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22-26 April, Hanoi, Vietnam

"Geospatial Information for a Smarter Life
and Environmental Resilience"



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Practical Issues and Solutions in BIM GIS Interoperability

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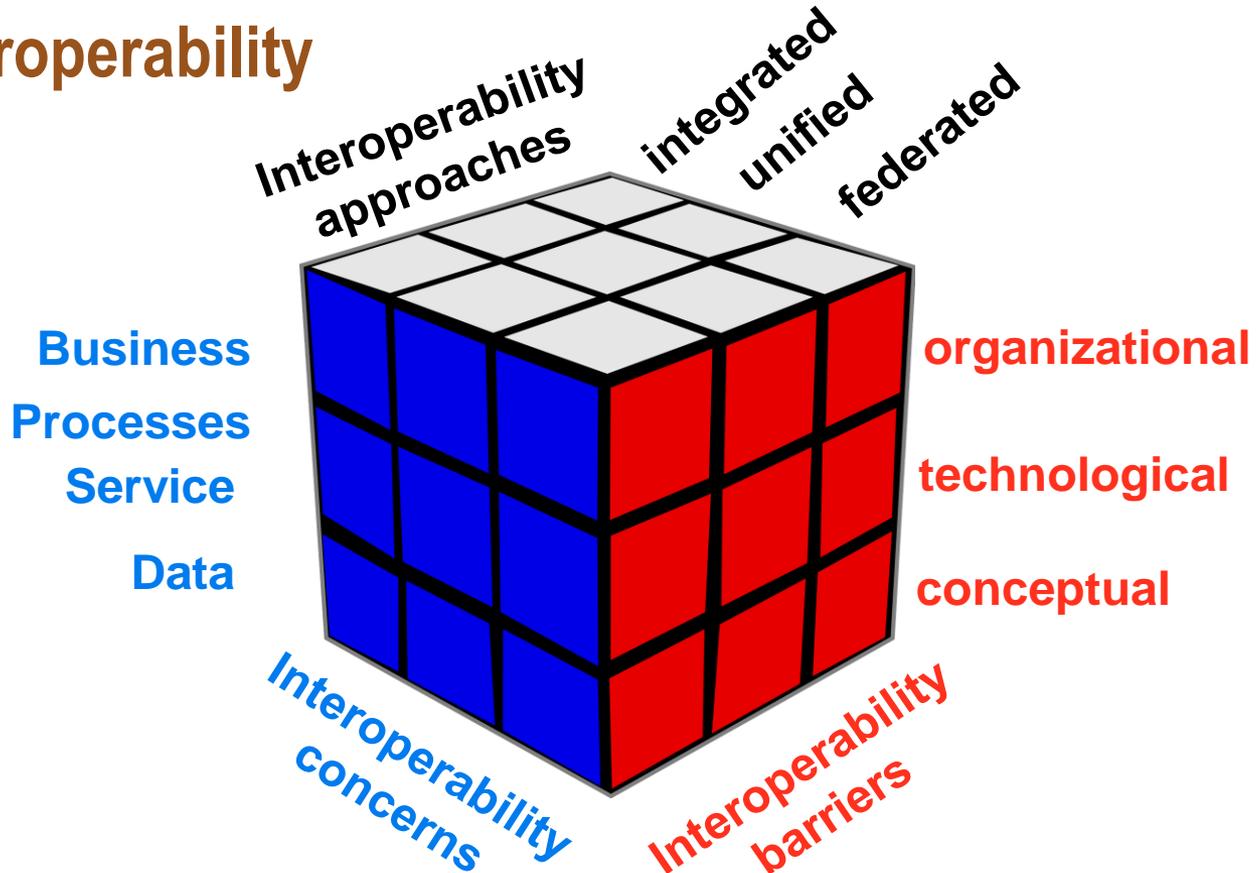
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BIM GIS Interoperability



cf. ISO 11354-1

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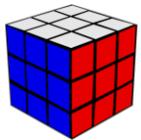
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Our Principle

- We want to rely on Open-BIM standards → IFC
- The implemented tools follow a integrated conceptual and data driven interoperability concept



integrated
conceptual
Data

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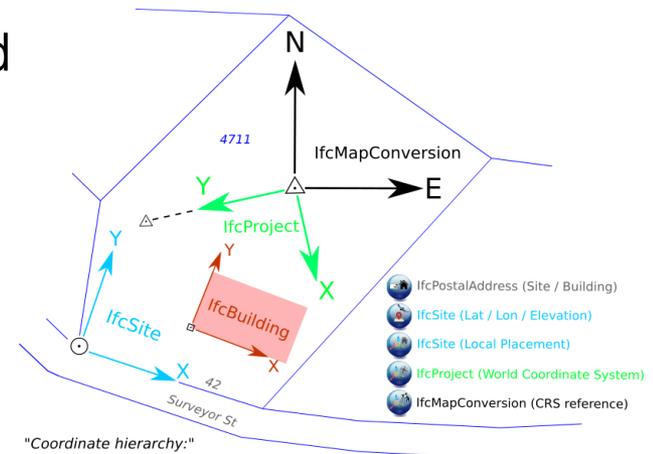
Need for Georeferencing BIM

Issue:

- Co-ordinated placement of related BIM-Models required
- Way of georeferencing should be identifiable
- Pessimistic assumption: building models in IFC are not perfectly referenced in practice

Our Solution:

- Delivered BIM-Models should be automatically checkable for georeferencing
 - Level of Georeferencing Concept
 - GeoRefChecker tool



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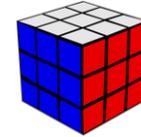
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Level of Georeferencing (LoGeoRef) Concept



integrated
conceptual
Data

- The higher the LoGeoRef is, the more information of georeferencing
- Increment is 10 – intermediate steps possible e.g. for elevation or project specific extensions
- Higher levels do not automatically include information out of lower levels.



