IFC Rail Project

Context & Approach

The readme file of the IFC Rail Project

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Contents

1. Introduction

The aim of this document is to summarise the organisation, methodology, scope and other essential information of the Phase I of the IFC Rail project. It is built to support the reader to navigate and understand the deliverables of the Project, and how these deliverables fit into the overall project.

This first version of the document was delivered on September 1st, 2019, together with the deliverables submitted to the SC Executive members by that date: the "Requirements Analysis Report" and the "Conceptual Model Report".

A second, updated, version of the document is delivered by October 28th, 2019 to support the reading of the other deliverables presented during the buildingSMART Summit in Beijing", and, more in general, to help any reader to navigate the project documentation.

A third, final, version of the document will be delivered by the end of 2019, to support the voting process of the final deliverable submitted to the SC Executive members: the IFC Rail Standard Specification.

2. Project organization

In 2017 China Railway BIM Alliance and 7 European Rail-Infrastructure-Managers decided to step in the development of a common strategic concept and implementation strategy for the digitalization of rail infrastructure under the flag of the Building Information Modeling (BIM) Idea to bring the digitalization of rail infrastructure on step further. In 2015, China Railway BIM Alliance publicly released the first IFC Rail Specification standard for the railway industry at buildingSMART. These became the foundation of the IFC Rail project proposal and the IFC Rail consortium.

The stakeholders of the IFC Rail Project are:
- Austria: ÖBB-Infrastruktur AG
- China: CRBIM
- Finland: FTIA Väylävirasto (formerly Liikennevirasto)
- France: MINnD
- France: SNCF Réseau
- Italy: RFI
- Sweden: Trafikverket
- Switzerland: SBB Infrastruktur

The IFC Rail Project organisation for the Phase I (February 2018 – December 2019) is summarised in the diagram below.
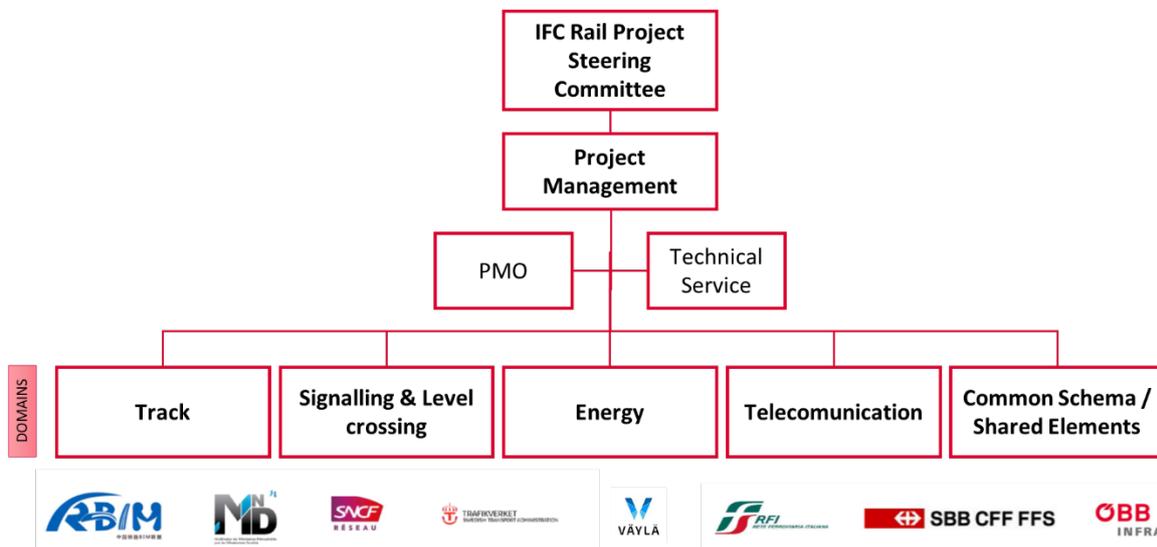

Figure 1 IFC-Rail Project Organization

- **IFC-Rail Steering Committee.** Founded during the preparation of the project and commissioned by the stakeholders in the consortium agreement to oversee the IFC-Rail Project;
- **Project Management and PMO.** One of the most important topics of this international, multicultural and multilingual project was the clear and well-established Project Management Office (PMO). As for Domains, one person from Europe and one from China were nominated in the project management. The PMO was also able to recruit

