RB Rail AS
Reg. No 40103845027
K. Valdemāra iela 8-7
Riga, LV-1010, Latvia

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Detailed BIM Strategy

BIM Manual

Detailed BIM Strategy Guidelines

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Authors:

Diego González, Idoia Martínez, Manrique Gómez (AECOM Madrid)

David Philp & Stefan Mordue (AECOM i3)

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Contents

FIGURES

TABLES

1. Introduction

RB Rail AS is implementing BIM for the delivery of the projects to return significant time, cost and quality improvements in the way that the Program will be delivered, constructed and ultimately operated. BIM processes will provide RB Rail AS with a digital asset that can be used to better understand the project and to improve the decision making, engagement with key stakeholders, planning, improved asset management and knowledge of the assets.

This document and its supporting ecosystem of documents, forms and templates describe and provide the BIM Strategic processes and workflows to be followed by both Rail Baltica and the Supply Chain during the Lifecycle of the projects, being this ecosystem a live documentation that will evolve during the lifecycle of the Rail Baltica BIM program to capture technological and methodology advancements. All revisions and amendments will be communicated to the Supply Chain as required.

The BIM Manual documentation should be used for all the project phases as indicated in the Employer Information Requirements (EIR) of each project and is designed to define the framework for the BIM delivery at each of the specific project phases.

This documentation has been prepared by AECOM Madrid Civil & Infrastructure and AECOM i3, being part of the *Detailed BIM Strategy* Contract. This Strategy is the development of the main guidelines given by the *BIM Strategy Framework,* as part of the *Framework of Principles for the Development of the Detailed BIM Strategy* of RB Rail AS Contract, prepared by Intra-Team IT Consultants LTD.

2. References

2.1. Reference documents

This manual makes reference to the following documents of the project (most of those are not available with Public draft v0.1):

- BIM Strategy Framework
- CAD Standards (RBR-DOC-BIM-BMA-0002)
- Codification Tables (RBR-DAT-BIM-BMA-0004)
- Codification Standards (RBR-DOC-BIM-BMA-0003)

- BIM Objects Parameter Matrix (RBR-DAT-BIM-BMA-0005)
- Level of Definition (LOD) (RBR-DOC-BIM-BMA-0006)
- BIM Objects LoG Matrix (RBR-DAT-BIM-BMA-0007)
- BEP Post-Contract template (RBR-DOC-BIM-BMA-0020)
- TIDP template (RBR-DAT-BIM-BMA-0021)
- MIDP template (RBR-DAT-BIM-BMA-0022)
- BIM Delivery Report template (RBR-DAT-BIM-BMA-0030)
- QAQC CAD/BIM Checklist Report template (RBR-DOC-BIM-BMA-0031)
- Clash Check Report template (RBR-DOC-BIM-BMA-0032)
- QEX template (RBR-DAT-BIM-BMA-0033)
- QTO template (RBR-DAT-BIM-BMA-0034)
- Data Drop template (RBR-DAT-BIM-BMA-0035)

2.2. Standards, norms and guidelines

This manual makes use of the following technical standards:

- ISO/DIS 19650-1.2 Organisation of information about construction works -- Information management using building information modelling -- Part 1: Concepts and principles
- ISO/DIS 19650-2.2 Organisation of information about construction works -- Information management using building information modelling -- Part 2: Delivery phase of the assets
- PAS 1192-2:2013 Specification for information management for the capital/delivery phase of construction projects using building information modelling.
- PAS 1192-3:2014 Specification for information management for the operational phase of assets using building information modelling.
- PAS 1192-4:2014 Collaborative production of information.
- PAS 1192-5:2015 Specification for security-minded building information modelling, digital built environments and smart asset management.

In addition to the previous standards, other international Standards have been considered as a reference:

- BIM FORUM LOD
- UNI 11337-2017

2.3. Specific terminology

List of basic BIM concepts used in this document:

Term	Description
2D	Two-dimensional representation of an object, typically plans, sections, elevations and details. It can be created from scratch or generated from a 3D model.
3D Model	3D geometric models derived from engineering design applications, consisting of 3D solid objects and triangulated surfaces. Models may have varying levels of detail and development depending on the project phase.
4D	The intelligent linking of individual 3D CAD/BIM components or assemblies with time- or schedule-related information. 4D is 3D plus schedule/time.
5D	The intelligent linking of individual 3D CAD/BIM components or assemblies with quantities- or cost-related information. 5D is 3D plus quantities/cost.
6D	The intelligent linking of individual 3D CAD/BIM components or assemblies with project lifecycle-related information. The 6D model is provided with all the necessary data for the Operation and Maintenance stage. It is also called Asset Information Model (AIM). 6D is 3D plus project lifecycle information.
Asset Data Dictionary Definition Document (AD4)	These documents describe what the information requirements are, by defining the specific attributes (type-specific level) and how those attributes have to be populated.
Aggregated Model	A compilation of multiple models into a single manageable model. For example, an Aggregated Model may include a building model plus a site model, or several Mono-Discipline Models aggregated into a single Multi-Discipline Model. Aggregation - as a term - applies to both Integrated Models and Federated Models

Asset	An entity of value. In Asset Management, an asset refers to physical entities of tangible financial value similar to buildings, land, equipment, and inventory
Asset Information Model	File based federated BIM (models), set of BIM extraction (drawings, data drops) and project related documentation (reports and forms) developed during the operation and maintenance stages and that is regularly updated
Attribute	Data field populated with pieces of information attached to each BIM object to provide different types of information, like physical/geometrical characteristics, classification codes, locations, relationships, or data related to the BIM use cases. Some Authoring Tools call it "Parameter".
Authoring Tools	BIM Software developed by different providers that enable the creation and modification of BIM Models.
BCF	Open file format that allows the addition of textual comments, screenshots and more on top of the IFC model layer for better communication between coordinating parties. It separates the communication from the actual model
BIM Execution Plan Post-Contract	Re-submitted by the supplier to show all relevant parties have agreed and committed to the BEP. The BEP facilitates the management of delivery of the project. The post-contract BEP will be developed in detail over time as more members of the Supply Chain are appointed.
Building Information Modelling	Set of technologies, processes and policies enabling multiple stakeholders to collaboratively design, construct and operate a Facility in virtual space.
BIM Model	3D models containing information and attribute data.
BIM Use	The intended or expected Project Deliverables from generating, collaborating-on and linking Models to external databases. It represents the interactions between a User and a Modelling system to generate Model-based Deliverables (*e.g. Clash Detection, Cost Estimation, and Space Management*)
Clash rendition	Rendition of the native format model file to be used specifically for spatial coordination processes, to achieve clash avoidance or to be used for clash detection.
Common Data Environment	Single source of information for any given project, used to collect, manage and disseminate all relevant approved project documents for multi-disciplinary teams in a managed process

Data Drop (Data Files)	Extraction of the data information stored in the BIM Models. This data is extracted to spreadsheets or databases.
Data Exchanges	BIM Deliverables (Model files + Data files + Document files)
Employer's Information Requirements	Pre-tender document setting out the information to be delivered, and the standards and processes to be adopted by the supplier as part of the project delivery process
Federated Models	A BIM Model which links (does not merge) several Mono-Discipline Models together. As opposed to Integrated Models, Federated Models do not merge the properties of individual models into a single database
Gate Review	Design review carried out by RB Rail As and/or the National Implementing Bodies to confirm design outputs
IFC	Data model neutral and open specification (e.g. one that is not controlled by a single software vendor or group of vendors) that is used by BIM programs and that contains a model of a building or facility, including spatial elements, materials, shapes and information and attribute data.
Information Exchange	Structured collection of information at one stage of a project in a defined format and fidelity
Level of Definition	Collective term used for and including the "Level of Geometric detail" (LoG) and the "Level of Information" (LoI).
Master Information Delivery Plan	Post-Contract award deliverable which includes a plan listing all the information deliverables of a project including models, drawings, specifications, equipment, schedules, data drops and other kind of deliverables such as 4D videos. It identifies when project information is to be prepared, by whom, and defines the Levels of Definition and the procedures. It is created by collating the TIDPs of all the discipline of a project
Milestone	Scheduled event marking the due date for accomplishment of a specified task or objective. A milestone may mark the start, an intermediate point or the end of one or more activities.
Parameter	Synonym of "Attribute" used in some Authoring Tools. This document uses the term Attribute.

Project Implementation Plan	Post-Contract award deliverable which assesses the capability, competence and experience of the potential supplier bidding for the project, along with quality documentation
Project Information Model	File based federated BIM (models), set of BIM extraction (drawings, data drops) and project related documentation (reports and forms) developed during the design and construction stages
Supply Chain or Supplier	Provider of services
Task Information Delivery Plan	Post-Contract award deliverable, which includes a plan listing all the information deliverables of an specific discipline of a project including models, drawings, specifications, equipment, schedules, data drops and other kind of deliverables such as 4D videos. It identifies when project information is to be prepared, by whom, and defines the Levels of Definition and the procedures.
Virtual Construction Review	Team review of the digital engineering construction model
Virtual Design Construction	Use of 3D CAD or BIM models to check design and ensure geometrical accuracy as a rehearsal of the physical construction process.
Virtual Design Review	Team review of the digital engineering design model
Work Breakdown Structure	Multilevel framework that organizes and graphically displays elements representing work to be accomplished in logical relationships. Each descending level represents an increasingly detailed definition of a project component. Project components may be products or services. It is the structure and code that integrates and relates all project work (technical, schedule, and cost) and is used throughout the life cycle of a project to identify and track specific work scopes.
World Coordinate System	Coordinate system whose origin is specified by a user. This system enables multiple projects or models to use a common coordinate system for position designation.

Table 1: Specific terminology

2.4. Abbreviations

List of abbreviations used in this document:

Abbreviation	Meaning
AD4	Asset Data Dictionary Definition Document
AIM	Asset Information Model
AIR	Asset Information Requirements
AR	Asset Register
BCF	BIM Collaboration Format
BEP	BIM Execution Plan
BIM	BIM Information Modelling
BOQ	Bill of Quantities
CDE	Common Data Environment
EIR	Employer's Information Requirements (referred to BIM)
EIR/TS	Employer's Information Requirements and Technical Specifications
GIS	Geographic Information System
IFC	Industry Foundation Classes
IP	Intellectual Property
LOD	Level of Definition
LoG	Level of Geometric Detail
LoI	Level of Information
MEP	Mechanical Electrical Plumbing
MEPF	Mechanical Electrical Plumbing & Fire-Protection
MIDP	Master Information Delivery Plan
PI	Professional Indemnity
PIM	Project Information Model

PIP	Project Implementation Plan
QAQC	Quality Assurance & Quality Control
QC	Quality Control
QTO	Quantities Take-Off
RB	Rail Baltica
TIDP	Task Information Delivery Plan
VCR	Virtual Construction Review
VDC	Virtual Design Construction
VDR	Virtual Design Review
WBS	Work Breakdown Structure
WCS	World Coordinate System
WMS	Web Map Service

Table 2: Abbreviations

3. Principles and Goals

3.1. BIM Goals

Rail Baltica has taken a step forward in the digitalisation process that the BIM Methodology is shaping in the Civil and Rail sector, with the purpose to benefit of the BIM capabilities from the start of the development of the Rail Baltica project, and throughout the design, construction and operation stages.

The goals fixed by Rail Baltica are:

A) To focus on a lifecycle centric approach for information delivery and use.

B) The Pre-Construction Design by means of BIM models, achieved by creating virtual assets prior to construction and translating those virtual assets into physical assets. This workflow eliminates potential issues before construction and captures information during the process, in which the design, construction, performance and operations can be managed, visualized and simulated.

C) The mitigation of the loss of information during the lifecycle of the assets, stage to stage, by capturing relevant information once but using it several times throughout the process, reducing duplication of effort and maximizing its use in analysis, procurement and eventual operation.

D) To extend the use of BIM beyond 3D models to include wider information attributes, functional requirements, asset information together with linked documentation such as drawings, pictures, videos and related information sets.

E) Developing a set of common shared asset object types, providing a standardised and integrated structure to the data throughout the RB Rail projects, delivered under different procurements and contracts.

F) To capture operational and asset management information configured by the operator during the design and build process ready to users once complete, reducing the period of transition of data during the handover.

G) The escalation of the value of information through projects, enabling cross project information, by sharing data, resources and allowing a seamless coordination.

H) Encourage and support the design and construction Supply Chain to use BIM tools and technology in design and construction of the railway. With the specific aim of improved cross project coordination, removing errors early in the design process, reducing Requests for Information (RFI) between contracted parties, better quality and trustworthiness of deliverables.

I) To encourage the Supply Chain to freely use the best technology to achieve the information requirements thus not restricting them to specific design tools, sometimes with captive strategies.

J) To implement the technologies, the methodology and the BIM culture that supports these objectives recognizing the evolving nature of BIM and related technology.

3.2. BIM Strategy Principles

The principles of the BIM Strategy followed in the development of the BIM Manual and its supporting documents are:

A) **Gathering and Organisation the information** , capturing and coordinating the information at overall project level. Collecting, reviewing, approving and coordinating the information.

B) **Coordination and Standardisation** across RB Rail AS and national implementing bodies, but not other national authorities. Contracting delivery from Supply Chain following consistent Rail Baltica requirements / needs throughout the Rail Baltica project with consistent shareable, federated and useable formats.

C) **Drawing / Model - based Management of the documentation** , for other national approving authorities, by extracting and printing/plotting the data.

D) **File based federated coordinating delivery of information** . Allowing any kind of segregation and aggregation, from assets to projects and from files to databases

E) **An 'Open BIM' approach structure** , making possible (where feasible and through project standards where not) to allow a interoperability among the different actors involved in the project lifecycle, leaving the Supply Chain to choose their own tools and solutions for the production of the information.

F) **Definition of a Strategy evolvable** during the period of the project, because the BIM methodologies and the supporting local/international regulations are still being shaped.

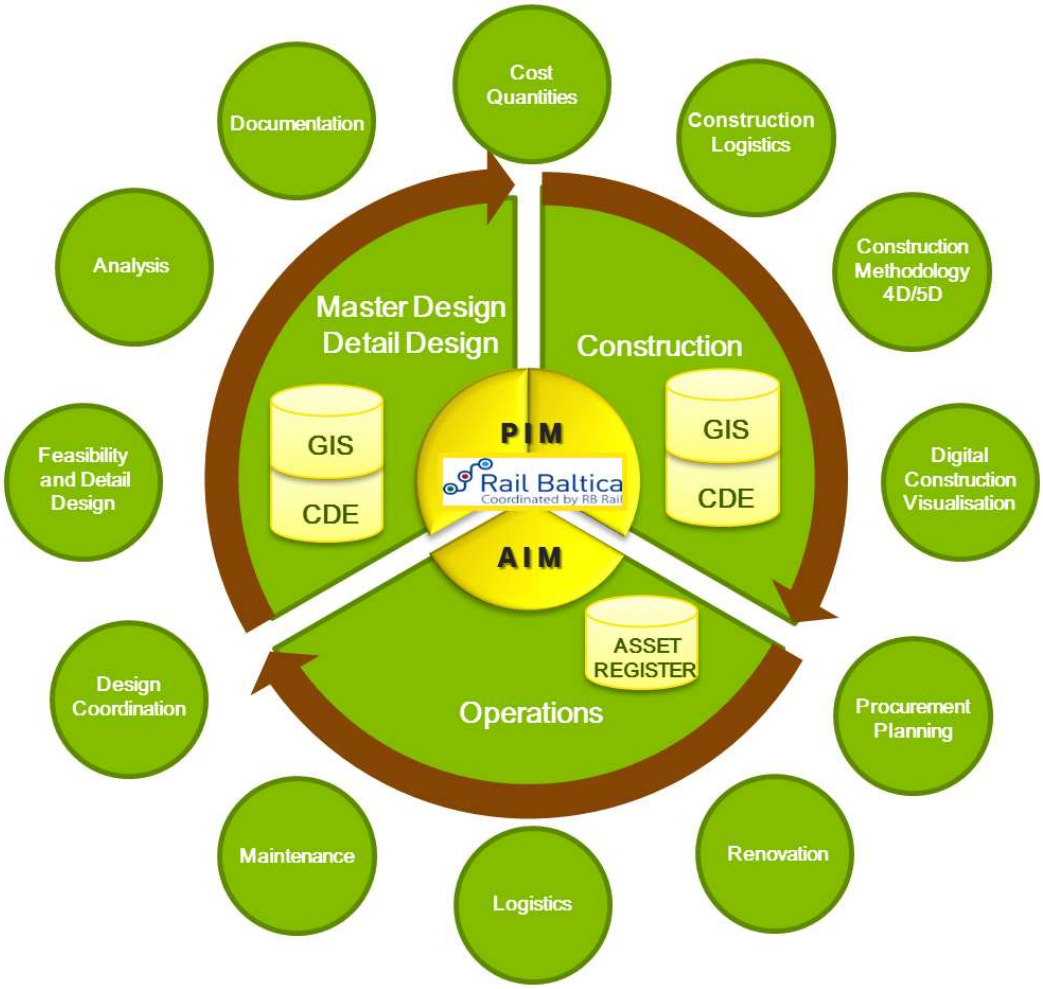

Figure 1: BIM Strategy Principles

3.3. BIM Use Cases

BIM information (both graphical models and non-graphical data) is initially created by the Supply Chain during the Design phases of the project. This information will be consumed by later functions where that data can input into their work processes. These "Use Cases" are summarised in the list below against each function. Some Use Cases are mandatory for any Rail Baltica project and the rest are optional. The optional Use Cases can be requested in the EIR or offered by the Supply Chain as an extra scope during the procurement phase. All the BIM Use Cases to be applied in each project shall be defined in the BIM Execution Plan.

The following table shows the mandatory and optional Use Cases. It should be noted that this is a guideline and that for each project the EIR indicates the specific Use Cases that are compulsory.

Mandatory (M) / Optional (O)	Design Authoring (Collaboration)	Engineering Analysis	2D Drawing & Schedule Generation	Interference Management (Clash Checks)	Interactive Design Reviews	Structural Detailing	Quality Control	Visualisations	Phasing and Construction Sequencing Simulations (4D)	Field Progress Tracking	Quantity Take-Off (5D)	Vendor Equipment Submittals	Augmented and Virtual Reality	Digital Fabrication	As-Built documentation	Operations & Maintenance Information
Value Engineering	M	O	M	O	M	O	O	O	O	-	O	O	O	-	-	-
Master Design	M	O	M	M	M	O	O	M	M	-	M	O	O	-	-	-
Detailed Technical Design	M	O	M	M	M	M	M	O	M	-	M	M*	O	-	-	O
Design for Administrative Approvals	M	-	M	M	-	-	-	O	-	-	O	-	-	-	-	-
Construction & As-Built	M	O	M	M	M	M	M	O	M	M	M	M	O	O	M	O
Operation	-	O	-	-	-	-	-	O	-	-	M	M	O	-	M	M

Table 3: BIM Use Cases

* - if the vendor can be specified in the project's documentation.

3.3.1. Design Authoring (Collaboration)

A BIM model of the principal elements of the Civil Works scope including Tunnels, Viaducts, Stations, Trackwork and Depots, covering architectural, structural, and MEPF works will be created by the applicable designers, in accordance with the Master Information Development Plan (MIDP) using discipline-based software which each designer controls, and where the required information from other teams is referenced from the CDE, using OpenBIM formats when technologically possible.

The **Design Authoring** is a **mandatory Use Case** for the Design and Construction Stages.

3.3.2. Engineering Analysis

The geometric BIM models produced from the core BIM authoring tools will be linked to, or exported to, analysis software for *Structural* / *Mechanical* / *Electrical* / *others* design analysis and calculation.

The **Engineering Analysis** is an **optional Use Case**, unless particularly specified in the EIR of the project.

3.3.3. 2D Drawing & Schedule Generation

General arrangement drawings, coordination drawings, location drawings and schedules of elements, objects, components and materials for all work scope that is modelled will be generated from the BIM model as sheet sets (data drops) that are contained in the BIM project model for that discipline. Typical details, assembly and component details, and shop drawings may be created separately from the BIM model depending on the Level of Definition of a particular Stage (see "Level of Definition" in this BIM Manual).

The details of drawings generated separately from BIM Models are to be stated in each sub-contractor's BIM Execution Plan Pre- and Post-Contract.

The **2D Drawing & Schedule Generation** is a **mandatory Use Case** for the Design and Construction Stages.

3.3.4. Interference Management (Clash Checks)

Design coordination between disciplines will be supported by running clash checks in both the authoring and reviewing software to identify spatial interferences between modelled elements. A clash register will be maintained for review and action during design reviews (the Clash Check Report is a deliverable). Lead Engineers will not be permitted to approve an element unless it is confirmed as being clash free (or free of relevant clashes) against all related models for that work.

The **Interference Management** is a **mandatory Use Case** for the Design and Construction Stages.

3.3.5. Interactive Design Reviews

The BIM model will be viewed live during interactive design reviews for all work scope and disciplines. Actions arising will be recorded against specific objects, zones or models and issued as comments to the model authors either through meeting minutes, comment sheets or reports.

The **Interactive Design Reviews** is a **mandatory Use Case**, unless particularly specified in the EIR of the project.

3.3.6. Structural Detailing

Concrete and Steel structural detailing of rebar and fabrication details will be completed from the BIM Model geometry and to specific Detailing BIM models, which will be the base for the shop drawings. The Design Subcontractor will confirm to Construction that the resultant detailed models are in compliance with the Design Model and can be incorporated into the BIM Construction Model.

The **Structural Detailing** is a **mandatory Use Case** when the Level of Definition reaches that requirement.

3.3.7. Quality Control

Validation of the BIM data received from the engineering or shop drawing process into the Construction Management Model.

The **Quality Control** is a **mandatory Use Case** when the Level of Definition reaches that requirement, Detailed Design and Construction Stages.

3.3.8. Visualisations

The BIM model will be used to create graphic visualisations and animations to assist communication of the works to Sub-Contractors, Suppliers, the Owner and other Stakeholders. This will also include demonstrating and illustrating safe methods of working, both to enhance graphics and posters for craft labour and through animations and toolbox talks, (e.g. showing the safe work method on a smartphone / tablet on site, an example being excavation support).

The **Visualisation** is a **mandatory Use Case** for Master Design, unless particularly specified in the EIR of the project.

3.3.9. Phasing and Construction Sequencing Simulations (4D)

Simulations of project phasing, construction installation sequences and operations will be created by linking the BIM models to the project schedule. Critical interfaces and critical path activities will be prioritized. Individual sequences may be associated with method statements and show particular installations or generic sequences. 4D sequences will not only be stored in the native file, but also be saved as video files, published as part of a design package, and used to validate constructability during Gate Reviews.

The **Phasing and Construction Sequencing Simulations** is a **mandatory Use Case**, to be developed according to the general Level of Development of each particular Phase (e.g. the 4D is more generic during Design Phase than during Construction Phase) The EIR will define the BIM Case in every project. To be agreed when not defined.

3.3.10. Field Progress Tracking

The BIM model will be used to both visualize and report the status of construction progress on site. Progress updates will be stored in the Construction BIM model with object tags against elements (based on WBS) being used to link that progress status to the BIM Objects using specific attributes for that purpose. It can be directly related to the 4D BIM Use Case.

The **Field Progress Tracking** is a **mandatory Use Case** during the Construction stage.

3.3.11. Quantity Take-Off (5D)

Quantity take-offs (QTO) will be extracted from the BIM model and made available in the CDE in a standard format for the whole Rail Baltica project, which will, as a minimum, align with the Rail Baltica Classification system for Bill of Quantities (BoQ) and Work Breakdown Structure (WBS) format.

The BoQ are a deliverable, included in the group of the Data Drops.

The **Quantity Take-Off (5D)** is a **mandatory Use Case**.

3.3.12. Vendor Equipment Submittals

Sub-Contracts and Purchase Orders for Suppliers, Vendors and Sub-Contractors whose scope of work includes the provision of equipment, materials, systems or assemblies will include for the supply of BIM models of that work scope in compliance with the BIM Standards for object modelling and associated attributes. By definition these supplied models will be at LOD 400. Supplier BIM Models will be verified by the Lead Designer for that work scope prior to incorporation into the Construction BIM Model.

The **Vendor Equipment Submittal** is a **mandatory Use Case**, discipline related and since the Detailed Design stage.

3.3.13. Augmented and Virtual Reality

The BIM model will be made available on site using mobile devices and will be viewable using Augmented Reality technology to visualize accurately on site both hidden elements and yet to be constructed elements of the works. This may include temporary works.

The **Augmented Reality** is an **optional Use Case**, unless particularly specified in the EIR of the project.

3.3.14. Digital Fabrication

The BIM model will be made available to manufacturers for the automatic fabrication of building components using Computer Numerical Control (CNC) machines to minimize tolerances and waste and maximize productivity. In particular, for structural steelwork, rebar and metalwork (ductwork) production.

Depending on the authoring tool, the manufacturer will require a further refinement of the BIM model or adaptations, these adaptations will be performed by the manufacturer in accordance with the supply chain.

The **Digital Fabrication** is an **optional Use Case**, unless particularly specified in the EIR of the project.

3.3.15. As-Built documentation

The BIM model will be revised as work packages are completed to record the as-built status of the works, and if necessary to re-adapt the positioning / shape / type of the objects to the actually built condition.

The **Record Modelling (As-Built)** is a **mandatory Use Case** for the Construction Stage. The Supplier during the Design Stage will develop a model that can be used / updated as a base for the As-Built models. The As-Built documentation will be also stored and used during the Operation stage.

3.3.16. Operations & Maintenance Information

The BIM model will be used to both visualize and report the status of construction testing and the collation of work packages ready for handover to the Owner for Operations and Maintenance. Test results will be stored in an Asset Register with object tags against elements (based on WBS and Asset Attributes).

The **Operations & Maintenance** is an **optional Use Case**, unless particularly specified in the EIR of the project. For this Use Case Rail Baltica or the Final Operator will provide the specific Asset Attributes. To be agreed when not defined. This Use Case becomes **mandatory** when the project reaches the Operation Phase after the Hand-Over.

4. Purpose

4.1. General

This BIM Manual sets guidelines and obligations for the Supply Chain in the context of the provision and exchange of "BIM" data with RB Rail AS and National Implementing Bodies in the form of digital models.

It aims to establish coherence between the various deliverables produced within the framework of BIM digital exchanges, particularly in terms of data consistency and geo-referencing.

This document is intended to evolve over time to define the technical rules necessary for the creation of all the BIM digital deliverables desired by the contracting authority, relating to the construction of the Rail Baltica projects, different phases of project, execution and operation.

This manual also includes specific appendixes or annexes for different purposes, such as templates for some of the deliverables.

This document may be subject to an update, but a newer version of the BIM Manual will not significantly modify the BIM strategy. However, the documentation present in the Annexes is subject to a periodical update, and it is composed of forms, templates, data dictionaries and checklists. Both the main document and the annexes are defined with a date and a version, therefore during the BIM kick-off meeting RB Rail AS / National Implementing Body (Client) and the Service Provider / Supplier will verify that the production will be made focusing the latest versions of the documents.

4.2. For whom is this manual

This version of the guide is intended for contractors and companies involved in all Rail Baltica projects.

The specifications of this document concern the following:

- All service providers involved in studies, projects and their subcontractors are referred to in this document as "Supply Chain", “Service Providers” or “Supplier”.
- RB Rail AS / National Implementing Bodies’ staff (or third parties acting on their behalf) who produce or update the digital documentation / data / models.
- Companies involved in the construction of the project and producing digital models. These organisations will create and use content for the design, definition and construction of the infrastructure until the Hand-over.
- Operation & Maintenance organisations that will consume the data from the Project Information Model (PIM) prepared during the Design and Construction stages. These organisations will define asset information dataset requirements for the BIM objects so that they can consume and complete the data for their Operation stage. They will take over the PIM and will migrate it to the Asset Information Model (AIM) for their use.
- Beneficiaries and other Stakeholders, as long as the RB Rail AS has granted them access to the data, or just a relevant discipline/part of a project, upon their request.

4.3. Use of this manual

The different sections in this document and its annexes explain the What, Why, Who, Where and How that RB Rail AS expects from the Supply Chain and their deliveries.

The BIM Manual and its updates are managed exclusively by RB Rail AS.

The successive versions of the manual and its appendix are exclusively managed in the-website XXX (Codification, validation, version management, distribution, etc. ...)

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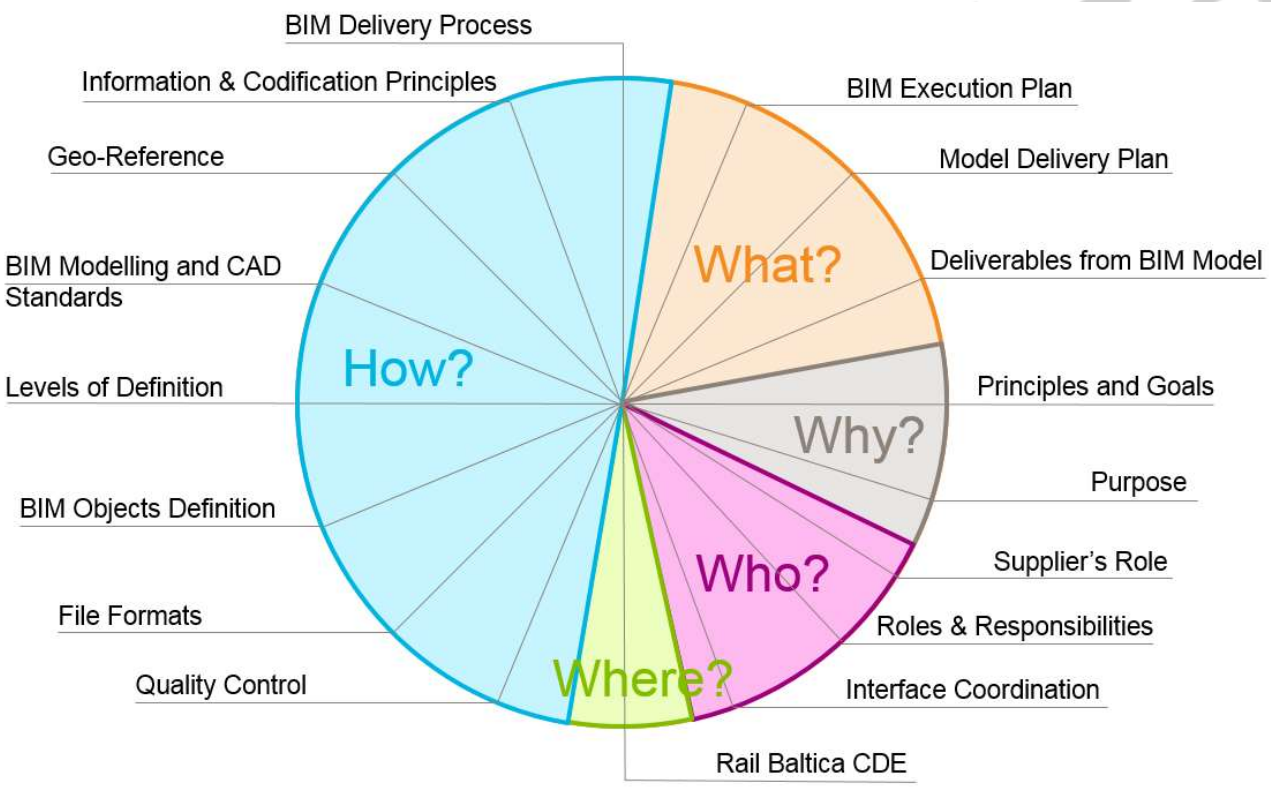


Figure 2: BIM Manual Sections

4.4. BIM Manual documents ecosystem

The BIM Manual has a list of supporting documents, forms and templates, structured as follows:

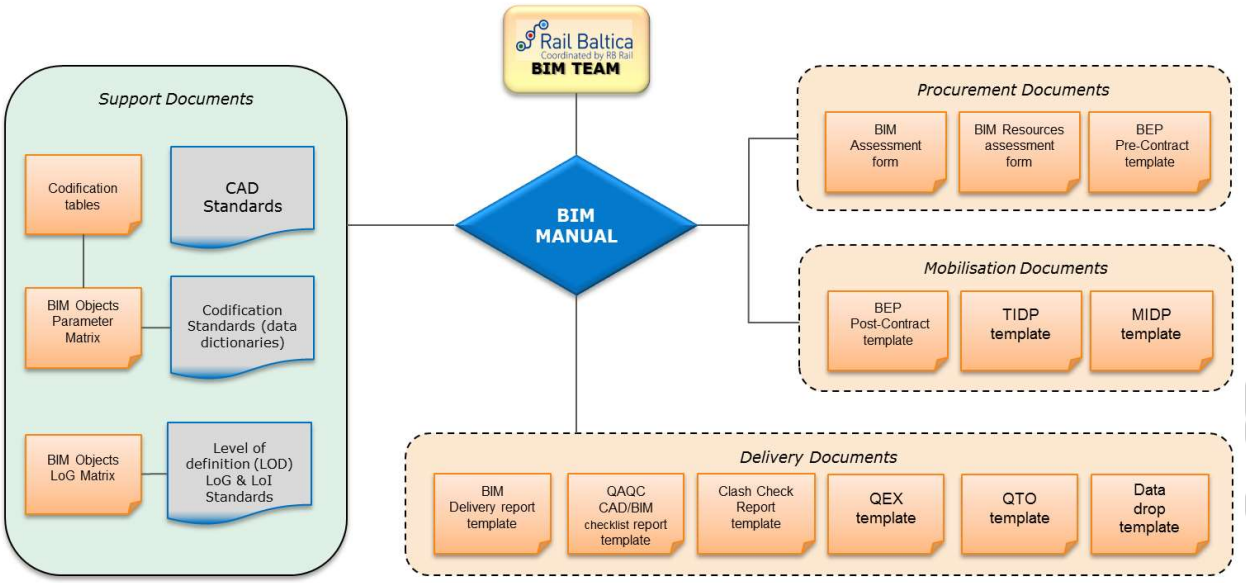


Figure 3: BIM Manual Documents

4.5. Technical Production Software: OpenBIM

RB Rail AS does not impose any specific software for the realisation of the deliverables. On the other hand, it defines the supply format of these, which will be Open so that any actor can have access to the data. This approach will, in practice, mean that most of the files will be delivered in both formats, native and open. Native formats, and their support files, will be required when the open one cannot assure the possibility to update its content in future stages by only importing the file with any kind of authoring tool.

Example: CSV will be the open format for spreadsheets, but the XLSX can also be submitted as native if there is a specific capability that cannot be maintained by exporting to CSV format. In any case, CSV will always be released as the open format. This approach can be extrapolated to any other format, like BIM models with the IFC format. See "File formats" Section for further details.

RB Rail AS recalls that it is engaged in a process of "license compliance", it asks all of its partners to respect this program. RB Rail AS reserves the right not to accept documents from all partners who do not respect this protocol (use of "education" license or "pirate" license).

4.6. Deliverables ownership

The Supply Chain shall transmit the BIM data to the representative of RB Rail AS at the end of each project phase.

Any use of BIM data or images from BIM data for commercial purposes or remote from the project needs to be subject of a request to RB Rail AS, and an agreement formalized by it.

The Supply Chain undertakes not to disclose BIM data or associated documents transmitted by RB Rail AS in the execution of its mission.

RB Rail AS shall acquire legal title to and ownership in the Intellectual Property in all Documentation delivered by the Supply Chain as of the moment of delivery; provided, however, that RB Rail AS has paid the Service Fee or other consideration payable under the agreed terms with respect to the relevant part of the Service or Deliverable. For the avoidance of any doubt, such title and ownership shall confer upon RB Rail AS, without limitation, each of the following:

- the right to reproduce the Documentation, or any part thereof, and distribute copies of the Documentation or any part thereof;
- the right to modify, amend and supplement the Documentation, or any part thereof;
- the right to licence the Documentation, or any part thereof, for use by others; and
- the right to transfer ownership in the Documentation, or any part thereof, to others.

4.7. Intellectual Property

RB Rail AS acquires legal title to and ownership in the Intellectual Property (IP) in all Documentation deliverable to RB Rail AS as of the moment of delivery, which includes any documentation stored in Rail Baltica's CDE.

The Service Provider / Supplier must inform the RB Rail AS BIM Manager of any perceived IP concerns or restrictions in the development and issue of the specified BIM deliverables. Any IP concerns will be considered with respect to the impact on the BIM deliverables, but the resolution of any impact to the agreement of the RB Rail AS BIM Manager will be the responsibility of the Service Provider.

4.8. Service Provider / Supplier Insurance

The Service Provider / Supplier shall take out all insurance necessary to cover its liability, both with regard to its professional liability and its liability for damages to Rail Baltica or third parties for death or injury, loss or damage of property.

Each Service Provider is to review all the Detailed BIM Strategy documents to ensure that they are satisfied with the requirements and that they are in line with their insured area of expertise.

4.9. Phases of the Project Information Model process

The Rail Baltica Project Information Model (PIM) is structured in the following phases:

- Value Engineering

- Master Design
- Detailed Technical Design
- Design for Administrative Approvals, (not a stage itself, but a specific submission will be needed during the previous stages, as defined particularly in the EIR, depending on the local authorities)
- As-Built

The content of the BIM data expected to be delivered by the Supply Chain varies depending on the phase. As the project advances, the BIM requirements will be higher as the design information will have to be more detailed and developed and the Supply Chain BIM capabilities will also be more mature. These requirements are described in this Manual and also, and more detailed, in the Employer Information Requirements (EIR) of each project.

After the PIM comes the Asset Information Model (AIM), if Rail Baltica and the Infrastructure Operators decide to implement it. The AIM is structured in the next stages, and unlike the PIM, the stages can coexist:

- Operation itself.
- Maintenance, Minor Works. Regular maintenance.
- Maintenance, Major Works. Refurbishing, major repair or new delivery of assets.
- Decommissioning
- Dismantling

4.10. Evolution of deliverables – The BIM Deliverable (BIM Implementation Plan)

The process initiated by RB Rail AS introduces a new deliverable, the **BIM deliverable**, which is the central element of the design of the works and also the source for other deliverables such as 2D drawings and Object Data Tables. Thus, it should help to promote exchanges and improve the understanding of the design.