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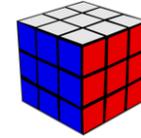
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LoGeoRef 10



integrated
conceptual
Data

- Simplest way to add (indirect) georeferencing information using an address
- Address defined by: Postal code, town, region, country and address line
- Only a rough approximation for setting the location of a IfcSite or IfcBuilding



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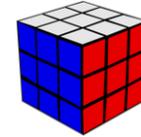
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LoGeoRef 20



integrated
conceptual
Data

- IfcSite instances must contain RefLatitude and RefLongitude
- Specified as geographic coordinates with respect to WGS84
- Elevation as a metric value related to a local datum



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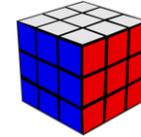
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LoGeoRef 30



integrated
conceptual
Data

- Georeferencing on IfcBuilding/-Site level using a single point and the direction of X- and Z-axis
- No specification of used CRS
- kind of misuse since IfcProject should contain these information



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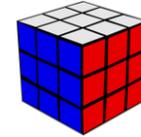
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LoGeoRef 40



integrated
conceptual
Data

- Georeferencing for IfcProject using IfcGeometricRepresentationContext
- World CRS can be specified
- In addition: true north attribute \square deviation of project north to true north



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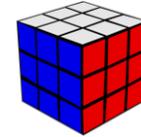
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LoGeoRef 50



integrated
conceptual
Data

- Specifies transformation parameters for transforming from the local coordinate system to the world coordinate system using a IfcMapConversion
- Ability to specify EPSG-Code
- Introduced in IFC Version 4



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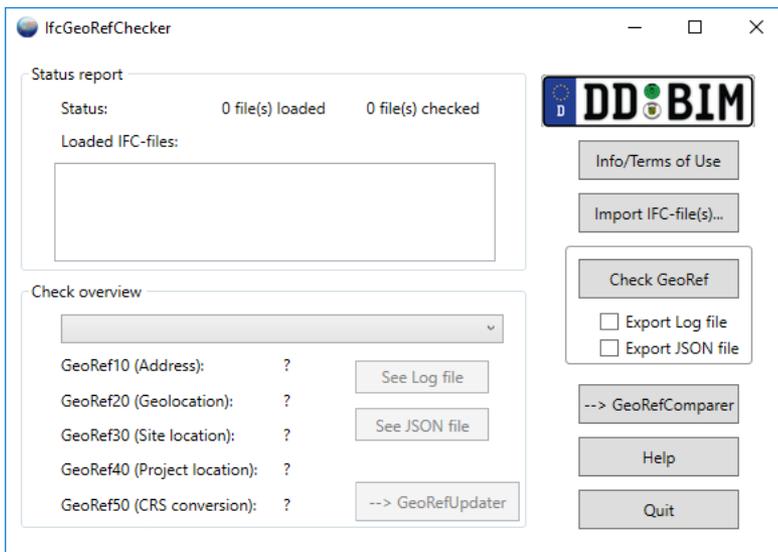
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Solution: GeoRefChecker tool

- Application for determining the LoGeoRef for a IFC-File
- saves result in a Log-File



```
Bauwerkmodell [EDITED_Ohne_STLB].ifc | ResData.cs | aBauwerkmodell.FC4.ifc | Bauwerkmodell [EDITED_Oh...
52 Rotation X-axis = (1/0/0)
53 Rotation Z-axis = (0/0/1)
54
55 TrueNorth:
56 If present there is a rotation of the XY-plane towards the True
57 (Caution: IFC-schema does not define an attribute for Grid North)
58
59 There is no value for TrueNorth mentioned.
60
61 LoGeoRef 40 = false
62
63 -----
64 Specific entities for georeferencing (only in scope of IFC4; IfcM
65 -----
66 There is a conversion of the world coordinate system (WCS) in a
67
68 Project Context element which is referenced by IfcMapConversion:
69
70 Conversion parameters (WCS to CRS): #2= IfcMapConversion
71 Translation:
72 Eastings: 3458715.92
73 Northings: 5439966.65
74 Orthogonal height: 113.7
75 Rotation of the XY-plane:
76 Abscissa of the X-axis (vector component): 0.270600445976
77 Ordinate of the X-axis (vector component): 0.962691746426
78 Scale:
79
80 Definition of the CRS:
81 Target system (CRS): #1= IfcProjectedCRS
82 Name: EPSG:31467
83 Description: DHDN / 3-Degree Gauss-Krueger Zone 3
84 Geodetic Datum: ETRS89
85 Vertical Datum:
86 Projection:
87
88 Name: Gauss-Krueger
89 Zone: 3
90
Normal text file
```

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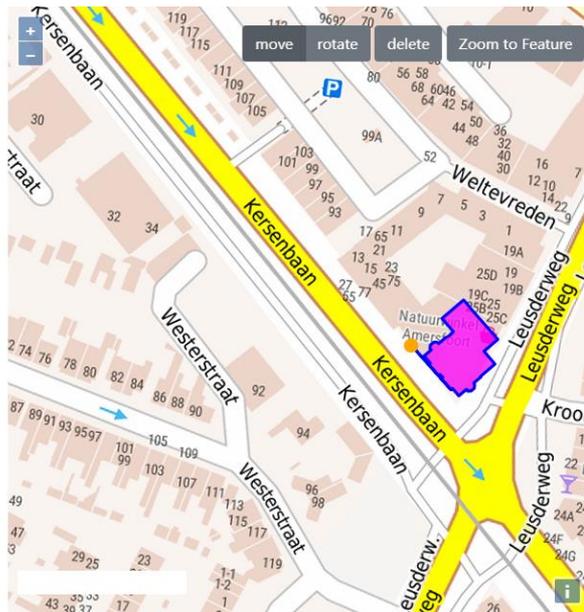
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GeoRefChecker updating function

- Extracts building footprints and saves it as Well Known Text
- Place building accordingly in map and write back results of LoGeoRef 50 to IFC File



HTW Dresden Building Locator

1. Select File
2. Show Existing Georef Information
3. Select Map Projection
4. Position Building
5. Query Building Address
6. Save Position and Download File

[Save Settings](#) [Download JSON-File](#)

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Need for Digital Terrain Models in BIM

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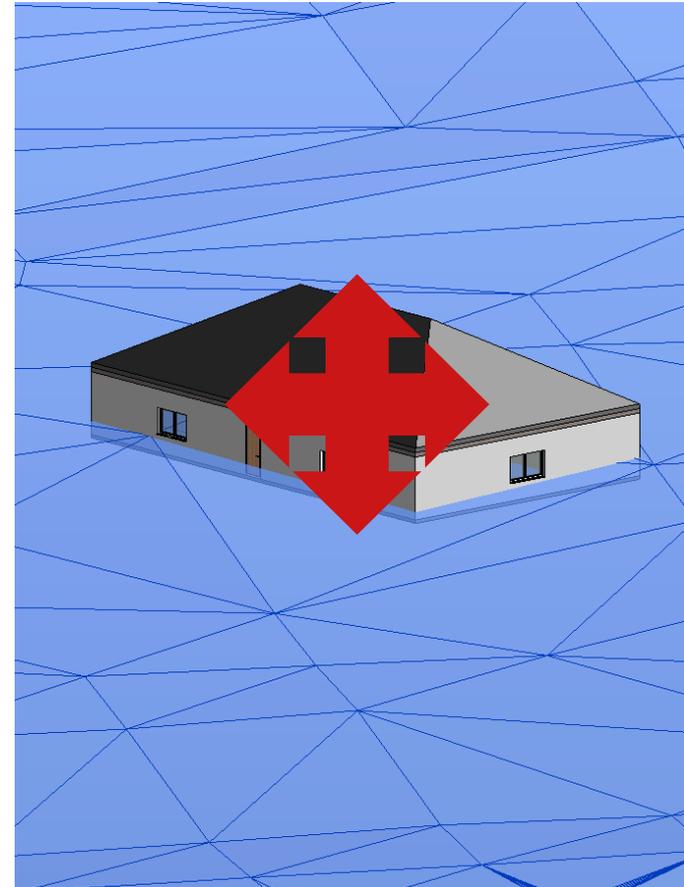
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Need for Digital Terrain Models in BIM

