

Construction Configurator

Brent Smeekes 4607643

Existing work

The status quo of construction configurators

What is a configurator?

Nike sneaker configurator



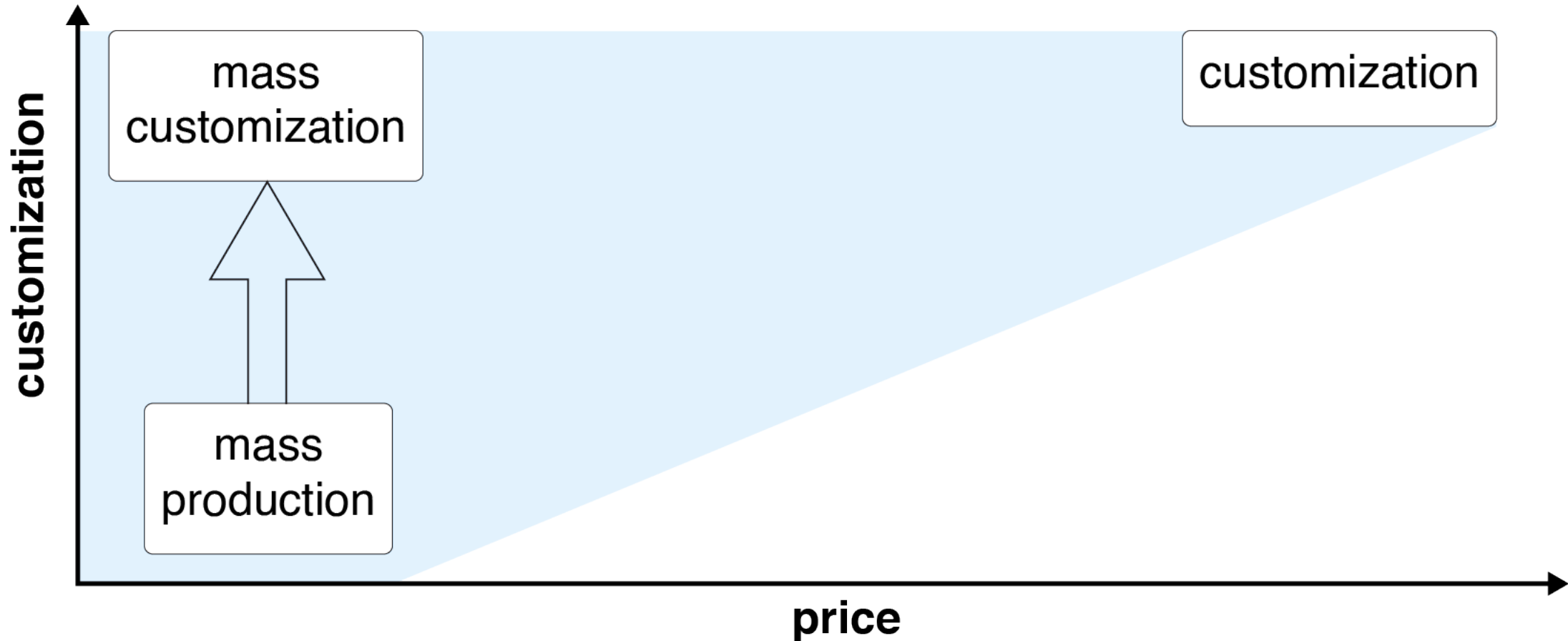
What is a configurator?

Mass production



What is a configurator?

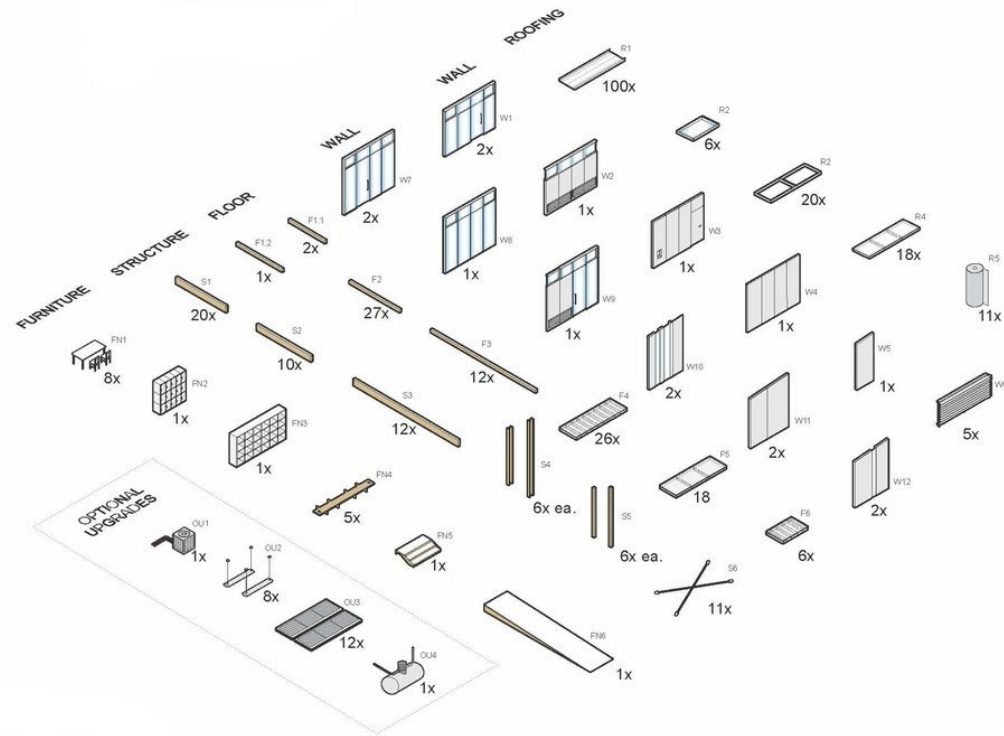
Mass customisation



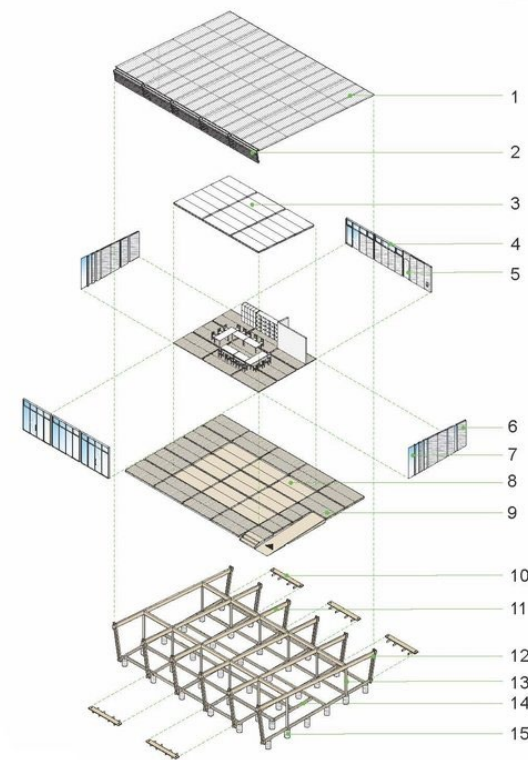
What is a configurator?

Definition of configurators

Kit-of-parts

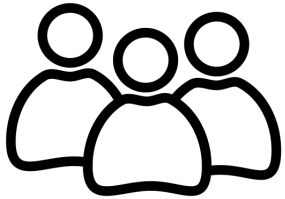


Configuration rules

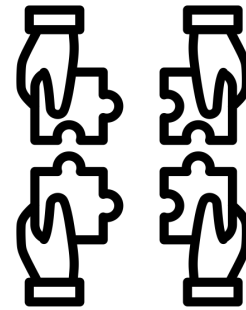


Why do we need configurators?

Trends in construction



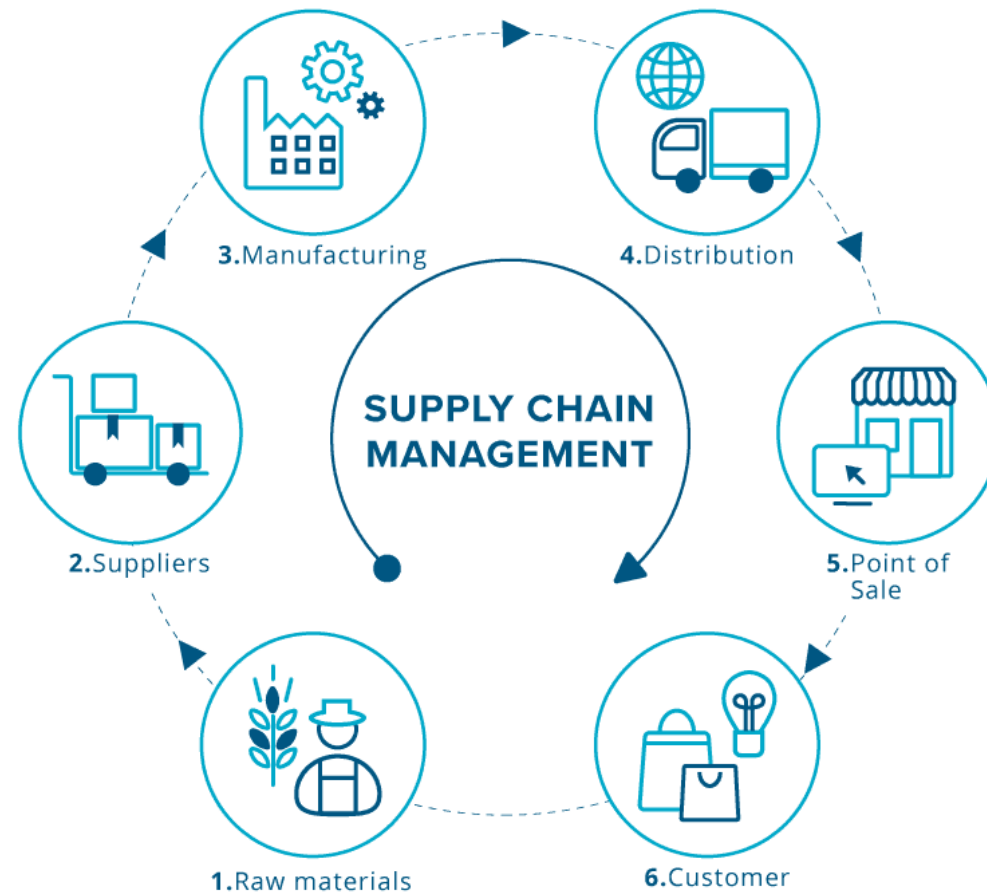
Rise in number
of parties
involved.



Importance of
collaboration

Why do we need configurators?

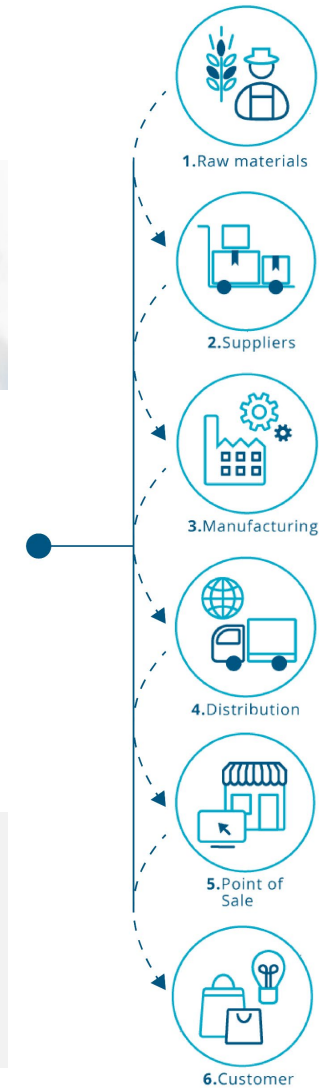
Potential to integrate design-to-production



What configurators currently exist?

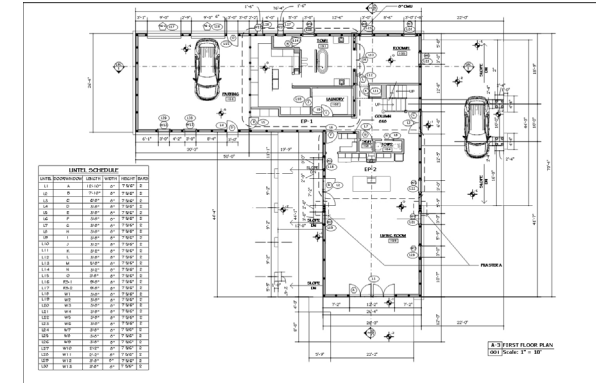
CODP scenarios

- Engineer to order, define design and manufacturing rules.
- Modify to order, edit design parameters.
- Configure to order, select scalable modules and module interfaces.
- Select variant, select off-the-shelf products.



What configurators currently exist?

Typologies of construction configurators



Planning

Design

Production

What configurators currently exist?

Integrated construction configurator

Includes planning, design, and production in the configurator.



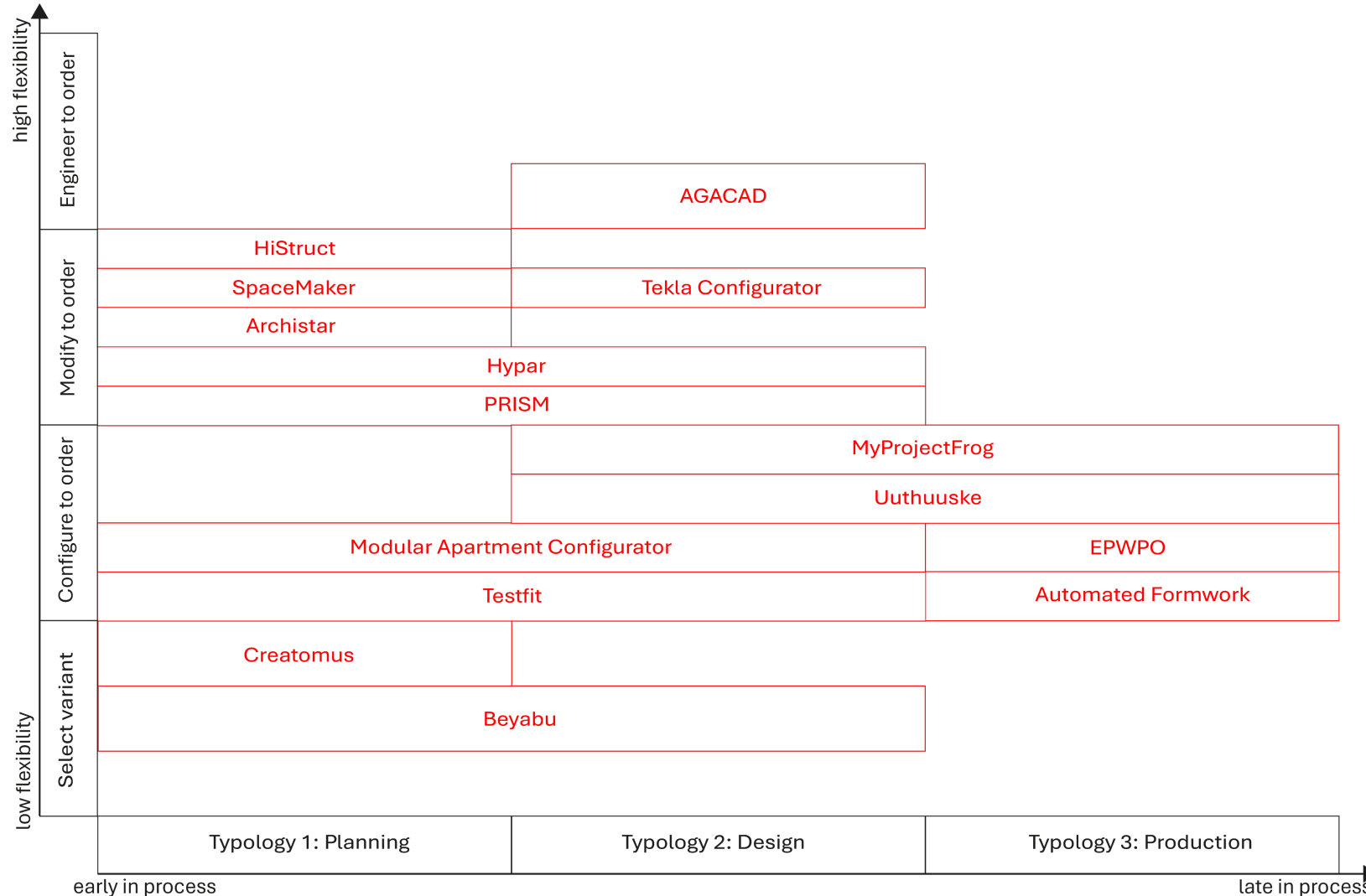
Planning

Design

Production

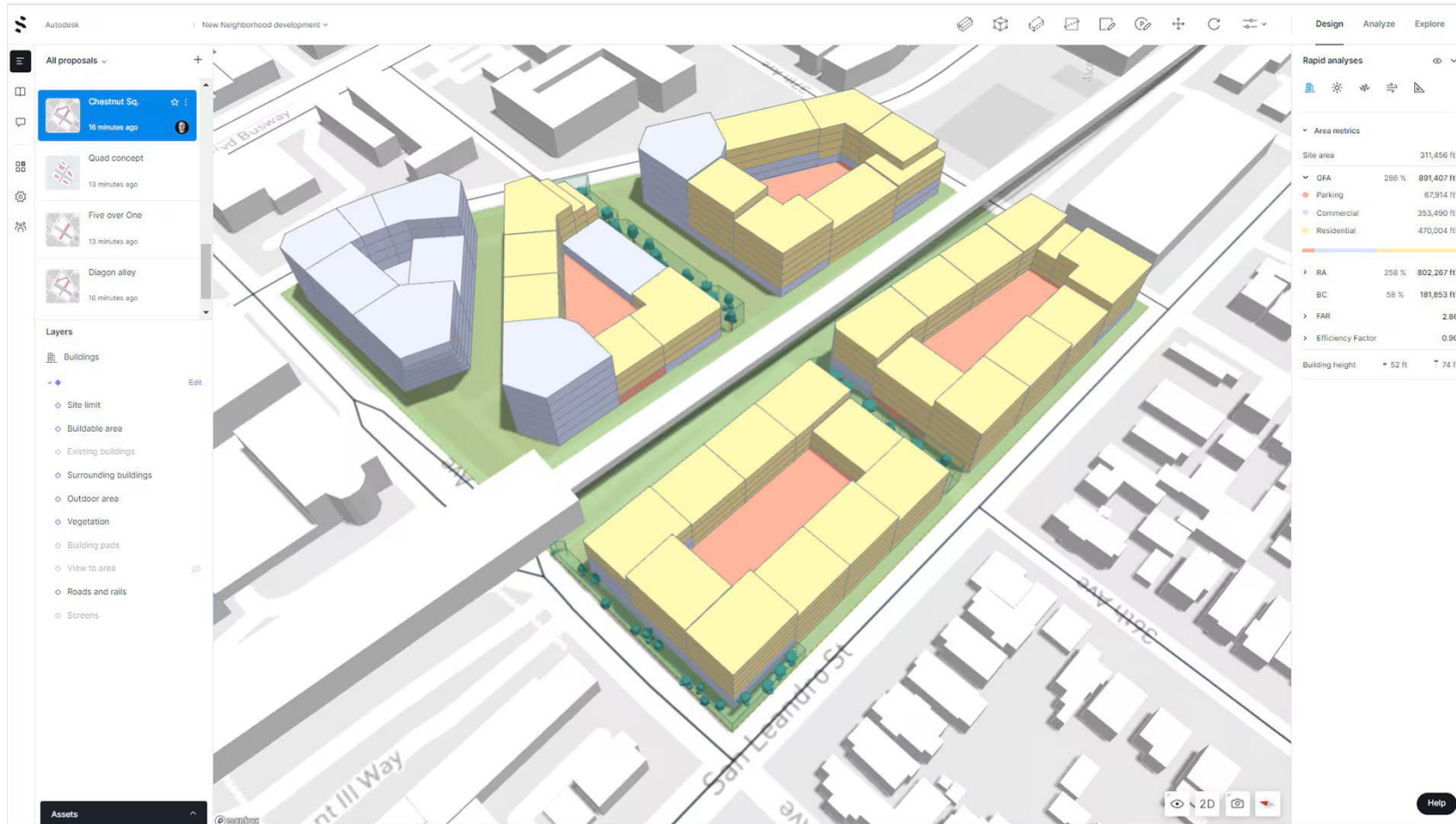
What configurators currently exist?

Overview of existing configurators



What configurators currently exist?

Planning: Spacemaker



What configurators currently exist?

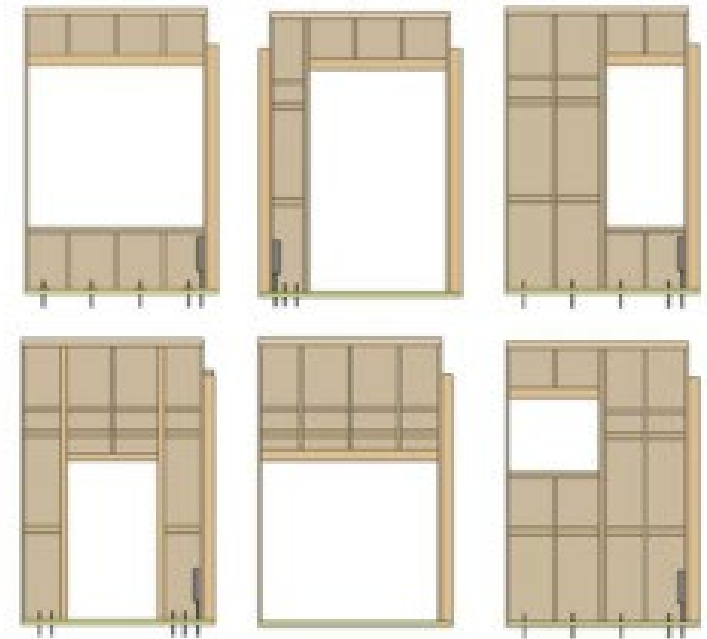
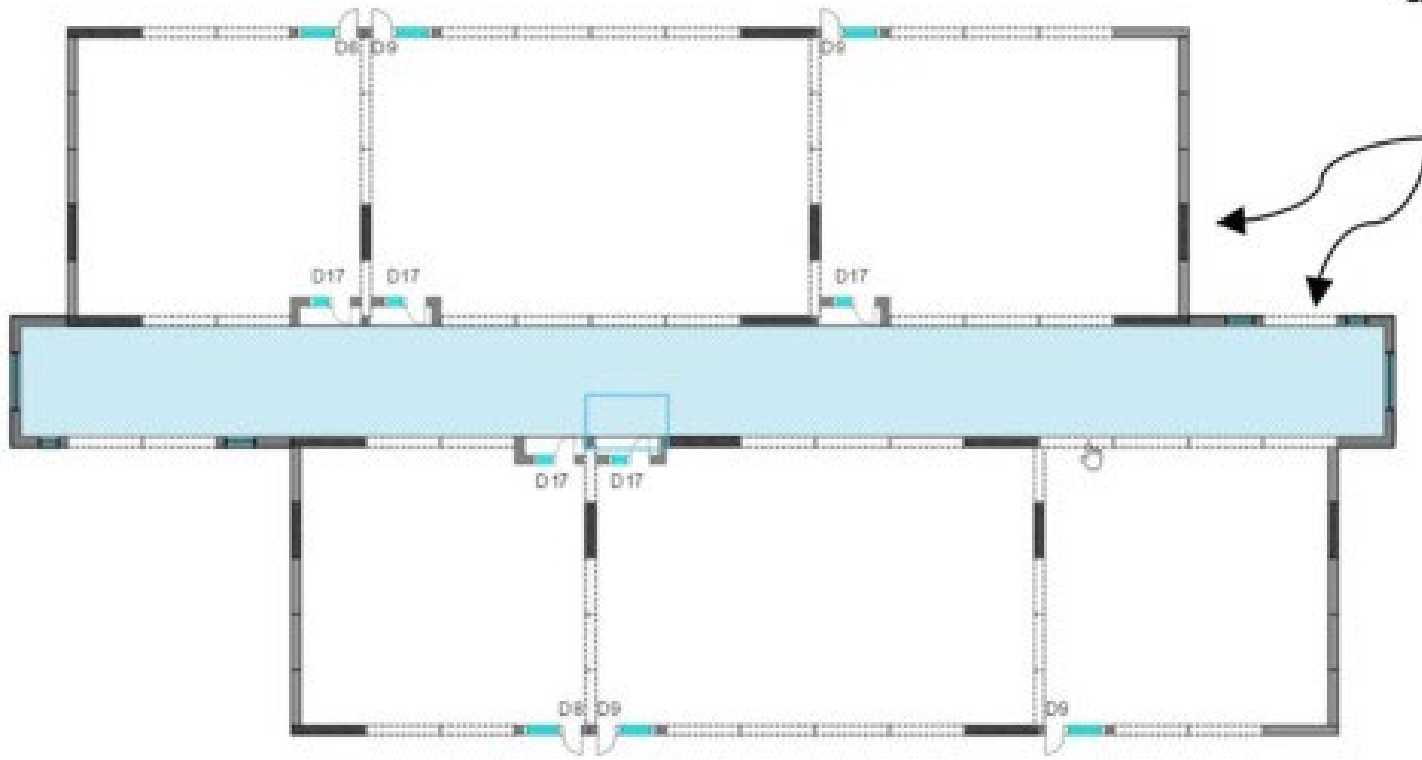
Design: Hypar



What configurators currently exist?

Production: ProjectFrog

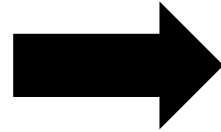
Select panel types from toolbox
and place them in panel slots



Problem statement:

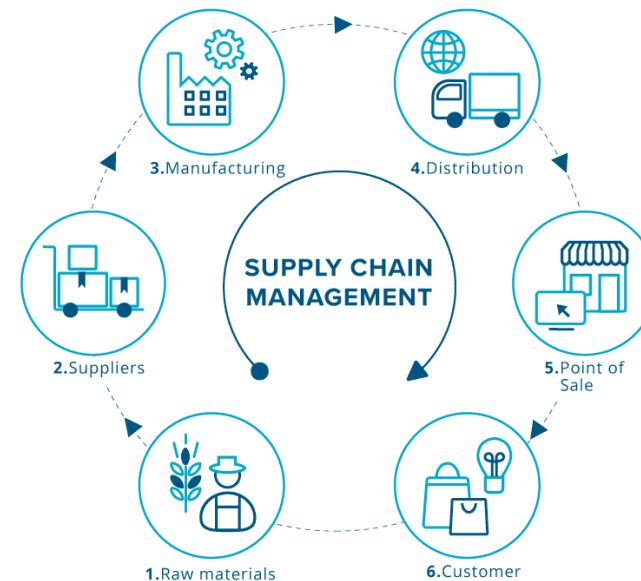
Why isn't the application of configurators in construction common practice?

