Geographic Information in IFC4
- linking BIM to the Earth

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Geographic Information in IFC4

In this section, inheritance graphs and attributes for relevant IFC entities are displayed. Attributes necessary to perform the transformation are bolded and discussed more in-depth.

**WorldCoordinateSystem**: Establishment of the engineering coordinate system (often referred to as the world coordinate system in CAD) for all representation contexts used by the project.

The attribute **WorldCoordinateSystem** is a Euclidean 3D coordinate system providing a global origin for the model. Contrary to what the name indicates, the **WorldCoordinateSystem** has no direct relation to the earth or any geographic coordinate systems. The coordinate system defined by the attribute **WorldCoordinateSystem** is the source for the transformation and will be referred to as **Engineering System**.
ENTITY IfcGeometricRepresentationSubContext
  SUBTYPE OF (IfcGeometricRepresentationContext);
  ParentContext : IfcGeometricRepresentationContext;
  TargetScale : OPTIONAL IfcPositiveRatioMeasure;
  TargetView : IfcGeometricProjectionEnum;
  UserDefinedTargetView : OPTIONAL IfcLabel;
  DERIVE
    SELF\IfcGeometricRepresentationContext.WorldCoordinateSystem : IfcAxis2Placement := ParentContext.WorldCoordinateSystem;
    SELF\IfcGeometricRepresentationContext.CoordinateSpaceDimension : IfcDimensionCount :=
    ParentContext.CoordinateSpaceDimension;
    SELF\IfcGeometricRepresentationContext.TrueNorth : IfcDirection := NVL(ParentContext.TrueNorth,
      IfcConvertDirectionInto2D(SELF\IfcGeometricRepresentationContext.WorldCoordinateSystem.P[2]));
    SELF\IfcGeometricRepresentationContext.Precision : IfcReal := NVL(ParentContext.Precision,1.E-5);
  WHERE
    ParentNoSub : NOT('IFCREPRESENTATIONRESOURCE.IFCGEOMETRICREPRESENTATIONSUBCONTEXT' IN TYPEOF(ParentContext));
    UserTargetProvided : (TargetView <> IfcGeometricProjectionEnum.USERDEFINED) OR ((TargetView = IfcGeometricProjectionEnum.USERDEFINED) AND EXISTS(UserDefinedTargetView)) ;
    NoCoordOperation : SIZEOF(SELF\IfcGeometricRepresentationContext.HasCoordinateOperation) = 0;
END_ENTITY;
ENTITY IfcCoordinateReferenceSystem
ABSTRACT SUPERTYPE OF (IfcProjectedCRS);
Name : IfcLabel;
Description : OPTIONAL IfcText;
GeodeticDatum : OPTIONAL IfcIdentifier;
VerticalDatum : OPTIONAL IfcIdentifier;
INVENS
HasCoordinateOperation : SET [0:1] OF IfcCoordinateOperation FOR SourceCRS;
END_ENTITY;

ENTITY IfcProjectedCRS
SUBTYPE OF (IfcCoordinateReferenceSystem);
MapProjection : OPTIONAL IfcIdentifier;
MapZone : OPTIONAL IfcIdentifier;
MapUnit : OPTIONAL IfcNamedUnit;
WHERE
IsLengthUnit : NOT(EXISTS(MapUnit)) OR (MapUnit.UnitType = IfcUnitEnum.LENGTHUNIT);
END_ENTITY;

**Name**: Name by which the coordinate reference system is identified (EPSG code).

**VerticalDatum**: Name by which the vertical datum is identified. The vertical datum is associated to the height axis of the coordinate reference system and indicates the reference plane and fundamental point defining the origin of a height system. Examples for vertical datums include height above mean sea level at Dover in 1952 and other sea levels.

*IfcProjectedCRS* defines the projection which is the target for the transformation. Name is a unique identifier for the map projection, e.g. EPSG:3006 (SWEREF99 TM). This is needed in order to determine the latitude, φ₀, and longitude, λ₀, of the origin of the *Engineering System* from *Eastings* and *Northings* belonging to the entity *IfcMapConversion*. *VerticalDatum* specifies which geoid is used as a reference for heights. This is needed to calculate the height over the ellipsoid, h₀, from the *OrthogonalHeight*, HO, belonging to the entity *IfcMapConversion*, [see Figure 2](#).
**ENTITY** IfcMapConversion

**ENTITY** IfcCoordinateOperation

- SourceCRS : IfcCoordinateReferenceSystemSelect;
- TargetCRS : IfcCoordinateReferenceSystem;

**ENTITY** IfcMapConversion

- Eastings : IfcLengthMeasure;
- Northings : IfcLengthMeasure;
- OrthogonalHeight : IfcLengthMeasure;
- XAxisAbscissa : OPTIONAL IfcReal;
- XAxisOrdinate : OPTIONAL IfcReal;
- Scale : OPTIONAL IfcReal;

**END_ENTITY**;

*SourceCRS*: Source coordinate reference system for the operation.

