Modélisation des INformations INteropérables pour les INfrastructures Durables

IfcBridge

IFC4.3 Validation

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I. ABSTRACT

Abstract	During the first season (2015-2018) of the MINnD research project, the IFC Bridge working group focused on common bridges: slab bridges, girder bridges, frame bridges, rigid frame bridges and culverts. The MINnD deliverable "IFC-Bridge State of the Art & Missing Concepts" (available at www.minnd.fr) provided a state of the art about the applicability of Industry Foundation Classes (IFC) entities to describe the data exchange model associated to a bridge under construction. The study considered the results of Use Cases, in particular the analyses of the IFC files exported according to the ISO 16739 standard, with entities developed for buildings. As a conclusion, concepts not appropriately addressed have been listed and proposals have been given for developing the missing IFC entities. As the version 4.3.1 of IFC has been submitted to ISO as a draft international standard, this document aims to verify if recommendations from MINnD season 1 are covered by this latest version of IFC schema specifications.

Résumé	Lors de la première saison (2015-2018) du projet de recherche MINnD, le groupe de travail dédié aux IFC Bridge s'est concentré sur les ouvrages dits « courants » : ponts-dalles, ponts à poutres, ponts cadres et ponceaux. Le livrable MINnD intitulé « IFC Bridge State of the art and Missing Concepts » (disponible sur www.minnd.fr) a produit un état de l'art sur la pertinence des IFC à décrire un modèle d'échanges de données d'un ouvrage d'art en construction. L'étude s'est appuyée sur l'analyse de Cas d'Usages, et notamment l'exploitation de fichiers IFC exportés selon la norme ISO 16739, et à partir des classes IFC développées pour les bâtiments. En conclusion, le livrable dresse la liste des concepts spécifiques aux ouvrages d'art qui ne sont pas correctement traités, ainsi que les classes IFC nécessaires pour y remédier. La version 4.3.1 du format IFC ayant récemment été soumise à la certification ISO, le présent livrable vise à vérifier si les points de blocage relevés lors de la saison 1 du projet MINnD sont levés.

1.1 Abbreviations

Abbreviation	Signification
AADT	Average Annual Daily Traffic
ABRV	Alignment Based Reference View
bSDD	buildingSMART Data Dictionary
bSI	buildingSMART International
IDS	Information Delivery Specification
IFC	Industry Foundation Class
LOIN	Level Of Information Needs
MoU	Memorandum of Understanding
MVD	Model View Definition
RV	Reference View
XML	eXtensible Markup Language

Main key words (Eng) MINnD; Research; Construction; Infrastructure; BIM; Digital model;

Deliverable key words (Eng) IfcBridge; IFC4.3; axis system; validation; exchange requirements;

Mots clés principaux (Fra) MINnD ; Recherche ; Construction ; Infrastructures ; BIM ; Maquette numérique ;

Mots clés spécifiques au livrable (Fra) IfcBridge ; Ouvrage d'art ; Pont ; IFC4.3 ; système de coordonnées ; validation ; exigences d'échange ;

2. INTRODUCTION

2.1 Issues of the IFC-BRIDGE Working Group 1.1

MINnD S1 Continuity

In the first phase of the national MINnD research project, the working group dedicated to IFC Bridges was mainly interested in common bridges: slab bridges, girder bridges, frame bridges, rigid frame bridges and culverts. All complex bridge's types such as prestressed or suspended bridges were out of scope.

MINnD project and other international initiatives contributed to the IFC-Bridge Fast Track Project led by buildingSMART International that aimed at extending the IFC data model to allow the precise description of the semantics and geometry of bridges: the IFC 4.2 schema specifications.

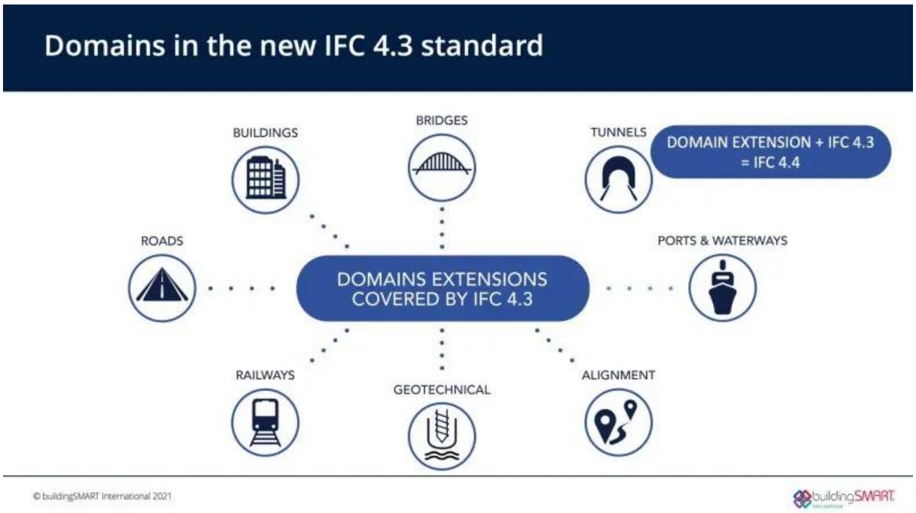

Fig.1 : Domain extensions covered by IFC 4.3

Since this initial work, which led to the development of IFC 4.2, then to IFC 4.3, some software editors have progressively started implementing these new classes of objects in their authoring tools. The second phase of the national research project must therefore continue its work in order to cover all types of structures, in particular prestressed and cable-stayed structures.

In addition, under the impetus of the development of IFC-Bridge, the other infrastructure domains (tunnel, road, rail, etc.) have mobilized to specify classes of complementary objects to cover all civil-engineering domains. This work in silos has made it possible to quickly mobilize the experts in each field, but now requires work on consistency and verification of the interfaces between the major fields of infrastructure (for example: a road or a railway line sometimes passes over a bridge or in a tunnel). It is therefore essential to identify the scope of study for each area, and to identify the topics that must absolutely be dealt with by the working group dedicated to the IFC Bridge. The goal is to ensure that the subjects essential to the field of bridges, and yet transverse to the other fields, have been correctly treated and correctly consider the particularities of this field.

In addition, since the development of IFC 4.1 (IFC Alignment) partly implemented by software vendors, some gaps and shortcomings have been identified during the first tests and first uses.

MINnD S1 deliverables dealing with IFC-Bridge

The first phase of the MINnD project took place from March 2014 to March 2016. The Use Case 3 "IFC Bridge" working group studied the state of art of the IFC. The latter is related to the field of the bridge design and construction. It identifies missing concepts and recommends a holistic approach to:

- Derive IFC definitions.
- Complete concepts used by users and stakeholders involved in the bridge's lifecycle.

The second phase of the MINnD project took place from March 2016 to December 2018. The working group goes deeper into the design process. It took the example of a typical bridge:

- Exhibiting a fair amount of all events and problematic that can be encountered during a bridge project.
- Considered from the complete lifecycle perspective.

The following deliverables were the first documents dedicated to IFC-Bridge development recommendations and were delivered to the buildingSMART IFC-Bridge dedicated team.

