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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Streamer

European research on energy-efficient healthcare districts

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

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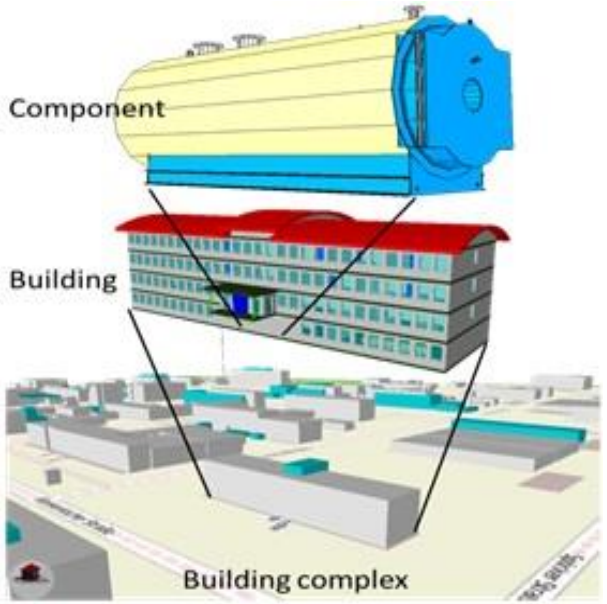
European research on energy-efficient healthcare districts

Context and focus

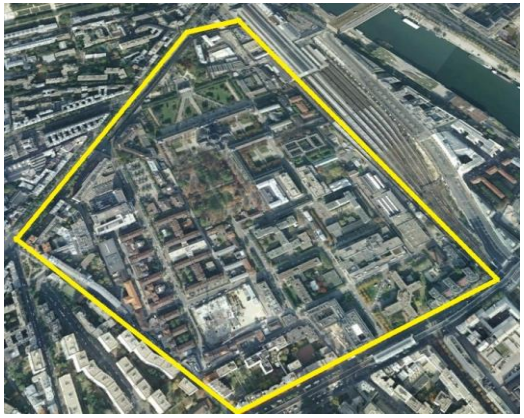


Context: Hospital campus – mixed-use area with an integrated energy system, consists of various buildings (e.g. hospitals and clinics, research and educational buildings, offices)

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

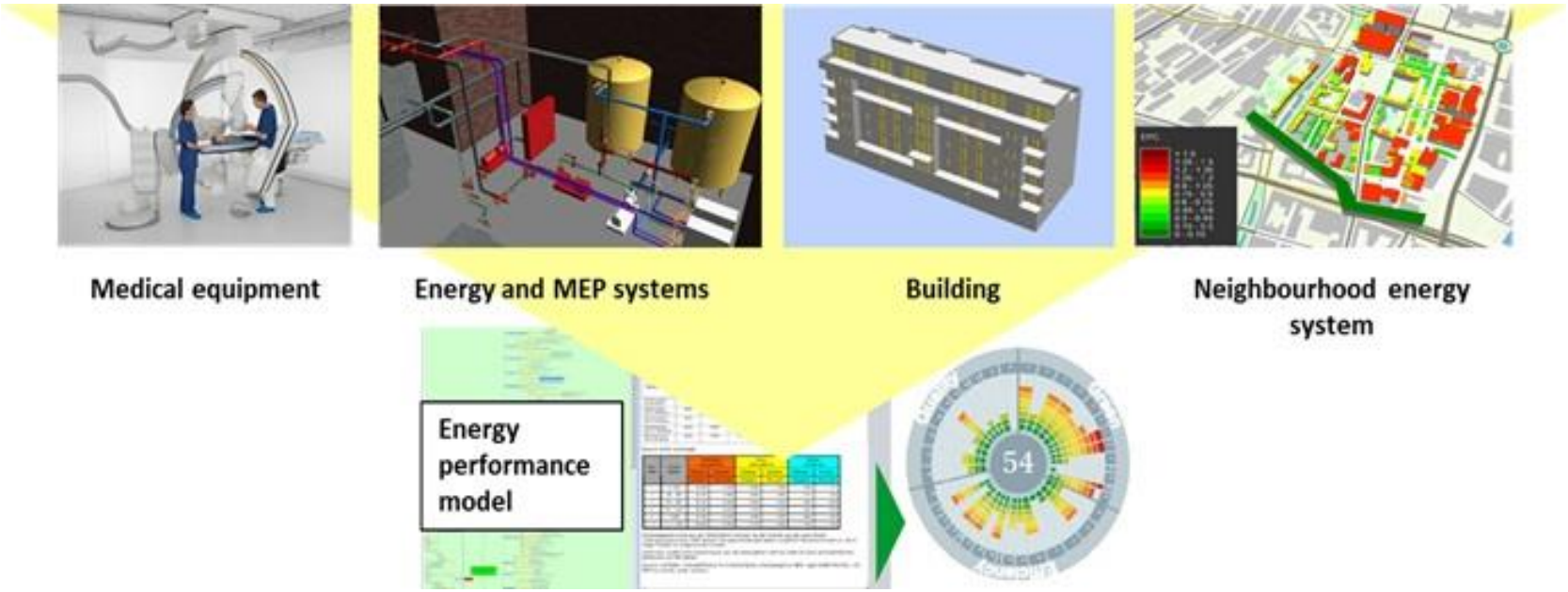


Strategic aim and research goals

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

Research: EeB **design optimisation** 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.)



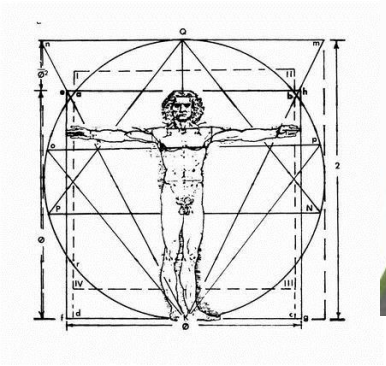
Targeted key research achievement

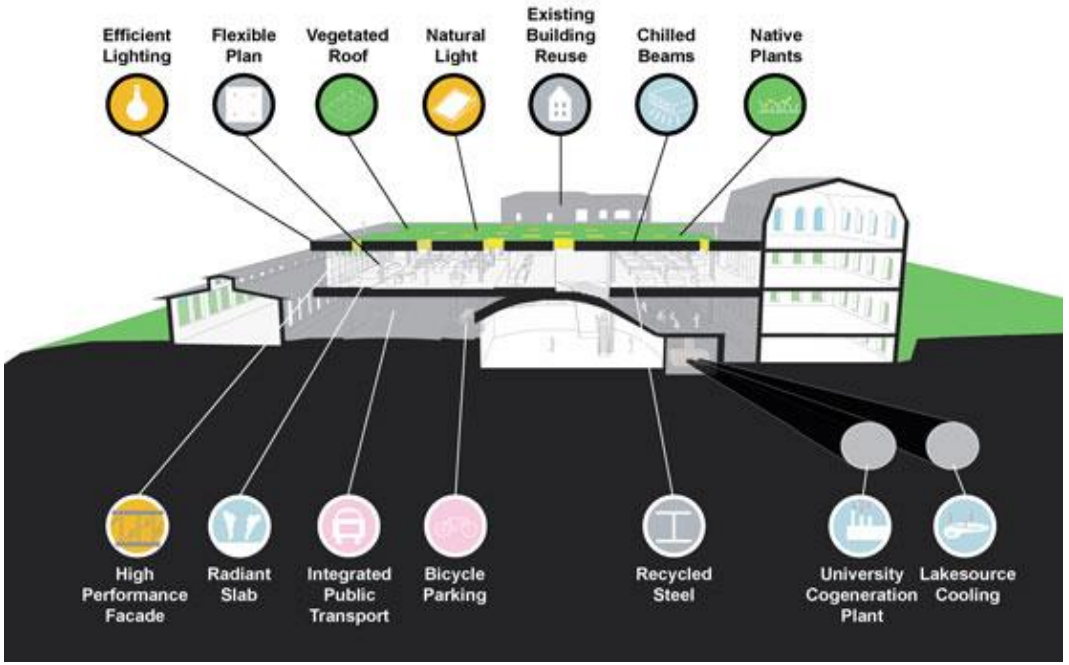
Generic semantic BIM+GIS typology models

of Energy-efficient Buildings in healthcare districts:

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

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

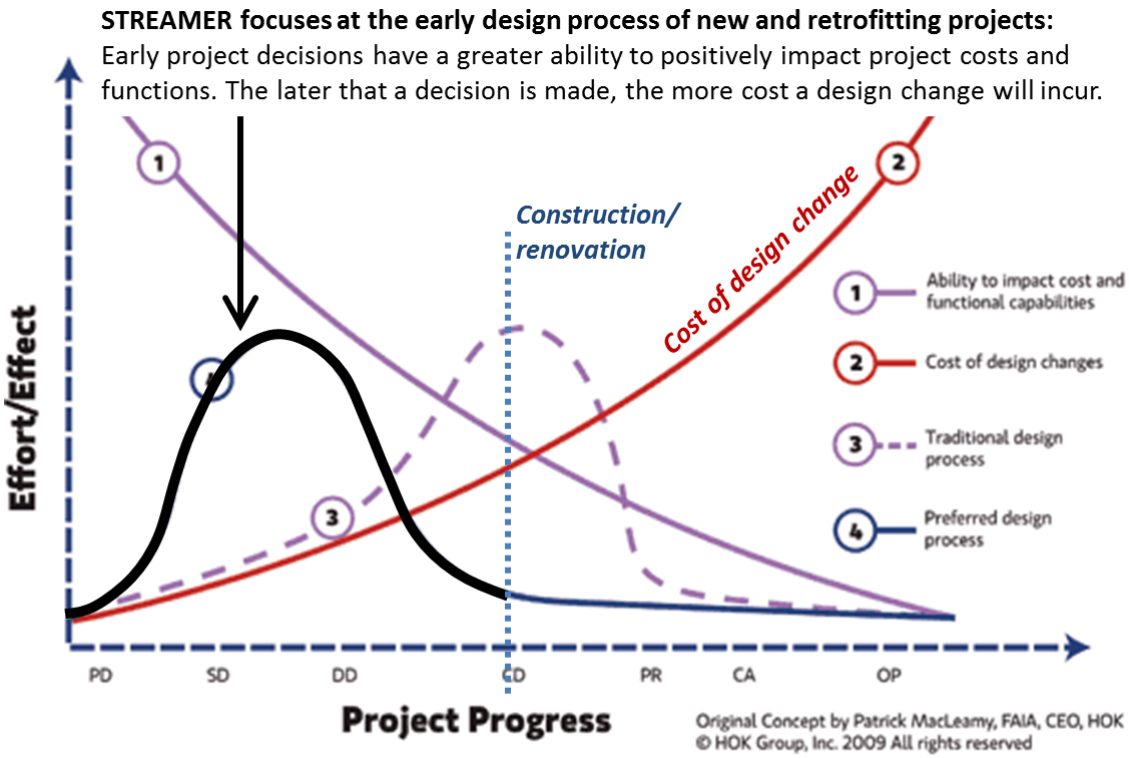


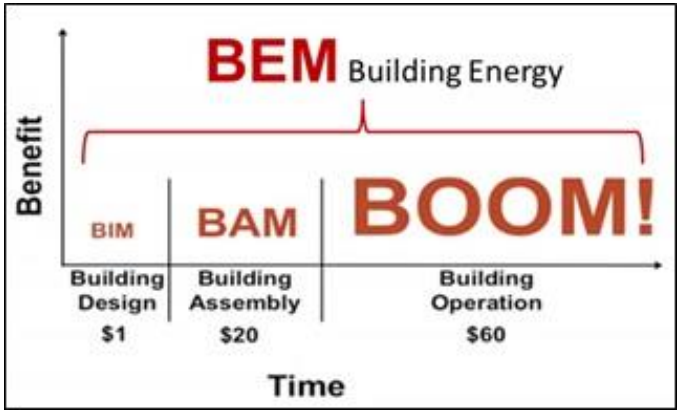


Targeted key research achievement

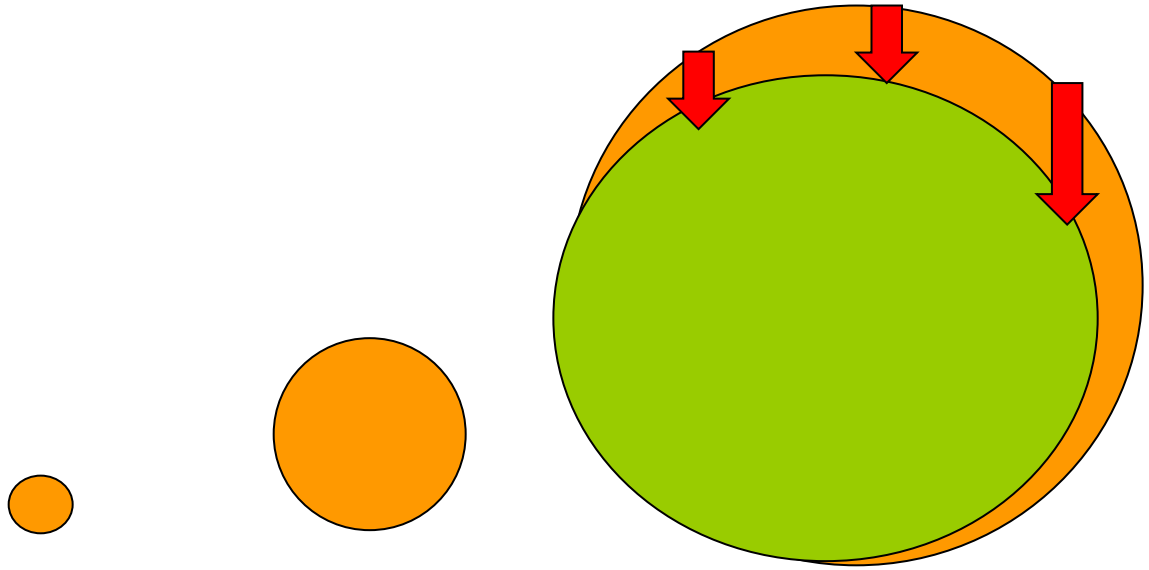
Framework for BEM (Building Energy Model)

lifecycle model inter-connecting BIM, BAM, BOOM.





From ‘service delivery’ to lifecycle design



Decrease costs

Building Design	Building Assembly	Operational Phase
€1 *	€20 *	€60-200 *

* Comparative proportion

Our aim: increase the ‘value of design’ by knowledge transfer between phases (using BIM), 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:

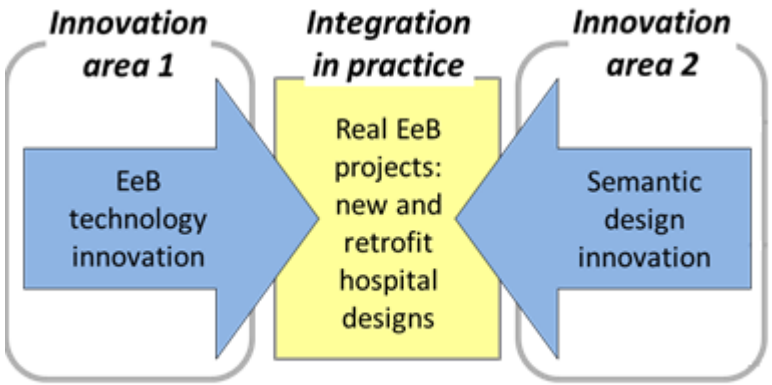
a) Inter-operable BIM and GIS models

b) Analysis of energy performance, lifecycle-cost, and functional optimisation

c) Stakeholder's / user's requirements, decision criteria and priorities.

Overall objectives

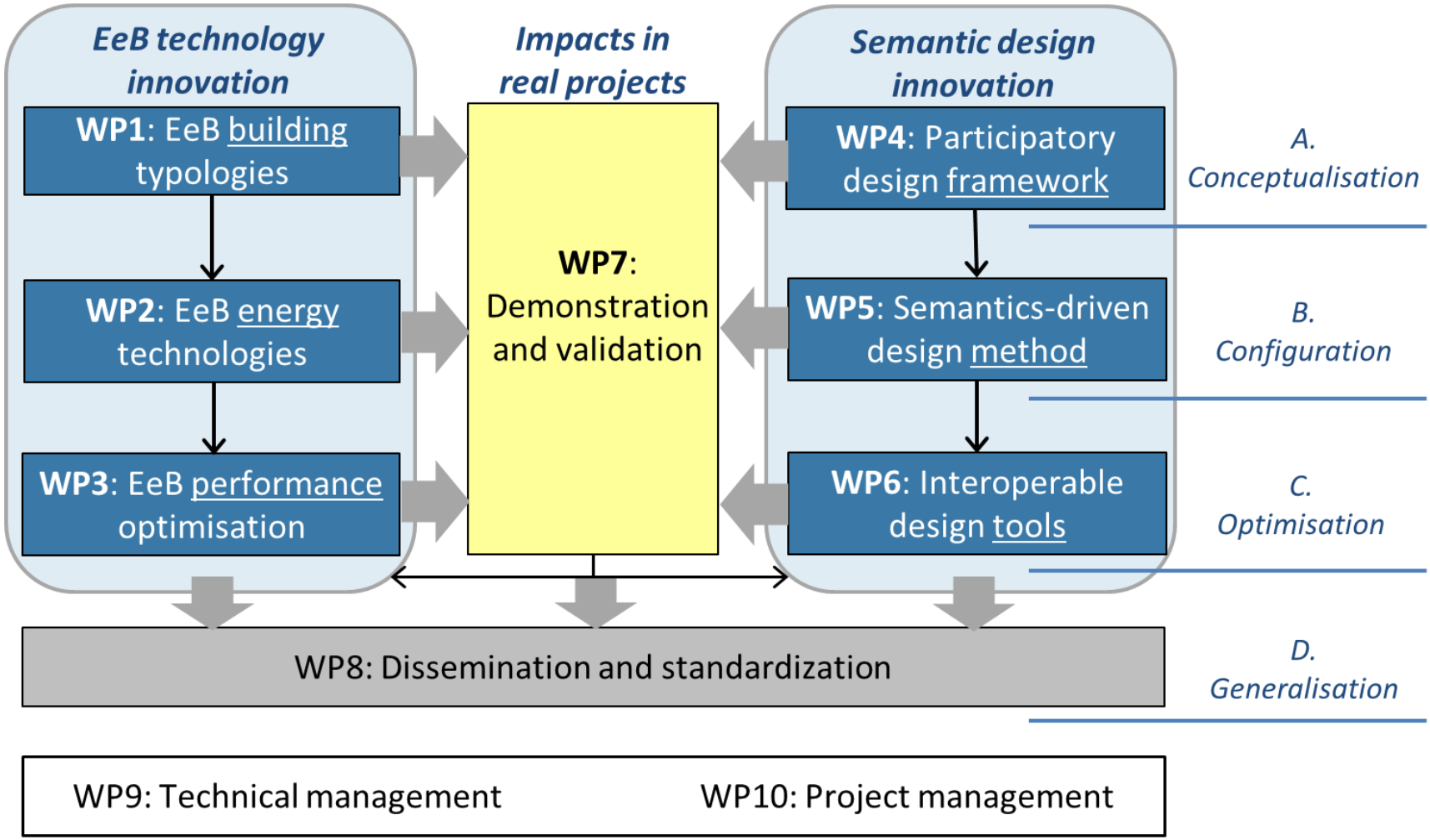
- On the basis of typologies of buildings / districts (WP1), technologies for envelope and MEP (WP2) and aims in terms of energy consumption (WP3) – Innovation area 1 …
- … Research and develop optimised Semantics-driven Design methods and interoperable tools for Building and Geo Information Modelling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

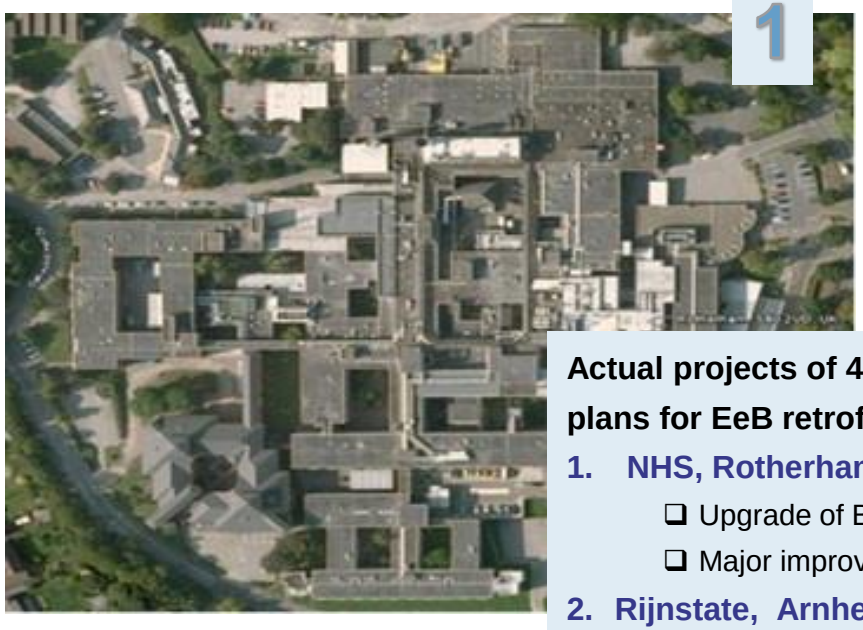


Key barriers to overcome

- 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.

