IFC Rail Project

Phase 1 Report

Status: final

Version: 1.0

Date: 03. 2020

Contents

1. Introduction

This report summarises the results, organisation, methodology, scope and other essential information of the IFC Rail project Phase 1. The purpose of this report is to proof the progress of the IFC Rail project Phase 1, together with the deliverables which were submitted to the bSI Standard Committee Executive (SCE): Requirements Analysis Report, Conceptual Model Report, Data Requirements Report, the Harmonised IFC UML Report, and Harmonized IFC Specification.

The results of IFC Rail Phase 1 were elaborated within two years by 1) domain experts which are skilled in design, construction, management, operation and 2) technical experts for data modelling of linear assets and neighbouring domains. The trigger was the proposal made by China Railway BIM Alliance (CRBIM) from 2014 to buildingSMART (bSI) and the common project proposal from the Stakeholders in 2018. Use cases were formulated in order to find a global consensus despite national regulations. These requirements are thus expanding the 'classical' use of IFC which are seen benefitting the design stage of buildings. Key of this extension is the previously mentioned target of supporting operation processes. Thus, a lifecycle view on data is introduced resulting in a demand driven approach. Examples on logical and technical level are: the importance of alignment, parts of the assets and sites having geometric dimensions of hundreds of kilometres whilst maintaining high numeric precision, implementing or referring to existing data concepts which are already used by the stakeholders, topological descriptions, requirements to represent legal ownership, etc. One key finding is: the ability to have localisation of the standard.

2. Project organization

In 2017 CRBIM 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 one step further. In 2015, CRBIM publicly released the first IFC Rail Specification for the railway industry at bSI. These became the foundation of the IFC Rail project proposal and the IFC Rail consortium.

The stakeholders of the IFC Rail Project Phase 1 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 1 (February 2018 – March 2020) is summarised in the diagram below.

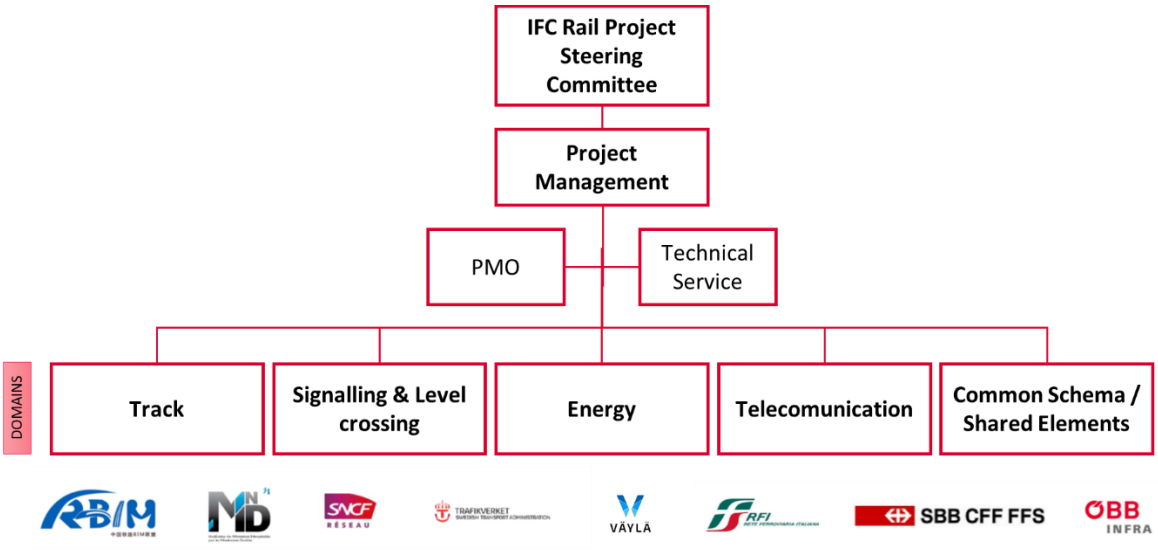

Figure 1 IFC Rail Phase 1 Project Organization

- **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; IFC Rail has monthly Steering Committee Meeting to report and comment on the progress of the 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 of 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 (b) 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, unified and standardized IFC version.
- **Co-Lead.** All the Domains and Functions are co-led by one person from the European stakeholders and one person from CRBIM. PMO has been staffed with Chinese citizens living in Europe and European representants to secure clear communication. Language skills of PMO cover English, French, German, Chinese and some very basic Italian.

