#### **STREAMER** Deliverable D8.5

# TRAINING MATERIALS ON BIM AND GIS STANDARDS, EVIDENCE-BASED AND DESIGN DECISION-SUPPORT TOOL FOR HOSPITALS



#### Version

: Final version

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#### Goal of the deliverable

- To provide short introductions into the EU project STREAMER and some related EU projects, and to provide descriptive information material on the basic technologies on which STREAMER is based.
- It is not intended to give a complete and detailed documentation of the STREAMER deliverables.
- The presentation is not intended to be self-contained and self-explanatory. Additional technical information can be found in the referenced literature and in various STREAMER reports.
- This presentation contains material for training courses for two target groups (hospital communities and university students).
  - Part 1 is relevant for both target groups
  - Part 2 is mainly relevant for university students
  - Part 3 and 4 are mainly relevant for hospital communities



#### Remarks

- If the material of this deliverable is used in presentations, a reference to the EU project STREAMER (Grant agreement no. 608739) should be given
- The stated references to literature, examples, web resources and free software are not exhaustive.
- All web resources were accessible in July 2015



# Synopsis

1. Introduction of the STREAMER project

#### 2. Technical knowledge on BIM and GIS

- Modeling languages (EXPRESS, UML, Ontologies, XSD)
- BIM standards(IFC, gbXML, BCF, mvdXML)
- GIS standards (CityGML, INSPIRE, OSM)
- Web Services (WFS, WMS, BIMsie)
- Summary

#### 3. Related EU research projects on BIM and GIS

- PROFICIENT
- PANTURA
- INSITER
- INCEPTION

#### 4. STREAMER applications for hospital (re)designing

- Evidence-based design
- Design decision-support tool

# Part 1 INTRODUCTION OF THE STREAMER PROJECT

#### TARGET GROUPS: HOSPITAL COMMUNITIES AND UNIVERSITY STUDENTS





### Context and focus





<u>Context: Hospital campus</u> – mixed-use area with an integrated energy system, consists of various buildings (e.g. hospitals and clinics, research and educational buildings, offices)

**Focus: Building design** – design optimization of new and existing buildings in 3 areas: MEP/HVAC systems; building envelop and spatial layout; energy grid in campus and surroundings.

### The STREAMER context

- A healthcare district is a good candidate to progress on the design of complex energy efficient buildings and neighborhood:
  - a HC district is composed of a set of buildings...
  - ...with different types of activities.
  - The interaction between the HC district and it's environment is of paramount important
- Specific characteristics of healthcare districts :
  - the interaction between building and medical equipment is also very important
  - Significant impact of energy efficiency measures





# 2.

### Strategic aim and research goals

*Aim:* 50% reduced energy-use and CO2 emission of healthcare districts in 10 years.

**Research**: EeB <u>design optimisation</u> in 3 levels / areas:

- Building MEP/HVAC systems in relation with high-tech medical equipment
- Building envelope and spatial layout in relation with new healthcare services
- Building energy systems in relation with neighbourhood systems (grid, storage, etc.)



## Targeted key research achievement



#### Generic semantic BIM+GIS typology models

of Energy-efficient Buildings in healthcare districts:

adjustable semantic BIM+GIS design models as templates for new design and retrofitting.

- Object  $\rightarrow$  Knowledge modelling
- Evidence  $\rightarrow$  Experience
- Visualisation  $\rightarrow$  Interpretation
- Data / specifications → Performance





### Targeted key research achievement

#### Framework for BEM (Building Energy Model)

lifecycle model inter-connecting BIM, BAM, BOOM.









### From 'service delivery' to lifecycle design



Our aim: increase the 'value of design' by <u>knowledge transfer between phases</u> (<u>using BIM</u>), decrease of operational costs and increase of revenue earning capacity through effective healthcare processes supported by sustainable buildings.

Aligning all actors in one collaborative design team will make this possible!

### Targeted key research achievement



#### **Design decision-support tool**

as an interactive tool which accommodates:

- a) Inter-operable BIM and GIS models
- b) Analysis of energy performance, lifecycle-cost, and functional optimisation
- c) Stakeholder's / user's requirements, decision criteria and priorities.





### **Overall objectives**

- On the basis of typologies of buildings / districts (WP1), technologies for envelope and MEP (WP2) and aims in terms of energy consumption (WP3) – Innovation area 1 …
- … Research and develop optimised Semantics-driven Design methods and interoperable tools for Building and Geo Information Modelling (BIM–GIS) – Innovation area 2
- Apply the whole on real demonstration and validation projects across Europe.





### Key barriers to overcome

- Lack of a holistic approach to tackle multi-disciplinary complexity.
  - Design is not only about technology, but also, and mainly, about healthcare-related services and building operations: "how can we continue to provide high quality services in a context of budget cuts and reduction of personnel ?"
- Lack of a multi-scale optimisation (components buildings neighbourhood).
  - Trial-and-error approach causes many ad hoc changes during the construction stage. This hampers the optimal configuration of the solutions for whole lifecycle benefits as the design solutions cannot cope with rapidly changing healthcare policies, processes and technologies.



