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Development and performance of model checks

Deliverable Other D5.3: Methods and tools for rule-based model checking and data

Deliverable Report: D5.3 (accompanying report), issue date on 31.10.2021

BIM-SPEED
Harmonised Building Information Speedway for Energy-Efficient Renovation

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Development and performance of model checks

D5.3: Methods and tools for rule-based model checking

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Produced by	HOCHTIEF ViCon GmbH
Main author	Jessica Steinjan (HTV)
Co-authors	Jan-Derrick Braun (HTV)
Contributors	CARTIF, CYPE
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Reviewed by	Nadya Stamatova (ASP), Nicolas Pastorelly (CSTB)
Approved by	Timo Hartmann (TUB)
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Publishable executive summary

Deliverable 5.3 is a result of Task 5.3, in which methods and tools for rule-based model checking will be evaluated and defined. The outcomes of these model checks should become part of the regular process when uploading data to the BIM-Speed platform. This deliverable presents the methods and tools for rule-based model checking and data validation according to the defined extract, transform and load (ETL) processes, and the outcomes of the evaluation of the selected real demonstration cases (in conjunction with WP8) to ensure the compatibility and interoperability of the data to be uploaded to the BIM-SPEED Platform (WP6).

Starting this report by explaining the underlying approach to setup methods for model checking, the subsequent chapters are defined as inventory, definitions and demonstration:

- Chapter 1 of this deliverable describes the need of inventorying the required data and information, which will define the constraints to perform model checks on a regular basis. It will also give a brief overview of available software to be used to perform model checks.
- Chapter 2 describes the different kinds of checks, which will be used in the BIM-Speed project. It gives an explanation of what are semantical-, numerical-, geometrical-checks and introduces additional validation methods like the deviation analysis. This chapter gives an overview of how to define working model checks.
- Chapter 3 finally provides a demonstration of the model checking methodology and evaluates the several verification methods on BIM-Speed demonstration projects. It provides examples and detailed information on the evaluation methods.

This report is written in a general way to provide the whole picture and a complete overview of the model checking methodology. When it comes to more details, several guidelines to perform the mentioned model checks will be placed in the annexes to provide step-by-step manuals and to guide the interested reader.

While deliverable D7.3 is focusing on semantic design rules and how to break them down to model requirements and therefore modelling rules, this deliverable D5.3 takes over and describes how to define and setup model checking rules for model verification. It describes the usage of model validation tools, which have been performed on several demonstrator projects.

Deliverable D5.3 is of type 'other', which means that it is not a document but a set of several general model checks and pre-defined roles, tools and elaborated processes to be implemented into the BIM-Speed platform. Therefore, this document is created accompanying several model-validation tools to explain the functionalities and the process steps behind them.

List of acronyms and abbreviations

BEP:	BIM Execution Plan
BEM:	Building Energy Model
BG:	Bulgaria
BIM:	Building Information Model
CPA:	packed project file of Desite BIM
e.g.:	for example
ES:	Spain
ETL:	Extract, Transform, Load (process)
HTV:	HOCHTIEF ViCon GmbH
IDM:	Information deliverable plan
IFC:	Industry Foundation Classes
IT:	Italy
LIC:	Location Identification Code
LOD:	Level of Detail
MEP:	Mechanic Engineering Piping
MIDP:	Master Information Deliverable Plan
NL:	Netherlands
PIC:	Plant Identification Code
PL:	Poland
PBS:	Project Breakdown Structure
QC:	Quality Checks

Definitions

Business process

The Business Process describes the general task to be done in the design and construction phase to reach the Renovation Goal, e.g. energy analysis.

BIM use case

The BIM Use Case complies with BIM requirements. That means the **Business Process** is broken down into detailed use cases and automated processes and/or data analysis are implemented, e.g. BIM based energy analysis.

Clash Detection

Clash detection is a method of checking BIM model elements for the geometric intersection. The method is used in the context of BIM coordination and aims to avoid collisions.

Deviation Analysis

Deviation analysis is a method in which a BIM model is checked for geometric correctness. Specifically, the model is compared with a point cloud of the as-built state to identify possible deviations.

ETL Process

The ETL (extract, transform and load) process involves several individual steps through which data from different data sources can be loaded into a common database by means of extraction and transformation.

Model Checking

The procedure of model checking verifies the BIM model system description against a specification.

Contents

Approach

Work Package 5 focuses on developing interoperable solutions and providing input for standardized BIM use cases in the required quality and quantity with the aim to ease a harmonised way for collaboration between different project partners in a renovation project. To provide relevant data via BIM methodology the information as well as the 3D models have to be verified.

The first key aspect is to identify the required information, which must be extracted, transformed, prepared and provided for the BIM data exchange. The base for this knowledge are the outcomes of Work Package 1, which defined the data to be collected to perform specific use cases. To be able to forward these information correctly and to enable a smooth data flow, it has to be guaranteed that the information are accessible. The validation of quality, quantity and correctness of the data is therefore mandatory and should be realized by performing model checks.

Additionally, the requirements towards 3D models, which are defined by the use cases, will become part of the modelling guidelines defined in task T2.3. To verify and guarantee that these requirements are met and therefore the use cases will be performed properly, the focus of this deliverable D5.3 is to validate the 3D models against the modelling guidelines.

The general approach defines the setup of model checking rules in three main process steps, which will be described in detail in the following chapters. There will be given a general overview on technologies, in particular available model checking software on the market and their functionalities, but also an insight of the analysis of the process to perform the BIM use case "Model Checks" itself.

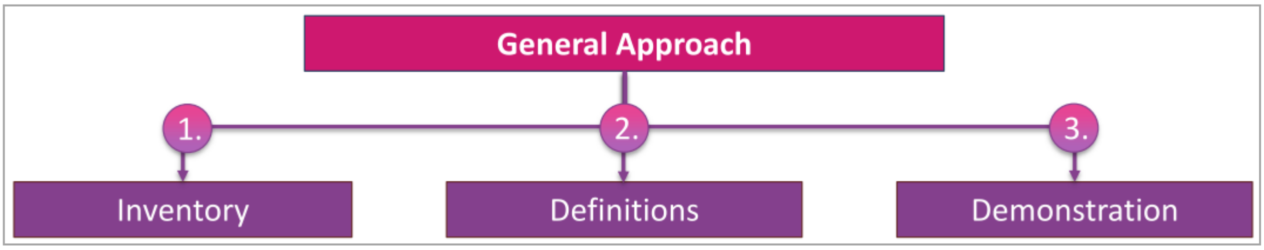


Figure 1 - general approach task 5.3

Step 1 "Inventory"

will identify relevant requirements for the 3D models (3D model elements, attributes, structuring). Additionally, model check software including their functionalities, which cover the consideration of main aspect technologies, will be identified. The preparation to set up model checks, assumes collecting relevant information of the inventory (e.g. input data and their formats, additional attributes and their acceptable values, tolerances/exceptions...) and defining the project or use case specific requirements.

Step 2 "Definitions"

will identify the relevant quality checks for the BIM use cases to be performed on BIM Speed projects. This will include the analysis of the model check process itself, which takes place in close coordination with task 7.2. Based on the inventory and identified requirements, a validated software for model checking will be chosen and rules for model checking can be setup. Once the preparation is complete the execution of the model checks follows. Compiled rules can be implemented and performed in the model checking software.

Step 3 "Demonstration"

will verify and demonstrate this methodology of model checking on demo site projects. The results of the model checks have to be categorized and verified. If all checks have been performed, categorized and verified, the results are ready to be evaluated. The aim of the evaluation is to estimate whether further use cases can be performed based on the 3D model or not.

Having a verified 3D model will reduce cost and time because mismatch and errors can be identified before the projects come to construction and on site. Additionally, the verification of attached energy efficient data will increase the possibilities to set up the BEM process. In the end this could lead to a reduction of energy loss and therefore also to benefit for the inhabitants comfort.

This use case "Model Checks" will be documented as BIM-SPEED standard in the building SMART Use Case Development definition.

Summarized the main activities in task 5.3 are

- To identify the relevant requirements against which information and data have to be validated and verified;
- To define suitable model checks and verification methods (incl. Setting up validation processes and workflows);
- To set-up model checks and verify the validation process; to extend IDM to include additional validation model checking, such as the proper naming of elements in the model, categorisation of elements, size of models;
- To perform model checking and validation of the BIM and other data models from the real demonstration cases (in conjunction with WP8).

1. Inventory

3D models need to fulfil all requirements coming from the intended BIM use cases to achieve the objectives of renovation projects. To ensure the correctness of a 3D model, which should support these BIM use cases, it is necessary to perform model checks, thereby errors or mismatches can be detected early within the design process. Generally, model checks should ensure the following objectives:

Guarantee	that the results of calculations are correct and further work steps can be processed correctly based on the information contained in the model
Reliability	that all relevant information is verified and can be accessed correctly
Time savings	through automated testing and avoiding repeating coordination issues

The intention of the first process-step "inventory" is to identify requirements to guarantee smooth workflows of specific BIM use cases. Therefore, the process starts by defining the BIM use cases to retrieve the relevant requirements towards information and/or towards 3D models. These requirements will be specified in **modelling guidelines** (see D2.4: Guidelines for as-built BIM modelling of existing buildings) to enable the setup of model checks. All relevant data should be checked against the definitions given in those guidelines to validate whether the data and 3D models are able to cover the requirements of the BIM use cases. Therefore, this inventory is mandatory to enable model checking and to guarantee the correctness of data and 3D models uploaded to the BIM-SPEED platform.

The following items are most relevant for the inventory process:

- ***BIM Use Cases*** (relevant use cases to be verified by task T5.3)
  Requirements regarding information and 3D models will be retrieved from those BIM use cases.
- ***Modelling Guidelines*** (definition on how the model has to be created)
  Identified requirements (e.g. naming, structuring, granularity, information) have to be listed and specified in the modelling guidelines to enable model checking. Without any clear definitions on how models and information must be specified, it would not be possible to define model checks.
- ***Model Checking Software***
  To decide later on, which tool should be used to perform specific model checks, there is the need for an overview about which software is available to perform those checks and which functionalities do they provide.

1.1 BIM Use Cases

The basis for the BIM Use Case analysis is the list of use cases, elaborated in task T4.1. Not all of these use cases require a 3D BIM model to be performed. But there are some, which cannot be set up without a 3D model, these are the so called “BIM use cases”. Beside a 3D model, these BIM use cases require specific data and information, to be performed. These requirements have been put together within Work package 1 into an inventory table helping to understand the required data and information.

In task T5.3 the focus has been set to these BIM use cases, which require 3D elements and which are aimed at refurbishment processes.

The following use cases have been chosen to explain the process of model checking in task T5.3, in detail:

- Energy analysis of existing buildings
- Planning and visualization of renovation measures
- Cost calculation
- Performance prediction / Energy analysis of renovation measures

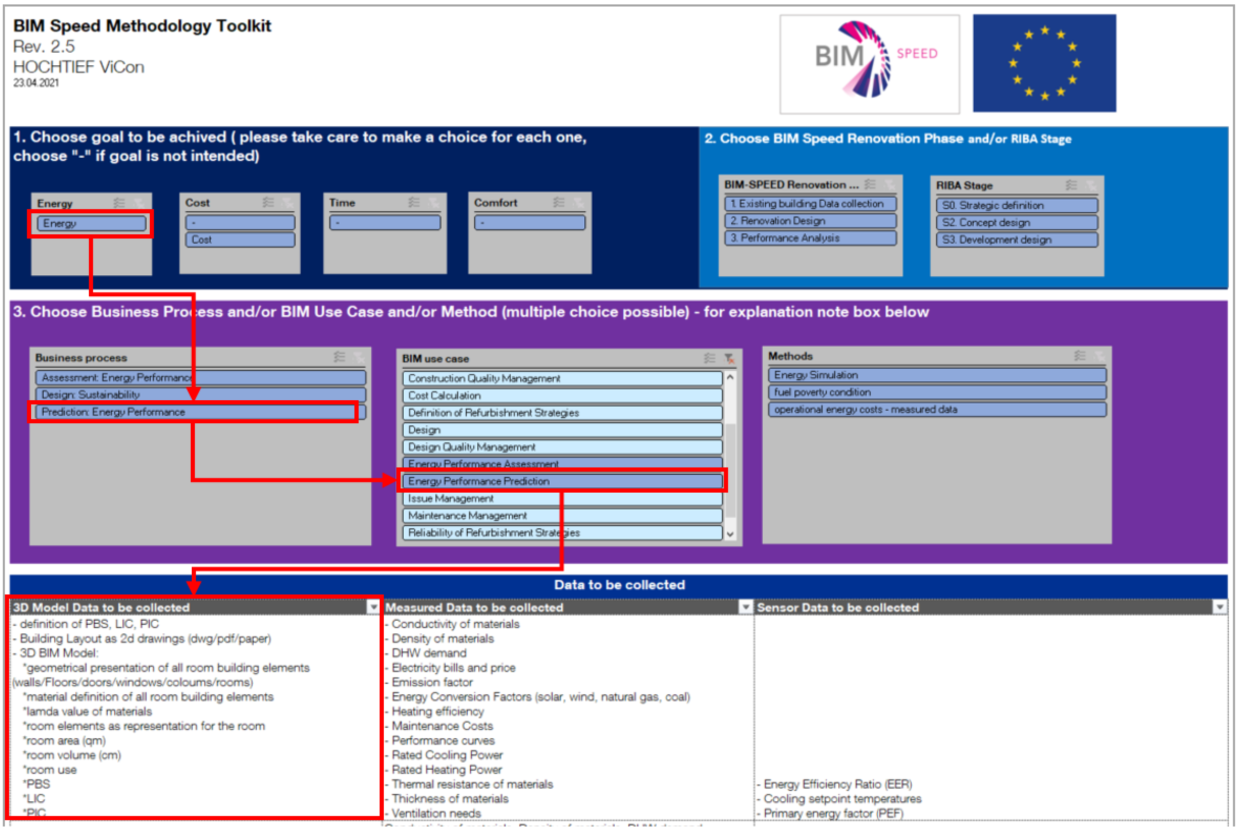


Figure 2 - BIM Speed Methodology Toolkit – Use case example for “Performance prediction / Energy analysis of renovation measures

The inventory table generated within Work package 1 has been translated into a BIM Speed Methodology Toolkit, which enables the user to clearly identify the required data to perform above mentioned use cases. Summarized for these selected BIM Use cases the requirements are the following:

- Definition of Project Breakdown Structure (PBS), Location Identification Code (LIC) and Plant Identification Code (PIC) and existence of corresponding attributes within the 3D model
- Geometrical presentation of all room building elements (walls/floors/doors/windows/columns/rooms)
- Room area (m^2)
- Room volume (m^3)
- Point cloud (if available)
- Attributes for energy analysis (Air Tightness, Heat Transfer, Thermal Resistance, Sound pressure level, Energy Consumption, etc.)
- Material definition for all model elements, including thickness and additional description information/values

1.2 Modelling Guidelines / 3D models

Modelling guidelines are most important to specify the way models have to be created to match all requirements for BIM use cases. To enable all persons involved in the design and 3D model creation process to match the given requirements, the participants have to be aware of relevant guidelines and standards to be respected. This includes country specific building regulations, general superordinated ISO Standard documents and also project specific regulations. The BIM Speed modelling guidelines (elaborated in Work Package 2) must be part of documents to be checked against as well. Awareness about all these guidelines and regulations is most important to enable an effective way to define model checks and to verify that BIM models are matching all these guidelines in a sufficient way. Therefore, inventorying all relevant guidelines and regulations is the most important approach.

In addition to the general modelling guidelines developed in WP2, more specific modelling guidelines have been defined for each software that requires them. These guidelines have been included in each deliverable where the use of the tool has been explained. This is the case of the BIMtoBEPS tool, which has an internal checker to validate if the materials of each layer of the walls includes their thermal properties. If these properties are not included, the tool launches a process to enhance the IFC with these parameters, using the user's support. More information can be found in D3.2- A set of support tools and standardized procedures for BEM creation and in D5.2- BIM Connectors for interoperability between different BIM tools and with the BIMSPEED Platform.

For implementing BIM use cases a clear structuring and definition of the required 3D models are needed. Therefore, Project Breakdown Structure, Naming Convention, Granularity of BIM Model Elements and Attributes have to be defined in modelling guidelines.

Project Breakdown Structure

At the beginning of a project a discipline and phase comprehensive Project Breakdown Structure (PBS) must be implemented. The PBS splits the whole project into meaningful parts according to the structure of the project. The 3D model has to respect and follow this PBS.

Naming convention

The key aspect of standardized information management is a consistent naming convention. This naming convention has to be mandatory for all used data and information. This comprises not only the file naming, but also naming for all used data within a 3D model: levels, zones, materials, layers, attributes, and of course model elements themselves.

Granularity of BIM Model Elements

To perform use cases based on geometry it is mandatory that all model elements are created as 3D solid elements and represent the real dimensions of the element in real life. Another compulsory requirement is to model the elements exactly as the type of element that it represents in real life. A column must be a column, a wall has to be a wall, etc. False application will lead to wrong attachment of property sets while exporting into an IFC file and therefore deliver wrong data.

Attributes

Attributes are non-geometrical information that are added to the 3D model elements and important providers of additional data related to specific elements. Not only additional information and descriptions are commonly represented by attributes, but also information about manufacturer, maintenance, delivery, costs, etc. Attributes represent the Level of Information (LOI) for each 3D element. A clearly defined list of attributes, including data type definition and allowed values should be provided elementwise and per phase at the beginning of a project.

For the BIM Speed project (in close coordination with task 7.2) a Revit Shared Parameter file with all required attributes will be provided. Such a template has also been created for user defined BIM Speed property sets.

Implementing model checks all above mentioned requirements can be verified:

- Structuring and Partition of 3D models
- Granularity of 3D model elements
- Naming convention conformance
- Existence, Completeness and Value of Attributes

For more Details on 3D model structuring, naming convention, 3D model elements and attributes, please regard Appendix 001 – Structuring 3D Models.

1.3 Model Checking Software

There are numerous software and/or Add-Ins for CAD Applications on the market. Each software provides its own advantages and disadvantages. Some are fee based and some are free. The decision about which is the best or the more suitable software depends on the availability, but also on the preferences and behaviours of the person who will use it. The following chapters will list available Model Checking Software on the market and outline the highlights and intended application.

Overview of Model Checking Software

For this investigation market-leading software has been identified. One main criteria of decision was the ability to manage huge 3D models without performance issues.

The preselected software listed below, provide a 'free of charge' version with the minimum of a 3D model viewer component and a 'fee-based' version with a greater functionality. The schedule below outlines main features and specifies, whether the application can be used just for geometry checking or includes also functionalities to access properties (information).

Vendor	Product - Free Version	Product - Fee-Based Version	Used Version within BIM SPEED project	Features	Specification	
					Geometry	Information
Autodesk	Autodesk Navisworks - Freedom	Autodesk Navisworks - Manage	n/a	• Clash Detection • Possibility to import large amount of different non-proprietary and native model data formats • BCF-Workflows are only supported when using a plug-in, for the free version a BCF-workflow is not supported at all even when using a plug-in • With the free version „Freedom" no redlining function for commenting on models is included • Intuitive handling and navigation of the model, showing attributes and	x	
thinkproject	n/a	Desite BIM	Version 2.8	• Possibility of individually configurated rule-based model checking (only in DESITE MD) • New attributes or calculated attributes can be added (only in DESITE MD) • Integration of external data sources to show BoQs and room information • Intuitive handling and navigation of the model, showing attributes and room information etc.	x	x
Nemetscheck	Solibri Anywhere	Solibri Model Office	n/a	• Provides a large data base of predefined checking rules and automated review • No possibility to create or show a 4D construction sequence visualisation • Only IFC-Format and DWG-Files can be imported • Intuitive handling and navigation of the model, showing attributes and room information etc.		x
Leica	Cyclone 3DR Viewer	Cyclone 3DR	Version: 2020.0.6.35838	• All-In one solution for point cloud analysis, management and modelling • Full interoperability with common design formats, including IFC and Revit model files • No free version, only test versions available	x	
KUBUS	BIMcollab ZOOM Free	BIMcollab ZOOM	n/a	• Check pointclouds agains IFC models • Clash Detection • Rule based property validation • Share Lists for Microsoft Power BI reporting and export information to Excel, CSV, PDF	x	x

Figure 3 - Overview Model Checking Software, Vendors and Features

Functionalities

After having an overview of available suitable software for model checks, a deeper look at the functionalities should provide a more detailed decision base. The given table (see below) lists different criteria, which have been investigated.

All applications have been tested to be able to ***handle huge models***. All listed software packages could do this without mentionable performance issues.

Additionally, different ***import and export formats*** have been tested. The main focus for the BIM Speed project has been given to the investigation of IFC file format, but also other common BIM use case related formats have been considered. It must be mentioned that some of the free version viewers failed in this concern.

Reporting functionalities of the software have been evaluated as well. Besides possibilities to measure elements or to use and save viewpoints, it is also necessary to be able to outline mismatches or errors in the 3D model so the author can get effective feedback about the violated rules.

Finally, a feature for ***verification of the existence of attributes*** is also required to check the value of an attribute against predefined requirements.