Current configurators lack scalability



Integrated configurator

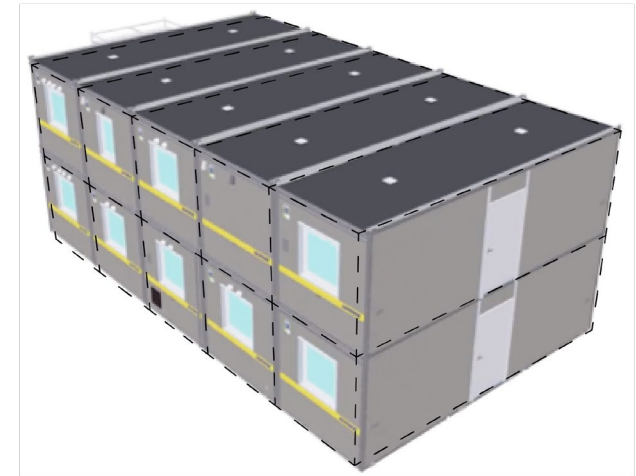
- Insufficient cross-organizational collaboration
- Insufficient integration with supply chains



Problem statement:

Why isn't the application of configurators in construction common practice?

Need research on increasing the design space



Research question:

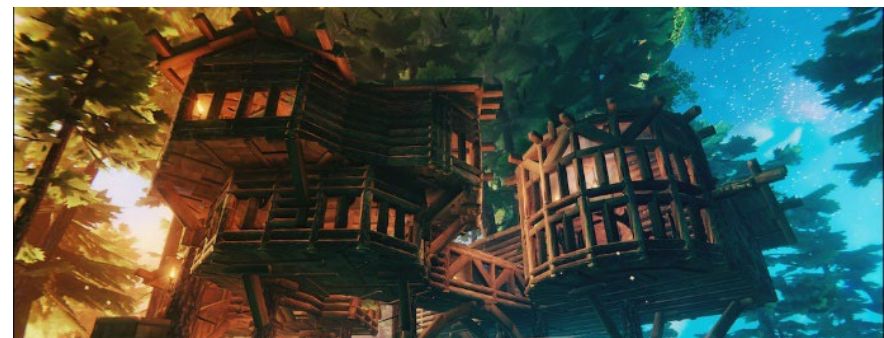
How can the design space of integrated
construction configurators be enlarged?