### Work packages





WP9: Technical management WP10: Project management





Actual projects of 4 hospital districts with real plans for EeB retrofitting or new design:

#### 1. NHS, Rotherham, UK

- Upgrade of Building Management Systems
- Major improvements in overall building fabric

#### 2. Rijnstate, Arnhem, NL

- Mid-life renovation to replace MEP systems
- □ 10,000 m2 extension and new buildings

#### Careggi (AOUC), Firenze, Italy

- Overhaul of electricity and heat distribution
- Optimisation of inter-building functions

#### **AP-HP**, Paris, France

- □ Improvement of logistic and waste systems
- Re-arrangement of building spaces





# Part 2 TECHNICAL KNOWLEDGE ON BIM AND GIS

#### TARGET GROUP: UNIVERSITY STUDENTS





# **MODELING LANGUAGES**

#### TARGET GROUP: UNIVERSITY STUDENTS







## Modeling languages

- EXPRESS
- Unified Modeling Language UML
- Ontology
- XML-Schema Definition (XSD)



# **Example: EXPRESS**



ENTITY IfcSpatialStructureElement ABSTRACT SUPERTYPE OF (ONEOF (IfcBuilding ,IfcBuildingStorey ,IfcSite , IfcSpace)) SUBTYPE OF (IfcProduct); LongName : OPTIONAL IfcLabel; CompositionType : IfcElementCompositionEnum; INVERSE ServicedBySystems : SET [0:?] OF IfcRelServicesBuildings FOR RelatedBuildings; ContainsElements : SET [0:?] OF IfcRelContainedInSpatialStructure FOR RelatingStructure; WHERE WR41: (HIINDEX(SELF\lfcObjectDefinition.Decomposes) = 1) AND ('IFC2X3.IFCRELAGGREGATES' IN TYPEOF(SELF\lfcObjectDefinition.Decomposes[1])) AND

(('IFC2X3.IFCPROJECT' IN TYPEOF (SELF\lfcObjectDefinition.Decomposes[1].RelatingObject)) OR ('IFC2X3.IFCSPATIALSTRUCTUREELEMENT' IN TYPEOF (SELF\lfcObjectDefinition.Decomposes[1].RelatingObject))); END\_ENTITY;

#### ENTITY IfcSite

SUBTYPE OF (IfcSpatialStructureElement); RefLatitude : OPTIONAL IfcCompoundPlaneAngleMeasure; RefLongitude : OPTIONAL IfcCompoundPlaneAngleMeasure; RefElevation : OPTIONAL IfcLengthMeasure; LandTitleNumber : OPTIONAL IfcLabel; SiteAddress : OPTIONAL IfcPostalAddress; END\_ENTITY:

#### END\_ENTITY;

#### ENTITY IfcBuilding

SUBTYPE OF (IfcSpatialStructureElement); ElevationOfRefHeight : OPTIONAL IfcLengthMeasure; ElevationOfTerrain : OPTIONAL IfcLengthMeasure; BuildingAddress : OPTIONAL IfcPostalAddress;

#### END\_ENTITY;

#### ENTITY IfcBuildingStorey

SUBTYPE OF (IfcSpatialStructureElement); Elevation : OPTIONAL IfcLengthMeasure;

END\_ENTITY;

#### Part of the EXPRESS Definition (EXPRESS-G / EXPRESS)



### Example: UML



Section of the UML modell of the CityGML energy extension (Energy ADE)



### Example: XSD

<pre><element name="thermalZones" substitutiongroup="bldg:_GenericApplicationPropertyOfAbstractBuilding" type="energy:ThermalZonePropertyType"></element></pre>
<annotation></annotation>
<appinfo></appinfo>
<gml:targetelement>energy:ThermalZone</gml:targetelement>
<pre><element name="usageZones" substitutiongroup="bldg:_GenericApplicationPropertyOfAbstractBuilding" type="energy:UsageZonePropertyType"></element></pre>
<annotation></annotation>
<appinfo></appinfo>
<gml:targetelement>energy:UsageZone</gml:targetelement>
BoundarySurface
<pre><element name="equippedWith" substitutiongroup="bldg:_GenericApplicationPropertyOfBoundarySurface" type="energy:_SolarEnergySystemPropertyType"></element></pre>
<annotation></annotation>
<appinfo></appinfo>
<gml:targetelement>energy:_SolarEnergySystem</gml:targetelement>
<pre><element name="correspondsTo" substitutiongroup="bldg:_GenericApplicationPropertyOfBoundarySurface" type="energy:ThermalBoundarySurfacePropertyType"></element></pre>
<annotation></annotation>
<appinfo></appinfo>
<gml:targetelement>energy:ThermalBoundarySurface</gml:targetelement>