State of the art [MINnD UC03 01]

This deliverable aims at providing a state of the art about the applicability of Industry Foundation Classes (IFC) entities to describe the data exchange model associated to a bridge under construction. The study is based on the knowledge of ISO 16739 standard (IFC) and the preparatory works for the IFC-Bridge extension. The study has also considered the results of Use Cases, in particular the analyses of the IFC files exported according to the ISO 16739 standard, with entities developed for buildings. As a conclusion, concepts not appropriately addressed have been listed and proposals have been given for developing the missing IFC entities.

Bridge data dictionary from conception to bSDD [MINnD UC03 02]

This document presents the complete method to create a data dictionary (objects and their properties) dedicated to bridges.

It starts from existing documentation and standards, and go in detail through the methodology, till the transfer to the buildingSMART data dictionary (bSDD).

IDM Bridge design process [MINnD_UC03_03]

This document details the process of a typical bridge. It underlines how the conclusions and works carried out could be affected by other types of bridges.

During this process, the manipulated concepts are identified, and how they could be described within the framework of a theoretical and complete IFC. A final section defines globally the extensions required and places them into the more global contexts of the IFC extensions under discussion in the infraRoom of buildingSMART International.

Finally, the last part details the input data necessary for the design of a bridge whose geometry (architectural model) is strongly related to the computation (analytical model). This chapter specifies the mechanical properties related to the geometrical elements to be integrated in the IFC model.

Methodology to feed bSDD with a new Data Dictionary [MINnD UC03 04]

This document:

- Presents the method used to add concepts of any domain into the buildingSMART Data Dictionary (bSDD).
- Shows the work on the data dictionary with the concepts related to the bridge domain added in the bSDD.
- Aims to be used as a guide to manage a data dictionary by avoiding mistakes and loss of time.

BuildingSMART deliverables

IFC Bridge became an official project in buildingSMART in October 2016 following the MoU supported by the Infrastructure Room. The project was initiated following the IFC alignment work and harmonization opportunity presented by the IFC4 release. The project team also recognized the importance of gaining support from software vendors, addressing missing property sets and the scope for overall extensions. The French organization MINnD was the driving force behind the technical requirements and deliverables in this phase, with 4 objectives:

1. Provide a description for the extension scope for IFC 4 related to bridges.
2. Develop a set of specifications for the extension of the IFC 4 conceptual model.
3. Create a dedicated space in the bSDD for bridge property sets including US specification.
4. Develop a set of specifications for bridge MVDs for machine readable bridge models.

Project Proposal

Capture the requirements for IFC Bridge project and align to the IFC 4 standard. This project plan was split into two parts and enabled cross-collaboration between different national requirements.

https://app.box.com/s/3f4kc490jnfc6olo8f7nk3e128377ghd

Requirements Analysis

To analyse the requirements from the different stakeholders and look at the feasibility of the proposed project. This report focused on common use cases.

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Conceptual Mode

The Conceptual Model focused on the necessary data structures for modelling prestressing systems. This report covers the scope, use cases and bridge types that are covered by future extensions of IFC Bridge.

https://app.box.com/s/w3r53huy4srhfg8t2vr0o12ot93hflsa

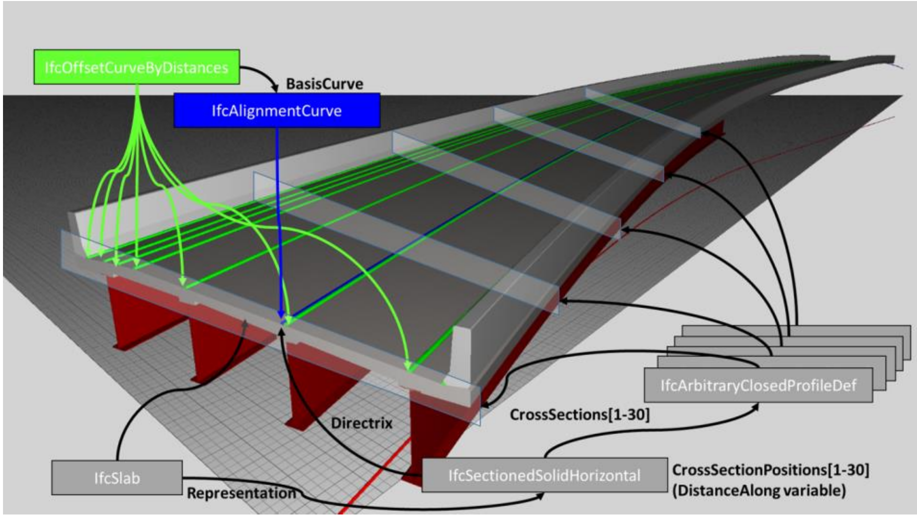

Fig.2 : The conceptual model included IFC extension requirements that were collected by the project teams.

Candidate Standard

The IFC Bridge Candidate Standard was delivered by the project team. This significant milestone brought together teams across the various projects to deliver this standard. You can read the standard below.

https://standards.buildingsmart.org/IFC/DEV/IFC4_2/FINAL/HTML/

IFC Bridge Information Exchange	This document contains the specification of the IFC standard. The specification consists of the data schema, in EXPRESS and as an XML Schema specification, and reference data represented as XML. http://docs.buildingsmartalliance.org/IFC4x2_Bridge/

2.2 IFC schemas specifications

IFC Bridge

IFC-Bridge was one of the first identified infrastructure domains in the buildingSMART roadmap.

This link leads to the different release specifications of IFC development.

https://technical.buildingsmart.org/standards/ifc/ifc-schema-specifications/ifc-release-notes/

IFC 4.1

The main purpose of IFC4.1 is to provide a basis for the various infrastructure domain extensions currently being developed (e.g., Rail, Road, Tunnel, Ports & Waterways). Extensions made to the IFC4 schema include:

- Description of alignment as a combination of horizontal and vertical alignment
- Linear Placement according to ISO 19148
- IfcSectionedSolidHorizontal as a new geometry representation particular useful for describing infrastructure facilities

IFC 4.2

The main purpose of IFC4.2 is to extend the IFC schema to include the description of bridge constructions. Extensions made to the IFC4.1 schema include:

- The spatial structure was extended by IfcFacility and IfcFacilityPart as a basis to describe the spatial breakdown structure of infrastructure facilities.
- IfcBridge and IfcBridge part were added to represent bridges and bridge parts.
- Bridge elements have been integrated into a number of predefined types of building elements.
- IfcBearing, IfcDeepFoundation, IfcVibrationDamper and IfcTendonConduit were added to represent the respective bridge elements.
- IfcRelPositions was added to better support positioning along the alignment

IFC 4.3 RC1

The main purpose of IFC4.3 is to extend the IFC schema to cover the description of infrastructure constructions within the domains of Railways, Roads, Ports and Waterways including the elements that are common across those domains. The IFC4.3 schema has been developed to:

- enhance the current definition of alignment and linear positioning to include railway cant within its geometric representation and span placements to provide "from-to" positioning;
- enhance the current geometry definitions for advanced sweeps to add a sweep operation taking cant into account, and for advanced surfaces to represent road surfaces;
- rationalize and enhance the definition of spatial structure to uniformly define a breakdown structure for all domains in question;
- rationalize and enhance the current specialization structure of products and product types to reflect the taxonomy of the new domains Railways, Roads, Ports and Waterways and common domains such as geotechnics and earthworks.