Current project's configurator

This project's developed configurator

Inspiration from game industry

Games with building systems

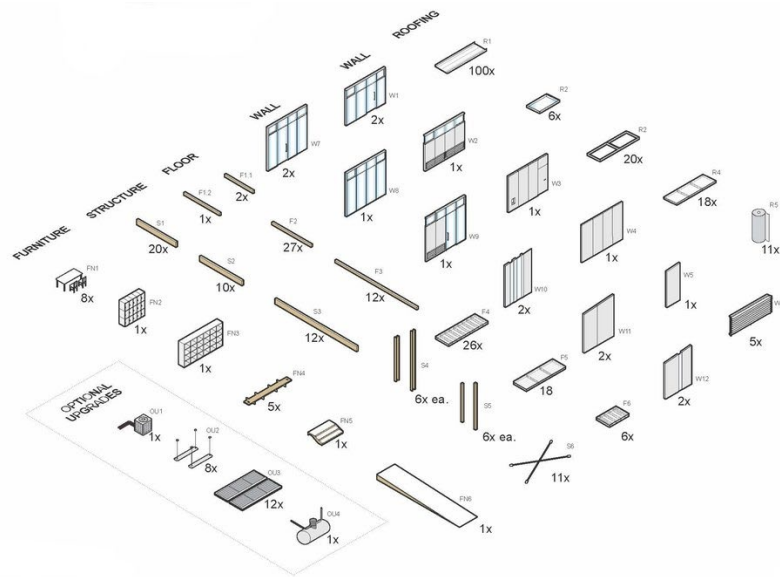


- Minecraft, Fortnite, The Sims 4, Valheim

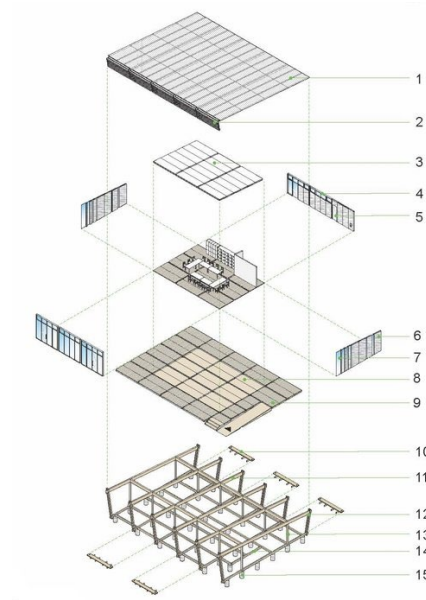
Inspiration from game industry

Fundamental features of configurators + grid

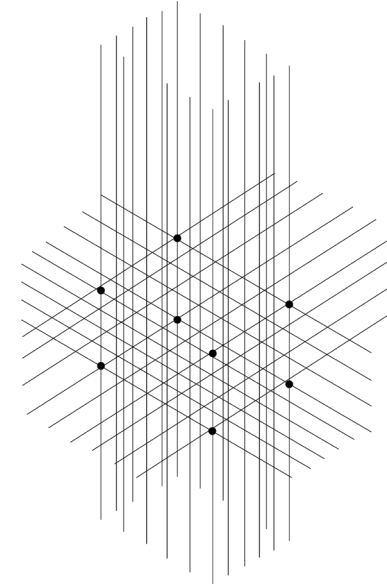
Kit-of-parts



Configuration rules



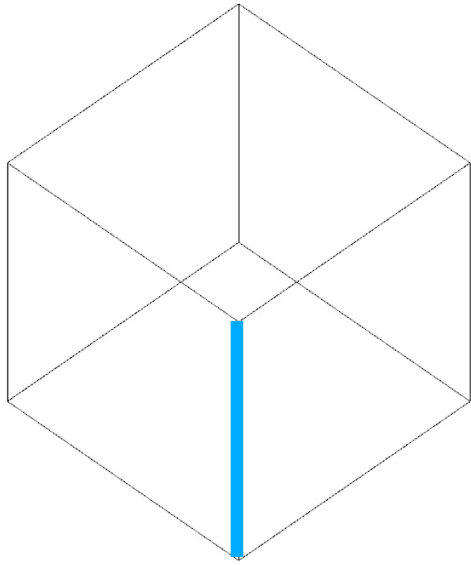
Grid



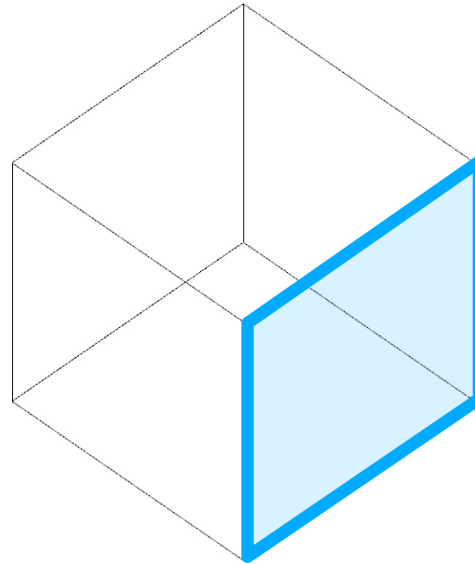
Inspiration from game industry

Types of building components

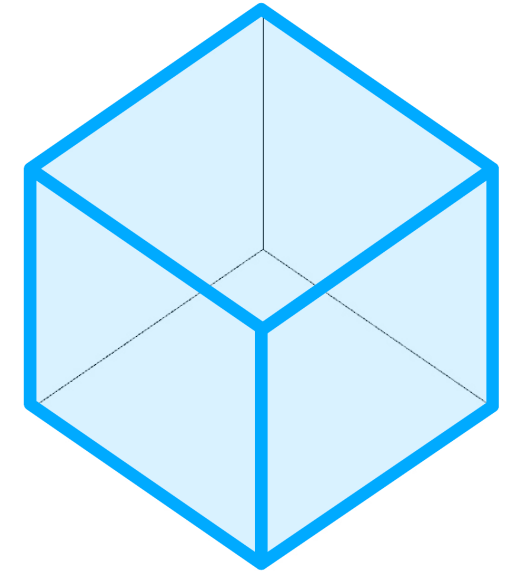
Linear
components



Planar
components



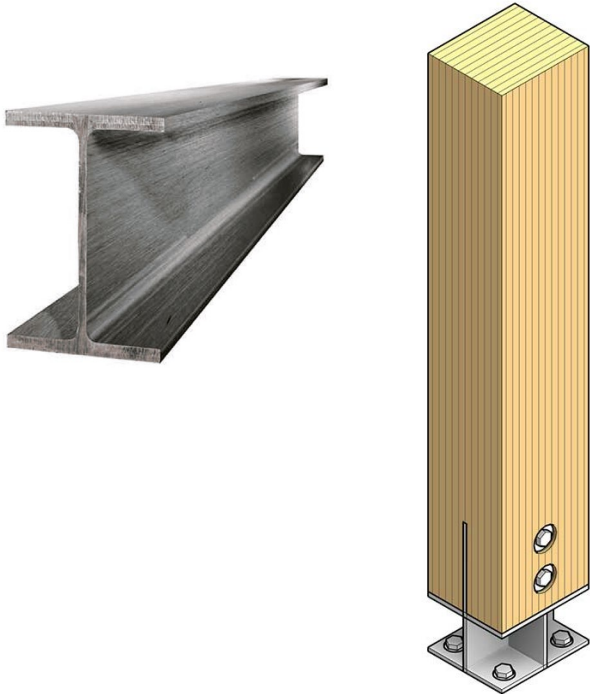
Volumetric
components



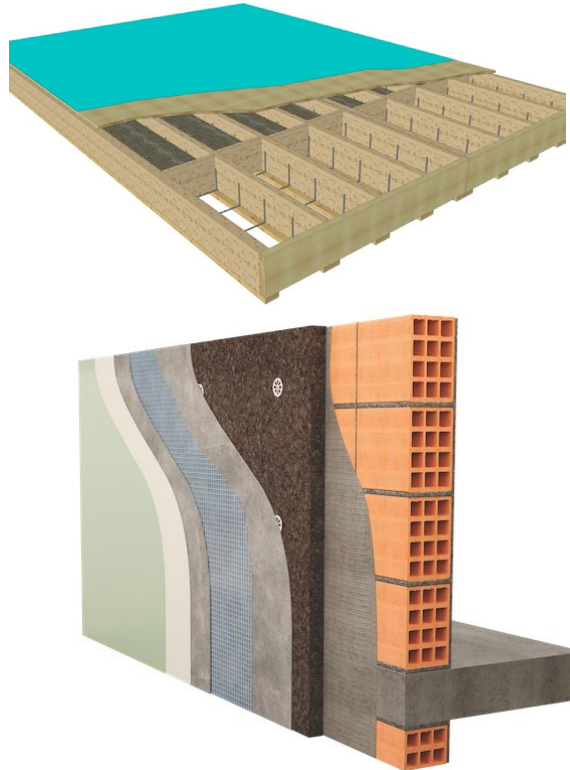
Inspiration from game industry

Database of building components

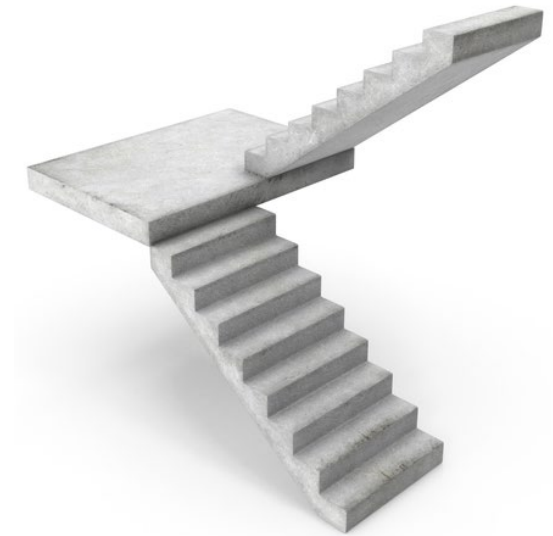
Linear
components



Planar
components



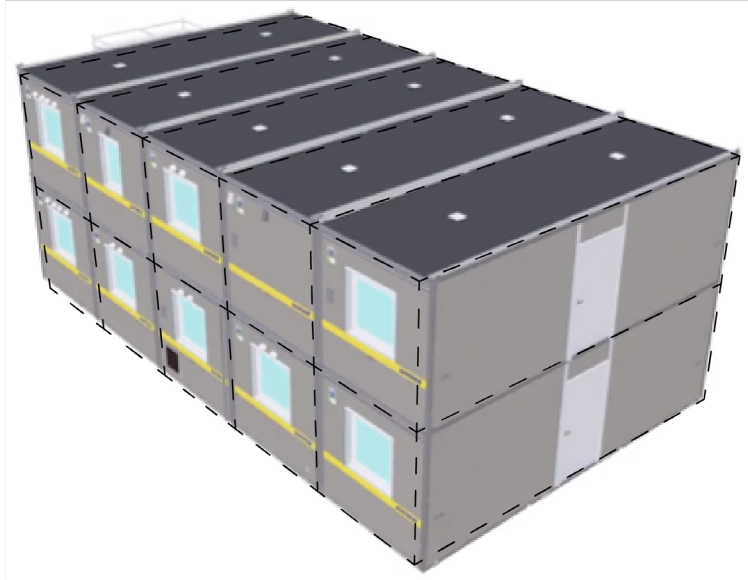
Volumetric
components



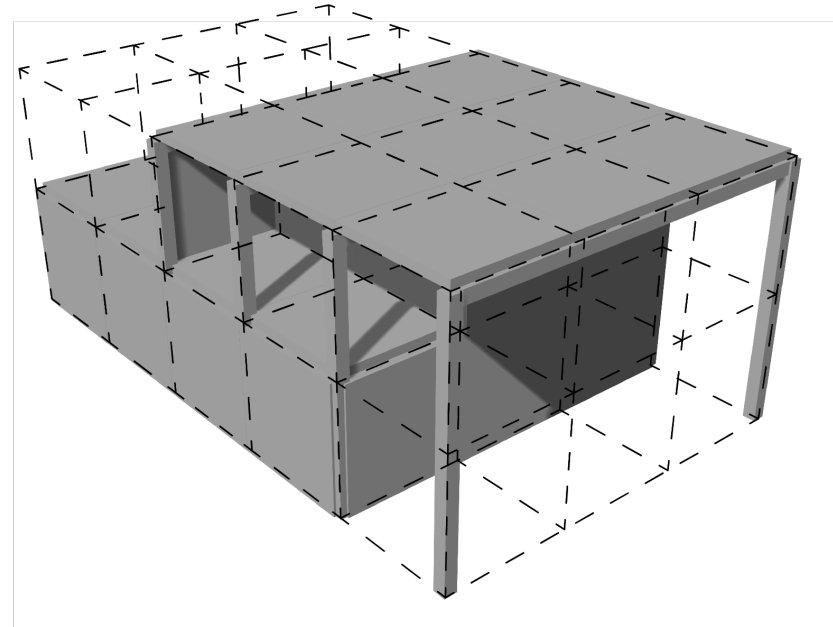
Inspiration from game industry

Modularity on building component level

Room-sized modules

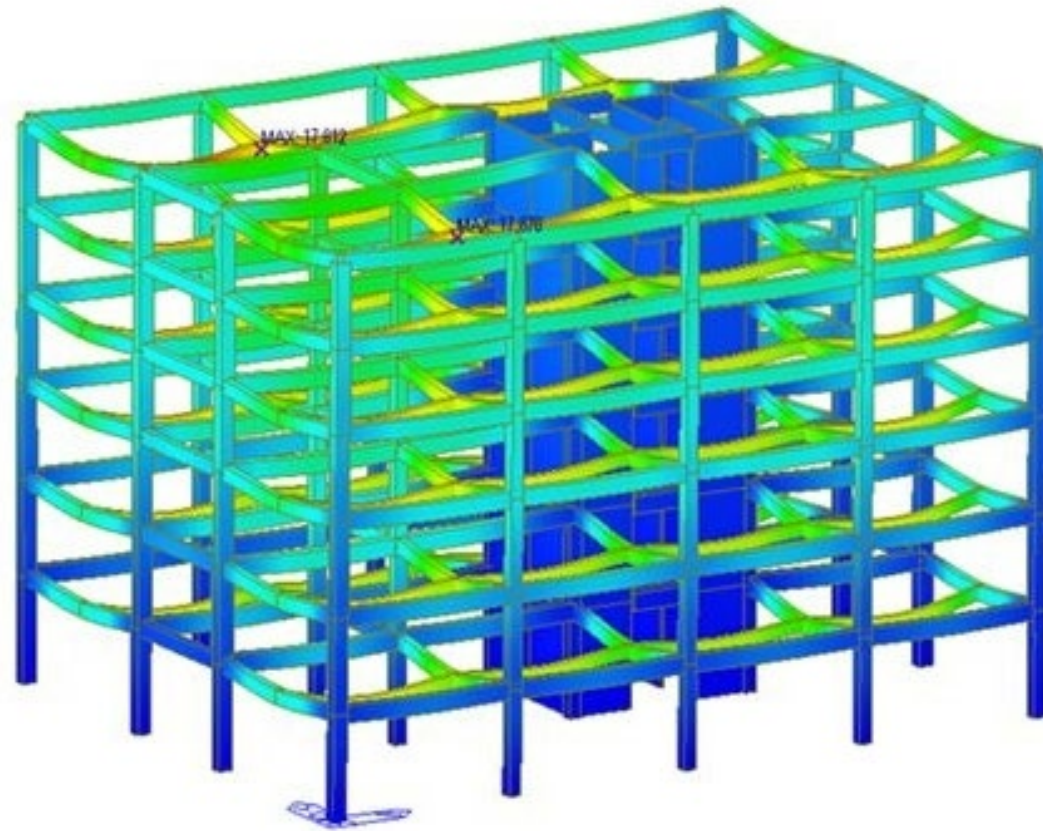


Building component-sized modules



Inspiration from game industry

Structural analysis ensures assembly of components is possible



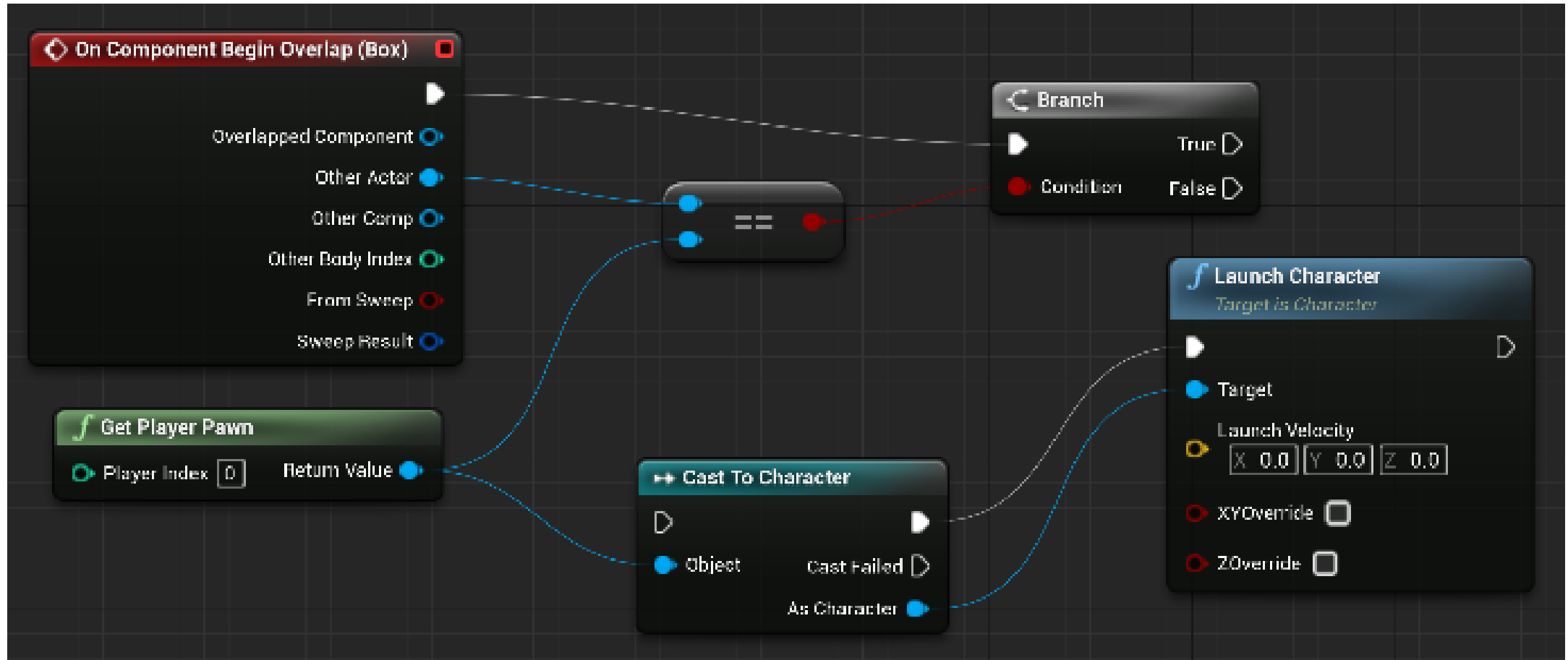
Development in Unreal Engine

Unreal Engine 5.3



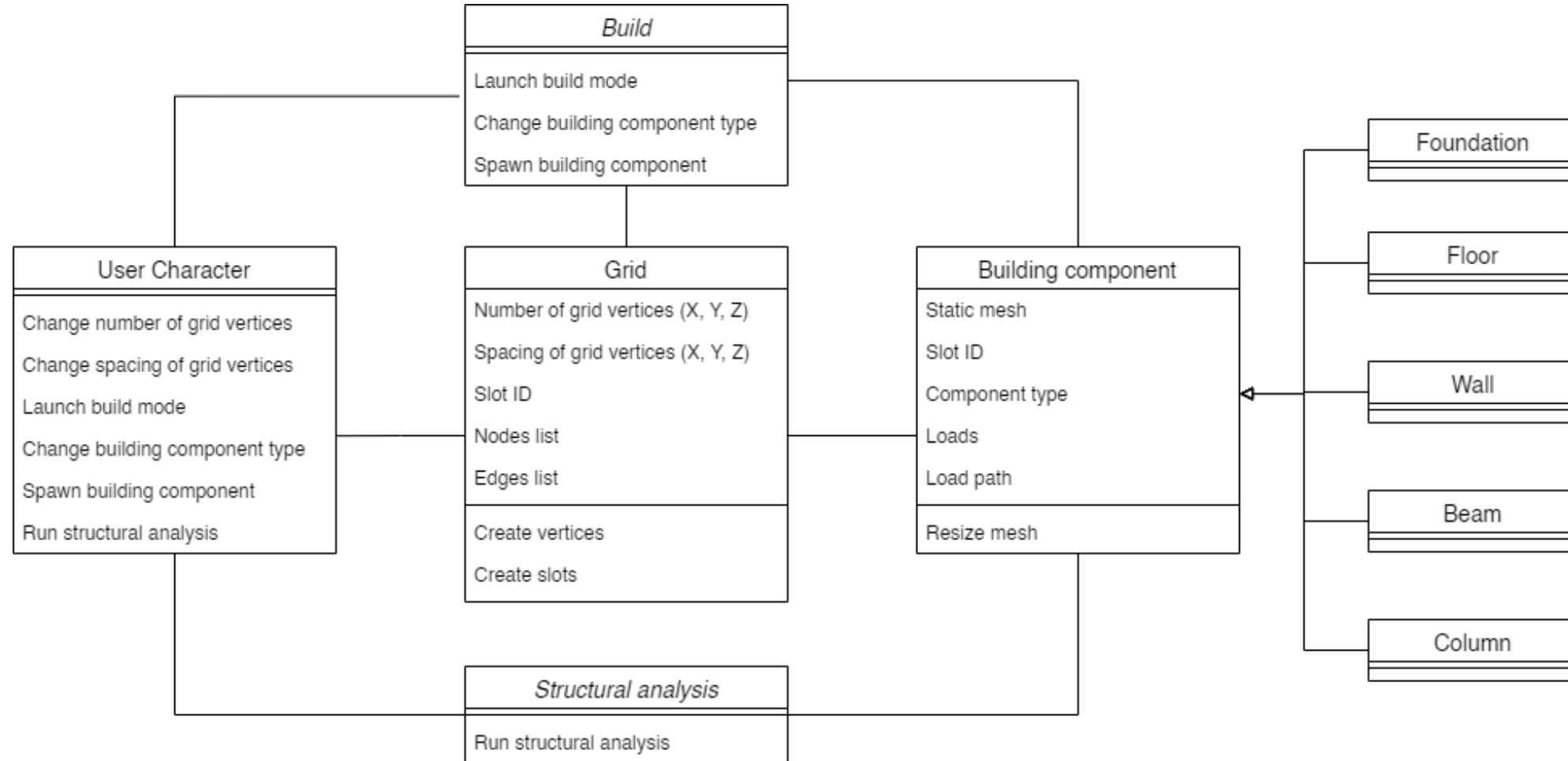
Development in Unreal Engine

Blueprints



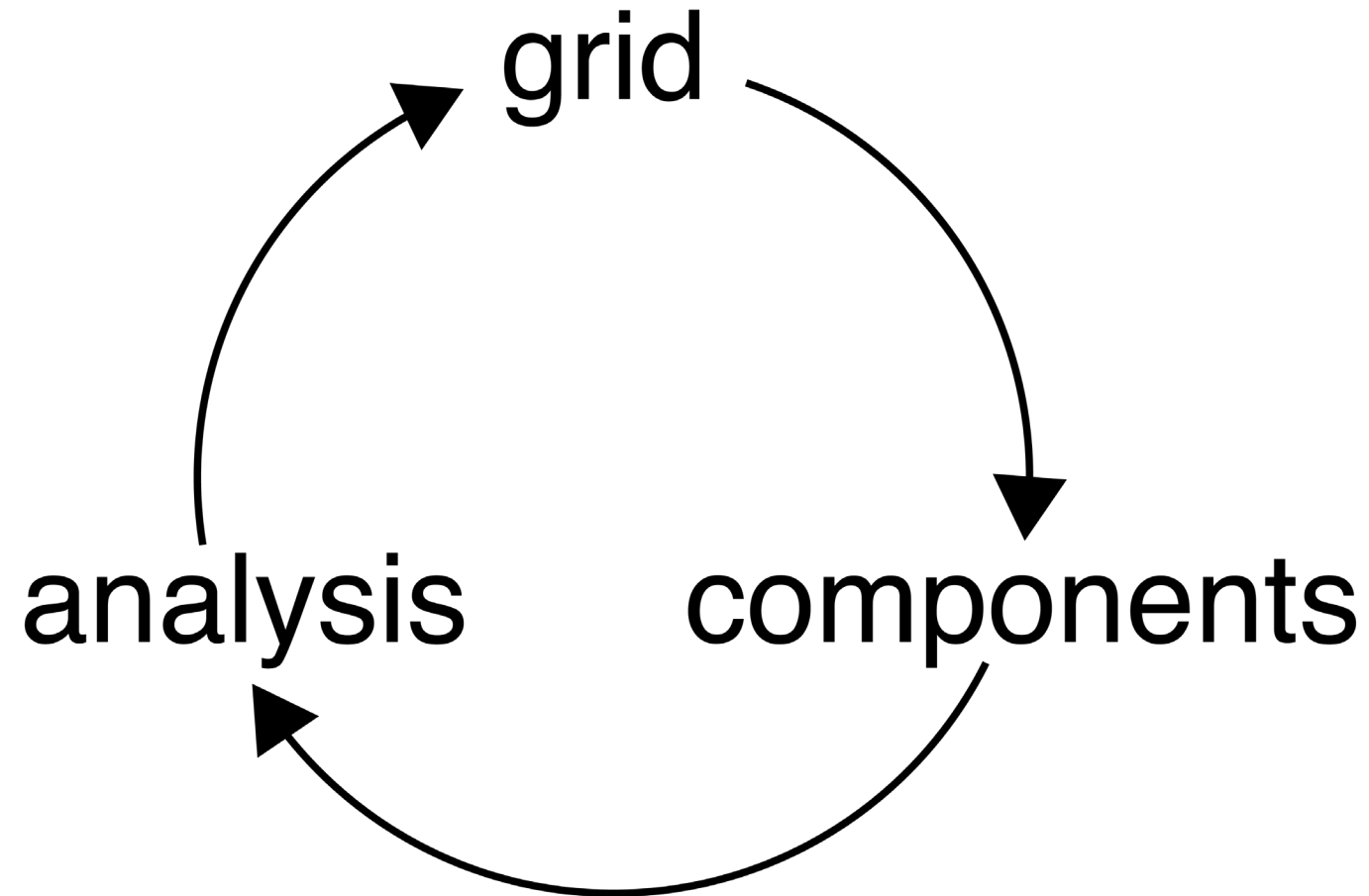
Development in Unreal Engine

Blueprint interaction



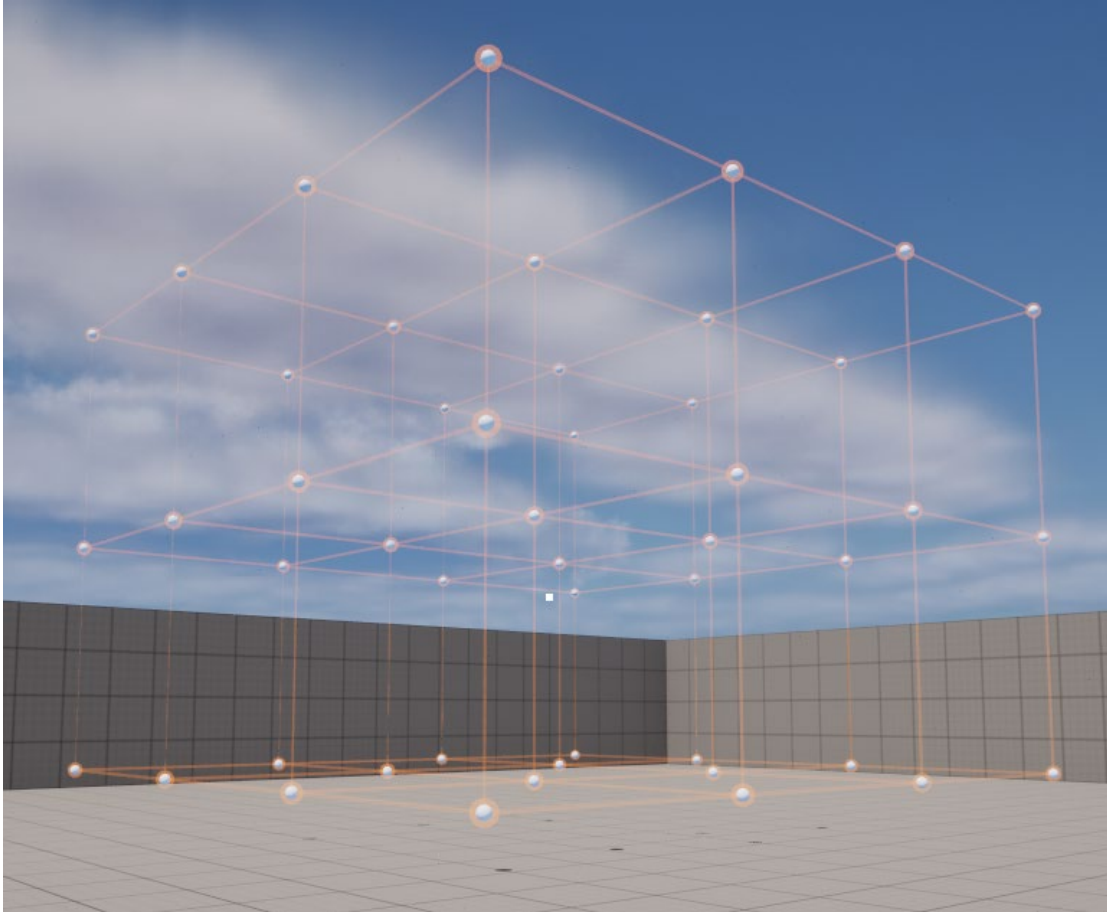
Configuration process & software development

Iterative configuration process



Configuration process & software development

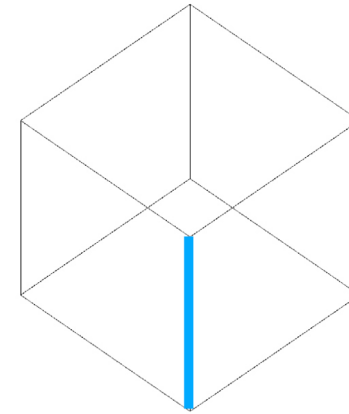
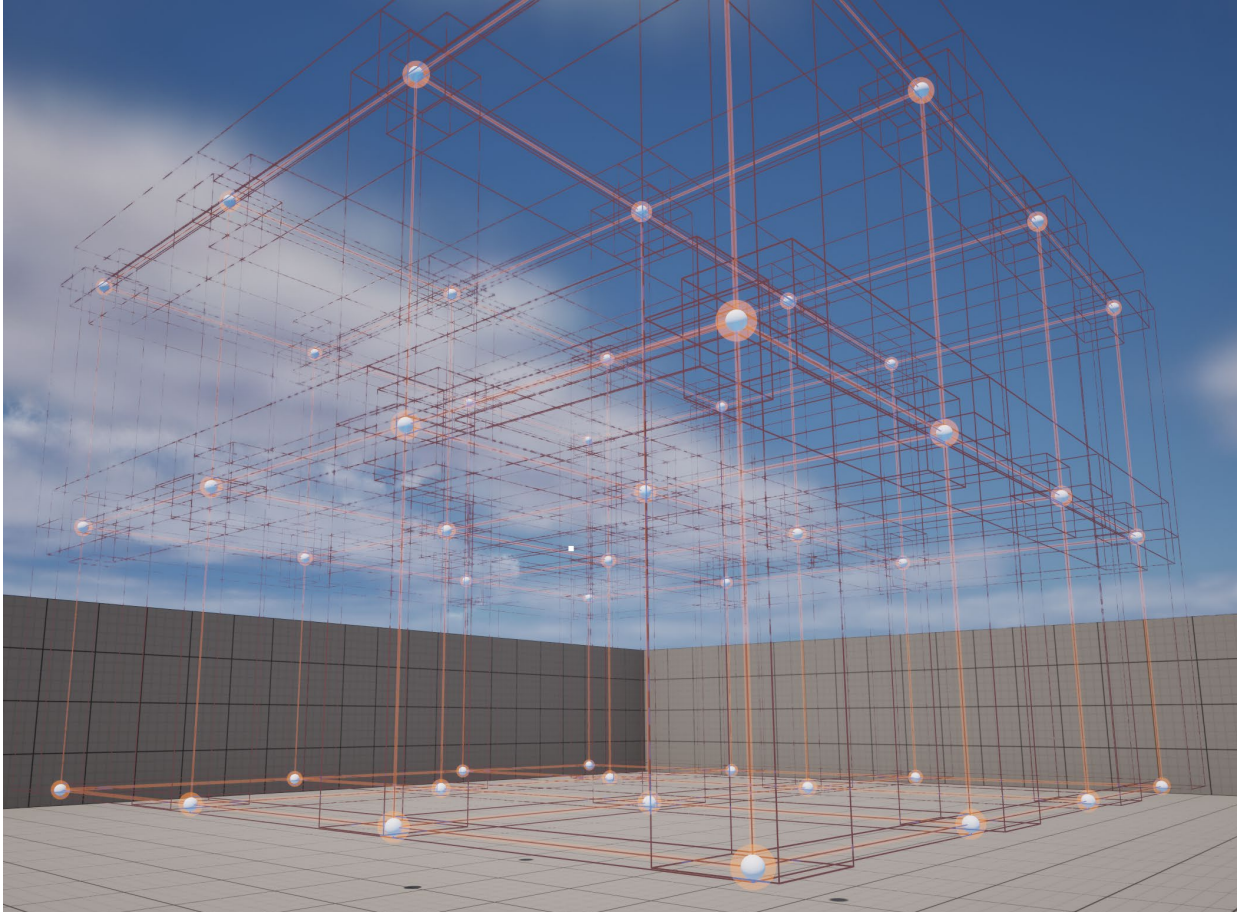
3D grid of vertices



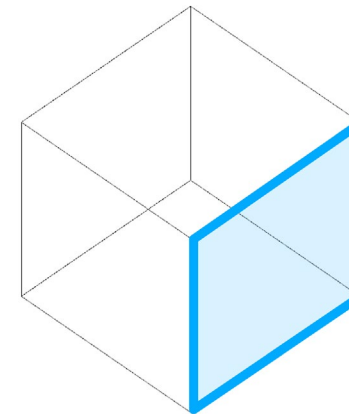
▼ Grid Dimensions		
Num X	<input type="text" value="4"/>	↩
Num Y	<input type="text" value="4"/>	↩
Num Z	<input type="text" value="3"/>	
Dist X	<input type="text" value="400,0"/>	
Dist Y	<input type="text" value="400,0"/>	
Dist Z	<input type="text" value="400,0"/>	

Configuration process & software development

Grid slots



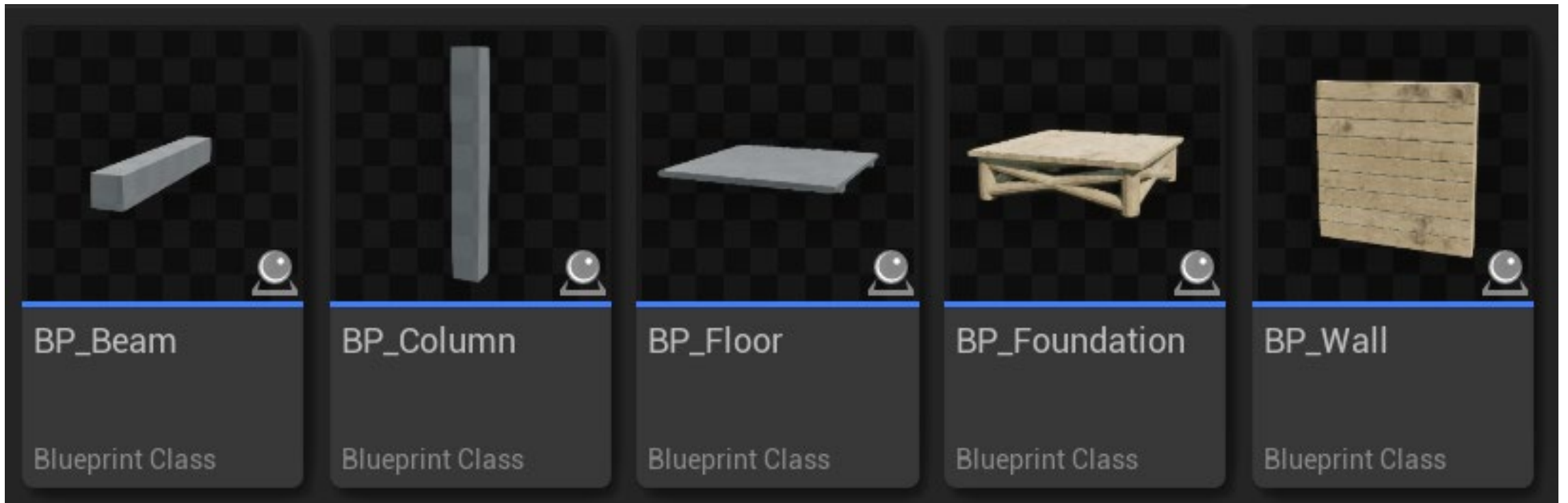
Edges



Faces

Configuration process & software development

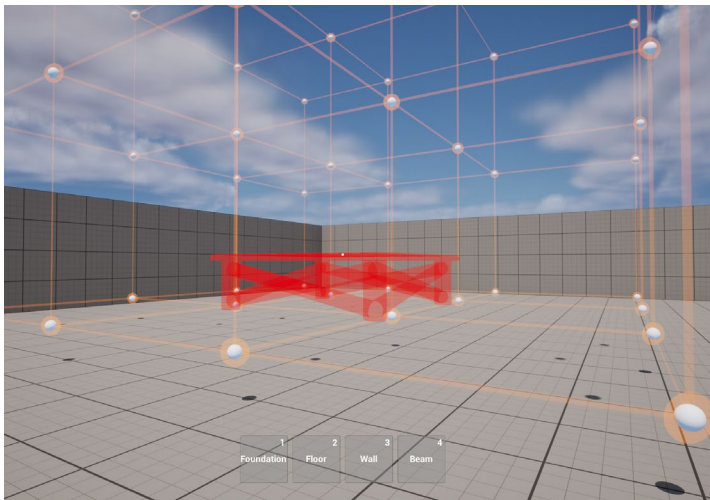
Types of components



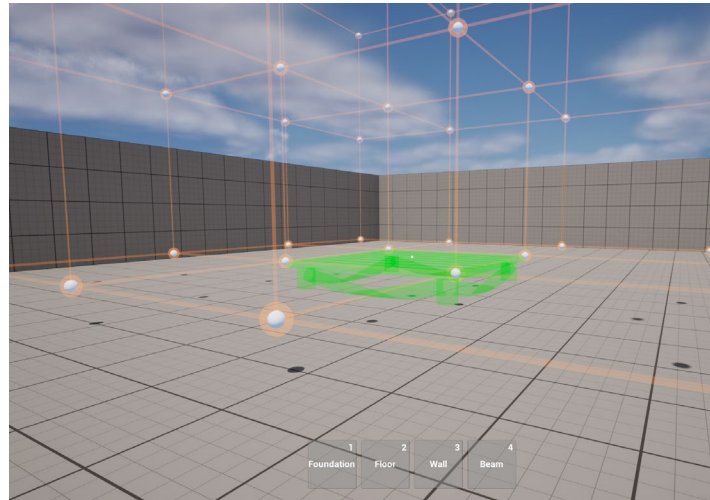
Configuration process & software development

Snapping components to slots in grid

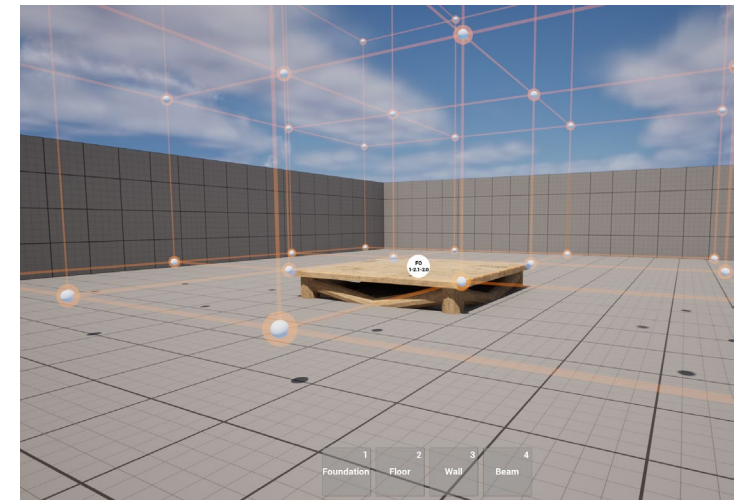
No snap



Snap



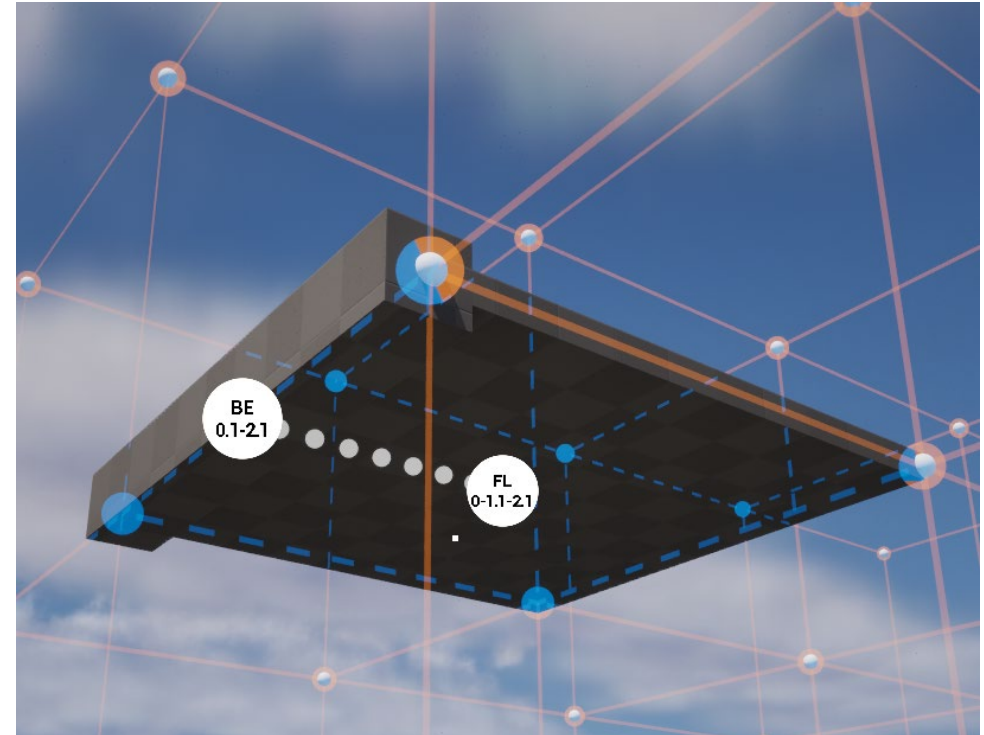
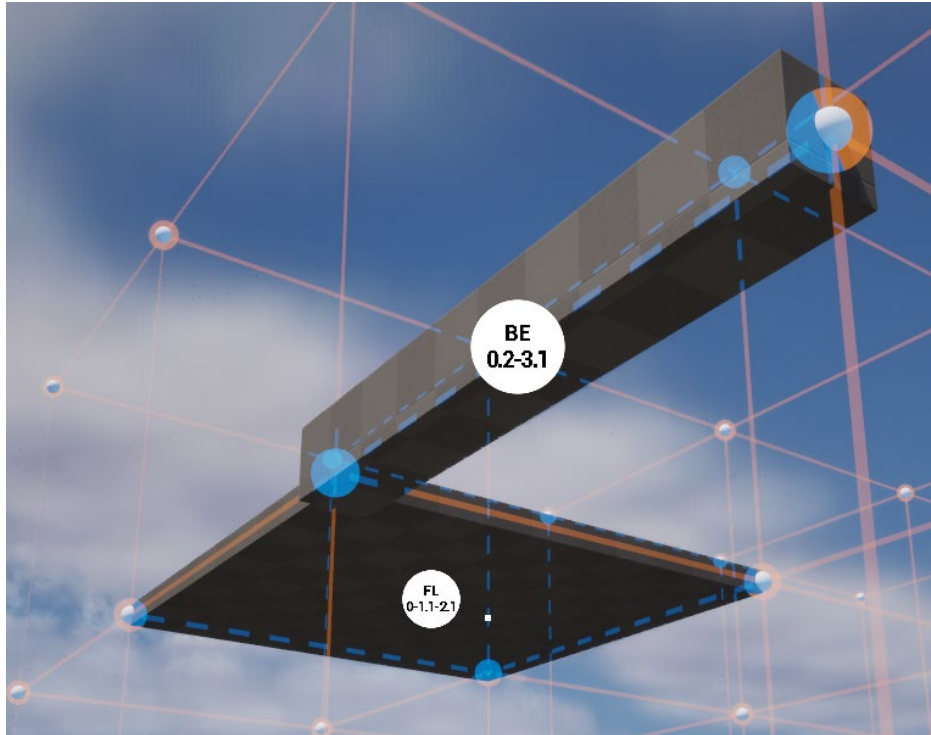
Placement done



Configuration process & software development

Connection conditions

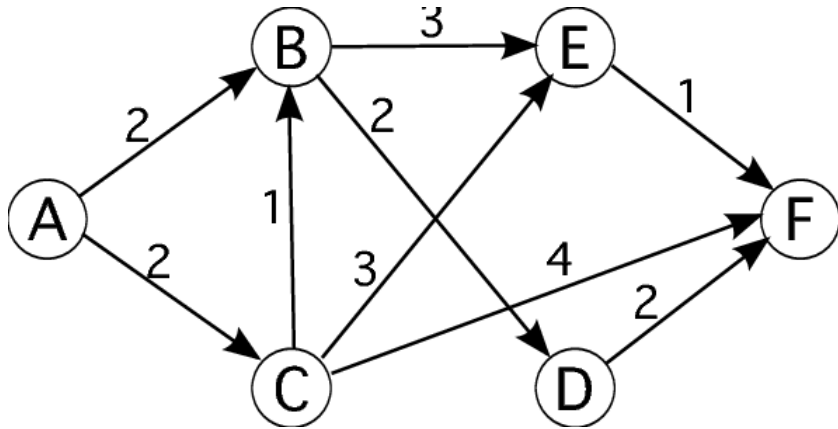
- Neighbours
- Structurally connected



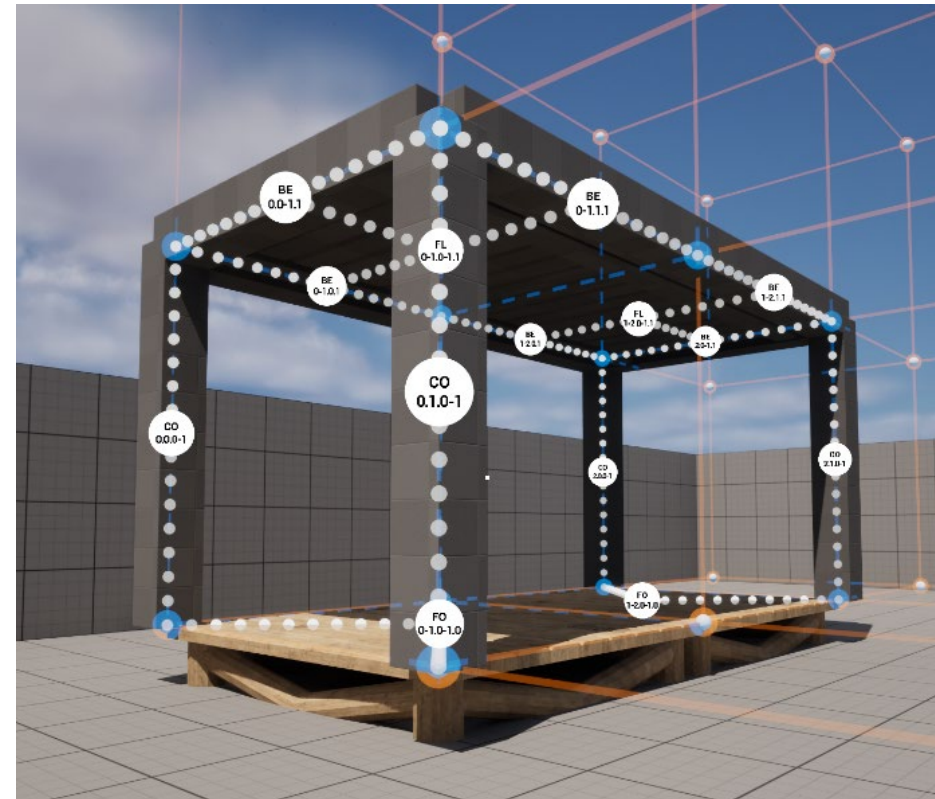
Configuration process & software development

Network graph

A simple flow network



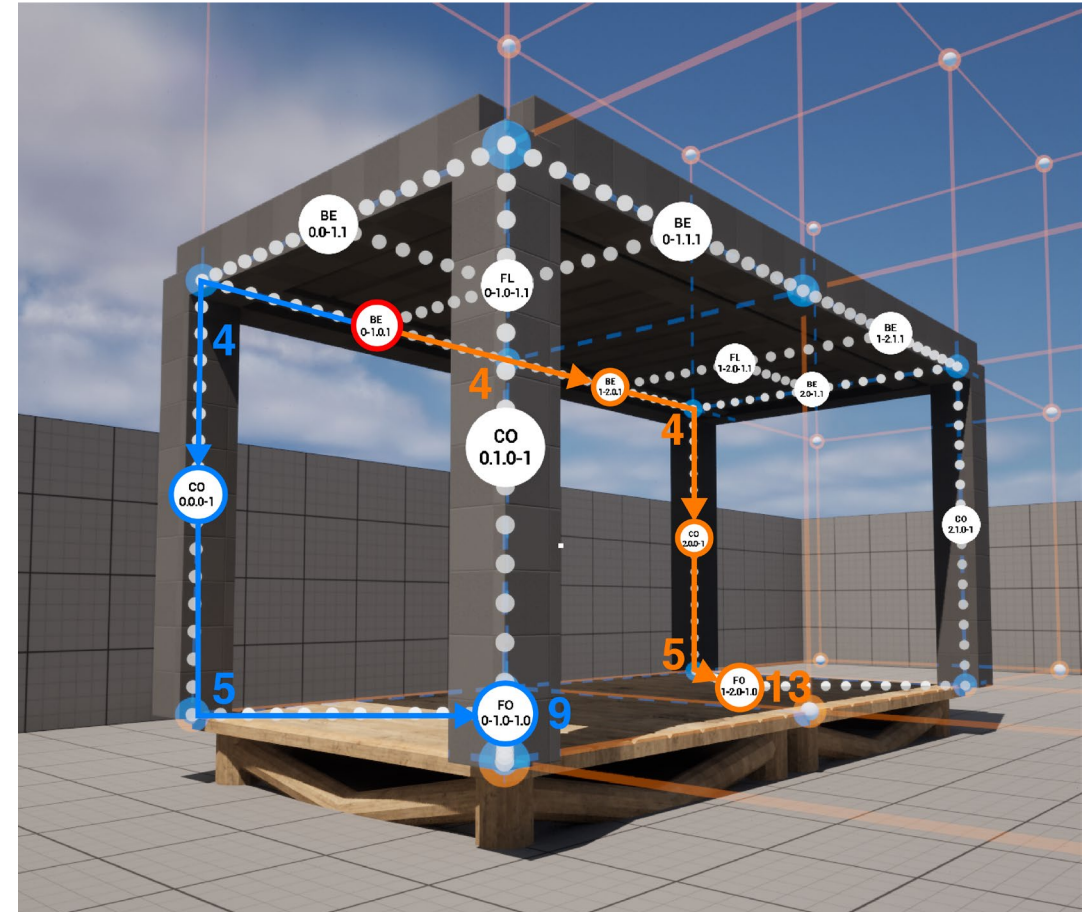
Network of connected components



Configuration process & software development

Dijkstra shortest path algorithm

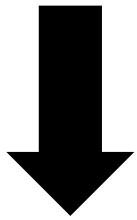
Compare shortest paths to foundations



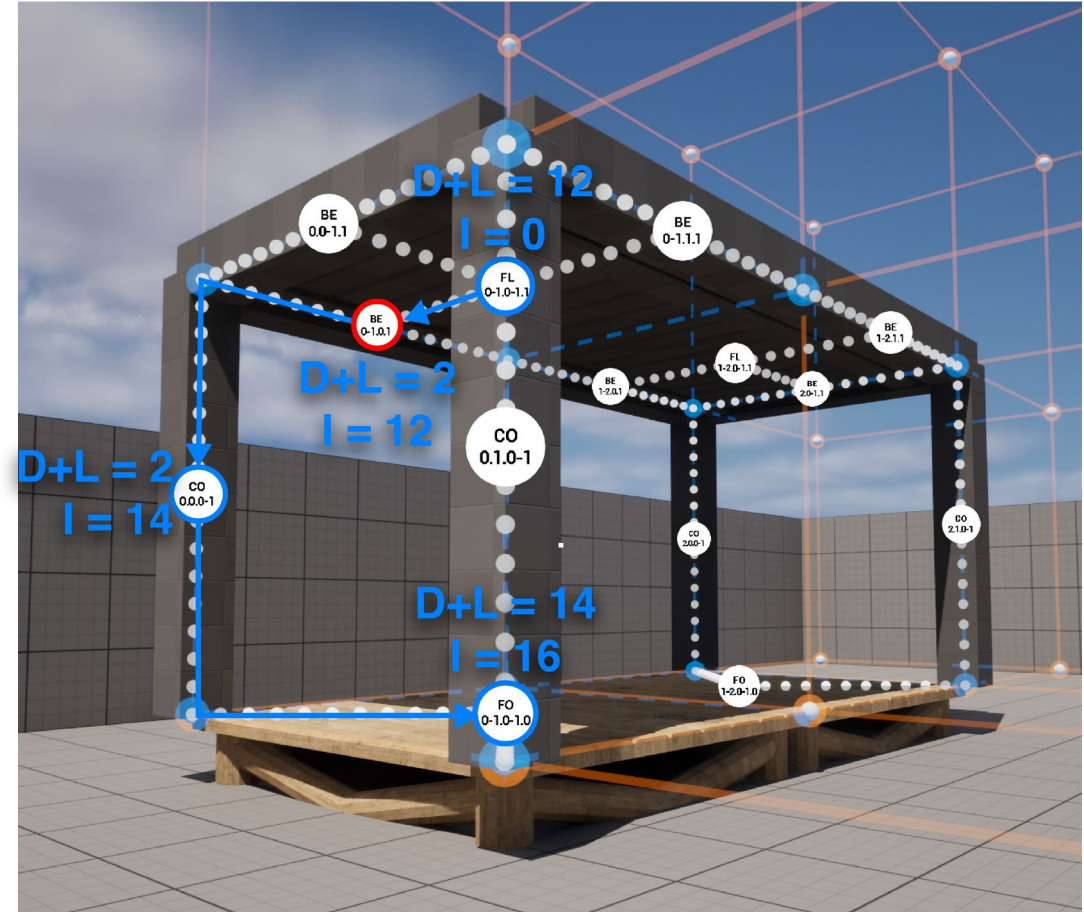
Configuration process & software development

