Summer School of Linked Data in Architecture & Construction 2022

Comply

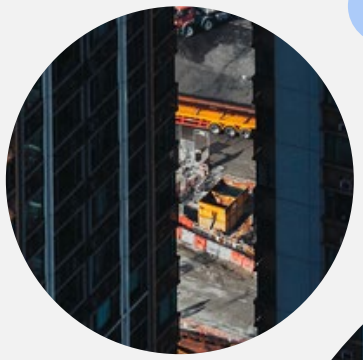
Ontology-based completeness & compliance checking

June 10, 2022

Team8; The compliance checkers

Contents

- Team
- Problem statement
- Process
- Solution
- Future work



Team

Adam

Detlev

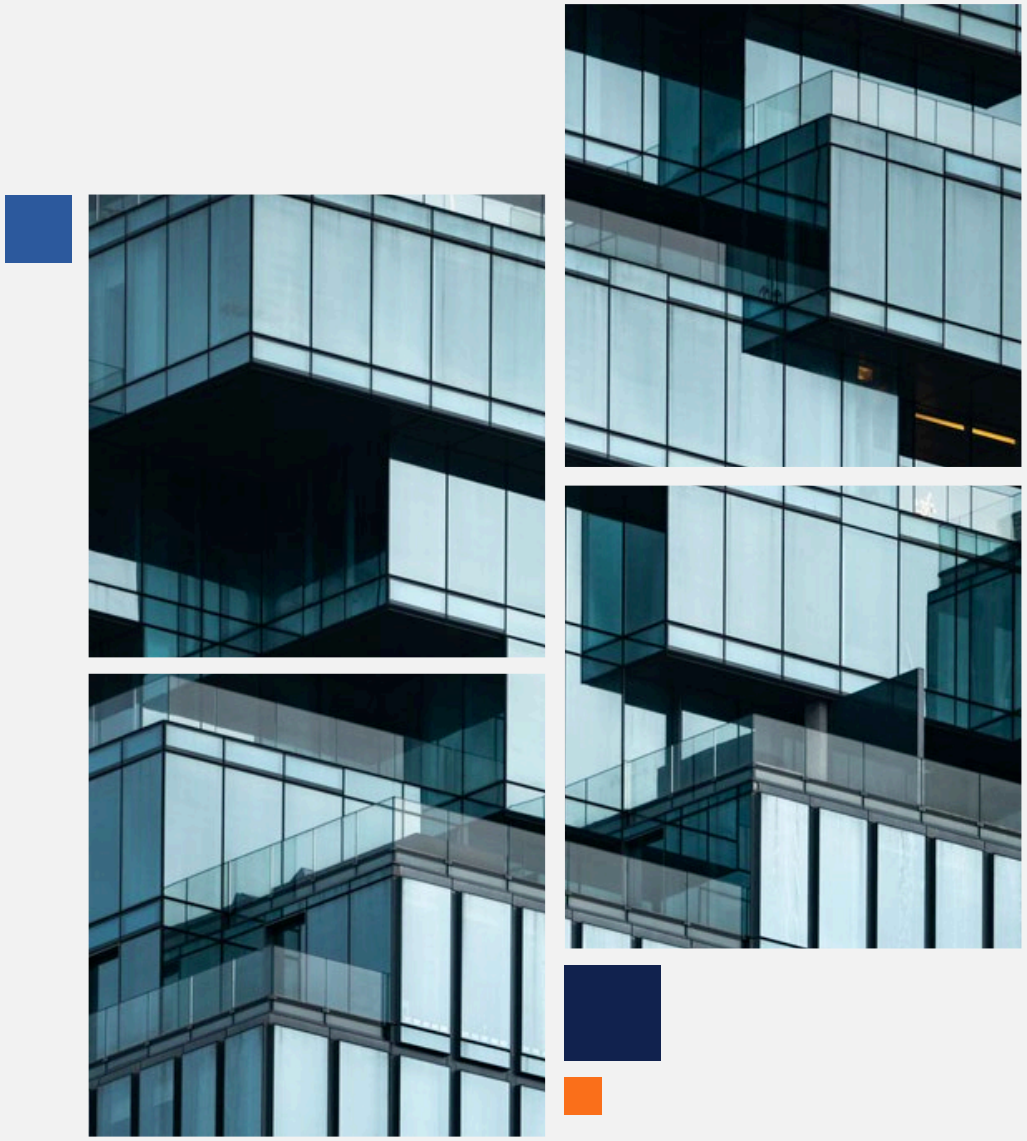
Diellza

Dimitris

Problem statement

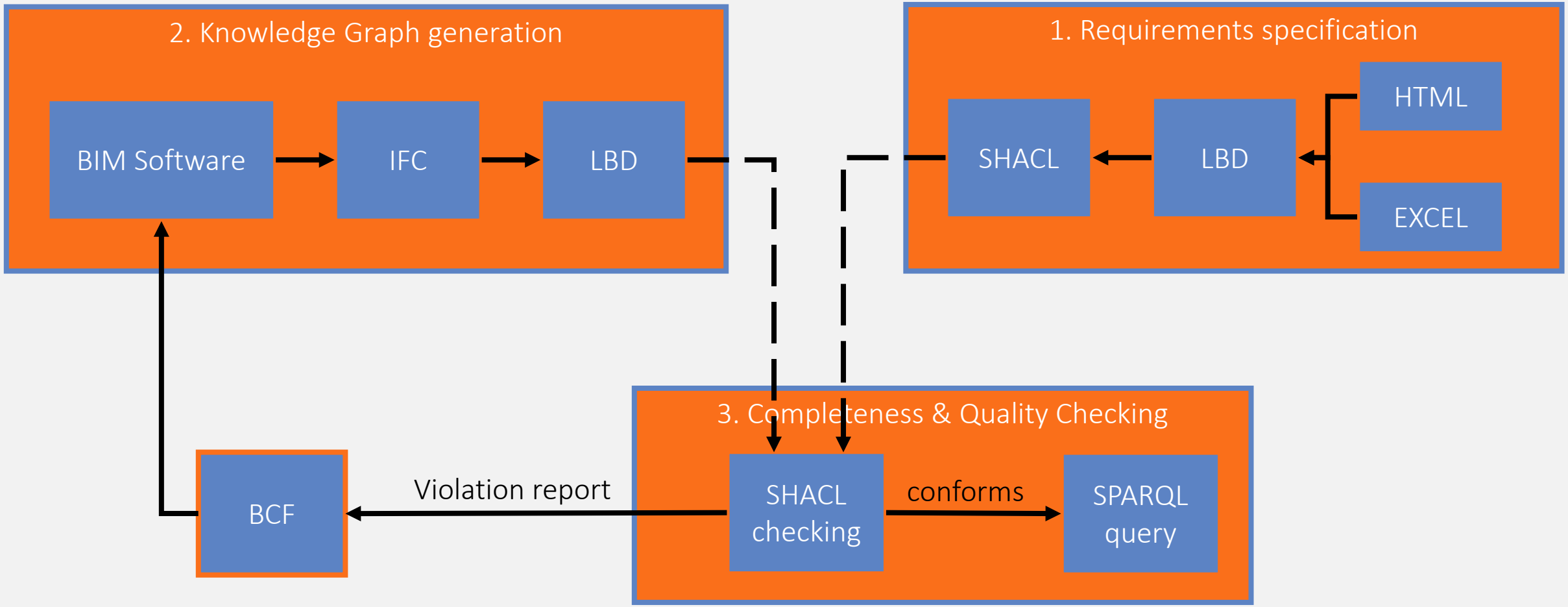
Challenge 5: Ontology-based Compliance Checking

- Physical buildings need to meet regulations,
- Building models need to be of sufficient quality to check regulations,
- Linked data supports homogenization of data
- There is no clear method in checking and reporting the quality of linked building data

