IFC Rail Project

Storyline (SL) Implementation Report (IR)

Urban Railway infra-system integration (UR) – MINnD

Detailed Design Phase (DD)

Modélisation des INformations INteropérables pour les INfrastructures Durables

SL-IR-UR-DD-MINnD

Contents

Room:	Railway Room	**Date:**	2022.03.11
Project/Activity:	IFC Rail Phase 2	**Test Leader:**	Vincent KELLER
Document Title:	WP1: Storyline (SL) Implementation Report	**ID:**	SL-IR-UR-DD-MINnD
Version:	0.0	**Stakeholder:**	MINnD

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1 Storyline documentation update

MINnD's stakeholders from Egis, Systra, Colas Rail, Bouygues TP and Setec jointly participated in the storyline with the technical support of Railenium.

The organization adopted allowed the group to achieve the objectives even if it was not possible to organize physical meetings.

The work was divided in 3 phases :

1- **Storyline definition** where specialists from urban railway design (track, energy, bridge, utilities, road, interface management, design supervision) were involved in order to focus on high valuable exchange scenarios for business needs.

2- **Storyline test** where a core team of specialists from urban railway design, technical experts from the TS and software vendors were involved in order to define the storyline test plan, to provide the data sets, to organize the tests with the software vendors, to carry out the tests and to check the results of the tests. During this phase, several meetings with the specialists from urban railway design were organized in order to present the progress and fix the priorities and the preferred options in case of choice to be made.

3- **Storyline reviews** where the initial specialists from urban railway design and technical experts from the TS reviewed the results.

The Stakeholder Team scheduled regular meetings to update everyone on the progress of the MINnD and SNCF Storylines and also of the other storylines.

The Test Leader organized also periodic meetings with all Software Vendors and the Stakeholder Team technical experts to give instructions on the test execution plan, to share the updates on test progress and verification/validation process and to answer all possible Software Vendors clarifications requests.

The Software Vendors also had the opportunity to ask for dedicated meetings in case of any doubts.

The storyline testing plan was organized in 2 different milestones regarding the **2 selected exchange scenarios** (spatial structure and cabling) and each milestone consisted of several steps, where domain models were produced, exchanged and validated.

The exchange of the produced models, for the validation process, was done through the GitHub repository

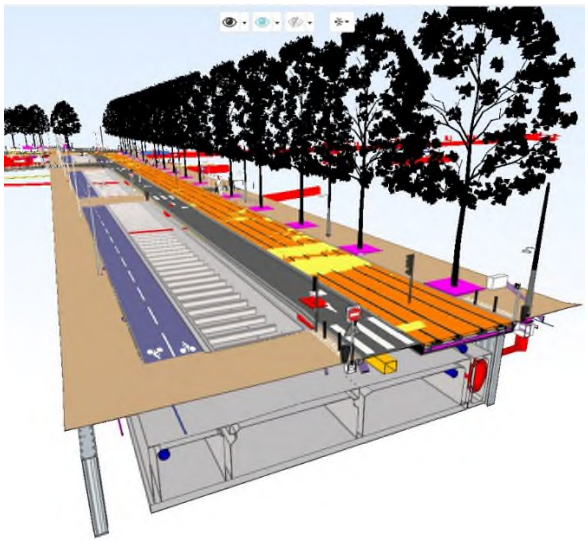
1.1 Updated Storyline Synthesis

Room:	**Railway Room**	Author: Domain Expert	**Vincent Keller**
Project/Activity:	**IFC Rail Phase 2**	Verification: Technical Expert	**Matthieu Périn** **Sylvain Marie**
Document Title:	**Storyline**	Approbation: Test leader	**Vincent Keller**
Version:	**1.2**	PMO checker:	**Guy Pagnier**
Date:	**2021.02.25**	ID:	**URSL**
Description (a)	**This operation concerns the design of an urban railway.** MINnD (composed by 60 French stakeholders like owner, contractors and engineering companies) is interested by delivering multidisciplinary projects (railway, metro, light rail transit) with a high quality interface management, a smooth collaboration between disciplines based on an **open CDE**. MINnD expects that authoring tools, analysis tools and open BIM platform/viewers support the common and multidisciplinary concepts of IFC 4.3 in order **to manage interfaces and to coordinate the design**, in a reference spatial structure (by projects), thanks to automated checks and automated generation of 3D and 2D quoted views, compliant with the usual practices the business.		
Project Phases (b)	☐ PL - Planning ☒ ID - Intermediate design ☒ DD - Detailed design	☐ Build ☐ Operation & Maintenance ☐ Dismiss	
	The storyline aim to verify the capacity of IFC to coordinate a multidisciplinary (detailed) design through an interface management process and the assembly of several multidisciplinary IFC models in a viewer or in an authoring tool. The spatial structure has been defined at the intermediate design phase.		
Use Cases (b)	☒ 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 ☒ 2DV - 2D Visualization ☐ QTO - Quantity Take-Off ☐ INMP - Handover from Builder to Maintainer (Information Needed for Maintenance Perspective)		
Domains	☒ Track (*)	Planned : Spatial structure with geometry, Alignment, trackbed, rail Actual : Spatial structure with geometry, Alignment	
	☒ Signaling (*)	Planned : Spatial structure with geometry, Cable, Cable Multiduct, Chamber, Signs, Technical room Actual : Spatial structure with geometry, Multiduct, Chamber, Sign	
	☒ Energy (*)	Planned : Spatial structure with geometry, Cable, Cable Multiduct, Chamber, Pole, Technical room, Pole founding Actual : Spatial structure with geometry, Cable, Cable Multiduct, Chamber, Technical room	
	☒ Telecom (*)	Planned : Spatial structure with geometry, Cable, Cable Multiduct, Chamber, Signs, Technical room	

		Actual : Spatial structure with geometry, Multiduct, Chamber, Sign
	☒ Alignment (*)	Planned : Horizontal and vertical, parabolic vertical profile Actual : Horizontal and vertical, parabolic vertical profile
	☒ Other (*)	Road > Planned : Spatial structure with geometry ; Actual : Spatial structure with geometry Bridge > Planned : ; Actual : Spatial structure with geometry Drainage > Planned : Spatial structure ; Actual : out of scope Utilities > Planned : Spatial structure with geometry, Cable, Cable multiduct ; Actual : Spatial structure with geometry, Cable, Cable multiduct
Tested Concepts (d)	**Common Infra Unit Test topics** ☒ Geo-reference ☒ Alignment (Horizontal+Vertical) ☒ Linear Placement (Point) ☒ Linear Span Placement (From-To) ☒ Linear Placement with broken chainage ☒ Terrain ☐ Geotechnics ☒ Bridge ☒ Utilities ☒ Drainage ☐ Earthworks ☐ Subgrade **Railway Specific Unit Test topics** ☐ Cant Alignment ☐ Linear Placement with Cant ☒ Swept Area Solid Geometry (with constant section, with variable section) ☒ Railway Spatial Structure and Spatial Zone ☒ System functional breakdown ☐ Wireless connection ☒ Track elements (a panel or very small section of track) ☒ Signal elements ☐ Overhead Contact Line elements ☒ Telecom elements ☒ Energy elements **Existing concepts but essential for the storyline** ☒ System ☐ System of systems ☒ Assembly of assemblies **Others :** ☒ Interference relationships ☒ Gauge	

