IFC Rail Project

Storyline (SL) Documentation

BIM2FIELD2BIM (BF) – Maintenance and Operation (MO)

SLBF-MO

Contents

1 Storyline documentation update

1.1 Management Abstract

This document was created in the team of the IFC-Rail subproject BIM2FIELD2BIM.

BIM2FIELD2BIM deals with the specific process of tamping, which is an important activity in the field of railway construction and maintenance.

Tamping is the precise production of a track geometry by high performance and high precision machines. These machines require as input a precise alignment, asset data and pre-tamping measurement data and return a rich set of post-tamping measurement data

The main goal was to evaluate whether IFC 4.3 would be a viable tool for organizing data flows in what turned out to be quite complex tamping processes.

The collaboration of four rail infrastructure managers (FTIA, OEBB, SBB, SNCF), a tamping service provider (STRABAG), a tamping machine software specialist (tmc), and IFC software experts (RDF) suggests that this goal is certainly achievable.

IFC offers a comprehensive vocabulary that can be used to capture almost every aspect of railway infrastructure design and construction.

In projects of this kind, the challenge will be to find the proper mix of a global international standard and a flexible representation of local specifics.

Project outcomes are:

- Completion and extension of the process model for tamping.
- Comprehensive collection of test data.
- A tentative definition of the elements of the two analysed data exchanges.
- A first sample implementation of a core alignment IFC input file.
- A first implementation of an IFC interface on a typical tamping machine with proof that the data can be processed for tamping.

1.2 Details of the work organization

The storyline BIM2FIELD2BIM was proposed by OEBB. It was supported by FTIA, SNCF and SBB. Participating Software Vendors are tmc and RDF. Strabag represents the perspective of a service provider.

The collaboration of the participants was quite intense. More than 40 meeting hours were spent on presentations, discussions and evaluations.

The storyline proposal was prepared by a small OEBB-workgroup.

After that it was discussed and validated by a working group consisting of representatives of FTIA, OEBB, SNCF and SBB.

After reaching an agreement about content and scope potential Software Vendors were approached.

All stakeholders provided raw input data for testcases.

tmc implements an IFC based interface for the tamping machine software based on the specification. RDF provides test data in IFC format.

Categories of meetings:

- Workgroup for stakeholder discussions.
- Software vendor specific meetings.
- Workgroup meetings with all participants.
- Adminstrative meetings (mostly information for PMO).

The number of participants increased during the project.

IFC Rail stakeholders nominated additional experts.

Software vendors involved occasionally management members.

The participation of Strabag added the perspective of service provideds to the project.

1.3 Details and modifications of Storyline related objectives

OEBB's original storyline proposal was heavily influenced by OEBB processes and OEBB strategies. It soon became clear that there were significant differences in the way tamping work was organized in the various stakeholder organizations.

In addition tmc started a discussion for so called tamping obstacles. This was welcomed by all other storyline members.

Considering existing time and budget restrictions only one aspect was added to the original work plan. All the other additional aspects are documented in the backlog section of this report.

Additional work item

1. Experiments with company specific property sets using the buildingSMART service bsDD to support company specific data exchanges

Documentation to be considered as backlog.

1. Individual tamping process

2. Tamping obstacles
3. Total station data as input for tamping

1.4 Generalization of tamping process model

Discussion of the original storyline definition was very lively and enlightening especially on the stakeholder level.

The tamping work for ballast tracks itself is very similar all over the world. But the data used to controll the tamping machines themselves differ in some relevant details. Especially contract data and measurement data depend on local regulations, local organisation and specific contracts.

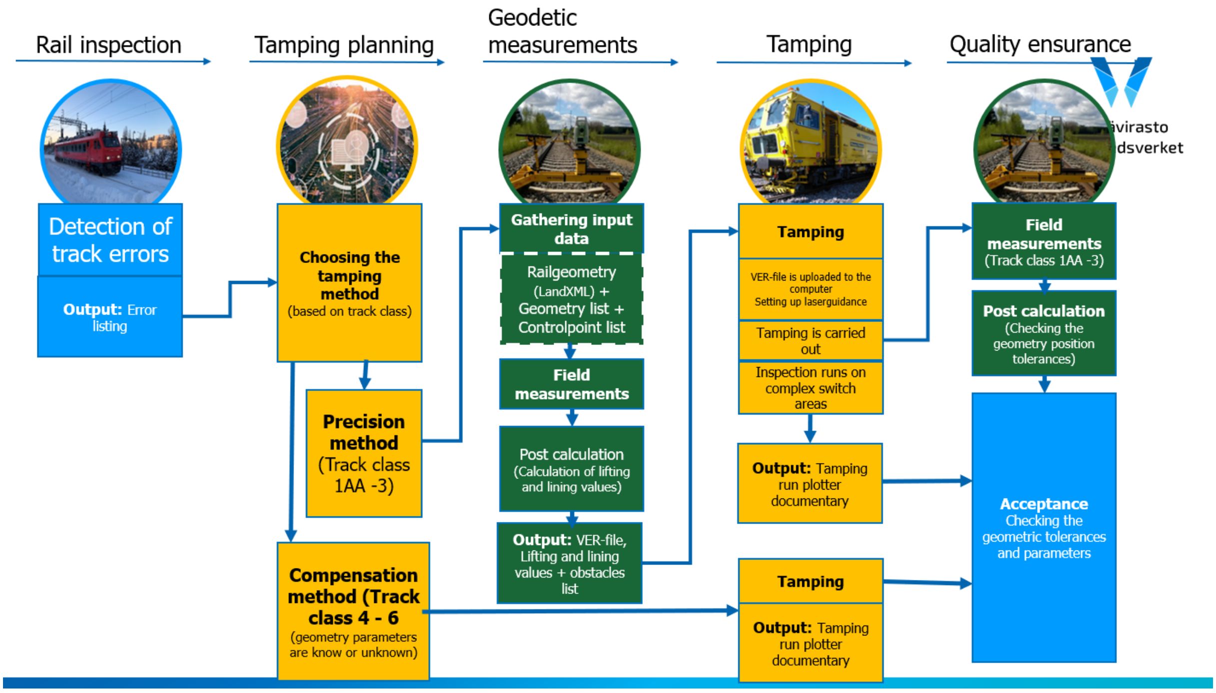
As already mentioned the original storyline definition was based on established processes and the perspective of OEBB. So it was one of the major objectives to generalize the model of tamping process. The Finnish stakeholder FTIA and service provider STRABAG contributed both detailed information on their respective processes. FTIA added the valuable perspective of a surveying data based method. STRABAG added the valuable view of a contractor, who is providing the actual maintenance services and measurement data.