2.1 Relationship with other projects and domains

To achieve the common goal, the extension of IFC 4.2 to IFC 5, 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).

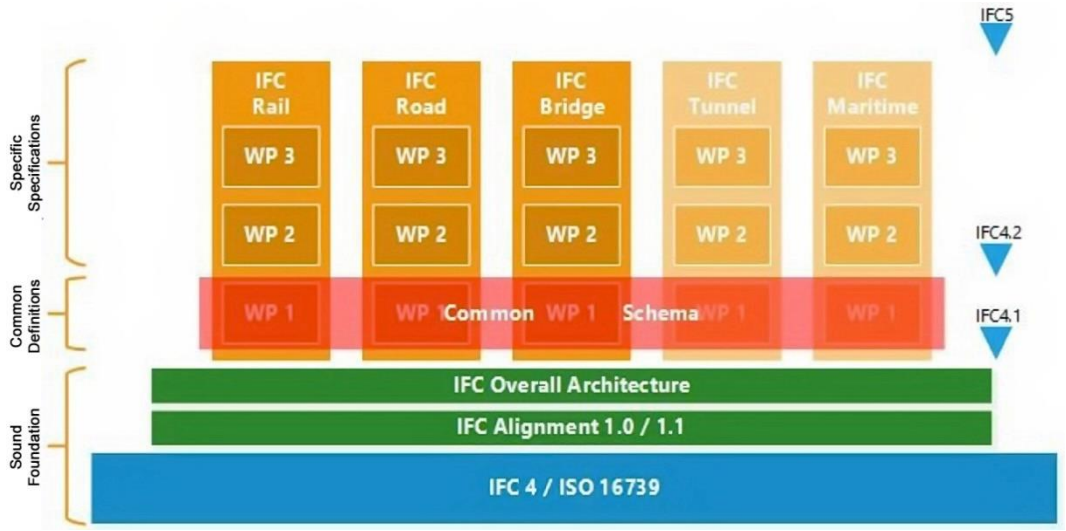

Figure 2 IFC Rail project in the context of IFC and buildingSMART roadmap

3. Methodology

The project is accomplished through a strong collaboration between the Technical Experts 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 a 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.