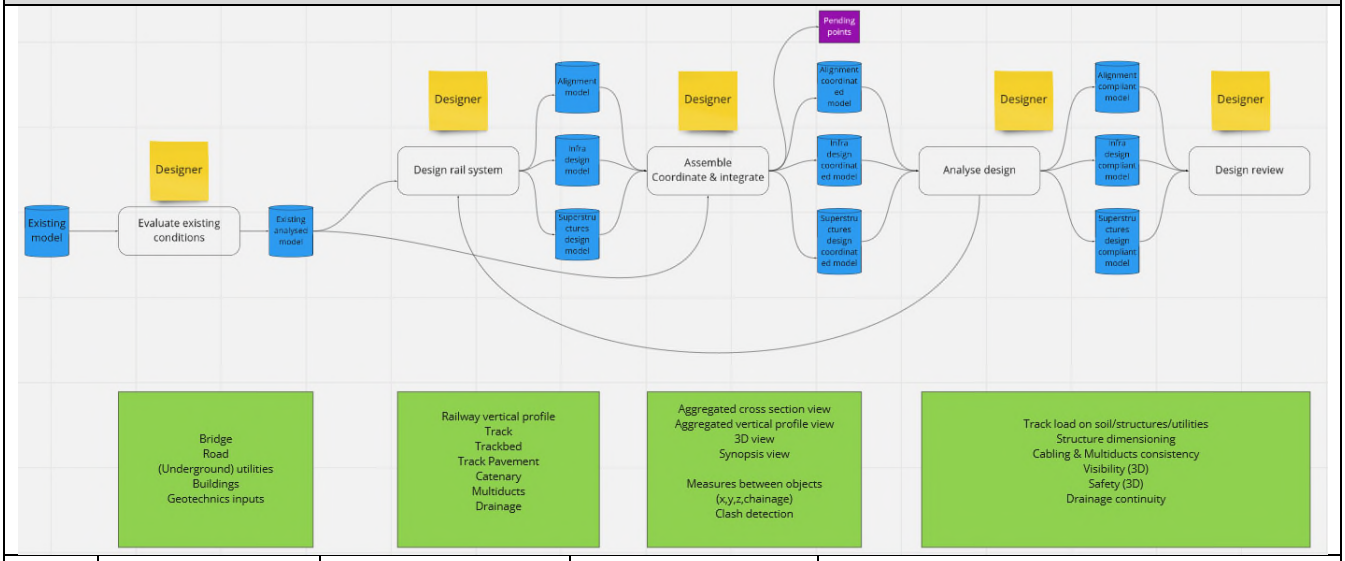
Test Leader TL (e)	Vincent KELLER vincent.keller@egis.fr
Domain Experts DE (e)	SYSTRA - Lise NELSON – Track, Bridge, Road SYSTRA - Eric PRUVOST - CSSE COLAS RAIL - Erik GARDON – CSSE, Energy COLAS RAIL - Grégory OKONSKI, Mikael AUGROS – Energy COLAS RAIL - Pascal WALET – Telecom COLAS RAIL - Thomas De GUIBERT - Track EGIS - Vincent KELLER – CSSE, Track, Utilities (Energy, Telecom, Signalling), Road EGIS - Mohammad KASSIR – CSSE, Track, Utilities (Energy, Telecom, Signalling), Road
Technical Experts TE (e)	RAILENIUM - Matthieu PERIN RAILENIUM - Sylvain MARIE
Software Vendors SW (e)	GEODESIAL – Olivier BERRIER ACCA software - Michelangelo CIANCIULLI CSTB (EveBIM) – Guillaume PICINBONO RDF – Peter BONSMA
Test Dataset (e)	MINnD (Egis)

1.2 Updated Storyline Description

Description of the Business case	A new urban railway design : vertical profile, trackbed dimensioning & sequencing, pole positioning & dimensioning, level crossing management, impact on buildings, impact on existing bridges/walls, impact on existing utilities, consistency between cabling schema and ducts network architecture, physical & electrical gauge issues, electrical impact on structures …
Duration	Around 6/12 months for a complete design / 10 km
Aim	The aim of the study is to design : • The vertical profile of the track and the pavement • The definition of the constraints from the existing conditions • The sequencing of the trackbed types • The positioning of the poles for catenary and signs • The design of the renewal/modification of several bridge components (sealing, pavement, superstructure, transition slab, earthworks, …) • Walkway positioning (longitudinal, level crossings) • The dimensioning of pole founding • Terminals & cabinet positioning • Cabling definition • Cable ducts dimensioning & architecture • Drainage design The aim of the study is also to make analysis like : • Consistency verification between design of the sub-system (positioning, loads, distances, connections • Structural analysis for bridge/walls/utilities • Visibility verifications • Rolling stock speed verification • Vibration/acoustic analysis for building • Vibration analysis for walls / bridges • Physical and electrical gauge verification • Analysis of electrical impact on structures • Security verifications 

In Scope	• Existing conditions • Track/Trackbed • Level crossing • Gauge • Cabling (energy, telecom, signaling) • Utilities (energy, telecom, signaling) • Bridge • Road
Out of Scope	• Catenary • Pole founding • Renewal/modification of several bridge components (sealing, pavement, superstructure, transition slab, earthworks, …) • Drainage design • Geotechnics • Rolling stock speed verification • Vibration/acoustic analysis for building • Vibration analysis for walls / bridges • Physical and electrical gauge verification • Analysis of electrical impact on structures Security verifications

Specific Detailed Process Map for this Storyline

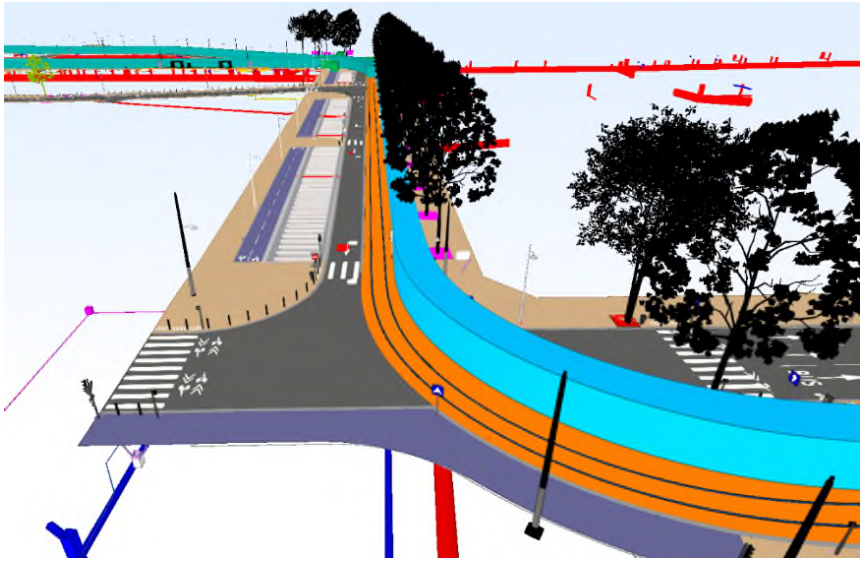


HLRP	ES nbr	From	To	Note [optional]
	URSL-DD-ECM-ES1	Surveyor	Designer (all)	Existing model
	URSL-DD-ECM-ES2	Designer (geotechnics, bridge, utilities, hydraulic, buildings, …)	Designer (all)	Existing analysed model
	URSL-DD-ICM-ES3	Alignment designer Infra designer / dimensioning & positioning (structure, trackbed, leveling, drainage, multiducts) Systems designer dimensioning & positioning (catenary, signaling)	Designer (integrator)	Alignment model (vertical profile) Infra design model Supertructure design model
	URSL-DD-ICM-ES4	Designer (integrator)	Designer (assembly simulations/analysis)	Alignment coordinated model (vertical profile) Infra design coordinated model Supertructure design coordinated model
	URSL-DD-3DV-ES5	Designer (PMO)	Owner/stakeholders	Alignment compliant model (vertical profile) Infra design compliant model Supertructure design compliant model

2 Exchange Scenario (ES) and Tests

2.1 Selection of exchange scenarios

The MINnD's storyline has developed 8 exchange scenarios.



The storyline test plan focuses on **2 of those exchange scenarios**.

#	Exchange scenario	Description
1	**Common spatial structure for interface management**	Common spatial structure definition Based on the following exchange scenario defined in the storyline : Design interference management on an (existing) bridge/structure **(Analyzed existing conditions URSL-DD-ECM-ES2c & Design model URSL-ICM-ES3c)**
2	**Cabling**	Design analysis - Cabling & multi-duct / cable-carrier design consistency Based on the following exchange scenario defined in the storyline : Design analysis – Cabling & multi-duct / cable carrier design consistency **(Design model URSL-DD-ICM-ES3f)**

The exchange scenarios are based on data sets extracted from a real project data set : tramway line (about 400 meters long).

2.2 Testing goals

Each exchange scenario tends to demonstrate the capacity of the IFC 4.3 schema (and the bsDD) to support the exchange of information that are necessary to manage interface issues between multiple disciplines and the best practices to do it.

Two business principles are crucial to be managed in BIM projects in accordance with the ISO 19650 part 1 & part 2 :

1- each discipline is supposed to generate, share and deliver its own IFC models as outputs of its own contract

2- each discipline is also supposed to be able to import and assemble IFC models coming from other stakeholders / disciplines and to use the information they include.

That means that :

1- authoring tools should be able to read information included in IFC file generated by other authoring tools, that are needed to play each exchange scenario

2- viewing tools should be able to generate views of assembly of multidisciplinary IFC files, that are relevant for the business needs, especially for interface management.

The tools addressed are :

- Authoring tools for Railways
- Authoring tools for Road
- Authoring tools for Bridges
- Authoring tools for utilities
- Authoring tools for cabling
- Viewers for infrastructure projects
- Analysis tools for interface management

Those goals can be detailed for each exchange scenario as following.