Swiss-based employees from China who played a key role not only in internal project communication, but also in the forward-looking handling of the project content. French, German and English-speaking experts were also represented in the PMO Team;

- **Technical Services**. This group was responsible for the development of all methods, processes and toolsets which are necessary to develop the IFC Rail Standard. Furthermore, the group is responsible for the mapping process from business requirements into IFC based concepts. The available bSI methods and toolbox had to be adapted, mainly due to the scale the IFC Rail Project. The work of the Technical Service Team (namely, process and methodology summarised in the following paragraphs) is now proposed as part of the new reference methods and toolset in bSI;

- **Domains**. The railway experts are divided into four rail domains: Track, Energy, Signalling and Telecommunication. A fifth "domain" is the so called "Common Schema & Shared Elements-Domain" (CSSE) and it is responsible for the concepts which are: (a) common between the railway domains (shared elements) or common between railway and other infrastructures (bridge, tunnel, road, etc.). It is very important to harmonize all objects with each domain and/or project to get a stable, common and unified standardized IFC version.

- **Co-Lead.** All the Domains and Functions are double-led by one person of the European- and one person of CRBIM Consortium. PMO has been staffed with Chinese Citizens living in Europe and European Representants to secure clear communication. Language skills of PMO covered English, French and Chinese and some very basic Italian.

2.1 Relationship with other projects and domains

To achieve the common goal, the extension of IFC4.2 to IFC5, the interplay between the other projects and overlapping topics is an inherent task of the IFC Rail project. The project organization was taken into consideration by the creation of the working group "Common Schema" (see Figure 2).
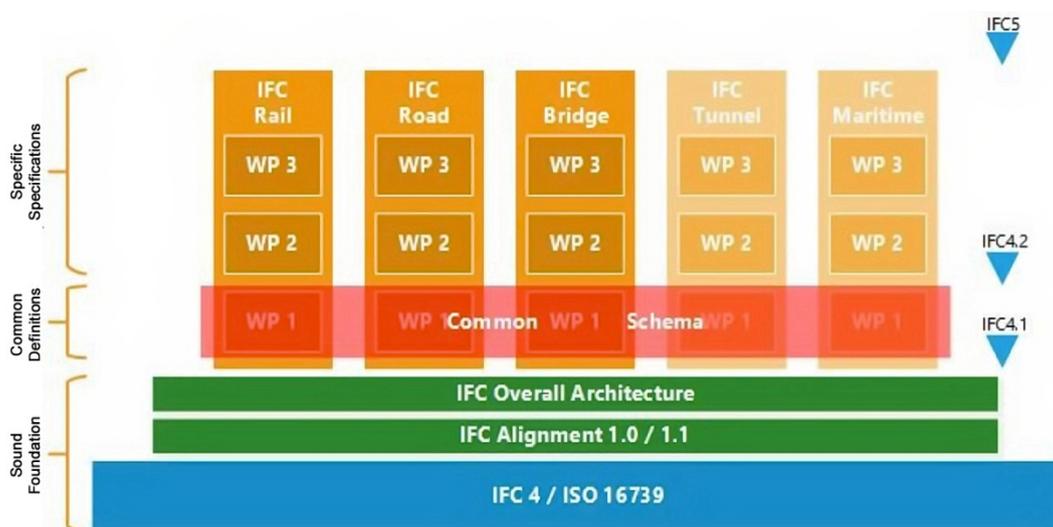

Figure 2 - IFC Rail project in the context of IFC and buildingSMART roadmap

3. Methodology

The project is accomplished through a strong collaboration between the Technical- and Domain Experts: Technical Experts provide methods and knowledge on modelling principles and IFC, while Domain Experts provide expertise in the railway sector and on the application of the BIM methodology to this sector. Such collaboration is coordinated by the PMO.