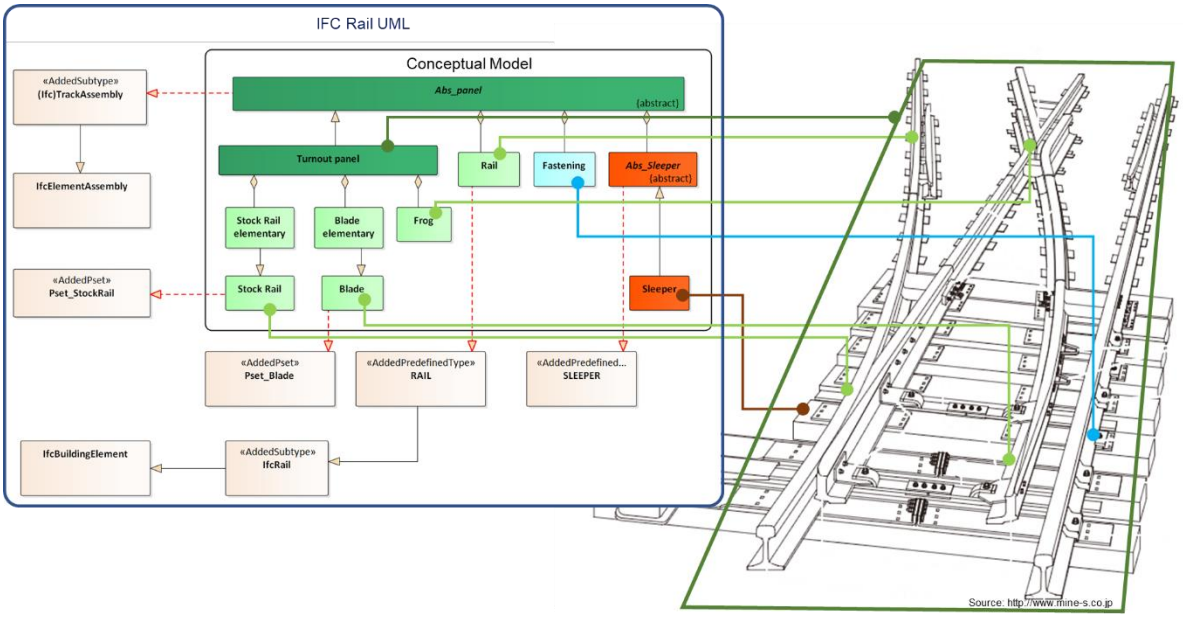

Figure 3 From business requirements to IFC

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 Phase 1 are the Data Requirements Report, Requirements Analysis Report, the Conceptual Model Report, the Harmonised IFC UML Report, and the Harmonised IFC Specification. The first three were submitted to the voting process by September 1st 2019, and they were accepted as Candidate Standards. The Harmonised IFC UML Report is jointly produced by IFC Rail, IFC Road, IFC Port & Waterway and Common Schema projects. It reports a harmonized IFC model encoded in UML, covering the IFC extension proposals based on IFC 4.2 made from all these projects. It has been delivered to bSI for Standard Committee voting process. Based on this report, a Harmonized IFC Specification is generated semi-automatically, that contains the IFC EXPRESS schema and an initial list of Property Sets, and HTML documentation of them. The next step is to publish this work as IFC 4.3 and it will be published by bSI.

The following list contains a brief description of all these deliverables.

