI, test case, requirement, etc. that the user was working on when the link was accessed by default, although this can be modified by the user while entering the required information for the knowledge artifact. Once the required information is entered by the user, the PTC ILM system will store the information entered in the Knowledge Management database.

5.4.8.3 Viewing Knowledge Artifacts

Once uploaded to the knowledge management database, artifacts can be located by any authorized user through a customized search of the knowledge artifact ID, title, linked reference (i.e., referenced ICI, test case, requirement, etc.), user reference, or date range.

Knowledge artifacts can also be accessed through links in other areas of the PTC ILM system user interface. When a user is viewing an item in the PTC ILM system that is referenced in a knowledge artifact, the PTC ILM system will include a link to the knowledge artifact. When followed, the link will allow the user to easily navigate to the relevant knowledge artifact in the Knowledge Management user interface and back to the area that the link was accessed from.

When a knowledge artifact is selected, either from a search of the Knowledge Management database or through a link from another area of the PTC ILM system, the information relating to the knowledge artifact will be displayed in the knowledge artifact viewer. The user can choose to view the artifact in the user interface or download the artifact for external use.

5.4.9 Administrative Capabilities

The preceding subsections of Section 5.4 outline the core capabilities of the PTC ILM system. To support these core capabilities, a number of administrative capabilities are also required. This section briefly describes these capabilities.

5.4.9.1 User Account Management

Users are managed by a PTC ILM System Administrator and are provided access to various system functions based on their assigned user class. The PTC ILM system will provide capability for a PTC ILM System Administrator to add new railroads to the list of participating railroads. When adding a new railroad, the PTC ILM system will require the PTC ILM System Administrator to enter the following information for the new railroad:

- Railroad name
- Railroad Standard Carrier Alpha Code (SCAC)
- Railroad email addresses for email notifications
- Other fields, TBD

The PTC ILM system will also provide capability for the PTC ILM System Administrator to add new users. When adding a new user, the PTC ILM system will require the PTC ILM System Administrator to enter the following information for the new user:

- Username
- User railroad/organization
- User roles (see Section 5.3)
- Other fields, TBD

The PTC ILM System Administrator will have the capability to manage user accounts – for example, to remove a user or change the roles of a user.

5.4.9.2 System Configuration

The PTC ILM system has a number of configurable and customizable features, as described throughout Section 5.4. Configurable parameters include items such as the standard number of days to respond to a normal change and configurable parameters in the CMDB.

The PTC ILM system will provide a user interface for configuring the system and developing the customizable aspects of the system. This user interface will be accessible only by the user class that is authorized to make changes to the configurable features of that aspect of the system.

5.4.9.3 Documentation

The PTC ILM system will include capability for users to view documentation related to PTC ILM (such as process and procedure manuals) and documentation related to the PTC ILM system (such as user manuals). User classes authorized to modify these documents can be established by a PTC ILM System Administrator.

5.5 Priorities among Capabilities

As the industry continues to deploy and operate PTC across the network, the PTC ILM processes will continue to mature. The capabilities of the PTC ILM system described in Section 5.4, as well as potential additional future capabilities, will be needed to support these processes. This section describes the priorities and potential expansion of the PTC ILM system.

One of the key needs for the PTC ILM system is to enhance visibility of changes to PTC deployments that affect interoperability and to support change and configuration management on a broad scale. Processes are already established for PTC Interoperable Release Management, Interoperable Configuration Management, and Interoperable Change Management. However, these processes are still maturing and the tools currently available to support them are limited in various ways. The highest priority capabilities for development of the PTC ILM system, therefore, are to support Interoperable Release Management (Section 5.4.3), Interoperable Configuration Management (Section 5.4.5), and Interoperable Change Management (Section 5.4.6). Additionally, development of the PTC ILM system user interface framework, dashboard (Section 5.4.2), and administrative capabilities (Section 5.4.9) are high-priority, from the perspective of establishing the foundational and look and feel of the PTC ILM system. Finally, in terms of high-priority needs, is the development of capabilities to support Knowledge Management (Section 5.4.8). The Knowledge Management capabilities are foundational in terms of encouraging the documentation, sharing, and use of lessons learned by the interoperable community, and are core to the overall purpose of PTC ILM.

Secondary priorities, in terms of capabilities, are Interoperable Design Coordination and Requirements Management and Industry Test Management. These capabilities will be required to support identification, at the requirements level, of changes and the impacts of those changes, to ICIs and PTC Interoperable System Releases over time, as well as supporting industry joint interoperable testing. These processes are currently being handled by each railroad individually and, while the capabilities to support these processes are secondary to those described above, this is primarily due to the current level of maturity of the processes at the industry level and not due to the level of importance.

Other PTC ILM system capabilities may be identified in the future – for example, to support additional ITIL processes at the interoperable level, or to incorporate other interoperable

processes related to PTC ILM that are currently being handled elsewhere. The PTC ILM system should be developed with extensibility in mind, to support these potential future capabilities.

Although the PTC ILM system will first focus on PTC deployments that are ITC-compliant, expansion of the system to support ACSES system deployments may be implemented in a later phase.