Passing the load

Previous component:
Dead load + live load



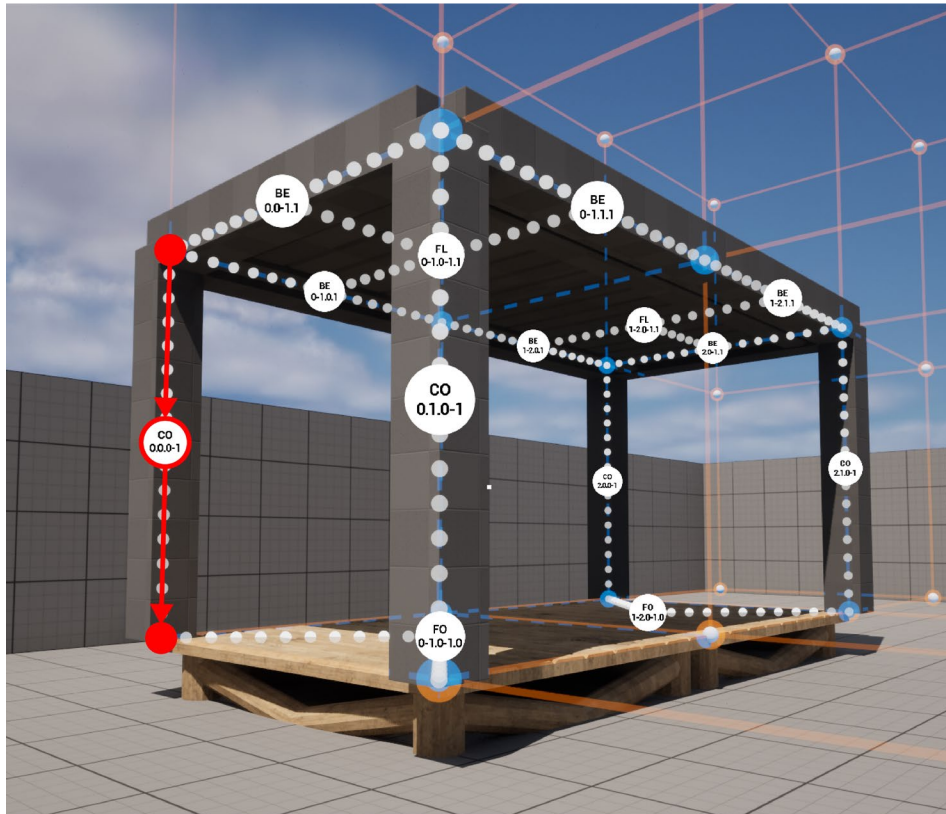
Next component:
Imposed load



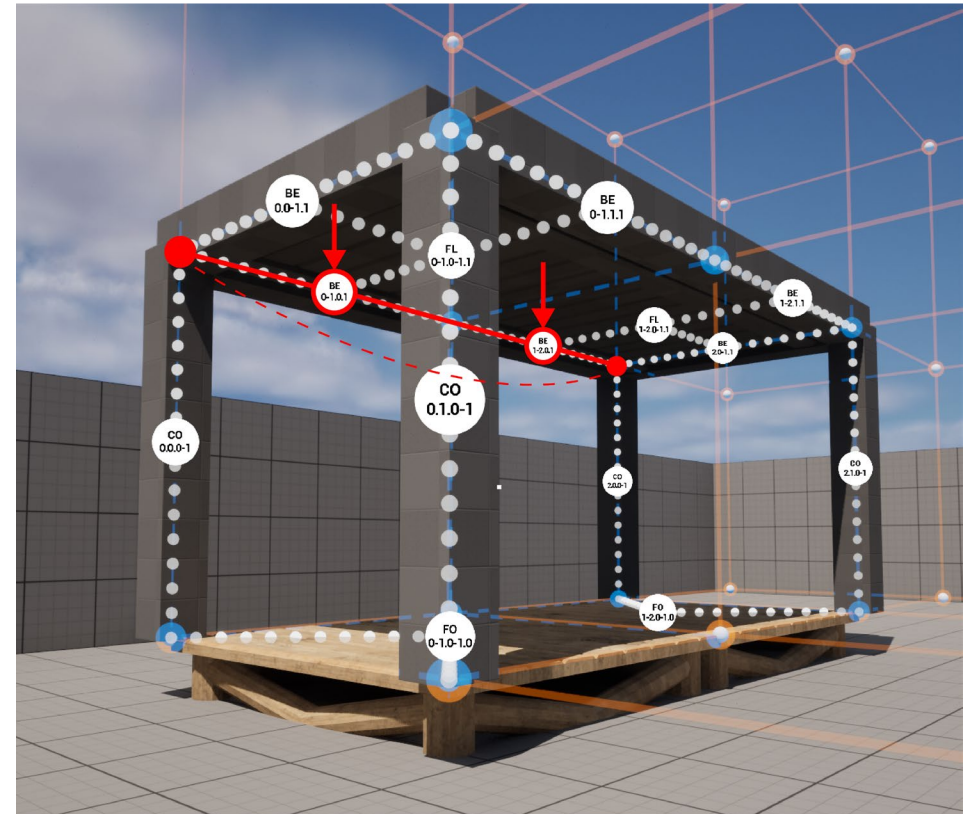
Configuration process & software development

Calculating the stress

Axial compression: F/A



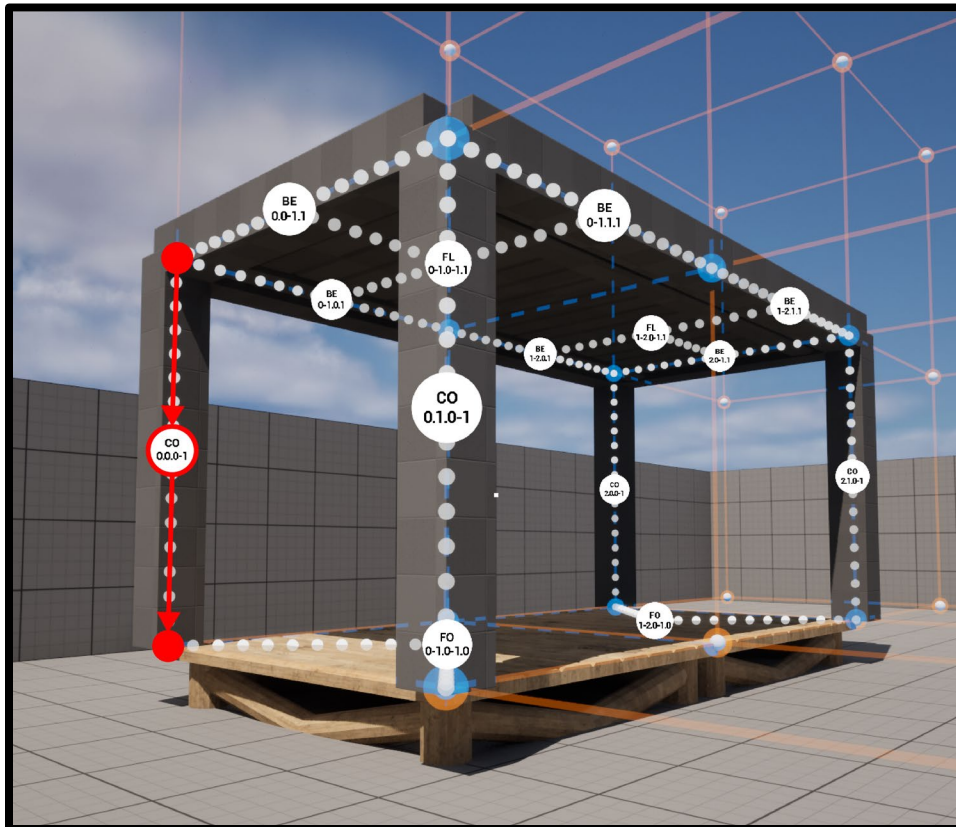
Bending: $1/8ql^2$



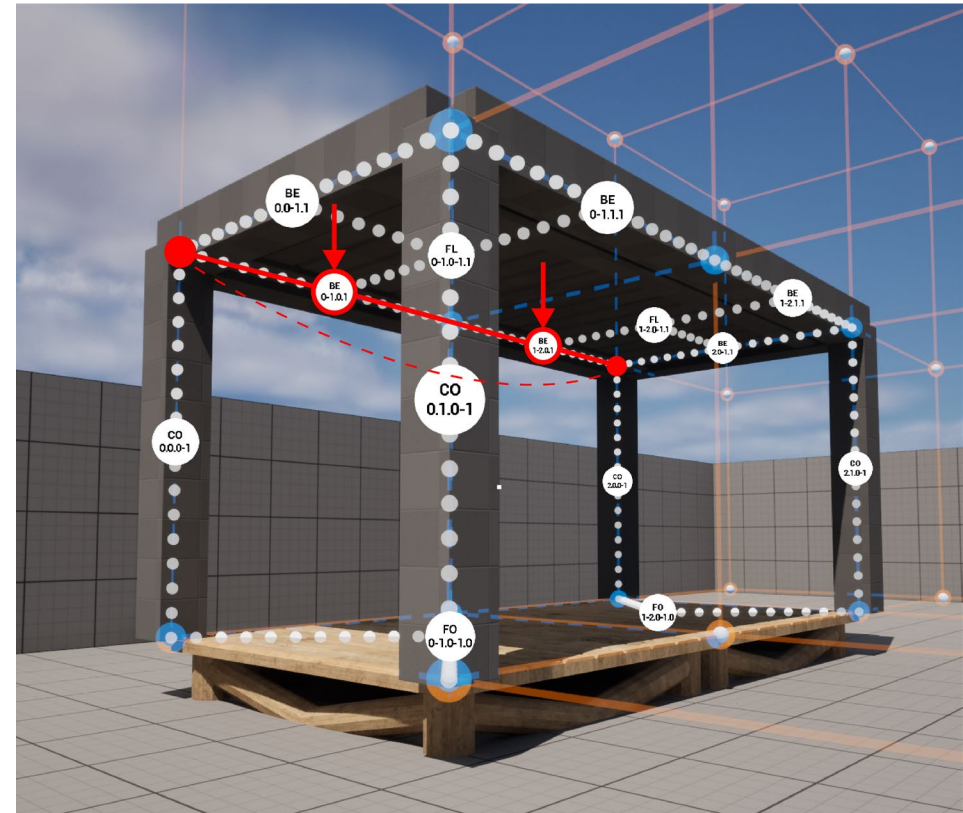
Configuration process & software development

Calculating the stress

Axial compression: F/A



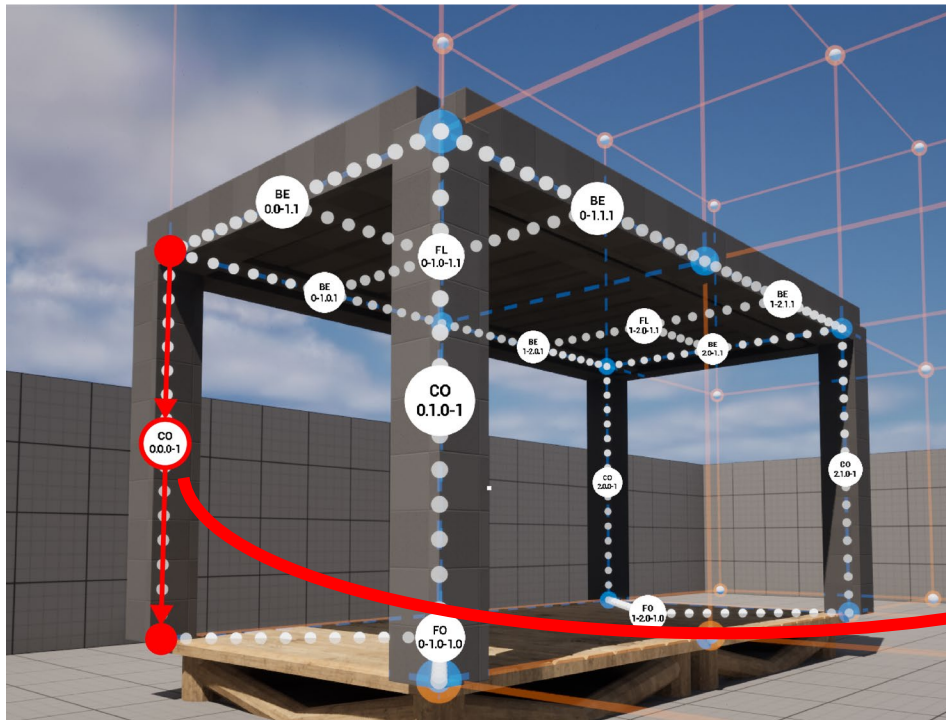
Bending: $1/8ql^2$



Configuration process & software development

Compression stress & resizing

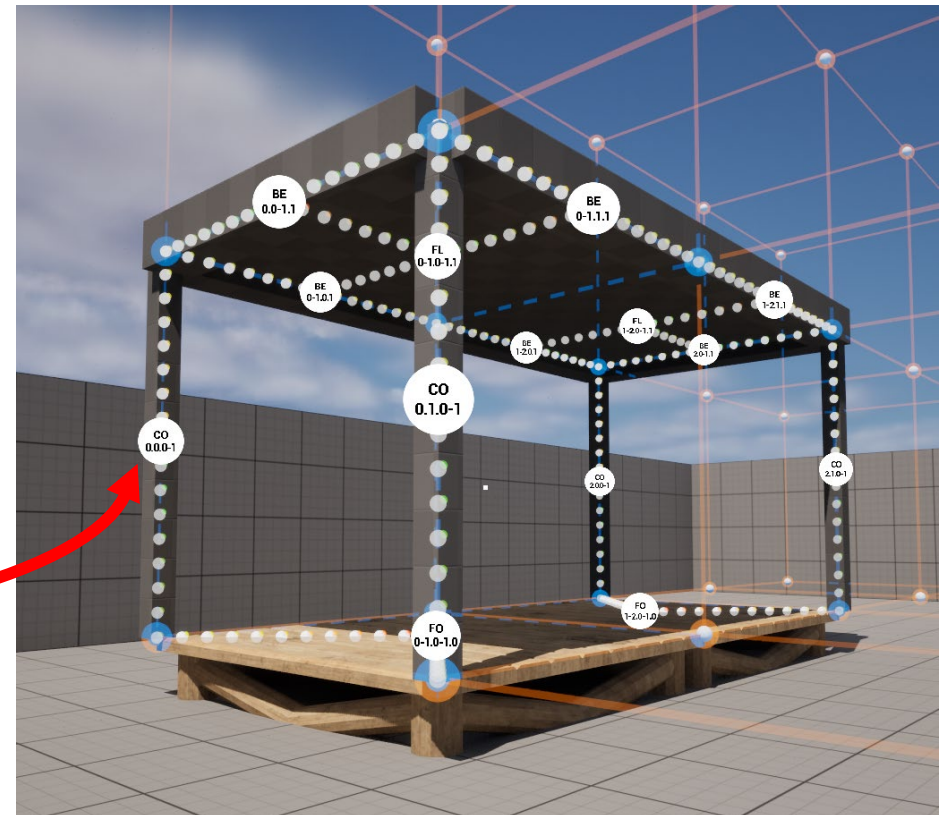
Axial compression:



Compressive load

Column properties

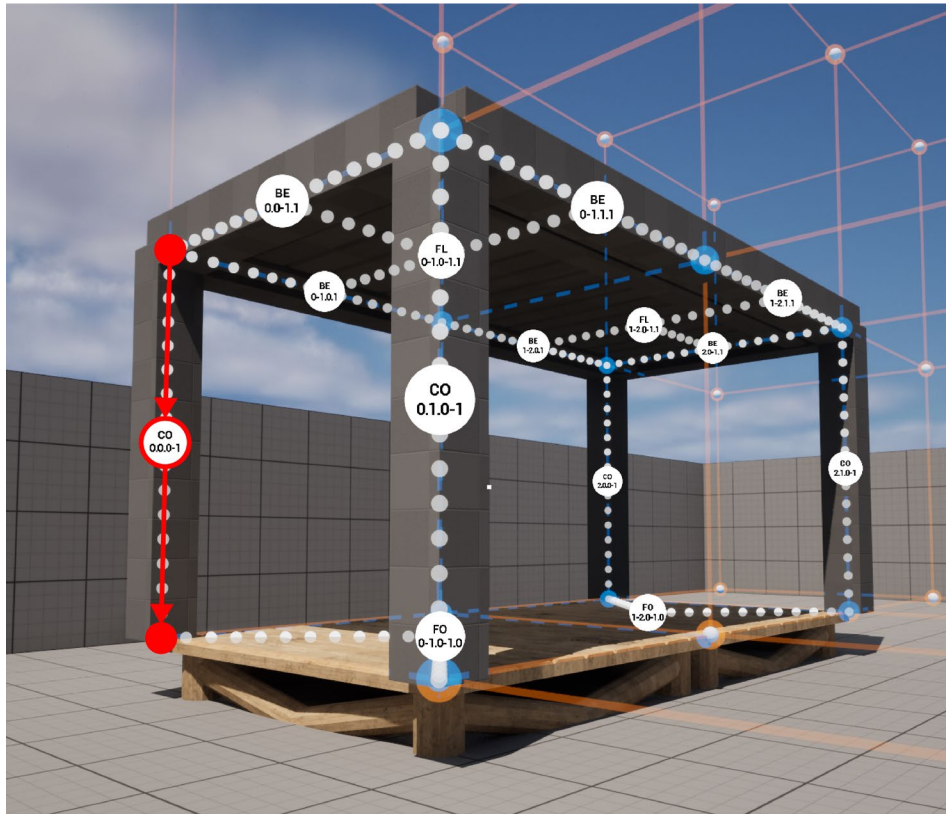
Resize columns



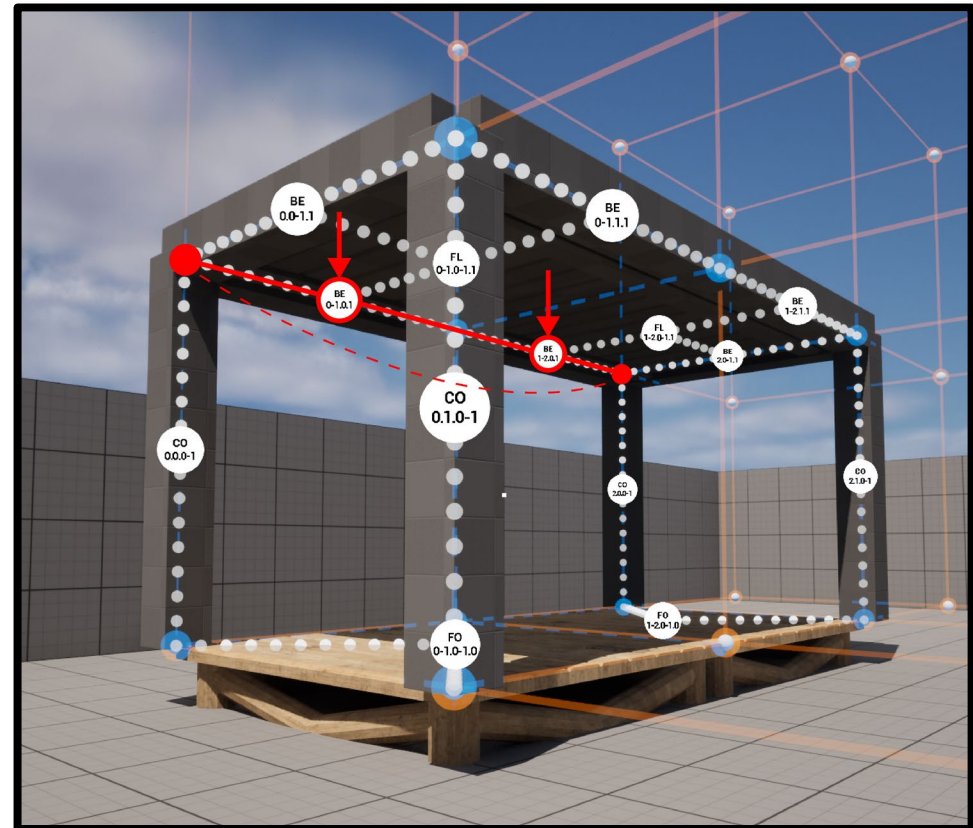
Configuration process & software development

Calculating the stress

Axial compression: F/A

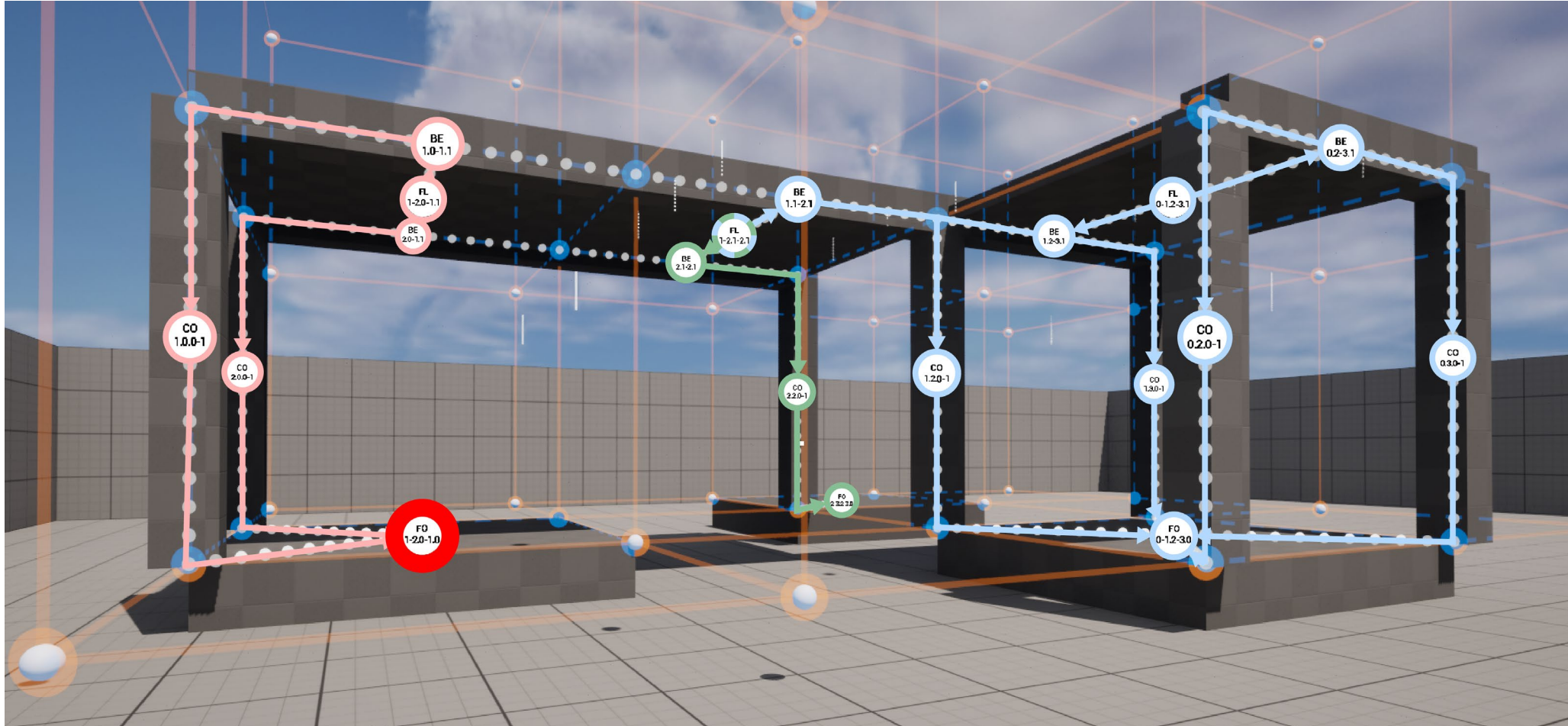


Bending: $1/8ql^2$



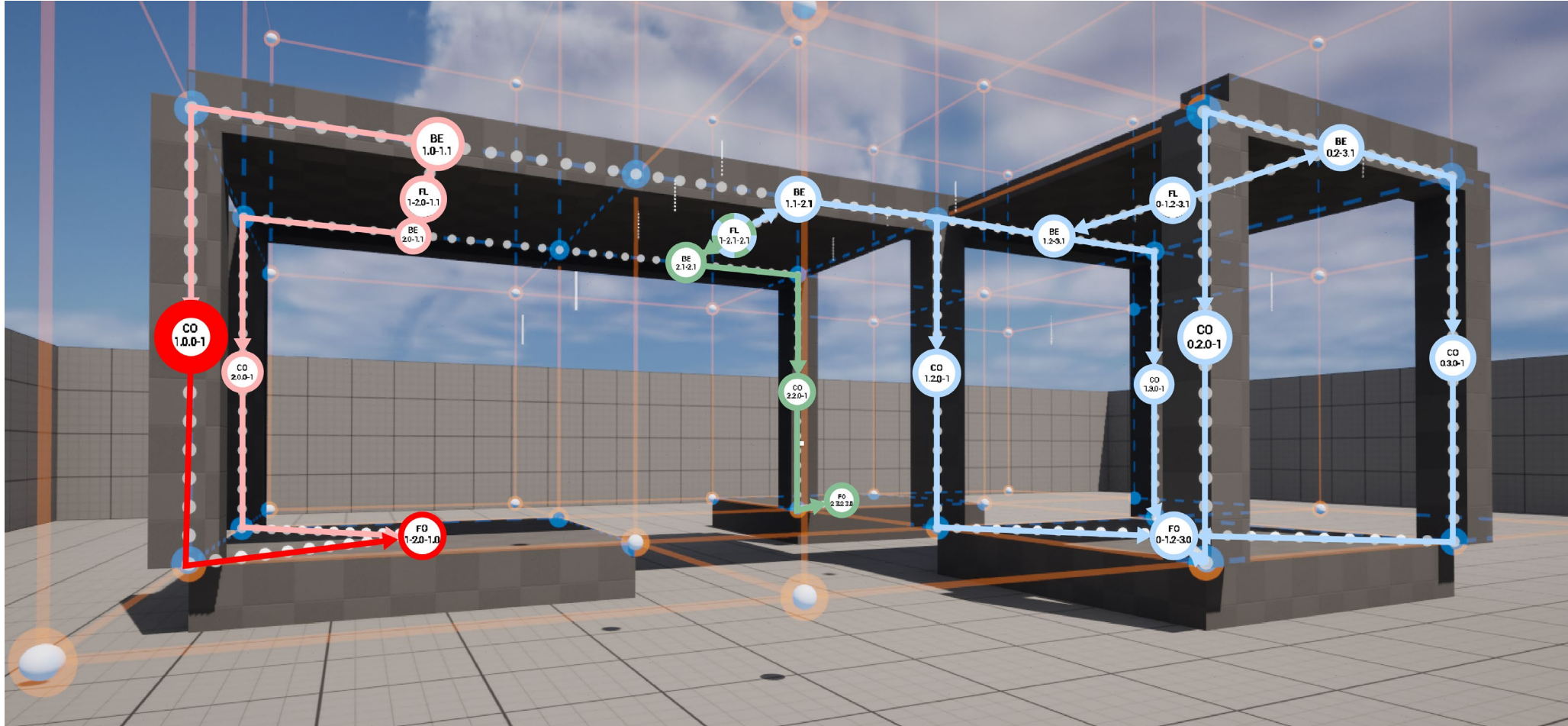
Configuration process & software development