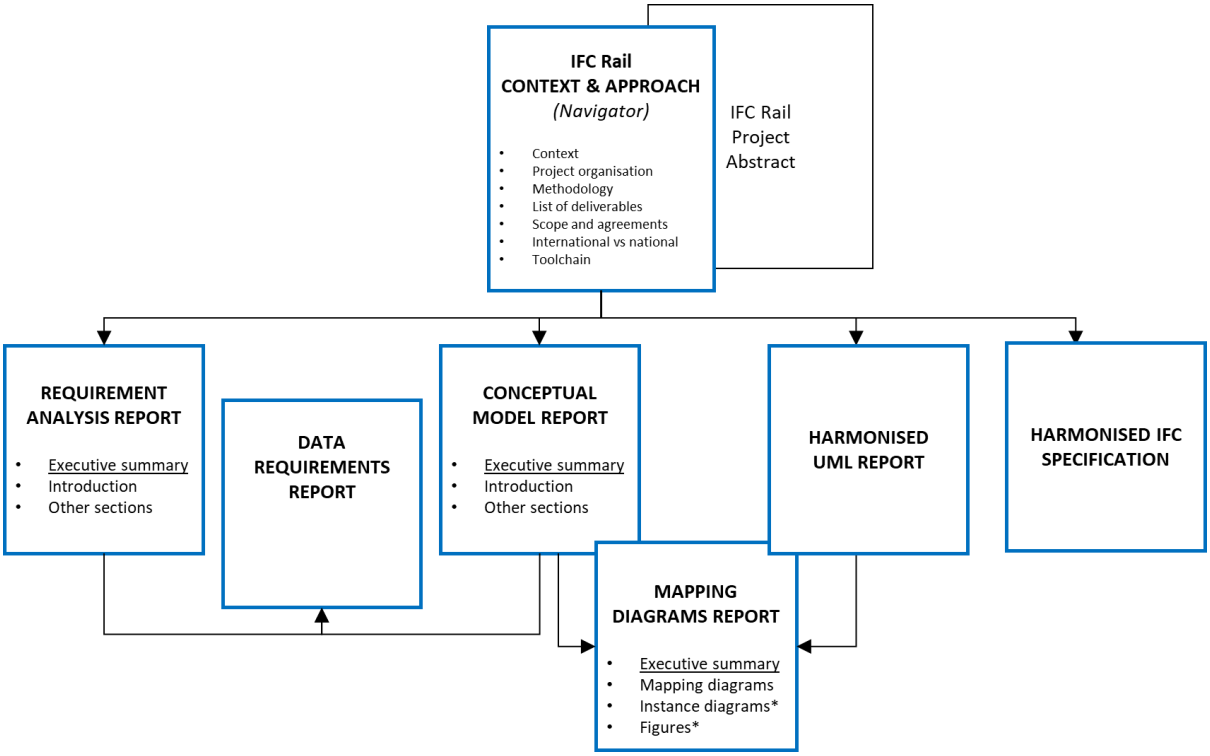

Figure 4 IFC Rail documentation structure

- **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 –Harmonised IFC UML Report:** a list of pdf documents containing the harmonized IFC extension encoded in UML based on IFC 4.2, covering the proposed extensions from IFC Rail (in IFC Rail project the extension is reported by **IFC Rail UML Report**), IFC Road, IFC Port & Waterway, and of course IFC Bridge, which is a part of IFC 4.2. **Harmonized IFC Specification**: a set of HTML documents with supporting materials containing the proposed specification of IFC, including IFC EXPRESS Schema, an initial set of Property Sets and documentations of them. This Harmonized IFC Specification is an extension of IFC 4.2. They are delivered to bSI for Standard Committee voting process and will be published by bSI once this process is finished.

The internal deliverables of the IFC Rail project Phase 1 are Guidelines for Domains, the Data Requirements, the Information Delivery Manual (IDM), the IFC Rail UML Report, the Mapping Diagrams Report. These complimentary, internal deliverables are subject to change during validation process and will be finally released after final acceptance of the standard.

- **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. The content of this deliverable is superseded by **Harmonized IFC UML Report**.
- **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.

3.2 Delivery process overview

The overall IFC Rail process is summarised in the following diagram.

