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Data Exchange Plan

Systematic Approach to Data Exchange for ERTMS Implementation and System updates

DIGI
RAIL

Version	Date.	Author	Reviewers	Approver	Comments
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Summary

Data Exchange Plan outlines the key strategies and procedures for managing and exchanging data within the project's framework. The document suggests roles and responsibilities of stakeholders involved in the data exchange process, assesses the types of data exchange formats available, and provides a combination solution. It discusses the needs for continuous development and change management. The plan also sets forth timelines, reporting requirements, and methods for resolving any issues or discrepancies that may arise. The plan aims to provide guidance for decision making and has been written with the understanding that many issues directly affecting the decision of data exchange formats are still pending and may need to be resolved prior to putting this plan into action.

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1 Introduction

The transformation of Finland’s railway infrastructure presents an opportunity for advanced data management and digitalization. As the nation modernizes its rail network with the implementation of the European Rail Traffic Management System (ERTMS), a coherent, strategic approach to data exchange becomes indispensable. This Data Exchange Plan has been devised to define the principles, methods, governance, and processes required to ensure secure, efficient, and standardized exchange of railway infrastructure data, particularly in the context of implementing and updating ERTMS. The plan provides a framework for all stakeholders, ensuring transparency, compliance, and the realization of digitalization benefits throughout the railway ecosystem.

1.1 The Need

ETCS is a safety-critical system, responsible for preventing collisions and ensuring the integrity of train movements. Consequently, both functional safety and cybersecurity place stringent constraints on how data is managed, shared, and used. Functional safety refers to the reliance on technology to perform its intended function without causing unacceptable risk of harm. In the context of ETCS, this means ensuring that the data upon which the system acts—track layouts, speed limits, position reports—is not only accurate but also delivered reliably and securely. Any error or unauthorized modification could potentially lead to catastrophic outcomes.

This requirement fundamentally limits open data exchange. While integrating asset management or predictive maintenance data with ETCS could improve efficiency, any such integration must be tightly controlled and rigorously validated. Interfaces between safety-critical systems and external repositories are subject to strict certification processes, and only data deemed essential to operational safety is allowed to traverse these boundaries. The tension between the desire for open, integrated data environments and the realities of safety-critical operations creates a unique challenge. Implementing ETCS involves not only addressing the technical requirements of train control but also considering the broader use cases of railway operation. Asset management, predictive maintenance, and digital twin simulations all offer potential for enhanced performance and cost savings. Yet, the means by which data is exchanged between systems must reflect the fundamental differences in risk profiles.

ETCS must be implemented with full consideration of its operational use cases. For example, real-time position reporting may be shared with traffic management systems to optimize train scheduling, but not with external analytics platforms. Asset data may be integrated with maintenance planning tools, but only after thorough validation and approval. Predictive maintenance algorithms may receive sensor data from rolling stock, but only under conditions that preserve the integrity and confidentiality of safety-critical information.

Each use case demands a tailored approach to data exchange, balancing the benefits of integration against the risks to functional safety and cybersecurity. Clear governance structures and decision-making processes are essential, ensuring that every interface and data flow is justified, documented, and continuously monitored.

1.2 Purpose

The principal objective of this Data Exchange Plan is to establish a systematic approach for exchanging railway infrastructure data in Finland in the context of implementing a new signalling system, ERTMS. This plan supports the overall data management and digitalization strategies of the Finnish rail sector, but does not aim to cover all aspects of data exchange needs. By defining clear protocols and standardized practices, the plan enables seamless integration of diverse systems, enhances operational efficiency, and ensures that all stakeholders have access to accurate, timely, and secure data. In particular, the plan underpins the implementation and needed updates of the ERTMS system, which is critical for safe, efficient, and interoperable rail transport across Europe.

1.3 Scope and Future development

The data to be exchanged under this plan comprises a broad array of railway infrastructure information produced or utilized during the deployment and update of the ERTMS system. ERTMS, understood as a comprehensive system of systems, is currently being deployed through a process, which requires multiple rounds of repetitive, manual production of various files and plans, and numerous rounds of error correction. In order to put this plan into action, major changes in the process need to be addressed and all parties involved must commit to the plan. This plan only considers use-cases related to the implementation of the ERTMS system. To achieve a comprehensive approach to data transfer and data management, the plan should also be evaluated from the perspective of potential additional use-cases and, if necessary, expanded as their requirements become clearer. Other use-cases refer, among other things but not limited to, to the development of traffic management systems, various infrastructure models, and the needs of maintenance.

