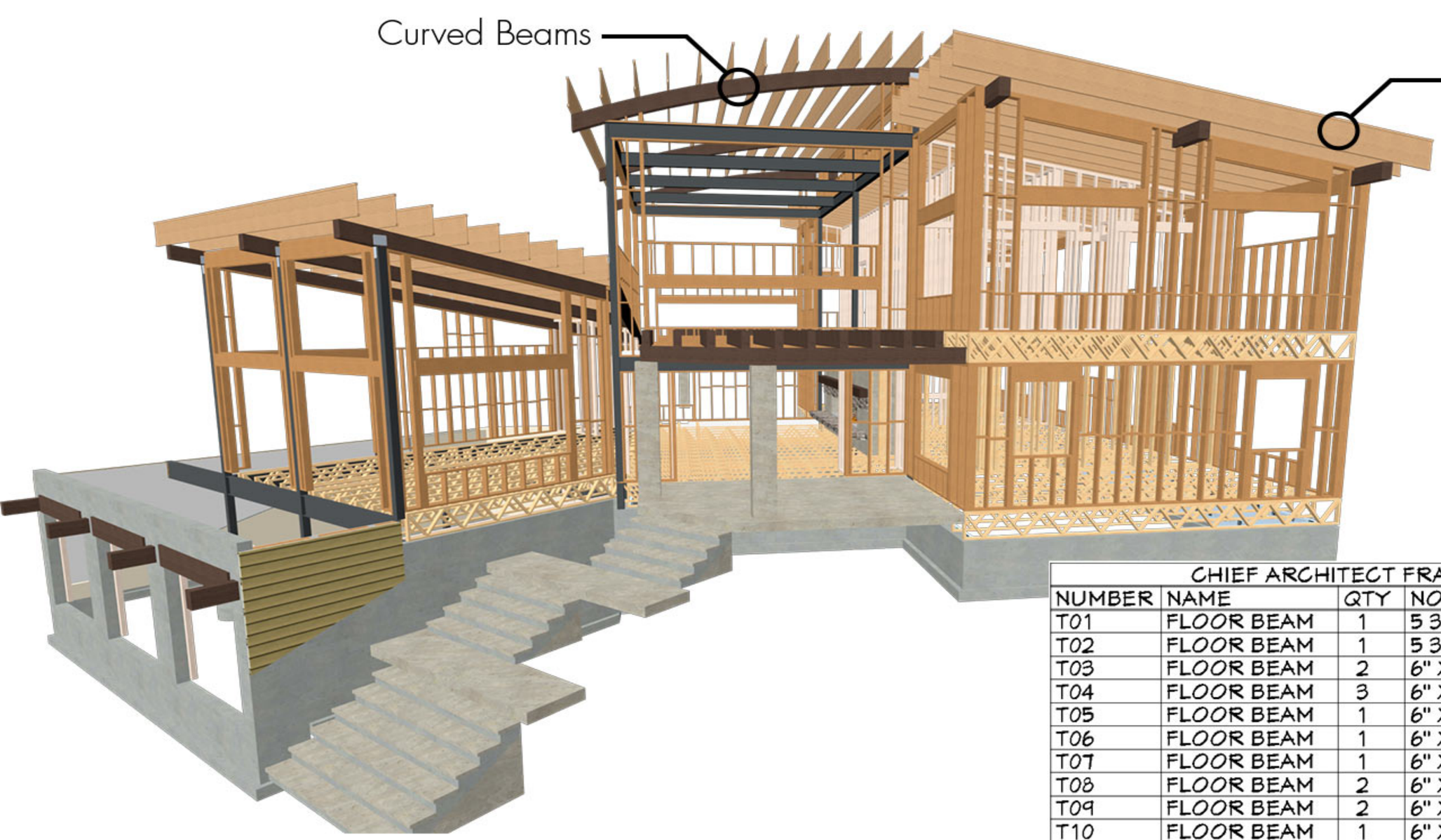
Naadloos een 3D gebouw in een 3D omgeving plaatsen

(maar dan moeten we eerst Geo-BIM integratie regelen…)

Hugo Ledoux (TU Delft) & Friso Penninga (Geonovum)


Dare to Dream



CHIEF ARCHITECT FRAMING SCHEDULE					
NUMBER	NAME	QTY	NOMINAL	LENGTH	TYPE
T01	FLOOR BEAM	1	5 3/8" X 12"	36 7/16"	STEEL-I
T02	FLOOR BEAM	1	5 3/8" X 12"	446"	STEEL-I
T03	FLOOR BEAM	2	6" X 12"	234 3/8"	STEEL-I
T04	FLOOR BEAM	3	6" X 12"	236"	STEEL-I
T05	FLOOR BEAM	1	6" X 12"	245 1/2"	STEEL-I
T06	FLOOR BEAM	1	6" X 12"	245 9/16"	STEEL-I
T07	FLOOR BEAM	1	6" X 12"	422 7/8"	STEEL-I
T08	FLOOR BEAM	2	6" X 12"	454"	STEEL-I
T09	FLOOR BEAM	2	6" X 17"	423 1/8"	STEEL-I
T10	FLOOR BEAM	1	6" X 17"	472 5/8"	STEEL-I
T11	FLOOR TRUSS	117		21"	LUMBER
T12	HEADER	4	2" X 10"	77"	LUMBER
T13	HEADER	2	2" X 10"	89"	LUMBER
T14	HEADER	2	2" X 11 3/8"	46"	LUMBER
T15	HEADER	2	2" X 11"	40"	LUMBER
T16	HEADER	4	2" X 12"	101"	LUMBER

Het ontwerp

De 3D omgeving

GEONOVUM

Bepalen impact

GEONOVUM

Vergunningverlening

Daarom…

- Integratie van Geo en BIM modellen
- Doel: ontwikkel een interface tussen CityGML en IFC
- Uitvoering:

TU Delft TU/e Technische Universiteit Eindhoven University of Technology

- Partners:

Gemeente Rotterdam Den Haag Rijkswaterstaat Ministerie van Infrastructuur en Milieu BIM Loket

not only the two of us...

Ken Arroyo Ohori
Postdoc (TUD)

Jakob Beetz
Assistant-prof. (TU/e)

Abdoulaye Diakité
Postdoc (TUD)

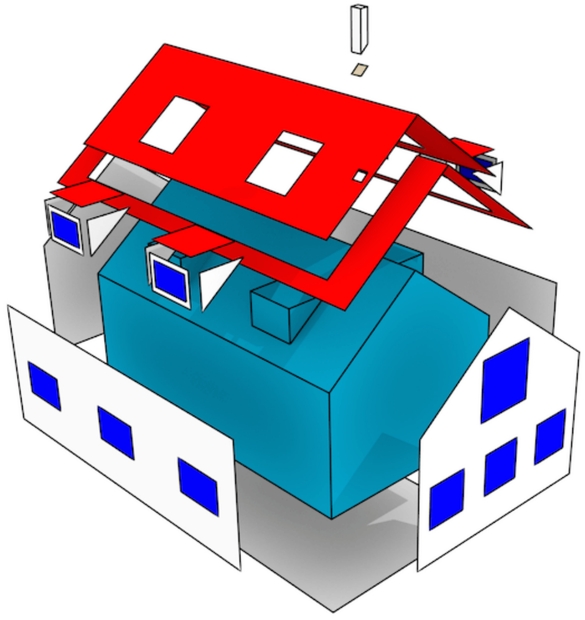
Thomas Krijnen
PhD candidate (TU/e)

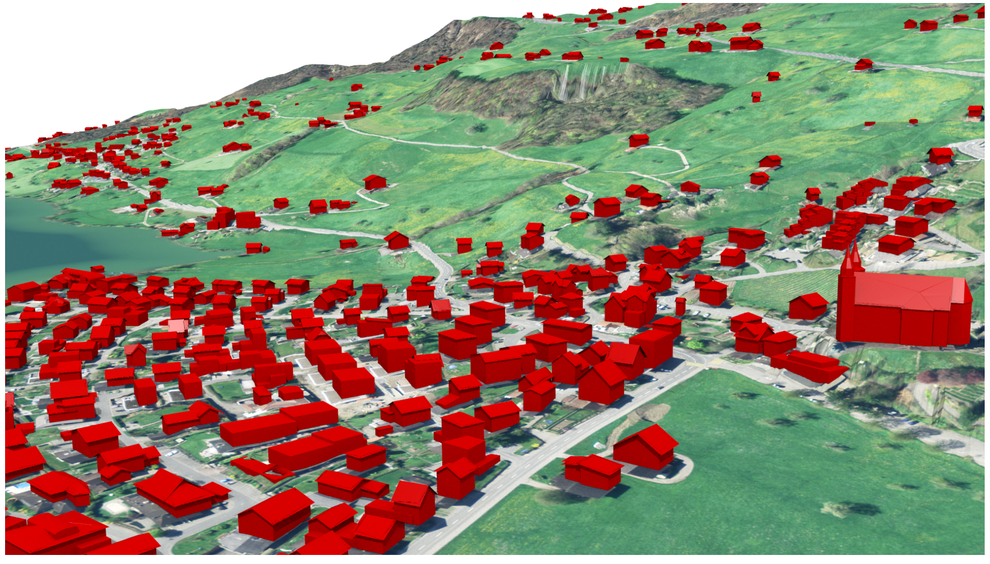
Hugo Ledoux
Associate-prof. (TUD)

Jantien Stoter
Professor (TUD)

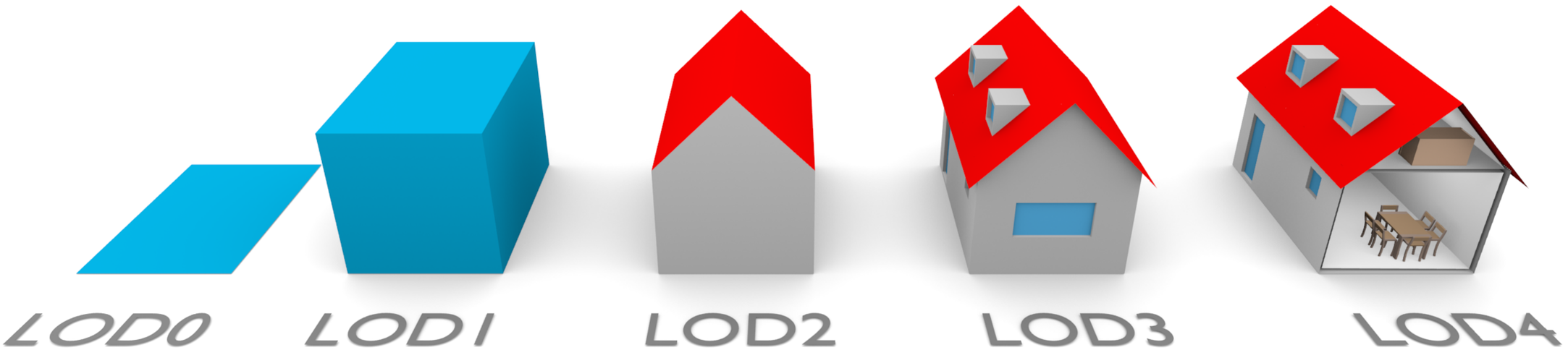
CityGML

- int'l standard for representing and storing 3D city models
- mostly scale of the city/neighbourhood
- boundary representation used (b-rep)





CityGML: 5 Levels-of-detail

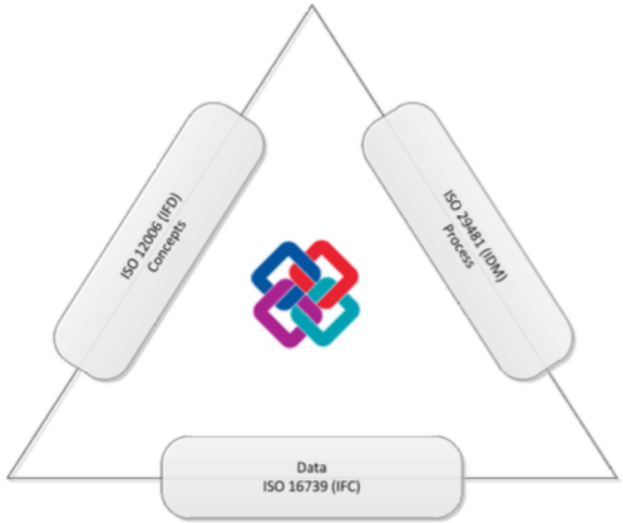


there usually reconstructed ‘as-built’, because “easy” with point clouds

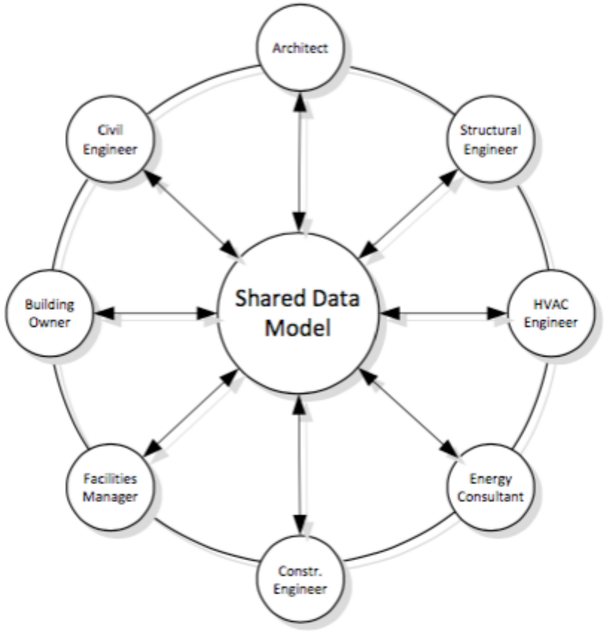
rather rare in practice, because costly and complex to acquire data

IFC (Industry Foundation Classes)

- open data model for *buildings* and construction industry data
- one implementation of BIM (Building Information Modelling)



(A) buildingSMART standards for BIM



(B) IFC, a shared data model

IFC (Industry Foundation Classes)

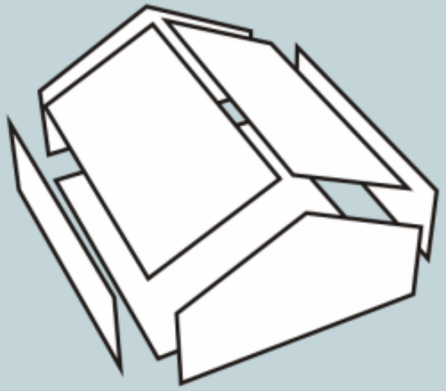
IfcActuatorType
IfcAirTerminalBoxType
IfcAirTerminalType
IfcAirToAirHeatRecoveryType
IfcAlarmType
IfcAnnotation
IfcBeam
IfcBoilerType
IfcBuildingElementPart
IfcBuildingElementProxy
IfcBuildingStorey
IfcCableCarrierFittingType
IfcCableCarrierSegmentType
IfcCableSegmentType
IfcChillerType
IfcCoilType
IfcColumnType
IfcCompressorType
IfcCondenserType
IfcControllerType
IfcCooledBeamType
IfcCoolingTowerType
IfcCovering
IfcCurtainWall
IfcDamperType
IfcDistributionChamberElementType
IfcDistributionControlElement
IfcDistributionElement
IfcDistributionFlowElement
IfcDoorType
IfcDuctFittingType
IfcDuctSegmentType
IfcDuctSilencerType
IfcElectricApplianceType
IfcElectricFlowStorageDeviceType
IfcElectricGeneratorType
IfcElectricHeaterType
IfcElectricMotorType
IfcElectricTimeControlType
IfcElementAssembly
IfcEnergyConversionDevice
IfcEvaporativeCoolerType
IfcEvaporatorType
IfcFanType
IfcFastenerType
IfcFilterType
IfcFireSuppressionTerminalType
IfcFlowController
IfcFlowFitting
IfcFlowInstrumentType
IfcFlowMeterType
IfcFlowMovingDevice
IfcFlowSegment
IfcFlowStorageDevice
IfcFlowTerminal
IfcFlowTreatmentDevice
IfcFooting
IfcFurnishingElement
IfcFurnitureType
IfcGasTerminalType
IfcHeatExchangerType
IfcHumidifierType
IfcJunctionBoxType
IfcLampType
IfcLightFixtureType
IfcMechanicalFastenerType
IfcMemberType
IfcMotorConnectionType
IfcOpeningElement
IfcOutletType
IfcPile
IfcPipeFittingType
IfcPipeSegmentType
IfcPlateType
IfcProtectiveDeviceType
IfcPumpType
IfcRailing
IfcRamp
IfcReinforcingBar
IfcReinforcingMesh
IfcRoof
IfcSanitaryTerminalType
IfcSensorType
IfcSite
IfcSlab
IfcSpace
IfcSpaceHeaterType
IfcStackTerminalType
IfcStair
IfcSwitchingDeviceType
IfcSystemFurnitureElementType
IfcTankType
IfcTransformerType
IfcTransportElementType
IfcTubeBundleType
IfcUnitaryEquipmentType
IfcValveType
IfcWall
IfcWasteTerminalType
IfcWindowType

900+ in total

IFC (Industry Foundation Classes)

