Development of a conceptual digital deconstruction platform with integrated Reversible BIM to aid decision making and facilitate a circular economy

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European Regional Development Fund

Buildings frequently undergo Demolition due to :

- degradation of materials and more technology dependent components
- Inability to remove and exchange building systems and components
- unfitted for recycling
- difficult to repair
- difficult to access
- difficult to disconnect

▼

demolition

▼

building waste

▼

- 40% of energy consumption in Europe is building related
- 50% of material resources taken from the nature are building related
- over 50% of national waste production comes from the building sector

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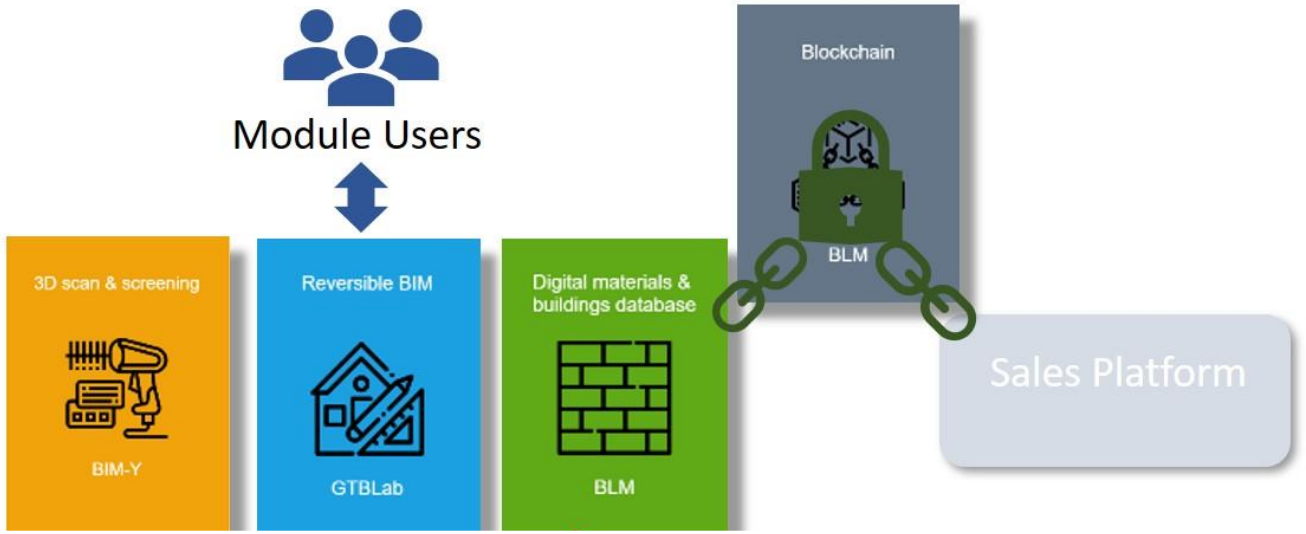
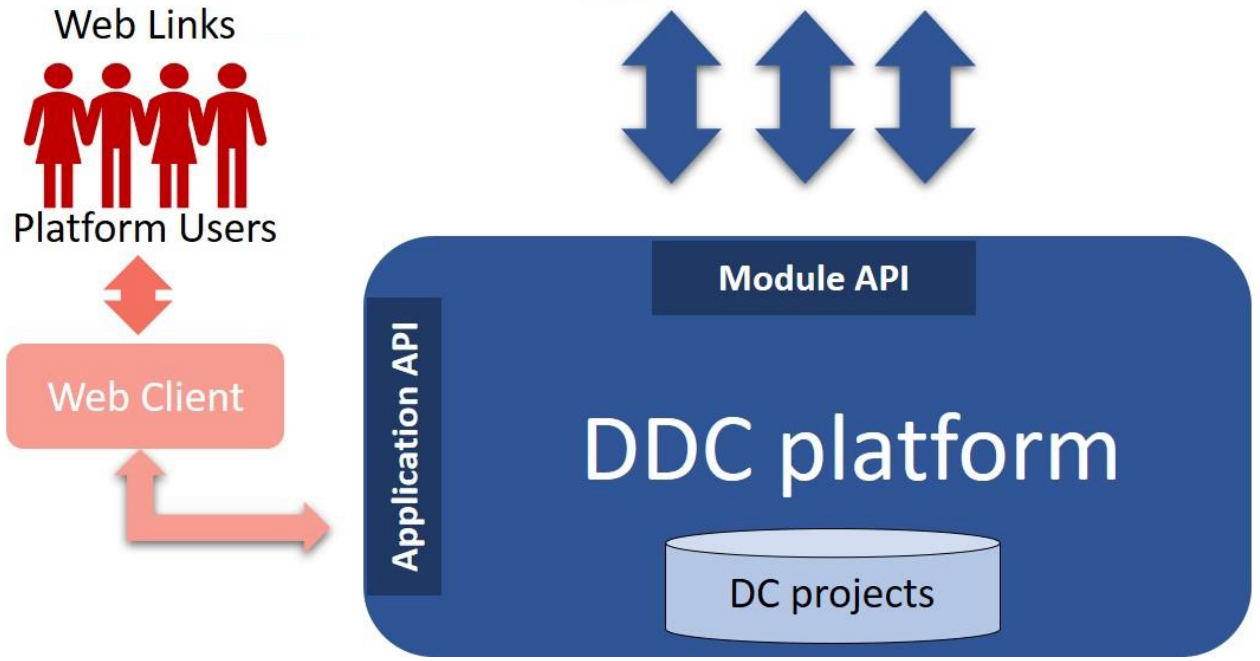
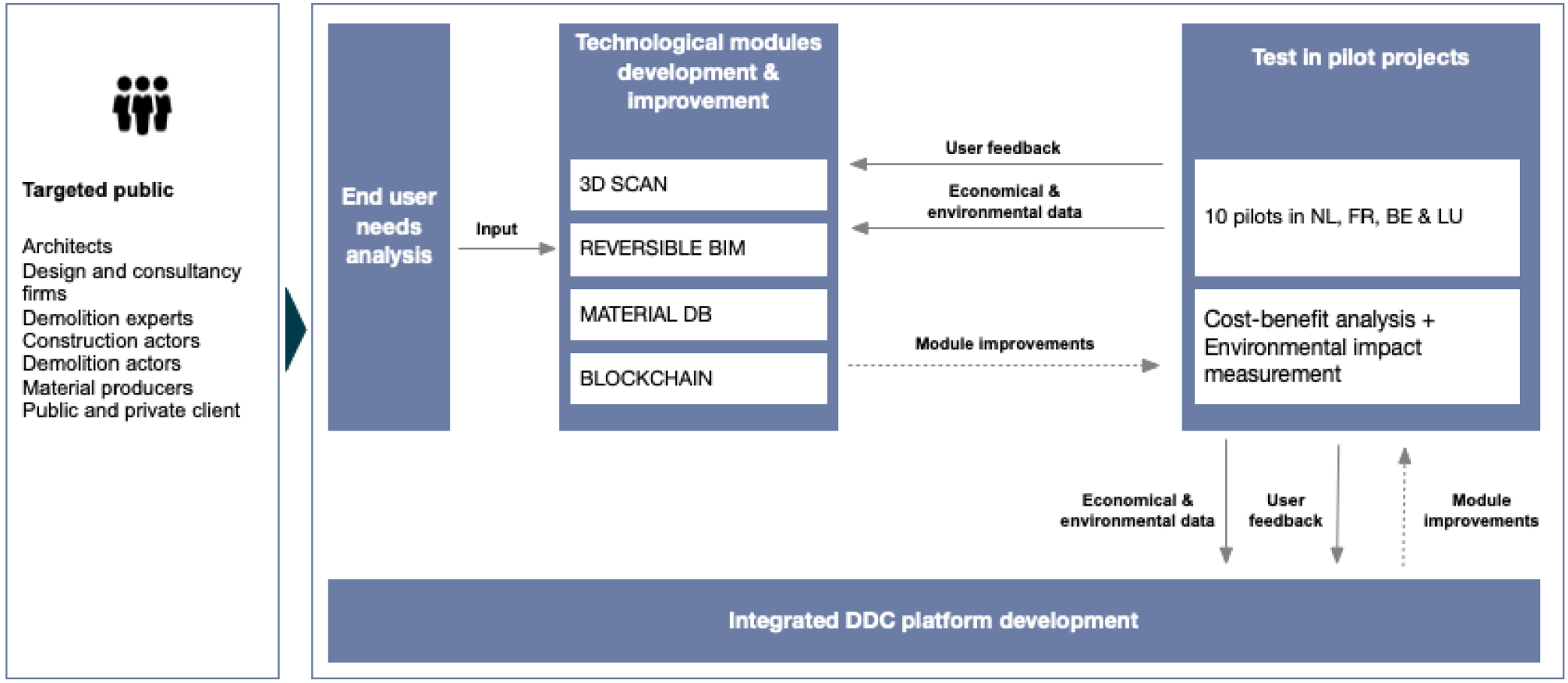




Targeted public

Architects
Design and consultancy firms
Demolition experts
Construction actors
Demolition actors
Material producers
Public and private client



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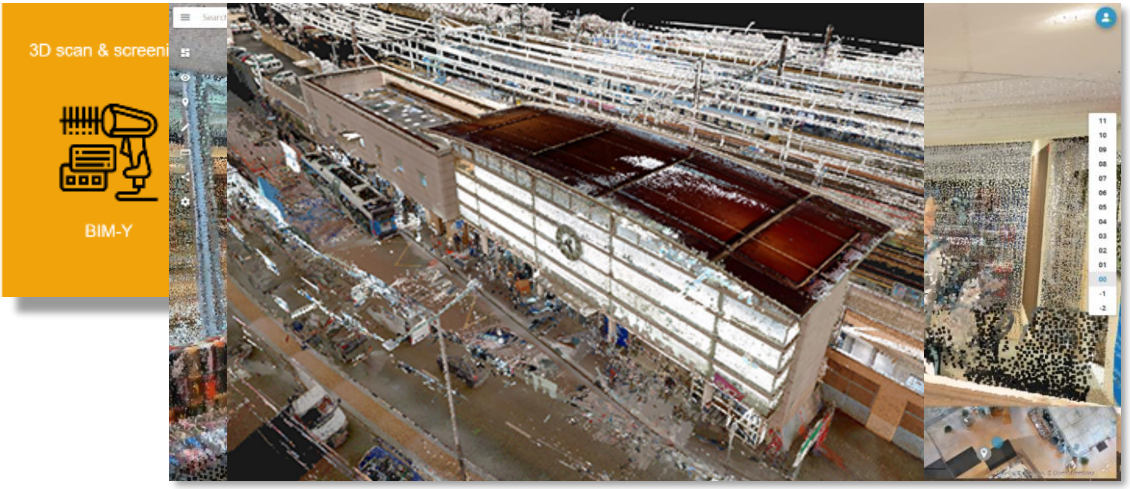

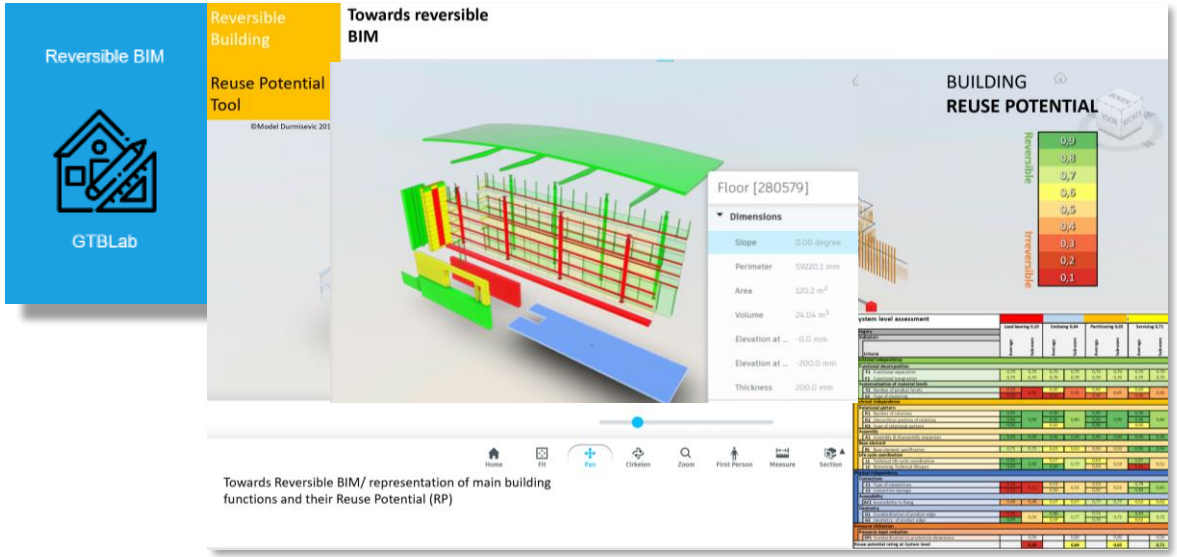

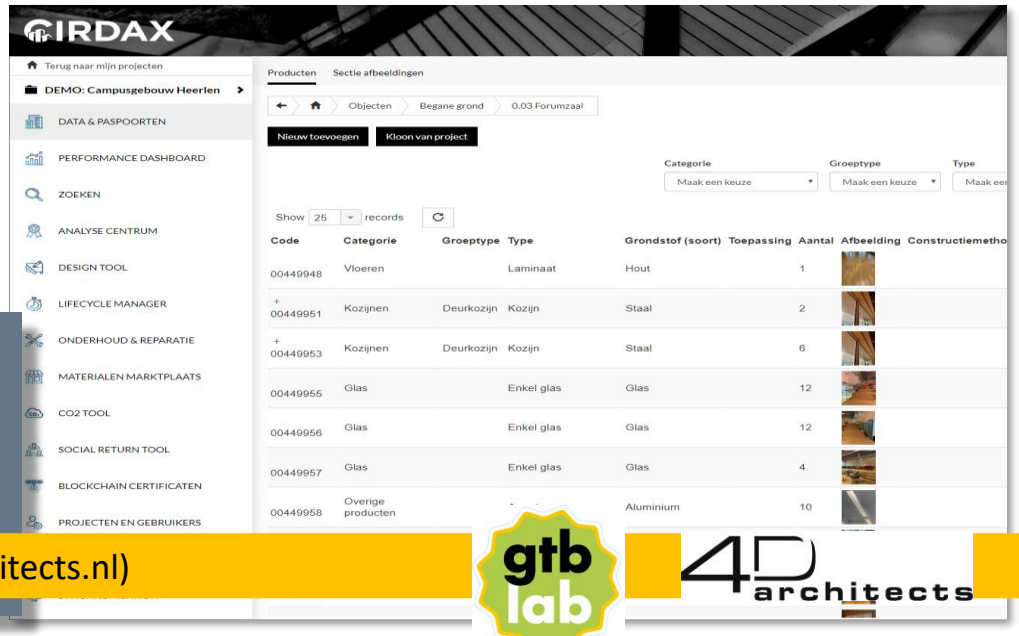

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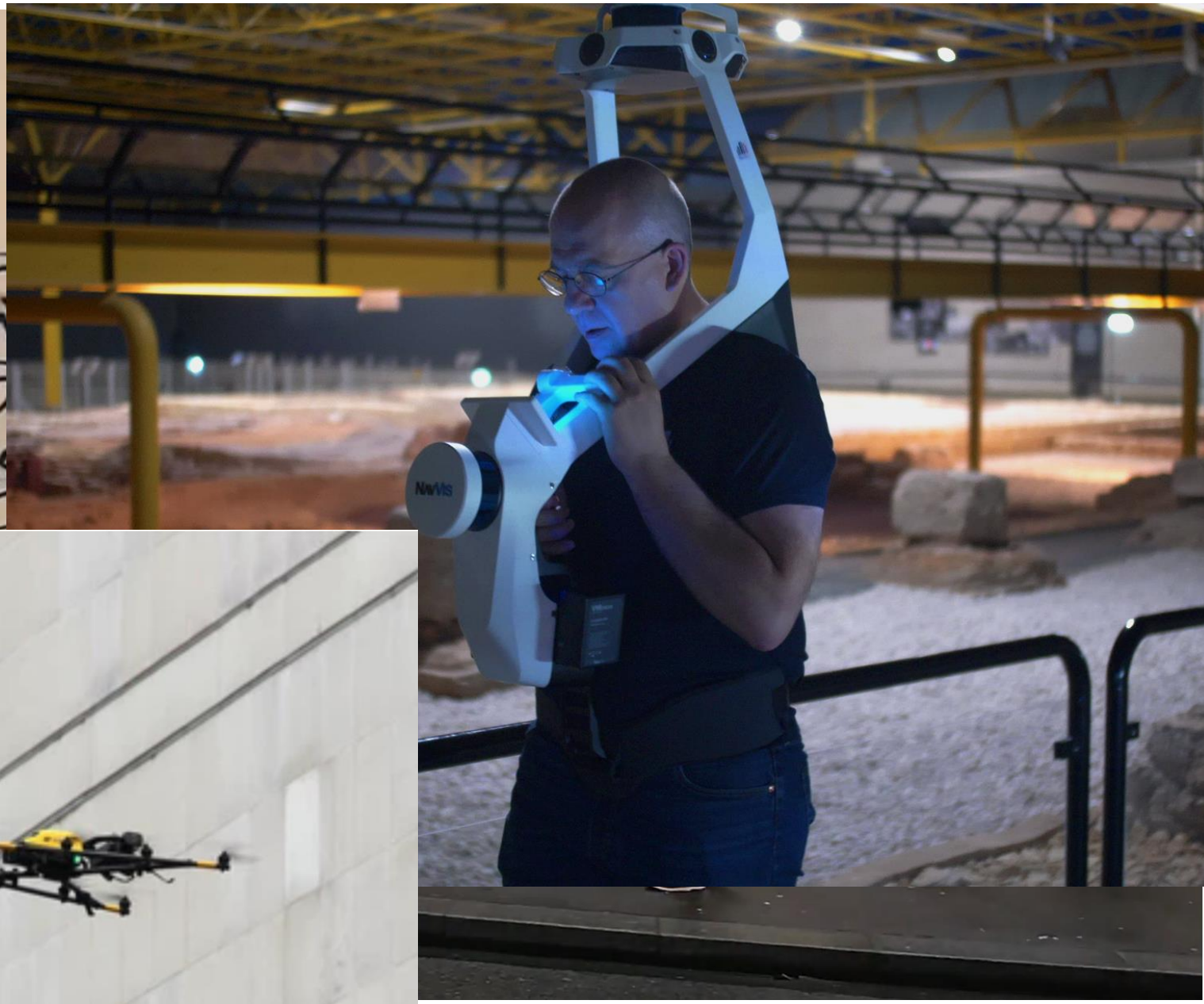
3D scan & screening