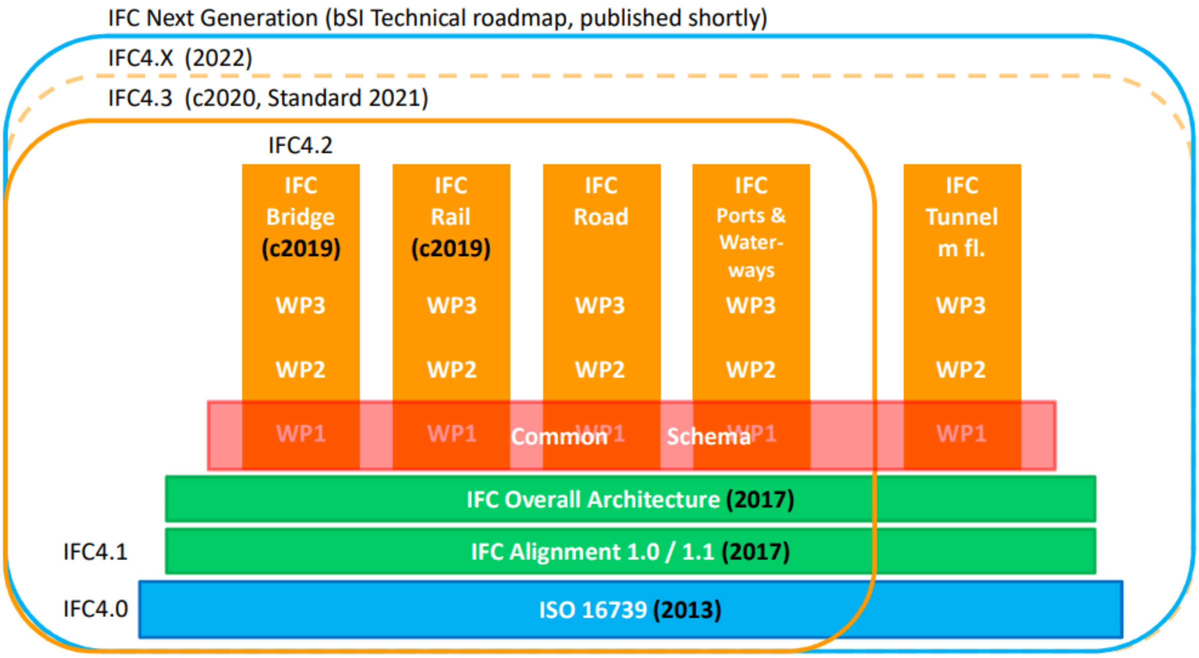

Fig.3 : buildingSMART International IFC-Infra roadmap

3. IFC 4.3 Validation

MINnD S1 deliverable

This chapter reviews all recommendations and missing concepts addressed in the MINnD UC03 deliverable "IFC-Bridge State of the Art & Missing Concepts[1]".

3.1 Exchange requirements

Objectives

The issue of exchange requirements has been thoroughly studied in the MINnD deliverable mentioned above. This section aims to remind the exchange requirements between road/rail domain and bridge domain during the design process, regarding the alignment of the project. These requirements will be clarified in a future submission to describe associated unit tests, with relevant bridge datasets, as part of a project to provide additional documentation for the Alignment Based Reference View (ABRV) MVD for IFC4.3.

This section focuses on spatial data: elementary data, exchanged between road/rail domain and bridge domain during the design process, are described. Thus, this data must be contained in a bridge model.

The section is organized as follows:

- definitions of alignment, axis and coordinates systems used in the bridge domain are reminded.
- exchange requirements for a common bridge are exposed, then summarized; and finally.
- exchange requirements for an uncommon bridge are detailed.

Definitions

Alignment

An alignment can be defined as:

- a single horizontal alignment defined in the x/y plane of the engineering coordinate system.
- a vertical alignment, defined along the horizontal alignment in the distance along / a coordinate space.

Axis

An axis can be defined as the sum of:

- A horizontal alignment.
- A vertical alignment.
- A cant (rail) / superelevation (road) alignment.

Axis systems

During the first season of the MINnD project, it was underlined that "[a] problem to be solved by the designer is related to axis systems. [...] all these different points of view must be consistent and linked to each other" (extract from MINnD S1 delivery "IFC-Bridge State of the Art & Missing Concepts"). Indeed, several coordinates' systems are used to describe a project geometry.

[1] MINnD_UC03_01_IFCBridge_State_of_the_art_002_2015 at www.minnd.fr

Global geodetic coordinates

Linear infrastructures (such as roads or rail lines) geometry is usually defined in global geodetic coordinates, as illustrated in Fig. 4.

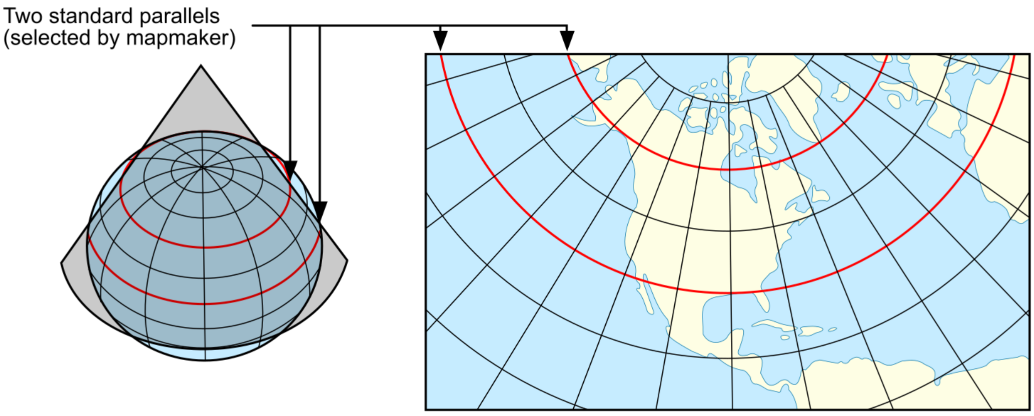

Fig.4 : Geodetic coordinates (Wikipedia)

Local Cartesian coordinates

Structures geometry (such as bridges) is usually defined in local Cartesian coordinates, as illustrated in Fig.5.

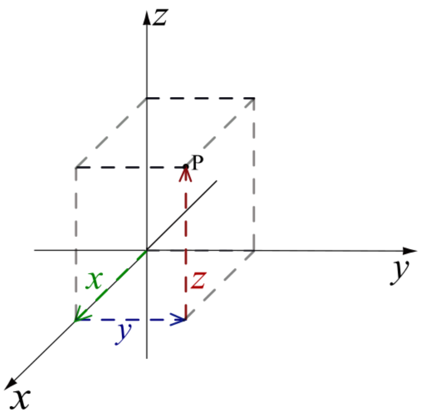

Fig.5 : Cartesian coordinates (Wikipedia)

Linear placement, along a horizontal alignment

Isolated elements position can be described with a linear placement, along a horizontal alignment.