#### Part of the XML-Schema encoding of the CityGML Energy ADE

# Example: Ontology





<owl:Class rdf:about="http://buildingsmart.org/ontology/IFC#IfcBuilding"> <ns0:subClassOf rdf:resource="http://buildingsmart.org/ontology/IFC#IfcSpatialStructureElement"/> <ns0:subClassOf> <owl:Restriction> <owl:onProperty rdf:resource="http://buildingsmart.org/ontology/IFC#BuildingAddress"/> <owl:onClass rdf:resource="http://buildingsmart.org/ontology/IFC#lfcPostalAddress"/> <owl:maxQualifiedCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxQualifiedCardinality> </owl:Restriction> </ns0:subClassOf> <ns0:subClassOf> <owl:Restriction> <owl:onProperty rdf:resource="http://buildingsmart.org/ontology/IFC#ElevationOfTerrain"/> <owl:onClass rdf:resource="http://buildingsmart.org/ontology/IFC#lfcLengthMeasure"/> <owl:maxQualifiedCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxQualifiedCardinality> </owl:Restriction> </ns0:subClassOf> <ns0:subClassOf> <owl:Restriction> <owl:onProperty rdf:resource="http://buildingsmart.org/ontology/IFC#ElevationOfTerrain"/> <owl:allValuesFrom rdf:resource="http://buildingsmart.org/ontology/IFC#IfcLengthMeasure"/> </owl:Restriction> </ns0:subClassOf> <ns0:subClassOf> <owl:Restriction> <owl:onProperty rdf:resource="http://buildingsmart.org/ontology/IFC#ElevationOfRefHeight"/> <owl:allValuesFrom rdf:resource="http://buildingsmart.org/ontology/IFC#IfcLengthMeasure"/> </owl:Restriction> </ns0:subClassOf> <ns0:subClassOf> <owl:Restriction> <owl:onProperty rdf:resource="http://buildingsmart.org/ontology/IFC#BuildingAddress"/> <owl:allValuesFrom rdf:resource="http://buildingsmart.org/ontology/IFC#IfcPostalAddress"/> </owl:Restriction> </ns0:subClassOf> <ns0:subClassOf> <owl:Restriction> <owl:onProperty rdf:resource="http://buildingsmart.org/ontology/IFC#ElevationOfRefHeight"/> <owl:onClass rdf:resource="http://buildingsmart.org/ontology/IFC#lfcLengthMeasure"/> <owl:maxQualifiedCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxQualifiedCardinality> </owl:Restriction> </ns0:subClassOf> </owl:Class>

Part of IFC Definition represented in OWL

### **BIM STANDARDS**

#### TARGET GROUP: UNIVERSITY STUDENTS







### **BIM Standards**

- Industry Foundation Classes (IFC)
- Green Building XML (gbXML)
- BIM Collaboration Format (BCF)
- Model View Definition XML (mvdXML)



# IFC – Building Information Model

#### • Version IFC4

- 768 Entities
- Application support under development
- Version IFC2x3
  - 653 Entities
  - IFC Certification (CoordinationView 2.0, subset of 329 entities)
  - Supported by large number of AEC applications
- Based on EXPRESS (STEP Part 12)
- Instance Documents
  - STEP Physical File (SPF STEP Part 21)
  - XML (STEP Part 28)
- Predefined and user defined property sets



# IFC – Building Information Model





# **IFC Building Elements**



### Geometry in IFC

- Building and Storey in IFC have no geometry (Coordination View)
- Geometry is attached to Building Elements (wall, roof, slab etc.)
- Normally usage of solid geometry (e.g. to enable quantity take-off)
- Constructive Solid Geometry
- Different representations are possible (e.g. wall body and wall axis)
- Local coordinate systems (LCS)







### Properties in IFC

- Attributes for all Spatial Structure Elements and all Building Elements (e.g. NumberOfStoreys, GrossAreaPlaned, NetAreaPlaned, IsExternal, LoadBearing, FireRating, ThermalTransmittance, ArticleNumber, Manufacturer)
- Material properties (e,g. SolarRefractionIndex, SolarTransmittance, CO2Content)
- Appearance properties (e.g. IfcSurfaceStyleShading, IfcSurfaceStyleWithTextures)

IFC attributes are arbitrarily extensible be user defined property sets

### Georeferencing in IFC

- Usage of local Cartesian coordinates
- Origin normally within project boundaries
- Latitude and longitude as attributes of the "building site\*
- Elevation above sea level as attribute of the "building site"
- North direction as orientation vector
- Since IFC4: Support of arbitrary coordinate reference systems



80

- Ha

1,0

2,0

oh. 95

,20

\*Relating to the local origin of the building site





### **IFC Examples**







#### Architecture

- Walls
- Roofs
- Slabs
- etc.

#### HVAC

- Components
- Port connections
- Systems including flow directions

#### Structural analysis

- Steelwork
- Structural model
- Structural loads



## **Further information**

- Literature
  - Eastman, C. M.: Building Product Models: Computer Environments Supporting Design and Construction, CRC Press LLC, 1999, ISBN 0-8493-0259-5
  - Industry Foundation Classes: IFC2x Edition 3 Technical Corrigendum 1, buildingSMART 2007, <u>http://www.buildingsmart-</u> tech.org/ifc/IFC2x3/TC1/html/index.htm
- Web resources
  - IfcWiki: http://www.ifcwiki.org/
  - buildingSMART Homepage: <u>http://www.buildingsmart-tech.org/</u>
- Free software
  - FZKViewer: <u>https://www.iai.kit.edu/www-extern/index.php?id=2315&L=1</u>



# Green Building XML - gbXML

- Actual version 5.12
- XML based
- 306 XML elements
- 104 specific enumerations
- Predefined property sets
- No inherent extension mechanism