Lastly, it is expected that the PTC ILM system will be expanded in the future to support other developing interoperable technologies. In some cases, these technologies will be to support enhanced functionality or capabilities of PTC and other train control technologies, but they may also include related railroad operations support technologies. While concepts for these new technologies are only now being developed or may have not yet been considered at all, the foundational concepts of interoperable lifecycle management will apply to any train control or operations support technology that has an interoperability requirement and will change and evolve over time.

Appendix B. PTC ILM System Interoperable Change and Configuration Management Requirements PTC Interoperable Lifecycle Management System

System Requirements Specification (Draft)

Version 0.2

March 31, 2019

Revision History

Date	Revision	Description	Author
12/27/2019	0.1	Initial Draft	Paul Martinez, Sri Atluri
3/31/2019	0.2	Reorganization of document, edits to wording of requirements, and document formatting	Paul Martinez, Sri Atluri, Joe Brosseau

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1. Background and Scope

This document specifies the system requirements for the Positive Train Control (PTC) Interoperable lifecycle management (ILM) system, which is intended to support industry lifecycle management activities for interoperable PTC systems. The objective of this specification is to document the basic, high-level requirements for the system, from which a more comprehensive design can be developed. This document is not intended as a complete software requirements specification; rather it is intended to support a consensus on the key functions the system must perform to support the applicable industry processes.

The requirements included in this specification are derived from the PTC ILM System Description and Operational Concept, which provides a conceptual description of the envisioned system.

The system specified within this version of the document is limited in its scope to supporting users of PTC systems that comply with the Interoperable Train Control (ITC) standards but may be expanded upon in the future to support other types of PTC systems, as well as other train control and operations technology.

Additionally, the scope of this version of the document is limited to the following functional areas, described within the PTC ILM System Description and Operational Concept:

- PTC Interoperable Release Management
- PTC Interoperable Configuration Management
- PTC Interoperable Change Management

It is intended that additional functional areas described within the PTC ILM System Description and Operational Concept will be included in subsequent versions, as many additional functional areas are yet to be determined.

Each section of this document generally contains two parts: narrative text and explicit requirements. The narrative text includes background information, goals, and other supplemental information provided to clarify the requirements. The explicit requirements, each containing the word “shall,” follow in a numbered or lettered list beneath the narrative text. Goals are explicitly identified as such and use “will” rather than “shall.”

2. Applicable Documents

The following document applies to the PTC ILM system to the extent in the text of this specification:

- PTC ILM System Description and Operational Concept v0.4 (Draft)

3. System Overview

The PTC ILM system is conceived to provide a centralized software platform for supporting the primary lifecycle management activities related to interoperable operations of PTC. The system is intended to support industry-defined policies and procedures relating to these activities with customization and flexibility in mind to support continuous improvement of the processes supported and future extensibility of the capabilities of the system. The PTC ILM system incorporates a web-based service management tool allowing for industry access and management of the interoperable configuration items (ICIs) that comprise the interoperable aspects of the system throughout their lifecycle.

The PTC ILM system will initially focus on six functional areas that are of most critical importance:

- PTC Interoperable Release Management
- PTC Interoperable Design Coordination and Requirements Management
- PTC Interoperable Configuration Management
- PTC Interoperable Change Management
- PTC Industry Test Management
- PTC Knowledge Management

Each of these functional areas are accessible by users of the PTC ILM system according to user access levels defined by assigned user classes. Data is stored in four logical system databases, which are accessed by each of the functional areas of the system:

- Configuration Management Database (CMDB) – stores data relating to ICIs and their versions, interoperable change requests (ICRs), and PTC Interoperable System Releases.
- Requirements Management Database – stores data relating to PTC requirements specifications and interface documentation.
- Industry Testing Database – stores data relating to PTC industry test cases, test results, and test artifacts.
- Knowledge Management Database – stores data relating to knowledge management artifacts.

Figure 1 depicts an overview of the PTC ILM system functional areas and databases.