Linear placement, along road/rail horizontal alignment

Station or PK is similar to linear placement when it refers to a road/rail alignment.

Coexistence of coordinates systems

Each point in space can be described with one of the 4 previous coordinates systems, as illustrated in Fig. 6.

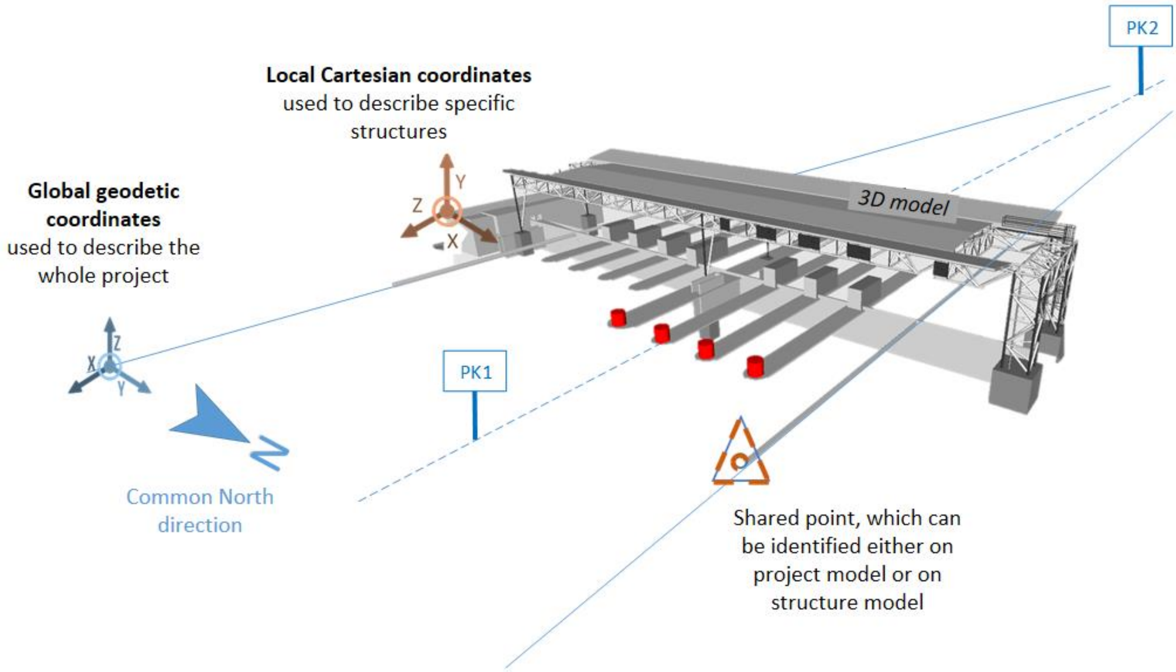

Fig.6 : Coexistence of coordinates systems (MINnD S1)

A bridge model should contain the exact supports positions in the four coordinates systems:

- Global coordinates (geodetic)
- Local coordinates (Cartesian)
- Linear placement, along the bridge axis
- PK: Linear placement, along road/rail horizontal alignment

Alignment Base Reference View Project

This project, carried by buildingSMART International and partially funded by MINnD, aims to provide test instructions and exchange requirements for Bridge Alignment documentation, based on ABRV (Alignment Base Reference View) MVD (Model View Definition) for IFC 4.3.

ABRV consists of a selection of concept templates based on IFC 4.3. This selection of concept templates will be used for software-certification. As a reminder, a concept template is a graph of entities and attributes, with constraints and parameters, required to exchange specific data.

This additional documentation will favor clarification for software implementation of ABRV. The project is broken down in several steps:

- Collection of use cases.
- Comparison of use cases and existing tests instructions.
- Selection of additional test instructions, i.e., overview of use cases not covered by existing test instructions.
- Development of additional test instructions.
- Selection of exchange requirements.

- Review of exchanges requirements and proposals for the next ABRV.
- Finalization of deliverables.

The main deliverable will be the additional documentation (test instructions and exchange requirements) as a clarification of using the ABRV for software certification for Bridge Alignment.

Level of detail / level of development / level of information need

During the first season of the MINnD project, it was identified that "the data model schema can describe all stages of the project life cycle. Consequently, many of the entity attributes are optional. But in order to guarantee a consistent and usable exchange, it is mandatory, for each stage, to clearly define which attribute is mandatory and which one is absolutely forbidden. When an attribute can be covered by different entities (the best example is the geometry representation), the only one that could be used has also to be defined. Relationships are critical to allow machine-readable information. Here also, the mandatory relationships must be listed according to a given stage. Properties and their restricted content have also to be clearly defined. Such a need has been already identified and tried to be addressed through the Level of Definition (LOD) approach. However, we must go more in detail. If this work is not carried on, we will continue to produce nice pictures, but certainly not machine interpretable information that could be used efficiently."

A wide selection of methods allows to define information requirements, such as:

- Information Delivery Manual (IDM).
- IFC Property templates.
- Information Delivery Specification (IDS).
- Etc.

Tomczak et al. (2022)[2] identified and compared several methods to specify these information requirements. Figure Fig.7 presents a summary of their work.

○ – No
◑ – Partial
● – Yes
* – under development
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			Fields					Value constraints				Content			Geom.		Metadata		
	Standardised	Applicability	Info. type	Data type	Unit of meas.	Description	References	Equality	Range	Enumeration	Patterns	Existence	Documents	Structure	Representation	Detailedness	Purpose	Actors	Process map
Spreadsheet	○	◑	◑	◑	◑	◑	◑	◑	○	○	○	○	○	○	○	○	◑	○	○
PDT*	●	◑	◑	●	●	◑	●	○	◑	●	○	◑	○	○	○	○	◑	○	○
Data Dict.	●	○	●	●	◑	●	●	●	◑	●	◑	○	○	○	○	○	○	○	○
IDS*	●	●	●	●	●	◑	◑	●	●	●	●	●	○	◑	○	○	●	◑	○
mvdXML	●	●	●	●	●	◑	○	●	●	◑	◑	◑	○	●	●	○	○	◑	○
idmXML	●	◑	◑	◑	◑	●							●		◑	◑	●	●	●
LOIN*	●	◑	◑	●	●	◑	◑	○	○	●	○	○	●	◑	◑	●	●	●	○
IFC P.T.	●	◑	◑	●	●	◑	○	○	○	●	○	○	○	○	○	○	○	○	○
LD+SHACL	○	●	●	●	●	◑	●	●	●	●	●	◑	◑	●	●	○	◑	◑	○

Fig.7 : Information requirement support in the various methods, from Tomczak et al. (2022)[2]

[2] Tomczak, Artur & van Berlo, Léon & Bolpagni, Marzia & Krijnen, Thomas & Borrmann, Andre. (2022). A review of methods to specify information requirements in digital construction projects. IOP Conference Series Earth and Environmental Science. 1101. 10.1088/1755-1315/1101/9/092024.

Among these methods, the Information Delivery Specification (IDS), is a standard currently developed by buildingSMART International. It allows the definition of information requirements that can be interpreted by humans but are also machine-readable. IDS defines how objects, classifications, properties, values, and units need to be delivered and exchanged. This can be a combination of Industry Foundation Classes (IFC), Domain Extensions, and additional classifications or properties. This is one standardized method to define your Level of Information Need (LOIN).