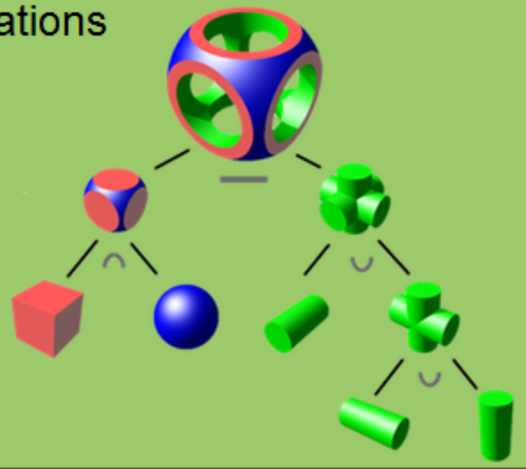
Boundary Representation

Aggregation of boundary surfaces, which enclose the body completely



Constructive Solid Geometry

- 3D primitives
- Combined by boolean operations



Sweep Volume

Extrusion of a face along a defined path

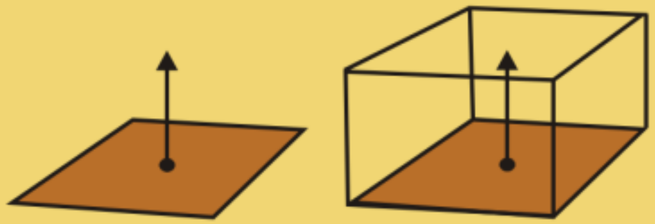
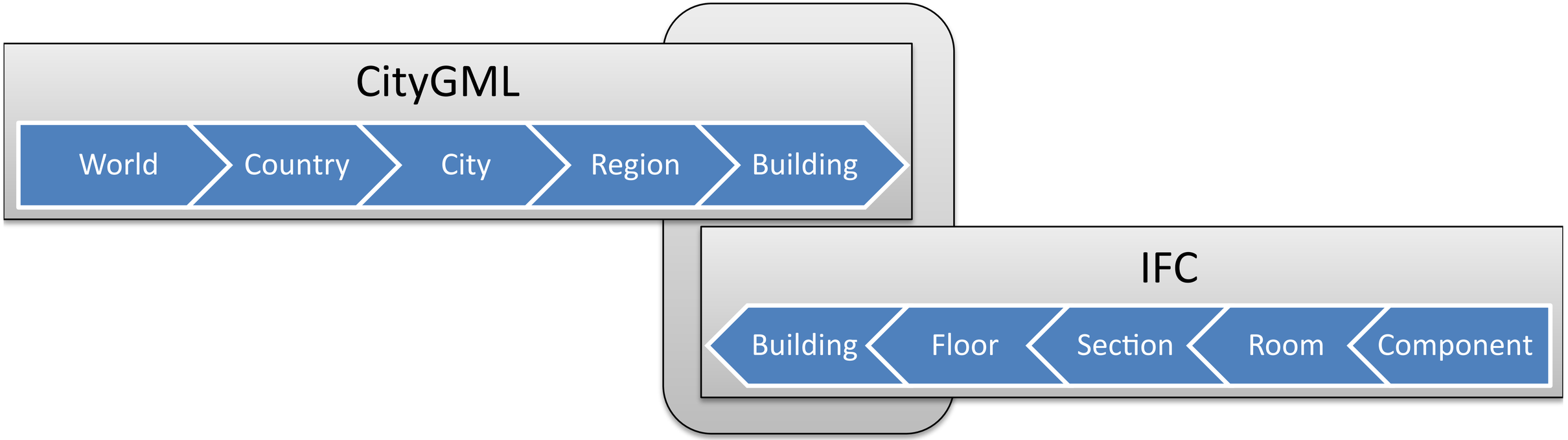


Figure adapted from Kolbe and Plümer (2004)

explicit representation

implicit representation
(need to be discretised to be manipulated with GIS objects)

IFC vs CityGML



IFC vs CityGML

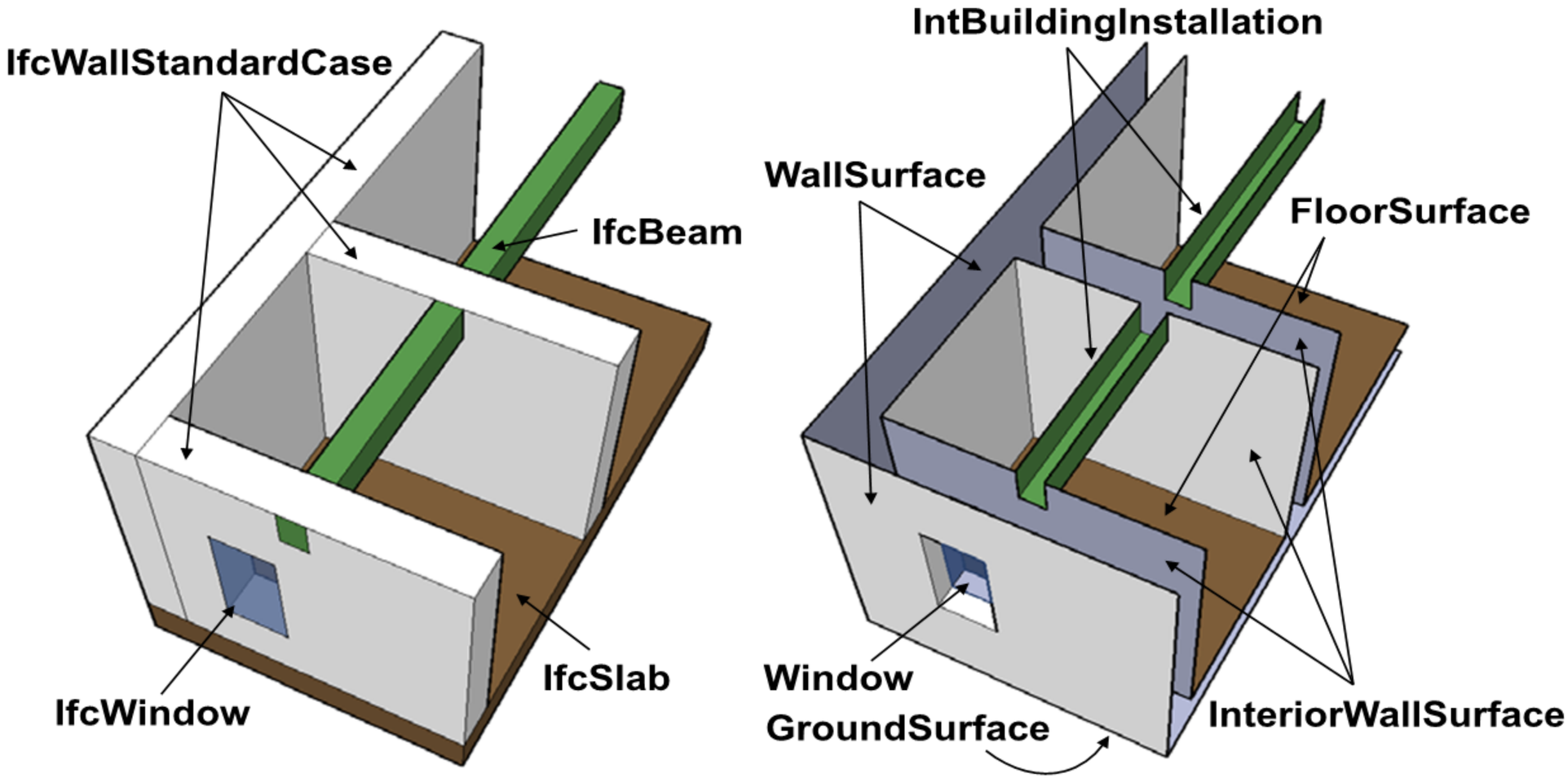


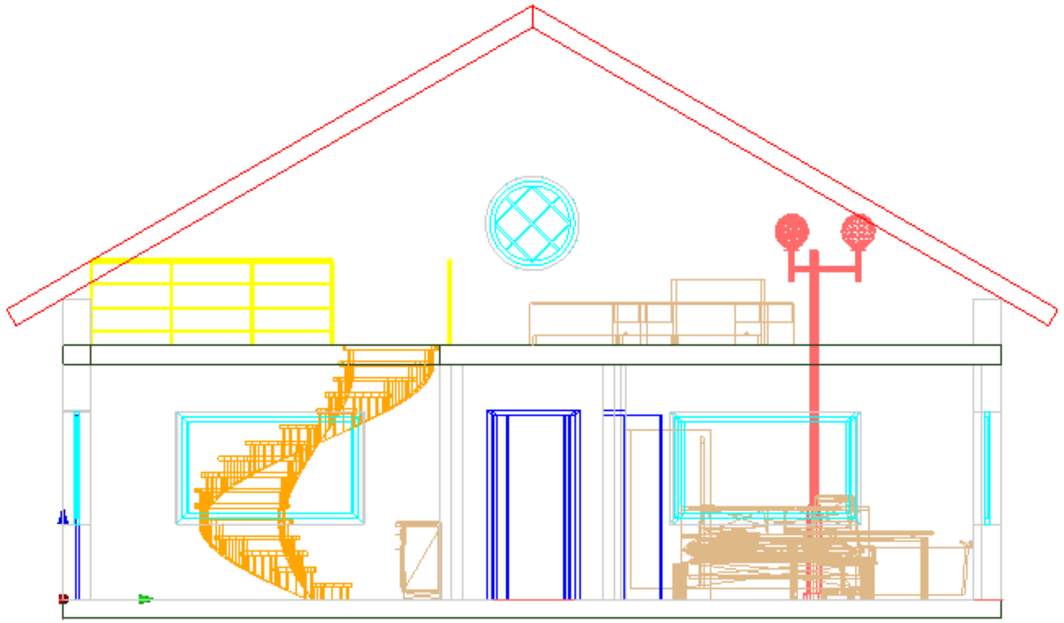
Figure Nagel et. al (2009)

Bridging the gaps between IFC and CityGML

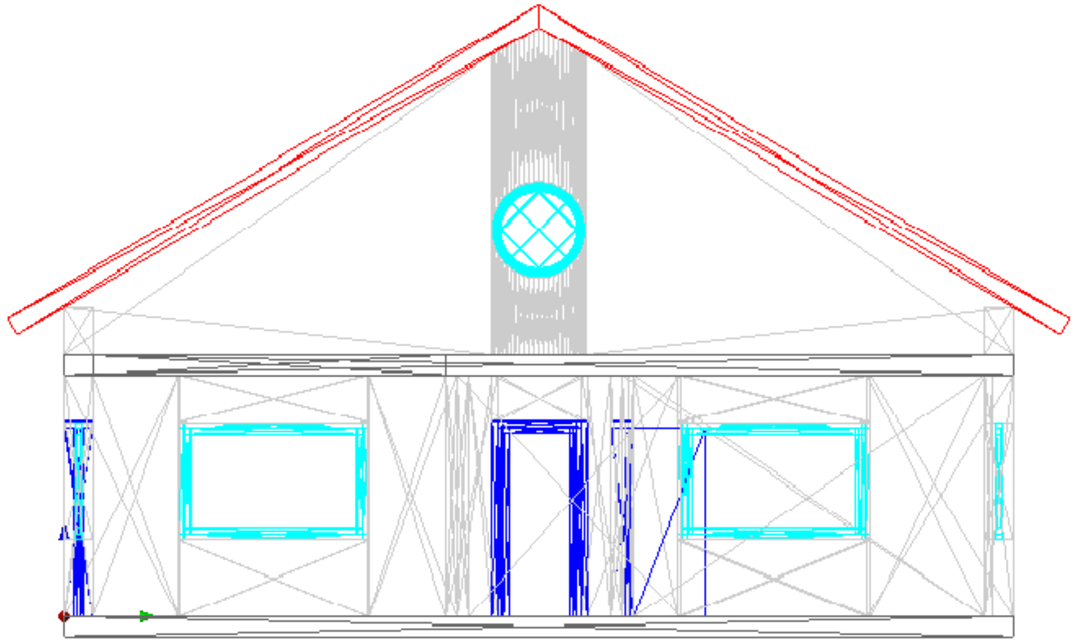
1. gap in semantic
2. gap in geometry/topology
3. gap in coordinate reference systems

Results with current commercial software

most geometries are converted



IFC



CityGML

Our goal

Develop an interface between CityGML and IFC to prepare for a fundamental solution to bridge the gap between Geo and BIM.

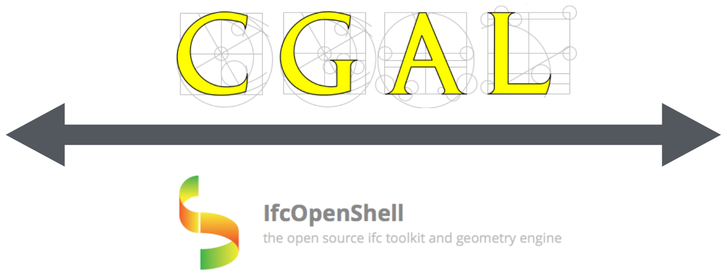
1. open-source API to represent IFC + CityGML with the same data structure
2. recommendations for future integration

CGAL + IfcOpenShell

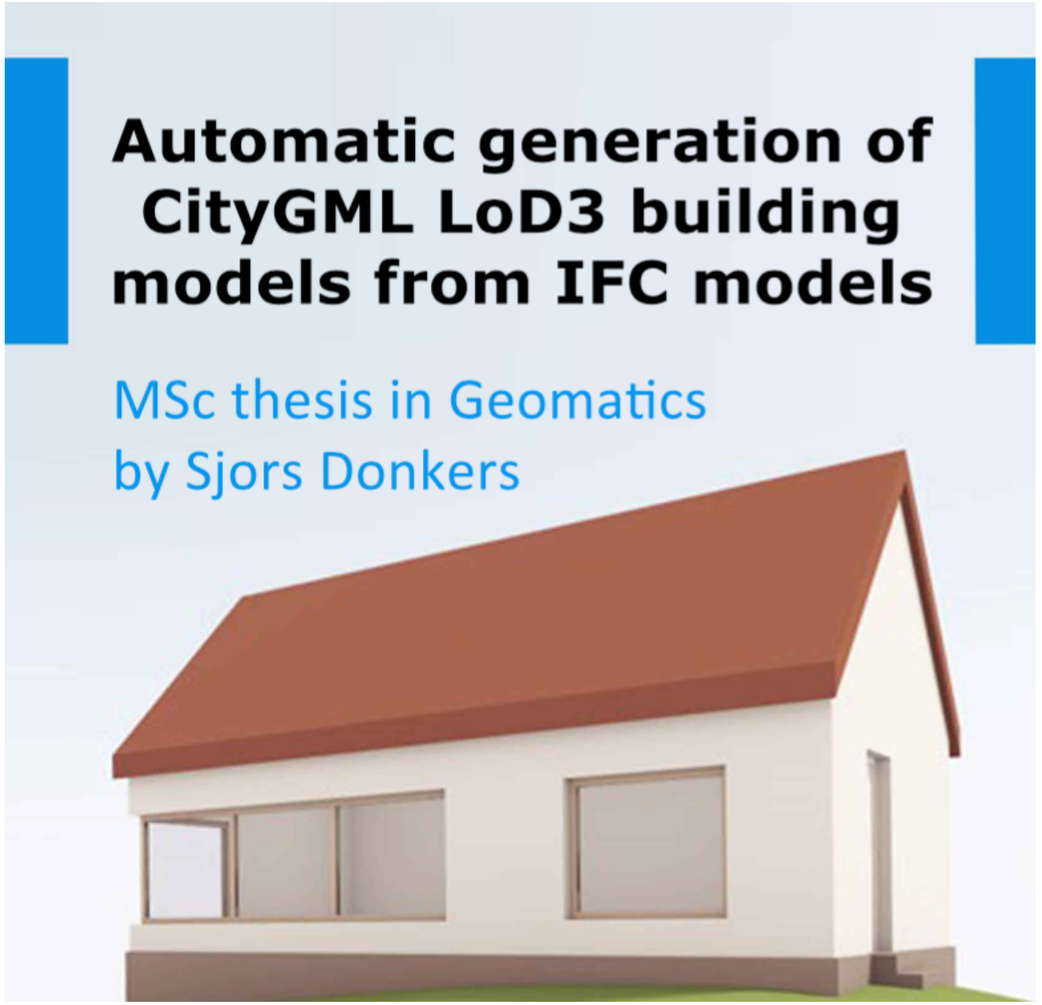
the open source ifc toolkit and geometry engine

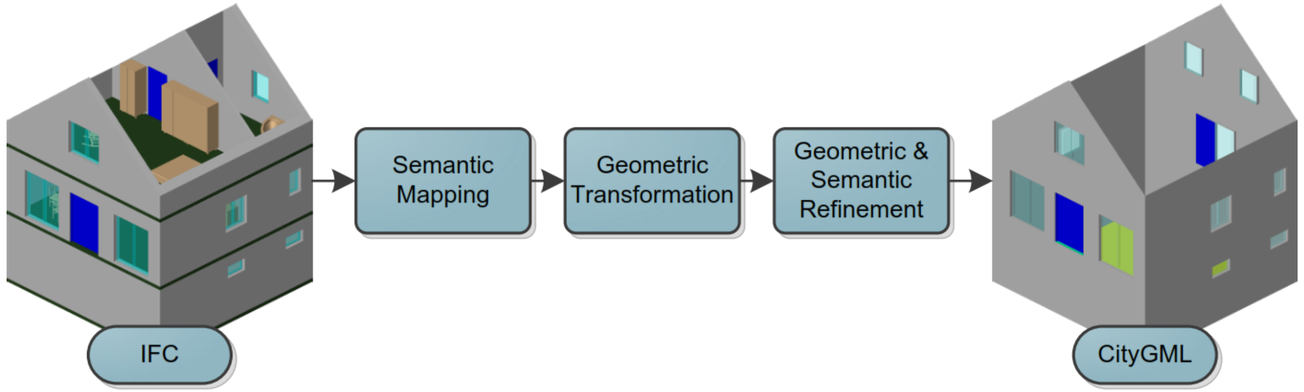
Use-case #1

Supporting the lifecycle of objects with a continuous information chain, ie using geoinformation in BIM application and IFC datasets in GIS applications.