It is requested that all the deliverables will be extracted from the BIM Model and will be referred to a particular BIM model defined with a particular version, date, naming and WBS:

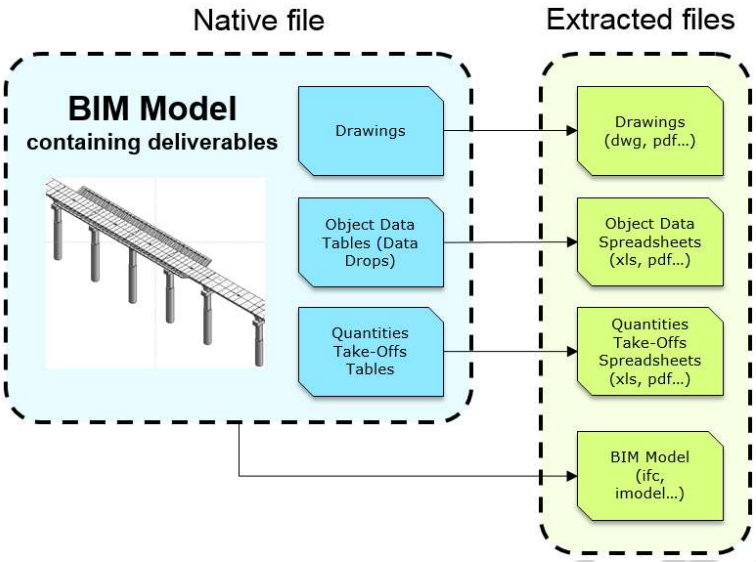


Figure 4: The BIM Deliverable

The submission of items that are not extracted from the BIM Model is allowed as long as RB Rail AS approves it. The responsible of the deliverable shall specify when this is the case, because the quality controls to check the coordination and coherence of these items are different from the ones extracted from the BIM Model.

The production of the BIM Model requires the passage through the following steps:

- **Step 0 (Value Engineering):** the concept drawings are produced in 2D. Specific parts of the project only will be applied in BIM (LOD).
- **Step 1 (Master Design):** the BIM Model, a 3D model containing information and attribute data, is generated, making possible to produce the contractual 2D data (dwg / pdf) and becoming itself a deliverable. It also enables the production of a simplified 4D planning and a 5D Quantity take-off and Cost Estimating of the modelled elements with sufficient detail (it could be needed to include quantities non-modelled because of the lack of definition of the stage in certain cases)
- **Step 2 (Detailed Technical Design):** the BIM Model makes it possible to produce not only the contractual 2D data (dwg / pdf), but also 4D and 5D data, which are also contractual deliverables. The 5D quantity take-off and cost estimating should be carried out mainly with data directly extracted from models.
- **Step 3 (As-Built):** more BIM uses are integrated and their data will be prepared for the next step, the Operation and Maintenance (6D).
- **Step 4 (Operation & Maintenance):** the BIM Model is updated according to the maintenance carried out during the life of the asset. More BIM uses can be integrated during this phase, such as failure prediction.

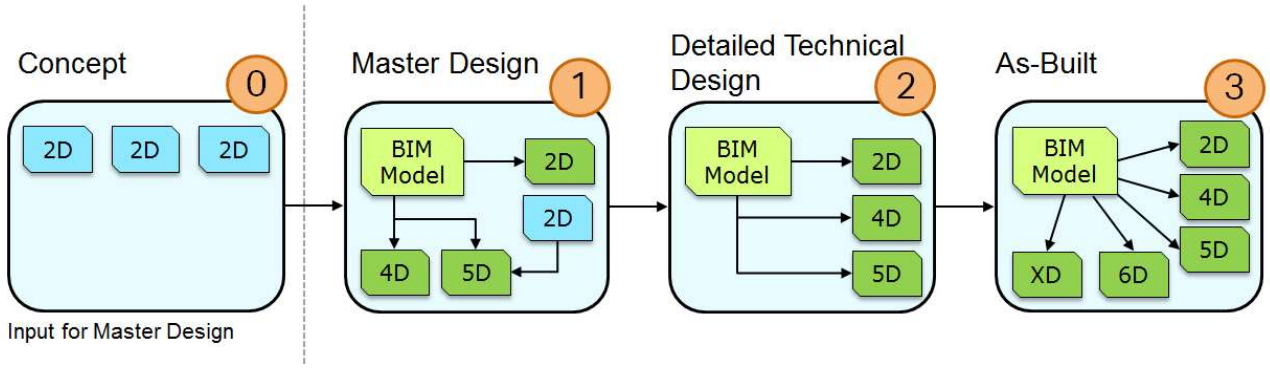


Figure 5: Steps from 2D to As-Built BIM Model

This document describes the necessary processes to apply Step 1, 2 and 3.

After the Step 3 comes the Step 4, where the produced BIM models and its BIM extractions: XD (any bespoke use), 2D, 3D, 4D, 5D and 6D (asset data ready for O&M) gets translated from a file based to a data-based structure that also has a file based structure (BIM models for instance) inherited from the Step 3.

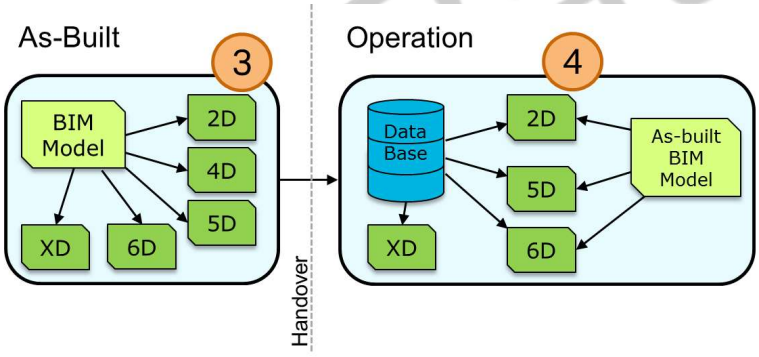


Figure 6: Steps from As-Built Model to Operation Model (Handover)

This document briefly indicates the process to apply from Step 3 to 4, because the actual Operator/s must provide the necessary inputs, the uses, requirements = Asset Information Requirements (AIR), the data preferences and the most important the Assets the Operator will be interested on managing (whether some like 1 or more stations, tunnels, utilities or the complete portfolio of the Infrastructure). For further information see "Rail Baltica CDE" Section and "Information Lifecycle through PIM and AIM" point in "BIM Delivery Process" Section.

4.11. Differences between 3D model and BIM Model

The BIM Strategy focuses on an approach based on two different kind of models, the 3D models (only Geometry) and the BIM models (Geometry + information data attached to the objects). The first ones, while geometrically defining elements, objects and assemblies permitting a 3D coordination by means of a clash detection, are not providing a full set of information in the way the BIM methodology pursues. Therefore, these 3D models, no matter

their format and the authoring tool they have been prepared with (even with BIM software), will be limited to deliverables concerning non-buildable objects, or in other words, to out of scope objects/models. This limits the possible 3D models to environments, existing utilities, third parties' scopes/models and Point Clouds.

The distinction between 3D model and BIM Model is mainly at the level of the information provided. The following table sums up the differences:

	3D Model	BIM Model
Information Content	Only geometry	Geometry + Data Its elements must contain the required data in the form of attributes
Use	Project visualisation Source or input for the design	Project design Every asset to be designed and constructed
BIM Manual application	Does not need to follow the information data configuration, 3D models will follow the naming and the Work Breakdown Structure (WBS)	Must follow all the BIM Manual, information data configuration included.
Software	Made from any 3D software (BIM or not), provided that importing the model into BIM software retains all the generated forms	Made from any BIM software
Links	Linked as reference in the BIM models No linked models inside it	Linked as reference in other BIM models Can have 3D models and BIM models linked inside it
Examples	3D Terrain Models (topographic type similar to that provided on the area concerned by the works) materializing the ground and its immediate facilities involved in the operation, as well as their connection to the existing Existing utilities and infrastructures Environmental works of the projects, not affected by it	Infrastructure: architectural, structural, installations or utilities models Building: architectural, structural, installations or utilities models Railways or roads models

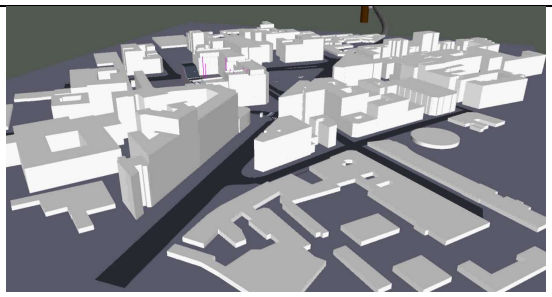
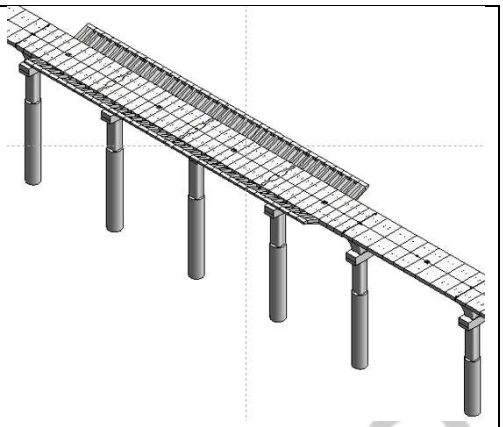
		

Table 4: Differences between 3D and BIM Model

5. BIM Delivery Process

The lifecycle of a BIM project has some particularities in comparison with a traditional one, most of them strictly related to the new workflows and processes, what makes necessary to dedicate time to understand the differences, not only in the requirements, but also in the way the deliverables are consumed so as to be in the position to prepare them correctly. This Section focuses on the steps and the new deliverables needed during the process.

5.1. Life cycle approach

The Rail Baltica BIM Strategy follows the approach set out in the European standard ISO 19650-1, which fits with the BuildingSMART International Delivery Standards. Previously the British Standards 1192 series (PAS 1192:2-2013 in particular) had already defined the lifecycle process in depth.

This life cycle approach is focused on the life expectancy of the **Assets**, physical entities of tangible financial value similar to buildings, land, equipment, and inventory, from the Design to the Operation and Maintenance phase, passing through the Construction phase. There is a replacement of costs in the delivered data, from the Operation to the Construction and Design phases, and from the Construction to the Design phase. Thereby the owner gets a benefit in the overall costs because even if the process may cost more initially (especially during Design), the savings are overall higher because the **decision making** is improved at the moment where the ability to impact cost and functional capabilities is higher and the costs are lower. See graphic below (source www.theNBS.com):

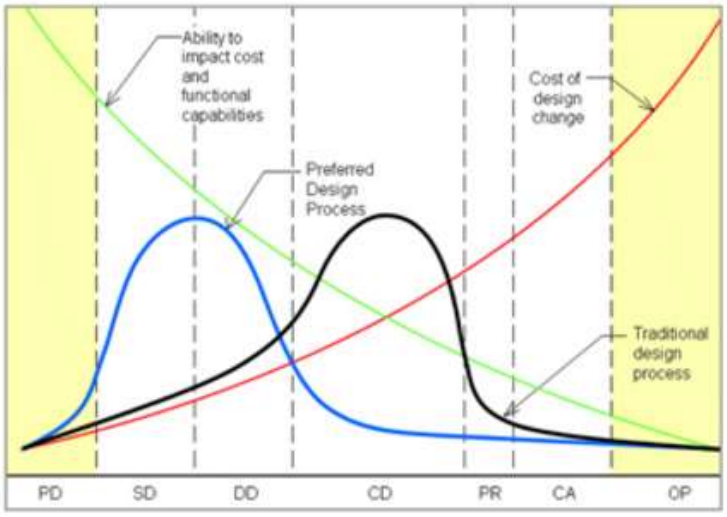


Figure 7: Lifecycle costs comparison

The life cycle approach closes (or actually begins) the cycle when during the Operation & Maintenance phase there is a feedback to the BIM Strategy to enhance the processes and the data structures by improving the EIRs (or directly setting up and providing the requirements needed so that the Design provider and the Construction supplier deliver the BIM models with the data needed for the Operation phase). Having said that, BIM becomes a lifecycle having the end in mind since the start. This approach takes shape in the Rail Baltica's stages as follows:

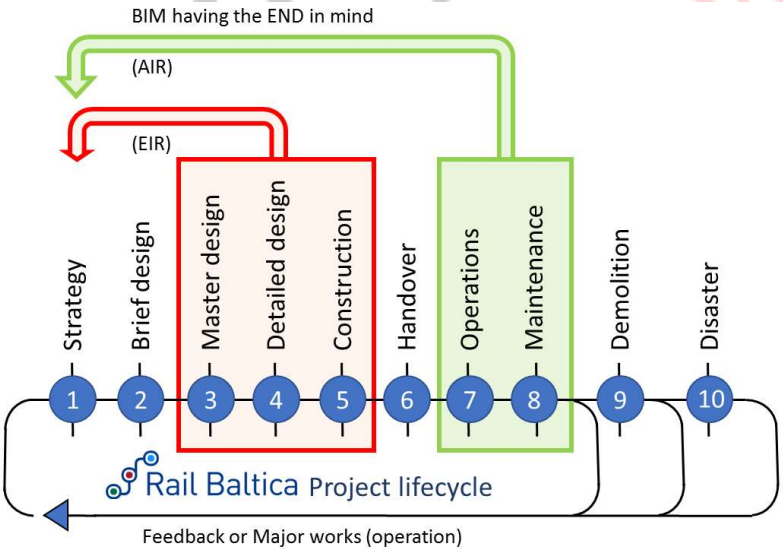


Figure 8: Project lifecycle

Therefore, the BIM Strategy sets up the processes for the BIM route, which needs various ruling procedures. This configures an ecosystem of requirements that is generally led by the BIM Manual and is particularly driven by the Employer Information Requirements (EIR) for the Design & Construction phases and the Asset Information

Requirements (AIR) for the Operation & Maintenance phase. This BIM Manual differentiates between EIR and AIR but RB Rail AS may call both of them EIR in an undifferentiated way.

The translation of this approach into a phase & procedure-related workflow is shown below:

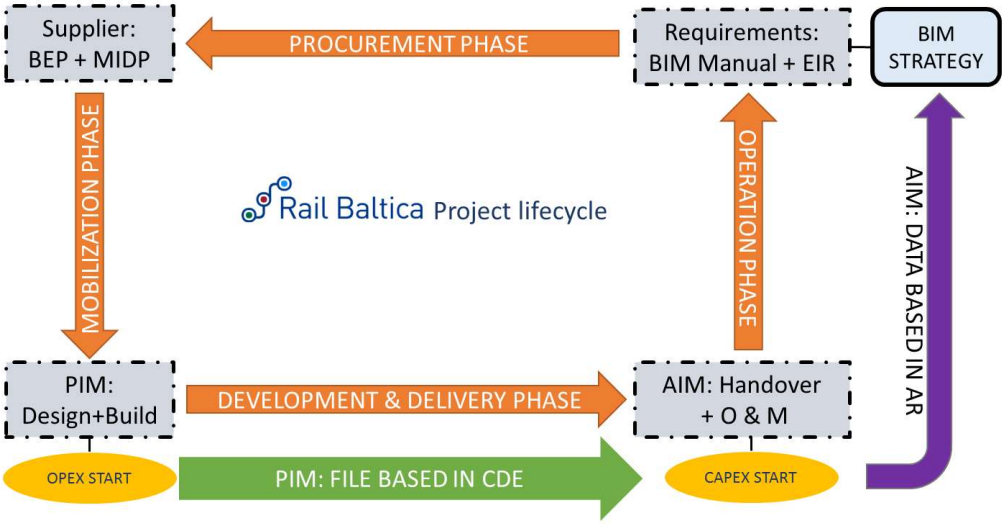


Figure 9: Lifecycle Phase&Procedure workflow

It is important to mention that the Design and Construction phases make use of a **file based approach**, shaped in the form of models (geometry and data information) creating the Project Information Model (PIM) and being stored collaboratively in a Common Data Environment (CDE).

In the same way, the Operation & Maintenance phase makes use of a **data based approach**, creating the Asset Information Model (AIM) and being stored in an Asset Register (AR).

The cycle with all the different phases is described in the next points:

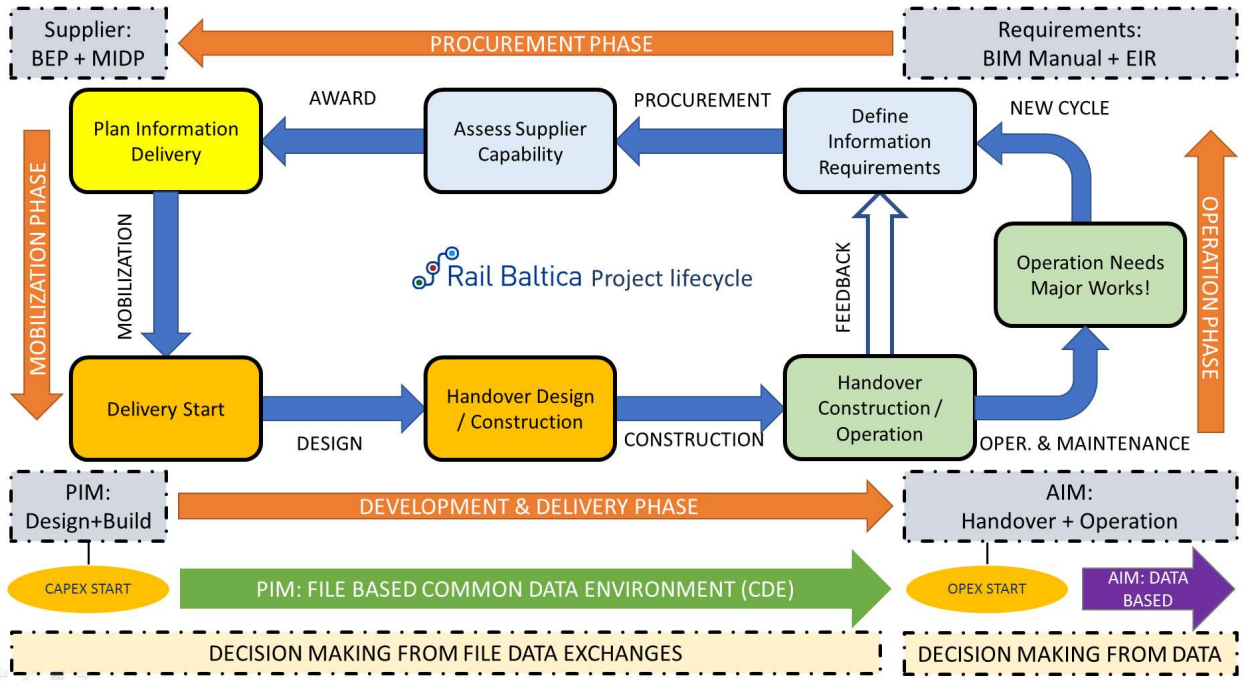


Figure 10: Lifecycle phases' workflow

5.2. Gathering Existing Information & Contract Briefing

The starting point of the Delivery process begins by collecting the available information from earlier analysis, surveys and databases in addition to those taken from previous projects.

The setting out of the Employer Information Requirements and the delivery standards for the information takes place, including format and structure of the data. The BIM rules and standards of reference are defined in the BIM Manual, stating how the information will be exchanged, coordinated, validated and approved. This makes the delivery of required information a contractual obligation to use a CDE approach to information delivery.

5.3. BIM Delivery Plans

On award of contract, the selected designer/contractor produces, in discussion with the client, a detailed BEP (called Post-Contract BEP) which includes the Task Information Delivery Plans of each discipline/package (TIDPs), a Master Information Delivery Plan (MIDP) collating all the packages together, and the Supplier CAD Manual (Adaptation of the "RBR-DOC-BIM-BMA-0002_CADStandards" to its authoring tool). This sets out what data models will be delivered, lists those deliverable, how they will be broken down and who is responsible for those deliveries. BEP, TIDP and MIDP templates are included in the annexes, as well as a drawing template (DWG).

As part of that delivery plan the designer/contractor will demonstrate how they will ensure that the delivery is co-ordinated and meet the requirements of Common Data Environment (CDE) including delivering data to the Rail Baltica Common Data Environment for approval and wider sharing.

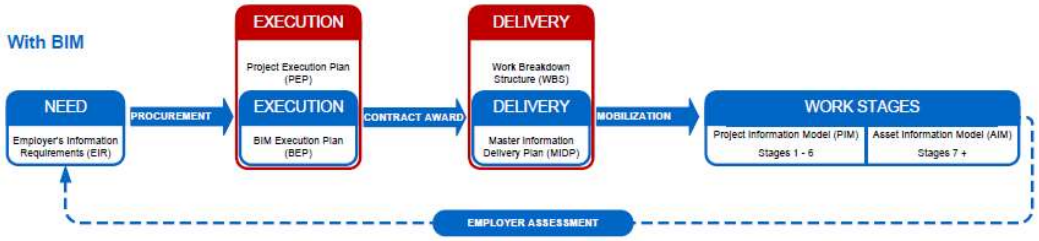


Figure 11: Procurement & Contracting Deliverables

5.3.1. Mobilisation Phase

Before the delivery phase, there is a stage that focuses on mobilising the technologies, people and communications to enable delivery and data exchanges to take place. This is an important moment because if these tasks are not carried out before the commencement of the Design, they will therefore affect to the first months of the Delivery, being one of the key reasons of failure in the BIM implementation.

In the case of Rail Baltica, it is proposed that central systems are set up ready for each project. This should include technology, start-up materials, training and education plus a central support mechanism. Hence mobilisation for each project will consist of plans and implementation of communication, roles and responsibilities, systems and system connection.

Time and resources should be planned for this mobilisation set up.

5.4. Delivery Phase

BIM Project information delivery starts supported by the project Common Data Environment. Data is collected progressively fulfilling the project 'Information Requirements' stage by stage coordinating across the project.

The Delivery phases (Design and Construction) are detailed in the "Model Delivery Plan" Section. It is worthy to mention that even the Operation & Maintenance phase has specific deliverables and shares the same structure of deliverables when they are file based, and therefore this section also includes details about the O&M phase.

5.4.1. Delivery Content

The Delivery content is described in depth in the "Deliverables from BIM models" and "File Formats" sections.

5.5. Delivery Collaboration and Coordination CDE

In order to support project wide collaboration and coordination it is proposed that a Common Data Environment (CDE) process and technology is implemented during the preparation of the Project Information Model (PIM) = Design + Construction phases and another during the Asset Information Model (AIM) = Operation phase. Both CDEs could be the same if correctly configured for that purpose.

An example of such a CDE can be found in the principles of ISO 19650. These principles define the process and standards for carrying out coordination between multiple Supply Chain sources and controlling the delivery of that information. These processes are described in the "Rail Baltica CDE" Section.

The CDE acts as an information funnel process capturing and coordinating each layer of the Supply Chain into a coherent and validated data set. It can be used at each layer of the Supply Chain and eventually deliver assured federated data sets to the project.

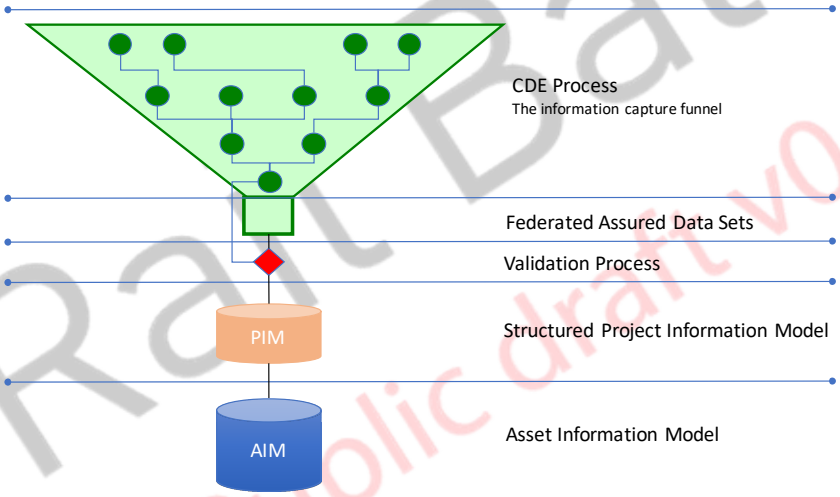


Figure 12: From the CDE Information to the AIM

5.6. Information Lifecycle through PIM and AIM

The Information Life cycle is the story of how the project data is developed during the Design and Construction (generating the PIM) in response to the requirements set out in the EIR. After a migration according to the AIR to comply with the OIR, the project data becomes built asset data, which is used during the operational phase of an infrastructure (generating the collated set of information of the AIM).

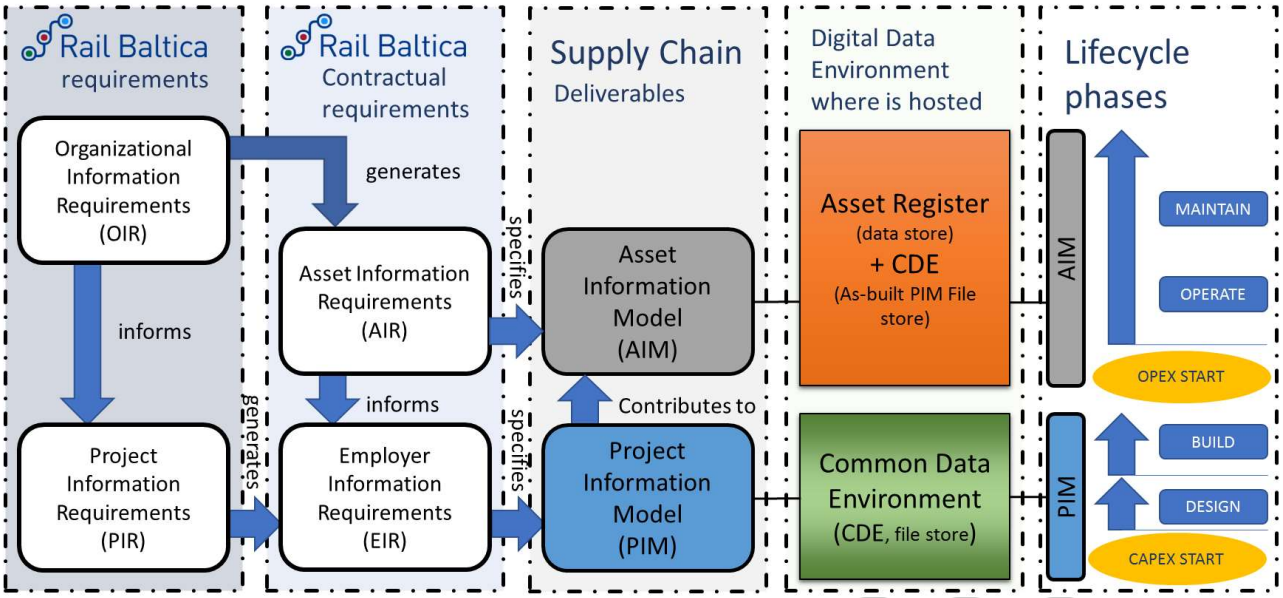


Figure 13: Lifecycle – PIM and AIM

The PIM consists in a file based federated BIM (models), a set of BIM extraction (drawings, data drops) and project related documentation (reports and forms).

During the development of the PIM, the Level of Definition (LOD) increases gradually and at a certain point the PIM becomes a virtual pre-construction model composed by objects and defined in a way that could be constructed, manufactured or installed. The final output is the complete set of As-Built BIM (models) and non-graphical information generated in the PIM.

Once the Handover takes place, the AIM gets generated with a mapping process taking as the base the As-Built data from the PIM (thus disregarding any non-constructed design intent) and generating a dual information ecosystem: an Asset Register collating all the information from the PIM and any new data during the operation phase in a data-based structure, and a new CDE with a file-based structure hosting both the PIM As-Built data and any new documentation generated during the operation of the AIM.

It is important to mention that the structure of the AIM relies upon the OIR and the AIR and is developed jointly between the owner (Rail Baltica) and the Operator/s. It should be correctly defined prior to the development of the PIM so that the Design and the Construction generate the BIM models dataset focusing on the Operation needs and uses.

6. Suppliers' role

6.1. Competency Framework

It is the main role of the Suppliers to complete the design of the works assigned in their scopes, complying with all the requirements described in the "Detailed BIM Strategy" and the Employers Information requirements (EIR) in terms of content, detailing, deliverables, formats and quality.

Following the BIM Delivery Process described in the former Section, the Suppliers shall deliver various documents along the different stages.

6.2. Contract Award

Once the contract has been awarded to the selected Supplier, this shall deliver a **Post-contract BIM Execution Plan (BEP)**, which confirms its capabilities and shaping the details for the actual development of the BIM deliveries, and the **Master Information Delivery Plan (MIDP)** and the Task Information Delivery Plan (TIDP).

These documents will need to be approved by RB Rail AS and in the event of not compliance with the EIR and the BIM Manual may be subject to contractual penalties.

In addition, the Service provider / Supplier shall provide a CAD Manual defining the adaptation of the CAD standards to the chosen authoring tools, which could be integrated inside the BEP.

6.3. Mobilisation

During this phase, the supplier shall make sure that the information management solution works before any design work is started, as well as the selected software, IT systems and infrastructure, including the CDE, are procured, implemented and tested.

In the event the Contract was awarded without justifying an appropriate level of BIM implementation in the organisation, a specific BIM implementation plan will be required by RB Rail AS. That Plan will include the teams, the timeframe and the upskilling methods that will be used to reach the minimum level of maturity agreed with RB Rail AS. The Implementation plan could be lied to a specific process of capability verification by RB Rail AS, with possible penalties in case of failure.

6.4. Production

The **Project Information Model (PIM)** shall be progressively developed and delivered to the employer through a series of information exchanges as defined within the BEP and this BIM Manual, at key points to coincide with the

employer's decision-making processes as defined by the EIRs. The deliveries shall be made through the CDE, as described in Section "RB Rail CDE".

During the development of the Design / Construction there are some collaboration meetings that the Service Provider / Supplier will attend in order to manage the standards, the coordination and the performance of the production. A more detailed description of the meetings is given in the "Collaboration" point in the "Deliverables from BIM models" Section.

At the Handover and Close-out stage all necessary information about the product shall be included in the handover document and attached to the commissioning and handover documentation. The **As-Built model** shall represent the as-constructed project in content and dimensional accuracy, and shall be the start point for the **Asset Information Model (AIM)**, which RB Rail AS and the Operators will use for the Operation and Maintenance stage.

The following figure based on the PAS1192-2 Figure 2 indicates the documentation created by the different actors from Tender to Mobilisation:

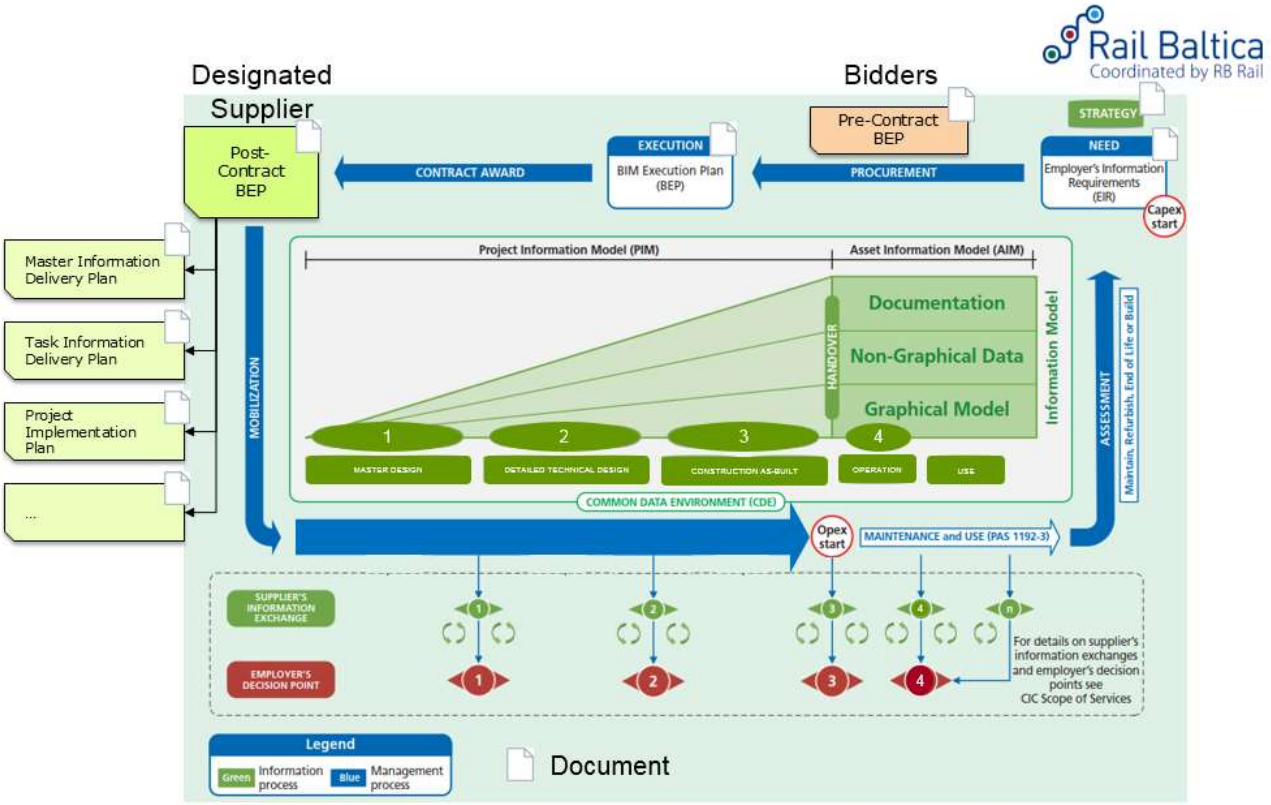


Figure 14: Documentation from Tender to Mobilisation

6.5. CDE Processes

The Suppliers will have to upload all their deliverables to the CDE complying with all the requirements and processes described in the section "Rail Baltica CDE". CDE of this document in terms of content, detailing, scheduled dates, formats and quality.

The delivery of the required information by means of the use of the CDE approach is a contractual obligation.

7. BIM Execution Plan (BEP)

7.1. General

A "BIM Execution Plan" (BEP) is a plan prepared by the Suppliers to explain how the information modelling aspects of a project will be carried out. The plan is developed in both the pre- and the post- contract and is prepared as a direct response to the Employer's Information Requirements (EIR) and will detail the project deliverables stipulated by the contract and the information exchange requirements detailed in the BIM Manual.

This plan is prepared at the beginning of the project, but must be updated later for each project stage. It is recommended to deliver it during the inception report after the signature of the contract.

7.2. Post-contract BIM Execution Plan (BEP)

Once the contract has been awarded, the Supplier must provide the post-contract BIM Execution Plan in order to explain more in detail how they intend to carry along all the BIM Objectives in accordance with the RB Rail AS BIM Strategy. Its purpose is to facilitate the management of delivery on the project. This includes the contractual information exchange requirements set out in a BIM protocol alongside the wider project deliverables established by the contract.

BIM Execution Plan includes Specific Annexes for the different disciplines and authoring tools describing how all the procedures shall be implemented.

The contents of the post contract-award BEP shall consist of everything requested in the EIR plus the following information:

- Management:
    - Roles, responsibilities and authorities
    - Major project milestones consistent with the project programme (to be completed in the MIDP)

- Survey strategy including the use of point clouds, light detecting and ranging (LIDAR)

- Planning and documentation:
  - Revised PIP confirming the capability of the Supply Chain
  - BIM Use Cases
  - Agreed project processes for collaboration and information modelling
  - Agreed matrix of responsibilities across the Supply Chain
  - TIDP (to be collated in the MIDP); template provided in "Annexes" Section.
  - MIDP (if not defined independently from the BEP); template provided in "Annexes" Section.
- The standard method and procedure:
  - File Naming Convention, including volume strategy (Rail Baltica's BIM Manual Naming Convention will be used, any change will need to be approved by RB Rail AS)
  - Geo-location & Coordinates system (which will be geo-referenced to the earth's surface using the specific projection and coordinate system defined for the project in the BIM Manual)
  - Levels of definition
  - Specific Annexes from the different disciplines and authoring tools (one per authoring tool), describing:
    - Modelling standards (including model's size and length recommendations)
    - Workflows
    - Agreed construction tolerances for all disciplines
    - Drawing sheet templates
    - Supplier CAD manual (Adaptation of the CAD Standard to its authoring tool)
    - Attribute data (Rail Baltica's BIM Manual Attribute Data will be used, no changes are possible, however the Supplier is free to add any other Data in addition to Rail Baltica's one)
- The IT solutions:
  - Software versions

- Exchange formats
- Security & Extranet Access

It is worthy to mention that if the Post-Contract BEP does not include the MIDP, that document will need to be submitted and agreed with RB Rail AS independently.

The Post-Contract BIM Execution Plan is composed by the main document (describing the overall information of the BEP) and a list of annexes including the TIDP, the MIDP and the different *BIM Authoring tools – specific procedures and workflows.*

The template for the Post-Contract BEP is included in the Annexes of the BIM Manual.

7.2.1. BIM Authoring tool – specific procedures and workflows

There must be at least one annex by BIM Authoring tool and there could be various if the Supplier considers it necessary, for instance due to the existence of various disciplines developing the project with the same BIM Authoring tool.

This annex (or annexes) shall include a small mock-up model to show that the models geo-locate correctly. It will be an aggregated model containing at least two BIM models from different disciplines, and will be submitted in the delivery format defined in the BEP (preferably IFC). The content of the model is irrelevant: a simple 3D solid (a cube, a sphere) with some populated attributes (RBR-Northing, RBR-Easting, RBR-Elevation) is enough. With this mock-up, RB Rail AS and the National Implementing bodies will be able to evaluate the capability of the Supplier to geo-locate models correctly, to link models with each other and to export to IFC without (or with a minimal) loose of information.

7.2.2. Supplier CAD Manual

In addition to the Post-Contract BEP main document and the MIDP, the Supplier must provide a CAD Manual, which could be integrated within the different *BIM Authoring tools specific procedures and workflows* documents, to particularize the CAD Manual to each Authoring tool.