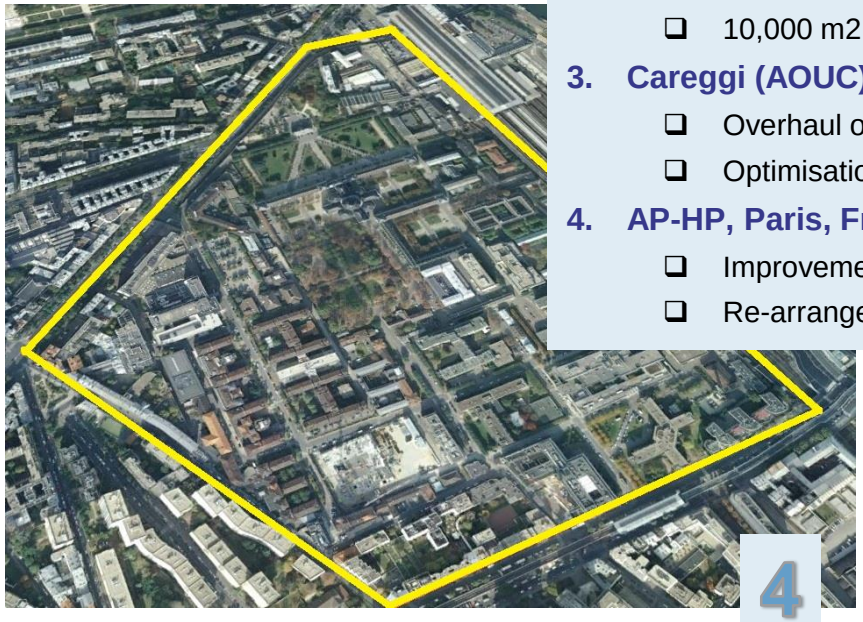
Work packages

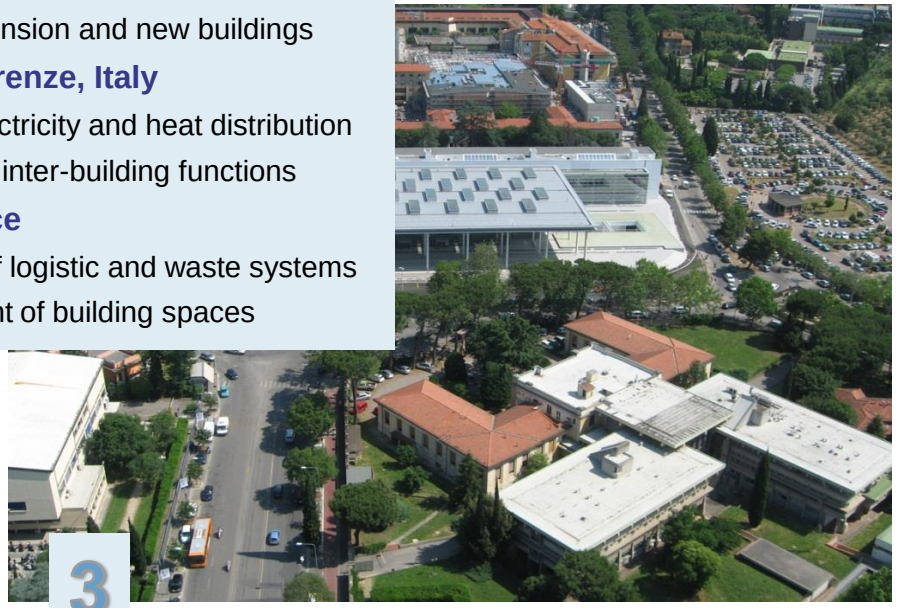




Actual projects of 4 hospital districts with real plans for EeB retrofitting or new design:

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
3. **Careggi (AOUC), Firenze, Italy**
   - ❑ Overhaul of electricity and heat distribution
   - ❑ Optimisation of inter-building functions
4. **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

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European research on energy-efficient healthcare districts

MODELING LANGUAGES

TARGET GROUP: UNIVERSITY STUDENTS

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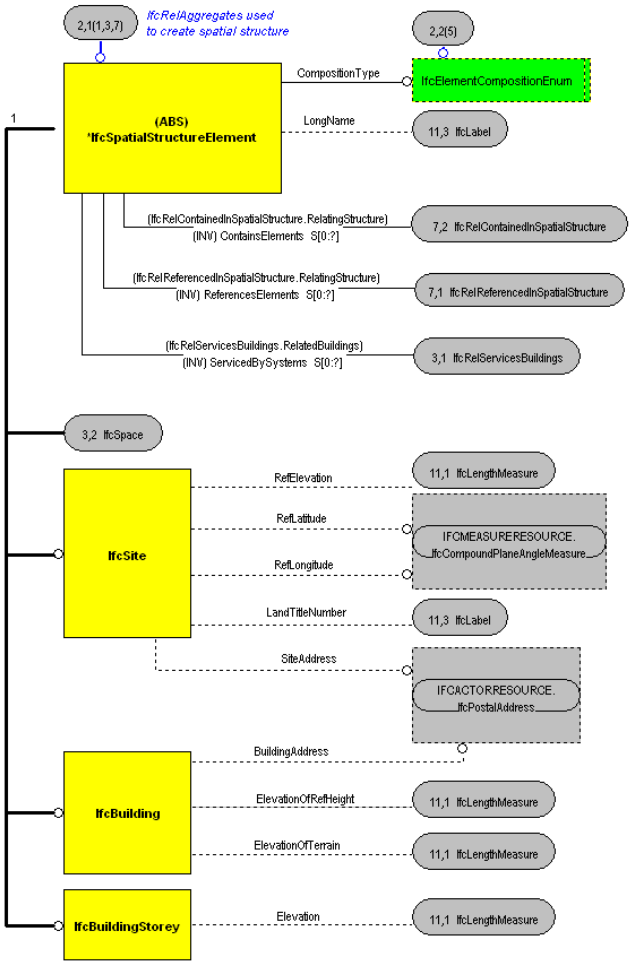
European research on energy-efficient healthcare districts

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\IfcObjectDefinition.Decomposes) = 1)
          AND
          ('IFC2X3.IFCRELAGGREGATES' IN TYPEOF(SELF\IfcObjectDefinition.Decomposes[1]))  AND
           (('IFC2X3.IFCPROJECT' IN TYPEOF (SELF\IfcObjectDefinition.Decomposes[1].RelatingObject)) OR
           ('IFC2X3.IFCSPATIALSTRUCTUREELEMENT' IN TYPEOF (SELF\IfcObjectDefinition.Decomposes[1].RelatingObject)));
END_ENTITY;

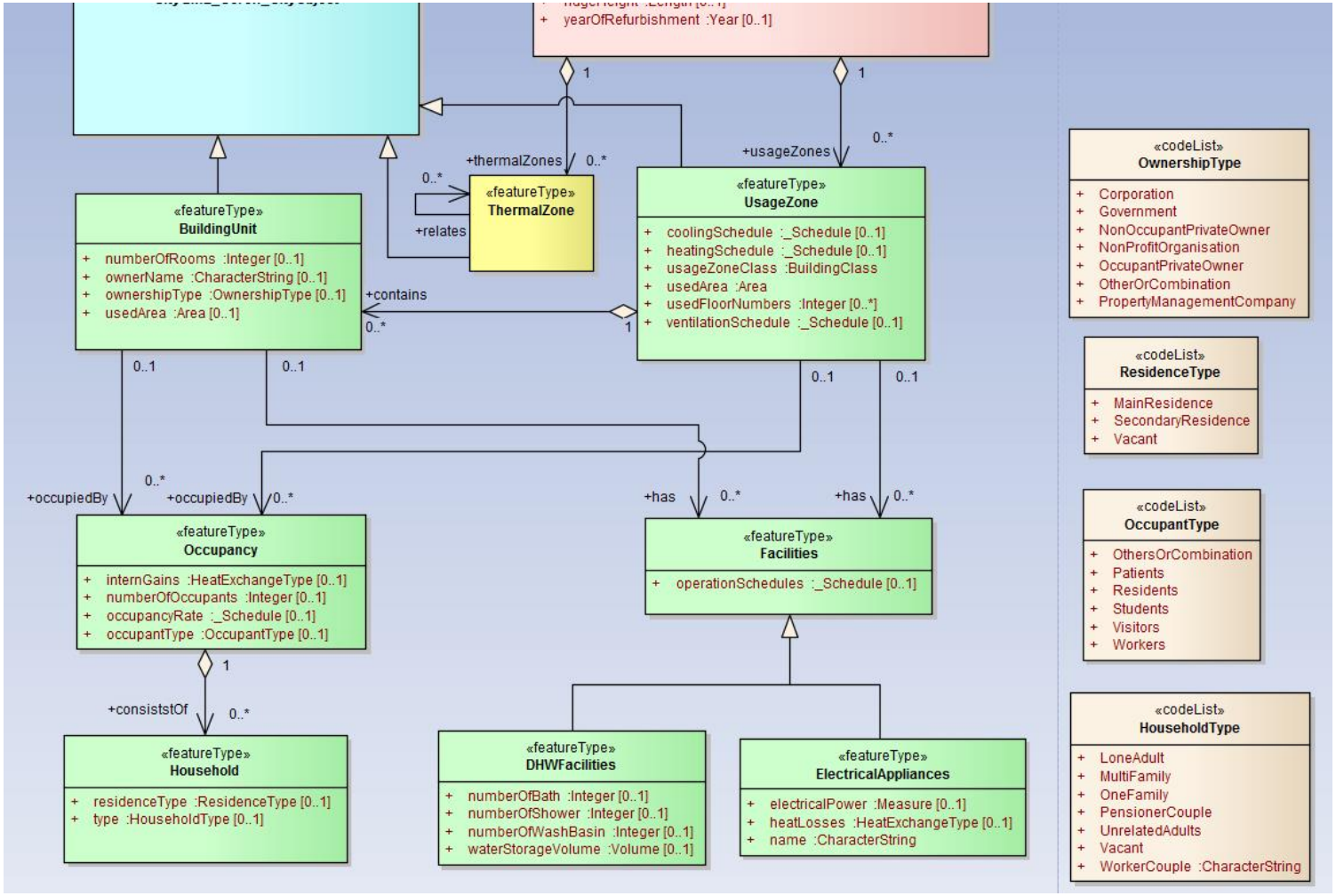
ENTITY IfcSite
 SUBTYPE OF (IfcSpatialStructureElement);
            RefLatitude : OPTIONAL IfcCompoundPlaneAngleMeasure;
            RefLongitude : OPTIONAL IfcCompoundPlaneAngleMeasure;
            RefElevation : OPTIONAL IfcLengthMeasure;
            LandTitleNumber : OPTIONAL IfcLabel;
            SiteAddress : OPTIONAL IfcPostalAddress;
END_ENTITY;