3.2 Geometry representation

Geometry description

"[…] there are two contradictory ways to define the geometric representation: on one hand (structural analysis domain), the member is limited by two nodes; on the other hand, an **IfcLocalPlacemen**t is used and for instance an extrusion along a given direction on a given length. To manage these two domains in a consistent way could be easily a nightmare. To solve this problem, the geometry description of the IfcProduct should be derived from **IfcStructuralCurveMember** geometry, thru an extrusion along the member axis, completed by Boolean operations at the ends."

In the version 4.3.1 of IFC, the geometry description of an **IfcProduct** is not derived from **IfcStructuralCurveMember** geometry. Indeed, the geometric representation of an **IfcProduct** is provided by an **IfcProductDefinitionShape**.

3.3 Structural analysis

Inconsistency related to different authoring tools

"Regarding a structural analysis model, an **IfcStructuralCurveMember** entity is linked to an **IfcStructuralPointConnection** entity at each end. This relationship is described by an **IfcRelConnectsStructuralMember**.

In parallel the associated shape representation is described by attributes. To ensure the same coordinates, the example provided in IFC4 documentation uses the same **IfcCartesianPoint**, which is not possible if the data providers are different."

We see here the limit of IFC exports from different authoring tools, in order to federate models. It is imperative to readjust all the models defined in relation to their own **IFcCartesianPoint** in the common coordinate system, by manually keying the correct values.

Structural analysis model

"The third problem to be solved is the close link between the architectural model and the structural analysis model. On one hand there is a model defined by an assembly of components defined relatively to a local axis system implemented in the global model. The components are derived from IfcRoot, but the local axis system is just an attribute of the entity as the shape representation. On the other hand, there is a model defined by nodes derived from IfcRoot and members derived from IfcRoot and connected to nodes."

The **IfcStructuralAnalysisModel** is used to assemble all information needed to represent a structural analysis model. It encompasses certain general properties (such as analysis type), references to all contained structural members, structural supports, or connections, as well as loads and the respective load results. Functionalities for the description of an analysis model are derived from existing IFC entities:

- From **IfcSystem** it inherits the ability to couple the built system via **IfcRelReferencedInSpatialStructure** to one or more **IfcSpatialElement** subtypes, as necessary.
- From **IfcGroup** it inherits the inverse attribute **IsGroupedBy**, pointing to the relationship class **IfcRelAssignsToGroup.** This allows the grouping of structural members (instances of **IfcStructuralMember**) and supports (instances of **IfcStructuralConnection** which belong to a specific analysis model.

Besides, IFC4 integrated an additional attribute *SharedPlacement,* allowing for easy retrieval of the common object placement and for specification of the analysis model's coordinate system before any structural item.

3.4 Design information

Design traffic volume

During the first season of the MINnD project, it was identified that "if the bridge spans over a road, it is important to know the associated volume of the road passing under" (extract from MINnD S1 deliverable "IFC-Bridge State of the Art & Missing Concepts").

The traffic volume used for planning and design purposes can be specified as the number of vehicles per day (AADT – Average Annual Daily Traffic) using the ***DesignTrafficVolume*** property of the property set ***Pset_RoadDesignCriteriaCommon***.

Skew angle

During the first season of the MINnD project, it was underlined that "in general there is a skew angle between the two alignments [of the carried road and the crossed road] which impacts the shape of bridge supports" (extract from MINnD S1 delivery "IFC-Bridge State of the Art & Missing Concepts").

In IFC 4.3, an ***IfcAlignmentHorizontal*** is a linear reference projected onto the horizontal x/y plane. The horizontal alignment is defined by segments that are connected end-to-start, using ***IfcAlignmentHorizontalSegment***. The direction of the tangent at the start point of the segment is given by the property **IfcPlaneAngleMeasure**. Then, the skew between alignments of the carried road and the crossed road can be assessed.

Clearance and support locations

During the first season of the MINnD project, it was underlined that "a volume should be added if clearance is included to guarantee a clash free traffic with the bridge seen as an obstacle. [...] In addition, there could be constraints (to be expressed again as gauges or calibres) regarding the support locations at ground level due to soil conditions or spaces already occupied by other facilities. This means that out of the environment that can be described without semantics at all, some elements need to have a proper definition with envelopes and possibility of relations through gauges with elements of the bridge" (extract from MINnD S1 delivery "IFC-Bridge State of the Art & Missing Concepts").

In IFC 4.3, a virtual element is a special element used to provide imaginary, placeholder, or provisional areas, volumes, and boundaries. Virtual elements are usually not displayed and do not have quantities, associated materials, and other

	measures. They can be defined with **IfcVirtualElement**. For example, a placeholder for the necessary space allocation for future civil elements or to guarantee clash-free traffic can be exchanged using the **PredefinedType = CLEARANCE**.

Ground	"To build a bridge means necessary cuts and fills to connect the existing surrounding terrain […] the earthworks needed for the bridge must be described. […] Ground entities should be able to define the modifications of the existing terrain, including ground cutting for the piles, ground excavations for the footings, embankments for the approach structures…" In version 4.3 of IFC, **IfcEarthworksElement** allows defining a type of built element created by earthwork activities to build subgrade, to raise the level of the ground in general, reinforce, or stabilize soil by some mechanical or chemical method. On the other hand, **IfcEarthworksCut** allows defining the resulting void from modification of existing terrain or road structure by excavation or by other means of removing material.

3.5 Other information

Construction sequence	"[…] properties and quantities could be associated to the entities, 4D viewers could show the different sequences of the construction. " The construction sequence of a bridge project can be described with IfcTask. A task may nest other tasks as sub-items; the nesting relationship is modeled by **IfcRelNests** as shown in the Figure Fig.8 below.