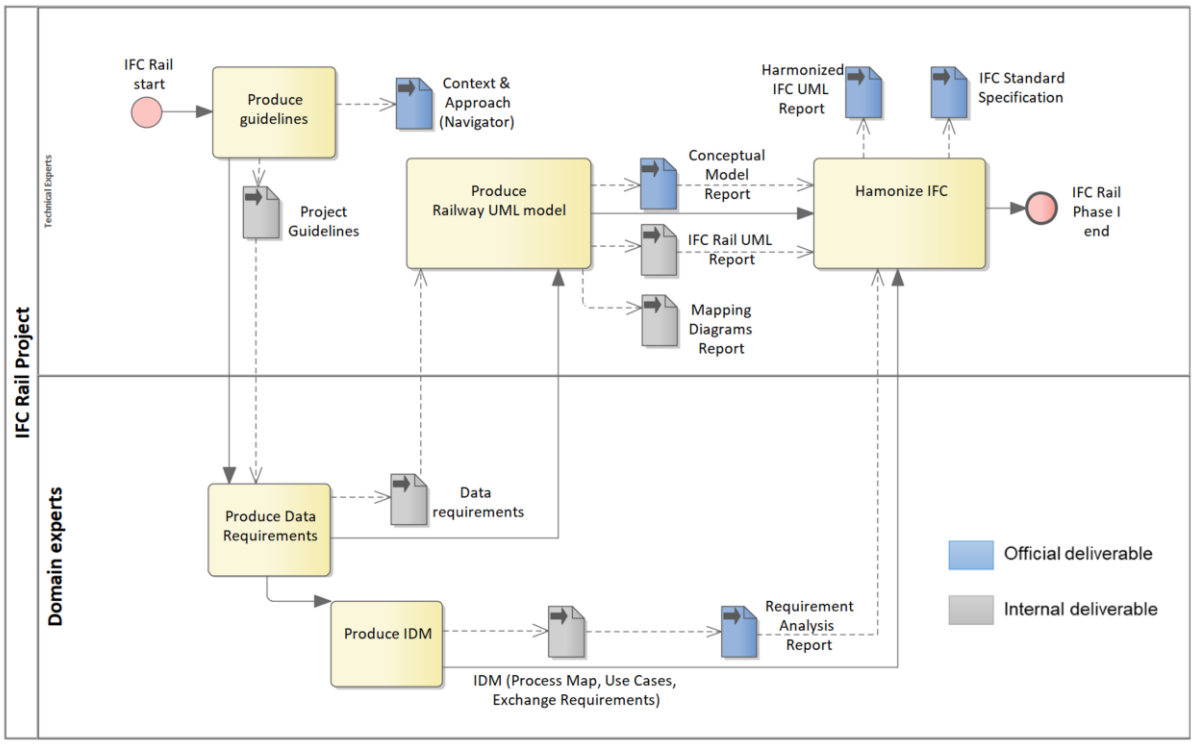

Figure 5 Overall process and relative documentation of the IFC Rail Project (Phase I)

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
Harmonize IFC	Provide a new version of the IFC Specification that can be implemented by the software vendors.	ISO 16739	Enterprise Architect; 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.
    - Every Railway System must conform to a set of regulations
    - 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 project, 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 requirements.

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 subtype 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.

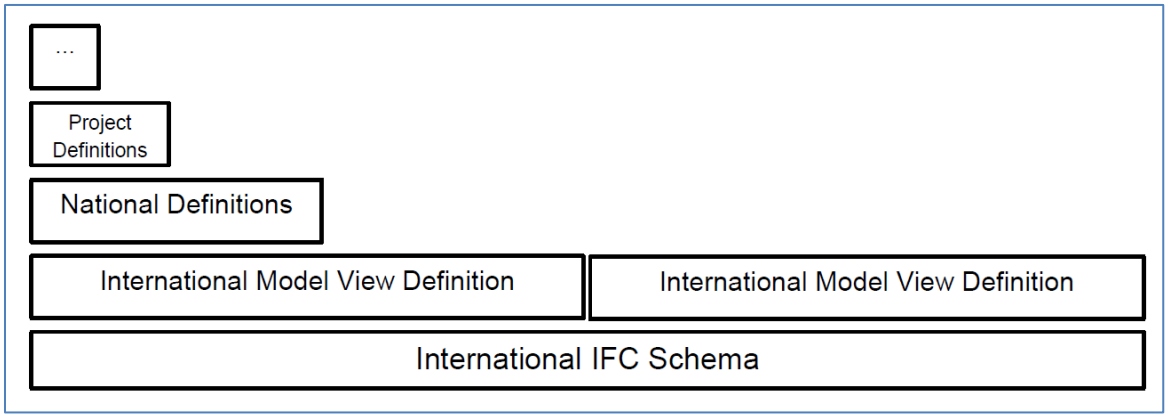

Figure 6 Model View Definitions at different scales[1]

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.

[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.