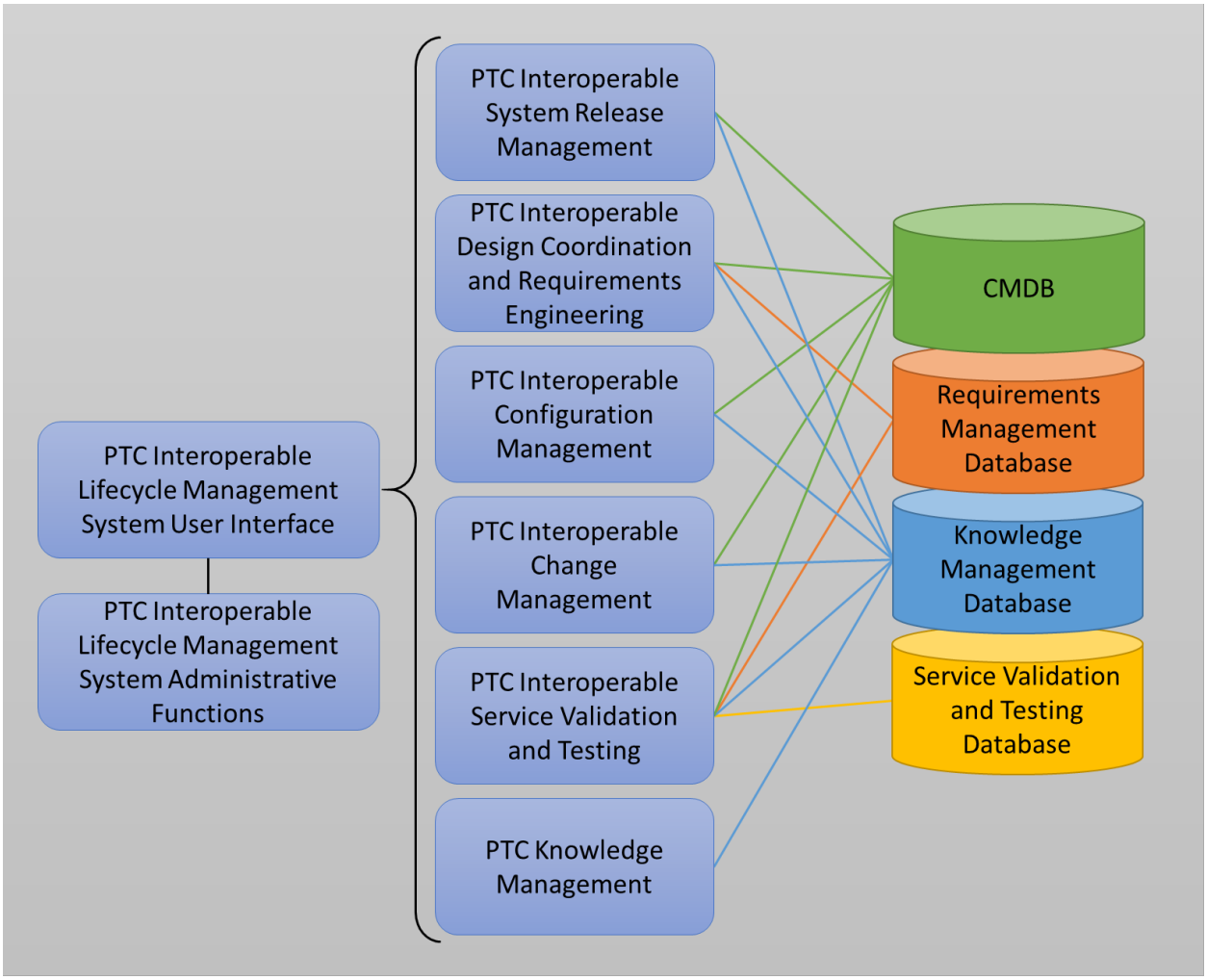

Figure 10: Interoperable Lifecycle Management System Overview

As shown in Figure 1, all functional areas of the system are accessible through the PTC ILM system user interface. The functional areas store and retrieve data from the four databases, as shown in the diagram.

Users can access the PTC ILM system to share information; communicate and approve interoperable releases, deployment changes, and system configuration details; and access requirements and testing information, including requirements traceability and testing results and artifacts. The user interface is conceived to be highly interactive and user contextual, making it easy for a user to access the most critical information for their role, and navigate easily between the PTC ILM system functional areas.

4. Functional Requirements

This section contains the basic, high-level functional requirements for the PTC ILM system.

4.1 System User and User Accessibility Requirements

The PTC ILM system is intended to be accessible by users employed by different organizations in various geographic locations. As a result, the system must support remote access.
The PTC ILM system shall be accessible to users remotely via a web application or user client application.

The PTC ILM system shall maintain a database of users and their login credentials.

The PTC ILM system user database will also contain additional user attributes (e.g., the organization they represent), as required to support the capabilities and required functions of the system.

The PTC ILM system shall require user login credentials to access the system.

The PTC ILM system shall support defined user classes.

User classes define the various types of users of the PTC ILM system. The areas of the system that can be accessed and the actions that can be taken by a user are defined by their assigned user class. It is possible for a user to be assigned to multiple user classes if they must act in multiple roles within the PTC ILM system. Draft user classes are included in the PTC ILM System Description and Operational Concept but may be modified or expanded upon as the system design is progressed.

The PTC ILM system shall restrict access for an individual user based on their user class.

The PTC ILM system shall include a System Administrator user class.

The PTC ILM system shall support addition and deletion of users from the system by a user assigned to the System Administrator user class.

The PTC ILM system shall support assignment of users to user classes by a user assigned to the System Administrator user class.

User Interface Home Page Requirements

The PTC ILM system user interface shall include a home page, accessible to the user at any time, from any other area of the user interface.

The home page is intended to support efficient navigation of the PTC ILM user interface. The home page will be the landing page when the user logs in.

The PTC ILM system home page shall include a dashboard with links to the six core subsystems of the PTC ILM system.

The six core subsystems of the PTC ILM system are:

Interoperable Release Management

Interoperable Design Coordination and Requirements Management

Interoperable Configuration Management

Interoperable Change Management

Industry Test Management

Knowledge Management

The PTC ILM system home page will also provide other content that is most relevant to the user class of the user logged in, as described in the PTC ILM System Description and Operational Concept.

