Flow of Events for Use Case – Define Coordinate System

Change Log	
12.11.2004	The use case has been clearly defined by scope, following the discussions of the last expert group meeting in Oslo (Map Card) on 30.09.04.
12.11.2004	The object and attribute definitions are updated according to the last agreements
12.11.2004	Latest additions in blue

Overview

Defines the coordinate system in which coordinates used within a file or database are expressed.

Typically, for a small area, a Cartesian coordinate system will be used. For larger areas where surface curvature has to be taken into account, other forms of coordinate system may need to be defined.

Note that the IFC model currently assumes a Cartesian coordinate system and does not provide for any other form (local coordinate systems being Cartesian coordinate systems related to that of the project or 'world' coordinate system).

NOTE: First a general scoping decision needs to be made, before this use case can be addressed. There are two separate options on how to handle coordinate system references in an IFC context:

1. the IFC model should allow the direct use of several geodetical coordinate reference systems to be used for the geometric and topological representations used within the context of an IFC file.
   - *Answer: No – using different coordinate systems within the same project file is clearly out of scope*

2. the IFC model remains restricted to the use of only Cartesian coordinate systems, but has a capability to store the transformation to a geodetical coordinate reference system by providing an (explicit or implicit) transformation (by a transformation function or by –at least- two geo-referenced points). So instead of storing the geometric representation in some geodetical coordinate system, the map is stored in Cartesian coordinate, but (at least) two opposite corner points, found in the Cartesian model, still contain additionally the original map coordinates
   - *Answer: YES – this is the approach used, however it will be further restricted to keeping the conversion to the originating map coordinate system (and whether these maps can be transferred into geodetic coordinate systems remains within the scope of GIS systems and not within IFC)*

From an practical approach, i.e. keeping IFC to the construction world (and not duplicating gml) the option 2 is the preferred option. It would allow that IFC files (for typical CAD systems in the construction industry) still guarantees Cartesian (right handed) coordinate systems. but allows for the transformation back to a geodetical coordinate reference system. See also the following quote from Even Stangebye – document "transformations.doc":

- *As mentioned above, the building will most likely be projected in a local mathematical co-ordinate system without any datum. To get this transformed to the co-ordinate system used by the municipality, it will need to have a number of points (with local coordinates) that can be found in the situation map (i.e. existing building edges, man holes, road edges). Knowing the coordinates of certain objects/points in two co-ordinate systems, it will be possible to make a direct transformation.*

In addition to the case of the adoption of (2), certain points may need to be identified specifically as 'Ground Control Points' that are the points having known coordinates in the two coordinate systems.

Process

Preconditions

Map exists and coordinate operations to build the map based on a geodetic coordinate space are in place. The map has all the necessary datum references defined (geodetic datum and vertical datum), the map has a distinct name, projection, projection zone and units.

Actors

The local community that has the authority to issue situation and land-use plans/maps and that hands those plans over to the developers and architects.
The developers and architects that obtain the situation and land-use plans/maps and base their development/design work on top of the maps. They also send updated maps back to the communities.

Main Flow

1. Select the map coordinate system to be used by name, projection, zone and units. Identify the geodetic and vertical datum.
2. Determine point of origin of the local engineering coordinate system in relation to the map coordinates (easting, northing, orthogonal height) of the local point of origin
3. Determine the direction of the local X axis in the map coordinate system (ratio of easting/northing)
4. Determine the scale by converting the map units to the local units.

Post Conditions

Local engineering Coordinate system is defined. The transformation requirements/provisions are specified as a map conversion between the local coordinate system and the map coordinate system based on two points (one 3D and one 2D point to be free of redundancy).

IFC Usage and Extension Requirements

Existing Entity/Class Usage

Entity Class Name	***Usage***
IfcGeometricRepresentationContext	Established the local engineering coordinate system for all geometry used in the project.

Existing Entity/Class with Proposed Modification

Entity Class Name	***Usage***

ARM	***Attribute***	***Cardinality***	***Datatype***	***Definition***

ARM	***#***	***Type (DER, U, WHERE)***	***Proposition***

New Entity/Class Requirement

Entity Class Name	*Usage*
IfcCoordinateOperation	mathematical operation on coordinates that does not include any change of Datum. The best-known example of a coordinate conversion is a map projection.

Attribute	*Cardinality*	*Datatype*	*Definition*
SourceCRS	1		Source coordinate reference system for the operation.
TargetCRS	1		Target coordinate reference system for the operation.

#	*Type*	*Proposition*

Entity Class Name	*Usage*
IfcMapConversion	The map conversion deals with transforming the local engineering coordinate system, often called world coordinate system, into the coordinate reference system of the underlying map.