BIM-Y



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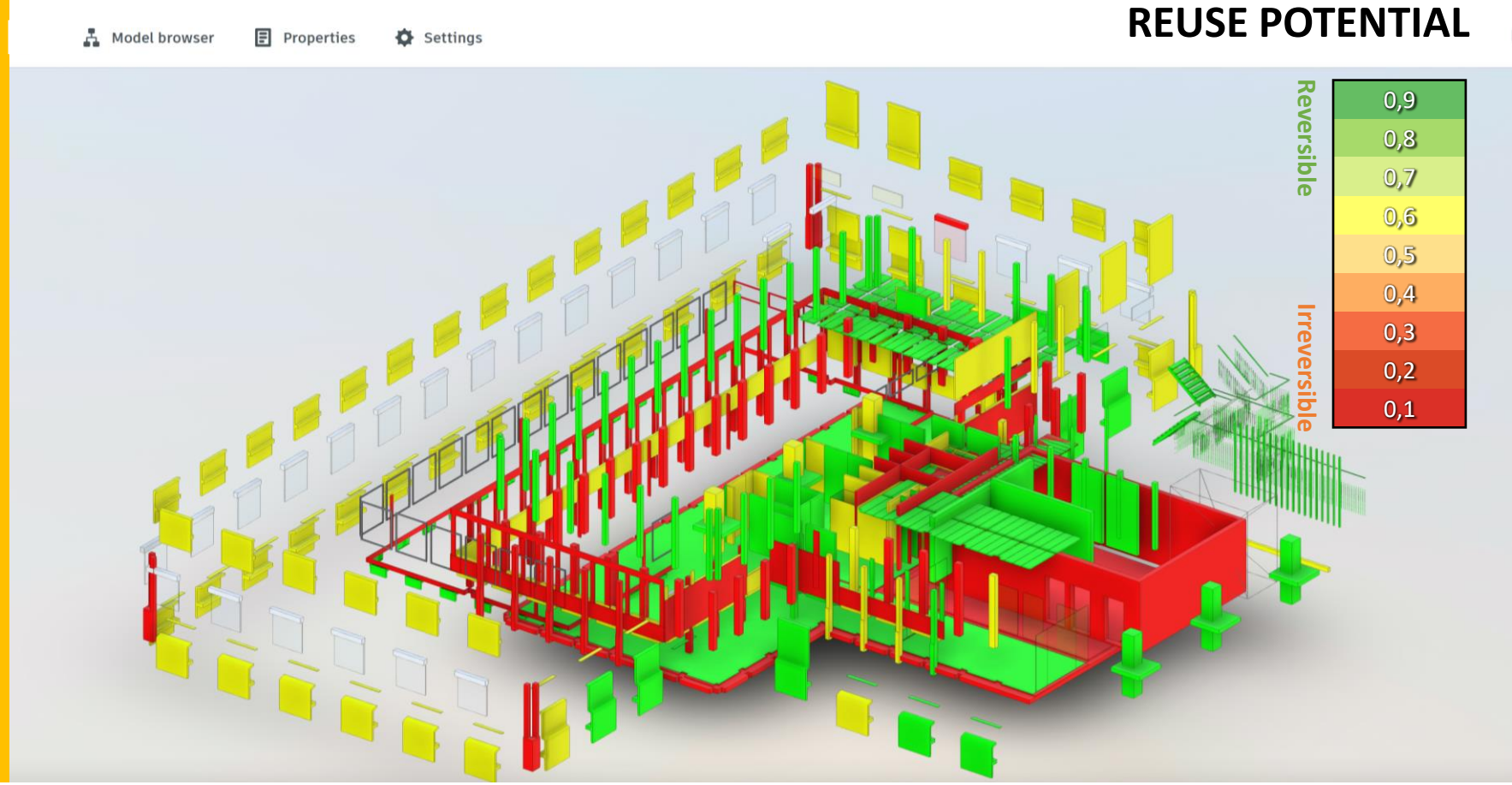
Reversible BIM

Digital Reversibility/ Reuse Potential Assessment



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Reversible Building

Reuse Potential Tool

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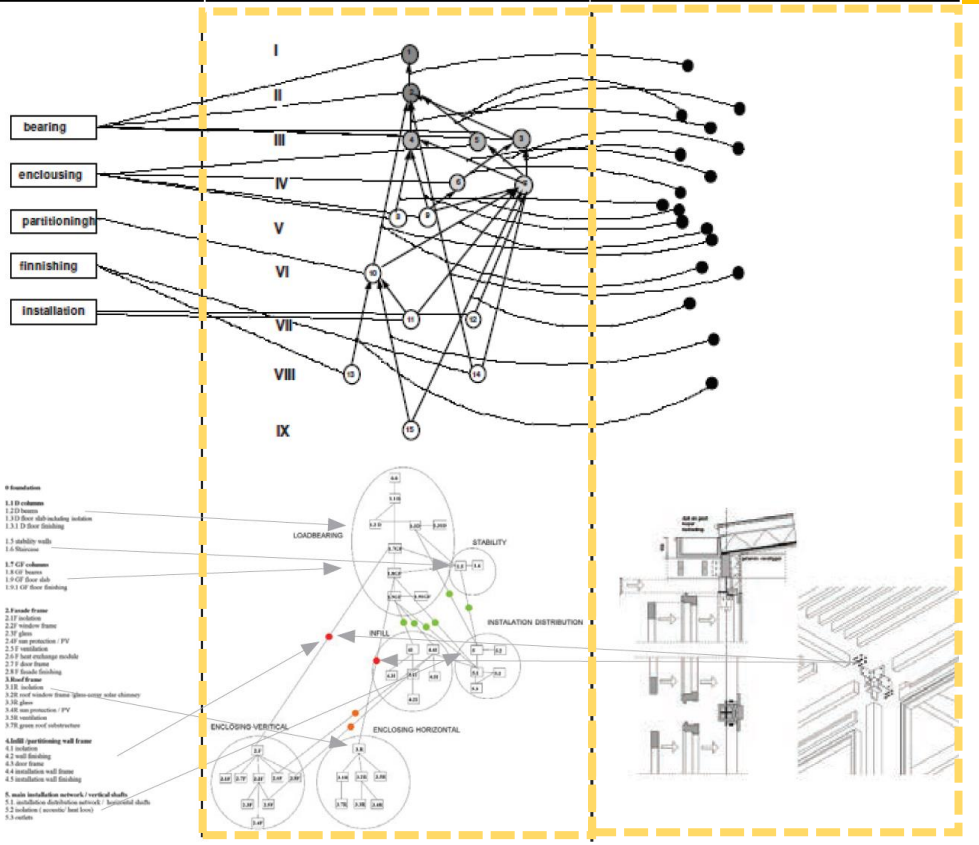
Technical Reversibility

Functional dependence	Technical dependence	Physical dependence



Reversible Building

Reuse Potential Tool

INDICATORS/ Technical Reversibility

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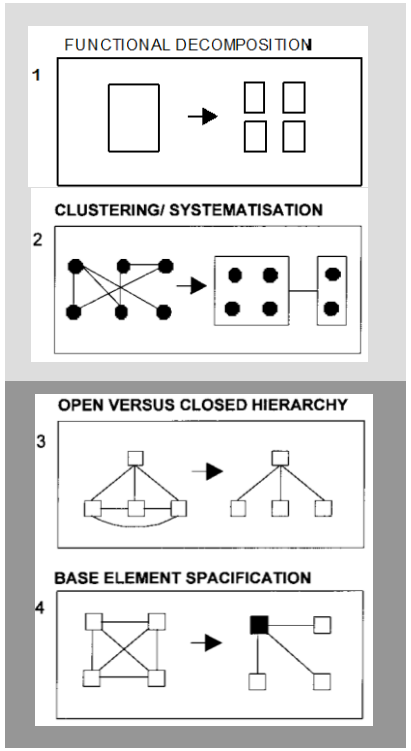
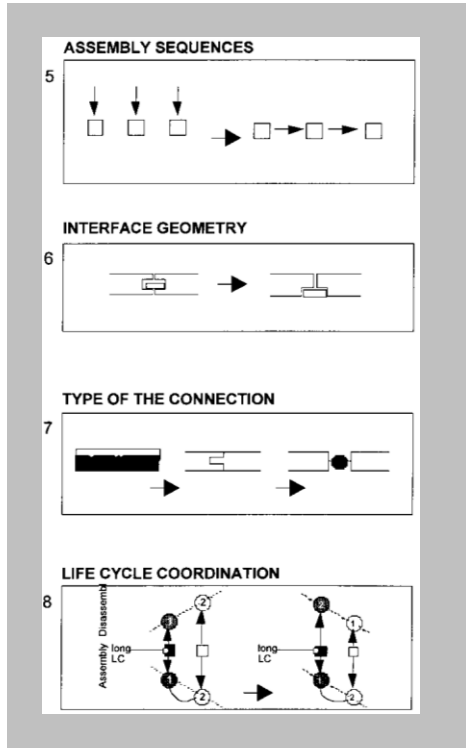
8 ASPECTS OF REVERSIBLE BUILDING STRUTURE

FUNCTIONAL decomposition

TECHNICAL dependences

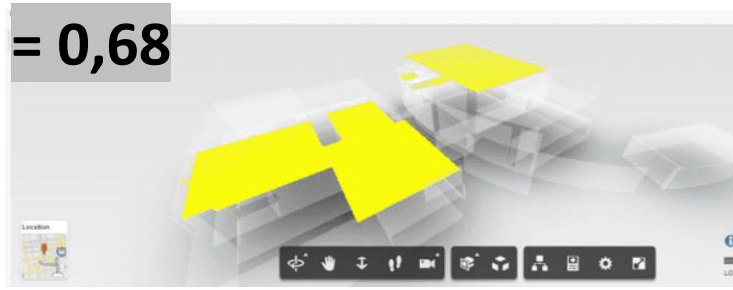


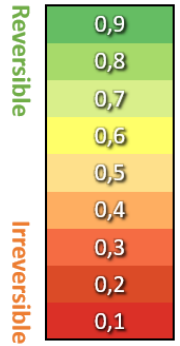


PHYSICAL dependences

Reuse potential

= 0,68

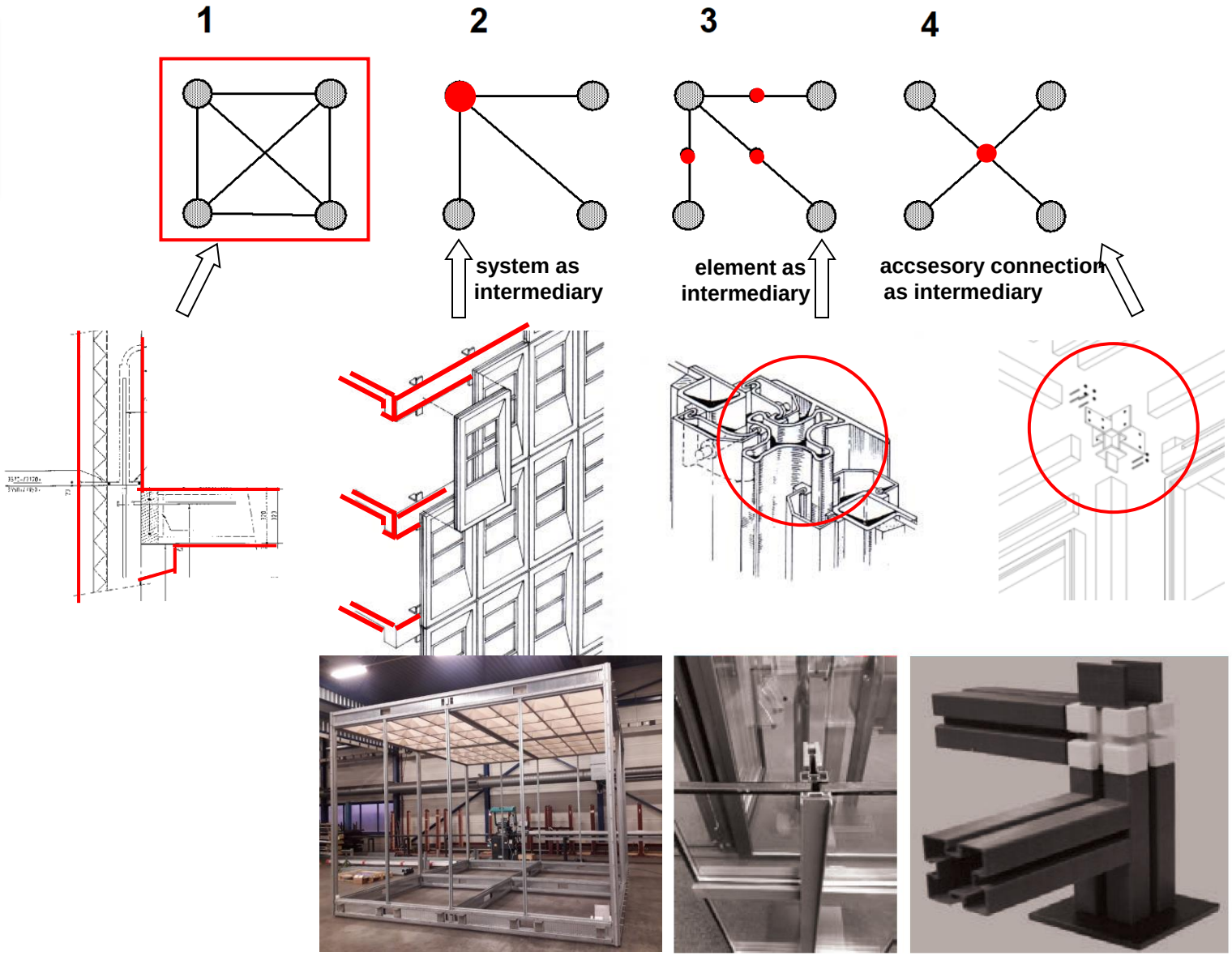




Reuse options:

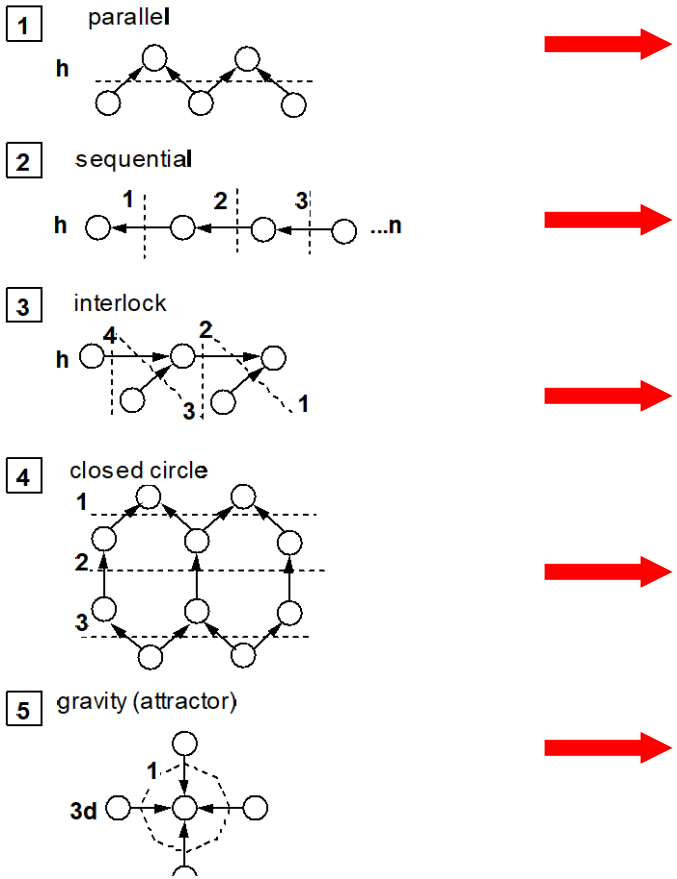
- **RP > 0,7** = Direct reuse by minor repair or reconfiguration, upgrading
- **RP >0,4 and RP < 0,6** = Reuse by major repair Re-manufacture
- **RP > 0,3** = Recycle

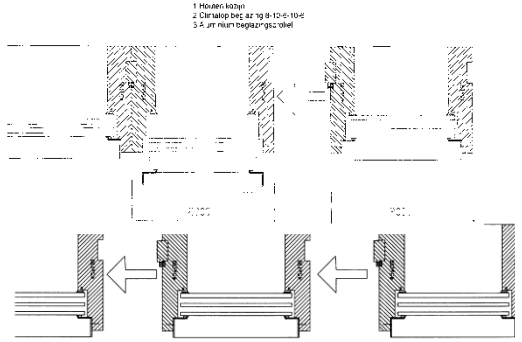
Reversible Building Reuse Potential

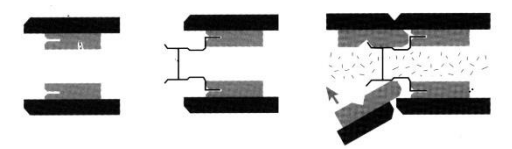


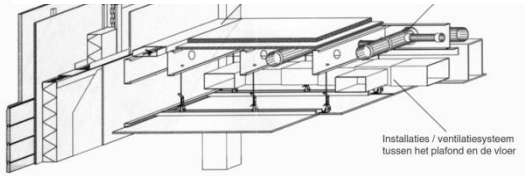
Reversible Building Reuse Potential

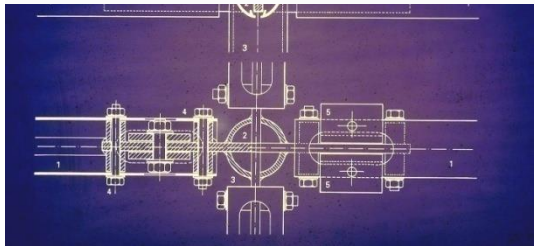
ASSEMBLY SEQUENCES

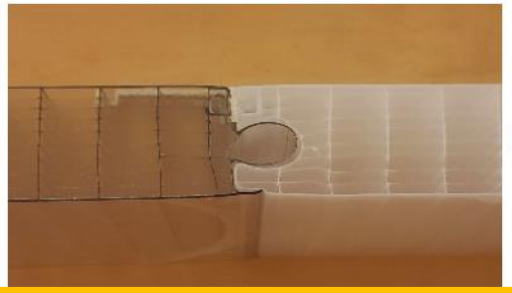








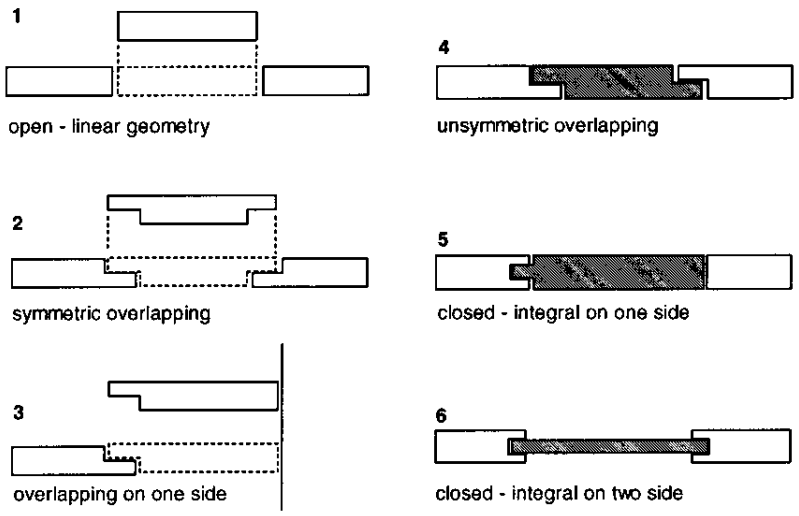


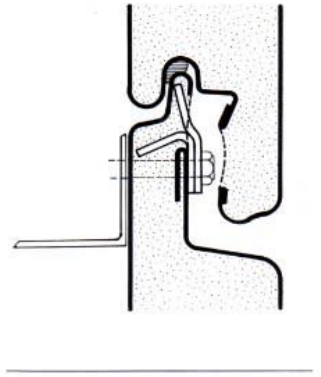


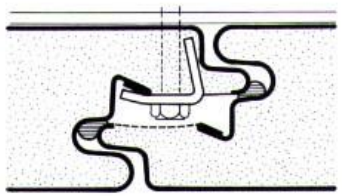
Dr. Elma Durmisevic, Head of the research EU Horizon 2020/BAMB Revisable Buildings Design, Design leader of GTB Lab and GDC pilots