The Supplier CAD Manual shall include a mock-up drawing in order to verify the compliance with the CAD standards defined in this strategy.

A template drawing (DWG) is included in the Annex "RBR-DOC-BIM-BMA-0002_CADStandards"

7.2.3. Delivery Process

After the contract award, the delivery process of the Post-Contract BEP shall be the following:

1. Delivery of Post-Contract BEP with all its annexes except the mock-ups

2. Conditional Approval (or rejection) of the defined procedures from RB Rail AS
3. Delivery of Mock-ups (BIM model and 2D drawing) to prove the capability to geo-locate models, to link models with each other and to export to IFC
4. Definitive Approval (or rejection) of the defined procedures from RB Rail AS after evaluating the performance of the mock-ups

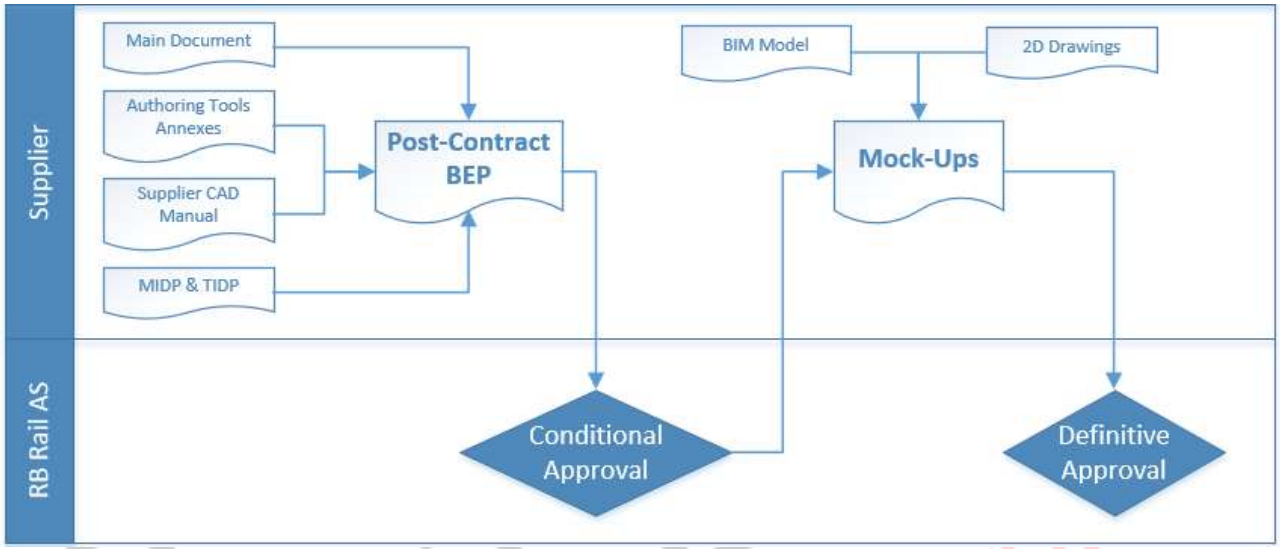


Figure 15: Post-Contract BEP Delivery Process after Contract Award

8. Model Delivery Plan

8.1. General

Sections "BIM Delivery Process", "Suppliers' role" and "BIM Execution Plan (BEP)" make reference to a document called Master Information Delivery Plan (MIDP), which is a plan defining **what** project information is to be prepared, by **whom, when** and to **what** Level of Definition (LOD, see "Level of Definition" Section).

This section explains how the BIM approach is reflected in the project lifecycle, which needs to be internalized by the Service Provider / Supplier during the lifecycle of the project. This approach shows the information that must be taken into consideration for the development of both the MIDP and its materialisation, the Delivery.

8.2. Definition of the main deliverables

The BIM Project Information Delivery takes place supported by the project **Common Data Environment** (see "Rail Baltica CDE" Section), where data is collected, structured and stored progressively fulfilling the project "Information Requirements" stage by stage across the project.

The BIM strategy is a **file based information delivery**, where the featuring files can be consumed independently but also used, viewed and referenced together, by means of the federation of the files according to the Work Breakdown Structure (WBS) and the way the Service Provider / Supplier structures the delivery. The Federation of models attempts, as much as possible and depending on the CDE environments deployed by Rail Baltica and the Service Providers / Suppliers, to build one single model but using multiple sources files controlled by the CDE. If the files are models (and aggregated models), this single federated model is called **Aggregated Model**.

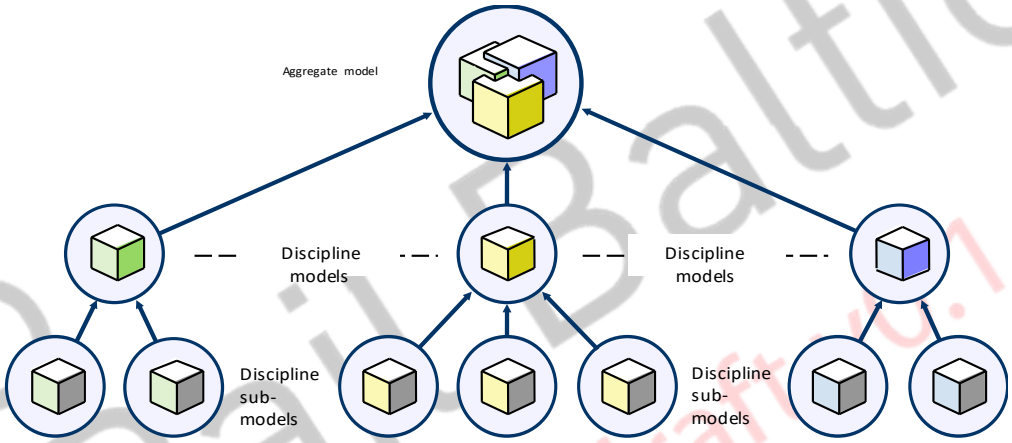


Figure 16: Aggregated Model

The delivered data (files, documentation and models) is stored and referenced within the CDE and multiple users can carry out their tasks and deliver newly created information back to the overall CDE.

In order to have a correct integration and standardisation, this BIM Manual, its supporting documents and the EIRs of each project define the requirements, templates and general processes to be followed, so that the integration throughout the project lifecycle can be achieved. The QAQC processes take a remarkable importance because otherwise the pretended escalation strategy that involves any kind of deliverable will not be possible. In the diagram below, the independent models must follow the BIM standards (geo-reference, geometry modelling rules, data set information structure…) so that the data extractions can be rolled up into integrated DataBases and integrated BIM models (Aggregated models).

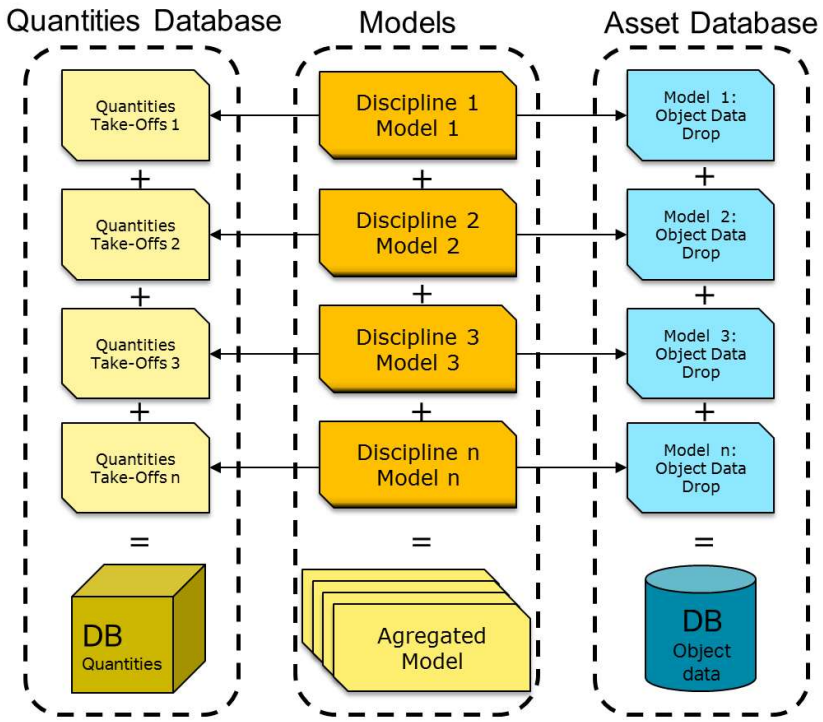


Figure 17: Aggregated Models and DataBases

For a complete description of the deliverables, see "Deliverables from BIM models" Section.

8.2.1. Open BIM approach

Rail Baltica shall not impose any specific authoring tools, therefore, if the deliverable prepared by the authoring tools is not an Open format, both the native (including its support files) and the Open format equivalent will be delivered. Further information about this approach can be found in the "File Formats" Section.

8.2.2. BIM Models

The BIM Models are the core deliverables in the Project Information Model Phase (Design and Construction Stages), and the way the information is provided and driven. These models become the source of any information provided in the different stages, up to the point of taking precedence in the event of discrepancies and inconsistencies between models and drawings if the LoG is equal or higher to 350 (see "Level of Definition" Section). For lower LoGs, drawings will be given priority if the definition is superior to the one shown in BIM models.

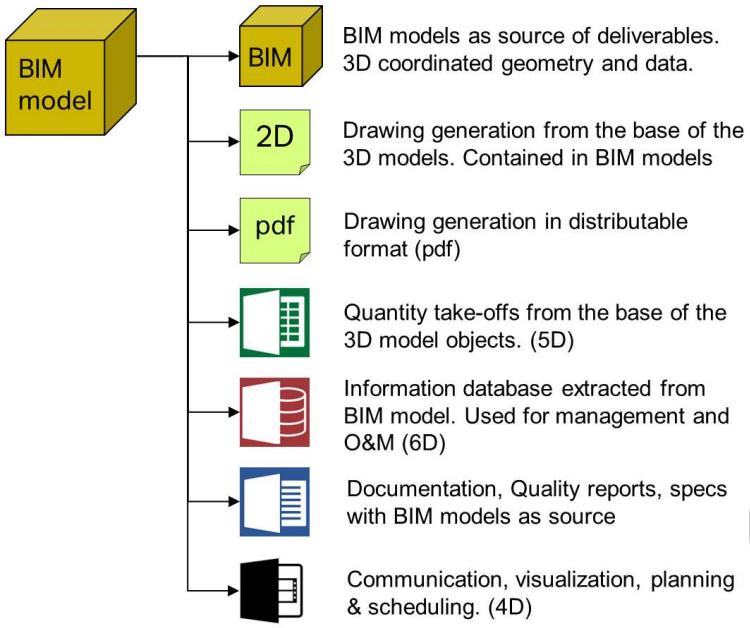


Figure 18: BIM Models and its Deliverables

The Master Information Delivery Plan (MIDP) will include the estimated list of BIM models. It will not be necessary to develop in depth the breakdown of models for each particular discipline/package, but the list must include at least one model per present discipline per package/segment and submission. The Level of Definition, LoG (Geometry) + LoI (Information), will be shown for each deliverable.

8.2.3. Drawings

Drawings keep being the preferred source of information for the transmission of information among the different actors of the construction sector, from contractors to authorities; the main reason is the lack of maturity in the digital transformation methods that is taking place in the latest years. The intent of this BIM Strategy is not the substitution of the existing systems of information, but the complementation of the existing ones, drawings in this case, so as to offer better information for the decision-making process and the management of the different tasks performed in the project lifecycle.

The MIDP will include the forecast of drawings needed for every submittal. It is important to mention that the first stages will not have highly detailed BIM models and therefore the 3D BIM models could not be accurate/detailed enough for the preparation of some typical detail drawings (or any other), so in that cases an extra 2D work will need to be carried out.

8.2.4. Visualisation and Scheduling

One of the benefits of the BIM Methodology is the fact of being based on 3D models, which contributes to have a better geometrical coordination, documentation and communication.

Communication gets enhanced with the 3D BIM models by adding better transmission of ideas thanks to the visualisation, which can be by extracting 3D views or by using the BIM model for the Virtual Reviews.

The 4D scheduling files (videos, planning reports,…) will need to be included in the MIDP list, whilst other like the visualisation works do not necessarily have to be included if not included in a specific deliverable.

8.2.5. BIM Data drops and extractions

The BIM data drops will be two by BIM model: the Quantity Take-off spreadsheet (submitted using the standard templates provided in the Annexes, divided in a spreadsheet with QTOs by model and another spreadsheet with QTOs rolled up by package) and the BIM data drop itself, an information dataset extraction for digital management and Operation & Maintenance purposes, the latest one only if the stage is As-Built and Operation.

Those Data drops and QTOs will be included in the MIDP.

Several templates are provided for these proposes:

RBR-DAT-BIM-BMA-0035_DataDropTemplate.xlsx

RBR-DAT-BIM-BMA-0034_QTOTemplate.xlxs

RBR-DAT-BIM-BMA-0033_QEXTemplate.xlsx

8.3. Project lifecycle and Delivery

Each project stage has its own goals and the BIM modelling and the deliverables are adapted accordingly. The differences among the stages are based on:

- BIM Use Cases expected; see “BIM use cases” point in “Principles and Goals” Section.
- Level of Definition; see “Level of Definition” Section.
- Main stage goal
- The local (Latvia, Lithuania, Estonia) approach to the scope of the stage, which will be specified in each project’s EIR and Technical Specification.

8.3.1. Value Engineering

During the Master Design and Detailed Technical Design stages, RB Rail AS may request by means of the EIR some specific submissions in order to enhance the decision making and understandability of the designed solutions.

The Value Engineering will focus in a specific criteria defined by RB Rail for each case, such as geometrical – technical coherence, simplicity, constructability, operability & maintenance and economy. The BIM approach allows

both Supplier / Service Provider and RB Rail AS to take into consideration some extra data (quantities, geometrical relationship with the environment…) from the various options prepared during the Value Engineering process.

8.3.2. Master Design

The Master Design stage has the intent to find the best possible solution so that it is developed in depth in the next stage, the Detailed Technical Design.

This stage will take into consideration the technical requirements of each discipline to fit the solution to all the parties involved. As such, the Level of Definition will be more focused on the geometrical coordination of the solution, preparing the models taking into account the spatial reservation and the space allowances of the different elements from the technical point of view. Thus, it might be possible to need to complete the drawings with further 2D detailing because the models possibly have not the minimal detail for the generation of all the required drawings, in particular the detailed typical sections.

The BIM objects of the model will include the basic dataset needed for the identification and tracking of the objects throughout the project, whose data extraction will be the Drawings, the Quantity take-offs and a 4D scheduling simulation, with a detail consistent with the definition of the Master Design stage.

Additional information shall be provided in the Technical Specification of the project.

8.3.3. Detailed Technical Design

The Detailed Design stage has the intent to develop in depth the solution defined briefly in the Master Design stage, by adding detail to the documentation so that the design could be buildable. Other goal of the stage (if still not performed in the previous one) is the preparation of the documentation for the local authorities' permits and compliance of regulation verification.

This stage advances in the detail of the model and all the drawings and quantity take-offs should be in the position to be extracted without any external support, being 2D or with non-modelled elements.

This stage includes BIM models, Drawings, Quantity take-offs, Data Drops and more detailed 4D scheduling simulations as deliverables.

Additional information shall be provided in the Technical Specification of the project.

8.3.4. Design for Administrative Approvals

As explained previously, the EIRs will define at what stage and with what kind of deliverables will be needed to obtain the documentation requested for local authorities' requirements compliance verifications.

It is likely that during the first years of the implementation the deliverables could be the traditional ones, but it is expected that after a certain moment the deliverables could become BIM-focused, as the European Union released a the Directive 2014/24/EU to promote the adoption of BIM in Public Procurements.

8.3.5. Construction and As-Built

The Construction stage adapts the detailed construction project of the previous stage to the particularities of the market, in particular by modifying the objects to suit the final geometry of the brand/model of certain elements (such as the utilities and MEP elements and certain in the other disciplines). Besides, the Construction will have deliverables as there will be geometrical verifications of shop drawings against the model, the already mentioned adaptation of the models/design/drawings due to the particular brand/model and specially because of the generation of the As-Built documentation, which include the same deliverables that there were in the previous stage, but with a higher Level of Definition.

It is worth to mention that if the Operator has provided guidance of the information needed and an object data asset structure for their specific O&M tasks, the As-Built models will have to integrate them into their attribute structure, which has been defined in order to make it possible. See “Information and Codification principles” Section. This Asset Information Requirements will need to be defined within the EIR of the project.

8.3.5.1. Delivery times of the updated models during Construction

The time milestones are identified below, during which the contractor must carry out the activities described in the table below.

Milestone	When?	Description
ML1	During the mobilization phase	Submit BEP for this stage for RB Rail AS/National Implementing Bodies review and approval. (Shared in CDE)
ML2	After BEP approval	Publish BEP in RB Rail CDE
ML2	Progress of works coinciding with yy% of the contract amount	As-built model of the executed construction part with the required information for the construction/as-built Phase.
ML3	Progress of works coinciding with zz% of the contract amount	As-built model of the executed construction part with the required information for the construction/as-built Phase.
ML4	Progress of works coinciding with aa% of the contract amount	As-built model of the executed construction part with the required information for the construction/as-built Phase.
ML5	Progress of works coinciding with bb% of the contract amount	As-built model of the executed construction part with the required information for the construction/as-built Phase.
ML6	Progress of works coinciding with 100% of the contract amount	As-built model of the executed construction part with the required information for the construction/as-built Phase.

Table 5: Delivery times of the updated models during Construction. Days and percentages – according to Technical Specification and contract documentation.

The contractor will deliver the BIM model updating the work for each milestone as defined in the previous table.

The model will be uploaded in the CDE according with the settled workflows.

RB may, on each occasion it deems appropriate, summon the contractor and its representatives responsible for the BIM model activity, in order to allow the examination of the informative contents of the BIM model.

Below you can find a proposed workflow that represents the interaction of different stakeholders across the design, procurement and construction phase in order to obtain an as built model.

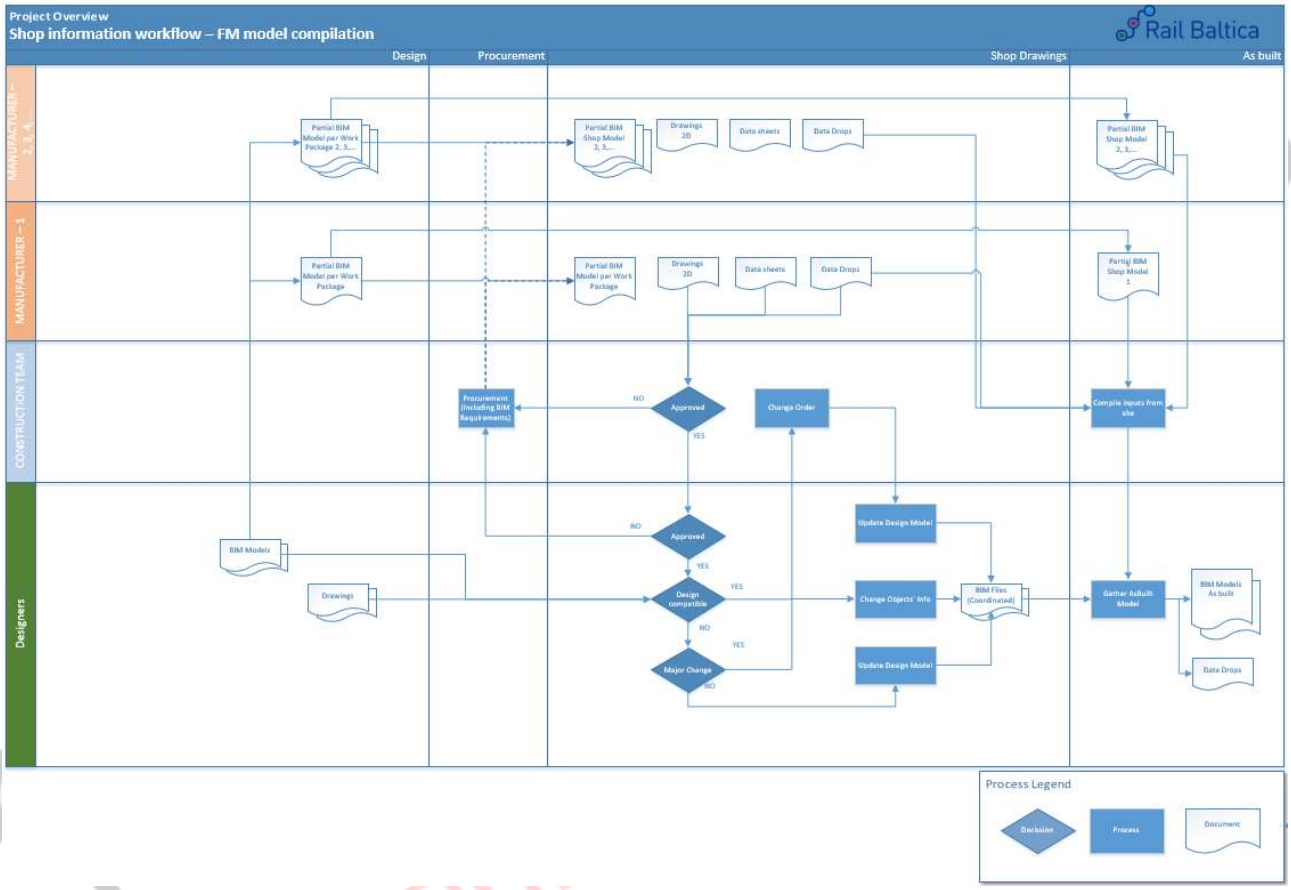


Figure 19: Shop Information Workflow

8.3.6. Operation & Maintenance

This stage will have specific deliverables, such as the O&M Manuals and the procedures of usage of the digital Supporting Technology, the Asset Register.

When a major maintenance work will take place, the design & construction documentation will have to be delivered in the same way as defined in the previous Design + Construction stages.

8.4. Master Information Delivery Plan (MIDP)

The Master Information Delivery Plan (MIDP) is a main Post-Contract award deliverable, which includes a plan listing all the information deliverables of a project including models, drawings, specifications, equipment, schedules, data drops and other kind of deliverables such as 4D videos. It identifies when project information is to be prepared, by whom, and defines the Levels of Definition and the procedures.

The MIDP incorporates all relevant Task Team Information Delivery Plans (TIDP), which list all the information deliverables of a discipline of a project, and an updated / detailed Responsibility Matrix. The MIDP is an independent deliverable, while the TIDPs commonly are included within the Post-Contract BEP. The TIDP could be also included within the MIDP documentation.

The Planning documents TIDP & MIDP and the Deliverable Submittal Report have templates in the Annexes.

8.5. Delivery milestones per Stage and Design Reviews

For each design stage RB Rail AS and/or the National Implementing Bodies shall request from the Supplier not only a final delivery but also some intermediate "sub-stage" deliveries in order to check the advance of the design. The number and frequency of these deliveries are defined in the EIR and the Supplier shall have them into account when filling their MIDP and TIDP in.

8.5.1. Design reviews for each sub-stage

In order to guarantee the quality of the design on each sub-stage, it is strongly recommended that the Supplier carries out a series of design reviews using the BIM Model as the basis, and in which all the involved people (BIM Coordinator/Manager, Design/Project Managers, Engineers, etc) participate. All needed corrections after each review should be amended before proceeding with the following review. These reviews are the following:

- **Discipline review:** internal review to check that the discipline BIM Model complies and is aligned with the design defined for that sub-stage. This model could be stored in the Supplier's CDE.
- **Inter-disciplinary coordination review:** internal review to check the coordination among all the disciplines involved in the design. The review is carried out by using the aggregated BIM Model containing all the disciplines' BIM models. This aggregated model could be stored in the Supplier's CDE.
- **Gate review:** review between the Supplier and RB Rail AS and/or the National Implementing Bodies to check, by using the aggregated BIM Model containing all the disciplines' BIM models, that the complete design complies with the defined requirements. This aggregated model should be stored in the Supplier's CDE.

- **Delivery:** once the aggregated model is amended with the corrections agreed during the Gate review, it must be delivered in the RB Rail CDE as "Shared" in the file formats defined the BEP. For the 100% stage final delivery it must be stored in the RB Rail CDE as "Published".

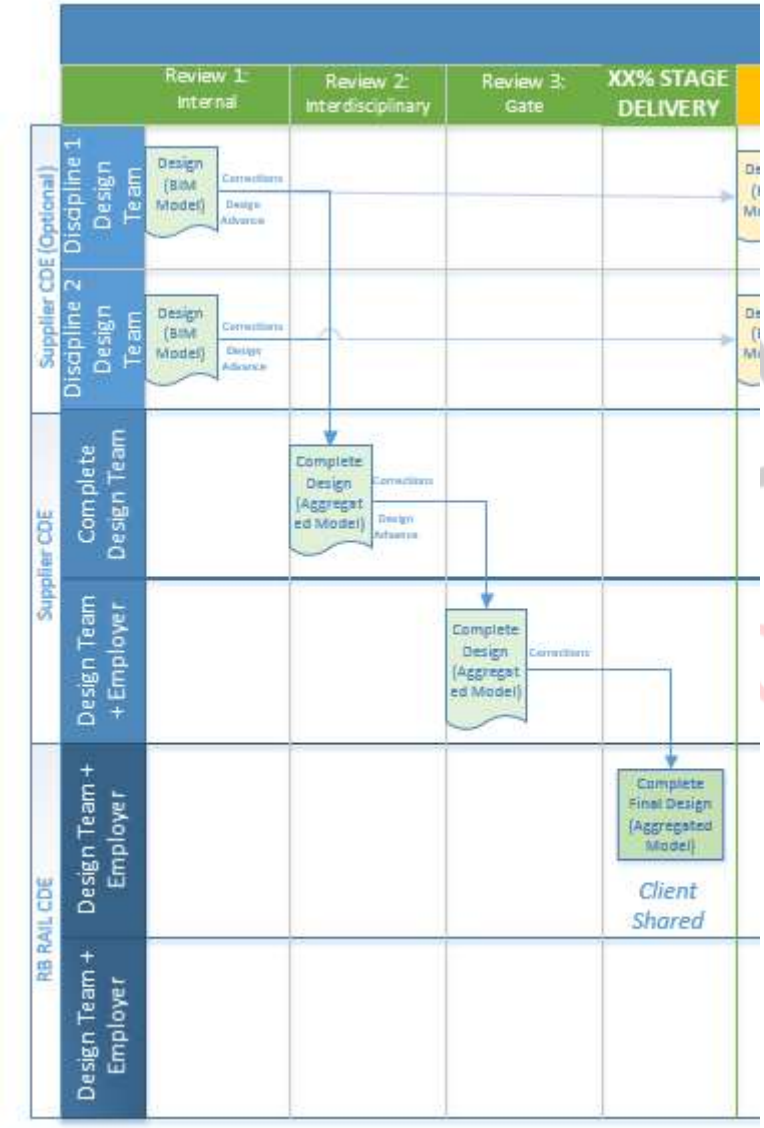


Figure 20: Milestones per Sub-Stage

8.5.2. Sub-stages number and frequency

As explained before, the number and frequency of these deliveries are defined in the EIR, but the recommendation according to the stages is of four sub-stages for the Design and five for Construction.

		1st sub-stage	2nd sub-stage	3rd sub-stage	nth sub-stage	N+1th sub-stage
Design stages (Value Engineering, Master Design, Detailed Technical Design)	Percentage	XX%	YY%	ZZ%	WW% (Final)	-
	Status on CDE	Shared	Shared	Shared	Published	
Construction & As-built	Percentage	AA%	BB%	CC%	DD%	EE% (Final)
	Status on CDE	Shared	Shared	Shared	Shared	Published

Table 6: Delivery sub-stages

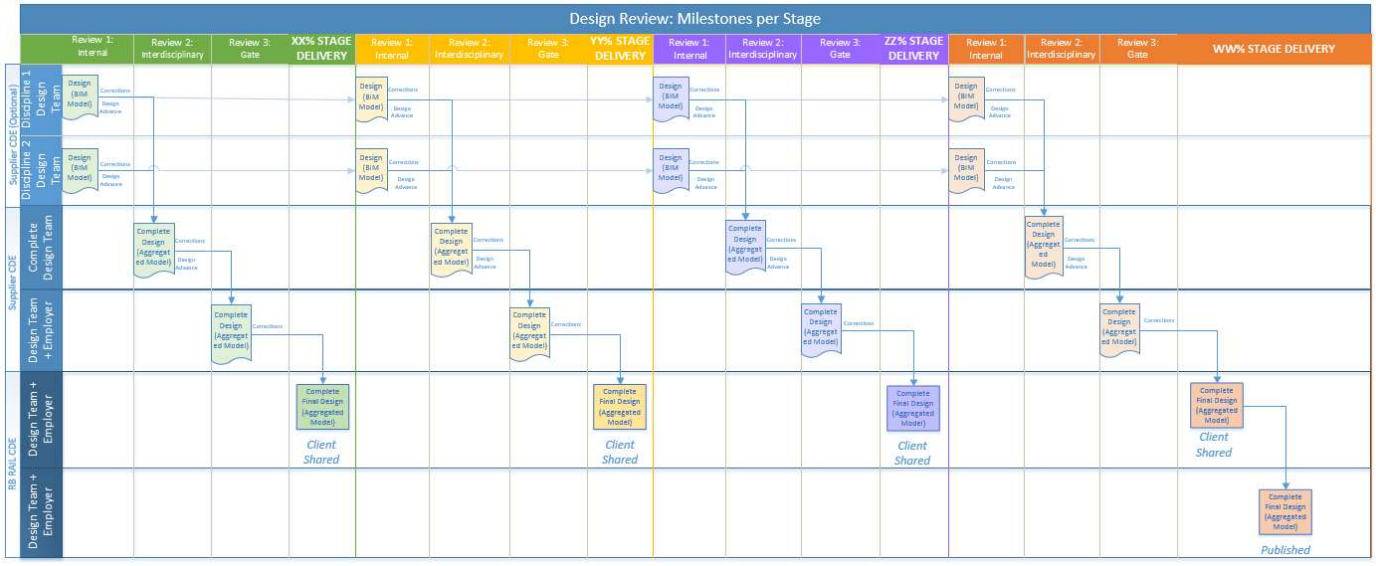


Figure 21: Milestone per Sub-stage and Stage

The number of sub-stages will be stated in the contract and Technical Specification/EIR.

Depending on what is stated in the contract and the EIR, the sub-stage change will require the prior approval of RB RAIL AS.

More detailed information about the Design review process is described in the sections “Interface Coordination” and “Quality Control”.

9. Information and Codification principles

9.1. Introduction

Information is what makes different CAD 3D and BIM, the jump from a 3D coordinated preconstruction model to a holistic database including both 3D and data information to assist an enhanced decision making throughout the life cycle of the infrastructure, their assets and their individual components.

This section focusing on the description and explanation of the information data that will be populated within the BIM models and how that information is gathered, structured, and classified along through the stages of the project.

The BIM Manual defines the strategy and the principles of the codification, which is defined in detail (and updated during the project by RB Rail AS) in the supporting document called "RBR-DOC-BIM-BMA-0003_CodificationDataManagement".

9.2. Data standardisation

Any kind of information is structured by means of standard file / model namings and codifications, and classified / structured by location, function and classification.

- **Location,** ***High Level***: the project is split according to a Work Breakdown Structure (WBS) defined by RB Rail AS, which at *High Level* allows the identification by location of the files / models.

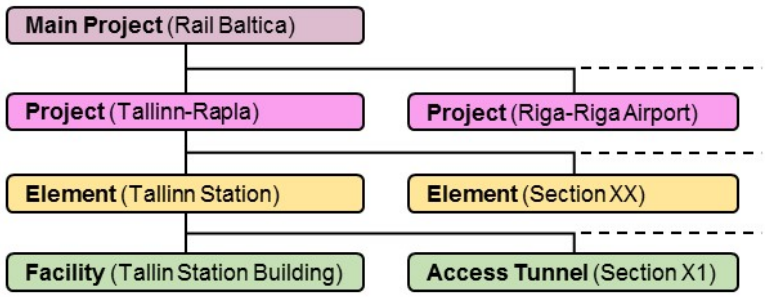


Figure 22: WBS by location

- **Location,** ***Low Level***: Project Sections or Project Facilities are then split hierarchically in models and assets. Models will be divided and organised according to their own WBS, to be defined in the Post-Contract BEP. Assets could also be sub-divided by Components and Sub-Components if required for Operation purposes (to be defined in the EIRs, after a specific Operation request).

9.3. Attributes as data containers

As explained in the point "Information Lifecycle through PIM and AIM" within the section "BIM Delivery Process", the information data changes its shape depending on the phase of the project, based on file based federated BIM models and BIM extractions (data drops) within the CDE during the PIM phase and based on as-built BIM models, as-built BIM extractions and databases within CDE + Asset Register during the AIM phase. Due to the fact the 3D objects are the base of the BIM methodology, information is stored as attributes within the model objects. Those attributes are standardised and structured in order to suit the BIM Use Cases needs and to facilitate the data consumption.

9.3.1. Attributes and goals

The Attributes are data fields populated with pieces of information attached to each BIM object to provide different types of information, like physical/geometrical characteristics, classification codes, locations, relationships, or data related to the BIM use cases, for instance. Attributes are divided in groups according to their subject and the gathering of information is gradual according to the scope/purpose of the project lifecycle stages, and it is defined depending on the LoI (Level of Information, see "Level of Definition" Section).

9.3.2. Object identification: Member Mark and Asset Mark

Each Object has to be uniquely marked and identified. This combines some attributes to create a complete object identifier to describe the components through *Component Tag Identifiers* (CTI). In the Rail Baltica Project there are two CTIs, one related to the PIM and another related to the AIM:

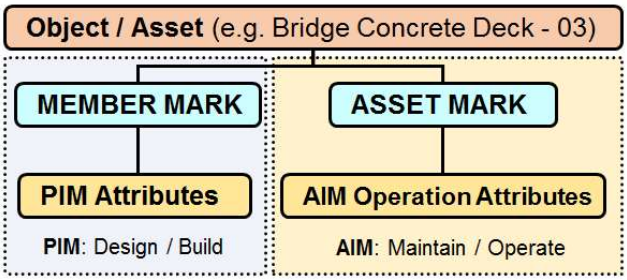


Figure 23: Member Mark and Asset Mark

- **PIM CTI, also known as the "MEMBERMARK"** and it has correlation to the WBS but is not the same as the WBS. Only the Object Label section of the CTI will appear on sheets-drawings. But within the models resides the infrastructure/facility, via project attributes, to derive the full MEMBERMARK from the models. That is to say, the MEMBERMARK is not an attribute itself but a set of attributes that together generate that PIM CTI.

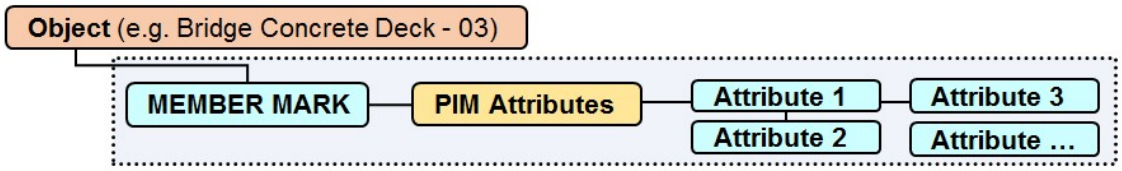


Figure 24: PIM Attributes

The MEMBERMARK can be considered the passport number of each object, therefore when referring to a BIM object during the Project Information Model (PIM), this codification shall be used. The definition of the MEMBERMARK (and its forming attributes) can be found in the supporting document called "RBR-DOC-BIM-BMA-0003_CodificationDataManagement".

- **AIM CTI, also known as the "ASSETMARK",** which has correlation to the WBS but is not the same as the WBS. Within the As-Built models resides the infrastructure/facility, via project attributes, to derive the full ASSETMARK from the models.

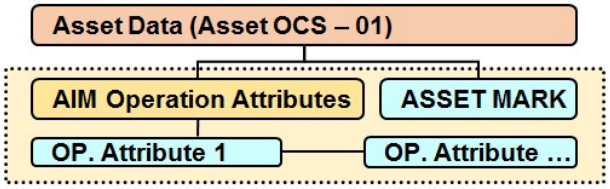


Figure 25: AIM Attributes

The ASSETMARK only will be created during the Asset Information Model (AIM) that takes place during the Operation Phase, but most of its forming attributes will be created and populated during the Project Information Model (PIM), that is to say, during Project and Construction Phases and depending on the LoI (See Level of Definition Section) of the BIM objects assigned to each project lifecycle stage.

Note: it is important to mention that most of the attributes / attributes that will be used during the operation phase will be gathered during the Design and Construction phases, thus many of the *AIM Operation Attributes* will be directly transferred from the *PIM Attributes*.

9.3.3. Data storage and exchange

The Rail Baltica Strategy sets up an Open BIM approach focusing on the open accessibility to any sort of data, such as BIM models and information data. The data information must be shared by means of the DATA DROPS, which are spread sheets that includes the data stored in the BIM models referenced by means of the MEMBER MARK (or the MEMBER MARK attributes).

The RAIL BALTICA BIM Strategy proposes two options to manage the information. The Supplier / Service Provider will define which of these two options will be followed when preparing the BEP Post-Contract. This will be agreed with RB Rail AS BIM Management team.

- **All data information stored within model objects** and shared by means of **Data Drops**. Every BIM object has all the attributes populated with data. This way the Data Drops are 100% data extractions of the BIM models. This option makes the BIM models heavier but on the other hand the BIM models become the unique source of BIM data.