1.4.1 Tamping Process on Finnish Railway Network

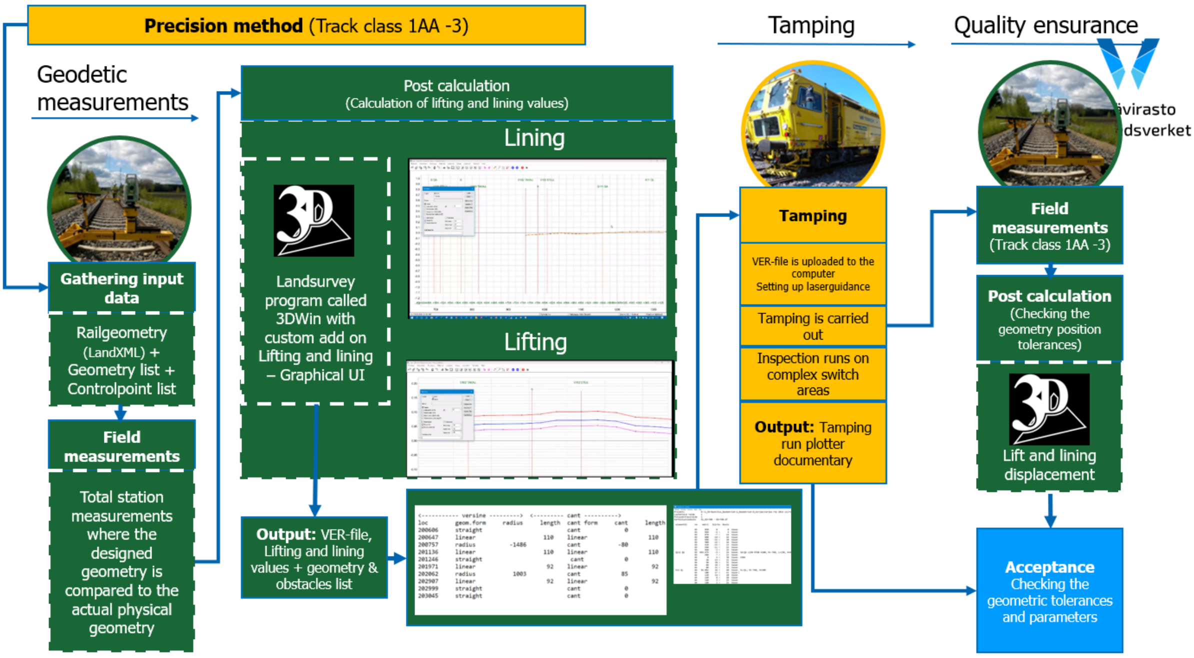
The Finnish Railway Network is hard to maintain with high quality standards as the conditions are challenging. Due to relatively warm summers and cold winters, temperature deviations can be high. The record coldest temperature measured has been -51.5 °C and the highest 37.2 °C. That combined with challenging soil types including swamps and wetlands, building and maintaining railways is nothing but an easy task in Finland. Therefore strict regulations and tolerances must be followed to ensure train safety.

The tamping process on the Finnish railway network is quite simple. After the rail inspection an error listing is given to the maintenance contractor who then plans the actual tamping and chooses the correct tamping method. Precision method is used on track classes from 1AA - 3 and compensation method is used for track classes from 4 - 6. As the compensation method is only based on measuring the relative geometry, the precision method is based on geodetic total station measurements where a total station system is oriented to the reference coordinates system via accurately known control points. The track geometry is then measured using a prism cart or and prism adapter. Also the obstacles are measured to help the tamping machine workers spot them during the tamping run. In the post calculation the lifting and lining values are determined by comparing the designed and measured geometry. Finally a VER-file is uploaded to the tamping machines computer. After the tamping is finished, field measurements are carried out again using the same method as in the precision method and the measurements and the design geometry is compared.

The quality assurance consists of checking tamping machines plotter recordings for relative geometry and the absolute track position (precision method). And as the tamping professionals always say "eyeballing the track after tamping is critical: what looks good probably is good". And the rail inspection is repeated on a regular basis.



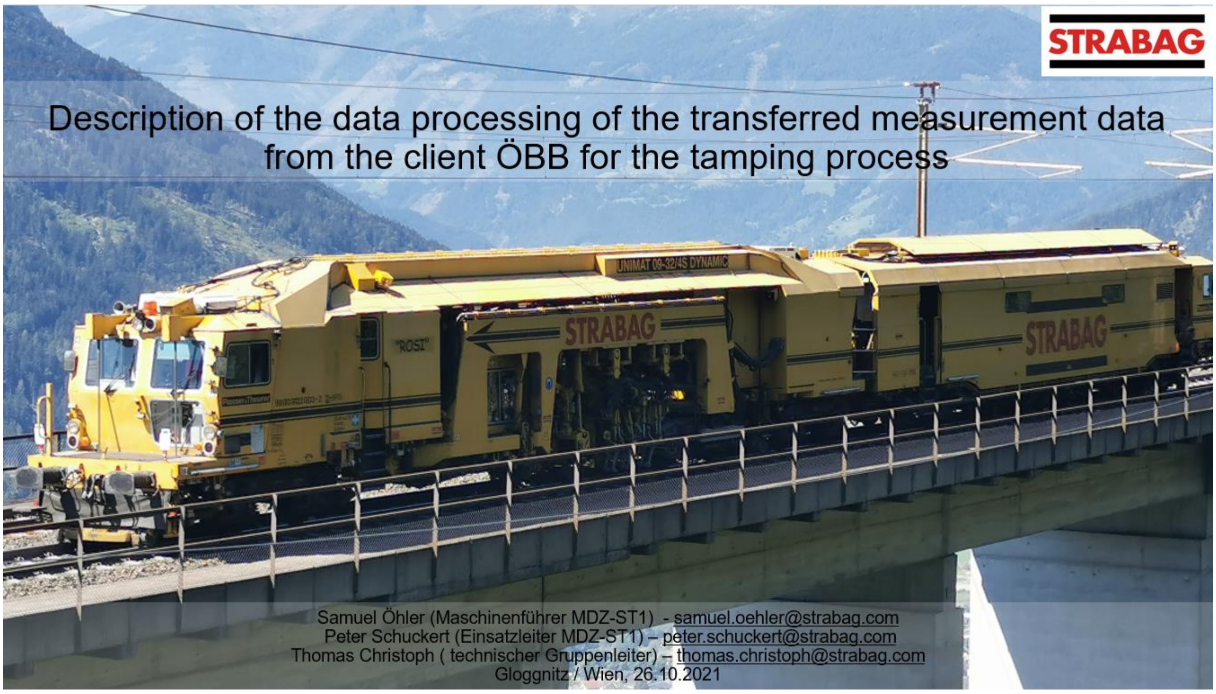
The Finnish case added the „Precision method“. As described above this is an elaborated data collection activity based on surveying. With total station equipment field measurments are taken and compared with the documented design of alignment using specialised software.