Each data attribute shall be defined according to standardized models and specifications, when available, ensuring uniformity and compatibility across diverse platforms. This plan does not provide detailed specifications of data content. Instead, its focus is on defining the key principles for selecting, adopting, and governing data exchange formats. The intention is to establish a framework of decision-making and best practices that can guide the use and implementation of exchange formats, rather than prescribing the exact structure of the data itself.

1.4 Key Data Types

- Spatial design and to-be-built data (signalling design plans)
- Validated as-built data (final construction and configuration documentation)
- Configuration data of each subsystem and interface
- Logical operational data: functional data for operational purposes (train routes etc.)
- Maintenance data: historical and dynamic records, predictive analytics, fault logs of existing signalling system components, which are re-used in the implementation or update

2 Data Exchange Formats

Numerous initiatives, spearheaded by Shift2Rail and other organizations, have been undertaken to propose standards for data exchange within the railway domain (Wegele et al., 2019, 11). Notable examples include:

- IFC Rail (Industry Foundation Classes) by bSI, aimed at applying building information modeling to rail
- RTM/RSM (RailTopoModel/RailSystemModel) by UIC, for a comprehensive description of railway systems
- EULYNX DataPrep by EULYNX, for signaling specifications, models information needed to engineer a signalling system to a specific site
- TRANSMODEL, European Reference Data Model for public transport, serving software suppliers in planning, operation, and information processes
- RailML, facilitates data exchange between railway applications

The IFC Rail Project, part of the buildingSMART community, is designed to improve data exchange and interoperability in the railway sector, with harmonization efforts extending across multiple infrastructure domains. Its focus is on creating consistent standards, enhancing interoperability, and supporting continuous improvement through a phased approach that aligns with industry needs.

In Finland, the implementation of IFC Rail is forthcoming, with the Finnish Transport and Infrastructure Agency (FTIA) leading the effort. The adoption will bring Open BIM development closer to goals like predictive maintenance, monitoring, control, and better utilization of artificial intelligence, though significant progress is still needed. IFC Rail addresses asset information management primarily in spatial dimensions, but to fully implement systems like ERTMS, managing functional data is also necessary.

RailSystemModel (formerly RailTopoModel) facilitates interoperability across various railway domains without aiming to dominate any particular process. It collaborates with domain-specific projects such as Eulynx (signaling), IFC Rail (BIM), and ERA RINF

(European infrastructure), supporting high-level concepts spanning tracks, signaling, energy, telecommunications, rolling stock, planning, and management, across dimensions like functional, spatial, topology, geometry, time, lifecycle, and observation.

IFC coordinates with RailSystemModel and railML.org to clarify how functional and spatial data models relate and complement each other, ensuring continuity between construction and operation.

Transmodel is a European standard (EN 12896) for data exchange in public transport operations, particularly for real-time information and network/timetable services. However, Transmodel does not support static spatial objects or ERTMS-specific data, limiting its use for ERTMS deployment but making it valuable during system operation.

EULYNX is a European initiative standardizing railway signaling systems by defining common interfaces, promoting modularity, cost reduction, interoperability, and digital transformation. Finland is a leading participant, and EULYNX has been chosen as the principal interface format for Finland's ERTMS systems.

railML, launched in 2002, addresses integration challenges among diverse railway applications by providing XML-based solutions for seamless data exchange. It consists of three main components: Infrastructure, RollingStock, and Timetable, each with specialized subschemas. While railML focuses on operational purposes and does not always detail geometry (though essential for maintenance), its license restricts modification, preventing its use in logical or conceptual data models.

To ensure consistency, interoperability, and alignment with international and sector standards, this plan defines the following data exchange formats to be employed for different use cases and data categories:

- Primary Data exchange format: railML 3.x and evolving versions: The railML (Railway Markup Language) version 3.x, and its future evolutions, will serve as the primary data exchange standard for topology, coordinates, functional infrastructure elements, and interlocking information. This XML-based format is widely adopted within the railway sector for comprehensive and interoperable data sharing across different systems and vendors.