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

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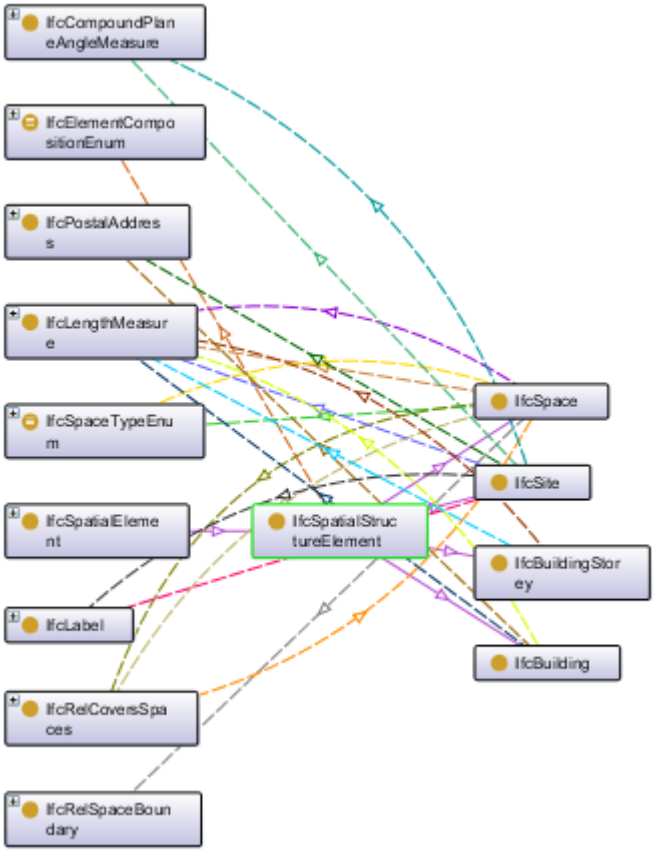
<element name="thermalZones" type="energy:ThermalZonePropertyType" substitutionGroup="bldg:_GenericApplicationPropertyOfAbstractBuilding">
  <annotation>
    <appinfo>
      <gml:targetElement>energy:ThermalZone</gml:targetElement>
    </appinfo>
  </annotation>
</element>
<element name="usageZones" type="energy:UsageZonePropertyType" substitutionGroup="bldg:_GenericApplicationPropertyOfAbstractBuilding">
  <annotation>
    <appinfo>
      <gml:targetElement>energy:UsageZone</gml:targetElement>
    </appinfo>
  </annotation>
</element>
<!--======================================================================================-->
<!--_BoundarySurface-->
<!--======================================================================================-->
<element name="equippedWith" type="energy:_SolarEnergySystemPropertyType" substitutionGroup="bldg:_GenericApplicationPropertyOfBoundarySurface">
  <annotation>
    <appinfo>
      <gml:targetElement>energy:_SolarEnergySystem</gml:targetElement>
    </appinfo>
  </annotation>
</element>
<element name="correspondsTo" type="energy:ThermalBoundarySurfacePropertyType" substitutionGroup="bldg:_GenericApplicationPropertyOfBoundarySurface">
  <annotation>
    <appinfo>
      <gml:targetElement>energy:ThermalBoundarySurface</gml:targetElement>
    </appinfo>
  </annotation>
</element>
```

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>
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      <owl:onProperty rdf:resource="http://buildingsmart.org/ontology/IFC#BuildingAddress"/>
      <owl:onClass rdf:resource="http://buildingsmart.org/ontology/IFC#IfcPostalAddress"/>
      <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#IfcLengthMeasure"/>
      <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"/>
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      <owl:onProperty rdf:resource="http://buildingsmart.org/ontology/IFC#ElevationOfRefHeight"/>
      <owl:onClass rdf:resource="http://buildingsmart.org/ontology/IFC#IfcLengthMeasure"/>
      <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

Streamer
European research on energy-efficient healthcare districts

BIM Standards

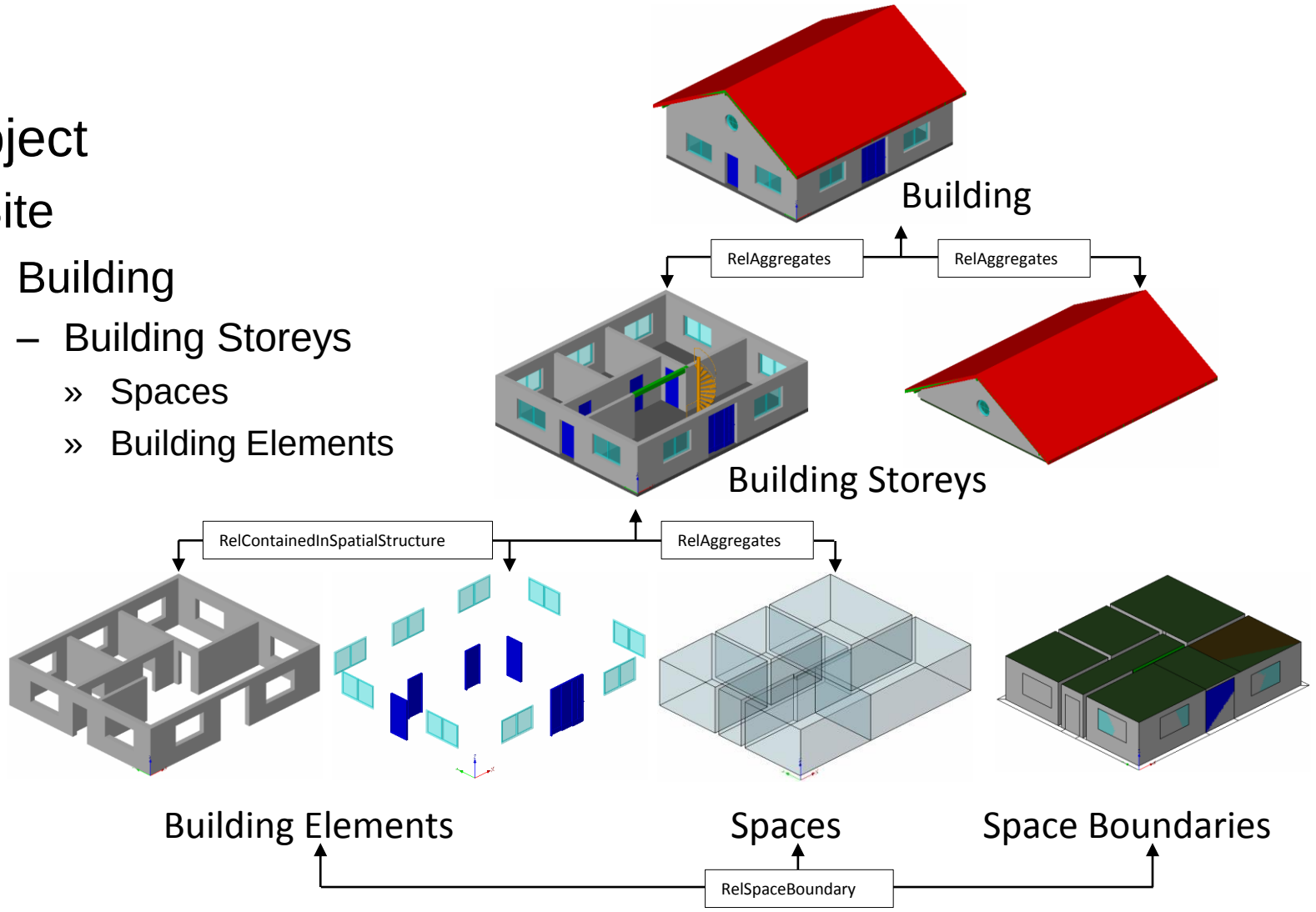
- Industry Foundation Classes (IFC)
- Green Building XML (gbXML)
- BIM Collaboration Format (BCF)
- Model View Definition XML (mvdXML)

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

- Project
  - Site
    - Building
      - Building Storeys
        - » Spaces
        - » Building Elements

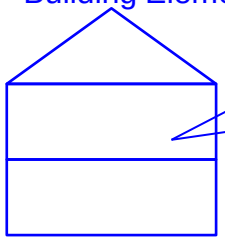


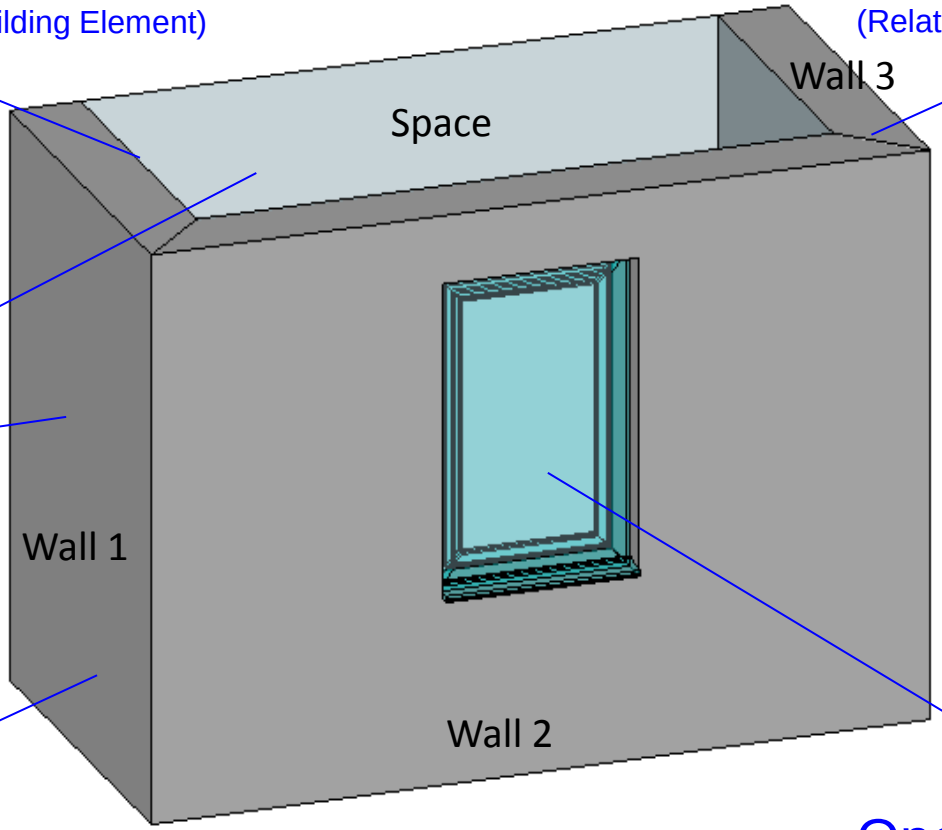
IFC Building Elements

Space Boundary
(Relation between Space and Building Element)

Wall Connection
(Relation between Walls)

Containment
(Relation between Storey and Building Element)



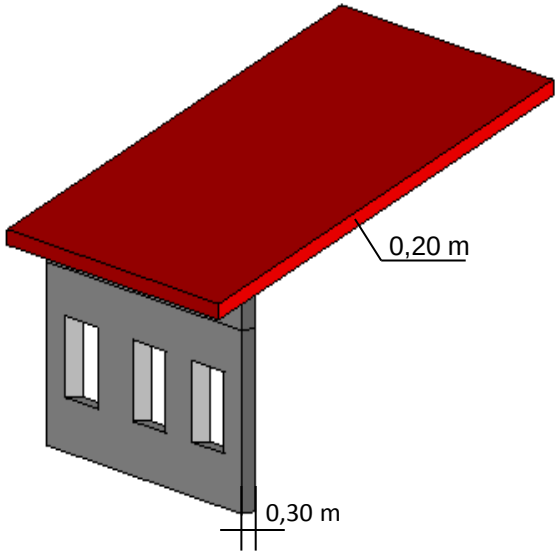


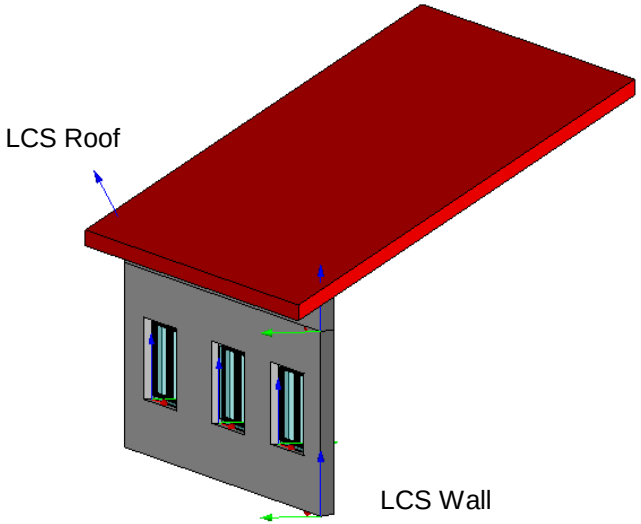
Material

Opening Element
(Opening geometry,
Relation to Wall and Window)

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)





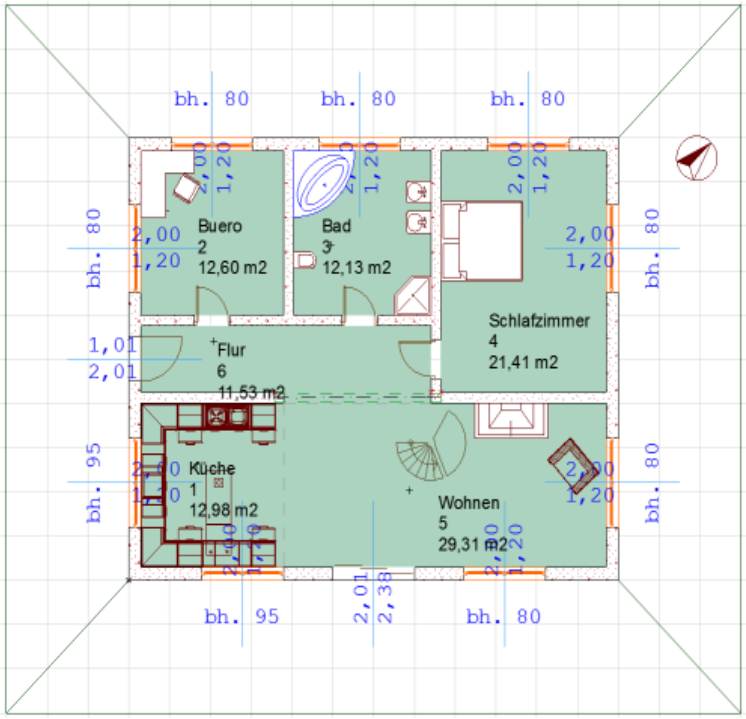
Properties in IFC

- 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

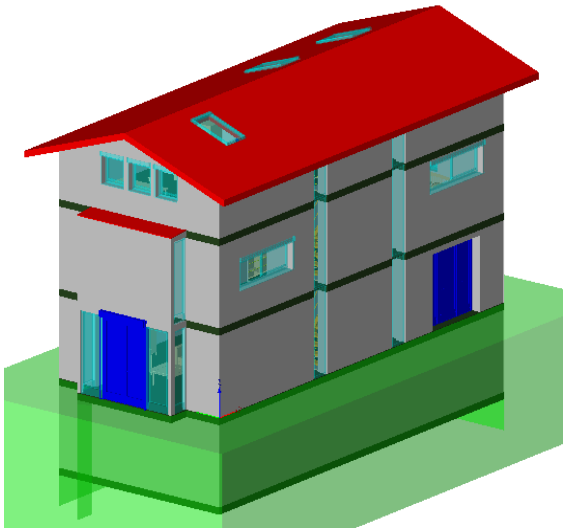
Georeferencing in IFC

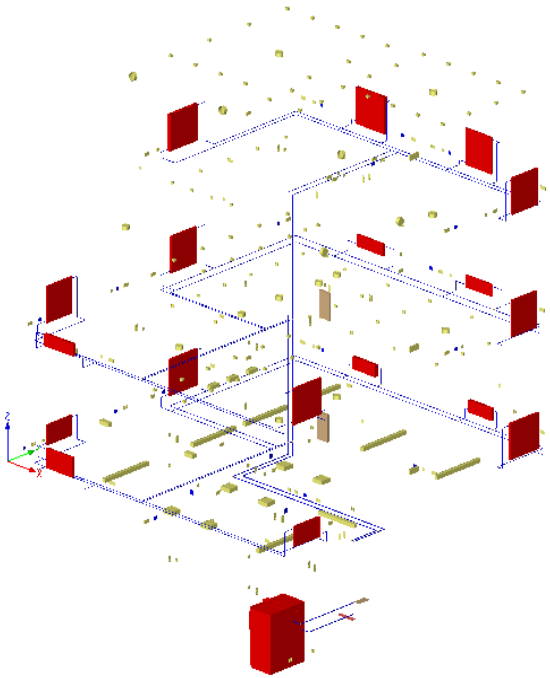
- Usage of local Cartesian coordinates
- Origin normally within project boundaries
- Latitude and longitude as attributes of the “building site*
- Elevation above sea level as attribute of the “building site*
- North direction as orientation vector
- Since IFC4: Support of arbitrary coordinate reference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

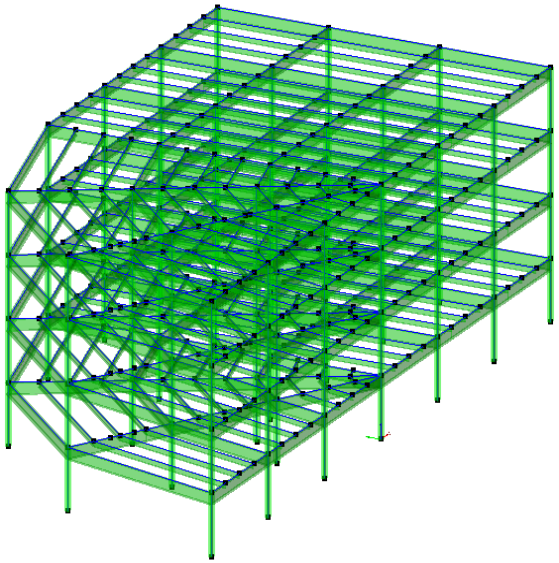


*Relating to the local origin of the building site

IFC Examples







Architecture

- Walls
- Roofs
- Slabs
- etc.

HVAC

- Components
- Port connections
- Systems including flow directions

Structural analysis

- Steelwork
- Structural model
- Structural loads

Further information

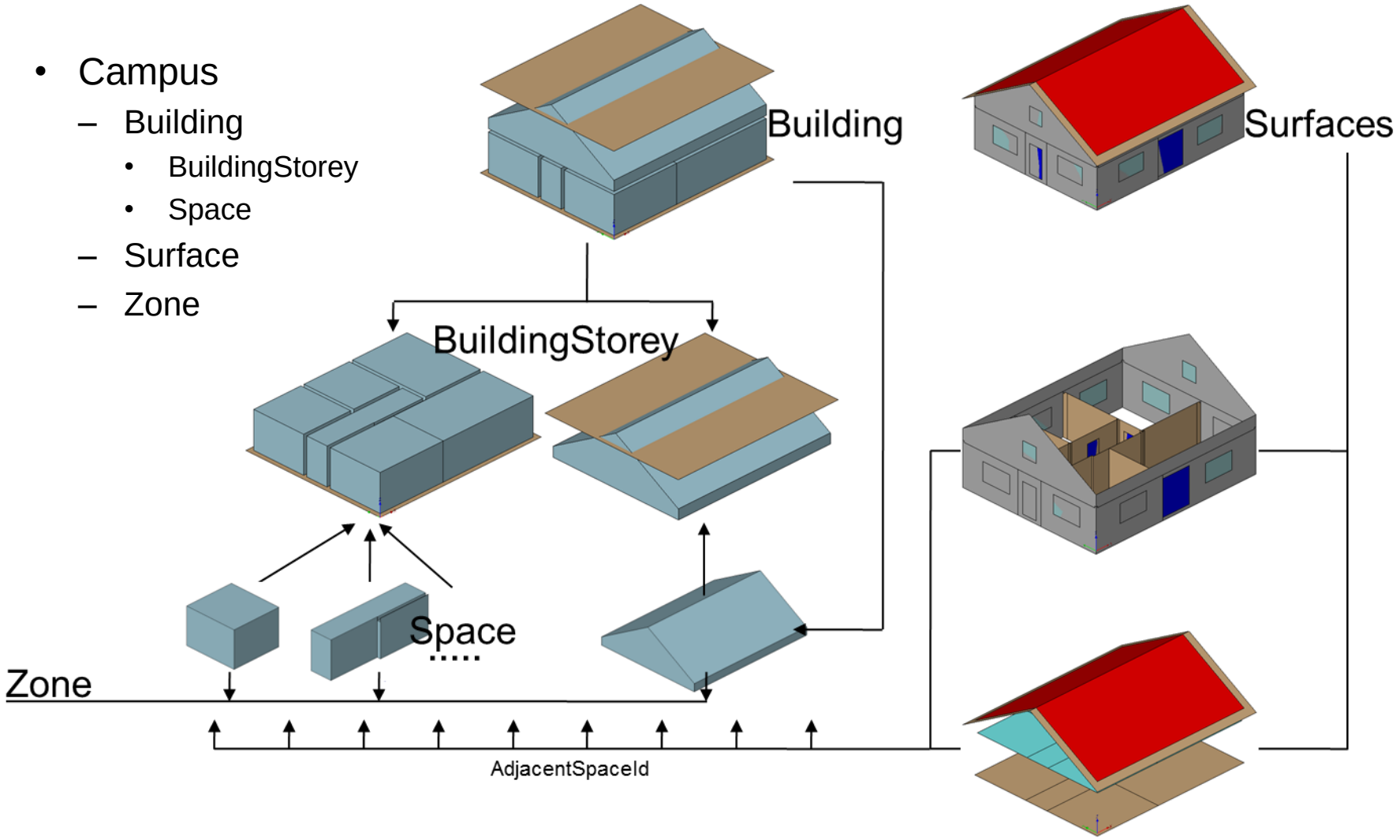
- Literature
  - **Eastman, C. M**.: Building Product Models: Computer Environments Supporting Design and Construction, CRC Press LLC, 1999, ISBN 0-8493-0259-5
  - **Industry Foundation Classes:** IFC2x Edition 3 Technical Corrigendum 1, buildingSMART 2007, http://www.buildingsmart-tech.org/ifc/IFC2x3/TC1/html/index.htm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

Green Building XML - gbXML

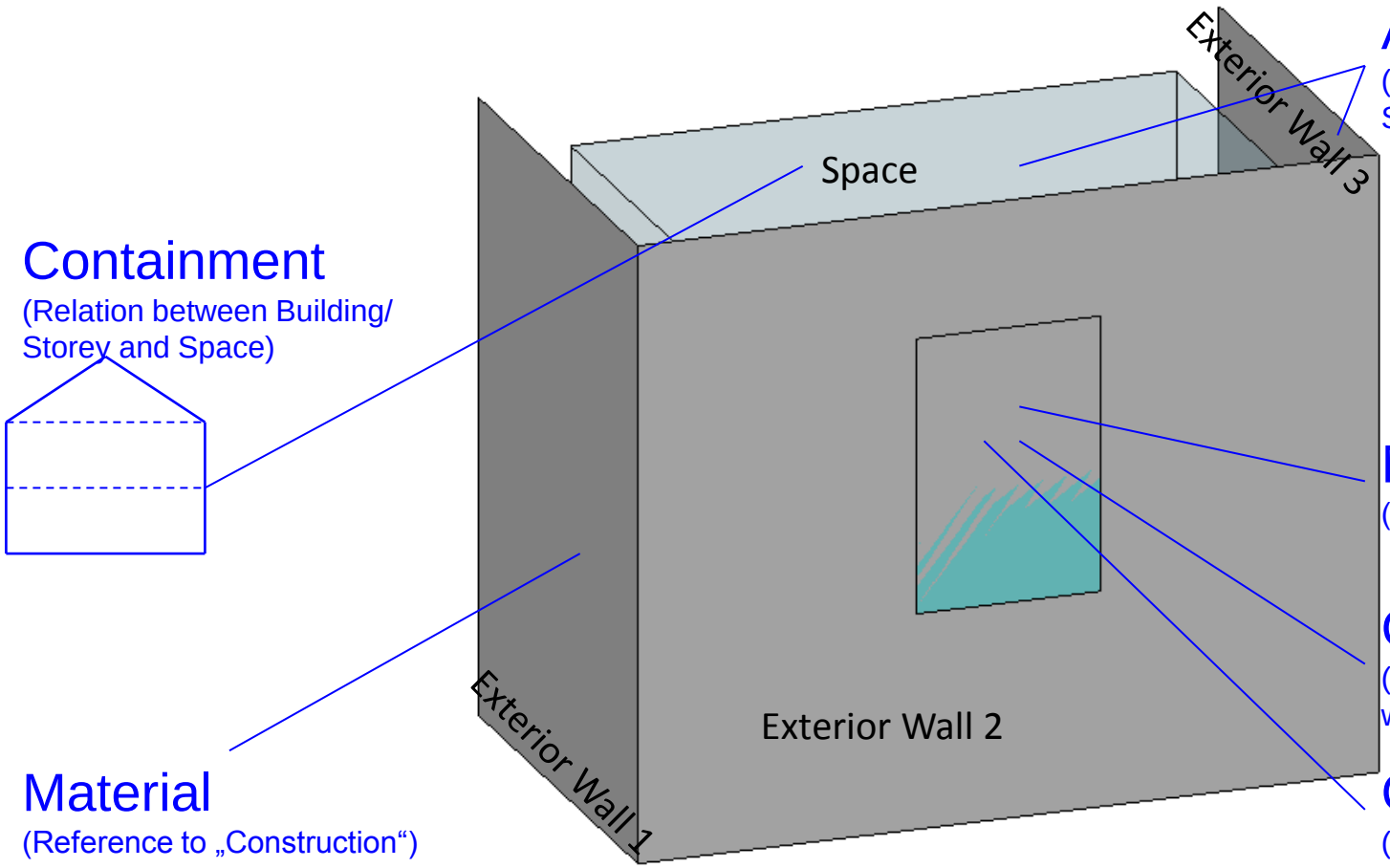
- Actual version 5.12
- XML based
- 306 XML elements
- 104 specific enumerations
- Predefined property sets
- No inherent extension mechanism

gbXML – Structure

- Campus
  - Building
    - BuildingStorey
    - Space
  - Surface
  - Zone



Surface in gbXML



AdjacentSpaceId
(Reference from Surface to Space)

Containment
(Relation between Building/ Storey and Space)

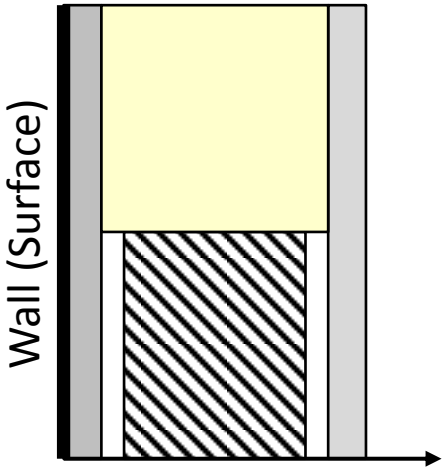
Material
(Reference to „Construction“)

OpeningType
(Reference to door and window types)

Material
(Reference to „Construction“)

Opening
(Reference from Surface)

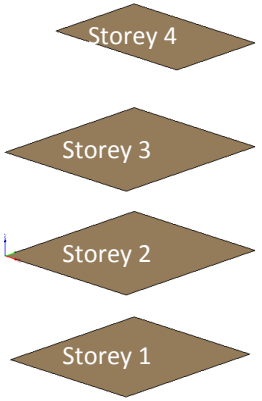
Construction in gbXML

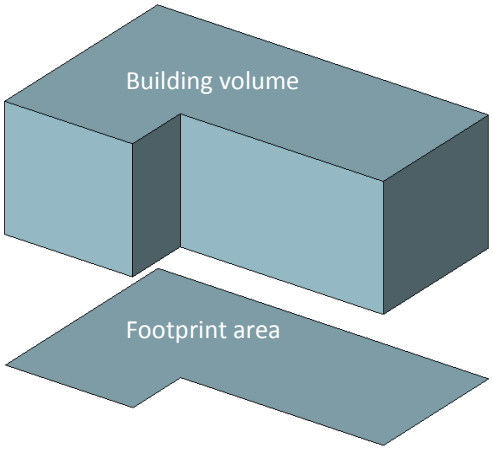


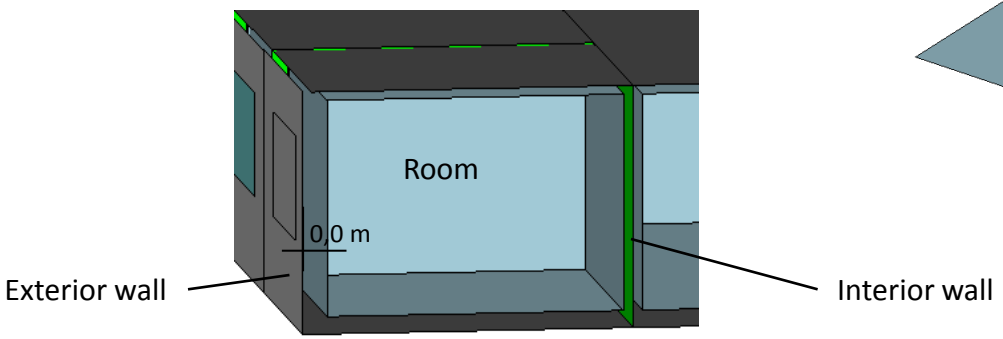
Layered material structure with different material thickness

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)

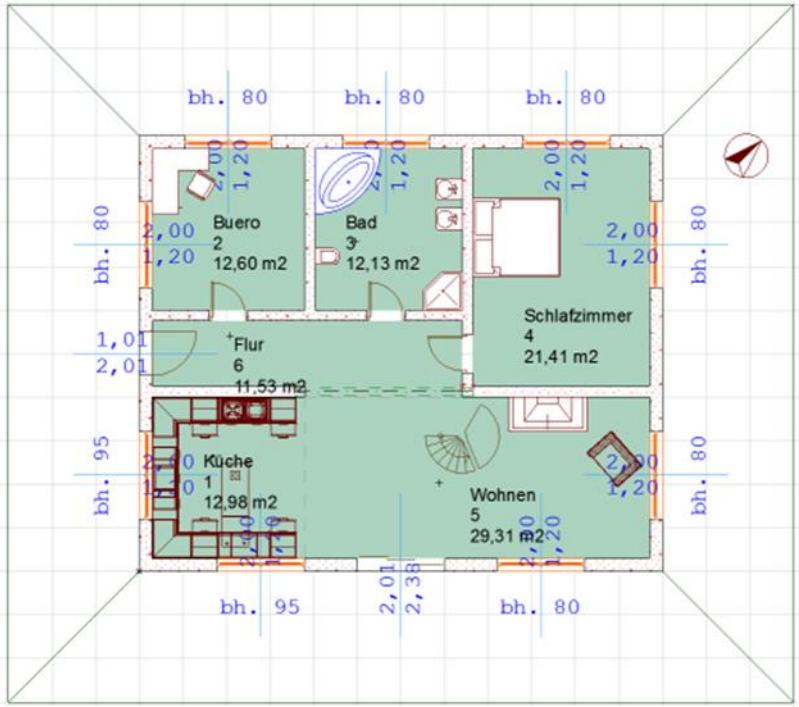




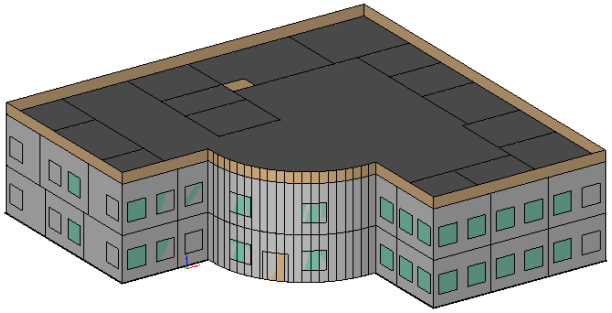


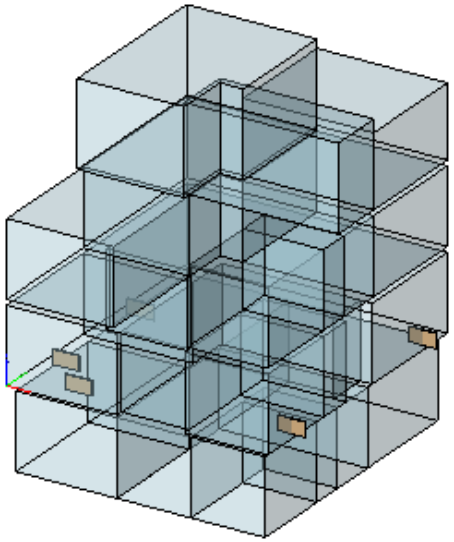
Georeferencing in gbXML

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



gbXML Examples