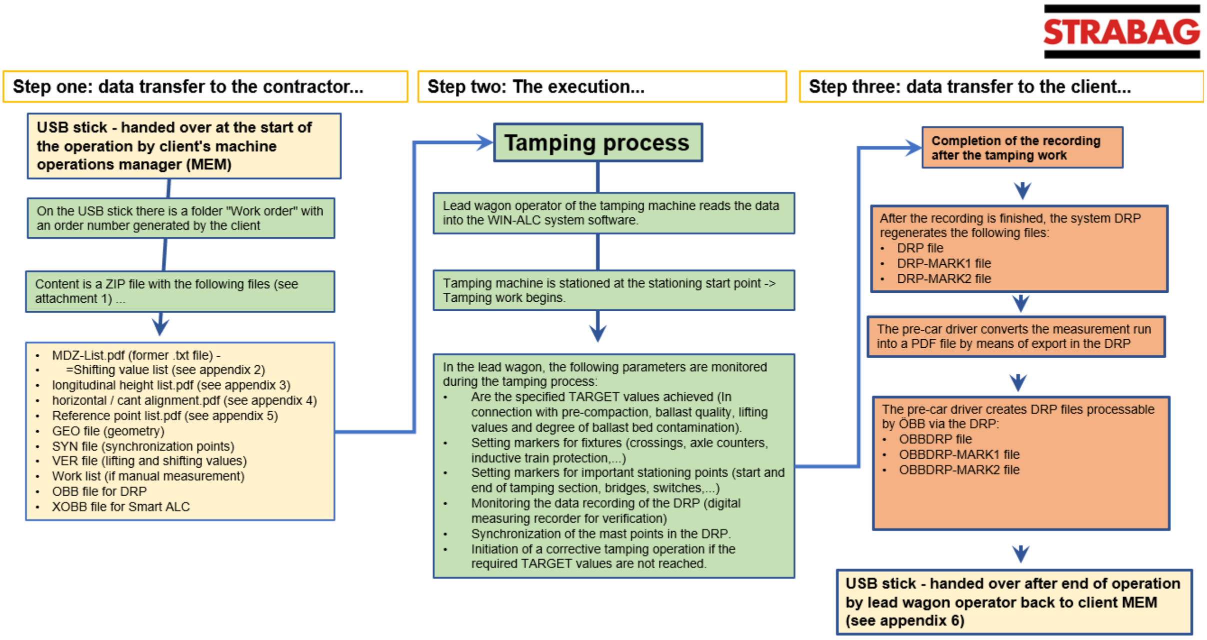
1.4.2 STRABAG - perspective of the contractor

STRABAG is an Austrian construction company with its headquarters in Vienna. As one of the largest companies in Europe it is active on a global scope. The contribution to the BIM2FIELD2BIM storyline was very valuable due to STRABAG's extensive experience in railway construction.

In this chapter one finds a good overview of data flows and data processing on the tamping machine.



The contractor receives input data in up to 10 different files. The STRABAG contribution gives an insight how the input data are used using the automatic guidance system of the tamping machine.



A special subsystem is processing the recorded tamping data into a specific data format. The generated file is an essential deliverable containing order data and postmeasurement data for the client.

1.4.3 Conclusion

Core exchange scenarios

The core exchange scenarios are correctly defined.

Completeness

As the Finnish case shows the extension with surveying data is a potentially interesting exchange scenario. It can be assumed that this will be an interesting usecase with exchange scenarios not only applicable for tamping but also for other railway construction, inspection and maintenance processes. Surveying exchange scenarios should have a high priority in the BIM2FIELD2BIM backlog.

Variations – Flexibility

In the discussion, it became clear quite quickly that the tamping processes are different for all parties involved. The track geometry itself is a good candidate for global standardization, as are the central guiding parameters for the tamping machine such as shifting and lifting the track.

On the other hand, the order data and the post-measurement data are different for each railway infrastructure manager. Here the specification needs to support flexibility.

2 Storyline Synthesis

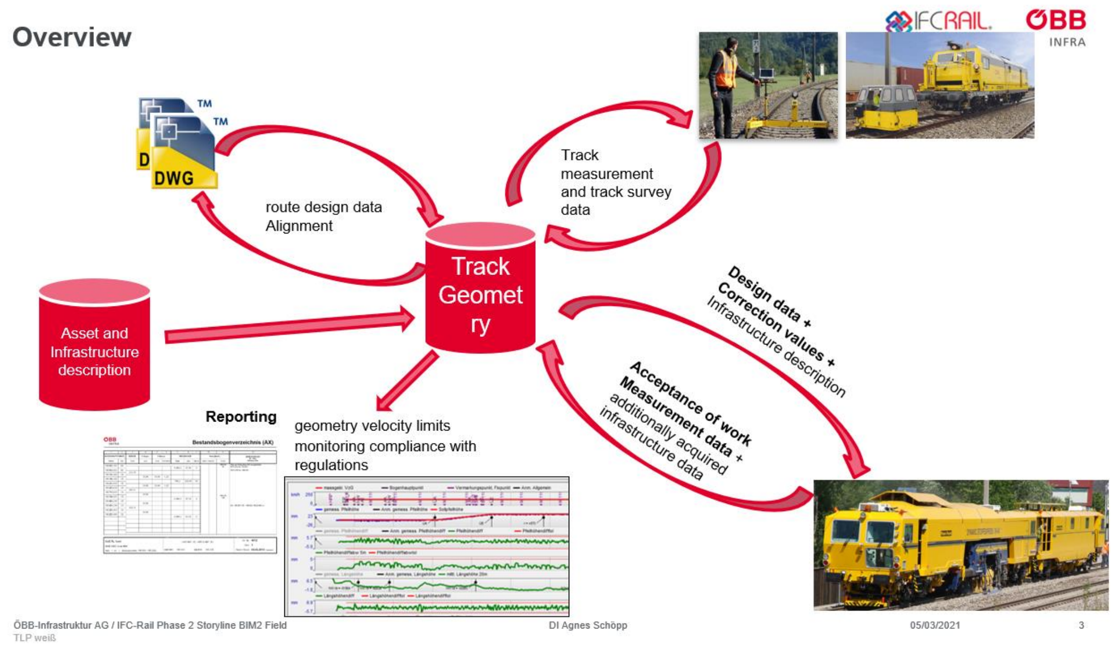
Overview of the Storyline *[the overview and meta- information of the Storyline]*			
Room:	Railway Room	Test Leader:	Agnes Schöpp
Project/Activity:	IFC Rail Phase 2	Leading Stakeholder:	OEBB
Document Title:	Storyline: BIM2FIELDBIM	ID:	SLBF-MO
Version:	0.2	PMO Checker:	Guy Pagnier
Date:	2021.04.12	TS Checker:	Andreas Pinzenöhler
Description[1]	This storyline contains two exchange scenarios between 3D models and tamping machines. Tamping is both a construction (build) and a maintenance activity.		
Project Phases[2]	☐PL - Planning ☐ ID - Intermediate design ☐ DD - Detailed design	☒ Build ☒ Operation & Maintenance ☐ Dismiss	
Use Cases[2]	☐ ECM - Existing Condition Modelling ☐ RDM - Railway Design Modelling ☐RDM.FSR - Feasibility Study for Railway ☐ RDM.RIDM - Railway Intermediate Design Modelling ☐ RDM.RDDM - Railway Detailed Design Modelling ☐ ICM - Interference and Coordination Management ☐ 3DV - 3D Visualization ☐ QTO - Quantity Take-Off ☒ INMP - Handover from Builder to Maintainer (Information Needed for Maintenance Perspective)		
Domains[3]	☒ Track (*)	Ballasted track	
	☐ Signalling (*)		
	☐ Energy (*)		
	☐ Telecom (*)		
	☒ Alignment (*)		
	☒ Other (*)		
Tested Concepts[4]	Cant, alignment, linear placement, linear referencing, broken chainage, track breakdown structure, spatial structure, track elements (rail…),		
Test Leader TL [5]	Agnes Schöpp Agnes.Schoepp@oebb.at		
Domain Experts DE[5]	Marion Schenkwein / FTIA / Marion.Schenkwein@vayla.fi Cédric Simon-Nguyen / SNCF / cedric.simon@reseau.sncf.fr Marc Pingoud / SBB / pim@rpag.ch		
Technical Experts TE[5]	Andreas Pinzenöhler (andreas.pinzenoehler@iqsoft.com)		
Software Vendors SW[5]	**Track machine connected (TMC)**		
Test Dataset[5]	**OEBB, FTIA, SNCF and SBB datasets for track maintenance**		