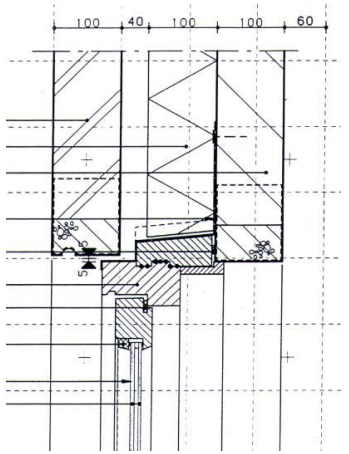
Reversible Building Reuse Potential

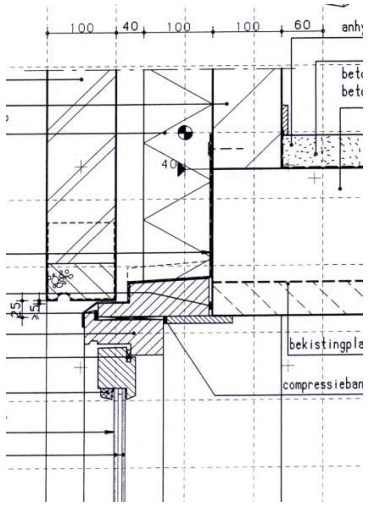
- **GEOMETR OF COMPONENT EDGES**

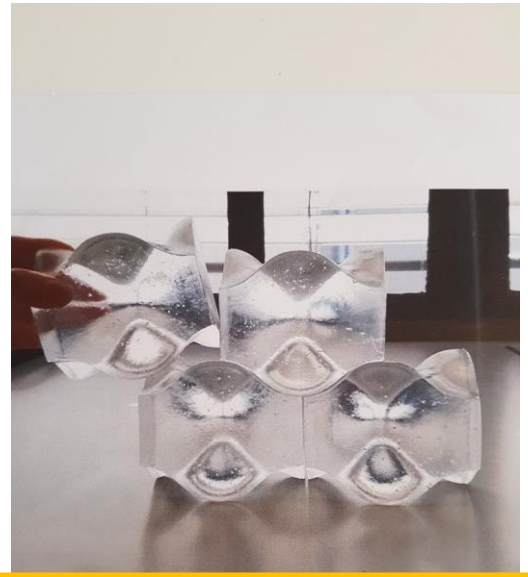








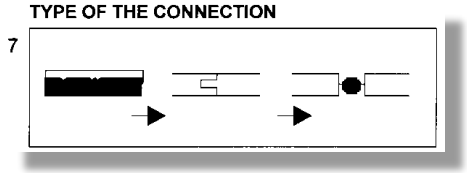




source: model durmisevic

Reversible Building Reuse Potential

Indicator of exchangeability



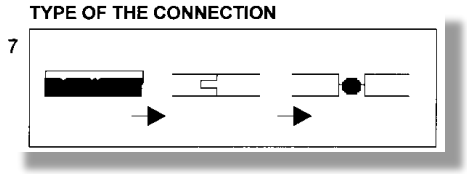
Irreversible

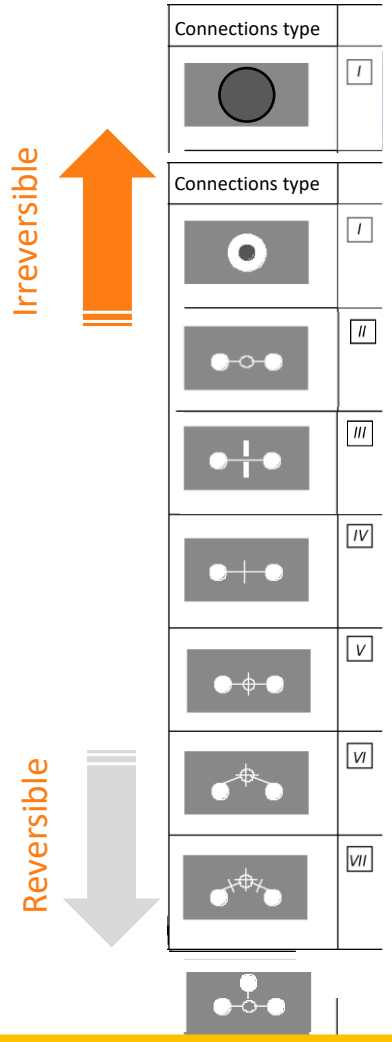
Reversible

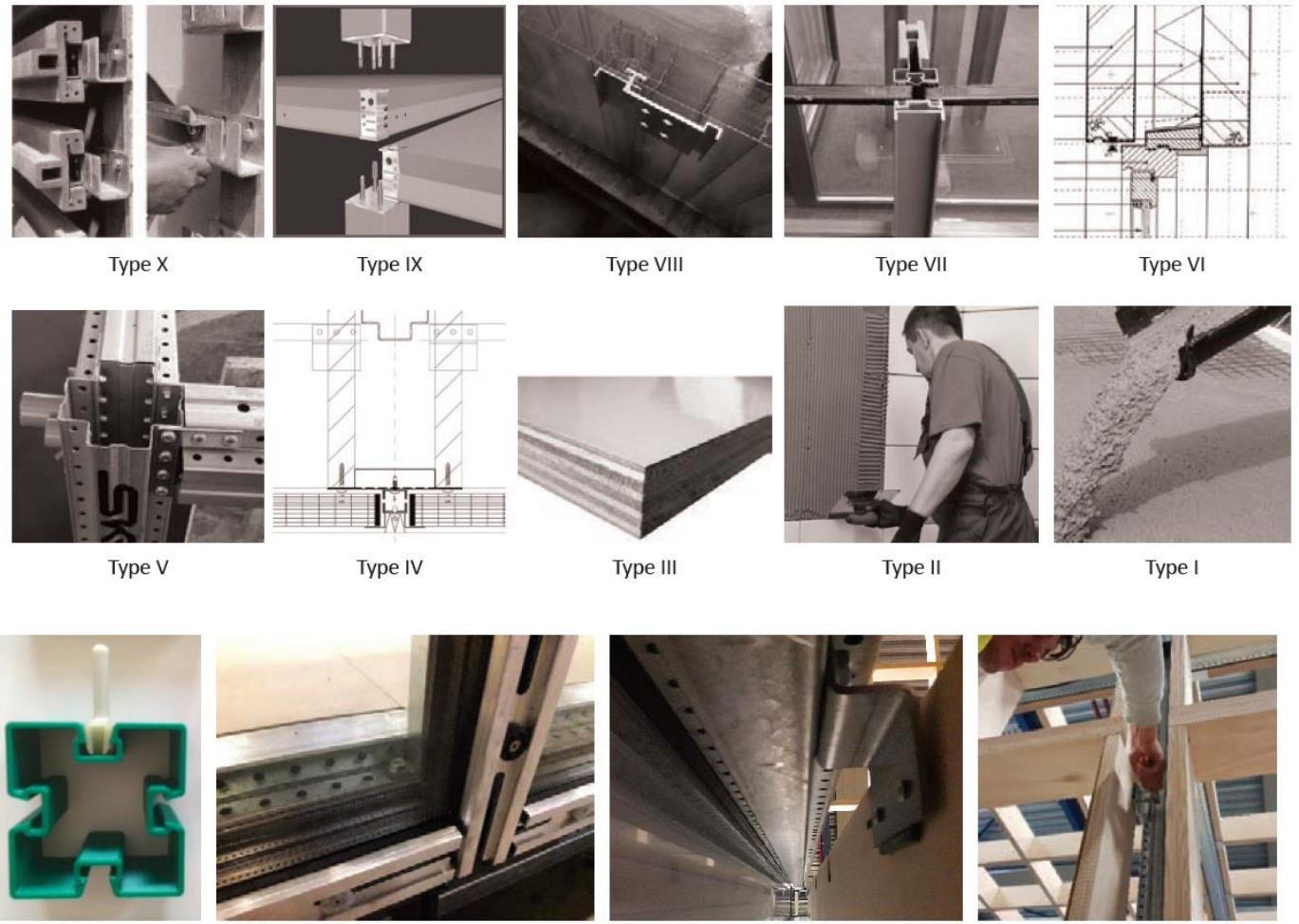
Connections type		Connections type examples		
	I	m1 m2	m2 m1	m1 m2

Connections type		Connections type examples		
	I	m1 el2	m2 el1	m1 m el2
	II	el1 m1 el2	e1 e2	el1 m1 el2
	III	el1 el2	el1	el1 m light el2
	IV	e1 e2	e1 e2	el1 c1 el2
	V	el1 c1 el2	el1 c1 el2	el1 c1 el2
	VI	el1 c1 el2 c2	el1 c1 el2 c2	el1 c1 el2 c2
	VII	e3 C e1 e2	e1 e2	e3 C e1 e2
			el1 el2	el1 el2

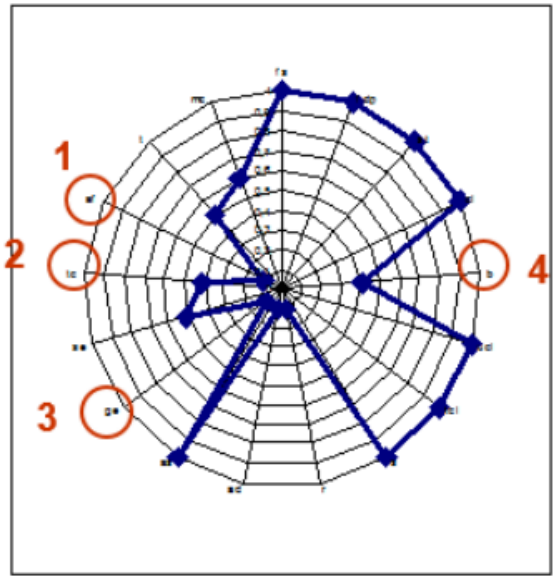
Reversible Building Reuse Potential

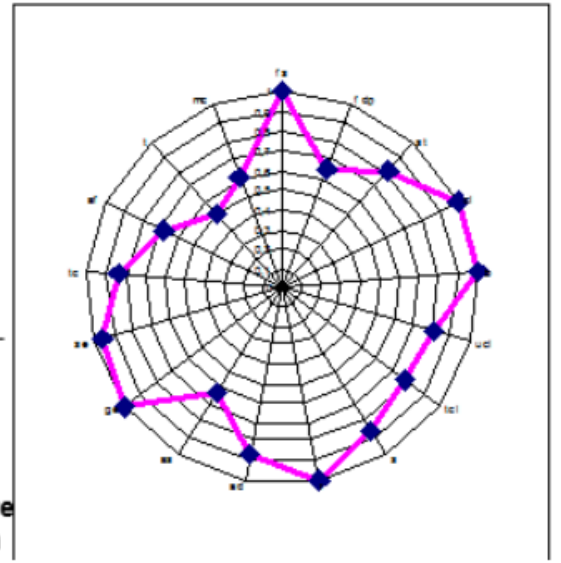


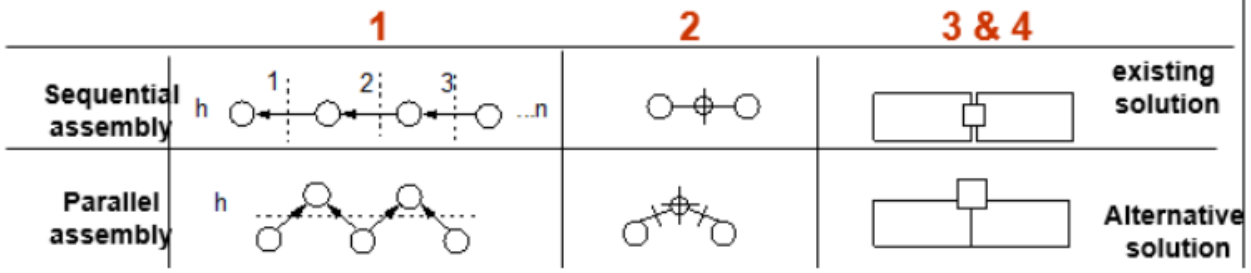




nr.	Design for Disasembly Aspects	nr.		Determining Factors
1	FD (Functional decomposition)			
		1.1.	fs	(functional separation)
		1.2.	fdp	(functional dependence)
2	SY (Systematisation)			
		2.1	st	(structure of material levels)
		2.2	c	(type of clustering)
3	BE (Base elements)			
		3.1	b	(type of base element)
4	LCC (Life cycle coordination)			
		4.1	ucl	(use life cycle coordination)
			tcl	(technical life cycle coordination)
			s	(coordination of life cycle and size)
5	RP (Relational pattern)			
		5.1	r	(type pf relational pattern)
6	A (Assembly process)			
		6.1	ad	(assembly direction)
			as	(assembly sequences)
7	G (Geometry)			
		7.1	gp	(geometry of product edge)
		7.2	spe	(standardisation of product edge)
8	C (Connections)			
		8.1	tc	(type of connections)
		8.2	af	(accessability to fixings)
		8.3	t	(tolerance)
		8.4	mj	(morfology of joints)



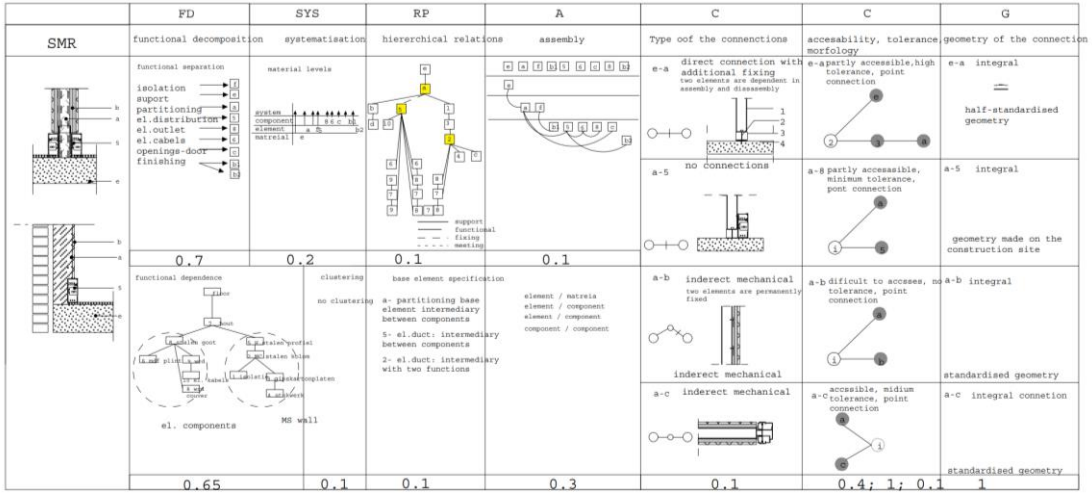


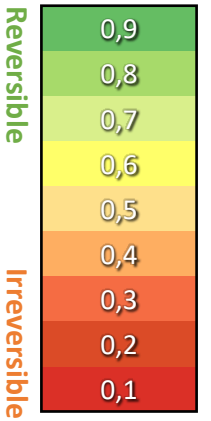


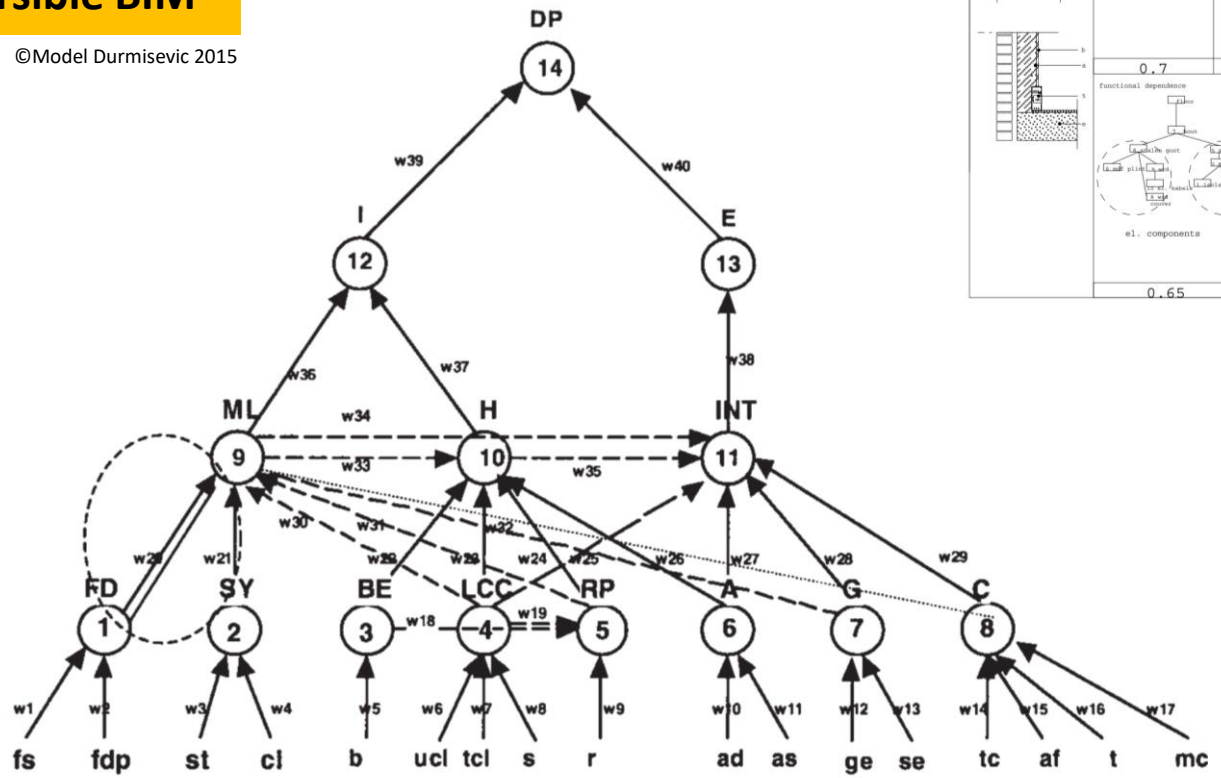
Reversible Building

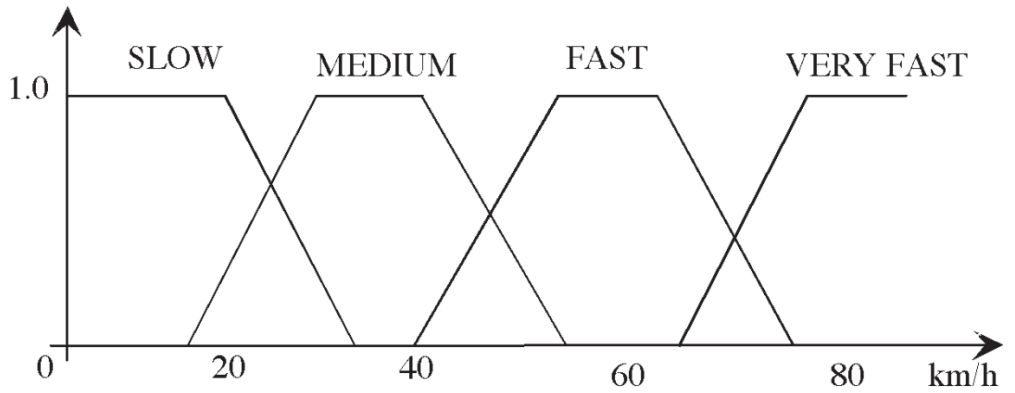
Reuse Potential Tool- towards **Reversible BIM**

BUILDING **REUSE POTENTIAL**





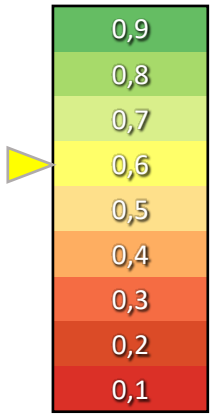




Reversible Building

Reuse Potential Tool- towards **Reversible BIM**

BUILDING
REUSE POTENTIAL



Reuse potential

= 0,68

Reuse options:

RP> 0,3 = Recycle
RP >0,3 and RP < 0,6 = Reuse by major repair or Re-manufacture
RP > 0,6 = Direct reuse by minor repair or reconfiguration, upgrading

REUSE POTENTIAL TOOL

	Indicators		Criteria	Bottom floor	Top floor	Average both lev	Sub-score	Factors
independence	Functional independency	Functional decomposition	F1	Functional separation	0,6	0,6	0,60	0,67	1
			F2	Functional integration	0,73		0,73		
		Systematisation of material levels	S1	Number of material levels	0,9	0,9	0,90	0,75	2
			S2	Type cluster - clustered parts vs non-clustered parts	0,6	0,6	0,60		
	Technical independence	Relational pattern	R1	Number of relations	0,6	0,9	0,75	0,82	1
			R2	Hierarchical position of relations	0,9	0,9	0,90		
			R3	Type of relational pattern - open vs closed pattern	0,8	0,8	0,80		
		Assembly	A1	Assembly sequences	0,7	0,7	0,70	0,70	1
		Base element	B1	Type of base element	0,50	0,50	0,50	0,50	1
		Life cycle coordination	L1	Technical life cycle coordination	0,90	0,90	0,90	0,85	1
			L2	Remaining Technical lifespan	0,81	0,79	0,80		
Exchangeability	Physical independency	Connections	C1	type of connections	0,54	0,51	0,52	0,52	3
		Accessibility	AC1	Accessibility to fixing	0,70	0,69	0,69	0,69	1
		Geometry	G1	Standardisation of product edge	0,84	0,84	0,84	0,82	1
			G2	Geometry of product edge	0,80	0,80	0,80		
	Dimension	Production Dimension	PD1	Standardisation to production dimensions	0,78	0,78	0,78	0,78	1
				total score*				0,68	

RP Score per sub indicator

RP Score per indicator

RP total Score

2

Embodied Environmental Impact
Embodied Value (EV)

Reversible Building

I M P A C T S

3 CATEGORIES OF MATERIAL STREAMS

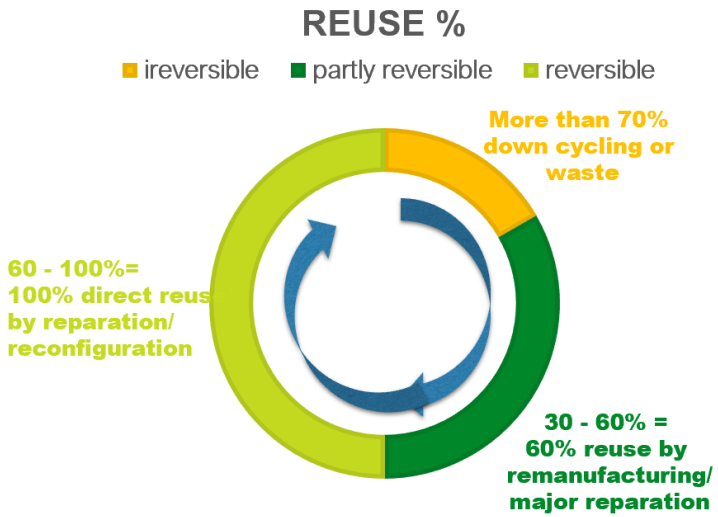
in relation to the RP score

Technical reversibility presented through RP and related indicators

IRREVERSIBLE
if RP indicates that a system has **RP < than 0,3** these systems will be characterised as irreversible and **the end of life options** = **RECYCLING/DOWN CYCLING**.