Configuration Management Database (CMDB) Requirements

The PTC ILM system shall incorporate a Configuration Management Database (CMDB).

The PTC ILM system CMDB contains all of the data and relationships associated with the defined ICIs, ICRs, and PTC Interoperable System Releases used in the PTC ILM process.

The PTC ILM system CMDB shall maintain a record of all Interoperable Configuration Items (ICIs).

Requirements for the addition of ICIs to the CMDB are included in section 4.5.1.

The PTC ILM system CMDB shall maintain a record of the required attributes associated with each ICI.

Draft required attributes associated with each ICI are included in the PTC ILM System Description and Operational Concept but may be modified or expanded upon as the system design is progressed.

The PTC ILM system CMDB shall support addition of configurable ICI attributes.

Requirements for the definition of configurable ICI attributes are included in Section 4.5.1.

The PTC ILM system CMDB shall maintain a record of relationships and types of relationships between ICIs.

Draft ICI relationship types are included in the PTC ILM System Description and Operational Concept but may be modified or expanded upon as the system design is progressed.

The PTC ILM system CMDB shall support addition of configurable ICI relationship types.

Requirements for the definition of configurable ICI relationship types are included in Section 4.5.2.

The PTC ILM system CMDB shall maintain a record of all versions of ICIs.

New versions of ICIs are introduced through railroad configuration baselining (Section 4.5.3) or through the interoperable change management process (Section 4.6).

The PTC ILM system CMDB shall maintain a record of the required attributes associated with each version of each ICI.

Draft required attributes associated with each version of ICI are included in the PTC ILM System Description and Operational Concept but may be modified or expanded upon as the system design is progressed.

The PTC ILM system CMDB shall support the addition of configurable ICI version attributes.

Requirements for the definition of configurable ICI version attributes are included in Section 4.5.1.

The PTC ILM system CMDB shall maintain a record of the current status of each ICI.

ICI status can be set to Proposed, Adopted, or Retired, as described in the PTC ILM System Description and Operational Concept. Requirements for setting the current status of an ICI are included in Section 4.5.1.

The PTC ILM system CMDB shall maintain a record of relationships between versions of ICIs.

The PTC ILM system CMDB shall maintain a record of the deployment date, decommission date, and comments associated with each version of each ICI on each participating railroad.

The PTC ILM system CMDB shall maintain a record of each version of each PTC Interoperable System Release.

Requirements for addition of PTC Interoperable System Releases to the CMDB and versioning of PTC Interoperable System Releases are included in Section 4.4.1.

The PTC ILM system CMDB shall maintain a record of the release date and retirement date of each PTC Interoperable System Release.

The PTC ILM system CMDB shall maintain a record of each version of each ICI contained within each PTC Interoperable System Release.

Requirements for definition of ICIs contained within a PTC Interoperable System Release are included in Section 4.4.1.

The PTC ILM system CMDB shall maintain a record of comments associated with each PTC Interoperable System Release and each ICI within each PTC Interoperable System Release.

The PTC ILM system CMDB shall maintain a record of the current status of each PTC Interoperable System Release.

PTC Interoperable System Release Status can be set to Draft, Approved, Active, or Retired, as described in the PTC ILM System Description and Operational Concept. Requirements for setting the current status of a PTC Interoperable System Release are included in section 4.4.1.

The PTC ILM system CMDB shall maintain a record of all Interoperable Change Requests (ICRs).

Requirements associated with creation of ICRs are included in Section 4.6.2.

The PTC ILM system CMDB shall maintain a record of all data associated with each ICR.

Data associated with ICRs is described in the PTC ILM System Description and Operational Concept. Requirements associated with Interoperable Change Management are included in Section 4.6.

Interoperable Release Management Requirements

PTC Interoperable System Release Management Requirements

The PTC ILM system shall allow an Industry Release Manager to create a new PTC Interoperable System Release.

When an Industry Release Manager creates a new version of a PTC Interoperable System Release, the PTC ILM system shall prompt the Industry Release Manager to enter the major version number, the target release date, and the target retirement date for the PTC Interoperable System Release.

When an Industry Release Manager creates a new PTC Interoperable System Release, the PTC ILM system shall set the status of the new PTC Interoperable System Release to Draft.

While a PTC Interoperable System Release is in Draft status, the PTC ILM system shall allow an Industry Release Manager to edit the target release date, target retirement date, versions of each ICI, and comments associated with the PTC Interoperable System Release.

When an Industry Release Manager makes edits to a PTC Interoperable System Release in the Draft status, the PTC ILM system shall increment the draft version and prompt the Industry Release Manager to enter comments associated with the new draft version.

PTC Interoperable System Release versioning while in the Draft status is described within the PTC ILM System Description and Operational Concept.

When a PTC Interoperable System Release if in Draft status, the PTC ILM system shall allow an Industry Release Manager to update the status to Approved.

When an Industry Release Manager updates the status of a PTC Interoperable System Release to Approved, the PTC ILM system shall set the version to the initial approved version for that PTC Interoperable System Release.

PTC Interoperable System Release versioning while in the Approved or Active status is described within the PTC ILM System Description and Operational Concept.