```
<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>
<EndDate>
2012-12-31
</EndDate>
<WeekScheduleId weekScheduleIdRef="wk-schdl-
1"/>
</YearSchedule>
</Schedule>
```

Model

- Spaces
- Surfaces
- Shading

HVAC

- Equipment
- Loops
- Lighting
- Thermal loads

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

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

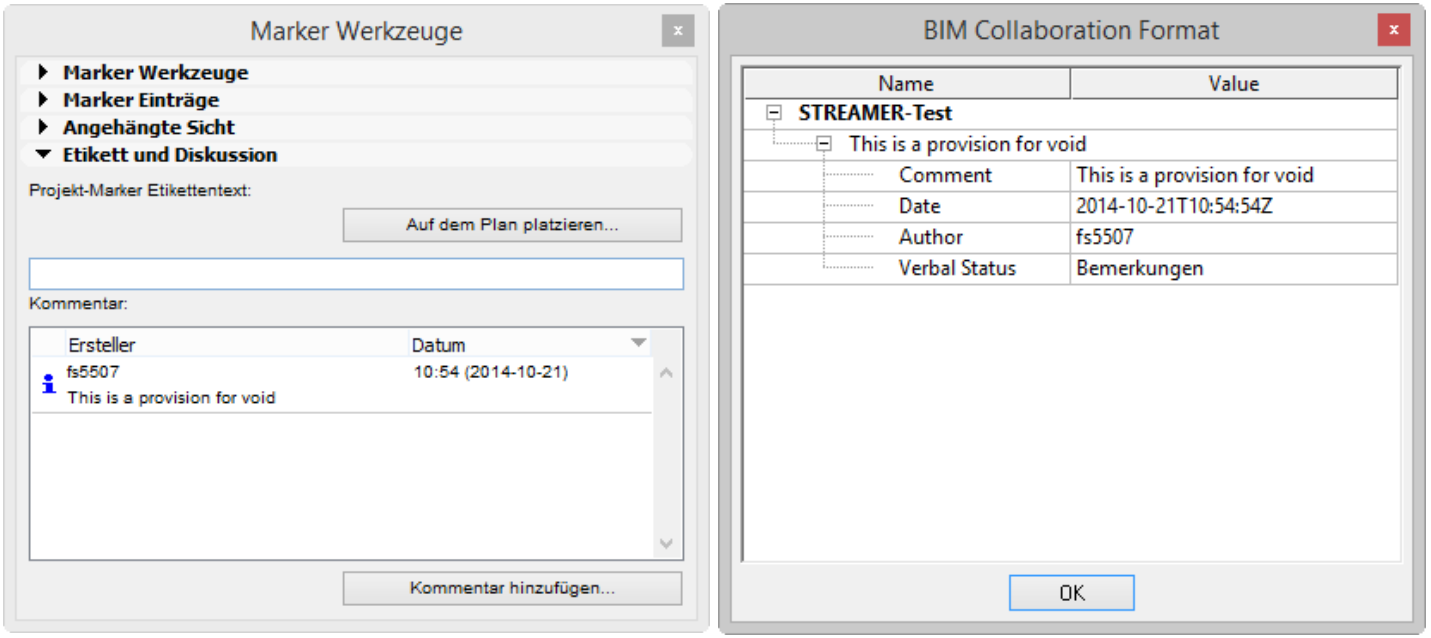
- A BCF file is a zip archive containing one folder for each topic. The root of the BCF zip archive contains the following files:
  - project.bcfp (Version 2.0, optional)
  - bcf.version (Version 2.0)

- 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

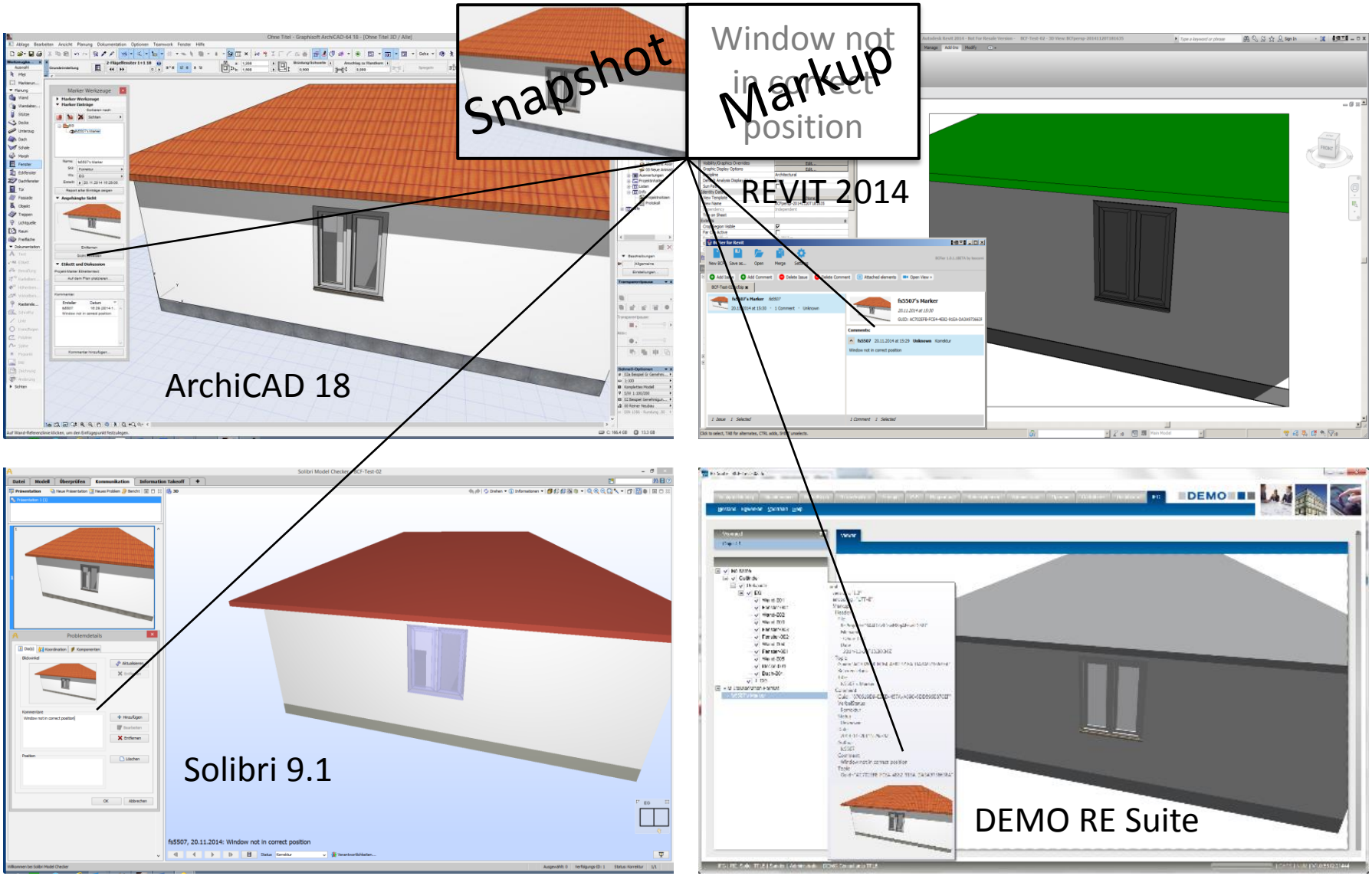
- The Markup file contains the following sections
  - Header: The header section contains information about the IFC files, which are relevant for this topic
  - Topic: The topic section contains all information of the topic (e.g. Description, Priority, creationDate, ModifiedAuthor)
  - BimSnippet (optional): 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



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

BCF Examples



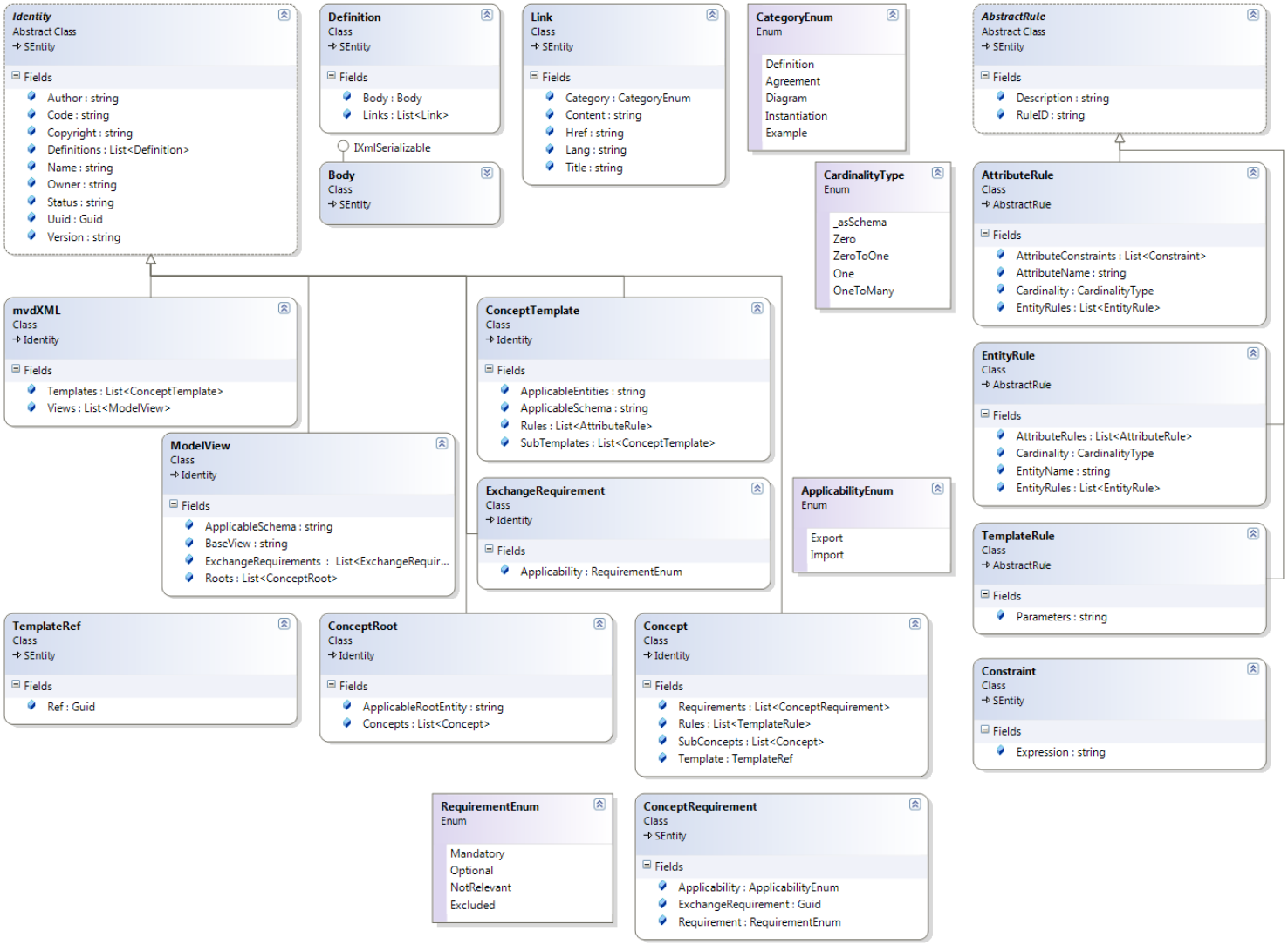
Further information

- Literature
  - **Paasiala, P**.: BIM Collaboration Format, 2013, https://github.com/BuildingSMART/BCF-XML/blob/master/Documentation/BIM%20Collaboration%20Format%20Improvements.pdf
  - **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:** https://github.com/BuildingSMART/BCF-API
- Free software
  - **Tekla BIMsight:** http://www.teklabimsight.com
  - **DDS-CAD Viewer:** http://www.dds-cad.net/downloads/dds-cad-viewer/

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; http://www.buildingsmart-tech.org/downloads/accompanying-documents/formats/mvdxml-documentation/mvdXML_V1-0.pdf
- Examples
  - https://github.com/BuildingSMART/mvdXML/tree/master/mvdXML1.1/xml
- Web resources
  - **mvdXML:** https://github.com/BuildingSMART/mvdXML
  - **MVD Overview:** http://www.buildingsmart-tech.org/specifications/mvd-overview/mvd-overview-summary
- Free software
  - **ifcDoc:** http://www.buildingsmart-tech.org/specifications/specification-tools/ifcdoc-tool/ifcdoc-beta-summary
