Building information models

GEO1004:
3D modelling of the built environment

https://3d.bk.tudelft.nl/courses/geo1004

3D geoinformation
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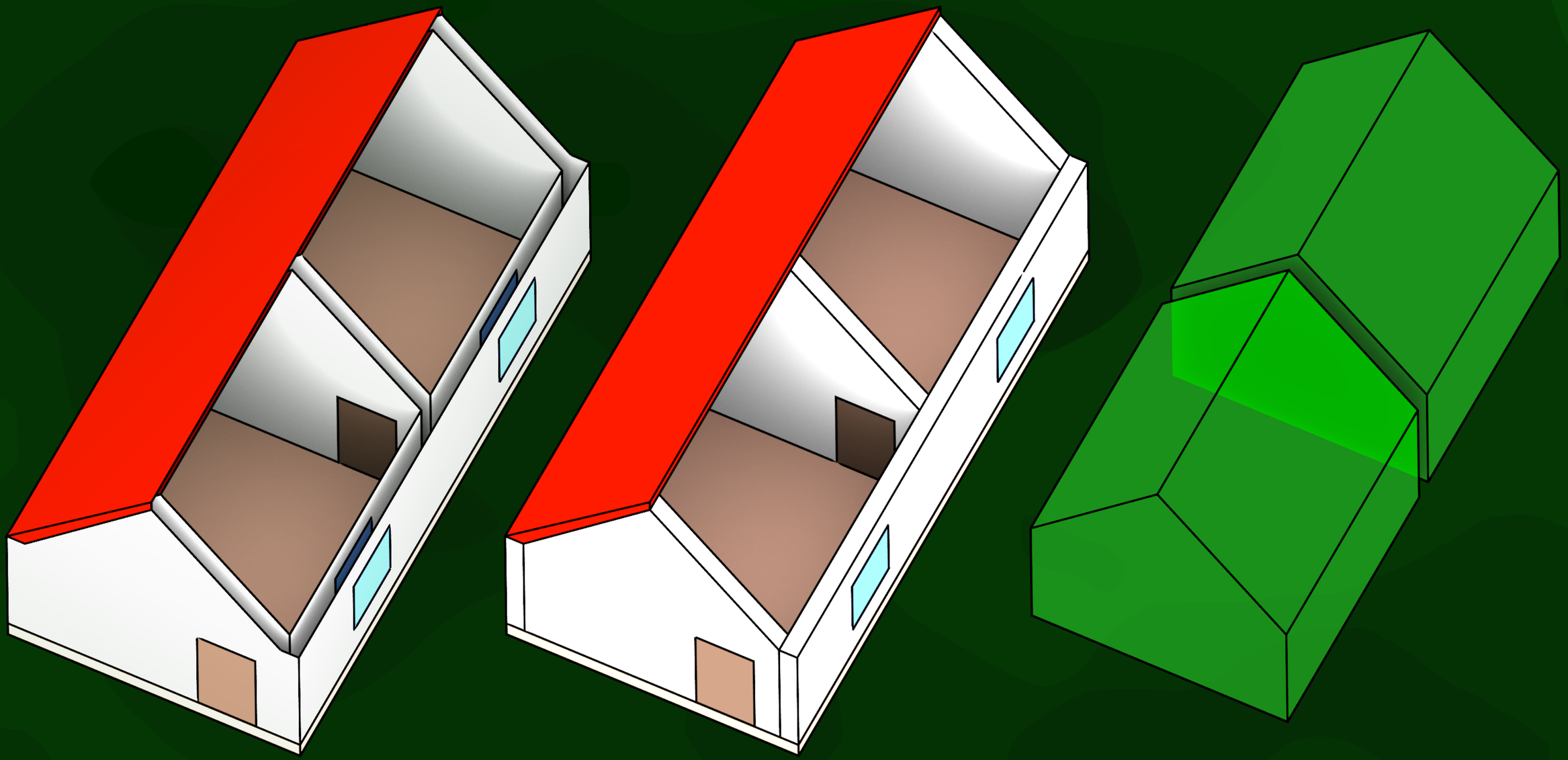
What is BIM?

- a methodology (not just 3D models)
- ...to create and use detailed 3D models (in both geometry and semantics)
- ...of buildings or infrastructure projects
- ...for design and construction (and more).

	BIM	geo (3D city models)
origins	architecture, CAD	cartography, maps
scale	one construction site	large regions
made	mostly manually as design	processed sensed data
detail (geom/semantics)	very detailed	less detailed
models	volumetric built elements	visible semantic surfaces
up to date	as designed, maybe as built	based on input data
focus	buildings and infrastructure	everything but mainly cities
strengths	design and construction	spatial analyses