2.3 Exchange Scenario: Common spatial structure for interface management

2.3.1 Exchange scenario description

Id	**Common spatial structure for interface management** based on : Design Interference management on an existing bridge/structure

Exchange Scenario Description

[please describe the ES and define In/Out of Scope topics]

Scenario: Design Interference management on an existing bridge/structure. Cases where it is not necessary to create a new bride/structure.
Purpose: Verify the compatibility of the tramway transport system (trackform including drainage, cable ducts structure) with the existing structure; OHL poles treated separately.
Phase: Detailed design;
Available data from previous phases:

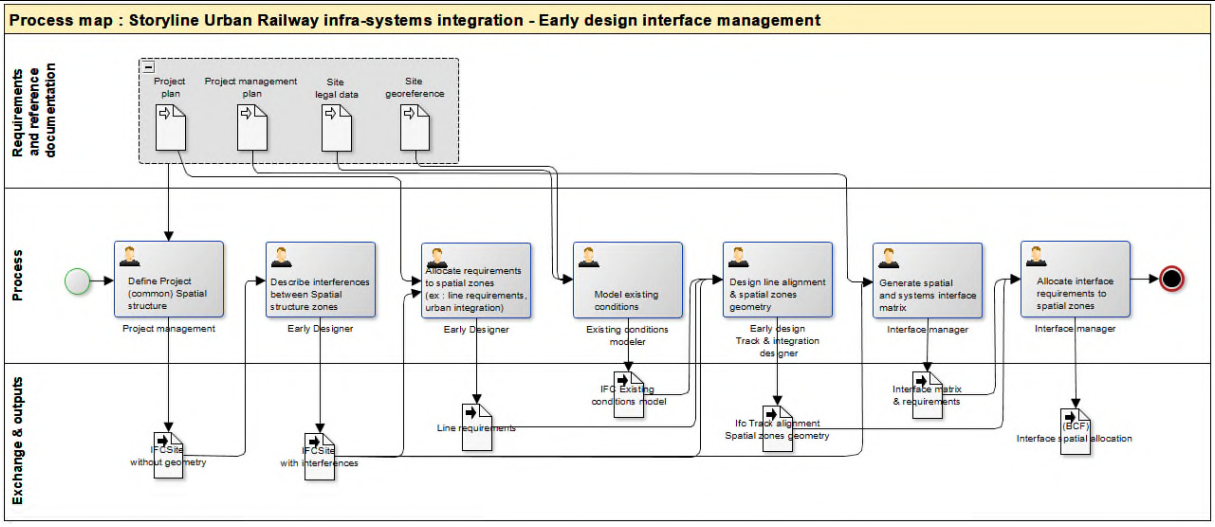
- Horizontal alignment of the track;
- Vertical alignment of the track;
- Pre-dimensioning of the trackbed (thickness);
- Pre-dimensioning of the cable-duct structure;
- Principle of cable-duct routing on the existing structure: on, under or inside the deck;
- Principle of the trackbed's drainage on the existing structure (including evacuations).

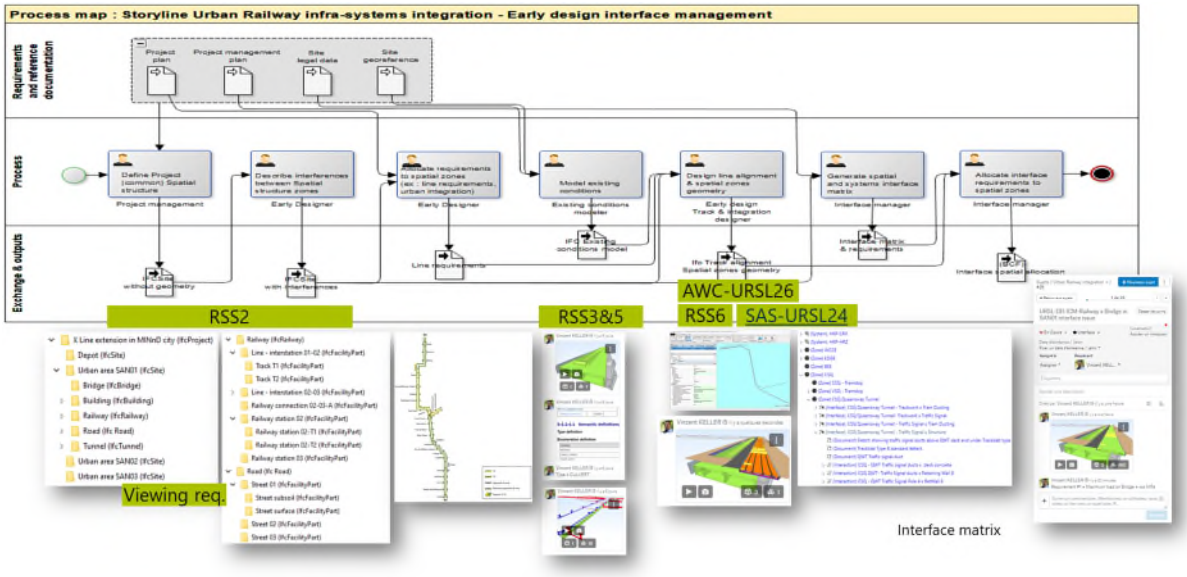
Given I am a **track engineer**. I need as input:

- 3D Model of the existing or reinforced structure (including waterproofing layer and eventual waterproofing protection);
- 3D Model of the transition slabs (existing or to be created);
- The maximum permissible trackbed thickness on the structure (related to load capacity of the existing or reinforced structure) or validation from civil engineer of the Pre-dimensioning of the tramway transport system from previous phases;
- The necessity to implement rail-dilatation devices;
- The positioning of the structural joint.

I want to:

- Verify the possibility to implement rail dilatation devices on the track;
- Optimize the vertical profile of the track regarding the positioning of the extrados of the structure and the trackbed thickness;
- Optimize the trackbed thickness on the structure taking into account the waterproofing layer and eventual waterproofing protection (for construction realization);
- Implant the cable-duct structure on the structure and study into detail the crossing of the bridge bearings (case of crossing inside or under the deck);
- Implant the track's drainage devices (track-collector and drainage system through the structure);
- Study into detail the interface between the structural joint and the rail (joint interruption, drainage, coatings);
- Implant the rail supports (sleepers, …) depending on the bias of the joints of the structures;
- Send the 3D Model of the tramway transport system for checking of the load descent and bearing capacity of the structure, interfaces relating to the equipment of structures (joints, waterproofing, waterproofing's drainage, ...).





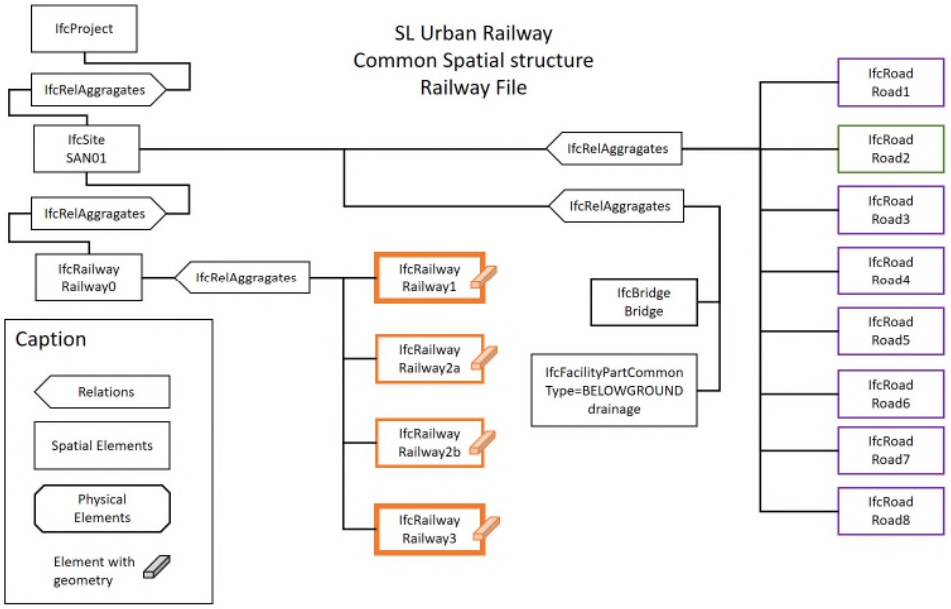
Geometry and positioning requirements *[General description / concepts => specific on Excel sheets]*
Bridge, trackbed, track pavement : Generate objects by using an alignment and typical (variable) cross sections that can be stored in IFC as “solids along an alignment” (and not as BREP) and that can be regenerated in an another tools by using IFC (without using BREP).
Spatial requirements *[General description of spatial element requirements => specific on Excel sheets]*
Bridge Facility part Trackbed facility part Pavement facility part (road) Utility facility part (multiduct) Drainage facility part
Physical and functional requirements *[General description of physical elements, functional elements and important information => specific on Excel sheets]*
Bridge Trackbed Pavement (road) Utilities (multiduct) Drainage system