- Secondary data exchange format: when data type is not available in railML, IFC 4.x: The Industry Foundation Classes (IFC) version 4.x format will be used for spatial infrastructure elements, particularly in scenarios related to Asset Management and Configuration Management. IFC 4.x enables the structured exchange of building and infrastructure data, supporting complex geometries and semantic information crucial for lifecycle management.

- Tertiary data exchange format: National Extensions. Where required, national extensions will supplement standard exchange formats to address country-specific requirements not yet covered by IFC or railML schemas. However, as international standard formats mature and extend their coverage, the role and scope of national extensions will

gradually diminish, ensuring ongoing harmonization and reduced reliance on bespoke solutions.

These data exchange formats will be periodically reviewed, and the plan will be updated as the standards evolve, ensuring continued compatibility and support for emerging needs.

2.1 Data Sources and Destinations

Data sources in the ERTMS implementation phase include:

- Master Data Repository (to be defined later): The central repository for all infrastructure data needed in the implementation and updates of ERTMS
- Each implementing project’s Inframodel: Project-specific models and datasets
- Configuration data from system suppliers: Data provided by vendors for each subsystem

Design plans, to-be-built documentation, and validated as-built data reside in the Master Data Repository. During railway operation, maintenance and dynamic data will also be retrieved and stored within this repository, ensuring a single source of truth for all data needs across the infrastructure lifecycle.

2.2 Data Flow Overview

- Input: Design, configuration, and implementation data from projects and suppliers
- Storage: Centralized in Master Data Repository for consistency and accessibility
- Output: Operational and maintenance data for use by traffic controllers, maintainers, analytics platforms, and regulatory bodies

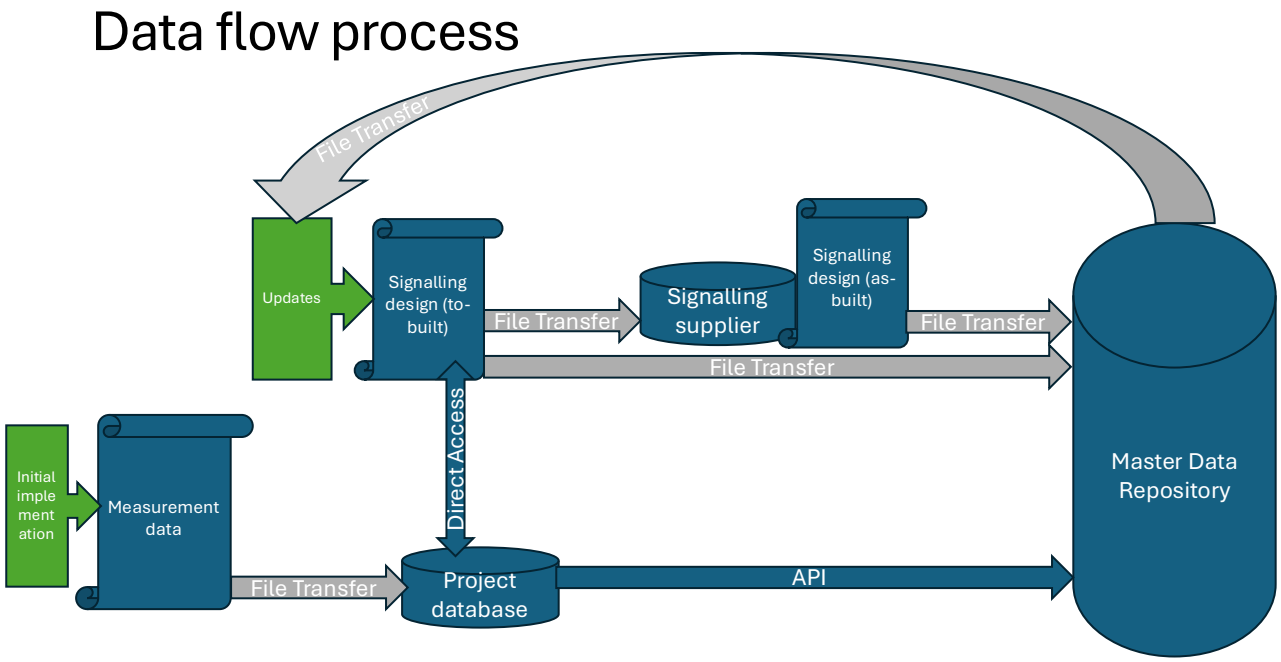

Figure 1 Data Flow Process

2.3 Methods of Data Exchange

During the initial phase, two primary methods of data transfer are employed:

- File Transfers: Secure, batch-based exchange of structured files between systems and stakeholders
- Shared Database: Direct access to the Master Data Repository for authorized users

As the data exchange ecosystem evolves, development will focus on deploying Application Programming Interfaces (APIs) to facilitate real-time, automated data exchange. APIs will be designed according to industry standards and will support both push and pull mechanisms, ensuring scalability and interoperability. APIs shall be the primary method of data transfer.

2.4 Future Development

- Transition from file-based to API-based data exchange
- Implementation of service-oriented architecture for modular integration
- Support for machine-to-machine communication

3 Governance and Management

Effective governance is critical for maintaining high standards of data quality, consistency, and reliability. Further agreements and more defined responsibilities for each role are discussed and agreed upon in a separate discussion between FTIA and Fintraffic and this plan does not aim to guide that discussion. The following roles and responsibilities have been recognized during the forming of this plan:

- Data Exchange Manager: Oversees the implementation and operation of the exchange system
- Infrastructure Manager (Finnish Infrastructure Agency, FTIA): Owns the data and sets strategic direction
- Data Quality Assurance: Monitors and enforces quality standards according to ISO 8000-150 framework
- Project Teams: Responsible for providing accurate project-specific data
- System Suppliers: Ensure the quality and integrity of configuration data
- Governance Manager: Awarded by FTIA to oversee exchange management, participates in the relevant development communities (IFC, railML), plans, coordinates and executes data exchange updates periodically.

Regular reviews, audits, and updates to the Data Exchange Plan will ensure ongoing alignment with best practices and evolving technological and regulatory landscapes.

3.1 Key Security Measures

- Role-based access control (RBAC): Ensuring that only authorized personnel can view, modify, or transmit data
- Encryption: Applying cryptographic techniques to secure data in transit and at rest
- Authentication and authorization: Multi-factor authentication, digital certificates, and secure tokens
- Audit trails: Logging all data exchanges to ensure traceability and accountability

Information security roles and responsibilities shall be defined in accordance with FTIA information security guidelines and processes developed in close cooperation with the development of data repositories and data models.

3.2 Legal Agreements

Clear legal agreements are essential to define the rights and responsibilities related to data exchange. The Finnish Infrastructure Agency (FTIA) holds sole responsibility for data ownership, usage rights, and liability of infrastructure data used and produced in the implementation of signalling systems. FTIA may award governance of the Data Exchange Management to a third party as necessary. Responsibilities defined here do not consider ownership of other infrastructure data.

- Data Ownership: All exchanged data is owned by FTIA
- Usage Rights: Data may be used only for approved operational, maintenance, regulatory, and analytical purposes, based on the security classification of the information
- Liability: FTIA assumes all legal responsibility for the data, including compliance with national and European regulations
- Data Governance: FTIA may delegate data governance to qualified external organizations under formal agreements
- Intellectual Property: Protection of proprietary data and technologies according to Finnish and European law

4 Data Exchange Development

To ensure the successful deployment of the Data Exchange Plan, a phased implementation roadmap will be followed. This roadmap is designed to systematically address each critical aspect of the plan, ensuring thorough preparation, execution, and continuous improvement.

Phase 1: Assessment and Stakeholder Engagement

In this initial phase, a comprehensive assessment of the current data exchange environment will be conducted. This includes identifying existing data sources,

understanding data flow, and recognizing any gaps or challenges. Engaging with stakeholders is crucial during this phase to gather their input, address their concerns, and ensure their support and collaboration throughout the project.