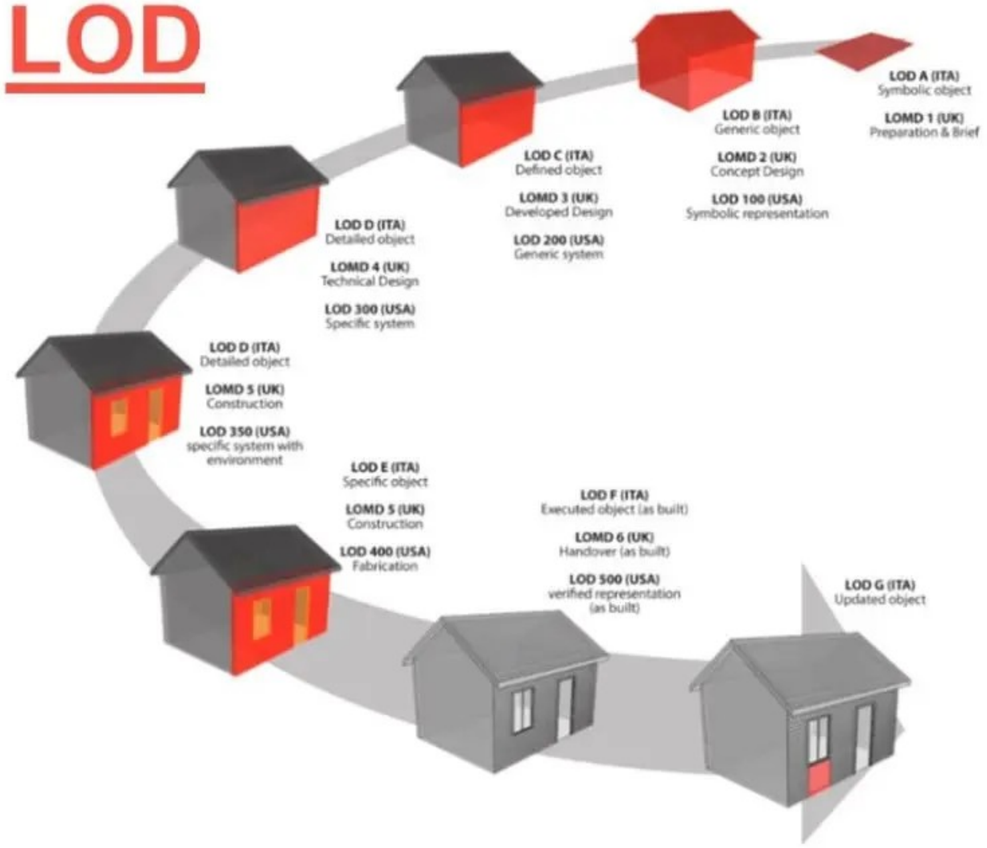


BIM in practice

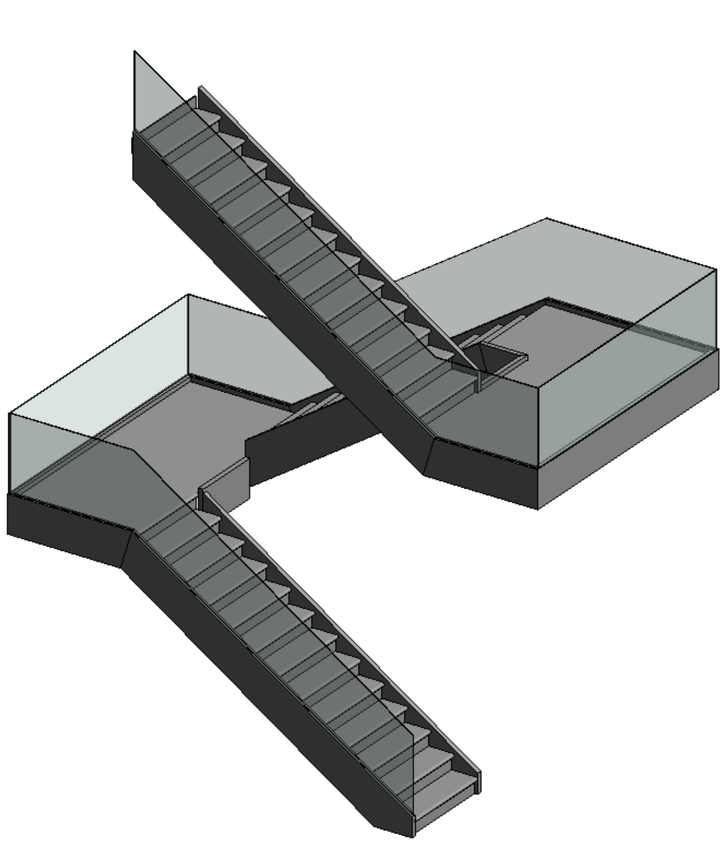
- Closed software + platforms: organisations using internally the same software/platform and its formats, e.g. Autodesk Revit, ArchiCAD, Trimble Connect, Allplan, etc.

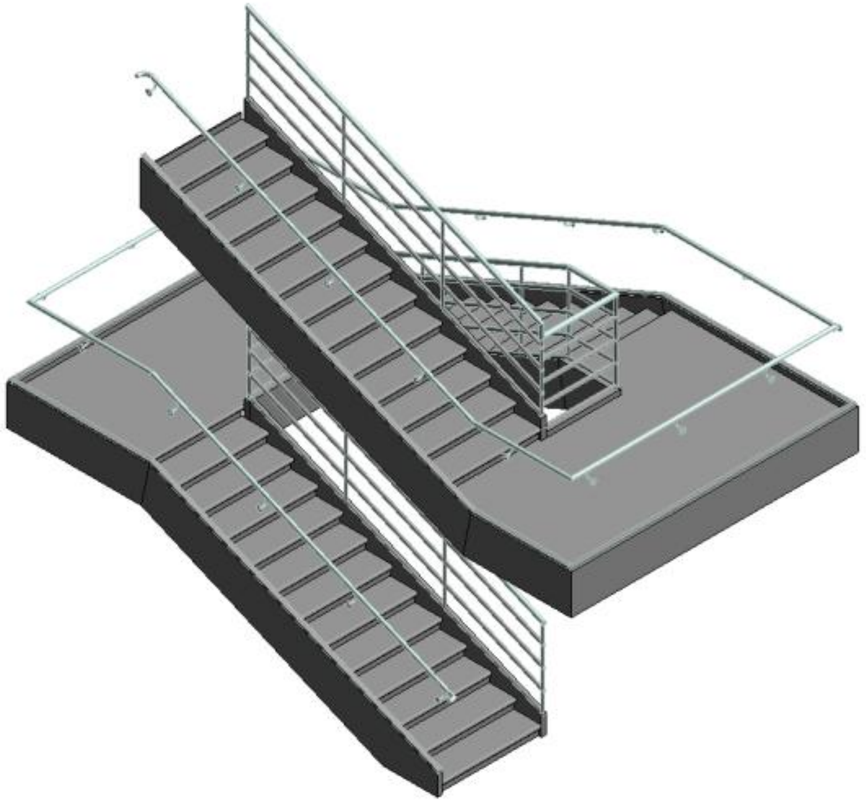
- Open standards + software (openBIM): different organisations exchanging IFC files, using BIMserver, processing with IfcOpenShell, etc.

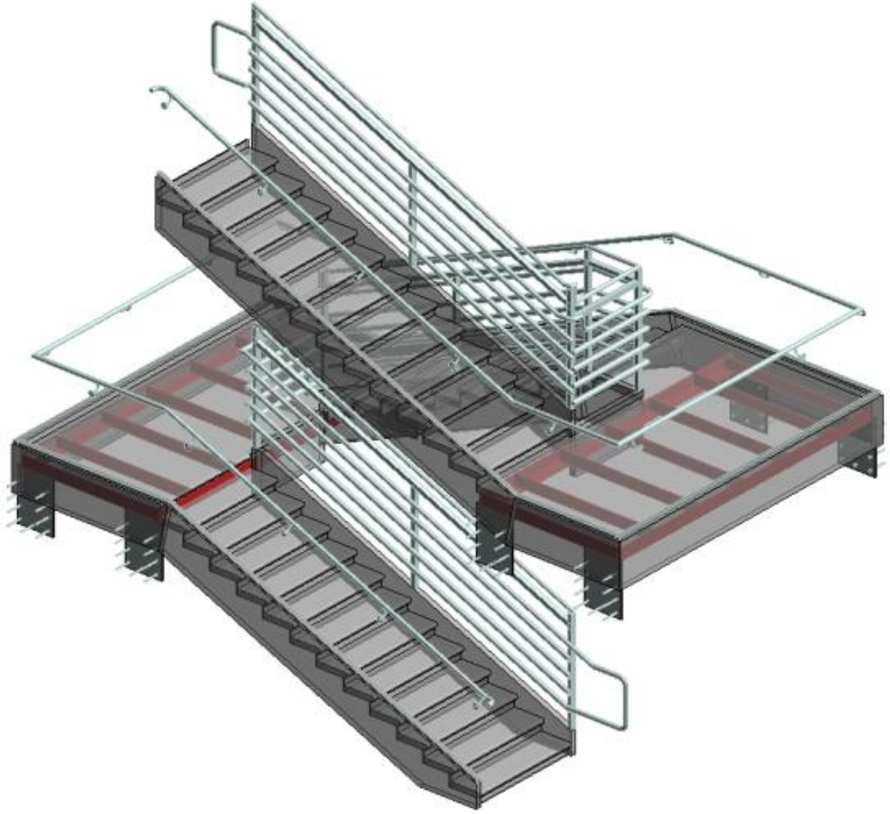
LOD(efinition), LOD(evelopment), LOIN



LOD(efinition), LOD(evelopment), LOIN







BIM Forum

IFC

- open standard by the buildingSMART Consortium
- large standard (322 defined types, 191 enumeration types, 138 select types, 1061 entities, 54 functions, 22 rules, 1000+ property sets in IFC 4.3)
- defined using EXPRESS data modelling language
- encodings: STEP (almost always), plus rarely others (XML, Turtle, RDF, etc.)