Listed below are also specific BIM use case related functionalities like the possibility to perform a 4D simulation, to generate a BOQ report and so on. For more details have a closer look at the table below. The following screenshot shows an extract of this elaboration. The complete list can be found in [Appendix 004 – Comparison of Software functionalities.](#)

Criteria for choosing a 3D Model Checking Tool

Criteria-ID	Explanation of criteria	Autodesk Navisworks Freedom free of charge	Autodesk Navisworks Manage fee-based	thinkproject Desite BIM fee-based	Nemetschek Solibri Model Viewer free of charge	Nemetschek Solibri Model Checker fee-based	Cyclone 3DR Standard free of charge	Cyclone 3DR Pro fee-based	BIMcollab ZOOM Free free of charge	BIMcollab ZOOM fee-based
B - Basic Information										
Performance	Handling of large models hase been done?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
D - Data, Interfaces & Output Options										
IFC-Import	Can 3D-Models be importet in IFC format?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
IFC-Version 2x3	Does the tool support IFC Version 2x3?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
IFC-Version 4	Does the tool support IFC Version 4?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
DWG-Import	Can DWG-Files be imported?	No	Yes	Yes	Yes	Yes	No	Yes	No	No
DWF(x)-Import	Can DWF- or DWFx Files be imported?	Yes	Yes	Yes	No	No	No	No	No	No
Non-proprierytary file formats	Which additional non-propriertary file formats can be imported?	-	.sat, .iges, .it, .stp, .step	.cpixml, .landxml, .vpxml, GAEB, .obj, .json, .csv, GIS-Data	-	-	.stl, .pbi, .dxf, .poly, .obj, .msh, VRML files	.stl, .pbi, .dxf, .poly, .obj, .msh, VRML files	-	-
Native file formats	Which native file formats from BIM autohring tools are supported?	-	.rvt, .skp, .3dm, .dgn, .model, .prt, div. Lasscanning-Formats, Scheduling-Formats	.3ds, Orthophoto, Scatter Plots, WebService	-	-	.rvt, div. Point cloud formats, .obj	.rvt, div. Point cloud formats, .obj	point cloud format E57	point cloud format E57
Model consolidation	Can several models be imported and consolidated in one file?	No	Yes	Yes	No	Yes	Yes	Yes	-	-
3D-Export	Can data be exported from the tool in an open 3D-format (e.g. STL, OBJ, FBX, COLLADA, 3DS, IGES; STEP, and VRML/X3D.) for further analysis?	No	Yes	Yes	No	No	Yes	Yes	No	No
XLS-Export	Can data be exported from the tool in an XLS for further analysis?	No	Yes	Yes	No	Yes	No	No	No	No
BCF-Support	Is it possible to create BCF-files with tool?	0	0,5	1	1	1	0	0	0	1

Figure 4 - Investigation on criteria to choose suitable software

2. Definitions

After the relevant information such as the requirements to perform selected BIM use cases, national regulations and specifications, modelling guidelines have been inventoried on one hand and on the other hand the available software and their functionalities, benefits and drawbacks have been identified, the next step is to define appropriate model checks and their related processes.

By defining an adequate model checking process for the BIM Speed project, suitable verification methods will be established.

Finally, at the end of this chapter common model checks for evaluating attributes, performing a deviation analysis and guides for applying clash detection will be provided.

2.1 Types of Model Checks

As mentioned earlier, there are different kinds of checks needed to verify a 3D model, these kinds of model checks have been divided into three categories**: semantical, numerical and geometrical** checks. The geometry has to be checked e.g. by doing a clash detection or a deviation analysis and verifying the granularity and consistency of the 3D model elements themselves. Additionally, the integrated and attached data and information need to be approved as well. This validation and verification is done by semantical and numerical checks.

The semantical check approves the consistency of the 3D model elements, such as choosing the right category for model generation, following the naming convention, availability of attributes, etc. Whereas numerical checks, in approve the value of the entered information. This means, it will be checked, whether the value of a specific attribute is correct regarding the threshold of values (e.g. Does the thermal transmittance has the correct value? Does it use the correct units?). Finally, the geometrical check will validate the geometry of the 3D model elements themselves and geometrical relationships to other elements. The following sketch gives an overview and outlines examples for the check types.

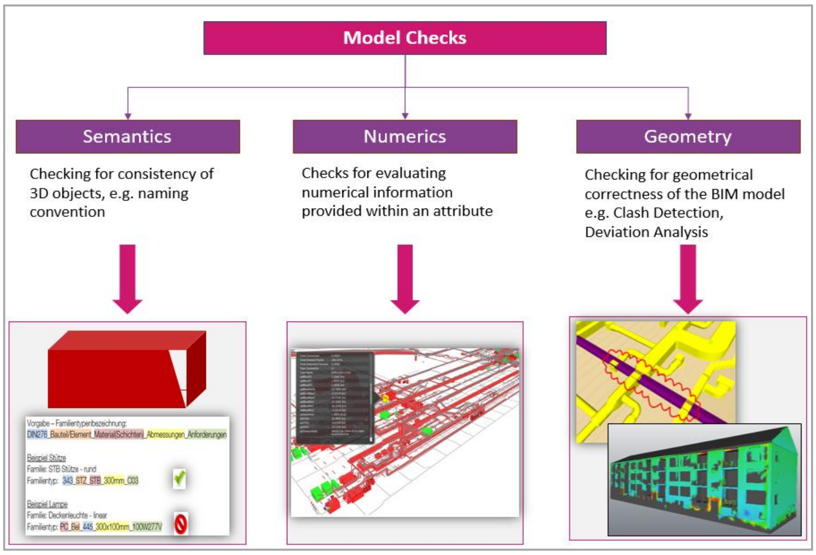


Figure 5 - Overview of Model Check definitions

Semantical Checks

Semantical checks verify the consistency of the elements. That includes checking the nature of the elements as it might be, that some of the shown elements in the model are not real 3D elements. Additionally, the existence of all needed attributes will be verified and finally, all the naming conventions, (file/elements/levels/layers/attributes/etc.) will be confirmed.

Semantical Checks provide **security** that all relevant information is included. They create **confidence** that all integrated information is provided correctly and all needed calculations are **error free** and fully checked. This enables the possibility to perform ongoing zero-defect BIM processes.

Numerical Checks

Numerical Checks guarantee the evaluation of numerical information. The existence of all needed attributes is verified by the semantical checks, but the numerical check additionally verifies the values of all attributes for each element. Given values will be verified as well as the correctness of selectable or calculated values.

Numerical Checks are the **verification** that the design applies to design specifications. BIM based checking tools **optimize** the design and **highlight** critical elements/areas/files/etc. Finally, working with automatic quality checks is a big **saving of time** as well.

Geometrical Checks

Geometrical checks are necessary to verify clashes between disciplines (clash detection) and to assign the task to solve this issue to the corresponding parties. On the other hand, these checks will be used to guarantee that the given 3D model corresponds to the as-is situation on site (deviation analysis).

The **reliability** of having conflict-free 3D models of different disciplines leads to a collision-free construction. This increases the **confidence**, that all the important aspects of the design have been elaborated. One more benefit is, that routes of piping and/or openings in walls/slabs can be **prefabricated**. Clashes between disciplines are discovered and can be solved before the construction phase on site begins. This helps to avoid afterwards revisions of the design or doubled installations. All this results in a **minimization of costs and time**.

Besides dividing the checks into three validation types, the checks can also be categorized to receive a focus on specific topics. The long list of uncategorized checks, which can be performed, should be clustered according to the following categories (example-questioning given):

Naming: Has the naming convention been followed?

General: Are all project information correct? Is there a limitation of file size? Is the model purged? Are there unneeded links/xref in it? Are the correct units set for the model?

Location: Is the model in the right location? Does it have valid coordinates?

Model class.: Are the elements assigned to correct Uniclass code? Do they belong to the correct discipline?

Attributes: All required attributes available? All values and formats correct?

Geometry: Are all elements solid?

Lists: Are required tables of building elements/materials/etc. available and in the correct format?

Version: Comparison of two versions of the same model. What has changed?

Export format: Is the exported file in the correct format and free of error?

The table below shows the clustering of several checks and the corresponding model checks to be performed. The complete list is attached as Appendix 005 – Check Categories.

Category	Check	What for?	What will be checked?	General model check		
				semantics	numerical	geometrical
Naming	Naming convention	Level	Does the naming convetion correspond to the BEP ?	x		
	Naming convention	Model	Does the the general naming for elements / rooms / spaces / etc. has Space / additional character in it's name ?	x		
General	File Size	File	Does the file exceed the suggested file size of 200 Mb ?	x		
	Project Information	Model	Are the project information correctly filled ?	x		
	Simplification	Model	Is the model purged ? Are all unused elements / families / defintions removed ?			x
	Linked files	Model	Are all linked files (xrefs, pdfs, dwgs etc.) removed ?			x
	Referred models	Model	Are all referred models removed ?			x
	Warnings	Model	Are all resolvable programe warnings resolved ?			x
Location	Coordinates	Model	Is the model placed on the correct and real-world coordinates ?		x	
	Enviromental Information	Model	Is the model filled with enviromental information (for example the weather) ?	x		
	planing grid	Model	Is the planning grid incooperated in			

Figure 6 - Check Categories

As a result of task T5.3 user-guides for the following model checks will be provided (workflows and templates):

Numerical and Semantical model checks

- Ensuring that the BIM models comply with the design rules developed in Task 7.3, by checking if the developed structure, naming convention and relationships of model elements have been considered correctly

Geometrical model checks

- Ensuring the geometrical correctness of a 3D model or rather the consistency of the 3D model with the as-built state by performing a deviation analysis and comparing a 3D mesh of the BIM model with a point cloud
- Ensuring geometrical correctness of renovation planning by performing a clash detection and detection clashes between various discipline planning

Additionally, a Template of a QC (quality check) list will be generated. This list should help the involved persons (BIM Author/BIM Coordinator/BIM Manager) to set up their own checking protocol and follow it step by step. [Appendix 006 – QC List](#) gives an example for this checklist.

QUALITY MANAGEMENT - BIM MODEL CHECKLIST

FACILITY	select...	**SUBMISSION DAT**	YYYY-MM-DD
DISCIPLINE CODE	select...	**QA/QC DATE**	YYYY-MM-DD
FILE NAME	copy file name here	**+**	**Approved**
REVISION	select...	**-**	**Not Approved**
AUTHOR	select...	**o**	**Not Required**
EXAMINER	select...		**Not checked**

No	Checkpoint	Process/ Tool	1. QC (EXAMINER)			Feedback Author	2. QC (EXAM	
			Status Approval	Reference	Comment	Comment	Status Approval	Reference
QC-GENERAL								
1	**File naming as per 3D Modeling Standards**	Desite BIM						
2	**Landing Page as per 3D Modeling Standards**	CAD Application						
3	**Linked Files unloaded**	CAD Application						
4	**Model is purged**	CAD Application						
5	**Units**	CAD Application						
6	**Coodinates**	Desite BIM						
7	**Structure of model according to PBS**	Desite BIM						
8	**Virus Free**	Windows						
9	**Filesize**	Windows						
10	**Levels and Grids defined**	CAD Application						

Figure 7 – Extract of Example QC list

2.2 Process for Model Checking

The process of checking and validating a 3D model must be implemented into the general design process. Design coordination is a big task that covers not only the checking of the 3D models but offers possibilities to coordinate the design and avoid mismatching or clashing before starting on site construction. This will lead to reducing efforts in terms of costs and time. The validation of attached energy-relevant-data and -information will ease the BIM to BEM process and therefore by the end reduce energy costs and improve inhabitants comfort.

Task 5.3 investigated several methods to verify 3D models. One part is to approve and verify the given information of a 3D model (attributes and their values) by setting up ***numerical and semantical checks***. Another method is to set up ***geometrical checks,*** therefore it is necessary to validate the design regarding intersecting disciplines against each other by doing a ***clash detection***. Furthermore, another method of geometrical check can be performed, which is not that common one but also of interest. The comparison of an existing or newly generated laser scan point cloud with the 3D model to verify the as-built situation by performing a ***deviation analysis***. All these kinds of different model checks have to be embedded in the design processes of refurbishment projects. Additionally, the involved personnel must be identified and their roles in the model checking process have to be specified.

In the process of design coordination there are three roles involved:

Designer: Design responsible person, is the BIM author of the 3D model, who generates the design, relevant 3D models and 2D drawings with respect to design related requirements and in compliance with official and law-related regulations, as well as BEP (BIM Execution Plan), Modelling guidelines and MIDP (Model Information Delivery Plan)

BIM Coordinator: Generates numerical and semantical model checks to verify the 3D model (not responsible for the design but for the 3D model)

BIM Manager: Consolidation of all available relevant 3D models, approves the 3D models in terms of BIM relevant regulations and standards and project specific ones, assures superordinated design coordination

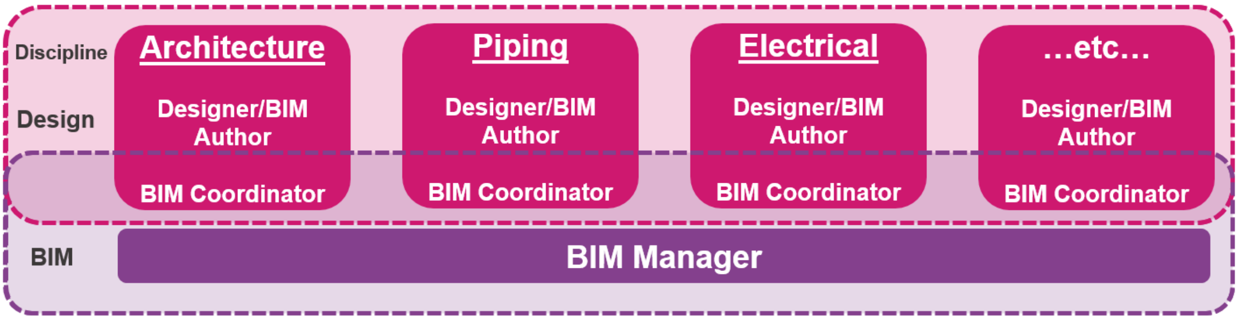


Figure 8 - Related Roles in Design Process for Design and BIM

Start of the design coordination process is the necessity to generate a 3D model. Gathering needed input documents and information like the design itself, BEP, modelling guidelines and MIDP, the designer starts generating the 3D model of his responsibility (e.g. Architecture, Piping, etc.). The designer is the author of the 3D model in this case. Before giving the model to a superordinated BIM Manager, the BIM coordinator will assure the correctness of the 3D model by performing semantical and numerical checks. According to the quality assurance convention, the BIM Coordinator cannot be the same person as the author due to the four-eyes principle. If no more revision is needed, then the 3D model will be delivered to the BIM Manager.

If possible the BIM Manager can do a deviation analysis between a laser scan point cloud and the 3D model to verify the conformance of the 3D model with an as-built situation. This may cause the need of revising the 3D model.

If there is no point cloud data available or if the project does not need this confirmation, then the BIM Manager jumps directly to the next step. A consolidated model of all available discipline models will be created in this step. By doing this, the BIM Manager is enabled to perform the clash detection. The clash detection will – as the name already implies – reveal clashes between different disciplines. Findings are summarized in a clash report, which will be a basis for a coordination meeting with all involved design responsible. Clarifying the clashes with other disciplines may lead to a revision of the design and therefore as well for the 3D model. The checking sequence will be repeated until all clashes will be solved (or defined as to be solved on site). Although this might become a time-consuming process, it will save a lot of time and costs in the end, because clashes are identified and solved at a very early stage and the design is approved before it comes on site. Finally, the Designer will generate the final 2D drawings directly out of the now verified 3D model. At this stage, the 3D model has a verified status and can be used for further use cases.

A visual layout of the process of design coordination is shown in the process chart below. The overall process chart is divided into two parts due to better readability.

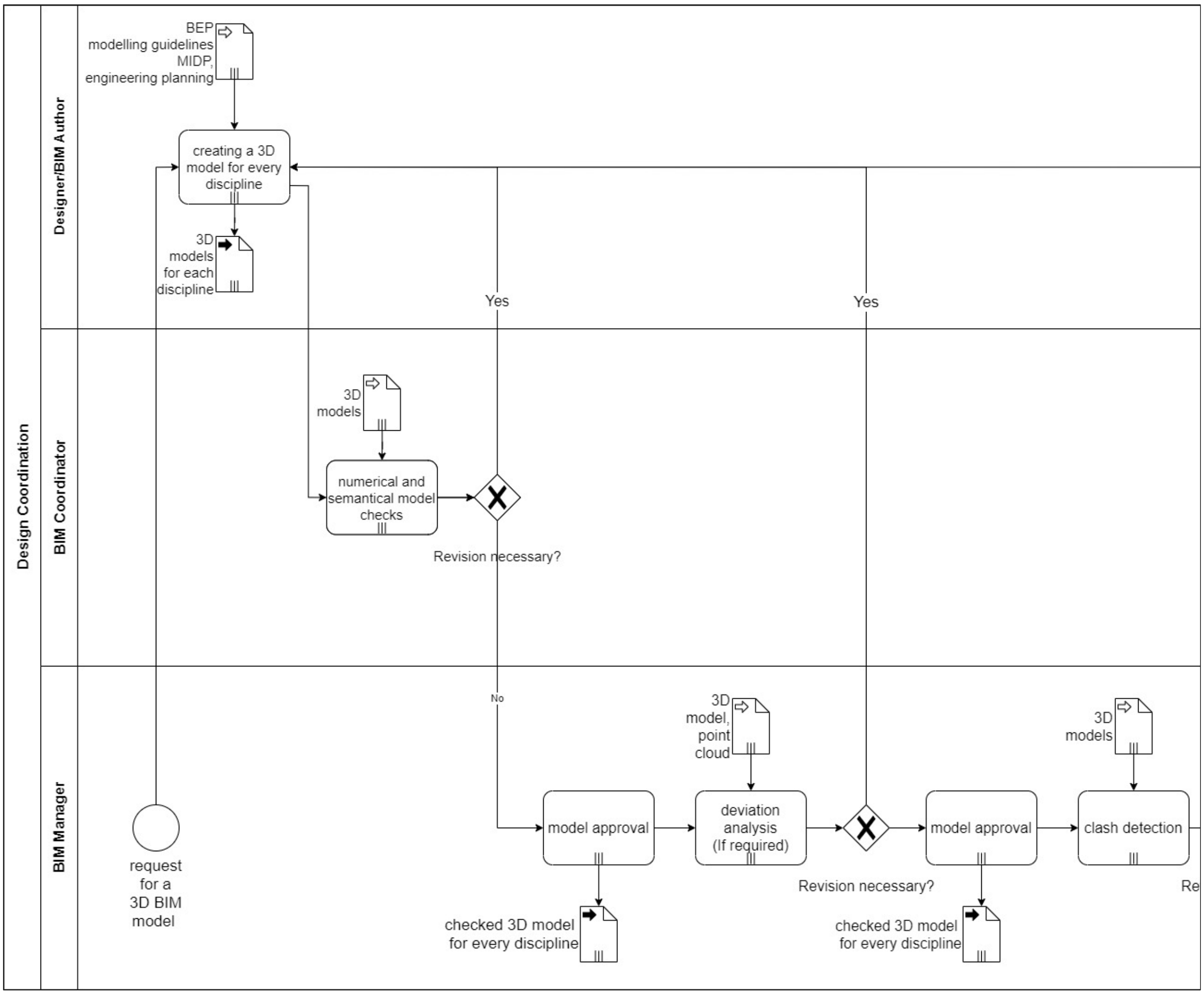


Figure 9 - Design Coordination Process Part 1

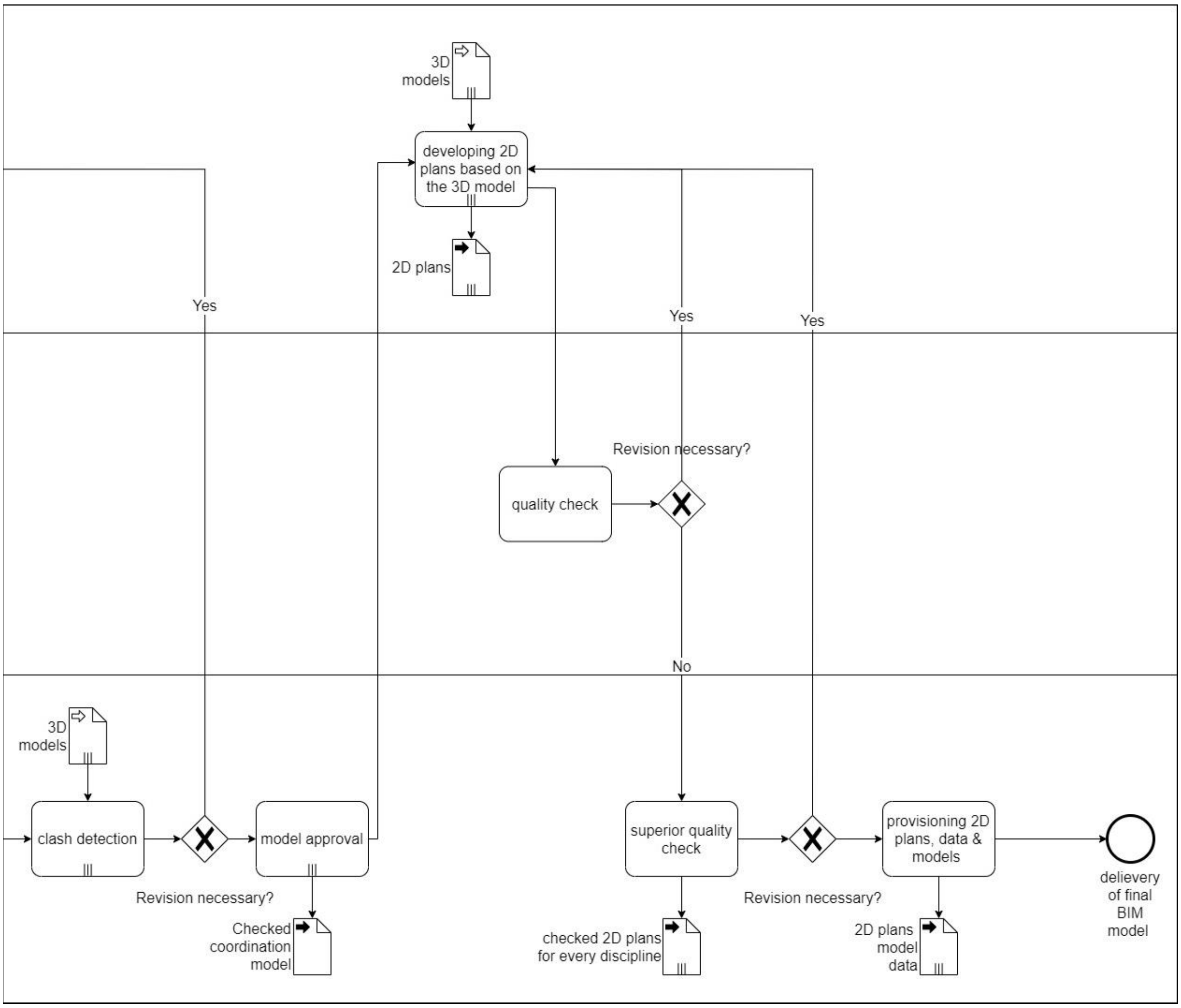


Figure 10 - Design Coordination Process Part 2

The following process charts show the workflows for the three quality check processes in detail. First is the semantical/numerical check, followed by the deviation analysis and concluding with the clash detection.