we’re building on our previous results



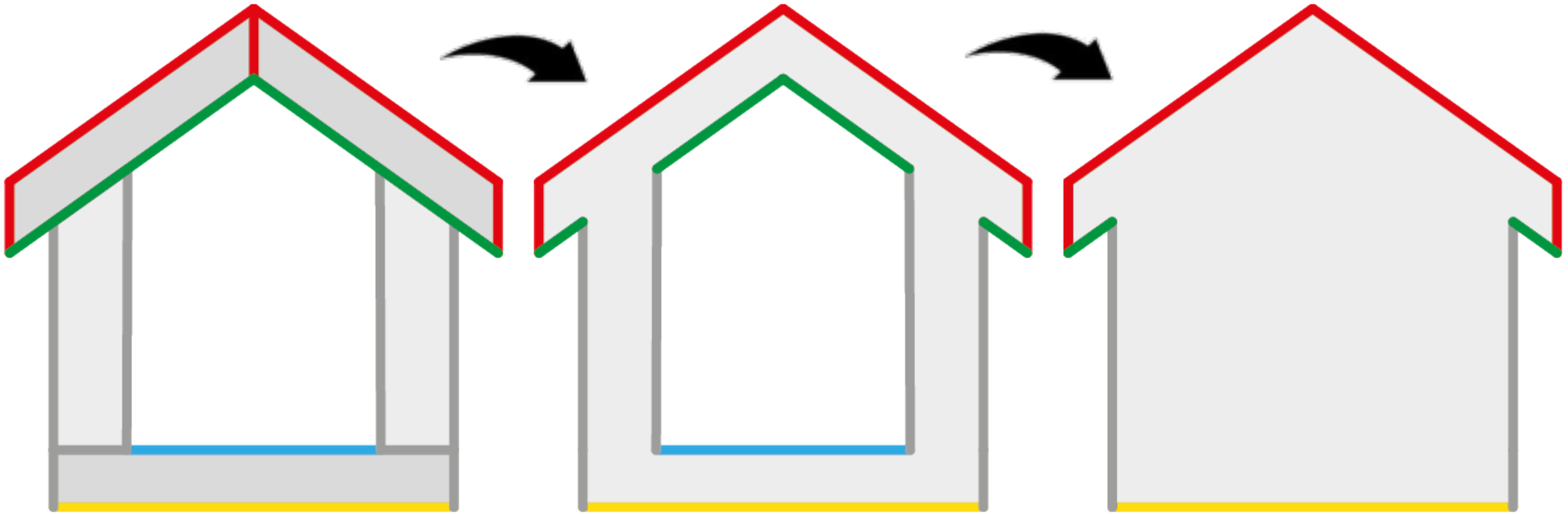


a series of geometric transformation

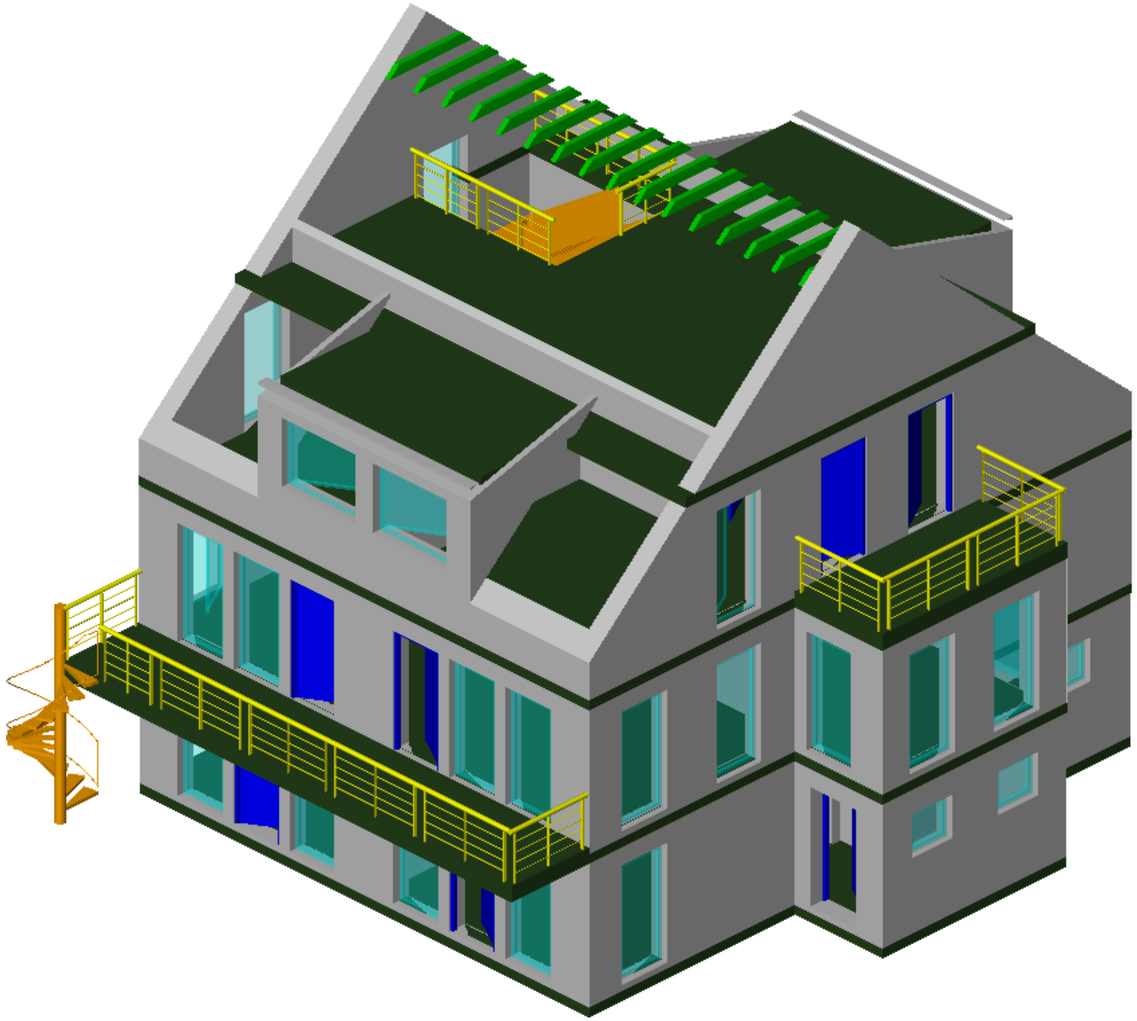
input IFC

union of all solids

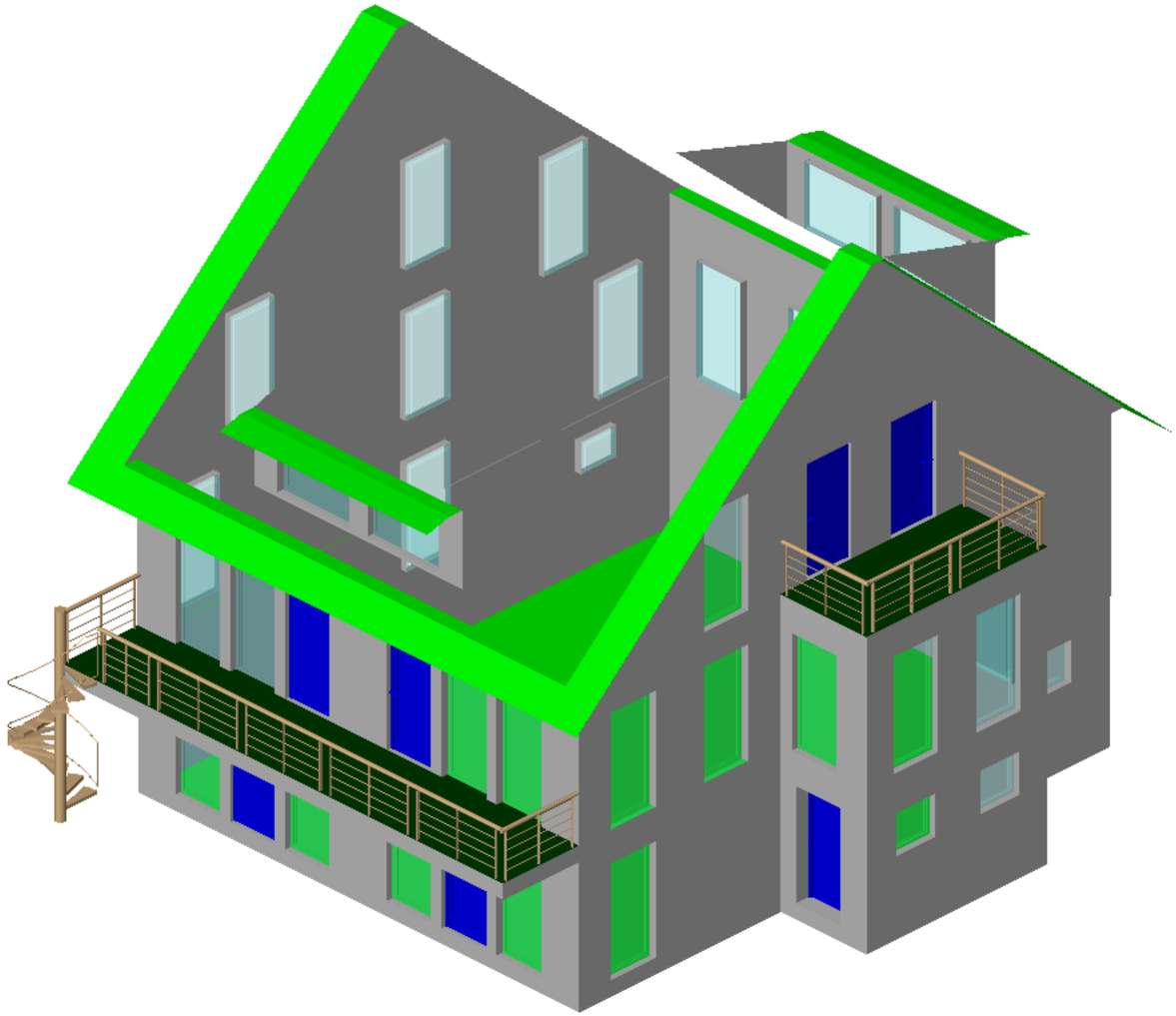
removal interior



we’re building on our previous results, for instance:



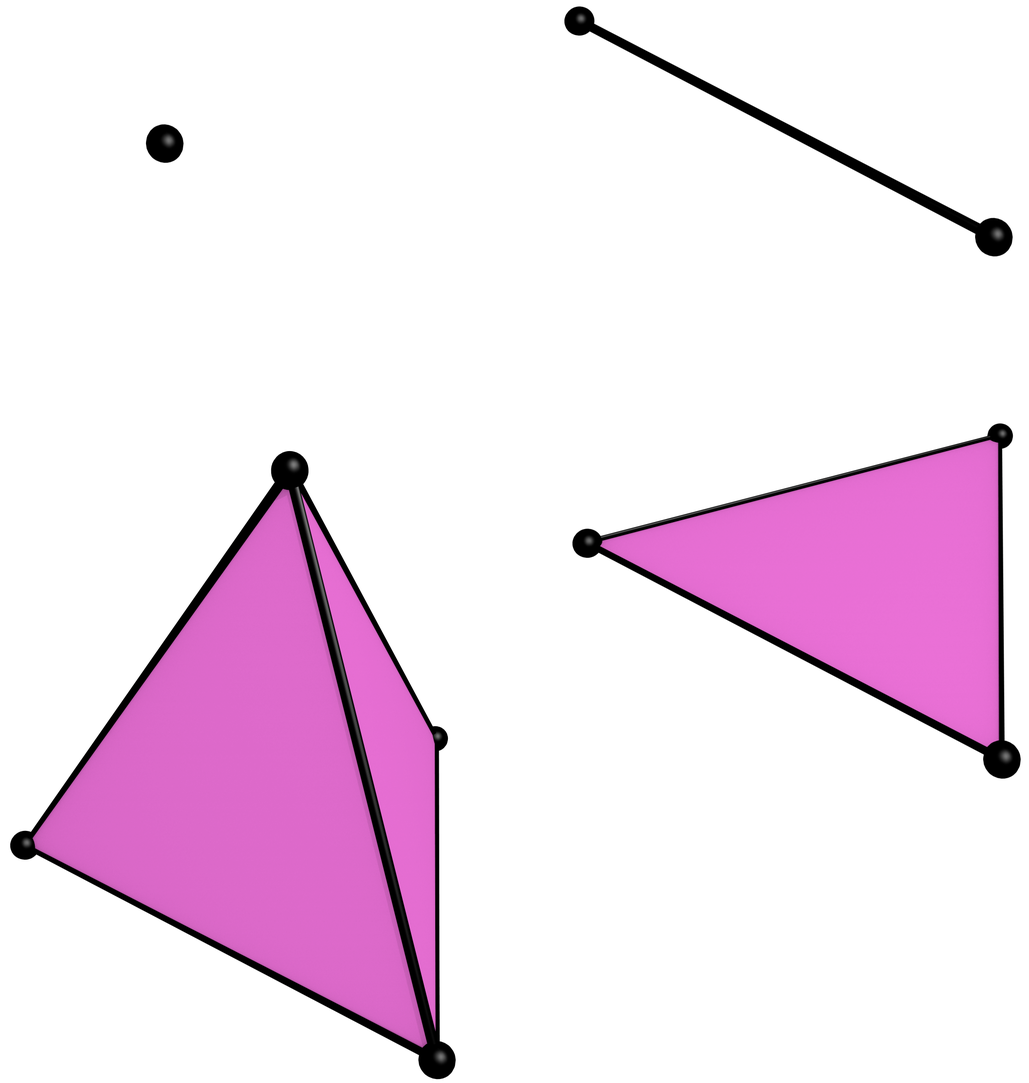
IFC



CityGML

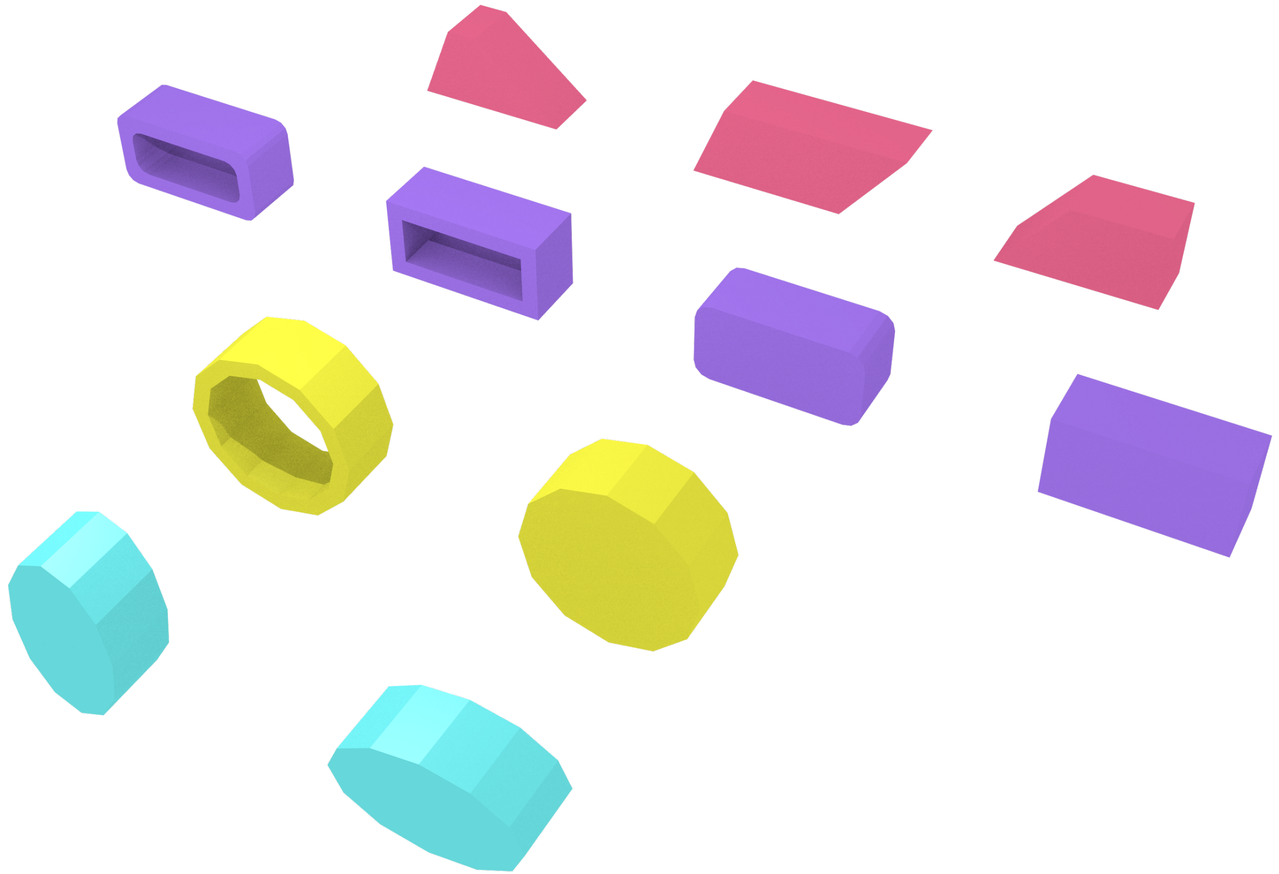
Simple primitives to support

- IfcCartesianPoint
- IfcDirection
- IfcVector
- IfcPlane



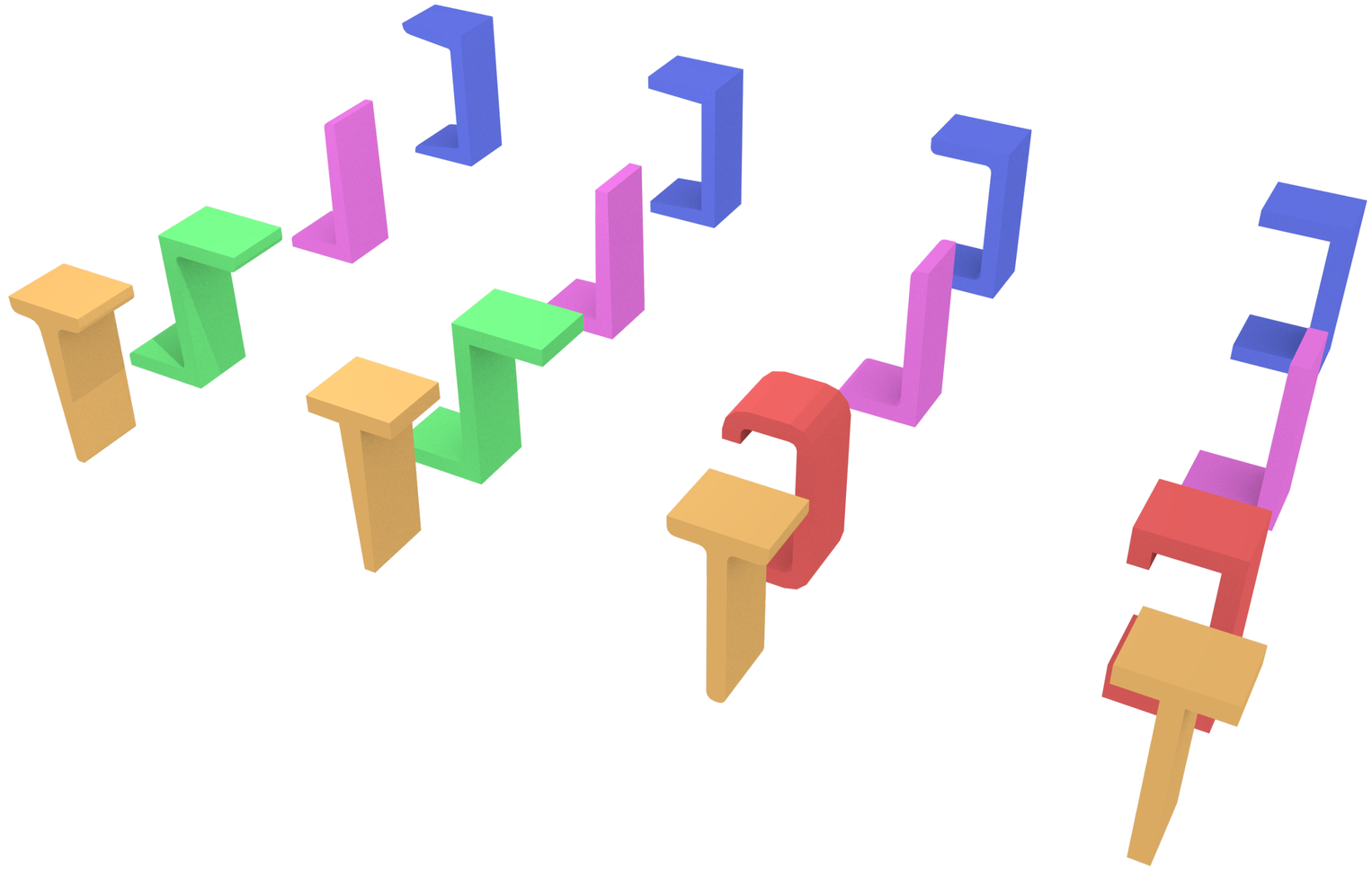
More complex primitives to support

- IfcArbitraryClosedProfileDef
- IfcArbitraryProfileDefWithVoids
- IfcRectangleProfileDef
- IfcRoundedRectangleProfileDef
- IfcRectangleHollowProfileDef
- IfcTrapeziumProfileDef
- IfcCircleProfileDef
- IfcCircleHollowProfileDef
- IfcEllipseProfileDef
- IfcFace



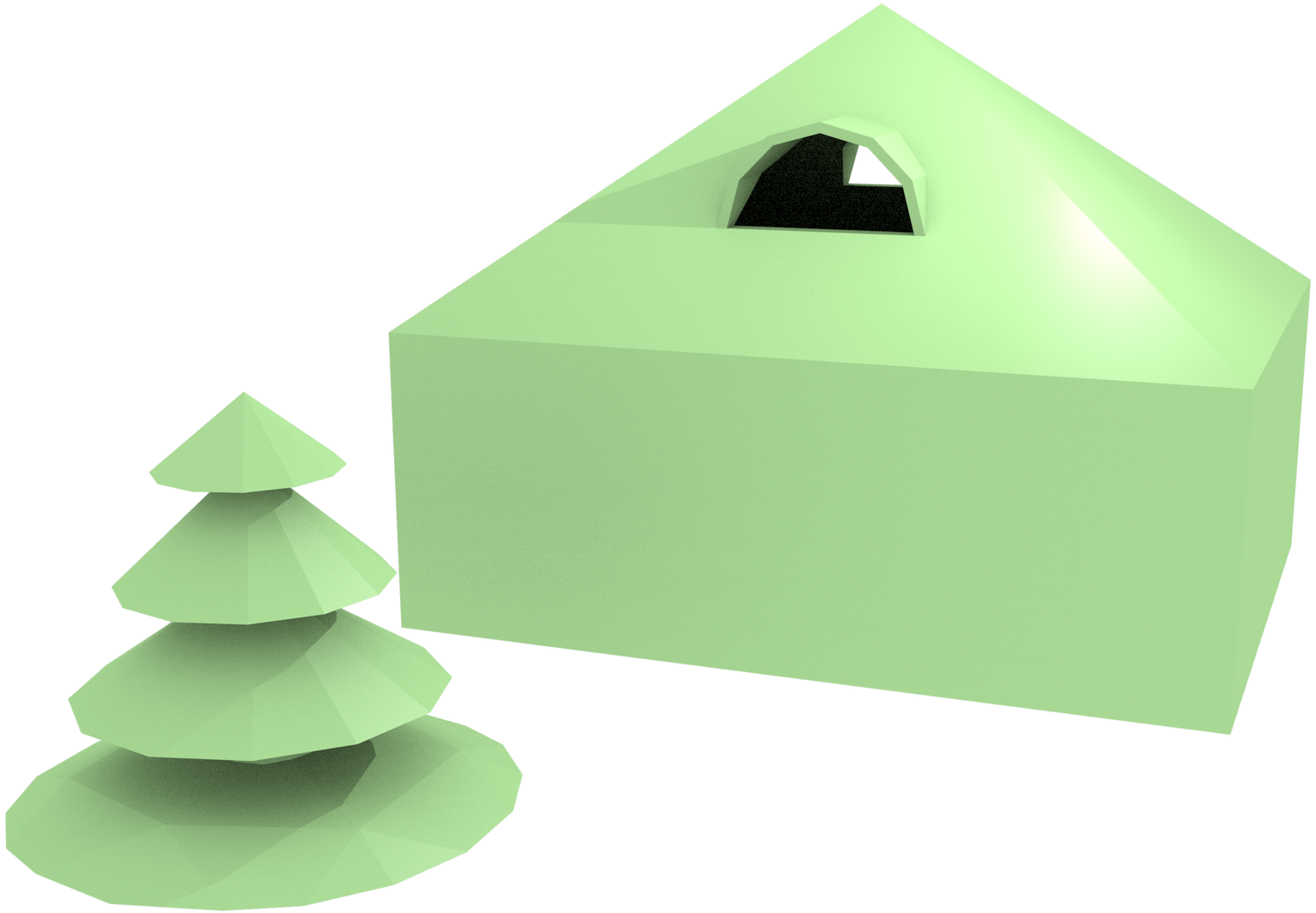
More complex primitives to support (more!)

- IfcCShapeProfileDef
- IfcLShapeProfileDef
- IfcIShapeProfileDef
- IfcTShapeProfileDef
- IfcUShapeProfileDef
- IfcZShapeProfileDef
- IfcDerivedProfileDef

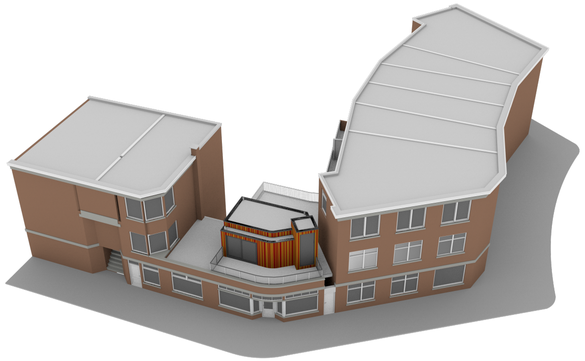


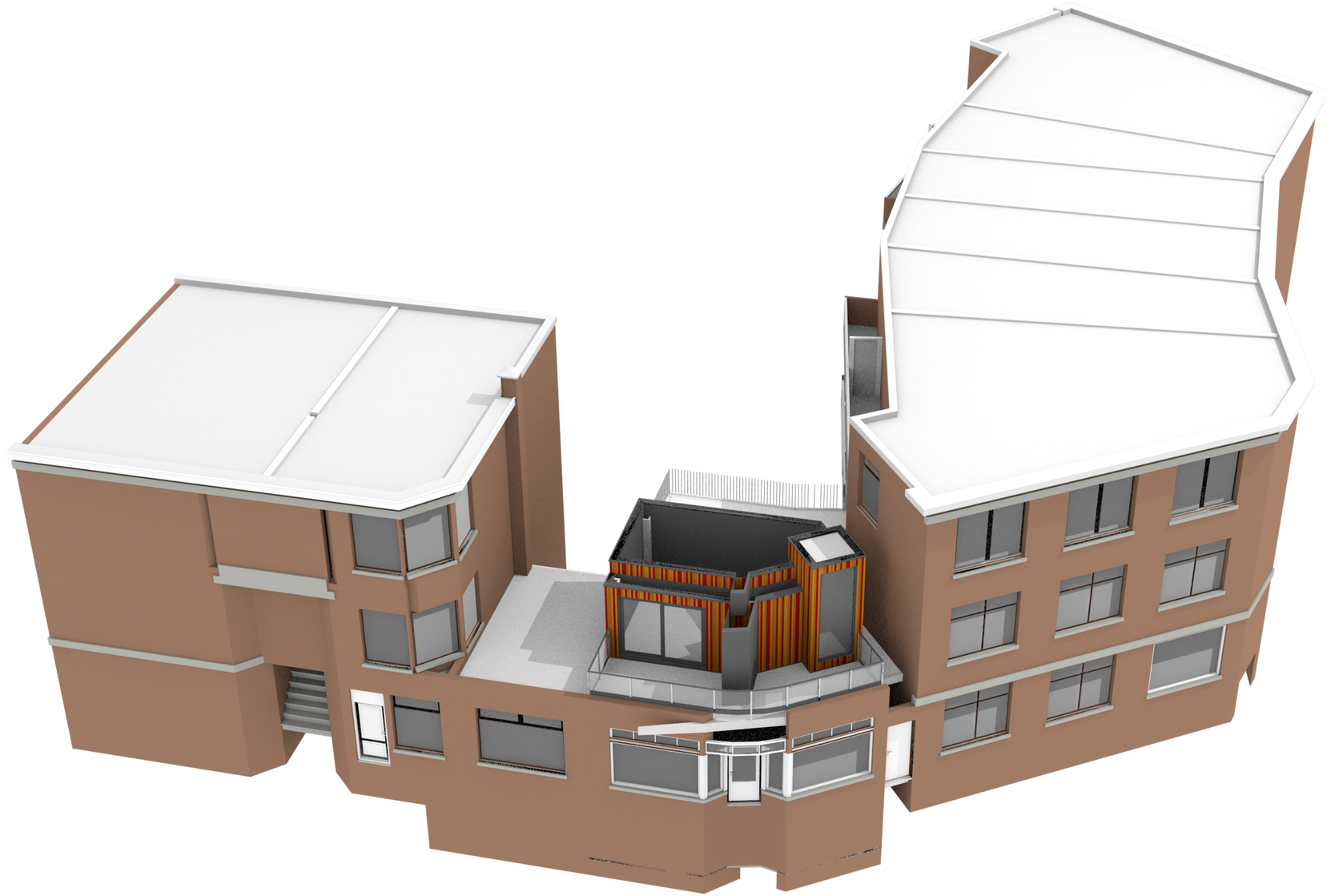
Volumetric shapes also

- IfcExtrudedAreaSolid
- IfcExtrudedAreaSolidTapered
- IfcConnectedFaceSet
- IfcCsgSolid
- IfcBlock
- IfcBooleanResult
- IfcSphere
- IfcRectangularPyramid
- IfcRightCircularCylinder
- IfcRightCircularCone
- IfcTriangulatedFaceSet
- IfcHalfSpaceSolid

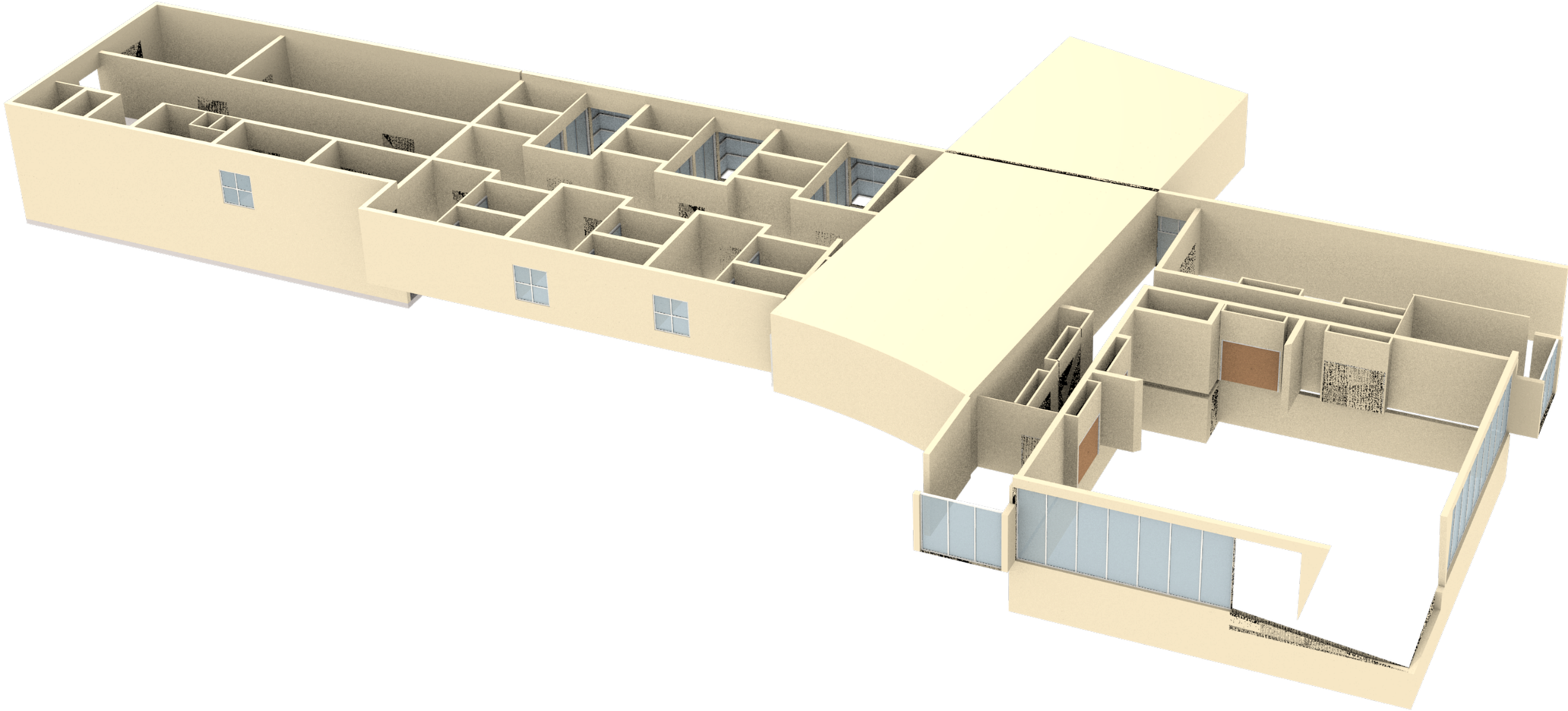


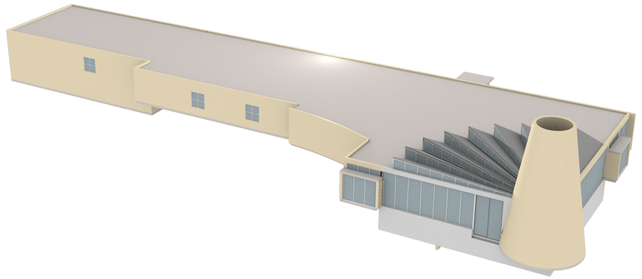
Our current results: Rabarberstraat144





Our current results: CUVO Ockenburghstraat KOW





Use-case #2

Submission of IFC model to a building permit-application portal: automatic validation of the design against physical world (eg noise, shadows, zoning plans)