PARTLY REVERSIBLE
If system has **RP> 0,3 and RP < 0,6 end of life options** =**REMANUFACTURE/ MAJOR REPAIR,**

REVERSIBLE
If system has **RP > 0,6** this would mean that besides **DIRECT REUSE AND MINOR REPAIR** of its parts the system can be **RECONFIGURED AND UPGRADED** and its **dimensions adjustable to fit new requirement**.



Elma Durmisevic, Head of the research EU Horizon 2020/BAMB Revisable Buildings
University of Twente / 4D architects

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Reversible Building

Reuse Potential Tool

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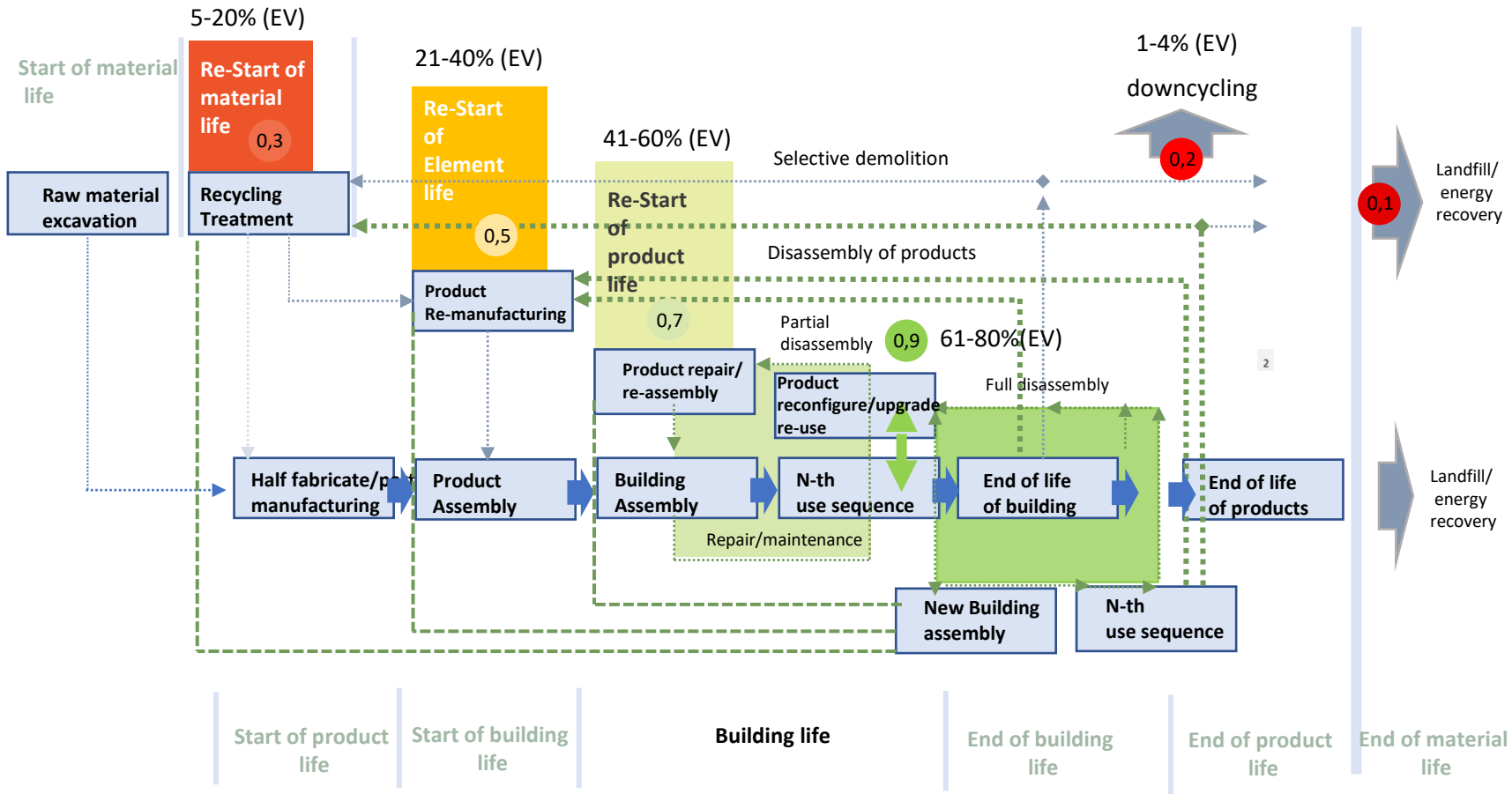
6

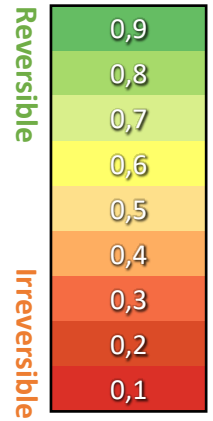
REPORTING REVERSIBILITY

Reuse options Deconstruction staps & embodied value

REUS OPTIONS AND STRATEGIES

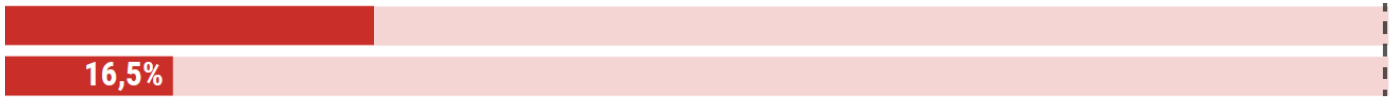


BUILDING **REUSE POTENTIAL**



Dr. Elma Durmisevic, developer of Reversible Building tools 4D architects

Embodied Value (EV)
Embodied Environmental impact



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BUILDING
REUSE POTENTIAL

Project name: <Example project>
Location: <city, country>
Function: <office>

Total score:

0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1

0,9

The Transformation Capacity score measures spatial building performance indicators addressing the capacity to accommodate different functions without causing major reconstruction works, demolition and material loss. The less effort is needed to transform a building, the higher the transformation potential will be. The greater the variety and number of modification options (reuse options of buildings), the higher the transformation potential.

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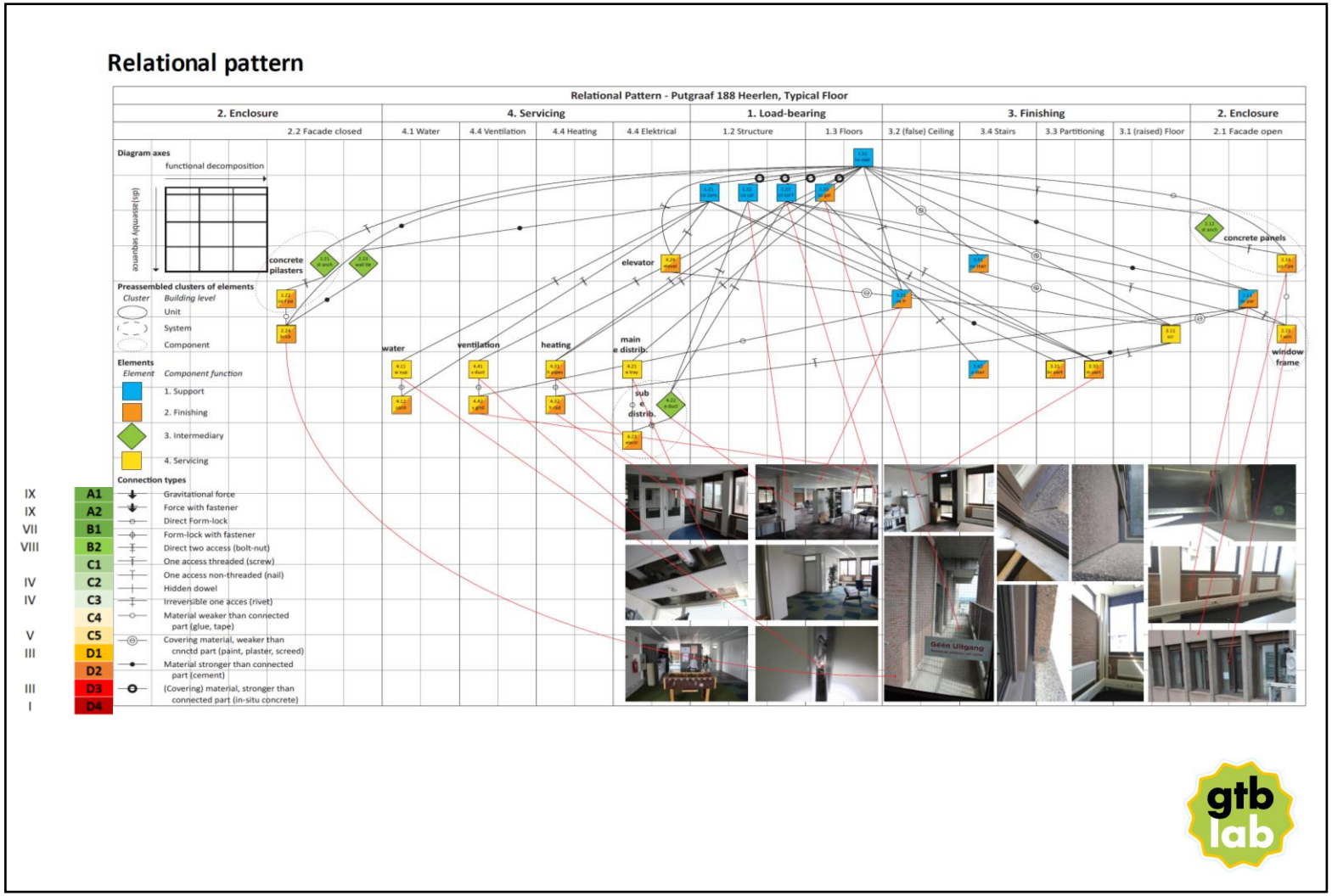
REUSE POTENTIAL/ BUILDING LEVEL

1. Input relational diagram

Relational pattern



Dr. Elma Durmisevic, developer of Reversible Building model 4D architects, GTB Lab

Reversible BIM Module

Reuse Potential (RP)Tool

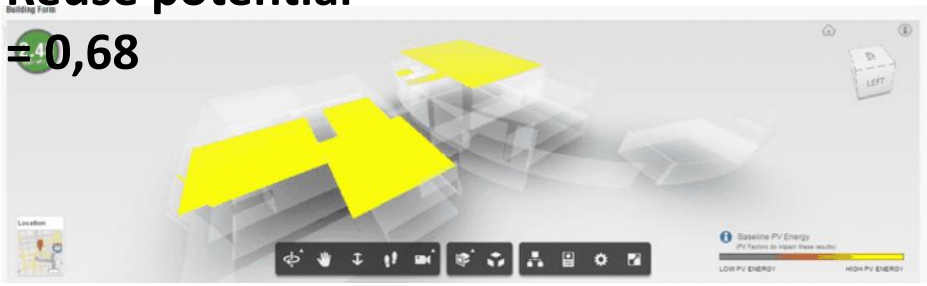
Reversible

0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1

Irreversible

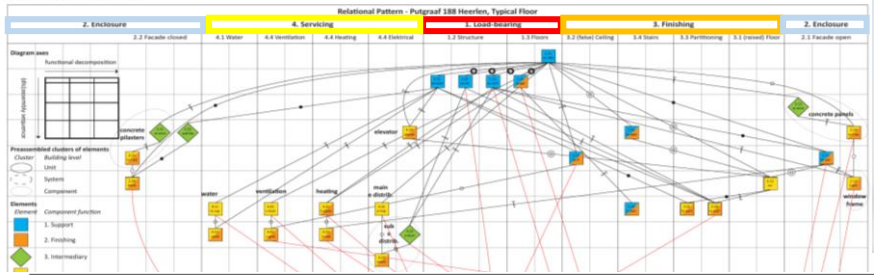
Reuse potential

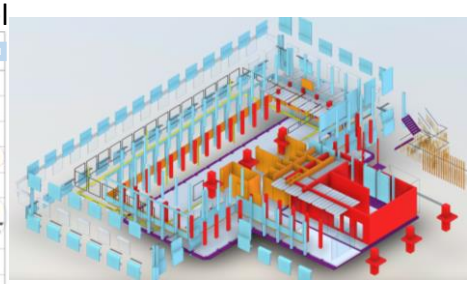
= 0,68



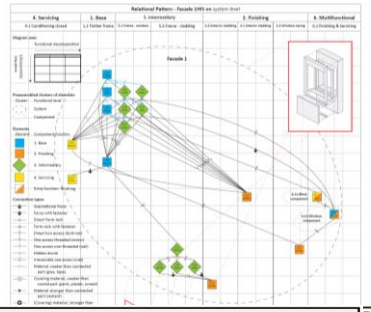
Relational pattern

RP BUILDING level

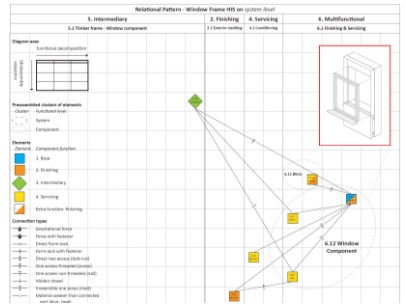




SYSTEM level



PART level



System level assessment

Category / Indicators / Criteria	System level							
	Load bearing 0,10		Enclosing 0,64		Partitioning 0,65		Servicing 0,71	
	Average	Sub-score	Average	Sub-score	Average	Sub-score	Average	Sub-score
Functional independency								
Functional decomposition								
F1 Functional separation	0,70	0,70	0,70	0,70	0,70	0,70	0,70	0,70
F2 Functional integration	0,70		0,70		0,70		0,70	
Systematisation of material levels								
S1 Number of product levels	0,30	0,20	0,60	0,35	0,60	0,45	0,60	0,45
S2 Type of clustering	0,10		0,10		0,30		0,30	
Technical independence								
Relational pattern								
R1 Number of relations	0,90	0,90	0,90	0,80	0,90	0,90	0,90	0,80
R2 Hierarchical position of relations	0,90		0,90		0,90		0,90	
R3 Type of relational pattern	0,90		0,60		0,90		0,60	
Assembly								
A1 Assembly & disassembly sequences	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90
Base element								
B1 Base element specification	0,75	0,75	0,63	0,63	0,50	0,50	0,90	0,90
Life cycle coordination								
L1 Technical life cycle coordination	0,90	0,90	0,67	0,79	0,63	0,59	0,87	0,51
L2 Remaining Technical lifespan	0,90		0,90		0,54		0,16	
Physical independency								
Connections								
C1 Type of connections	0,10	0,11	0,52	0,51	0,53	0,51	0,78	0,81
C2 Connection damage	0,12		0,50		0,50		0,84	
Accessibility								
AC1 Accessibility to fixing	0,48	0,48	0,67	0,67	0,77	0,77	0,62	0,62
Geometry								
G1 Standardisation of product edge	0,10	0,50	0,86	0,77	0,72	0,71	0,83	0,72
G2 Geometry of product edge	0,90		0,69		0,70		0,61	
Resource Utilization								
Resource input reduction								
SP1 Standardisation to production dimensions		0,00		0,00		0,00		0,00
Reuse potential rating at System level		**0,10**		**0,64**		**0,65**		**0,71**

System level assessment

ory / icators / Criteria	Sub-system Enclosing						
	2.1 Facade open0,67		2.2 Facade closed 10,6		2.3 Facade closed 20,6		
	Average	Sub-score	Average	Sub-score	Average	Sub-score	Factors
ional independency							
uctional decomposition							
F1 Functional separation	0,70	0,70	0,70	0,70	0,70	0,70	1
F2 Functional integration	0,70		0,70		0,70		1
tematisation of material levels							
S1 Number of product levels	0,90	0,90	0,30	0,20	0,30	0,20	2
S2 Type of clustering	0,90		0,10		0,10		
ical independence							
ational pattern							
R1 Number of relations	0,90	0,63	0,90	0,80	0,90	0,80	2
R2 Hierarchical position of relations	0,90		0,90		0,90		
R3 Type of relational pattern	0,10		0,60		0,60		
embly							
A1 Assembly & disassembly sequences	0,90	0,90	0,90	0,90	0,90	0,90	1
e element							
B1 Base element specification	0,10	0,10	0,90	0,90	0,90	0,90	1
cycle coordination							
L1 Technical life cycle coordination	0,90	0,90	0,90	0,90	0,37	0,63	1
L2 Remaining Technical lifespan	0,90		0,90		0,90		
al independency							
nections							
C1 Type of connections	0,53	0,42	0,51	0,56	0,52	0,48	3
C2 Connection damage	0,30		0,60		0,45		
essibility							
AC1 Accessibility to fixing	0,90	0,90	0,60	0,60	0,68	0,68	1
ometry							
G1 Standardisation of product edge	0,90	0,85	0,85	0,76	0,85	0,76	1
G2 Geometry of product edge	0,80		0,68		0,68		
rce Utilization							
ource input reduction							
SP1 Standardisation to production dimensions		0,00		0,00		0,00	1
Reuse potential rating at Sub-System level		**0,67**		**0,65**		**0,62**	