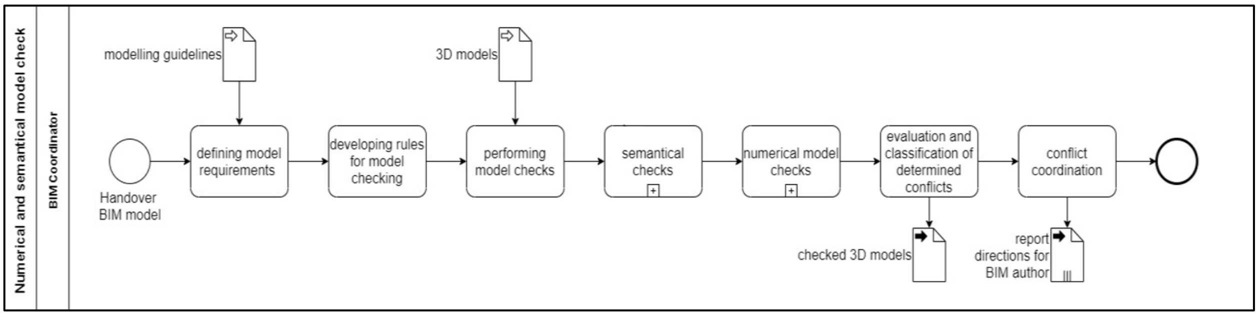


Figure 11 - Process Chart Numerical and Semantical Check

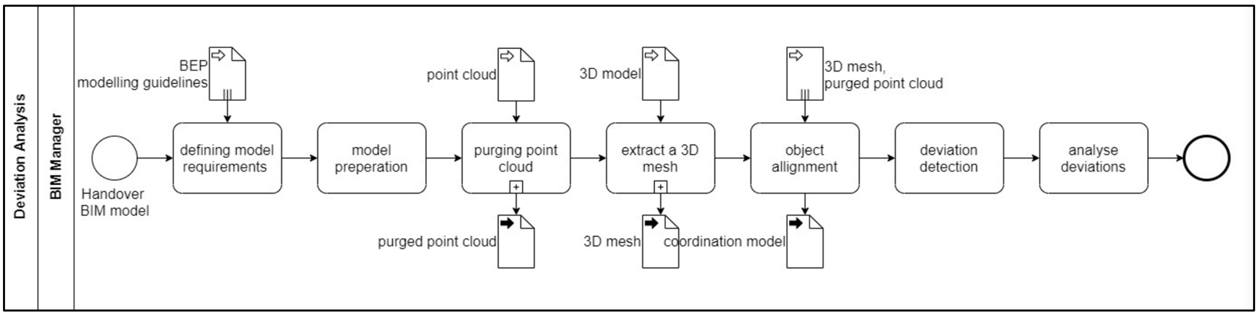


Figure 12 - Process Chart Deviation Analysis

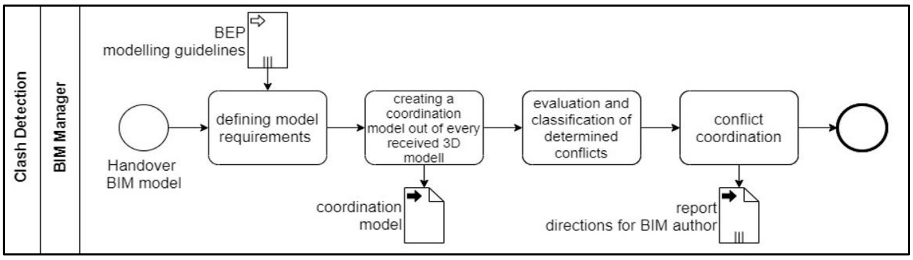


Figure 13 - Process Chart Deviation Clash Detection

2.3 Suitable Model Checking Software

As already identified in chapter 1.3 the market for software solutions provides several tools, which can be used to perform model checks. Each software has different features and its advantages and disadvantages. The elaboration of the model checks for BIM-Speed projects in this task T5.3 has been performed with software applications according to the following table:

Software Solution	General model check categorization			Furhter information
	Semantics	Numerics	Geometry	
Cyclone 3DR			x	Deviation analysis: Comparing a 3D mesh with a point cloud
Autodesk Navisworks - Manage			x	Clash Detection: Checking models of different disciplines
thinkproject DESITE MD	x	x		Ensuring the correctnes of attribution

Figure 14 - Identification of suitable model checking software

2.4 Examples for common Model Checks

To provide a practical approach to the user, this chapter will provide common examples for the different kinds of model checks. Detailed user guides for setting up the checks are attached as Appendix 002 – Guide for model checks using Desite BIM and Appendix 003 – Guide for Deviation Analysis using 3D Reshaper.

Attribute Check

Attributes are non-geometrical information that are added to the model elements. In different project phases, the number and accuracy of attributes and information can be different. Following the usual progress of a design project, the amount of required attributes increases.

To use the attributes and enter their values correctly a consistent and meaningful naming convention has to be developed and implemented. Furthermore, the unit or rather the datatype and the value of the numerical information provided within an attribute has to be defined. Depending on the process, wrong or missing assignments can have a negative impact on further use cases.

The attributes to be used must be defined at the beginning of a project, based on the model element to which they belong. An overview must be provided in the modelling guidelines, which needs to be accessible for every model author.

The attributes integrated to the 3D model serve a various number of BIM Use Cases. To ensure the availability and applicability of the provided information, an attribute check needs to be set up. There are six consecutive steps to be followed to setup a general checking routine:

1. Import:
   Importing the BIM model to the model checking software.
2. Checking of compliance with the modelling guidelines:
   Identifying required attributes. Checking of naming convention.
3. Dependencies:
   Identifying relationship/dependencies of elements and/or attributes.
4. Definition of rules for model checks:
   - ✓ Which attributes should be addressed within the check?
   - ✓ To what kind of datatype does the check apply (Boolean, string, integer...)?
   - ✓ What relationship/dependency exists and how can it be represented in the check (e.g. definition of a prerequisite)?
   - ✓ Which values or range of values for this attribute are allowed?
   - ✓ What are the results of the check, if the case is undefined?
5. Evaluation:
   Evaluation of the checks.
6. Report:
   Exporting the check results as an easy to read report and understandable for the BIM author.

Deviation Analysis

The critical point for starting a renovation project is the quality of as-built documentation. Often there are 2D drawings available, but being sure that they match the as-built situation is usually not certain and ensuring that available drawings and existing building geometry are matching, requires high efforts to be verified.

3D models for renovation projects are often generated on basis of 2D drawings and therefore represent the status shown in these drawings. Depending on the objectives of the project and planned activities a 3D model corresponding to the exact as-built situation is required. There are two ways to get the 3D model matching with the as-built situation by using a point cloud. Doing a laser or photogrammetry scan room-wise in the applied building will show the exact as-built situation.

One way to work with this point cloud is to import the data to the CAD application and take it as a basis for the 3D model generation. Although this is generally a very time-consuming process, CARTIF

developed a plugin to ease the process of identifying and modelling specific elements like walls from point clouds (see WP1, Deliverable 1.1). The other way to use a point cloud is to compare it with an already existing 3D model and analyse the deviation of both. The result are measurable deviations, which will lead to an easy decision if an update of the 3D model is needed or not.
To explain the general approach of performing a deviation analysis, the 3D Reshaper of Leica has been used.
The following description and the user guide in Appendix 003 – Guide for Deviation Analysis using 3D Reshaper is based on the use of Reshaper.

In order to perform a deviation analysis between the point cloud and the 3D model the following steps have

to be performed:

1. Import:

First, the BIM model and the corresponding point cloud are imported into the Reshaper software.

2. Purging the point cloud:

   The point cloud contains a large amount of point data, but only a fraction of this point data is relevant to perform the deviation analysis. All unneeded points/areas of points should be deleted.

3. 3D mesh:

   Extracting a 3D mesh from the 3D model.

4. Alignment:

   Aligning the point cloud and the 3D mesh.

5. Deviation analysis:

   Results of the deviation analysis can be displayed by colour schemes or other visualization options.

6. Report:

   Evaluation and classification of determined deviations.

Clash Detection

Clash Detection is one key aspect in the process of design coordination. It outlines interferences between the designs of different disciplines before construction starts on site. This saves a lot of time and money because revising of design to avoid clashes will be done virtually beforehand and will avoid facing an issue on site. The result of the clash detection is a well-coordinated design of all disciplines.

To perform a clash detection the following steps have to be performed:

1. Check discipline models:

   To create a coordination model of various disciplines the following points must be assured:

   - ✓ Units – must be the same for all models
   - ✓ Geographical information – each discipline model has to be located correctly
   - ✓ 3D model elements – each model element has to be 3D solid

2. Coordination model:

   Consolidating all discipline models to a superordinated coordination model

3. Clash Matrix:

   Before starting the clash run a clash matrix must be created. This matrix outlines which discipline will be clashed against which discipline. It also identifies which disciplines can clash and don't need to be checked.

4. Tolerances:

   Defining allowed tolerances between different disciplines.

5. Clash Run:

   Performing the deviation analysis. Clustering clashes and excluding doubled or ignorable ones.

6. Report:

   Creating a clash report with results of the clash run to publish and coordinate with the responsible designer.

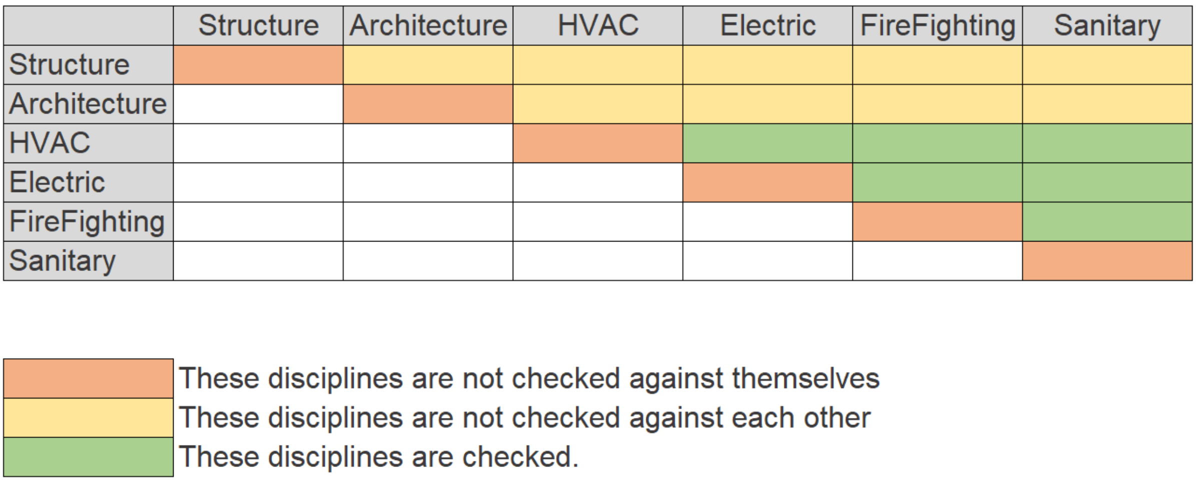


Figure 15 - Example Clash Matrix

3. Demonstration

To evaluate whether the defined methods and approaches to verify 3D models and their information can be applied in a practical example, the different kinds of model checks have been demonstrated on BIM-Speed's Spanish and Dutch demonstration sites.

The following chapter will describe what has been done with the two demo sites' 3D models. Results and feedback from the partners will directly influence the output of task 5.3 and optimization will be incorporated.

3.1 Demonstration Cases

The following items and information are generally required to perform the intended model checks:

- 3D model (best for different disciplines)
- laser scan point cloud of the building and/or its environment
- Identification of the most relevant model checks to be performed

To verify the approach of task 5.3 and to develop workflows and templates for model checks within the BIM Speed project the following two examples have been identified. The list below shows which type of checks have been performed for the two examples.

Check Type	Demonstrator		Further information
	NL	ES	
Numerical check of 3D Model	x	x	Confirmation of values within the required attributes.
Semantical check of 3D Model	x	x	Confirmation of existance of required attributes.
Deviation Analysis (Pointcloud # 3D Model)	x		Comparison of point cloud (only of surrounding) and 3D Model
Clash Detection			Both models provide only architectural models, no clash detection possible.

Figure 16 - Identification of relevant demonstrators

3.2 Setup of Model Checks

The following model checks for the Dutch and Spanish demo site projects have been setup.

Semantical and Numerical checks

In coordination with task 7.2, several required design rules have been identified to approve the design of a planned building. These design rules are defined by existing building regulations of each country, specific project requirements and other current standards. The description of these rules can be consolidated and documented in depth, but as such they are not usable for setting up automated checking rules. Within task 7.2 it has been researched how to break down this rule description into a format to be used in a scripting routine in task T7.2 as well for model checking methods of task T5.3. The result is a long list of required general and country-specific attributes that need to be attached to the 3D model elements (see figure below). Complete list to be found in [Appendix 007 –Attribute List](#).

BIMSPEED Properties					
Model Element/ IfcEntity	Country	BIMSPEED General	BIMSPEED Country Specific	Type	Value
IfcBuilding	General	BIMSPEED_Building	BIMSPEEDCountry	STRING	Spain; Germany; Netherlands; Poland; Romania; Bulgaria; Italy
IfcBuilding	General	BIMSPEED_Building	BIMSPEEDOccupancyType	STRING	MultiFamily; Single Family
IfcBuilding	General	BIMSPEED_Building	BIMSPEEDNumberOfStoreys	INTEGER	Number of Storey
IfcBuilding	ES	BIMSPEED_Building	ES_BIMSPEEDClimateZone	STRING	α; A; B; C; D; E
IfcBuilding	IT	BIMSPEED_Building	IT_BIMSPEEDClimateZone	STRING	α; A; B; C; D; E; F
IfcZone	General	BIMSPEED_Zone	BIMSPEEDPubliclyAccessible	BOOLEAN	Truth; False
IfcZone	General	BIMSPEED_Zone	BIMSPEEDNetAreaPlanned	INTEGER	[m^2]
IfcZone	NL	BIMSPEED_Zone	NL_BIMSPEEDFireCompartment	BOOLEAN	Truth; False
IfcZone	BG	BIMSPEED_Zone	BG_BIMSPEEDHandicapAccessible	BOOLEAN	Truth; False
IfcZone	NL	BIMSPEED_Zone	NL_BIMSPEEDHeight	INTEGER	[m]
IfcZone	NL	BIMSPEED_Zone	NL_BIMSPEEDGrossArePlanned	INTEGER	[m^2]
IfcZone	NL	BIMSPEED_Zone	NL_BIMSPEEDDistanceToExit	INTEGER	[m]
IfcSpace	General	BIMSPEEDSpace	BIMSPEEDCategory	STRING	Kitchen; Bathroom; WC; Auxilary Room; Corridor; Hall; Stairs; Living Room; Bedroom

Figure 17 - Extract BIM Speed Properties

This overview list has been investigated afterwards with the aim to identify relationships of model elements interdependently.

Example

The design rule states: *In Spain in climate zone A-E each external wall needs to have an acoustic rating of more than 35dB.*

The figure below shows, how this rule description has been translated in a way that model checks, based on scripts, easily can be set up.

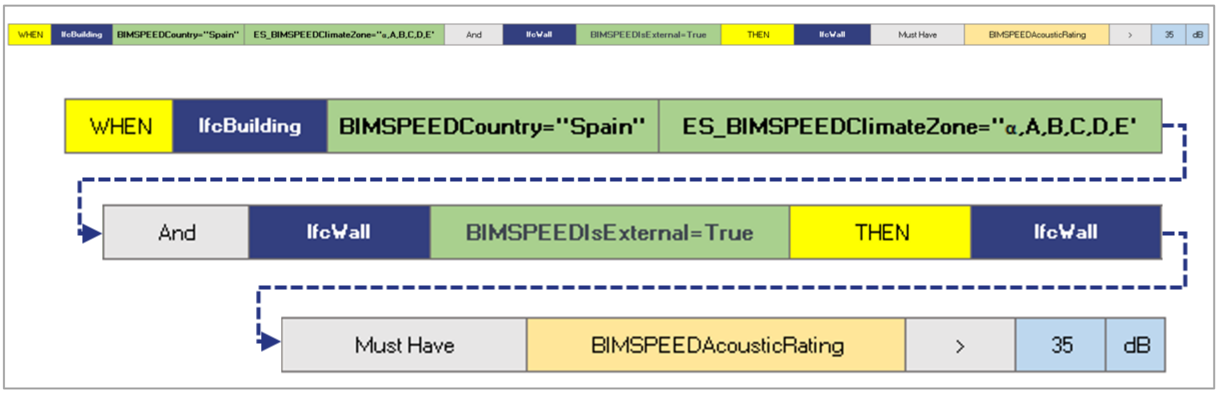


Figure 18 - Example of Transition of Design Rule to checkable format

Figure 18 described in words:

If there is a geometry model of a building, then there will be an entity "IfcBuilding". When there is an entity "Ifc Building" and the general attribute "BIMSPEEDCountry" provides the value "Spain" as well as the country specific attribute "ES_BIMSPEEDClimateZone" provides one of the values "a, A, B, C, D or E", AND if the entity IfcWall can by identified as external wall using the attribute "BIMSPEEDIsExternal" providing the value "True", then this entity of "IfcWall" must have the attribute "BIMSPEEDAcousticRating" with a value bigger than 35,00db.

This is just an example to understand the elaboration of the design rules developed in tasks 5.3 and 7.2. The complete list of all defined design rules is given in Appendix 008 – Design Rules.

Taking this list as input, semantical and numerical model checks for task 5.3 have been set up in Desite BIM. As a **Result of this Deliverable** all generated checks for each Design Rule of the Spanish Demo Site are provided as single **xml-files** to be imported when using Desite BIM. This are **59 semantical and numerical checks**, which can be used as a template for setting up more checks as well.

In addition, the **complete Desite BIM project file** for checking the Spanish demo site is provided in native .pfs format (including all data structure) and as a packed Desite BIM project file (*.cpa-format).

For Details refer to Appendix 009 – Desite BIM Project and Checks.

Additionally, a user guide has been generated, which will help the users to set up a check by themselves. See Appendix 002 – Guide for Model Checks using Desite BIM.

Deviation Analysis

The Dutch demo site project has been investigated by performing laser scans of the surrounding of the complete building complex on site in Warmond. In parallel, the 3D model was generated based on the existing 2D drawings. This was the starting point for performing a deviation analysis between the point cloud information and the 3D model. The impressive result is shown in Proof of Concept.