- Correct Placement of building models



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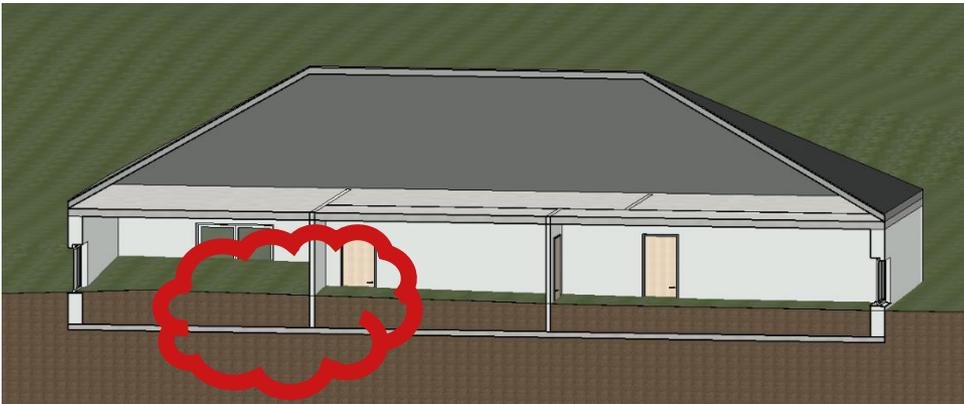
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Need for Digital Terrain Models in BIM

- Correct Placement of building models
- Clash Detection



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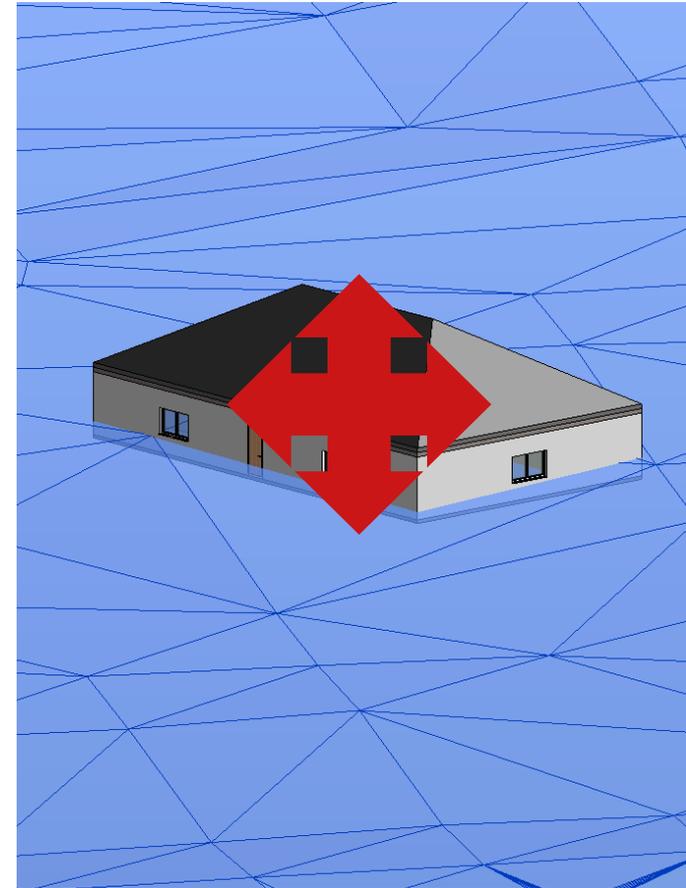
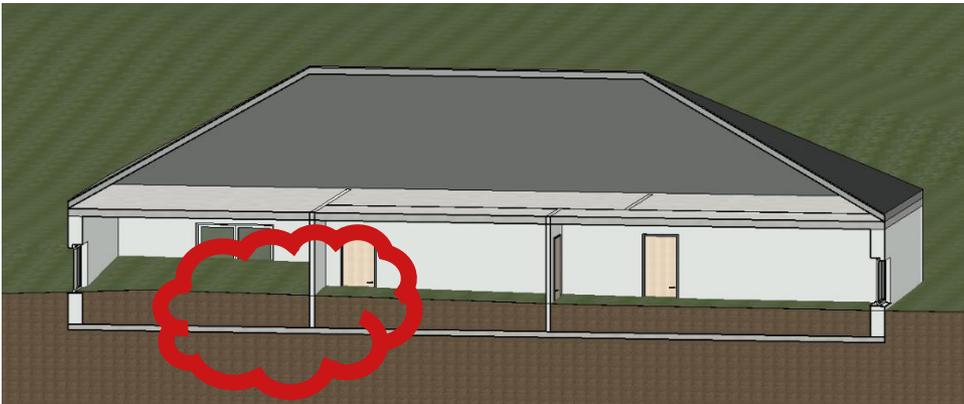
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Need for Digital Terrain Models in BIM

- Correct Placement of building models
- Clash Detection
- Visualization



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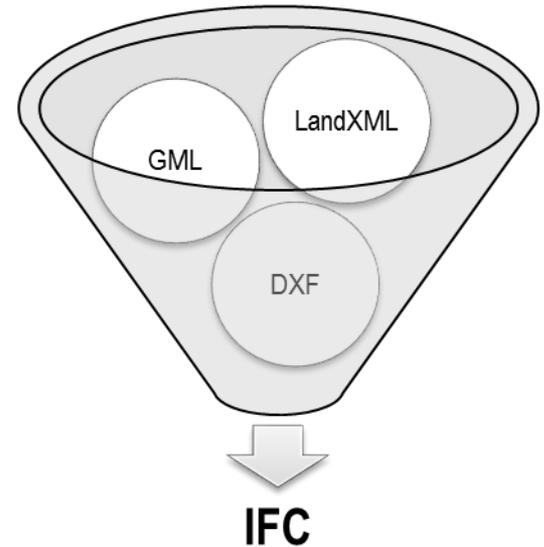
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Need for Digital Terrain Models in BIM