[1] 2 lines description
[2] choose maximum 1 phase and 4 use cases for a storyline
[3] select involved domains and list subdomains if needed
[4] covered concepts subject to Unit Test
[5] specify names, companies and emails

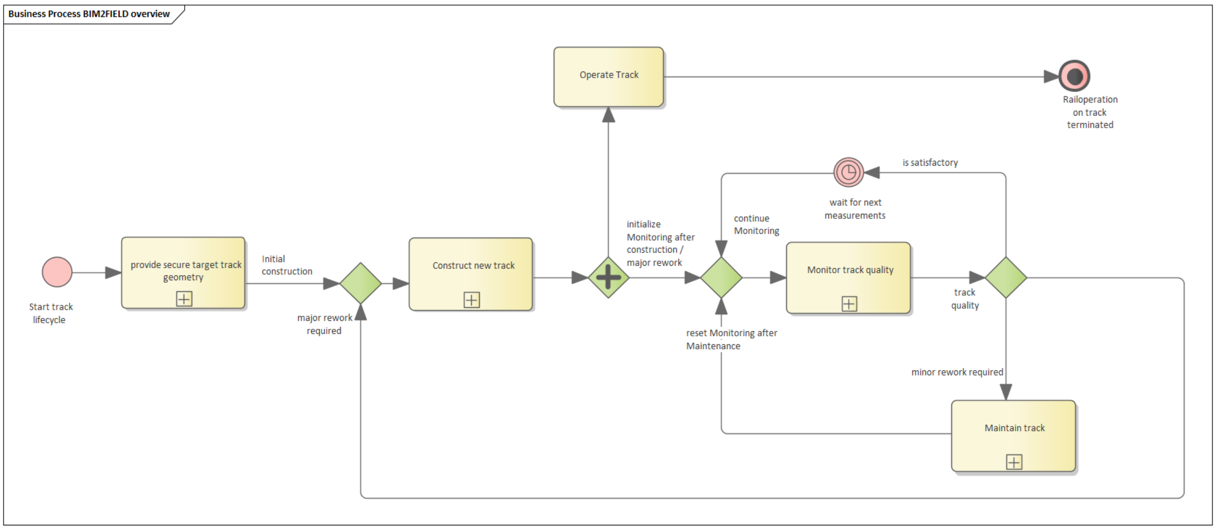
3 Storyline Description

Description and process of the Storyline *[The context, in/out of scope, business process and exchange scenario overview of the Storyline]*	
Description of the Business case	• Correct track position including track geometry is important for safety and riding comfort • Over time track geometry deteriorates → restoration of track geometry for renewal or maintenance • Tamping Machine puts track in right position (lifting and lining of track meanwhile packing the ballast under the sleeper) • Modern tamping machines work with high precision input data for track geometry + reference to superstructure.:
Duration	According IFC-Rail overall timeline.
Aim	The aim of the study is to establish whether the upcoming IFC specification can support an important maintenance process for railway tracks. The assessment is based on two specific exchange scenarios: • Transfer track design data + correction values + infrastructure description + mission data from a future 3D model to the guidance systems of tamping machines. • Transfer measurement data required for acceptance of work processes from the tamping machines and/or supporting measurement devices back to the future 3D model.
In Scope	As built model / initial data model: • existing railway track alignment with cant (semanctic part) • precise locations of alignment segments along the alignment • precise locations for positioning markers (often mounted on catenary poles) + precise lateral and vertical distance values • sufficiently precise locations for track assets (e.g. switches) • sufficiently precise locations for trackside assets + sufficiently precise lateral and vertical distance values Track geometry: • Alignment with cant Trackside assets: • positioning markers and their mount points on asset (in most cases catenary poles) • constraint points (trackside assets to be observed for structure gauge restrictions)
(optionally) in Scope – to be analysed	• Ballast profiles • Tamping obstacles • (geodectic) coordinates • Multiple tracks
Out of Scope	• Full 3D-model rerpresentation for tamping constraint points (bridges, tunnels, platforms, level crossings etc.) • Terrain and soil model
Specific Detailed Process Map for this Storyline	

[Process map that defines realistic exchange scenarios between software applications ; reference to general processes defined in the IFC Rail Requirements analysis report Chapter 2 : IFC Rail Reference Process Map also called High-level Reference Process Map (HLRP)][6]
In this document focus is on existing software interfaces for which an unified IFC-based representation shall be developed. Moreover additional dataelements will be evaluated which will become available in a 3D modeling environment.