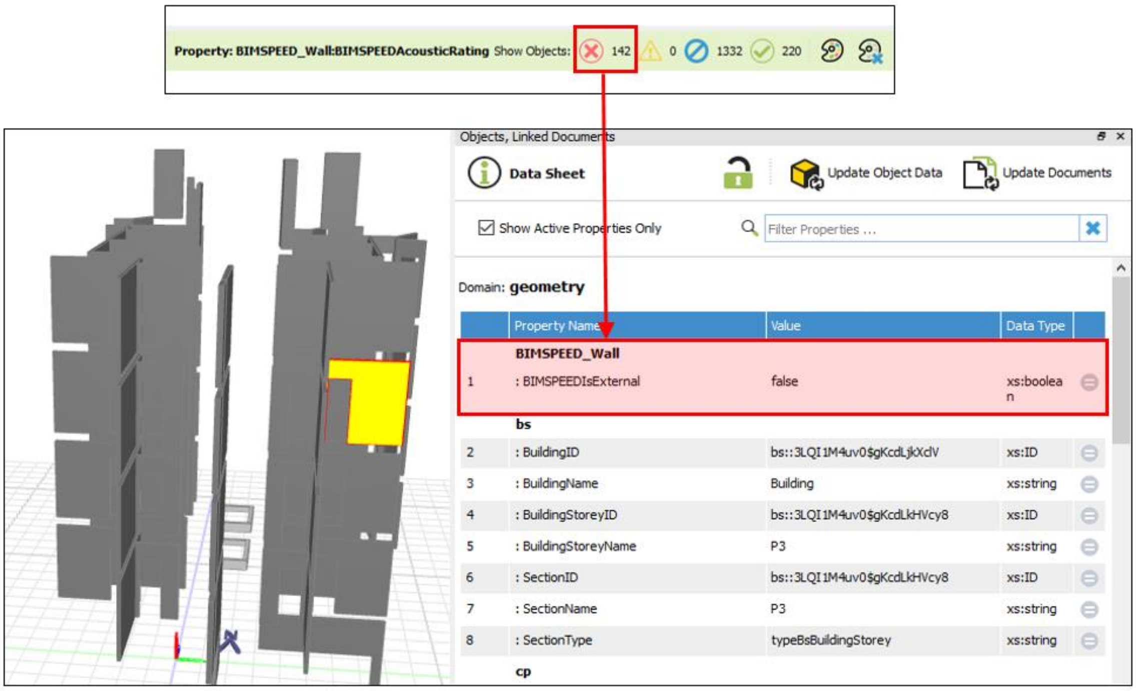
There is no rule for performing a deviation analysis. Since it is "just" the comparison to identify deviations, it is not possible to provide a template here, but a short introduction tutorial as a guide for the user is given in Appendix 003 – Guide for Deviation Analysis using 3D Reshaper.

3.3 Proof of Concept

After setting up the checks, the approach of task 5.3 must be verified. If the results of all checks really outline issues in 3D models that can be revised to improve the quality of the 3D models, then this demonstrates that procedures defined by task 5.3 contribute to enhancing the renovation process. In the next chapters, there is a deeper look into these results.

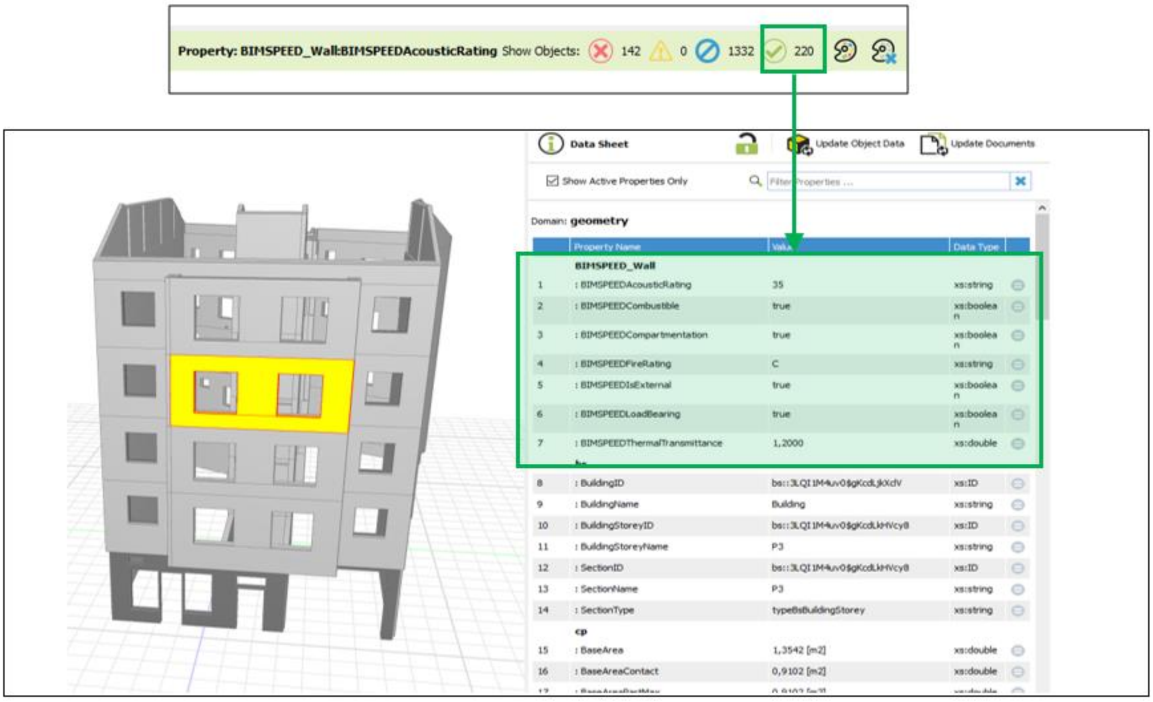
Semantical and Numerical model checks

The semantical and numerical checks have been setup for the identified demo site projects. Following the results of the checks done for the Spanish demo site are illustrated. There have been two versions of the 3D model. Both versions are exactly the same in terms of their provided geometrical information, but they have different values within the attached attributes. One of the models does comply with the guidelines, the other one does not. Checking these two 3D models clearly reveals if the model checks work or not.
The following figures show the results.



NOT COMPLY: Attribute BIMSPEEDAcousticRating is missing in Pset IfcWall

Figure 19: Not comply



COMPLY: Attribute BIMSPEEDAcousticRating is provided in Pset IfcWall

Figure 20 - Comply

Another descriptive example is the result of the already investigated design rule: “*In Spain in climate zone A-E each external wall needs to have an acoustic rating of more than 35dB*”. Pleases note the picture below. There are 142 elements in the model that do not comply with this requirement. Additionally, there are 1332 elements that have been ignored in the check routine because they are not relevant. This means they are either not an external wall or not a wall at all and therefore have been excluded from running the check routine. But luckily there are also 220 elements that do comply with the requirements.

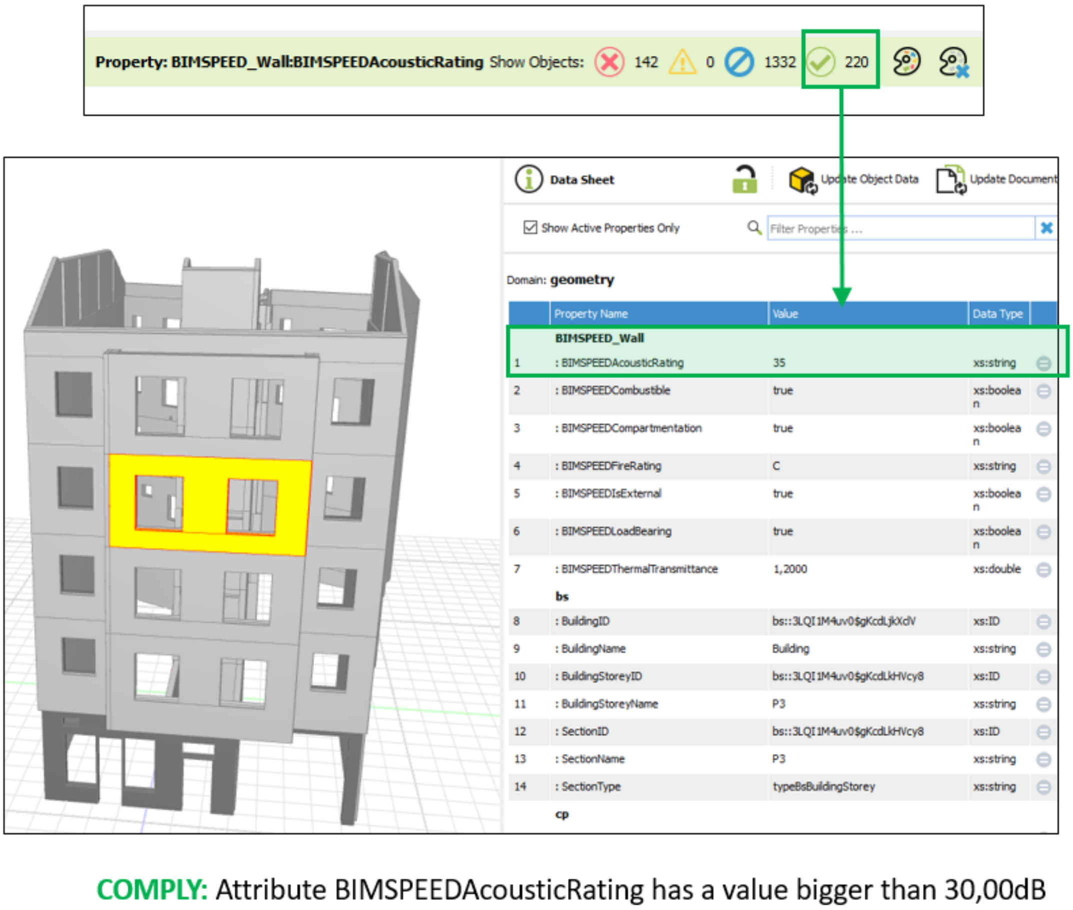


Figure 21 - Comply

Summarized the results of the performed numerical and semantical property checks of both models are shown in the table below.

Property	Version of 3D model COMPLY	Version of 3D model NOT COMPLY
BIMSPEED_Buidling:BIMSPEEDClimateZone	Parameter is assigned and values does comply with defined value.	Not assigned
BIMSPEED_Buidling:BIMSPEEDCountry	Parameter is assigned and values does comply with defined value.	Not assigned
BIMSPEED_Wall:BIMSPEEDAcousticRating	Parameter is only assigned to external walls.	Parameter is only assigned to external walls.
BIMSPEED_Wall:BIMSPEEDIsExternal	Parameter is assigned and filled correctly.	Parameter is assigned and filled correctly.
In Spain in climate zone A-E each external wall needs to have an acoustic rating of more than 35dB.	COMPLY: The acoustic rating for all relevant walls is > 35 dB	NOT COMPLY: the acoustic rating for all relevant walls is not > 35 dB

Figure 22 - Overview of the results of the model checks

Deviation analysis

An exemplary execution of a deviation analysis was performed on the Dutch demonstrator. The model was created based on existing 2D drawings and as mentioned before, the result is very impressive. No one has expected such a small deviation between these old existing 2D drawings and the reality captured as point cloud. Following some impression of the results.

The colour scheme at the side shows the deviation. Blue means that the point cloud differs regarding the inner direction to the building shell, while red shows deviation in direction to the outer surrounding. The frame around the entrance doors was captured by the laser scanner and it clearly deviates from the model where it is missing.

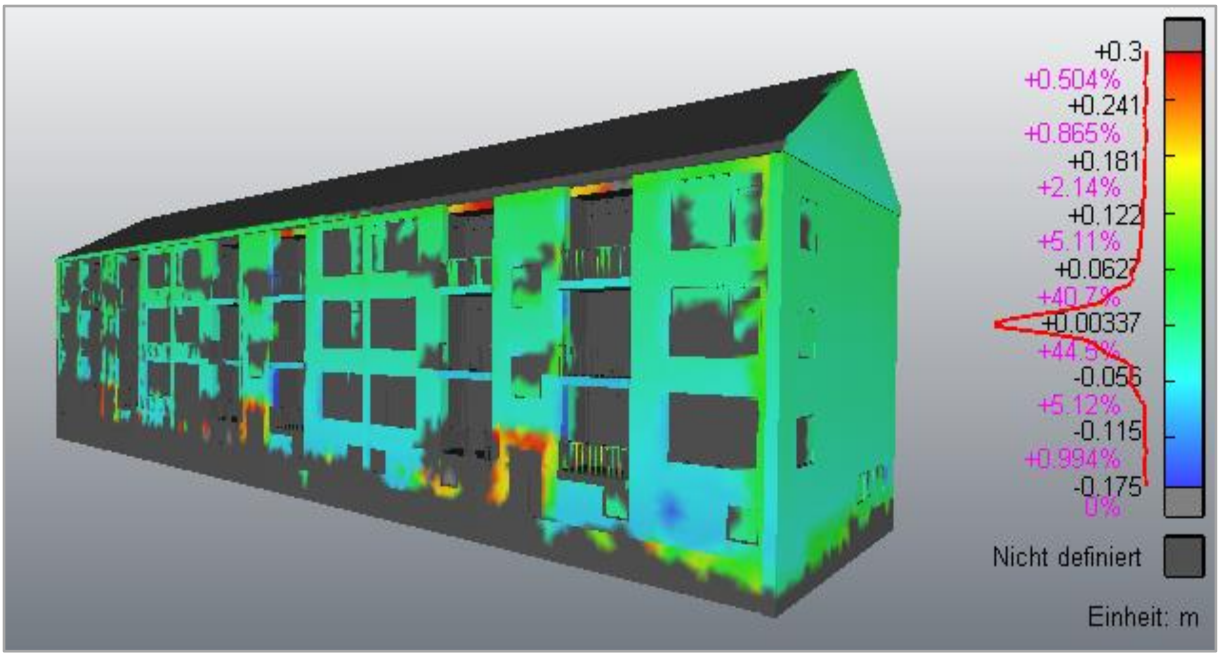


Figure 23 - Deviation Analysis

Deliverable 5.3 – Output and Attachments

As the deliverable of task 5.3 is of type other, the outputs are several required Appendices to provide User Guides, 3D Model and Check Definitions and at least a complete project template to be used in Desite BIM. Following these exemplifications, the user will be able to approve and verify the 3D Model to perform the identified BIM Speed use cases.

This accompanying report completes the Deliverable by giving additional descriptions and guidance.

Appendix 001 – Structuring 3D Models

Project Breakdown Structure

At the beginning of a project a discipline and phase comprehensive Project Breakdown Structure (PBS) has to be implemented. The PBS splits the whole project into meaningful parts according to the structure of the project. The 3D model has to respect and follow this PBS, which benefits the fact to have 3Dmodel files in performant file size. An example of a project PBS is shown in the picture below.

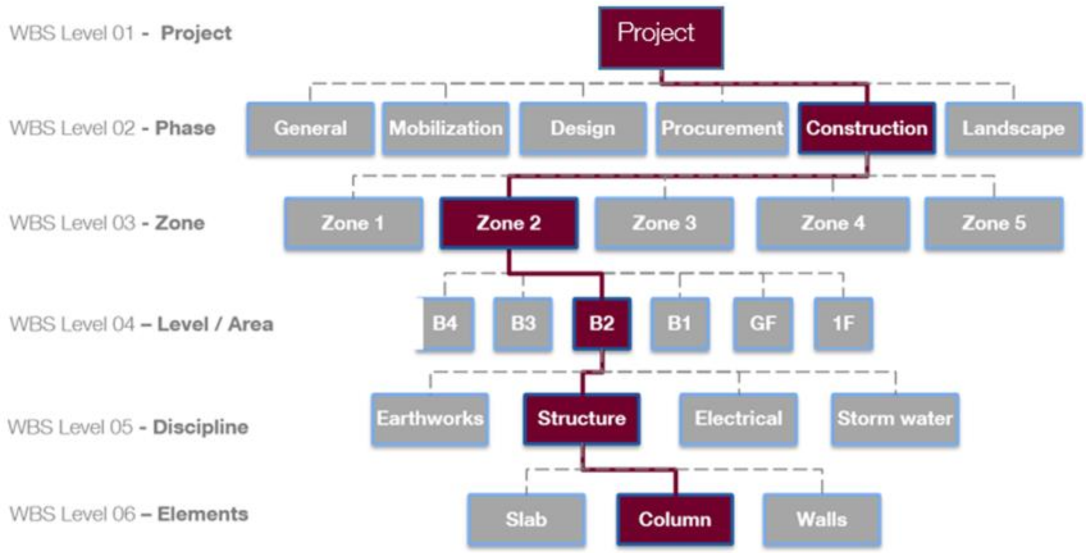


Figure 24 – Project Breakdown Structure (example)

Architectural and structural 3D models should respect this splitting, especially since the splitting at each level is easily convertible for these disciplines. Different to this are the disciplines of mechanical, electrical and piping (MEP). Those networks have to be modelled according to their corresponding system. Based on logical correlations those networks cannot be modelled Area or level-wise, otherwise the meaning of the engineering would fail. In addition to the MEP elements, there may be exceptions for facades and precast elements as well.

More information to PBS is also described in Work Package 1, Deliverable 1.1.

Discipline 3D Models – Consolidated 3D Model

Following the defined PBS, it is mandatory not having one general discipline comprehensive 3D model but to have separate 3D models for each discipline. This provides some essential benefits for further processing:

- There will be no performance problems when working with the 3D model data. The file size is kept to a useful size.
- As each designer is responsible for their specific 3D model, updating of the corresponding discipline 3D model can easily be done, without affecting other disciplines. Coordination issues are minimized.
- No export and import issues regarding transformation problems or data loss.

It is recommended to put all discipline 3D models together to one consolidated 3D model in a software independent viewer at the end. All investigated software applications within this deliverable can do this.

Level Definition

For the intended BIM Use Case Clash Detection, it is essential to split the 3D model of each discipline level wise, which also is in compliance with the defined PBS. This regulation should be followed as far as it is possible. As already mentioned, this is not realizable for the MEP disciplines as they are modelled system wise.

For architectural and structural 3D models the best practice experience of level definition is from top of the structural slab to top of the structural slab and the reference level height is to be taken from the top of the respective floor slab. Horizontal supporting slab elements (e.g. beams) belong to the respective slab and level it supports (see picture below).

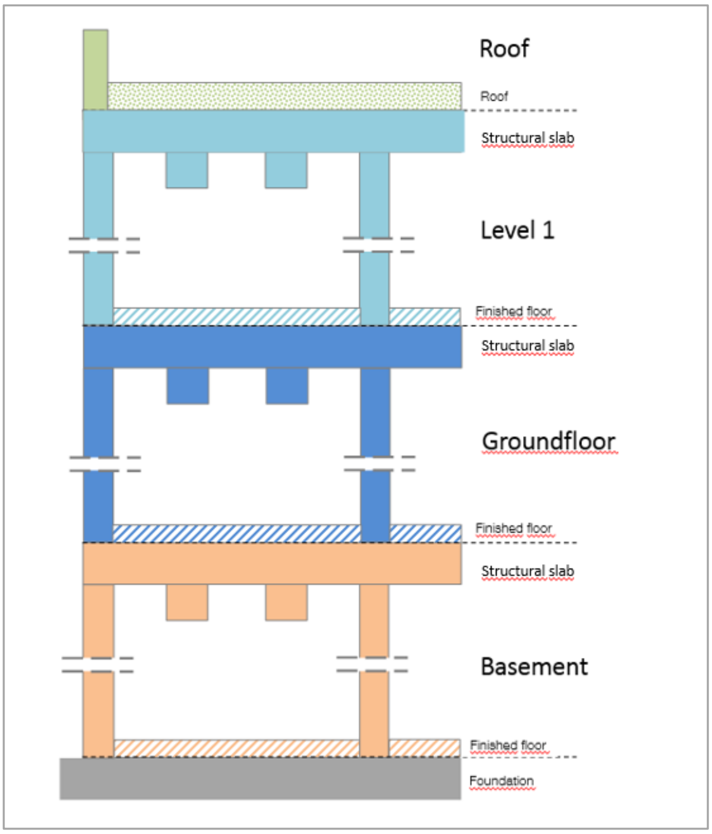


Figure 25 - Level definition

Naming convention

BIM models comprise 3D objects that represent building elements in their geometry and functionality. These 3D model elements should follow a project specific standardized naming convention to enable further usage and a point of connection for other evaluations. This includes the labelling of really everything in relation with the 3D model like labelling of files, levels, views, attributes, materials, etc. Doing this, a unified approach for identifying 3D model elements and attached information across the discipline 3D models is provided.

Important for all naming conventions is, that it is a kind of code with a minimum defined number of fields with specific content.

A complete naming convention should be set up at the beginning of the project.

Following an example for the naming convention for levels. Naming conventions for all other elements should be set up similar.

Example Naming Convention for Levels:

Level Number_LevelHeightInMeters_LevelName_LevelFunction

03_+6.00_CONCOURSE LEVEL_FFL

BIM Speed:

It is recommended to set up also a naming convention for the BIM Speed project. At least the model file itself, model elements and especially required Attributes should follow the same structure.
At the current stage of the BIM Speed project, this has not been added to the modelling guidelines in task 2.3 so far. It is recommended to finalize this, after finishing this report of task 5.3.

At this point of the project, required BIM Speed attributes are defined in BIM Speed property sets with attaching "BIMSPEED" as a prefix in general and in case of country specific attributes additionally the country specific abbreviation plus the attributes description.
Examples:
General BIMSpeed Attributes:
PrefixDescription:

- BIMSPEEDCountry
- BIMSPEEDFireRating
- BIMSPEEDThermalTransmittance
- ...