  - **ReqCap**: http://85.10.201.48:4570/ (STREAMER internally)

GIS-STANDARDS

TARGET GROUP: UNIVERSITY STUDENTS

Streamer
European research on energy-efficient healthcare districts

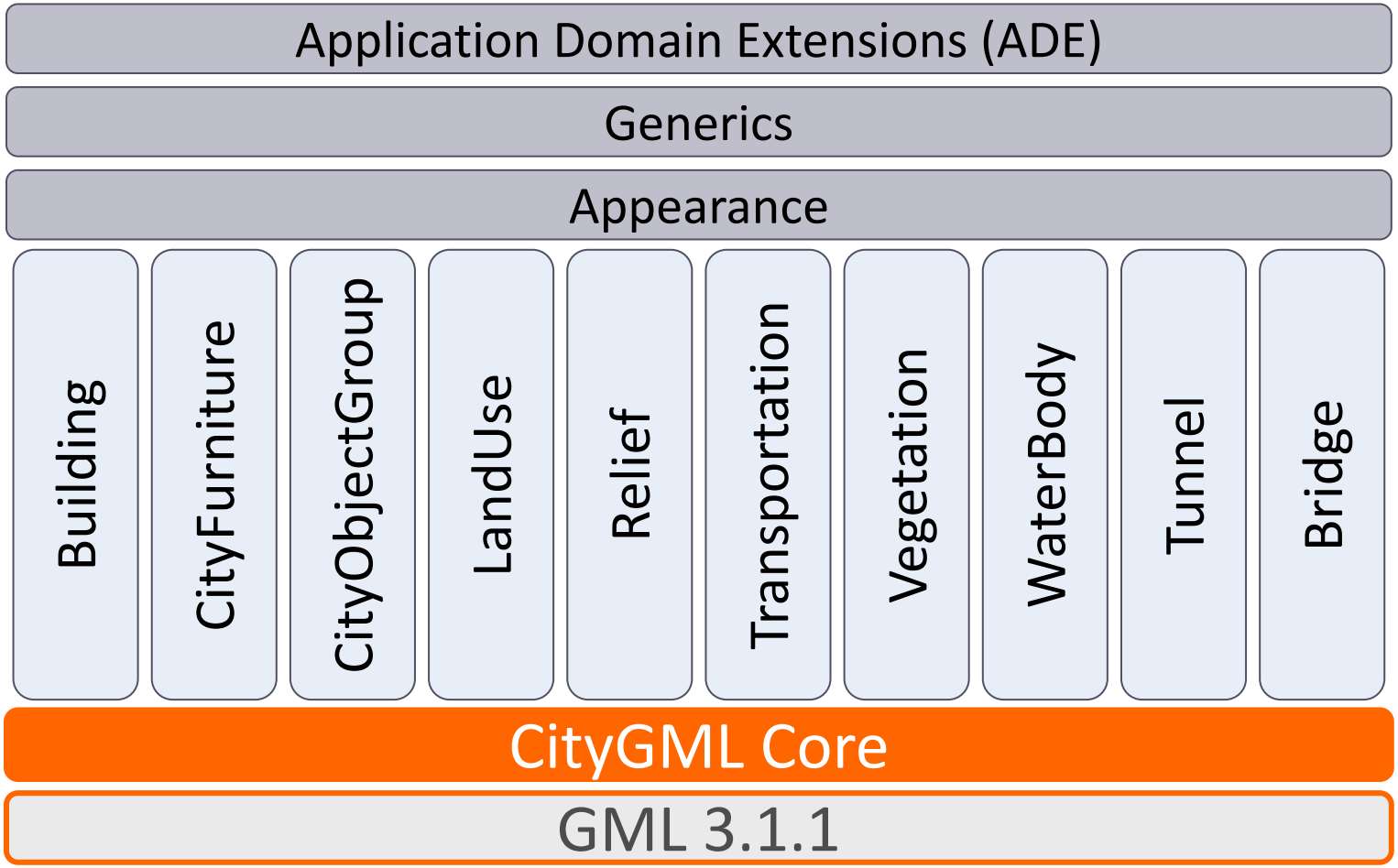
GIS-Standards

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

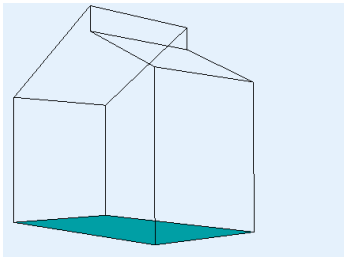
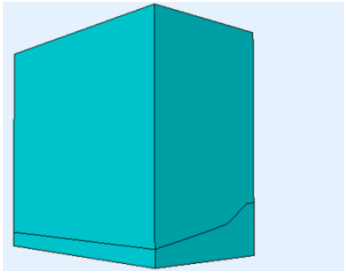
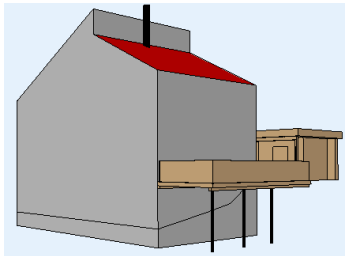
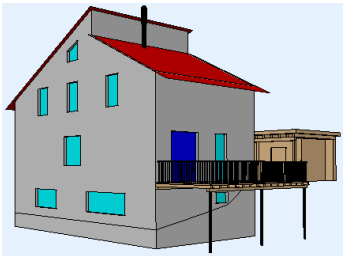
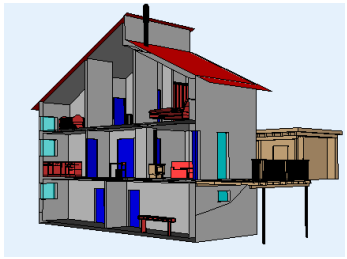
CityGML

- 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



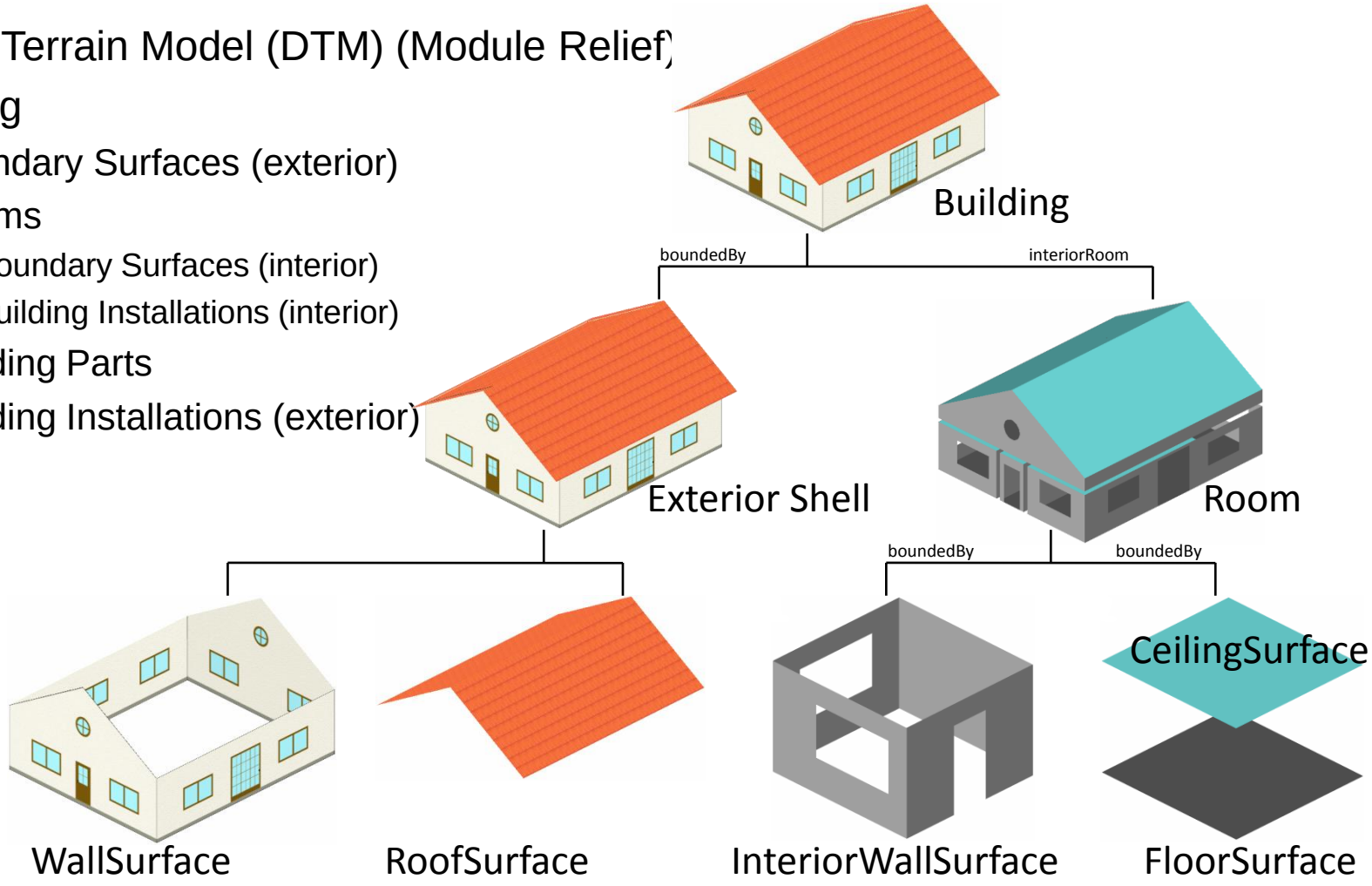
CityGML 2.0 Levels of Detail (LoD)

Horizontal surface	Prismatic block model	Generalized exterior shell	Detailed exterior shell	Interior model
				
CityGML LoD 0	CityGML LoD 1	CityGML LoD 2	CityGML LoD 3	CityGML LoD 4

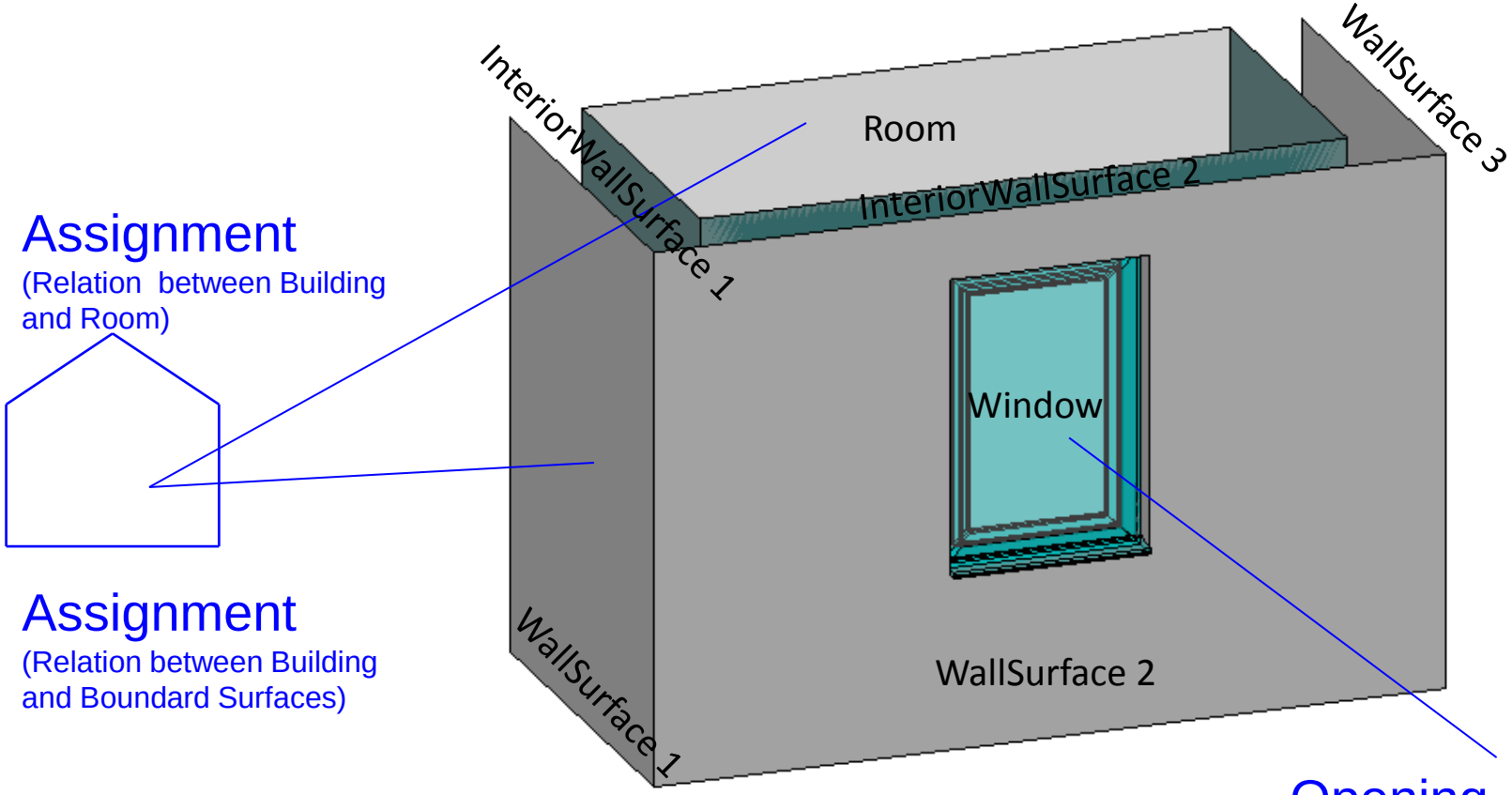
Modeling of real world objects in different geometric and semantic detailing

CityGML – Building Structure

- Digital Terrain Model (DTM) (Module Relief)
- Building
  - Boundary Surfaces (exterior)
  - Rooms
    - Boundary Surfaces (interior)
    - Building Installations (interior)
  - Building Parts
  - Building Installations (exterior)



CityGML Boundary Surfaces of Building and Room



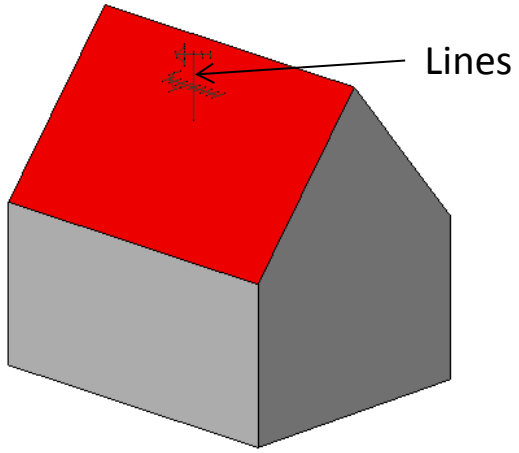
Assignment
(Relation between Building and Room)

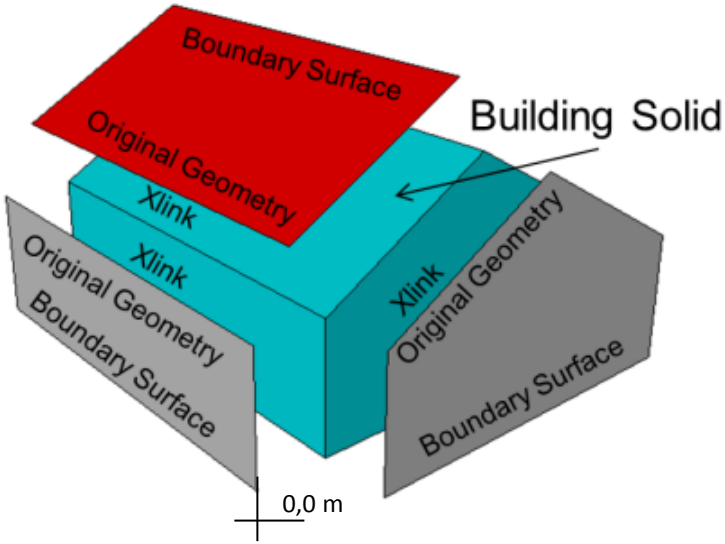
Assignment
(Relation between Building and Boundard Surfaces)

Opening
(Relation between WallSurface and Window)

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)

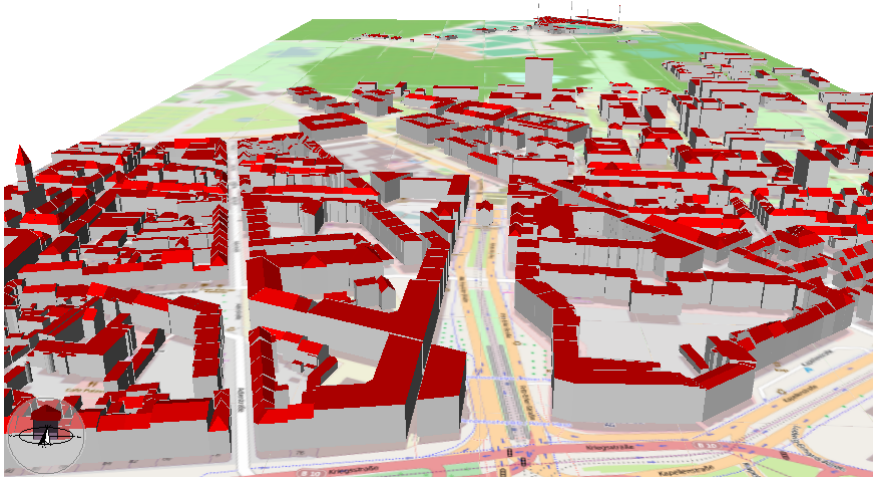
- Attributes inherited from GML
  - name, description, boundedBy, etc.;
- Common attributes of all CityGML objects
  - creationDate, terminationDate, relativeToTerrain, relativeToWater, externalReference, generalizesTo;
- Specific Building attributes
  - class, function, usage, yearOfConstruction, yearOfDemolition, 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

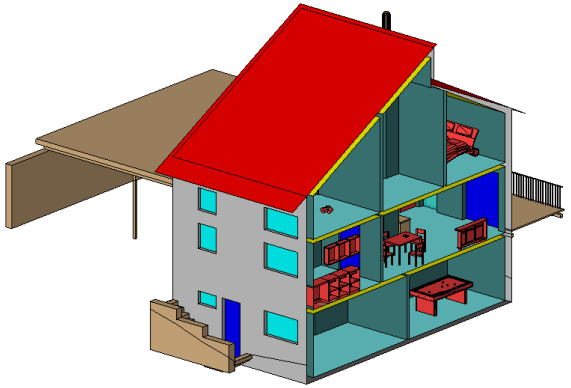
CityGML Examples

Karlsruhe LOD 1*



Karlsruhe LOD 2*

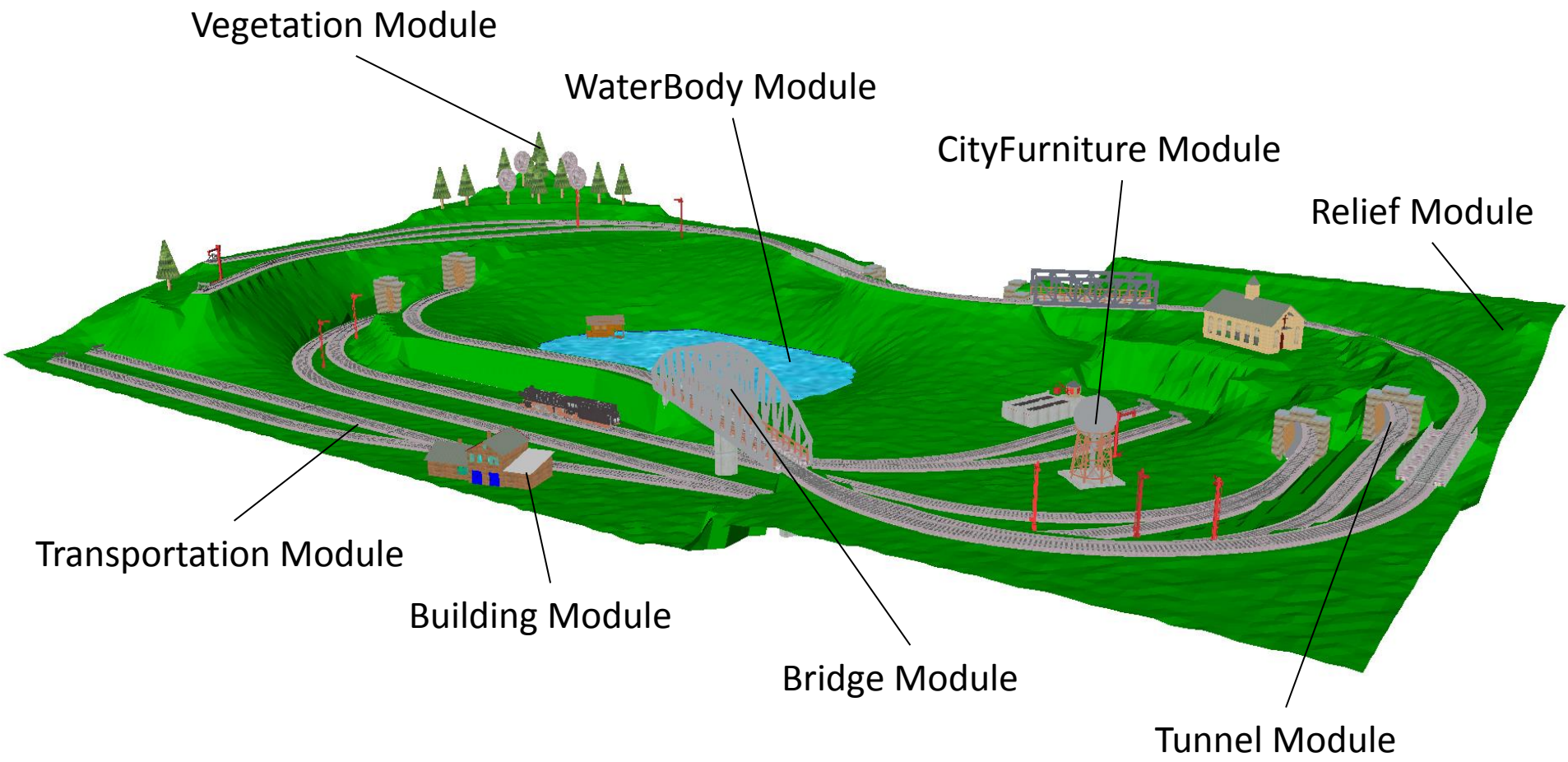
GeoRes LOD 4



KIT LOD 4

* Courtesy of the city of Karlsruhe

CityGML - Example