### gbXML – Structure





# Surface in gbXML




#### Construction in gbXML



Layer 3

Layered material structure with different material thickness

## 1

## Geometry in gbXML

- Storeys optionally have an explicit geometrical representation
- The volume and/or the footprint area of a room may be represented
- Building elements like walls are modeled with surface geometry (planar polygons or parametric rectangles)
- The position of the surfaces depends on the building element's function (e.g. exterior or interior wall)

Room

0,0 m



Exterior wall



#### Georeferencing in gbXML

- Local Cartesian coordinates
- Latitude and longitude (decimal)
- CADModelAzimuth for the overall model
- Azimuth for Surfaces
- · Elevation as height above sea level





#### gbXML Examples





Model

- Spaces
- Surfaces
- Shading

#### HVAC

- Equipment
- Loops
- Lighting
- Thermal loads

<Schedule id="schdl-1" type="Fraction"> <Name> Common Office Occupancy - 8 AM to 5 PM </Name> <YearSchedule id="yr-schdl-1"> <BeginDate> 2012-01-01 </BeginDate> 2012-01-01 </BeginDate> 2012-12-31 </EndDate> <WeekScheduleId weekScheduleIdRef="wk-schdl-1"/> </YearSchedule> </Schedule>

#### HVAC and User Behaviour

- Schedules
- Occupancy
- Profiles
- Climate



#### **Further information**

#### • Literature

- gbXML Patent: Kennedy et al.: United States Patent, Systems and Methods for automatic energy analysis of buildings, US 2004/0239494A1, Dec. 2, 2004
- gbXML V5.12 Schema: <u>http://www.gbxml.org/currentschema.php</u>

#### • Examples

- <u>http://www.gbxml.org/samplegbxmlfiles.php</u>
- Web resources
  - Official Website: <u>http://www.gbxml.org/index.php</u>
  - GitHub Repository: https://github.com/gbxml
  - **gbXML Validator**: <u>http://www.controlsestimate.com/Validator/Pages/TestPage.aspx</u>
- Free software
  - FZKViewer: <u>http://www.iai.kit.edu/www-extern/index.php?id=2315&L=1</u>
  - DDS-CAD Viewer: <u>http://www.dds-cad.net/downloads/dds-cad-viewer/</u>



### **BIM Collaboration Format - BCF**

- Version 1.0 and Version 2.0
- XML based format
- All information is stored in a zip file, which contains one folder for each topic



#### **BCF** - Structure

- A BCF file is a zip archive containing one folder for each topic. The root of the BCF zip archive contains the following files:
  - project.bcfp (Version 2.0, optional)
  - bcf.version (Version 2.0)
- The folder name is the GUID of the topic. This GUID is in the UUID form. The folder contains the following files:
  - markup.bcf (Version 1.0 and 2.0)
  - viewpoint.bcfv (Version 1.0 and 2.0)
  - snapshot.png (Version 1.0 and 2.0)
  - Attached documents (Version 2.0)
  - BIM-Snippets (Version 2.0)



## BCF – Element Markup file

#### • The Markup file contains the following sections

- Header: The header section contains information about the IFC files, which are relevant for this topic
- Topic: The topic section contains all information of the topic (e.g. Description, Priority, creationDate, ModifiedAuthor)
- BimSnippet (optional): The BimSnippet section contains embedded or external BimSnippets (IFC, ifcXML etc.)
- DocumentReference (optional): embedded or external documents (PDF, Word, Excel etc.)
- RelatedTopics (optional): The RelatedTopic section establish relations between topics.
- Comment: The Comment section contain a comment for each topic. A Comment consists of e.g. Status, Date, Author, Comment, Topic
- Viewpoints: The Viewpoints section contains references to viewpoint.bcfv and to snapshot.png



## **BIM Collaboration Format - BCF**

Marker Werkzeuge		x	BIM Collaboration Format			
<ul> <li>Marker Werkzeuge</li> <li>Marker Einträge</li> </ul>			1	Vame	Value	
Angehängte Sicht     Etikett und Diskussion			SIKEAMEK-Iest			
Projekt-Marker Etikettentext:	Auf dem Plan platzieren			Comment Date Author	This is a provision for void 2014-10-21T10:54:54Z fs5507	
Kommentar: Ersteller	Datum			verbal Status	bemerkungen	
1 fs5507 This is a provision for void	10:54 (2014-10-21)	_				
	Kommentar hinzufügen	~			OK	

Model mark-up in ArchiCAD (left) and the corresponding BCF import in the IFCExplorer (markup.bcf)



#### **BCF Examples**





## **Further information**

- Literature
  - Paasiala, P.: BIM Collaboration Format, 2013, <u>https://github.com/BuildingSMART/BCF-</u> XML/blob/master/Documentation/BIM%20Collaboration%20Format%20Improveme <u>nts.pdf</u>
  - Linhard, K., Steinmann, R.: BIM-collaboration processes from fuzziness to practical implementation. ECPPM 2014, CRC Press/Balkema, ISBN 978-1-138-02710-7
- Examples
  - Not yet available
- Web resources
  - BCF-XML: https://github.com/BuildingSMART/BCF-XML
  - BCF-API: <a href="https://github.com/BuildingSMART/BCF-API">https://github.com/BuildingSMART/BCF-API</a>
- Free software
  - Tekla BIMsight: <u>http://www.teklabimsight.com</u>
  - DDS-CAD Viewer: <u>http://www.dds-cad.net/downloads/dds-cad-viewer/</u>