Country specific BIMSpeed Attributes:
Country_PrefixDescription:

- PL_BIMSPEEDRoofWindow
- NL_BIMSPEEDRoofWindow
- ES_BIMSPEEDFireVestibule
- ...

Granularity of BIM Model Elements

Each model element represents a 3D solid element. The granularity of all 3D solid elements shall correspond with the realistic measurements, coming e.g. from 2D drawing information, point cloud information, etc.
An exception are surfaces, they can represent digital terrain models, due to performance issues.

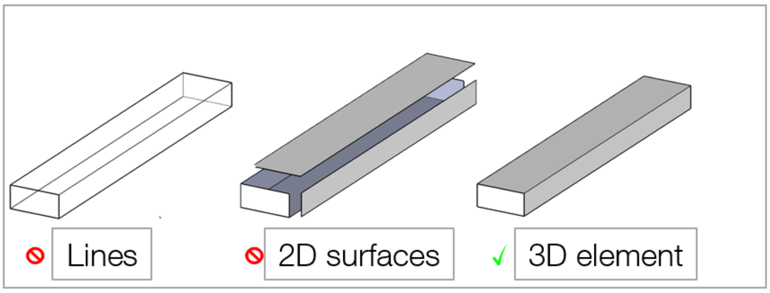


Figure 26 - Definition solid 3D elements

2D elements cannot display any necessary element for the 3D model. Further BIM purposed analysis is not possible with 2D elements. Nevertheless, it is of course possible to add Model Lines/Grids/Texts/Annotations/Xrefs for the creation of 2D drawings.

While modelling the 3D elements in the CAD software, it is mandatory to ensure, that each 3D element really represents the corresponding building element. A column as a building element in reality is a column in the 3D model and not a wall, for example. Otherwise, the corresponding property set will show wrong information, e.g. wall information and not column information and ifc export will lead to wrong results.

Attributes

Attributes are non-geometrical information that are added to the model elements with a descriptive purpose. This covers information regarding the classification of elements (e.g. Uniclass) as well as additional design information, manufacturer, maintenance data, etc. The number and accuracy of attributes and information provided within the attribute depends on the defined Level of Information (LoI). The LoI can differ from element types and depends on the current stage and phase of the project.

This attached information can be used for different BIM use cases and data integration in general.

It is recommended to define the LoI before starting with the 3D model generation. Special attention should be given to the required property sets for further processing. For the BIM Speed project, there have been identified required use case specific attributes to enable the consecutively BIM to BEM process. For the modelling process with Autodesk Revit there is a Shared Parameter File available based on requirements for the Spanish demo site. This shared parameter file may be updated for other demo site projects. Within this shared parameter file the required BIM Speed property sets have already been regarded. For smooth export of 3D model data to the IFC format there is also a template to define a User Defined BIM Speed property set within the IFC export settings available.

Appendix 002 – Guide for Model Checks using Desite BIM

While elaborating task 5.3 a huge amount of semantical and numerical checks has been set up to perform model checks on basis of the 3D model of the Spanish demo site. These checks are part of the attached documents to deliverable 5.3.

For setting up a new attribute check the following guide will help the user to do this on its own.

General information and approach

Desite BIM provides different tools for defining a model check.

In Tab “Tools” it is possible to set up the following checks:

- Contact Check: Checks relation of elements, e.g. column cuts wall, Slab cuts wall, non-structural wall does not cut structural wall, etc.
- Clashes: Checks clashes of elements against each other (less functionalities than in NavisWorks Manage)
- ID Check: Checks if each element has its own unique ID or if there is a double
- Geometry: Checks if model element is a solid element
- Attributes: Definition of semantical and numerical checks
- Versions: Comparison of 2 versions of the same 3D model
- Own Checks: Definition of own script by using superordinate scripts or property scripts

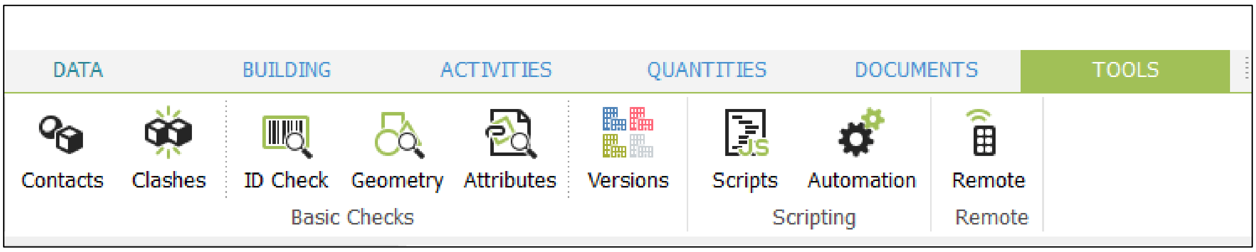


Figure 27 - Checks in Desite BIM

There are three general steps for setting up an attribute check:

A. Create a new check

B. Define preconditions, if needed

C. Define the check rules.

The following screenshot shows where to find the buttons.

Following additional information to rule definition:

- Property name: Name of property (attribute) that will be checked
- Datatype: Definition of data type of parameter (string/integer/Boolean/etc.)
- Case Undefined: In Chapter "Prerequisite" definition, if check should run or not, in chapter "Attribute Rule" definition, if output should "Ok", "Warning" or "Failed".
- Patterns: Definition of allowed values/range of values

It is possible to define more than one check rule for the same parameter. It can be differentiated, if all defined rule are valid (AND) or if only one of them is valid (OR).

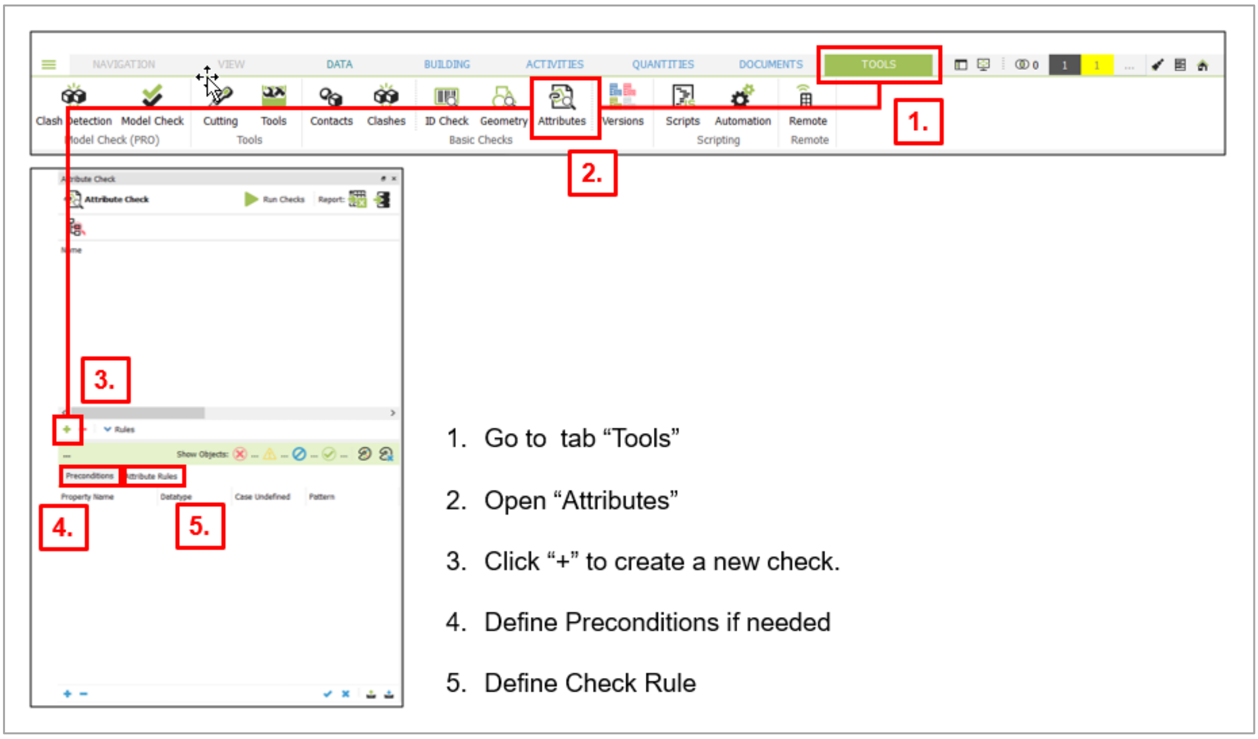


Figure 28 - General Steps for setting up attribute checks

Rules for Spanish Demosite

As elaborated in the accompanying report of this deliverable the design rules, developed within task 7.2 have been broken down into a format that is easy to perform as model check rule.

Again the Design rule No.1 of Spanish Demosite will deal as example for the setting up process.

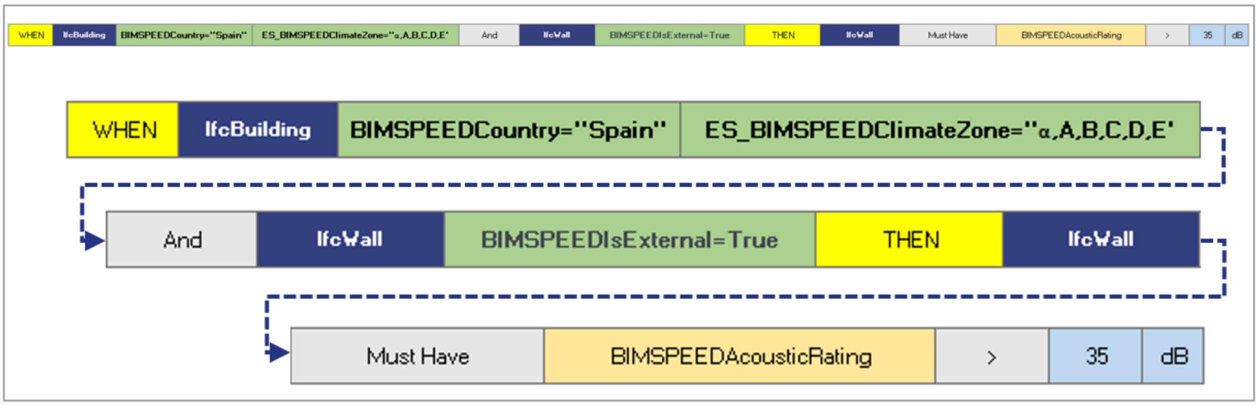


Figure 29 - Rule No.1 Spanish Demosite

Interpreting this rule definition, there are two entities (Building and Wall) and four attributes (Country, ClimateZone, AcousticRating, IsExternal) to be checked:

BIMSPEED Properties					
Model Element/ IfcEntity	**Country**	**BIMSPEED General**	**BIMSPEED Country Specific**	**Type**	**Value**
IfcBuilding	General	BIMSPEED_Building	BIMSPEEDCountry	STRING	Spain; Germany; Netherlands; Poland; Romania; Bulgaria; Italy
IfcBuilding	ES	BIMSPEED_Building	ES_BIMSPEEDClimateZone	STRING	α; A; B; C; D; E
IfcWall	General	BIMSPEED_Wall	BIMSPEEDAcousticRating	STRING	[dB]
IfcWall	General	BIMSPEED_Wall	BIMSPEEDIsExternal	BOOLEAN	Truth; False

Figure 30 - Required attributes to be checked

Set up of Attribute Check for Rule No. 1

After identifying the above it is clear what has to be investigated. Going back into Desite BIM now the following steps have to be performed:

1. Loading the 3D model into Desite BIM
2. Open Tools > Attributes and click on "+"
3. Creating a new check and give it an appropriate naming

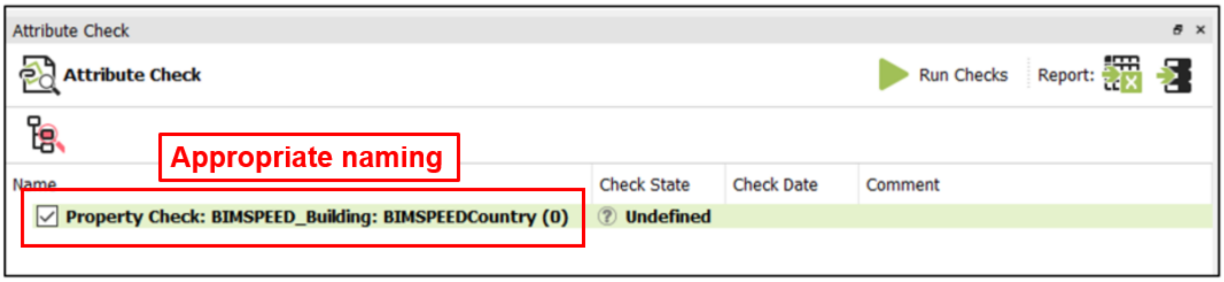


Figure 31 - New Check

4. Definition of precondition, if needed. E.g. if a rule should only check specific elements, only walls/windows/etc or only elements, that contain a specific parameter and all other should be

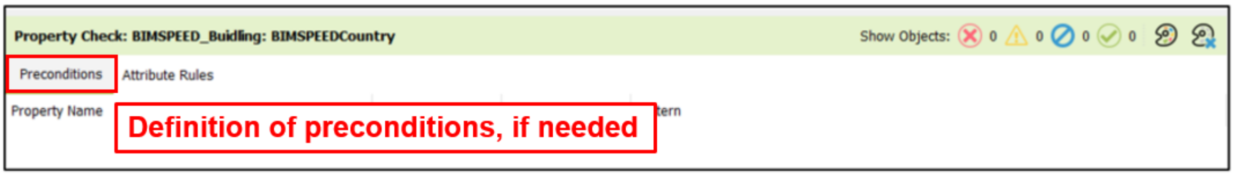


Figure 32 - Defining Preconditions

ignored, etc.

5. Definition of check rule. In this case the attribute "BIMSPEEDCountry" in property set "BIMSPEED_Building" will be checked. Type of this attribute is "string". If there are elements, that do not have this attribute attached, then the result should be "failed". Allowed values of this attribute are: "Spain" or "Germany" or "Netherlands" or etc. (see table above). If value is different, then the result will also be "failed".

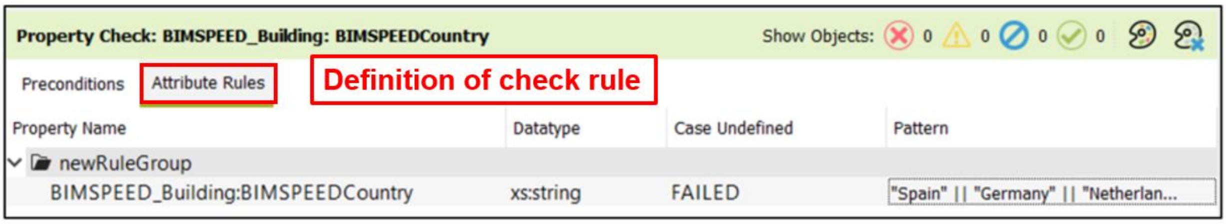


Figure 33 - Defintion of first check rule

6. Repeating step 3 – 5 for the other attributes “ES_BIMSPEEDClimateZone”, “BIMSPEEDAcousticRating” and “BIMSPEEDIsExternal”
   Example for creating a required precondition and having no specific allowed values is the attribute “BIMSPEEDIsExternal”. For this attribute there has to be defined a precondition, because this check should only check model elements of type “ifcWall”. Type of this attribute is “Boolean” and it has to be filled with “yes/no”, no empty value is allowed. Therefore the check rule checks, if there is this attribute is filled or not. The pattern says: Not undefined.

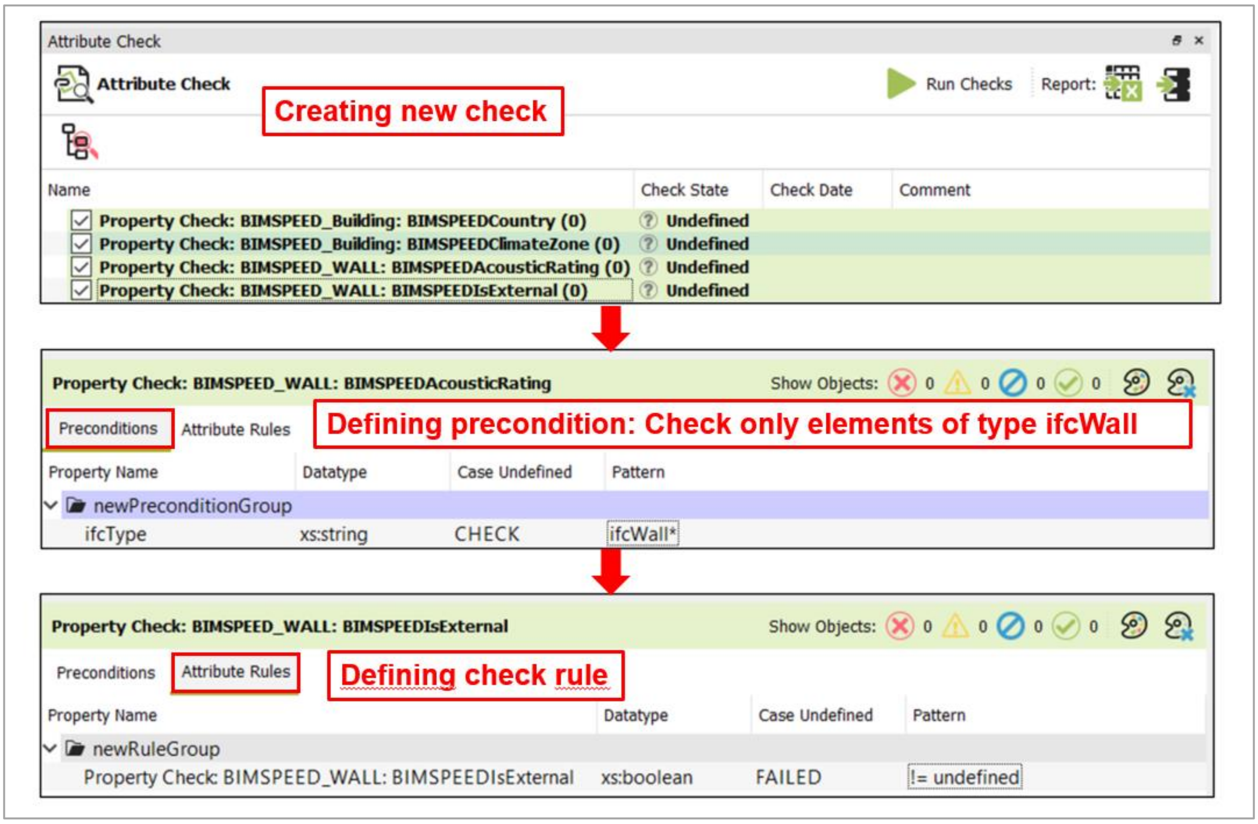


Figure 34 - Definition of attribute that is not allowed to be empty

7. Starting the checks (A).
8. Exporting check results to Excel (B) or into database (C) if connected.

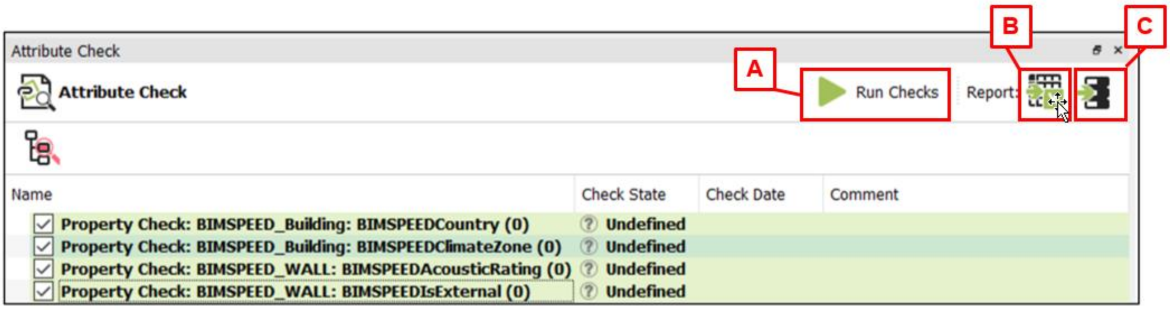


Figure 35 - Starting Check Runs and Exporting Results

The check results are shown in the top bar of the check rule definition window. It is shown how many model elements have failed or passed, how many have been ignored and how many give a warning as output. For better visualisation the 3D model can be coloured according to the element status.