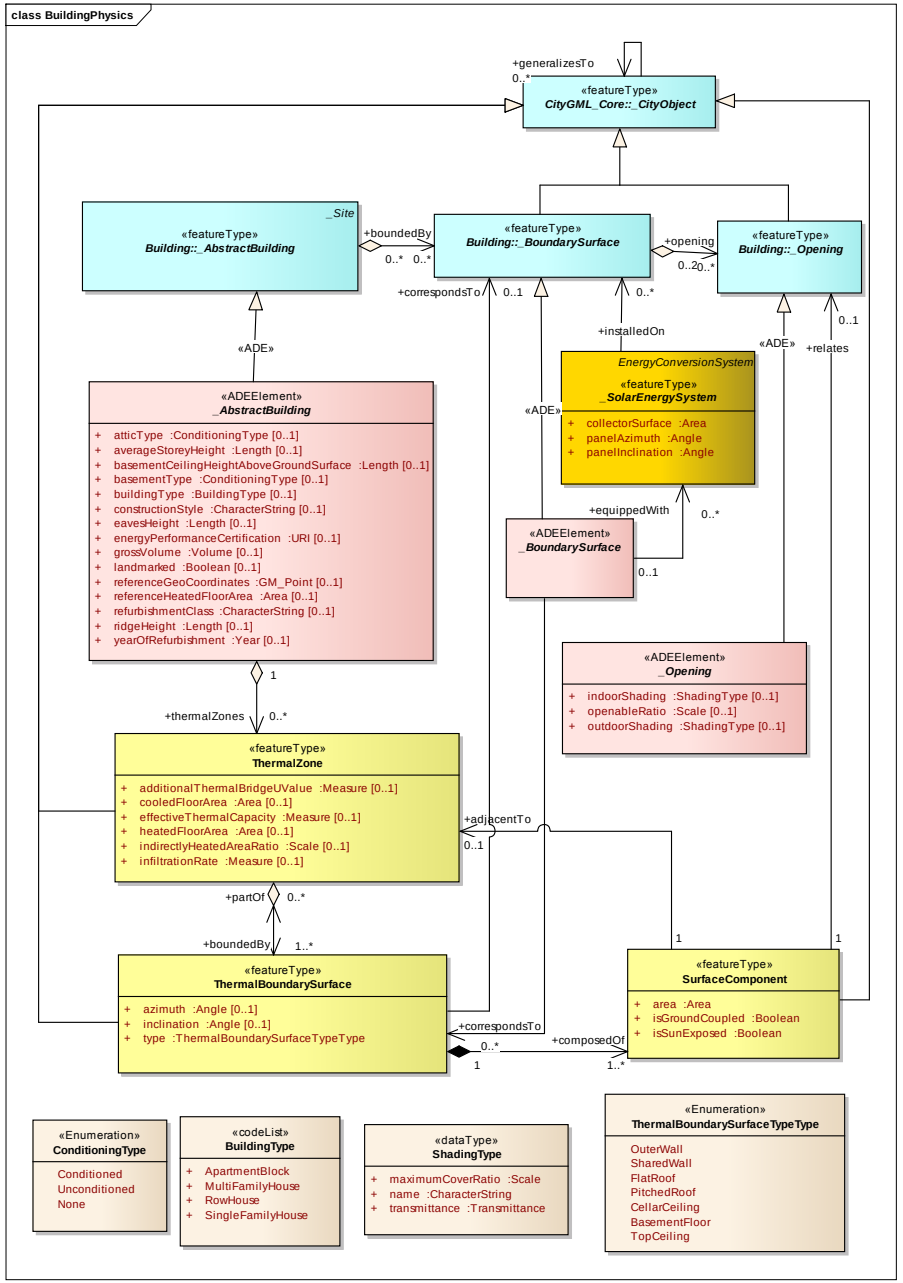
CityGML – Extension mechanisms

- 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

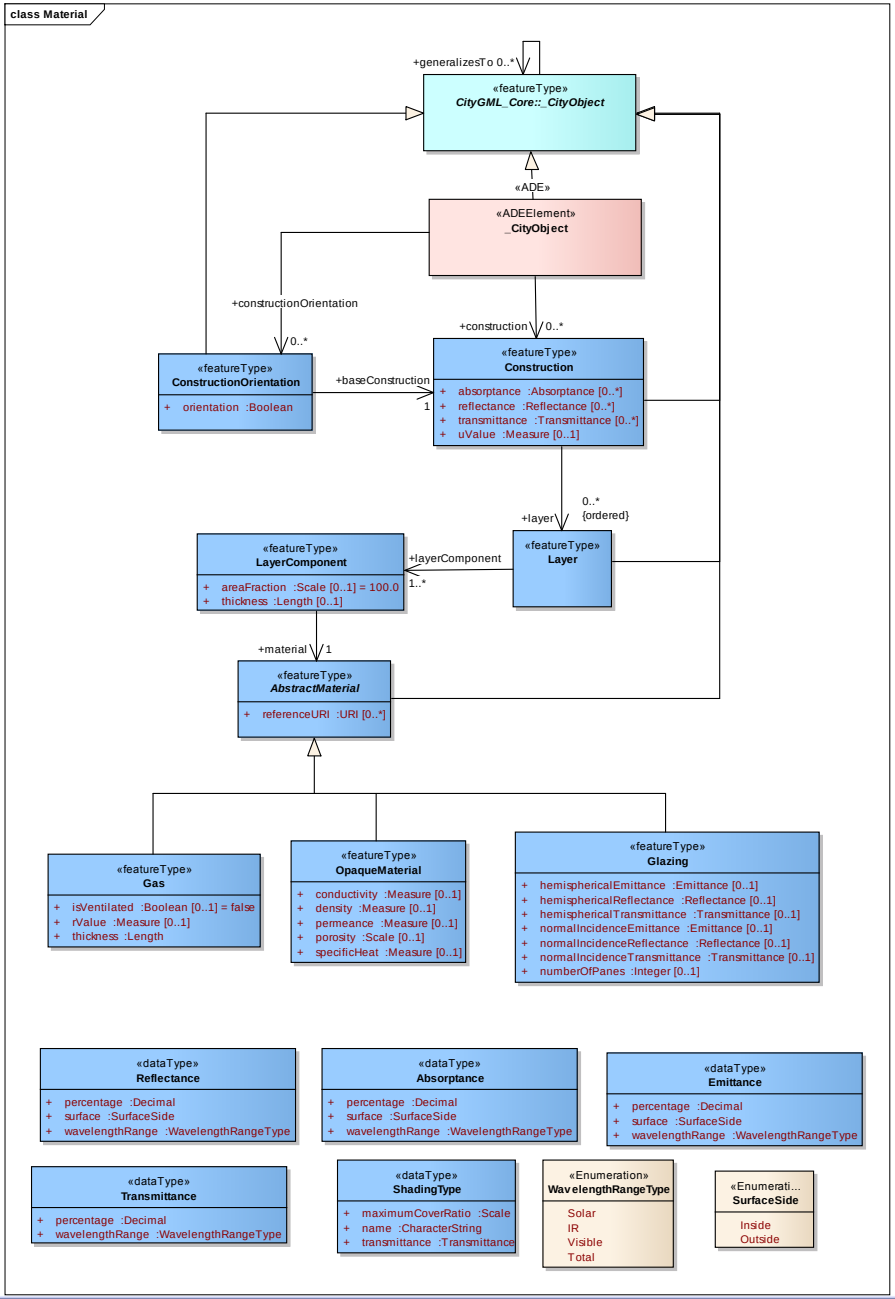
CityGML Energy ADE

- 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

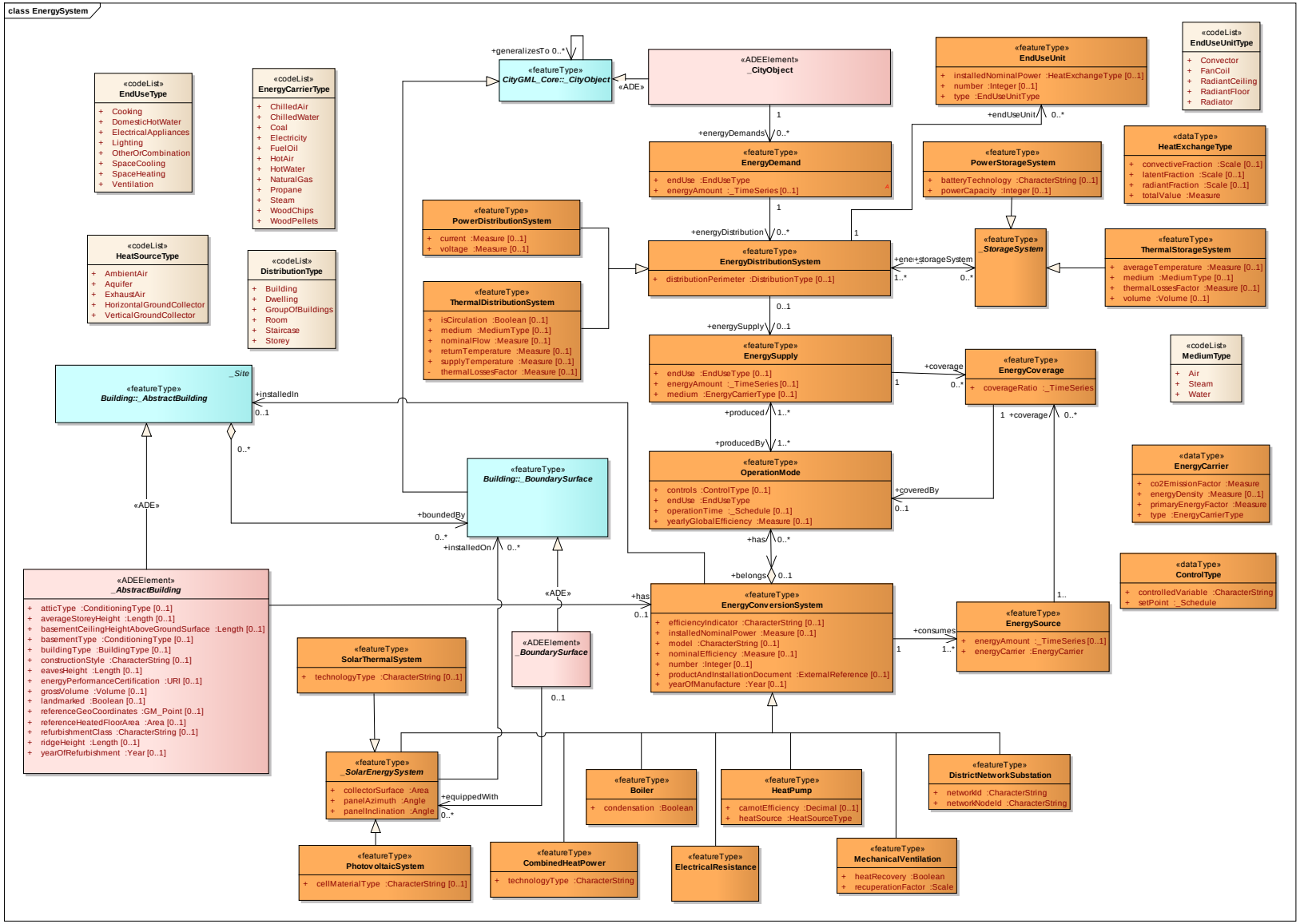
CityGML Energy ADE
Building physics



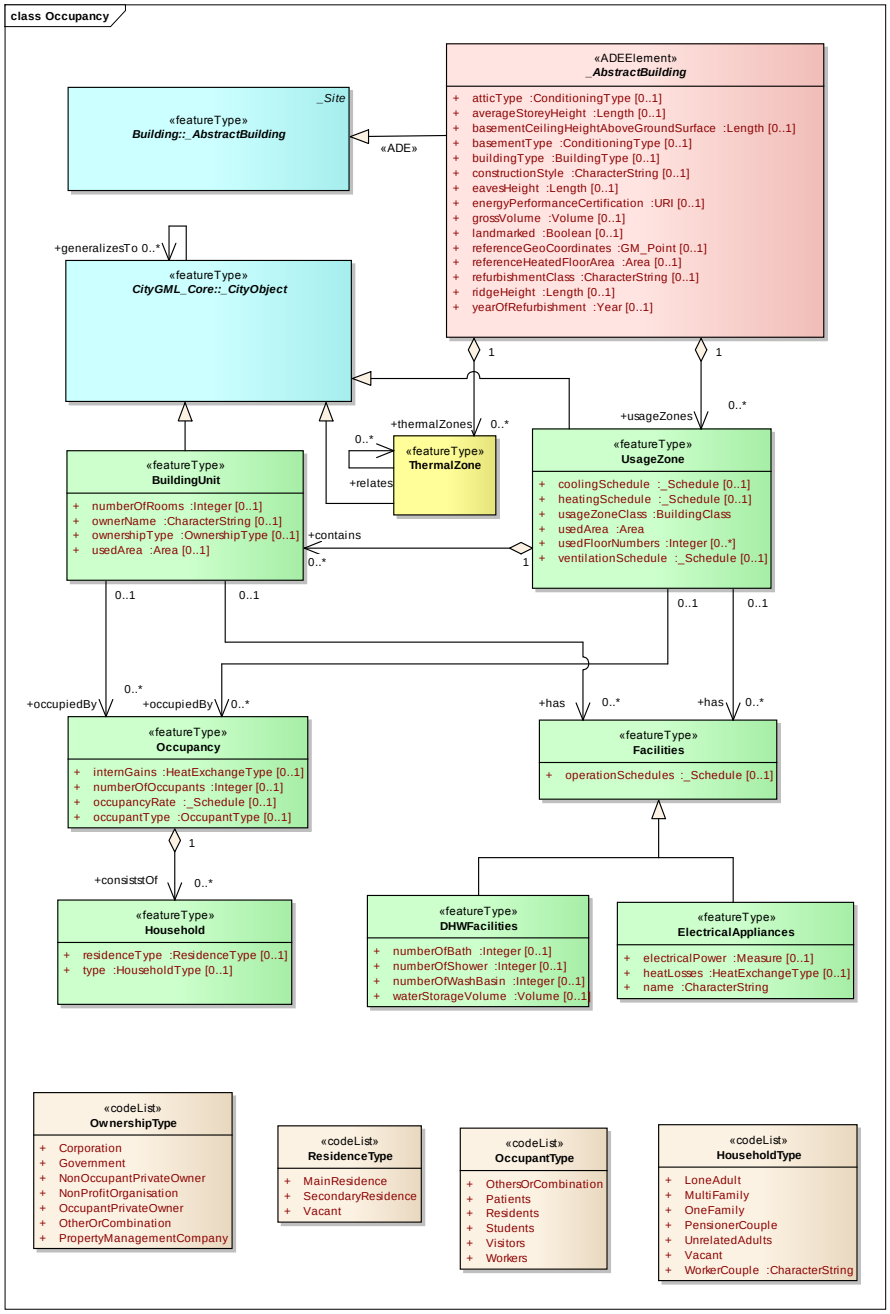
CityGML Energy ADE
Material



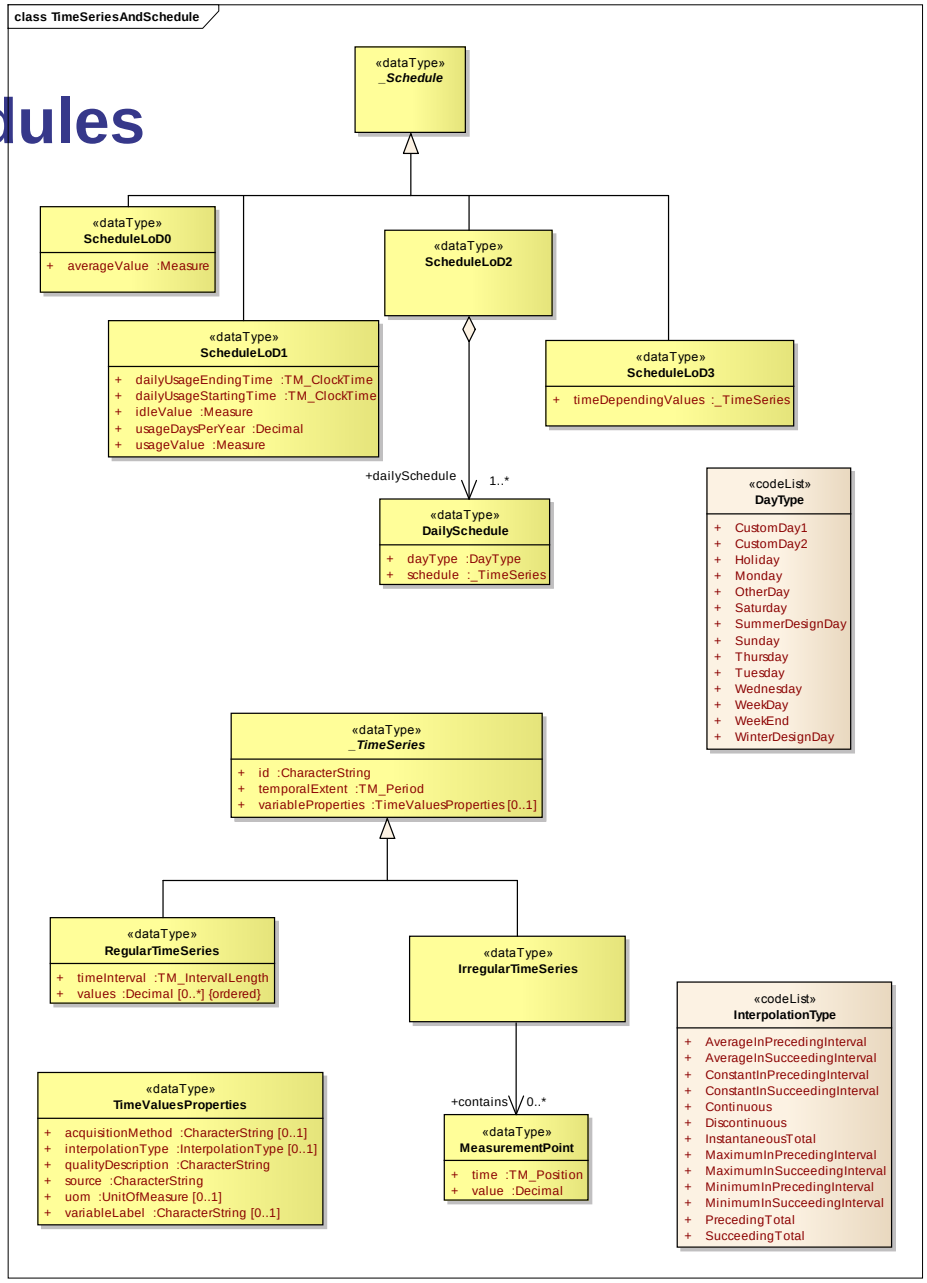
CityGML Energy ADE **Energy system**



CityGML Energy ADE
Occupants behaviour



CityGML Energy ADE
Time series and schedules



Further information

- Literature
  - **CityGML specification**: OpenGIS®City Geography Markup Language (CityGML) Encoding Standard, Version 2.0.0, OGC 08-007r2. https://portal.opengeospatial.org/files/?artifact_id=47842
- 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**: http://www.opengeospatial.org/standards/citygml
  - **CityGML Homepage**: www.citygml.org/
  - **CityGML Wiki**: http://www.citygmlwiki.org/index.php/Main_Page
- Free software
  - **FZKViewer**: http://www.iai.kit.edu/www-extern/index.php?id=2315&L=1
  - **tridicon CityDiscoverer Light**: http://www.tridicon.de/dowload/tridicon-citydiscoverer/?L=1
  - **3D City Database:** https://github.com/3dcitydb

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

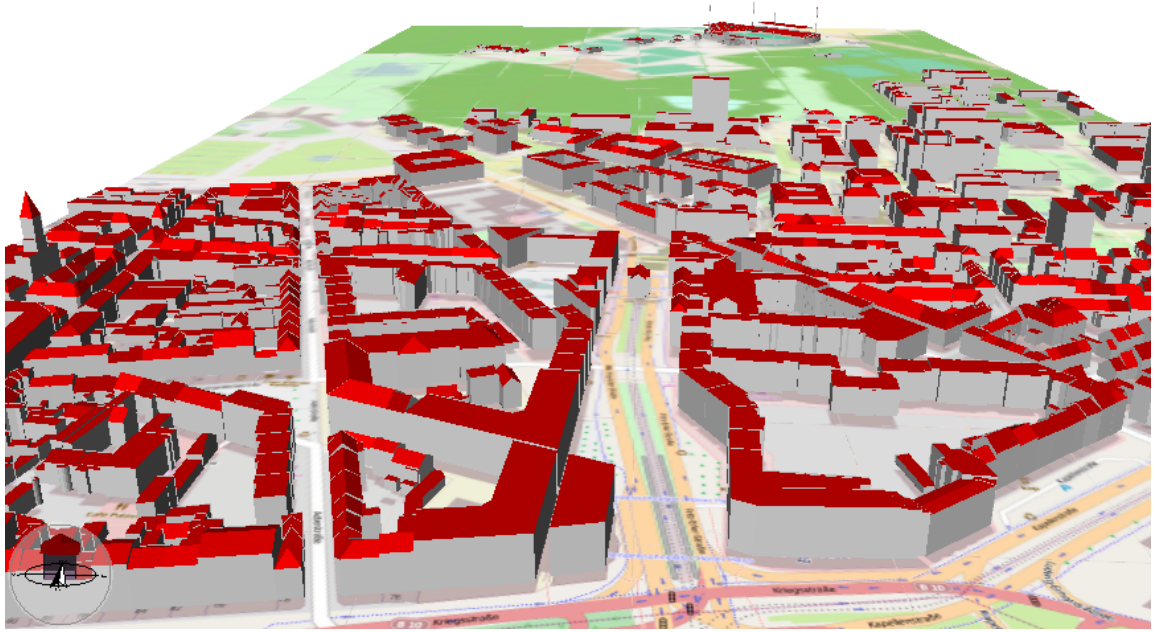
- 34 themes with relevance for environmental applications, divided into 3 blocks ("Annex I – Annex III")

- Coordinate reference systems
- Geographical grid systems
- Geographical names
- Administrative units
- Addresses
- Cadastral parcels
- Transport networks
- Hydrography
- Protected sites

- Elevation
- Land cover
- Orthoimagery
- Geology

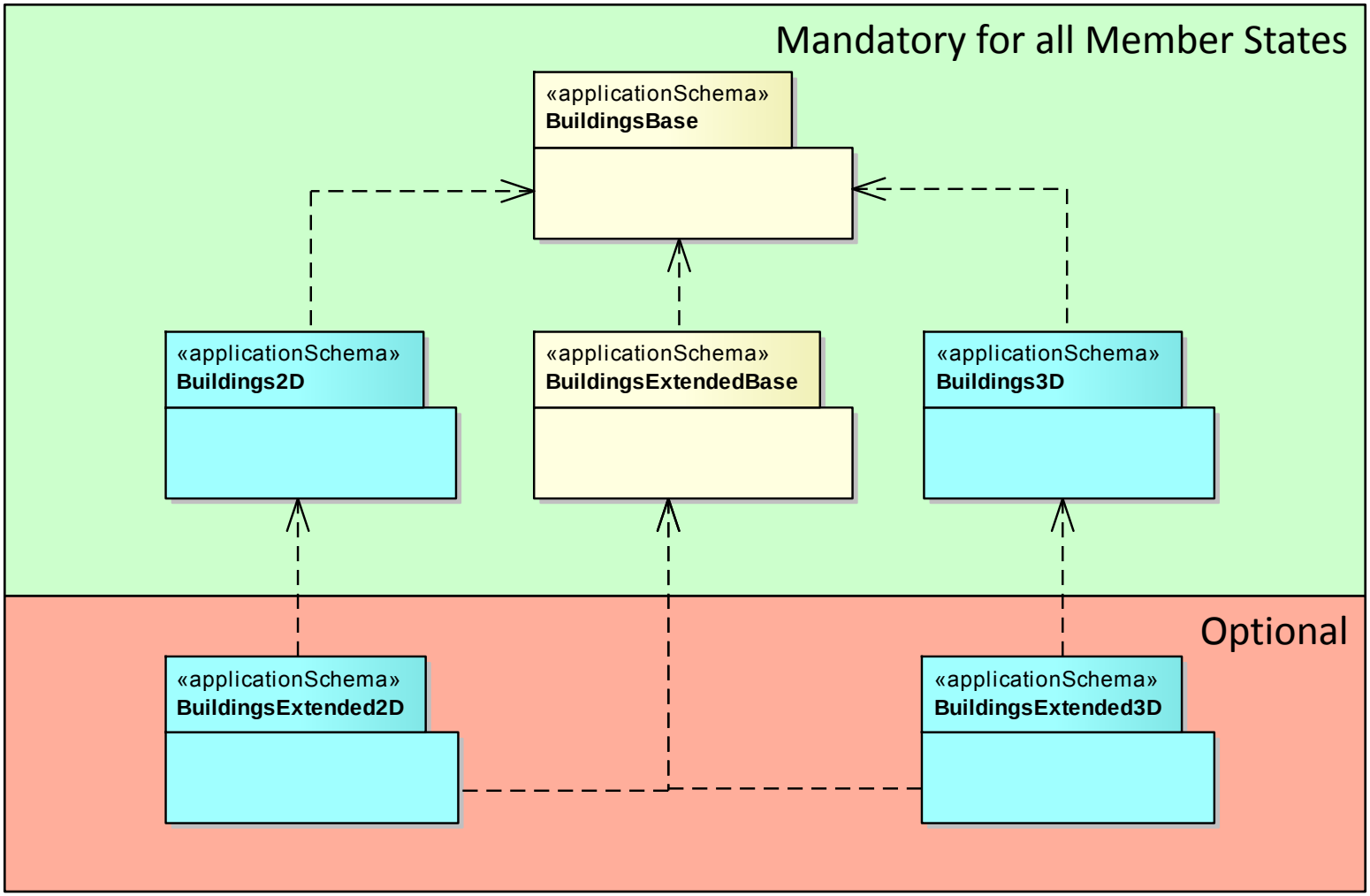
- Statistical units
- Buildings
- Soil
- Land use
- Human health and safety
- Utility and governmental services
- Environmental monitoring Facilities
- Production and industrial facilities
- Agricultural and aquaculture facilities
- Population distribution and demography
- Area management / restriction / 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

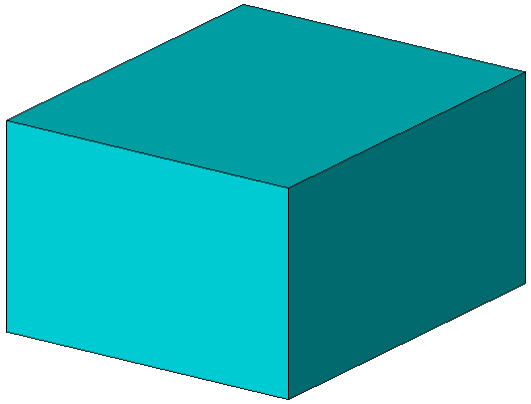
INSPIRE Building – Structure



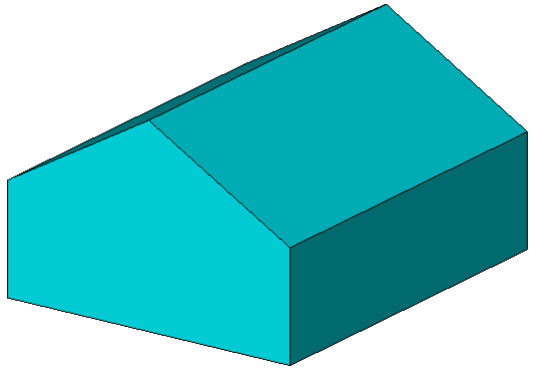