Part level assessment

Category / Indicators / Criteria	2.21 co fa		2.22 br par		2.23 st pin		2.24 st ang		2.31 co pil	
	Average	Sub-score	Average	Sub-score	Average	Sub-score	Average	Sub-score	Average	Sub-score
Functional independency										
Functional decomposition										
F1 Functional separation	0,70	0,70	0,70	0,70	0,70	0,70	0,70	0,70	0,70	0,70
F2 Functional integration										
Systematisation of material levels										
S1 Number of product levels	0,30	0,20	0,30	0,20	0,30	0,20	0,30	0,20	0,30	0,20
S2 Type of clustering	0,10		0,10		0,10		0,10		0,10	
Technical independence										
Relational pattern										
R1 Number of relations	0,90	0,80	0,90	0,80	0,90	0,90	0,90	0,90	0,90	0,70
R2 Hierarchical position of relations	0,90		0,90		0,90		0,90		0,90	
R3 Type of relational pattern	0,60		0,60		0,90		0,90		0,30	
Assembly										
A1 Assembly & disassembly sequences	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90
Base element										
B1 Base element specification	0,10	0,10	0,10	0,10	0,90	0,90	0,90	0,90	0,10	0,10
Life cycle coordination										
L1 Technical life cycle coordination	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90
L2 Remaining Technical lifespan	0,90		0,90		0,90		0,90		0,90	
Physical independency										
Connections										
C1 Type of connections	0,40	0,35	0,30	0,30	0,90	0,90	0,90	0,90	0,40	0,35
C2 Connection damage	0,30		0,30		0,90		0,90		0,30	
Accessibility										
AC1 Accessibility to fixing	0,90	0,90	0,90	0,90	0,30	0,30	0,30	0,30	0,90	0,90
Geometry										
G1 Standardisation of product edge	0,90	0,85	0,70	0,80	0,90	0,70	0,90	0,70	0,90	0,85
G2 Geometry of product edge	0,80		0,90		0,50		0,50		0,80	
Resource Utilization										
Resource input reduction										
SP1 Standardisation to production dimensions		0,00		0,00		0,00		0,00		0,00
Reuse potential rating at Sub-System level		**0,57**		**0,55**		**0,72**		**0,72**		**0,55**

Dr. Elma Durmisevic

EUROPEAN UNION

4D architects

Reversible BIM

Reuse Potential Tool

4D architects

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Interreg North-West Europe

EUROPEAN UNION

Digital Deconstruction

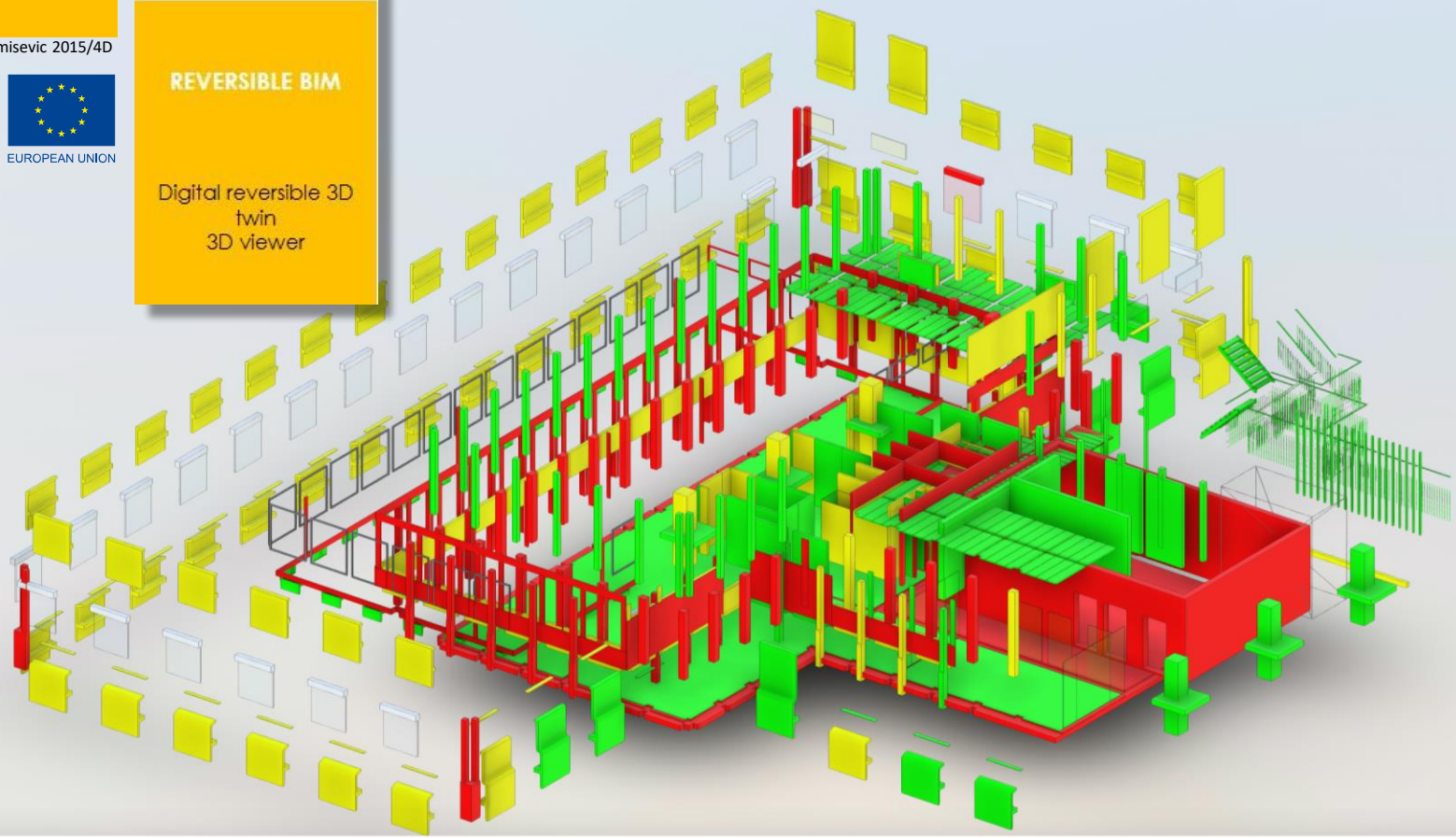
European Regional Development Fund

gtb lab

5

REVERSIBLE BIM

Digital reversible 3D twin
3D viewer



BUILDING
REUSE POTENTIAL

Reversible

0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1

Irreversible

Home | Fit | Pan | Cirkelen | Zoom | First Person | Measure | Section | Explode

Reversible BIM

Reuse Potential Tool

4D architects

EUROPEAN UNION

1

DATA GATHERING

Drawings
point cloud
site visit

2

DATA PROCESSING

Product coding for assessment & BIM template

3

BIM PLUGINS

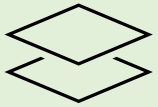
Reversibility assessment Dynamo Autodesk

4

REVEIVT2 EXCL2REVIT

Full Reuse Potential Calculation

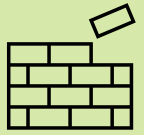
5



REVERSIBLE BIM

Digital reversible 3D twin
3D viewer

6



REPORTING REVERSIBILITY

Reuse options
Deconstruction staps
& embodied value

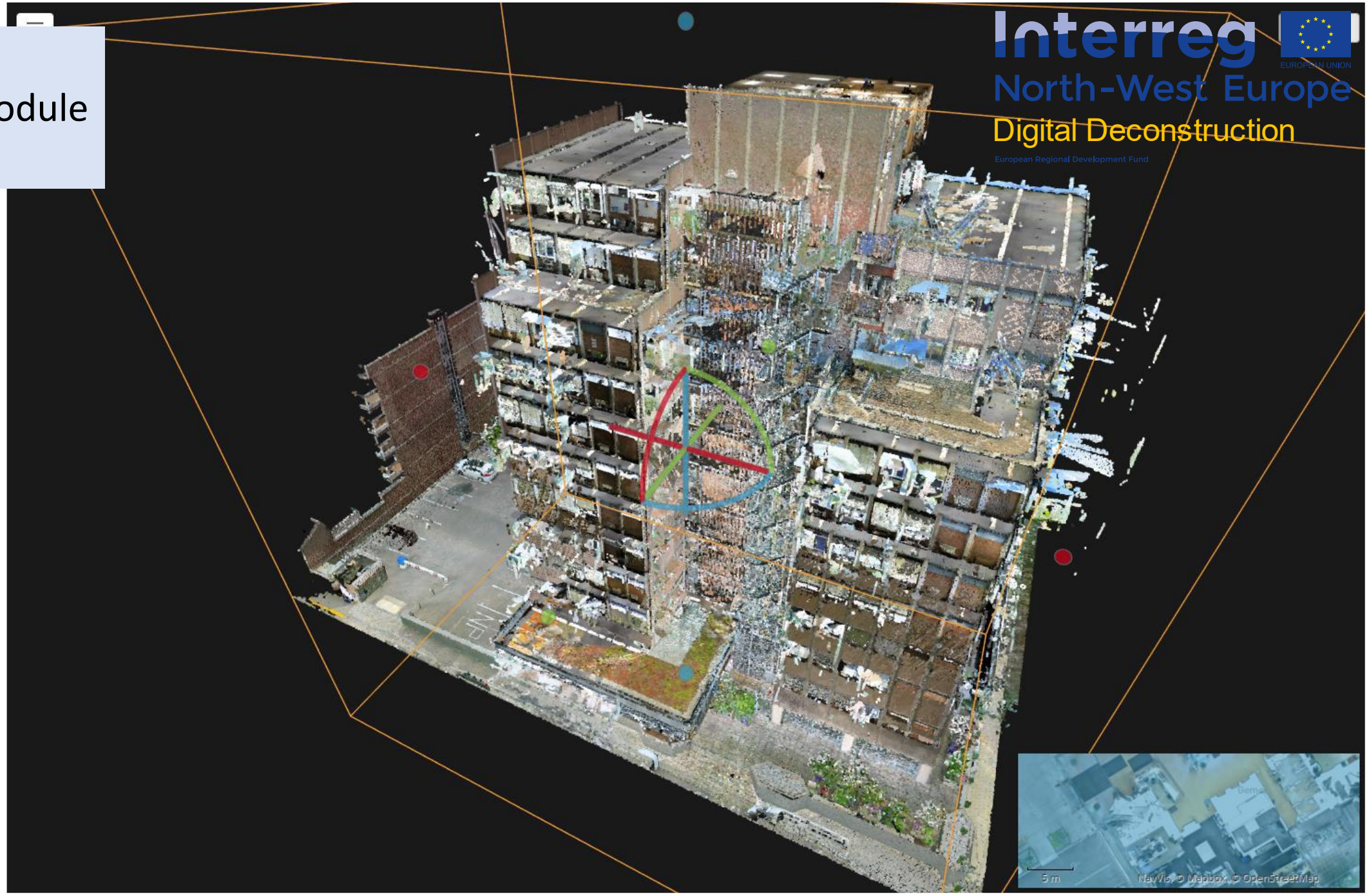
7

BIM OBJECTS LIBRARY

BIM based catalogues of reusable elements

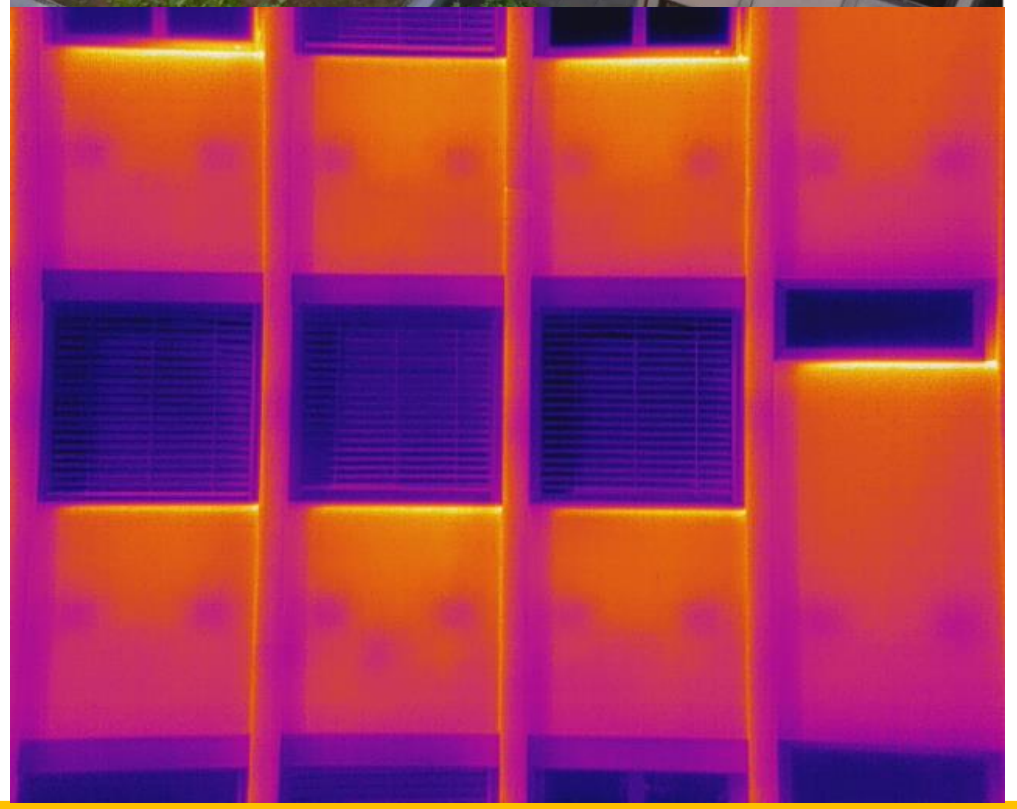
3/

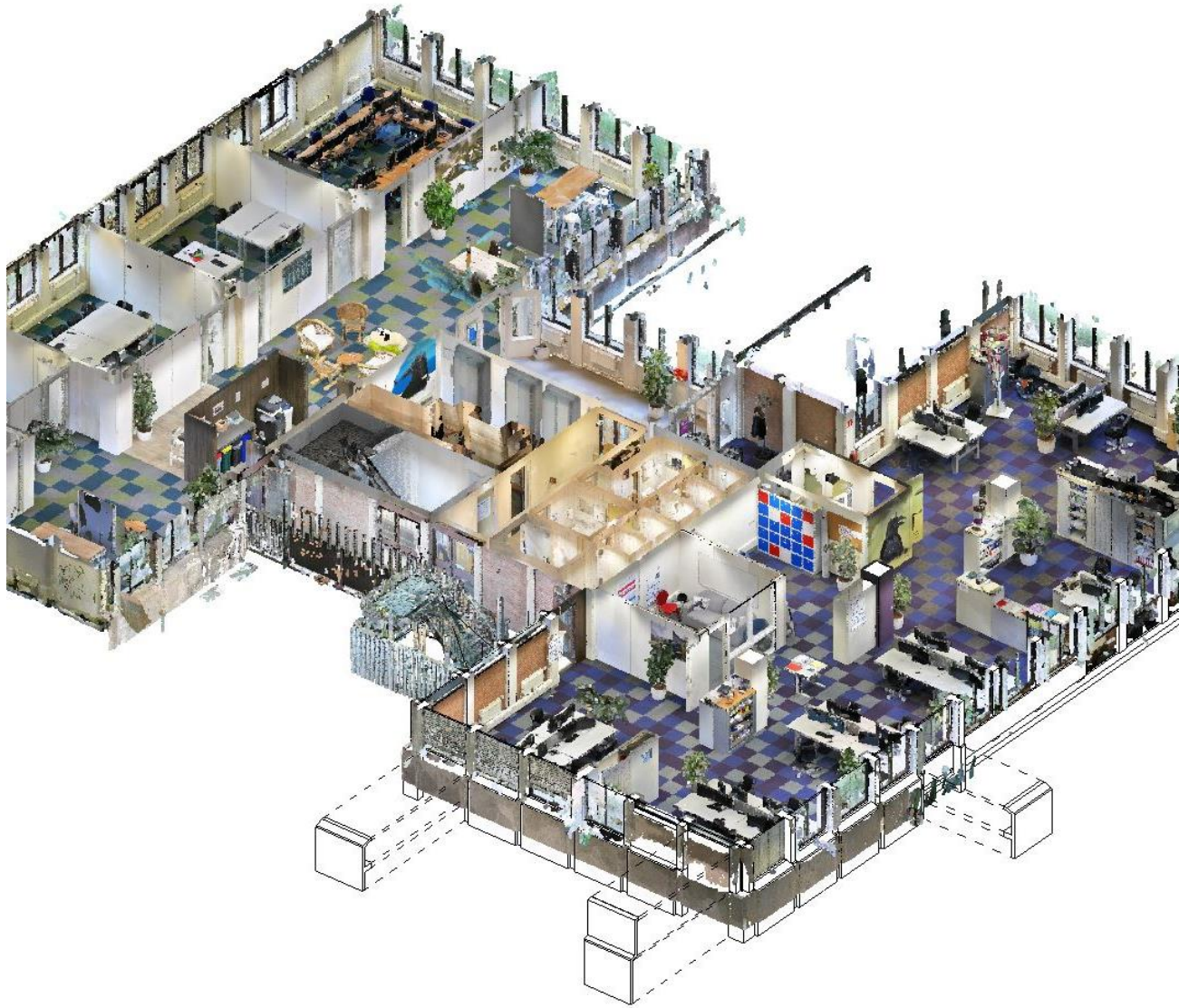
WPT1 modules
3D Scanning Module
BIM_Y



Reversible BIM Module

Reuse Potential (RP)Tool





Autodesk Revit 2018.3 - Project1 - 3D View: {3D}

File | Architecture | Structure | Systems | Insert | Annotate | Analyze | Massing & Site | Collaborate | View | Manage | Add-Ins | Reversible BIM | Modify

Modify | Link Revit | Link IFC | Link CAD | DWF Markup | Decal | Point Cloud | Coordination Model | Manage Links | Import CAD | Import qbXML | Insert from File | Image | Manage Images | Load Family | Load as Group

Select | Link | Import | Load from Library

Properties

3D View

3D View: {3D} | Edit Type

Graphics

View Scale	1 : 100
Scale Value ...	100
Detail Level	Fine
Parts Visibility	Show Original
Visibility/Gra...	Edit...
Graphic Dis...	Edit...
Discipline	Architectural
Show Hidde...	By Discipline
Default Anal...	None
Sun Path	

Extents

Crop View	
Crop Regio...	