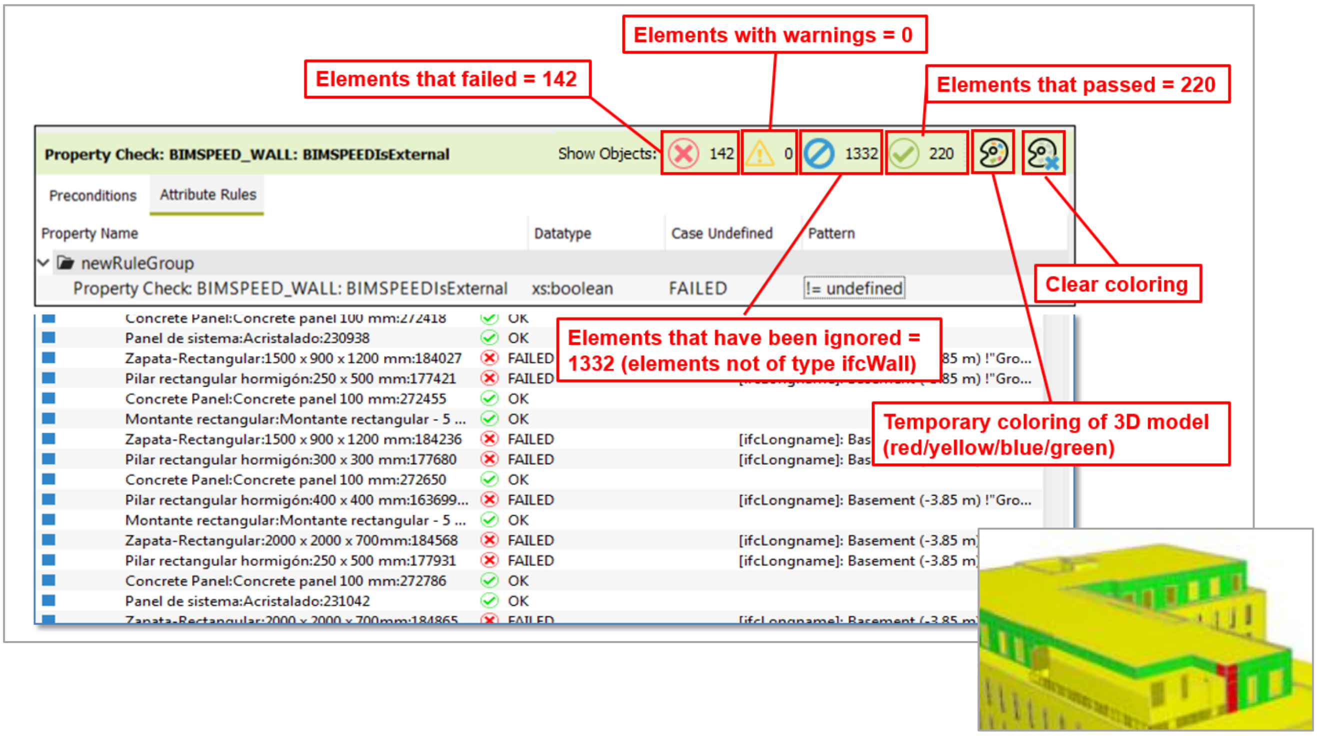


Figure 36 - Result of check

After exporting the check results to excel or into the database, this data can be prepared as QC report and can be given to the corresponding designer/BIM Author for updating the 3D model.

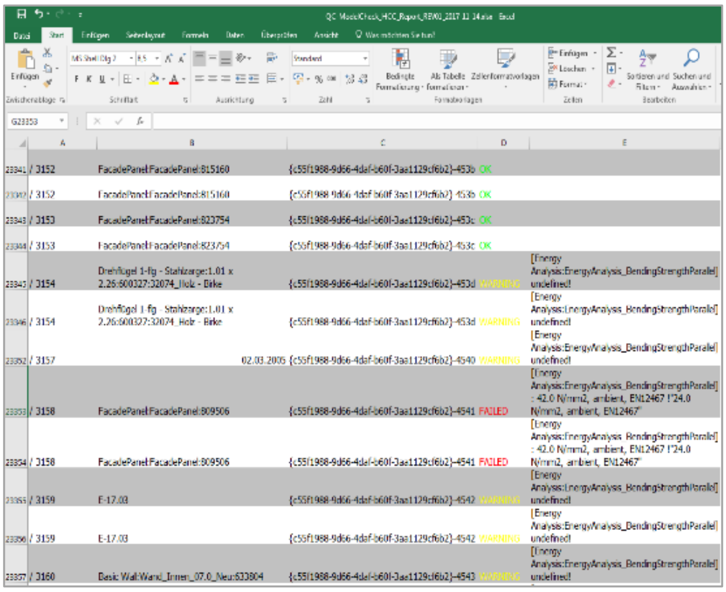


Figure 37 - Check Result Excel Export

Check to identify the relationship of elements

The main challenge while implementing semantic rules that require knowledge of relationship between 3D model elements was the identification of such. As introduced in work package 1 and described within this deliverable in section 3.2, the solution was the implementation of LIC and PIC as additional information attached to the 3D model elements. By doing so a geometrical reference has been established, which provided the required relationship between the 3D models to enable the design checks.

Deliverable 1.1 of Work Package 1 gives more details on the generation and usage of LIC and PIC. By integrating them to the project data structure, they built the point of connection for all kind of data and information.

Relating to Task 7.2 and 5.3 the integration of LIC into the 3D model elements, enabled the required identification of geometrical relationship between 3D model elements and therefore the smooth usage of Design and Model Checks.

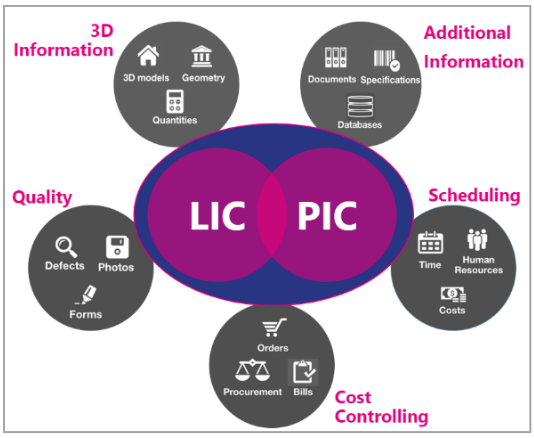


Figure 38 - LIC and PIC

In case the LIC and PIC does not exist within the 3D model, there are also some possibilities to identify relationships. This is not trivial and should only be used by experienced user. Additionally, it has to be regarded, that this procedure will not work for every needed identification of relationships. This is only possible by simply integrating the LIC and PIC to the 3D model elements.
But to get an idea and an impression how to generate a script for identification manually, the following guide will give some instruction.

For this demonstration rule No. 44 of Spanish Demo site will deal as example. The rule says in words: *In Spanish buildings, in Fire Exit Staircases, there has to be at least one door with definition "Fire Exit".*
Broken down in checkable format it looks like this:

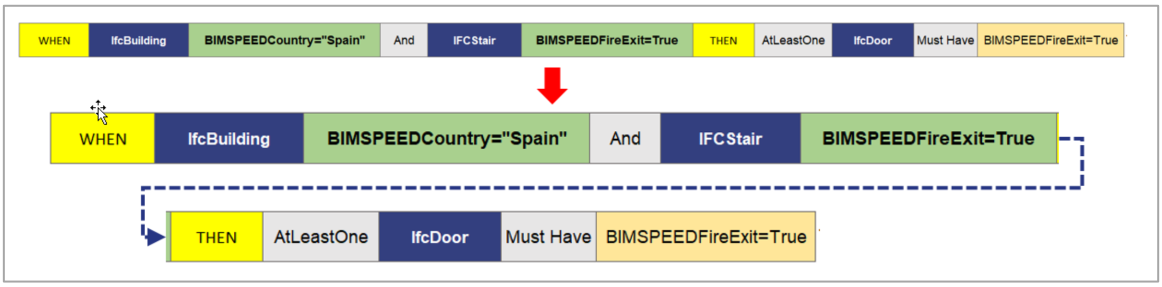


Figure 39 - Rule No. 44

To set up a check for rule 44 it is necessary to identify the relevant doors that do belong to the Staircase. That means a relationship between the entity door and the entity stair has to be made.

Easiest way to do this is of course the integration of LIC and PIC to the elements. Doing this, the door would have the same LIC assigned as the staircase. But not having the LIC another routine is possible at least for this specific rule. If identifying of other relationships between elements it has to be carefully evaluated, if same procedure may work.

In this case a JavaScript has been implemented, that can be run in Desite BIM using the “Script” tool.

To enable the user to create same script on its one, the following screenshots may help.

The script runs through 5 steps:

Step 1: Select all entities that are spaces.

Step 2: Select all entities that are stairs and defined as fire exits.

Step 3: Select all entities that are doors.

Step 4: Create a list of Stairs, Spaces and Doors. Identifiy stairs assigned as Fire Exit. Compare the list of spaces with list of stairs (Fire Exits). Give overlapping as output (=list of spaces).

Step 5: Compare the output list of spaces (Step 4) with the list of doors. Give overlapping as output. Add a parameter “DoorHasContactToFireExitStairs” to the uotput elements.

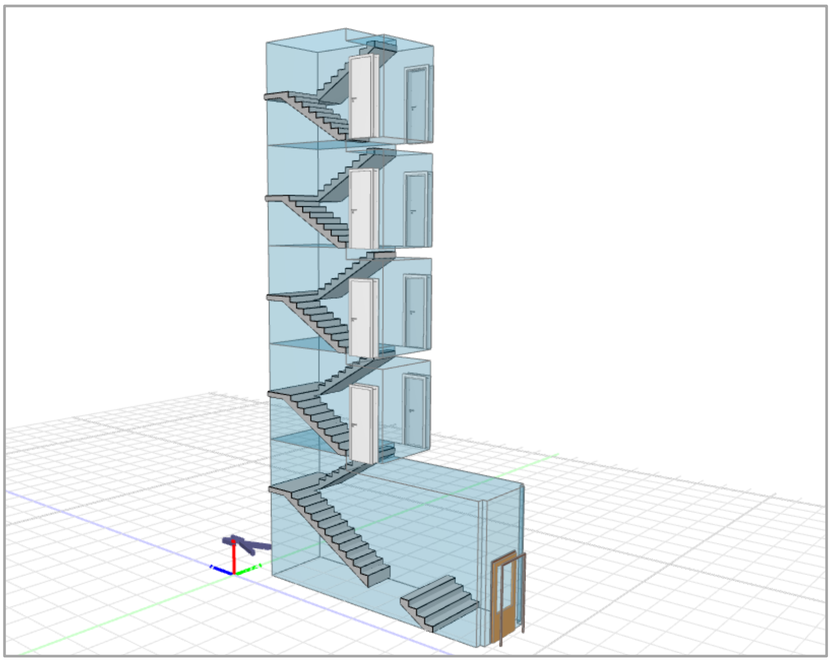


Figure 40 - Result of script: Identifying relevant spaces, stairs and doors

Final script including explanating commands is provided as attachement to this accomponying report of Deliverable 5.3.

```

// Schritt 1:

desiteAPI.itClear()
var it=desiteAPI.itByFilter("ifcType","xs:string","ifcSpace",true,"geometry")
var roomlistSTR=desiteAPI.itGetObjectList()


// Schritt 2:

desiteAPI.itClear()
it=desiteAPI.itByFilter("ifcType","xs:string","ifcStair*",true,"geometry")
it=desiteAPI.itByFilter("BIMSPEED_Stair:BIMSPEEDFireExit","xs:boolean",true,true,"geometry")
var stairlistSTR=desiteAPI.itGetObjectList()


// Schritt 3:

desiteAPI.itClear()
it=desiteAPI.itByFilter("ifcType","xs:string","ifcDoor",true,"geometry")
var doorlistSTR=desiteAPI.itGetObjectList()


// Schritt 4:

var roomlist=roomlistSTR.split(";")
var stairlist=stairlistSTR.split(";")
var doorlist=doorlistSTR.split(";")
var roomswithfireexitstairs=[]
for (var i=0; i<roomlist.length;i++){
        for (var k=0; k<stairlist.length;k++){
                if(desiteAPI.isIncludedIn(stairlist[k],roomlist[i]) == true
                || desiteAPI.checkIntersection(stairlist[k],roomlist[i]) == true){
                roomswithfireexitstairs.push(roomlist[i])
                }

        }
}


// Schritt 5:

var doorsWithContactToFireExitStairs=""

for  (var m=0; m<roomswithfireexitstairs.length; m++){
            for (var n=0; n<doorlist.length; n++){
               if(desiteAPI.checkIntersection(roomswithfireexitstairs[m],doorlist[n]) == true){
               doorsWithContactToFireExitStairs=doorsWithContactToFireExitStairs+";"+doorlist[n]
               desiteAPI.setPropertyValue(doorlist[n],"DoorHasContactToFireExitStairs","xs:boolean",true)
            }
      }
}

// Ausgabe:

var test=""
for (var l=0; l<roomswithfireexitstairs.length;l++){
     test=test+";"+roomswithfireexitstairs[l]
     }
desiteAPI.showElementsOnly(test)
desiteAPI.showElements(stairlistSTR)
desiteAPI.showElements(doorsWithContactToFireExitStairs)
"fertig"
```

Figure 41 - Screenshot of Script ("Schritt"=Step, "Ausgabe"=Output)

After running the script now an usual attribute check can be set up as model check by checking the new generated parameter "DoorHasContactToFireExitStairs".

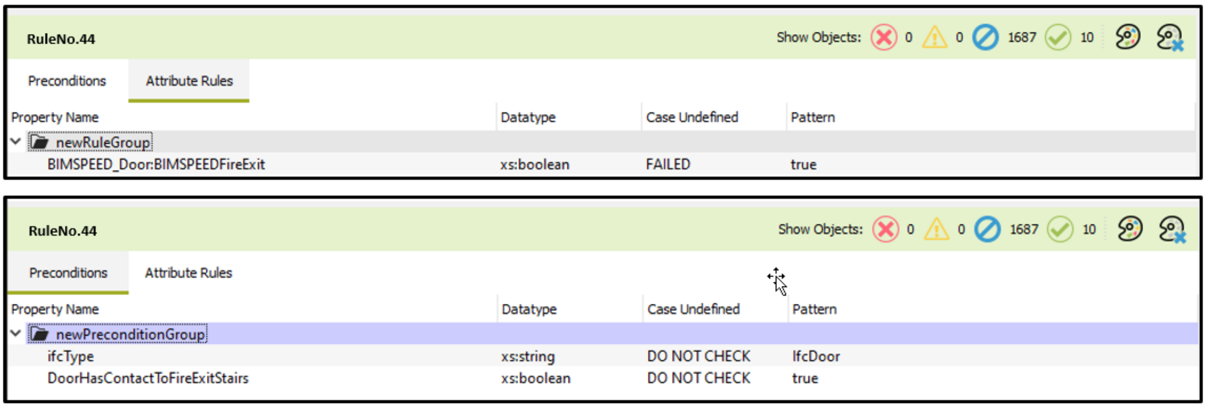


Figure 42 - Set up of corresponding attribute check

Check of two model versions

In case there is an update of the 3D model, DesiteBIM also provides a possibility to check the changes between two versions of a 3D model.

Figure 43 - Setting up of version check

By opening the tool "Versions" a dialog box pops up.

Now simply drag and drop the two versions of the 3D model into this dialogue and let the check run.

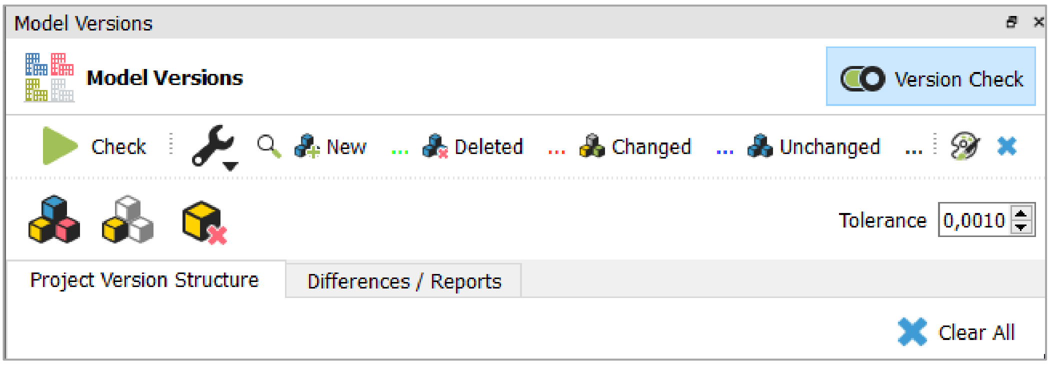


Figure 44 - Version Check

Result is an overview list of elements and attributes that are new or changed, as well as these, that have been deleted or are unchanged and additional information on how much etc.

The version check has been executed on the Spanish demosite, therefore the model *Comply* has been compared to the model *Not Comply*. The results are shown exemplarily in the figure below.

Object	Old Value	New Value
Tubo con uniones:Tubo:752654		
28SIHfBhb0IvYrQ$xGE0VV		
BIMSPEED_Building:BIMSPEEDCountry		Spain
BIMSPEED_Building:BIMSPEEDNumberOfStoreys?		6
BIMSPEED_Building:BIMSPEEDOccupancyType		Multi Family
BIMSPEED_Building:ES_BIMSPEEDClimateZone?		D
Elevation		104.000
RefLatitude		42° 51' 5.899658"
RefLatitudeDD		428.516
RefLongitude		-2° -40' -34.-426975"
RefLongitudeDD		-26.762
ifcCompositionType		ELEMENT
ifcHeaderData:TimeStamp	2021-07-13T15:42:41	2021-07-22T18:01:39
ifcLongName		P3
ifcOwnerHistory	LKS_PLZ (LKS INGENIERIA S.Coop) : NOCHANGE @2021-06-29T18:02:43	LKS_PLZ (LKS INGENIERIA S.Coop) : NOCHANGE @2021-06-29T11:40:42
ifcRelConnectsPortToElement	2jnvg$fM5EMuFpi2V5rB8B;2YEAlcx4D7vf9__9RbwVCv	1Au7zf55n72QZ5FePIVv0W;2G3CanlvP1q8TQzTWrcaBt
ifcServicedBySystems	Suministro hidrónico 4;Suministro hidrónico 10;Suministro hidrónico 11;Suministro hidrónico 13;Suministro hidrónico 12;Suministro hidrónico 14;Suministro hidrónico 28;Suministro hidrónico 27;Suministro hidrónico 29;Otro 1;Otro 14;Otro 15;Otro 16;Otro 3;Otro 17;Otro 18;Otro 19;Otro 4;Otro 20;Otro 21;Otro 22;Otro 5;Otro 6;Otro 7;Otro 8;Otro 9;Otro 10;Otro 11;Otro 12;Otro 13;Otro 23;Otro 25;Otro 24;Otro 26;Otro 28;Otro 27;Otro 30;Otro 29;Otro 31;Agua fría doméstica 2;Agua fría doméstica 1;Agua fría doméstica 3;Agua fría doméstica 4;Agua caliente doméstica 1;Agua caliente doméstica 2	Suministro hidrónico 4;Suministro hidrónico 10;Suministro hidrónico 11;Suministro hidrónico 13;Suministro hidrónico 12;Suministro hidrónico 14;Suministro hidrónico 28;Suministro hidrónico 27;Suministro hidrónico 29;Otro 14;Otro 1;Otro 15;Otro 16;Otro 17;Otro 3;Otro 18;Otro 19;Otro 4;Otro 20;Otro 21;Otro 22;Otro 5;Otro 6;Otro 7;Otro 8;Otro 9;Otro 11;Otro 10;Otro 12;Otro 13;Otro 23;Otro 24;Otro 25;Otro 26;Otro 27;Otro 28;Otro 30;Otro 29;Otro 31;Agua fría doméstica 2;Agua fría doméstica 1;Agua fría doméstica 3;Agua fría doméstica 4;Agua caliente doméstica 1;Agua caliente doméstica 2

Figure 45 - Result of version check

Appendix 003 –Guide for deviation analysis using 3D Reshaper

The deviation analysis is a use case for comparing a point cloud with an existing 3D model. This can be relevant in case the 3D model has been generated based on existing 2d drawings and it is not clear, if these 2d drawings are current or outdated.

For BIM Speed project the 3D Model of the Dutch Demo site has been generated based on existing 2D drawings. In parallel a laser scanning of the surrounding and outer shell has been done. The result was very impressive as the deviation was really very low. But more on this later. The following guide should help the user to set up a deviation analysis using 3D Reshaper on its own.

First step is to create a 3D mesh of the model data.