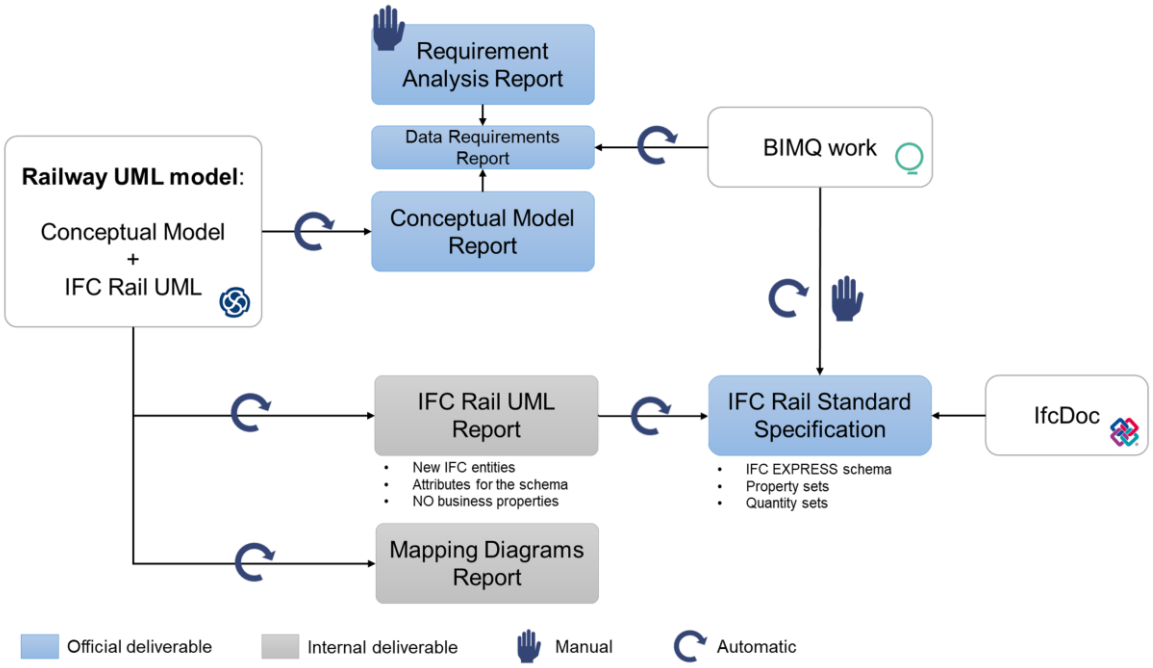

Figure 7 Summary of the tool-chain[3]

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.

[3] This diagram does not contain the process of harmonization with other IFC extension projects in InfraRoom. However, regarding tooling used in harmonization, the process from IFC UML model in Enterprise Architect to IFC Standard Specification in ifcDoc is the same as illustrated in this diagram.

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

7. Financials

7.1 Budget

The original budget for the project was set up and agreed during the Beijing Summit 2018 for 8 Stakeholders. The Cash Budget amounted a total of EUR 2'830'000. Due to the change in the stakeholder composition (DB replaced by RFI, TRV and FTIA sharing one seat) the final project budget was reduced to a total of EUR 2'479'375.-

The budget was divided as below (seeTable 2)

Table 2 The Budget

Final IFC Project Budget	**CRBIM**	**RFI**	**FTA**	**MINnD**	**ÖBB**	**SBB**	**SNCF**	**TRV**	
% per member			**50.0%**					**50.0%**	***Total 2018-19***
Project Management	108'750	108'750	54'375	108'750	108'750	108'750	108'750	54'375	761'250.00
PMO	90'000	90'000	45'000	90'000	90'000	90'000	90'000	45'000	630'000.00
Tech Services	108'750	108'750	57'500	108'750	108'750	108'750	108'750	54'375	764'375.00
Infra Room Admin	11'250	11'250	5'625	11'250	11'250	11'250	11'250	5'625	78'750.00
Travel	22'500	22'500	11'250	22'500	22'500	22'500	22'500	11'250	157'500.00
bsi Mgmt Fee	12'500	12'500	6'250	12'500	12'500	12'500	12'500	6'250	87'500.00
Total cash contr./member	**353'750**	**353'750**	**180'000**	**353'750**	**353'750**	**353'750**	**353'750**	**176'875**	**2'479'375**

Note: As FTIA has agreed to round up to EUR 180'000 we have adjusted the difference of Eur 3'125 to Tech Services.