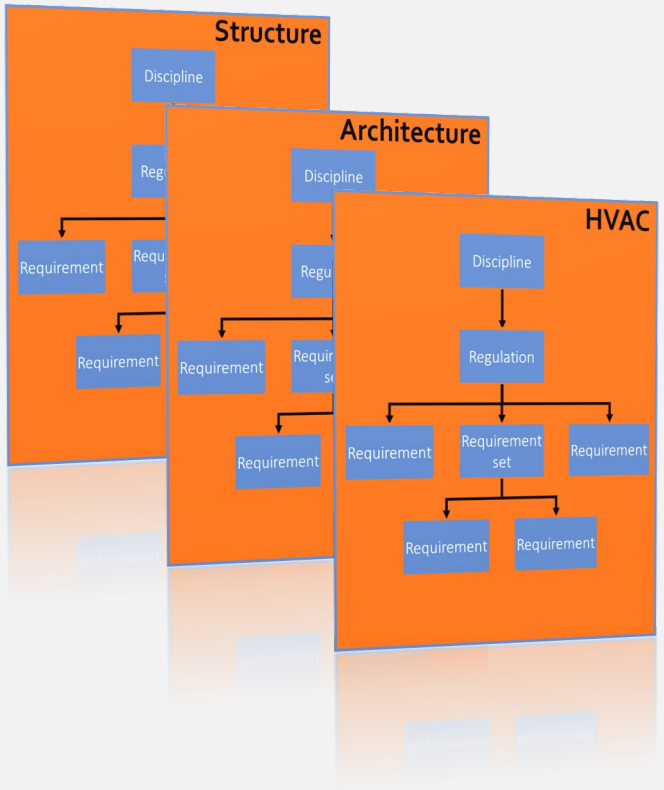


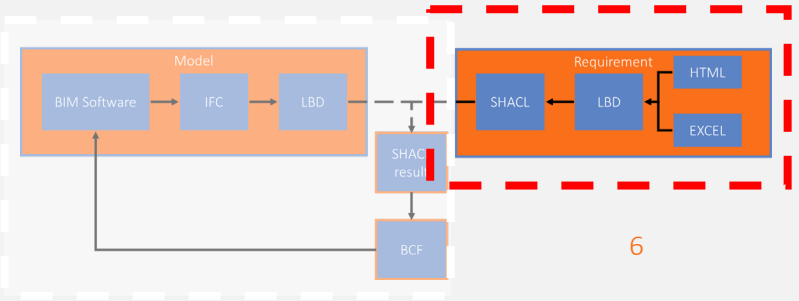
Process Diagram

Ontology-based completeness & compliance checking



1. Requirements Specification





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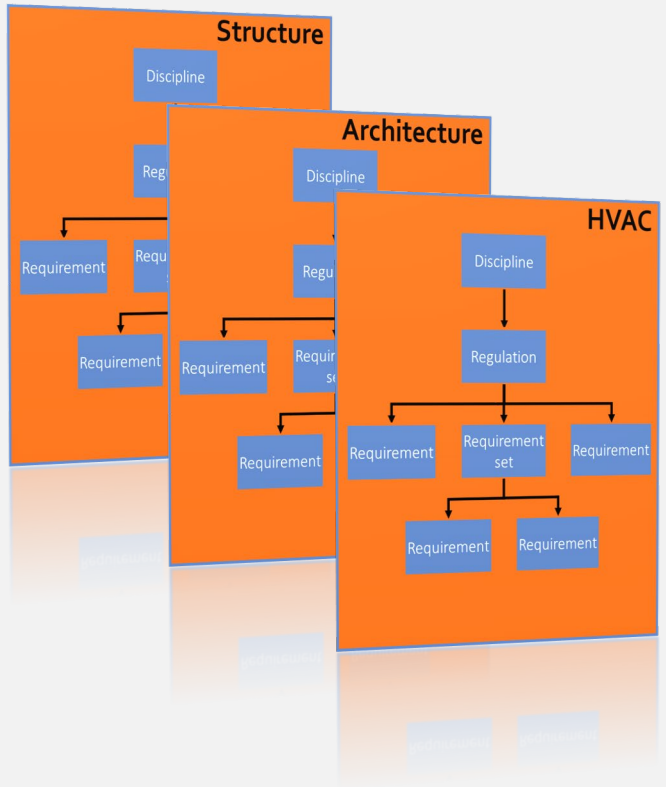