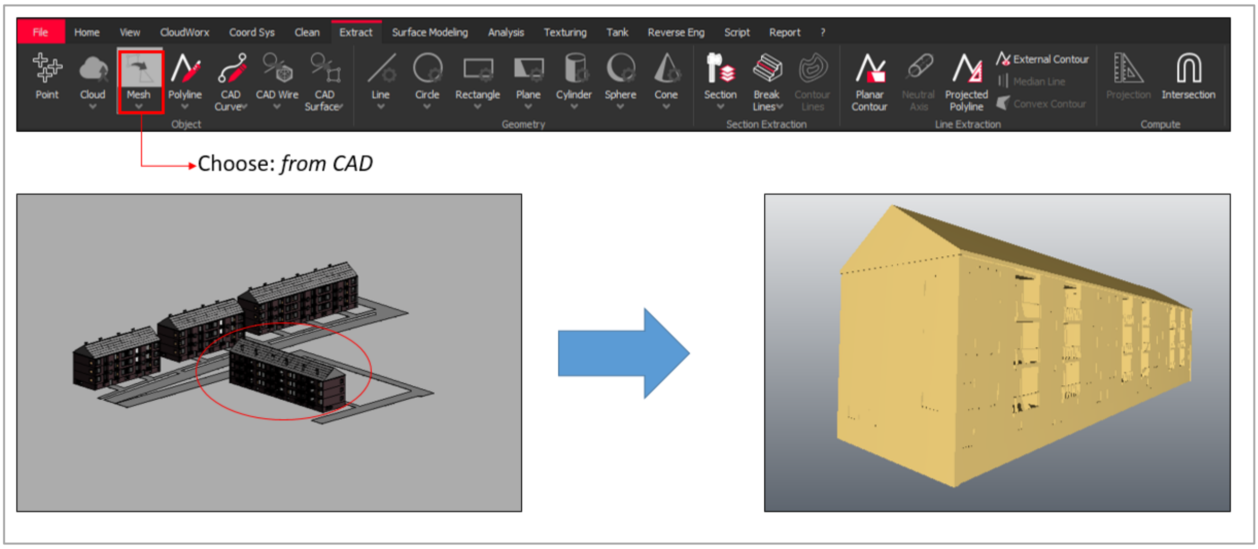


Figure 46 - Creating 3D Mesh

After performing laser scans on site all the collected information is available as several individual point clouds. To use them as a single source of information the separated point clouds have to be combined. The following image shows the general process to do so.

Task	To Dos	Results
Import	Load Laserscans to Leica Cyclone	Unregistered Pointclouds
Purge Scans	Remove wrong (mirror dots) and unwanted points from single point clouds	Purged Point Clouds
Registration	Choose two separate scans Rotate a scan to bring them in line Adjust height to bring them in line Optimize Adjustment (post-computing)	Registered Scan World (aligned)
Evaluation	Check errors and their weight	Combined scans to one Point Cloud

Figure 47 - general process steps of registering point clouds

This process step describes the manual way of aligning the several point clouds. The common way used by surveying experts is to use markers on site, which enables automatically registration of point clouds. For the purpose of deviation analysis between point cloud and 3D BIM models created on base of 2D drawings the manual way is sufficient and leads to less effort.

After importing the point cloud data to the software, this data has to be purged. Since there are several reasons for the laser scanner to recognize wrong measurements, the imported point clouds have to be purged. Wrong measurements can occur due to mirroring effects of windows or flat surfaces like puddles.

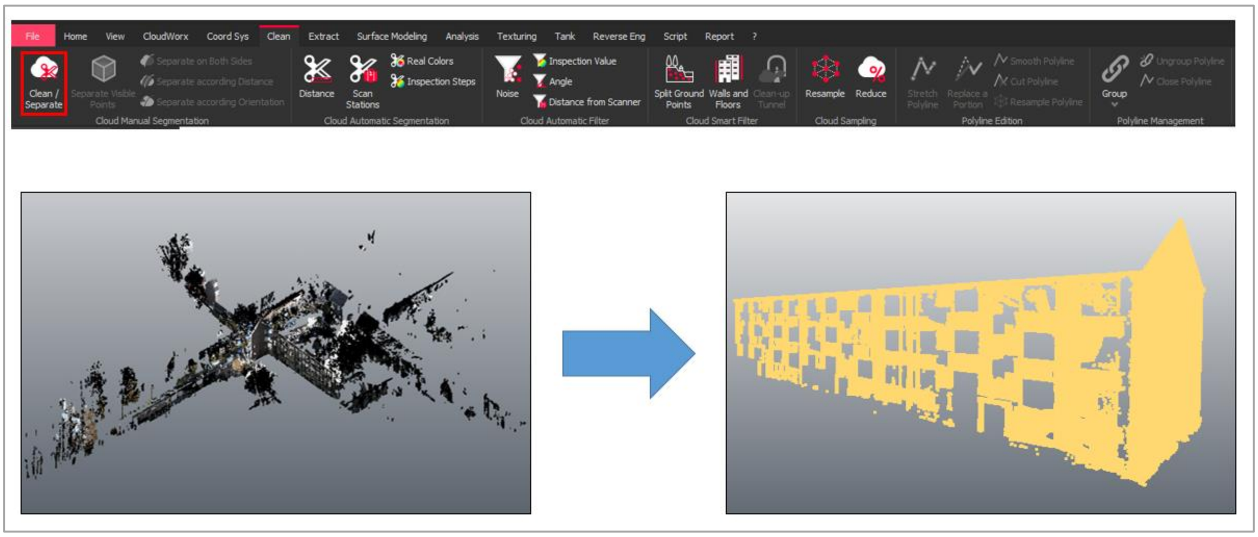


Figure 48 - Purging the point cloud

To bring the several point clouds together, they have to be grouped and aligned. Therefore it is necessary to adjust them accordingly (rotate/move/etc.).

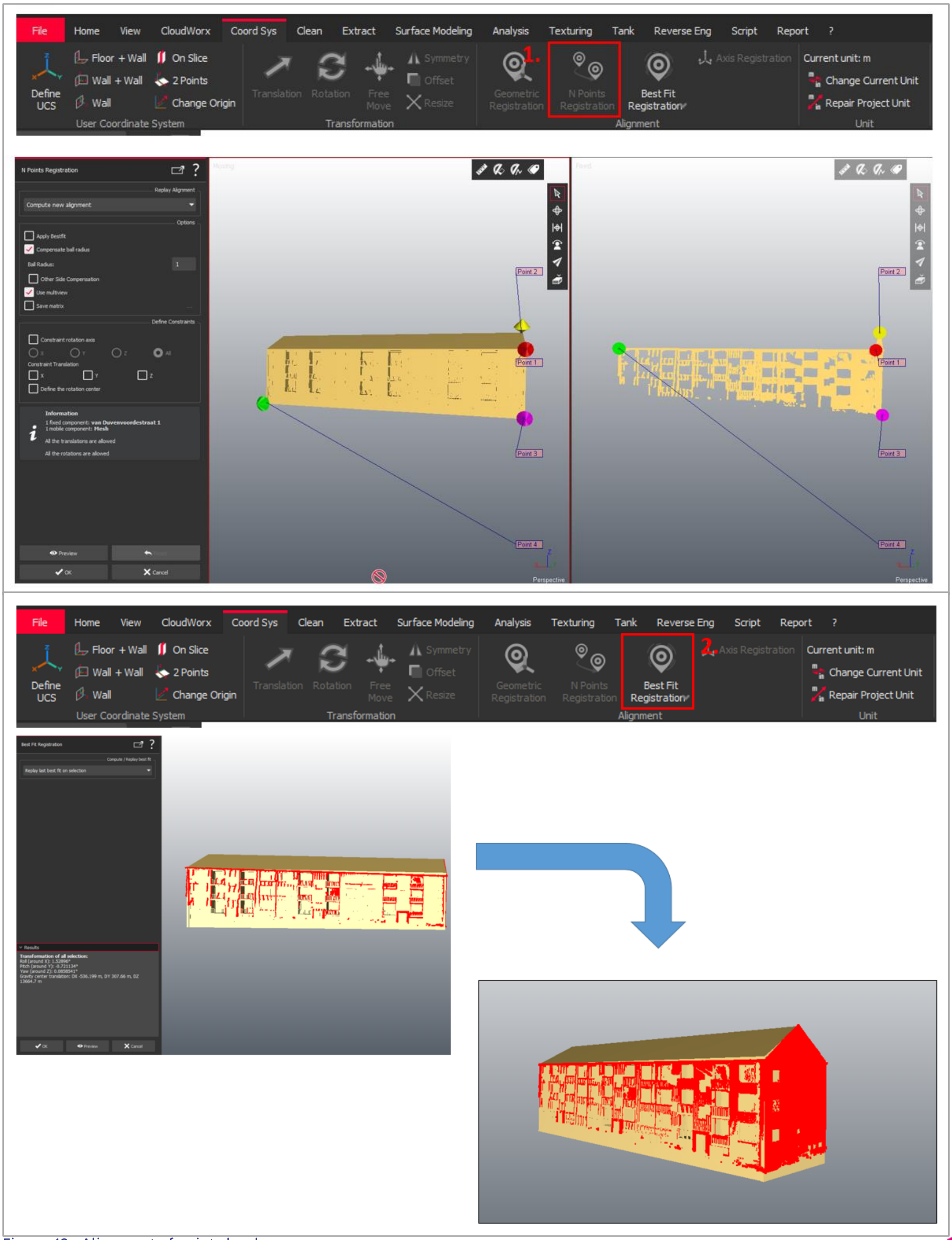


Figure 49 - Alignment of point clouds

After the manual alignment the results will be optimized by the computer to match the best possible results. The results have always to be reviewed to evaluate, whether the alignment is accurate enough for the further use cases. On case they are not sufficient the above mentioned process steps have to be repeated. A possible solution is to combine other scans to each other to merge all scans.

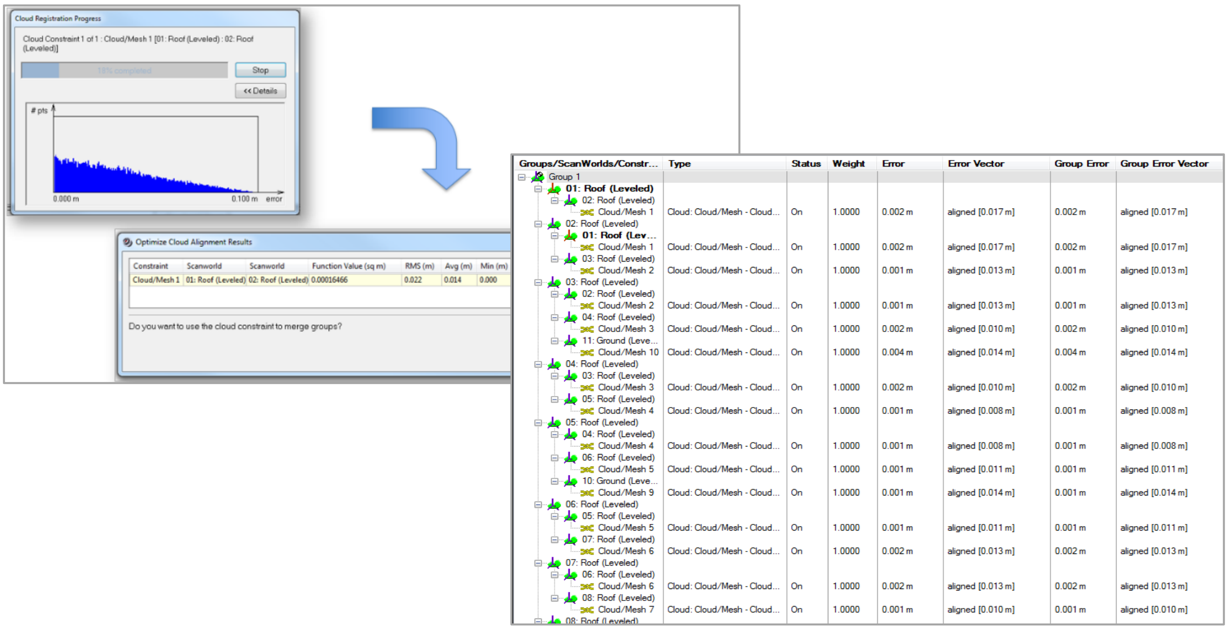


Figure 50 – Analysing and Optimizing results

Appendix 004 – Comparison of Software functionalities

Criteria for choosing a 3D Model Checking Tool

Criteria-ID	Explanation of criteria	Autodesk Navisworks Freedom (free of charge)	Autodesk Navisworks Manage (fee-based)	thinkproject Desite BIM (fee-based)	Nemetschek Solibri Model Viewer (free of charge)	Nemetschek Solibri Model Checker (fee-based)	Cyclone 3DR Standard (free of charge)	Cyclone 3DR Pro (fee-based)	BIMcollab ZOOM Free (free of charge)	BIMcollab ZOOM (fee-based)
B - Basic Information										
Performance	Handling of large models hase been done?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
D - Data, Interfaces & Output Options										
IFC-Import	Can 3D-Models be importet in IFC format?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
IFC-Version 2x3	Does the tool support IFC Version 2x3?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
IFC-Version 4	Does the tool support IFC Version 4?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
DWG-Import	Can DWG-Files be imported?	No	Yes	Yes	Yes	Yes	No	Yes	No	No
DWF(x)-Import	Can DWF- or DWFx Files be imported?	Yes	Yes	Yes	No	No	No	No	No	No
Non-propriertary file formats	Which additional non-propriertary file formats can be imported?	-	.sat, .iges, .it, .stp, .step	.cpixml, .landxml, .vpxml, GAEB, .obj, .json, .csv, GIS-Data	-	-	.stl, .pbi, .dxf, .poly, .obj, .msh, VRML files	.stl, .pbi, .dxf, .poly, .obj, .msh, VRML files	-	-
Native file formats	Which native file formats from BIM autohring tools are supported?	-	.rvt, .skp, .3dm, .dgn, .model, .prt, div. Lasscanning-Formats, Scheduling-Formats	.3ds, Orthophoto, Scatter Plots, WebService	-	-	.rvt, div. Point cloud formats, .obj	.rvt, div. Point cloud formats, .obj	point cloud format E57	point cloud format E57
Model consolidation	Can several models be imported and consolidated in one file?	No	Yes	Yes	No	Yes	Yes	Yes	-	-
3D-Export	Can data be exported from the tool in an open 3D-format (e.g. STL, OBJ, FBX, COLLADA, 3DS, IGES; STEP, and VRML/X3D.) for further analysis?	No	Yes	Yes	No	No	Yes	Yes	No	No
XLS-Export	Can data be exported from the tool in an XLS for further analysis?	No	Yes	Yes	No	Yes	No	No	No	No
BCF-Support	Is it possible to create BCF-files with tool?	0	0,5	1	1	1	0	0	0	1
I - Information, View, Review										
Show attributes	Is is possible to show attributes of certain objects of the model with the tool? Is it possible to create an overview?	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Add attributes	Can attributes be added at the model?	No	Yes	Yes	No	No	No	No	No	No
Calculate values	Can values be calculated based on existing attributes?	No	No	Yes	No	No	No	No	Yes	Yes
Rule-based model checking	Can models be checked rule-based/automated? (e.g. consistency of attributes)	No	No	Yes	No	Yes	No	No	Yes	Yes
Measuring functions	Which geometrical values can be measured in the model (length, area, volume)?	(summed) lengths, areas, angles, volumes usually attribut	(summed) lengths, areas, angles, volumes usually attribut	Point, Line, Polylines, Areas, Polygons, Distance	Distance between points, edges, corners, area and volume via attribut	Distance between points, edges, corners, area and volume via attribut	Distance between two points, angle between two planes or two lines.	Distance between two points, angle between two planes or two lines.	-	-
Viewpoints	Can predefined viewpoints be saved to allow a structural review of models?	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Exchange of viewpoints	Can predefined viewpoints be imported/exported?	No	Yes	Yes	No	Yes	No	No	Yes	Yes
Colour Scheme	Can colour schemes be created and displayed for different values of attributes?	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Transfer of clour scheme	Can colour schemes be extracted and transfered from an old version of a model to a newer one?	No	Yes	No	Yes	Yes	No	No	Yes	Yes
Redlining	Is a redlining function included to document model reviews?	No	Yes	Yes	Yes	Yes	-	-	-	-
Comparison of 3D-Versions	Can different versions / alternatives of 3D models be compared graphically?	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
4D-Animation	Can the tool show a 4D-construction sequence (linkage between model and time schedule) that has been created within the product family?	Yes	Yes	Yes	No	No	No	No	No	No
BoQ	Can the tool show a bill of quantity, which has been created within the product family?	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Linkage of external data	Can external data be retrieved through linkage of model elements?	Yes	Yes	Yes	No	No	No	No	Yes	Yes
Adjustment of frontend	Can the Frontend/User Interface be adjusted for different purposes?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Room information	Can information regarding rooms be shown?	Yes	Yes	Yes	Yes	Yes	No	No	-	-
Room information for room book	Collection of room information from different responsible persons for the preparation of a room book: - Specification of values for design (thermal load, power supply, fresh air) - Planned values above target value for change management	No	No	Yes	No	Yes	No	No	-	-
Evaluation	Implementation of figures for high level reporting (really only defined in conjunction with integration platform)	0	0,5	1	0	0	0	0	Yes	Yes
Point cloud management	Is a point cloud management function with automated point cloud analysis and modelling included	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes

Appendix 005 – Check Categories

Category	Check	What for?	What will be checked?	General model check			Comments
				semantics	numerical	geometrical	
Naming	Naming convention	Level	Does the naming convetion correspond to the BEP ?	x			
	Naming convention	Model	Does the the general naming for elements / rooms / spaces / etc. has Space / additional character in it's name ?	x			
General	File Size	File	Does the file exceed the suggested file size of 200 Mb ?	x			
	Project Information	Model	Are the project information correctly filled ?	x			
	Simplification	Model	Is the model purged ? Are all unused elements / families / defintions removed ?			x	
	Linked files	Model	Are all linked files (xrefs, pdfs, dwgs etc.) removed ?			x	
	Referred models	Model	Are all referred models removed ?			x	
	Warnings	Model	Are all resolvable programe warnings resolved ?			x	
Location	Coordinates	Model	Is the model placed on the correct and real-world coordinates ?		x		
	Enviromental Information	Model	Is the model filled with enviromental information (for example the weather) ?	x			
	planing grid	Model	Is the planning grid incooperated in the model ?		x		
Model classification	Element Classification	Element	Are the elements correctly classified according to Uniclass 2015 ?	x			
	3D objects which are not part of a verified library	Element	Have been every point of the checklist for 3D objects which are not part of a verrified library followed ?	x	x		
	Spaces	Model	Are all areas in the building model covered in spaces ?	x		x	- No overlaps between the space volume and the attached building elements - There are no void volumes
	Spaces	Model	Do the spaces include all necessary information ?	x	x		Define the peole, lightnings and electrical equipments (density and schedule) at each space, selecting the space type and if the space is occupiable.
	Room	Model	Are all rooms defined with the correct properties (Type, Room-No, Area, etc.) ?	x	x		
	Level	Model	Does the level defintion correspond with the as-built informations ?	x	x	x	The name of the level should be defined above the structural part of the floor and below the finishing.
	Building Type	Model	Is the building type and the infiltration class defined ?	x	x	x	
Attribute / Parameter	Check if existing	Attribute / Parameter	Is attribute/parameter set in model according to the BEP?	x	x		Requires a list of possible values
	Check if existing	Attribute / Parameter	Is attribute/parameter filled out in model?		x		
	Check if existing	Attribute / Parameter	Does attribute/parameter value generally match with given values (e.g. COBie sheets/Uniclass-Codes) ?		x		
	Check if existing	Attribute / Parameter	How often is an attribute/parameter value set in the model ?		x		
	Check if existing	Attribute / Parameter	Are specific values only used once in the model ?		x		
	Check if existing	Attribute / Parameter	Are all given attribute/parameter values in the model ?	x	x		
	Check if existing	Attribute / Parameter	Is combination of 2 or more attribute/parameters given in the model and is this combination correct ?		x		Requires a list of possible combinations
	Check if existing	Attribute / Parameter	Does every element have a unique ID ?		x		
	Units	Attributes / parameter values	Do the used units correspond to the guideline for units (general and MEP) ?		x	x	
Geometry	Check of 3D consistence and relationship	Element	Is every element a closed 3D object?			x	
	Check of 3D consistence and relationship	Element	Is the model free of 2D elements ?			x	
	Check of 3D consistence and relationship	Element	Have been the relationship of 3d elements incorparated ?			x	For example: The slab needs to be modeled on top of the coloumn, it is not allowed to have a clash or a space there.
	Check of 3D consistence and relationship	Element	Are elements modeled on and assigned to correct level ?	x	x	x	
	Check of 3D consistence and relationship	Element	Are elements assigned to correct room ?	x	x	x	
	Check of 3D consistence and relationship	Element	Are elements assigned to correct space ?	x	x	x	
	Check of 3D consistence and relationship	Element	Is the LOD of 3D objects according to the suggestions of RIBA stage ?		x	x	
	Check of 3D consistence and relationship	Element	Are elements assigned to the correct modelling phase ?		x	x	
	Check of 3D consistence and relationship	Element	Are elements assigned to the maintance group ?	x	x		
	Check of 3D consistence and relationship	Element	Are elements modelled according to the existent as-built information ?			x	
	Check of 3D consistence and relationship	Element	Are elements assigned to a component category ?	x	x		For example: column as column
	Check of 3D consistence and relationship	Element	Is the model free from overlaying elements / doublings ?			x	
Lists	Lists	Element	Have lists of doors/windows/rooms been created by CAD system (to be compared with given values) ?	x	x		It is recommendable to structure all lists the same.
Version	Model version	Model	Comparison of 2 revisions of a model concerning 3D elements and/or attribute/parameters				Which elelemnts/attribute/parameters are new/deleted/revised?
Export	Export Format	Model	Required export format: IFC 2x3 or IFC 4	x	x	x	

Appendix 006 – QC List

QUALITY MANAGEMENT - BIM MODEL CHECKLIST

FACILITY	select...	SUBMISSION DAT	YYYY-MM-DD
DISCIPLINE CODE	select...	QA/QC DATE	YYYY-MM-DD
FILE NAME	copy file name here	+	Approved
REVISION	select...	-	Not Approved
AUTHOR	select...	o	Not Required
EXAMINER	select...		Not checked