While a PTC Interoperable System Release is in Approved status, the PTC ILM system shall allow an Industry Release Manager to edit the release date, target retirement date, versions of each ICI, and comments associated with the PTC Interoperable System Release.

When an Industry Release Manager makes edits to a PTC Interoperable System Release in the Approved status, the PTC ILM system shall increment the version and prompt the Industry Release Manager to enter comments associated with the new version.

When a PTC Interoperable System Release in in Approved status and the release date is reached, the PTC ILM system shall update the status of the PTC Interoperable System Release to Active.

While a PTC Interoperable System Release is in Active status, the PTC ILM system shall allow an Industry Release Manager to edit the target retirement date, versions of each ICI, and comments associated with the PTC Interoperable System Release.

When an Industry Release Manager makes edits to a PTC Interoperable System Release in the Active status, the PTC ILM system shall increment the version and prompt the Industry Release Manager to enter comments associated with the new version.

When a PTC Interoperable System Release is in Active status and the retirement date is reached, the PTC ILM system shall update the status of the PTC Interoperable System Release to Retired.

Interoperable Release Management User Interface and Reporting Requirements

The PTC ILM system Interoperable Release Management user interface shall include a graphical view of Retired, Active, Approved, and Draft PTC Interoperable System Releases that illustrates the release date (or target release date) and retirement date (or target retirement date) for each PTC Interoperable System Release on a scrolling time scale.

The PTC ILM system shall allow a user to search for and select a version of a PTC Interoperable System Release for viewing in the Interoperable Release Management user interface.

The PTC ILM system shall allow users to export data associated with a PTC Interoperable System Release an external file.

The PTC ILM system shall allow a user to search for and select two versions of PTC Interoperable System Releases for comparing in the Interoperable Release Management user interface.

The PTC ILM system shall allow users to export a report on a comparison between two PTC Interoperable System Releases to an external file.

Interoperable Configuration Management Requirements

ICI Management Requirements

The PTC ILM system shall allow an Industry Configuration Manager to add a new ICI to the CMDB.

When an Industry Configuration Manager adds a new ICI to the CMDB, the PTC ILM system shall prompt the Industry Configuration Manager to enter the attributes for the new ICI and optionally enter an adoption date.

When an ICI is in the Proposed status, the PTC ILM system shall allow an Industry Configuration Manager to update the ICI adoption date.

When the adoption date for an ICI in the CMDB has not been reached, the PTC ILM system shall set the ICI status to Proposed.

When the adoption date for an ICI with a Proposed status is reached, the PTC ILM system shall set the ICI status to Adopted.

The PTC ILM system shall allow an Industry Configuration Manager to set a retirement date for an ICI.

When the retirement date for an ICI is reached, the PTC ILM system shall set the status of the ICI to Retired.

When the status of an ICI is set to Retired, the PTC ILM system shall remove it from any PTC Interoperable System Releases in the Draft, Approved, or Active status.

The PTC ILM system shall allow an Industry Configuration Manager to update the attributes for an ICI in the Proposed or Adopted status at any time.

The PTC ILM system shall allow an Industry Configuration Manager to update the attributes for a version of an ICI at any time.

The PTC ILM system shall allow the Industry Configuration Manager to create configurable ICI attributes.

The PTC ILM system shall allow the Industry Configuration Manager to create configurable ICI version attributes.

ICI Relationship Requirements

The PTC ILM system shall allow an Industry Configuration Manager to create configurable relationship types for relationships between ICIs and ICI versions.

The PTC ILM system shall allow an Industry Configuration Manager to create relationships between ICIs.

When an Industry Configuration Manager creates a relationship between two ICIs, the PTC ILM system shall prompt the Industry Configuration Manager to select the type of relationship.

The PTC ILM system shall allow an Industry Configuration Manager to create relationships between versions of ICIs.

When an Industry Configuration Manager creates a relationship between two versions of ICIs, the PTC ILM system shall prompt the Industry Configuration Manager to select the type of relationship.

ICI Deployment Record Management Requirements

When a new railroad is added to the PTC ILM system, the PTC ILM system shall allow a Railroad Configuration Manager representing that railroad to enter the version(s) of each ICI deployed on their railroad.

When a new ICI is added to the CMDB, the PTC ILM system shall allow a Railroad Configuration Manager to enter the version(s) of the new ICI deployed on their railroad.

Interoperable Configuration Management Viewing and Reporting Requirements

The PTC ILM system shall allow users to run custom searches of the CMDB.

Users may choose to search for ICIs, ICI versions, or railroad deployment records and specify the search criteria.

When a user runs a custom search of the CMDB, the PTC ILM system shall display the results of the search.

The PTC ILM system shall allow a user to select results from a custom search of the CMDB.

When a user selects results from a custom search of the CMDB, the PTC ILM system shall display details associated with the selected search result.

Details for the search result will depend on the custom search. As an example, if the user selects an ICI from a search of ICIs, the details of the selected ICI would include the attributes, relationships and versions of the ICI.

The PTC ILM system shall allow users to create and save custom reports from the CMDB.