BimReq

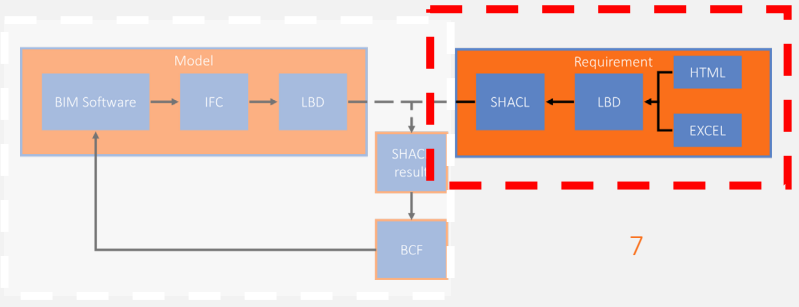
IRI:
http://demo.dsd.sztaki.hu/bimreq#

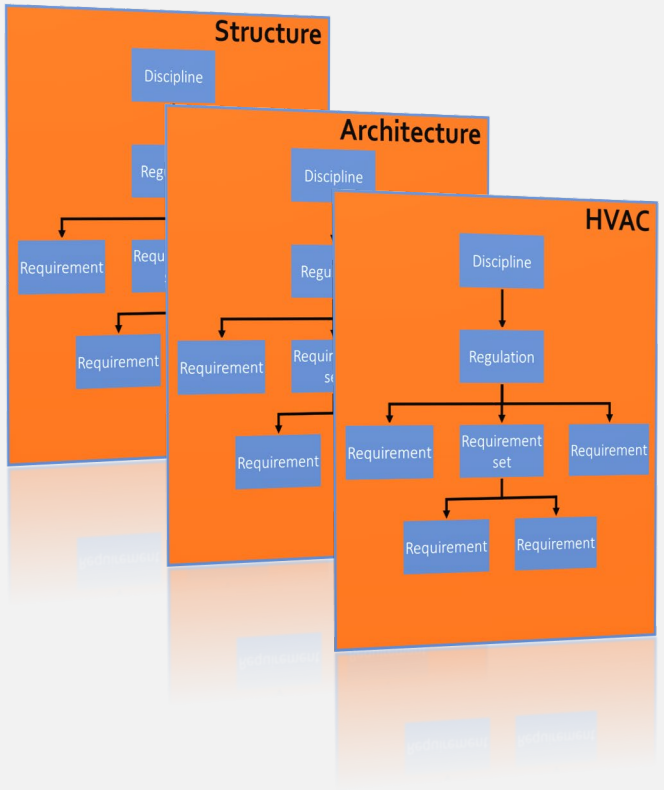
Current version:
0.9

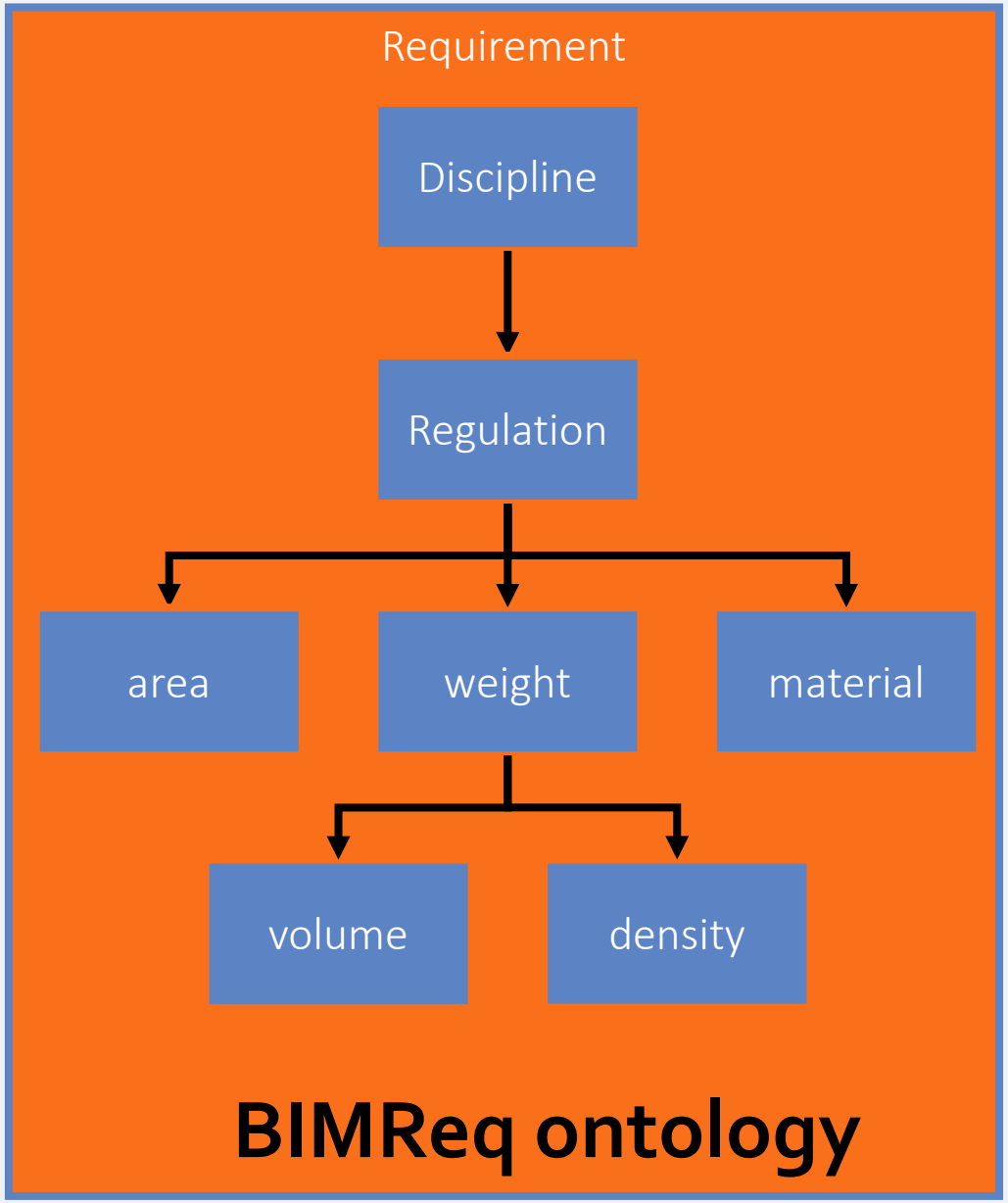
Authors:
András Micsik, Ádám Kovács

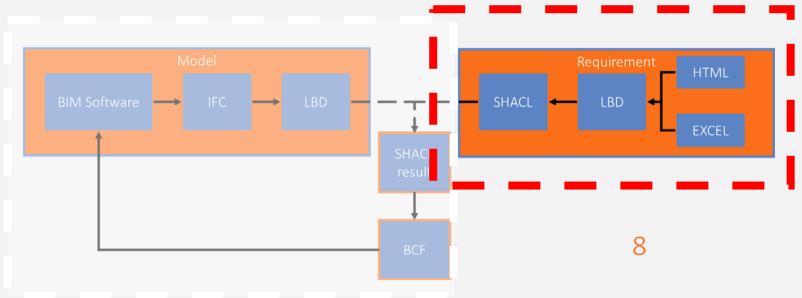
Imported Ontologies:
http://www.w3.org/ns/shacl# (visualise it with LODE)
http://xmlns.com/foaf/0.1/ (visualise it with LODE)
https://w3id.org/express# (visualise it with LODE)

Other visualisation:
Ontology source



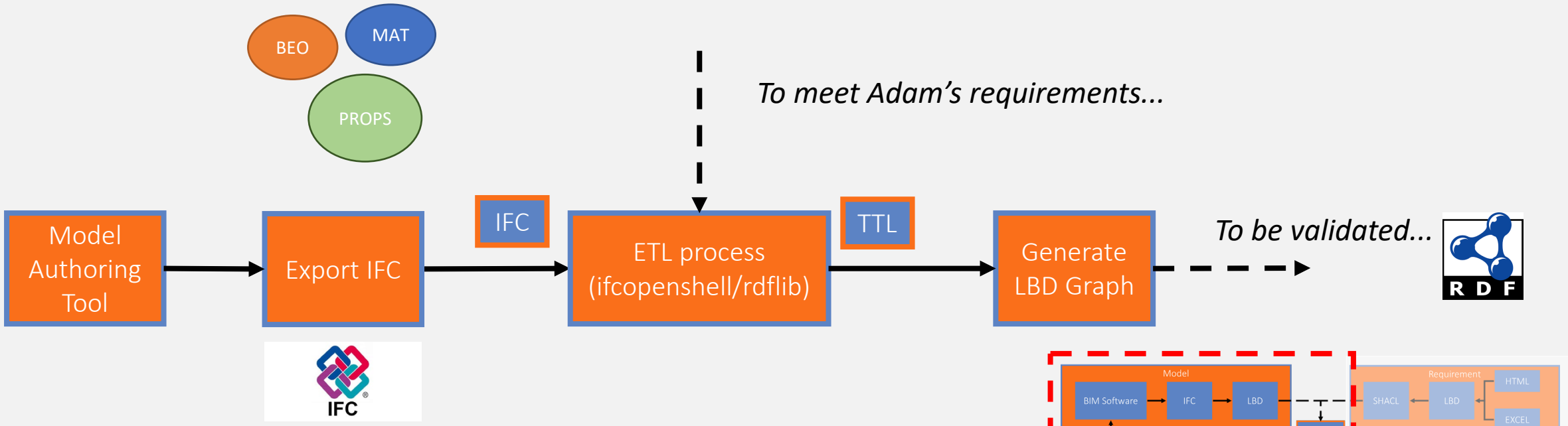

Structure
Discipline
Architecture
Discipline
Requirement
Requirement
HVAC
Discipline
Regulation
Requirement
Requirement set
Requirement
Requirement
Requirement


Requirement
Discipline
Regulation
area
weight
material
volume
density
BIMReq ontology


Model
BIM Software
IFC
LBD
Requirement
SHACL
LBD
HTML
EXCEL
BCF

2. Knowledge Graph generation

- **IFC-to-LBD converter / KGG** could not produce what we wanted (need for further enrichment)
- ETL process using ifcopenshell/rdflib to create the knowledge graph