No	Checkpoint	Process/ Tool	1. QC (EXAMINER)			Feedback Author	2. QC (EXAMINER)			Feedback Author
			Status Approval	Reference	Comment	Comment	Status Approval	Reference	Comment	Comment
QC-GENERAL										
1	File naming as per 3D Modeling Standards	Desite BIM								
2	Landing Page as per 3D Modeling Standards	CAD Application								
3	Linked Files unloaded	CAD Application								
4	Model is purged	CAD Application								
5	Units	CAD Application								
6	Coodinates	Desite BIM								
7	Structure of model according to PBS	Desite BIM								
8	Virus Free	Windows								
9	Filesize	Windows								
10	Levels and Grids defined	CAD Application								
11	All elements unique ID	Desite BIM								
12	All elements 3D solids	Desite BIM								
QC-STANDARDS										
13	File Naming	Desite BIM								
14	Level Naming	Desite BIM								
15	Material Naming	Desite BIM								
16	Attribute Naming	Desite BIM								
17	Element Naming	Desite BIM								
18	Color Code	Desite BIM								
QC-Attributes										
19	Completeness according to required definition	Desite BIM								
20	Correct Values according to required definition	Desite BIM								
QC-MODEL										
21	3D Room Elements existing	Desite BIM								
22	Assignemt of Elements (level or system wise)	Desite BIM								
23	Segregation of elements according to PBS	Desite BIM								
24	All Model elements represent correct type (wall = wall, coloumn = coloumn,	Desite BIM								

Appendix 007 – Attribute List

BIMSPEED Properties					
Model Element/ IfcEntity	**Country**	**BIMSPEED General**	**BIMSPEED Country Specific**	**Type**	**Value**
IfcBuilding	General	BIMSPEED_Building	BIMSPEEDCountry	STRING	Spain; Germany; Netherlands; Poland; Romania; Bulgaria; Italy
IfcBuilding	General	BIMSPEED_Building	BIMSPEEDOccupancyType	STRING	MultiFamily; Single Family
IfcBuilding	General	BIMSPEED_Building	BIMSPEEDNumberOfStoreys	INTEGER	Number of Storey
IfcBuilding	ES	BIMSPEED_Building	ES_BIMSPEEDClimateZone	STRING	α; A; B; C; D; E
IfcBuilding	IT	BIMSPEED_Building	IT_BIMSPEEDClimateZone	STRING	α; A; B; C; D; E; F
IfcZone	General	BIMSPEED_Zone	BIMSPEEDPubliclyAccessible	BOOLEAN	Truth; False
IfcZone	General	BIMSPEED_Zone	BIMSPEEDNetAreaPlanned	INTEGER	[m^2]
IfcZone	NL	BIMSPEED_Zone	NL_BIMSPEEDFireCompartment	BOOLEAN	Truth; False
IfcZone	BG	BIMSPEED_Zone	BG_BIMSPEEDHandicapAccessible	BOOLEAN	Truth; False
IfcZone	NL	BIMSPEED_Zone	NL_BIMSPEEDHeight	INTEGER	[m]
IfcZone	NL	BIMSPEED_Zone	NL_BIMSPEEDGrossArePlanned	INTEGER	[m^2]
IfcZone	NL	BIMSPEED_Zone	NL_BIMSPEEDDistanceToExit	INTEGER	[m]
IfcSpace	General	BIMSPEEDSpace	BIMSPEEDCategory	STRING	Kitchen; Bathroom; WC; Auxilary Room; Corridor; Hall; Stairs; Living Room; Bedroom
IfcSpace	PL	BIMSPEEDSpace	PL_BIMSPEEDElectricCooker	BOOLEAN	Truth; False
IfcSpace	PL	BIMSPEEDSpace	PL_BIMSPEEDOccupancyNumber	INTEGER	Number of People
IfcSpace	PL	BIMSPEEDSpace	PL_BIMSPEEDVentilationAirFlowrate	INTEGER	[m^3/h]
IfcWall	General	BIMSPEED_Wall	BIMSPEEDAcousticRating	STRING	[dB]
IfcWall	General	BIMSPEED_Wall	BIMSPEEDFireRating	INTEGER	EuroClass
IfcWall	General	BIMSPEED_Wall	BIMSPEEDCombustible	BOOLEAN	Truth; False
IfcWall	General	BIMSPEED_Wall	BIMSPEEDThermalTransmittance	STRING	[W/m^2K]
IfcWall	General	BIMSPEED_Wall	BIMSPEEDLoadBearing	BOOLEAN	Truth; False
IfcWall	General	BIMSPEED_Wall	BIMSPEEDCompartmentation	BOOLEAN	Truth; False
IfcWall	General	BIMSPEED_Wall	BIMSPEEDIsExternal	BOOLEAN	Truth; False
IfcWall	PL	BIMSPEED_Wall	PL_BIMSPEEDHeatLabel	STRING	Private_Heated; Common_Heated; Basement_Heated; Basement_Unheated
IfcWall	DE	BIMSPEED_Wall	DE_BIMSPEEDHeatLabel	STRING	Private_Heated; Common_Heated
IfcWall	RO	BIMSPEED_Wall	RO_BIMSPEEDHeatLabel	STRING	Basement_Heated; Basement_Unheated
IfcWindow	General	BIMSPEED_Window	BIMSPEEDAcousticRating	INTEGER	[dB]
IfcWindow	General	BIMSPEED_Window	BIMSPEEDThermalTransmittance	INTEGER	[W/m^2K]
IfcWindow	PL	BIMSPEED_Window	PL_BIMSPEEDHeatLabel	STRING	Private_Heated; Common_Heated; Basement_Heated; Basement_Unheated
IfcWindow	DE	BIMSPEED_Window	DE_BIMSPEEDHeatLabel	STRING	Private_Heated; Common_Heated
IfcWindow	BG	BIMSPEED_Window	BG_BIMSPEEDFrameMaterial	STRING	PVC; Wood; Aluminium
IfcWindow	NL	BIMSPEED_Window	NL_BIMSPEEDGlassLayers	INTEGER	Number of Layers
IfcWindow	PL	BIMSPEED_Window	PL_BIMSPEEDRoofWindow	BOOLEAN	Truth; False
IfcWindow	NL	BIMSPEED_Window	NL_BIMSPEEDRoofWindow	BOOLEAN	Truth; False
IfcRoof	General	BIMSPEED_Roof	BIMSPEEDFireRating	STRING	EuroClass
IfcRoof	General	BIMSPEED_Roof	BIMSPEEDThermalTransmittance	INTEGER	[W/m^2K]
IfcRoof	General	BIMSPEED_Roof	BIMSPEEDIsExternal	BOOLEAN	Truth; False
IfcRoof	BG	BIMSPEED_Roof	BG_BIMSPEEDWarm	BOOLEAN	Truth; False
IfcRoof	BG	BIMSPEED_Roof	BG_BIMSPEEDCold	BOOLEAN	Truth; False
IfcRoof	PL	BIMSPEED_Roof	PL_BIMSPEEDHeatLabel	STRING	Private_Heated; Common_Heated; Basement_Heated; Basement_Unheated
IfcRoof	DE	BIMSPEED_Roof	DE_BIMSPEEDHeatLabel	STRING	Private_Heated; Common_Heated
IfcStair	General	BIMSPEED_Stair	BIMSPEEDRequiredHeadroom	INTEGER	[m]
IfcStair	General	BIMSPEED_Stair	BIMSPEEDFireExit	BOOLEAN	Truth; False
IfcStair	NL	BIMSPEED_Stair	NL_BIMSPEEDRiserHeight	INTEGER	[m]
IfcStair	NL	BIMSPEED_Stair	NL_BIMSPEEDTreadLength	INTEGER	[m]
IfcStair	ES	BIMSPEED_Stair	ES_BIMSPEEDProtected	BOOLEAN	Truth; False
IfcStair	ES	BIMSPEED_Stair	ES_BIMSPEEDSpecialProtected	BOOLEAN	Truth; False
IfcStair	ES	BIMSPEED_Stair	ES_BIMSPEEDFireVestibule	BOOLEAN	Truth; False
IfcFlowTerminal	General	IfcFlowTerminal	BIMSPEEDHeatingSource	STRING	Gas; Fuel; Other-Pellet; Other-Wood; Hotwater; Electricity
IfcFlowTerminal	RO	IfcFlowTerminal	RO_BIMSPEEDThermalEfficiency	INTEGER	[%]
IfcFlowTerminal	RO	IfcFlowTerminal	RO_BIMSPEEDOutputCapacity	INTEGER	[kW]
IfcDoor	General	BIMSPEED_Door	BIMSPEEDFireExit	BOOLEAN	Truth; False
IfcDoor	General	BIMSPEED_Door	BIMSPEEDFireRating	INTEGER	EuroClass

Appendix 008 – Design Rules

(dark blue)	Ifc ENTITY
(green)	PROPERTY OF EACH ENTITY. (ENTITIES ARE ALWAYS LOCATED ON THE LEFT OF THE PROPERTIES)
(grey)	QUANTITY AND LOGICAL OPERATORS
(yellow)	PROPERTY TO CHECK
(light blue)	VALUE AND MEASURE OF PROPERTY UNDER CHECK

	NO																		
+	1	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	And	IfcWall	BIMSPEEDIsExternal= True	THEN	IfcWall	Must Have	BIMSPEEDAcousticRating	>	35	dB				
+	2	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys <=8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=True	BIMSPEEDCombustible=True	BIMSPEEDCompartmentation= True	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	B
+	3	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys >8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=True	BIMSPEEDCombustible=True	BIMSPEEDCompartmentation= True	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	=	A
+	4	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys <=8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=True	BIMSPEEDCombustible=True	BIMSPEEDCompartmentation= False	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	C
+	5	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys >8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=True	BIMSPEEDCombustible=True	BIMSPEEDCompartmentation= False	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	B
+	6	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys <=8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=True	BIMSPEEDCombustible=False	BIMSPEEDCompartmentation= True	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	B
+	7	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys >8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=True	BIMSPEEDCombustible=False	BIMSPEEDCompartmentation= True	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	=	A
+	8	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys <=8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=True	BIMSPEEDCombustible=False	BIMSPEEDCompartmentation= False	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	C
+	9	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys >8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=True	BIMSPEEDCombustible=False	BIMSPEEDCompartmentation= False	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	B
+	10	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys <=8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=False	BIMSPEEDCombustible=True	BIMSPEEDCompartmentation= True	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	B
+	11	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys >8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=False	BIMSPEEDCombustible=True	BIMSPEEDCompartmentation= True	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	=	A
+	12	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys <=8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=False	BIMSPEEDCombustible=True	BIMSPEEDCompartmentation= False	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	C
+	13	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys >8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=False	BIMSPEEDCombustible=True	BIMSPEEDCompartmentation= False	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	B
+	14	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys <=8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=False	BIMSPEEDCombustible=False	BIMSPEEDCompartmentation= True	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	B
+	15	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys >8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=False	BIMSPEEDCombustible=False	BIMSPEEDCompartmentation= True	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	=	A
+	16	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys <=8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=False	BIMSPEEDCombustible=False	BIMSPEEDCompartmentation= False	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	D

+	17	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	BIMSPEEDBIMSPEEDNumberOfStoreys > 8	And	IfcWall	BIMSPEEDIsExternal=True	BIMSPEEDLoadBearing=False	BIMSPEEDCombustible=False	BIMSPEEDCompartmentation=False	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	C
+	18	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	And	IfcWall	BIMSPEEDIsExternal= False	THEN	IfcWall	BIMSPEEDFireRating	Check Not Available							
+	19	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone α"	And	IfcWall	BIMSPEEDIsExternal= True	THEN	All	IfcWall	Must Have	BIMSPEEDThermalTransmittance	<=	0,80	W/m2.K			
+	20	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone A"	And	IfcWall	BIMSPEEDIsExternal= True	THEN	All	IfcWall	Must Have	BIMSPEEDThermalTransmittance	<=	0,70	W/m2.K			
+	21	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone B"	And	IfcWall	BIMSPEEDIsExternal= True	THEN	All	IfcWall	Must Have	BIMSPEEDThermalTransmittance	<=	0,56	W/m2.K			
+	22	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone C"	And	IfcWall	BIMSPEEDIsExternal= True	THEN	All	IfcWall	Must Have	BIMSPEEDThermalTransmittance	<=	0,49	W/m2.K			
+	23	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone D"	And	IfcWall	BIMSPEEDIsExternal= True	THEN	All	IfcWall	Must Have	BIMSPEEDThermalTransmittance	<=	0,41	W/m2.K			
+	24	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone E"	And	IfcWall	BIMSPEEDIsExternal= True	THEN	All	IfcWall	Must Have	BIMSPEEDThermalTransmittance	<=	0,37	W/m2.K			
+	25	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	And	IfcWall	BIMSPEEDIsExternal= True	THEN	IfcWall	BIMSPEEDThermalTransmittance	Check Not Available							
+	26	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	And	IfcWall	BIMSPEEDIsExternal= True	THEN	All	IfcWall	Must Have	BIMSPEEDFireRating	<=	D				
+	27	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	And	IfcWall	BIMSPEEDIsExternal= False	THEN	IfcWall	BIMSPEEDFireRating	Check Not Available							
+	28	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone α"	And	IfcRoof	BIMSPEEDIsExternal= True	THEN	All	IfcRoof	Must Have	BIMSPEEDThermalTransmittance	<=	0,55	W/m2.K			
+	29	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone A"	And	IfcRoof	BIMSPEEDIsExternal= True	THEN	All	IfcRoof	Must Have	BIMSPEEDThermalTransmittance	<=	0,50	W/m2.K			
+	30	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone B"	And	IfcRoof	BIMSPEEDIsExternal= True	THEN	All	IfcRoof	Must Have	BIMSPEEDThermalTransmittance	<=	0,44	W/m2.K			
+	31	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone C"	And	IfcRoof	BIMSPEEDIsExternal= True	THEN	All	IfcRoof	Must Have	BIMSPEEDThermalTransmittance	<=	0,40	W/m2.K			
+	32	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone D"	And	IfcRoof	BIMSPEEDIsExternal= True	THEN	All	IfcRoof	Must Have	BIMSPEEDThermalTransmittance	<=	0,35	W/m2.K			
+	33	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone E"	And	IfcRoof	BIMSPEEDIsExternal= True	THEN	All	IfcRoof	Must Have	BIMSPEEDThermalTransmittance	<=	0,33	W/m2.K			
+	34	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	And	IfcRoof	BIMSPEEDIsExternal= False	THEN	IfcRoof	BIMSPEEDThermalTransmittance	Check Not Available							
+	35	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="α,A, B,C,D,E'	THEN	All	IfcWindow	Must Have	BIMSPEEDAcousticRating	>	30,00	dB						

+	36	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone α"	THEN	All	IfcWindow	Must Have	BIMSPEEDThermalTransmittance	<=	3,20	W/m2.K					
+	37	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone A"	THEN	All	IfcWindow	Must Have	BIMSPEEDThermalTransmittance	<=	2,70	W/m2.K					
+	38	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone B"	THEN	All	IfcWindow	Must Have	BIMSPEEDThermalTransmittance	<=	2,30	W/m2.K					
+	39	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone C"	THEN	All	IfcWindow	Must Have	BIMSPEEDThermalTransmittance	<=	2,10	W/m2.K					
+	40	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone D"	THEN	All	IfcWindow	Must Have	BIMSPEEDThermalTransmittance	<=	1,80	W/m2.K					
+	41	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	ES_BIMSPEEDClimateZone="Zone E"	THEN	All	IfcWindow	Must Have	BIMSPEEDThermalTransmittance	<=	1,80	W/m2.K					
+	42	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	THEN	All	IfcStair	Must Have	BIMSPEEDRequired Headroom	>=	2,00	m						
o	43	WHEN	IfcStair	ES_BIMSPEEDProtected=True	ES_BIMSPEEDSpecial Protected=True	THEN	User Input Error	*Message: "The IfcStair cannot be at the same time protected and special protected."*										
+	44	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IFCStair	BIMSPEEDFireExit=True	THEN	AtLeastOne	IfcDoor	Must Have	BIMSPEEDFireExit=True	This rule checks if a fire door is present, given that a fire exit stair exists in the building.					
+	45	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcDoor	BIMSPEEDFireExit=True	THEN	IfcDoor	Must Have	BIMSPEEDFireRating=A	This rule checks if the fire door complies with the minimum fire rating standard.						
+	46	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=True	THEN	IfcStair	Must Have	ES_BIMSPEEDFireVestibule=True	This rule checks if the fire stair includes a fire vestibule or not.						
-	47	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=True	ES_BIMSPEEDProtected=True	ES_BIMSPEEDSpecial Protected=False	ES_BIMSPEEDFireVestibule=True	And	IfcWall	BIMSPEEDCompartmentation=True	THEN	IfcWall	Must Have	BIMSPEEDFireRating<=B	This rule checks the fire rating of a surrounding wall of a fire exit and also protected stairway.
-	48	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=False	ES_BIMSPEEDProtected=False	ES_BIMSPEEDSpecial Protected=True	ES_BIMSPEEDFireVestibule=True	And	IfcWall	BIMSPEEDCompartmentation=True	THEN	IfcWall	Must Have	BIMSPEEDFireRating<=B	This rule checks the fire rating of a surrounding wall of special protected stairway, that also includes a fire vestibule.
-	49	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=True	ES_BIMSPEEDProtected=False	ES_BIMSPEEDSpecial Protected=True	ES_BIMSPEEDFireVestibule=True	And	IfcWall	BIMSPEEDCompartmentation=True	THEN	IfcWall	Must Have	BIMSPEEDFireRating<=B	This rule checks the fire rating of a surrounding wall of a special protected stairway, that is also a fire exit.
-	50	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=False	ES_BIMSPEEDProtected=False	ES_BIMSPEEDSpecial Protected=True	ES_BIMSPEEDFireVestibule=False	And	IfcWall	BIMSPEEDCompartmentation=True	THEN	IfcWall	Must Have	BIMSPEEDFireRating<=B	This rule checks the fire rating of a surrounding wall of a special protected stairway, that does not include a fire
-	51	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=False	ES_BIMSPEEDProtected=True	ES_BIMSPEEDSpecial Protected=False	ES_BIMSPEEDFireVestibule=True	And	IfcWall	BIMSPEEDCompartmentation=True	THEN	IfcWall	Must Have	BIMSPEEDFireRating<=C	This rule checks the fire rating of the surrounding walls of a protected stairway, that also
-	52	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=False	ES_BIMSPEEDProtected=True	ES_BIMSPEEDSpecial Protected=False	ES_BIMSPEEDFireVestibule=False	And	IfcWall	BIMSPEEDCompartmentation=True	THEN	IfcWall	Must Have	BIMSPEEDFireRating<=C	This rule checks the fire rating of the surrounding walls of a protected stairway, that does

-	53	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=True	ES_BIMSPEEDProtected=False	ES_BIMSPEEDSpecial Protected=False	ES_BIMSPEEDFireVestibule=True	And	IfcWall	BIMSPEEDCompartmentation=True	THEN	IfcWall	Must Have	BIMSPEEDFireRating<=C	This rule checks the fire rating of the surrounding wall of a protected stairway, that does
O	54	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=True	ES_BIMSPEEDProtected=False	ES_BIMSPEEDSpecial Protected=False	ES_BIMSPEEDFireVestibule=False	THEN	IfcStair	Does Not Comply	*Message: "The IfcStair serves as fire exit and a fire vestibule is required."*				
-	55	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=True	And	IfcDoor	BIMSPEEDFireExit=False	THEN	IfcDoor	Does Not Comply	*Message: "The IfcStair serves as fire exit and a fire door is required."*				
O	56	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=True	ES_BIMSPEEDProtected=False	ES_BIMSPEEDSpecial Protected=True	ES_BIMSPEEDFireVestibule=False	THEN	Stair Does Not Comply	*Message: "The IfcStair serves as fire exit and thus, a fire vestibule is required."*					
O	57	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=True	ES_BIMSPEEDProtected=True	ES_BIMSPEEDSpecial Protected=False	ES_BIMSPEEDFireVestibule=False	THEN	Stair Does Not Comply	*Message: "The IfcStair serves as fire exit and thus, a fire vestibule is required."*					
O	58	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=True	ES_BIMSPEEDProtected=False	ES_BIMSPEEDSpecial Protected=False	ES_BIMSPEEDFireVestibule=False	THEN	Stair Does Not Comply	*Message: "The IfcStairCommon serves as fire exit and a fire vestibule is required."*					
O	59	WHEN	IfcBuilding	BIMSPEEDCountry ="Spain"	And	IfcStair	BIMSPEEDFireExit=False	ES_BIMSPEEDProtected=False	ES_BIMSPEEDSpecial Protected=False	ES_BIMSPEEDFireVestibule=True	THEN	Message to User	*Message: "The IfcStairCommon does not serve as fire exit and thus, a fire vestibule is not required."*					

Appendix 009 (zip) – Desite BIM Project and Checks

This Appendix can be found in following repository on DepositeOnce

http://dx.doi.org/10.14279/depositonce-12627