Use-case #2

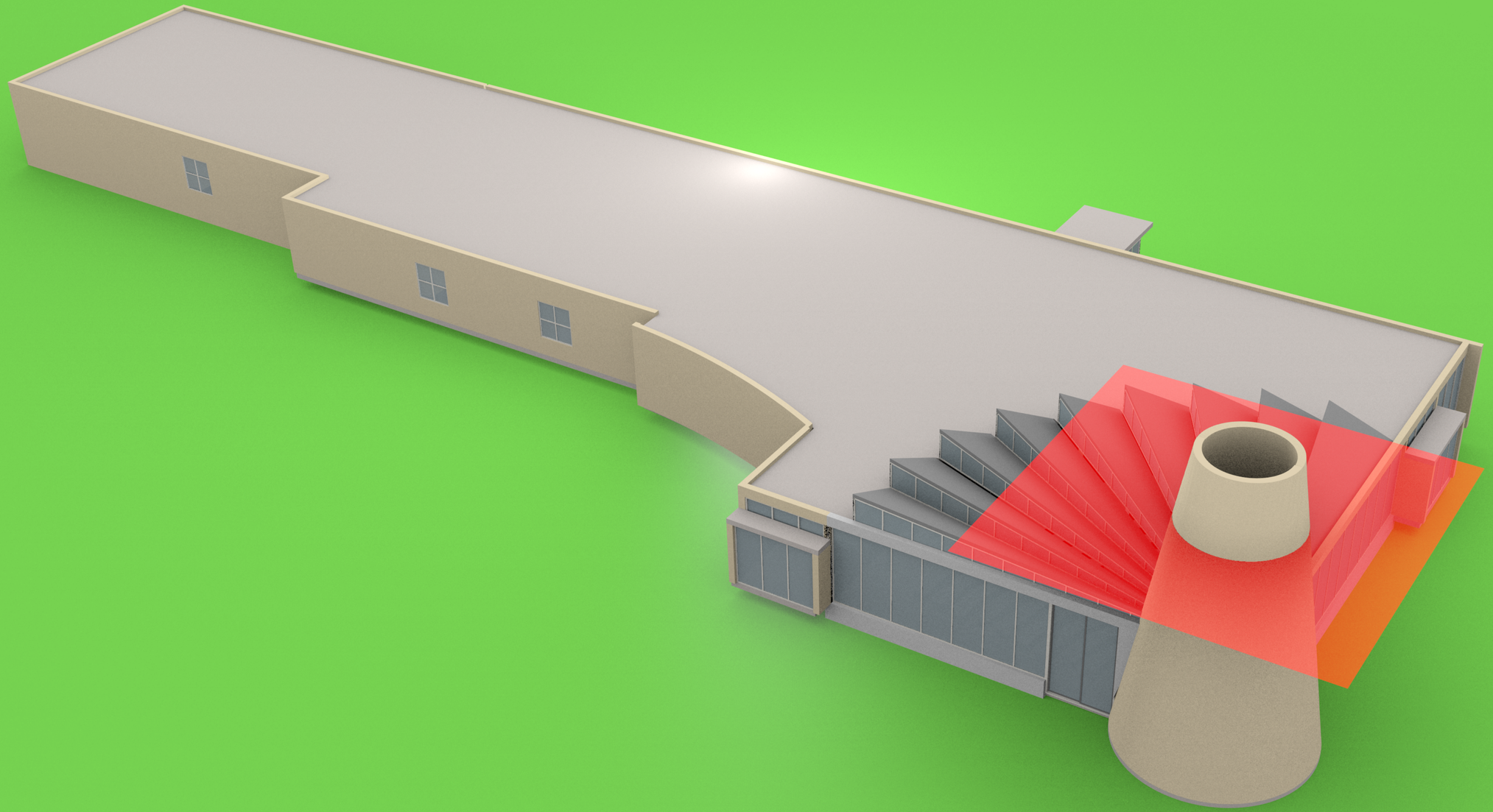
Submission of IFC model to a building permit-application portal: automatic validation of the design against physical world (eg noise, shadows, zoning plans)

georeferencing = a problem in practice (really?)

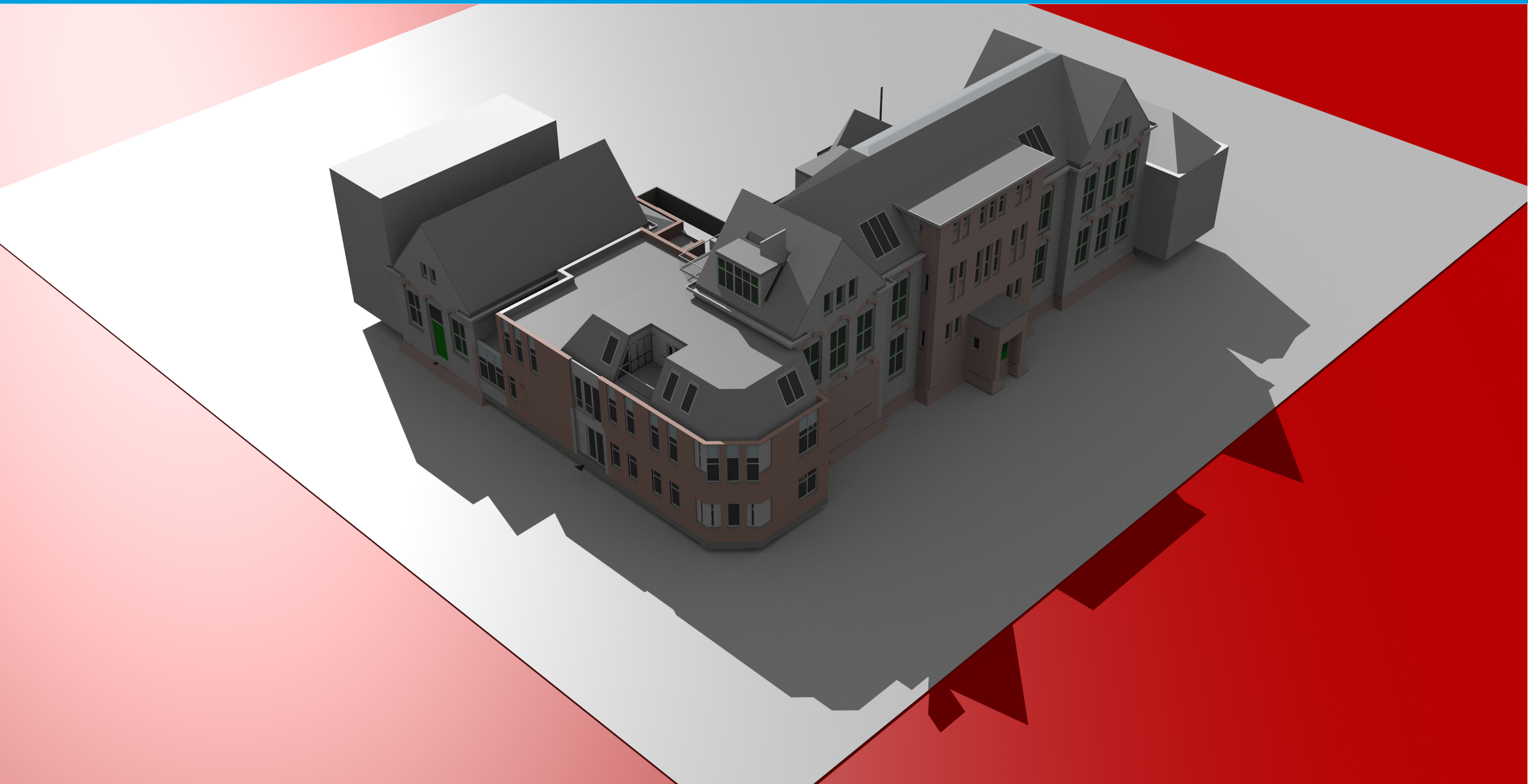
location in the IFC file

in reality it is a
few kms away

example use-case: verify maximum height allowed (zoning plans)

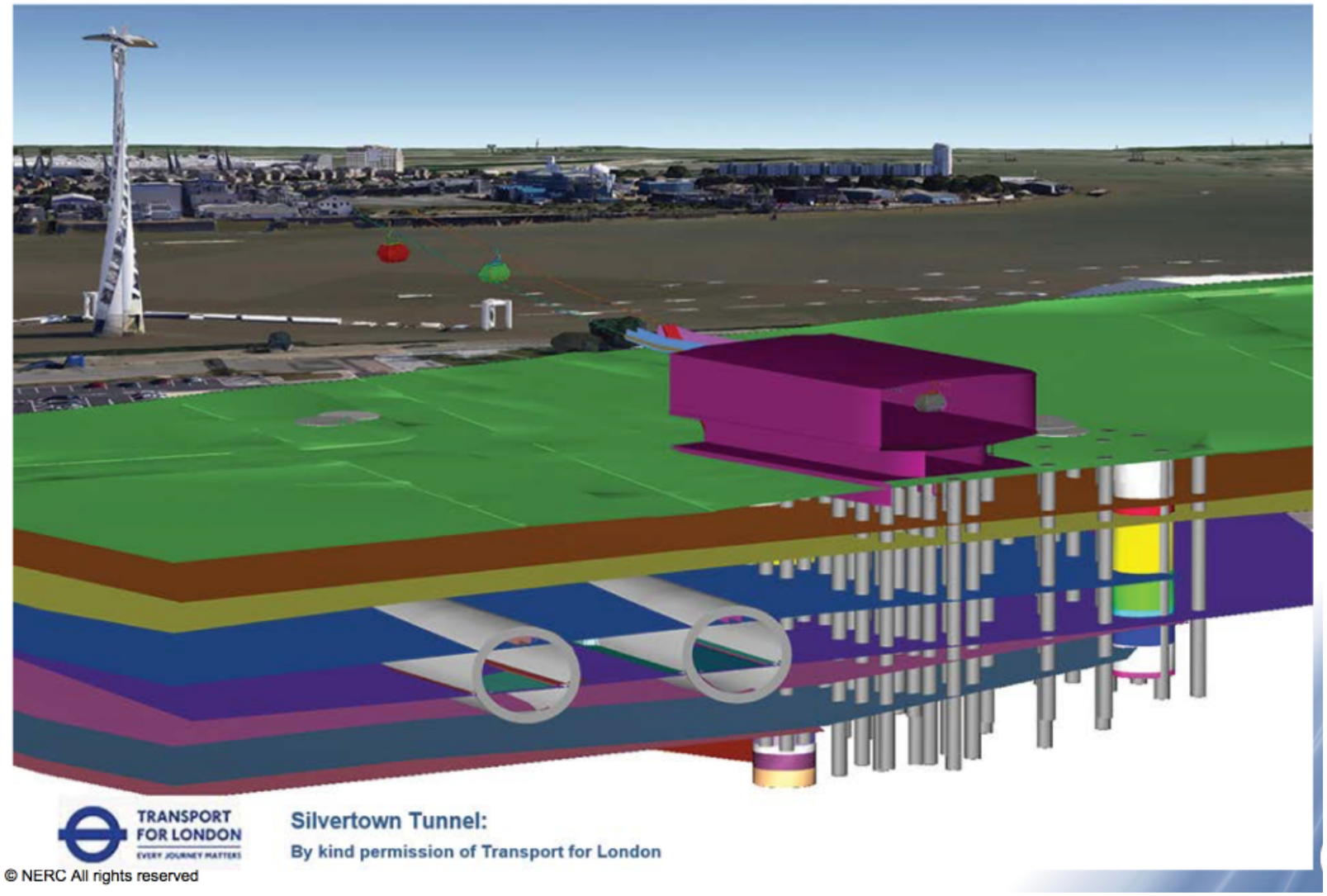


example use-case: verify the shadow on the surroundings



Use-case #3

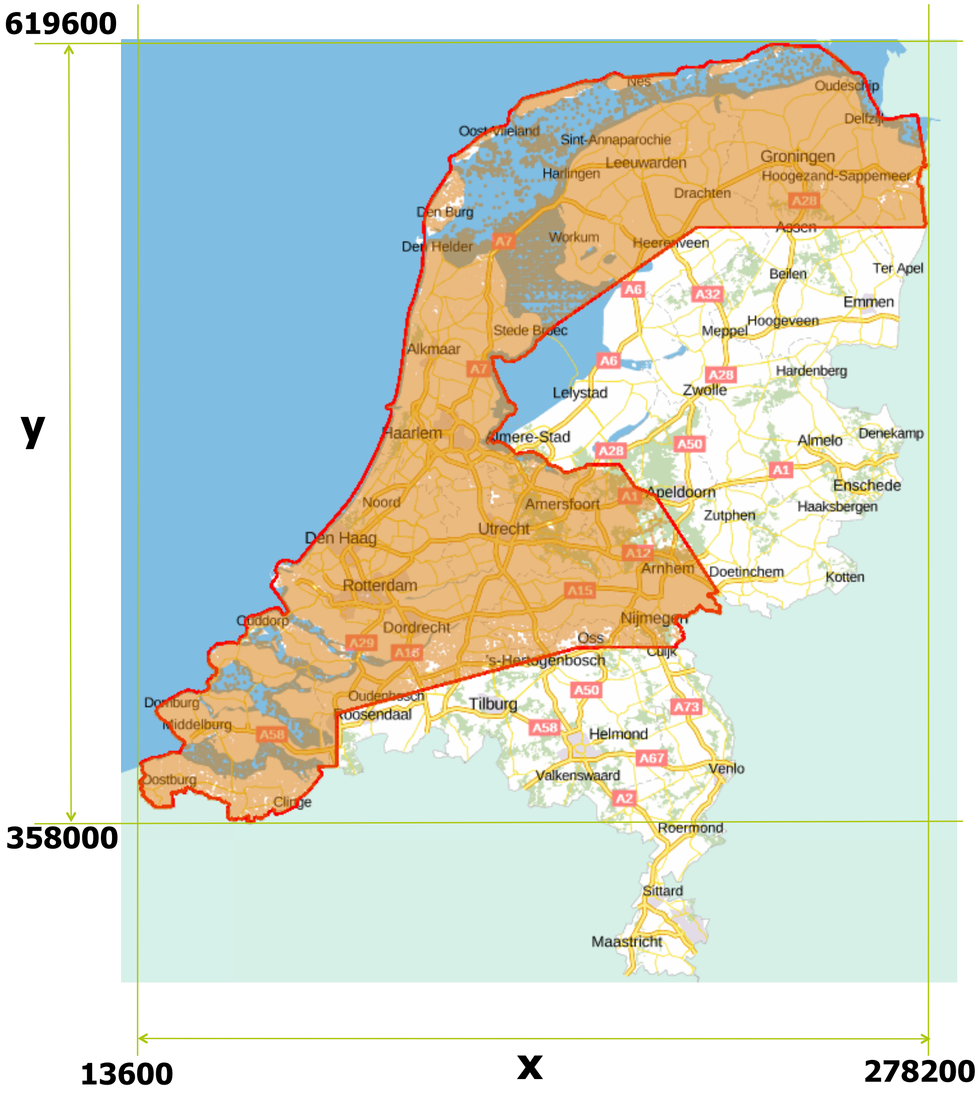
Integration of subsurface information in the BIM design process



Silvertown Tunnel:

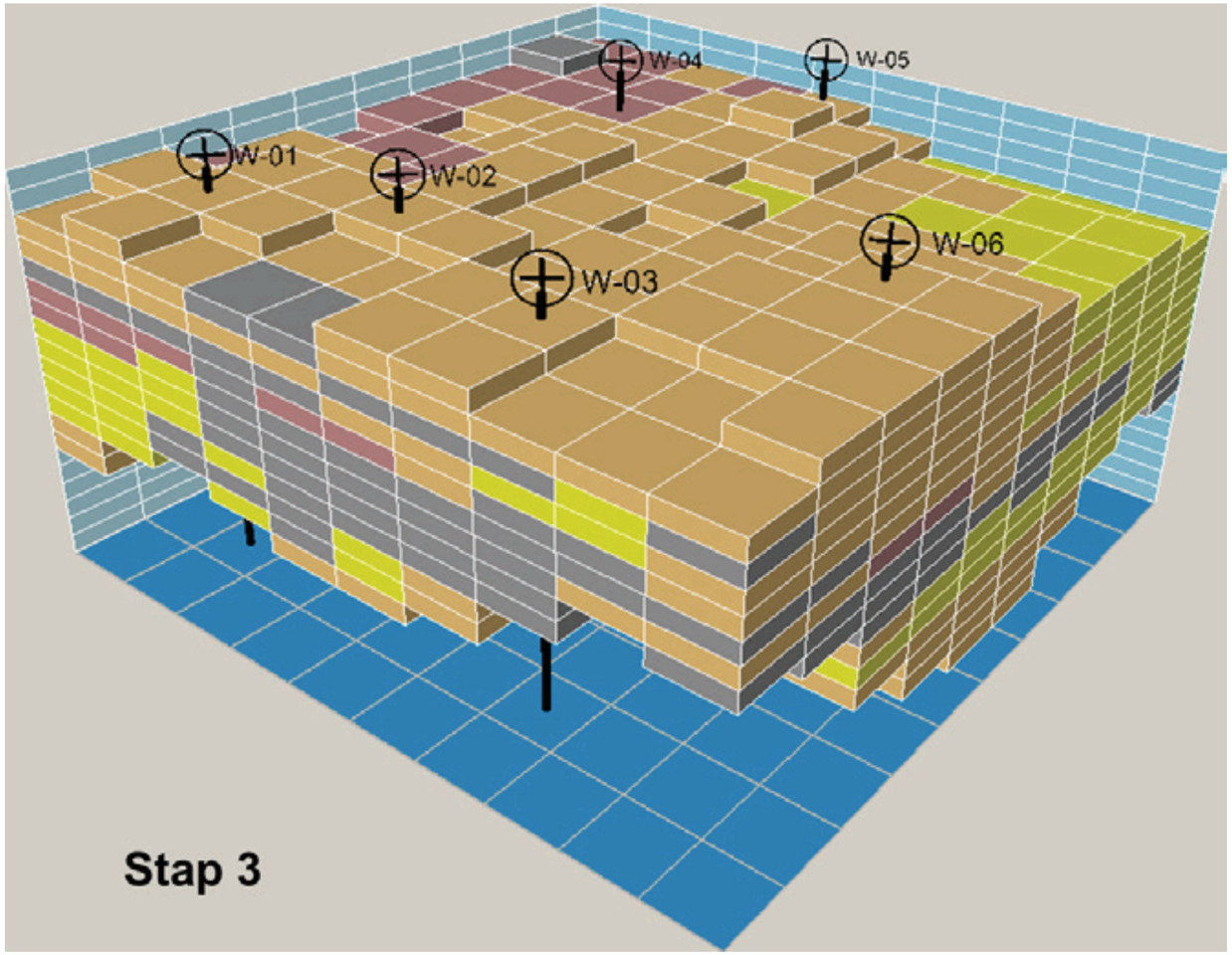
By kind permission of Transport for London

Subsurface data: BRO



- Available online (BRO; dataset: GeoTOP)
- netCDF format (30 Gb)
- Z axis ranging from -50 to 106.5m (NAP is the 0 reference)
- Voxels of size: 100m x 100m x 0.5m

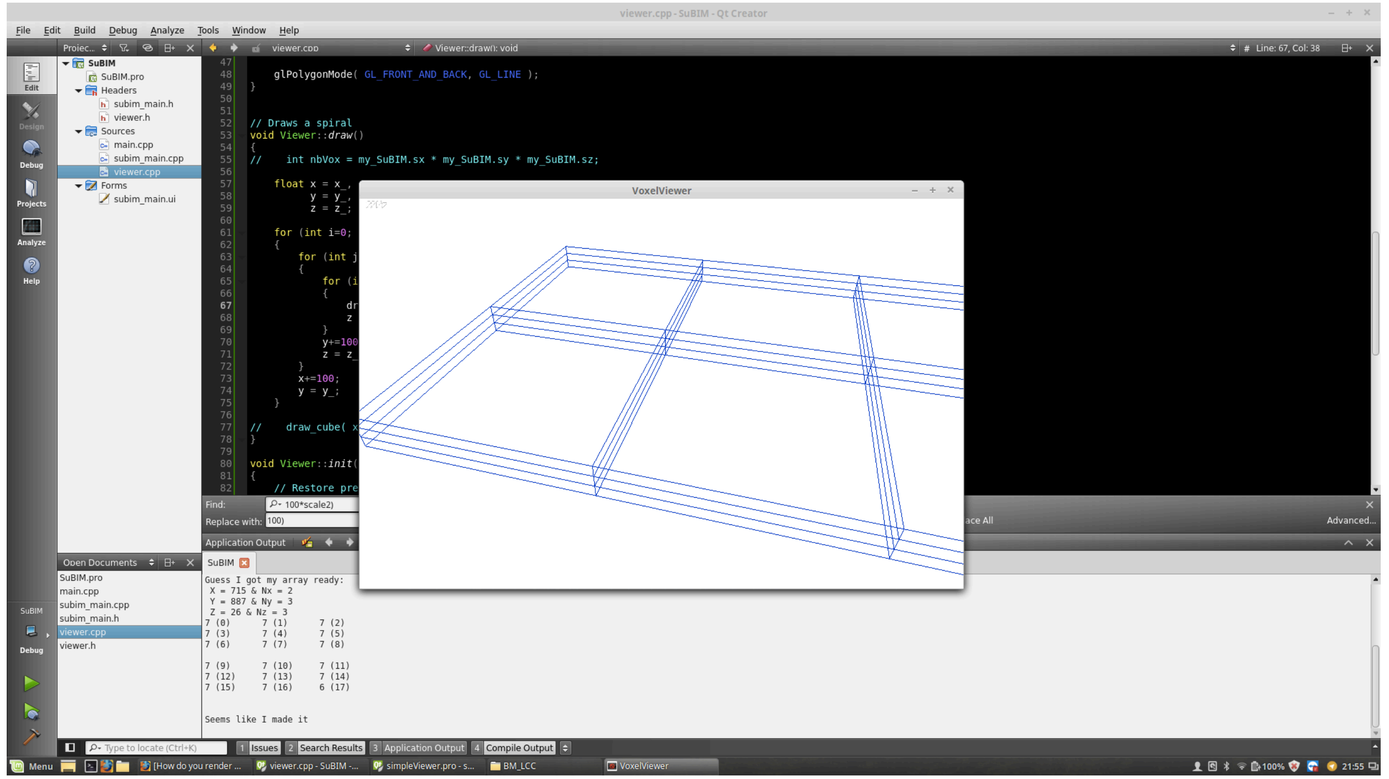
Subsurface data: BRO



- Available online (BRO; dataset: GeoTOP)
- netCDF format (30 Gb)
- Z axis ranging from -50 to 106.5m (NAP is the 0 reference)
- Voxels of size: 100m x 100m x 0.5m

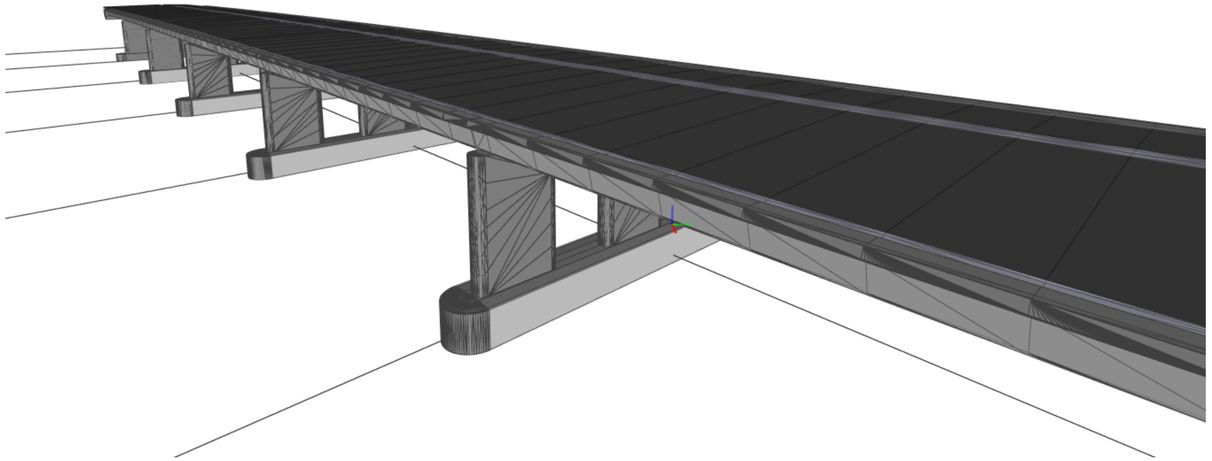
Our Solution: automatic conversion to IFC

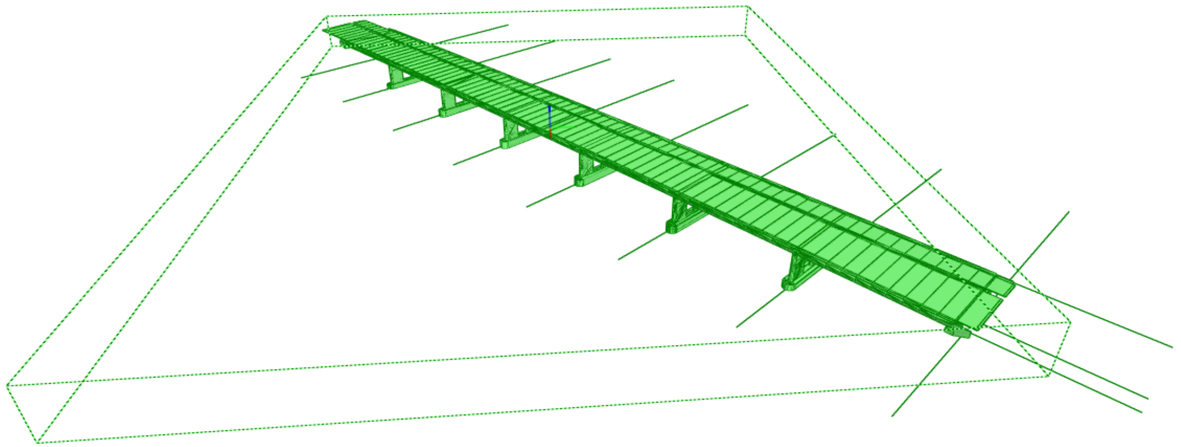
1. C++ script to extract the needed data
2. Identification of the corresponding voxels and their values
3. Transfer of the voxels geometry and semantic to an IFC output



Ongoing work: Merging with another IFC file

- Alignment of the coordinates required
- One option could be the use of Bounding Boxes of models to align.
- How to automate the process?





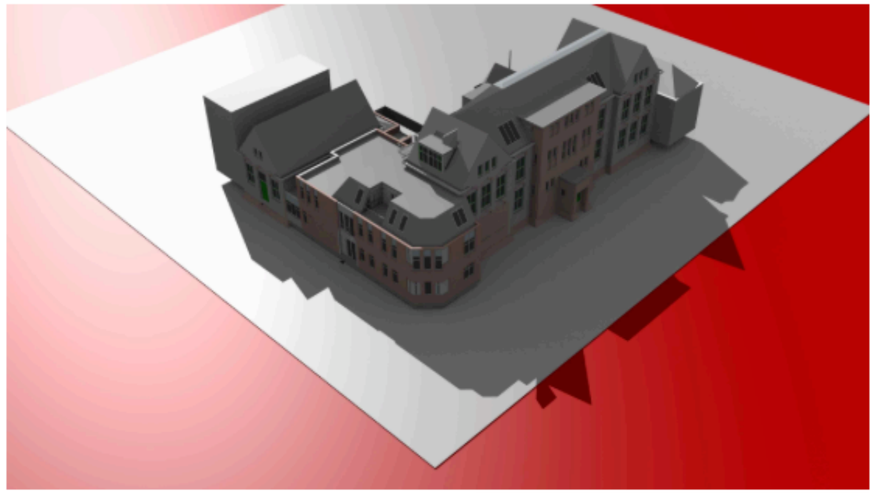
all details on the project webpage

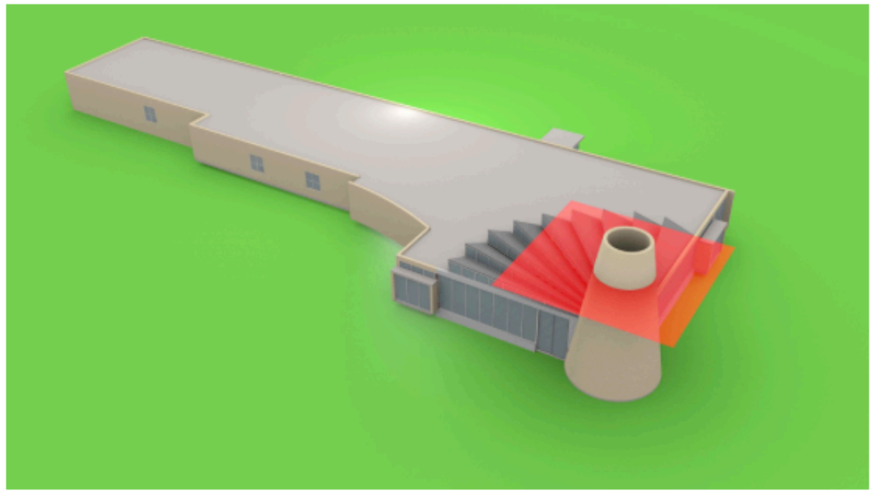
3d.bk.tudelft.nl/projects/geobim/

TUDelft 3D geoinformation

about research education download etc

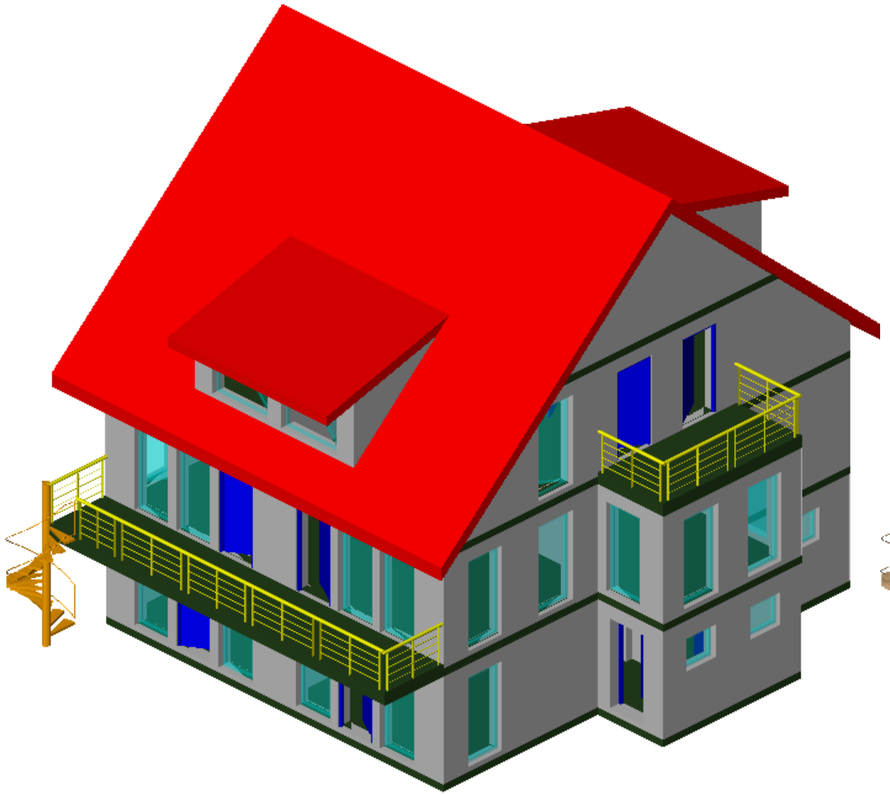
GeoBIM: Bridging the gap between Geo and BIM



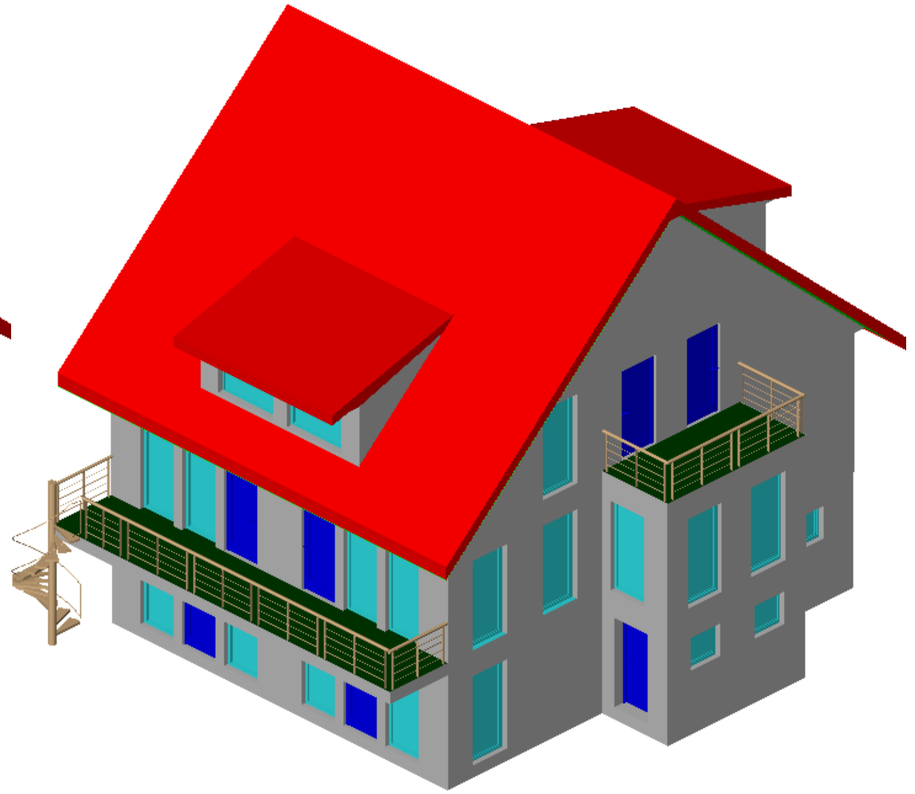


thank you.