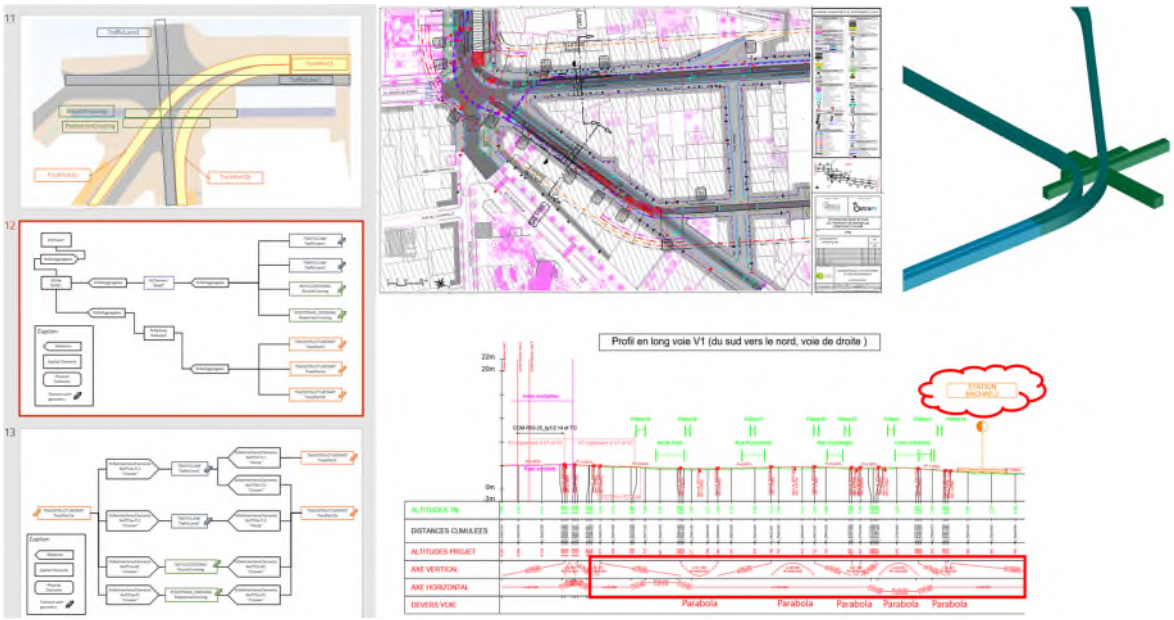
Covered Unit Test: to be filled by Technical Expert	
ID	Unit Test
RSS2	This Unit Test intends to test the capablity to have a project based on a existing ifcSite that contains an IfcRailway spatial structure. These Railway structures is then veiw with another ifc file that is containing surrounding Roads & Tunnels.
RSS3	This Unit Test intends to test the addition of IFcRail Spatial structure with geometry to an existing BIM project that contains IfcProducts (Duct and drainage items) in order to check clearance.
RSS5	This Unit Test intends to test the interaction between a fine grade spatial structure (IfcFacilityPart / TrackPart) and interference spatial zone (with IfcRoad)
RSS6	Generate spatial zones with SAS along an alignment
SAS-URSL24	Generate spatial zones by using an alignment and typical (variable) cross sections that can be stored in IFC as “solids along an alignment” (and not as BREP) and that can be regenerated in an another tools by using IFC (without using BREP). Object classes : all the object types included in cross section view (bridge, trackbed (layers), pavement, …), gauge, geotechnical layer/excavation/cut/fill/trench, cabling, cabling infra/superstructure.
PCC1	This Unit Test intends to experiment the use of IFC to represent the topology of the **multiduct system** in order to complete the piping system description.
PCC-URSL19	This Unit Test intends to experiment the use of IFC to represent the topology of the **drainage system** in order to complete the piping system description.
2DV-URSL22	Ability to generate a cross section view wherever we need (by using a mileage value along an alignment), with usual quotation for the business / discipline.
2DV-URSL22a	From a 2D view, click on an object and obtain all geometrical and technical relevant information (including axis/alignment)
3DV-URSL22b	From a 3D view, click on an object and obtain all geometrical and technical relevant information (including axis/alignment)

2.3.2 Testing goals

Testing goals	Tools
101- Generate a view of the common spatial structure breakdown of the project by extracting information from several assembled IFC files and not only the spatial structure of each IFC file.	101- authoring, analysis or viewing tools (spatial structure breakdown view)
102- Attach geometry to facility parts.	102- authoring, analysis or viewing tools (spatial structure breakdown view)
103- Visualize and use a geometry associated to each spatial zone/facility part in 1D (synopsis), 2D (reservation on plan view or cross sections) and 3D (reservation).	103- authoring, analysis or viewing tools (including GIS)
104- Generate shapes for facility parts based on a linear element (using an alignment) and sectioned swept area solids.	104- authoring tools
105- Allocate spatial information to facility parts, like interference between them.	105- authoring tools or dedicated tools
106- Allocate requirements to facility parts by using their unique ID in the IFC file.	106- authoring tools or requirement management tools

107- Check clashes (geometry and requirements) between facility parts shapes and other objects. 108- Generate & position punctual objects relatively to a linear spatial element. 109- Generate a "project" IFC file including the complete common spatial structure and use it to implement new authoring models.	107- analysis tools 108- authoring tools 109- authoring tools





2.3.3 Test plan

The storyline test plan refers to some dedicated unit tests that are documented in Github :

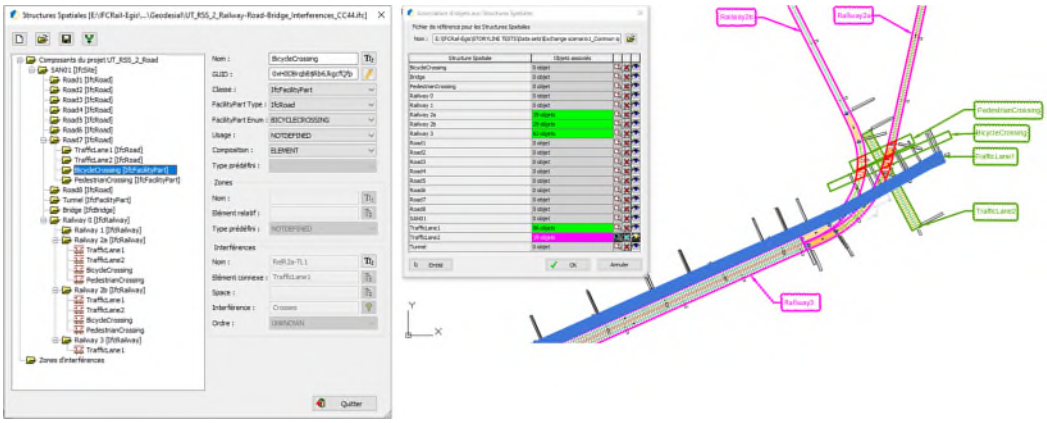
- RSS2 : https://github.com/IFCRail/IFC-Rail-Unit-Test/tree/master/4_Railway%20Spatial%20Structure%20(RSS)/UT_RSS_2
- RSS3 : https://github.com/IFCRail/IFC-Rail-Unit-Test/tree/master/4_Railway%20Spatial%20Structure%20(RSS)/UT_RSS_3
- RSS5 : https://github.com/IFCRail/IFC-Rail-Unit-Test/tree/master/4_Railway%20Spatial%20Structure%20(RSS)/UT_RSS_5
- SAS4 : https://github.com/IFCRail/IFC-Rail-Unit-Test/tree/master/3_Swept%20Area%20Solid%20(SAS)/UT_SAS_4

Step	Unit test	Input	Activity	Output	Deadline
1001			***Test leader*** *provides the storyline test plan and the data sets.*		*From 8th to 11th June*
1002			***Technical services*** *provide unit test definition and some IFC reference files*		*From 8th to 21st June*
❶		INITIATE THE PROJECT SPATIAL STRUCTURE			
1101	RSS2 export	RSS2 on Github coordinate system French Coordinate System : RGF93 Lambert Zone 3 (New Zone/NZ 3) Code : RGF.CC44 EPSG Code : 3944 Units : Meter Insertion Point (X=1892146.3459 ; Y=3126337.9035 ; Z=3.9521)	**Writer 1** generates the basic spatial structure of the project (Railway+Road+Bridge) : Geospatial reference, Project, Site, Facilities, Facility parts	Spatial structure (“IFC site” without geometry) : 1 IFC file Railway+Road+Bridge	5th july
1102	RSS2 import	IFC file from 1101	**Writer 2 (rail)** imports the basic spatial structure of the project (Railway+Road+Bridge) and use it to generate automatically the basic spatial structure of the project (Railway+Road+Bridge) in its own tool. **Option :** maintain the UID for each facility part	Spatial structure : 1 IFC file Railway	5th july
1103	RSS2 import	- IFC file from 1101	**Writer 3 (road)** imports the basic spatial structure of the project (Railway+Road+Bridge) and use it to generate automatically the basic spatial structure of the project (Railway+Road) in its own tool. **Option :** maintain the UID for each facility part	- Spatial structure : - 1 IFC file Road	5th july
1103	RSS2 import	- IFC file from 1101	**Writer 4 (bridge)** imports the basic spatial structure of the project (Railway+Road+Bridge) and use it to generate automatically the basic spatial structure of the project (Railway+Road+Bridge) in its own tool. **Option :** maintain the UID for each facility part	- Spatial structure : - 1 IFC file Bridge	5th july