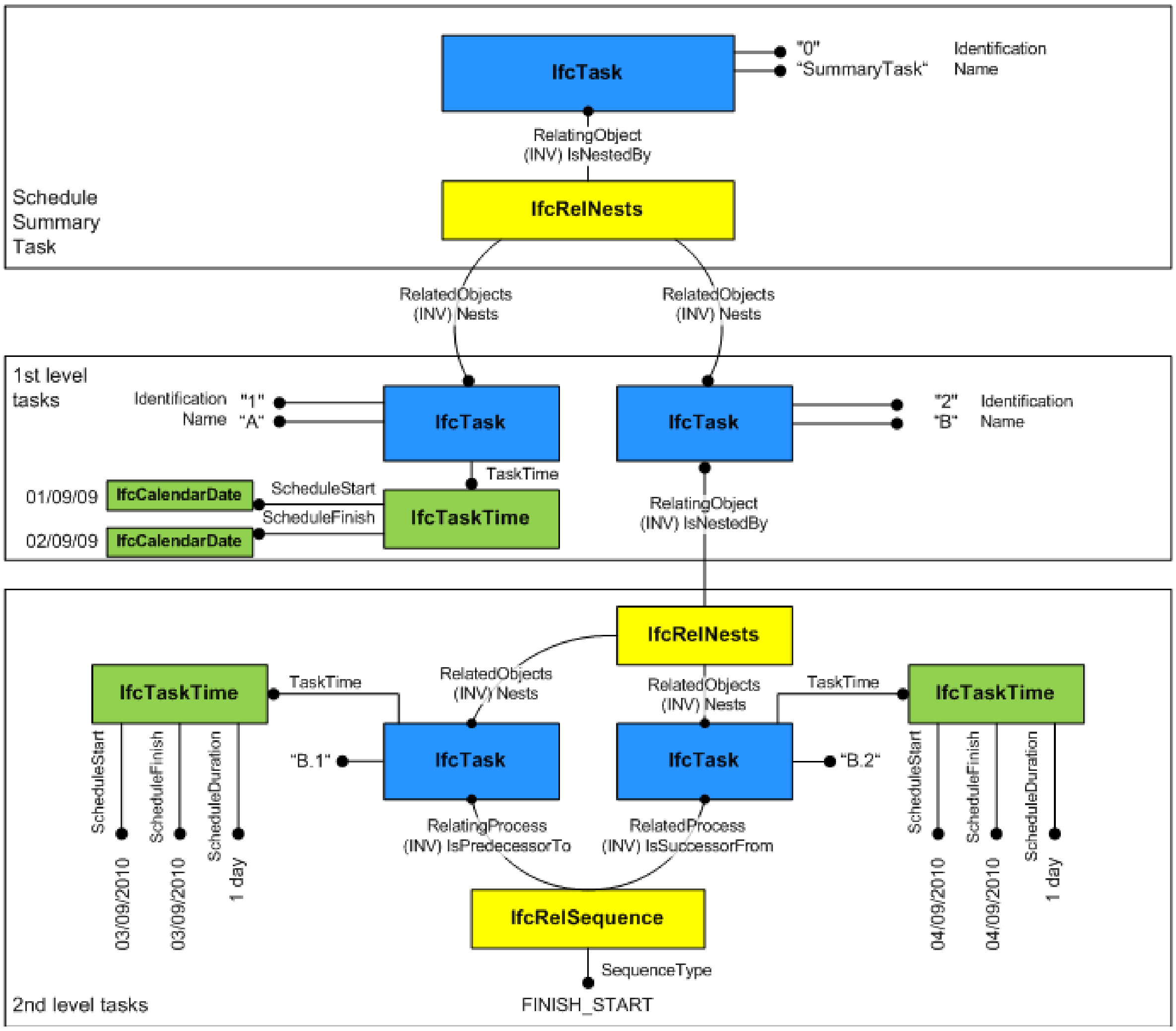

Fig.8 : Task nesting relationships (buildingSMART International)

The relationship **IfcRelSequence** can be used to indicate control flow. An **IfcTask** following another **IfcTask** indicates logical sequence on how these tasks should be performed.

Temporary works

"Last, but not least the bridge construction will surely require temporary works and structures (sheet piling, cofferdam, dams, additional supports, etc.)."

The **IfcResource** entity contains the information needed to represent the costs, schedule, and other impacts from the use of a thing in a process. As suggested by bSI, construction equipment such as earth-moving vehicles or tools, which are not currently modeled within the IFC, can be represented using subtypes of **IfcResource**.

Owner history

"We must keep in mind that data described in attributes should only be used by one entity only but should be addressable indirectly via the entity. All entities derived from IfcRoot have an owner history attributes. That is not the case for attributes, particularly regarding geometry description. Therefore, changes cannot be traced!"

IFC 4.3 class **IfcOwnerHistory** defines all history and identification related information. It is directly attached to all independent objects, relationships, and properties. However, it seems that only the last modification can be stored.

4. Conclusions

Concluding remarks

This document aimed to compare recommendations from MINnD season 1 with the version 4.3.1 of IFC schema, submitted to ISO as a draft international standard.

Overall, the version 4.3.1 of IFC schema meets the requirements stated during the first season of MINnD. However, regarding geometry representation and structural analysis, careful consideration should be given to the export and federation of models as definition issues could arise.

Besides, a specific focus was on verifying that IFC 4.3.1 could handle properly the exchange requirements on alignment of a linear infrastructure. Conclusions are drawn below.

Exchange requirements

An appropriate information exchange between the bridge domain and road/rail domain is necessary during the design process, particularly regarding the alignment. The latest version of IFC schema (4.3.1) can meet this crucial requirement for linear infrastructures. Besides, ABRV project will provide additional documentation on this matter to ensure that the software implementation of IFC4.3 meets the needs of bridge domain regarding alignment.

5. ANNEXE A - REMINDER ABOUT THE DIFFERENT BRIDGE TYPES

5.1 Typical Bridge

Scope

Small bridges are built to allow an infrastructure to cross another one at a different level.

Road/rail data required by bridge designers

The data required by bridge designers from road/rail designers are:

- Bridge axis;
- Crossed Road/rail axis;
- Clearance height;
- Width or opening.

Bridge or road/rail axis are contained in a digital file, for example of type LandXML.

```xml
<?xml version="1.0"?>
<LandXML xmlns="http://www.landxml.org/schema/LandXML-1.2" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schem
    <Units>
        <Metric areaUnit="squareMeter" linearUnit="meter" volumeUnit="cubicMeter" temperatureUnit="celsius" pressureUnit="
    </Units>
    <Project name="D:\DATA\A.LEDAN\Documents\Personnel\CloudStation\MS BIM\THESE\01_PRODUCTION\IFC\OA.dwg"></Project>
    <Application name="AutoCAD Civil 3D" desc="Civil 3D" manufacturer="Autodesk, Inc." version="2018" manufacturerURL="www
    <Alignments name="">
        <Alignment name="Axe en plan Retablissement" length="88.92285249969" staStart="41.91255" desc="">
            <CoordGeom>
                <Line dir="72.884546531311" length="88.92285249969">
                    <Start>146607.055779999995 482298.946844999969</Start>
                    <End>146692.040566000011 482325.116672000033</End>
                </Line>
            </CoordGeom>
            <Profile name="Axe en plan Retablissement">
                <ProfSurf name="Surface1 - Surface (2)" state="existing">
                    <PntList2D>41.91255 0. 107.519535673381 0. 130.83540249969 0. 130.83540249969 0.</PntList2D>
                </ProfSurf>
                <ProfAlign name="Profil en long Retablissement">
                    <PVI>52.885 199.32</PVI>
                    <PVI>92.885 198.92</PVI>
                </ProfAlign>
            </Profile>
        </Alignment>
        <Alignment name="Axe en Plan Section Courante" length="1879.825206838658" staStart="5013.13145" desc="">
            <CoordGeom>
                <Line dir="340.238179599783" length="1879.825206838658">
                    <Start>147116.257360999996 480970.174690999964</Start>
                    <End>146480.668005999993 482739.290001000045</End>
                </Line>
            </CoordGeom>
            <Profile name="Axe en Plan Section Courante">
                <ProfSurf name="Surface1 - Surface (1)" state="existing">
                    <PntList2D>5013.13145 0. 6733.751697175911 0. 6892.956656838658 0. 6892.956656838658 0.</PntList2D>
                </ProfSurf>
                <ProfAlign name="Profil en long Section Courante">
                    <PVI>6182.054999999993 186.516999999993</PVI>
                    <ParaCurve length="622.642999999982">6493.376499999984 198.403134545281</ParaCurve>
                    <PVI>6804.697999999975 186.059000000008</PVI>
                </ProfAlign>
            </Profile>
        </Alignment>
    </Alignments>
```

Fig.9 : LandXML file example

Data exchange

With this data, designers are then able to determine the further information, which can be used to check that road/rail designers and bridge designers use the same data set:

- the coordinates of the intersection of horizontal alignments
- the axis parameters at this position.