*TargetCRS*: Target coordinate reference system for the operation.

*Eastings*: Specifies the location along the easting of the coordinate system of the target map coordinate reference system.

*Northings*: Specifies the location along the northing of the coordinate system of the target map coordinate reference system.

*OrthogonalHeight*: Orthogonal height relative to the vertical datum specified.

*XAxisAbscissa*: Specifies the value along the easting axis of the end point of a vector indicating the position of the local x axis of the engineering coordinate reference system.

*XAxisOrdinate*: Specifies the value along the northing axis of the end point of a vector indicating the position of the local x axis of the engineering coordinate reference system.

*Scale*: Scale to be used, when the units of the CRS are not identical to the units of the engineering coordinate system. If omitted, the value of 1.0 is assumed.

*IFCMapConversion* contains information regarding how the Engineering System is related to a map projection specified using *IFCProjectedCRS*. Eastings specifies the location of the origin of the Engineering System along the East-axis of the target map projection and Northings specifies the location of the origin of the Engineering System along the North-axis of the target map projection. *OrthogonalHeight* specifies the height of the origin of the Engineering System over the vertical datum. The optional attributes *XAxisAbscissa* and *XAxisOrdinate* defines the rotation of the Engineering System in relation to the target projection, see Figure 1. The optional attribute *Scale* is a scalar which is applied to all axes. *SourceCRS* can refer to either a *WorldCoordinateSystem* belonging to a *IfcRepresentationContext*, as in this transformation, or a *IFCProjectedCRS*. *TargetCRS* has to refer to a *IFCProjectedCRS*. 

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**SourceCRS** : Source coordinate reference system for the operation.

**TargetCRS** : Target coordinate reference system for the operation.

**Eastings** : Specifies the location along the easting of the coordinate system of the target map coordinate reference system.

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**OrthogonalHeight** : Orthogonal height relative to the vertical datum specified.

**XAxisAbscissa** : Specifies the value along the easting axis of the end point of a vector indicating the position of the local x axis of the engineering coordinate reference system.

**XAxisOrdinate** : Specifies the value along the northing axis of the end point of a vector indicating the position of the local x axis of the engineering coordinate reference system.

**Scale** : Scale to be used, when the units of the CRS are not identical to the units of the engineering coordinate system. If omitted, the value of 1.0 is assumed.

**IFCMapConversion** contains information regarding how the Engineering System is related to a map projection specified using **IFCProjectedCRS**. Eastings specifies the location of the origin of the **Engineering System** along the East-axis of the target map projection and Northings specifies the location of the origin of the **Engineering System** along the North-axis of the target map projection. **OrthogonalHeight** specifies the height of the origin of the **Engineering System** over the vertical datum. The optional attributes **XAxisAbscissa** and **XAxisOrdinate** defines the rotation of the **Engineering System** in relation to the target projection, see **Figure 1**. The optional attribute **Scale** is a scalar which is applied to all axes. **SourceCRS** can refer to either a **WorldCoordinateSystem** belonging to a **IfcRepresentationContext**, as in this transformation, or a **IFCProjectedCRS**. **TargetCRS** has to refer to a **IFCProjectedCRS**.
Figure 1: Translation and rotation of Engineering System

\[ E_O = IfcMapConversion : Eastings \]
\[ N_O = IfcMapConversion : Northings \]
Abscissa = IfcMapConversion : XAxisAbscissa
Ordinate = IfcMapConversion : XAxisOrdinate
EngineeringSystem = IfcGeometricRepresentationContext : WorldCoordinateSystem
Figure 2: Reduction of points in Engineering System, \( P_1 \) and \( P_2 \), to the ellipsoid, \( P'_1 \) and \( P'_2 \).

\[ H_O = IfcMapConversion : OrthogonalHeight \]
\[ Geoid = IfcProjectedCRS : VerticalDatum \]
\[ h_O = \text{Derived from } H_O \text{ and Geoid} \]
\[ \varphi_O = \text{Derived from } IfcMapConversion : Northing \text{ and } IfcProjectedCRS : Name \]
\[ \lambda_O = \text{Derived from } IfcMapConversion : Easting \text{ and } IfcProjectedCRS : \]
Figure 3: Projection of points $P'_1$ and $P'_2$. A map projection has no definition of height and the initial $z$-value of each point will be preserved through the transformation.