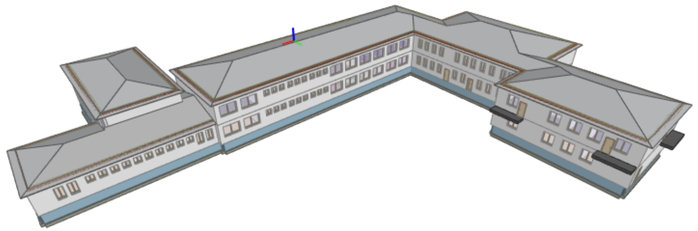
IFC

```
#365=IFCDIRECTION((1.,0.,0.));
#367=IFCDIRECTION((0.,0.,1.));
#369=IFCCARTESIANPOINT((0.,0.,0.));
#371=IFCAXIS2PLACEMENT3D(#369,#367,#365);
#372=IFCDIRECTION((0.766044443119,0.642787609687));
#374=IFCGEOMETRICREPRESENTATIONCONTEXT($,'Plan',3,1.00000000000E -5,#371,#372);
#375=IFCGEOMETRICREPRESENTATIONSUBCONTEXT('Box','Plan',*,*,*,*,#374,$,. PLAN_VIEW.,$);
#377=IFCCARTESIANPOINT((-3.,-3.,-1.));
#379=IFCBOUNDINGBOX(#377,18.,16.,1.);
#380=IFCSHAPEREPRESENTATION(#375,'Box','BoundingBox',(#379));
#383=IFCPRODUCTDEFINITIONSHAPE($,$,(#355,#380));
#389=IFCSITE('0KMpiAlnb52RgQuM1CwVfd',#12,'Gelaende','Ebenes Gelaende',' LandUse',...
#400=IFCRELAGGREGATES('1GO86xgv8B470LzUwG9dnQ',#12,$,$,#66,(#389));
#406=IFCPROPERTYSINGLEVALUE('BuildingHeightLimit',$, IFCPOSITIVELENGTHMEASURE(9.),$);
#407=IFCPROPERTYSINGLEVALUE('GrossAreaPlanned',$,IFCAREAMEASURE(0.),$);
#408=IFCPROPERTYSET('1pzemvk20um3F9bx64I1e9',#12,'Pset_SiteCommon',$ ,(#406,#407));
#412=IFCRELDEFINESBYPROPERTIES('2w5hE3w6ce8Clm81uDvALx',#12,$,$,(#389) ,#408);
#416=IFCQUANTITYLENGTH('GrossPerimeter',$,$,0.,$);
#419=IFCQUANTITYAREA('GrossArea',$,$,0.,$);
```

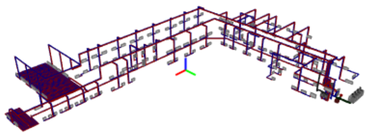
IFC

- among others, models:
  - actors (people, organisations)
  - controls (specifications, regulations, schedules and other requirements)
  - processes (actions during construction)
  - products (physical building elements and other spatially defined objects)
  - project (where it is placed)
  - resources (cost, materials and equipment)