Issue:

- Different GIS/CAD file formats (LandXML, DXF, ...)
- Different BIM-Viewer capabilities
- not everyone has professional BIM software



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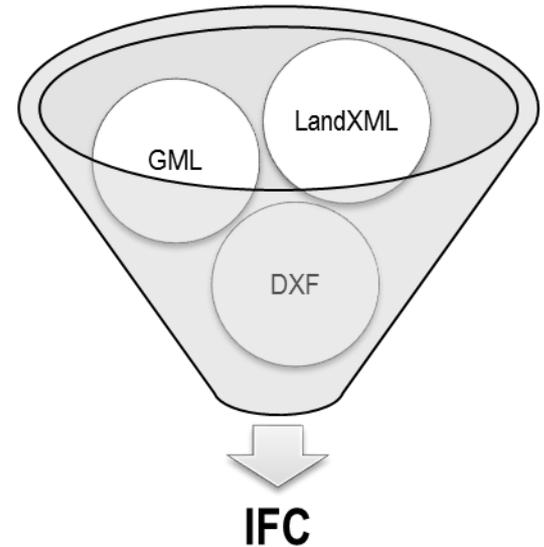
Need for Digital Terrain Models in BIM

Issue:

- Different GIS/CAD file formats (LandXML, DXF, ...)
- Different BIM-Viewer capabilities
- not everyone has professional BIM software

Our Solution:

- Small tool, reads different file formats, writes IFC only
- TINs preferred
- Different IFC geometric representations possible



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Different Input File Formats

- Reading is possible if a format description available (LandXML, DXF, ...)
- The main problem is the geometric representation of the DTM.



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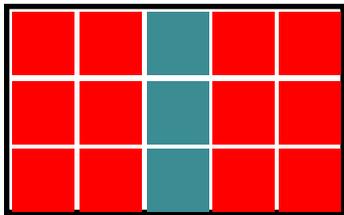
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Grid

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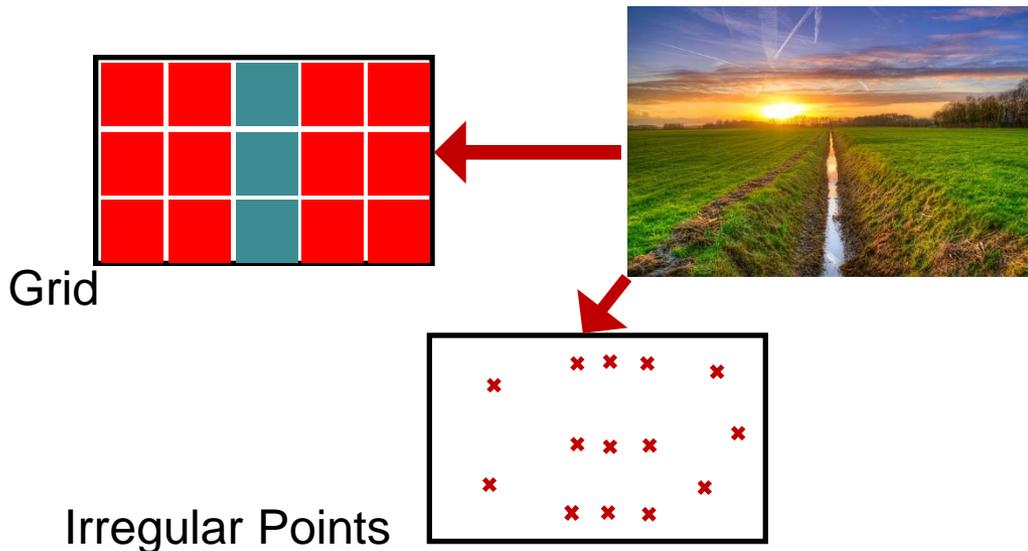
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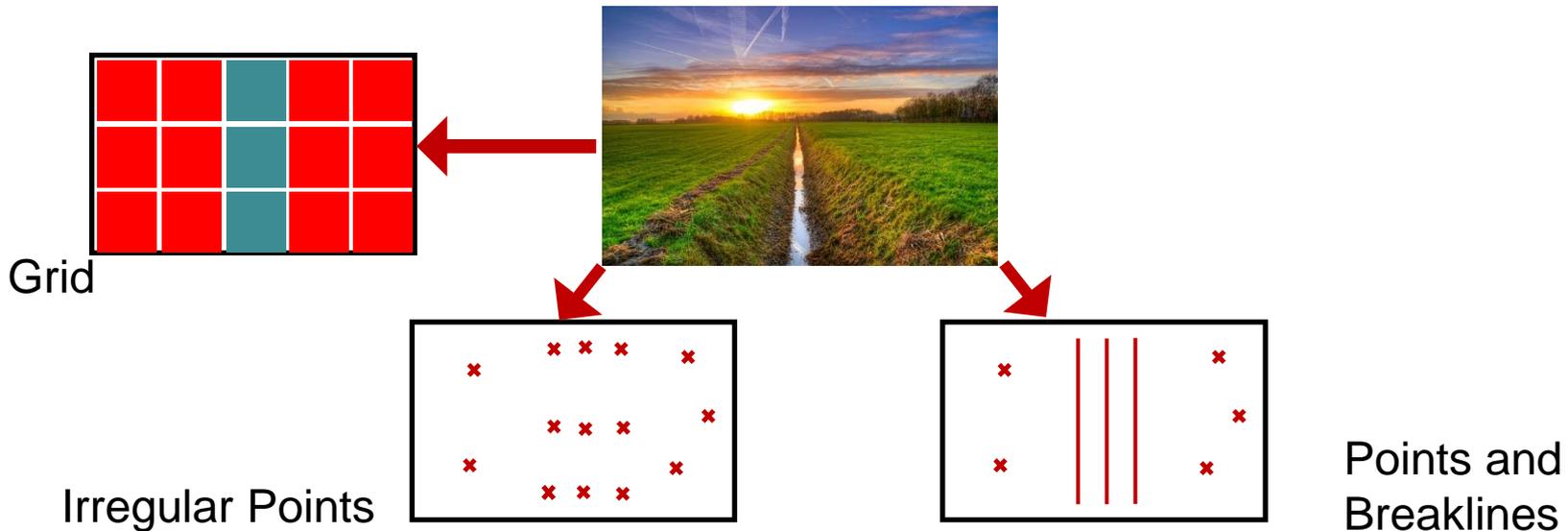
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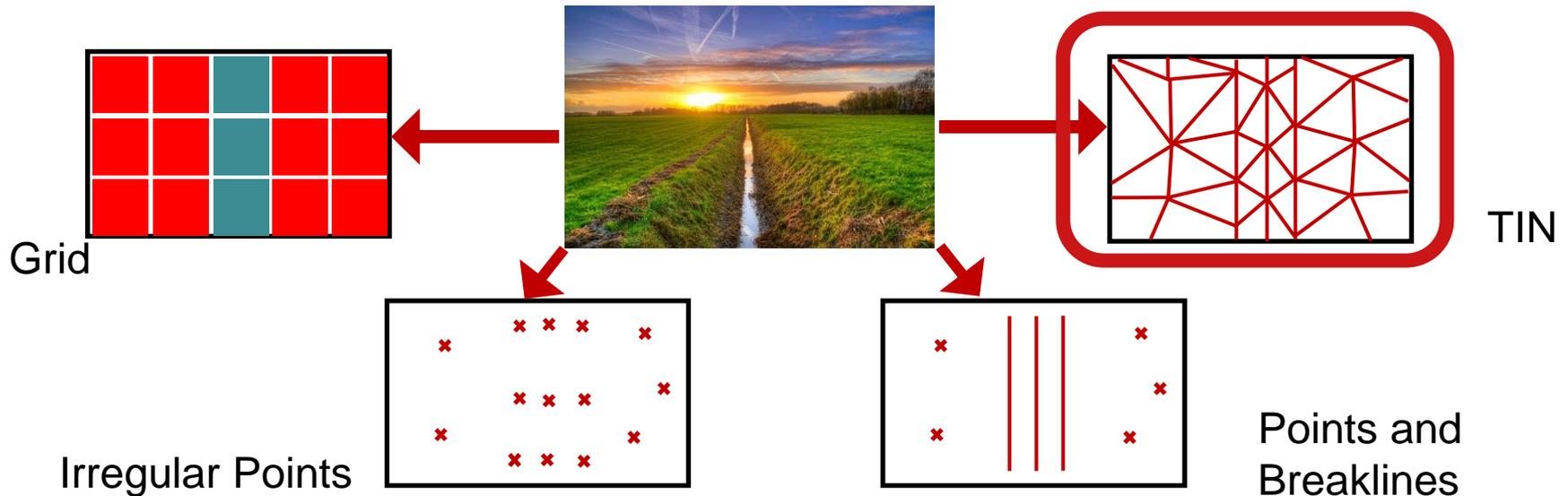
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Different Input File Formats