3.1 Processmap overview



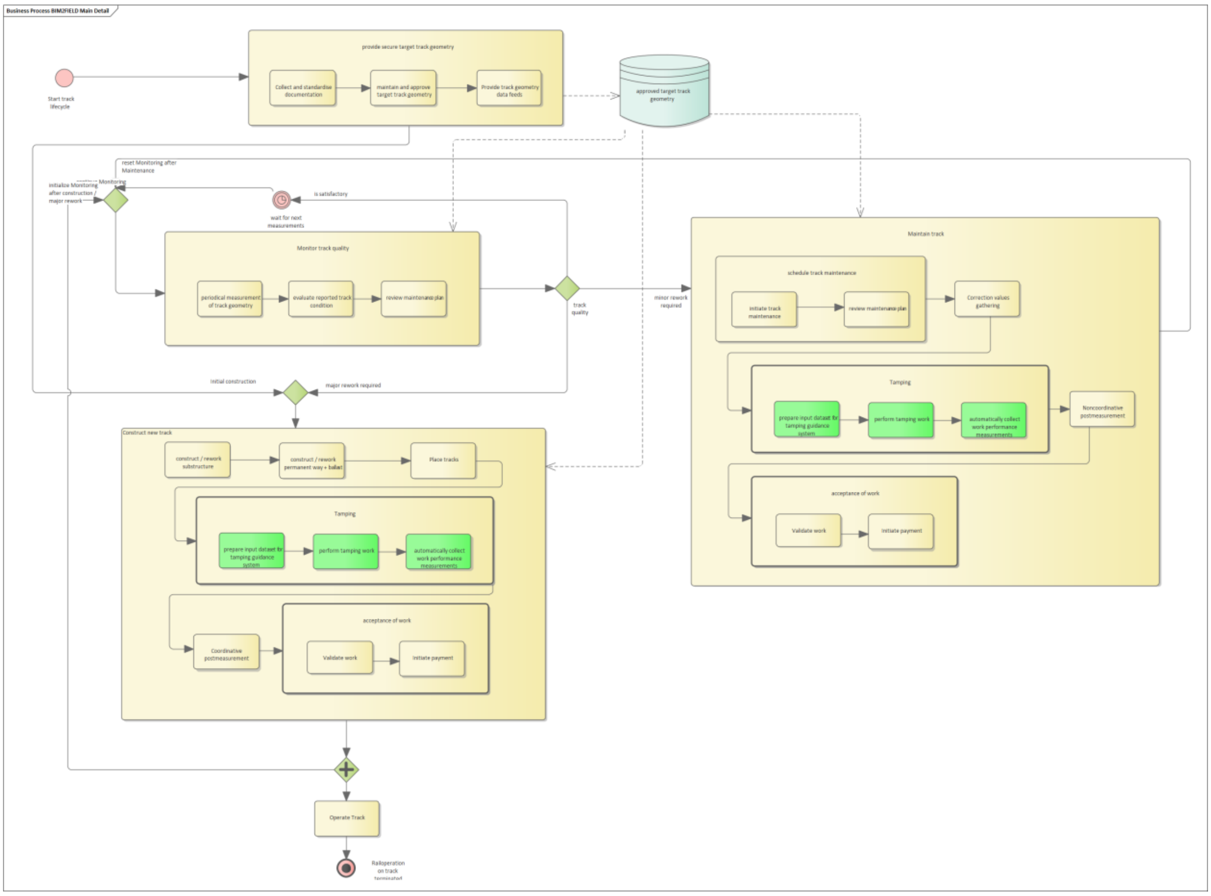
The overview processmap shows the toplevel processes from the track tamping perspective.

[6] The Requirement Analysis Report is available here: https://www.buildingsmart.org/wp-content/uploads/2019/10/RWR-IFC_Rail-Requirement_Analysis_Report_-_.pdf

- Provide secure target track geometry
- Construct new track
- Monitor track quality
- Maintain track
- Operate track

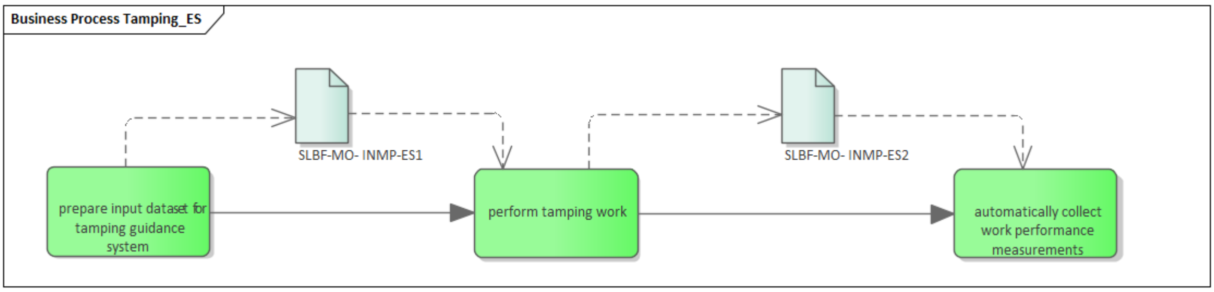
A proven and secure target track geometry is central to all subprocesses. Both in construction and in maintenance phase track geometry has to conform to safety regulations. It is the basis for monitoring track quality and for defining instructions to the tamping machines.

3.2 Processmap detailed



The toplevel processes are expanded to show the most detailled process parts. For all processmap diagrams supplementary documents are provided which allow to inspect the processmap in detail. The green activities show the common core subprocess of the storyline (see chapter “Processmap core).

3.3 Processmap core



Automated tamping work requires precise guidance information to produce a sufficiently conforming real world track geometry. This is the core content of SLBF-MO-INMP-ES1. During tamping and immediately after tamping acceptance of work measurements are taken. The automatic transfer of this work site data into the central processes is the core content of SLBF-MO-INMP-ES2.