Due to the size of the IFC Rail project, a considerable amount of resources is invested in formalizing the business requirements in an UML model. This approach is alternative to the approach adopted by other IFC extension projects (e.g. IFC Bridge or IFC Road), which directly jump from Excel-based business requirements into IFC-based concepts and extension proposals. In the IFC Rail project, business requirements are captured in the Conceptual Model, while IFC-based concepts are captured in the IFC Rail UML Model (see Section 3.1).
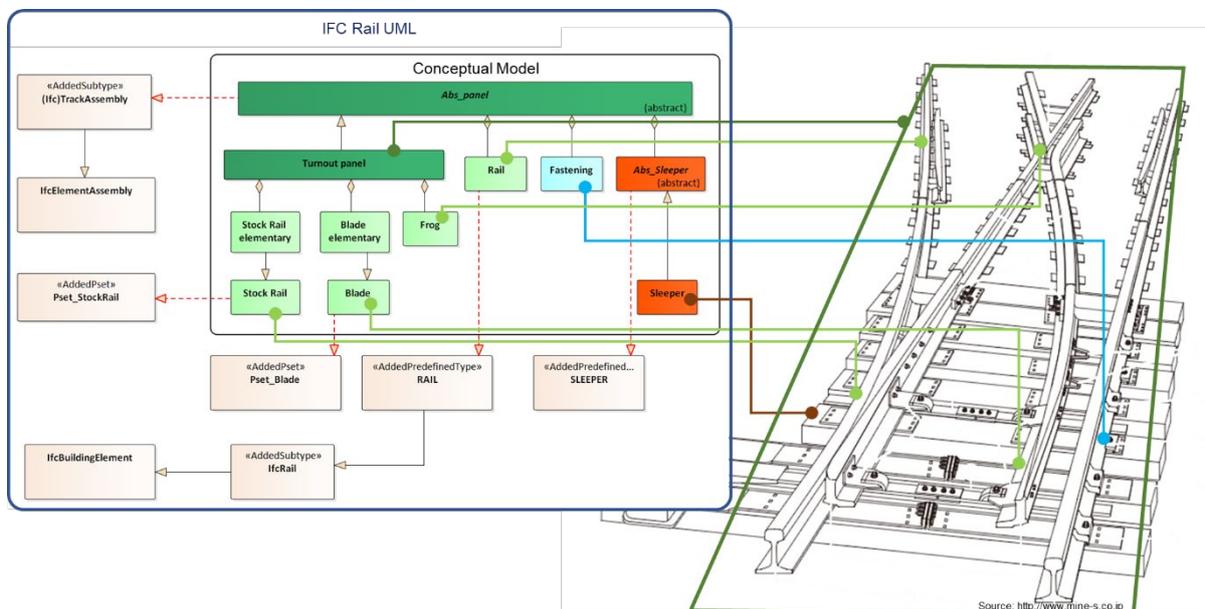
Figure 3 - From business requirements to IFC

In the image above, an example is used to represent the connection between real-world elements, business concepts contained in the Conceptual Model, and IFC-based concepts contained in the IFC Rail UML Model.

The project outcomes are both official and internal deliverables. The official deliverables are subject to the bSI voting process, while the internal deliverables are used for supporting the activities of the project. The internal deliverables are part of the know-how of the project and they are valuable for further phases or projects.

3.1 Deliverables

The official deliverables of the IFC Rail project are the Requirements Analysis Report, the Conceptual Model Report, and the IFC Rail Standard Specification. The first two were submitted to the voting process by September the 1st 2019, and they were accepted as candidate standards. The IFC Rail Standard Specification will be presented in a draft version by October the 28th 2019, when the buildingSMART Summit will take place in Beijing. Such presentation will be accompanied by two other interal deliverables: the IFC Rail UML Report, and the Mapping Diagrams Report. The IFC Rail Standard Specification will be submitted to the voting process by the end of 2019. The time between the summit and the end of the year will be used to finalize the harmonization between the IFC Rail Standard Specification and the outcomes of the IFC Road and IFC P&W projects.