Properties help | Apply

Project Browser - Project1

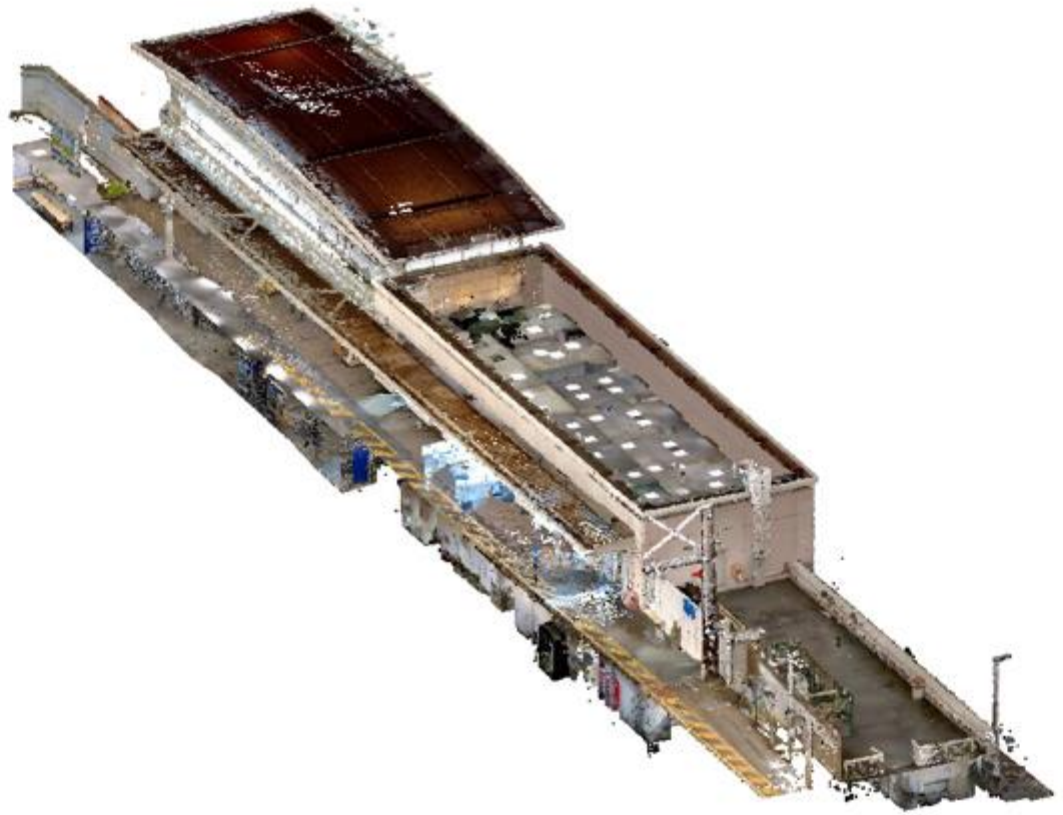
- Views (all)
  - Floor Plans
    - Level 0
    - Level 1
    - Site
  - Ceiling Plans
  - 3D Views
    - {3D}
  - Elevations (12mm Circle)
- Legends
- Schedules/Quantities (all)
- Sheets (all)
  - A100 - Unnamed
- Families
- Groups
- Revit Links

BUILDING
REUSE POTENTIAL

Reversible

0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1

Irreversible



Reversible BIM

Reuse Potential Tool

4D architects

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DATA GATHERING

Drawings
point cloud
site visit

1 : 100

Hold button and move mouse to Spin the View.

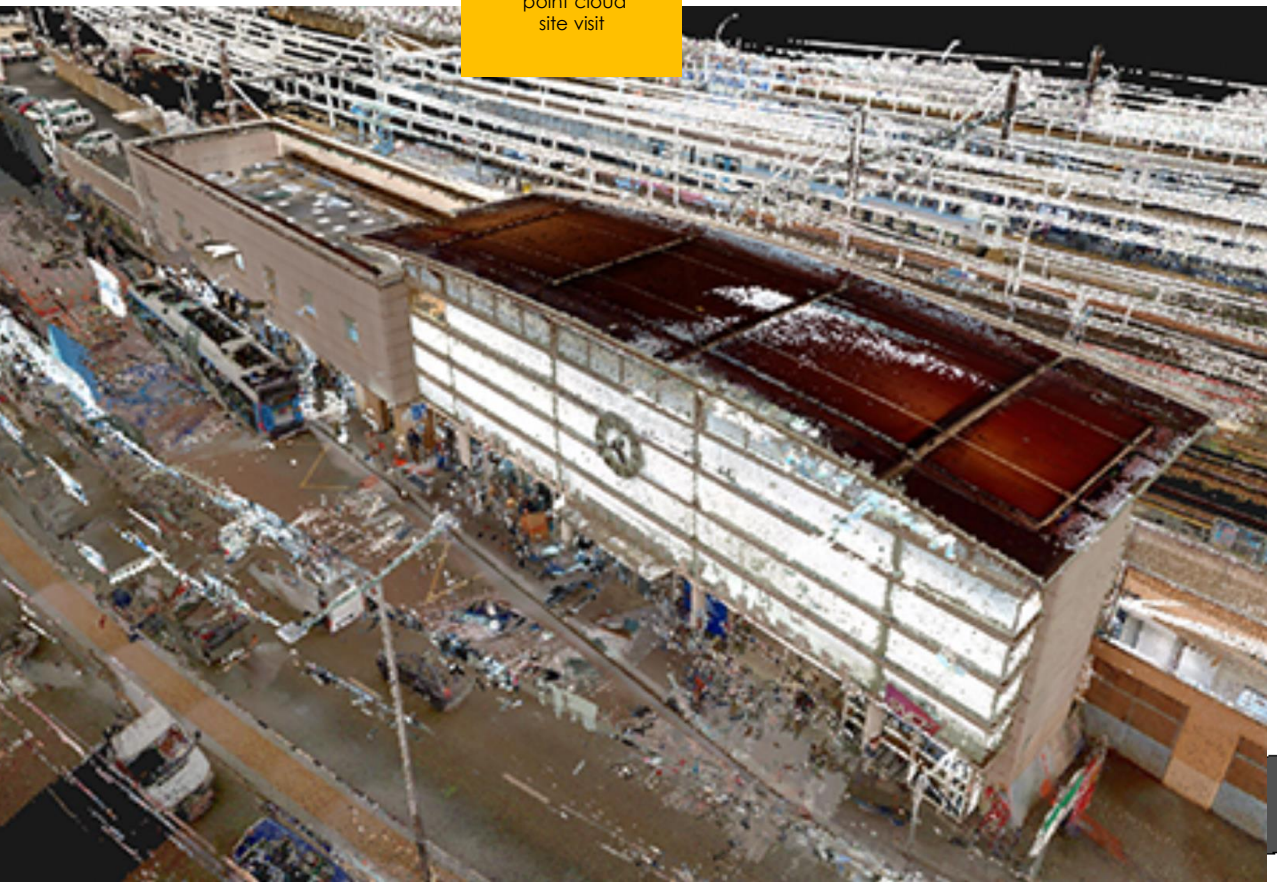
Main Model

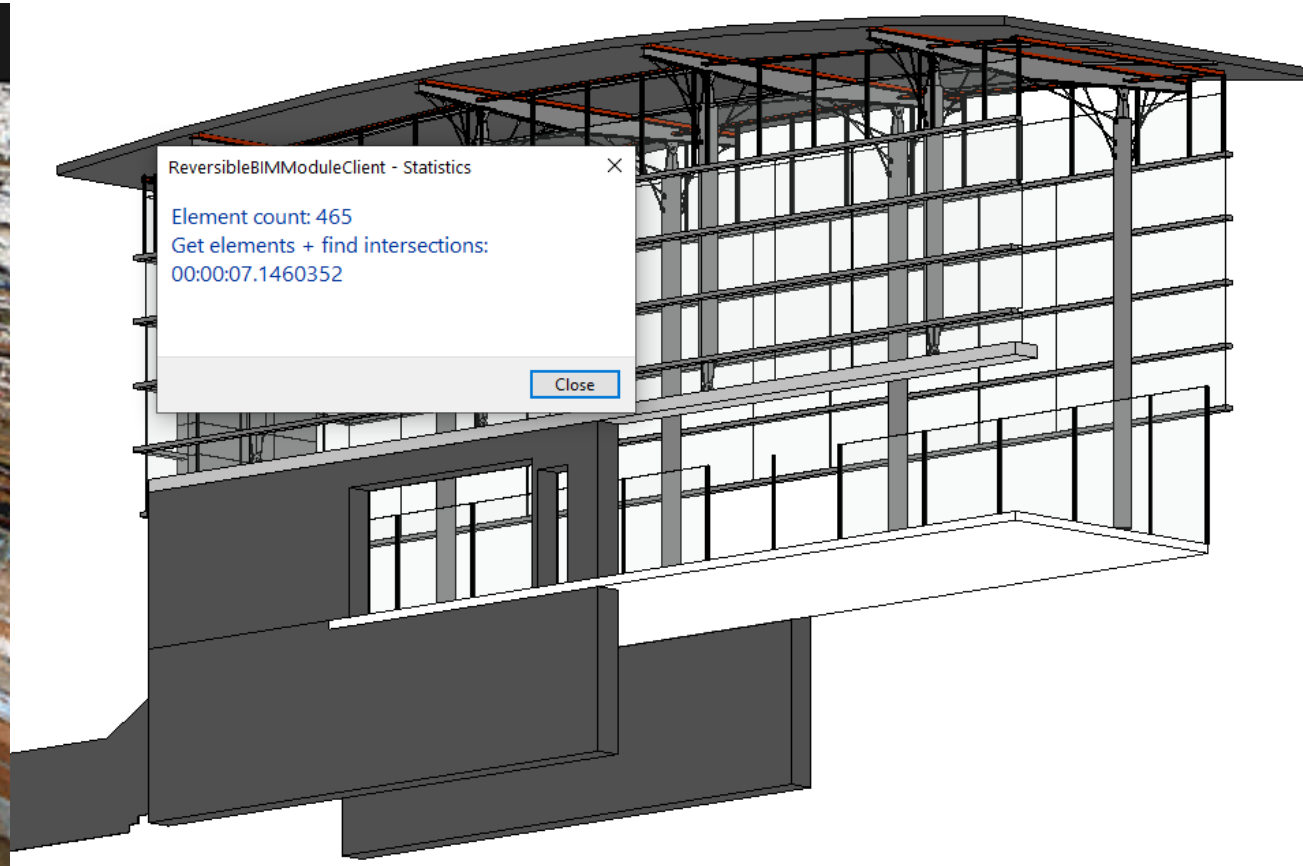
Reversible BIM

Reuse Potential Tool

DATA GATHERING

Drawings
point cloud
site visit





4D architects *Dr.Elma Durmisevic, Founder GTB lab*

Reversible BIM

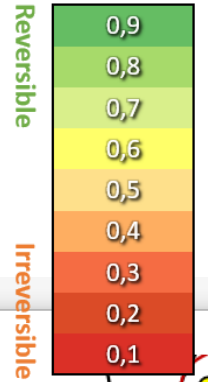
Reuse Potential Tool

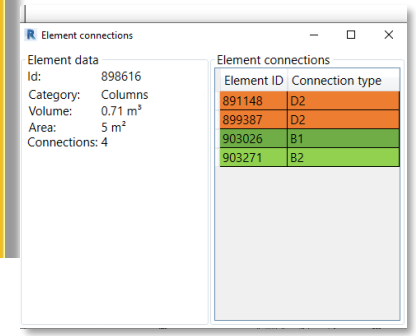
REVERSIBLE BIM

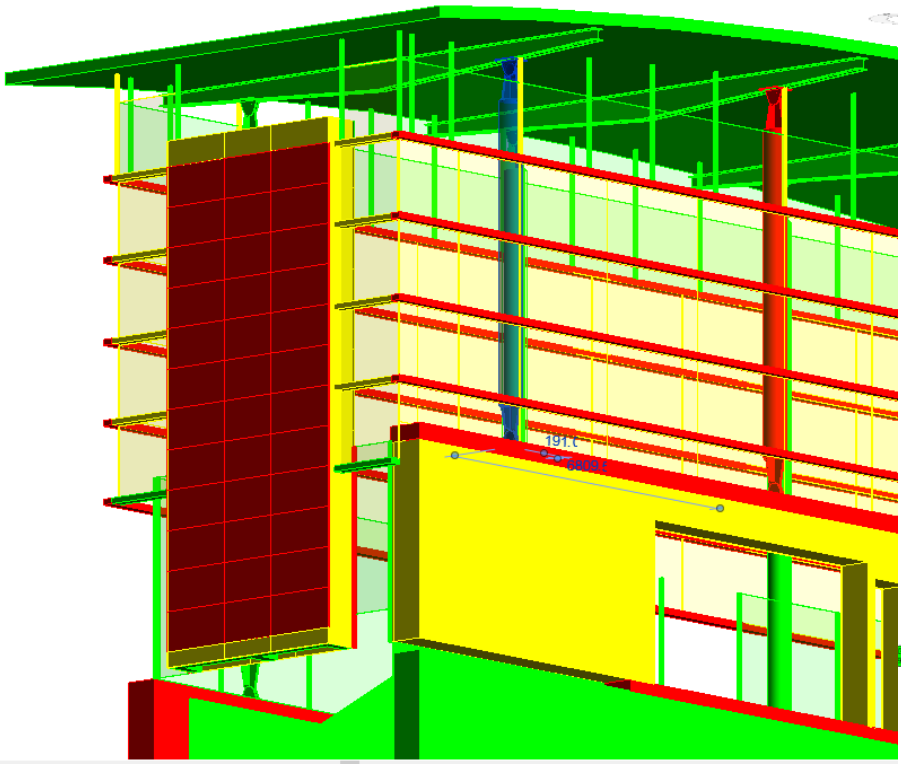
Digital reversible 3D twin
3D viewer

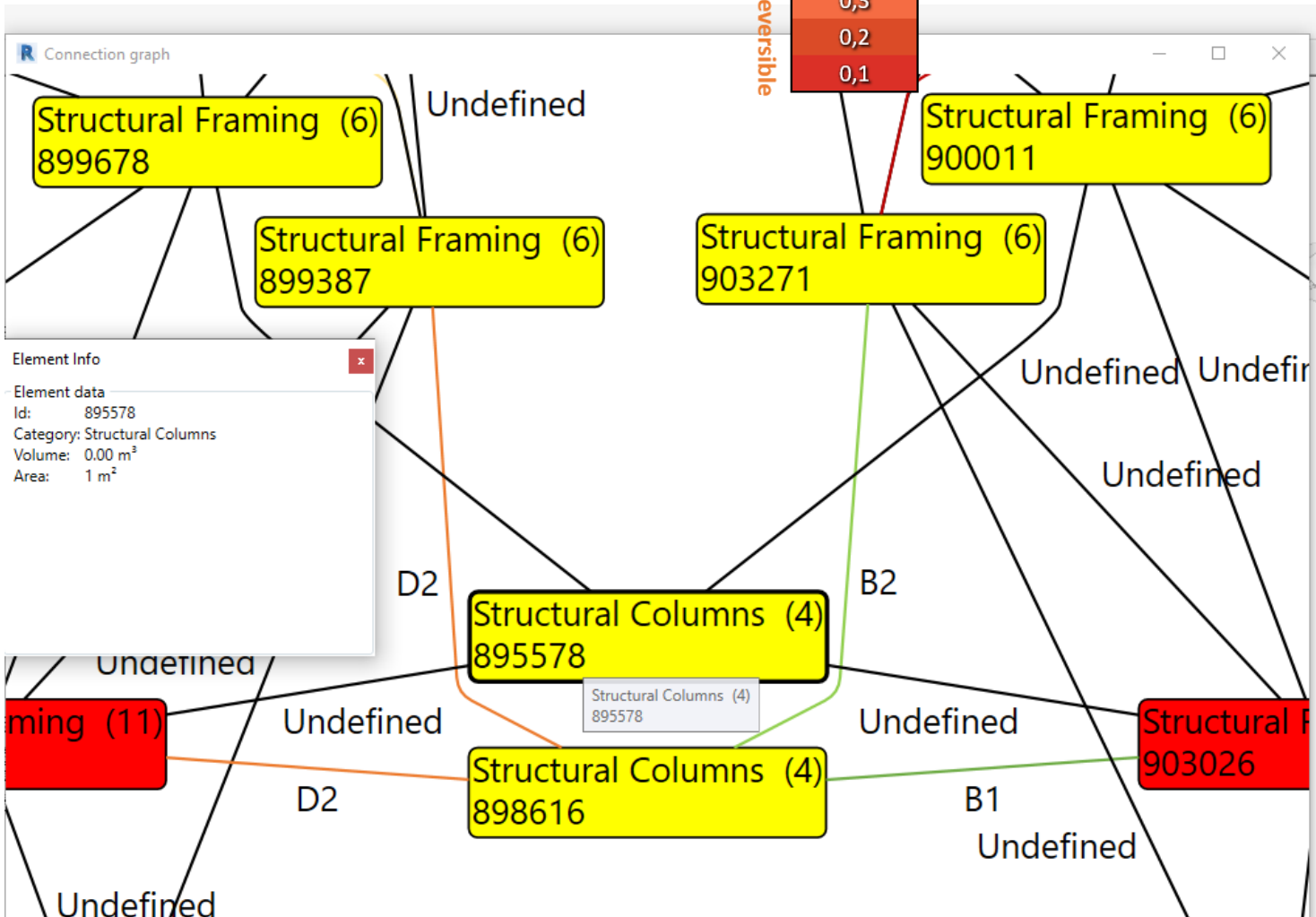
Colour coded diagram representing relational dependences between elements

BUILDING
REUSE POTENTIAL









Reversible BIM

Reuse Potential Tool

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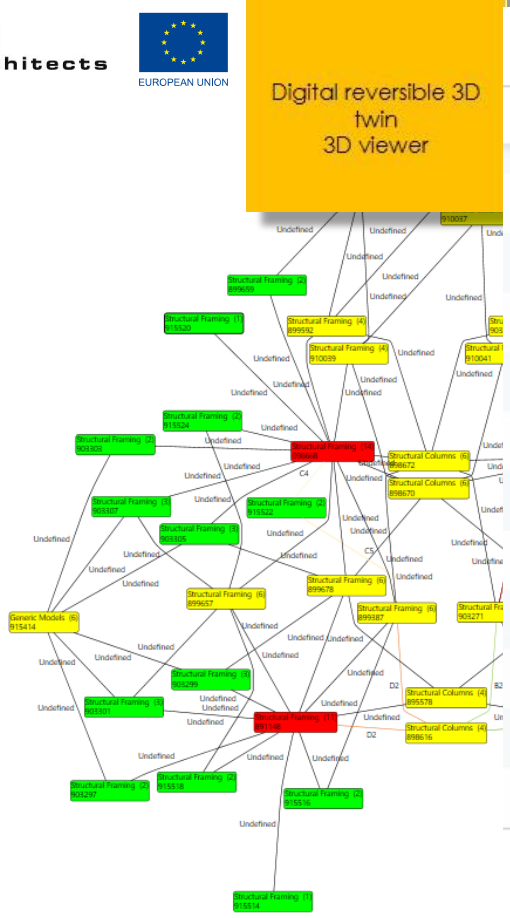
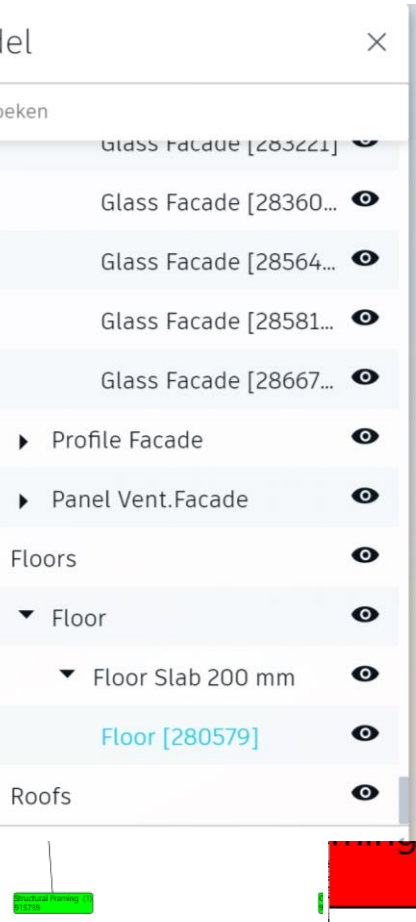
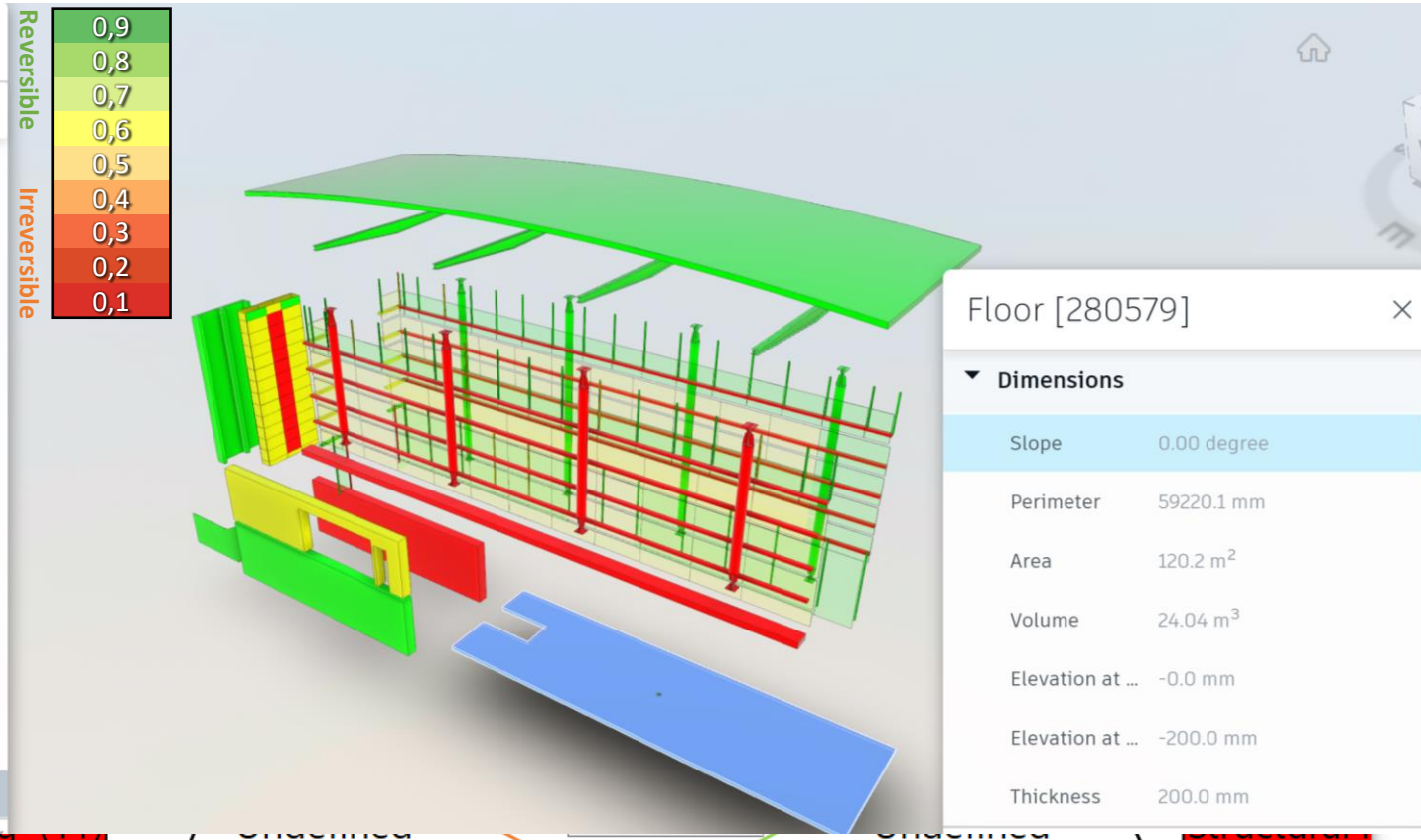
REVERSIBLE BIM