Exchange Scenario overview *[The context, in/out of scope, business process and exchange scenario overview of the Storyline]*				
HLRP	**ES ID**	**From**	**To**	**Note** *[optional]*
	SLBF-MO-INMP-ES1	Track geometry data manager	Track laying / tamping equipment + operators	Correction values
	SLBF-MO-INMP-ES2	Track laying / tamping equipment + operators	Track engineer	Acceptance of work mesurements

4 Exchange Scenario (ES)

4.1 Exchange Scenario: SLBF-MO-ABM.MOS-ES1

ID	**SLBF-MO-INMP-ES1**
Exchange Scenario Description *[please describe the ES and define In/Out of Scope topics]*	
Maintenance and operation (MO) to tamping machine For effective and efficient tamping work the guidance systems of tamping machines require a complex set of input data. Note: tamping is also an important activity in construction of new ballast tracks.	
Geometry and positioning requirements *[General description / concepts => specific on Excel sheets]*	
• Alignment: Horizontal alignment, straight line, circular arc, transition bends, vertical alignment, cant alignment, • Linear placement • Position and distance values for objects like catenary poles, platforms, bridges, tunnels, switches. Depending on the usage of this information these values have to be in high precision or in sufficient precision This will test LRS concepts (Linear Referencing System).	
Spatial requirements *[General description of spatial element requirements => specific on Excel sheets]*	
• Railway facility	
Physical and functional requirements *[General description of physical elements, functional elements and important information => specific on Excel sheets]*	
• Line name/ID and number, railway geometry elements (aka alignment segments), track id, design speed • Turnouts/railroad switch • Relevant assets for track geometry correctness • Deviation / correction values to move track geometry from faulty state back to valid state.	
Covered Unit Test *[Covered Unit Test concepts to be filled by Technical Expert(s)]*	
ID	Unit Test

4.2 Exchange Scenario: SLBF-MO-ABM.MOS-ES2

ID	SLBF-MO-INMP-ES2
Exchange Scenario Description *[please describe the ES and define In/Out of Scope topics]*	
Tamping machine to maintenance and operation (MO) Transfer measurement data required for acceptance of work processes from the tamping machines and/or supporting measurement devices back to the future 3D model. Note: tamping is also an important activity in construction of new ballast tracks.	
Geometry and positioning requirements *[General description / concepts => specific on Excel sheets]*	
• Alignment: Horizontal alignment, straight line, circular arc, transition bends, vertical alignment, cant alignment, • Linear placement • Position and distance values for objects like catenary poles, platforms, bridges, tunnels, switches. Depending on the usage of this information these values have to be in high precision or in sufficient precision. This will test LRS concepts (Linear Referencing System).	
Spatial requirements *[General description of spatial element requirements => specific on Excel sheets]*	
• Railway facility	
Physical and functional requirements *[General description of physical elements, functional elements and important information => specific on Excel sheets]*	
• Acceptance of work data related to track geometry segments (alignment segments)	
Covered Unit Test: to be filled by Technical Expert	
ID	Unit Test

4.3 Supplementary Exchange Scenarios

ID	Supplementary Exchange Scenarios
Exchange Scenario Description *[please describe the ES in general]*	
Supplementary exchange scenarios Supplementary exchange scenarios are related to the central exchange scenarios of BIM2FIELD2BIM storyline. Although correct execution is important for a successful process execution, they are listed for better understanding of the storyline only. Moreover they might differ in detail in the specific infrastructure manager organisations.	
Geometry and positioning requirements *[General description / concepts => specification on Excel sheets]*	
Not applicable	
Spatial requirements *[General description of spatial element requirements => specification on Excel sheets]*	
Not applicable	
Physical and functional requirements *[General description of physical elements, functional elements and important information => specification on Excel sheets]*	
Not applicable	
Covered Unit Test *[Covered Unit Test concepts to be filled by Technical Expert(s)]*	
ID	Unit Test

Supplementary exchange Scenario overview
[The context, in/out of scope, business process and exchange scenario overview of the Storyline]

HLRP	Content	From	To	Note *[optional]*
	Target track geometry	Civil engineer	Track geometry data manager	
	Target track geometry + max speed indications	Track geometry data manager	Network data manager	
	Target track geometry	Track geometry data manager	Track measurement equipment + operators	
	Measurement points, correction values	Track measurement equipment + operators	Track geometry data manager	
	Lateral and vertical distances for position markers and constraint points	Track measurement equipment + operators	Track geometry data manager	

Supplementary role overview *[The context, in/out of scope, business process and exchange scenario overview of the Storyline]*	
Rolename	**Note** *[optional]*
Civil engineer	Service supplier tasked with design of a track or a set of tracks for a defined topography
Track geometry data manager	Responsible for regulation conformance and secure and reliable documentation of track geometry.
Track engineer	Responsible for track related planning and engineering tasks
Track measurement equipment + operators	Provides real world measurements of existing tracks or tracks under construction
Track laying / tamping equipment + operators	Operates tamping machines according to design geometry and correction values, collects in process measurement data for acceptance of work checks.
Network data manager	In the context of BIM2FILED2BIM storyline responsible for introduction of track geometry and related data in operational processes (time table construction, simulation, train disposition systems)

5 Supporting Files

5.1 Exchange Requirements (ER)

Test Leader (TL)	The template of **Exchange Requirements** will be **provided** to TL in a digital format (**Excel files**) issued from BIMQ data base.
Test Leader (TL)	The TL will **make sure**, all the adequate ER data are fulfilled by DE for each exchange scenario (ES) as defined in the previous chapter and code with the reference Nbr of the ES (ex. In version 1: SLTI-PL-ECM-ES1 v1.xls).
Domain Expert(s) (DE)	All Exchange Requirements are **ticked** by DE for each column of one Exchange Scenario (in Excel sheet).
Domain Expert(s) (DE)	**If changes** are required (i.e. missing data), please highlight the cell(s) and **inform** TE and TL.
Technical Expert(s) (TE)	TE will **confirm** any new **changes**.
Test Leader (TL)	**When completed**, please issue it formally on BOX.

Files will be exchanged and shared through BOX. If required, access/link are available by PMO to BOX.

5.2 Test Dataset

Test Leader (TL)	TL is responsible to provide Test Dataset (which includes several files) to TE. The dataset should match the Requirements of each Exchange Scenario.
Technical Expert(s) (TE)	TE will be responsible to control quality or revise the package datasets before providing it to Software Vendors (SW).
Software Vendor (SW)	SW will transform dataset to IFC or create IFC based on them.

Note: Please refer to Principle and Guidelines of IFC 4.3, Chapter 3.2 Workflow, Deliverable 4.

Datasets are:

- Structured datasets in open format or proprietary format accepted by Software Vendors,
- 2D drawing file or 3d models,
- Images and other supporting files.

6 Available input and output data

6.1 Input data

Inputdata was available mostly as a textformat, in one case as XML-Format.

6.1.1 OEBB

OEBB provided three pseudonymised dataset. The main file is in XML-format. It is an OEBB enhanced version of the current Plasser Theurer (P+T) exchange format. Support files in Textformat are available too.

6.1.2 FTIA

Trackgeometrie in Sweco Format

Shifting and Lifting Values in P+T ver-Format.

6.1.3 SBB

Trackgeometrie (Toporail Format)

Shifting and Lifting Values as text file.

Example protocol for reporting postmeasurment data.

6.1.4 SNCF

Trackgeometrie and Shifting and Lifting Values in one file (text format).