The following list contains a brief description of such deliverables.
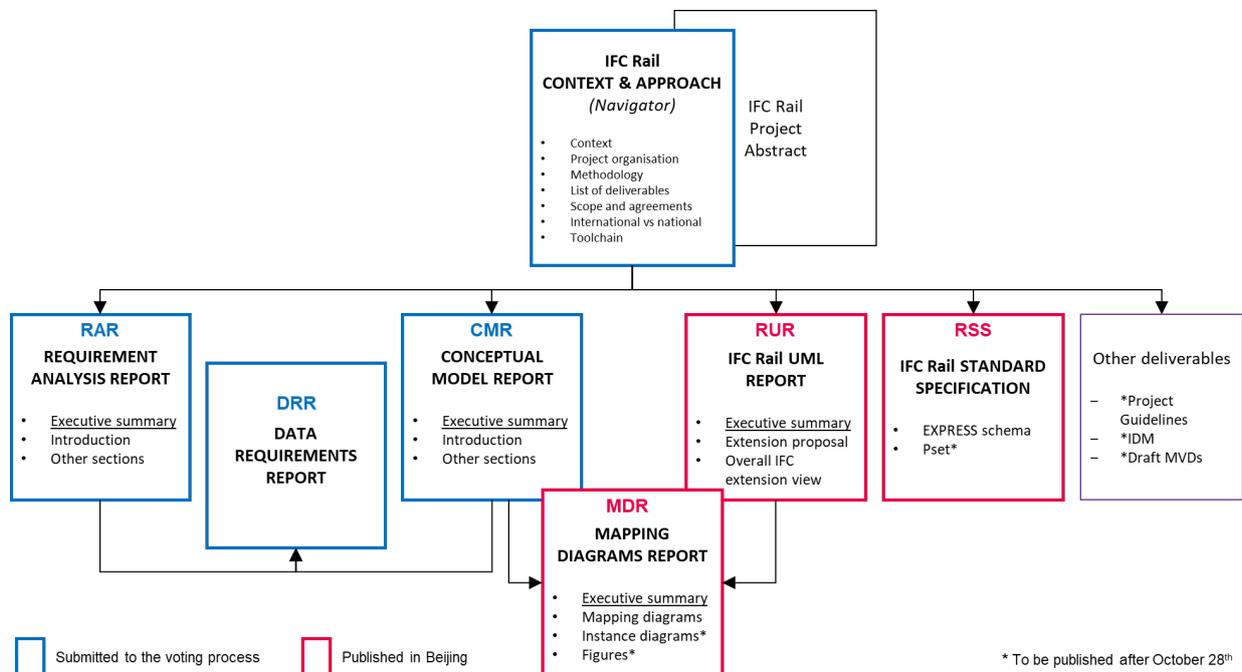
Figure 4 - IFC Rail documentation structure

- **WP2 – Requirement Analysis Report**: a pdf document containing the railway requirements for the extension of the IFC. This report contains an introduction to the project, a Reference Process Map for IFC Rail, the IFC Rail use cases and their priority, general requirements for modelling the railway infrastructure, such as alignment and spatial structure, a detailed specification of the data requirements from the domains, and the estimated Model View Definitions (MVDs). This document refers to the **Data Requirements Report** document.

- **WP3 – Conceptual Model Report**: a pdf document containing an introduction to the model-based approach that is adopted by the project, and the documentation that is automatically generated from the UML Conceptual Model. The Conceptual Model is a UML class diagram that captures the business requirements expressed by the Domain Experts. Such model is a conceptualization of the data requirements contained in the

Requirement Analysis Report. The Conceptual Model is decoupled from the later IFC specification, but it serves as a reference for the extension proposal of IFC. This document refers to the **Data Requirements Report** document.

- **WP3 – The IFC Rail Standard Specification**: an html document containing the proposed specification of IFC. The proposal is an extension of IFC version 4.2.

The internal deliverables of the IFC Rail project are Guidelines for Domains, the Data Requirements, the Information Delivery Manual (IDM), the IFC Rail UML Report, the Mapping Diagrams Report, and the draft MVDs. The internal deliverables will be publicly distributed when, and if, the official deliverables are accepted as candidate standards.