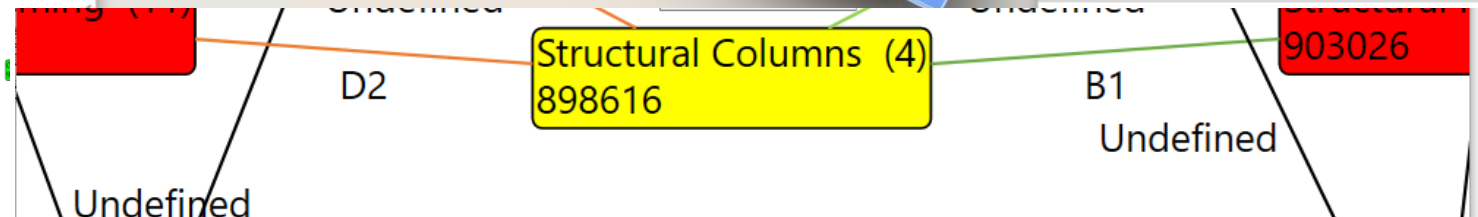
Digital reversible 3D twin
3D viewer

BUILDING
REUSE POTENTIAL





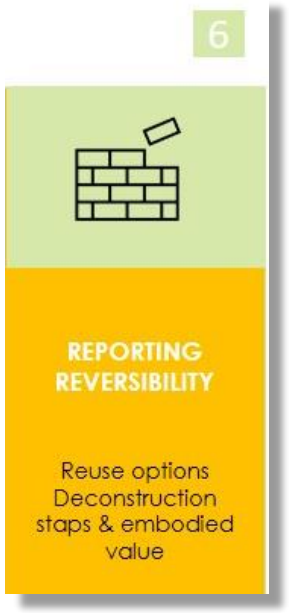




Reversible BIM

Reuse Potential Tool

Formatting outputs



Sequence no.	ID	Type	Material name	Volume	Area	Number of connections
1	245275	Structure - Wall YV 600	Concrete	31.01 mÂ³	52 mÂ²	10
2	280579	Structure - Floor Slab 200 mm	Concrete	24.04 mÂ³	120 mÂ²	21
3	260398	Facade - Shaft Wall	Concrete	8.94 mÂ³	1 mÂ²	3
3	244905	Structure - Wall IV 600	Concrete	17.26 mÂ³	29 mÂ²	5
4	388651	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
4	386510	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
4	388845	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	1
4	243485	680x280	Concrete	4.97 mÂ³	25 mÂ²	19
4	388888	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	1
5	203304	Structure - Main Column 1	Steel	1.24 mÂ³	7 mÂ²	8
5	203327	Structure - Main Column 1	Steel	1.19 mÂ³	7 mÂ²	8
5	203265	Structure - Main Column 1	Steel	1.19 mÂ³	7 mÂ²	8
5	201756	Structure - Main Column 1	Steel	1.24 mÂ³	7 mÂ²	9
6	385427	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
6	385418	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
6	385409	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
6	385224	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
7	203356	Structure - Main Column 2	Steel	0.70 mÂ³	5 mÂ²	11
7	231268	Structure - Main Column 2	Steel	0.75 mÂ³	5 mÂ²	11
7	231298	Structure - Main Column 2	Steel	0.70 mÂ³	5 mÂ²	11
7	231284	Structure - Main Column 2	Steel	0.75 mÂ³	5 mÂ²	11
8	247155	Structure - Roof Beam	Steel	0.08 mÂ³	8 mÂ²	23
8	258596	Structure - Roof Beam	Steel	0.08 mÂ³	8 mÂ²	23
8	258159	Structure - Roof Beam	Steel	0.08 mÂ³	8 mÂ²	24
8	259848	Structure - Roof Beam	Steel	0.08 mÂ³	8 mÂ²	21
9	383560	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
9	385407	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
9	388763	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
9	388750	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
9	386793	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2
9	388774	Intermediary - Column Joint	Steel	0.01 mÂ³	0 mÂ²	2

4D architects

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Reversible BIM

Reuse Potential Tool

4D architects

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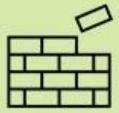
6



REPORTING REVERSIBILITY

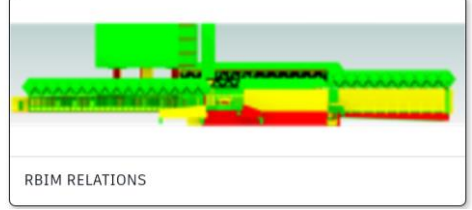
Reuse options
Deconstruction staps & embodied value

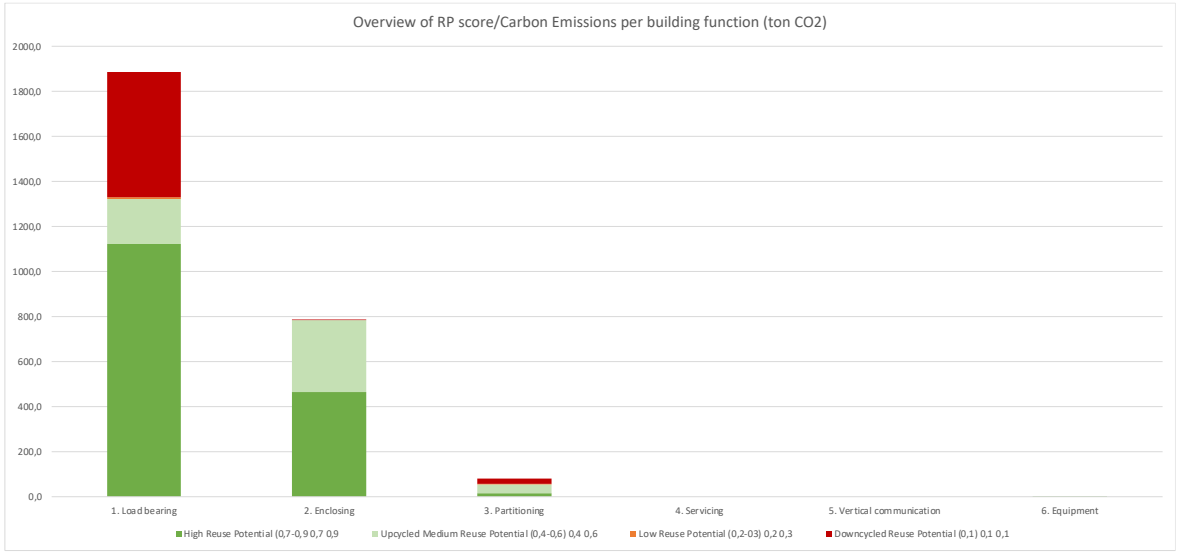
Preview 'typePerElement.csv'

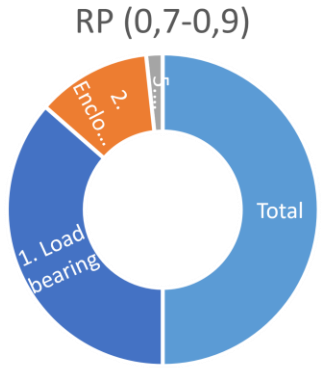
ID	Type	Material name	Volume	Area	Number of con	RP(r1)	RP(r2)	RP(a1)	RP(c1)	RP(c2)	RP
934028	2400x4800x3625	Steel	0.67 m³	20 m²	76	0.1	0	0	0.72	0.6	0.39
940005	4800x2400x3625	Steel	0.48 m³	13 m²	42	0.1	0	0	0.72	0.6	0.39
1045845	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045833	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045937	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045807	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1050083	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045798	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045938	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045947	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045948	Z-connection2	Steel	0.00 m³	0 m²	3	0.9	0	0	0.78	0.6	0.52
1045949	Z-connection2	Steel	0.00 m³	0 m²	3	0.9	0	0	0.78	0.6	0.52
1045939	Z-connection2	Steel	0.00 m³	0 m²	3	0.9	0	0	0.78	0.6	0.52
1045940	Z-connection2	Steel	0.00 m³	0 m²	3	0.9	0	0	0.78	0.6	0.52
1045946	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045563	Z-connection2	Steel	0.00 m³	0 m²	3	0.9	0	0	0.78	0.6	0.52
1045579	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045591	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045525	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045538	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045550	Z-connection2	Steel	0.00 m³	0 m²	3	0.9	0	0	0.78	0.6	0.52
1045607	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045757	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045772	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045789	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045620	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1045639	Z-connection2	Steel	0.00 m³	0 m²	3	0.9	0	0	0.78	0.6	0.52
1045652	Z-connection2	Steel	0.00 m³	0 m²	3	0.9	0	0	0.78	0.6	0.52
1046284	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1047231	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1047264	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5
1047298	Z-connection2	Steel	0.00 m³	0 m²	2	0.9	0	0	0.7	0.6	0.5

Reversible BIM

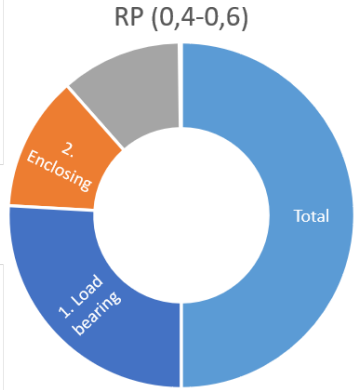
Reuse Potential Tool



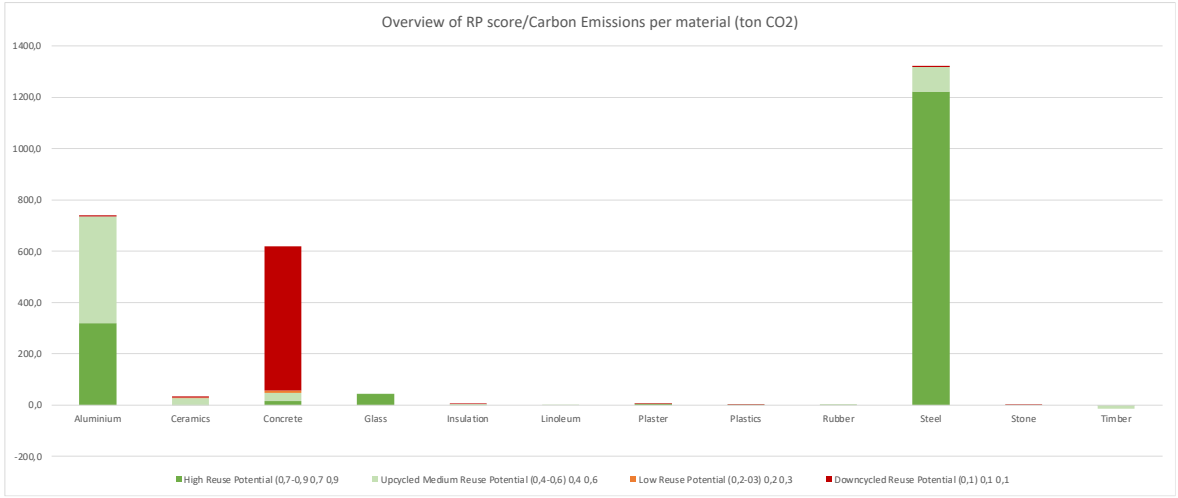




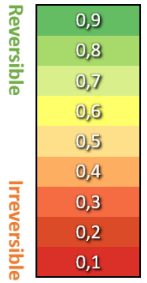
Direct reuse

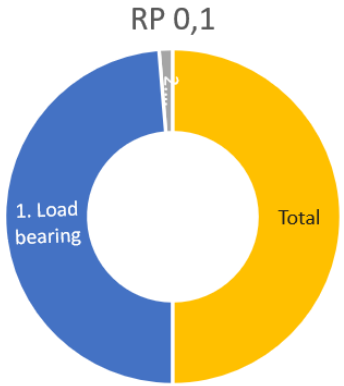


Reus by Reparation remanufatur ing



BUILDING
REUSE POTENTIAL





No high value reuse/ Downcycling

Dr.Elma Durmisevic, Founder GTB lab

Carbon emissions

Carbon emissions per material (ton CO2)

	Aluminium	*Asbestos*	*Bitumen*	*Ceramics*	*Concrete*	*Glass*	*Insulation*	*Linoleum*	*Plaster*	*Plastics*	*Steel*	*Stone*	*Timber*	*Total*	*Proportion*
High Reuse Potential (0,7-0,9	57,2	0,0	0,0	0,0	1,0	5,8	0,2	0,0	2,8	0,5	139,3	0,0	-5,0	**201,7**	8%
Upcycled Medium Reuse Potential (0,4-0,6)	39,7	0,5	3,7	2,1	14,0	0,0	12,5	3,0	4,1	52,5	1118,7	0,0	-23,3	**1227,5**	47%
Low Reuse Potential (0,2-03)	21,1	0,1	0,0	0,0	0,4	2,0	0,0	0,0	0,5	0,0	340,6	0,0	0,0	**364,6**	14%
Downcycled Reuse Potential (0,1)	13,6	11,5	0,0	13,6	744,1	6,9	0,0	5,6	0,9	0,0	3,3	13,9	0,0	**813,3**	31%
Total	**131,6**	**12,1**	**3,7**	**15,7**	**759,4**	**14,6**	**12,7**	**8,6**	**8,3**	**52,9**	**1601,8**	**14,0**	**-28,3**	**2607,1**	100%
Proportion	5%	0%	0%	1%	29%	1%	0%	0%	0%	2%	61%	1%	-1%	100%	

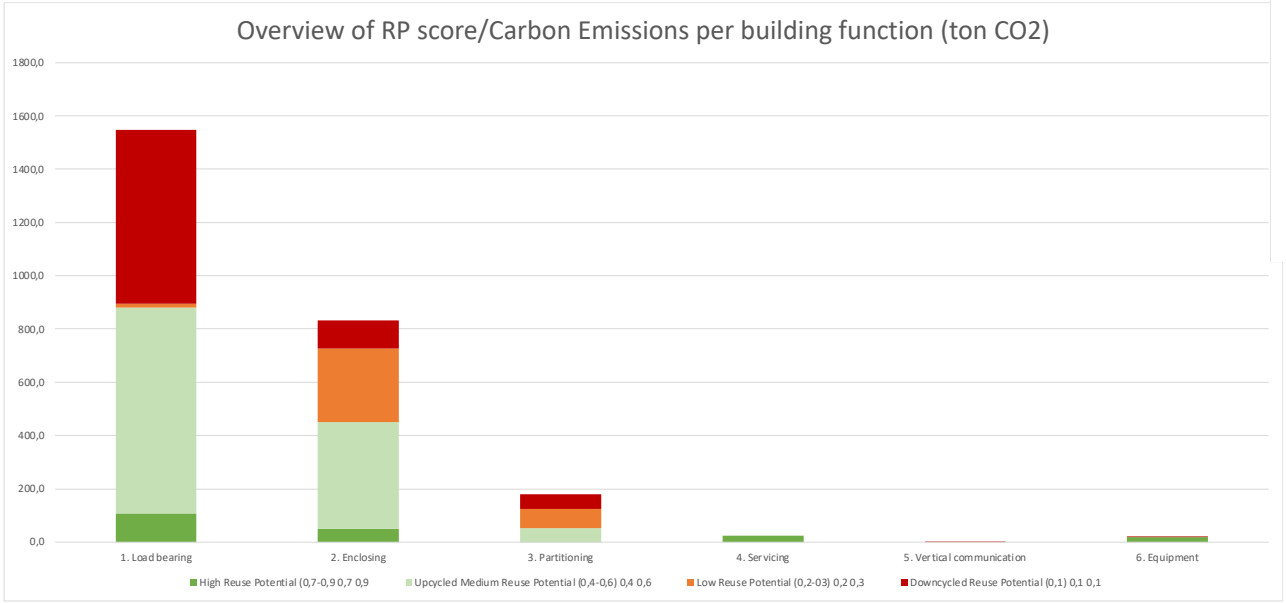
Carbon emissions per function (ton CO2)

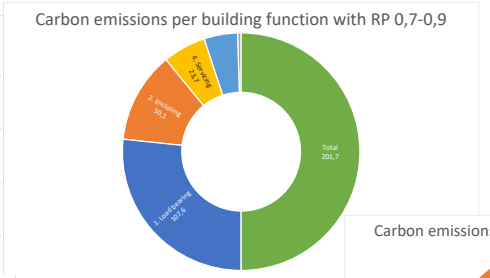
	1. Load bearing	*2. Enclosing*	*3. Partitioning*	*4. Servicing*	*5. Vertical communication*	*6. Equipment*	*Total*	*Proportion*
High Reuse Potential (0,7-0,9	107,6	50,1	2,0	23,7	0,0	18,4	**201,7**	8%
Upcycled Medium Reuse Potential (0,4-0,6)	773,1	400,7	49,4	3,6	0,0	0,7	**1227,5**	47%
Low Reuse Potential (0,2-03)	13,6	276,9	74,1	0,0	0,0	0,0	**364,6**	14%
Downcycled Reuse Potential (0,1)	653,1	103,9	55,2	0,0	0,2	0,9	**813,3**	31%
Total	**1547,5**	**831,5**	**180,6**	**27,3**	**0,2**	**20,1**	**2607,1**	100%
Proportion	59%	32%	7%	1%	0%	1%	100%	