An exchange document, containing this information is usually shared with the data set.

Data set illustration

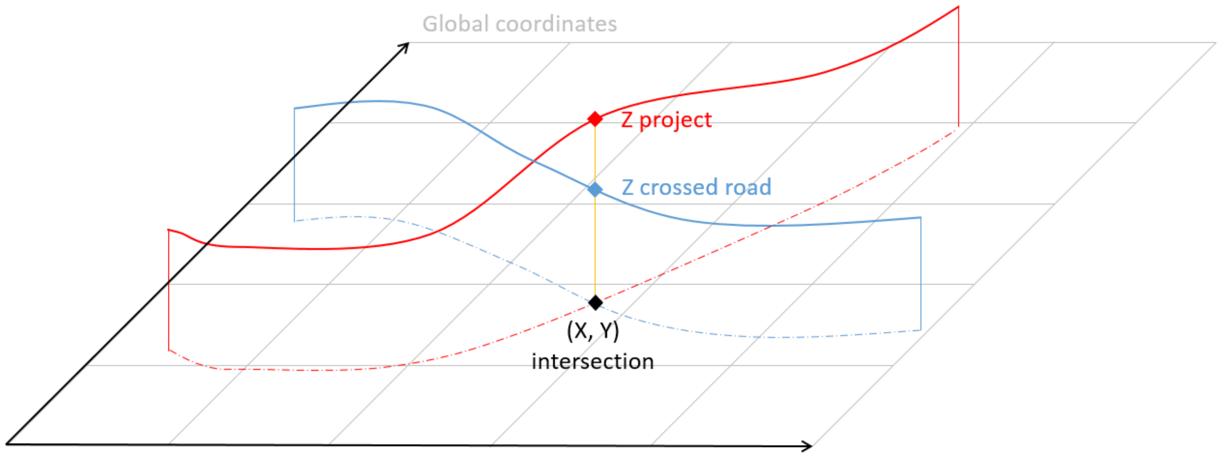

Fig.10 : Project and crossed road 3D axis

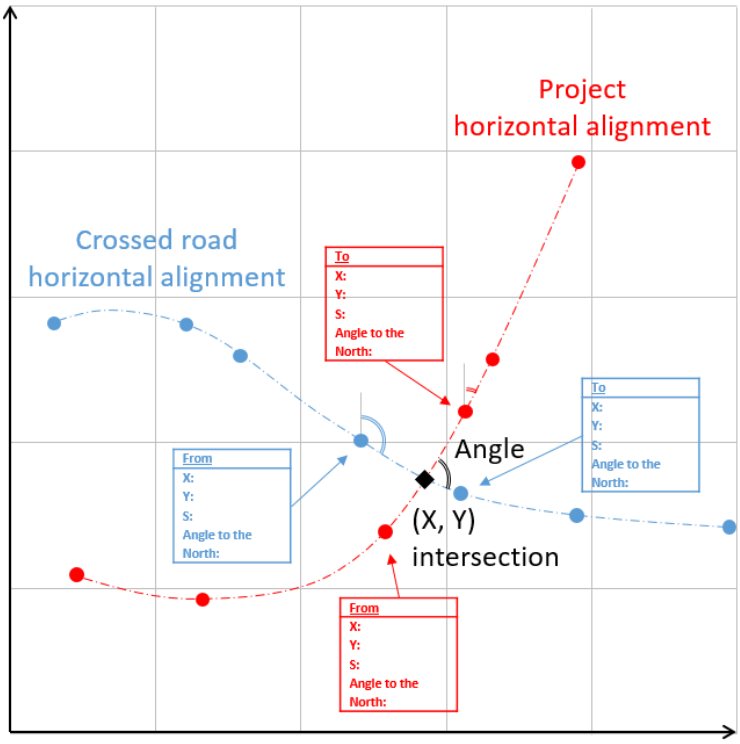

Fig.11 : Horizontal alignments

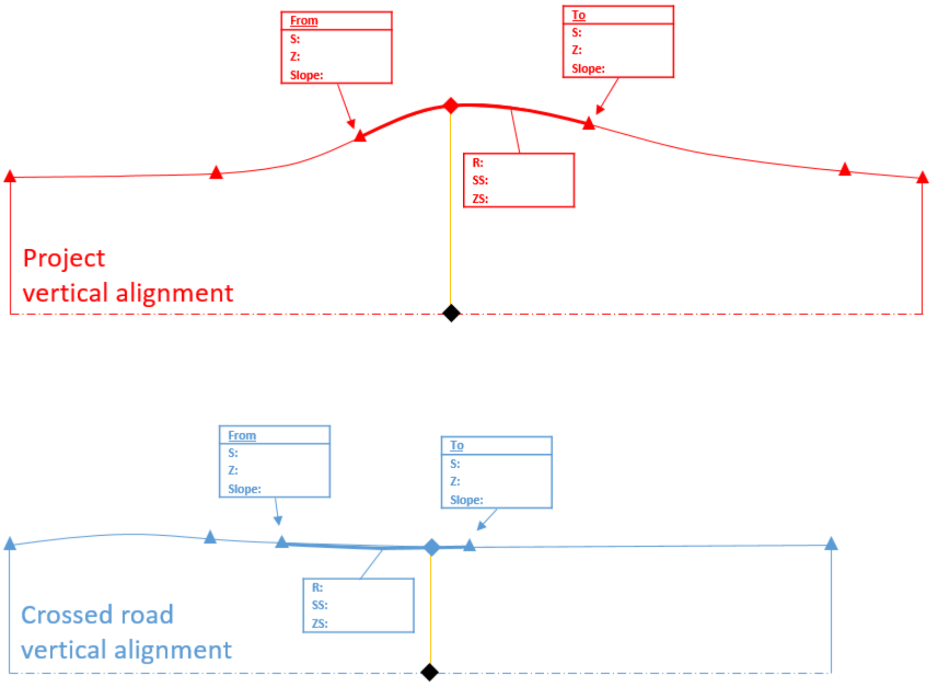

Fig.12 : Vertical alignments

Exchange requirements / Exchange document A bridge model should contain the information summered in the following exchange document (**Fig.13**)

Project name:	Exchange document	Bridge id.:
Date: Version: Modification object:		Bridge design office Written by: Checked by:

Town: From town of crossed road: To town of crossed road:	Bridge type: Clearance height: Width or opening:

Intersection Angle: X: Y:	**Intersection in project** PK: Z:	**Intersection in crossed road** PK: Z:

Project

Horizontal alignment

Element type: Length:		
From	**To**	
X: Y: S: Angle to the North:	X: Y: S: Angle to the North:	R: XC: YC: X Y: PAR: Angle to the North:

Vertical alignment

Element type: Length:		
From	**To**	
S: Z: Slope:	S: Z: Slope:	R: SS: ZS:

Crossed road

Horizontal alignment

Element type: Length:		
From	**To**	
X: Y: S: Angle to the North:	X: Y: S: Angle to the North:	R: XC: YC: X Y: PAR: Angle to the North:

Vertical alignment

Element type: Length:		
From	**To**	
S: Z: Slope:	S: Z: Slope:	R: SS: ZS:

Fig.13 : Exchange document example

5.2 Non-typical and long-range Bridges

Scope	Long bridges are built for example to cross a whole valley.