- **Project Guidelines**: pdf documents containing instructions, tutorials, and guidelines provided to the project participants.
- **IDM**: a pdf document containing the Reference Process Map for IFC Rail, the IFC Rail use cases with highest priority, and the Exchange Requirements. The Exchange Requirements indicate which Data Requirements apply to the use case.
- **IFC Rail UML Report**: a pdf document containing the description of the IFC Rail UML Model. This model contains an UML representation of the IFC version 4.2 EXPRESS schema and the concepts added in the proposed IFC specification (see official deliverables), This deliverable targets the IFC experts and the IFC implementers, and it shows the delta between IFC 4.2 and the new IFC Rail Standard Specification.
- **Mapping Diagrams Report**: a pdf document containing UML diagrams that show the mapping between the Conceptual Model and the IFC Rail UML Model. Such mapping is also documented through examples and instance diagrams. This deliverable targets the stakeholders, and it shows how the business needs expressed in the Conceptual Model are satisfied by the new IFC Rail Standard Specification.
- **Draft MVDs**: each MVD is delivered as an html document, structured like the IFC specification, and as an mvdxml file, which is a computer-readable representation of the MVD that supports the IFC implementation and certification processes. MVDs define a subset of the complete schema to specify required data representations for exchange scenarios.

3.2 Delivery process overview

The overall IFC Rail process is summarised in the following diagram.
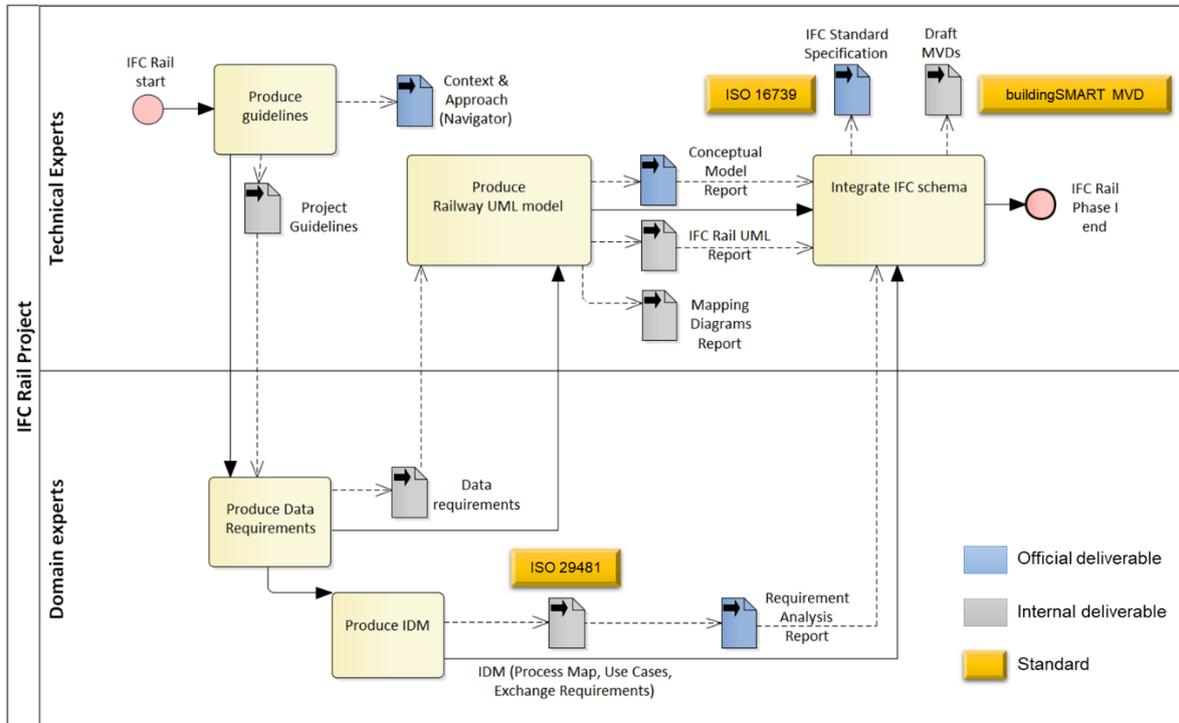
Figure 5 - Overall process and relative documentation of the IFC Rail Project (Phase I)

The major activities of the above process are further described in the following table. For each of it, objective, supporting documents and tools are displayed.