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How to represent DTM geometry in IFC?

- Terrain is geometrically represented by an closed surface
- Three IFC types of geometric representation are suitable, depending on input format and viewer capabilities:

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How to represent DTM geometry in IFC?

- Terrain is geometrically represented by an closed surface
- Three IFC types of geometric representation are suitable, depending on input format and viewer capabilities:

| | IfcGeometric-CurveSet |
|------------------------|------------------------------|
| Grid | possible |
| Points | possible |
| Points and Break lines | best |
| TIN | possible |

*since IFC Version 4

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How to represent DTM geometry in IFC?

- Terrain is geometrically represented by an closed surface
- Three IFC types of geometric representation are suitable, depending on input format and viewer capabilities:

| | IfcGeometric-CurveSet | IfcShellBased-SurfaceModel |
|------------------------|------------------------------|-----------------------------------|
| Grid | possible | 0 |
| Points | possible | 0 |
| Points and Break lines | best | 0 |
| TIN | possible | good |

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How to represent DTM geometry in IFC?

- Terrain is geometrically represented by an closed surface
- Three IFC types of geometric representation are suitable, depending on input format and viewer capabilities:

| | IfcGeometric-CurveSet | IfcShellBased-SurfaceModel | IfcTriangulated-FaceSet* |
|------------------------|------------------------------|-----------------------------------|---------------------------------|
| Grid | possible | 0 | 0 |
| Points | possible | 0 | 0 |
| Points and Break lines | best | 0 | 0 |
| TIN | possible | good | best |

*since IFC Version 4

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How to represent DTM in IFC semantically?

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Implementation

- Small desktop application built on .Net-Framework and xBIM-Toolkit*

*docs.xbim.net

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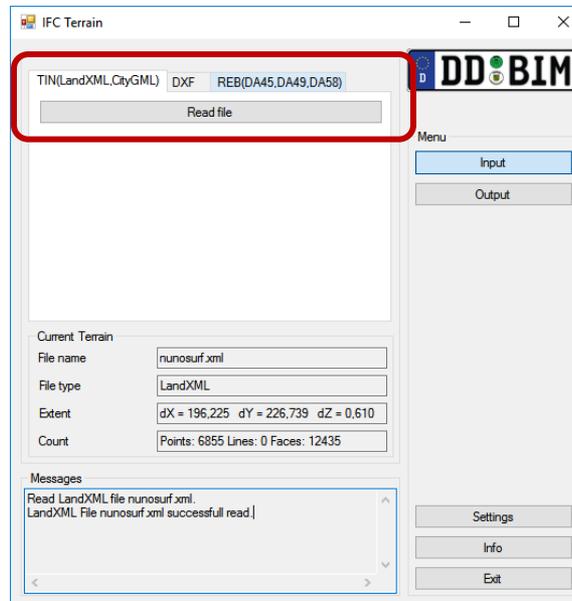
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Implementation

- Small desktop application built on .Net-Framework and xBIM-Toolkit*
- 3-Step conversion:
 1. Read Source