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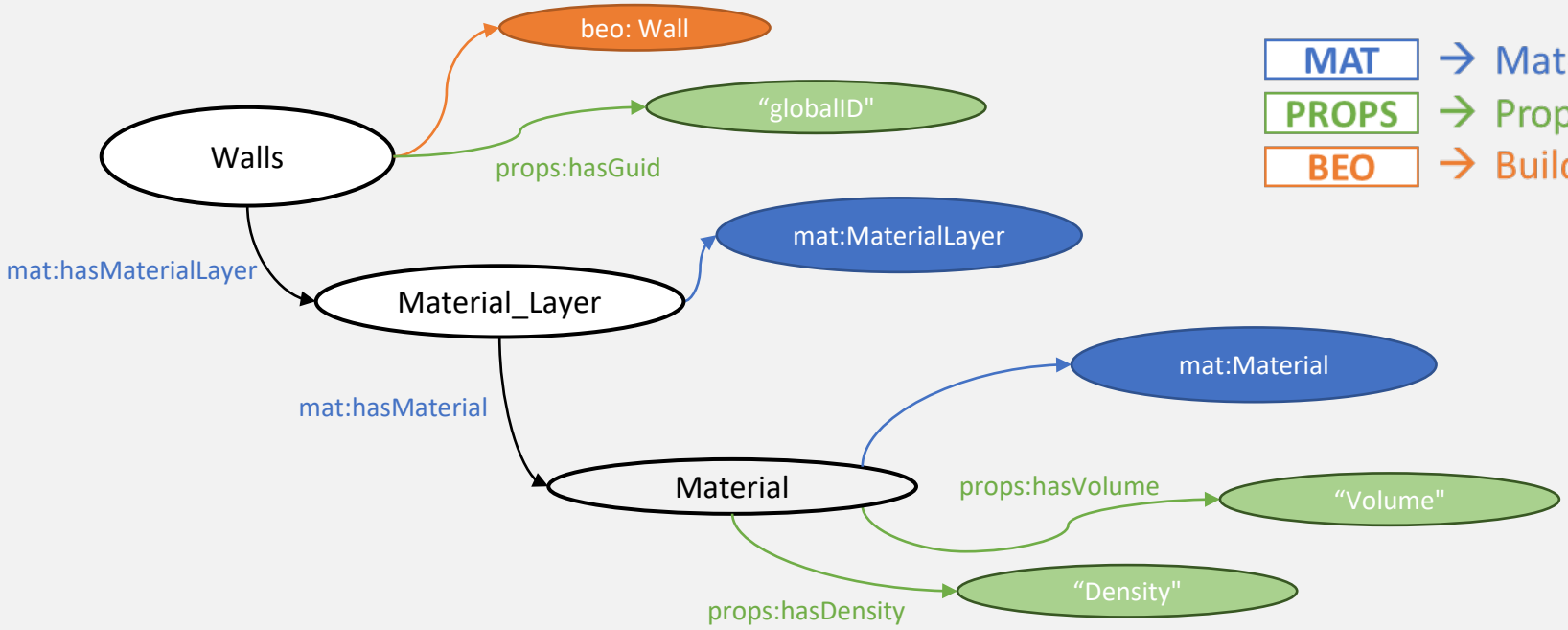
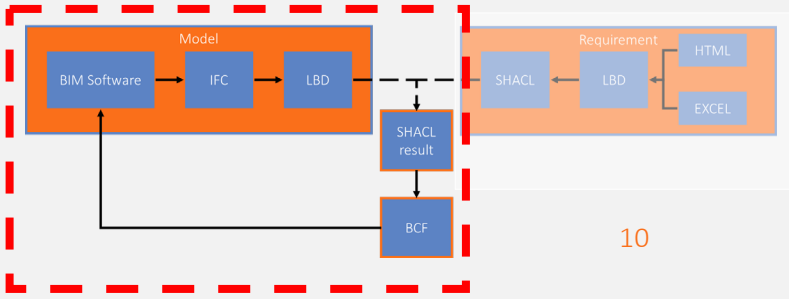
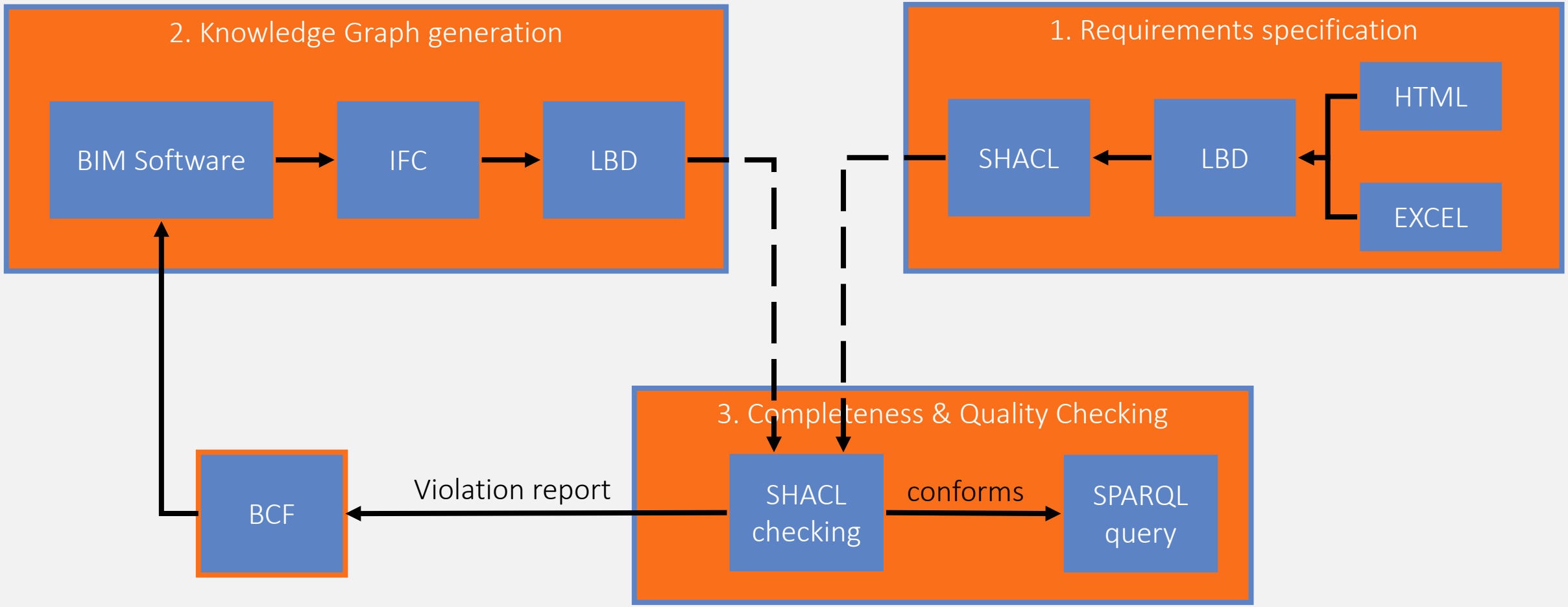


MAT → Materials
PROPS → Properties of walls, windows etc.
BEO → Building Elements (e.g. walls, spaces…)