As examples, the user may choose to run the following reports:

A report on the deployment record for an ICI, showing the versions deployed by each railroad over a specified date range

A report on the relationships between all ICIs

A report on the attributes and relationships for a specified ICI

These are intended as examples that a user may wish to report on. The user interface for the Interoperable Configuration Management component will allow development of any customized report from the CMDB.

The PTC ILM system shall allow users to run saved custom CMDB reports at any time.

The PTC ILM system shall allow users to set saved custom CMDB reports to automatically run and be sent to the user at defined periods.

The PTC ILM system shall allow users to export custom CMDB reports to an external file.

Interoperable Change Management Requirements

Interoperable Change Management User Interface Requirements

The PTC ILM system shall include a dashboard for the Interoperable Change Management subsystem.

The Interoperable Change Management dashboard shall display a list of active ICRs for which the user's railroad is the sponsor.

The Interoperable Change Management dashboard shall display a list of active ICRs that are applicable to the user's railroad.

An ICR is applicable to a user's railroad unless a user associated with that railroad has responded to the ICR indicating it is not applicable to that railroad.

For Railroad Change Managers, the Interoperable Change Management dashboard shall display a list ICRs awaiting response from the user's railroad and the response due date.

The Interoperable Change Management dashboard shall allow the user to search for any ICR per user-defined search criteria.

The Interoperable Change Management user interface shall allow a user to view the forms and responses associated with any stage of any ICR.

ICR Creation Requirements

The PTC ILM system shall allow a Railroad Change Manager to create a new ICR.

When a Railroad Change Manager creates a new ICR, the PTC ILM system shall prompt the user to select one of the following ICR types:

Normal

Expedited to Business Approval

Expedited to Deployment Approval

Decommissioning

Latent Change

The PTC ILM system shall allow a Railroad Change Manager to create an ICR that is an extension of a prior ICR if the original ICR has previously been advanced to the Deployment Approval-Approved stage and the Railroad Change Manager's railroad has not previously deployed the version(s) of the ICI(s) in the ICR.

When a Railroad Change Manager creates an ICR that is an extension of a prior ICR, the PTC ILM system shall maintain a reference to the original ICR with the new ICR.

When a Railroad Change Manager creates an ICR that is an extension of a prior ICR, the PTC ILM system shall set the change type to Expedited to Deployment Approval.

Change Sponsor Requirements

When a Railroad Change Manager creates a new ICR, the PTC ILM system shall set the Change Sponsor to the railroad the user represents.

While an ICR is active, the PTC ILM system shall allow an Industry Change Manager to select a new railroad to act as the Change Sponsor.

Interoperable Change Management Form Requirements

The PTC ILM system shall include the following Interoperable Change Management forms:

Change Notification form

Latent Change Notification form

Decommissioning Change Notification form

Expedited to Business Approval Change Notification form

Expedited to Deployment Approval Change Notification form

Business Approval form

Expedited to Deployment Approval form

Deployment Approval form

Close Out form

Interoperable Change Management forms are completed by the Railroad Change Manager acting as the Change Sponsor.

Interoperable Change Management forms may contain general information fields and railroad-specific information fields. General information fields are for the Railroad Change Manager acting as the Change Sponsor to provide information that is applicable to all railroads responding to the ICR. Railroad-specific information fields are for each Railroad Change Manager to provide information relevant to the ICR that is specific to their individual railroad.

For each Interoperable Change Management form, the PTC ILM system shall include a response form.

Interoperable Change Management response forms shall include only the railroad-specific information fields.

Interoperable Change Management response forms are completed by each Railroad Change Manager in response to the completion of an Interoperable Change Management form. Requirements associated with responses to an ICR are in Section 4.6.9.

The PTC ILM system shall allow an Industry Change Manager to create configurable general information fields for any of the Interoperable Change Management forms.

The PTC ILM system shall allow an Industry Change Manager to create configurable railroad-specific information fields for any of the Interoperable Change Management forms.

The Change Notification form, Latent Change Notification form, Decommissioning Change Notification form, Expedited to Business Approval Change Notification form, and Expedited to Deployment Approval Change Notification form shall include the following general information fields:

ICI(s) Affected

Version(s) of Affected ICI(s)

Proposed Change Summary

Other Configurable Fields

The Business Approval form, Expedited to Deployment Approval form, and Deployment Approval form shall only include configurable general information fields.

The Interoperable Change Management forms, with the exception of the Close Out form, shall include the following railroad-specific fields:

Impact Level

Railroad-specific Comments

Other Configurable Fields

The Impact Level field in the Interoperable Change Management forms shall include the following options:

Impacted

Applicable

Not Applicable

Further information on the Impact Level field options can be found in the PTC ILM System Description and Operational Concept.

When a Railroad Change Manager completes an Interoperable Change Management form as the Change Sponsor, the PTC ILM system shall set the impact level to Impacted by default.

The Close Out form shall include the following railroad-specific fields:

Indication of whether ICR was completed

Other Configurable Fields

When a Railroad Change Manager is completing an Interoperable Change Management form, the PTC ILM system shall allow the Railroad Change Manager to attach external files as supplemental material for the ICR.