Attribute	*Cardinality*	*Datatype*	*Definition*
Parameters	1	Length measure	Easting, northing, orthogonal height
Parameters	1	Real	X axis (in map easting/northing direction) and Scale

#	*Type*	*Proposition*

Entity Class Name	*Usage*
IfcCoordinateReferenceSystem	*Definition of a coordinate reference system by means of qualified identifiers only. The interpretation of the identifier is expected to be well-known to the receiving software.*

Attribute	*Cardinality*	*Datatype*	*Definition*
Parameters	*1*	*Label*	*Name and description*
Parameters	*1*	*Identifier*	*Geodetic and vertical datum*

#	*Type*	*Proposition*

Entity Class Name	*Usage*
IfcProjectedCRS	*Coordinate reference system of the map to which the map translation of the local engineering coordinate system of the construction or facility engineering project relates.*

Attribute	*Cardinality*	*Datatype*	*Definition*
Parameters	*1*	*Identifier*	*Projection and zone of the projection method used*
Parameters	*1*	*Unit*	*Unit used in the source coordinate system*

#	*Type*	*Proposition*

Existing Property Set Usage

Property Set Name	*Usage*
none	

Existing Property Set with Proposed Modification

Property Set Name	*Usage*
none	

ARM	*Property*	*Type*	*Datatype*	*Unit*	*Definition*

New Property Set Requirement

Name:	
Applicability:	
Applicable Classes:	
Applicable Type Value:	
IFC Version:	
Definition:	

Property	*Type*	*Datatype*	*Unit*	*Definition*

Issue List

Question	*Answer*
List of coordinate systems that may be used is required	
Each coordinate system that may be used requires parameters for its identification	
Each parameter may require to be specified other than as *IfcLengthMeasure*.	
find a way to include geo-referenced reference points (or datum) that can be used to obtain the transformation to the original reference system.	

Appendix A – Definitions from GML

NOTE

The following extract is taken from the current GML specification in respect of defining and using Coordinate Reference Systems (CRS's).

7.6 Coordinate Reference Systems

GML requires a coordinate reference system (CRS) to be referenced whenever location coordinate information is given. This CRS provides the meaning for location coordinates. The referencing is generally given using the srsName attribute which is provided by gml:AbstractGeometryType which is the basis for the content models for all GML geometry elements:

<gml:Point srsName="utm27n">. . .

where 'utm27n' will lead to a full definition of some CRS.

7.6.1 Documentation of CRS schemas

The CRS portion of GML is intended to document the meaning of the CRS reference, which includes transformations and conversions between coordinate reference systems. The relevant documents for understanding the CRS schemas are:

1. OGC Abstract Specification Topic 2 "Spatial Referencing by Coordinates", document 02-102

2. Future OGC Recommendation Paper "Recommended XML encoding of coordinate reference system definitions", incomplete draft in document 02-036r6

There is a set of six XML schema documents for encoding CRS definitions. These six files include documentation text, and are named coordinateReferenceSystems.xsd, datums.xsd, coordinateSystems.xsd, coordinateOperations.xsd, dataQuality.xsd, and referenceSystems.xsd.

NOTE: The XML schema documents for encoding CRS definitions that are included in this specification are not yet final, and some future changes are planned. For the convenience of GML3 users they are included in informative Annex D. The revised version of these schemas will be documented in successors to document 02-036r6.

7.6.2 Meaning of the CRS

The primary object to be referenced is a CRS. The method of referencing is specified in other clauses of this document which describe the various objects and their properties. The CRS instance will give information about the coordinates, including the order of the coordinates, the unit of measure that goes with each coordinate, and the physical meaning in terms of its attachment to the earth (that is, the datum). Also, it is sometimes necessary to express a conversion or transformation to another CRS. Definitions of coordinate conversions and transformations are also encoded using the CRS schemas. Most CRSs used with GML will be references to standard or well-known coordinate reference systems. The XML schemas allow information for a set of standard CRSs to be stored in a dictionary. It is then necessary only to reference the proper CRS in such a dictionary, which will contain all the information needed to understand the coordinates. It is also possible to convert coordinate data into another CRS, using a coordinate transformation service. There is already an OGC Implementation Specification for such a service, document 01-009, and available implementations of this service. Using this service, a set of coordinates in one CRS can be converted to another CRS. Another possible use is when coordinates are not in a standard coordinate reference system. In this case, it is necessary for the XML document to reference a non-standard CRS, which may be defined within the same document. The definition may be as simple as giving the meaning of the axes (order and units of measure) and the datum, or it may include a transformation or conversion to a standard CRS. Thus, the CRS schemas allow a XML document to specify the meaning of its coordinates, and their relationship to a standard, earth-related coordinate system.