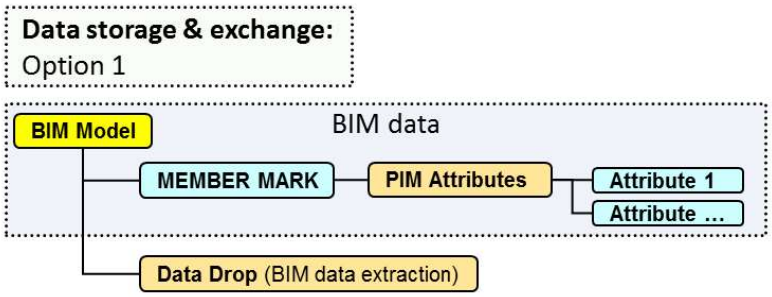


Figure 26: Data storage and exchange Option 1

- **Data information is partially stored within model objects** and is **completed within the Data Drops**. BIM objects will have the minimum information required to track the objects, the MEMBER MARK attributes, which will be extracted to the Data Drops, where the rest of the information will be completed. This way, BIM models and Data Drops are related by the objects MEMBER MARK. This option makes the BIM models lighter, but as a consequence the BIM models must be always accompanied by the Data Drops in order to store the complete BIM data (3D models + data).

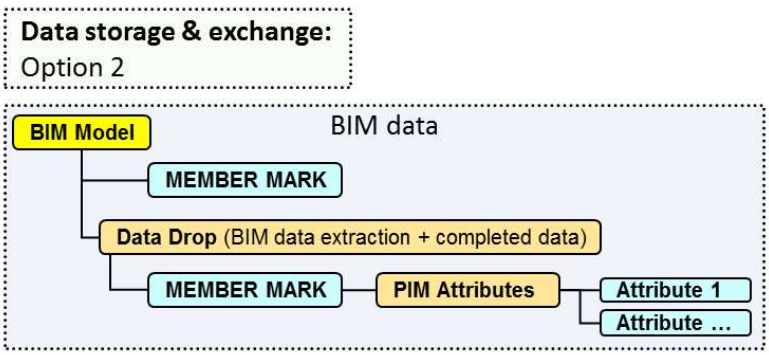


Figure 27: Data storage and exchange Option 2

Notes:

1) RB Rail AS has the option to force to follow one of the options by defining it within the EIRs.

2) Option 2 does not necessarily mean that only MEMBER MARK attribute group is populated within models. Other groups could be also populated within models in the event the BIM use cases makes it useful / necessary.

3) In both cases the migration from PIM to AIM will take place from Data Drops.

9.4. BIM object / asset relationship

The BIM object hierarchy for the PIM and the AIM is mainly defined as follows:

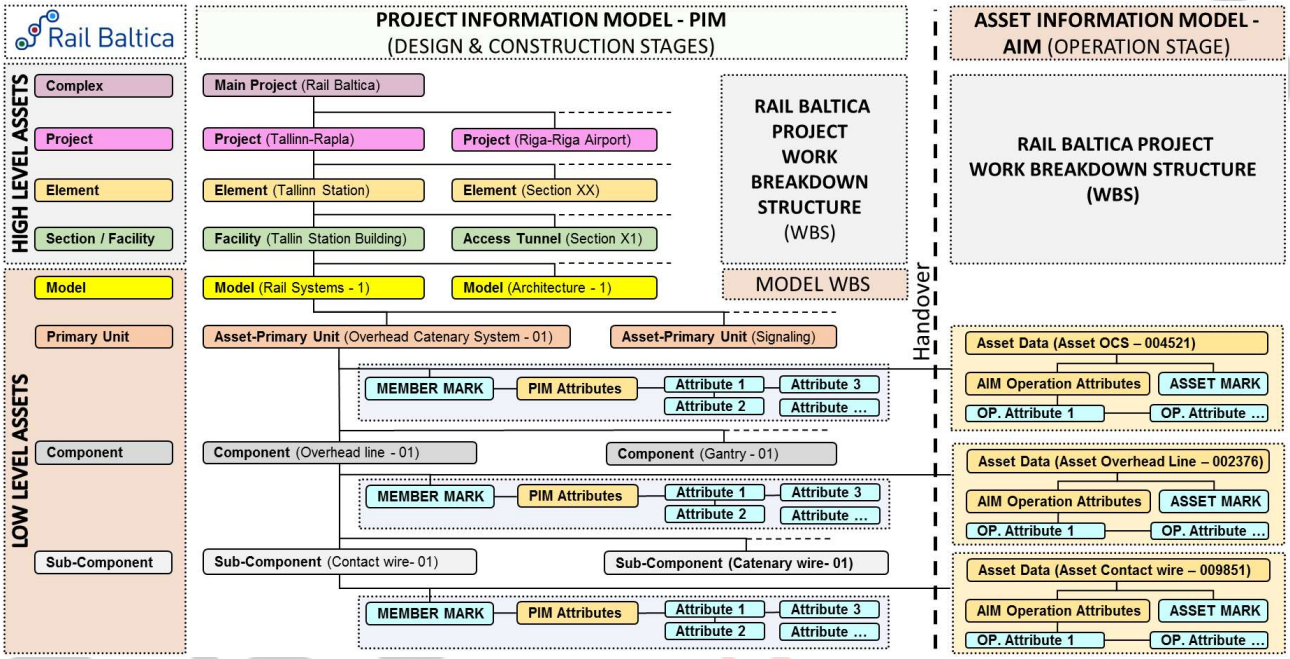


Figure 28: BIM object / asset relationship

The object breakdown is fundamentally the same during the PIM and the AIM, but the attribute approach of the BIM authoring tools may differs from one to another. The intent is to have the data information (stored within object attributes) in the lowest level as modelled in the BIM models, and the AIM will create an aggregation of assets to generate the upper levels. Operators may provide guidelines or additional attributes in order to make this happen easily, there are two attribute groups that can be defined by Operators by means of Asset Data Definition Documents (AD4), to be referred within EIRs in case of being defined. Mentioned groups are “Common Asset Data” and “AIM Operation – Element Asset Data”, see “RBR-DAT-BIM-BMA-0007_BIM_Objects_LoG_Matrix”.

In the diagram below a possible use of the attributes “RBR-Asset Name 1” & “RBR-Asset Name 2” is shown.

10. BIM Models' Geo-reference

10.1. Geographical coordination

10.1.1. General

Some general considerations that need to be taken into account for geographical coordination are the following:

- All models, whether 2D or 3D, should be created using a common project origin and orientation using a conventional Cartesian axis and common unit of length.
- Models should be created at 1:1.
- Units should be SI units of measure.
- The basic unit of length within models should be agreed to be meters for infrastructure projects or millimetres for building.

NOTE: The accuracy achievable using the chosen units and origins might need to be checked by the Service Provider / Supplier according with the chosen Authoring tool.

10.1.2. Space

A statement or diagram of the project origin and orientation should be included with the BEP (Post-Contract BEP). The origin should be related to both the project grid and to the site context. The orientation should be related to a specific geospatial north.

NOTE: The project origin is best located within or close to the project or site extent.

10.1.3. Geospatial

A statement or diagram should relate the project space to a named global geospatial system in three dimensions (decimal degrees latitude, longitude and elevation in meters) and a plan orientation (decimal degrees clockwise rotation from north)

NOTE: A decimal latitude in degrees requires eight decimal places to achieve positioning to within 1 mm.

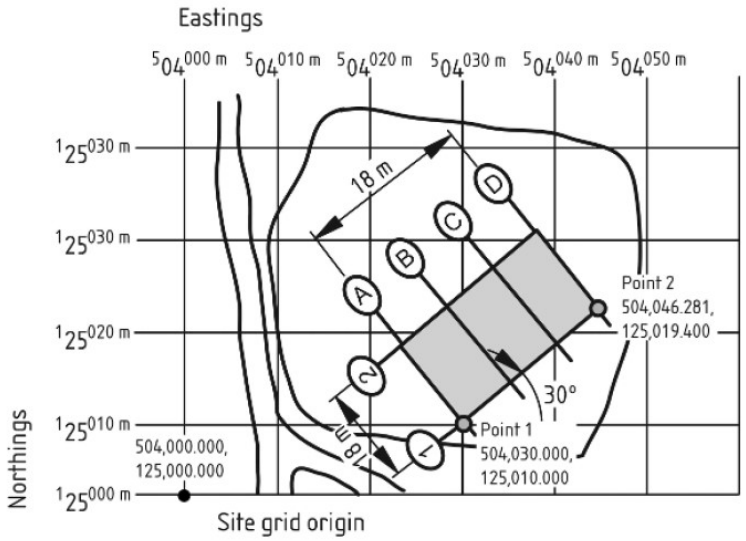


Figure 29: Example of Geo-location diagram

10.2. Coordinates and altimetry system

Coordinate and altimetry systems in use are referenced to World Geodetic System 1984 (WGS84) and European Vertical Reference Frame 2007 (EVRF2007).

Real heights will be used in the models accordingly with the height system in use.

Country	Coordinate System	Height System
Estonia	EST97	EH2000
Latvia	LKS92	LAS-2000,5
Lithuania	LKS94	LAS07

Table 7: Coordinates and Height System by country

There are currently on-going cross-governmental talks regarding this topic. If there should be an integrated system across all three Countries, it is possible that in the future this integrated system should be acquired and implemented in the project.

In the interface zone between two coordinate systems (Cross-border project sections), where the coordinate system changes from one to another, the limit models should be georeferenced in **both systems**, in order to allow both teams/projects/sectors to reference the others models correctly.

Each two neighbouring design sections shall be geo-referenced with each other in order to minimize possible errors.

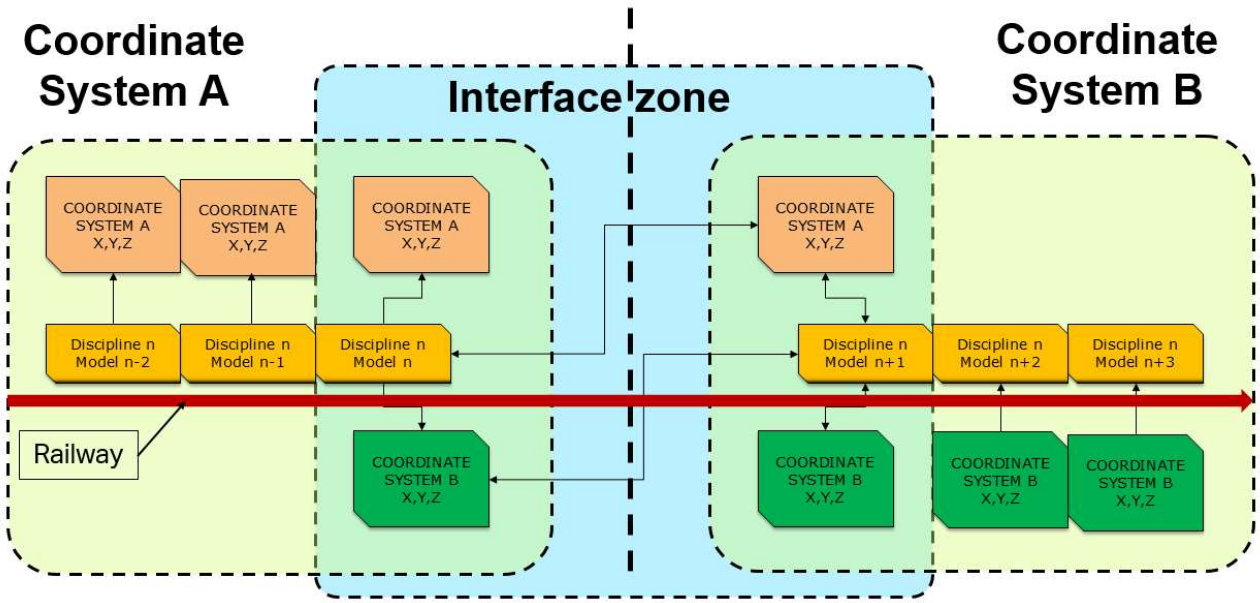


Figure 30: Relation between Coordinate Systems

For linear models, it is recommended to limit the length of the study in the interface zone to no more than 3 km, as long as it does not contradict any recommendation of the software provider. The interference zone must be agreed between RB Rail AS and the supply chain.

10.3. Geographical Information System (GIS)

Geographical Information Systems (GIS) and BIM models are two different databases that live, technologically speaking, in different worlds. The distance exists because of the strong differences that define them. GIS is a database originally defined for large scale areas and assets, (although nowadays it is also being applied to detailed design) as its most powerful use is for spatial and 3D analysis, whilst BIM is a database defined for smaller scales and more detailed ecosystems.

DIFFERENCES	GIS	BIM
Model / file structure	User defined	Highly standard
Data structure	Parametric – user defined	Parametric - highly structured
Relational system	Server based. Relational database	File based. Object family/template structured.
Exchange system	File and web services. (WMS)	File based. Local and CDEs.

Data integration among different software	Flexible and high level	Rigid and limited to IFC
Amount of users / integration in public org.	Large / mature and largely extended	Small / vaguely implemented in organisations
Scale of territory managed	Extended areas without performance issues	Limited extensions,
Asset scale	From World to Facility	From Facility to any buildable object
Level of geometric detail	Very limited when not strictly 2D	High. Any LOD is possible

Table 8: GIS and BIM

The GIS capabilities will be implemented in Rai Baltica BIM Strategy by means of three approaches (as a reference, the pictures shown are Civil 3D & ArcGIS):

- **GIS as geo-reference and data input (GIS within BIM environment)**:

  The GIS data will be used for the geo-location structure of the CAD files and the BIM Models. Due to the fact BIM models do not import natively the GIS information, this will be done by means of a CAD-GIS geo-location. Similarly, GIS graphical information will be used, whenever possible, as an input of graphical data for the design with BIM. The geo-reference could be implemented within the CDE data structure if the platform includes that feature among the capabilities.

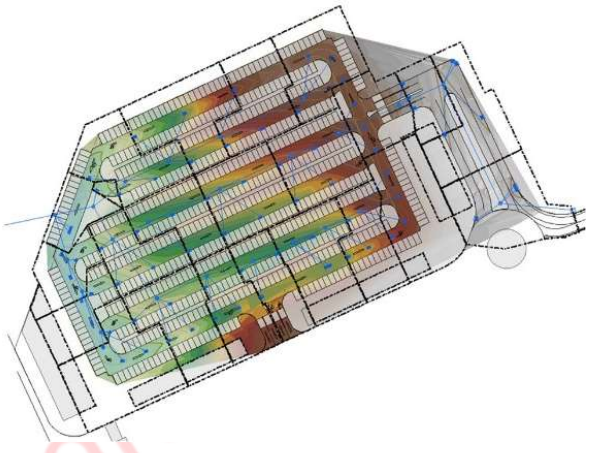


Figure 31: Example of drainage model

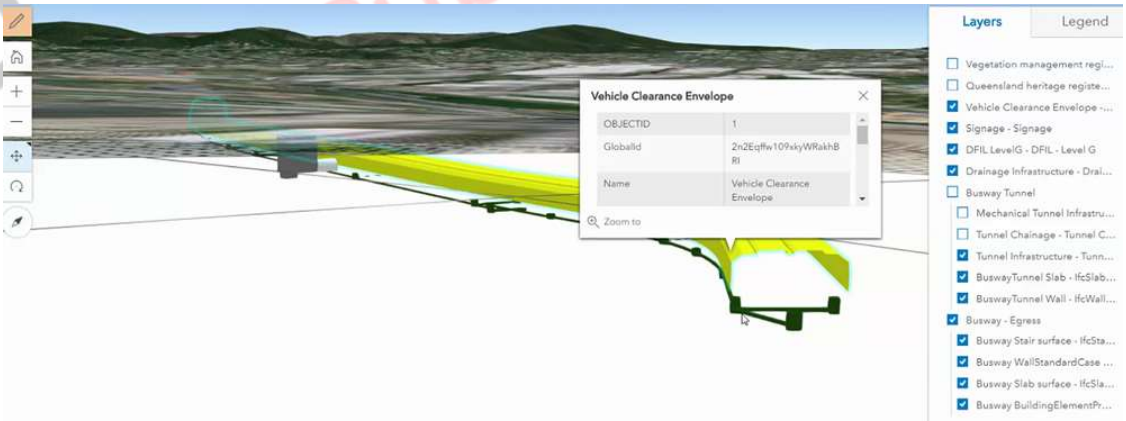


Figure 32: Example of BIM model integrated in a GIS model

- **BIM models integration within GIS environments** :

The latest advances in hardware and software are making possible the integration of the BIM models (by means of the IFC format, and others like the RVZ / FME, not Open formats) within the GIS environments. This use provides the possibility to have an easier access to the BIM data (both BIM objects and the data stored in the objects) with more spread and mature environments that the BIM ones, but on the other hand, the weight of the BIM models (mainly the size of the files) still make impossible to manage the BIM models with a high level of definition. While the hardware and the software are refined for a better interaction, it is recommended that only the LODs with a LoG=200 are imported into GIS environment. An improved LoI=200 (Identification Group + GIS Asset data) will be implemented when the BIM integration within GIS is a BIM use case.

Local authorities may request to integrate the LOD 200 (LoG 200 + LoI 200) model within their local GIS database, which would require a specific GIS data structure. In this case, the requested data from GIS would be included within the GIS Attribute group with Attributes to be created as defined according to the next structure (this data structure can be used for other GIS integration beyond the one related to local authorities). Any special GIS integration must be requested in the EIRs.

		Attribute Description		
Attribute		**Data Type**	**Units**	**Commentary**
Global Attributes				
GIS				
	RBR-GISParameter1			To be fulfilled in the LOI200 if the model is expected to be loaded to GIS
	RBR-GISParameter2			To be fulfilled if the LOI200 model is expected to be loaded to GIS

Figure 33: GIS-related attributes

A possible integration workflow is the one provided by ArcGIS and its Data Interoperability Extension, which enables the integration of the BIM Model (building BIM), the Civil Model (BIM IFC or LandXML) within the *Model Builder*, an edition and management application of ArcGIS (*Proprietary solution*). The CityGML format can also be used in this workflow.

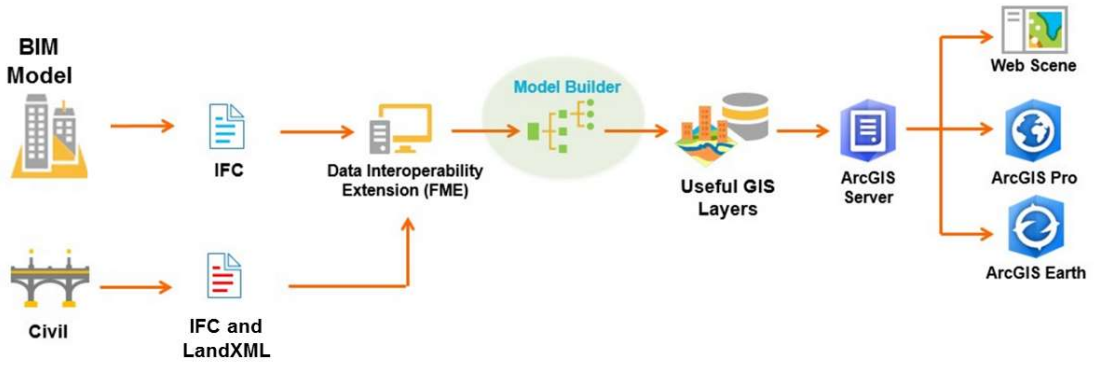


Figure 34: Example of BIM & GIS integration workflow

Other possible workflows of BIM integration within GIS are based on open 3D geometry formats, such as DAE (Collada), OBJ and KML/KMZ (Keyhole Markup Language). These options focus on importing 3D geometries from BIM models/objects, generally for urban context purposes. The imported geometry can integrate the desired data by populating the features within the GIS platform.

Note, some BIM authoring tools have no out-of-the-box exporters to these formats, but in some cases there are plug-ins for that purpose (for instance, the free exporter Lumion Revit plugin, which generates DAE files from Revit models).

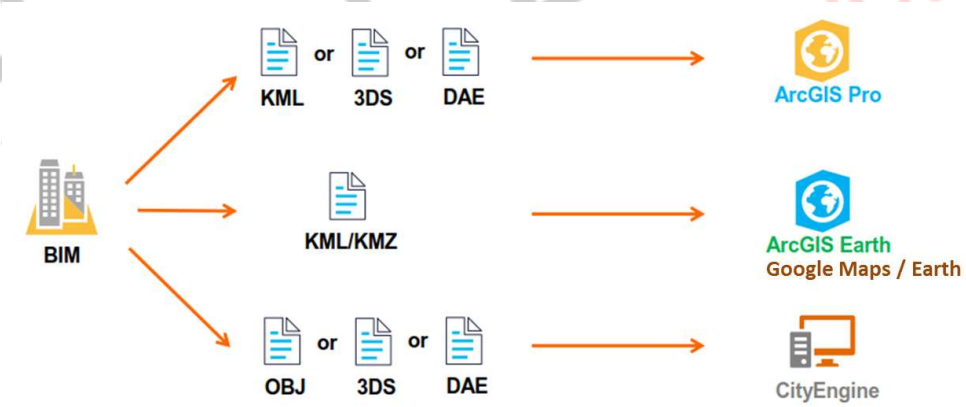


Figure 35: Examples of BIM exports to GIS

- **Integration of BIM + (selected) GIS data within the Asset Register** :

The Operation stage will include an Asset Register environment that will incorporate the PIM data of the BIM models. The GIS data can add further details to the objects imported from the BIM models by adding the relational asset information stored within GIS, more related to large scale information. In the schema below the traditional GIS and BIM spaces are shown, as explained by the Building Smart Alliance. (https://www.buildingsmart.org/)

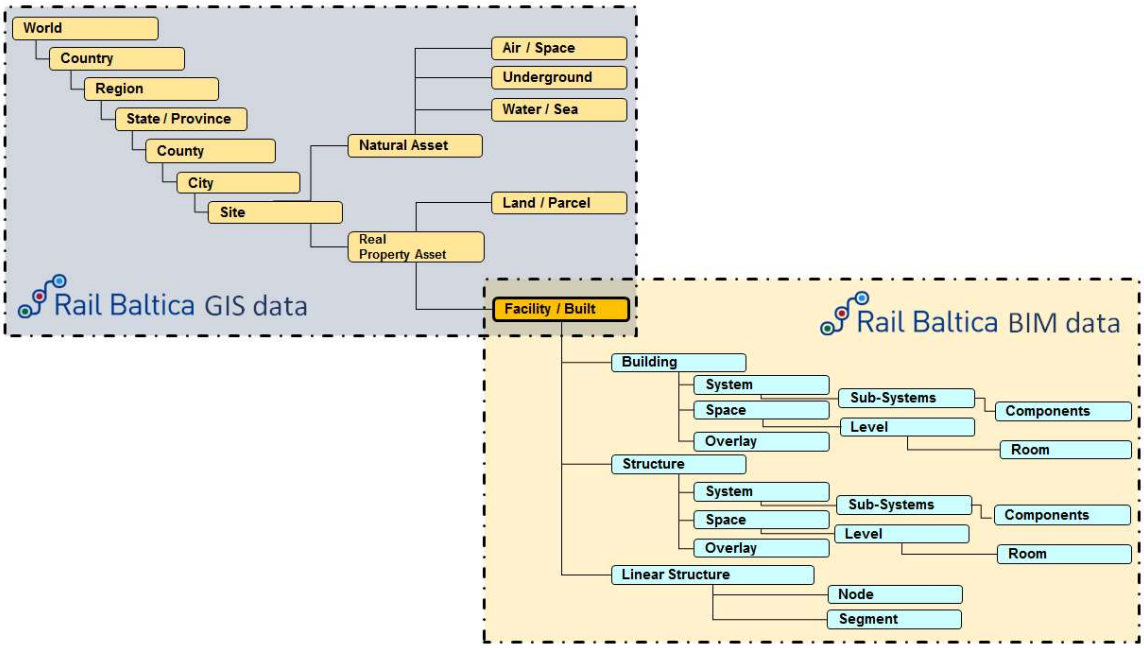


Figure 36: From GIS data to BIM data

11. BIM Modelling and CAD Standards

11.1. General

The Open BIM approach of the Rail Baltica BIM Strategy does not impose the use of any specific authoring tool, and therefore the CAD Standards are not tool / software related. This means that the CAD Standards are a set of guidelines to be assimilated and replicated by the Supply Chain in their project's specific authoring tools, by defining their own CAD Manual taking the CAD Standards as a base.

The CAD Standards can be found in the Annex "CAD Standards" RBR-DOC-BIM-BMA-0002.

11.2. CAD Manual development

The CAD Manual will be submitted for RB Rail AS's approval after the Contract award. RB Rail AS will define the schedule of release of the document, which is recommended to be released together or after the submission of the Post-Contract BEP, because of the direct relationship with the authoring tools' workflows and standards.

The CAD Manual will include the templates to be used by all the teams working with a specific authoring tool. The template can be discipline-related, and various templates may exist for the same authoring tool in that event.

Due to the wide variety of BIM authoring tools, with their own idiosyncrasy, it might happen that certain guidelines of the CAD Standards could not be technically achieved by certain authoring tools. In that case, the Supplier's CAD Manual will raise the possible issues and will propose alternatives or mitigation solutions, which will be agreed with RB Rail AS.

12. Level of Definition

12.1. Definition

The Level of Definition (LOD) is a collective term used to manage the expectations of the extent to which an object category is modelled for a certain purpose, normally related to project stages. This term is used to describe both the Level of Geometric detail (LoG) and the Level of Information (LoI).

LOD = LoG + LoI

It includes the level within the asset hierarchy, the geometric detail included (LoG), the accuracy of information required (LoI) and the attribute information expected for the different goals or at each delivery stage. It should be noted that depending on the contract, the discipline and the type of asset being described this may differ in content.

12.2. Level of Geometric detail (LoG)

The Level of Geometric detail (LoG) is the description of the quality of the graphical content of a container at a particular point during project delivery. It relates to how much detail is included within the model Space, System or Element.

The Levels of Detail in general and for all disciplines can be described as follows:

Level of Geometric detail (LoG)	Definitions
LoG 100	The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LoG 200. Elements are not geometric representations and any information obtained from a LoG 100 object must

	be considered approximate.
LoG 200	The Model Element is graphically represented within the Model as a generic system, space, object, or assembly with approximate quantities, size, shape, location, and orientation. The Model must be accurate enough to ensure that the design complies with the defined restrictions (clearances for administrative, legal, environmental, adjacent roads, railways, space for utilities/electromechanical systems verification or transversal discipline coordination) prior to detailing. As such, the LoG 200 is defined to reach the requirements of the Master Design, by focusing on the outer geometry and allowance of the objects. The elements may be recognizable as the components they represent or as volumes for space allocation and reservation. This LoG can be used to verify regulatory requirements if those are allowance-related (clearances).
LoG 300	The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation. Objects actually modelled can be measured directly from the model and those non-modelled can be calculated taking into account measures extracted from related objects (for instance by means of ratios, EIR permitting). This LoG can be used to verify any regulatory requirements unless those are related to specific brand/model/material.
LoG 400	The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. This LoG incorporates co-ordinated specialist sub-contract design models and reaches the highest level of definition geometrically speaking.
LoG 500	As per LoG 400 but with sufficient verification as to demonstrate the accuracy of the model as a constructed at handover. It is focused on the graphical information needed to support the model and the LoI for the Operation & Maintenance stage. It is important to mention that this LoG does not necessary need to reach the highest detail of the LoG 400.

Table 9: Levels of Geometric detail (LoG)

These levels have been further detailed for each particular discipline and model type in the "RBR-DAT-BIM-BMA-0007_BIM_Objects_LoG_Matrix.xlsx" see Annexes Section.

12.3. Level of Information (LoI)

The Level of Information (LoI) is the description of the quality of the non-graphical content of a container at a particular point during project delivery. It relates to the information that is included within the model's elements and that is contained in the elements' attributes. An example of this information could be (but not exclusive or limited to) performance specifications or asset management maintenance information.

The Levels of Information in general and for all disciplines can be described as follows:

Level of Information (LoI)	Definitions
LoI 100	The Model Element may be represented with some basic non-graphic information sufficient to depict preliminary design intent. The LoG and LoI are also included.
LoI 200	The Model Element is represented with identification properties which allow its traceability. GIS information should also be included, if required. It includes also the attributes from the LoI 100, updated.
LoI 300	The Model Element is represented with specific performance information to support Asset Data, Specifications and Quantities and Cost Estimation. It includes also the attributes from the LoI 200, updated.
LoI 400	The Model Element properties are updated reflecting data that has been verified following installation (e.g. as-built)
LoI 500	The Model Element is represented with specific maintenance information, which is updated whenever necessary.

Table 10: Levels of Information (LoI)

The attributes to be fulfilled for each level shall be further detailed for each particular discipline and model type in the BEP of each project. The template for this tables is included in the "RBR-DAT-BIM-BMA-0005_BIM_Objects_Attributes_Matrix.xlsx" Annex.

12.4. Levels of Accuracy

It should be noted that the information provided in the BIM model can be relied on until the degree defined by the LoG and LoI for that phase and discipline, and that any extra information over those levels should be considered only as a reference of how could advance the definition of the objects in future stages and not as a part of the stage.

These levels shall also be included on each element's attributes LoG and LoI, and the Level marked in those attributes will prevail over the detail of geometry and the amount of data.

It is strongly recommended to not over-define or over-populate the data, or in other words overcome the LoG and the LoI in order to avoid misunderstandings to the different actors consuming the models.

12.5. BIM Development Plan – LOD by Phase

The Level of Definition (LOD) required in a model at designated points throughout the lifecycle of the project (design, construction, operation…) shall be particularly defined in the EIR of each project and will be related to the Scope of Services requested and the project stages that conform the contract. The different countries integrating Rail Baltica have different approaches and requirements to each Design Stage, therefore, this document defines the general Model Development Plan that will be the base of reference for every project EIR.

Taking the PAS 1192-2:2013 (Figure 20) as reference, for the different phases of the project the following stage numbers should be considered:

- Models in **Master design** shall include the outer geometry for the front edge plate, foundations and major structures corresponding to "Stage number 3 - Definition". Based on the model, data and documents, as a minimal requirement, it shall be possible to extract information according to the requirements of Master design. The model is intended to be relied upon for coordination, general sequencing and estimation.
- Models in **Detailed technical design** have to include all the objects corresponding to "Stage number 4 – Design" or "Stage number 5 – Build". Based on the model, data and documents, as a minimal requirement, it shall be possible to extract information for the building design. The model is intended to be used to verify compliance with regulatory requirements, being dimensionally correct and coordinated, with information usable for fabrication and production. LOD (LoG+LoI) may differ depending on the discipline of the project.
- **As-built** models in **Construction stage** have to include objects corresponding to the same detailing level as detailed design, confirmed or revised by detailed surveys corresponding to "Stage number 6 – Handover and closeout".
- **Models in Operation stage** have to include objects corresponding to the same detailing level as detailed design, incorporating any changes since handover, including the data related to maintenance and operation purposes to "Stage number 7 – Operation". In this stage the LoI prevails over the LoG, making possible the creation of new elements only to act as place-holders for the LoI, if not previously defined.

Depending on the project, there will be specific Submissions for Administrative approvals by local authorities, to verify the compliance of the regulatory requirements. The deliverables related to this point will be defined in depth in the project's EIR and may vary according to the local authorities BIM maturity level.

RAIL BALTICA BIM DEVELOPMENT PLAN	RAIL BALTICA PROJECT PHASES				
	Value engineering	Master Design	Detailed Technical Design	Construction	Operation
BIM Stage definition (reference: PAS 1192-2) **BIM object LoG** (reference: "BIM Manual" + BIM Forum) **BIM object LoI** (reference: "BIM Manual")	**Stage 2 - Concept / Stage 3 - Definition**	**Stage 3 - Definition / Stage 4 - Design**	**Stage 4 - Design / Stage 5 - Build and commission**	**Stage 5 - Build and commission / Stage 6 - Handover and Closeout**	**Stage 6 - Handover and Closeout / Stage 7 - Operation**
BIM MODELS (Geometry + Data)	**Project models within RB Rail scope**				
Level of Geometric Detail (LoG)	LoG 200*	LoG 300*	LoG 400*	LoG 400 / 500*	LoG 500*
Level of Information (LoI)	LoI 200*	LoI 300*	LoI 400*	LoI 400 / 500*	LoI 500*
3D MODELS (Geometry)	**Environment models / Existing Utilities models / Buildable & Non-buildable out-of-scope elements models**				
Level of Geometric Detail (LoG)	LoG 200*	LoG 300*	LoG 400*	LoG 400 / 500*	LoG 300*
Level of Information (LoI)	LoI 0	LoI 0	LoI 0	LoI 0 / Relocated utilities 300*	LoI 0
All	**BIM Models & 3D Models**				
Geo-reference	Yes	Yes	Yes	Yes	Yes
Constrution scheduling / planning (4D)	**No**	Yes, briefly	Yes, approximate	Yes, accurate	No
Quantity Extraction (5D)	Partially, up to LoG detail	Partially, up to LoG detail	Yes	Yes	Asset Management related
Asset Management (6D)	No	No	Yes, basic according to LoI	Yes, detailed according to LoI	Yes, according to LoI
Analytical Calculations linked to BIM	Not a requirement	Not a requirement	Not a requirement	Not a requirement	Recommended

* - this is indicative target number and LoG and LoI for each discipline and system shall be agreed with the client separately in the BEP.

Table 11: Rail Baltica BIM Development Plan

12.6. Definition by phases and disciplines

Tabulation must clearly define what must be delivered at each stage of the project for each discipline, noting that different LoG's and LoI's may be required at each stage for different disciplines.

A table such as the following must be defined in the Post-Contract BEP of each project, specifying the LoG and LoI for each item type for the different disciplines and phases of the project, always following the EIRs instructions (which are at the same time based on the Rail Baltica BIM Development Plan (see Table 10)). Any change from EIRs will need to be approved by RB Rail AS.

	PROJECT PHASE							
	Design BIM						Construction BIM	
	Phase 1 Value Engineering		Phase 2 Master Design		Phase 3 Detailed Technical Design		Phase 4 As-Built	
Item Nr.	LoG	LoI	LoG	LoI	LoG	LoI	LoG	LoI
MAJOR DISCIPLINE A								
Item 1	200	200	300	300	300	300	300	300
Item 2	200	200	300	300	400	400	400	300
Item 3	200	200	300	300	500	500	500	500
Item 4	YYY	XXX	YYY	YYY	XXX	YYY	XXX	YYY
MAJOR DISCIPLINE B								
Item 1	XXX	YYY	XXX	YYY	XXX	YYY	XXX	YYY
Item 2	XXX	YYY	XXX	YYY	XXX	YYY	XXX	YYY

Table 12: LOD table per discipline and phase template

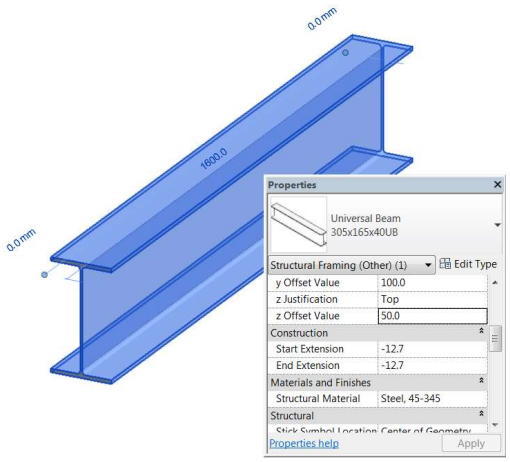
The specific definition of the LoG is included in "RBR-DAT-BIM-BMA-0007_BIM_Objects_LoG_Matrix.xlsx" Annex for every discipline/role. In case of discrepancy of what is included in a LoG, the BIM Forum LOD Specification will prevail (http://bimforum.org/lod/).

The specific definition of the LoI is included in the Point "Level of Information (LOI)" of this Section.

13. BIM Objects' definition

13.1. General

A BIM Model is composed of a set of linked BIM objects which are represented 3-dimensionally and that contain an amount of information attached in the form of attributes. This graphical and information definition of the objects must be as detailed as indicated by the Level of Definition, as it has been explained in the see section 12 "Level of Definition".



In addition to complying with the established Level of Definition for its discipline and project phase, the BIM objects must always:

- Be identifiable via the codification set up
- Include the attributes defined in the appendices
- Allow viewing of 3D footprint
- Be simple and generic

Figure 37: Example of BIM Object geometry and information attached

13.2. 3D graphic representation

Objects must be modelled in 3D from the BIM modelling tool selected by the Supply Chain, and always respect the rules of good practice when modelling:

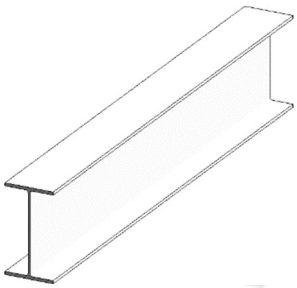


Figure 38: Example of BIM Object geometry

- Constraints
- Links with other objects
- Location in the project

The object must be made with the dimensions defined in the specifications or in accordance with the design reports.

When the modelling tool does not allow a correct modelling of the elements, a generic object will be created which will have to respect the codification set up (example of the false ceilings), as well as the LoG.

If an object is more detailed than obligated according to the Level of Definition for a certain phase, that extra detailing does not have to be considered.

13.3. BIM Objects' information (Data Management)

Each object is codified by a set of attributes to qualify it. This information is very diverse and can define or describe the object or refer to a requirement or classification system for various purposes, such as Geometry, Identification data, Analytical data, Construction Phases, Environmental specifications, Financial estimate or Exploitation data.

All this information is not included in the BIM object from the very beginning of the project, thus, some fields will be completed in the following phases of the project. This is defined for every phase by the Level of Information.

In the case of use of nested objects, each object will have to respect the codification set up in order to allow a correct extraction of the quantities. The name of the object must be meaningful and allow to classify it according to its most relevant characteristics, refer to the document "RBR-DOC-BIM-BMA-0003_CodificationDataManagement" for further details and examples.

When populating elements' data according to the different types and/or classifications systems, it is highly recommended to do it always from the same central source of information, such as a dictionary, in order to avoid errors.

The information entered in the object attributes is only in the project language.