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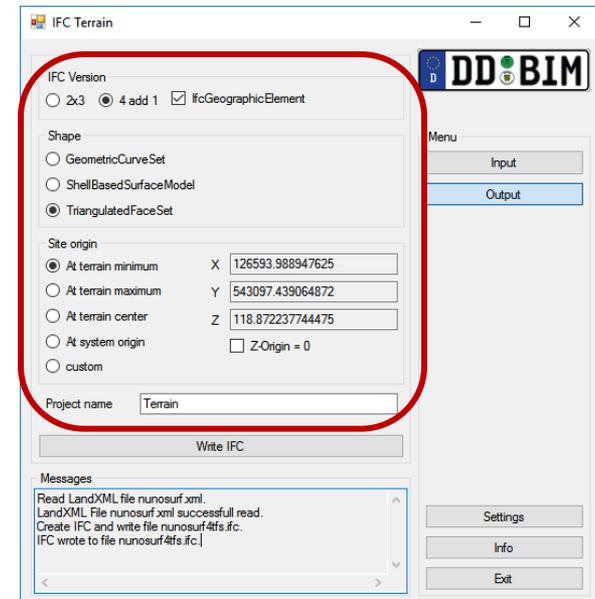
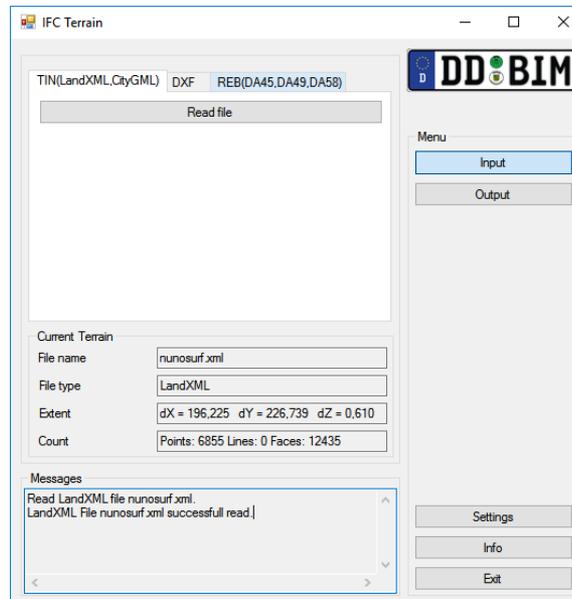
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Implementation

- Small desktop application built on .Net-Framework and xBIM-Toolkit*
- 3-Step conversion:
 1. Read Source
 2. Configure



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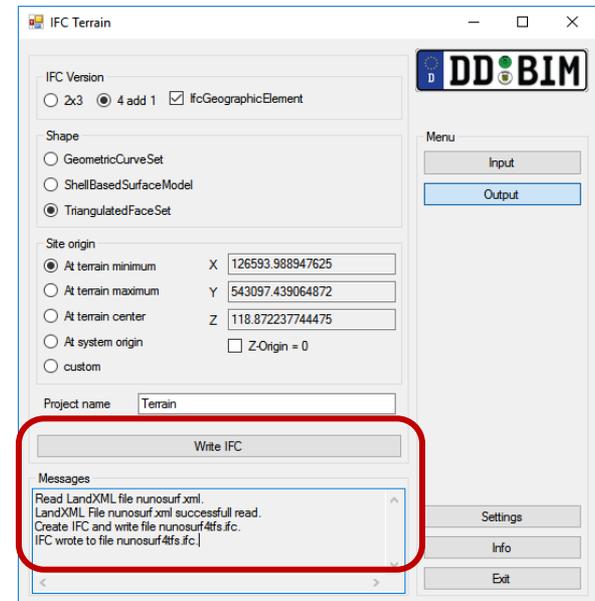
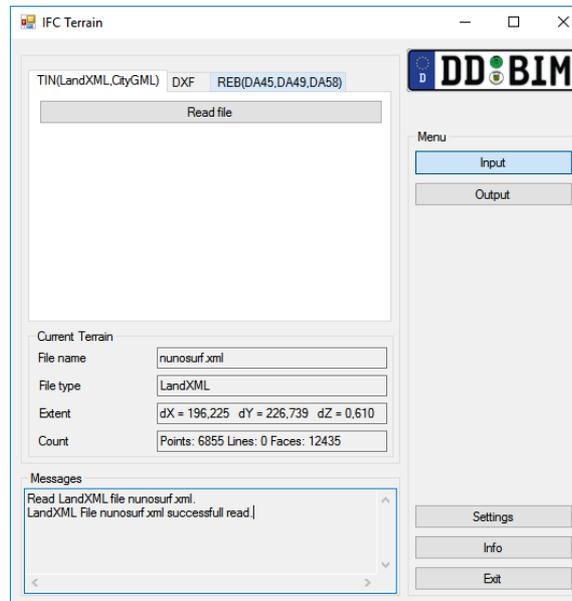
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Implementation

- Small desktop application built on .Net-Framework and xBIM-Toolkit*
- 3-Step conversion:
 1. Read Source
 2. Configure
 3. Write IFC



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Results

```
<?xml version="1.0" encoding="UTF-8"?>
<LandXML xmlns="http://www.landxml.org/schema/LandXML-2.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.landxml.org/schema/LandXML-2.0 http://
<Units>
  <Imperial linearUnit="USSurveyFoot" areaUnit="acre" volumeUnit="cubicFeet"/>
</Units>
<Application name="Precision 3D 2016" desc="Topo" version="2.0.0" manufacturer="Carlson Software" manufacturerURL="www.carlsonsw.com"/>
<CoordinateSystem ogcKtCode="PROJCS[&quot;CANQ-M6&quot;],GEOGCS[&quot;LL83&quot;],DATUM[&quot;NAD83&quot;],SPHEROID[&quot;GRS1980&quot;],6378137.000,298.25722210]],PRIMEM[&quot;Gre
<Surfaces>
  <Surface name="wald park_Design_Elevated-zn.tin">
    <SourceData>
      <Boundaries>
        <Boundary bndType="texture" n="1">
          <PntList3D>415977.399695 1782063.636323 390.000000 415977.363614 1782064.093632 390.000000 415977.323877 1782064.550637 390.000000 415977.280484 1782065.00731
        </Boundary>
        <Boundary bndType="texture" n="1">
          <PntList3D>415701.809960 1782013.955743 390.000000 415701.399620 1782014.161917 390.000000 415700.989376 1782014.368043 390.000000 415700.579208 1782014.57413
        </Boundary>
        <Boundary bndType="texture" n="1">
          <PntList3D>415595.015455 1782152.967648 390.000000 415560.353322 1782199.835517 390.000000 415560.378698 1782199.856960 390.000000 415550.580296 1782212.90529
        </Boundary>
        <Boundary bndType="texture" n="2">
          <PntList3D>415720.110180 1782110.267810 390.000000 415669.512990 1782072.311610 390.000000 415669.147300 1782064.069520 390.000000 415669.965630 1782055.86000
        </Boundary>
        <Boundary bndType="texture" n="2">
          <PntList3D>415604.743880 1782140.776740 390.000000 415604.743880 1782140.776740 390.000000 415674.989320 1782193.474200 390.000000 415621.503980 1782265.05193
        </Boundary>
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        </Boundary>
        <Boundary bndType="texture" n="5">
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      </Boundaries>
    </SourceData>
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      <Pnts>
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        <P id="2">415816.976180 1782036.839513 390.000000</P>
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        <P id="6">415821.728059 1782035.012036 390.000000</P>
        <P id="7">415625.979179 1782296.191439 390.000000</P>
        <P id="8">415626.437977 1782298.043703 390.000000</P>
        <P id="9">415629.069086 1782297.659259 390.000000</P>
        <P id="10">415637.514697 1782293.280171 390.000000</P>
        <P id="11">415550.852078 1782226.125464 390.000000</P>
        <P id="12">415551.089857 1782226.125464 390.000000</P>
        <P id="13">415551.327576 1782226.117856 390.000000</P>
        <P id="14">415551.565173 1782226.108347 390.000000</P>
        <P id="15">415551.802587 1782226.095038 390.000000</P>
      </Pnts>
    </Definition>
  </Surface>
</Surfaces>
```