In addition to that Cash Budget, stakeholders have agreed to assign technical specialists from their organizations as "In-Kind-Contributions". The agreed estimate (budget) for those in-kind contributions totaled 3962 hours at an average cost of 700 EUR/hr, total EUR 2'773'400. So the total project volume added up EUR 5'252'775.

7.2 Actuals

For the operational execution of the project, bSI and PM (applitec) have agreed that PM/PMO runs all payments to third parties with detailed reporting of expenditures to bSI. For that purpose, PMO has set up a separate bank account (Fiduciary Account) where all payments to third parties as well as all reimbursements from bSI were executed. All transactions had been reported in detail to bSI and the balances of the bSI internal reporting and the Fiduciary Account have been reconciled. bSI has reported no issues on the financial reporting of the project or on any payments made.

Execution of the Project:

After Beijing kick-off meeting, organized by CRBIM, Project Management in cooperation with bSI has started preparatory work and finalized the Project Work Plan, Financials and Agreements.

Project Work has started March 2018 after the founding session of the bSI Railway Room at 2018 bSI Spring Summit in Paris.

During the course of the project more than 50 physical workshops and meetings were performed with external Tech Specialists, delegates from stakeholders and PM/PMO. These meetings supported a lot the understanding in between the different cultural and technical background and differences. Today the Team is welded and have a good understanding of each other.

Stakeholders have nominated a total of 68 specialists divided in 5 domains.

The performance of the work was not limited to physical or online meetings, there were also countless individual discussions and work sessions self-organized within the domains and between individuals. It turned out to be impracticable to track in-kind hours.

Another concession to practicability was the reallocation and summarizing of some of the budget items, esp, to Tech Services/Travel away from PM/PMO/Admin.

In summary, the project was executed within the agreed budget. Effective cost management resulted in cash at hand of about 174'000 (7%).

Table 3 Budget vs Actual as per 31.03.2020

	Budget	Actual expensed	committed	contingency	Actual total	% of Budget
PMO/PM/Admin	1'470'000	1'461'819	-	-	1'461'819	99%
Tech Services/Travel	921'875	651'915	79'100	25'000	756'015	82%
bSI Mgmt Fee	87'500	87'500			87'500	100%
Cash at hand		174'041			174'041	
total	2'479'375	2'375'275	79'100	25'000	2'479'375	100%

PM suggests using the available funds to proceed with the preparation work for Phase 2.

8. IFC Rail Phase 2 planning

During the execution of the IFC Rail project it becomes clear that after the delivery of the first and important part - the IFC Rail Candidate Standard - there is still a significant amount of work to be done to build a Final Standard for the railway industry. Based on the results and deliverables of IFC Rail Phase 1, the project Proposal of Phase 2 was written by the Project Management Office and delivered to Steering Committee in December 2019.

The open tasks are mainly the integration and validation of the Candidate Standard into BIM software to become Final Standard. Further Use Cases on the railway domain, the earthworks topic, drainage topic, cabling topic must be extended in the schema and in the Use Cases. This must be solved in a tight cooperation with the output from Infrastructure Common Schema.