Bending: breadth first search



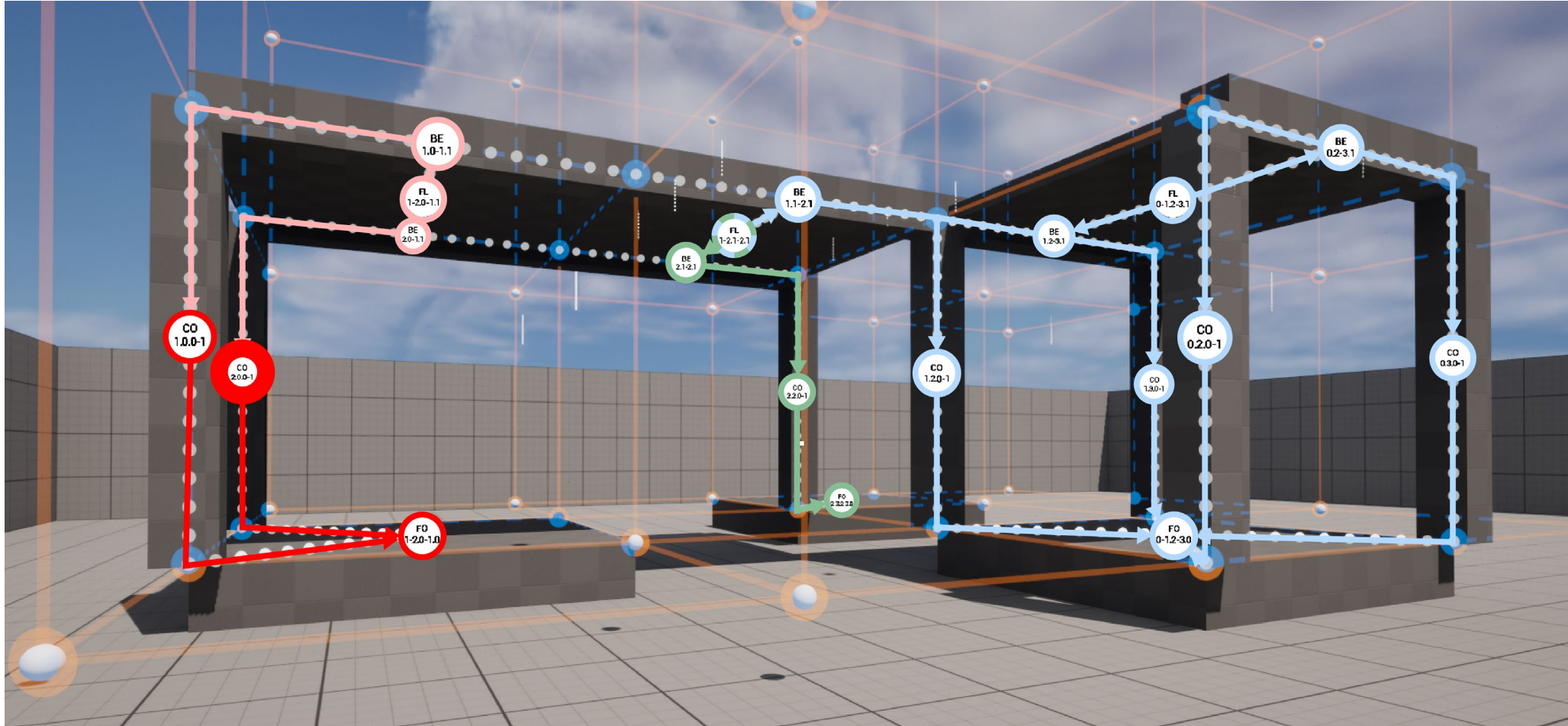
Configuration process & software development

Bending: breadth first search



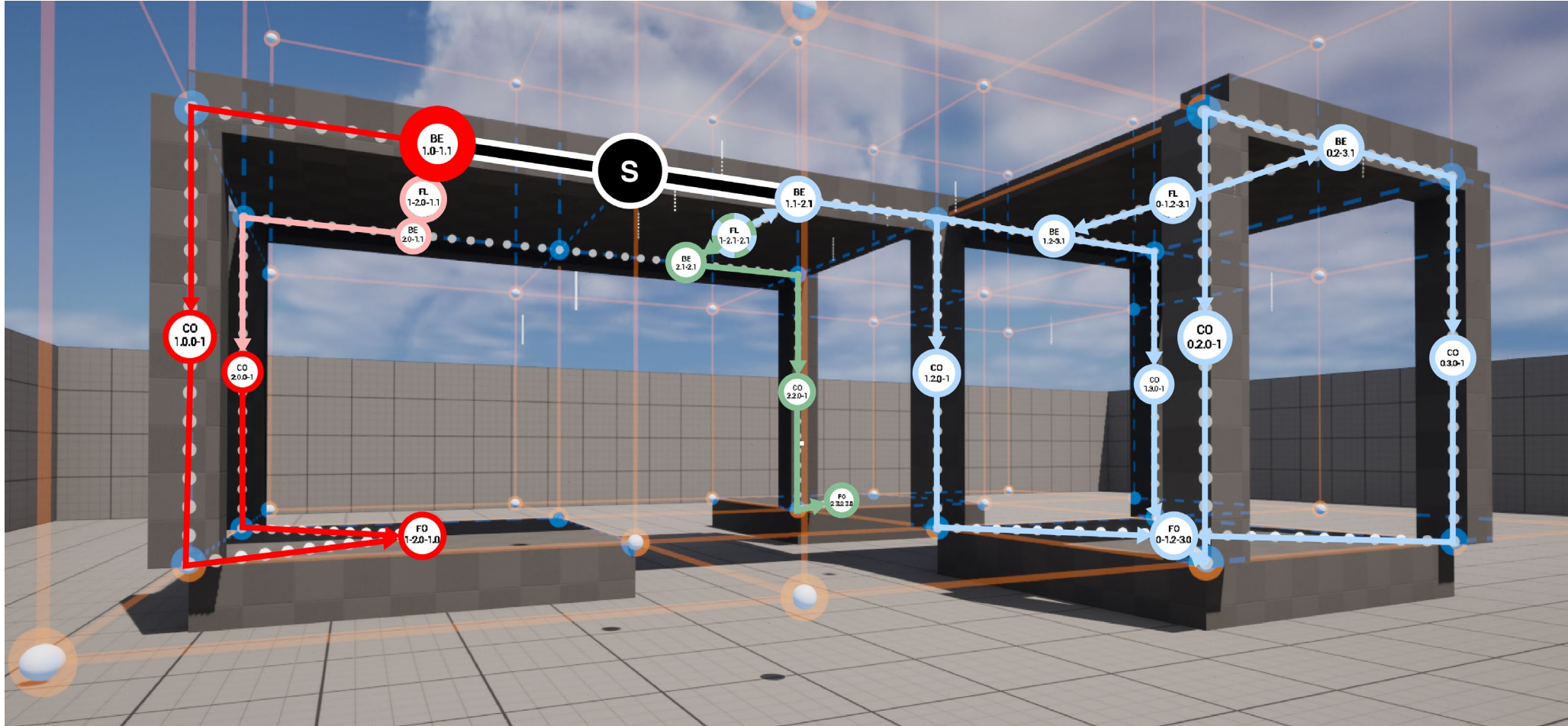
Configuration process & software development

Bending: breadth first search



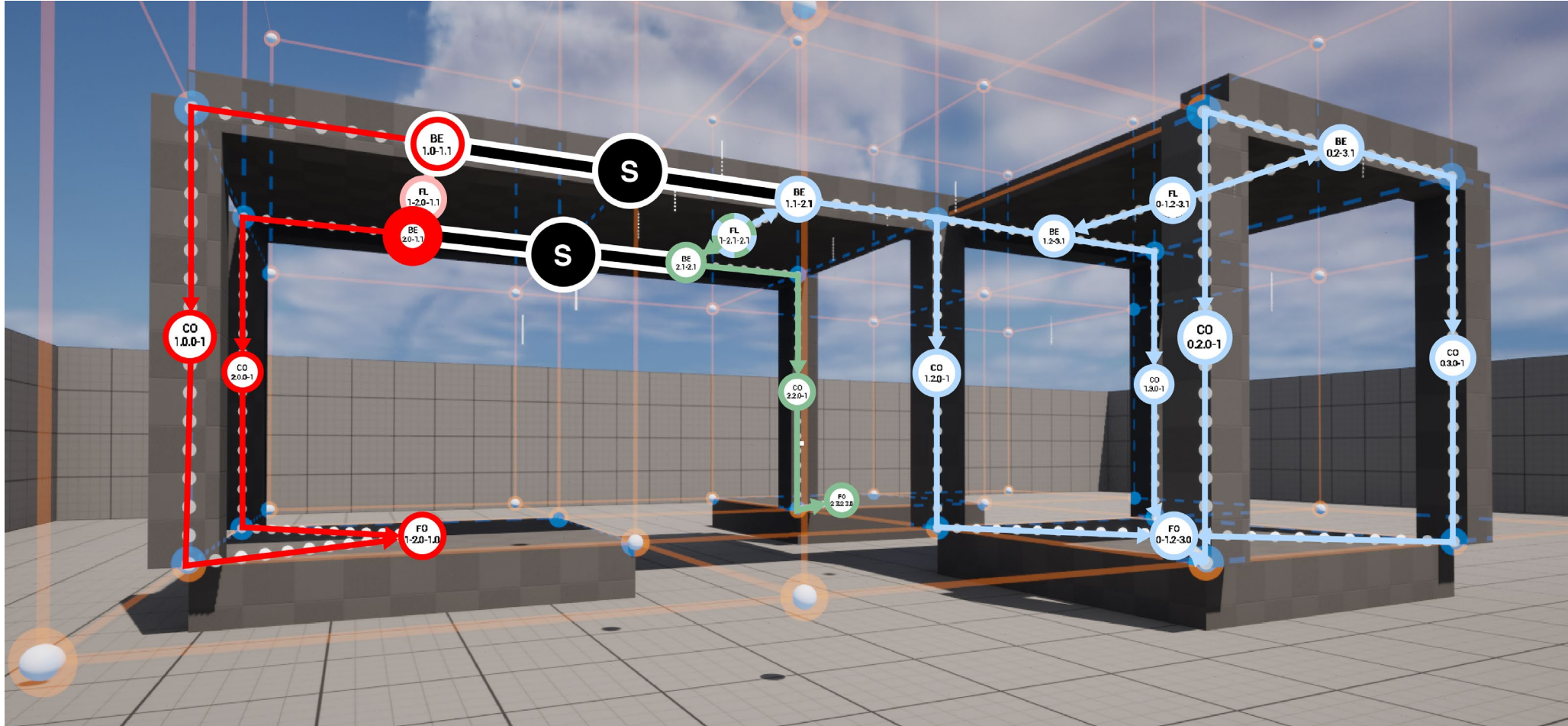
Configuration process & software development

Bending: split node found!



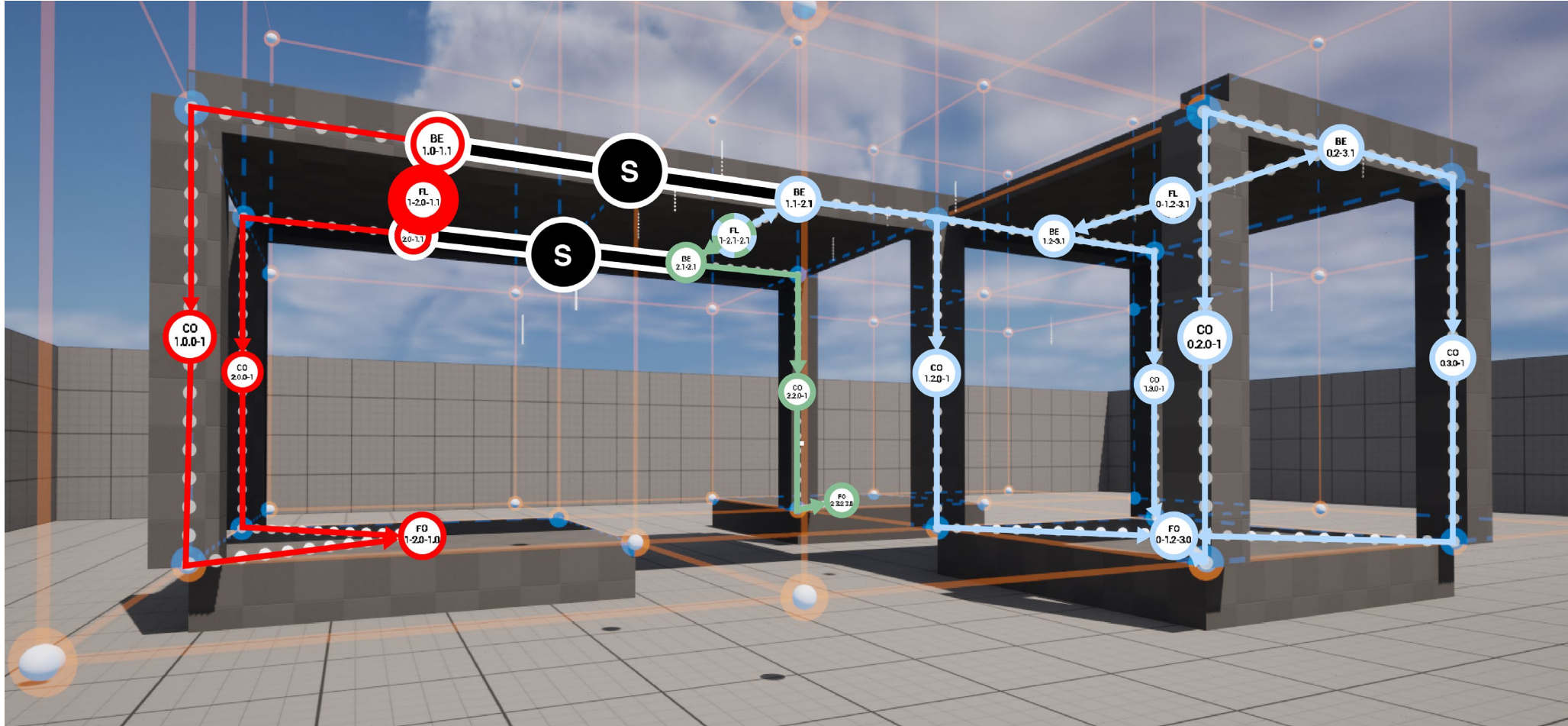
Configuration process & software development

Bending: another split node found!



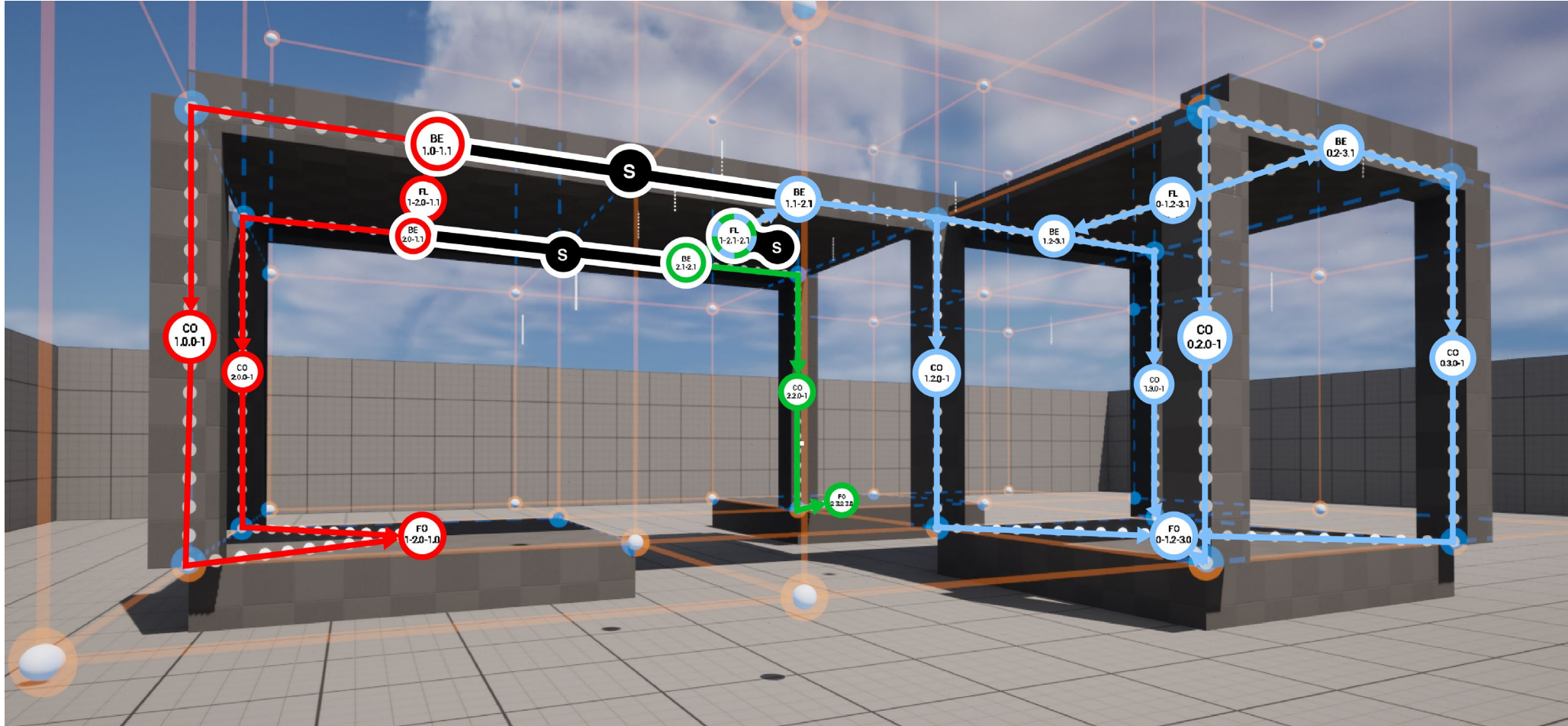
Configuration process & software development

Bending: breadth first search ends



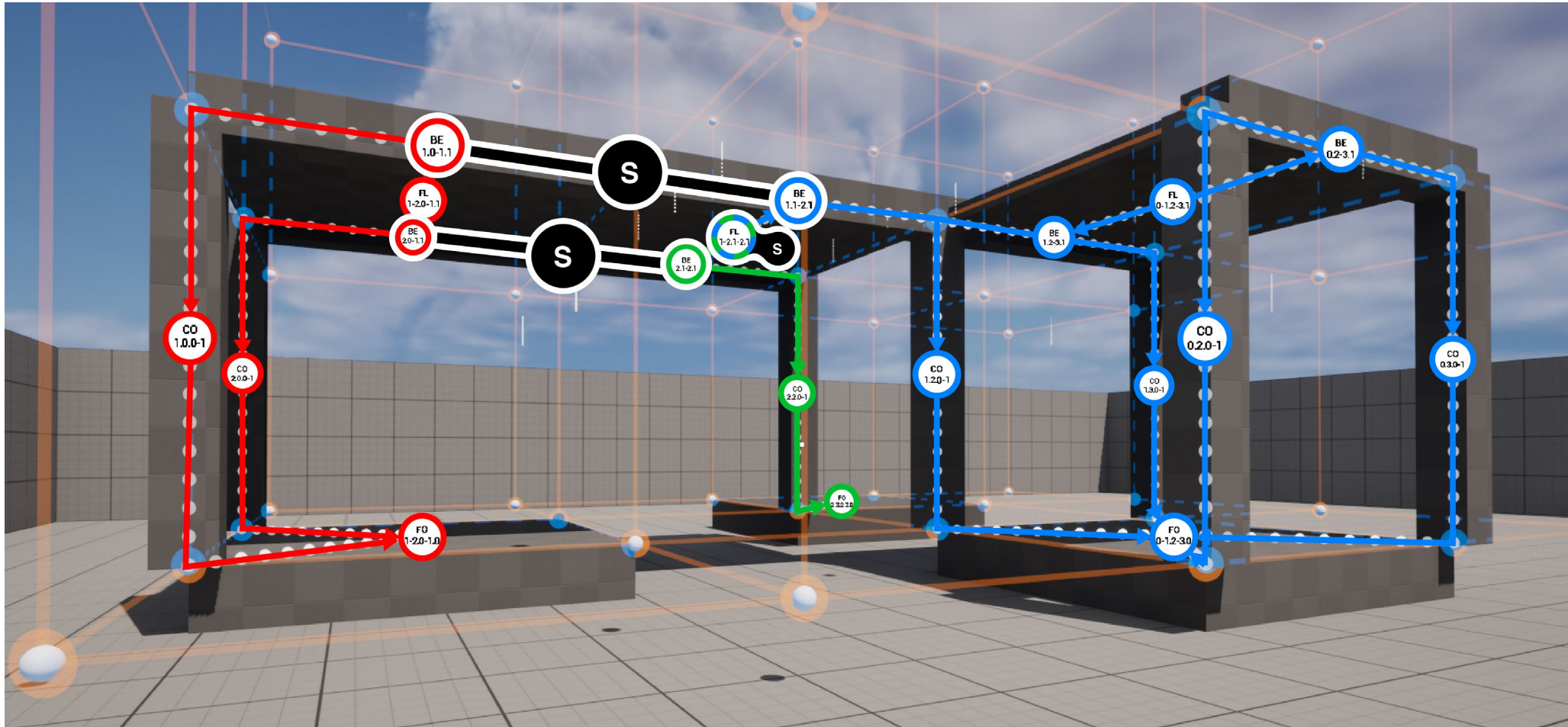
Configuration process & software development

Bending: breadth first search green



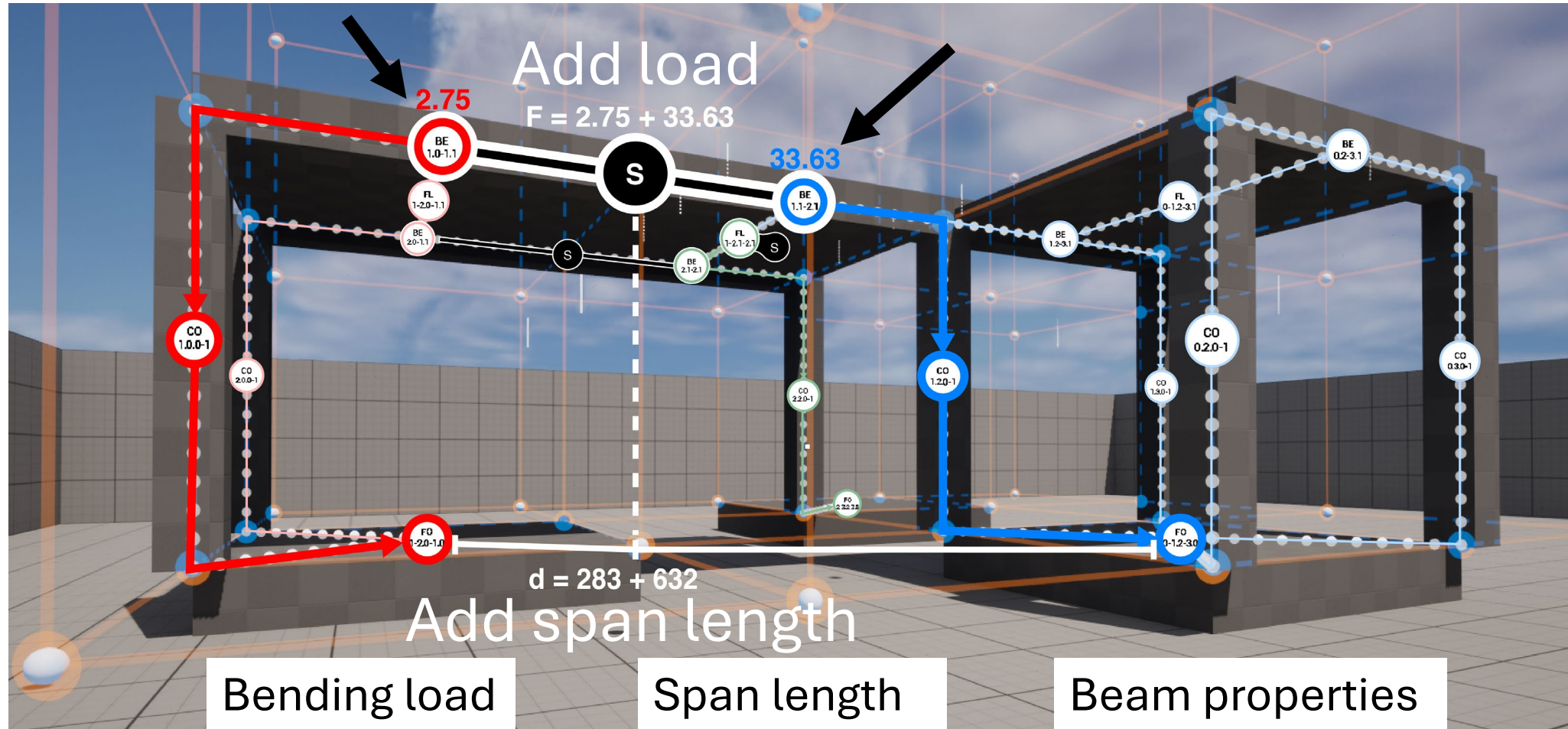
Configuration process & software development