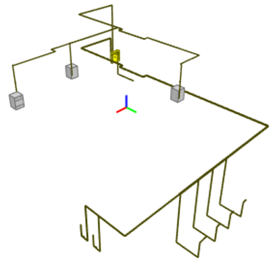
IFC: federated models



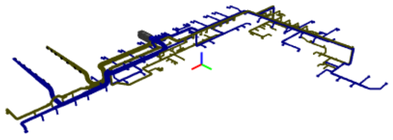
BIM Vision



BIM Vision



BIM Vision



BIM Vision

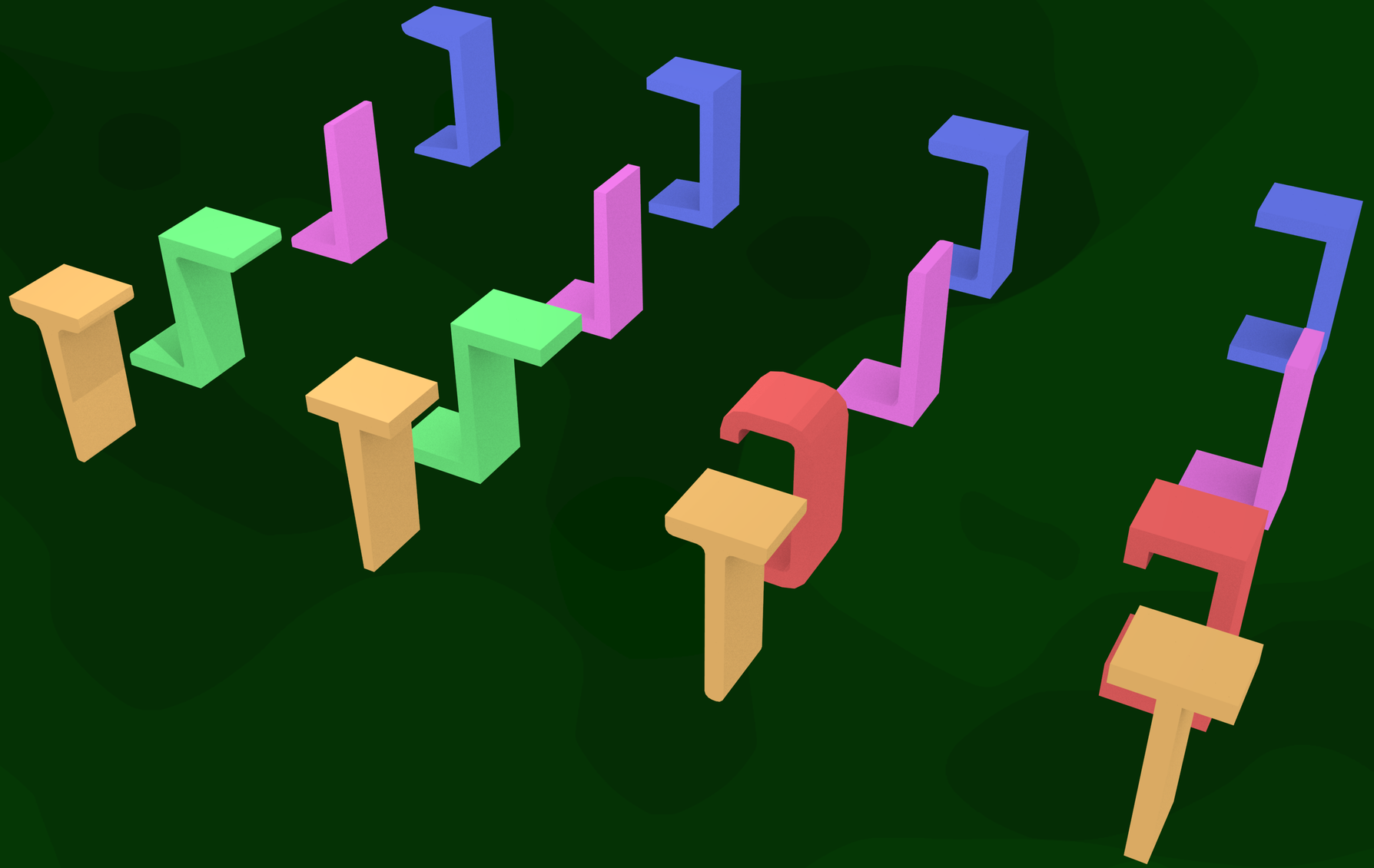
IFC

- geometry types:
  - primitive instancing, e.g. parametric 2D profiles
  - extrusions / sweeps
  - boundary representation
  - CSG with other types and half-spaces

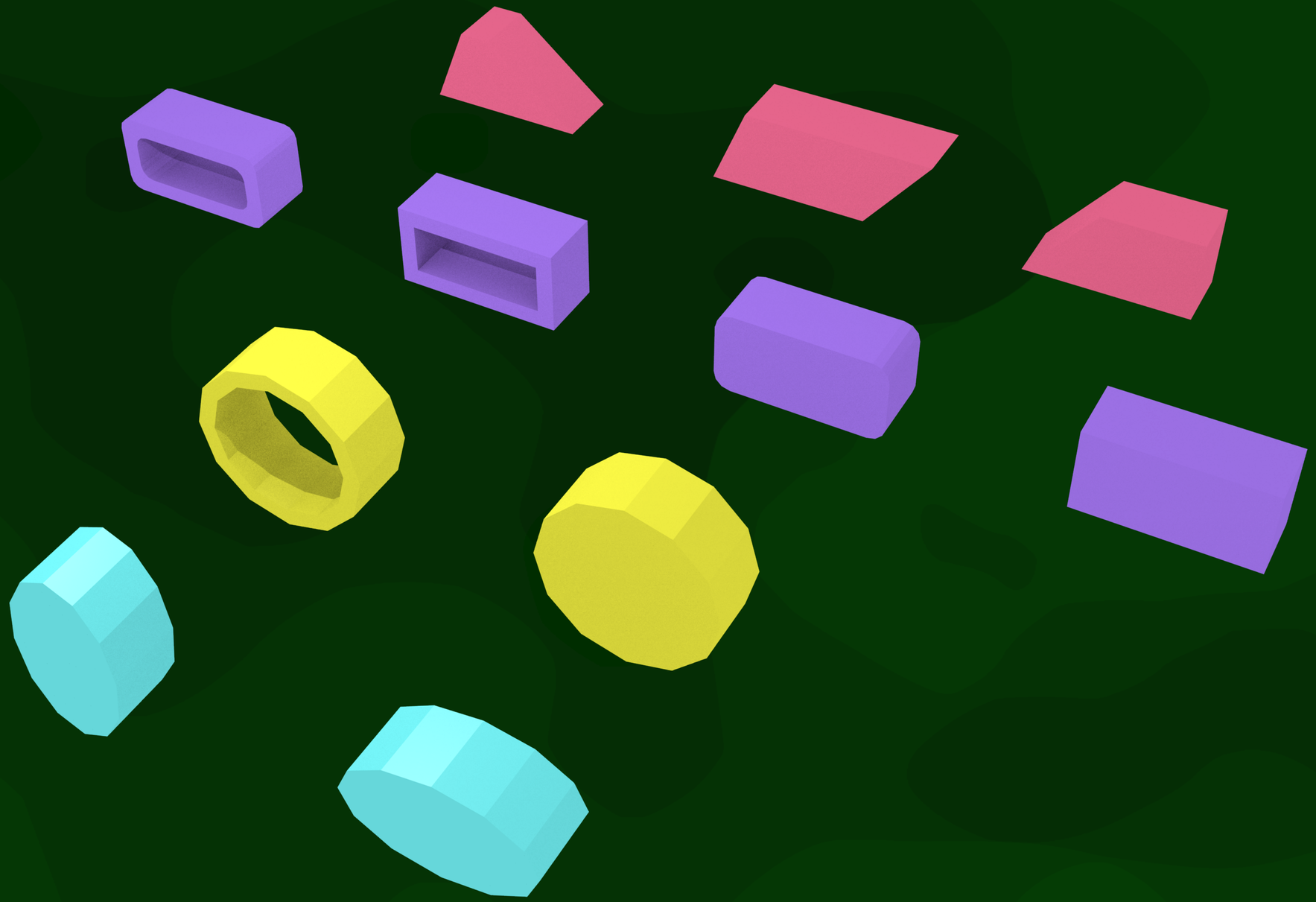
IFC: simple triangle

```
#120= IFCCARTESIANPOINT((-3.,13.,0.));
#122= IFCCARTESIANPOINT((12.,10.,0.));
#124= IFCCARTESIANPOINT((15.,13.,0.));
#126= IFCPOLYLOOP((#120,#122,#124));
```