The PTC ILM system shall allow an Industry Change Manager to set a configurable number of days following the completion of an Interoperable Change Management form for responses to be due.

The PTC ILM system shall set the response due date for an Interoperable Change Management form to the configurable number of days past the date the Interoperable Change Management Form was completed.

The response due date may be overwritten by a Change Sponsor for expedited ICRs as described in Sections 4.6.5 and 4.6.7.

Change Notification Requirements

When a Railroad Change Manager creates a new ICR and selects a Normal change, the PTC ILM system shall prompt the Railroad Change Manager to complete a Change Notification form.

When a Railroad Change Manager completes a Change Notification form, the PTC ILM system shall set the ICR stage to Change Notification.

When an ICR is in the Change Notification stage, the PTC ILM system shall allow a Change Sponsor to advance the ICR to Business Approval-Pending.

When an ICR is in the Change Notification stage, the PTC ILM system shall allow a Change Sponsor to expedite the ICR to Deployment Approval-Pending.

When a Railroad Change Manager creates a new ICR and selects a Latent change, the PTC ILM system shall prompt the Railroad Change Manager to complete a Latent Change Notification form.

When a Railroad Change Manager completes a Latent Change Notification form, the PTC ILM system shall set the ICR stage to Close Out.

When a Railroad Change Manager creates a new ICR and selects a Decommissioning change, the PTC ILM system shall prompt the Railroad Change Manager to complete a Decommissioning Change Notification form.

When a Railroad Change Manager completes a Decommissioning Change Notification form, the PTC ILM system shall set the ICR stage to Close Out.

When a Railroad Change Manager creates a new ICR and selects an Expedited to Business Approval change, the PTC ILM system shall prompt the Railroad Change Manager to complete an Expedited to Business Approval Change Notification form.

When a Railroad Change Manager completes an Expedited to Business Approval Change Notification form, the PTC ILM system shall prompt the Railroad Change Manager to enter the response due date for the ICR.

When a Railroad Change Manager completes an Expedited to Business Approval Change Notification form, the PTC ILM system shall set the ICR stage to Business Approval-Pending.

When a Railroad Change Manager creates a new ICR and selects an Expedited to Deployment Approval change, the PTC ILM system shall prompt the Railroad Change Manager to complete an Expedited to Deployment Approval Change Notification form.

When a Railroad Change Manager completes an Expedited to Deployment Approval Change Notification form, the PTC ILM system shall prompt the Railroad Change Manager to enter the response due date for the ICR.

When a Railroad Change Manager completes an Expedited to Deployment Approval Change Notification form, the PTC ILM system shall set the ICR stage to Deployment Approval-Pending.

When a Railroad Change Manager completes a Change Notification form, a Decommissioning Change Notification form, an Expedited to Business Approval Change Notification form or an Expedited to Deployment Approval Change Notification form, the PTC ILM system and the ICI(s) affected and versions of ICI(s) affected are identical to those of a previous ICR, the PTC ILM system shall delete the new ICR and prompt the Railroad Change Manager to either respond to the previous ICR or create an extension of the previous ICR.

Business Approval Requirements

When a Change Sponsor advances an ICR to Business Approval-Pending, the PTC ILM system shall prompt the Change Sponsor to complete a Business Approval form.

When a Change Sponsor completes a Business Approval form, the PTC ILM system shall set the ICR stage to Business Approval-Pending.

When an ICR is in the Business Approval-Pending stage, the PTC ILM system shall allow an Industry Change Manager to advance the ICR to Business Approval-Approved.

When an Industry Change Manager advances an ICR to Business Approval-Approved, the PTC ILM system shall prompt the Industry Change Manager to enter comments.

When an ICR is in the Business Approval-Approved stage, the PTC ILM system shall allow a Change Sponsor to advance the ICR to Deployment Approval-Pending.

Deployment Approval Requirements

When a Change Sponsor advances an ICR to Deployment Approval-Pending, the PTC ILM system shall prompt the Change Sponsor to complete a Deployment Approval form.

When a Change Sponsor expedites an ICR to Deployment Approval-Pending from Change Notification, the PTC ILM system shall prompt the Change Sponsor to complete an Expedited to Deployment Approval form.

When a Railroad Change Manager completes an Expedited to Deployment Approval form, the PTC ILM system shall prompt the Railroad Change Manager to enter the response due date for the ICR.

When a Change Sponsor completes a Deployment Approval form or an Expedited to Deployment Approval form, the PTC ILM system shall set the ICR stage to Deployment Approval-Pending.

When an ICR is in the Deployment Approval-Pending stage, the PTC ILM system shall allow an Industry Change Manager to advance the ICR to Deployment Approval-Approved.

When an Industry Change Manager advances an ICR to Deployment Approval-Approved, the PTC ILM system shall prompt the Industry Change Manager to enter comments.

When an ICR is in the Deployment Approval-Approved stage, the PTC ILM system shall allow a Change Sponsor to advance the ICR to Close Out.

Close Out Requirements

When a Change Sponsor advances an ICR to Close Out, the PTC ILM system shall prompt the Change Sponsor to complete a Close Out form.