Table 1 - Major activities of the Project and relative documentation

Activity	Objective	Supporting documents	Tools
Produce guidelines	Provide indications and rules for the project approach, the consensus process, the deliverables structure and conventions, and the tools usage.		Word, PowerPoint
Produce Data Requirements	Capture railway business data requirements.	Project Guidelines	Excel
Produce IDM	Formalise business requirements according to ISO 29481	ISO 29481	Word; Excel; BIMQ; Visio
Produce Railway UML model	Formalise the railway business concepts, and their relationships and mappings towards IFC standard.	Project Guidelines; ISO 16739	Enterprise Architect
Integrate IFC schema	Provide a new version of the IFC Specification and the MVDs that might be implemented by the software vendors.	ISO 16739	IfcDoc

*For further details on tooling see paragraph 6 (Toolchain)

4. Scoping and other (Project's) agreements

Early 2019 it was decided to apply the following priorities to the execution of the IFC Rail project and its rich set of business requirements. The IFC Rail project covers Priority 1 and settles the background for the achievement of the other priorities.

- **Priority 1:** Provide a geometric model of all lineside and trackside elements of a railway system

  - Track (provide physical guidance of rail vehicles)

  - Energy (power supply via overhead contact line)

  - Signalling (secure safety of rail traffic)

  - Telecom (provide communication links)

- **Priority 2:** Integrate geometric model of all lineside and trackside elements of a railway system with all the other IFC domains.

  - Bridge

  - Drainage

  - Earthwork

  - Geotechnics

  - Network

  - Road

  - Tunnel

  - Undergrounding / Cabling

  - Building

  - Station

  - Technical Building, Technical room

- **Priority 3:** Provide a minimal functional layer to IFC Rail to support the integrated and comprehensive digital twin vision.

  - Geometric model of IFC Rail is constrained by the function of the Railway System

  - Example: position / placement of a signal depends both on position of protected element (switch) and on functional properties (e.g. design speed)

    - Introduce a powerful model of a topological network (UIC RailTopoModel)

- **Priority 4:** Support an appropriate framework of communicating relevant regulations.

    o Every Railway System must conform to a set of regulations

    o In the future designers of a railway network shall get immediate feedback on conformance properties of their design.

        ▪ supply a framework for communication of the relevant parameters

The IFC Rail work is integrated with the IFC Infrastructure projects in the context of the IFC Common schema project (see Priority 2 tasks). Thus, initial efforts have been made with the representatives of the IFC Infrastructure projects, and of the IFC Common schema project.

Also, the minimal functional layer (Priority 3) needs to be integrated with other important Rail specifications. Examples are the RailTopoModel specification (UIC IRS 30100) and the EULYNX standardisation efforts in the field of Signalling and Interlocking. Comprehensive efforts have been made with representatives of UIC/RailTopoModel and EULYNX.

The methodology adopted by the project was affected by the IFC Rail stakeholders needs. The stakeholders had from the very beginning expectations which went beyond existing buildingSMART culture and tradition. It was very soon established that inside the IFC Rail project some changes and extensions to methodology and tooling were necessary. Two factors were specifically important:

- IFC Rail should support the digital twin vision of current IT system development in the rail business. Consequently, it was requested that besides the IFC encoding of IFC Rail also an UML encoding needs to be published.

- Time to market was required to be as short as possible. Consequently, an efficient methodology to organise use cases and corresponding data exchange requirements and producing compact Model View Definitions (as a basis for implementing certifiable software solutions) was very highly prioritized.

UML itself is used for many different aspects of IT. In IFC Rail UML was the platform to elaborate a comprehensive conceptual model. The conceptual model constitutes a "Platform-Independent Model" (PIM). The PIM is integrated with an established commercial software platform to manage properties and data exchange requirements (i.e. BIMQ).

In addition, UML is also used to provide an UML encoding of the proper IFC Express Schema, which is also known as "Platform specific model" (PSM). The PSM is used to integrate the EXPRESS centred IFC encoding. In addition, preparations were made for the upcoming bSDD platform.