Experimental results (Haus-G-H)



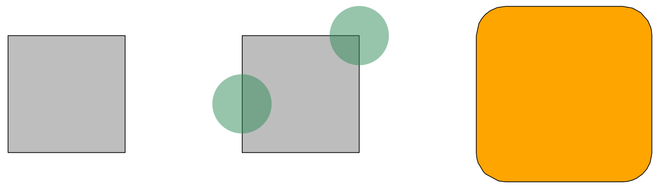
IFC



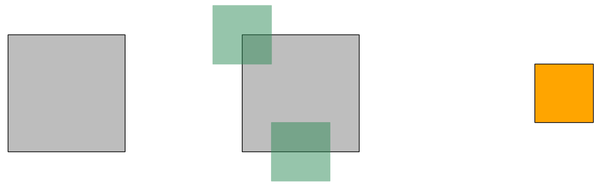
CityGML

step 2: “fixing” the geometry

morphological operators

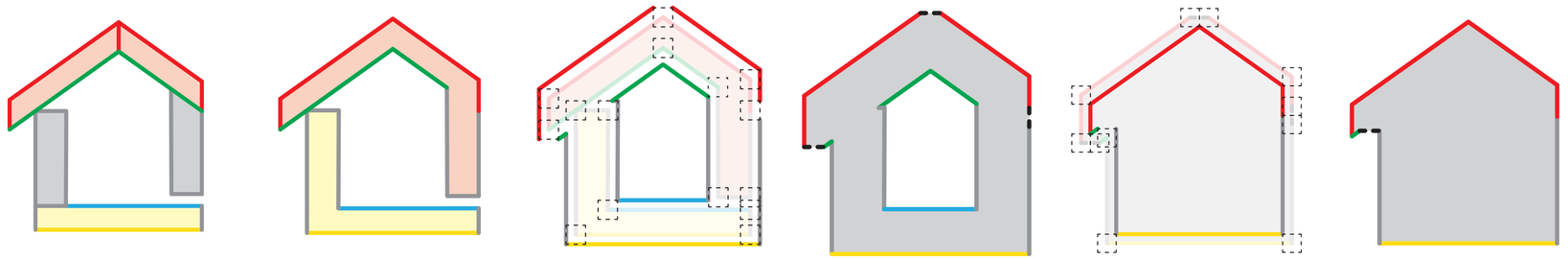


(a) dilation



(b) erosion

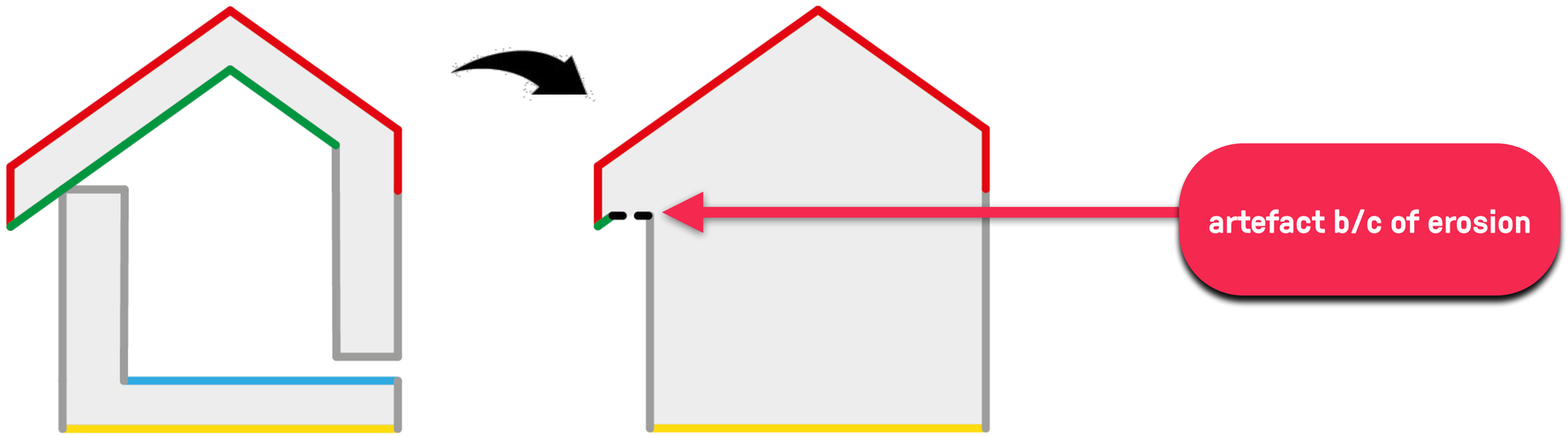
1. Geometries are dilated, thereby closing the gaps
2. Interior geometries are removed
3. The exterior shell is eroded back to it original size

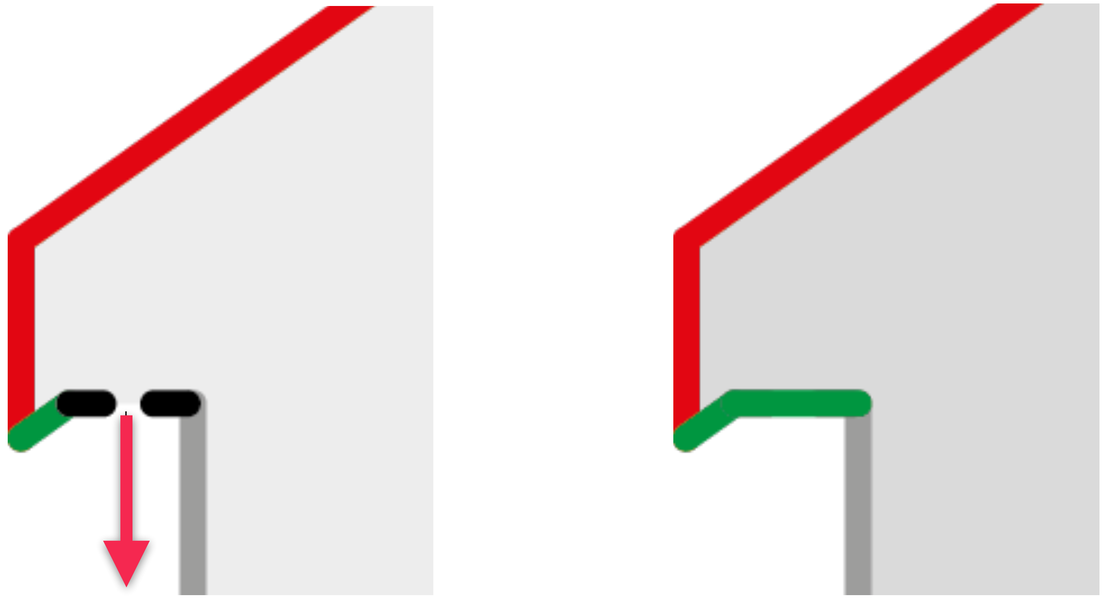


(a) input (b) union (c) dilation (d) result (e) erosion (f) final result

Figure 10: Closing operator applied to imperfect geometries.

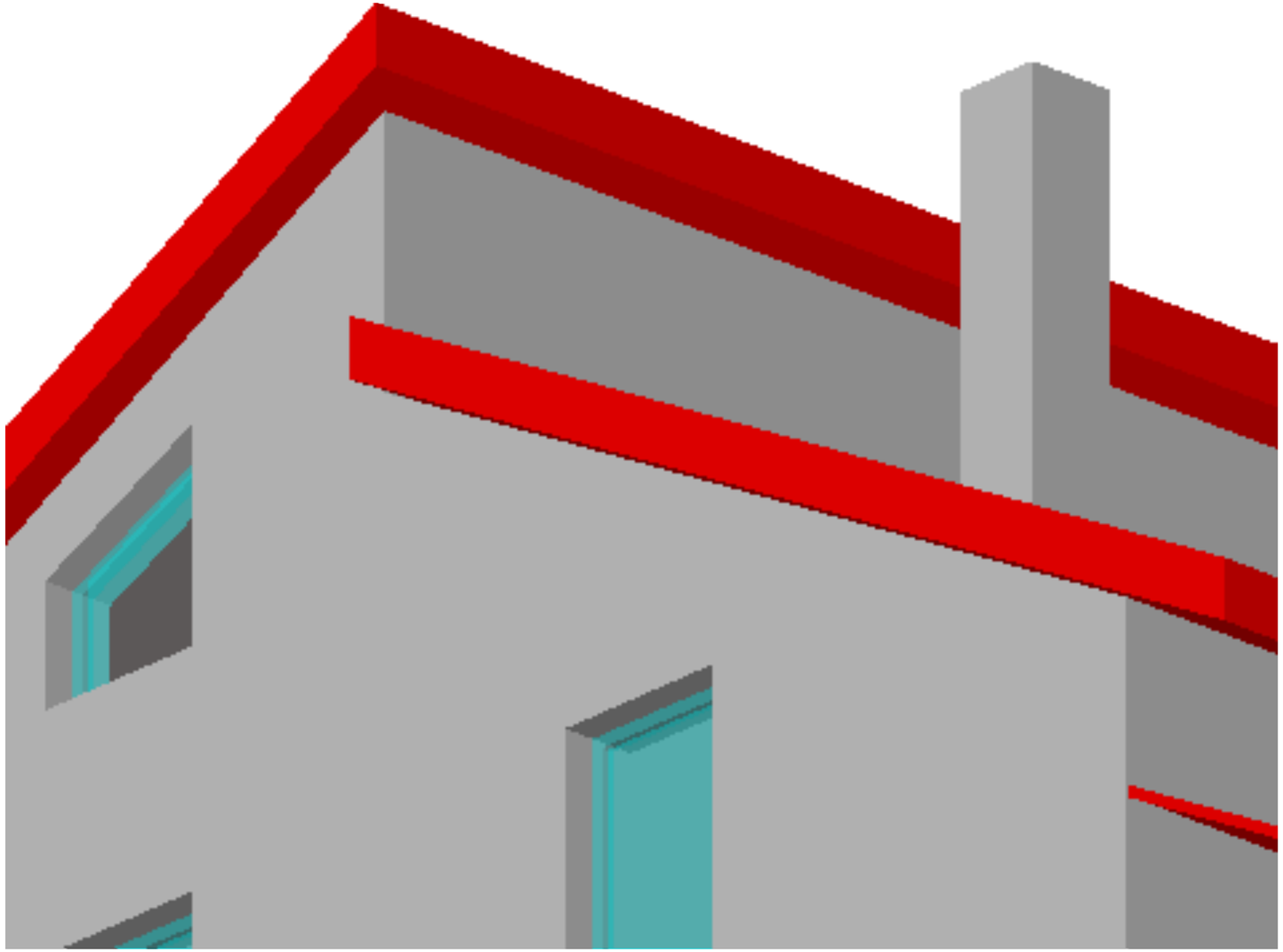
step 2: artefacts are however introduced



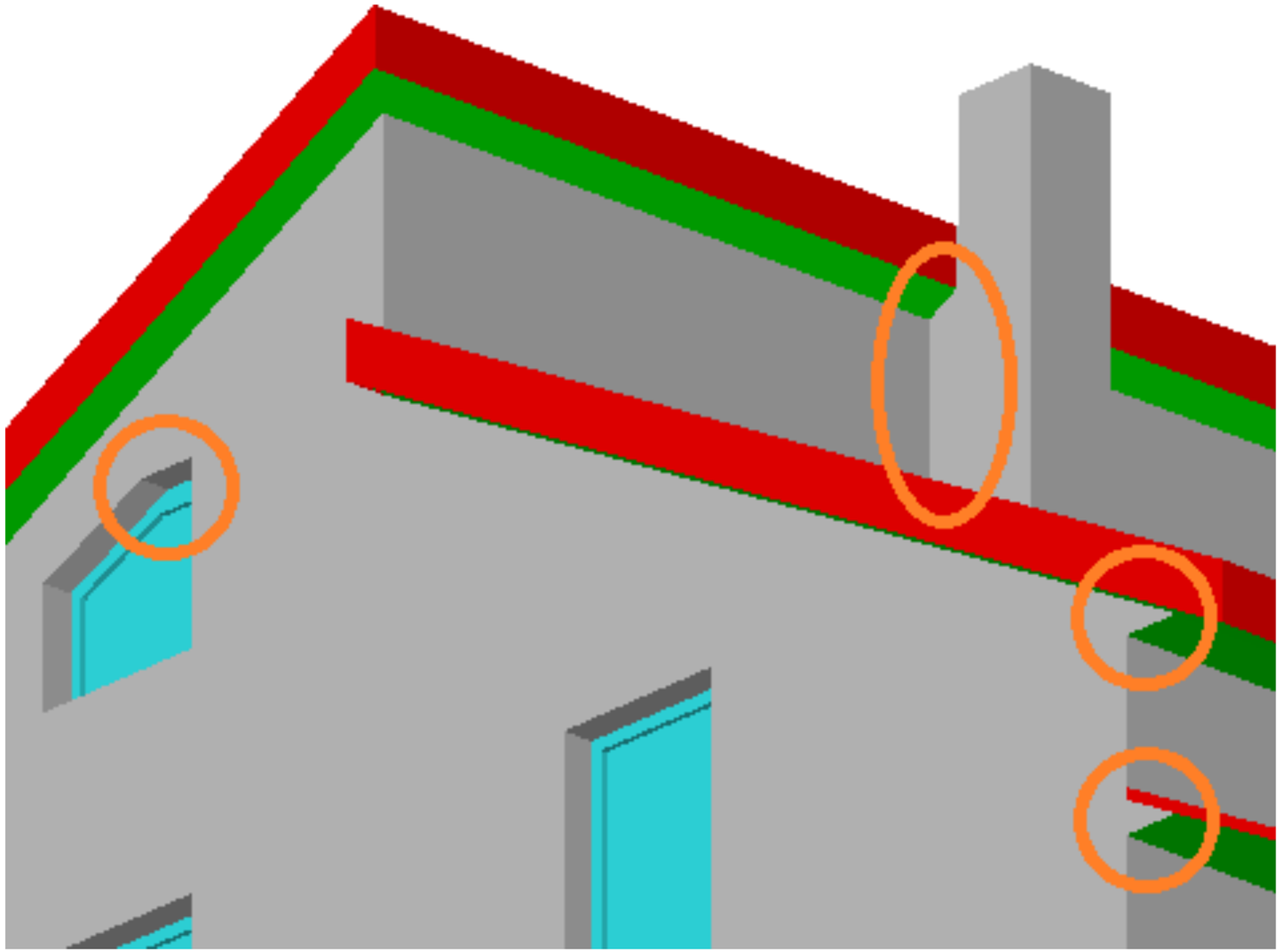


normal direction used to infer the semantic of the face

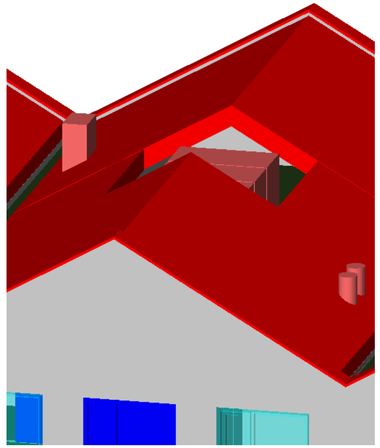
Artefacts caused by erosion/dilation (Haus-G-H)