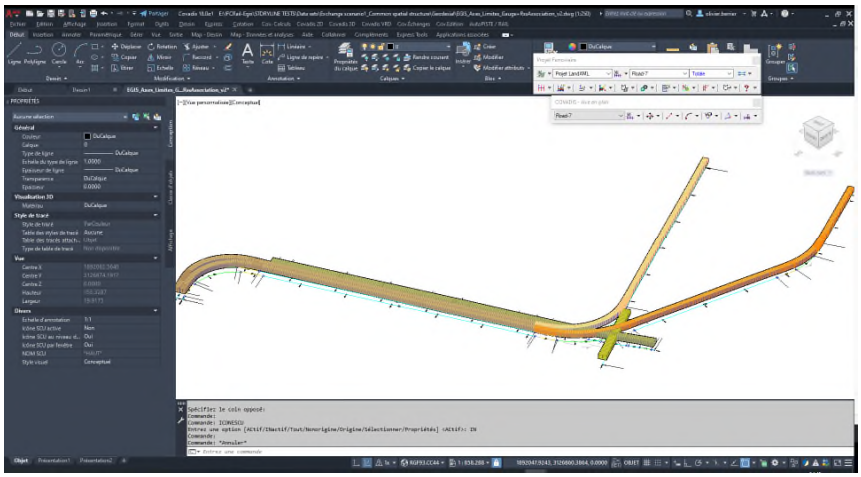
Step	Unit test	Input	Activity	Output	Deadline
❷		ASSOCIATE GEOMETRY TO THE SPATIAL STRUCTURE FOR LINEAR FACILITIES			
1201	AWC	- Vertical and horizontal alignments : Civil3D - LandXML - IFC4.0	**Writer 2 (rail)** generates alignments by using the basic spatial structure.	- Alignments : - 1 IFC file Railway	5th july
1202	AWC	- Vertical and horizontal alignments : Civil3D - LandXML - IFC4.0	**Writer 3 (road)** generates alignments by using the basic spatial structure.	- Alignments : - 1 IFC file Road	5th july
1203	SAS4	- Railway Corridor : DWG – IFC4.0 (from Civil3D) - Typical cross section : drawing - Right and Left Dynamic Rolling Stock Gauges : LandXML - DWG	**Writer 2 (rail)** generates sectioned swept area solid for each facility part.	- Sectioned Swept solid areas : - 1 IFC file Railway	5th july
1204	SAS4	- Railway Corridor : DWG – IFC4.0 (from Civil3D) - Typical cross section : drawing - Right and Left Dynamic Rolling Stock Gauges : LandXML - DWG	**Writer 3 (road)** generates sectioned swept area solid for each facility part.	- Sectioned Swept solid areas : - 1 IFC file Road	5th july
1205	RSS3	- Drawing on Github	**Writer 2 (rail)** associates geometrical information to each linear facility part : sectioned swept area solid	- Linear spatial structure ("IFC site" with geometry) : - 1 IFC file Railway	5th july
1206	RSS3	- Drawing on Github	**Writer 3 (road)** associates geometrical information to each linear facility part : sectioned swept area solid	- Linear spatial structure ("IFC site" with geometry) : - 1 IFC file Road	5th july
❸		ASSOCIATE GEOMETRY TO THE SPATIAL STRUCTURE FOR NON LINEAR FACILITIES			
1301	RSS3	- Solid : DWG, IFC4.0	**Writer 4 (bridge)** generates BREP for bridge facility part.	- BREP : - 1 IFC file Bridge	5th July
❹		DEFINE SPATIAL INTERFERENCES BETWEEN FACILITIES			
1401	RSS5	RSS5 on Github IFC files from 1205, 1206, 1301	**Writer 2 (rail)** informs spatial interferences between facility parts (Railway+Road+Bridge).	- Spatial structure Interferences ("IFC site with interferences"): - 1 IFC file Railway	19th July
❺		ASSOCIATE INFORMATIONS TO FACILITIES THROUGH SPATIAL ELEMENTS GUID AND BCF			
1501	-	IFC files from 1401, 1206, 1301	**Reader 1** imports 1 IFC file Railway + 1 IFC file Road + 1 IFC file Bridge and visualize : - the common spatial structure of the project - the ID of each facility part - the geometry associated to each facility part - the alignment associated to each facility part + starting point + ending point - the geometrical information of each alignment - the interference (including type)	- 3D Views & information views	2nd August
1502	-	IFC files from 1401, 1206, 1301	**Reader 1** selects 1 facility part geometry, generates an issue and export it in BCF.	- Issue : - 1 BCF file	2nd August
1503	-	IFC files from 1401, 1206, 1301 BCF from 1502	**Reader 2** imports the 2 IFC files and the BCF and isolate the facility part selected for the issue generation, extract the GUID of the facility part and answer the issue with the value of the GUID of the facility part, the value of the GUID of the alignment of the facility part.	- Issue : - 1 BCF file	16th August

2.3.4 Test completion

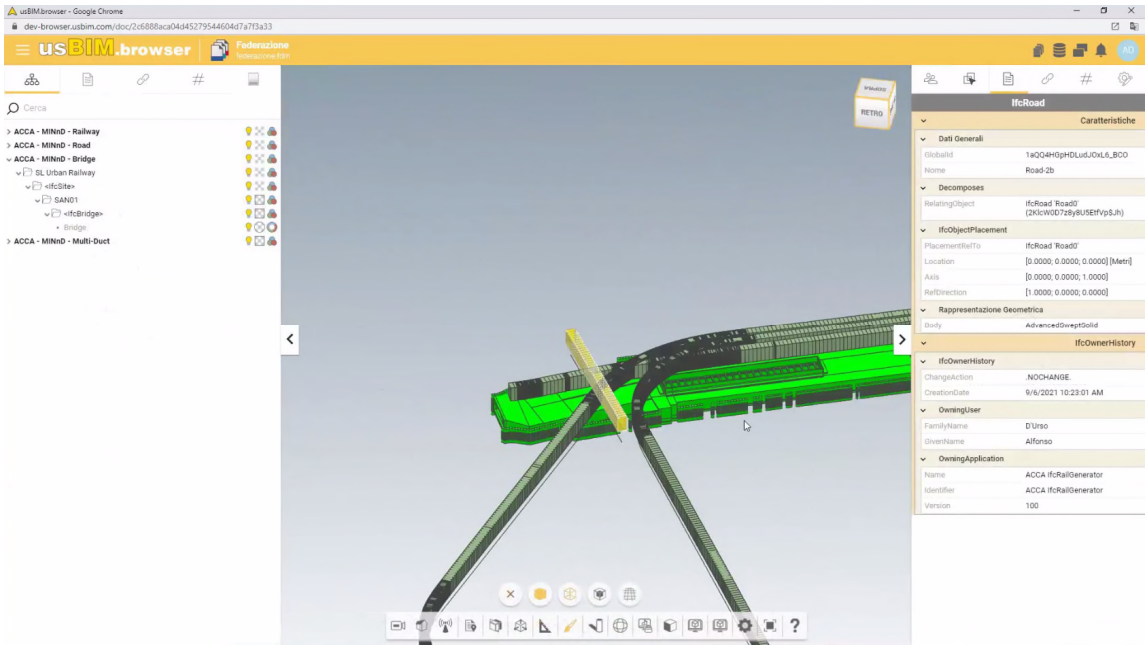
Test Completion (Specify level of completion and if reserves/punchlist opened, additional TS works….)
• All milestones were completed by the end of the testing phase (end of October 2021), except 1502 & 1503 that are not necessary for the test completion. • Several Software Vendors participated to the test, such as: ACCA, Autodesk, Bentley, Geodesial, RDF • Only some SV completed the milestones by producing models: ACCA, Geodesial • A document was created to report the control of the IFC files produced and several meetings between the software vendors and the Technical support was organized to explain and solve the issues. • As a result of the testing phase these models were produced : o Alignment model for a railway, including a parabolic curve in the vertical profile o Alignment model for roads o Spatial structure with geometry for Railway o Spatial structure with geometry for Road o Spatial structure with geometry for Bridge o Aggregated & related (interference definition) Spatial structure with Railway, Road and Bridge o Geometry with sectioned swept area solid for Railway o Geometry with sectioned swept area solid for Road • As a result of the testing phase functionalities were developed & used : o Generation of an aggregated & related spatial structure for Railway, Road & Bridge o Allocation of a geometry to facility part (parts of the spatial structure) o Visualization of an aggregated & related spatial structure for Railway, Road & Bridge All these models were validated and approved by MINnD's experts with the support of the Technical Service.
Test Team and Test Leader Satisfaction (Specify the Box/Github links to find the test results or documents….)
The exchange scenario "common spatial structure for interface management" was completed successfully, fully satisfying the expectations of the stakeholder. • Storyline testing plan can be found here in Box : https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/138758841345 • Storyline input documentation can be found here in Box: https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/138759047816 • Storyline control document can be found here in Box : https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/138759238828 • Recording and presentation of storyline meeting can be found here in Box: https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/138756191553 • Recording and presentation of the Storyline review (in French) with the MINnD's expert can be found here : https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/138759238828
Tests and Results Archives (Specify the Box/Github links to find the test results or documents….)
The Github repository for storyline test is here: https://github.com/IFCRail/IFC-Rail-Unit-Test/tree/SL10_Urban_Railway/8_Storylines%20Test%20(SL)/SL10_Urban%20Railway%20Infra-system%20Integration