ORGANISED BY



Enrico Romanschek, Tim Kaiser, Christian Clemen

PLATINUM SPONSORS





FIG WORKING WEEK 2019

22-26 April, Hanoi, Vietnam

"Geospatial Information for a Smarter Life and Environmental Resilience"



Results

```
<?xml version="1.0" encoding="UTF-8"?>
<landxml xmlns="http://www.landxml.org/schema/LandXML-2.0" xmlns:ISO-10303-21;
  <Units>
    <Imperial linearUnit="USSurveyFoot" areaUnit="acre" volu
  </Units>
  <Application name="Precision 3D 2016" desc="Topo" version="2"
  <CoordinateSystem ogcWktCode="PROJCS[&quot;CANQ-M6&quot;],GEO
  <Surfaces>
    <Surface name="wald park_Design_Elevated-zn.tin">
      <SourceData>
        <Boundaries>
          <Boundary bndType="texture" n="1">
            <PntList3D>415977.399695 1782063.636323
          </Boundary>
          <Boundary bndType="texture" n="1">
            <PntList3D>415701.809960 1782013.955743
          </Boundary>
          <Boundary bndType="texture" n="1">
            <PntList3D>415595.015455 1782152.967648
          </Boundary>
          <Boundary bndType="texture" n="2">
            <PntList3D>415720.110180 1782110.267810
          </Boundary>
          <Boundary bndType="texture" n="2">
            <PntList3D>415604.743880 1782140.776740
          </Boundary>
          <Boundary bndType="texture" n="3">
            <PntList3D>415589.535088 1781831.013317
          </Boundary>
          <Boundary bndType="texture" n="3">
            <PntList3D>415600.792958 1782108.567651
          </Boundary>
          <Boundary bndType="texture" n="4">
            <PntList3D>415714.812486 1782189.323306
          </Boundary>
          <Boundary bndType="texture" n="5">
            <PntList3D>415634.589602 1782077.410904
          </Boundary>
        </Boundaries>
      </SourceData>
      <Definition surfType="TIN">
        <Pnts>
          <P id="1">415819.792437 1782035.038711 390.0#30=IFCARTESIANPOINTLIST3D(((148.13727142495918,67.9270649732789,0.),(147.27887457454926,68.47595052071847,0.),(147.91400802641874,66
          <P id="2">415816.976180 1782036.839513 390.0#31=IFCTRIANGULATEDFACESET(#30,$,F.,((1,3,2),(6205,6204,3653),(6,4,1),(3,1,4),(5,4,6),(7,9,8),(8,5774,7),(9,5885,8),(7,10,9),(10,5867
          <P id="3">415819.059947 1782038.497944 390.0#32=IFCSHAPEREPRESENTATION(#20,'Body','Tessellation',(#31));
          <P id="4">415820.274732 1782039.224278 390.0#33=IFCGEOGRAPHICELEMENT('2tN0ix7dvBbxVveVfvgvq',#2,'TIN',$,$,#34,#39,$.TERRAIN.);
          <P id="5">415823.430396 1782036.519109 390.0#34=IFCLOCALPLACEMENT(#25,#35);
          <P id="6">415821.728059 1782035.012036 390.0#35=IFCAXIS2PLACEMENT3D(#36,#36,#37);
          <P id="7">415625.979179 1782296.191439 390.0#36=IFCARTESIANPOINT((0.,0.,0.));
          <P id="8">415626.437977 1782298.043703 390.0#37=IFCARTESIANPOINT((0.,0.,0.));
          <P id="9">415629.069086 1782297.659259 390.0#38=IFCDIRECTION((1.,0.,0.));
          <P id="10">415637.514697 1782293.280371 390.0#39=IFCDIRECTION((0.,0.,1.));
          <P id="11">415550.852078 1782226.125464 390.0#40=IFCLOCALPLACEMENT(#25,#35);
          <P id="12">415550.852078 1782226.125464 390.0#41=IFCLOCALPLACEMENT(#25,#35);
          <P id="13">415551.089857 1782226.123562 390.0#42=IFCLOCALPLACEMENT(#25,#35);
          <P id="14">415551.327576 1782226.117856 390.0#43=IFCLOCALPLACEMENT(#25,#35);
          <P id="15">415551.565173 1782226.108347 390.0#44=IFCLOCALPLACEMENT(#25,#35);
          <P id="16">415551.802587 1782226.095038 390.0#45=IFCLOCALPLACEMENT(#25,#35);
        </Pnts>
      </Definition>
    </Surface>
  </Surfaces>
  <Data>
    #1=IFCPROJECT('0cMqMbbSH2zBkh80qWvq',#2,'Terrain',$,$,$,$,#20,#23,#8);
    #2=IFCOWNERHISTORY(#5,#6,$.ADDED.1555422067,$,$.1555422067);
    #3=IFCPERSON($,'Mustermann','Klaus',$,$,$,$);
    #4=IFCORGANIZATION($,'HTW Dresden',$,$,$);
    #5=IFCPERSONANDORGANIZATION(#3,#4,$);
    #6=IFCAPPLICATION(#7,'0.2.0.0','IFCTerrain,Version=0.2.0.0,Culture=neutral,PublicKeyToken=null','IFCTerrain');
    #7=IFCORGANIZATION($,'HTW Dresden for DBTM',$,$,$);
    #8=IFCUNITASSIGNMENT((#9,#10,#11,#12,#13,#14,#15,#16,#17));
    #9=IFCSIUNIT(*,.LENGTHUNIT,$,.METRE.);
    #10=IFCSIUNIT(*,.AREAUNIT,$,.SQUARE_METRE.);
    #11=IFCSIUNIT(*,.VOLUMEUNIT,$,.CUBIC_METRE.);
    #12=IFCSIUNIT(*,.SOLIDANGLEUNIT,$,.STERADIAN.);
    #13=IFCSIUNIT(*,.PLANEANGLEUNIT,$,.RADIAN.);
    #14=IFCSIUNIT(*,.MASSUNIT,$,.GRAM.);
    #15=IFCSIUNIT(*,.TIMEUNIT,$,.SECOND.);
    #16=IFCSIUNIT(*,.THERMODYNAMICTEMPERATUREUNIT,$,.DEGREE_CELSIUS.);
    #17=IFCSIUNIT(*,.LUMINOUSINTENSITYUNIT,$,.LUMEN.);
    #18=IFCARTESIANPOINT((0.,0.,0.));
    #19=IFCAXIS2PLACEMENT3D(#18,$,$);
    #20=IFCGEOMETRICREPRESENTATIONCONTEXT('Building Model','Model',3,1.E-05,#19,$);
    #21=IFCARTESIANPOINT((0.,0.));
    #22=IFCAXIS2PLACEMENT2D(#21,$);
    #23=IFCGEOMETRICREPRESENTATIONCONTEXT('Building Plan View','Plan',2,1.E-05,#22,$);
    #24=IFCSITE('0$G$BARXt0r0Bn3zG_Np$,#2,'Site with Terrain',$,$,#25,$,$.ELEMENT.,$,$,$,$);
    #25=IFCLOCALPLACEMENT($,#26);
    #26=IFCAXIS2PLACEMENT3D(#27,#29,#28);
    #27=IFCARTESIANPOINT((1.26593.98894762508,543097.43906487175,118.87223774447548));
    #28=IFCDIRECTION((1.,0.,0.));
    #29=IFCDIRECTION((0.,0.,1.));
    #30=IFCDIRECTION((0.,0.,1.));
  </Data>
</landxml>
END-ISO-10303-21;
```