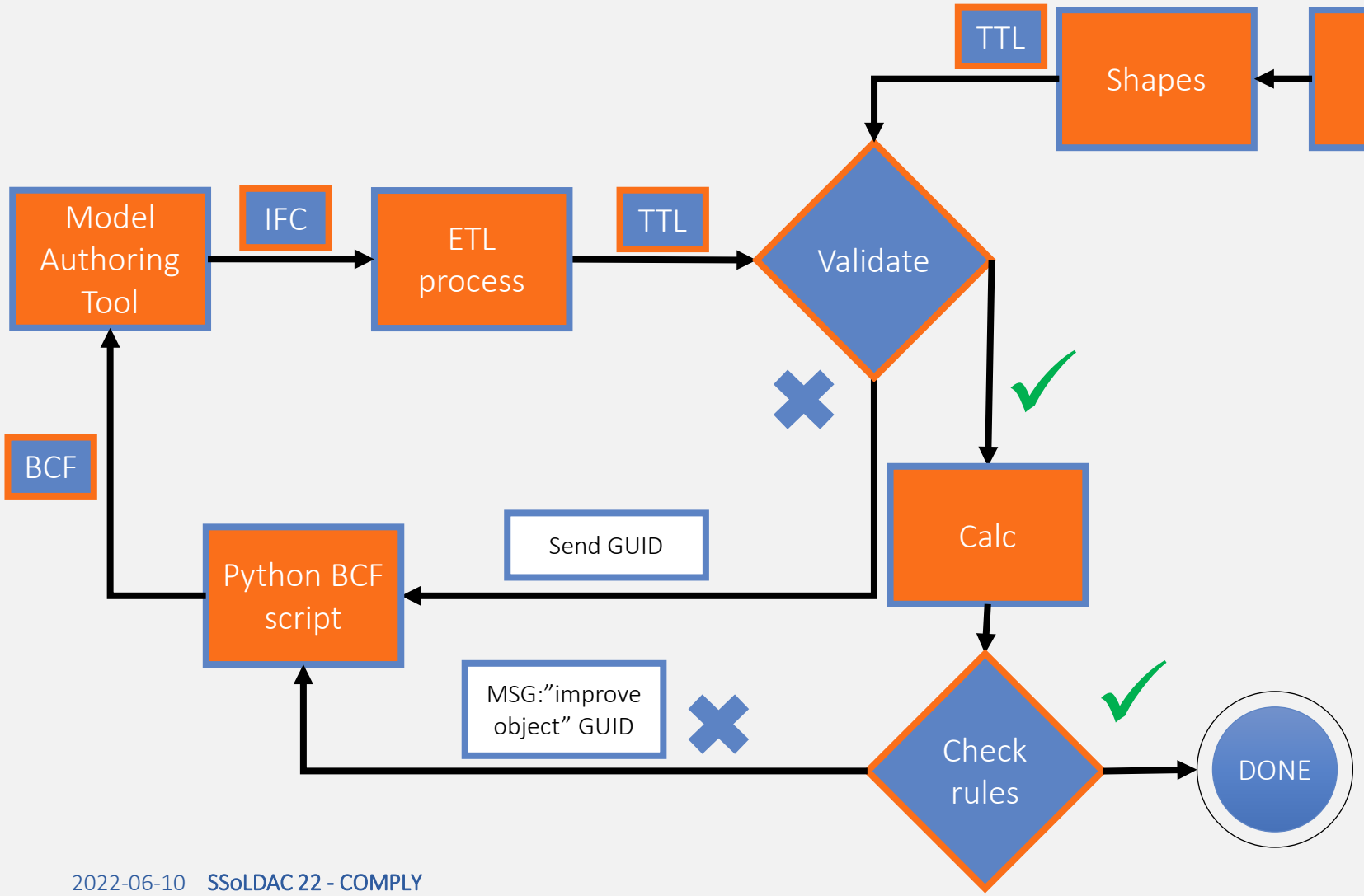


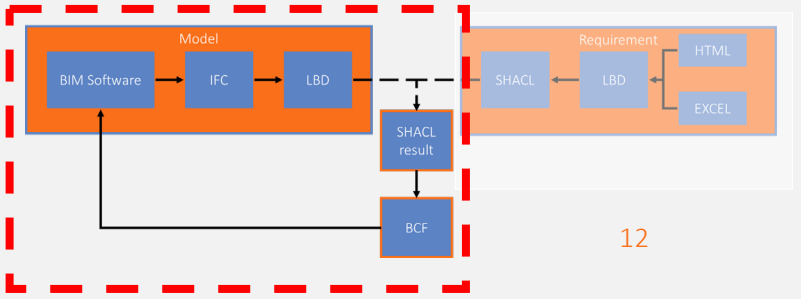
Process Diagram

Ontology-based completeness & compliance checking



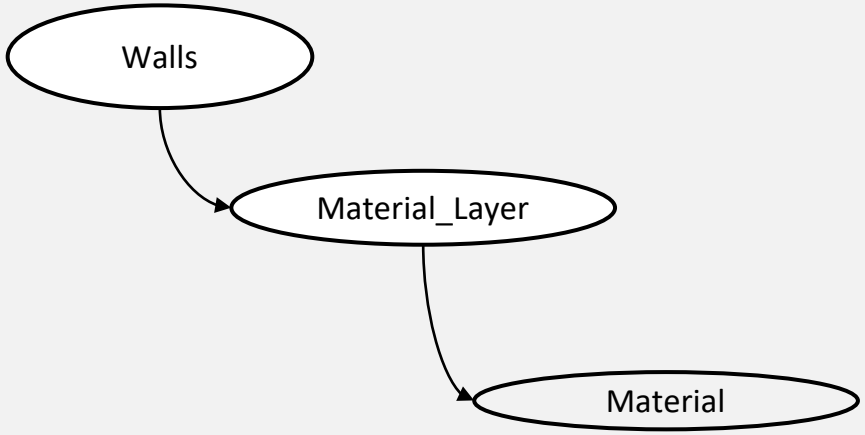
3. Completeness checking

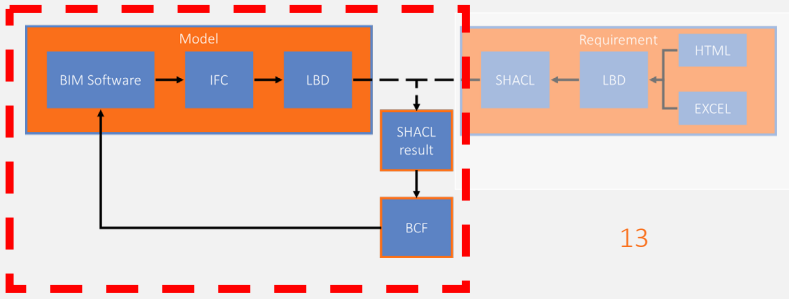




3. Completeness checking

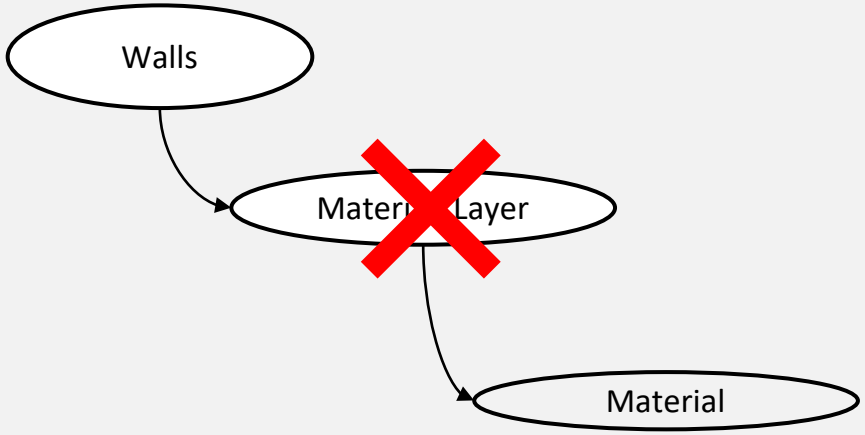
- Need to ensure SPARQL queries will work

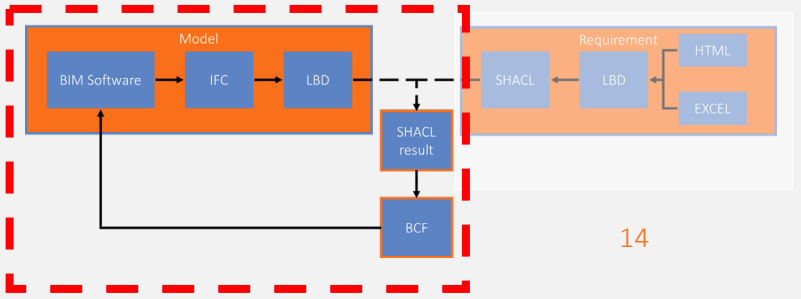




3. Completeness checking

- Need to ensure SPARQL queries will work
- What if there are no material layers in every wall?





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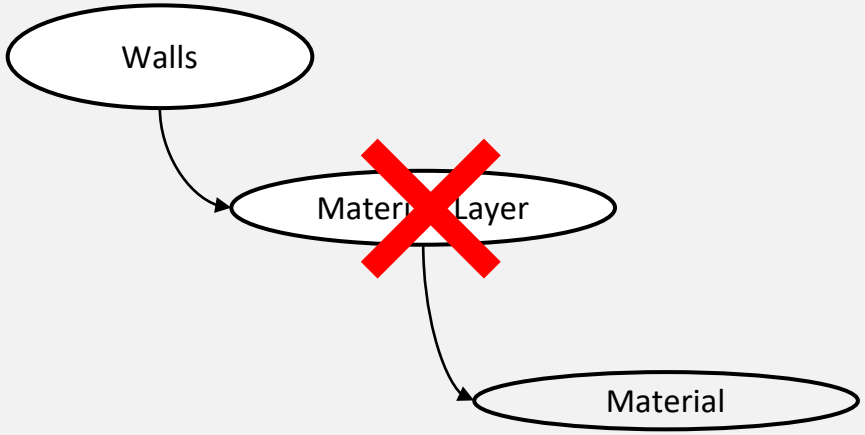
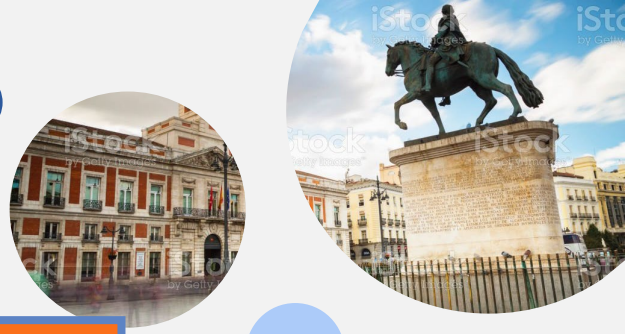