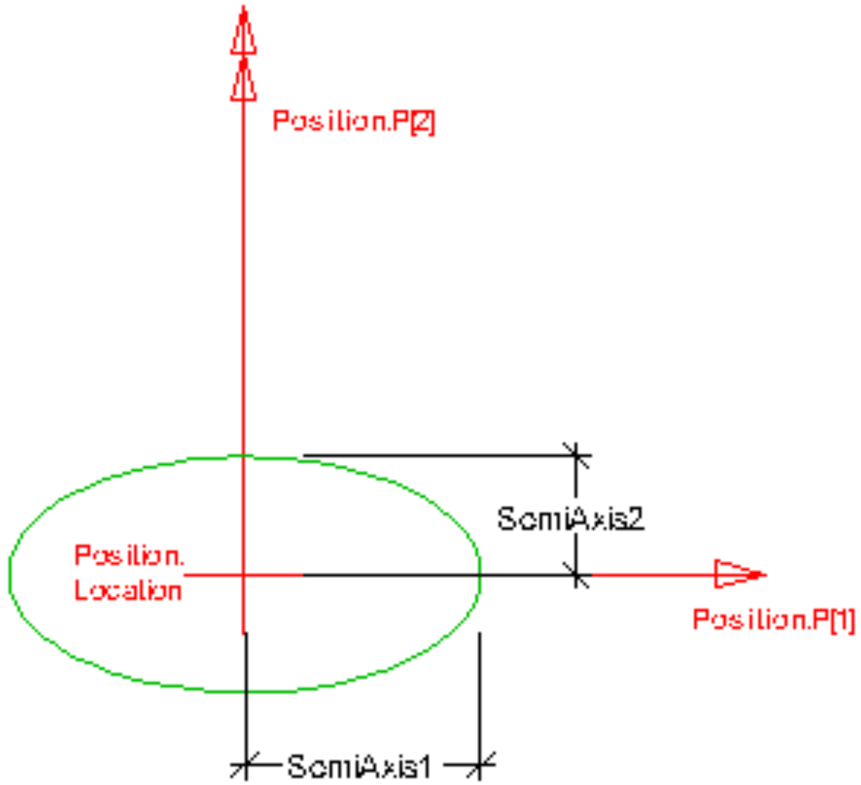
IFC: extrusions of profiles

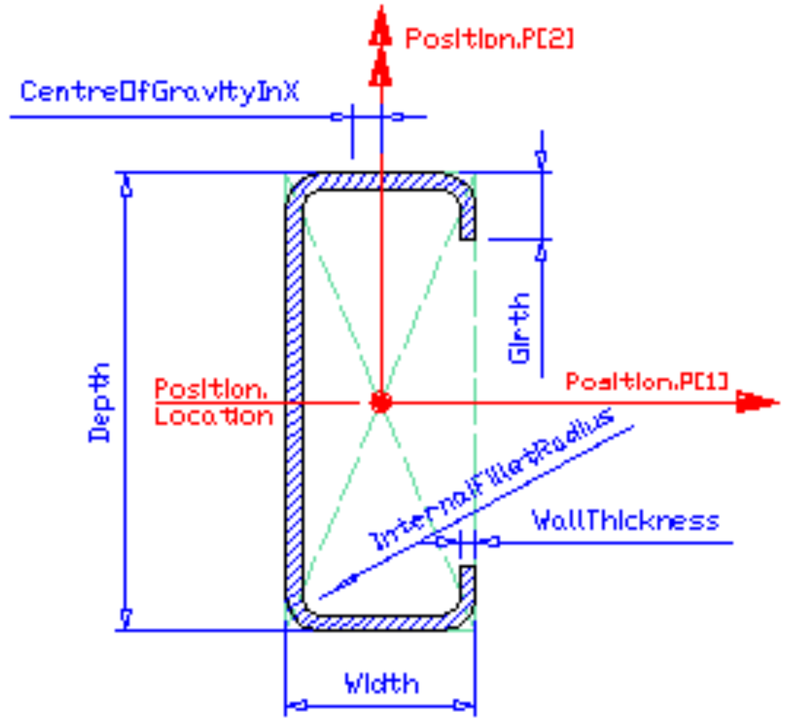


IFC: extrusions of profiles



IFC: extrusions of profiles

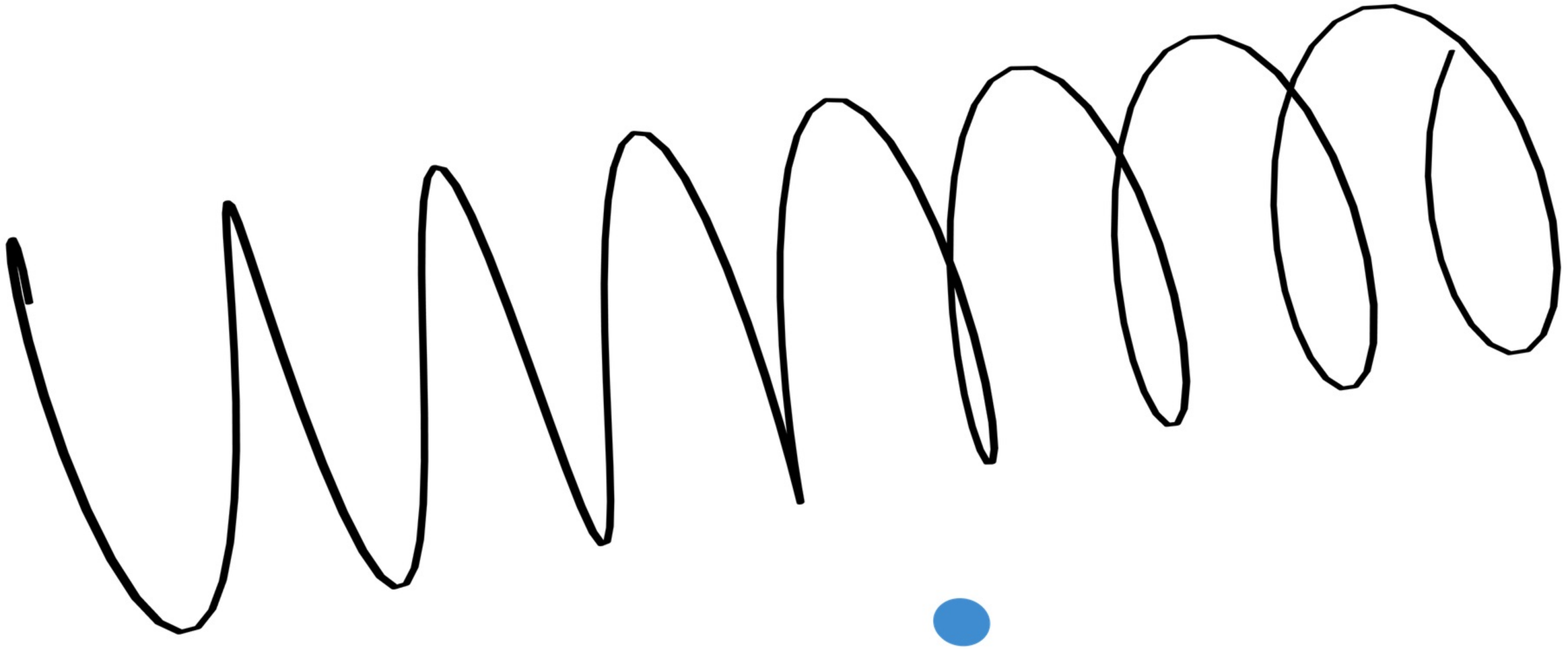




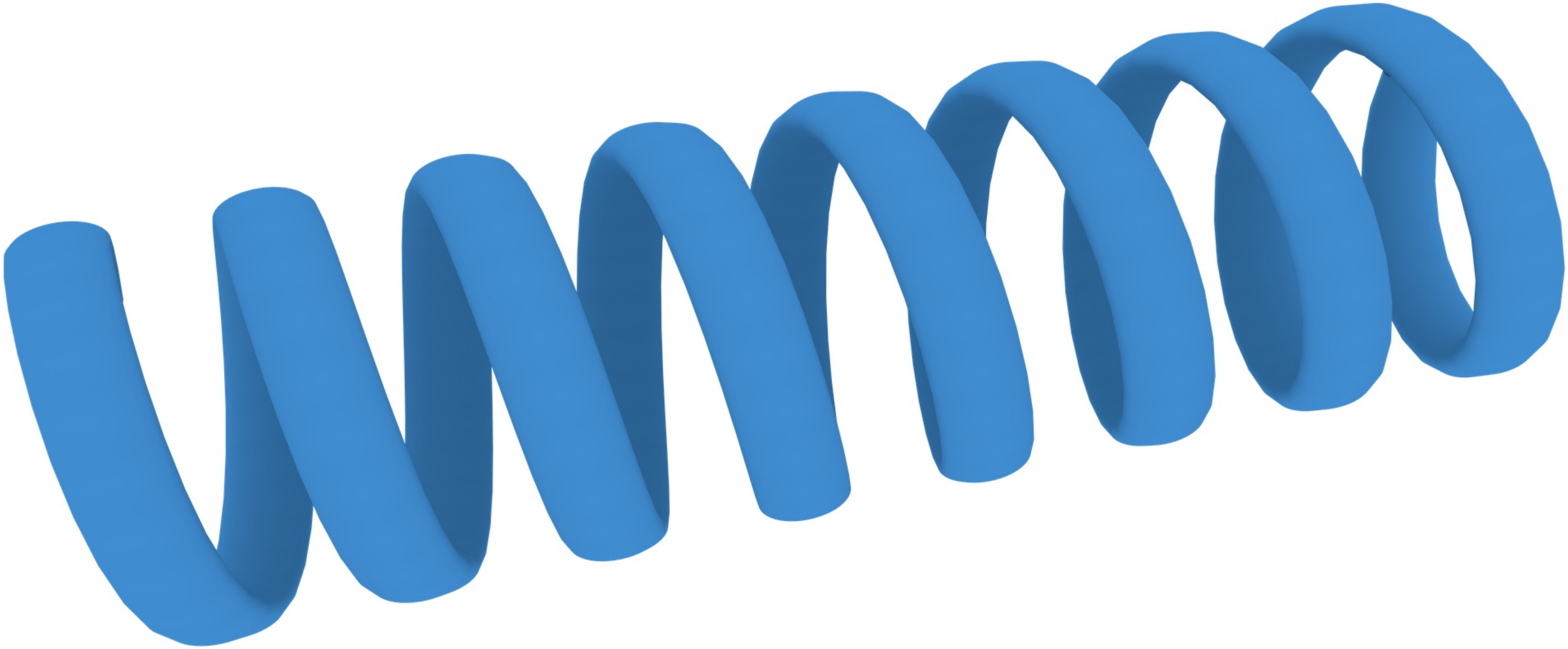
IFC: extrusions of profiles

```
#17079= IFCDIRECTION((1.,0.));
#17081= IFCCARTESIANPOINT((0.,0.));
#17083= IFCAXIS2PLACEMENT2D(#17081,#17079);
#17084= IFCRECTANGLEPROFILEDEF(.AREA.,'',#17083,0.885,2.01);
```

IFC: sweeps



IFC: sweeps



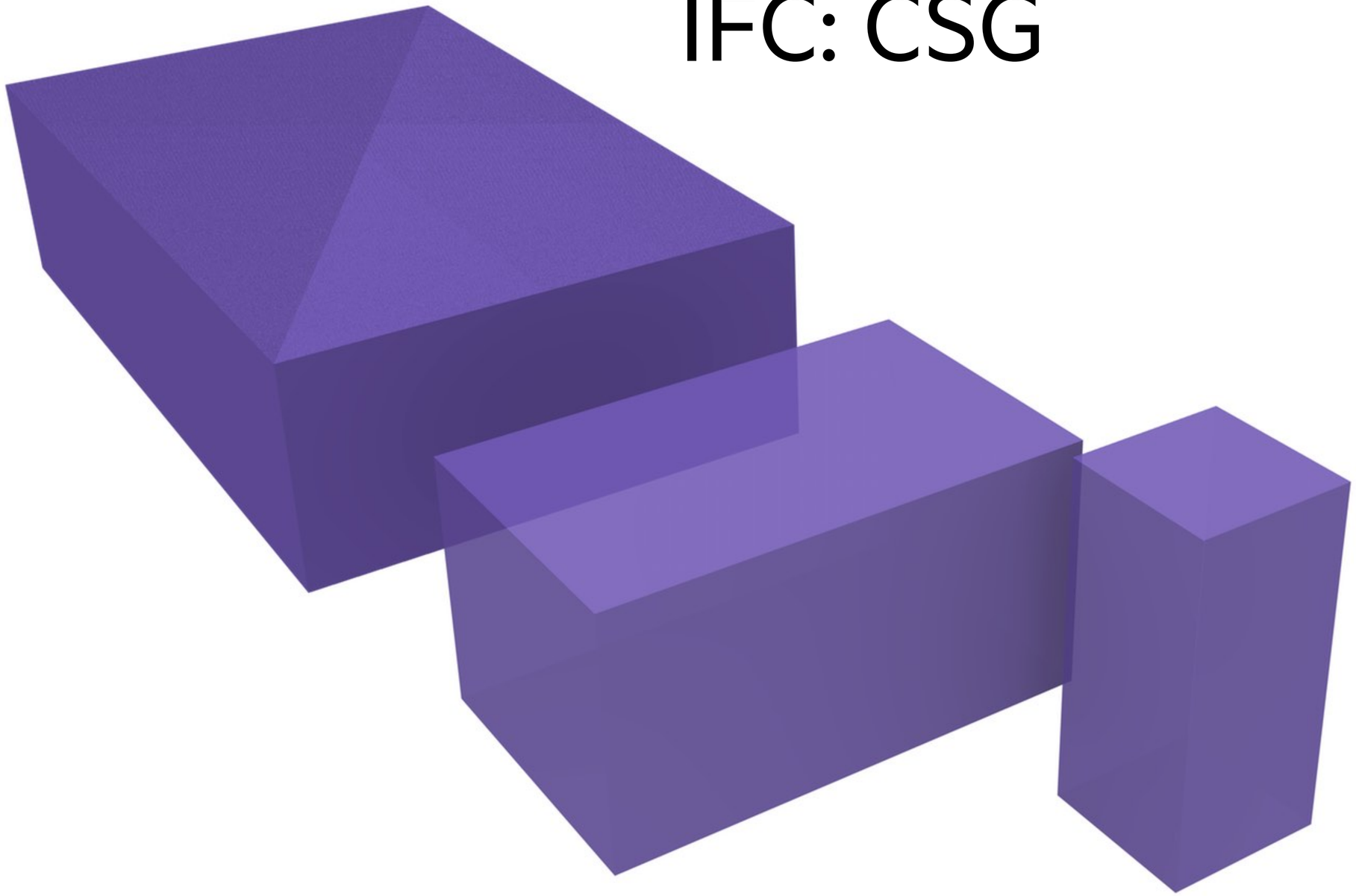
IFC: sweeps

```
#226649= IFCCOMPOSITECURVESEGMENT(.CONTINUOUS.,.T.,#226647);
#226654= IFCAXIS2PLACEMENT3D(#226652,#11,#21);
#226655= IFCCIRCLE(#226654,0.016);
#226656= IFCTRIMMEDCURVE(#226655,(IFCPARAMETERVALUE(270.)),
(IFCPARAMETERVALUE(360.)),.T.,.PARAMETER.);
#226659= IFCCOMPOSITECURVESEGMENT(.CONTINUOUS.,.T.,#226656);