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Results

The screenshot displays the FZKViewer application with an IFC schema file open. The left pane shows the XML code, and the right pane shows a 3D view of a terrain model.

```

<?xml version="1.0" encoding="UTF-8"?>
<LandXML xmlns="http://www.landxml.org/schema/LandXML-2.0" xmlns:ISO="10303-21">
  <Units>
    <Imperial linearUnit="USSurveyFoot" areaUnit="acre" volumeUnit="cubicFoot" />
  </Units>
  <Application name="Precision 3D 2016" desc="Topo" version="2" />
  <CoordinateSystem ogcWktCode="PROJCS[\"&quot;CANQ-M6&quot;],GEOGCS[\"&quot;NAD83&quot;],DATUM[\"&quot;North American Datum of 1983&quot;],SPHEROID[\"&quot;GRS 1980&quot;],PRIME_MERIDIAN[\"&quot;North American&quot;],UNIT[\"&quot;Meter&quot;],PROJECTION[\"&quot;NAD83 / UTM&quot;],PARAMETERS[\"&quot;UTM&quot;],SCALE_FACTOR[\"&quot;0.9996093192&quot;],FALSE_EASTING[\"&quot;500000.00&quot;],FALSE_NORTHING[\"&quot;0.00&quot;],FALSE_VERTICAL[\"&quot;0.00&quot;],ELLIPSOID[\"&quot;GRS 1980&quot;],SEMI_MAJOR_AXIS[\"&quot;6378137.0&quot;],SEMI_MINOR_AXIS[\"&quot;6356752.3141408&quot;],ECCENTRICITY_SQUARED[\"&quot;0.0067226754&quot;],ECCENTRICITY[\"&quot;0.0820945&quot;],LONGITUDE_OF_ORIGIN[\"&quot;0.0&quot;],FALSE_ORIGIN[\"&quot;0.0&quot;],TOWNSHIP_ORIGIN[\"&quot;0.0&quot;],NORTHING_ORIGIN[\"&quot;0.0&quot;],EASTING_ORIGIN[\"&quot;0.0&quot;],UNITS[\"&quot;Meter&quot;]&quot; />
  <Surfaces>
    <Surface name="wald park_Design_Elevated-zn.tin">
      <SourceData>
        <Boundaries>
          <Boundary bndType="texture" n="1">
            <PntList3D>415977.399695 1782063.636323
          </Boundary>
          <Boundary bndType="texture" n="1">
            <PntList3D>415701.809960 1782013.955743
          </Boundary>
          <Boundary bndType="texture" n="1">
            <PntList3D>415595.015455 1782152.967648
          </Boundary>
          <Boundary bndType="texture" n="2">
            <PntList3D>415720.110180 1782110.267810
          </Boundary>
          <Boundary bndType="texture" n="2">
            <PntList3D>415604.743880 1782140.776740
          </Boundary>
          <Boundary bndType="texture" n="3">
            <PntList3D>415589.535088 1781831.013317
          </Boundary>
          <Boundary bndType="texture" n="3">
            <PntList3D>415600.792958 1782108.567651
          </Boundary>
          <Boundary bndType="texture" n="4">
            <PntList3D>415714.812486 1782189.323306
          </Boundary>
          <Boundary bndType="texture" n="5">
            <PntList3D>415634.589602 1782077.410904
          </Boundary>
        </Boundaries>
      </SourceData>
      <Definition surfType="TIN">
        <Pnts>
          <P id="1">415819.792437 1782035.038711 390.0#30=IFCGARTES
          <P id="2">415816.976180 1782036.839513 390.0#31=IFCTRIANG
          <P id="3">415819.059947 1782038.497944 390.0#32=IFCSHAPER
          <P id="4">415820.274732 1782039.224278 390.0#33=IFCGEOGRA
          <P id="5">415823.430396 1782036.519109 390.0#34=IFCLOCALP
          <P id="6">415821.728059 1782035.012036 390.0#35=IFCGARTES2P
          <P id="7">415625.979179 1782296.191439 390.0#36=IFCGARTES
          <P id="8">415626.437977 1782298.043703 390.0#37=IFCDIRECT
          <P id="9">415629.069086 1782297.659259 390.0#38=IFCDIRECT
          <P id="10">415637.514697 1782293.280171 390.0#39=IFCDIRECT
          <P id="11">415550.852078 1782226.125464 390.0#40=IFCPRODUC
          <P id="12">415551.089857 1782226.123562 390.0#41=IFCRELCON
          <P id="13">415551.327576 1782226.117856 390.0#42=IFCRELAGG
          <P id="14">415551.565173 1782226.108347 390.0#43=IFCENDSEC
          <P id="15">415551.802587 1782226.095038 390.0#44=IFCENDSEC
          <P id="16">415551.802587 1782226.095038 390.0#45=IFCENDSEC
        </Pnts>
      </Definition>
    </Surface>
  </Surfaces>
</LandXML>
  
```

The 3D view shows a terrain model with a red-shaded area representing the site. The interface includes a Browser Toolbar, a 3D View window, and an Element Toolbar.

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Tools are available for download!

- http://www.dd-bim.org/?page_id=31
- Contact us if you find any bugs :)
dd-bim @ htw-dresden.de



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