9. Contributor List

Consortium	Company	Name
bSI	Aec3	Thomas Liebich, Sergej Muhic
	bSI	Aidan Mercer, Jon Proctor, Léon van Berlo, Richard Kelly, Richard Petrie, Sheila Kerai Lum
	PMO	Christian Erismann, Chi Zhang, Dieter Launer, Fei Wang, Guy Pagnier, Winfried Stix (RWR Chairman)
	RWR Steering Committee	Adrian Wildenauer, Christophe Castaing, Franz Josef Peer, Modestino Ferraro, Patrick Offroy, Pierre Etienne Gautier, Peter Axelsson, Sheng Liming, Suo Ning, Tarmo Savolainen
CRBIM	Engineering Management Center of China RAILWAY	Li Zhiyi, Liu Yanhong, Sheng Liming, Shen Dongsheng, Suo Ning
	China Academy of Railway Sciences Corporation Limited (CARS)	Bao Liu, Chen Xuejiao, Hao Rui, Lu Wenlong, Niu Hongrui, Qian Jin， Wang Huilin, Wang Chao, Wang Wanqi, Xie Yalong, Ye Yangsheng，Zhao Youming, Zhi Peng, Zhou Li, Zhu Jiansheng
	China Railway Design Corporation (CRDC)	Feng Yan, Kong Guoliang, Li Hualiang, Mao Ning, Qi Chunyu, Su Lin, Wang Changjin, Wu Weifan, Xu lingyan, Yang Xukun, Yao Yiming, Zhang Jian, Zhao Feifei
	China Railway First Survey And Design Institute Group Co.,Ltd.(FSDI)	Gong Yansheng, Hao Shuai, Huang Wenxun, Jin Guang, Li Zhibiao, Qiao Jinxin, Ren Xiaochun, Zhang Xin, Zhao Le
	China Railway SiYuan Survey & Design Group Co., Ltd. (CRFSDI)	Dai Sai, Du Guangyu, Feng Guangdong, Li Yifan, Liu Zhengzi, Liu Lihai, Shen Zhiling, Zhong Qing, Zhou Jieyun, Zhu Dan
	China Railway Eryuan Engineering Group Co. Ltd (CREEC)	Dong Fengxiang, Wang Yong, Wang Huaisong, Wang Xuelin, Yang Gang
FTIA	FTIA	Marion Schenkwein, Tarmo Savolainen, Teea Kantojärvi
MINnD	Egis	Christian Grobost, Christophe Castaing, Mourad Boutros, Vincent Keller
	Railenium	Matthieu Perin, Samir Assaf
	Systra	Louis-marie Borione

ÖBB	IQ soft	Andreas Pinzenöhler
	ÖBB	Alexander Wurm, Attila Szabo, Christoph Burkia, Ewald Griesser, Gerhard Weixler, Martin Neulinger, Richard Mair, Thomas Braatz, Thomas Redl
RFI	Engisis	Evandro Alfieri, Xenia Fiorentini
	RFI	Carpinteri Claudio, Colangiulo Giovanni, Cristofori Enrico, Di Giustino Federica. Domenico Fraioli, Giovanni Sorrentino, Guglielmi Giovanni, Lacomelli Alessio, Lannaioli Marco, Laterza Palma Zaira, Massari Filippo, Rambaldi Ivano
SBB	ETHZ	Odilo Schoch
	RPAG	Marc Pingoud, Claude Marschal, Adonis Engler, Simon Freihart, Patrik Meier, Linus Stauffacher
	SBB	Ali Tatar, Basil Apothéloz, Billal Mahoubi, Cédric Bapst, Daniel Kühni, Grit Meyer, Lukas Schweizer, Marcel Liniger, Rainer Mautz, Raimund Helfenberger, Samlidis Miltiadis
SNCF	SNCF	Achraf Dsoul, Alain Jeanmaire, Cedric Gniewek, Edouard Chabanier, Florian Hulin, Franco Tomassoni, Guillaume Chartier, Heidi Castellanos, Judicael Dehotin, Liliane Bas, Romuald Vernex, Sebastien Buchere, Sondes Karoui, Vincent Thuillier, Vincent Mathouraparsad
Trafikverket	Trafikverket	Lars Wikström, Jitka Hotovcova, Peter Axelsson
TUM	TUM	André Borrmann, Sebastian Esser

Note: names and companies are simply listed alphabetically

Annex 1 List of Figures

Annex 2 List of Tables