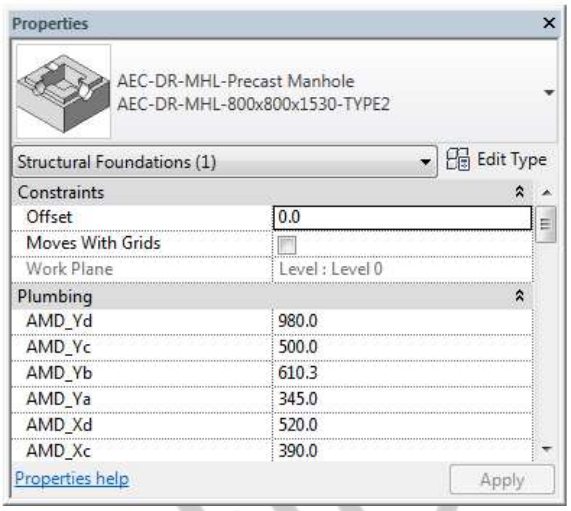


Figure 39: Example of attributes

13.3.1. Attributes

The Attributes are the pieces of information linked to each BIM object to describe one specific characteristic of it. They allow to define and identify each object instance in the BIM model and also to classify the objects in groups according to their material, specification, phase of creation, location, manufacturer or any other characteristic which could be of interest.

The possible attributes to be added to an object are endless, so it must be specified which attributes are needed and when in order to define the object to be designed, fabricated and put in place. RB Rail AS establish a number of attributes which are compulsory to fulfil, depending on the project phase and discipline, and the Supply Chain is free to add as many as they desire.

Refer to the documents RBR-DAT-BIM-BMA-0005_BIM_Objects_Attributes_Matrix and RBR-DOC-BIM-BMA-0003_CodificationDataManagement for further details.

The attributes are also classified according to their **application**:

- **Global:** Applied to every single BIM object
- **Discipline-Specific:** Applied to the objects of one specific discipline
- **Type-Specific:** Applied to specific object types

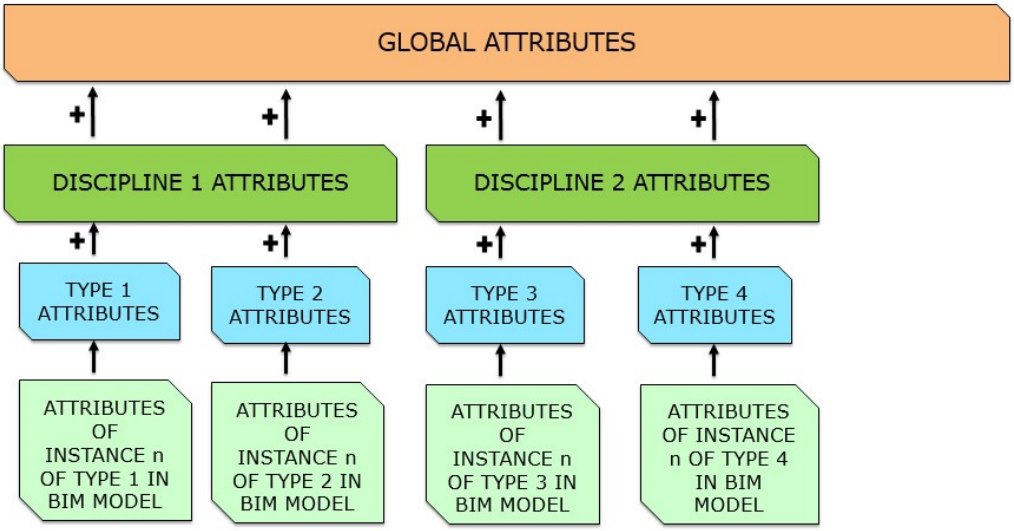
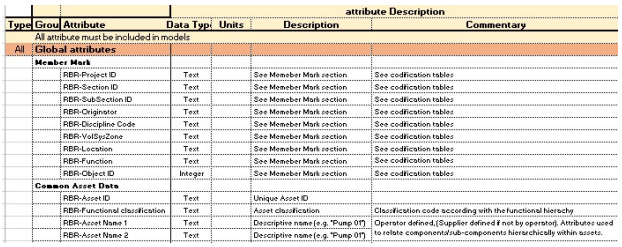


Figure 40: Attributes

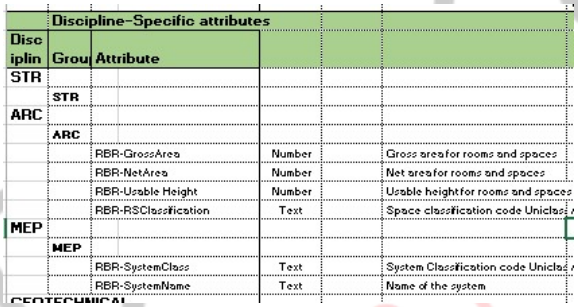
In order to ease the comprehension and use of the attributes, they are divided in **groups** according to their subject:

- Member Mark
- Common Asset Data
- Location Asset Data
- Element Asset Data
- LOD
- Specifications
- Quantities and Cost Estimation
- Time Liner
- Clash Detection
- Sustainability
- Life and Safety
- GIS
- Operation/Facility Management
- Dimensions. Constraints, measures…
- Analytical properties
- MEP
- Structural
- Architectural
- Civil
- Utilities
- Construction
- Others



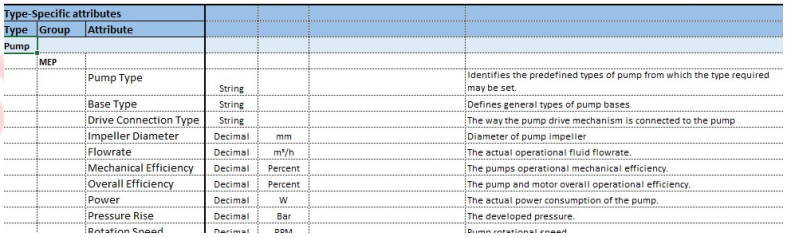
			attribute Description			
Type	Grou	Attribute	Data Typ	Units	Description	Commentary
		All attribute must be included in models				
All		Global attributes				
		Member Mark				
		RBR-Project ID	Text		See Memeber Mark section	See codification tables
		RBR-Section ID	Text		See Memeber Mark section	See codification tables
		RBR-SubSection ID	Text		See Memeber Mark section	See codification tables
		RBR-Originator	Text		See Memeber Mark section	See codification tables
		RBR-Discipline Code	Text		See Memeber Mark section	See codification tables
		RBR-VolEyeZone	Text		See Memeber Mark section	See codification tables
		RBR-Location	Text		See Memeber Mark section	See codification tables
		RBR-Function	Text		See Memeber Mark section	See codification tables
		RBR-Object ID	Integer		See Memeber Mark section	See codification tables
		Common Asset Data				
		RBR-Asset ID	Text		Unique Asset ID	
		RBR-Functional classification	Text		Asset classification	Classification code according with the functional hierachy
		RBR-Asset Name 1	Text		Descriptive name (e.g. "Pump 01")	Operator defined,(Supplier defined if not by operator). Attributes used to relate components/sub-components hierarchically within assets.
		RBR-Asset Name 2	Text		Descriptive name (e.g. "Pump 01")	

Figure 41: Example groups in global attributes



	Discipline-Specific attributes			
Disc iplin	Grou	Attribute		
STR				
	STR			
ARC				
	ARC			
		RBR-GrossArea	Number	Gross area for rooms and spaces
		RBR-NetArea	Number	Net area for rooms and spaces
		RBR-Usable Height	Number	Usable height for rooms and spaces
		RBR-RSClassification	Text	Space classification code Uniclas
MEP				
	MEP			
		RBR-SystemClass	Text	System Classification code Uniclas
		RBR-SystemName	Text	Name of the system

Figure 42: Example of discipline-specific attributes



Type-Specific attributes					
Type	Group	Attribute			
Pump					
	MEP				
		Pump Type	String		Identifies the predefined types of pump from which the type required may be set.
		Base Type	String		Defines general types of pump bases
		Drive Connection Type	String		The way the pump drive mechanism is connected to the pump
		Impeller Diameter	Decimal	mm	Diameter of pump impeller
		Flowrate	Decimal	m³/h	The actual operational fluid flowrate.
		Mechanical Efficiency	Decimal	Percent	The pumps operational mechanical efficiency.
		Overall Efficiency	Decimal	Percent	The pump and motor overall operational efficiency.
		Power	Decimal	W	The actual power consumption of the pump.
		Pressure Rise	Decimal	Bar	The developed pressure.
		Rotation Speed	Decimal	RPM	Pump rotational speed

Figure 43: Example of Type- specific attributes

13.3.1.1. Compulsory Attributes per LoI

The annex "BIM Objects Attributes Matrix" includes the list of compulsory attributes that the Supply Chain must fill in for each LoI. These attributes are identified with a "RBR-" at the beginning of their names and must be created and fulfilled in every BIM Model.

Type	Grou	Attribute	Data Typ	Units	Description	Commentary	200	300	400	500
	All attribute must be included in models									
All	**Global attributes**									
	Member Mark									
		RBR-Project ID	Text		See Memeber Mark section	See codification tables	X	X	X	X
		RBR-Section ID	Text		See Memeber Mark section	See codification tables	X	X	X	X
		RBR-SubSection ID	Text		See Memeber Mark section	See codification tables	X	X	X	X
		RBR-Originator	Text		See Memeber Mark section	See codification tables	X	X	X	X
		RBR-Discipline Code	Text		See Memeber Mark section	See codification tables	X	X	X	X
		RBR-VolSysZone	Text		See Memeber Mark section	See codification tables	X	X	X	X
		RBR-Location	Text		See Memeber Mark section	See codification tables	X	X	X	X
		RBR-Function	Text		See Memeber Mark section	See codification tables	X	X	X	X
		RBR-Object ID	Integer		See Memeber Mark section	See codification tables	X	X	X	X
	Common Asset Data									
		RBR-Asset ID	Text		Unique Asset ID		-	X	X	X
		RBR-Functional classification	Text		Asset classification	Classification code according with the functional hierarchy	-	X	X	X
		RBR-Asset Name 1	Text		Descriptive name (e.g. "Pump 01")	Operator defined, (Supplier defined if not by operator). Attributes used	-	X	X	X

Figure 44: Snapshot of LOI attributes table template

13.3.1.2. Project-Defined Attributes per LoI

In addition to the former attributes, the Supply Chain is free to define their own attributes in order to carry along their 4D, 5D, 6D, etc. strategy in their project. They shall add their own attributes in the annex "BIM Objects Attributes Matrix" (using as template the file "RBR-DAT-BIM-BMA-0005_BIM_Objects_Attributes_Matrix"), indicating if they are global, discipline or item-specific, and the LoI for which they must be filled in. With this complete list of attributes, it will be possible to implement and coordinate the attributes strategy for the whole project.

13.3.2. Asset Data

The key to asset information requirements is to define the metadata required to design, build, operate and maintain an asset throughout its lifecycle.

This metadata needs to be relevant and be capable of answering the critical questions asked by each discipline carrying out their tasks at each stage of the assets lifecycle.

The Asset data to be populated into the models is included into the "Common Asset Data" and the "Primary Asset Data" attributes group, and if needed by RB Rail AS and the future operators, RB Rail AS will complete it by adding that data to the "RBR-DAT-BIM-BMA-0005_BIM_Objects_Attributes_Matrix.xlsx".

At defined project phases the Supply Chain shall capture sufficient data in the model of the project in a format such to facilitate future information exchange into a Computerised Maintenance Management System (CMMS) and Service Life—Cycle Management.

13.3.3. Materials

BIM objects must have assigned materials. If the native software has a specific system to define element materials, this system must be used, or else an attribute named RBR-Material must be included and associated to every element and used to define the element material.

It is important to mention that most of the authoring tools manage the Quantity Take-offs by means of the object materials, therefore the Post-Contract BEP will define the quantity extraction strategy for each discipline/package authoring tool and if that is related to materials, a specific Material library/dictionary will need to be managed so as to have a consistent approach internally. Evidences of the management of the Materials will be provided.

13.4. Family / Component Content Libraries

An insufficient and inconsistent BIM content library can be a major obstacle to harnessing the benefits of BIM workflows, affecting to the quality, the production effectiveness and the production speed. Where this kind of issue is particularly clear is within packages of the same discipline, because the same object type should look similarly and be populated with the same data information throughout the project so that the aggregation and digestion could be integrated.

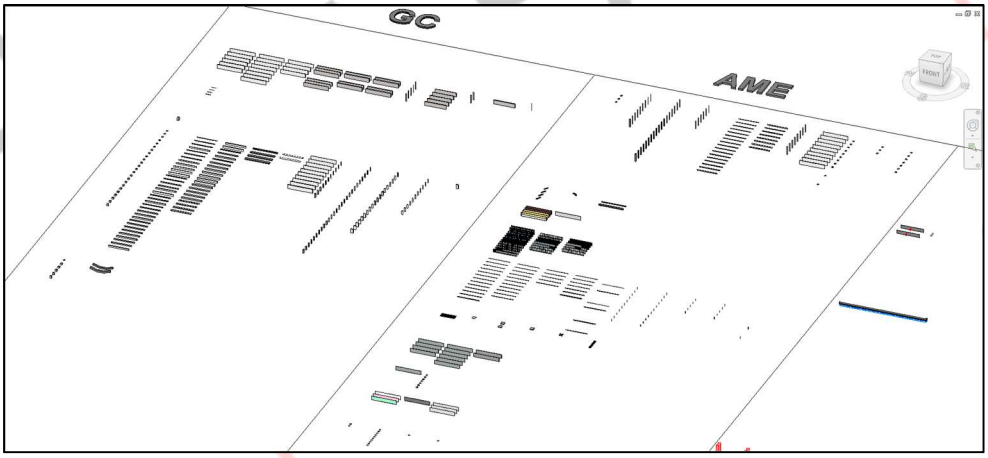


Figure 45: Example of BIM Objects content library

In order to ensure the consistency, each discipline/package within a project will create and maintain a Family / Component content library that will be used by all the members of that discipline within that package, being the Supplier's responsibility to submit the content library periodically, so that an external quality check could be performed by RB Rail AS or its BIM specialist assistance.

When the Rail Baltica project has already developed several projects, RB Rail AS will be able to decide whether to provide their particular RB Rail AS BIM content for some chosen elements (or even Datasets, restricting the objects the Suppliers can use to that BIM content) or letting the Supply Chain to keep creating their own.

It is important to mention that the different authoring tools refer to the BIM Content according to their technological structure. In the table below, a list of the different terminologies is shown:

BIM Software	Content name
Revit	family
Civil 3D	Assembly / subassembly & blocks
AECOsim	family part
Rail Track / Open Roads	features & components
ArchiCAD	components
Allplan	components
Tekla Structures	components
…	…

Table 13: Examples of BIM Objects terminology per software

13.5. Linear infrastructure objects

BIM was originally conceived to design buildings and not infrastructures, and therefore to date the tools maturity for these projects is lower. Moreover, the geometry of these objects is normally more complex, due to curved and double curved alignments and the placement of objects following it.

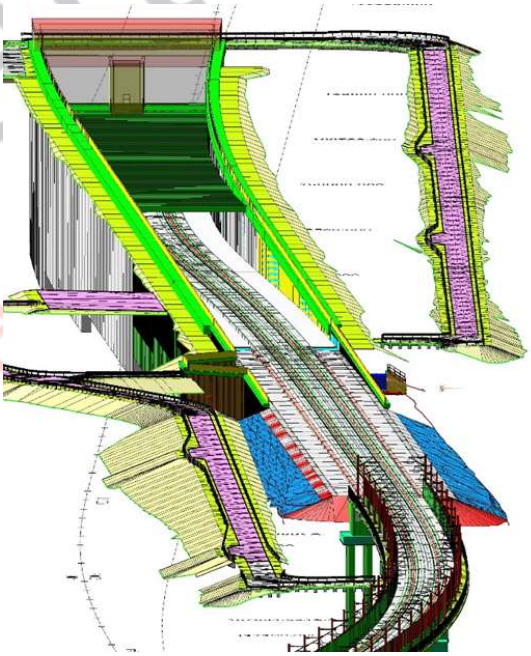


Figure 46: Example of linear infrastructure model

When choosing the BIM tool to model infrastructure, the Supply Chain should consider the following aspects:

- Interoperability among disciplines (bridge, rail, highways, geotechnical)
- Capability to handle geometrical variations over the length of linear alignment
- Capability to handle the BIM use cases described in section "BIM Goals" of this manual
- The level of BIM maturity of the tool and the capability to export IFC files, direct or indirectly

Even though the specific workflows and procedures for each project and discipline shall be agreed in the Post-Contract BEP, some considerations when modelling linear infrastructure objects are:

- The BIM elements shall be modelled in lengths of up to 100 m for Asset Management purposes
- Object representations will be according to the LoG defined and will contain the data required in the corresponding LoI
- The linear-specific software quantity extraction is commonly based on materials take-offs, but in some cases a classification or attribute-driven can be used for the object filtering and data extraction
- The linear objects could be both modelled with "traditional" building BIM authoring tools (like Revit or AECOsim among others) and with linear-specific BIM authoring tools (like Civil 3D or Power Rail Track among others). The building BIM authoring tools have no "out of the box" capabilities to model and interact with alignments, and even if they have some advanced tools that may support the linear modelling (like Dynamo or Generative Components for Revit and AECOsim respectively) those software are not linear-designed and any alignment modification would trigger a significant rework. Moreover, the capabilities of these building software to populate the information data (LoI) required is limited, if not impossible. Therefore, it is not compulsory but it is recommendable to model linear assets by means of linear-specific software.

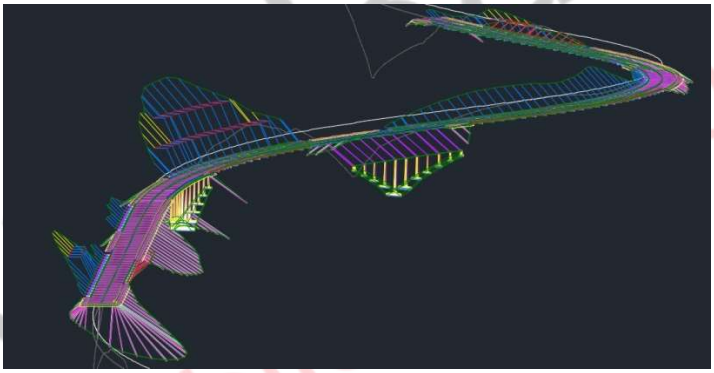


Figure 47: Example of linear infrastructure model

- The BIM linear software differ in the way the BIM objects are modelled and managed. While the building BIM authoring tools are based on discrete families/components/systems, the linear-specific software have alignment-related objects, which are driven by "intelligent" cross sections (features, assemblies/subassemblies,…) that get extruded along through the alignments (or tracks) from one starting chainage to an end chainage, creating corridors. These "intelligent" cross sections interact with land or other corridors generating embankments, cuttings or junctions.

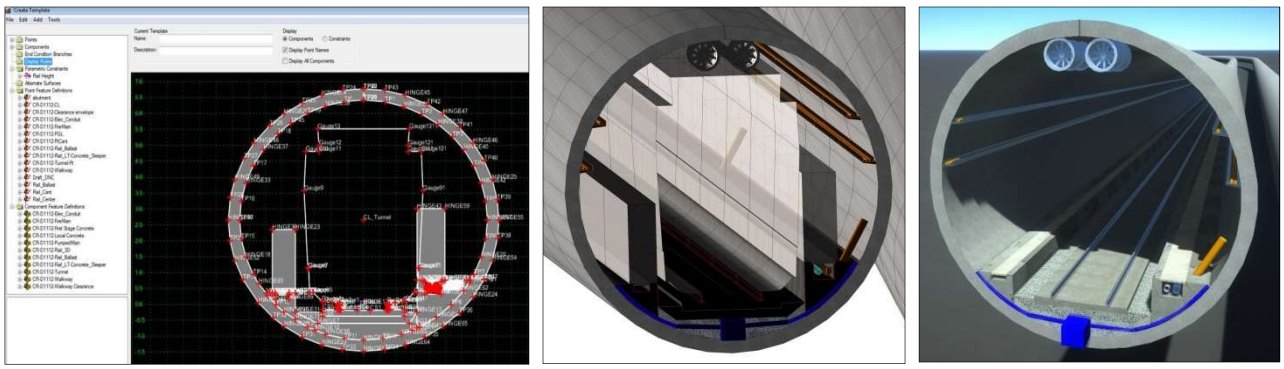


Figure 48: Example of tunnel model

- The level of Geometric Detail (LoG) of the non-linear objects created within the linear-specific software may not easily reach highly detailed LoGs for some elements, such as bridges for instance. For these cases, an appropriate authoring tool must be chosen in order to create a highly detailed BIM model for the discrete and complex elements (e.g. with TEKLA, Revit, Advance Steel, Allplan, ProStructures,…) while keeping the rest of the model for the linear-continuous elements, as long as the Open format can be created. The WBS will differentiate these models accordingly as soon as possible, that is to say, if it is intended to change the authoring tool during the project for certain elements within some models, it is recommended to have those models being independent from the first moment, as much as possible.
- The modelling will take into account the construction process, by dividing the elements accordingly, because some BIM Management software have not out-of-the-box tools for dividing elements.

13.6. Structural objects

Structural objects representation will be according to the LoG defined and will contain the data required in the corresponding LoI.

As quantity extractions will be extracted from models, structural elements shall be modelled with this in mind, in order to ensure precise extractions.

The structural objects shall be modelled according to the construction process, taking into account construction joints, expansion joints, etc.

If the analytical calculations BIM use case is intended to be implemented, the structural axis and the intersections of the elements will be taken into consideration when modelling. Some analytical software allow a bi-directional workflow (BIM model => analytical model => BIM model). It is recommended to limit this use to the software with mature BIM workflows, and otherwise to use only the unidirectional workflow (BIM model => analytical model) in order to avoid imprecisions and import errors.

Structural objects must be exportable to IFC, ensuring that the exported object complies with the LoG and LoI required in the current phase and accordingly with the point "Document Format" in its part related to IFC.

13.7. MEP objects

MEP objects representation will be according to the LoG defined and will contain the data required in the corresponding LoI.

As quantity extractions will be extracted from models, MEP elements shall be modelled with this in mind, in order to ensure precise extractions.

In initial stages, Space reservations shall be modelled in order to consider the needs, and also maintenance spaces for equipment, etc. For more detail, see “Level of Definition” Section.

MEP spaces will be created accordingly with Architectural rooms in order to follow a common criterion, which must be agreed by the implied parts. This does not mean that rooms and spaces will be equal, but a relationship criteria will have to be defined.

The use of complex elements with multiple nested elements must be carefully considered, as this complexity can have unintended consequences and even prevent the obtaining of the expected results.

MEP objects must be exportable to IFC, ensuring that the exported object complies with the LoG and LoI required in the current phase and accordingly with the point "Document Format" in its part related to IFC.

13.8. Architectural objects

Architectural objects representation will be according to the LoG defined and will contain the data required in the corresponding LoI.

As quantity extractions will be extracted from models, architectural elements shall be modelled with this in mind, in order to ensure precise extractions.

Carefully considerations shall be taken when modelling layered elements, keeping in mind the BIM model objectives.

When creating BIM objects driven by attributes, the creation of the attribute must agree not only with the graphical design, but also with the extraction of data from the element.

All rooms in the model will be created and rightly named accordingly with the naming standard.

Architectural objects must be exportable to IFC, ensuring that the exported object complies with the LoG and LoI required in the current phase and accordingly with the point "Document Format" in its part related to IFC.

13.9. Pre-existing objects and integration

The pre-existing objects will be modelled by the Supplier as 3D Models (only geometry) from the data available, normally 2D, but possibly in the future also in 3D or GIS format. This information has to be acquired by the Supplier, as the Employer provides only what is available to them, but it is neither exhaustive or enough. Therefore, existing conditions shall be modelled based on Supplier's surveys and anything additional provided by Employer and authorities.

These models will be identified as described in the"3D models and BIM models" point in the "Deliverables from BIM models" Section.

The responsibility of the creation of each pre-existing objects that may interact, connect, clash or simply visually interfere, will fall over the disciplines involved. For instance, the existing utilities like the sewage system will be modelled by the Plumbing team, because that discipline will connect to that existing network. This general rule also means that the existence of the sewage shafts could affect the structural or even the landscape team, so in those cases the affected teams could model the elements. The pre-existing objects will be modelled up to a distance of 10-15m from the limit of works. The Supplier BIM Information Manager (BIM Manager) will manage and organize the creation of the pre-existing objects so that any relevant pre-existence will be modelled as a 3D Model.

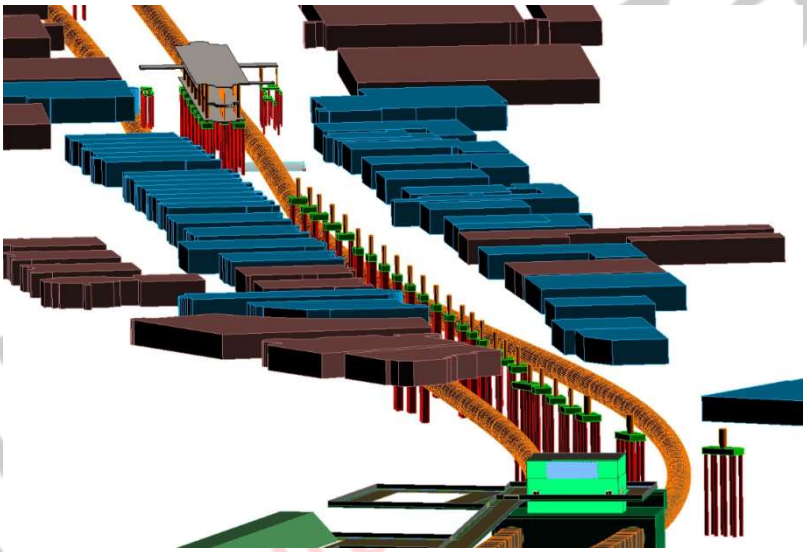


Figure 49: Example of pre-existing objects 3D model

In the case of existing structures that will undergo any kind of re-construction/demolition need to be modelled in such LoG that it would be possible to extract the re-construction/demolition quantities directly from the 3D/BIM model.

In the accompanying picture, a set of 3D models provide the information of an existing bridge foundations and station, which affects the Design of the rail access tunnels. The buildings footprints were also modelled for coordination purposes.

14. Deliverables from BIM models

14.1. General and scope

The following section defines the BIM deliverables for the Rail Baltica project. The service provider or supplier will deliver not only a list of independent models, but a complete set of BIM models and BIM extractions, which will include:

- BIM models (3D models with information data, geo-located according to a WCS) in both native and OpenBIM format.
- BIM aggregated models, which are combination or compilation of multiple models into a single manageable model.
- Data extractions (or data drops), such as data tables with object information and asset management; and quantity extractions. Quantity extractions (and the Cost Estimating) are commonly called 5D.
- Quality reports, documenting the compliance with the quality requirements of the BIM deliverables. The more common are the *Clash Check Report*, the *QAQC BIM/CAD Checklist* and the *Delivery Report* (templates provided in the Annexes).
- Planning / scheduling documentation, prepared or not as reports or videos. Normally called 4D.
- Other documents / files specified within the EIR of the project.

Rail Baltica - Viaducts B001 - 1&2 Submittal Report

Template version beta 1 (19/06/2018)

Project Code	666111
Project Title	Riga Airport
Author	XXX
Date Created	19/04/2018
Date Last Updated	15/06/2018
Document Reference	B001-R001-RP-CE-000001

Rail Baltica

[Project]-[Originator]-[Volume_System/Zone]-[Location]-[Type]-[Role]-[Number]

ABCDEF-RBR-E001AA-R001-BQ-AR-C Example file name

				Refer to file naming convention doc for info							INFORMATION DATA		DATA EXCHANGE #01			
				FILE NAME									STAGE:	BRIEF		
													PROGRAMME REF:	Viaducts B001 - 1&2		
DELIVERABLE (TITLE)	DESCRIPTION	NATIVE FORMATS	EXCHANGE FORMATS	PROJECT CODE	ORIGINATOR CODE	VOLUME_ SYSTEM / ZONE	LOCATION	TYPE	ROLE	NUMBER	CLASSIFICATION (UNICLASS 2015)	ASSET MNG CLASSIFICATION	OWNER	LEVEL OF DEFINITION		ISSUE DATE
														LoG	LOI	
VIADUCTS PACKAGE - SECTOR 12																
Viaduct B001_ Deliverable Report	Deliverable Report	XLSX	-	RBRRIG	RBR	B001	R001	RP	CE	000001	NO	NO	Civil and structural engineer	100		19/06/2018
BIM Model Viaduct B001-1_Native	Revit BIM model - native	RVT	-	RBRRIG	RBR	B001	R001	BI	CE	000001	YES	NO	Civil and structural engineer	200	200	19/06/2018
BIM Model Viaduct B001-1_IFC	Revit BIM model - OpenBIM - IFC	-	IFC	RBRRIG	RBR	B001	R001	BI	CE	000001	YES	NO	Civil and structural engineer	200	200	19/06/2018
BIM Model Viaduct B001-2_Native	Revit BIM model - native	RVT	-	RBRRIG	RBR	B001	R001	BI	CE	000002	YES	NO	Civil and structural engineer	200	200	19/06/2018
BIM Model Viaduct B001-2_IFC	Revit BIM model - OpenBIM - IFC	-	IFC	RBRRIG	RBR	B001	R001	BI	CE	000002	YES	NO	Civil and structural engineer	200	200	19/06/2018
BIM model Viaduct B001-1_Data Drop	Data drop	XLSX	-	RBRRIG	RBR	B001	R001	DB	CE	000001	YES	NO	Civil and structural engineer		200	19/06/2018
BIM model Viaduct B001-2_Data Drop	Data drop	XLSX	-	RBRRIG	RBR	B001	R001	DB	CE	000002	YES	NO	Civil and structural engineer	200		19/06/2018
Viaduct B001_QEX	Quantity Extraction	XLSX	-	RBRRIG	RBR	B001	R001	BQ	CE	000001	YES	NO	Civil and structural engineer	200		19/06/2018
BIM model Viaduct B001_ClashReport	Clash Check report	XLSX	-	RBRRIG	RBR	B001	R001	CR	CE	000001	YES	NO	Civil and structural engineer	200		19/06/2018
BIM model Viaduct B001_1&2_Aggregated	Navisworks BIM model aggregation	NWD	-	RBRRIG	RBR	B001	R001	CM	CE	000001	NO	NO	Civil and structural engineer	200	200	19/06/2018
Schedule Viaduct B001_4D	Estimated Planning - Video	AVI	-	RBRRIG	RBR	B001	R001	AF	CE	000001	NO	NO	Civil and structural engineer	200		19/06/2018
3D model Surroundings_Native	3D Model - Point Cloud - BY YYY, 05	RVT	-	RBRRIG	RBR	B001	R001	M3	CE	000001	NO	NO	Civil and structural engineer	100		19/06/2018
3D model Surroundings_IFC	3D Model - Point Cloud - BY YYY, 05	-	IFC	RBRRIG	RBR	B001	R001	M3	CE	000001	NO	NO	Civil and structural engineer	100		19/06/2018

Figure 50: Submittal Report template

RB Rail AS is not imposing any software for the deliverables, trying to follow as much as possible an Open approach. The supplier is requested to follow it and ensure the delivery of both Native and Open formats, in order to allow the consumption of the BIM data by the different actors involved in the processes.

The set of deliverables will be referenced to the original federated BIM models (in turn included in the deliverables), by defining clearly what model, version and stage is the source of the different BIM extractions and what model and information a deliverable rely upon.

The file formats for each particular deliverable are defined in Section “File Formats”.

14.1.1. Compliance Requirements

The service provider shall demonstrate integrity of the BIM models and other data sources and that they are maintained and adhere to quality assurance and control procedures.

Throughout the lifetime of the project, it will be necessary to review the BIM and its constituent models to maintain consistency of processes and data, adherence to the BIM Manual and to identify software/ hardware issues that require attention of the Rail Baltica BIM Team in cooperation with National Implementing Body's specialists (when required).

The Supplier Design/Construction/Operation BIM Manager (depending on the stage) will define the required setup, data structure (will justify when not fully adhered to the BIM Manual) and working process for the Service Provider to follow a controlled creation of the BIM design with consideration to survey, geo-location and GIS requirements.

BIM model and data checks will take place at regular intervals agreed with the Rail Baltica BIM Manager, which will be defined, discussed and agreed in the final version of the Post-Contract BEP. The RB Rail BIM Management team (or external expert appointed by RB Rail AS) will perform checks and will issue a report to the Supplier BIM Manager for comment and action at any moment.

The Supplier BIM Manager is responsible for closing out the actions identified in the audit and will be expected to elevate to RB Rail AS any issues beyond the control of the project team.

All published information exchanges will be validated using the Data Drop Template file “RBR-DAT-BIM-BMA-0035_DataDropTemplate.xlsx” (provided in the Annexes) against the MIDP during information exchanges to ensure the maintenance of the model integrity and other data sources. Only compliant exchanges will be accepted by RB Rail AS for upload into the RB Document Management System, CDE or Asset Register.

Individual organisations responding to the BIM EIR will demonstrate that they have suitable procedures for quality assurance and data control for both issuing and receiving data. This assessment will take place during the Procurement phase, being the Supplier BIM Manager who will define the required setup and working processes to follow a controlled creation of the BIM design.

14.2. 2D: drawing production and CAD Manual

All drawings and associated data must adhere to standards and protocol formats in accordance with Rail Baltica's requirements, or as otherwise specifically requested or agreed.

All Drawings will follow the CAD Standards to define their own CAD Manual, templates for drawing sheets, drawing attributes and drawing numbering protocols, according to their particular authoring tools. Where possible and as appropriate for the project phase, 2D drawings are to be produced from the BIM models without alteration, with the exception being detail drawings of which require a level of accuracy not contained in the model, always depending on the LoG of each stage. Any changes to the 2D drawings shall be kept to a minimum with the exception of annotations.

In case the authoring tool is not able to generate the necessary view or section (e.g. developed sections along a curve), drawings can be constructed using references from CAD (Xrefs) 2D/3D and/or BIM models, and are to be managed in accordance with the Supplier CAD Manual. If needed, references can be extracted from BIM models with their origins clearly defined within their naming conventions and versioning.

The Supplier CAD Manual shall document the drawing production processes and procedures for the project team referencing relevant standards. This document is to be submitted to the RB Rail / National Implementing Body BIM Manager together with the inception report after the award of contract.

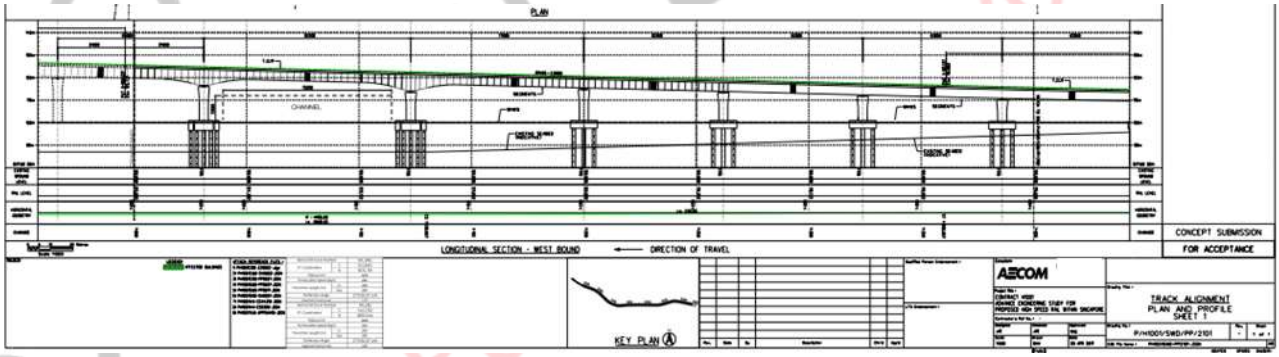


Figure 51: Example of drawing

14.3. 3D: geometrical definition

3D models are the core of the BIM methodology, by generating a file based environment of 3D geometries, divided and federated according to a structured Work Breakdown Structure (WBS) setting up the foundation for the definition of the BIM models by attaching data to the objects defined as geometries, and following several workflows that enhance coordination, collaboration and quality of the design. From that geometrical and information data, the digitalisation of the pre-construction takes place and allows a better decision-making along through the asset lifecycle.

The 3D models are composed by an aggregation of 3D objects, defined with a Level of Definition (LOD), which varies depending on the stage, the discipline and the BIM use cases related to the stage. A thorough description and explanation of the LOD can be found in the "Level of Definition" Section.

Even if not forbidden, it is recommended to not overcome the LOD (see "Levels of Accuracy" point in the "Levels of Definition" Section).

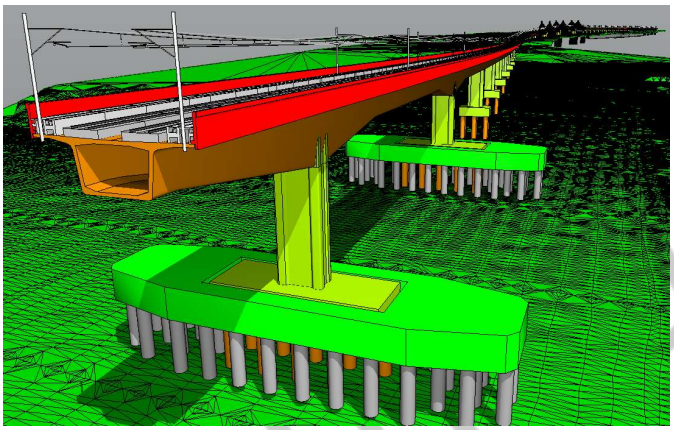


Figure 52: Example of viaduct 3D model

14.3.1. Federated-aggregated model

The aggregated Model is a compilation of multiple models into a single manageable model. This is a federated model which links, in other words does not merge, several models together. This aggregation may occur by joining different models:

- Generates the aggregation of several Mono-discipline models of a package, sector or project. This model must be provided within a discipline package when the discipline has been split because of any reason (to reduce model size, to allow different teams working in the same discipline,…).
- Generates the aggregation of several discipline models (or aggregation of models) of a package, sector or project. This model must be provided for every package or sector, and will be included in the MIDP as a deliverable.

The aggregated BIM model is to be produced from the Supplier design data by their BIM Manager. The federated BIM will be hosted in a Shared Area of the Supplier/contractor CDE, but in addition the federated BIM will be hosted within the RB Rail CDE to provide a live, but read only copy of the federated BIM on the different platforms managed / used by RB Rail AS, such as mobile platforms for instance.