Test result by Geodesial



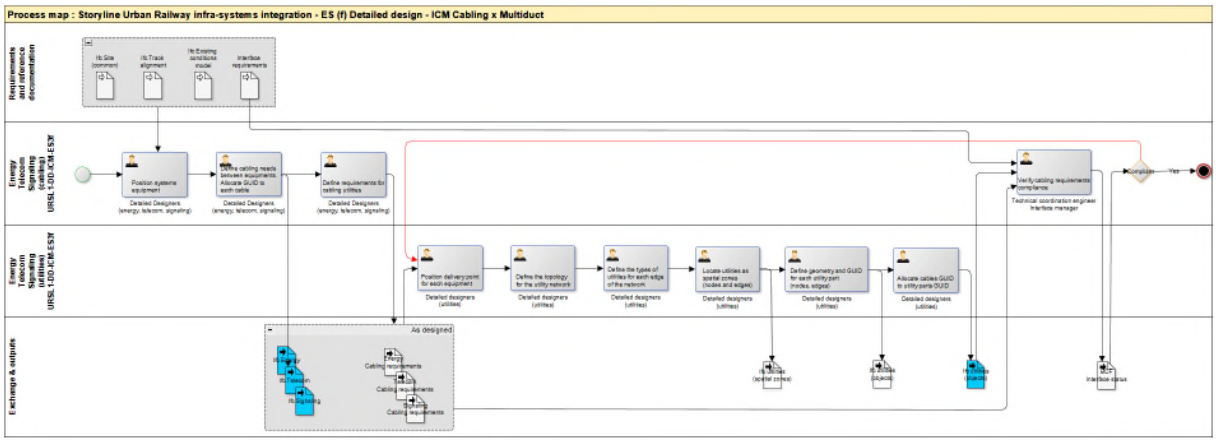
Test result by Geodesial

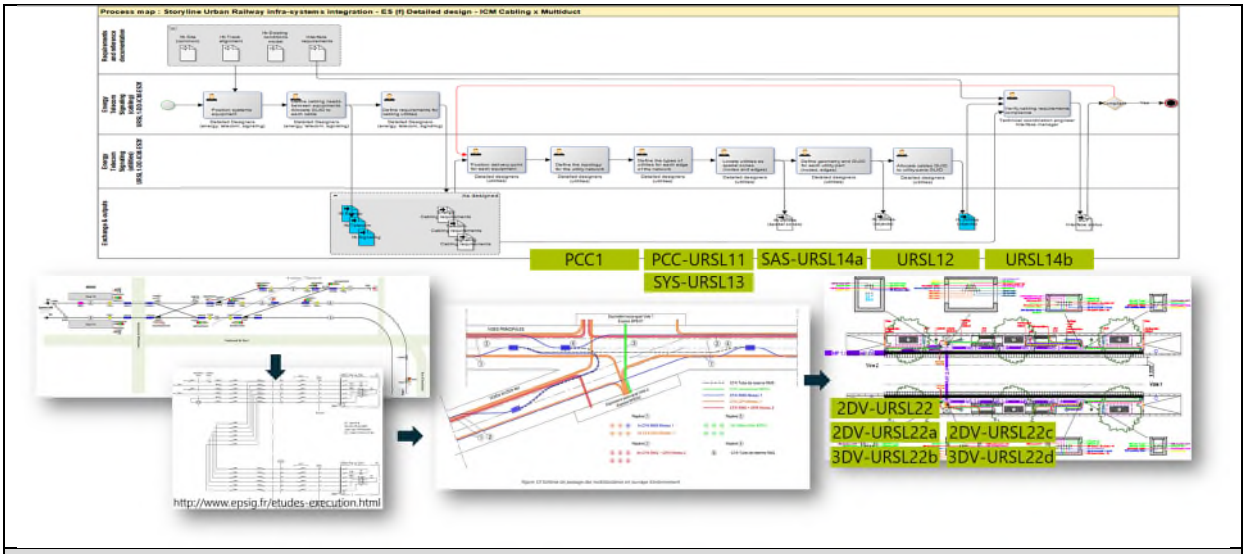


Test result by Acca

2.4 Exchange Scenario: Design analysis – Cabling & multi-duct / cable carrier design consistency

2.4.1 Exchange scenario description

Id	**(a) Design analysis** **Cabling & multi-duct / cable-carrier design consistency**
Exchange Scenario Description *[please describe the ES and define In/Out of Scope topics]*	
Ensure the constituency between the cabling needs definition/updates (by the system design team) and the cabling infrastructure/superstructure capacity (designed by the infrastructure team). Give I am a **system engineer**, I want to : Task 1 : locate/dimension terminal equipment (node), junction equipment (node), supply equipment (node). Task 2 : define the cabling (branch) between equipment items Task 3 : define requirements for the cabling (cabling process, minimum radius, distance between, …) Task 4 : verify features of the cabling infrastructure/superstructure designed by the civil engineer Given I am a **civil engineer**, I want to : Task 5 : locate/dimension/design the geometry of (multi-ducts)/culverts/cable carriers (branch of network) & chamber (node of network) based on to the cabling requirements Task 6 : associate relationship between cable #ID and ducts/culverts/cable carriers #ID (“duct includes cable”) Task 7 : play the following request for a cable item, identified by a unique #ID : “what are the infra elements that include the cable #xxx ?” Task 8 : play the request for a duct/cable carrier, identified by a unique #ID : “what are the cables included in the duct/cable carrier #xxx ?” Task 9 : view (plan view) the cable way (complete or part) by requesting a terminal, junction or supply equipment Task 10 : verify minimum radius compliance with requirements for each cable way (by using features of ducts, cable carriers, chambers, …)  	



Geometry and positioning requirements *[General description / concepts => specific on Excel sheets]*
Topology of a network : connection between objects (#ID from same/another IFC file, type of connection), branch/node Direction of objects (from ----> to) Direction of connection (from ----> to) Alignment for ducts/cable carrier Alignment for multi-ducts (axis + type section with ducts location) Network part > branch, node
Spatial requirements *[General description of spatial element requirements => specific on Excel sheets]*
Physical and functional requirements *[General description of physical elements, functional elements and important information => specific on Excel sheets]*
(Infra) Distribution element : ducts, cable carrier, culvert, chamber, … System terminal, junction, supply equipment Cable IfcRelConnects IfcRelContain (ID from separate IFC model)

Covered Unit Test: to be filled by Technical Expert	
ID	Unit Test
PCC1	This Unit Test intends to experiment the use of IFC to represent the topology of the **multiduct system** in order to complete the piping system description.
PCC-URSL11	Describe a cable network including information about the equipments that are connected to each cable (supplier/supplied)
URSL12 Relationship “contains”	Associates 1 cable in an IFC energy model to n ducts/chambers (in another IFC file through a GUID) that contain the cable.
SYS-URSL13	Assemble several ducts associated to a multiduct part
SAS-URSL14a	Ability to use an alignment as the axis of a duct/cable carrier/multi-duct/ … Generate the geometry of ducts in a multiduct by using an alignment and a typical cross section
URSL14b	Control the minimum radius along the ducts
2DV-URSL22	Ability to generate a cross section view wherever we need (by using a mileage value along an alignment), with usual quotation for the business / discipline.

2DV-URSL22a	From a 2D view, click on an object and obtain all geometrical and technical relevant information (including axis/alignment)
3DV-URSL22b	From a 3D view, click on an object and obtain all geometrical and technical relevant information (including axis/alignment)
2DV-URSL22c	From a 2D view, click on an object and obtain all geometrical and technical relevant information (including **supplier/supplied**)
3DV-URSL22d	From a 3D view, click on an object and obtain all geometrical and technical relevant information (including **supplier/supplied**)

2.4.2 Testing goals

DESIGN MODELLING (GEOMETRY)

201- Generate a multiduct (with unique ID) as assembly of ducts (with unique ID).
202- Generate the geometry (linear element and sectioned swept area solids) of ducts by using geometrical information inherited from the multiduct + definition of offsets on the typical cross section of the multiduct.
203- Generate the geometry (axis + swept area solids) of cables by using geometrical information inherited from the ducts.

DESIGN MODELLING (NETWORK/SYSTEM)

204- Describe the multiduct network by using (topological) relationships between distribution elements and fitting elements.
Describe the cable network without geometry by using (topological) relationships between distribution elements, fitting elements and terminals.