When a Change Sponsor completes a Close Out form, the PTC ILM system shall set the ICR stage to Close Out.

The PTC ILM system shall allow an Industry Change Manager to advance an ICR to the Closed stage from any other stage.

When an Industry Change Manger advances an ICR to the Closed stage, the PTC ILM system shall prompt the Industry Change Manager to enter comments.

ICR Response Requirements

When a Change Sponsor completes an Interoperable Change Management form, the PTC ILM system shall create an action for Railroad Change Managers representing other railroads to respond to the ICR.

When an Interoperable Change Management response form has not previously been completed for the current stage of an ICR by a Railroad Change Manager’s railroad, the PTC ILM system shall allow the Railroad Change Manager to complete a response form for the ICR associated with the stage the ICR is in.

When an Interoperable Change Management response form has previously been completed for the current stage of an ICR by a Railroad Change Manager’s railroad, the PTC ILM system shall allow the Railroad Change Manager to edit the response form for the ICR associated with the stage the ICR is in.

When an ICR is in the Deployment Approval-Approved or Close Out stage and an Interoperable Change Management response form has previously been completed for the Deployment Approval-Pending stage of the ICR by a Railroad Change Manager’s railroad, the PTC ILM system shall allow the Railroad Change Manager to edit the response form for the ICR associated with the Deployment Approval-Pending stage of the ICR.

This requirement allows a Railroad Change Manager to update deployment details on their railroad after the ICR has been through the Deployment Approval process.

When an interoperable Change Management response form is edited by a Railroad Change Manager, the PTC ILM system shall maintain a log of the edits made.

When a Railroad Change Manager is completing or editing an Interoperable Change Management response form, the PTC ILM system shall allow the Railroad Change Manager to attach external files as supplemental material for the ICR.

Interoperable Change Management CMDB Update Requirements

When an ICR is in the Deployment Approval-Approved or Close Out stage and the Deployment Date for a railroad deploying a new version of an ICI included on the ICR is reached, the PTC ILM system shall update the CMDB railroad deployment record to include the new version of the ICI for that railroad.

When an ICR is in the Close Out stage and a railroad completes a Close Out response form and the railroad indicated a version of an ICI would be decommissioned as part of the ICR, the PTC ILM system shall update the CMDB railroad deployment record to remove the version of the ICI decommissioned for that railroad.

Automated Email Notification Requirements

The PTC ILM system shall allow a user to subscribe to automated email notifications by the type of email notification.

When an Interoperable Change Management form is completed, the PTC ILM system shall send an automated email to subscribed users.

When an Interoperable Change Management response form is completed or edited, the PTC ILM system shall send an automated email to subscribed users.

When the Interoperable Change Manager advances an ICR to a new stage, the PTC ILM system shall send an automated email to subscribed users.

When an ICI is created or modified or the status of an ICI changes, the PTC ILM system shall send an automated email to subscribed users.

When an Interoperable PTC System Release is created or modified or the status of an Interoperable PTC System Release changes, the PTC ILM system shall send an automated email to subscribed users.

4.2 Performance Requirements

- The PTC ILM system shall support up to 10,000 users accessing the system simultaneously.
- The availability of the PTC ILM system shall be greater than or equal to 99.9 percent.
- All PTC ILM system data shall be recoverable in the event of system failure.

4.3 Extensibility Requirements

- The PTC ILM system shall be designed to support future Interoperable Design Coordination and Requirements Management functions.
- The PTC ILM system shall be designed to support future Industry Test Management functions.
- The PTC ILM system shall be designed to support future Knowledge Management functions.
- The PTC ILM system shall be designed to support other potential future subsystems.
- The PTC ILM system shall be designed to support other potential future PTC solutions.
- The PTC ILM system shall be designed to support other potential future railroad interoperable train control and operations support technology systems.

Abbreviations and Acronyms

Abbreviation or Acronym	Name
AAR	Association of American Railroads
ACSES	Advanced Civil Speed Enforcement System
AG	Advisory Group
CCM	Change and Configuration Management
CI	Configuration Item
CMDB	Configuration Management Database
COTS	Commercial Off-the-Shelf
CTC	Centralized Traffic Control
DTC	Direct Traffic Control
E-ATC	Enhanced Automatic Train Control
FRA	Federal Railroad Administration
ICAB	Interoperable Change Approval Board
ICI	Interoperable Configuration Item
ICR	Interoperable Change Request
IEEE	Institute of Electrical and Electronics Engineers
ILM	Interoperable Lifecycle Management
ITC	Interoperable Train Control
ITCS	Incremental Train Control System
ITIL	Information Technology Infrastructure Library
ITSM	Information Technology Service Management
MSRP	Manual of Standards and Recommended Practices
NEC	Northeast Corridor
PPM	Policies and Procedures Manual
PTC	Positive Train Control

Abbreviation or Acronym	Name
PTC IC	Positive Train Control Interoperability Committee
RSIA ‘08	Rail Safety Improvement Act of 2008
SACM	Service Asset and Configuration Management
TCCO	Train Control, Communications, and Operations
TTCI	Transportation Technology Center, Inc.
TWC	Track Warrant Control
UML	Unified Modeling Language