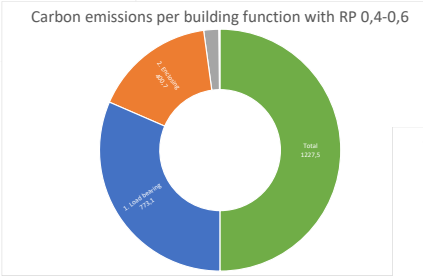
Carbon absorbed by

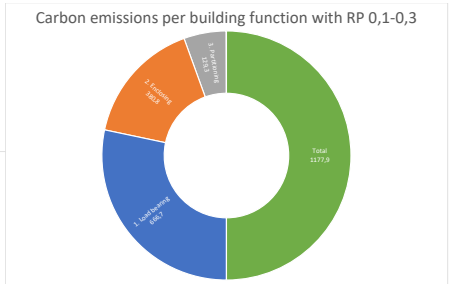
7900 football fields

of trees growing in one year





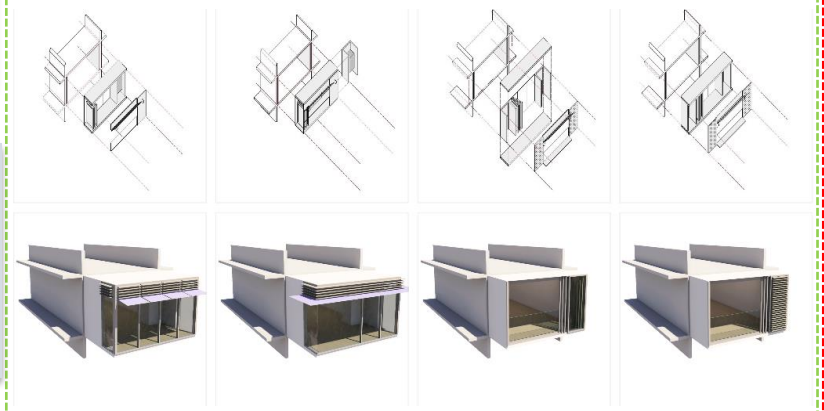




Circularity Profile based on Reversibility Indicators
= Reuse Capacity of Buildings and its Materials

	Circularity of building and building products	Circularity of materials
Reversible Building Circularity profile 0	**RBD Category 0** Spatial reversibility TC 0,1 Technical reversibility RP 0,1	Reused materials Less than 10% Element level reused 0%
Reversible Building Circularity profile 1	**RBD Category 1** Spatial reversibility TC 0,2 to 0,3 Technical reversibility RP 0,2 to 0,3	Recycling More than 20% Element level reused 0-20%
Reversible Building Circularity profile 2	**RBD Category 2** Spatial reversibility TC = 0,3 to 0,6 Technical reversibility RP 0,3 to 0,6 TC>07 RP 0,3 RP> 0,7 TC <0,3	Reused elements 30-50% Element level reused 20-50%
Reversible Building Circularity profile 3	**RBD Category 3** Spatial reversibility TC> 0,7 Technical reversibility RP > 0,7	Reused materials More than 50% Element level r eused more than 50%

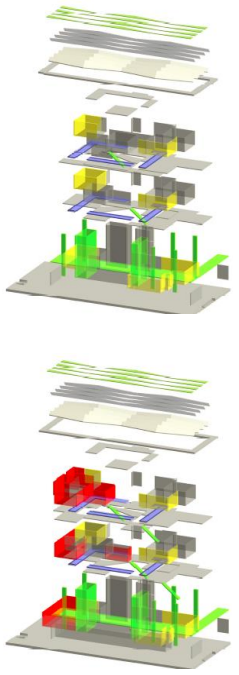
Technical Reversibility



Separate materials

Reconfigure structure

Spatial Reversibility



Adapt

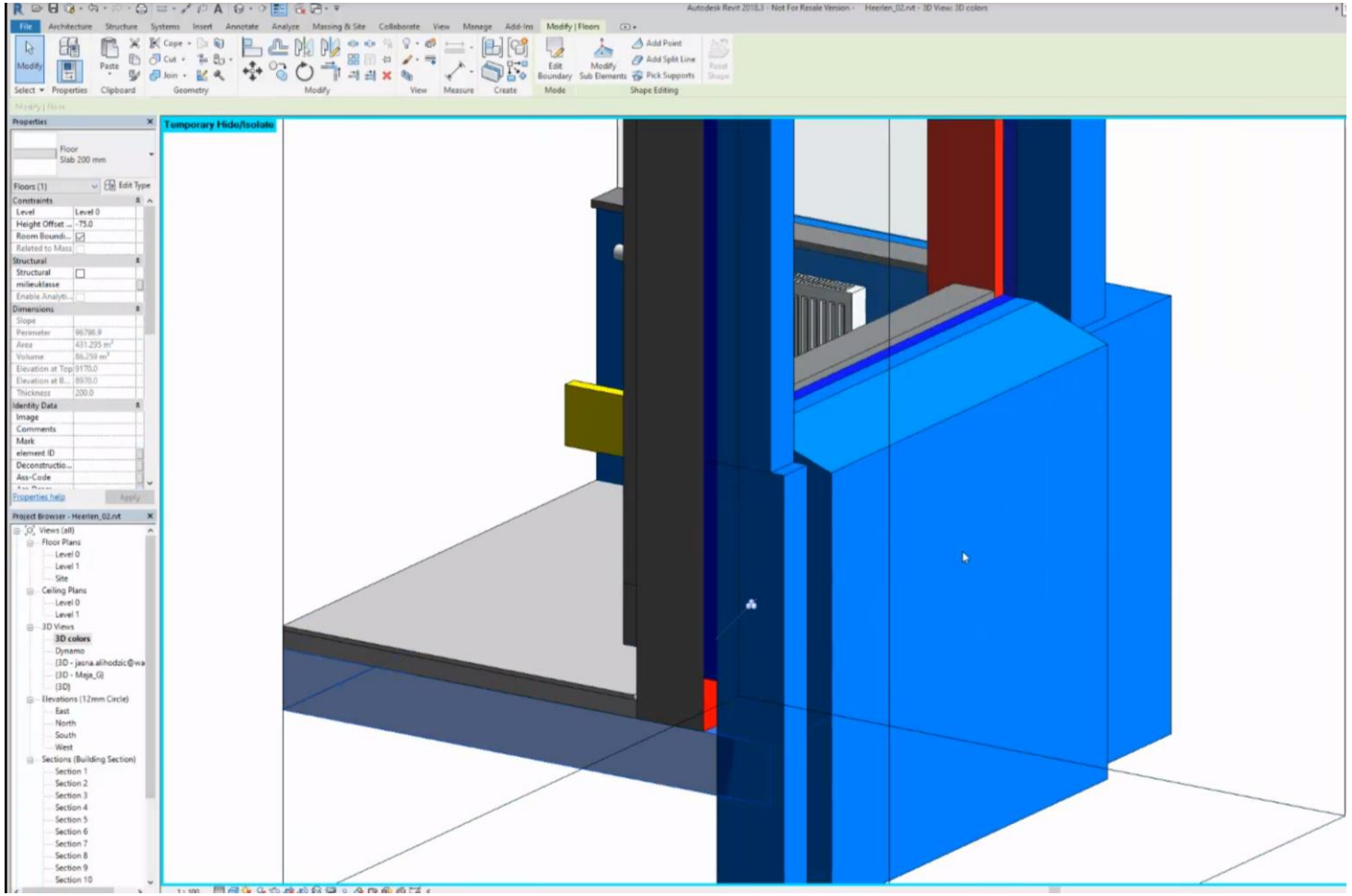
Elma Durmisevic, Head of the research EU Horizon 2020/BAMB Revisable Buildings /4D architects

Reversible BIM Moduel

Reuse Potential (RP)Tool

BIM objects

Digital library of reusable elements



1

‘Architecture / Design’ and ‘Consultancy firm / Demolition expert’

2

Construction phase: ‘Construction contractor’, ‘Demolition contractor’ and ‘Material producer’

3

Clients: ‘Private client’ and ‘Public client’

Interreg North-West Europe
Digital Deconstruction
European Regional Development Fund

1b ARCHITECTURE / DESIGN' AND 'CONSULTANCY FIRM / DEMOLITION EXPERT'

End user needs:

A. BIM-based assessment tool for reusability of building elements

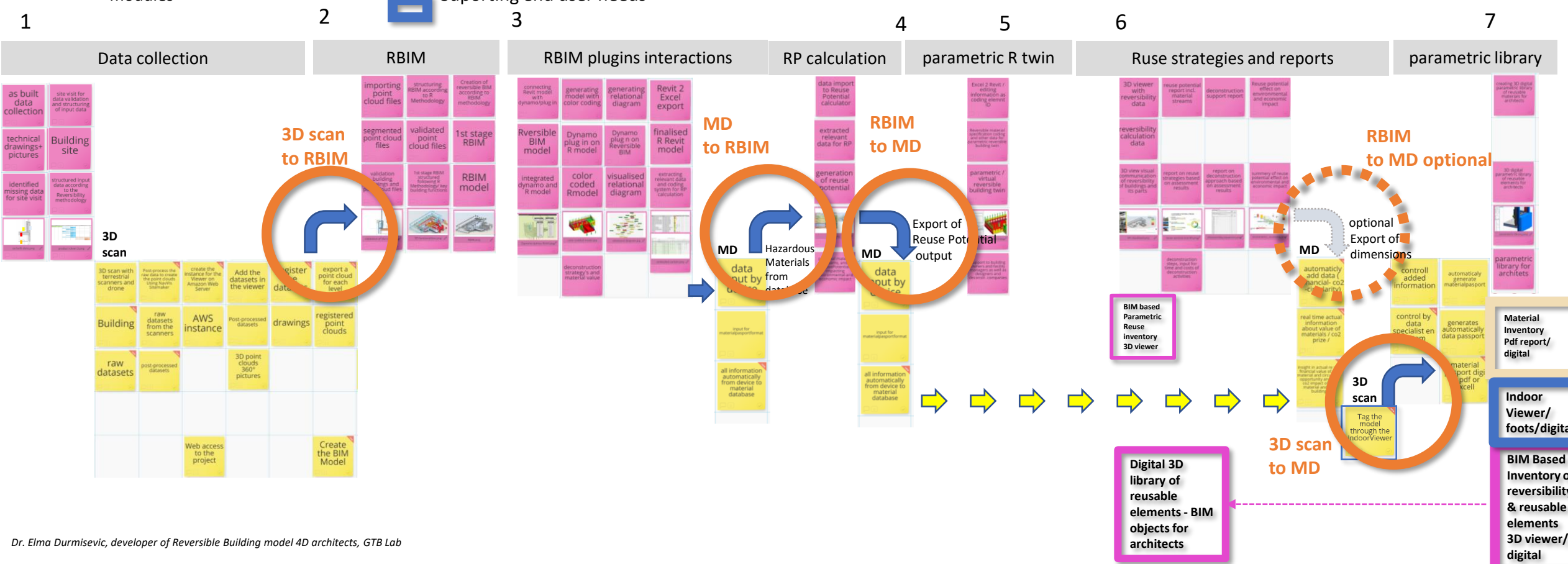
B. A tool to make materials inventory

C. A calculation tool assessing different scenarios and options for waste management

D. Identifying reusable building elements and assessing reusability of building materials (demountability, value, technical quality)

Connection points beween DDC modules

Outputs for the end user
Suporting end user needs



Dr. Elma Durmisevic, developer of Reversible Building model 4D architects, GTB Lab

Cost Benefits Analyses

		DDC scenario	Demolition scenario
Cost of overall project (€)	Inventory costs	- €	- 10,00 €
	Deconstruction costs	- €	
	Valorisation costs	1.500,00 €	
Amount of work (MH)		0	-20
CO2 emissions (kg)		0	500
Embodied energy		0	0
Resources reused (t)		#VERW!	0

Benefits				
Costs avoided	Consumption of resources /waste generation avoided	CO2 emissions avoided	Embodied energy avoided for futur projects	Job creation (Men Day)
0,00 €	**0**	**500**	**0**	**2,5**

Linear | Take - make – waste approach

Demolition Costs + Waste Disposal Cost = **Costs**

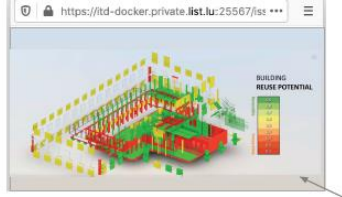
Circular | Take - make – remake approach

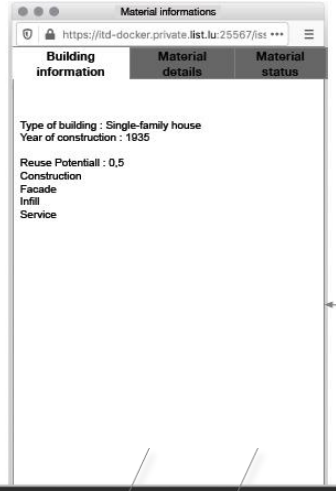
Costs:
Inventory Costs + DC costs + Storage cost
Benefits internal:
Residual Value of reused material
Benefits external:
Saved CO2 tax + saved Embodied energy cost + saved Taxation on raw material

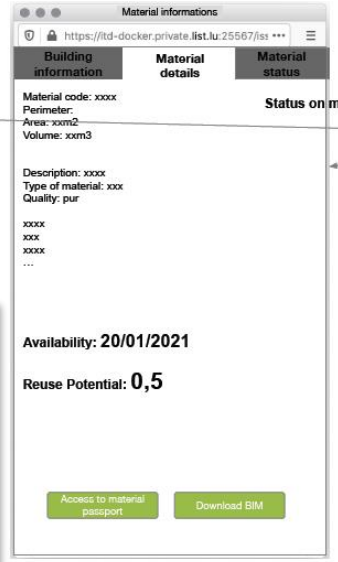
High Reversibility Index = de/construction costs **low** +environmental costs **low**

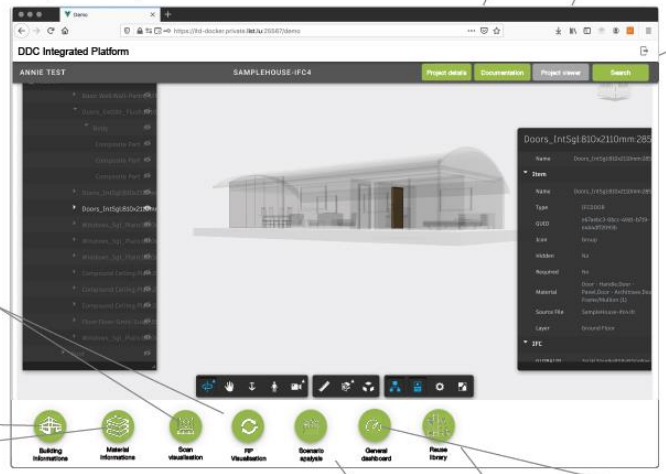
Low Reversibility Index = de/construction costs **high** +environmental costs **high**

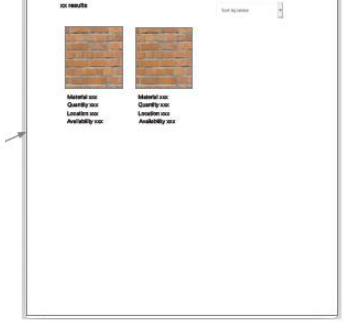
DDC Integrated platform : a decision support tool
A BIM-based dashboard including multiple visualizations

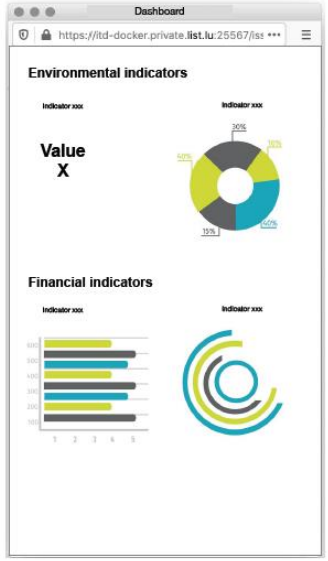


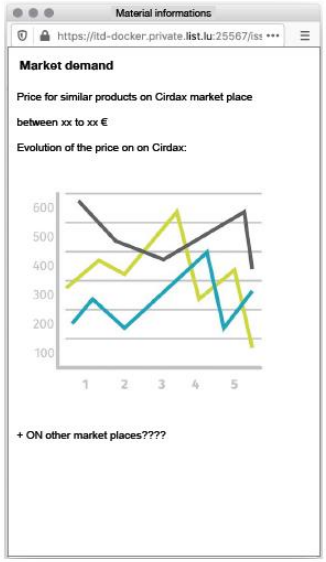


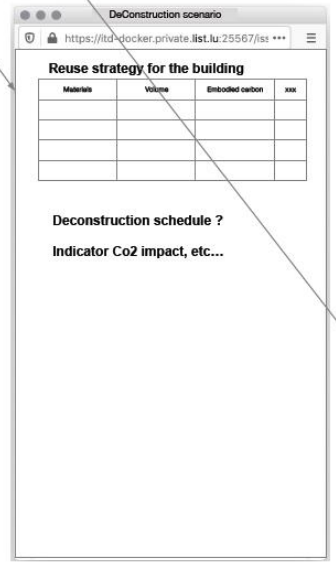


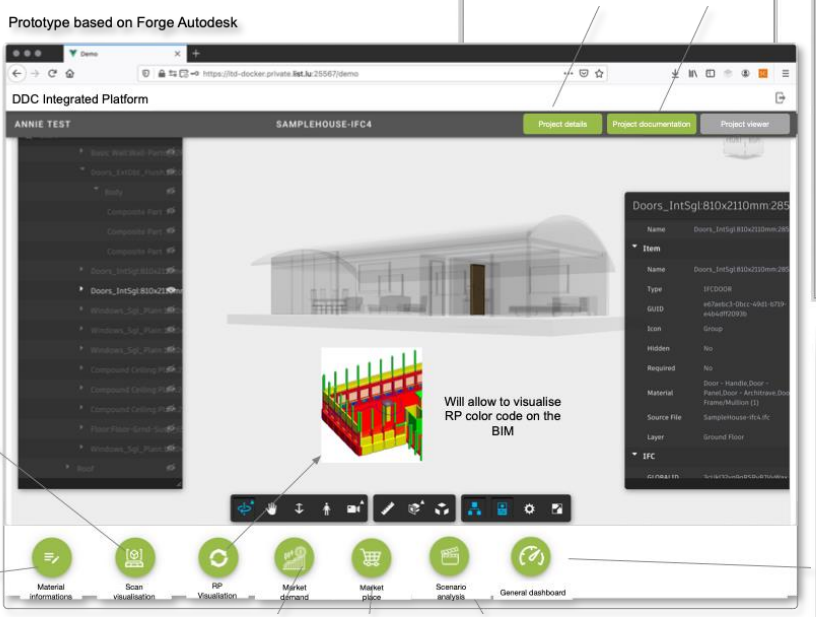


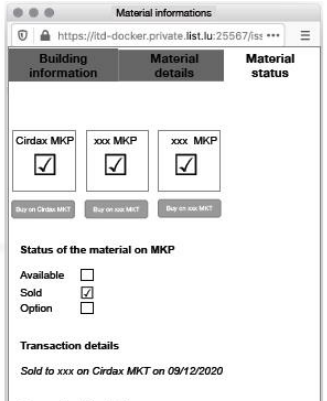


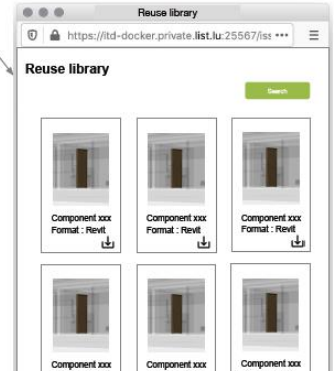












First sketches of interfaces intended to support discussions

Source: LIST