INTEFERENCE MANAGEMENT

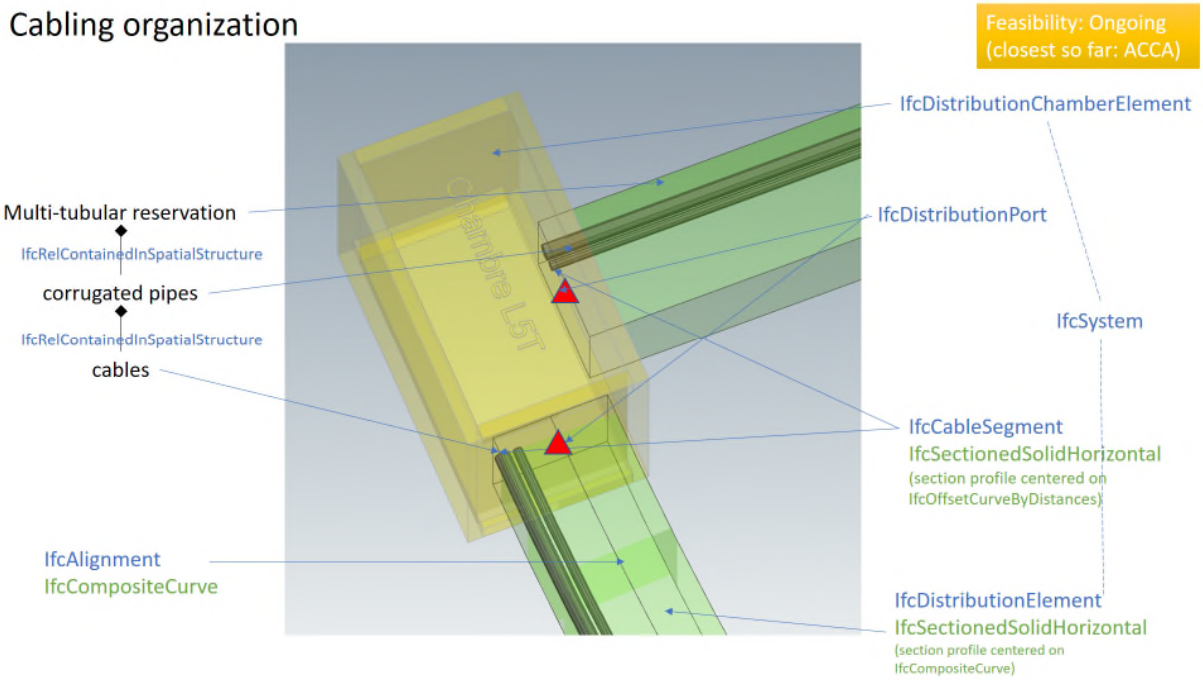
205- Generate the relationships “[cable #ID] is hosted by [duct#ID1] ; [duct#ID2] ; [duct#ID3] ; …”

3D VISUALIZATION

206- Visualize the multiduct network breakdown structure.
207- Visualize a synopsis of the multiduct network by using topological information and interference information extracted from the spatial zoning.
208- Visualize the cable network breakdown structure.
209- Visualize a synopsis of the cable network by using topological information.

DESIGN CHECKING

210- Check the occupancy rate of each duct (many iterations during a design phase).
211- Check the minimum radius for each cable.
212- Check the completion of the cabling network : each terminal is connected to the appropriate cable(s).
213- Check the continuity of the duct network hosting 1 cable.

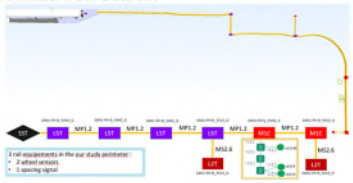


Example of illustration for modeling

2.4.3 Testing plan

Step	Unit test	Input	Activity	Output	Deadline
2001			***Test leader*** *provides the storyline test plan and the data sets.*		
2002			***Technical services*** *provide unit test definition and some IFC reference files*		
❶		INITIATE THE PROJECT SPATIAL STRUCTURE			
2102		- IFC file from 1101	**Writer 1** adds : - a facility part for the multiduct as IfcRailwayFacilityPart type LINESIDESTRUCTUREPART . - a facility part (building) for the substation	- Spatial structure : - 1 IFC file with multiduct	
2101		- IFC file from 2102	**Writer 2 (multiduct)** imports the common spatial structure of the project (Railway+Road+Bridge) and use it to generate automatically the spatial structure of the project (Railway+Road+Bridge) in its own tool. **Option :** maintain the UID for each facility part	- Spatial structure : - Authoring file	

❷		ASSOCIATE GEOMETRY TO THE SPATIAL STRUCTURE FOR MULTIDUCTS			
2201	AWC	- Vertical and horizontal alignments of multiducts : Civil3D – LandXML1.2	**Writer 2 (multiduct)** generates alignments by using the common spatial structure.	- Alignments : - Authoring file	
2202	AWC	- IFC files from 2201; typical cross sections of multiducts - IFC from Data set	**Writer 2 (multiduct)** - generates sectioned swept area solid for multiduct facility part. - Import the building shape and associates it to the substation facility part.	- Spatial structure with geometry : - 1 IFC file Railway	
❸		GENERATE THE MODEL OF THE MULTIDUCT NETWORK			
2301		- Spatial structure with geometry from 2202 - (Drawpit) Chambers : Dwg - IFC2x3 - Typical cross section for multiduct : drawing (pdf, dwg)	**Writer 2 (multiduct)** generates objects for chambers and swept area solids for 2 ducts (identified on the typical cross section), by using the external and internal sections in the property set. Add name to each duct.	- Objects : IFC file multiduct (spatial structure with geometry + objects)	

2302		- IFC files from 2202 - IFC model from Data set 	**Writer 3 (cabling)** generates objects for 3 rail equipments : 2 wheel sensors, 1 cable fitting element, 1 spacing signal & 1 cabinet in the substation. **Writer 3 (cabling)** generates 3 cables objects : - From cabinet to cable fitting element - From cable fitting element to wheel sensor 1 - From cable fitting element to wheel sensor 2 as terminal - From cabinet to spacing signal as terminal (without geometry if it is possible or with geometry = straight line) **Writer 3 (cabling)** generates the relationships (is connected to) between cables, cable fitting element, cabinet and terminals (wheel sensor and signal) in order to describe the multiduct network (by using port & connectivity classes) **Writer 3 (cabling)** informs the following properties for each duct : name, type (telecom, energy) and the section	- Objects : Authoring file IFC file	

2303		- IFC files from 2302	**Writer 2 (multiducts)** imports the cabling IFC file with equipments and generates the relationships (is hosted by) between cables and ducts and between cables and chambers in order to describe the multiduct network (by using port & connectivity classes)	- Relationships (port & connectivity) : IFC file with multiduct, ducts, equipments, cables	
2304		- IFC files from 2303	**Writer 2 (multiducts)** generates the shapes of cables as axis, by using the information coming from the equipments and the ducts. **Writer 2 (multiducts)** generates the shapes of cables as swept area solids, by using the section in the property set.	- Objects : IFC file with multiduct, ducts, equipments, cables	
❹		ANALYZE CABLE NETWORK			
2401		- IFC files from 2304	**Reader 3 (cabling and common)** imports the IFC file and generates a BCF for each cable with its name and the geometry of the cable. **Reader 3 (cabling and common)** imports the IFC file and generates a BCF for each cable with its name and the geometry of the ducts that host this cable.	- Assembly : BCF	
2402		- IFC files from 2304	**Reader 3 (cabling and common)** imports the IFC file and generates an excel file including the list of cables with its ID# and its ID#, the name and ID# of the 2 equipments connected for each cable and the length of each cable.	- List : Excel file	
2403		- IFC files from 2304	**Reader 2 (muldiduct)** imports the IFC file and generates an excel file including the list of ducts with the ID#, the name, the type and the section of all the cables included in the duct.	- List : Excel file	