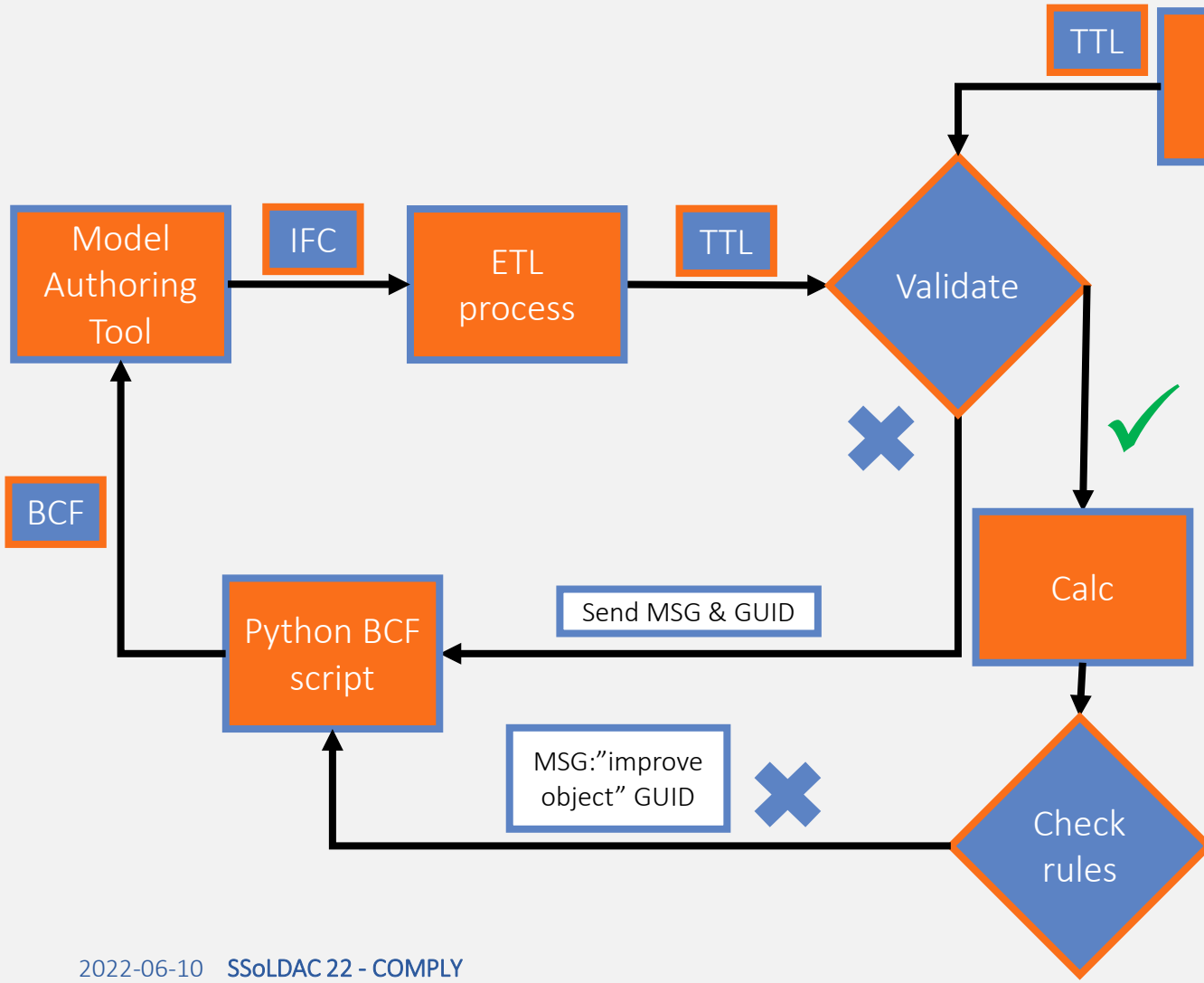

```
beo:Wall a rdfs:Class, sh:NodeShape ;
    sh:property [
        sh:path mat:hasMaterialLayer ;
        sh:name "Create material layer in this wall" ;
        sh:minCount 1 ;
    ].

mat:MaterialLayer a rdfs:Class, sh:NodeShape ;
     sh:property [
     sh:path props:hasThickness;
     sh:name "Specify thickness in this material" ;
     sh:minCount 1;
     sh:maxCount 1;
    ].

mat:Material a rdfs:Class, sh:NodeShape ;
     sh:property [
     sh:path props:hasDensity;
     sh:name "Specify density in this material" ;
     sh:minCount 1;
     sh:maxCount 1;
    ].
```

3. Compliance checking






```
beo:Wall a rdfs:Class, sh:NodeShape ;
    sh:property [
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        sh:minCount 1 ;
    ].

mat:MaterialLayer a rdfs:Class, sh:NodeShape ;
     sh:property [
     sh:path props:hasThickness;
     sh:name "Specify thickness in this material" ;
     sh:minCount 1;
     sh:maxCount 1;
    ].

mat:Material a rdfs:Class, sh:NodeShape ;
     sh:property [
     sh:path props:hasDensity;
     sh:name "Specify density in this material" ;
     sh:minCount 1;
     sh:maxCount 1;
    ].
```
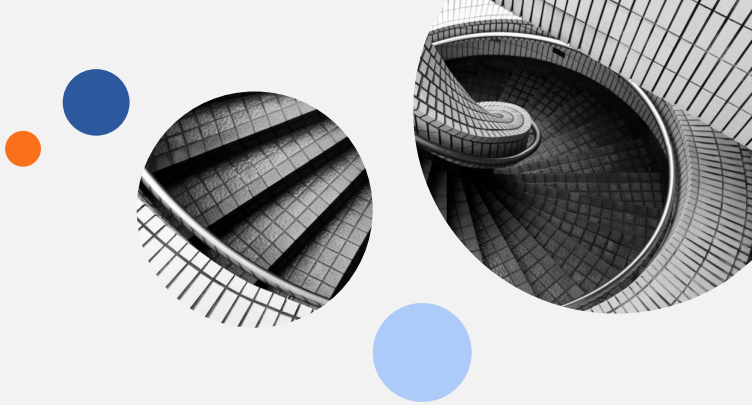

4. Compliance Checking



Governmental regulation

- Due to regulation rooms that are considered living space require at least one square meter of window area per 10m2

1. Find all the rooms that are considered living space (Kitchen, Living Room, Bedroom)
2. Derive area of rooms
3. infer area of windows
4. Derive windows in rooms
5. Compare area’s

Disciplinary restriction

- Due to fabricability the maximum weight of a wall element may not exceed 360 kg.

1. Find all the walls
2. Derive density of (material of) wall
3. Derive volume of wall
4. Multiply volume of wall with density
5. Compare mass of wall to allowed weight

Fabricability:
Check if the walls can be lifted by KUKA robots?