## Model View Definition XML - mvdXML

- buildingSMART standard for defining Model View Definitions
- Version 1.0
  - Focus on documentation purposes for IFC4 specification
- Version 1.1
  - BIM data management features
  - Exchange requirements
  - Validation rule definition



#### mvdXML - Structure





#### **Further information**

- Literature
  - CHIPMAN, T., LIEBICH, T., WEISE, M. (2012): mvdXML; <u>http://www.buildingsmart-tech.org/downloads/accompanying-documents/formats/mvdxml-documentation/mvdXML\_V1-0.pdf</u>
- Examples
  - <u>https://github.com/BuildingSMART/mvdXML/tree/master/mvdXML1.1/xml</u>
- Web resources
  - mvdXML: <u>https://github.com/BuildingSMART/mvdXML</u>
  - MVD Overview: <u>http://www.buildingsmart-tech.org/specifications/mvd-overview/mvd-overview-summary</u>
- Free software
  - ifcDoc: <u>http://www.buildingsmart-tech.org/specifications/specification-tools/ifcdoc-tool/ifcdoc-beta-summary</u>
  - ReqCap: <u>http://85.10.201.48:4570/</u> (STREAMER internally)

#### **GIS-STANDARDS**

#### TARGET GROUP: UNIVERSITY STUDENTS





#### **GIS-Standards**



- CityGML with Application Domain Extensions (ADEs)
- INSPIRE
- OpenStreetMap OSM



## CityGML

- Actual version CityGML 2.0
- XML based
- 14 modules (e.g. CityGML\_Core and Building)
- 119 XML elements + GML geometry + xAL address scheme
- Level of Detail Concept (5 Levels of Detail)
- Predefined attribute sets
- Inherent extension mechanisms



### CityGML 2.0 Modules



### CityGML 2.0 Levels of Detail (LoD)





#### Modeling of real world objects in different geometric and semantic detailing



## CityGML – Building Structure





## CityGML Boundary Surfaces of Building and Room





## Geometry in CityGML (Building module)

- Building / BuildingPart
  - Explicit line-, surface- or solid geometry
  - Relation (*boundedBy*) to Boundary Surfaces
  - Multiple usage of geometry objects (xlink)
- Rooms
  - Explicit surface- or solid geometry
  - Relation (*boundedBy*) to Boundary Surfaces
  - Multiple usage of geometry objects (xlink)
- Building Installations
  - Explicit line-, surface- or solid geometry
  - Usage of prototypes (*ImplicitGeometry*)
  - Relation (*boundedBy*) to Boundary Surfaces
  - Multiple usage of geometry objects (xlink)
- Boundary Surfaces with optional Openings
  - Surface geometry







## Properties in CityGML (Building)

#### Attributes inherited from GML

name, description, boundedBy, etc.;

#### Common attributes of all CityGML objects

 creationDate, terminationDate, relativeToTerrain, relativeToWater, externalReference, generalizesTo;

#### • Specific Building attributes

 class, function, usage, yearOfConstruction, yearOfDemolition, roofType, measuredHight, storeysAboveGround, storeysBelowGround, storeyHeightsAboveGround, storeyHeightsBelowGround, address.



## Georeferencing in CityGML

- Usage of global coordinate reference systems
- Specification of the used reference systems for position and height
   srsName (e.g. EPSG-Code)
- Geographic (latitude/longitude) or projected (Cartesian) coordinates



### CityGML Examples



Karlsruhe LOD 1\*



GeoRes LOD 4

Karlsruhe LOD 2\*





### CityGML - Example



## CityGML – Extension mechanisms



- Usage of application specific Codelists
- Generic Attributes can extend the properties on any CityGML feature type
   String, Int, Double, Date, Uri, Measure, Set
- Feature Type "GenericCityObject"
- Application Domain Extensions (ADE)
  - Extension is specified by an own XML-schema
  - Definition of new properties for existing CityGML feature types
  - Definition of new feature types, optionally derived from existing ones



## CityGML Energy ADE

- Specific CityGML extension to support energy demand estimations and simulations of buildings
- Integration of new feature types and properties modeling energy relevant aspects of buildings
  - Building physics
  - Material
  - Energy system
  - Building occupants behaviour
  - Time series and schedules

# CityGML Energy ADE **Building physics**



## CityGML Energy ADE Material





## CityGML Energy ADE Energy system

class EnergySystem



## CityGML Energy ADE **Occupants behaviour**









### **Further information**

- Literature
  - CityGML specification: OpenGIS<sup>®</sup>City Geography Markup Language (CityGML) Encoding Standard, Version 2.0.0, OGC 08-007r2.
     <u>https://portal.opengeospatial.org/files/?artifact\_id=47842</u>
- Examples
  - http://www.citygml.org/index.php?id=1539
  - http://www.iai.kit.edu/www-extern/index.php?id=1135&L=0
- Web resources
  - OGC CityGML site: <u>http://www.opengeospatial.org/standards/citygml</u>
  - CityGML Homepage: <u>www.citygml.org/</u>
  - CityGML Wiki: <a href="http://www.citygmlwiki.org/index.php/Main\_Page">http://www.citygmlwiki.org/index.php/Main\_Page</a>
- Free software
  - FZKViewer: <u>http://www.iai.kit.edu/www-extern/index.php?id=2315&L=1</u>
  - tridicon CityDiscoverer Light: <u>http://www.tridicon.de/dowload/tridicon-</u> <u>citydiscoverer/?L=1</u>
  - 3D City Database: <u>https://github.com/3dcitydb</u>