Bending: breadth first search blue



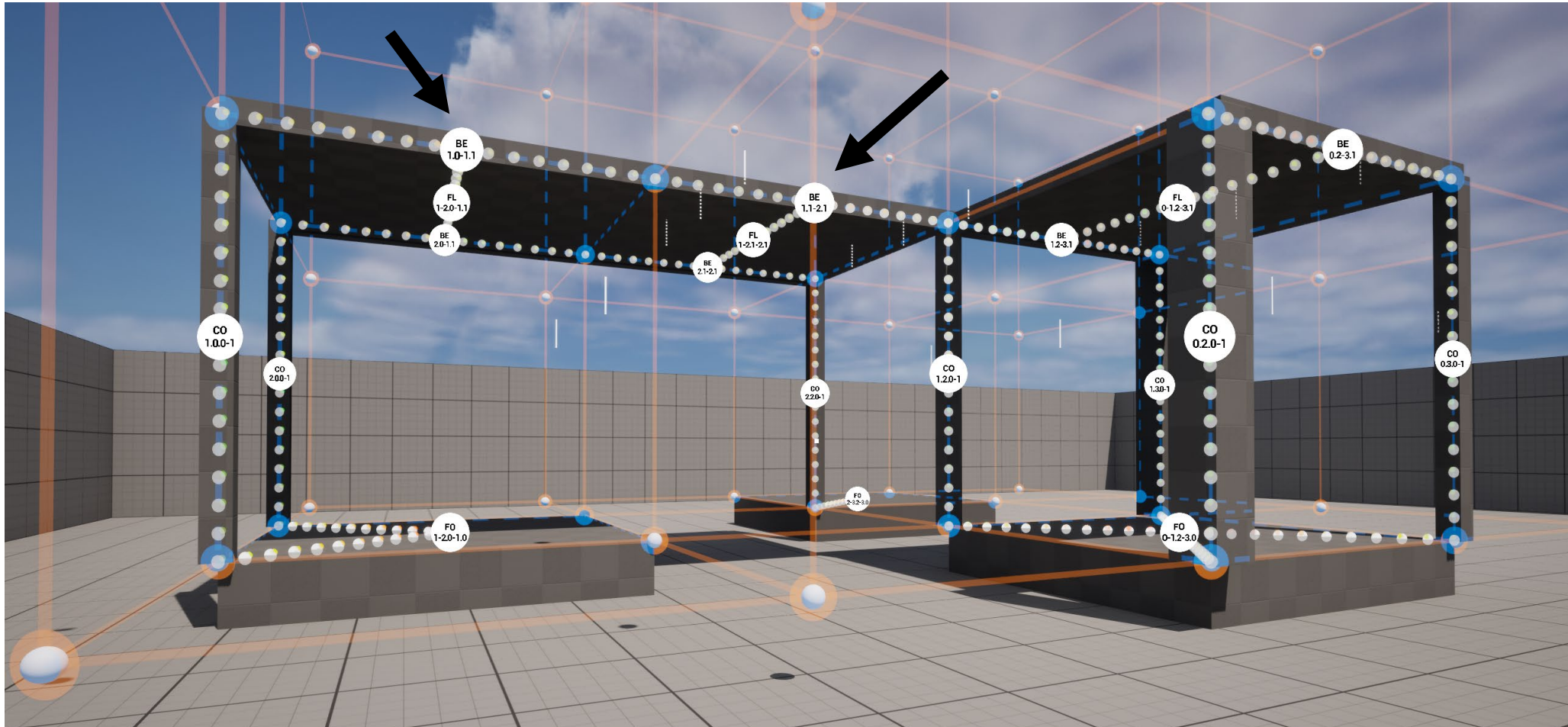
Configuration process & software development

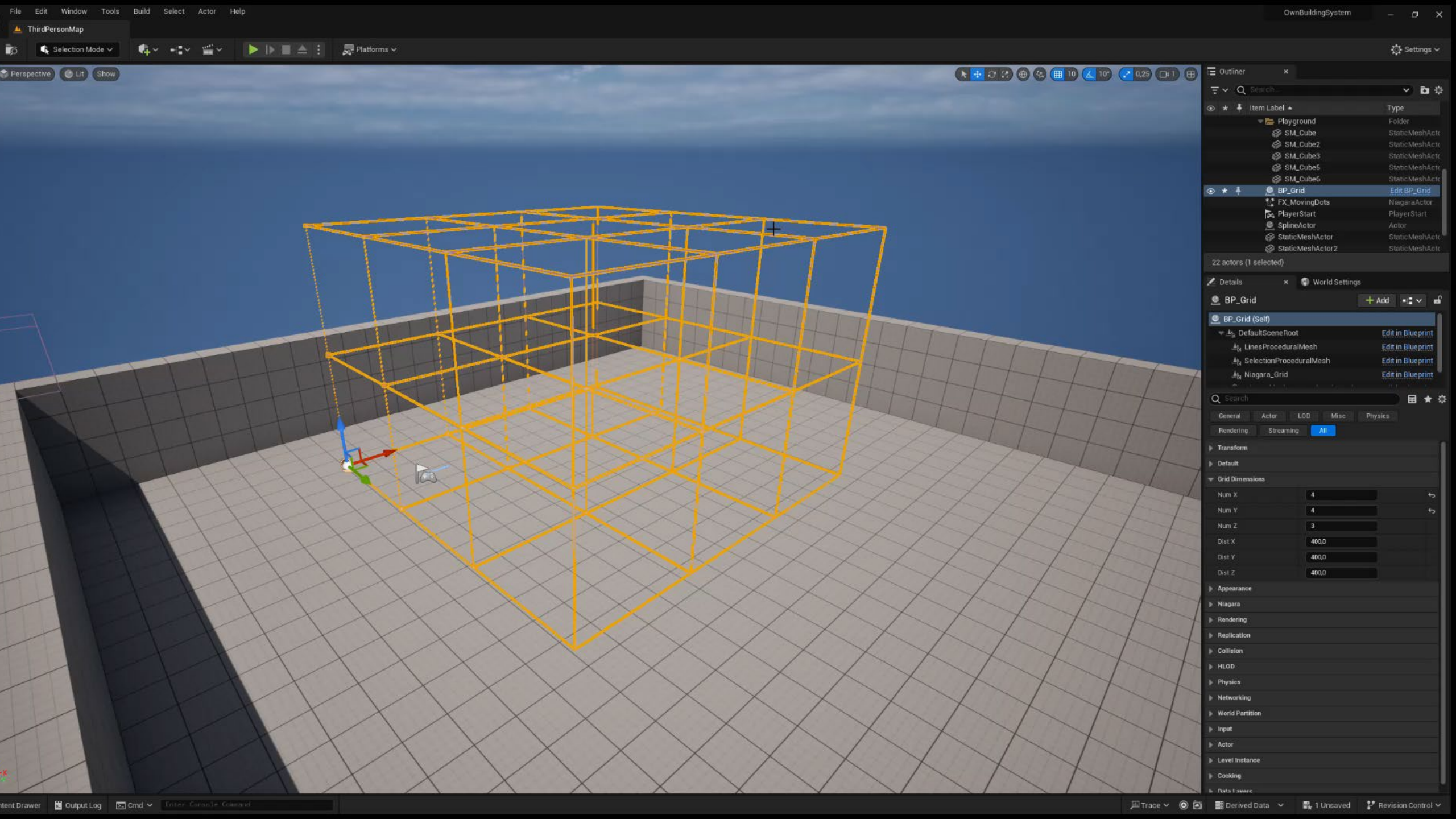
Calculate bending stress



Configuration process & software development

Resize beams





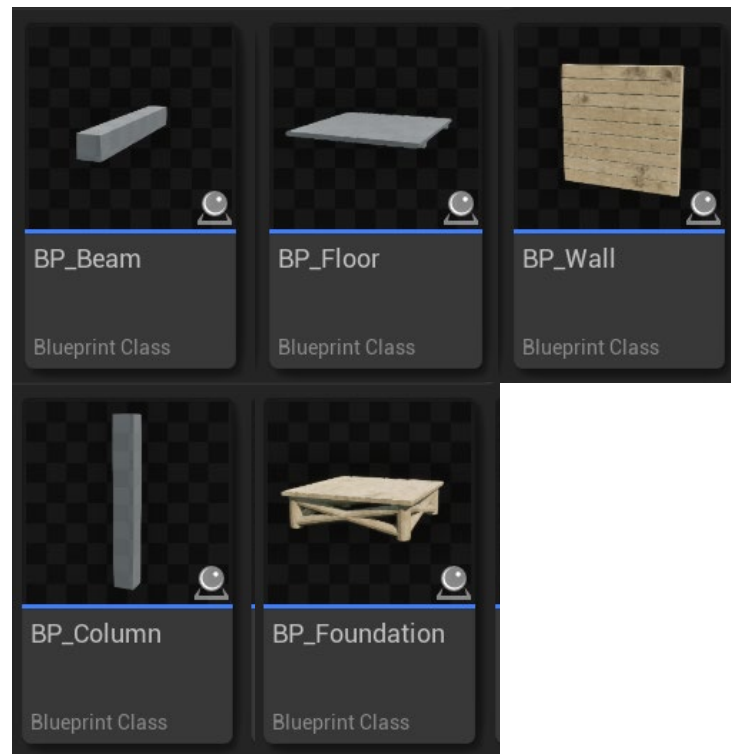
Future developments

Future developments for this project's configurator

Building product database

RQ: How can the design space of integrated construction configurators be enlarged?

Component types



Building product database

BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood LVL	410 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=400 mm l=1000-6000 mm	wood reclaimed	800 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=500 mm l=5000 mm	concrete, steel	2100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=350 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-


Building product registration

BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood LVL	410 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=400 mm l=1000-6000 mm	wood reclaimed	800 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=500 mm l=5000 mm	concrete, steel	2100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=350 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Building product database

Difference with existing BIM databases

Configurator's database

BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
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4,02		steel t beam	h=300 mm b=350 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Bouwconnect BIM database

Filterresultaten

Leveranciers

Fabrikant Abstract (739)

Keuzes

liggers

metaal

balk

ASB

HEA

HEA raatligger

HEB

HEB raatligger

HEM

hoek binnenhoek afgerond

hoek gelijkzijdig afgerond

hoek gelijkzijdig scherpkantig


hoek ongelijkzijdig afgerond

hoek ongelijkzijdig scherpkantig

Resultaat: 739 objecten


« < 1 2 3 4 5 6 > »

Cad Vergelijk




Metalen balk, koker 10x50x2

Vergelijk




Metalen balk, koker 20x40x3

Vergelijk




Metalen balk, koker 20x50x3

Vergelijk




Metalen balk, koker 20x60x3

Vergelijk




Metalen balk, koker 25x50x2

Vergelijk




Metalen balk, koker 30x40x2

Vergelijk



Metalen balk, koker 30x40x3

Vergelijk



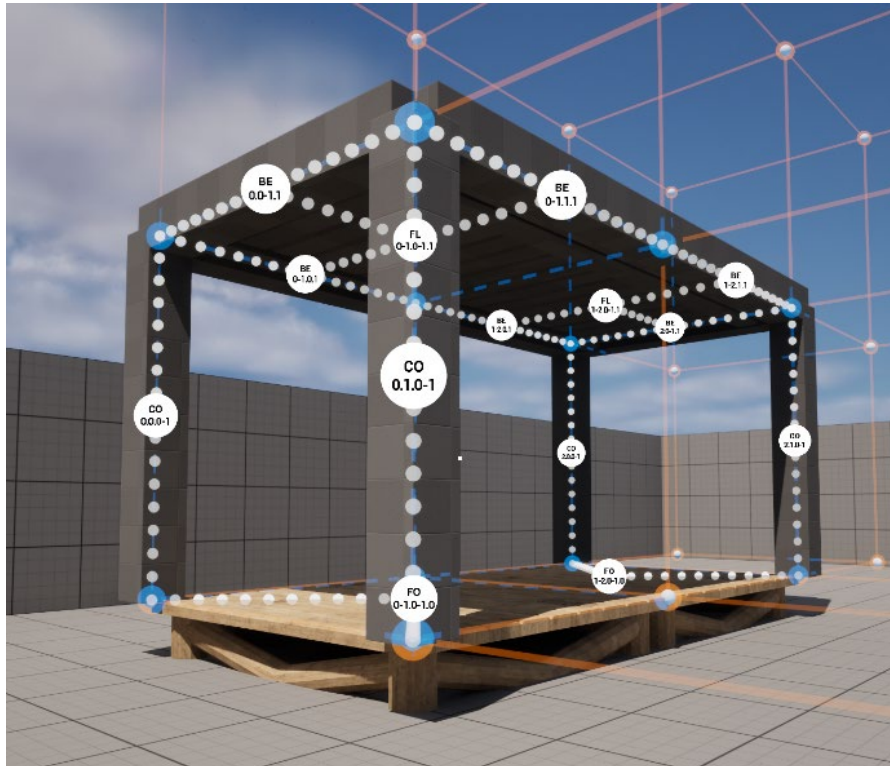
Metalen balk, koker 30x60x2

Vergelijk

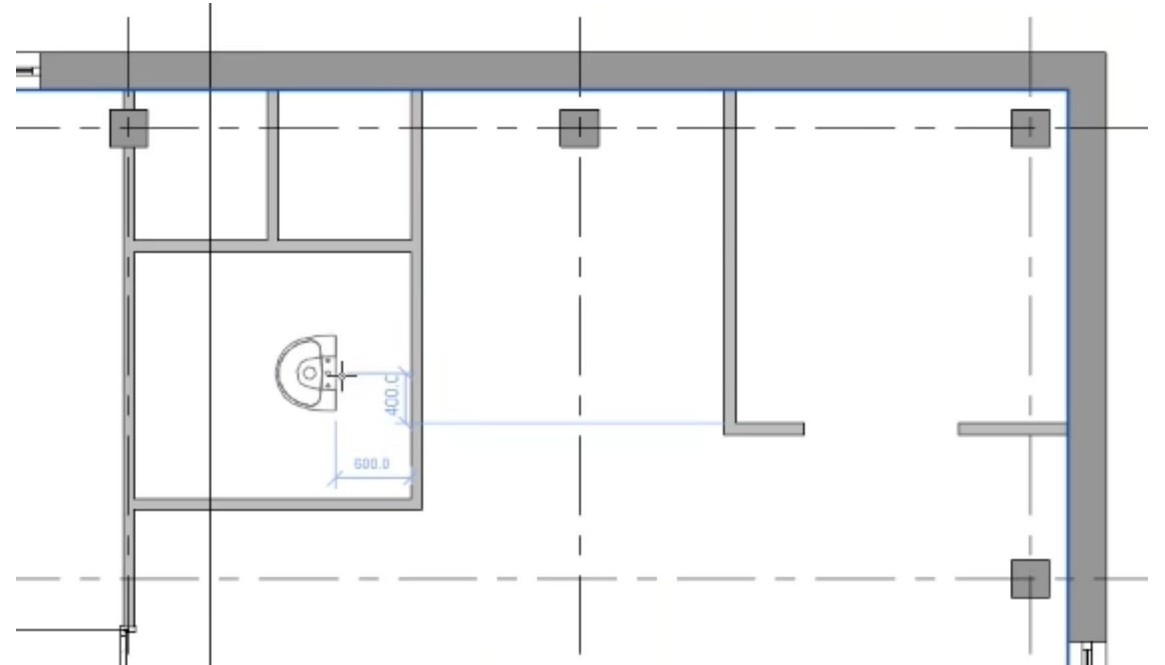
Building product database

Difference with existing BIM databases

Configurator's database

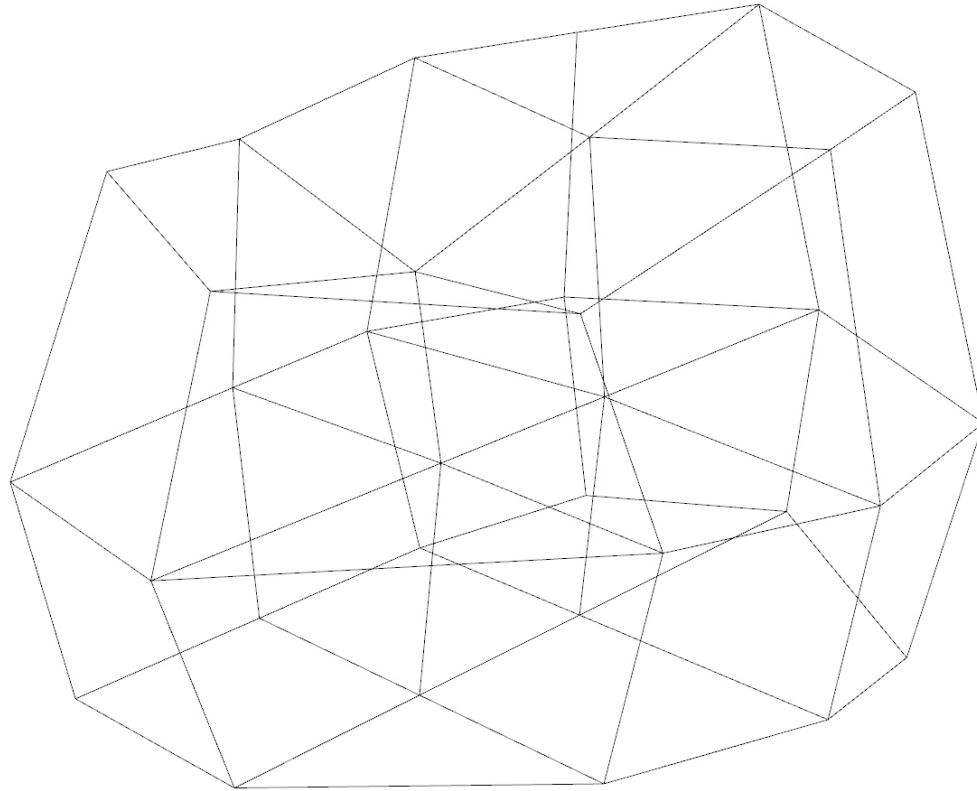


Bouwconnect BIM database



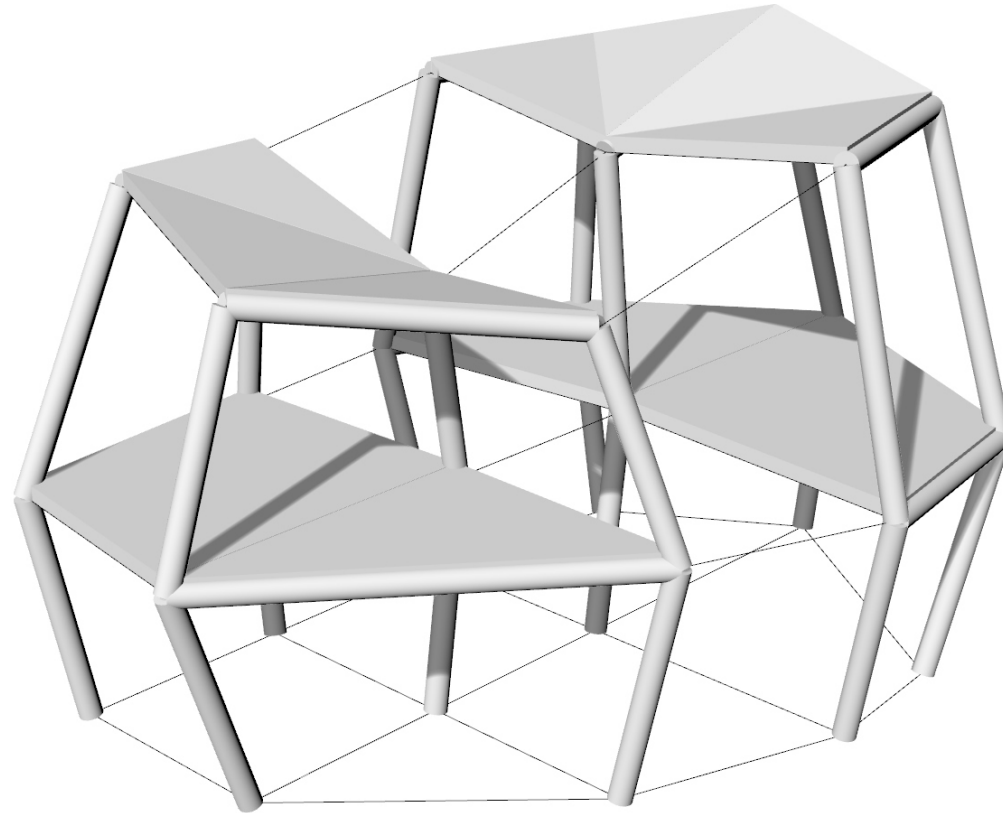
Configuration process

Designing the grid



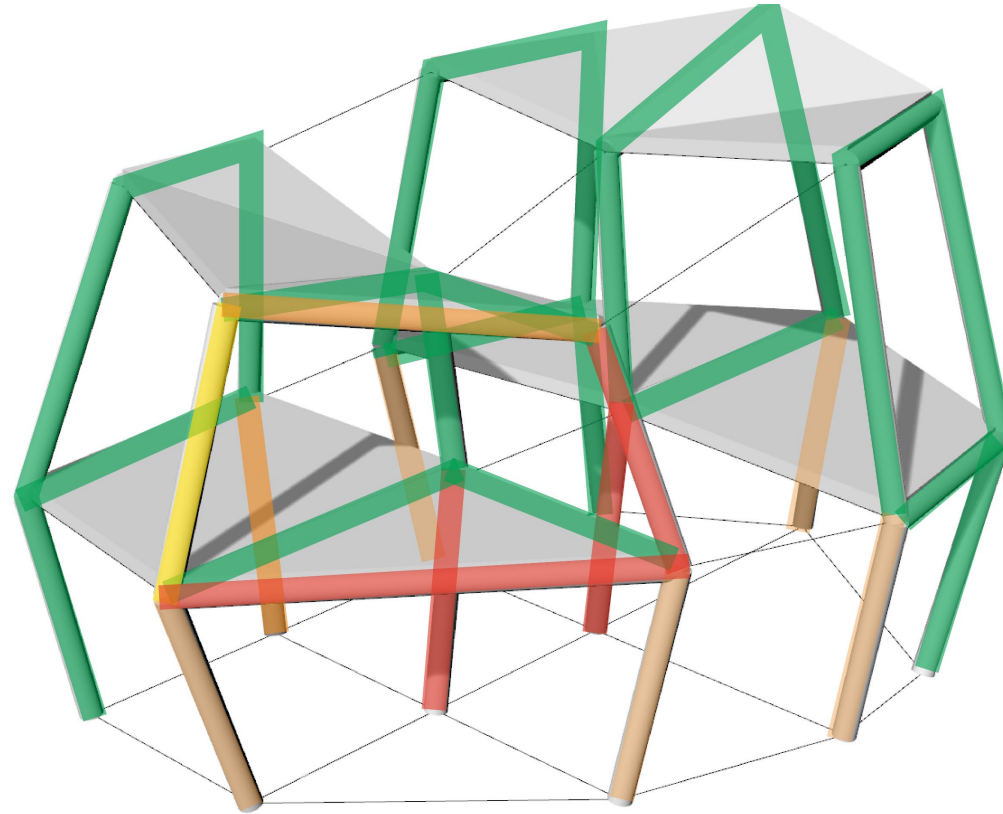
Configuration process

Place generic components



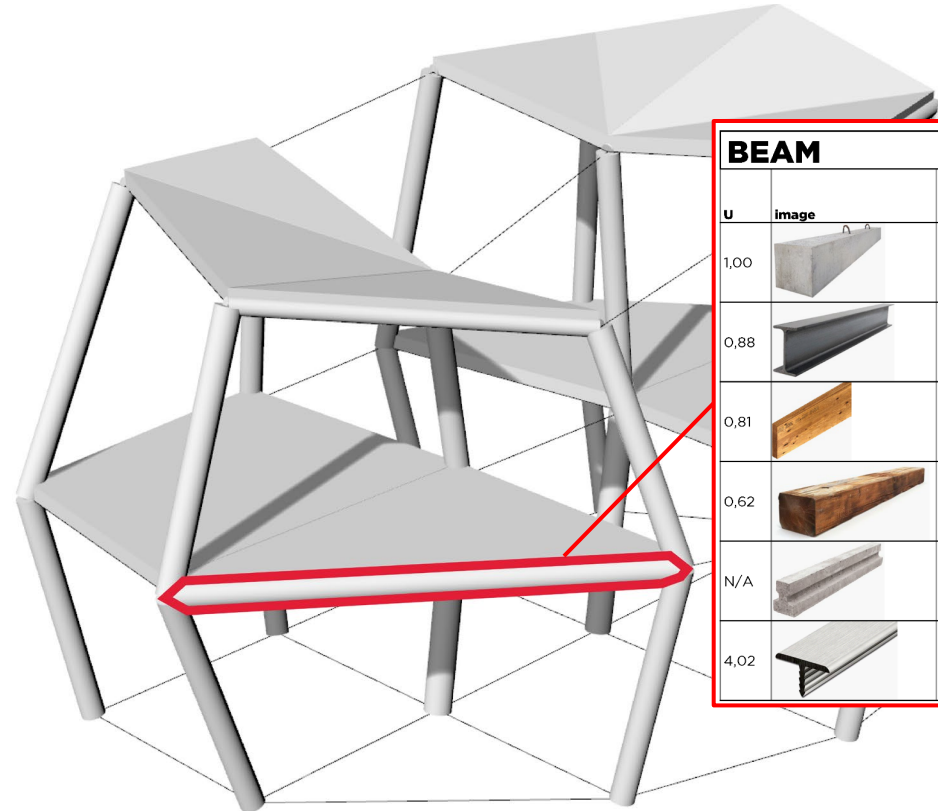
Configuration process

Structural analysis



Configuration process

Replace generic components with building products from the database

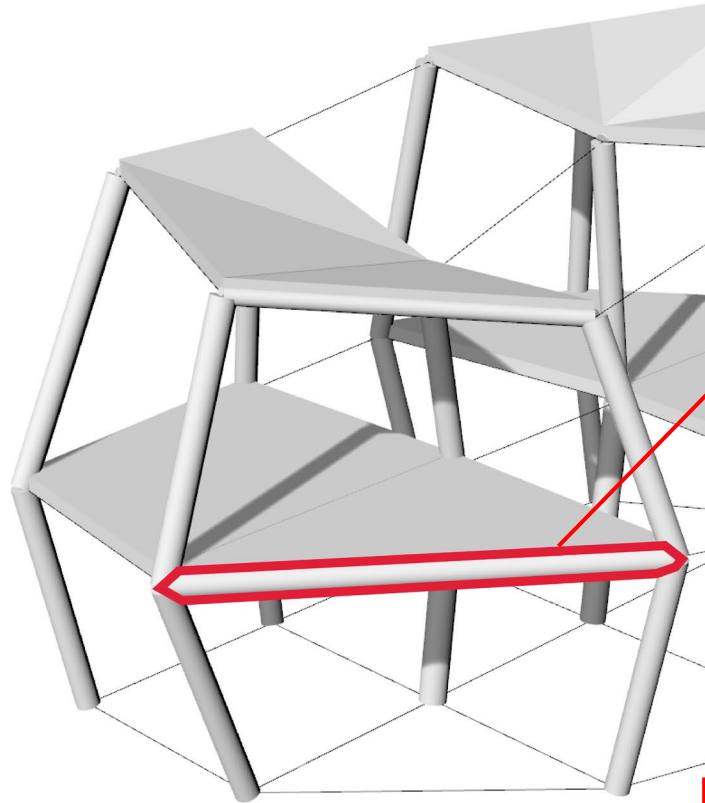


BEAM

U	Image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood LVL	410 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=400 mm l=1000-6000 mm	wood reclaimed	800 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=500 mm l=5000 mm	concrete, steel	2100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=350 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Configuration process