#226660= IFCCARTESIANPOINT((4.30451321708365,-0.809570161482404,-0.294));
#226662= IFCCARTESIANPOINT((4.30451321708365,0.046429838517952,-0.294));
#226664= IFCPOLYLINE((#226660,#226662));
#226666= IFCCOMPOSITECURVESEGMENT(.CONTINUOUS.,.T.,#226664);
#226667= IFCCARTESIANPOINT((4.30451321708365,0.046429838517952,-0.278));
#226669= IFCCARTESIANPOINT((4.30451321708365,0.046429838517952,-0.278));
#226671= IFCAXIS2PLACEMENT3D(#226669,#11,#15);
#226676= IFCCOMPOSITECURVESEGMENT(.CONTINUOUS.,.T.,#226673);
#226677= IFCCARTESIANPOINT((4.30451321708365,0.062429838517952,-0.278));
#226679= IFCCARTESIANPOINT((4.30451321708365,0.062429838517953,-0.2));
#226681= IFCPOLYLINE((#226677,#226679));
#226683= IFCCOMPOSITECURVESEGMENT(.CONTINUOUS.,.T.,#226681);
#226684= IFCCOMPOSITECURVE((#226649,#226659,#226666,#226676,#226683),.F.);
#226691= IFCSWEPTDISKSOLID(#226684,0.006,$,0.,183.);
```