2.4.4 Test completion

Test Completion (Specify level of completion and if reserves/punchlist opened, additional TS works….)
• All milestones were completed by the end of the testing phase (end of October 2021), except 2401 to 2403 that are not necessary for the test completion. • Several Software Vendors participated to the test, such as : ACCA, Autodesk, Bentley, Geodesial, RDF • Only some SV completed the milestones by producing models: ACCA • A document was created to report the control of the IFC files produced and several meetings between the software vendors and the Technical support was organized to explain and solve the issues. • As a result of the testing phase these models were produced : o Alignment for Railway utilities o Spatial structure with geometry for Railway utilities (multiduct/multitubular) o Geometry with alignment & sectioned swept area solid for Railway utilities (multiduct/multitubular) o Assembly of objects for a Railway utility (multiduct/multitubular) o Description of a Railway utility network (infrastructure) o Description of a Railway utility network (cabling) o Allocation of cables to utility infrastructure parts (relation “is contained by”) All these models were validated and approved by MINnD’s experts with the support of the Technical Service.
Test Team and Test Leader Satisfaction (Specify the Box/Github links to find the test results or documents….)
The exchange scenario “cabling” was completed successfully, fully satisfying the expectations of the stakeholder. • Storyline testing plan can be found here in Box : https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/138758841345 • Storyline input documentation can be found here in Box: https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/138759047816 • Storyline control document can be found here in Box : https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/138759238828 • Recording and presentation of storyline meeting can be found here in Box: https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/138756191553 Recording and presentation of the Storyline review (in French) with the MINnD’s expert can be found here : https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/138759238828
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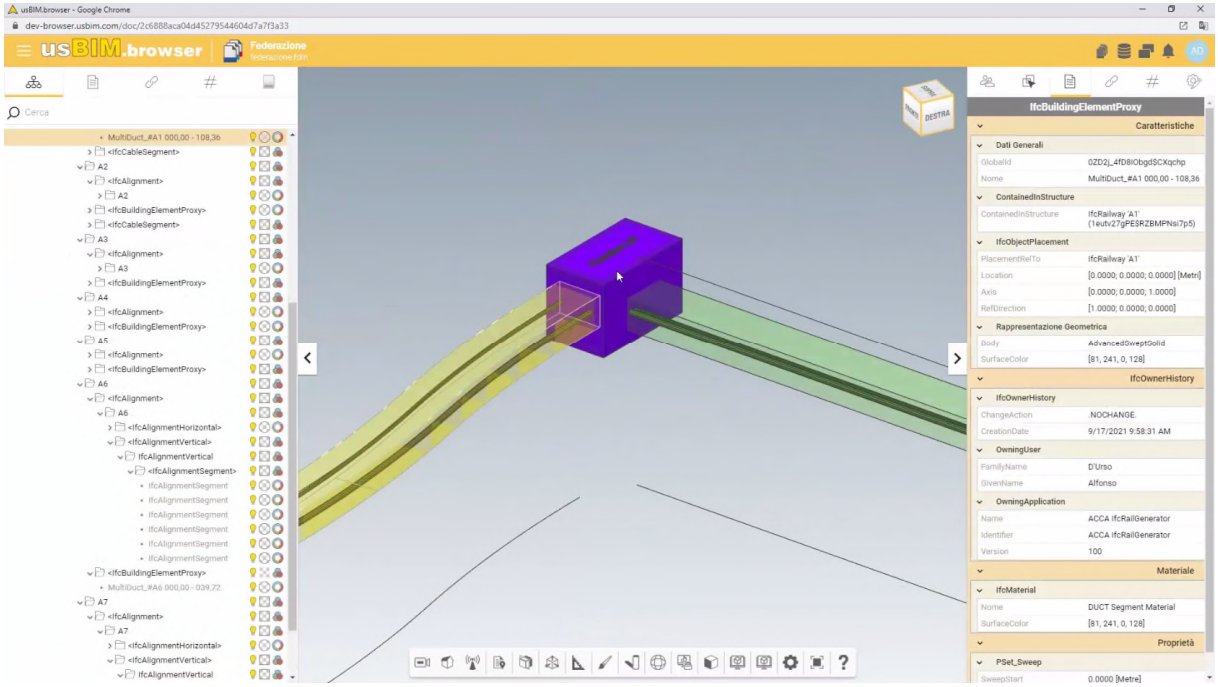


Test result by Acca

3 Supporting Files & Storyline Archives

All files and Data are archived in :

- BOX DIRECTORY : https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/119146953040
- GITHUB : https://github.com/IFCRail/IFC-Rail-Unit-Test/tree/SL10_Urban_Railway/8_Storylines%20Test%20(SL)/SL10_Urban%20Railway%20Infra-system%20Integration

3.1 Test Dataset

3.1.1 Exchange scenario : common spatial structure for interface management

Dataset
SLUR_Alignment_Horizontal.dwg SLUR_Alignment_Horizontal_Vertical.dwg SLUR_Gauge-Limit.dwg SLUR_Road-Alignment_Horizontal-Gauge-2.dwg SLUR_Road-Alignment_Horizontal-Gauge.dwg SLUR_Spatial-Structure-Areas.dwg SLUR_Spatial-Structure-Areas_V2.dwg SLUR_Alignment_Horizontal_Vertical_V2.ifc SLUR_Alignment_Horizontal_ifc4x1.ifc SLUR_Road-surface-Marking_ifc2x3.ifc SLUR_Road_ifc2x3.ifc SLUR_Spatial-Structure-Areas_ifc4.ifc SLUR_Spatial-Structure-Areas_ifc4x1.ifc SLUR_Underground-Bridge_ifc2x3.ifc SLUR_Alignement_Horizontal_Vertical_V2.xml SLUR_Alignment_Horizontal_Vertical.xml SLUR_Road-Alignment_Horizontal-Gauge.xml 2021-06-08_Dataset_schema.pptx 2021-07-19_Dataset_schema.pptx Common spatial structure definition_v1.0.docx
Dataset description
• Alignment model for a railway, including a parabolic curve in the vertical profile • Alignment model for roads • Spatial structure with geometry for Railway • Spatial structure with geometry for Road • Spatial structure with geometry for Bridge • “Common” Aggregated & related (interference definition) Spatial structure with Railway, Road and Bridge • Geometry with sectioned swept area solid for Railway • Geometry with sectioned swept area solid for Road
Dataset links
• https://github.com/IFCRail/IFC-Rail-Unit-Test/tree/SL10_Urban_Railway/8_Storylines%20Test%20(SL)/SL10_Urban%20Railway%20Infra-system%20Integration/Dataset • https://github.com/IFCRail/IFC-Rail-Unit-Test/tree/SL10_Urban_Railway/8_Storylines%20Test%20(SL)/SL10_Urban%20Railway%20Infra-system%20Integration/Documentation

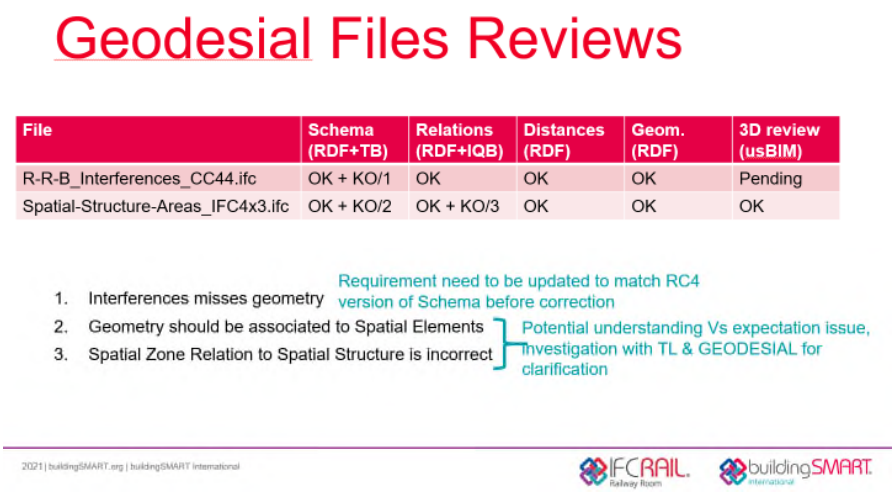
3.1.2 Exchange scenario : cabling

Dataset
SLUR_Multi-Duct-Alignments.dwg SLUR_Multi-Duct-Alignments_Swept_Area_Solids.dwg SLUR_Multi-Duct-Cross_sections.dwg SLUR_Multi-Duct-Alignments_IFC4x1.ifc SLUR_Multi-Duct-Alignments_Swept_Area_Solids-4.ifc SLUR_Multi-Duct-Alignments_Swept_Area_Solids-4x1.ifc SLUR_Multi-Duct-Substation-Architecture_IFC2x3.ifc SLUR_Multi-Duct-Substation-Electrical_IFC2x3.ifc URW_SL_Cabling.ifc SLUR_Multi-Duct-Alignments.xml MP1.2.pdf MS2.6.pdf Readme SLUR_Multi-duct-Cables-Path.pdf 2021-10-25 Slides pour SL URW-cabling+VKE.pptx
Dataset description
• Alignment for Railway utilities • Spatial structure with geometry for Railway utilities (multiduct/multitubular) • Geometry with alignment & sectioned swept area solid for Railway utilities (multiduct/multitubular) • Assembly of objects for a Railway utility (multiduct/multitubular) • Description of a Railway utility network (infrastructure) • Description of a Railway utility network (cabling) • Allocation of cables to utility infrastructure parts (relation “is contained by”)
Dataset links
• https://github.com/IFCRail/IFC-Rail-Unit-Test/tree/SL10_Urban_Railway/8_Storylines%20Test%20(SL)/SL10_Urban%20Railway%20Infra-system%20Integration/Dataset/Cabling • https://app.box.com/s/0aioos065zcsms8rydpkjmmf1g210i7v/folder/158139138548

4 Appendices

4.1 Storyline Control

Extract :



4.2 Example of checking report