SPARQL Query & Update

Editor only | Editor and results | Results only

Unnamed | Unnamed | Unnamed | Unnamed | Unnamed

```
1  PREFIX bot: <https://w3id.org/bot#>
2  PREFIX props: <https://w3id.org/props#>
3  PREFIX beo:   <https://pi.pauwel.be/voc/buildingelement#>
4  PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
5  SELECT ?wall ?ID  ?density ?v ?w
6  WHERE
7  {
8      ?wall props:hasCompressedGuid ?ID.
9      ?wall props:hasMaterialDensity ?density.
10     ?wall props:hasVolume ?v .
11     BIND ( (xsd:integer(?density) +xsd:integer(?v)) AS ?w) .
12     FILTER ( ?w  > 360 )
13 }
```

Run

keyboard shortcuts

Table | Raw Response | Pivot Table | Google Chart

Download as

Filter query results

Showing results from 1 to 3 of 3. Query took 0.1s, today at 08:29.

	wall	ID	density	v	w
1	om:Element_163943	"0LbdSMP8DEb8sJj7RLTIFZ"	"40"^^xsd:double	"500"	"540"^^xsd:integer
2	om:Element_163943	"0LbdSMP8DEb8sJj7RLTIFZ"	"40"^^xsd:double	"500"^^xsd:integer	"540"^^xsd:integer
3	om:Element_257883	"3NbD7zBF58uutiWZNqxEX0"	"40"^^xsd:double	"800"	"840"^^xsd:integer

Fabricability:
Check if the walls can be lifted by KUKA robots?

SPARQL Query & Update

Editor only | Editor and results | Results only

Unnamed | Unnamed | Unnamed | Unnamed | Unnamed

```
1  PREFIX bot: <https://w3id.org/bot#>
2  PREFIX props: <https://w3id.org/props#>
3  PREFIX beo:   <https://pi.pauwel.be/voc/buildingelement#>
4  PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
5  SELECT ?wall ?ID  ?density ?v ?w
6  WHERE
7  {
8      ?wall props:hasCompressedGuid ?ID.
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3	om:Element_257883	"3NbD7zBF58uutiWZNqxEX0"	"40"^^xsd:double	"800"	"840"^^xsd:integer

Natural Light:
Check the proportion between window area and space are.

SPARQL Query & Update

Editor only | Editor and results | Results only

Unnamed | Unnamed | Unnamed | Unnamed | Unnamed

```
PREFIX props: <https://w3id.org/props#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?space ?ID ?window ?sArea ?p
WHERE
{
 ?space props:hasCompressedGuid ?ID.
 ?space rdf:type bot:Space.
 ?space  props:hasArea ?sArea.
 ?space bot:containsElement ?window.
 ?window props:hasArea ?wArea.
BIND ( (xsd:double(?wArea)/ xsd:double(?sArea)) AS ?p) .
FILTER ( ?p  < 0.1 )
}
```

Run

keyboard shortcuts

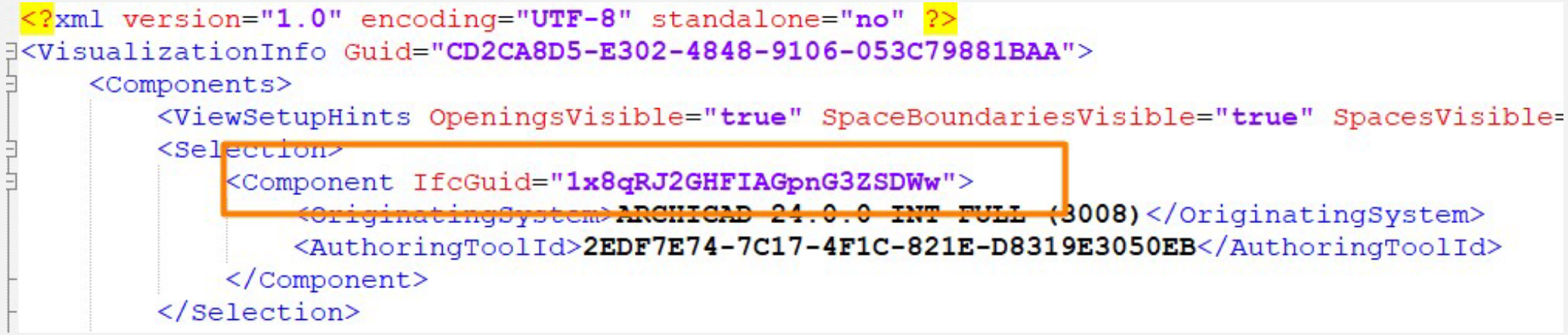
Table | Raw Response | Pivot Table | Google Chart

Download as

Filter query results

Showing results from 1 to 3 of 3. Query took 0.1s, minutes ago.

	space	ID	window	sArea	p
1	om:Space_8795	"0KLkXPBfvES9D1y7EjiiJP"	ifcowl:IfcWindow163943	"17.5412834745277"^^xsd:double	"0.08779289167957903"^^xsd:double
2	om:Space_2895	"0KLkXPBfvES9D1y7EjiiJP"	ifcowl:IfcWindow163945	"200.5412834745277"^^xsd:double	"0.0997300887552181"^^xsd:double
3	om:Space_2895	"0KLkXPBfvES9D1y7EjiiJP"	ifcowl:IfcWindow163941	"200.5412834745277"^^xsd:double	"0.0997300887552181"^^xsd:double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<ViewSetupHints OpeningsVisible="true" SpaceBoundariesVisible="true" SpacesVisible=
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<AuthoringToolId>2EDF7E74-7C17-4F1C-821E-D8319E3050EB</AuthoringToolId>
</Component>
</Selection>

markup.bcf | viewpoint.bcfv

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        </File>
    </Header>
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        <CreationAuthor>Kovács Ádám</CreationAuthor>
        <Title>Issue</Title>
        <Priority>Low</Priority>
        <ModifiedDate>2022-06-08T22:00:28Z</ModifiedDate>
        <ModifiedAuthor>Kovács Ádám</ModifiedAuthor>
    </Topic>
    <Comment Guid="0181A4BF-FC98-4D94-B33F-EAB28F2FBE2D">
        <ModifiedDate>2022-06-08T22:00:28Z</ModifiedDate>
        <ModifiedAuthor>Kovács Ádám</ModifiedAuthor>
        <Date>2022-06-08T22:00:28Z</Date>
        <Author>BIMreq validator</Author>
        <Comment>This wall is too heavy please redesign it!
</Comment>
    </Comment>
```
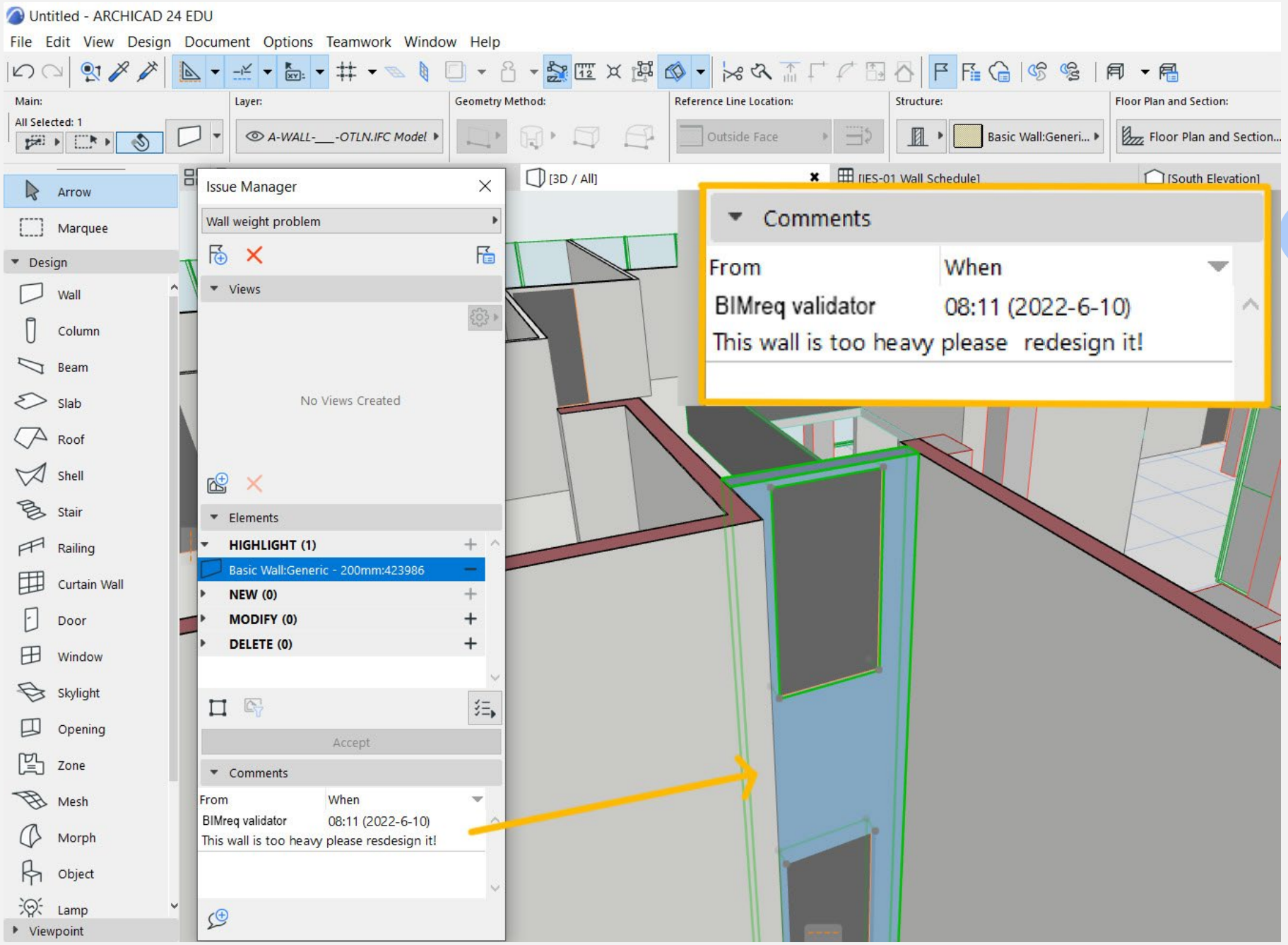
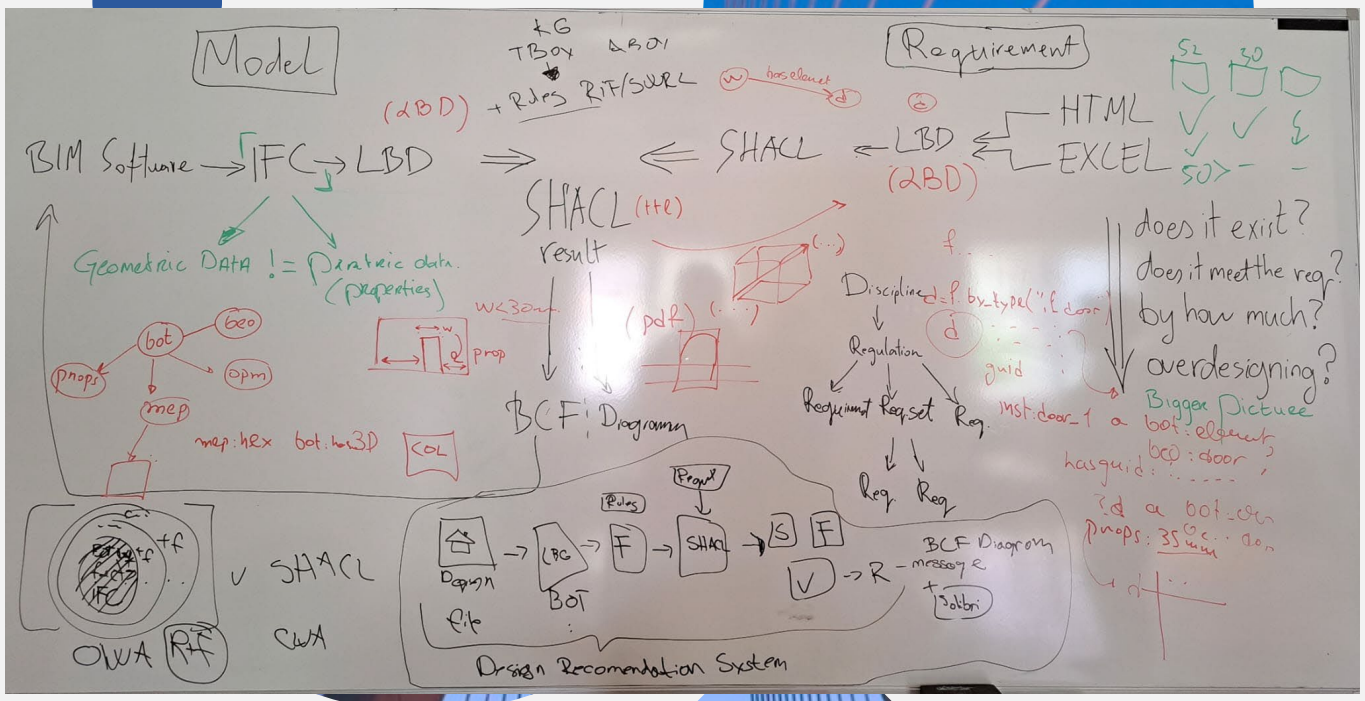