IFC: CSG

IFC: CSG

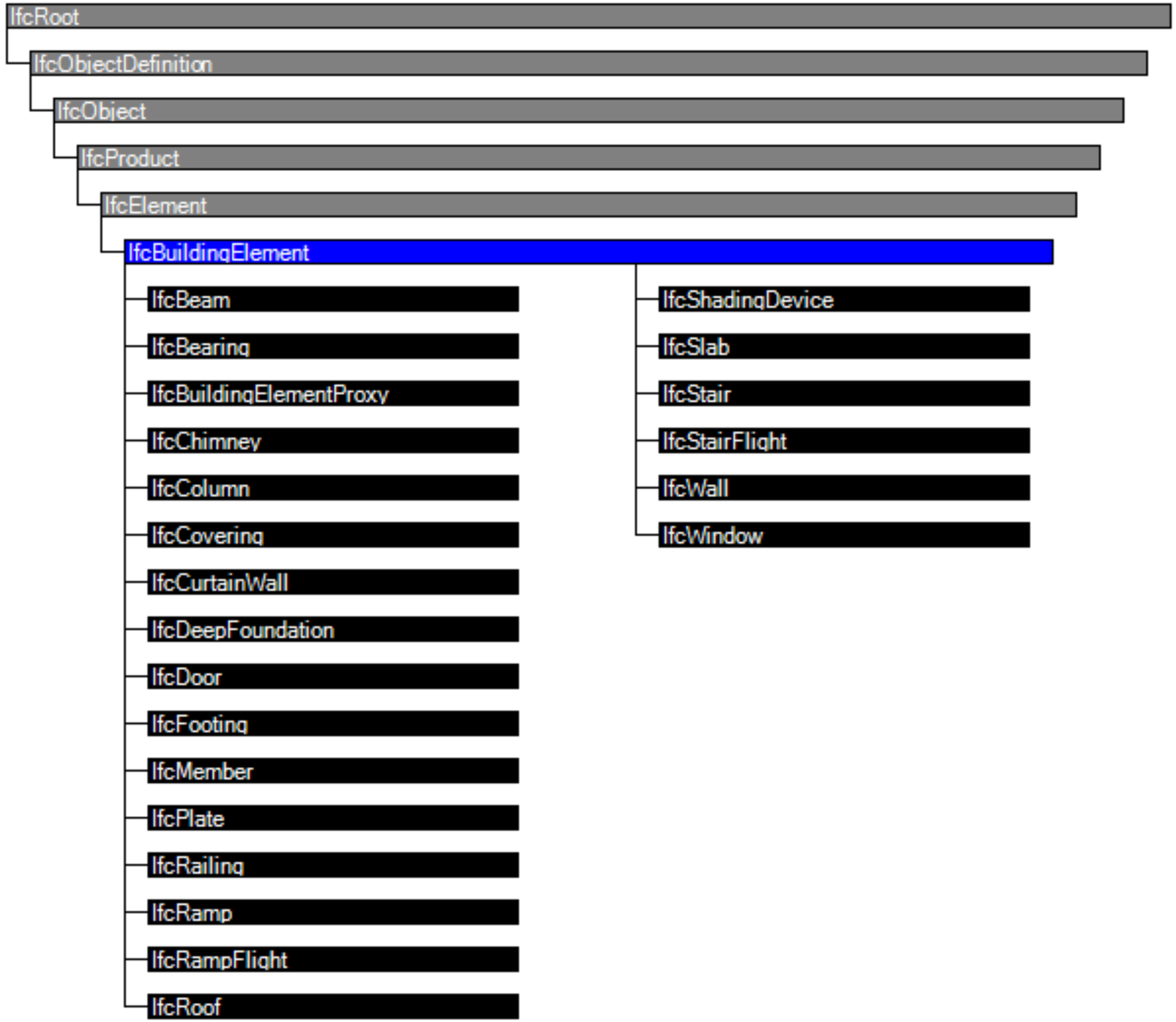
IFC: CSG



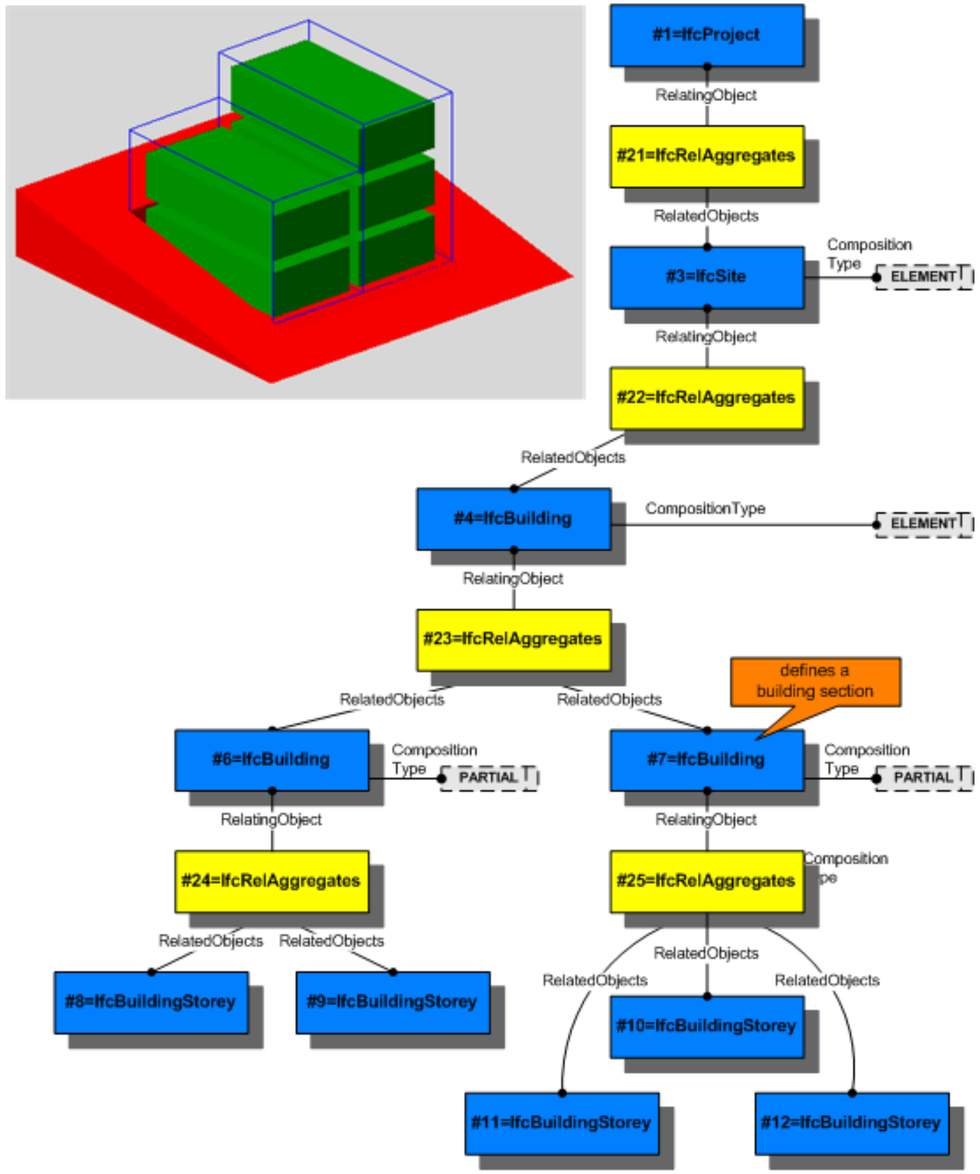
IFC

```
#237=IFCEXTRUDEDAREASOLID(#236,#234,#230,6000.);
#238=IFCDIRECTION((1.,0.,0.));
#239=IFCDIRECTION((-1.,0.,1.));
#240=IFCCARTESIANPOINT((-2500.,0.,3000.));
#241=IFCAXIS2PLACEMENT3D(#240,#239,#238);
#242=IFCPLANE(#241);
#243=IFCHALFSPACESOLID(#242,.F.);
#244=IFCBOOLEANCLIPPINGRESULT(.DIFFERENCE.,#237,#243);
```

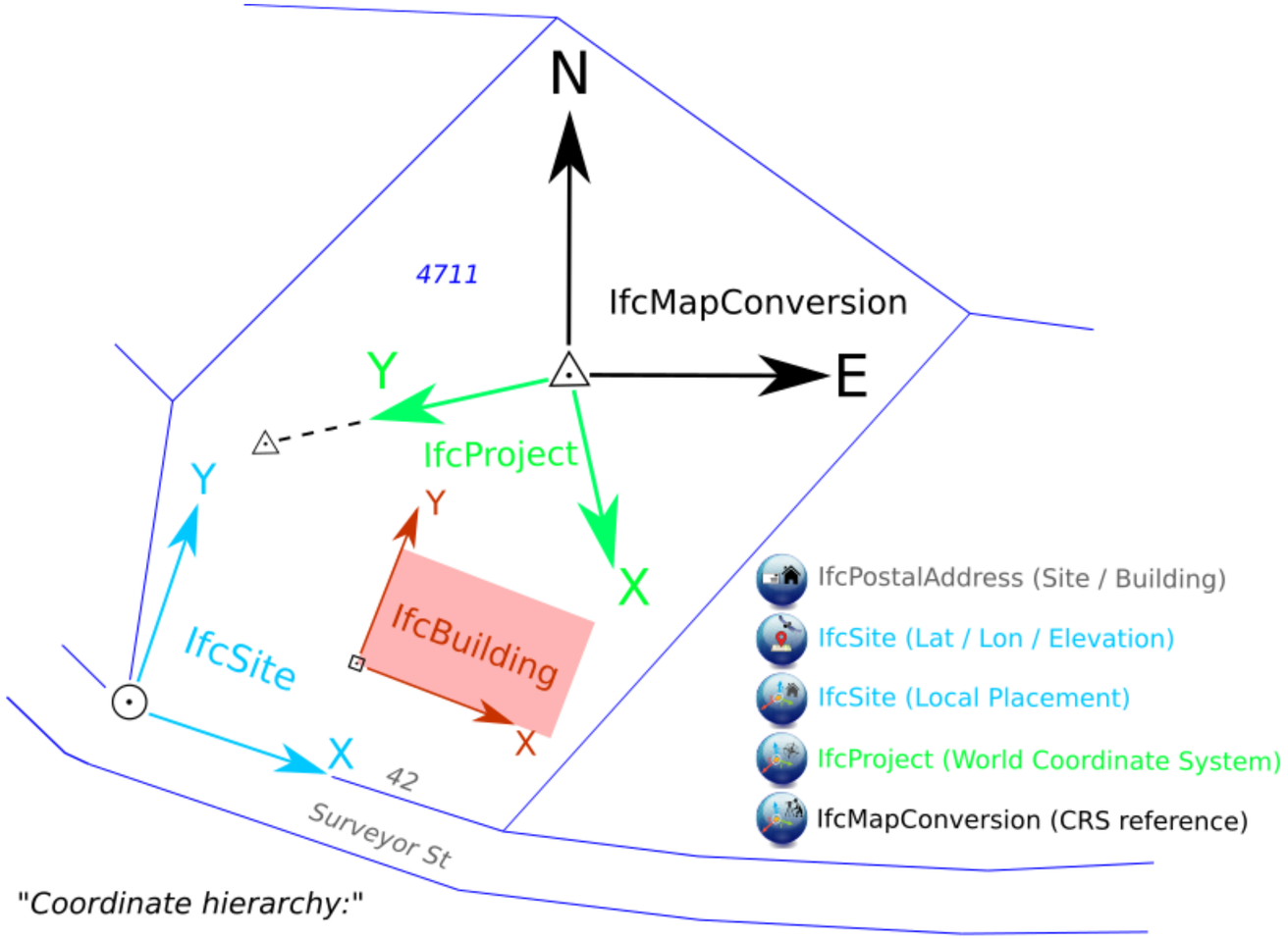
IFC in a built environment context



IfcSpatialStructureElement



Georeferencing in IFC



"*Coordinate hierarchy:*"

- Geodetic CRS or Engineering CRS (Geospatial domain)
  - Project CRS called World Coordinate System (WCS) (BIM domain)
    - Site Placement(BIM domain)
      - Building Placement (BIM domain)
        - ...

Christian, C., & Hendrik, G. (2019). Level of Georeferencing (LoGeoRef) using IFC for BIM. *Geod. Cartogr. Cadastre*, *10*, 15-20.

BIM example

Homework 3

What to do next?

1. Today:
    - Demo by Michele
    - Continue with Homework 2 (due Monday)
    - Go to geo1004 website and study today's lesson (3D book Chapter 11)
    - Start with Homework 3
2. Monday: 3D BAG guest lecture by Ravi

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