The federated BIM models will form part of the standard deliverables at agreed in the MIDP milestones for hosting on RB Rail AS CDE / Asset Register. The way they are developed will depend on the software proposed by the Supplier, the Supplier / Contractor CDE and the RB Rail AS CDE / Asset Register. Both software and process of generation and collaboration will be agreed by the Supplier and RB Rail AS BIM teams in the final version of the Post-Contract BEP.

The aggregated models have various uses, being the most important the possibility to make a more manageable model, both in terms of the computer performance of the software used for that purpose (BIM Management software like Navisworks, Solibri or Navigator have a better performance to manage aggregated models than the production authoring tools like Revit, AECOsim or Allplan linking several models from different sources) and in

terms of having a combined model with all the information rolled up together with a particular structural entity (discipline, package, sector, project,…) which makes it more easy to understand. Other uses are:

- The Clash Detection process
- The Virtual Design/Construction Review process

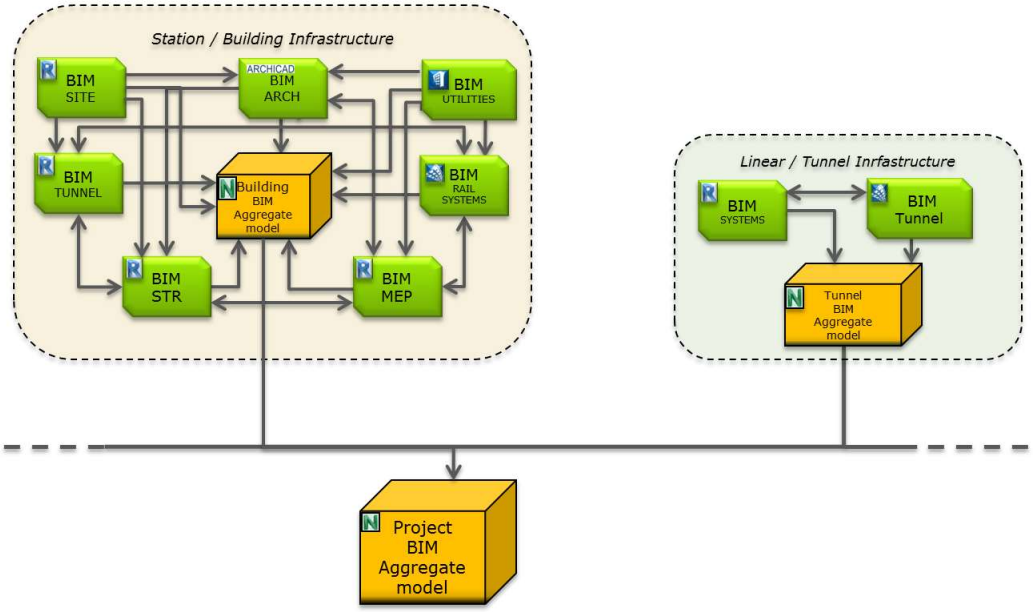


Figure 53: Example of aggregated model composition

An aggregation example is shown, above of these lines. A station infrastructure with several authoring tools (Revit, ArchiCAD, AECOsim and a Power Rail Track gets federated within the aggregated model of the station / building package. On the other hand, a tunnel (linear infrastructure) is composed by a Revit and a Power Rail Track models, in the same way as the station, it gets federated in an aggregated model of the tunnel package. One level beyond, both aggregated models are federated with other packages generating the project aggregated model.

It is advisable to keep the sizes of the files within a limit, in order to ensure good performance of the models and agile handling.

The following table lists some general recommendations. Depending on the software, and the manufacturer's recommendations, other sizes may be adopted as long as they do not compromise the performance of the models.

Desirable model file size	Maximum model file size
100 Mb	200 Mb

Table 14: Recommended file size

14.3.2. Coordination and Clash Detection Process

The Coordination and Clash Detection process are to be conducted throughout the design and construction phases of the project to verify the correct geometrical integration of the different BIM models. This process is to be undertaken by the Supplier BIM Management team as an internal Quality Control and Assurance process. During this process, the aggregated BIM models are generated, which will be the base not only for the Clash Detection process but also for the Design Review and the coordination among different disciplines / teams. This process is described in Section "Interface coordination".

14.3.3. Collaboration

The Supplier is responsible to manage the overall cross discipline BIM collaboration process, following the BIM Manual requirements and recommendations in order to develop the deliverables with the level of quality required by RB Rail AS. This includes the engineering, design, GIS and Survey requirements.

To achieve this, all design disciplines must produce a level of BIM data specified in the Post-Contract BEP and sufficient to allow coordination to take place. This coordination will take the form of the following specific tasks:

- Use of common setting out data across all disciplines, e.g. the use of a single-track alignment / architectural grid and level system. The coordinate systems and projection must align with the "BIM models' Geo-reference" Section.
- Direct referencing of inter and intra discipline BIM data from other disciplines during the creation of BIM Models to eliminate significant clashes during the BIM modelling / design, before carrying out a Clash Check verification.
- Design BIM models in native format will be 'shared' on an agreed schedule via the CDE for the use within Work In Progress (WIP) model development.
- Model exchange via IFC4 (IFC2x3 when IFC4 is not supported by the authoring tool). In the hypothetical case where no IFC format is supported, then 3D DWG shall be the exchange format and as a last option DGN. This shall be explained in the BEP and shall require the approval from RB Rail AS. Design BIM models will be "shared" on an agreed schedule via the CDE for the use within team, for verification and inclusion in the federated BIM collaboration model.
- Use of the federated BIM model as the main focus for resolution and progress of design using a virtual design/construction review process.
- Regular clash coordination sessions of strategic and important interface elements (inter contract and inter discipline), e.g. loading up the BIM data from every discipline into one common environment and

documenting all clashes. Clash reports are to be issued at project milestones with the design reports as a means to proving the design.

To facilitate collaboration a series of project specific BIM meetings and workshops should be facilitated that are relevant to each stage of delivery. BIM Meetings and workshops should be planned and agreed between the Supplier and the RB Rail AS Project Manager, and should be aligned with other design meetings and workshops planned for the project.

Meeting	Purpose and goals	Stage
BIM project Kick-off Meeting	At the start of the Delivery phase of the BIM project, the project team shall hold a meeting with RB Rail AS to develop a strategy which will include the need to agree the protocols, roles & responsibilities and certain tasks expected to be undertaken throughout the lifespan of the project. In this meeting the Supplier demonstrates that the size of the team working in the delivery is enough to reach the BIM requirements, sets the attributes for the rest of the project and the level of definition required within the BIM. This meeting will revise the state of the Post-Contract BEP to be used for the duration of the project and the collaboration processes and environment/s.	Any
BIM Strategy	To be held regularly at relevant stages of the project. It is expected that the project team will hold regular BIM Strategy Meetings to review BIM progress, project issues, protocols and documentation. This meeting is not intended as a technical workshop or coordination meeting.	Any
Virtual Design / Construction Reviews (VDR/VCR)	VDR/VCR Meetings should take place at more regular intervals than BIM Strategy Meetings and it is suggested that they are scheduled to be held as appropriate to the development of the design. Milestone delivery VDR's must be held with RB Rail AS.	Design & Construction
Construction planning meetings	Typically, during construction phase it would be expected that this meeting would involve reviewing key activities and forthcoming work stages	Construction
BIM Progress Meeting	At each milestone delivery, the project team must meet with RB Rail AS to demonstrate the level of completeness of the BIM. RB Rail AS may choose to audit internally or externally the quality, LoG and metadata content (LoI) of the BIM to assess the compliance of the BIM Manual.	Any

Table 15: Collaboration/Coordination meetings

14.3.4. Virtual Design / Construction Review

Virtual Design / Construction Reviews (VDR/VCR) are to be conducted throughout the design and construction phases of the project. The VDR process is designed to provide an iterative, interactive review of the complete BIM to ensure that any potential design or spatial coordination errors are detected at the earliest possible stage. A definition of the process can be found in the "Interface Coordination" Section. This process is based on the preparation of aggregated models.

14.3.5. 3D Models and BIM Models

In the point "Differences between 3D model and BIM Model" in the "Purpose" Section the BIM Manual defines the existence of two kind of models, the 3D Models without asset information and the BIM Models, which are also 3D Models but including asset information in the elements. The first ones are used as a reference of out of scope elements, whilst the BIM models are the "buildable" models of the project's scope.

The 3D models will also follow the BIM Manual standards and requirements, except the ones related to data because the LoI of those objects is zero.

The 3D models will be submitted within the deliverable set and a specific mention to the source of the information will be included in the Delivery report (see Annexes, "RBR-DAT-BIM-BMA-0030_BIMDeliveryReportTemplate.xlsx"):

- 3D model prepared by a Third Party, comment "3D MODEL BY THIRD PARTY: NAME & DATE".
- 3D model developed by the Supplier/Designer/Construction team from 2D documentation prepared by a Third Party, comment "3D MODEL DEVELOPED FROM 2D MODEL BY THIRD PARTY: NAME & DATE".
- Other 3D models, such as Point Clouds, comment "3D MODEL-POINT CLOUD- BY THIRD PARTY: NAME & DATE". For any other external source data, a similar comment will be included.

14.4. 4D: Planning and scheduling. Construction sequencing.

The Supplier / Contractor shall link the 3D BIM model objects to the project schedule as a planning and communication method to coordinate with the different project actors, from the final client (RB Rail AS) to the subcontractors and the staff involved in the construction or the operation.

The main advantages of the 4D are the enhance of the understanding of the planning and its physical site validation it can address issues as swing space during construction, parking interruptions, re-routing of vehicular / pedestrian traffic or any other construction work that could affect the infrastructure / building operations.

4D sequences will be saved in the native file to be delivered and also as video files (see Section "File formats"), published as part of a design package or used to validate constructability during Gate Reviews.

Depending on the required accuracy, it may be needed to complete the BIM models with auxiliary objects, such as formworks, falseworks, temporary structures, building / tunnels bracings for instance. Those auxiliary objects will be modelled in independent models and unless they have any recurrence or direct effect over the operation, those models lifecycle will finish with the Project Information Model (PIM) and therefore will not exist in the Asset Information model (AIM).

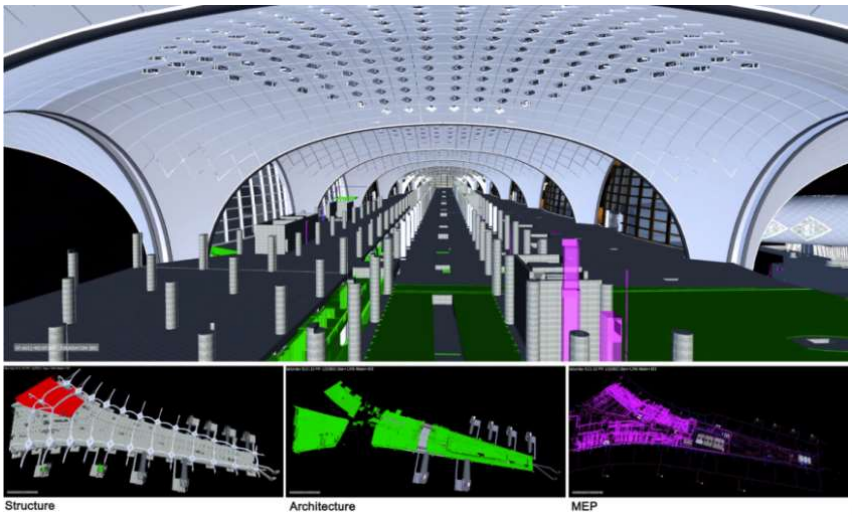


Figure 54: Example of 4D sequencing

Commercial scheduling software like Microsoft Project or Primavera (their planning will also a deliverable in Open Format, see "File Formats" Section) can be used for the planning, and with an independent aggregated model for this purpose a scheduling will be carried out. It is worthy to mention that if there are no auxiliary objects, the same aggregated model can be used for the 4D scheduling. The Supplier could even use non-BIM software for the 4D preparation if considered appropriate, in order to reach better appearance quality, but for the ease of the production it is recommended to use traditional BIM Management software as *Navisworks*, *Navigator*, *Solibri*, *Synchro* or similar. Some recommended non-traditional BIM software with a potential capability for high-standard 4D are *3D Studio Max*, *Rhinoceros*, *Unity*, *Unreal Engine*, *Lumion*, *Lumen RT* or any similar products.

14.5. 5D: quantity extraction and tracking

As an important deliverable, the Quantity take-offs (QTO) will be extracted from each BIM model and be delivered according to the Rail Baltica standards and WBS (template provided, see "Annexes"). The QTOs will take part on any Design Review between the Supplier and RB Rail AS, and there will be a register of the quantities of every submitted version of the BIM model, which will be provided to RB Rail AS.

The main quantities by discipline and/or by package will be compared among different versions of the BIM model, and will be justified in case of a significant variation. This variation percentage is to be agreed with RB Rail AS in the final version of the Post-Contract BEP for each design stage and main quantity. The increase of the LoG could be an acceptable (and the most common) reason for the variation, but this should be approved by RB Rail AS.

QEX File Name:	RBRRIG-RBR-B001-R001-RP-CE-000001							QEX Revision:	000	QEX Version:		QEX Status:	Detailed Design		
Prepared By:	I. Martínez							Prepared Date:	26-Jan-18	BIM Coordinator:	M. Gómez				
Model/Doc. Name:	RBRRIG-RBR-B001-R001-BI-CE-000002							Revision:	00C	Version:	v01	Status:	Detailed Design		
	BIM MODEL OBJECTS									SPECIFICATION/PROCUREMENT		COSTING			
Div	Unique ID	MEMBER MARK				Object Label		Object LOG	Object LOI	Project Spec. No.	UNI CLASS	QUANTITIES			
		Volume	Zone	Location	Trade	Item Type	Obj. ID Number				Assembly Code	Product Code	Description	Unit	Qty
03	3258299	2C3E50	B02B02	CB00	CIC	FCB	292	350	350	003300	22-03 31 00	23-13 29 15 11	Reinforced poured concrete; proportion normal weight concrete in	M3	48.50
03	3258446	2C3E50	B01G00	CB00	CIC	CCP	324	350	350	003300	22-03 31 00	23-13 35 11 13 15	Reinforced poured concrete; proportion normal weight concrete in accordance to ACI 211.1 and ACI 301 with compressive strength of 40 MPa	M3	15.91
03	3258448	2C3E50	B02G00	CB00	CIC	CCP	326	350	350	003300	22-03 31 00	23-13 35 11 13 15	Reinforced poured concrete; proportion normal weight concrete in accordance to ACI 211.1 and ACI 301 with compressive strength of 40 MPa	M3	17.97
03	3258595	2C3E50	B02B01	CB00	CIC	CCP	101028	350	350	003300	22-03 31 00	23-13 35 11 13 15	Reinforced poured concrete; proportion normal weight concrete in accordance to ACI 211.1 and ACI 301 with compressive strength of 40 MPa	M3	12.10

Figure 55: Quantities Extraction (QEX) template

The templates to be used are "RBR-DAT-BIM-BMA-0033_QEXTemplate.xlsx" for each BIM model (with quantities extracted by object), and "RBR-DAT-BIM-BMA-0034_QTOTemplate.xlsx" (see templates in "Annexes" Section) for each discipline / package / sector (with quantities rolled up by object type). RB Rail AS will determine the rules of measurement for every object. Those rules may vary depending on the location of the project, as this is an international project. In the event no guidance is provided, this BIM Manual proposes the NRM1 and NRM2 for Design / Construction stages and NRM3 for the Operation Stage. (NRM = New Rules of Measurement, https://www.rics.org/uk/knowledge/professional-guidance/guidance-notes/new-rules-of-measurement-order-of-cost-estimating-and-elemental-cost-planning/)

Among the Rail Baltica attributes included in this BIM Manual, there is a group of attributes called *Quantities and Cost Estimation*, which is defined not only for populating the QEX and QTO extractions (quantities data drops) but also to serve as a filtering tool and quantification attribute within the authoring tools. The Post-contract BEP will define briefly the QEX-QTO extraction strategy for every authoring tool. Each BIM software is prepared for the extraction of quantities by different means, typically by materials, by object type, by classifications or by more than one.

The quantity extraction and take-off has a double purpose:

1) The evaluation of the design or construction models by focusing on the amount of elements.
2) The assistance to the decision makers by providing the aggregated quantities by stage, package or even project. The ratio calculations or the trend of variation are some possible data consumptions proposed to benefit the data generated for a better decision making.

In the picture below it is shown an example of the trend of variation of a Railway station along through the partial submissions of a Design Phase. By being aware of the increase/decrease of the quantity of a specific item, the Design-Construction Managers / Leaders can pilot the Design-Construction with a higher level of information.

						RIGA CENTRAL STATION			
						Detailed Design			
DISCIPLINE	BOQ Code	Description	Unit	FST	FC3*	TOTAL 60%	TOTAL 90%	TOTAL 100%	TOTAL SUBMITTED
Mechanical, Electrical and Plumbing									
					0%	-24%	-43%	-46%	-37%
MEP	M06	Cable tray	M	0	89795	68495	51212	48902	56919
		Main building			84553	64469	47005	44735	52281
		Entrances			5241	4025	4207	4167	4638
					0%	4%	30%	44%	40%
MEP	M07	Conduits	M	0	340714	355451	443316	489955	477143
		Main building			340714	353709	441345	487974	475198
		Entrances			0	1742.33539	1971.635395	1980.779152	1945.095387

Figure 56: Example of main quantities trends

14.5.1. Object Type Dictionary

It is strongly recommended that the Supply Chain create and maintain an Object Type Dictionary, the easy way is an Excel spreadsheet, although other formats can be used, like databases.

This dictionary, enables to have a complete list of all the types existing in the project with all the needed data associated (specifications, units, technical data…)

The data in the dictionary can be populated within the models, ensuring a data consistency across all the types in the models, avoiding duplicated types with different data.

To allow linking data between model elements and the dictionary, two attributes are provided:

"**RBR-Pr_Code**": This attribute is mandatory and must be fulfilled with the product table of the Uniclass 2015. It will give us a first classification level of the element.

"**RBR-Type number**": This attribute can be used for the Supply Chain freely to achieve a more detailed identification of the types.

This attribute can be used in different ways, for example, subdivide this attribute in subgroups (xxxx.yyy.zzz) in order to achieve deeper classification levels. Another approach is to use a six integer number to differentiate each subtype within the first classification level. Examples:

RBR-Pr_Code	RBR-Type number: xxxx.yyy.zzz		
Pr_20_85_08_11	0001	001	007
Carbon steel beams	H-Beam 100x100x6x8	Grade Q345	Intumescent paint 60 min
Pr_20_85_08_11	0001	001	008

Carbon steel beams	H-Beam 100x100x6x8	Grade Q345	Intumescent paint 30 min
RBR-Pr_Code	**RBR-Type number: xxxxxx**		
Pr_20_85_08_11	000001		
Carbon steel beams	H-Beam 100x100x6x8, Grade Q345, Intumescent paint 60 min		
Pr_20_85_08_11	000002		
Carbon steel beams	H-Beam 100x100x6x8, Grade Q345, Intumescent paint 30 min		

Table 16: Examples of model elements codification

Object type dictionary that will be used by all the members of that discipline within that package, being the Supplier's responsibility to submit the content library periodically, so that an external quality check could be performed by RB Rail AS or its BIM specialist assistance.

14.6. 6D: Operation of the infrastructure

At defined project phases (see "Level of Definition" and "Model Delivery Plan" Sections) the Supplier shall capture sufficient data in the model in a format such to facilitate future information exchange into a Computerised Maintenance Management System (CMMS) and Service Life-Cycle Management, creating the Asset Information Model (AIM) from the Design & Construction data defined in the Project Information Model (PIM).

The operation data (Asset data) to be included is to be defined by the actors who will consume the data during the operation stage:

- **RB Rail AS and the Latvian, Lithuanian and Estonian local rail authorities** , who provides the information of the PIM to the Operator.
- **Operator**, who makes available and updates the AIM to the Maintainer, with the information of the works.
- **Maintainer**, who consumes and updates the data during the development of the maintenance minor works.
- **Other** like contractors and security forces, who carry out major works to the infrastructure and interact with it in the event of disaster or security reasons.

RB Rail AS still has not confirmed an appropriate system for the collection, management and integration into the project. Such implementation is to be advised.

14.6.1. Operation & Maintenance Manuals

During the Stage Operations of the project, Facility Management operations and maintenance manuals shall be captured in a digital form and indexed in a clear, logical manner such that the data can be linked at a later date to model objects and be utilised as part of the AIM. The processes will be defined RB Rail AS.

14.6.2. Asset Management for Operation & Maintenance

The Asset data to be populated into the models is included into the "Common Asset Data" & "Primary Asset Data" attributes groups, and if needed by RB Rail AS and the future operators, RB Rail AS will complete it by adding that data to the "RBR-DAT-BIM-BMA-0005_BIM_Objects_Attributes_Matrix.xlsx".

That Asset data will be defined by adding the attributes that will answer the questions that the O & M actors will pose. Those questions are related to:

- The information needed to make an informed decision
- The information needed to carry out an O & M key activity
- The information needed to answer a critical (even urgent) question. (in the event of disaster or security reasons)

That information will be defined in the Asset Information Requirements (AIR) that will be integrated within the EIR. This data must be agreed between RB Rail AS and the Operators of the infrastructure.

14.6.3. Asset Management for GIS integration

In addition to the Asset Operation data, some information may be requested to accompany the BIM objects when prepared to be integrated within a GIS environment. That information will be defined within the attributes group called "GIS", and will need to be defined by the GIS administrator and stored in the "RBR-DAT-BIM-BMA-0005_BIM_Objects_Attributes_Matrix.xlsx".

That information will be focused on entities defined with a LoG of 200. See "Level of Definition" Section. Thus, there will be a better integration and performance within the GIS environments.

14.7. Information exchange: Data drops

Among the deliverables of the BIM project, the Data drops and the BIM models are the ones related to the Information Delivery. Both of them contain the same information but in different formats, prepared for the consumption of different actors with different types of software.

- **BIM models** contain the BIM project itself, including both the geometry and the data attached to the objects. This information is to be consumed with specific BIM production and BIM management tools.
- **BIM Data Drops** contain the data extracted from the BIM models, stored in structured and standard spread sheet templates (see Annexes) for both the Quantity Take-Offs (QTO) and the Data Drops themselves. These spread sheets are to be consumed with no previous BIM experience and with traditional spread sheet tools (like Microsoft Office or OpenOffice).

The Data Drops will always be related to the source BIM models, by providing name, version, stage and authors, among other identifying data of the BIM models.

Element Name	RBR-Pr_Code	RBR-Type number	RBR-Product Name	RBR-Product Description	RBR-Mod
ORG-ME-AIG-Schako Air Grille 300x600	Pr_30 59 94 04	0003.002.01	Schako Grille BSG-St 300x600	Ventilation grille type BSG-St for supply and return air. Consisting of a frame with facing horizontal fixed profiled rods made of sheet steel painted to RAL 9010 (white)	HH-2516
ORG-ME-AIG-Schako Air Grille KG-Q-8 315x115	Pr_30 59 94 04	0003.002.02	Schako Grille KG-Q-8-315x115	Ventilation grille type KG-Q-8 horizontal blades, for installation in rectangular ductwork, For duct or wall mounting (type KG-Q) in supply air and return air installations of cinemas, shopping centres, halls and underground car parks	HH-5564
ORG-ME-DMP-Schacho multi-Leaf Damper HKP-180-1003x400	Pr_65 65 24 95	0003.007.01	Schako Multi-leaf damper HKP-180-1003x400	Multi-leaf damper, consisting of dimensionally stable profiled frame made of 1.5 mm galvanised sheet steel, frame depth 180 mm with profiled connection frame (4-screw duct connection), with joint flow-favouring hollow-body blades adjustable in opposite directions made of profiled galvanised sheet steel. Suitable for pressures up to 1000 Pa. The blades are adjusted via external, actuating lever, actuator/servo cylinder. Housing leakage according to DIN EN 1751, class B, at a duct pressure of up to 1000 Pa.	SS-14562
ORG-ME-FAN-ZERAX axial fan AZN250-2700	Pr_65 67 29 05	0045.010.05	Axial Flow Fans ZerAx AZN D250-2700	ZerAx fans for duct installation are designated AZN or AZW. Fans with inegrated inlet cones for building in to air handling units are designated AZN. Diameter 250mm 2700 m^3/h	LOKG-125

Figure 57: Data Drop table template

The Service provider / Supplier BIM Manager together with the Service provider / Supplier Design Manager are responsible for the internal preparation / collation of these deliverables, their content and their compliance to the requirements of this BIM Manual. Besides, the Data Drops are part of the QA/QC, and the RB Rail AS BIM Managers (or the specialist they could rely upon) will use them to perform Data Checks of Models' quality.

The Information Exchange requirements will be specified in the EIR for each project, and the frequency and the schedule must be clearly determined in the MIDP.

Delivery Stage	Information Exchanges - Data Drops	
	Quantity Take-Offs	Complete Data Drop
Value Engineering	✓	Not necessary
Master Design	✓	Not necessary
Detailed Technical Design	✓	✓
Release for local authority approvals	Not necessary, unless specified in EIR	Not necessary
Construction	✓	Not necessary, unless specified in EIR
As-built	✓	✓
Operation & Maintenance Minor Works	✓ but Operation related (a different template could be used)	✓

Operation & Maintenance Major Works	✓	✓

Table 17: Information Exchanges (Data Drops) per Delivery Stage

15. File Formats

15.1. General

The deliverables will follow the Principles, Objectives and goals defined in the "Principles and Goals" Section, and as such this BIM Manual has chosen the File formats so that those requirements could be fulfilled. Some of the formats have been chosen because they have proven functionalities even if they are Proprietary formats, but when it is possible to deliver any deliverable with an Open format it will always be preferred. Due to the fact some of the Open Formats are not modifiable, the native files (including its support files) will always be submitted, no matter the authoring tool has been used.

15.2. Document Format

Document formats will depend on the type of document being delivered. For every model submission, in addition to the model itself there will be a list of associated files that will be provided with different purposes. The Post-Contract BEP will define what formats will finally be used in the project, and that document will need to be agreed between the Supplier and the RB Rail AS BIM Management teams.

- **The BIM native format**. The model itself, produced with the Proprietary software chosen by the Service Provider / Supplier, together with its support files. Examples are RVT (Autodesk Revit), DGN (Bentley AECOsim, Rail Track, Open Roads and other Bentley software), NDW (Allplan), DWG (Autodesk Civil 3D) or PLN & PLA (ArchiCAD) among others.

- **The BIM Open Format**. Rail Baltica requires IFC as the BIM Open format. Every native model submitted will be exported to IFC4. In the event the authoring tool is not IFC4 compliant, IFC 2x3 could be utilized. The Supplier must verify that the IFC file generated has exported not only the geometry but also the dataset defined in the model and objects, therefore, the authoring tools IFC export must be configured accordingly.

  The Supplier can verify the capability of the authoring tool to export/import IFC in the buildingSMART site:

  Certified IFC import/export software: https://www.buildingsmart.org/compliance/certified-software/

For alignments, the required Open Format is LandXML, and for Point Clouds Data any of the Open Formats available, such as TXT, LAS, LAZ, E57, PTX, PTS, ASC or PLY.

- **The aggregated BIM model format**. The combined model with a Proprietary software used for the geometry verification, the design review and other BIM uses cases. NWD (Autodesk Navisworks), IMODEL-I.DGN (Bentley Navigator)

- **The Data Drops**. Microsoft Excel's XLSX and CSV will be used to provide the extracted database of the model. In addition, in future developments of Rail Baltica, other formats as JSON or XML could be implemented if the BIM team considers it necessary. CSV is the Open format to be delivered in any case.

- **The quantity extraction** (other Data Drops). Microsoft Excel's XLSX and/or CSV will be used to provide the quantity extraction of the model. CSV is an Open format.

- **Other BIM use cases**-related formats. Such as AVI, MPEG or MOV for the planning / scheduling (4D) and JPEG or PNG for visualisation purposes. The Supplier will propose a free viewer for the format proposed, and in case of need to have specific CODECS installed, those should be provided.

- **Documents** (Reports, Specifications e.g.) shall be delivered in XLSX, DOCX and additionally exported / printed to PDF.

- **Drawings** should be ideally delivered in the same format as the BIM Models, retaining their link to the objects within the model. By doing so the objects in the drawing can be related to the asset register. However, if not in model format then one of the de-facto drawing CAD formats namely DWG or DGN. PDF versions of delivered drawings will also be delivered. If the Supplier / Service Provider proposes a Proprietary Design Review / Coordination process, RB Rail AS BIM Management team will need to approve it, some of those Proprietary formats for Review/Coordination are DWFx or IMODEL – I.DGN.

- **Coordination comments and reviews** will take place because of the BIM Design / Construction Reviews, as described in the "Interface Coordination" Section. The Open format BCF is almost universally supported by the BIM Management software (Navisworks, Solibri…) and it is used to manage comments and points of views among BIM models. A proprietary format with this capability is the IMODEL.OVERLAY and works over Bentley's Navigator which to date does not support BCF.

It is worth noting that RB Rail and National Implementing Bodies will not be able to use all kinds of Proprietary Design tools and software to consume the BIM models, so the Supply Chain must ensure that the Proprietary formats that are provided could be opened with free-versions of those Proprietary software. (Navisworks Freedom, Tekla BIMsight…)

- **Exchange formats**. In addition to IFC (the BIM Open Format) there are some file formats that can be used for various interoperability purposes, such as OBJ, DAE (Collada) or CityGML (BIM integration within GIS).

These files do not need to be delivered if used as an interoperability file, but will be submitted if are part of a specific deliverables.

	Format required	Open?	Description	BIM Use	Delivery
1	Native file format (.RVT, .DGN, .NDW, .DWG, .PLA,…)	No	Proprietary BIM Software Platform	Design Authoring	Required in all stages
2.A	Open BIM format (.IFC)	Yes	Industry Foundation Class	Information and Model Exchange	Required in all stages (frequency to be agreed in the BEP)
2.B	Alignment Open BIM format (.LandXML)	Yes	Civil engineering and survey measurement data	Existing Conditions, Alignments and Civil engineering Information	Required in all stages
2.C	Point Clouds Open BIM format (.TXT, .LAS, .LAZ, .E57, .PTX, .PTS, .ASC, .PLY, …)	Yes	Point Clouds Data	Existing Conditions Information	Required in all stages
3.A	Aggregated - Navisworks (.NWC)	No	Navisworks Model Cache File	Design Review / Coordination	Required in all stages
	Aggregated - Navisworks (.NWD)	No	Navisworks Published Federated Model	Design Review / Coordination / Autodesk's CDE visualisation	
3.B	or Aggregated - Navigator (.IMODEL - I.DGN)	No	Navigator Published Federated Model	Design Review / Coordination / Bentley CDE visualisation	
3.C	or Aggregated - Solibri (.SMC)	No	Solibri Published Federated Model	Design Review / Coordination	
4.A	Native file format (.RVT, .DGN, .NDW, .DWG, .PLA,…)	No	Proprietary BIM Software Platform (CAD inside BIM models)	Drawing Deliverable	Required in all stages
4.B	or AutoCAD (.DWG)	No	Autodesk CAD Software Platform (CAD exported from BIM)	Drawing Deliverable	
4.B	or Microstation (.DGN)	No	Bentley CAD Software Platform (CAD exported from BIM)	Drawing Deliverable	
5.A	BIM Coordination format (.BCF)	Yes	Change Coordination / BIM Collaboration	Design Review / Coordination	Required in all stages
5.B	or I-Model Overlay (imodel.overlay)	No	Change Coordination / BIM Collaboration	Design Review / Coordination	
6.A	(.CSV , .XML , .GML)	Yes	Open BIM data base readable file format for the purposes of exchanging structured non-graphical data / information	Data Capture, classification and information	Detailed Design, Construction, As-Built and Operation Stages
6.B	or Excel spread sheet (.XLSX)	No	Excel data base readable file format for the purposes of exchanging structured non-graphical data / information	Data Capture, classification and information	
7	Word document (.DOCX)	No	Proprietary Documentation Software Platform	Documentation, Reports, Specs (Authoring)	Required in all stages
8	Document export (.PDF)	Yes	Portable Document Form	Information and Documentation Exchange	Required in all stages
9	Video (.AVI, .MPEG, .MOV)	No	Video formats	Sequencing visualisation	Required in all stages (EIR to determine when)
10	Image (.JPEG, .PNG)	No	Image formats	Image capture and render.	Required in all stages (EIR to determine when)

Table 18: File Formats

15.3. IFC format and configuration

The Industry Foundation Classes (IFC) is an open format designed for data sharing in the construction and facility management industries. It is a Data Standard defined within the ISO 16739 which is developed and maintained by buildingSMART International.

This standard defines three IFC data formats, IFC, IFCXML and IFCZIP. This BIM Manual always refer to the first one of them, but anyone else could be requested by the EIR.

Moreover, IFC has different versions or schemas, not all of them created or supported by all the authoring tools. BuildingSMART certifies every BIM authoring tool to be IFC compliant with each version. The current ones are:

- **IFC4**: the latest and the most advanced version, but still not widely supported by the authoring tools. The BIM Management tools support it. This ("IFC4 Design Transfer View") is the version requested in this BIM Manual, unless the service provider states there is any issue with the selected authoring tool, such as lack of accuracy, issues when exporting data or simply if it is not supported.
- **IFC2x3**: this is the most supported and stable format to date. It will be used if the IFC4 version is not supported by any stakeholder to be coordinated in a package. Besides, some authoring tools allow to set up the IFC with sub-formats such as the "IFC2x3 Coordination View Version 2.0", the "IFC2x3 COBie 2.4 Design Deliverable" or to interact with the internal mapping configuration. The Service provider will verify what configuration suits better so that the chosen BIM authoring tool can export correctly the Geometry without loss of detail and the information dataset of the objects.
- **IFC2x2**: this version is only proposed in the event none of the others above is supported.

The quality of the IFC creation is responsibility of the Service Provider / Supplier BIM Management team, and the quality of the IFC created will be one of the model checks.

The commented IFC format is the one related to the "Building" branch of the IFC family, which commonly are exportable from the Buildings BIM authoring tools (*AECOsim*, *Revit*, *Allplan*, *ArchiCAD*,…). There are other IFC versions that are under development which will also integrate IFC Alignment data (points, curves, lines,..) as the core for the IFC Bridge, IFC Tunnel and IFC Civil. It is important to verify that the exported IFC has the 3D data (volumetric for coordination) and the information data set. In case the IFC alignment wants to be used for alignment use, the naming will indicate that purpose.

On the other hand, to date some civil-rail authoring software do not export to IFC, even if are commonly called BIM tools (theoretically, a BIM tool is certified as a such if it can export/import IFC files), in that case the Service Provider / Supplier will propose a workflow to generate the IFC from the native formats (for instance, *Bentley's Power Rail Track* does not export to IFC, and a possible option would be opening the native DGN with *Bentley's AECOsim* and

export the IFC from that platform). The configuration of the dataset exportation is paramount in these cases and the process will have to be approved by RB Rail AS BIM Mng team.

15.4. Open BIM Viewers

It is not the intention of the BIM Manual to set up an extended list of free Open software but to recommend some possible Open software that enable the interaction and consumption of any user with the BIM data, whichever it is.

As a rule, any deliverable will be delivered in both native and Open format. No proprietary software/format will be accepted by RB Rail AS as a standalone deliverable if there is a fully operative Open alternative, and in case there is a specific functionality that justifies the adoption of a Proprietary format, it will be necessary to provide a free viewer so that the format could be consumed by the different actors involved.

The Aggregated BIM models cannot be delivered in an Open model to date, thus, those formats will not be accompanied by Open formats. Some of them are NWD/NWF (Navisworks Freedom), I-Model (Bentley View), SMC/SMV (Solibri Viewer) among others.

Open formats viewers																	
Free Software	IFC	BCF	XML	GML	i-mode, I-DGN	imodel.overlay	DWFx	NWD & NWC	SMC & SMV	DWG	RVT	DGN	XLSX	CSV	DOCX	PDF	AVI
Navisworks Freedom	✓	✓					✓	✓		✓	✓					✓	
Bentley View	✓				✓	✓				✓		✓					
Tekla BIMsight	✓		✓							✓		✓					
Solibri Model Viewer	✓	✓							✓								
FZK Viewer / GML toolbox	✓		✓	✓													
VLC																	✓
Open Office													✓	✓	✓		
Adobe Reader													✓	✓	✓	✓	
PROPRIETARY?					×	×	×	×	×	×	×	×	×		×		

Table 19: Open Format Viewers

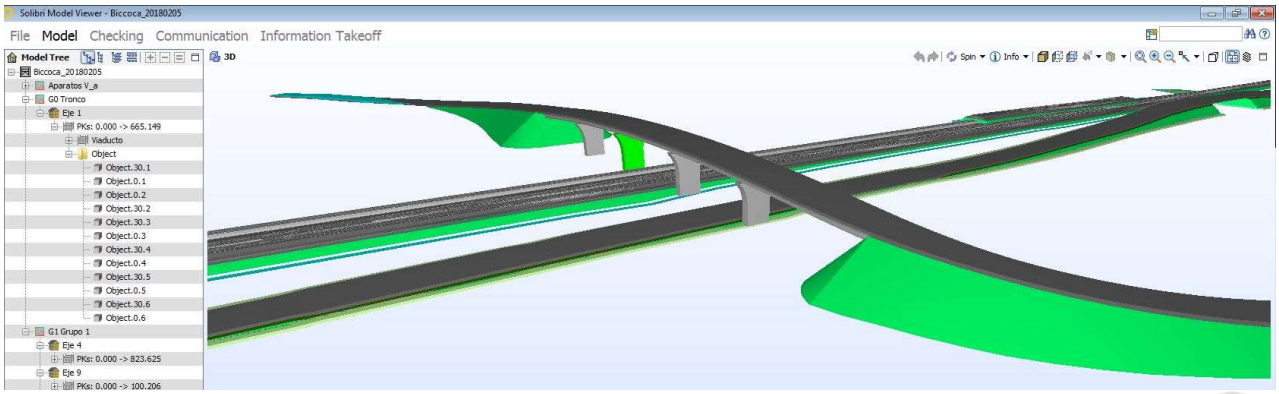


Figure 58: A free viewer example – Solibri Model Viewer

16. Roles & Responsibilities

16.1. General

The success of a BIM implementation strongly depends on how the methodology of the delivery and use of the digital information is learnt, understood and internalized, becoming usual and fluent. Technology, Processes, Standards and information have no value if the actors do not manage them properly. Therefore, BIM is a matter of involving **People** into a digital methodology.