INSPIRE Building – Core Profile

- 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

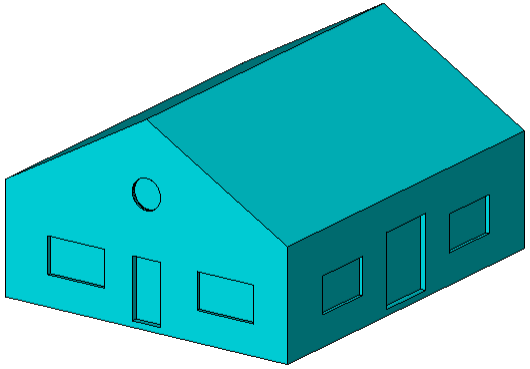
INSPIRE Building Core 3D – Examples



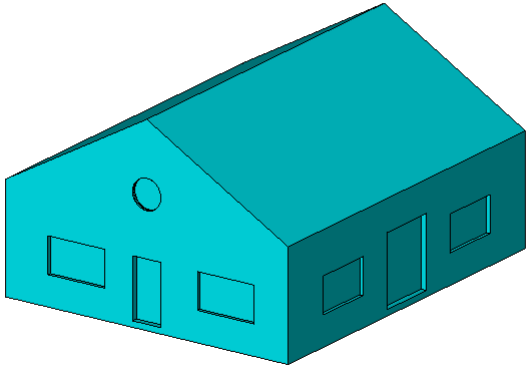
LOD 1



LOD 2



LOD 3

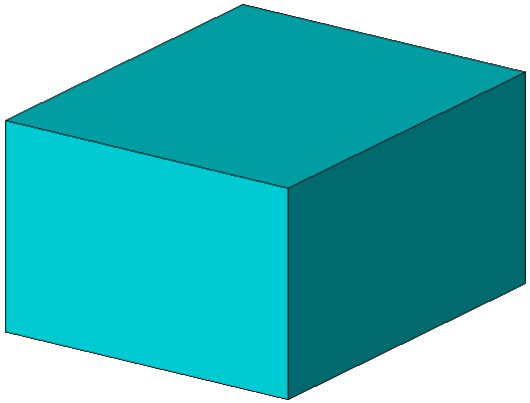


LOD 4

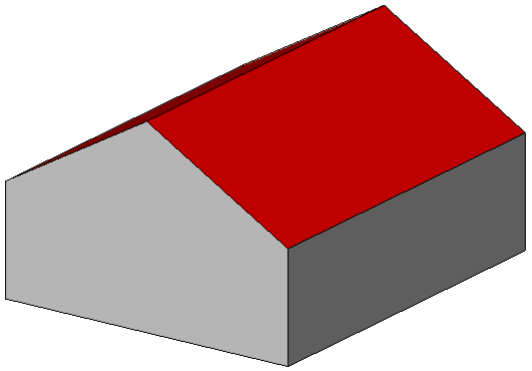
INSPIRE Building – Extended Profile

- 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

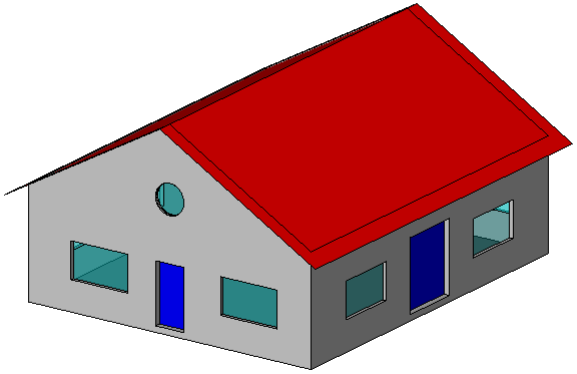
INSPIRE Building Extended3D – Examples



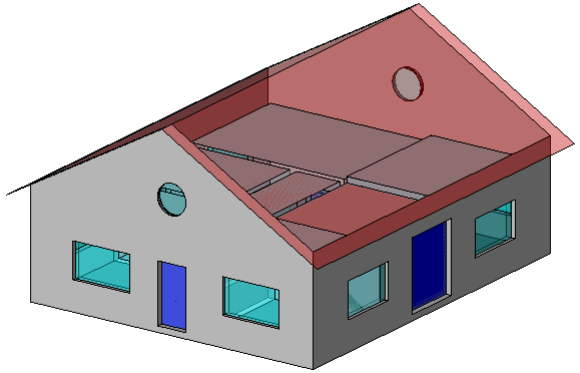
LOD 1



LOD 2



LOD 3



LOD 4

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**: http://inspire.ec.europa.eu/index.cfm
- Free software
  - Free software supporting the INSPIRE Building model is not yet available

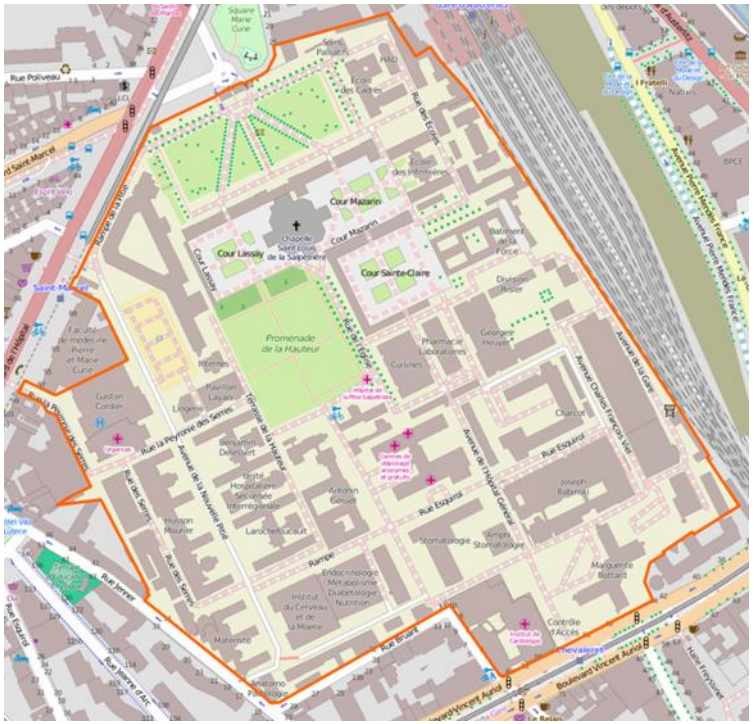
OpenStreetMap – OSM

- 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.

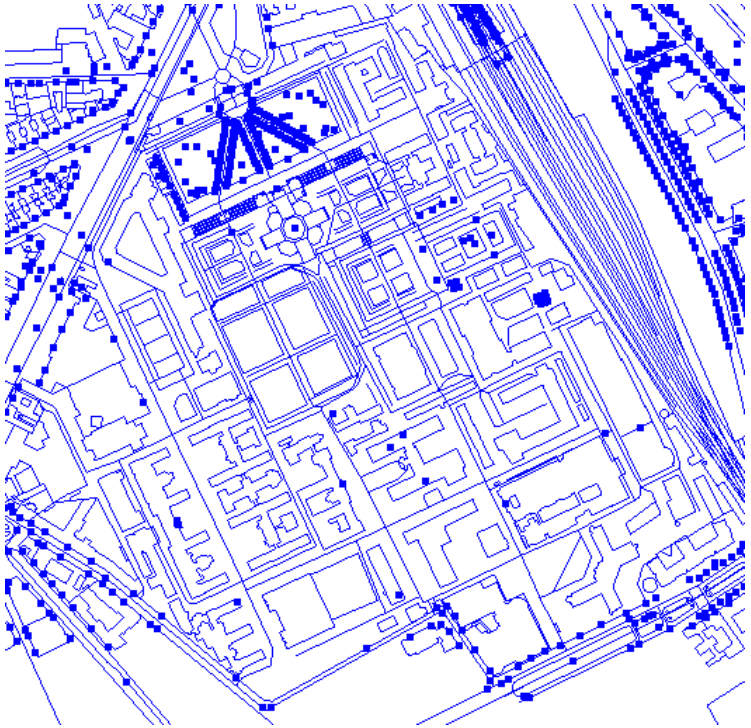
OSM – Elements, Attributes

- 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 multi-polygons
  - tags
    - Consists of key-value pairs to describe specific features

OSM - Example



Map



Feature data

OSM data of the healthcare district „Pitié Salpêtrière“, Paris

Further information

- Examples
  - http://openlayers.org/en/v3.2.1/examples/
- Web resources
  - https://www.openstreetmap.org/
  - http://wiki.openstreetmap.org/wiki/Main_Page
- Free software
  - http://wiki.openstreetmap.org/wiki/Software

WEB SERVICES

TARGET GROUP: UNIVERSITY STUDENTS

Streamer
European research on energy-efficient healthcare districts

Web Services

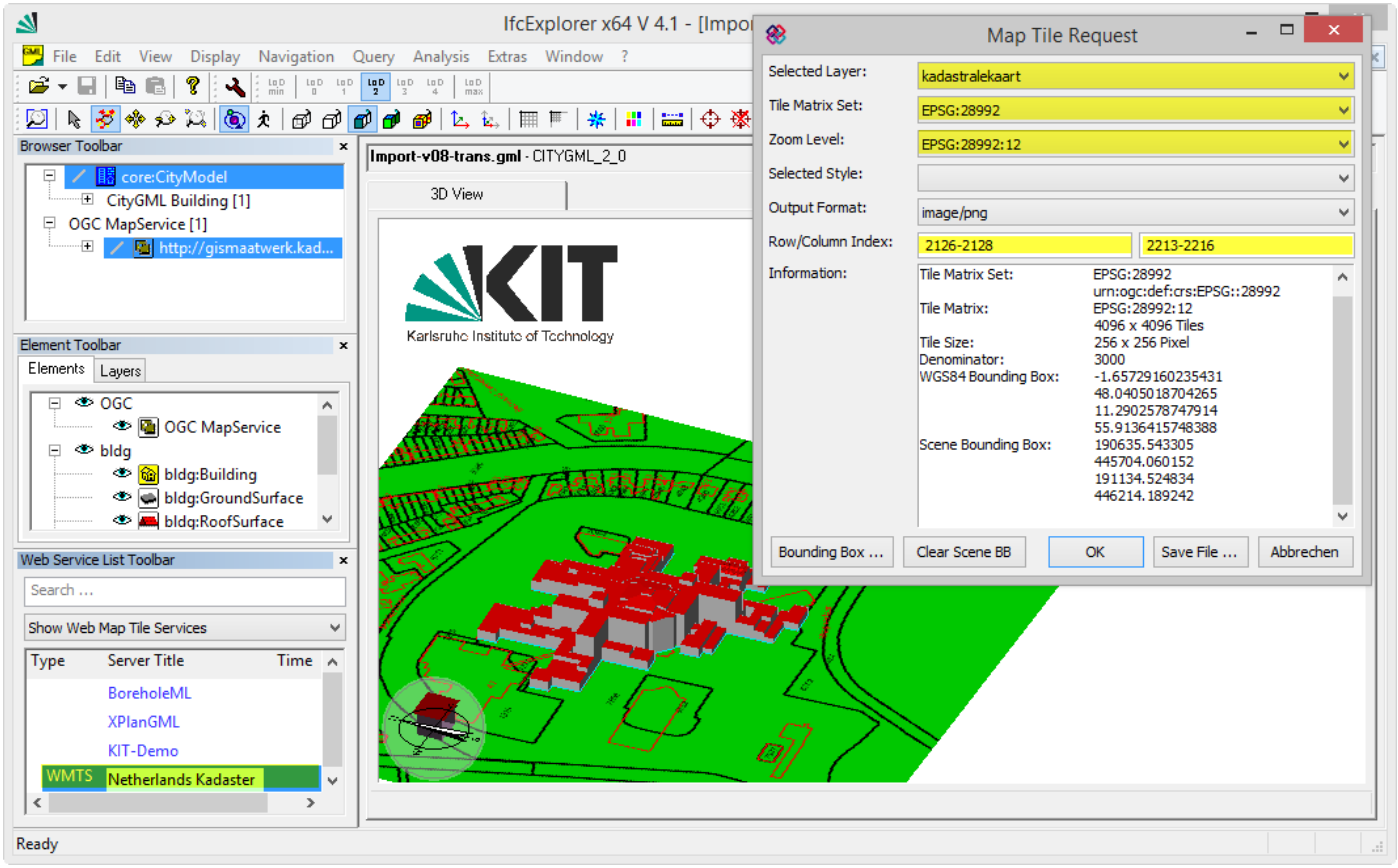
- OGC* Web Map Service – WMS
- OGC* Web Feature Service – WFS
- buildingSmart BIM Server Information Exchange - BIMsie

* 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

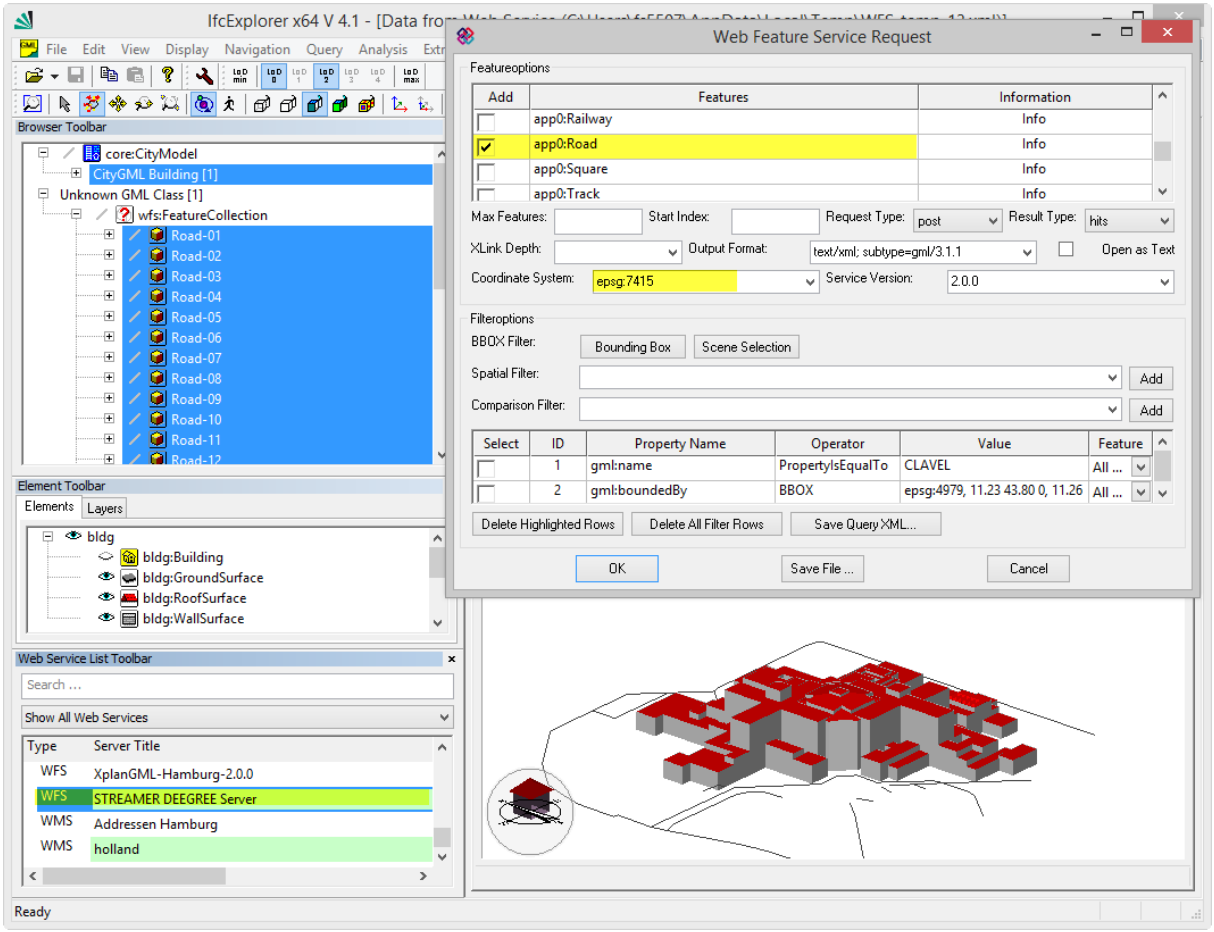


The building model (Rijnstate Hospital, Arnhem) is loaded from local disk, while the map (12 tiles) is added via WMS from a Dutch map server for cadastral data.

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



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

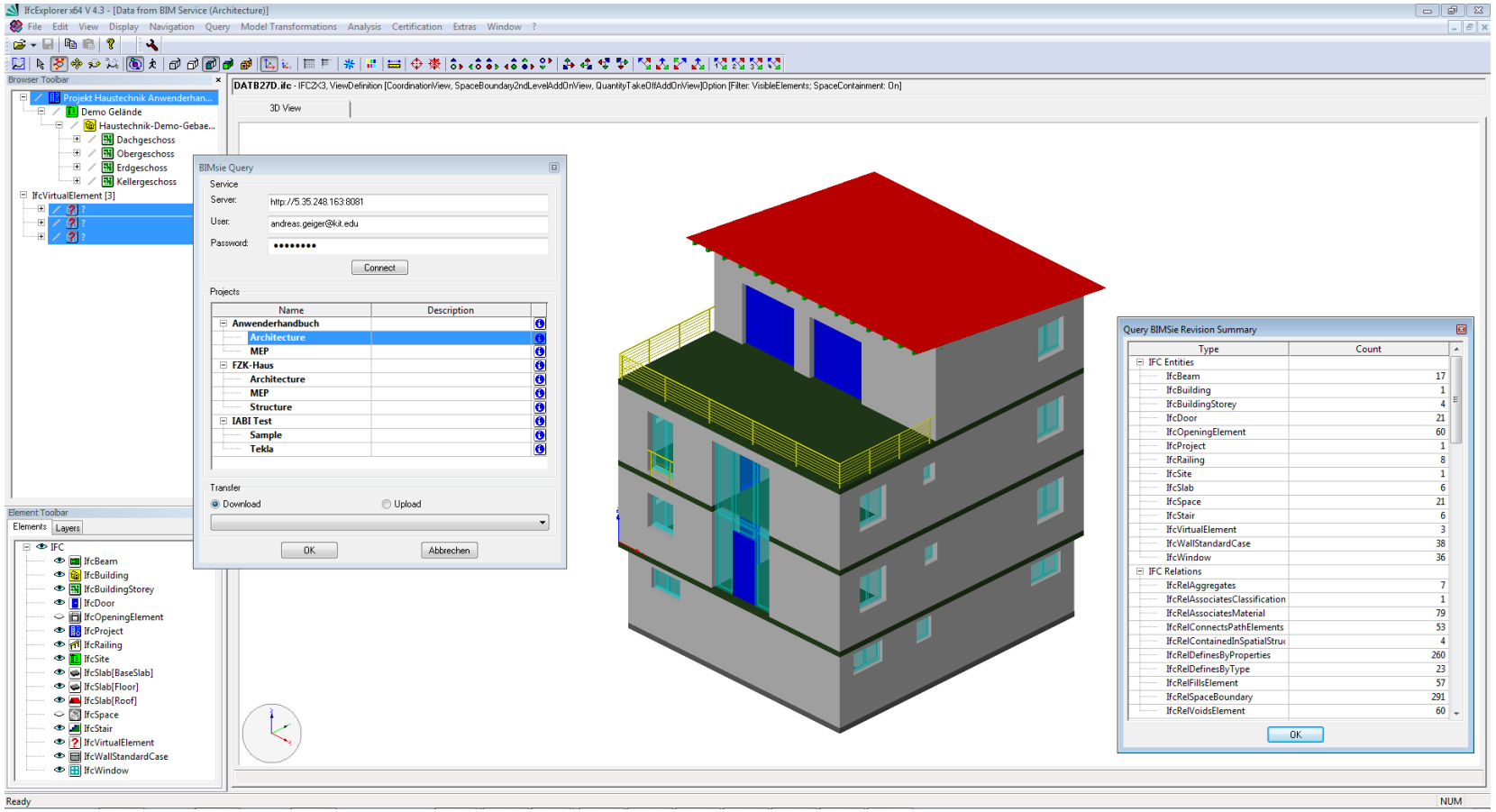
buildingSmart BIM Server Information Exchange - BIMsie