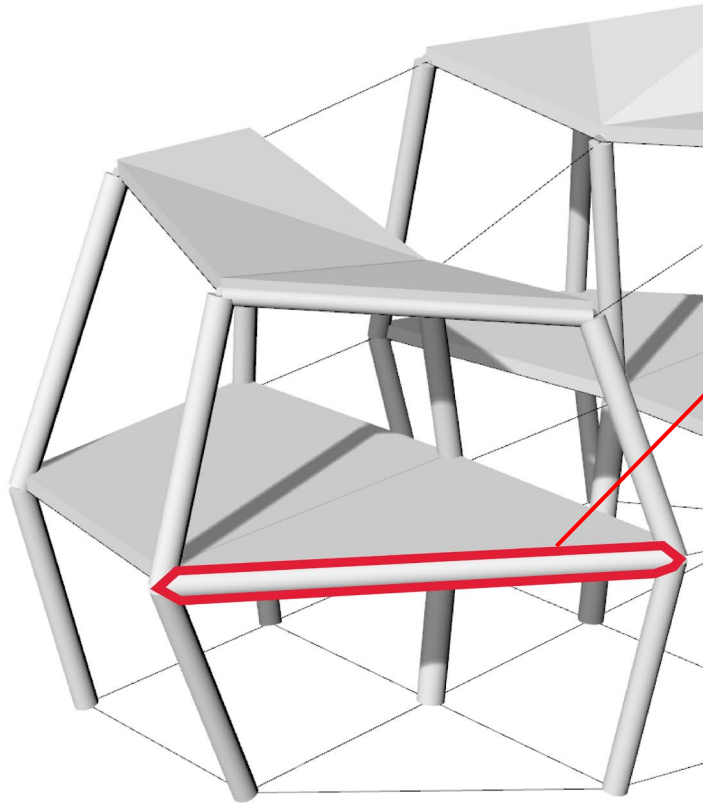
Replace generic components with building products from the database



BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood LVL	410 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=400 mm l=1000-6000 mm	wood reclaimed	800 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=500 mm l=5000 mm	concrete, steel	2100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=350 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Configuration process

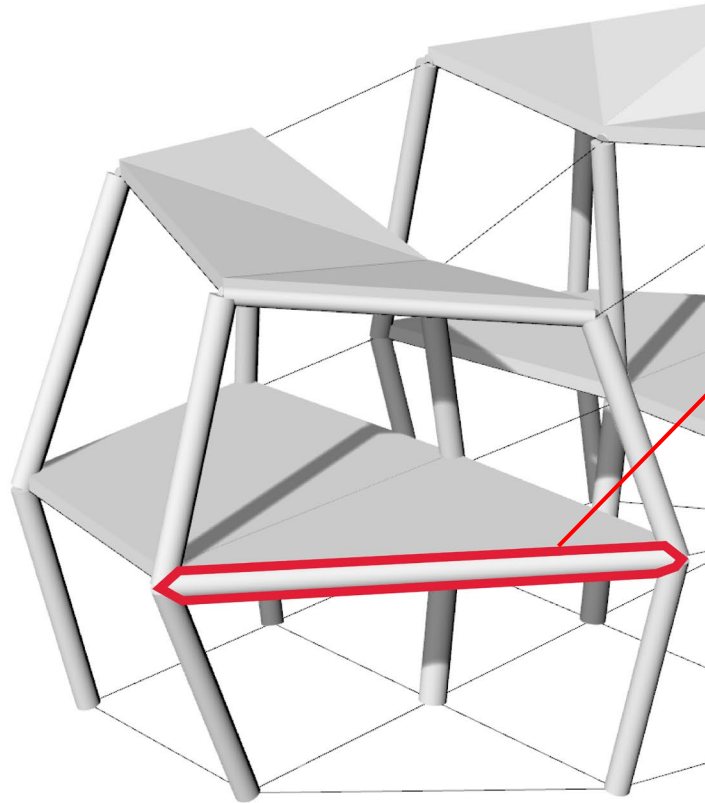
Replace generic components with building products from the database



BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood LVL	410 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=400 mm l=1000-6000 mm	wood reclaimed	800 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=500 mm l=5000 mm	concrete, steel	2100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=100-600 mm l=1000-6000 mm Too weak	steel	500 kg	€2500,-	€400,-

Configuration process

Replace generic components with building products from the database

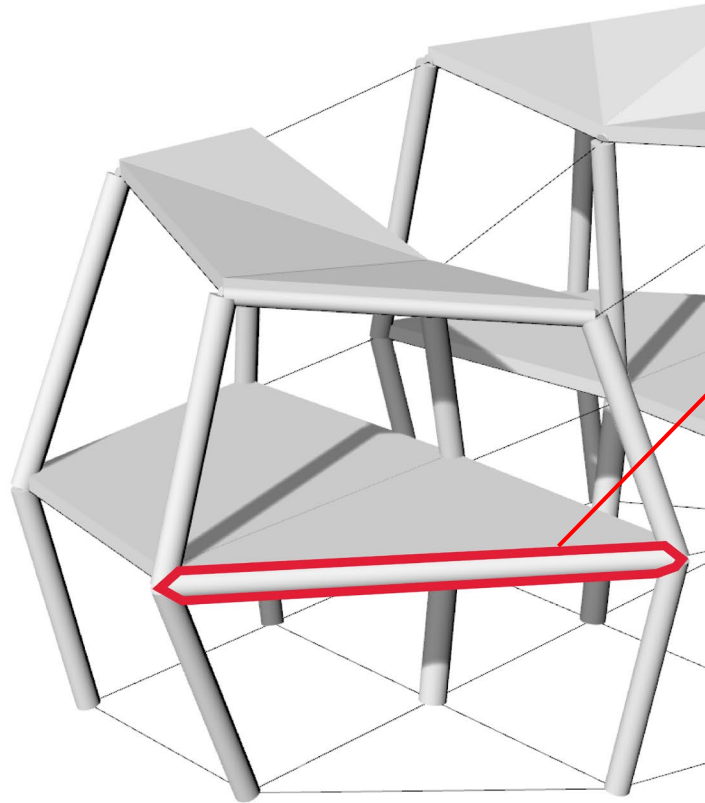






BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood LVL	410 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=400 mm l=1000-6000 mm	wood reclaimed	800 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=500 mm l=5000 mm	concrete, steel	2100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=100-600 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Too weak

Configuration process

Replace generic components with building products from the database



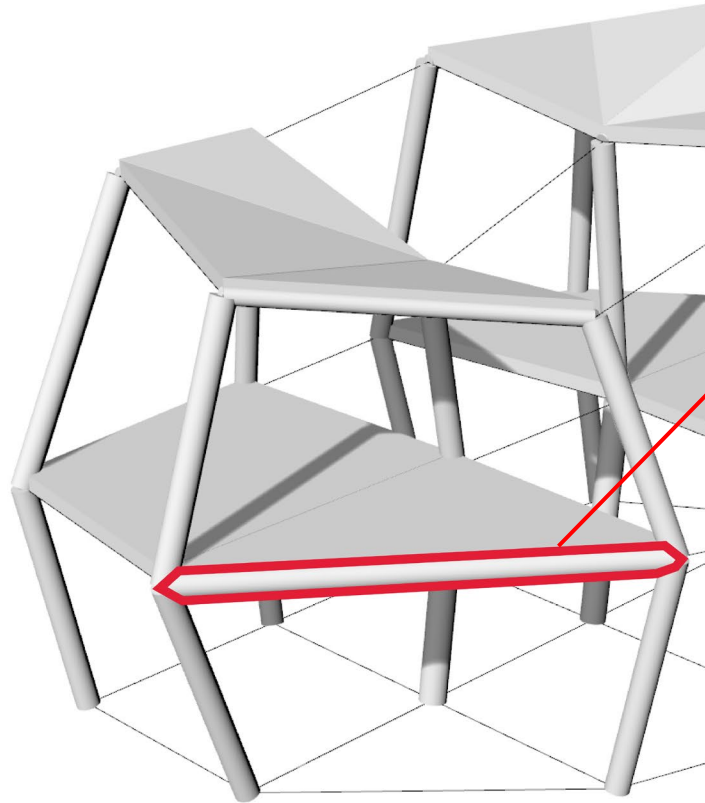
BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood LVL	410 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=400 mm l=1000-6000 mm	wood reclaimed	800 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=100 mm l=5000 mm	concrete, steel	1100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=100 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Inappropriate dimensions

Too weak

Configuration process

Replace generic components with building products from the database



BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood	1000 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=300 mm l=1000-6000 mm	wood	1000 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=300 mm l=5000 mm	concrete, steel	1100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=300 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Connection incompatibility

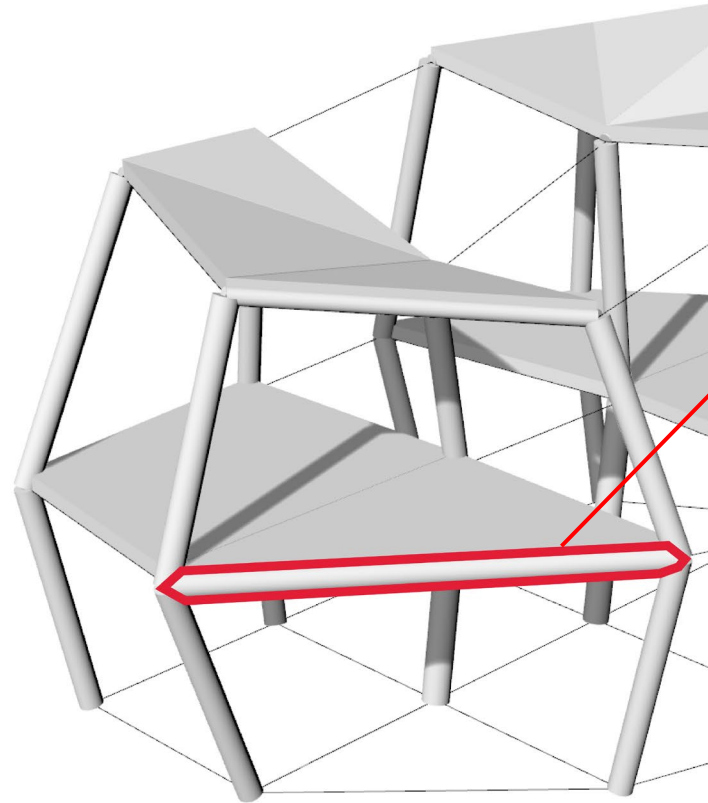
Connection incompatibility







Inappropriate dimensions

Too weak

Configuration process

Replace generic components with building products from the database



BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood	1000 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=300 mm l=1000-6000 mm	wood	1000 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=300 mm l=5000 mm	concrete, steel	1100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=300 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Connection incompatibility

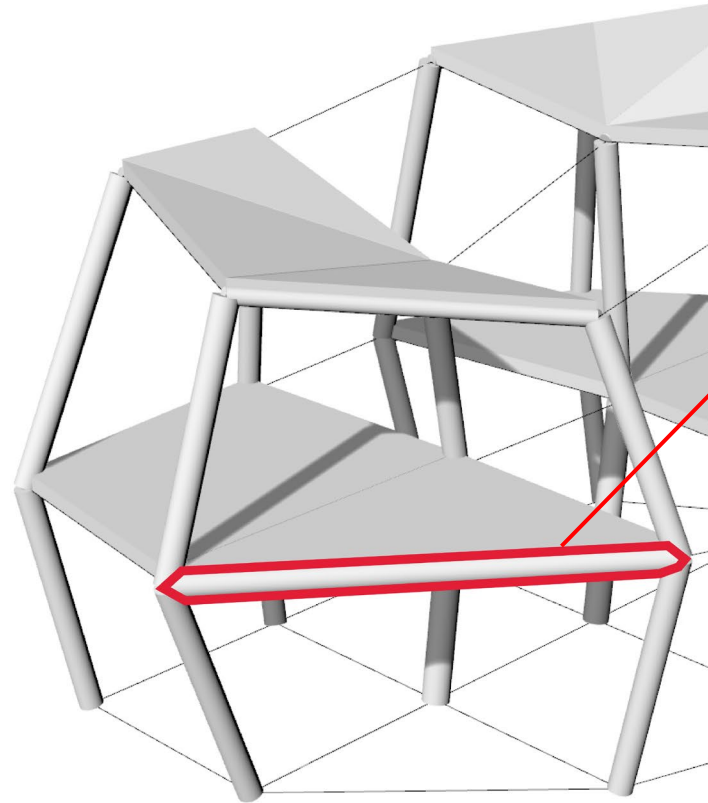
Connection incompatibility







Inappropriate dimensions

Too weak

Configuration process

Replace generic components with building products from the database



BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood	1000 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=300 mm l=1000-6000 mm	wood	1000 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=300 mm l=5000 mm	concrete, steel	1100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=300 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Connection incompatibility

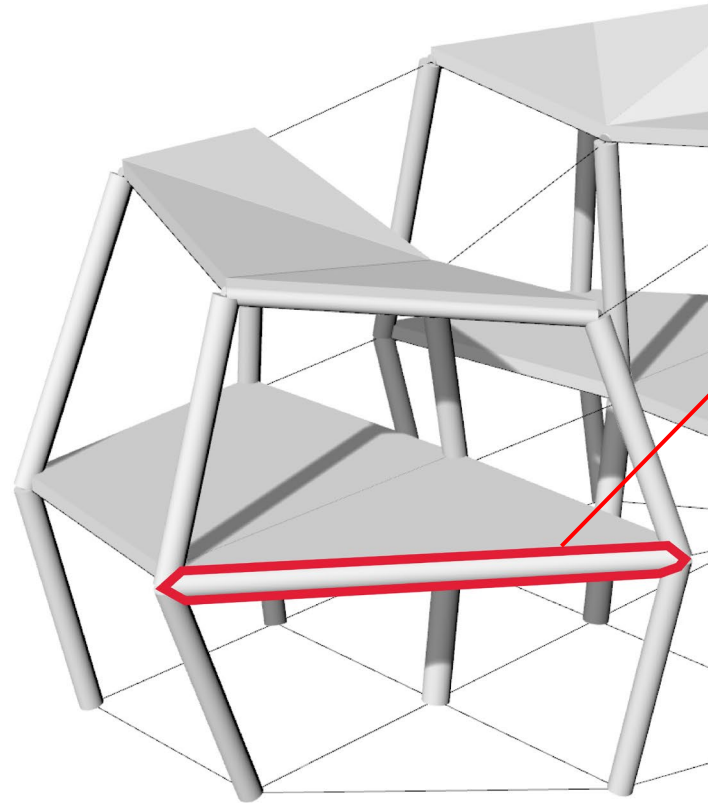
Connection incompatibility






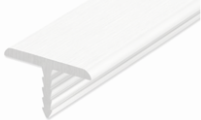
Inappropriate dimensions

Too weak

Configuration process

Replace generic components with building products from the database



BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood	1100 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=300 mm l=1000-6000 mm	wood	1100 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=300 mm l=5000 mm	concrete, steel	1100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=300 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Connection incompatibility

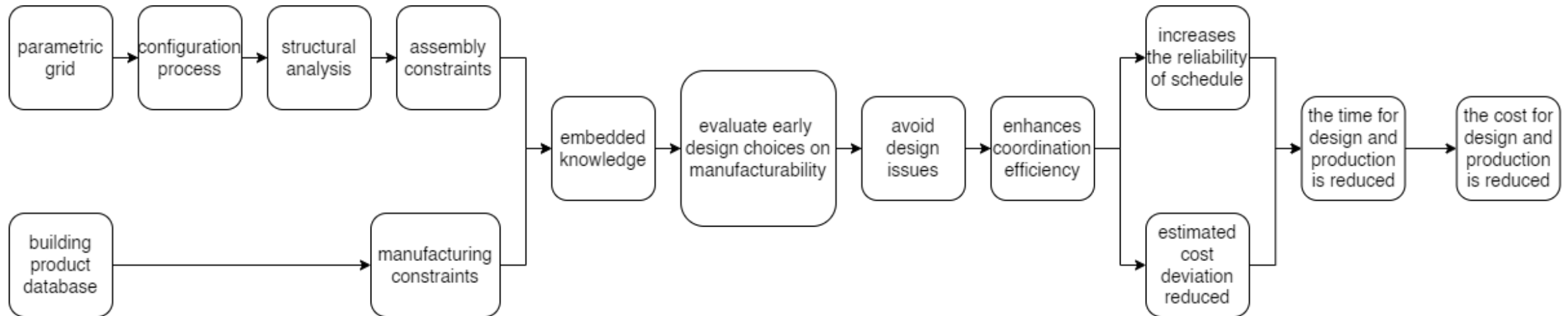
Connection incompatibility

Inappropriate dimensions

Too weak

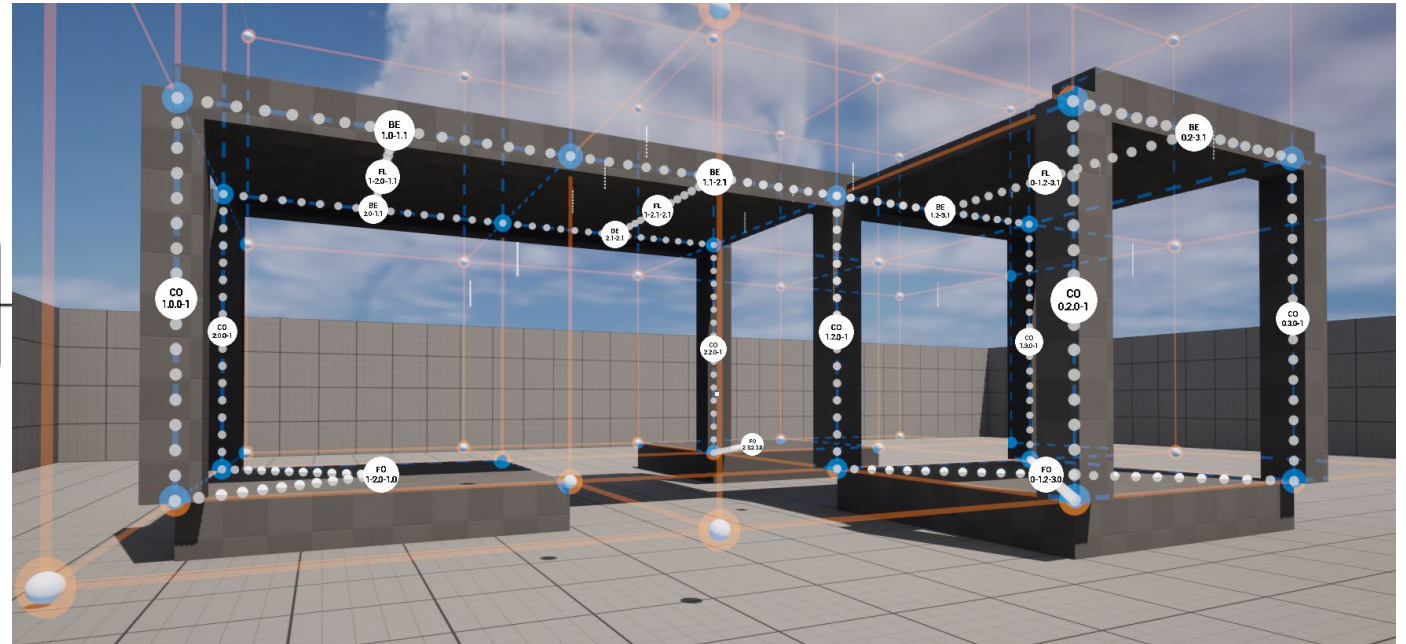
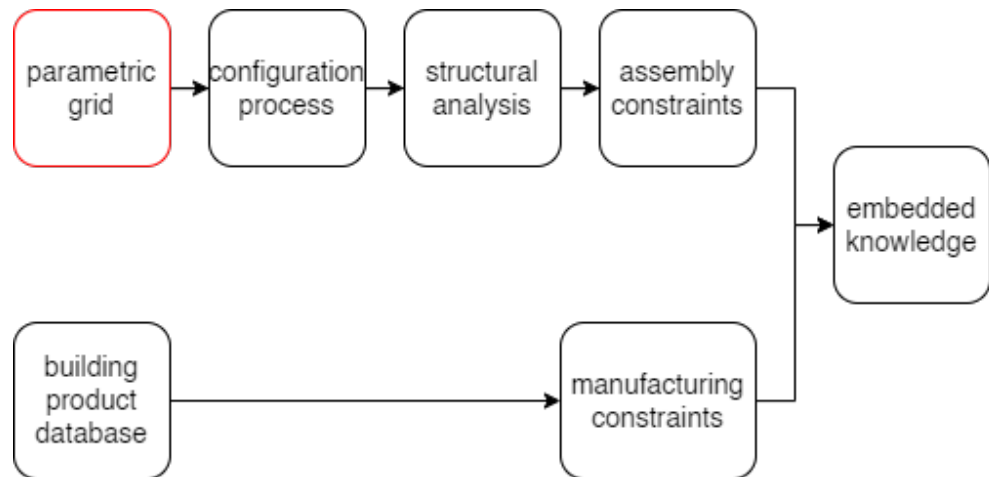
Benefits of the proposed configurator

Main benefits compared to BIM



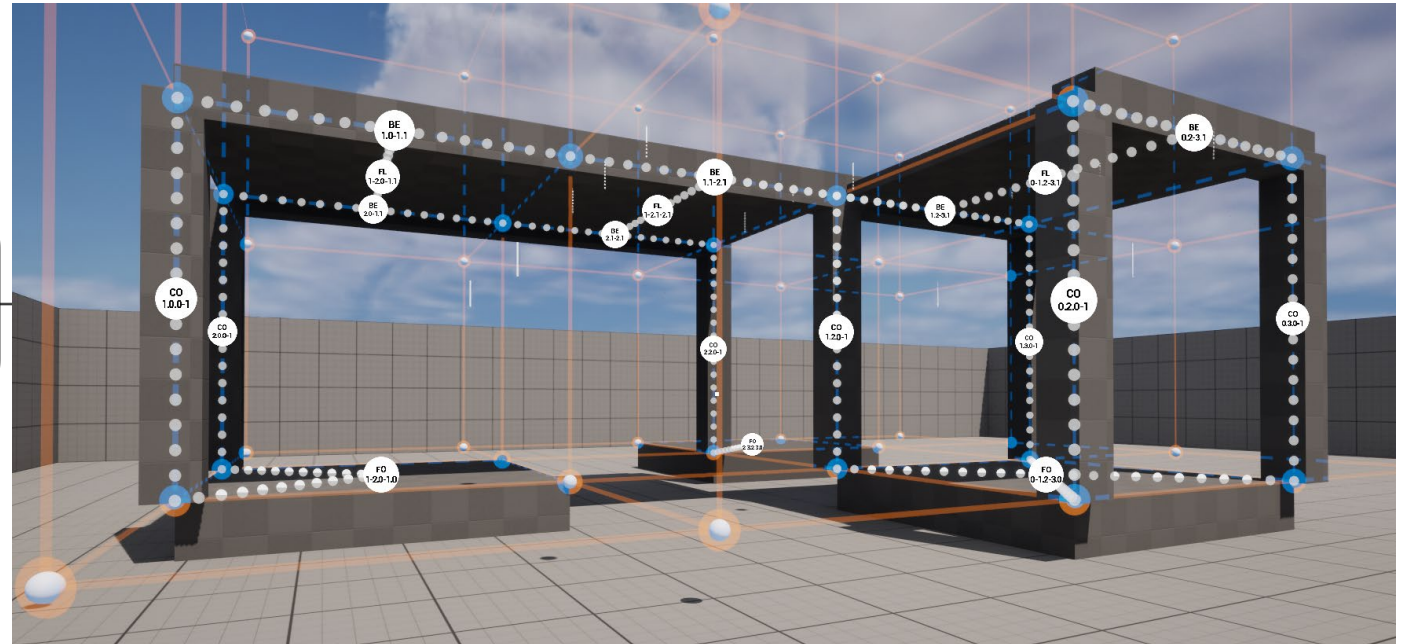
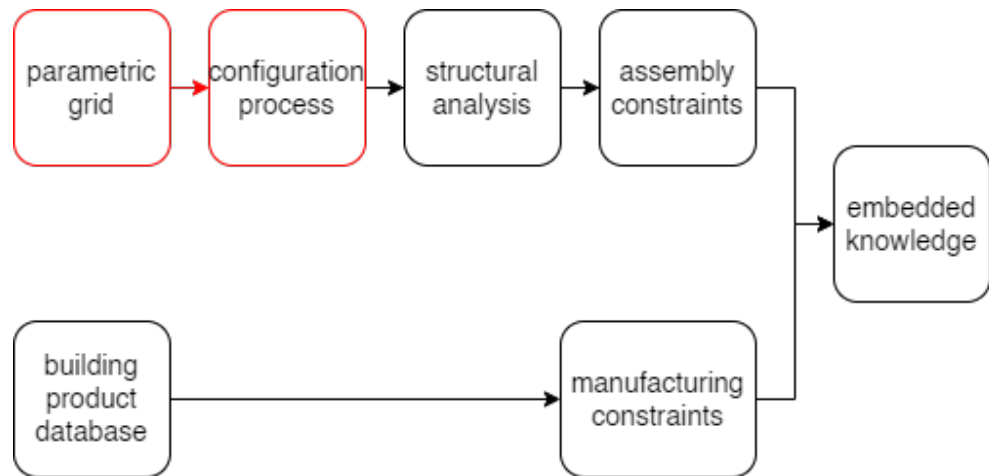
Benefits of the proposed configurator