Untitled - ARCHICAD 24 EDU
File Edit View Design Document Options Teamwork Window Help
Main:
All Selected: 1
Layer:
A-WALL-___-OTLN.IFC Model
Geometry Method:
Reference Line Location:
Outside Face
Structure:
Basic Wall:Generi...
Floor Plan and Section:
Floor Plan and Section...
Arrow
Marquee
Design
Wall
Column
Beam
Slab
Roof
Shell
Stair
Railing
Curtain Wall
Door
Window
Skylight
Opening
Zone
Mesh
Morph
Object
Lamp
Viewpoint
Issue Manager
Wall weight problem
Views
No Views Created
Elements
HIGHLIGHT (1)
Basic Wall:Generic - 200mm:423986
NEW (0)
MODIFY (0)
DELETE (0)
Accept
Comments
From
When
BIMreq validator
08:11 (2022-6-10)
This wall is too heavy please resdesign it!
[3D / All]
[IES-01 Wall Schedule]
[South Elevation]
Comments
From
When
BIMreq validator
08:11 (2022-6-10)
This wall is too heavy please redesign it!

Conclusion

- With the use of parsers we have been able to create linked data out of an IFC.
- With SHACL we have been able to validate the data.
- With the automated BCF output we have a closed loop workflow for generating regulation issues and handing them to the designer, independent of the discipline.



Team8

Our tool helps designers from discrete disciplines to check if their model satisfies requirements from all disciplines

Future work

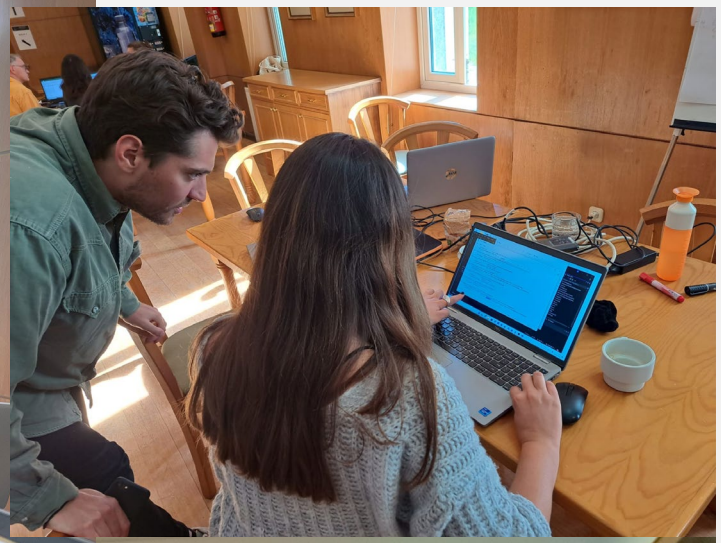
- Add User Interface for the requirement part
- Autopopulate the data in the model, instead of plain messaging to design
  - “autoresolve problem”
- Standardize building industry

Compliance check Hackathon experience

- Learned something ☑
- Had fun ☑
- Interacted in meaningful way ☑
- Fully operational product ☒
- Have #1 position TBD

Questions

Team8;
Adam
Detlev
Deillza
Dimitris




Bay of Ice
BLACKWATER BAY
IRON ISLANDS
The Sunset Sea
The Narrow Sea
The Shivering Sea
SHIELD ISLANDS
WESTEROS