5. Adaption of International Consensus to National or Regional Requirements

Every IFC extension proposal, including the IFC Rail one, is based on international consensus: the IFC specification is not specific to any nation or project, and the Model View Definitions (MVDs) match several generic business exchange scenarios. Therefore, IFC Rail doesn't consider every possible country- or project-specific requirement.

To close possible gaps between such specific requirements and the proposed extension, several IFC mechanisms can be used. These mechanisms include, but are not limited to,

- use user-defined Property Sets to define missing attributes on which international consensus wasn't reached;
- use Proxy elements to represent components which might not have a suitable IfcProduct type in the IFC data schema.

Such mechanisms can be enforced in country- or project- specific Model View Definitions (MVDs). MVDs can be as broad as nearly the entire schema (e.g. for archiving a project) or as specific as a couple object types and associated data (e.g. for pricing a curtain wall system). This flexibility allows to create MVDs on different scales, as shown in the following picture.
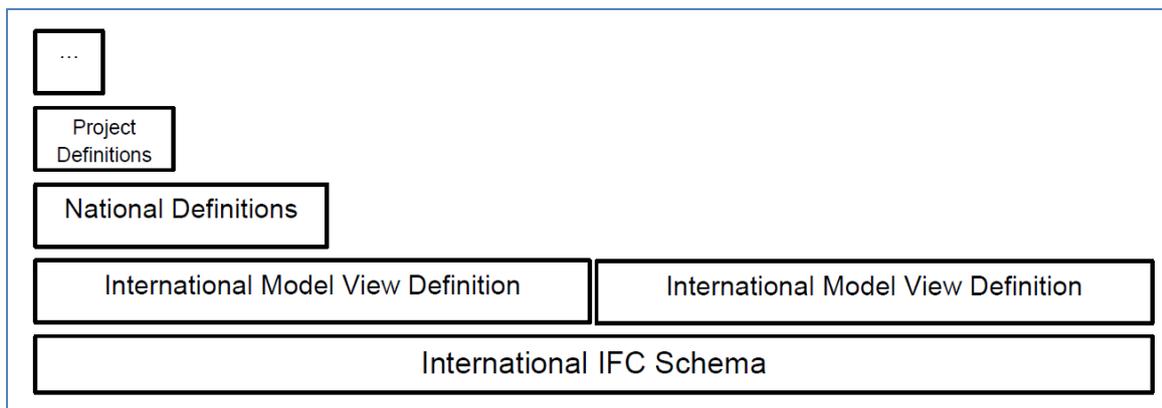
Figure 6: Model View Definitions at different scales[1]

The documentation of an MVD allows the exchange to be repeated, providing consistency and predictability across a variety of projects and software platforms[2]. Eventually, the country- or project- specific MVDs, coupled with mechanisms to extend the IFC specification, lead to software implementations that are compliant to the general IFC standard on one side, and that accommodate specific requirements on the other side.

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[1] Chair of Computational Modeling and Simulation, Technical University of Munich
[2] https://technical.buildingsmart.org/standards/mvd/

6. Toolchain

Different tools have been used in the IFC Rail process, all of them needed to interact to ensure consistency of data throughout such process. TS team adopted a toolchain to minimise these interactions and guarantee the quality of data.

Three main tools are used to support the creation of the deliverables: Enterprise Architect for the editing of the Railway UML model, BIMQ for the definition of the Data Requirements and the Data Exchange Requirements, and IfcDoc for the generation of the IFC specification.

The following image depicts how the tools are integrated to generate the deliverables, either manually or automatically.

Figure 7 – Summary of the tool-chain

The Conceptual Model Report, the IFC Rail UML Report, and the Mapping Diagrams Report deliverables are automatically generated from Enterprise Architect. From BIMQ the Data Requirements Report is also automatically generated. **Both the Conceptual Model Report and the Requirement Analysis Report contain a reference to the Data Requirements Report**. Coherence between the Conceptual Model and the BIMQ work is achieved through the adoption of unique identifiers and names, while the consistency between them is checked through automatic procedures.

The IFC specification is created through the IfcDoc tool: the extension of the IFC schema is manually derived from the IFC Rail UML Report, while the definition of the Property Sets and Quantity Sets is semi-automatically imported from BIMQ to IfcDoc. Documentation of the schema is manually added in IfcDoc.

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