6.1.5 RDF

RDF (http://rdf.bg/company/) is a Bulgarian-based software company specializing in software libraries for software vendors, especially for 3D applications. With its vast knowledge in the field of 3D and 4D geometrical data it belongs to the early adopters of the IFC 4.3 standard. For the IFC 4.3 standard, RDF also provides basic transformation functions for translating legacy data (e.g., LandXML) into the new IFC format.

In this capacity RDF converted available alignment data into an IFC input file (e.g. UT_AWC_1.ifc).

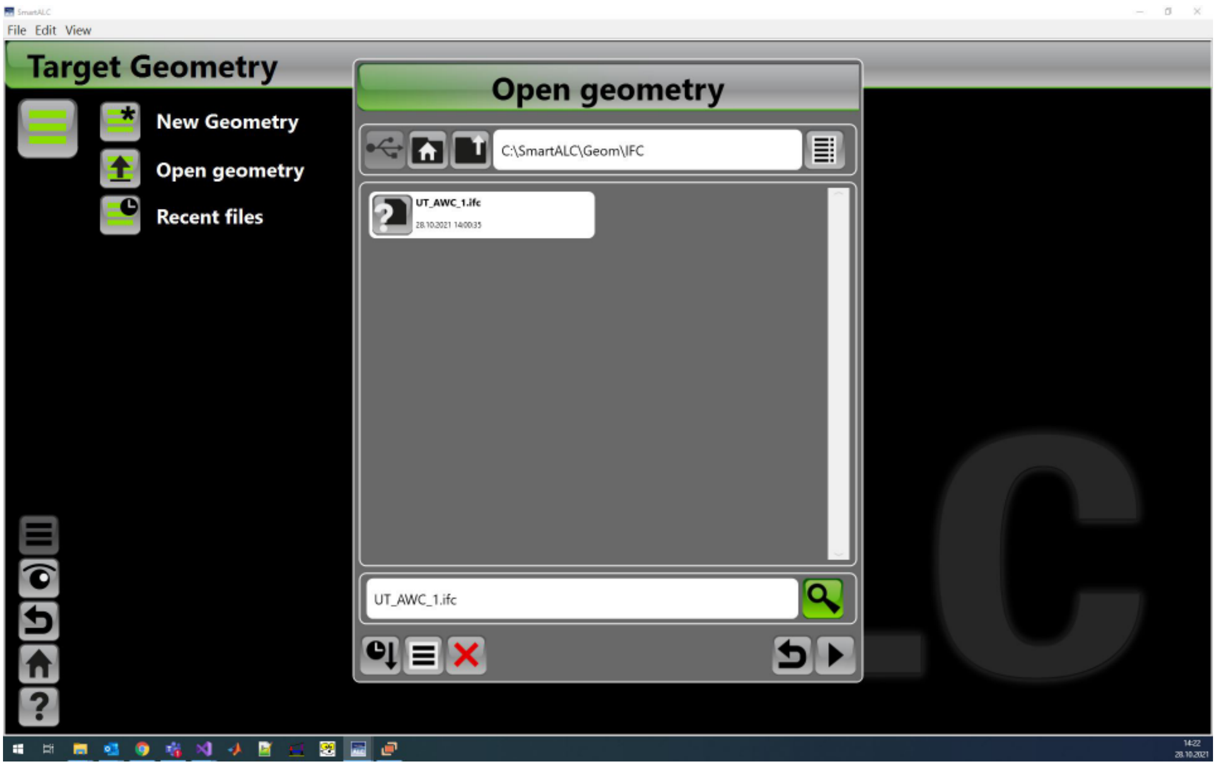
6.2 Output data

6.2.1 "tmc" (Track machines connected)

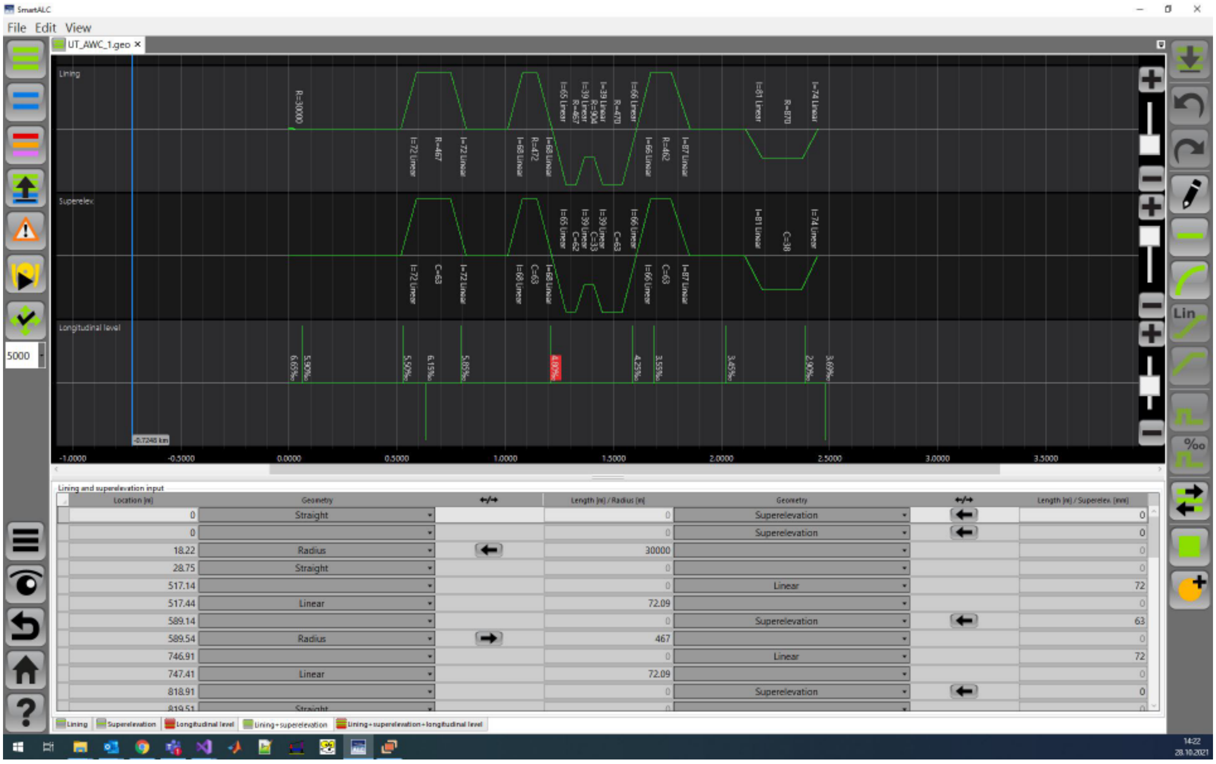
„tmc“ (https://www.tmconnected.com/en/home/) is an Austrian based company which specialises on software for digital track maintenance. Solutions are available for digital systems for track surveying, assistance systems for track machines and systems for track and fleet monitoring.