#### STREAMER Deliverable D8.5

## Infrastructure for Spatial Information in the European Community - INSPIRE

- Aims at "establishing an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment".
  - Metadata
  - Internet based services
  - Europe wide standardized semantic data formats, based on ISO 191xx / GML 3.2
- Based on the European Directive 2007/2/EC
- Transferred into national legislation in all member states
- Spatial Data Sets are affected by INSPIRE if:
  - available in electronic format,
  - held by or on behalf of a public authority,
  - falling within the scope of its public tasks,
  - relate to one or more of the themes listed in Annex I, II or III.







#### **Spatial Date Themes**

- 34 themes with relevance for environmental applications, divided into 3 blocks ("Annex I – Annex III")
- Coordinate reference systems
- Geographical grid systems
- Geographical names
- Administrative units
- Addresses
- Cadastral parcels
- Transport networks
- Hydrography
- Protected sites

- Elevation
- Land cover
- Orthoimagery
- Geology

- Statistical units
- Buildings
- Soil
- Land use
- Human health and safety
- Utility and governmental services
- Environmental monitoring Facilities
- Production and industrial facilities
- Agricultural and aquaculture facilities
- Population distribution and demography
- Area management / restriction / regulation zones & reporting units
- Natural risk zones
- Atmospheric conditions
- Meteorological geographical features
- Oceanographic geographical features
- Sea regions
- Bio-geographical regions
- Habitats and biotopes
- Species distribution
- Energy Resources
- Mineral Resources


## **Example: INSPIRE Building**



Constructions above and/or underground which are intended or used for the shelter of humans, animals, things, the production of economic goods or the delivery of services and that refer to any structure permanently constructed or erected on its site



## **INSPIRE Building – Structure**





## **INSPIRE** Building – Core Profile

#### • Semantic structure of a building

- One Building object, optionally sub-divided into BuildingParts

#### Geometry

- **BuildingCore2D**: Multiple 2D or 2.5D geometries
- BuildingCore3D: 3D-Geometry in alternatively 4 different LODs according to CityGML specification

#### • Attribute data

- Classification of status, nature and current use
- Important dates of the building's life cycle
- Elevation of the building
- Building height



## **INSPIRE Building Core 3D – Examples**





# **INSPIRE Building – Extended Profile**

#### • Semantic structure of a building

- BuildingExtended2D: Identical with BuildingCore2D
- BuildingExtended3D: Building object with optional semantic structure according to CityGML (BuildingPart, RoofSurface, WallSurface, Installation, Room)

#### Geometry

Identical with BuildingCore2D / BuildingCore3D

#### • Attribute data

- Connection to public infrastructure
- Energy performance data
- Material data
- Cadastral information
- Storey structure, door and window area
- Real estate information



#### INSPIRE Building Extended3D – Examples





## **Further information**

#### • Literature

- EU (2007): Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), 2007.
- INSPIRE Building (2013): D2.8.III.2 Data Specification on Buildings Technical Guidelines

http://inspire.jrc.ec.europa.eu/documents/Data\_Specifications/INSPIRE\_DataSpecification\_BU\_v3.0.pdf

- Examples
  - Examples for the INSPIRE Building model are not yet available
- Web resources
  - **INSPIRE Homepage**: <u>http://inspire.ec.europa.eu/index.cfm</u>
- Free software
  - Free software supporting the INSPIRE Building model is not yet available



## OpenStreetMap – OSM

- World-wide, collaborative project to create a free, editable digital map
- Main thematic areas:
  - Traffic networks (streets, cycle ways, railways) and corresponding infrastructure facilities;
  - Information about public transportation;
  - Electricity network and facilities;
  - Buildings;
  - Leisure and sports facilities;
  - Health and security facilities;
  - Natural geo objects like lakes, rivers or rocks;
  - Land use data;
  - Administrative boundaries.



#### **OSM – Elements, Attributes**

- XML based file format (no official XSD schema exists)
- Core data elements
  - node
    - Defining a singe point in geographic coordinates (latitude / longitude)
  - way
    - Used to model open or closed polygons, defining linear features and area boundaries
  - relations
    - Used to model logical or geographical relationships between objects, or to define multipolygons
  - tags
    - Consists of key-value pairs to describe specific features



#### **OSM - Example**



Мар

Feature data

OSM data of the healthcare district "Pitié Salpêtrière", Paris



## **Further information**

- Examples
  - http://openlayers.org/en/v3.2.1/examples/
- Web resources
  - <u>https://www.openstreetmap.org/</u>
  - <u>http://wiki.openstreetmap.org/wiki/Main\_Page</u>
- Free software
  - <u>http://wiki.openstreetmap.org/wiki/Software</u>

### **WEB SERVICES**

#### TARGET GROUP: UNIVERSITY STUDENTS







#### Web Services

- OGC\* Web Map Service WMS
- OGC\* Web Feature Service WFS
- buildingSmart BIM Server Information Exchange BIMsie

\* OGC – Open Geospatial Consortium



## OGC Web Map Service – WMS

- Supports the visualization of geospatial information
- Standardized interface for requesting geo-referenced map images (e.g. in GeoTIFF, PNG or JPG format) from geospatial databases
- WMS request defines one or more layers to be delivered in a certain area of interest



## WMS – Example



The building model (Rijnstate Hospital, Arnhem) is loaded from local disk, while the map (12 tiles) is added via WMS from a Dutch map server for cadastral data.