Road/Rail data required by bridge designers	The data required by bridge designers from road/rail designers are: • Bridge axis; • From location; • To location. Bridge axis is contained in a digital file, for example of type LandXML. Bridge designers can then determine in different coordinate systems: • The supports position

Particular cases

Bridge axis different from road rail/axis	Sometimes, the bridge axis can be different from the road/rail axis. Bridge axis refers to the structure whereas road/rail axis refers to the linear infrastructure.

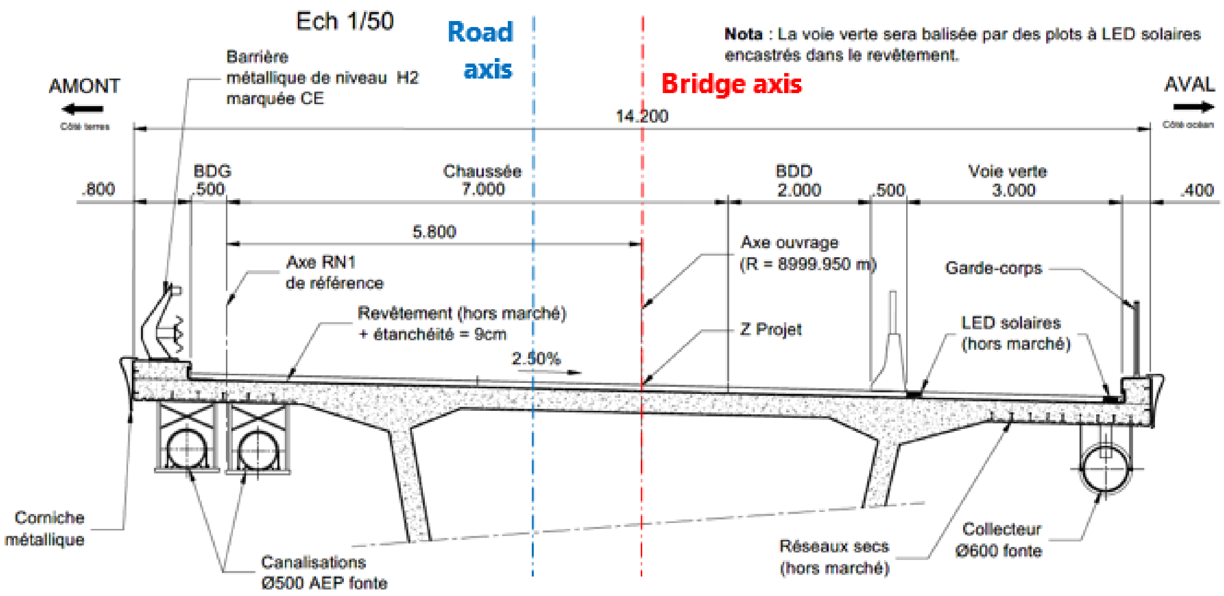

Fig.14 : Exchange of a bridge axis different from the road axis

When the bridge is curved, the distance between two stations along the bridge axis is different from the difference of stations (as shown on Fig.15)

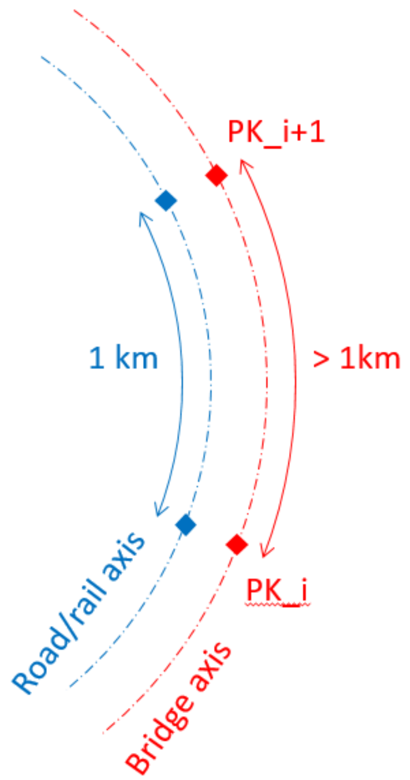

Fig.15 : Illustration of a bridge axis different from road rail/axis (horizontal alignments

Inclination and slope	Sometimes, because of inclination and slope, global coordinates (X, Y) of a support position are different from global coordinates of the point with the same station on the bridge axis.

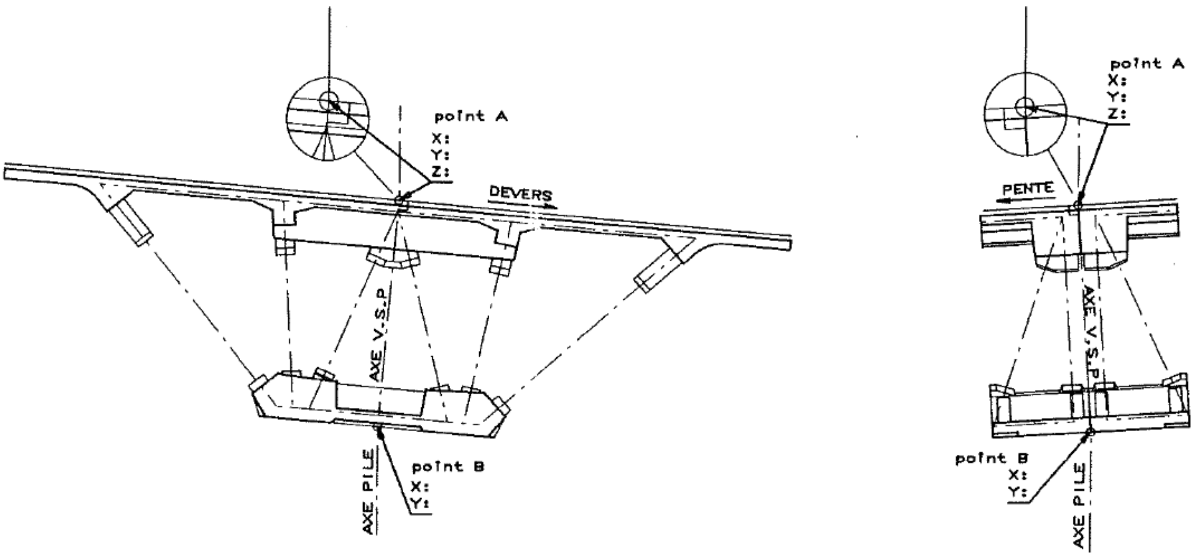

Fig.16 : Example of a bridge with inclination and slope: Point A is on the bridge axis & Point B refers to real supports position