Phase 2: Design and Specification of Data Models and Exchange Protocols

Once the assessment is complete, the next phase involves designing and specifying the data models and exchange protocols. This includes defining the structure, format, and standards for data exchange to ensure compatibility and interoperability between different systems. Detailed specifications will be created to guide the development and implementation of these models and protocols.

Phase 3: Deployment of Initial Methods (File Transfer, Shared Database)

In this phase, the initial methods for data exchange will be deployed. This may involve setting up file transfer mechanisms and shared databases to facilitate the exchange of data between systems. These methods will be tested and validated to ensure they meet the required standards and perform effectively.

Phase 4: Development and Rollout of APIs and Advanced Exchange Mechanisms

Building on the initial methods, this phase focuses on developing and rolling out APIs (Application Programming Interfaces) and other advanced exchange mechanisms. APIs will enable seamless and real-time data exchange between systems, enhancing the efficiency and effectiveness of the data exchange process. This phase may also involve the implementation of additional security measures to protect data integrity and confidentiality.

Phase 5: Ongoing Monitoring, Review, and Optimization

The final phase involves the ongoing monitoring, review, and optimization of the data exchange processes. Continuous monitoring will help identify any issues or areas for improvement, while regular reviews will ensure that the data exchange mechanisms remain aligned with evolving requirements and standards. Optimization efforts will focus on enhancing performance, scalability, and security to ensure the long-term success of the Data Exchange Plan.

Change Management

Effective change management is essential to ensure the smooth adoption and lasting success of the Data Exchange Plan. Each phase of the implementation roadmap presents distinct challenges and opportunities that require thoughtful strategies to guide individuals, teams, and the broader organization through transitions. Key aspects of change management to incorporate throughout the deployment include:

- Communication and Transparency: Clear, consistent communication is vital from the outset. Stakeholders should be regularly updated on the goals, progress, and benefits of the Data Exchange Plan. Early identification of potential concerns or resistance allows for proactive addressing, fostering an environment of openness and trust.
- Stakeholder Involvement and Leadership Support: Engaging stakeholders at all levels—data owners, system users, IT teams, system suppliers and leadership—ensures their perspectives are heard and their needs considered. Securing strong sponsorship from leadership is critical for driving commitment, allocating necessary resources, ensuring awarded contracts support the objectives of the Data Exchange Plan and championing the initiative's value across the organization.
- Change Readiness Assessment: Prior to each major project milestone, conduct readiness assessments to gauge organizational preparedness for changes. These evaluations help identify potential barriers, such as skills gaps or resource constraints, and inform targeted interventions to increase readiness and resilience.
- Feedback and Continuous Engagement: Establish mechanisms for collecting and incorporating feedback throughout the implementation phases. Open channels for dialogue enable rapid identification and resolution of issues, while also empowering stakeholders to contribute ideas for improvement. This continuous engagement not only improves solutions but also strengthens buy-in.

Continuous Development and Standards Alignment:

The long-term effectiveness of the Data Exchange Plan depends on the ongoing evolution of the data exchange format. Continuous development, carried out in close collaboration with recognized standards communities, ensures compatibility with emerging technologies and best practices. Regularly scheduled updates to the data exchange format are necessary to address changing requirements, enhance interoperability, and maintain security. It is equally important to communicate these updates promptly and clearly to all stakeholders, facilitating seamless transitions and minimizing disruption. By actively engaging with standards bodies and committing to transparent update cycles, the organization strengthens the sustainability and relevance of its data exchange processes.

4.1 Conclusion

The Data Exchange Plan for Finland’s railway infrastructure offers a robust framework for the systematic management and exchange of data throughout the implementation and updates of ERTMS. By setting out clear principles, procedures, and responsibilities, the plan supports the development for digital transformation, interoperability, security, and regulatory compliance. Ongoing collaboration between FTIA, project teams, system suppliers, and potential third-party managers will ensure that the railway network remains at the forefront of technological advancement, serving the nation with safety, efficiency, and innovation.

It is important to note that there are still significant challenges to be addressed regarding the maturity of exchange formats, clarification of roles and agreements, ensuring data quality, and decision-making in a multi-stakeholder environment. This plan is only the first step; its practical implementation will require sustained effort, active collaboration, and ongoing adaptation to real-world complexities.

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