## OGC Web Feature Service – WFS

- Enables access to geospatial vector data
- Supports GML-based, standardized data formats like CityGML
- Clients can retrieve features from the data store based upon user defined filter conditions on spatial or attributive feature properties
- Supports a standardized delivery of the Capabilities:
  - supported feature types,
  - supported coordinate reference systems,
  - querying functionality
  - To be added...



## WFS - Example

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The building model (Rijnstate Hospital, Arnhem) is loaded from local disk, while the roads are added via WFS from the STREAMER DEGREE Server



- Standard API for BIM WebServices
- Current Version 1.0
- Interaction between BIM services
- Protocol independent (currently documented for JSON and SOAP)
- Based on further web standards for:
  - Authentication
  - Encryption



## **BIMsie - Structure**

#### • API is spit into six modules:

- ServiceInterface (36 methods)
- NotificicationInterface (12 methods)
- RemoteServiceInterface (4 methods)
- Authinterface (7 modules)
- LowLevelInterface (60 methods)
- NotificationRegistryInterface (27 methods)
- Module for "Issue Management" is planed, based on BCF 2.0



## BIMsie – Example

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Data downloaded from a BIMserver using the BIMsie interface



## **Further information**

- Web resources
  - BIMSie https://github.com/BuildingSMART/BIMSie
  - BIMSie-API https://buildingsmart.github.io/BIMSie/
- Free software
  - BIMserver http://bimserver.org/

#### **SUMMARY**

#### TARGET GROUP: UNIVERSITY STUDENTS







## **Building Information Modelling**



\*AEC – Architecture, Engineering, Construction

\*GIS – Geospatial Information Systems



## Comparison of different models

	IFC	gbXML	CityGML
Application area	AEC	Energy performance	GIS
Modelling range	One / few building(s)	Some buildings	Many buildings
Model size	653 Entities	301 Elements	119 Features+GML
Geometry type	Parametric and (restricted) explicit	Explicit	Explicit
Building elements	Volumetric and (restr.) surface based	Surface based	Surface based
Building volume	Only indirectly	Directly	Directly
Georeference	Local coord. + global reference (lat/lon)	Local coord. + global reference (lat/lon)	Global coordinates
Storeys	Yes	Yes	No
Physical materials	Yes	Yes	No
Level of Detail	Only implicit	No	5 Levels of Detail

# Part 3 RELATED EU RESEARCH PROJECTS ON BIM AND GIS

#### TARGET GROUP: HOSPITAL COMMUNITIES





# BIM FOR ENERGY-EFFICIENT <u>NEIGHBOURHOODS</u>

• Overall research goal



Facilitating the development of energy-efficient neighbourhoods based on Collective Self-Organised (CSO) housing approach supported by an e-Marketplace platform for Small & Medium-size Enterprises (SMEs)





# **BIM FOR ENERGY-EFFICIENT NEIGHBOURHOODS**

• Key achievement





# BIM FOR LOW-DISTURBANCE URBAN PROJECTS

Overall research goal





Development of construction management methods and ICT tools for low-disturbance construction, refurbishment and maintenance of bridges in the cities.







# BIM FOR LOW-DISTURBANCE URBAN PROJECTS

• Key achievement



# **BIM FOR SELF-INSTRUCTION & SELF-INSPECTION**

Overall research goal

Development of intuitive and cost-effective BIM-based Augmented Reality for self-instruction and self-inspection at real time during the construction process



INSITER INTUITIVE SELF-INSPECT TECHNIQUE





# **BIM FOR SELF-INSTRUCTION & SELF-INSPECTION**

• Key achievement





Overall research goal

Development of BIM-based methods and instruments for time-dynamic 3D reconstruction of cultural heritage for building engineers, scholars, tourists and governments



Inclusive Cultural Heritage in Europe through 3D semantic modelling







# **BIM FOR 3D TIME-DYNAMIC CULTURAL HERITAGE**

• Key achievement



Software and AR tool for condition assessment and maintenance planning of cultural heritage buildings –

taking into account the values of cultural and RE assets, and the changes in technical condition over a long history



#### Part 4

# STREAMER APPLICATIONS FOR HOSPITAL (RE)DESIGNING

TARGET GROUP: HOSPITAL COMMUNITIES





# **EVIDENCE-BASED DESIGN**

#### TARGET GROUP: HOSPITAL COMMUNITIES







**Evidence-based medicine** is the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients (Sackett, 1996)

**Evidence-based design** is the process of basing decisions about the built environment on credible research to achieve the best possible outcomes.