The most recent version of tmc‘s machine guidance software is known as tmAGC (also known as SmartALC). tmc implemented a completely new interface to read IFC alignment data into their on board system.

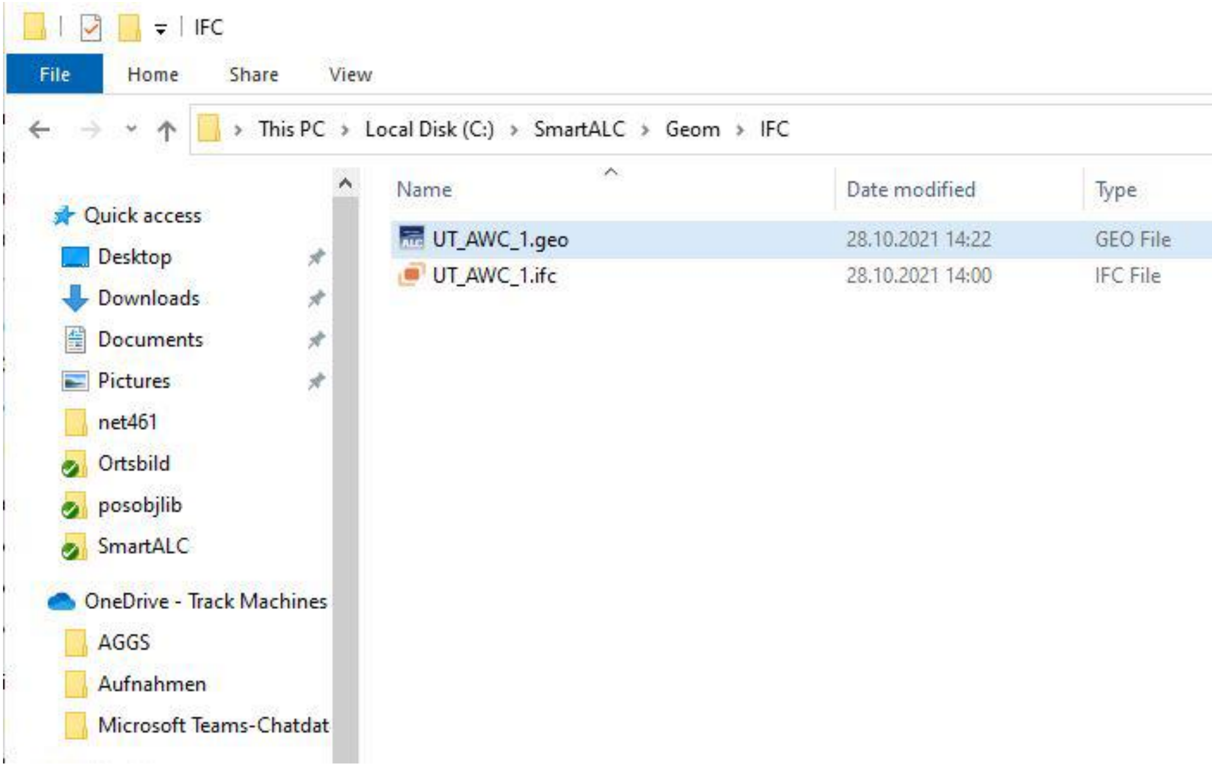
The first screenshots shows the data import dialogue. Target, or also called Design or Nominal Geometry is now supported to be imported as an IFC-conform file, besides other already supported file formats like geo.



The second screenshot shows the visualisation of the imported geometry in tmAGC. Independend of the imported file format, the resulting geometry is completely identical.



The last screenshot shows the corresponding „IFC.geo“ file for for comparison purposes. Not only importing ifc-conform Geometry is now possible but also converting existing geo-files into ifc-files is already working.



Both files are available as addendum to this report.

Besides the closing of the BIM2Field2BIM Storyline, tmc is planning to continue their work on IFC conformity and their intention is to be fully compliant to the exchange scenarios defined. The next step of support in tmAGC is not only the Design Geometry but also actual Measurement data. Additionally to that, also the tmDRP for post-work measurement recording, reporting and acceptance is planned to support ifc-based files for data import aswell as export.

7 Backlog

The analysis addressed many aspects of railway construction and maintenance at a general level. The topics of tamping obstacles and precision tamping were identified as particularly important for the tamping process.

7.1 Tamping obstacles

Operating a tamping machine on site requires good knowledge of some types of rail infrastructure. For example, a level crossing with an asphalt road surface is a double constraint on base tamping.

First of all, it is obvious that in the place of the road surface tamping must be avoided. Otherwise, the road surface would be destroyed and possibly the tamping machine itself would be damaged. Second, track sections near the intersection with the road cannot be raised or moved to the same extent as track sections along the open track.

The same restriction applies to platforms. Here, the safety requirements for passenger boarding and alighting require much tighter tolerances than on the open track.

Here you find a first list of typical tamping obstacles:

- Platform
- Spacers for platform (German: Abstandhalter, Festlegevorrichtung)
- Steps (German: Trittstufe)
- Indusi (magnetic safety device)
- Section with strength of ballast bed (trackbed strength → plate fixed to extremity of the sleeper → lateral shifting not possible)
- Contact for level crossings (detect approaching train, detect leaving train)
- Axle Counter
- Grounding guard plate (electrical earthing; German: Erdungsblech)
- Protective rail, Check rail (turnout and low radius bends) , Guard rail (bridge) (German: Schutzschiene, Fangschiene, Sicherheitsschiene)
- Hot axle box detector (surveillance of rolling stock)
- Wheel flat detection system (surveillance of rolling stock wheel quality; German: Flachstellendetektor)
- Level crossing system (e.g. BODAN)

- Cabels (running between the sleepers)

For a final tamping-specific exchange, it is necessary to know the position of a tamping obstacle. Assuming that modern 3D sensor systems will support tamping machines in the future, the advantage of 3D models of the track and its surroundings becomes obvious.

7.2 Precision Tamping

Chapter 1.4.1 „Tamping Process on Finnish Railway Network“ gives an insight into the methods and techniques used in Finland. Very important is certainly the so-called "precision tamping method" based on a tachymeter. The project schedule did not allow for a more detailed analysis.

The subject is therefore placed on the backlog. It is recommended that other typical coordinate-based measurement methods for rail infrastructure construction, inspection, and maintenance activities should be considered in a subsequent analysis.