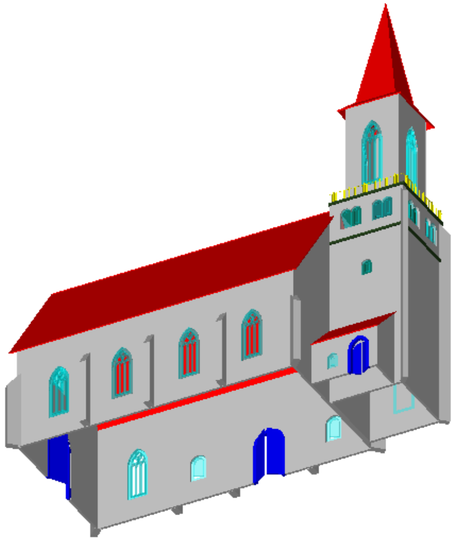


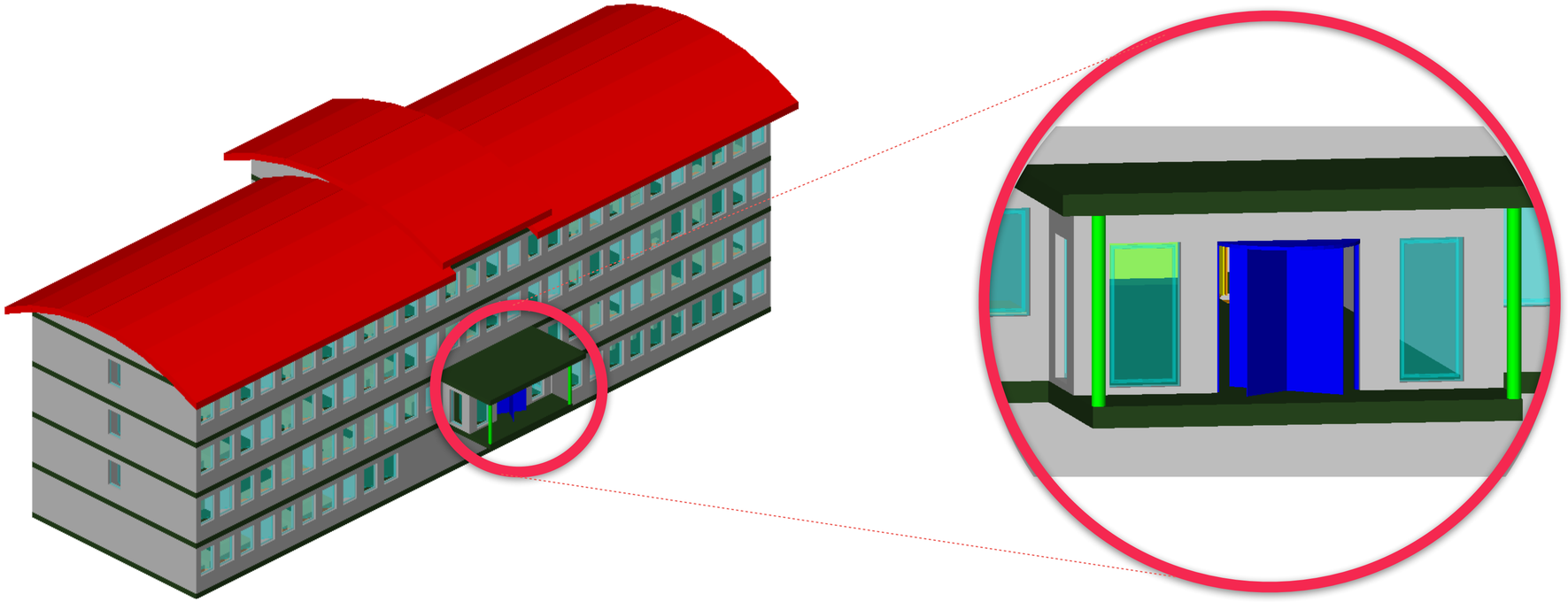
Artefacts caused by erosion/dilation (Haus-G-H)



Sometimes the world is not fair...







Conclusion

Is IFC a proper solution?

- Handled by most of the BIM tools (Revit, SketchUp, etc…)
- The GeoTOP data can be converted into IFC through IfcSpace objects
- How the analysis software will handle it is still to be checked…

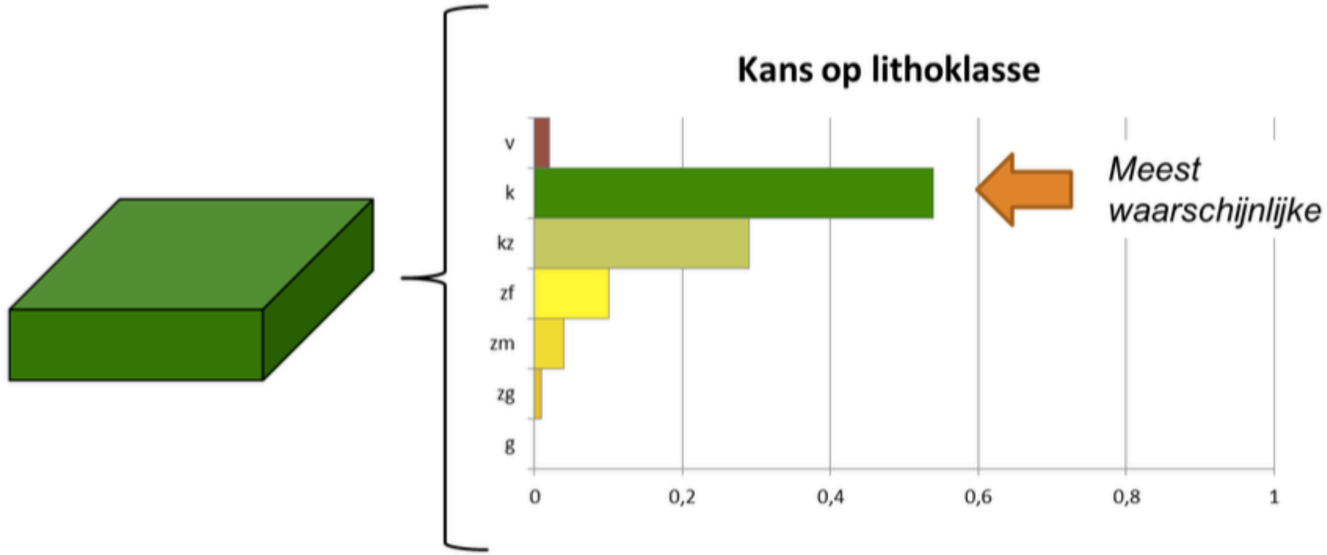
About the georeferencing?

- When it comes to designing software, it is not really about geographic coordinates finally.
- Maybe we need to rethink the problem of georeferencing BIM models?

Subsoil data

Uncertainty in GeoTOP

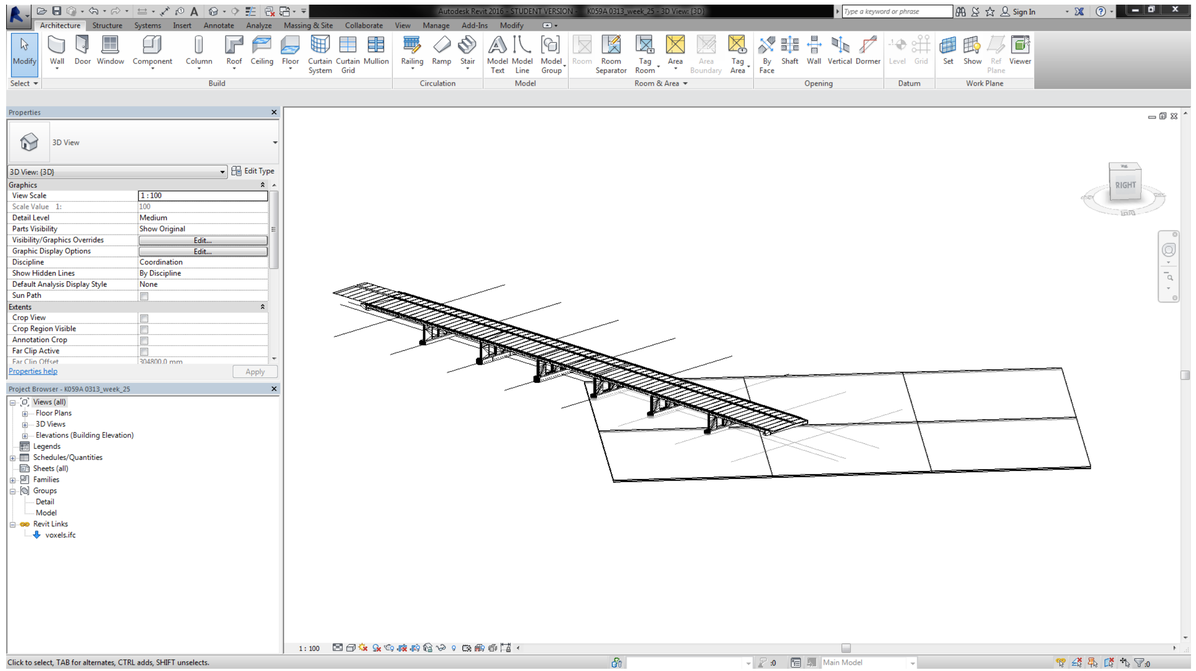
- Stochastic model
- Keeps the value of the most probable litho class



Ongoing…

Merging with another IFC

- Attempt of alignment on Revit…

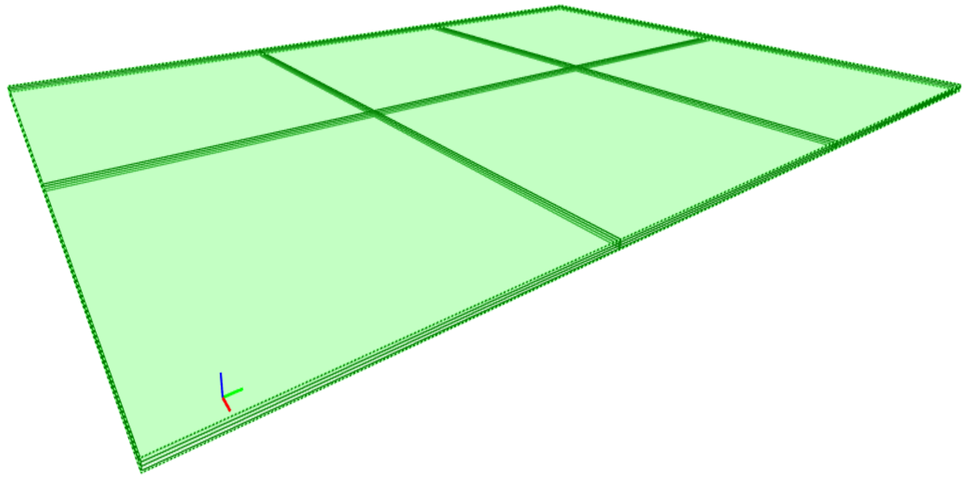


Generation of IFC

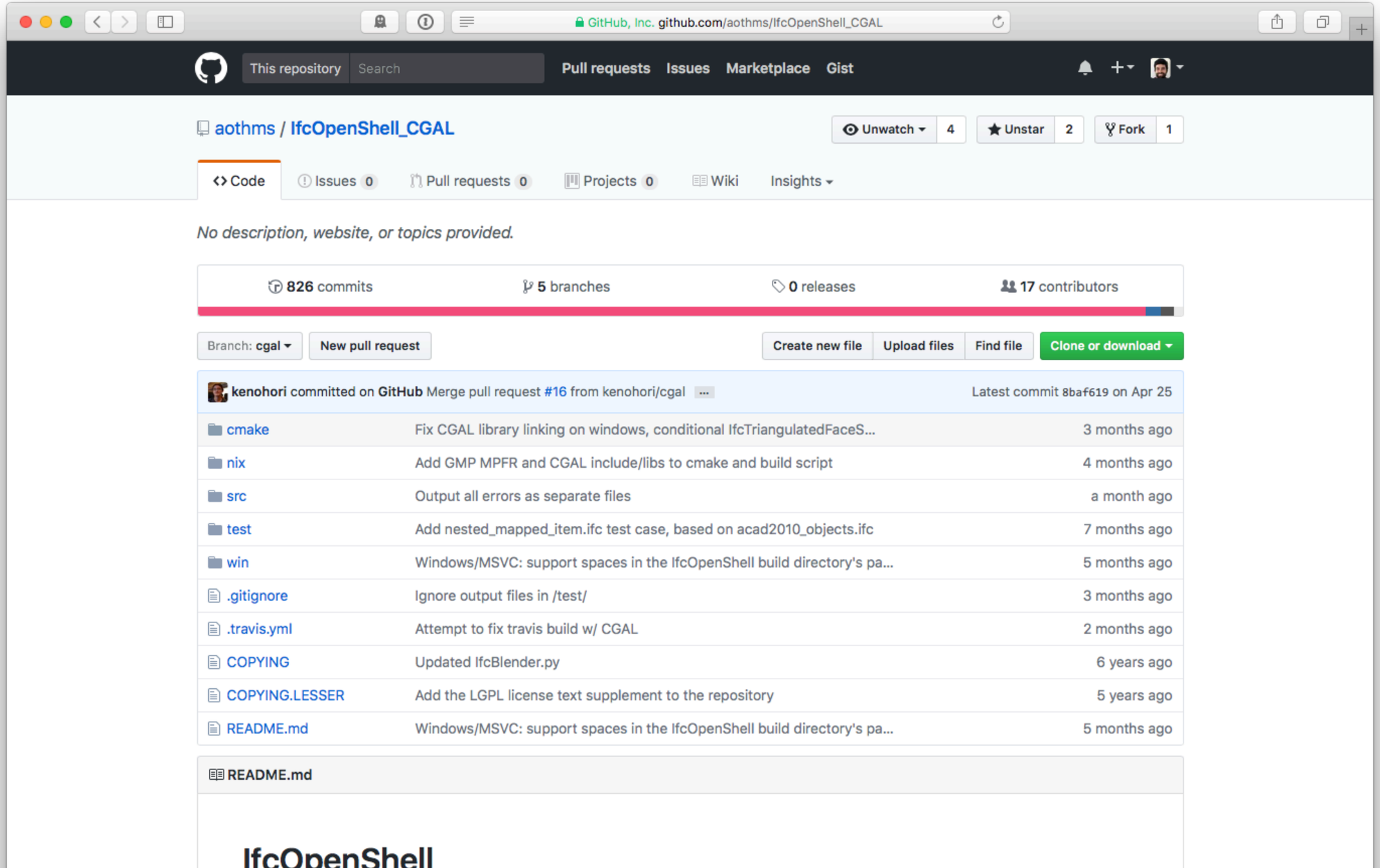
- Using IFC OpenShell

- IFC Attribute to provide subsurface information still to be determined (could be “Name” or “Description”)

- Georeferencing limitations: local coordinated are assigned to the voxels (or they will not be viewed…)



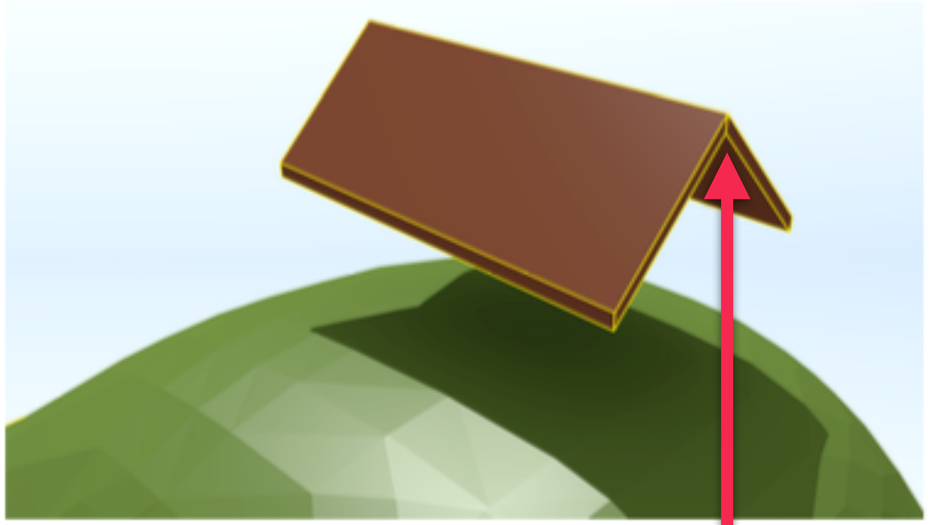
code already open-source (but very much alpha...)



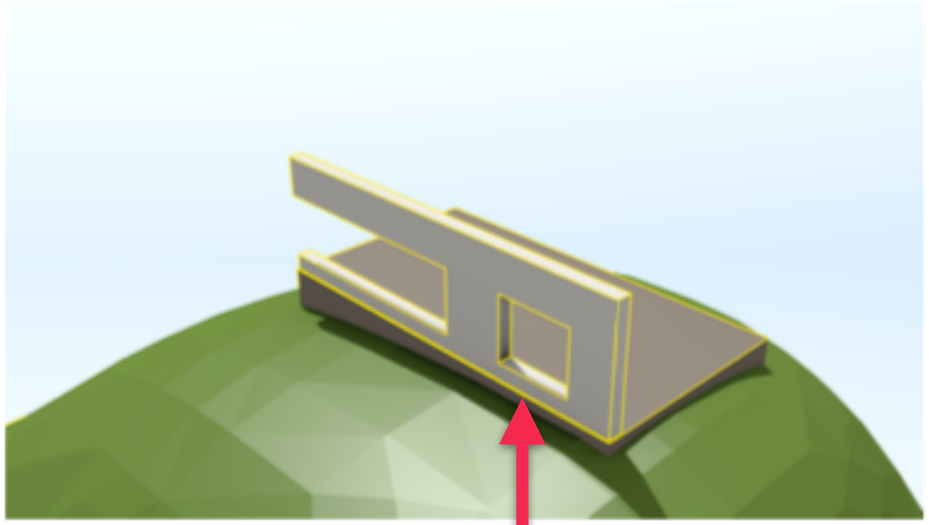
Problems encountered so far

- Validity issues in IFC datasets (e.g. precision, order-dependency, best way to do checks, etc.)
- Discretising curves and surfaces, fitting faces to planes
- Minimal approach in Geo vs. large number of classes in BIM
- BIM concepts that differ in Geo software (e.g. faces)

IFC models = CSG computations that can go bad...



2 roof parts do not touch



wall and ground overlap

IFC models = other errors