The goal is to "achieve the best possible outcomes for patients, families and staff while improving utilization of resources" (The Center for Health Design, 2008).


Evidence Based .....

#### *architects*

often rely too heavily on their own limited knowledge regarding a particular design ' they are often blind to, or unaware of, the wealth of knowledge contained in the literature or the expertise of colleagues in the field. This is due in part to ego and autonomy, but also to the lack of any effective system for sharing and distributing this knowledge.





#### Proven Healing Environment Outcomes & Top Research Priorities\*:

- increased perception of quality of care;
- higher customer (patient, staff or visitor) satisfaction\*;
- faster patient recovery;
- less medicine intake;
- fewer medical errors\*;
- lower infection rates\*;
- desired behaviour (e.g. fewer falls\*, less aggression);
- <u>enhanced operational efficiency and productivity\*;</u>
- personnel retention;
- patient safety
- patient waiting\*

\* Top priority areas defined by Centre for Health Design. According to Blair et all, 2011 an investment in EBD of 8% on top of the normal construction budget, has a return on investments within 3 years, due to significant improvements in above mentioned outcomes (Fable Hospital 2.0).



#### Research Design









	TASK	ACTIVITY
1	Identify the client's goals	Note most important and facility-related global and project-based goals
2	Identify firm's goals	Understand firm's strategic, project, and evidence-based design objectives
3	Identify the top 1-3 key design issues	Narrow the possible choices; work on high impact decisions
4	Convert design issues to research questions	Reframe statement of design issues to become research topics
5	Gather information <ul> <li>Benchmark examples</li> <li>Literature sources</li> <li>Firm's studies &amp; data</li> </ul>	Infinite possibilities must be narrowed; limited perspectives must be expanded
6	Critical interpretation of the evidence	No direct answers; requires open- minded creativity, balance and critical thinking
7	Create evidence-based design concepts	Based on creative interpretation of the implications of research findings
8	Develop hypotheses	Predict the expected results from implementation of your design
9	Select measures	Determine if your hypotheses are supported or not (never claim proof)



#### **Design Approach**

- From ideas & sketches to building blocks (concept design)
- Form building blocks into departmental layouts/floor plans
- From floor plans to detailed designs

Adding detail and information as the design progresses

Iterative process, capturing & storing information (enriching)





## BIM approach (top down & bottom up)

	Lifecycle	Program	Design	Plan	Build	Operate	Exploit
	Detail						
	Areas						
GIS	Buildings						
	Systems						
BIM	Building parts					time	
	Components						
	Materials						



#### In an ideal world.....



#### To help create better design decisions, now and in future



#### Interpretation so far...

- Common denominator is necessary between BIM world & Hospital designers ('LEGO' blocks + semantic labels)
- Link between design, use of design by hospital (activities + equipment) and energy performance is crucial
- It's about actual refurbishment projects!
- More logic and hierarchy between important hospital KPIs to make decision design-support tool of better value to others (safety, costs, satisfaction, flexibility)

**Eqpmnt:** 

**MRI** 





## **DESIGN DECISION-SUPPORT SYSTEM**

#### TARGET GROUP: HOSPITAL COMMUNITIES





STREAMER Deliverable D8.5



#### Real estate information management

+

Real Estate

Information Management



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1. RE Development	2. RE Land valuation	3. RE Asset management	4. RE Property control	5. RE Exploitation	6. RE Maintenance	7. RE Energy	8. RE Risk management	9. RE Fire safety scan	10. RE Infra & public space
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#### What is the problem?

- Cost (short and long term)
- Energy consumption
- Disruption of the primary process
- Lack of overview and insight
- Making decisions: daily practice versus prospects (JITI = Just In Time Information)
- All of the above?



## What is the purpose?

- Cost saving
- Resolving the lack of insight
- Ensure adequate understanding of the actual situation
- Gaining time for analysis
- Gaining insight in the analysis results for making correct assessments and decisions



#### How to come to a solution?

- Reasoning based on the existing information systems
- Gradual transition towards new systems
- Making use of existing data
- Enriching the existing data
- Transforming these data into relevant information
- Ensuring the sustainability of data
- Retaining the support within your organisation
- Thus, data evolution instead of data revolution

# Software application to display Key Performance Indicators



# Software application to display Key Performance Indicators



# Integrating software applications for building and energy and management





## Software application for analysis of the underlying data

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#### STREAMER Deliverable D8.5



## Software application for long-term building maintenance

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## Software application energy labelling

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## Software application for Life Cycle Cost

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## Software application for disclosing 3D GIS data

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## Software application for risk analysis

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## Multi-actor multi-criteria decision-support tool

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#### Post occupancy evaluation

- Building management systems
- iPad app





## What is needed?

#### • Software

- Software for building surveying with IPS support (Indoor Positioning Systems)
- Software for performance contract management

#### Methodology

- Norm or method for building condition assessment (such as NL NEN 2767)
- Development and integration of energy-related KPIs

#### Development

- BIM & GIS for the building operational phase
- Practical validation and implementation of the new tools

#### Colophon

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Streamer European research on energy-efficient healthcare districts

STREAMER Deliverable D8.5