Main benefits compared to BIM



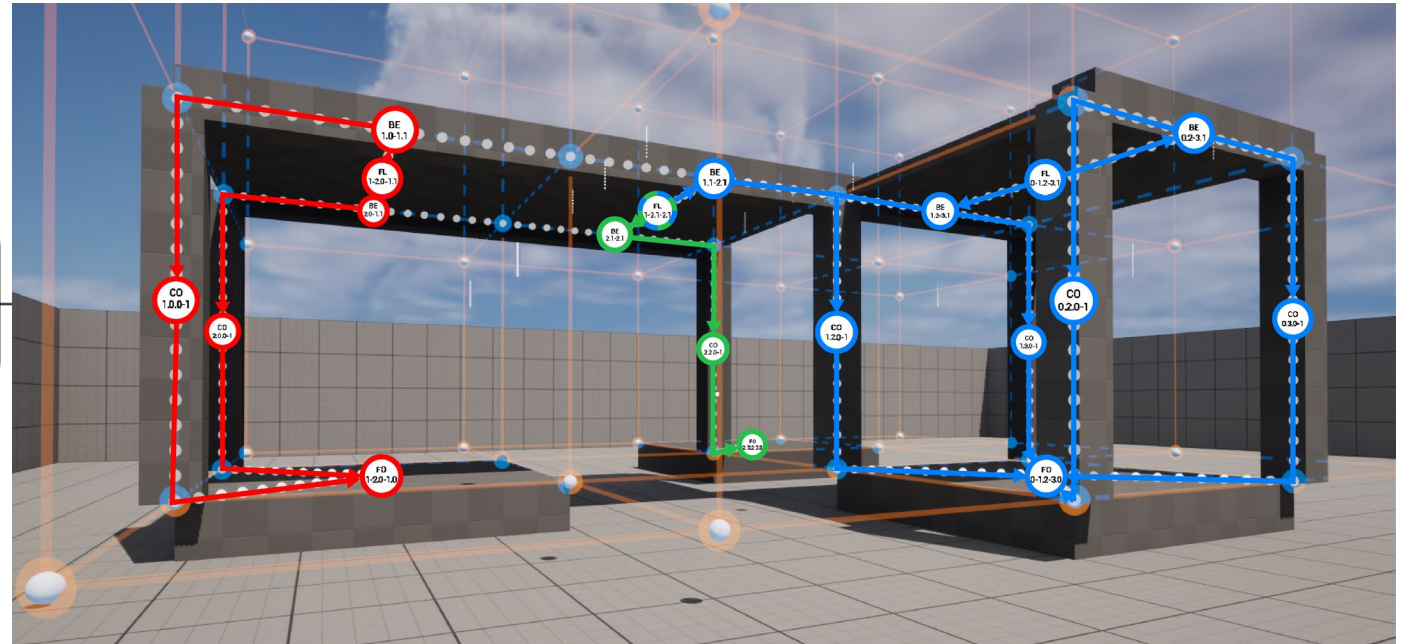
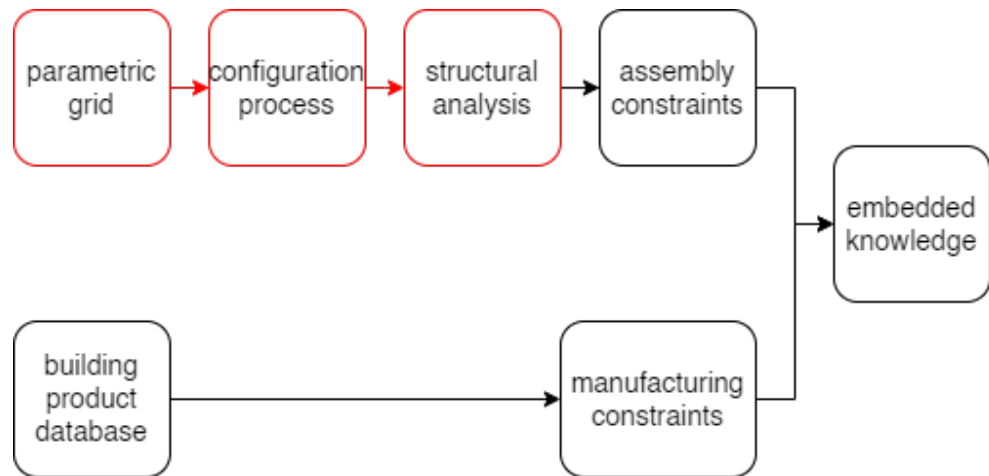
Benefits of the proposed configurator

Main benefits compared to BIM



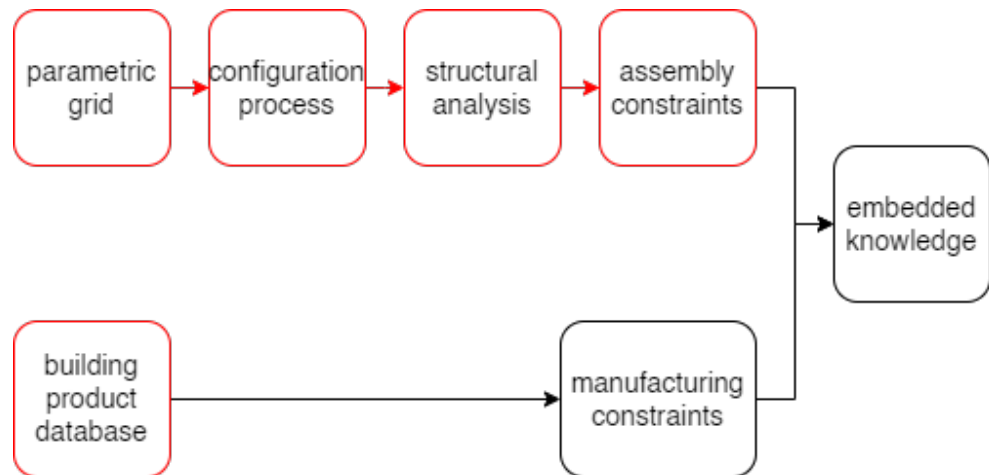
Benefits of the proposed configurator

Main benefits compared to BIM



Benefits of the proposed configurator

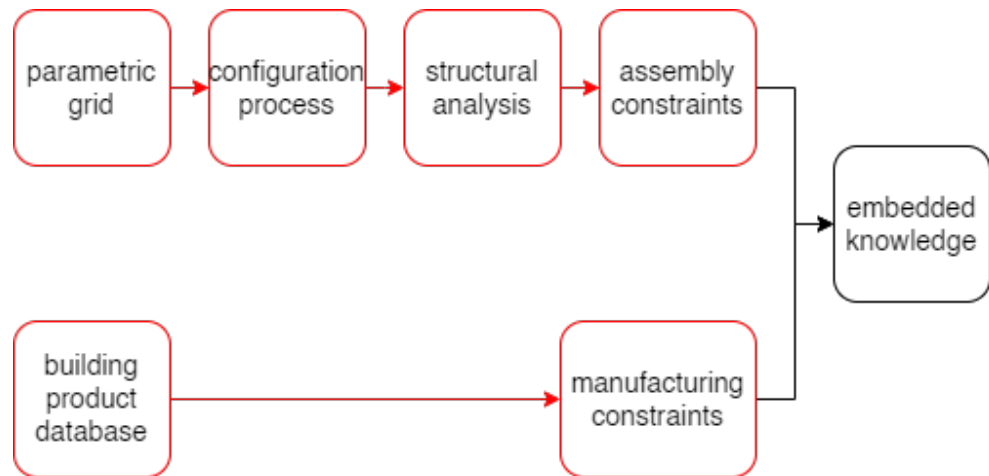
Main benefits compared to BIM



BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
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0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood LVL	410 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=400 mm l=1000-6000 mm	wood reclaimed	800 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=500 mm l=5000 mm	concrete, steel	2100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=350 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

Benefits of the proposed configurator

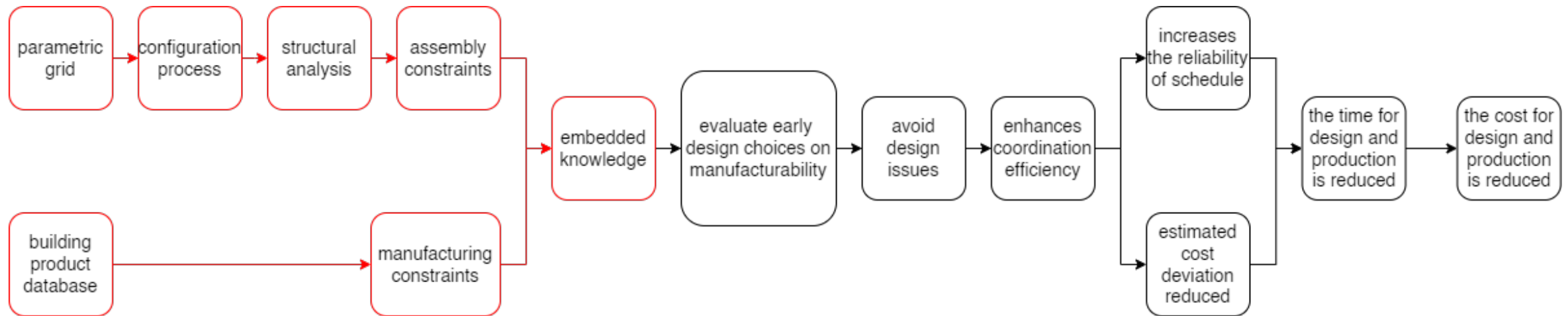
Main benefits compared to BIM



BEAM							
U	image	building product name	allowable dimensions	materials	weight	price	environmental costs
1,00		concrete beam	h=100-1000 mm b=100-600 mm l=1000-6000 mm	concrete, steel	1500 kg	€1500,-	€1500,-
0,88		HEA 500	h=500 mm b=300 mm l=4000 mm	steel	640 kg	€3000,-	€500,-
0,81		LVL beam	h=700 mm b=300 mm l=1000-6000 mm	wood LVL	410 kg	€5000,-	€50,-
0,62		reclaimed timber beam	h=1000 mm b=400 mm l=1000-6000 mm	wood reclaimed	800 kg	€3500,-	€0,-
N/A		prestressed concrete beam	h=600 mm b=500 mm l=5000 mm	concrete, steel	2100 kg	€1800,-	€1600,-
4,02		steel t beam	h=300 mm b=350 mm l=1000-6000 mm	steel	500 kg	€2500,-	€400,-

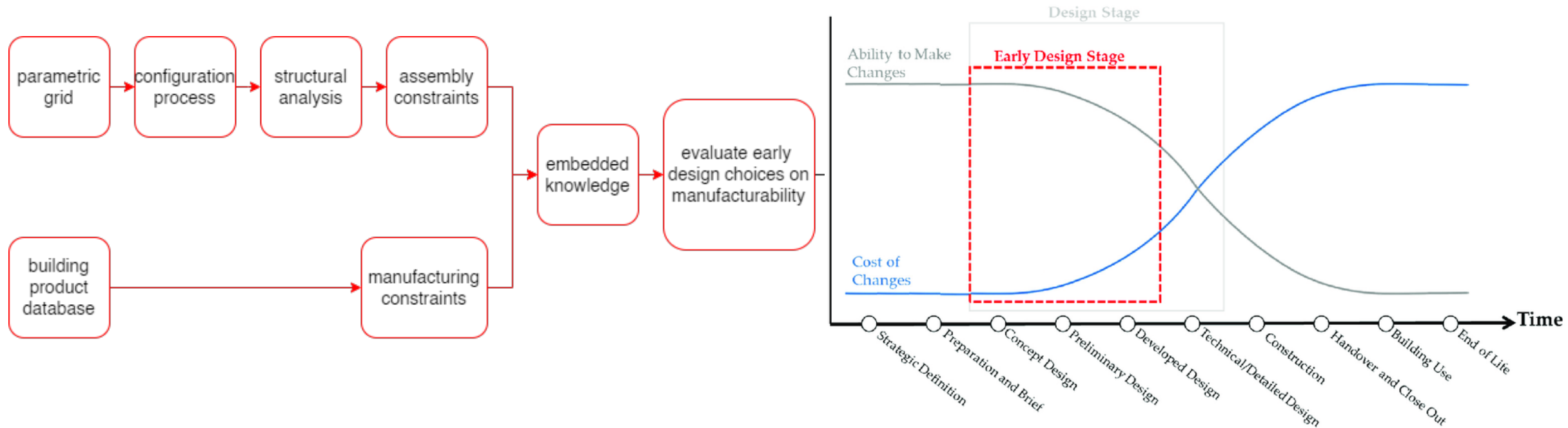
Benefits of the proposed configurator

Main benefits compared to BIM



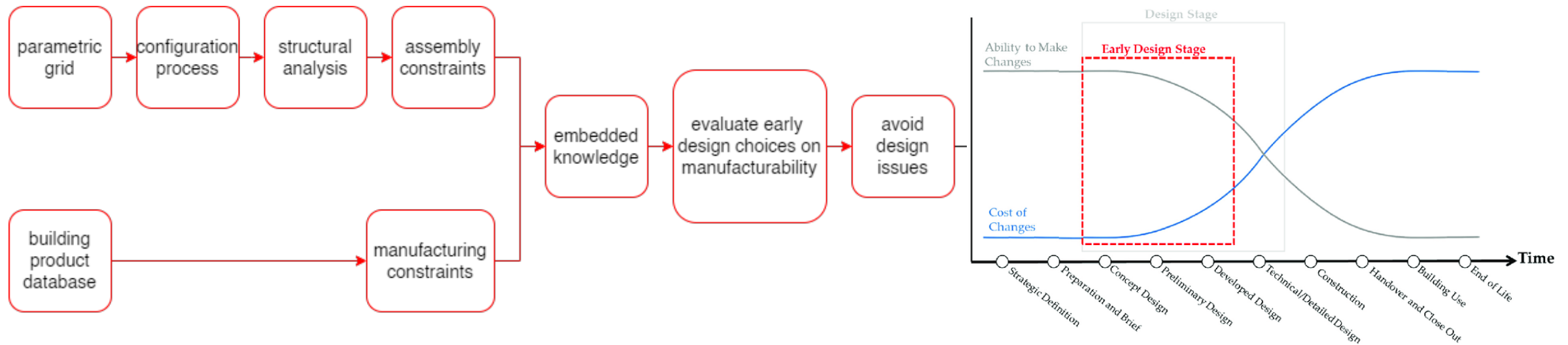
Benefits of the proposed configurator

Main benefits compared to BIM



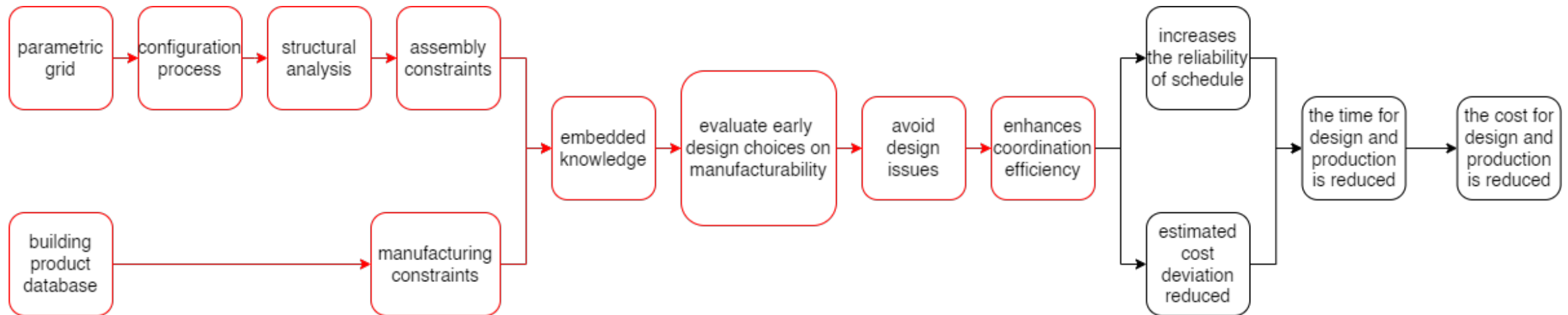
Benefits of the proposed configurator

Main benefits compared to BIM



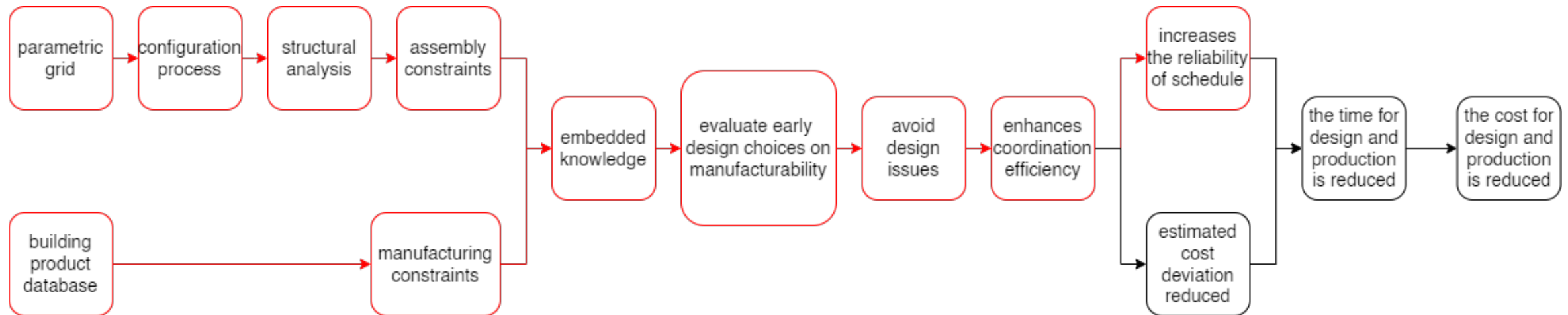
Benefits of the proposed configurator

Main benefits compared to BIM



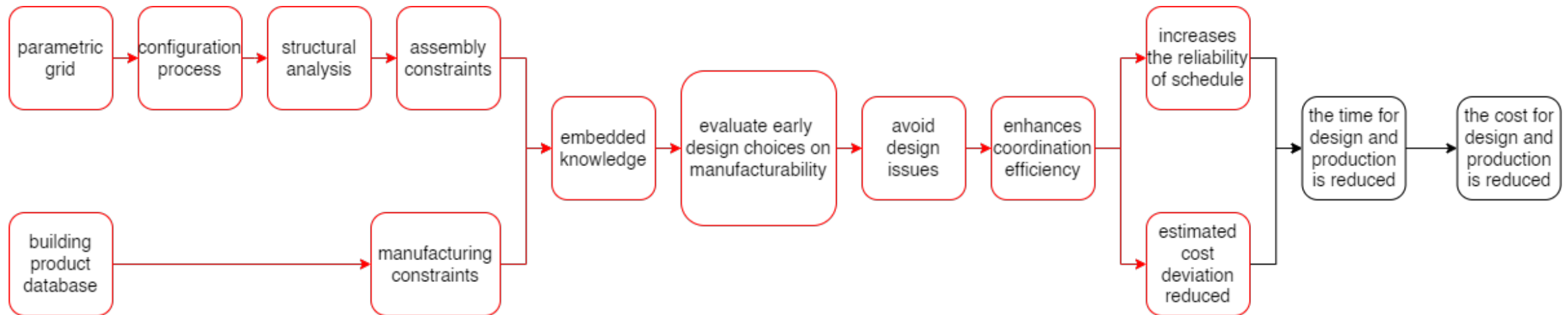
Benefits of the proposed configurator

Main benefits compared to BIM



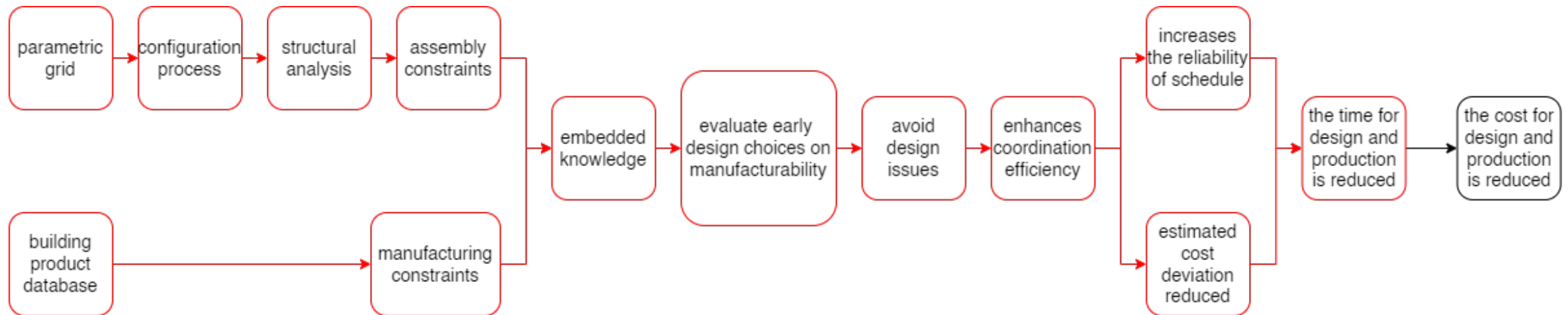
Benefits of the proposed configurator

Main benefits compared to BIM



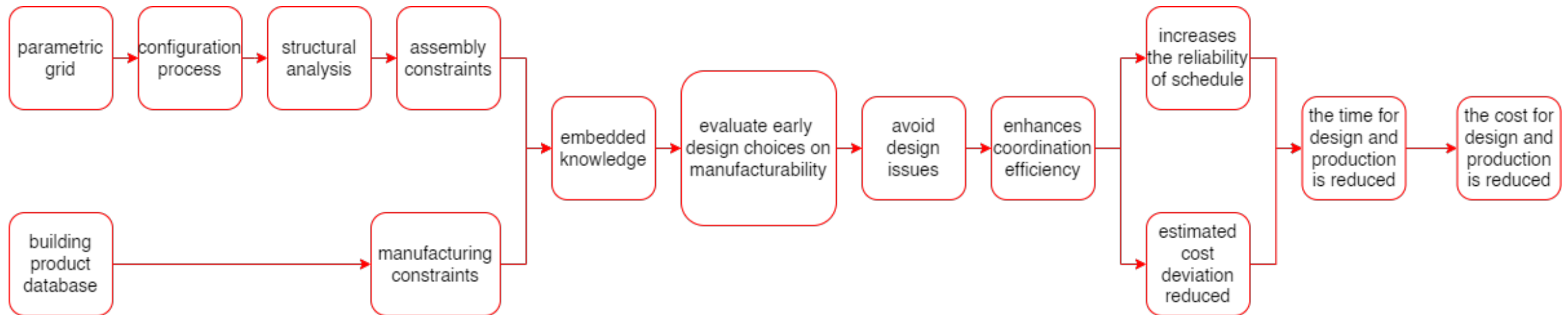
Benefits of the proposed configurator

Main benefits compared to BIM



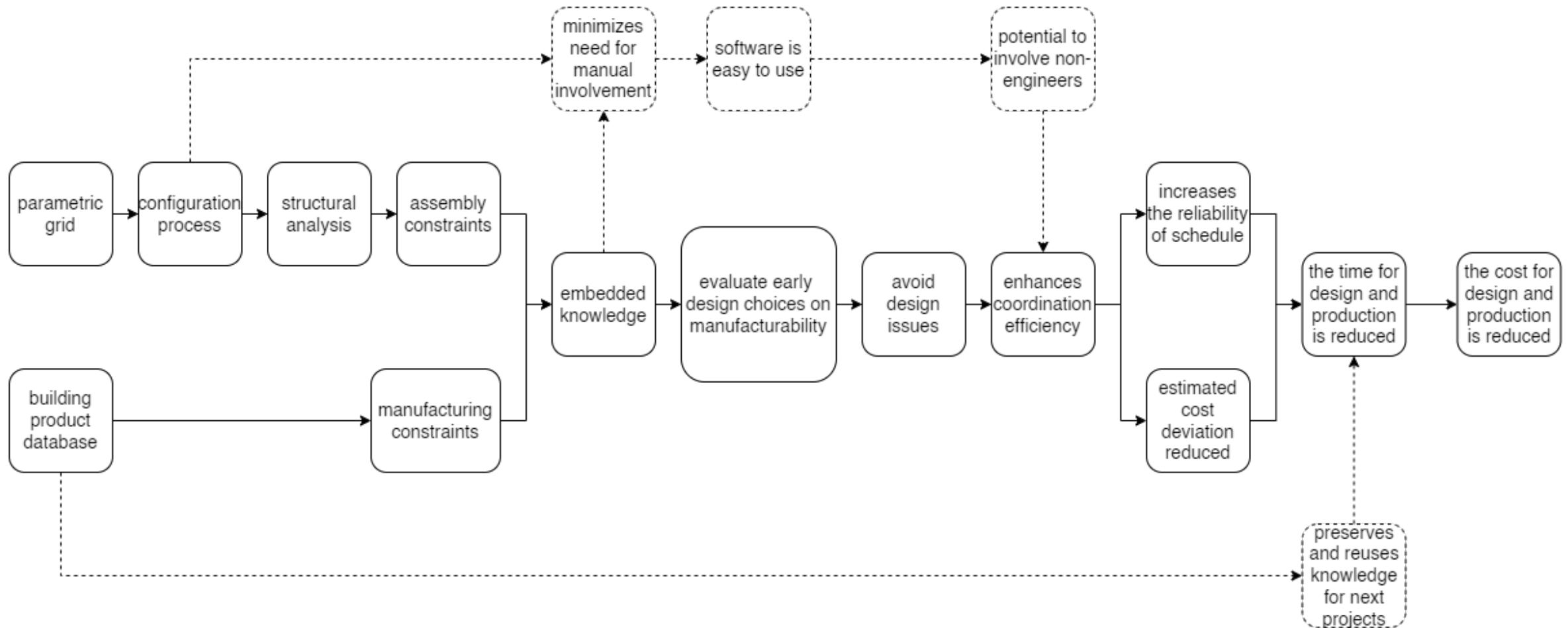
Benefits of the proposed configurator

Main benefits compared to BIM



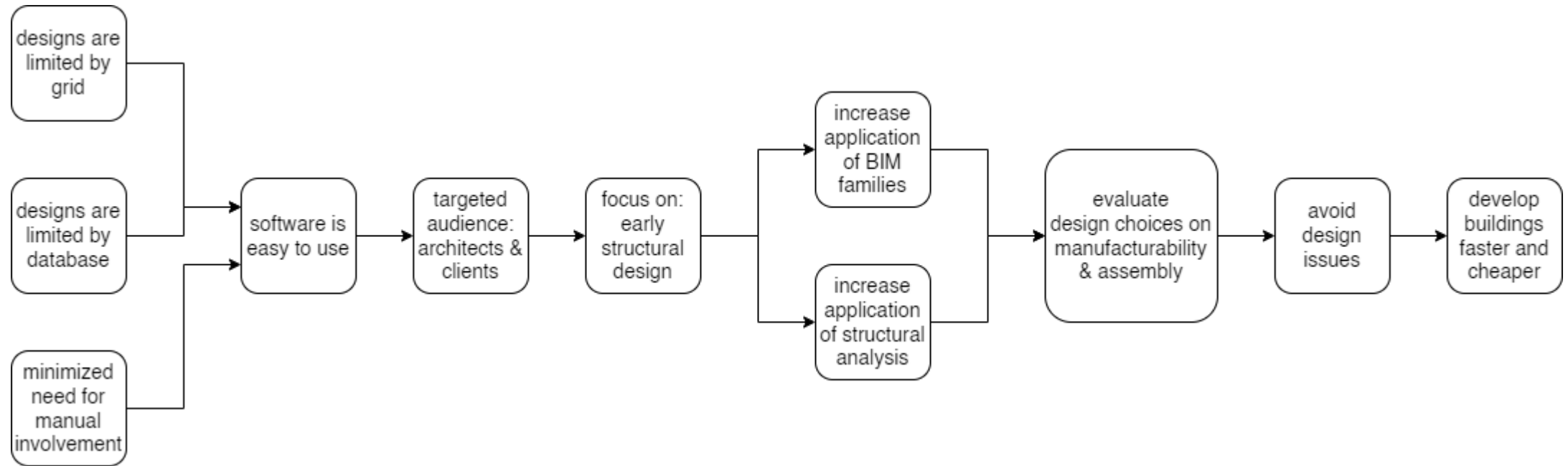
Benefits of the proposed configurator

Additional benefits



Benefits of the proposed configurator

Vision for the configurator



Thank you!