Rather than inventing new jobs and job titles, we want to involve all who are stakeholders in the project to work digitally and become BIM specialists.

However, and especially during the BIM implementation period, it is important that every team at every level counts with specialists who are able to implement, coordinate and manage all the BIM procedures and workflows as well as give support to the future BIM users. This way, we can differentiate two types of BIM profiles:

- **BIM specialists**: this group includes both the BIM Management team which implement and coordinate all the BIM standards across the whole project, and the group of all the BIM leaders for every stakeholder, responsible of transmitting all the BIM standards to their organization, internal coordination and quality, etc. This team also provides support to the rest of team and check the compliance of the models / data drops according to the BIM requirements.

  It is important to mention that there will be two BIM Management teams, one in each of both client and employer sides, being the BIM Management of the service provider / supplier the only BIM interface between client and supplier in terms of BIM.

- **BIM users**: this group includes every technician or manager participating in the project and who needs to make use of BIM but does not have a specific BIM role or a significant BIM knowledge.

This Section will focus on the profile of the BIM specialist, who has specific tasks beyond the production and consumption of the BIM data.

In the diagram below, a general diagram including the BIM specialists from RB Rail AS (BIM Management team) and the BIM Specialists (BIM Management team) and BIM users (Delivery team) Service Provider / Supplier is shown.

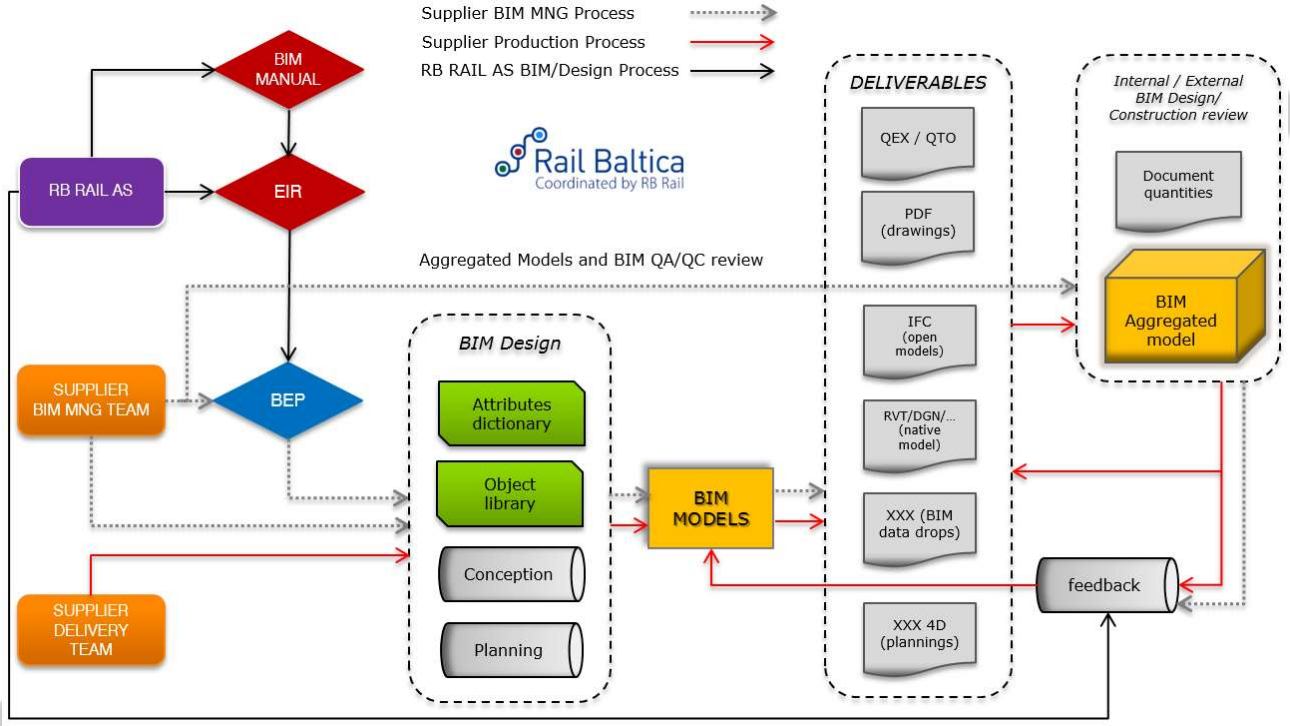


Figure 59: General BIM workflow

16.2. RB Rail AS side

The RB Rail AS BIM Management team is composed by 4 separate roles:

- **BIM Director**, acting as BIM leader of RB Rail AS. Role appointed by RB Rail AS employees.
- **BIM Implementer Information Manager** , acting as local BIM leaders of RB Rail AS (Latvia, Lithuania and Estonia). Role appointed by RB Rail AS employees.
- **BIM Information Manager**, acting as the BIM Manager from RB Rail AS side for what concern to projects. Role that could be performed both by RB Rail AS employees or by an external Assistance (BIM Technical experts)

- **CDE-AR Information Manager**, acting as the Supporting Technology Manager. Role that could be performed both by RB Rail AS employees or by an external Assistance (BIM Technical experts)

Depending on the scale of the projects managed, it is understood that the BIM Information Managers and the CDE-AR Information Managers can drive several projects at the same time. Those roles are strongly technical so it is recommended that these roles are covered by BIM Specialists. RB Rail AS will decide whether internal or external.

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RB Rail AS Roles	Description	Tasks / responsibilities
RB Rail Information Manager / BIM Director	The BIM Director leads the implementation of BIM throughout the project in compliance with RB Rail AS goals and leads the RB Rail AS BIM integrated team. The BIM Director is the primary point of contact for any BIM related issues within Rail Baltica partners (and local authorities), the Operators and the Supplier or Service Providers and will be part on any commercial discussion related to the BIM development and / or implementation.	- Define the BIM strategy and requirements for the project, identifying and maintaining the BIM goals and priorities - Review and approve the BIM Execution Plan and the MIDP - Lead the RB Rail AS integrated BIM team/s, tracking and monitoring their performance - Report to Rail Baltica upper management on any issues surrounding BIM implementation - Evaluate and report BIM scope change impact to upper management - Ensure the project provides the tools, processes, and support to manage the information in a structured, coordinated, and accurate way - Ensure any BIM related topic is adequately communicated among the project stakeholders - Ensure an effective relationship with all stakeholders on the project regarding BIM deployment - Coordinate efforts within the BIM Teams in accordance to project needs - Act as primary Stakeholder/Contractor interface on any BIM related issue - Facilitate the adoption of collaborative ways of working - Leads the deployment of the CDE and the Asset Register
RB Rail AS Implementer Information Manager (part of RB Rail AS BIM Mng integrated team)	Equivalent role to the BIM Director but focused on local (Latvia, Estonia, Lithuania) delivery aspects	- Same tasks of the BIM Director but in close discussion with local implementation bodies.
RB Rail AS Information Manager (part of RB Rail AS BIM Mng integrated team)	The RB Rail AS Information Manager liase with the Supplier / Service Provider Project Information Managers. Commonly called BIM Managers.	- Controls the BIM implementation during the project, from RB Rail AS side - Checks and approves the BIM Execution Plan in collaboration with the BIM Director in compliance with the project objectives - Ensure that design processes and procedures comply with the BIM Manual / BIM Strategy and follow the project BIM goals - Ensure that Design/Construction/Operation BIM uses are delivered according to the project schedule and in compliance with RB Rail AS BIM requirements (perform regular quality checks) - Proposes improvements or solutions if the progress or quality is not adequate. - Generates a performance and status report about the BIM development & quality of the project - Act as contact for any BIM related issues between RB Rail AS and the Supplier / Service Provider - Participate in BIM related meetings with Local authorities, Rail Baltica or other stakeholders - Support the Project Information Manager team in the adoption of BIM collaborative methods - Organizes and leads the BIM kick-off meeting with the Project Information Manager - Attends the recurring BIM meetings with RB Rail AS BIM specialists and Engineering BIM Leads, such as the Virtual Design / Construction Reviews, the BIM Strategy & BIM progress meetings.
RB Rail AS CDE-AR Information Manager (part of RB Rail AS BIM Mng integrated team)	The RB Rail AS CDE-AR Information Manager supports the CDE and/or AR within Rail Baltica	- Manages the deployment of the CDE and the Asset Register (including processes and procedures to enable reliable information exchange between Project Team members, the employer and other parties) - Provides access&roles to the CDE and Asset Register to the Service Provider / Supplier - Assists in the implementation and integration of projects data within the Supporting Technologies - Performs quality checks of the quality of the information delivered, in terms of naming, versioning, status and metadata (validates compliance with requirements and advise on non-compliance) - Supports the GIS integration within the CDE and Asset Register - Approves the BEP documentation related to CDE subjects

Table 20: RB Rail AS Roles and Responsibilities

16.3. Service provider / Supplier side

Service Provider / Supplier Roles	Description	Tasks / responsibilities
Service provider / Supplier Information Manager	The Service provider / Supplier Information Manager liase with the RB Rail AS Project Information Managers. Commonly called BIM Managers.	- Leads the BIM implementation during the project, from Service provider / Supplier side - Produces and updates the BIM Execution Plan in collaboration with the Project Manager in compliance with the project objectives - Produces the MIDP by collating the TIDP at the start of the project - Ensure that design processes and procedures comply with the BIM Manual / BIM Strategy and follow the project BIM goals - Ensure that Design/Construction/Operation BIM uses are delivered according to the project schedule and in compliance with RB Rail AS BIM requirements (performs regular internal quality checks) - Proposes improvements or solutions if the progress or quality is not adequate. - Act as contact for any BIM related issues between RB Rail AS and the Supplier / Service Provider - Leads the Service provider /Supplier Information Manager team (commonly called BIM Mng team) in the adoption of BIM methodology and collaborative methods - Organizes and leads the BIM kick-off meeting with the Project Information Manager - Attends the recurring BIM meetings with RB Rail AS BIM specialists and Engineering BIM Leads, such as the Virtual Design / Construction Reviews, the BIM Strategy & BIM progress meetings.
Service provider / Supplier CDE Information Manager	The Service provider / Supplier CDE Information Manager supports the CDE Implementation and the Document Management (part of the Service Provider / Supplier Information Management team)	- Manages the deployment of the CDE access roles, from the Service provider / Supplier's side - Manages and controls the assignment and the quality process within the CDE - Assists in the utilisation of the CDE within the organisation - Performs quality checks of the quality of the information delivered, in terms of naming, versioning, status and metadata - Supports the GIS integration within the CDE and Asset Register - Acts as a Document Controller within the CDE - Ensure all the BIM models are accurately georeferenced and named in the WBS - Responsible for the BIM Integrated Model (if the CDE allows this feature)
BIM discipline / package Coordinator	The BIM Discipline / Package Coordinator is responsible for the interdisciplinary coordination of the BIM models per segment / package. Commonly called BIM Coordinators. (part of the Service Provider / Supplier Information Management team)	- Reports to the Project Information Manager - Configure and develop Clash Detection analysis on a regular basis (generation of aggregated models) - Leads regular coordination meetings and track progress of the coordination process - Responsible for the integration and the geolocation of the models per segment. - Responsible for checking that drawings are extracted from the models. - Supports Interface Coordinators and Design Coordinators - Define the CAD Manual at the start of the project

Discipline BIM Specialist	Service Provider / Supplier BIM specialists report to the Project Information Manager and the BIM Coordinators and are responsible for the BIM deployment per discipline. (may be included in BIM Coordinator's responsibilities) Discipline BIM Specialists identified: - Track and systems - Civil - Structure (linear) - Mechanical and Electrical - Fixed facilities (Architecture and Structure)	- Define the BIM requirements per discipline together with the BIM Managers and participate in the production of the BEP - Ensure that the BIM processes and procedures per discipline are compliant with the project goals - Ensure the consistency and standardisation of the design and suppliers BIM models across the project per discipline - Ensure that discipline's models can be used to properly deliver the requested BIM uses - Supports and advises on the adoption of BIM processes - Defines and updates best practices and procedures per discipline - Act as key point of contact within the Service provider / Supplier BIM team for each discipline on any BIM related issue - Supports the BIM Content Specialist on the maintenance of the data base per discipline - Supports the BIM Coordinators on discipline specific issues - Defines the TIDP (per discipline) at the start of the project (deliverable)

Table 21: Supplier Roles and Responsibilities

17. Interface Coordination

Project members should share their models with other project members at regular intervals for reference. At certain milestones, models from different disciplines should be coordinated, allowing involved parties to resolve potential conflicts upfront and avoid costly abortive works and delays at the construction stage. Prior to Model Coordination (Clash Detection+ Model Review), the respective models should be checked, approved and validated as "fit for coordination" (see CDE section for more information).

It is especially important that when sharing models, precise instructions about how to manage that model are given to the rest of the teams.

The project team could leverage on the available software solutions to perform the coordination effectively. A common (software) platform is recommended, to reduce possibilities of data loss or errors when sharing different models. Issues that arose from the coordination should be documented and followed up.

Discrepancies discovered during the coordination process should be recorded, managed, and communicated to relevant model owners through coordination reports or BCF (See BCF section), including any specific location of interferences and suggested resolutions.

Multiple Clash Detection can be performed before the Model Review in order to solve the less important issues or those that can be solved without a Model Review.

Number and frequency of clash detection and model review procedures will be agreed by different parties, assuring quality coordinated final model.

Usually, Clash Detection procedure will be performed more frequently than Model Review procedure.

It is recommended that a revised version of the model is frozen and signed-off after the issues identified during the coordination exercise have been resolved.

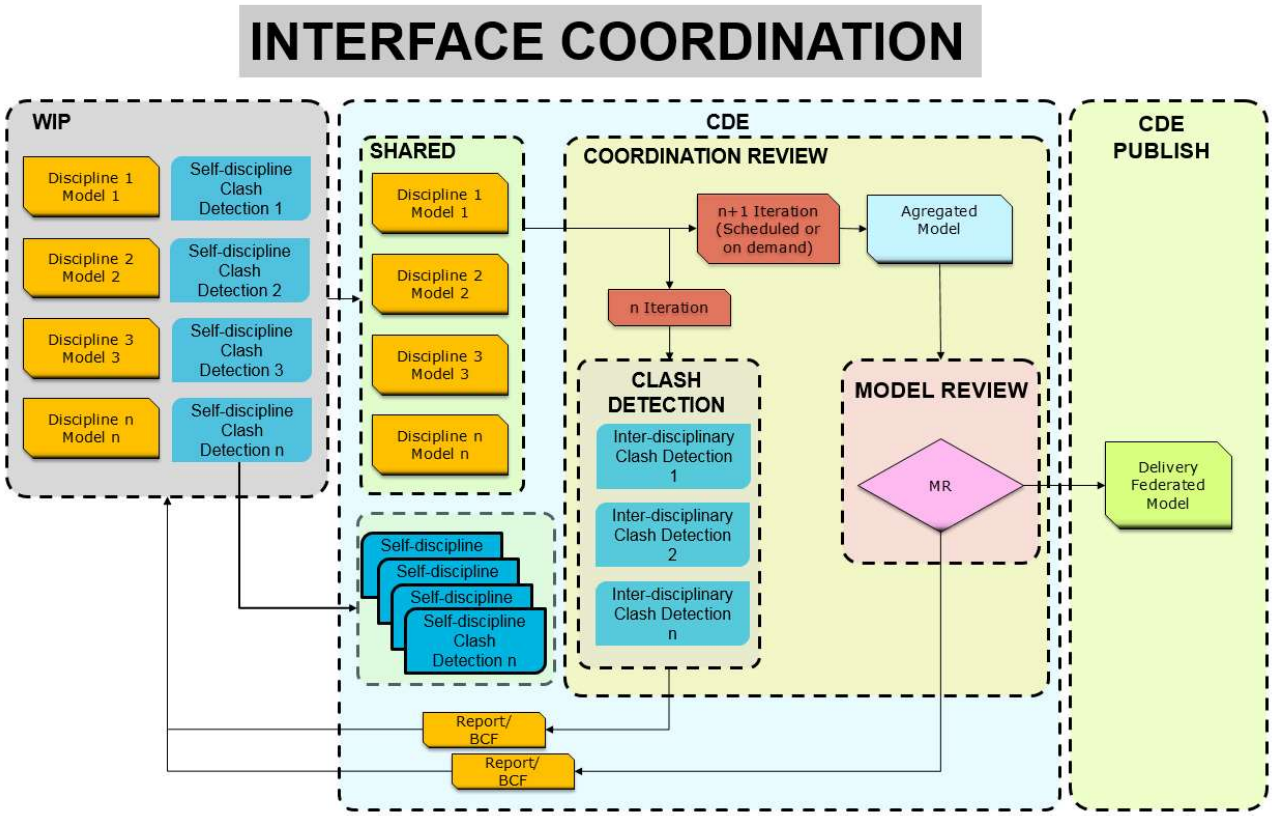


Figure 60: Interface Coordination workflow

17.1. Responsibilities during the coordination process

- Each party owns a discipline-specific model.
- Each model owner will be responsible for generating the clash rendition in the agreed format compatible with the coordination software and place it in the Supplier CDE so that the coordination process can be carried out. Also precise instructions shall be given about how to manage that model, to avoid that other teams can manage the model in the wrong way (Auxiliary elements that shall not be taken into account, temporary elements...).
- The BIM Manager responsible for the delivery package will be responsible for assembling the coordination aggregated model for the Model Review from the clash renditions that each owner has generated.

- During coordination, the most appropriate software can be chosen depending on the type of coordination needed.
- To resolve clash conflicts, each party carries out agreed changes on their own discipline-specific model
- Liabilities of each discipline-specific model remain the same, before and after the analysis.

17.2. Clash Detection (Coordination Review)

When the model reaches the desired stage of development, the clash rendition can be created in order to prepare the aggregated coordination model for the Model Review. Self-checking and single-discipline clash detection must be completed prior to this.

The aim of the clash-checking part of the design coordination process is to utilize automatic interference checking software to resolve design interferences between the elements, particularly between different design disciplines, so that coordination errors on site are eliminated. This is achieved by reviewing and closing all identified clashes. Note that generally it will not be possible that the design models are clash-free, since many spatial interferences among digital models will be resolved on site as part of the normal construction processes and the level of definition required to resolve them digitally would be unproductive (these clashes must be clearly identified and agreed between parties and registered).

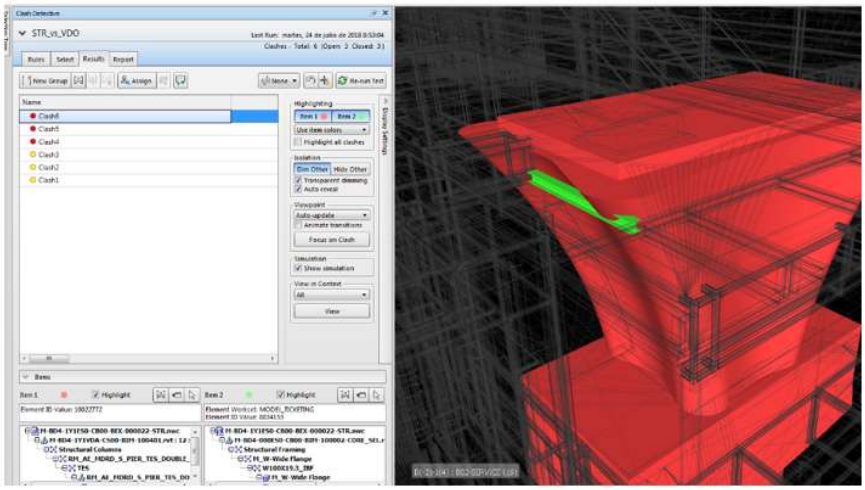


Figure 61: automatic interference checking software: Clash between Viaduct Structure and Station Structure

The BIM Model Coordinator, or other nominated BIM Modeller, performs the clash-check based on the guidelines in the procedure and makes sure that the model is delivered in compliance with the MIDP. This ensures that, in

addition to being consistent with all clashes closed, the model also has the correct content and level of definition. The result of the check must be documented in a report (BCF is recommended) and whether communicated to the other disciplines or discussed at the Model Review meeting, where the resolution of clashes will be recorded and the extent of any necessary follow-up will be agreed. The result of clash detection must be communicated to the designers responsible for the individual disciplinary models to enable them to perform the necessary corrections. They remain the responsible for the incorporation of these corrections.

The team shall review the model (Model Review) and pending Clashes in the Model Review meeting on a regular as-needed (generally weekly) basis throughout the design phases until all spatial and system coordination Issues have been resolved.

At every defined sub-stage a Model review shall be performed, as indicated in the section "Delivery milestones per Stage and Design Reviews"

17.2.1. Clash Checking Scope

The number of clash checks will be that which ensures a clash-free model and will include clashes of each model against itself and against other disciplines. A Clash Matrix should be developed and agreed internally and with RB Rail AS in order to ensure that all cases are evaluated.

Below you can find a Clash Matrix example:

x=to be performed	Architecture	Structures & Bridges	MEP	Geotechnical	Drainage & Flooding	Utilities	Tunnels	Rail
Architecture	x	x	x	x	x	x	x	x
Structures & Bridges		x	x	x	x	x	x	x
MEP			x	x	x	x	x	x
Geotechnical				x	x	x	x	x
Drainage & Flooding					x	x	x	x
Utilities						x	x	x
Tunnels							x	x
Rail								x

Table 22: Example of Clash Matrix

17.3. Model Review (Coordination Review)

A Model Review is a detailed review of the design utilising the approved Project model visualisation software to systematically review each area of the design package, including interfaces, with all required design and construction stakeholders prior to the production of the drawing deliverables.

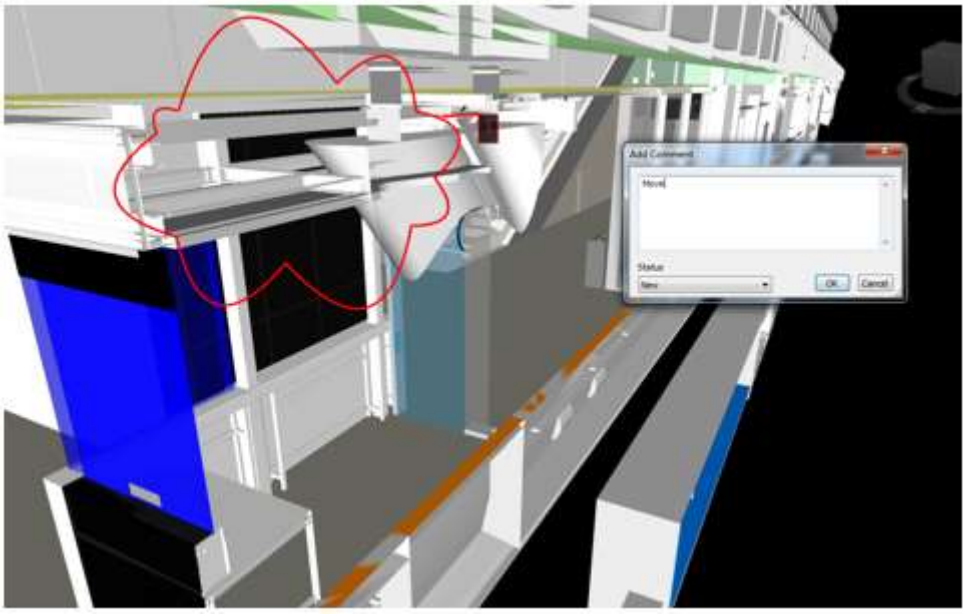


Figure 62: find of a clash during a Model Review

The model review is a method of efficiency demonstrating that the design systems and facilities are integrated, and cost effective, focusing on:

- **Design Coordination:** This utilizes a clash detection check undertaken prior to the review and the review determines or confirms the required actions for resolution of any physical, clearance and spatial clashes identified between modelled objects.
- **Interfaces:** To verify that physical interfaces identified are correctly coordinated, modelled and in accordance with the stated interface resolution.
- **Data Management:** To assure that all discipline designs and models comply with the data requirements for attributes assigned to the modelled elements as defined in the "BIM Objects Attributes Matrix" to facilitate data re-use by procurement, project controls and construction.
- **System functionality:** To check the systems and facilities as designed meet the contract requirements and comply with the design basis.

- **Quantities:** To review the principal quantities QTO scheduled from the model against the quantity baseline.
- **Constructability:** To obtain and check that constructability input into the design is reflected in the models, particularly in relation to the spatial requirements and clearances needed for installation of equipment, materials and components and for any temporary works, falsework or formwork, and access for plant and labour.
- **Operations:** To confirm that operational requirements have been addressed, particularly in relation to the spatial requirements for operating equipment.
- **Maintenance:** To confirm that maintenance requirements have been addressed. Particularly in relation to the spatial requirements and clearances needed for maintaining equipment.
- **Safety:** To check that the design is safe to construct, maintain and operate, particularly in relation to the spatial aspects of the life critical requirements, e.g. reducing working at height and the provision of fall protection measures; the creation of confined spaces; requirement and practicability for rigging, lifting an suspended personnel platform operations; the provision of barricades and safe routes; space for scaffolding erection and use; requirements for shoring, benching or sloping excavations.

Formal records of Model Reviews shall satisfy the requirement to provide evidence that constructability reviews and clash-checks have been undertaken (Report or BCF recommended).

Some examples of appropriate technologies and facilities to perform the Model Review are:

- Dedicated BIM room with screens and or projectors for broad scale team viewing with live screen and audio sharing, and video and tele-conference facilities available for remote dial in of offsite teams
- Virtual conferencing environment with live screen and audio sharing.

17.3.1. Scope

Model Reviews should be conducted for all design packages and for the entirety of the design scope by using aggregated BIM Models or even CAD Models (including 2D models) as a preproduction check on the designed information prior to drawing production from the model.

Model Reviews are not simply clash—detection reviews. The models should be used throughout the review process to provide ongoing assurance that the design process meets the requirements of the Design Management Plan as the design develops. They are a key process to be used by designers to “properly define and coordinate the interfaces undertaken at design coordination workshops and design reviews”.

This also applies to Model Reviews that are carried out with Fabricators, Suppliers or Subcontractors in the coordination, integration and verification of their Shop Designs prior to acceptance.

A model review schedule should be issued in advance of the first model review. It is important that the schedule be defined early in the development of the model and well in advance of the initial review so that the design teams can ensure that the appropriate personnel are available to support the reviews.

17.4. BCF (recommended)

BIM Collaboration Format (BCF) is an open standard for exchanging coordination information to enhance collaboration between the project team members. It is an initiative of buildingSMART.

BCF provides a standard protocol for communicating a model-driven environment. Figure below shows the process that can be used with BCF to identify and resolve coordination issues and clashes in the model data.

From the point of view of the number of BCF files used, multiple approaches can be used: one BCF per discipline, one BCF file per model, one BCF file per discipline and physical subdivision... Also the communication processes through BCF files can be implemented in any stage of the project and between any stakeholders or between RB Rail AS/National Implementing Bodies and stakeholders, even within the same stakeholder.

Below you can find a proposed workflow:

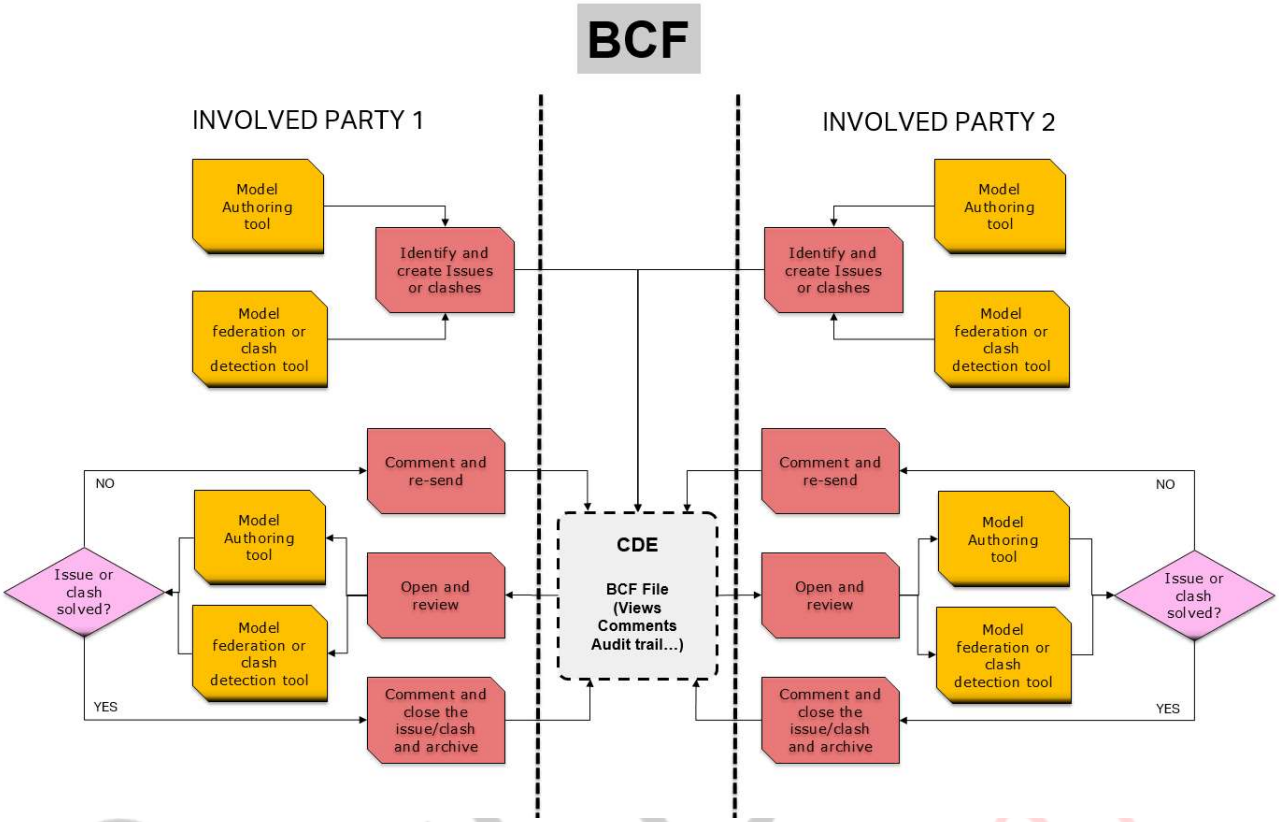


Figure 63: Example of General BCF communication Workflow

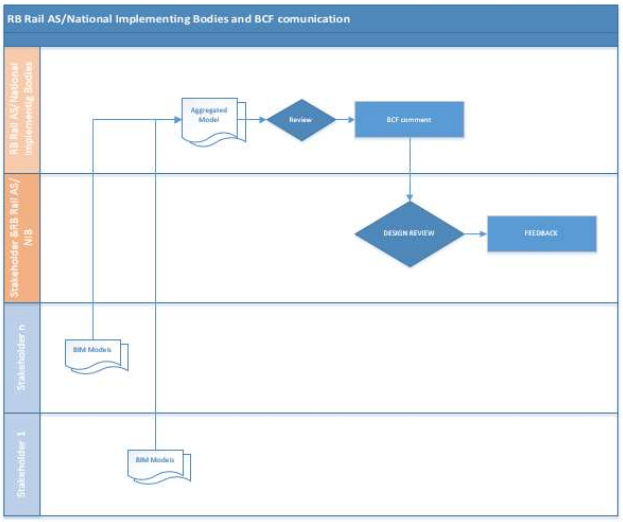


Figure 64. RB Rail AS/NIB BCF workflow

18. Quality Control

Quality Control Checks are the most important aspect of BIM model creation. Lack of quality checks and quality controls results into inaccurate as well as imperfect and incomplete BIM models.

The modeller should give as much importance to the data insertion in the BIM project model as to the graphical representation. The embedded data in the BIM are expected to be perfect, clear, and precise as well as complete, as they are crucial for the correct functioning of all the planned BIM Uses.

Crosschecking of clients data which are inserted in the BIM model is the first step towards Quality check. Final Quality checks are mainly done by BIM project manager or some experienced BIM personality. Before final dispatch BIM model goes through a number of self-checks. Accurate quality checks indirectly are the most efficient way of minimizing overall project completion time and cost. Proper quality checks result in error free models and provide 100% satisfaction at client's side.

18.1. Quality Checks

Following are the types of Quality Checks that should be performed throughout the project cycle:

18.1.1. Self-Check

Self check is a general review mainly done by the modeller on its own. It consists on reviewing that the BIM model matches the Client's requirements and the proposed design according to the established workflows and procedures. The modeller shall also check that the graphical representation and the inserted data comply with the LOD defined for that design stage.

During this check, the modeller assures that the data inserted in the model is up to the mark or not and thus highlights the data which is unclear or incomplete.

18.1.2. Visual Check

Under a visual check of the BIM model each and every component of the model are reviewed thoroughly. While performing this check, one should make sure that proper design steps are followed, that there is no unnecessary component in the model and that the model complies with the LoG defined for that design stage.

Model is correctly assembled through visual inspection.

See "Model Review" section for more details.

18.1.3. Clash Check

Clash check is mainly done to detect interferences between elements in the model (e.g. Frame of window clashing with wall). These clashes can be classified between:

- Self-clash: clash between elements contained in the same model
- Interdisciplinary clash: clash between elements contained in different disciplines' models

See "Clash Detection" section for more details.

18.1.4. Data Check

Crosschecking is done between client's data and data inserted in the software while creating BIM models. It must also be ensured that the dataset are populated with correct data and according to the defined LoI for that design stage and that the file format and naming conventions are conform the project Data Exchange protocols.

18.1.5. Standards Check

Ensure that the model is created based on the modelling guidelines and CAD standards.

QUALITY CONTROL CHECKS			
CHECKS	**DEFINITION**	**RESPONSIBLE PARTY**	**FREQUENCY (recommended)**
SELF-CHECK	General review: consistency, completeness and coherence of the design intent, graphic representation and inserted data	Modeller	Continuously
VISUAL CHECK	Ensure there are no unintended model components and the design intent has been followed	All project managers	Continuously
CLASH CHECK	Detect problems in the model where two components are clashing	BIM Manager/Assigned BIM specialist	Weekly
MODEL DATA/INTEGRITY CHECK	Ensure that the project data has no undefined, incorrectly defined or duplicated elements.	All project managers	Continuously
STANDARDS CHECK	Ensure that the BIM and CAD STANDARD have been followed	All project managers	Continuously

Table 23: Quality Control Checks Summary table

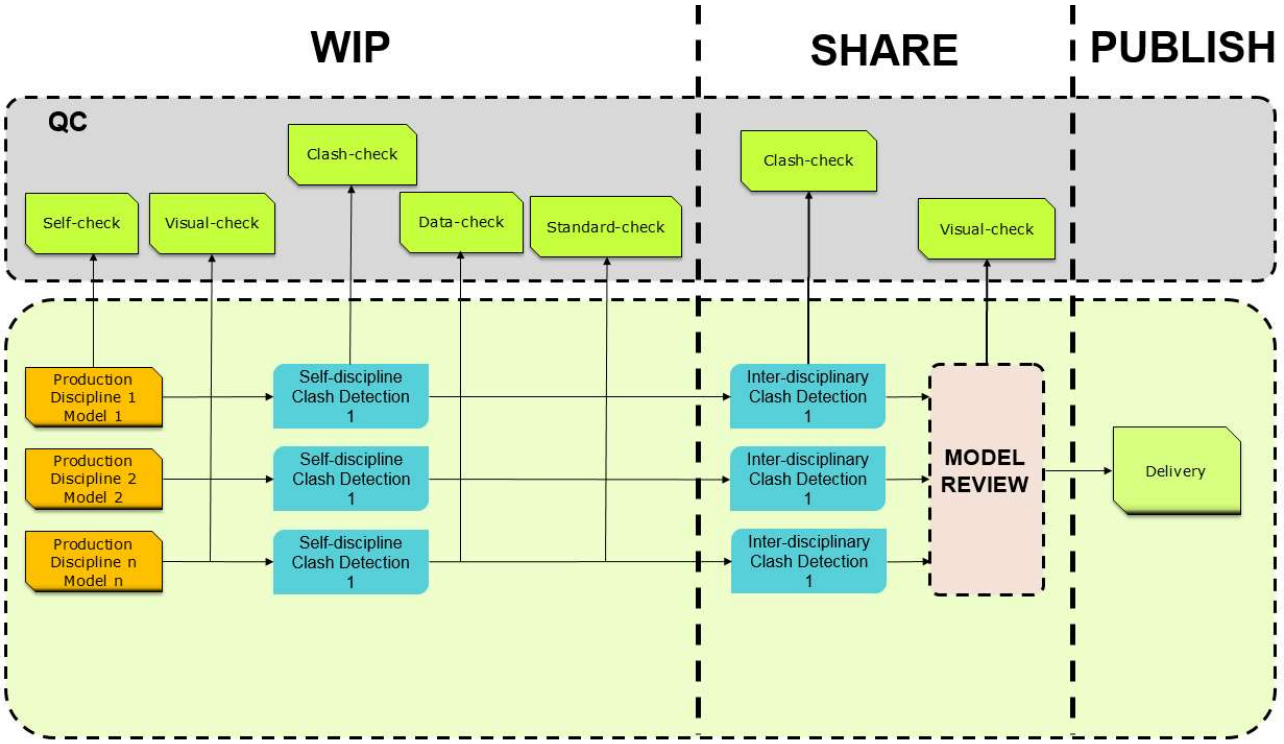


Figure 65: Quality Controls workflow

18.2. Quality Control Check Stages & Levels

Quality Control Checks can be divided into two major stages:

- **Primary QC stage:** In this stage the production team primarily checks its model assuring a free-clash model, compliant with BIM and CAD standards and contains appropriate and accurate data before share their models for the coordination review.
- **Secondary QC stage:** In this stage, when the coordination review is performed, multidisciplinary Clash Detection tests are performed and Model Review of the aggregated model is carried out. This is an iterative process: if issues or clashes are found, changes have to be done and the process starts again from the primary QC stage.

RB Rail AS can perform different checks in models and processes in order to ensure the quality of these. Depending on the project phase, different things will be verified.

Three levels of verification are defined:

Level 1: RB Rail AS will be able to carry out these verifications whenever it deems appropriate.

- Compliant with the collaboration processes.

- Compliant with the model codification Standard.
- Compliant with Model Break Down Structure.
- Compliant with the delivery schedule.

Level 2: RB Rail AS will be able to carry out these verifications in the scheduled intermediate submissions.

- Compliant with the elements codification.
- Compliant with the elements classification.
- Compliant with the Geolocation.
- Compliant with the procedures to determine and resolve the clash detection and the model inconsistencies.
- Compliant with the coherence of the data extracted from models (Data Drops).

Level 3: RB Rail AS will be able to carry out these verifications in the final submission of the models.

- Compliant with the complete and correct information associated with each model element
- Compliant with resolution of the clashes and model inconsistencies
- Compliant with the complete and correct enforcement of the BIM standards and regulations, as well as with the information requirements.

18.3. Quality evidences

In order to provide evidence that the corresponding quality controls have been carried out, two documents are provided as templates (included in the annexes), which must be completed and delivered with each submission:

- QAQC BIM/CAD Checklist
- Clash detection Report

19. Rail Baltica CDE

19.1. Outline of the Rail Baltica CDE

A **Common Data Environment (CDE)** is a single source of information for any given project or asset, used to collect, manage and disseminate all relevant approved project documents and data for multi-disciplinary teams in a managed process. The CDE must provide a secure, collaborative digital environment that all approved parties on a Rail Baltica project can access.

The CDE is core to the Rail Baltica Building Information Modelling [BIM] and information management processes and shall act as a means of providing a collaborative environment for sharing work in a consistent, managed and lean way for all project stakeholders.

The CDE shall support container-based collaboration where information management processes are applied to all information content (model files, drawings, documents and objects etc.). The project's CDE shall have the functionality to deliver secure, managed access to information based on a stakeholder's role in the project and the status of the information being accessed.

No information exchanges shall be permitted out with the Rail Baltica CDE environment including e-mails and models. This promotes a collaborative environment where all stakeholders can integrate and share appropriate content. Maintaining project content and information within a connected environment also promotes improved information security and confidentiality.

19.2. Container naming within the Rail Baltica Common Data Environment

The amount of data and information created by a Rail Baltica project and their supply-chain will be significant, and so it is important that good data structure and primary information hierarchies are established at the earliest opportunity. The provision of the CDE and a series of defined processes for the management of project information early in the project sets good practice and provides the platform for efficient design delivery, construction and operation phases of the project lifecycle.

The Rail Baltica common data environment will require careful development of its container structure. In a project of this magnitude information containers and master meta-data hierarchies will need to provide scope for identifying at least the following components such as contract, project phase, originator/organisational, work package, primary/sub asset, geospatial location, creating discipline and content type. The CDE shall be capable of using the container structure and master meta data hierarchies to deliver a unique identity for all project content.

[**Note**: a container is a named persistent set of data within a file, system or application data storage hierarchy]

The Rail Baltica CDE shall be based on at least the following naming codifications:

- Project
- Originator
- Volume_System / Zone
- Location
- Type
- Role
- Number

It is essential that naming conventions be adhered to meticulously to ensure accurate retrieval of information.

The CDE shall be capable of taking configuration that can support delivery of unique information codes for each project document.

Using a fixed container structure and master meta data hierarchies for the identification of project information provides the following benefits:

- Familiar consistent information structure for all stakeholders
- Preparation and use of project performance dashboards.
- Unique identity value for each piece of project information "single source of truth"
- Improved and more efficient information search and retrieval using CDE search engine
- Enables a more efficient delivery process
- Supports improved transition of information from design to construction and into operations and maintenance.

19.2.1. Project

This will consist of a distinct common project identifier (between four to six characters). On larger projects this will be divided into sub-projects based on contract codes.

19.2.2. Originator

This will consist of a unique identifier (three characters) for each organization on a Rail Baltica project responsible for creating data. A matrix of Originator codes shall be established at the project outset and updated as new organizations are contracted into the project.

19.2.3. Volume_System / Zone

This will consist of a unique identifier (six characters) defining each volume. A matrix of volumes, systems and zones will be created at the project outset.

Of the six characters, four characters are for Volume_System and two for Zone.

0000 is used as the default for “No volume” and “ZZZZ” for multiple volumes, 00 for “NO Zone” and ZZ for “multiple Zones.

19.2.4. Location

This will consist of a unique identifier (four characters) defining the location and where building assets are involved the appropriate level reference.

A matrix of location and level identifiers will be created at the project outset reflecting explicit needs e.g. location code plus work sub-locations)

19.2.5. Type

This will consist of a unique identifier (four characters) defining each type of information held within the container.

19.2.6. Role

This will consist of a unique identifier (two characters) defining each role on a Rail Baltica project.

19.2.7. Number

This will consist of a six numeric digits used sequentially to when a container is one of a series not distinguished by any other of the fields.

19.3. CDE Container Attributes

Containers within the Rail Baltica common data environment shall have the following attributes defined:

- Suitability / Issue Purpose

- Revision
- Classification

19.4. CDE Revision Attributes

Each container within the Rail Baltica common data environment shall have an attribute indicating the container revision.

Preliminary versions of content in the 'work in progress' state, shall also have a two-integer suffix to identify the version of the preliminary version e.g. P02. 15

The initial content shall be P01. 1

Preliminary versions of content shall, prefixed with the letter 'P' e.g. P01.1 to denote its preliminary status.

Following initial development, preliminary content that is "Shared" with a wider set of project stakeholders shall drop the suffix and assume a major revision status e.g. P02As content is further developed and published an alternative prefix shall be prefixed to the revision code field that defines the purpose for which the information is being published e.g. Content that is being published for the first time as Stage Complete may be adopt a revision of C01.

19.5. Classification

Each container within the Rail Baltica common data environment shall have an attribute indicating the classification of the information held within it and shall be based upon Uniclass 2015.

[**Note:** The Uniclass 2015 classification can be accessed via the NBS Website, where tables can be viewed or downloaded to a spread sheet format. https://toolkit.thenbs.com/articles/classification#classificationtables.]

19.6. Metadata

Metadata will provide the ability to find, monitor and maintain the data within the Rail Baltica CDE and will assist in linking the BIM and GIS environments.

Rail Baltica projects shall follow the metadata schema set out **in ISO 19115:2003 Geographic information – Metadata** and **ISO 19139** which contains the implementation rules for storing the information in XML files.

As a minimum the CDE meta data should capture all of the following information from the content

- Site / Land Reference
- Coordinate System

- E/N Coordinates
- Native File / Export
- Native File Application (defined list from BEP)
- Native Application Version (defined list from BEP)
- Applicable Add-Ons (defined list from BEP)
- Export Format
- Export Application
- Export Version
- Deliverable? Yes/No

The method of recording metadata may vary depending on software specific solutions; the content however, should remain the same.

The organization completing the metadata fields shall consider the following:

- All data (both sensitive and freely available) should have a corresponding metadata file
- Fields should be completed simply and consistently. The information should be concise and to the point, making it relevant and understandable
- If long paragraphs are being used to describe certain aspects of the theme (e.g., as in the abstract or purpose fields) then subtitles or bulleted lists should be used to help define and clarify long passages wherever possible
- They should also state clearly what each dataset is, and is not, to avoid misinterpretation of the dataset and avoid misuse
- They should avoid describing any sensitive information. If the dataset contains personal data, then a minimum description of what the dataset entails should be given. Anyone wanting to know more, will have to request it from the appropriate contact person
- They should maintain a focus on the potential, and should avoid using jargon; technical terms and abbreviations should be clearly defined.

19.7. CDE and the information lifecycle

The Rail Baltica information delivery lifecycle shall be supported by a CDE as a means of collecting, managing, disseminating, exchanging and retrieving information through a project lifecycle as illustrated below:

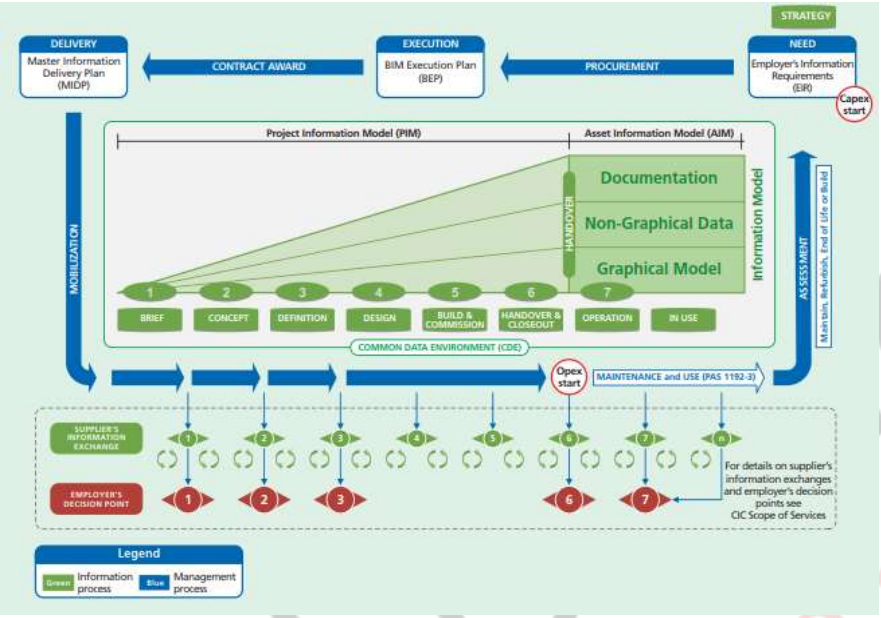


Figure 66: Extract from BSI PAS1192-2

The CDE will be used to support the progressive creation of the Project Information Model (PIM) comprising of a set of federated building information models.

Key to this are the Information exchanges between Rail Baltica project team members using the CDE as a vehicle are indicated by small GREEN balloons.

Information exchanges between the project team and the employer are indicated by larger RED balloons to answer the Plain Language questions posed by the employer defined in the employer's information requirements (EIR).

[**Note**: Following handover, the Rail Baltica operator shall curate the Asset Information Model (AIM) within their own CDE environment.]

19.8. Project workflow / states within the Rail Baltica CDE

The structured and efficient use of the Rail Baltica CDE will require strict discipline by all approved users to who will need to adhere to the agreed approaches and procedures. The principles below establish the Rail Baltica requirements in relation to the CDE that must be followed:

19.8.1. Delivery planning

It is essential that all CDE inputs are clearly defined through a hierarchy of information requirements established in the project's **Master Information Delivery Plan (MIDP)** e.g. a primary plan for when project information is to be prepared, by whom and using what protocols and procedures, incorporating all relevant task information delivery plans. The MIDP shall be agreed prior to finalisation of designer appointments or contract agreement with the main-contractor(s).

19.8.2. Capability and Capacity Assessment

Suppliers to Rail Baltica shall submit on behalf of their whole Supply Chain documented evidence of their capabilities regards use of a CDE environment on similar projects.

Appropriate question on: approach, experience and capabilities to the CDE should be included in the overall BIM assessment.

This assessment will be used as a basis to help identify project CDE training and upskilling requirements prior to contractual engagement.

19.8.3. Process and the Common Data Environment

The Rail Baltica CDE model has four principal phases, that are illustrated in the diagram below:

- **Work-in-Progress (WIP):** Used to hold unapproved information. [Supplier CDE]
- **Shared:** Used to hold information which has been approved for sharing with other organizations to use as a reference in design/construction development. [Supplier CDE]
- **Client Shared / RB Shared:** Used to release the information from the Supplier CDE to the Rail Baltica CDE, for sharing with RB Rail or the local implementing bodies. [Rail Baltica CDE]
- **Published:** Used to holds published information for use by the entire project team. (both design/construction team and Rail Baltica project team). [Rail Baltica CDE]
- **Archive:** used to store all progress as each project milestone is met. [Rail Baltica CDE]

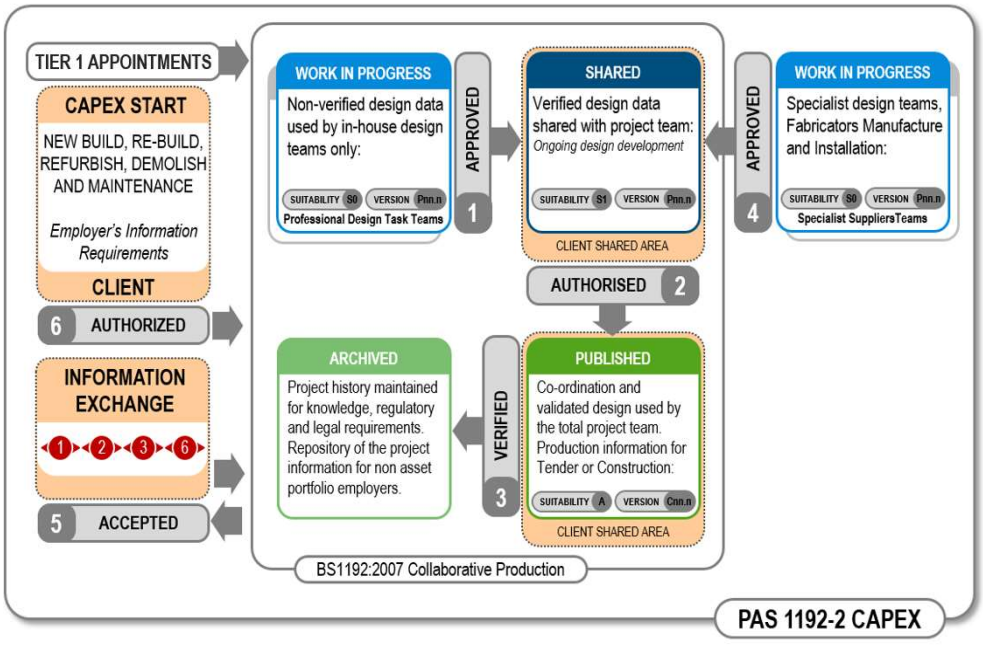


Figure 67: CDE model four principal phases

[**Note:** The Clients (RB Rail) and the Suppliers CDE are distinct entities. Each supplier in the capital delivery phase shall be responsible for the creation of Work in Progress Information within their own CDE using their own procedures to control the creation and coordination of their own files and data. The Tier 1 contractor shall be responsible for the provision of a shared space. RB Rail shall be responsible for the client side CDE consisting of Shared, Published and Archive.]

It is recommended that the Supplier CDE has an additional phase called **Client Shared**:

- **Client Shared**: used to hold information which has been approved for sharing with the client before the submittal of milestones. This phase would be between the Shared and Published (for the development project team).

Processing of work through the CDE involves passing data and information between each of the four phases with emphasis on processes related to:

- Checking
- Approving
- Authorizing and accepting

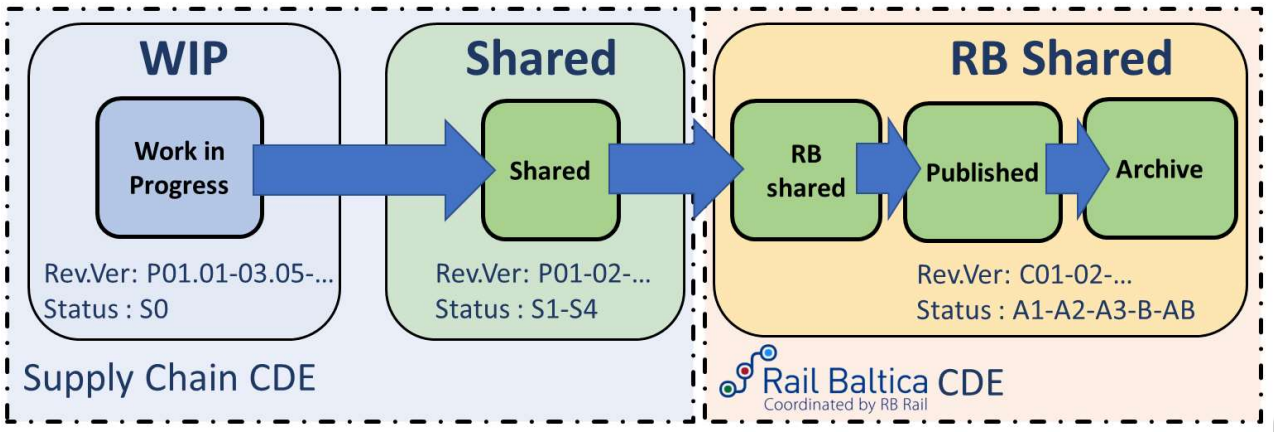


Figure 68: CDE workflow

19.8.3.1. Work in Progress (WIP)

The WIP area of the CDE is where members of the Rail Baltica project will undertake their own non-verified in-house activities such as design using their own organization's software systems for information sharing e.g. between departments and or offices. The supplier shall provide details of their proposed CDE environment for the WIP stage within their BIM Execution Plan.

The management process for models and documents during this stage shall be consistent with those set out in this manual.

Each organization is responsible for the quality of the WIP information and should ensure that appropriate checking and review processes are in place. Proposed methodology should be described within their BIM Execution Plan for approval.

Each organization shall take ownership of their own WIP information and model(s) and check and review these with their task team manager before issuing the information and model(s) to the SHARED part of the CDE.

Before information is moved into the Shared space on the CDE the authoring organization shall undertake a gateway review of information including:

- Model suitability check
- Technical content check
- Data completeness checks
- Review that all standards and methods have been followed
- Internal approval review and sign-off

[**Note:** During spatial co-ordination activities information will pass regularly form WIP to Shared for checking and then back to WIP for resolution until the lead designer is satisfied that all clashes are resolved.**]**

19.8.3.2. Shared

The SHARED section of the Supplier CDE shall be used to hold information which has passed through the WIP gateway and thus approved for sharing with other organizations primarily to support design/construction development and co-ordination activities.

When all design has been co-ordinated and completed it will pass into the Client SHARED / RB SHARED area. At this point the information is moving from the Supplier CDE Environment to the Client [Rail Baltica] CDE which may be different technology solutions.

19.8.3.3. Client Shared / RB Shared

The RB SHARED section of the Rail Baltica CDE shall be used to hold information which has been released (submitted) by the Supplier to RB Rail AS or the local implementing bodies. Meanwhile the package is in the RB SHARED area, the information is visible to all the organizations involved in the project, both from the Supplier and the Rail Baltica project side.

[Note: The information hosted in this area is not contractual until it has been approved by RB Rail As or the local implementing bodies, what takes place once the information reaches the PUBLISHED section, and not just but being stored within this area. The only fact that is contractually related fact is that the Supplier has released or submitted a package, so as to be taken into account in terms of submission deadlines.]

Before information is released into the Published space it will be subject to a Gateway review and authorization from the Rail Baltica representative including compliance with EIR deliverables and appropriate decision-making using the information as a basis.

19.8.3.4. Published

This section of the CDE contains all co-ordinated and validated (by RB Rail or the local implementing bodies) design output for use by the total project team. Production information at this time will likely have suitability for tender or construction purposes.

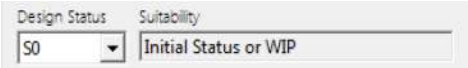
Once verified by the Rail Baltica representative the information will pass to the Archive section of the CDE.

19.8.3.5. Archive

The Archive section of the CDE shall be used to record all progress at each milestone, records of transactions and the "As-built" information model. The final "As Built" information model will be exchanged into the Rail Baltica Operators CDE at an appropriate juncture following verification and validation of the completed information.

19.8.4. Design Status and Suitability Codes

Every RB Rail container should have a field indicating the approved 'Suitability' for use of the contained information. Design Status codes will be used to define the 'Suitability' of information in an RB Rail model, drawing or document.



Status codes will be provided by all information originators on RB Rail project as a mean to define how information may be used during the different phases of the CDE process. Status codes will be used in connection with the gateways in the CDE. The project CDE should be configured to ensure that Suitability is changed as a result of a Completed Workflow in the CDE and not by a user simply changing a meta-data field. [Note: The Suitability codes are not related to version numbering].

CDE status codes are based on PAS 1192-2:2013 (Table 3), Specification for information management for the capital/delivery phase of construction projects using building information modelling, adapted to RB Rail as shown below.

Design Status Code	Description	Revision	CDE	CDE Status	Comments
S0	Initial status or WIP (Hidden)	P01.01, P01.02…	SUPPLIER	WIP	Hidden within Supplier CDE, only visible by the producer
S1	Issued for co-ordination.	P01, P02, P02…	SUPPLIER	SHARED	Shared for co-ordination within Supplier CDE
S2	Issued for information	P01, P02, P02…	SUPPLIER	SHARED	Shared for information (internal sub-stage)
S3	Issued for internal review and comment	P01, P02, P02…	SUPPLIER	CLIENT SHARED	Release for information within RB RAIL CDE
S4	Issued for stage approval	P01, P02, P02…	RB RAIL	CLIENT SHARED	Release for stage approval within RB RAIL CDE
S5	Issued for manufacture	P01, P02, P02…	RB RAIL	CLIENT SHARED	Release for approval
S6	Issued for PIM authorization	P01, P02, P02…	RB RAIL	CLIENT SHARED	Release for approval
S7	Issued for AIM authorization	P01, P02, P02…	RB RAIL	CLIENT SHARED	Release for approval
D1	Issued for costing	P01, P02, P02…	RB RAIL	CLIENT SHARED	Non Contractual - Use at risk
D2	Issued for tender	P01, P02, P02…	RB RAIL	CLIENT SHARED	Non Contractual - Use at risk
D3	Issued for contractor design	P01, P02, P02…	RB RAIL	CLIENT SHARED	Non Contractual - Use at risk
D4	Issued for manufacture/procurement	P01, P02, P02…	RB RAIL	CLIENT SHARED	Non Contractual - Use at risk
AM	As maintained	P01, P02, P02…	RB RAIL	CLIENT SHARED	Non Contractual - Use at risk
A1	Approved - Master Design	C01, C02, C03…	RB RAIL	PUBLISHED	Contractual documentation
A2	Approved - Detail Design	C01, C02, C03…	RB RAIL	PUBLISHED	Contractual documentation
A3	Approved for construction	C01, C02, C03…	RB RAIL	PUBLISHED	Contractual documentation
B	Partially signed-offcomment is resolved, then resubmitted for full authorization.	C01, C02, C03…	RB RAIL	PUBLISHED	For design/construction with minor comments from RB Rail. All minor comments should be indicated by the insertion of a cloud and a statement of "in abeyance" until the comment is resolved, then resubmitted for full authorisation - Use at risk
AB	As-built	C01, C02, C03…	RB RAIL	PUBLISHED	Handover documentation, PDF, native models, COBie, etc.

Table 24: Design Status and Suitability Codes

Extra suitability codes can be defined indicating other suitability for use, if required, with detailed descriptions, reflecting the contractual arrangements. These codes should not conflict with the standard code.

19.9. Responsibility for provision of the CDE Environment

	CDE Section	Who provides?
1.	**Work In Progress (WIP)**	To be provided by all individual design, main-contracting and specialist sub-contractors with design input.
2.	**Shared, Client Shared and Published**	Explicit detail will be provided in the EIR however this will normally be provided by the lead designer or main contractor. In some cases, the Lead-Designer will provide until a Main Contractor is on-boarded.
2A	**Client Shared and Published**	Rail Baltica
3	**Archive**	Rail Baltica
4	**AIM CDE**	Rail Operator

Table 25: Responsibility for provision of the CDE Environment

19.10. Roles relating to the management of the CDE

Roles for the effective establishment and implementation of the CDE on Rail Baltica projects shall be clearly defined and embedded into contracts, either through a specific schedule of services or more general obligations. These should be encompassed with other Information management activities over and above that of the CDE such as Project Information Management and Collaborative working, information exchange and project team management.

The following activities shall be allocated to ensure that the Common Data Environment is effectively managed on a Rail Baltica project. These shall be incorporated into an existing appointment such as lead-designer or main contractor. It is expected that the roles will shift from design team to contractor prior to start on site. Only in exceptional circumstances should these roles form a separate stand-alone appointment.

These roles are a minimum standard any additional requirements to suit project explicit needs shall be set out in the EIR.

Ref	Activity
1	Establish project specific Common Data Environment processes and procedures to enable reliable information exchange between Project Team Members, the Employer and other parties. *The processes should be based upon the framework described in this BIM Manual.*
2	Establish, agree and implement the information structure and maintenance standards for the Information Model.
3	Receive information into the Information Model in compliance with agreed processes and procedures. Validate compliance with information requirements and advise on noncompliance.
4	Maintain the Information Model to meet integrity and security standards in compliance with the employer's information requirement.
5	Manage Common Data Environment processes and procedures, validate compliance with them and advise on noncompliance.

Table 26: CDE Management main activities

19.10.1. CDE permissions and roles

Permissions and Roles for the effective establishment and implementation of the Common Data Environment (CDE) on Baltic Rail projects shall be clearly defined and embedded into contracts, either through a specific schedule of services or more general obligations. These should be encompassed with other Information management activities over and above that of the CDE such as Project Information Management and Collaborative working, information exchange and project team management.

The diagram below shows the various stages of the PIM CDE to give context to what stages the permissions and roles relate to.

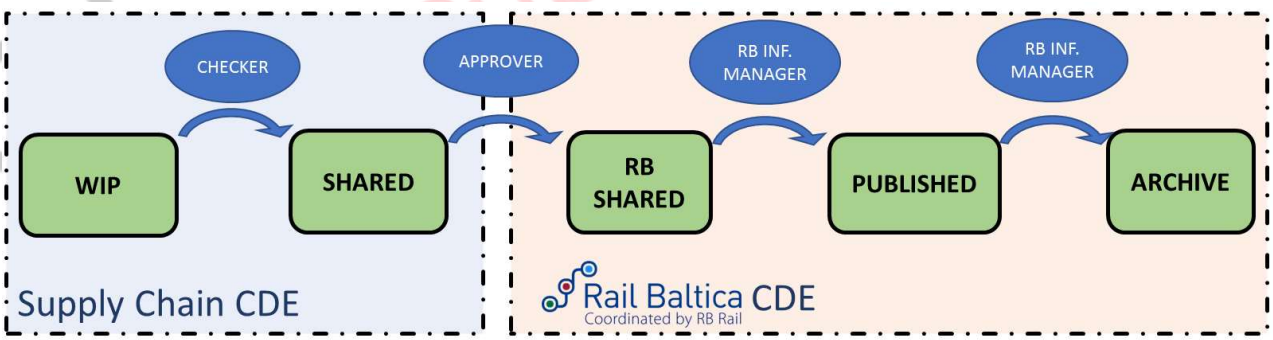


Figure 69: CDE workflow, permissions / roles

The activities shall be allocated to ensure that the Common Data Environment is effectively managed on a Baltic Rail project. These shall be incorporated into an existing appointment such as lead-designer or main contractor.

It is expected that the roles will shift from design team to contractor prior to start on site. Only in exceptional circumstances should these roles form a separate stand-alone appointment.

These CDE project roles are a minimum standard, any additional requirements to suit project explicit needs shall be set out in the EIR. These roles will be created within the CDE and will be assigned to the individuals performing those activities within the production/approval structure of their organization, both Supply Chain or RB Rail AS (or the local implementing bodies).

19.10.1.1. Supplier CDE Information Manager

The Supplier CDE Information Management role will undertake the following activities related to Information exchange activities :

Establish Supplier specific Common Data Environment processes and procedures to enable reliable information exchange between Project Team Members, the Employer and other parties. The processes should be based upon the framework described in the RB Rail BIM Manual.

Establish, agree and implement the information structure and maintenance standards for the Project Information Model.

Receive information into the Project Information Model in compliance with agreed processes and procedures. Validate compliance with information requirements and advise on noncompliance.

Maintain the Information Model to meet integrity and security standards in compliance with the employer's information requirement.

The information management role shall be responsible for the access permissions for those who can create, read, update and delete information. The control of access shall be in accordance with the projects security plan and associated security policies, processes and procedures.

[Note: during the early gateway stages the Information Manager Role may be undertaken by the Lead Designer and then by the Main Contractor following their contractual appointment.]

19.10.1.2. Information Producer

Each organization contributing to the creation of the PIM shall have an Information Producer role to develop in accordance with the MIDP their constituent parts of the information model in connection with specific tasks which will be uploaded onto the CDE following internal checking and approvals. This Supplier CDE role is the one that creates and prepare the documentation within the CDE, this role is assisted by the Supplier CDE Information Manager.

[Note: this BIM Manual lets open the internal workflow for the Supply Chain CDE before releasing to the Supplier CDE SHARED area (collaboration space within that CDE), that workflow will be defined in the BEP and will be agreed with RB Rail AS (or the local implementing bodies).]

19.10.1.3. Information Checker

Each organization contributing to the creation of the PIM shall have an Information Checker role to confirm that information they have produced is suitable for issue within the Supplier CDE (Common Data Environment).

Before information is moved into the Shared (collaboration space within the Supplier CDE) the authoring organization shall undertake a gateway review of information including as a minimum:

- Model suitability check
- Technical content check
- Data completeness checks

This role (or the Supplier CDE Information Manager if agreed that way in the BEP) undertakes the task to shift the status from WIP to SHARED within the Supplier CDE.

19.10.1.4. Supplier Information Approver

Before information is moved into the Shared area of the Rail Baltica CDE, called RB SHARED, files / documents / models follow the checking process and the authoring organization shall undertake a gateway approval review of information including:

- Accept or reject their organizations information prior to uploading onto the Rail Baltica project common data environment (Rail Baltica CDE).
- Approval that all standards and methods have been followed
- Internal approval review and sign-off
- Issue approved information within the Rail Baltica CDE.

19.10.1.5. Rail Baltica Information Approver

The Rail Baltica Information Approver acts within the RB Rail CDE, using a CDE profile with the privileges to move from RB SHARED to PUBLISHED and ARCHIVE. This role changes the status depending on the Rail Baltica organization approvals and register strategy.

- Accept or reject the RB Shared information prior to shifting to the Published status or area.

- Approval that all standards and methods have been followed
- Rail Baltica project official approval review and sign-off, by moving the information to PUBLISHED, becoming *de-facto* the information to be used or accepted to continue the life-cycle of the project. [Note: this approval can be approved completely or partially, see Suitability Codes]
- Move the data to the Archive area (or status) when a newer version of a package/file has been released, or when the package reaches the latest status within the CDE for that package. (such as As-Built, for instance)

19.11. CDE Security

All project information is to be treated with confidence and all models will be exchanged in the CDE using agreed metatags. The Suppliers' BEP shall demonstrate compliance processes and the means by which compliance is monitored and managed.

To support security and accessibility of information, upload protocols must be strictly adhered to. Any amendments to the naming or structure of the CDE workspace must be explicitly agreed with the project team, including the Information/BIM Manager.

It is essential that a holistic and mindful approach to the security of the CDE environment be considered. Anyone providing or planning to utilise a CDE on a Rail Baltica project will need to understand the security risks and requirements of the Employer and demonstrate their ability to meet them as part of their method statement or BIM Execution Plan.

While baseline needs will differ by project the following consistent issues should be considered and addressed as a minimum standard:

- Assessment of security risk for the CDE
- CDE Security strategy proportionate to mitigate risk issues
- Establishment of recognized IT and Cyber resilience standards
- Ensure that the CDE provider is contractually committed to the project CDE security requirements especially:
    - Physical location and legal jurisdiction of where data is stored, managed and processed.
    - Data centre security
    - Resilience and back-up methodology
    - Early testing of the CDE to demonstrate compliance

- Data in transit protection – ensure that interfaces between the CDE and a user's device and any other systems are protected using a Transport Layer Security (TLS) or Internet protocol security (IPsec) implementations.
- Creation and implementation of processes and workflows which will protect data and information in concert with the CDE Security strategy
- Clearly defined roles and responsibilities for the CDE
- Formation of a clear, navigable folder structure to aid consistency and allow controls to be applied especially around sensitive information
- Appropriate access controls and permissions, their application and monitoring.

19.12. Quality – Gateway Processes

The Gateway points between the various stages of the CDE are of vital importance and suppliers shall demonstrate within their BEP their proposals (tools and methodology) for verification, both of geometry / data and validation against the EIR.

19.13. Transfer of data from PIM to AIM

The handover process between the construction and operational stages and the effectual transfer of structured information to the asset lifecycle stages delivers considerable value. It is important that there is an effective transfer of the as-completed and verified Project Information Model [PIM] to the operations organizations Asset Information Model (AIM) and its associated software platforms such as a Computer Assisted Facilities Management (CAFM) or Asset Management System (AMS).

If the rail operator is known at the time of tender their operational systems should be described within the EIR and their asset information requirements (AIR) sought along with any additional attribute requirements.

To effectively enable this, formal handover processes shall be documented in the EIR. The EIR shall define the structure, process and content of information to be exchanged at handover.

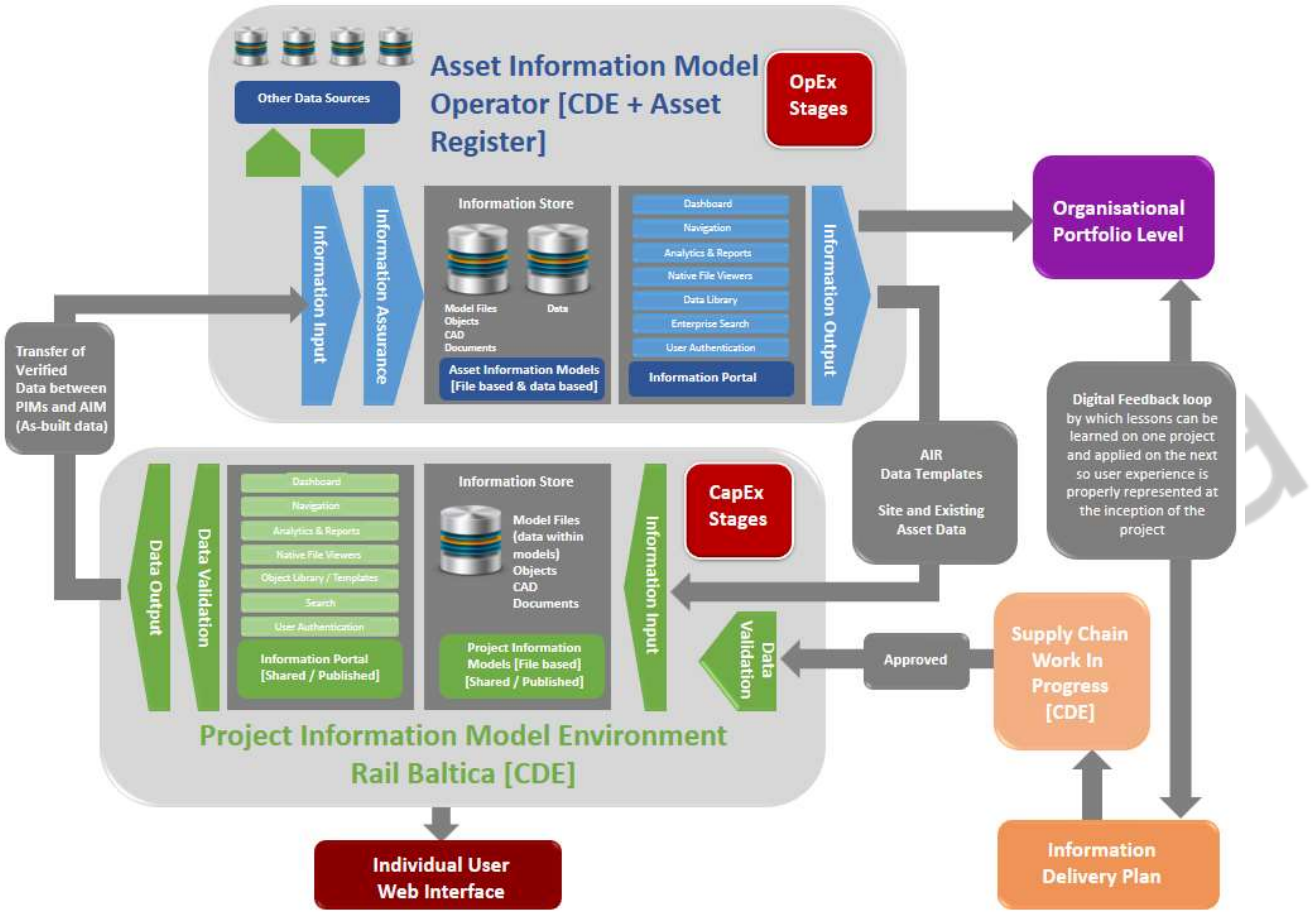


Figure 70: Transfer Data from PIM to AIM

The Operator shall be responsible for transferring the PIM into their AIM ecosystem. It is envisaged that an early test of the data transfer will be undertaken where practical.

[**Note:** the involvement of the operational team from the earliest opportunity in the creation of the AIR is essential to ensuring success in both defining information operational stage requirements and ultimately the data transfer to the AIM.]

19.14. Archiving of digital information

Suppliers shall demonstrate within their BEP how they will, on project completion, securely archive information within their WIP / Shared CDE environments and or destroy any sensitive information.

20. Annexes

20.1. Supporting Documents

20.1.1. CAD Standards

20.1.2. Codification & Data Management

20.1.2.1. Codification Tables

20.1.2.2. BIM Objects Attribute Matrix

20.1.3. Level of Definition (LOD) LoG and LoI Standards

20.1.3.1. BIM Objects LoG Matrix

20.2. Mobilisation Templates

20.2.1. Post-Contract BEP template

20.2.2. TIDP template

20.2.3. MIDP template

20.3. Delivery Templates

20.3.1. BIM Delivery Report template

20.3.2. QAQC CAD/BIM Checklist Report template

20.3.3. Clash Check Report template

20.3.4. QEX template

20.3.5. QTO template

20.3.6. Data Drop template