- 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



Data downloaded from a BIMserver using the BIMsie interface

Further information

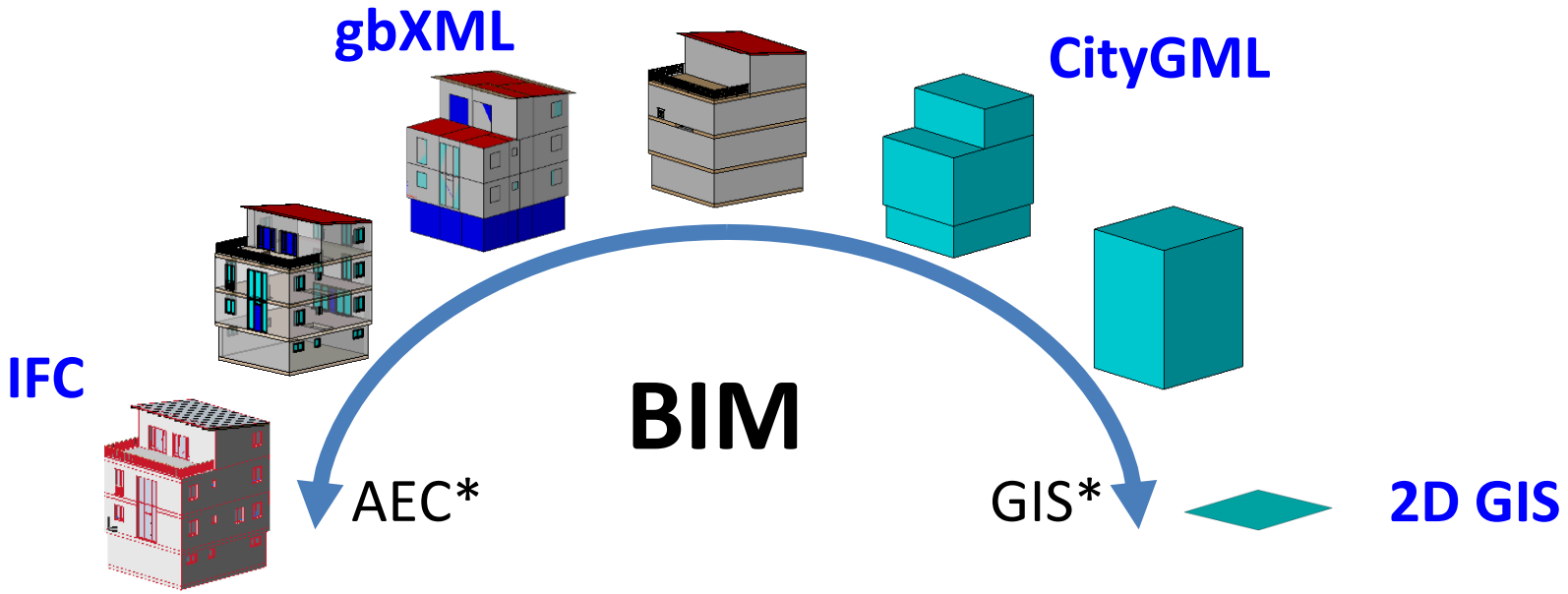
- Web resources
  - BIMSie - https://github.com/BuildingSMART/BIMSie
  - BIMSie-API - https://buildingsmart.github.io/BIMSie/
- Free software
  - BIMserver - http://bimserver.org/

SUMMARY

TARGET GROUP: UNIVERSITY STUDENTS

Streamer
European research on energy-efficient healthcare districts

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

Streamer
European research on energy-efficient healthcare districts

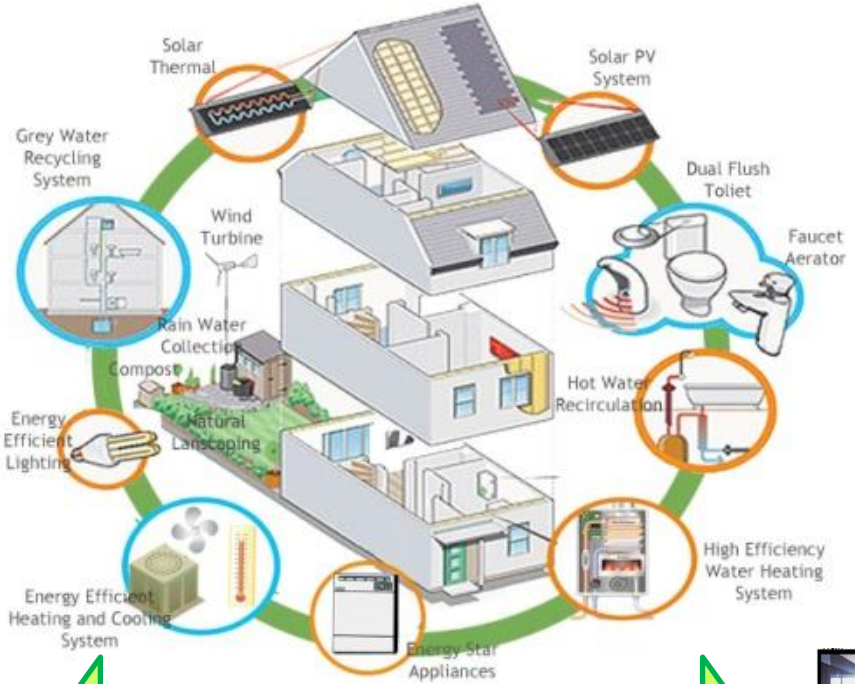
BIM FOR ENERGY-EFFICIENT NEIGHBOURHOODS

- 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



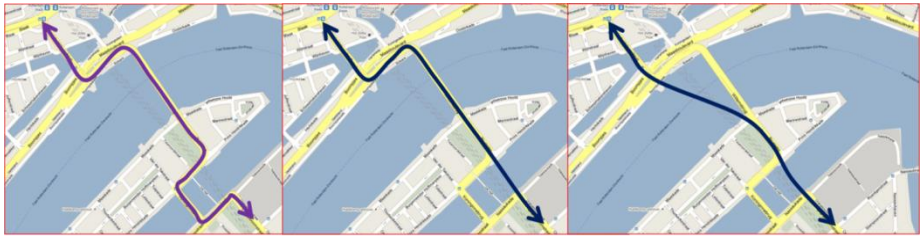
Collective home owners

BIM enabled e-Marketplace

BIM FOR LOW-DISTURBANCE URBAN PROJECTS

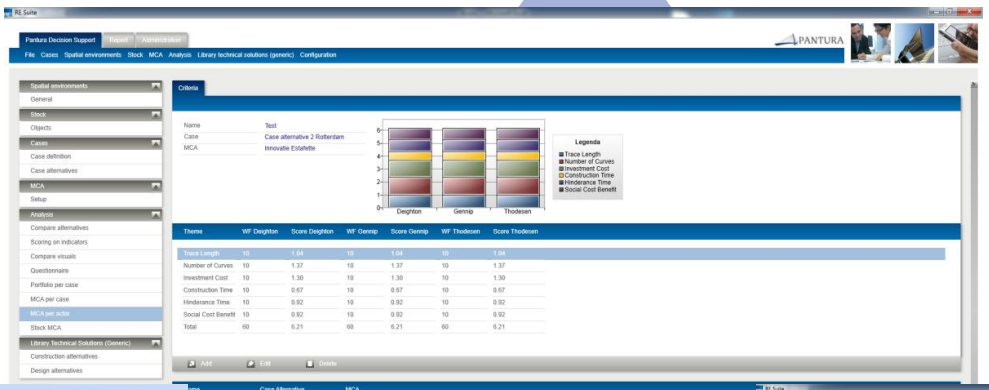
- Overall research goal

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

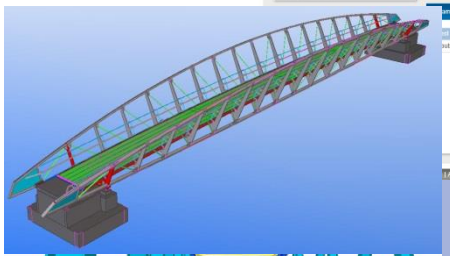


BIM FOR LOW-DISTURBANCE URBAN PROJECTS

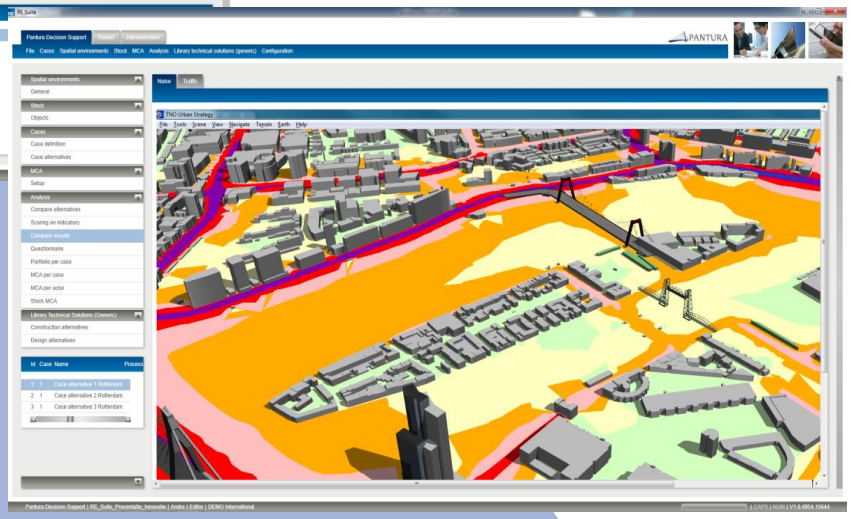
- Key achievement



Multi-actor & multi-criteria decision-support tool



Bridge engineering in BIM



Urban impacts in 3D GIS

BIM FOR SELF-INSTRUCTION & SELF-INSPECTION

- Overall research goal

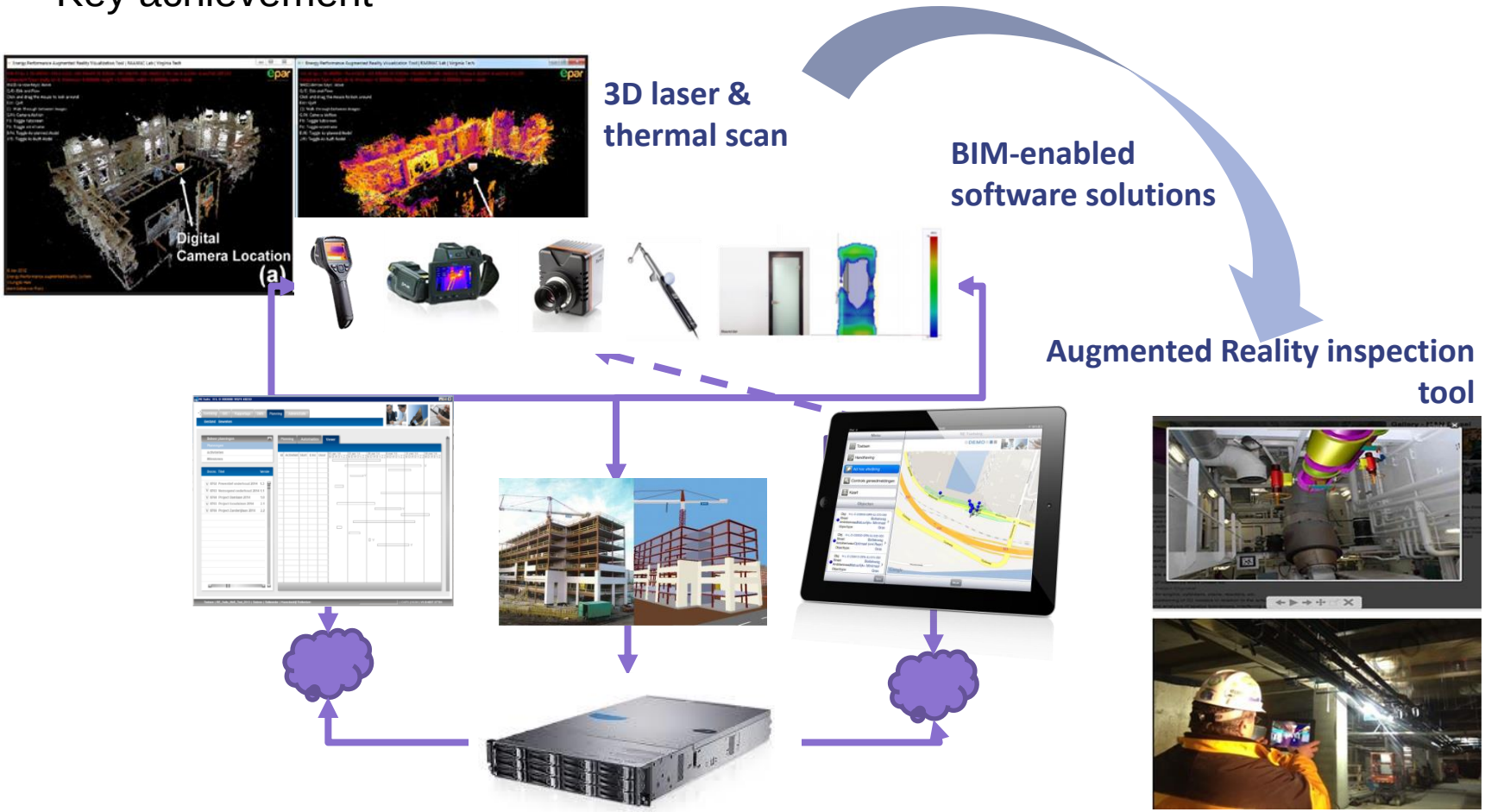
INSITER INTUITIVE SELF-INSPECTION TECHNIQUES

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION HORIZON 2020

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

BIM FOR SELF-INSTRUCTION & SELF-INSPECTION

- Key achievement



BIM FOR 3D TIME-DYNAMIC CULTURAL HERITAGE

- Overall research goal

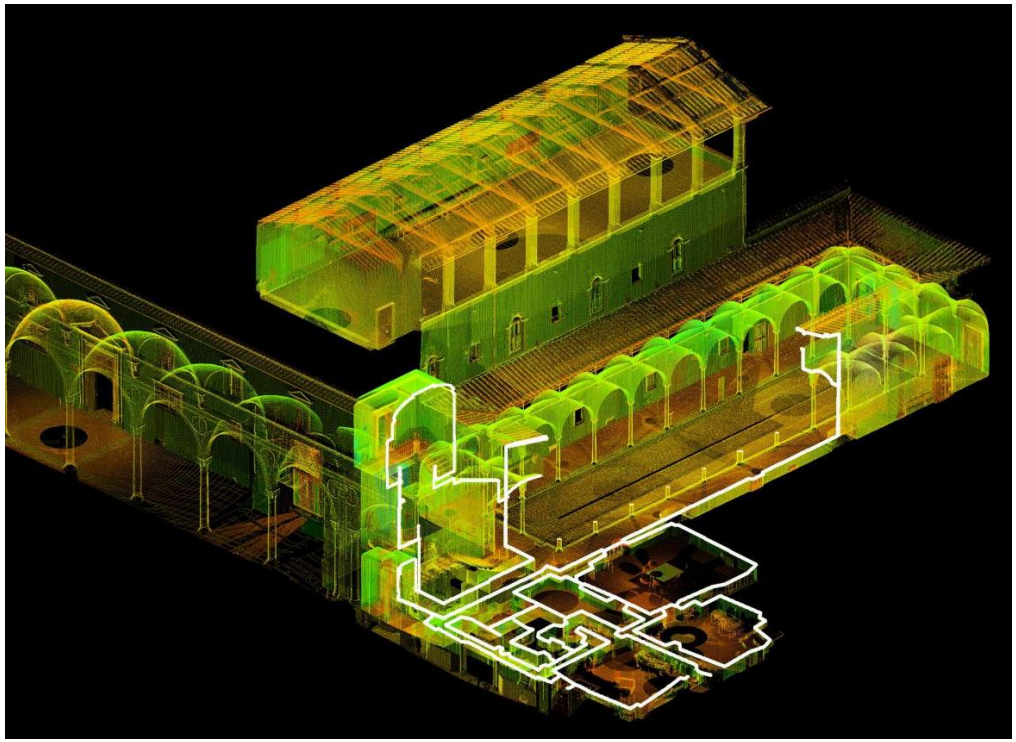
INCEPTION
Inclusive Cultural Heritage in Europe through 3D semantic modelling

HORIZON 2020
THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

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

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

Streamer
European research on energy-efficient healthcare districts

EVIDENCE-BASED DESIGN

TARGET GROUP: HOSPITAL COMMUNITIES

Streamer
European research on energy-efficient healthcare districts

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.*

p.231

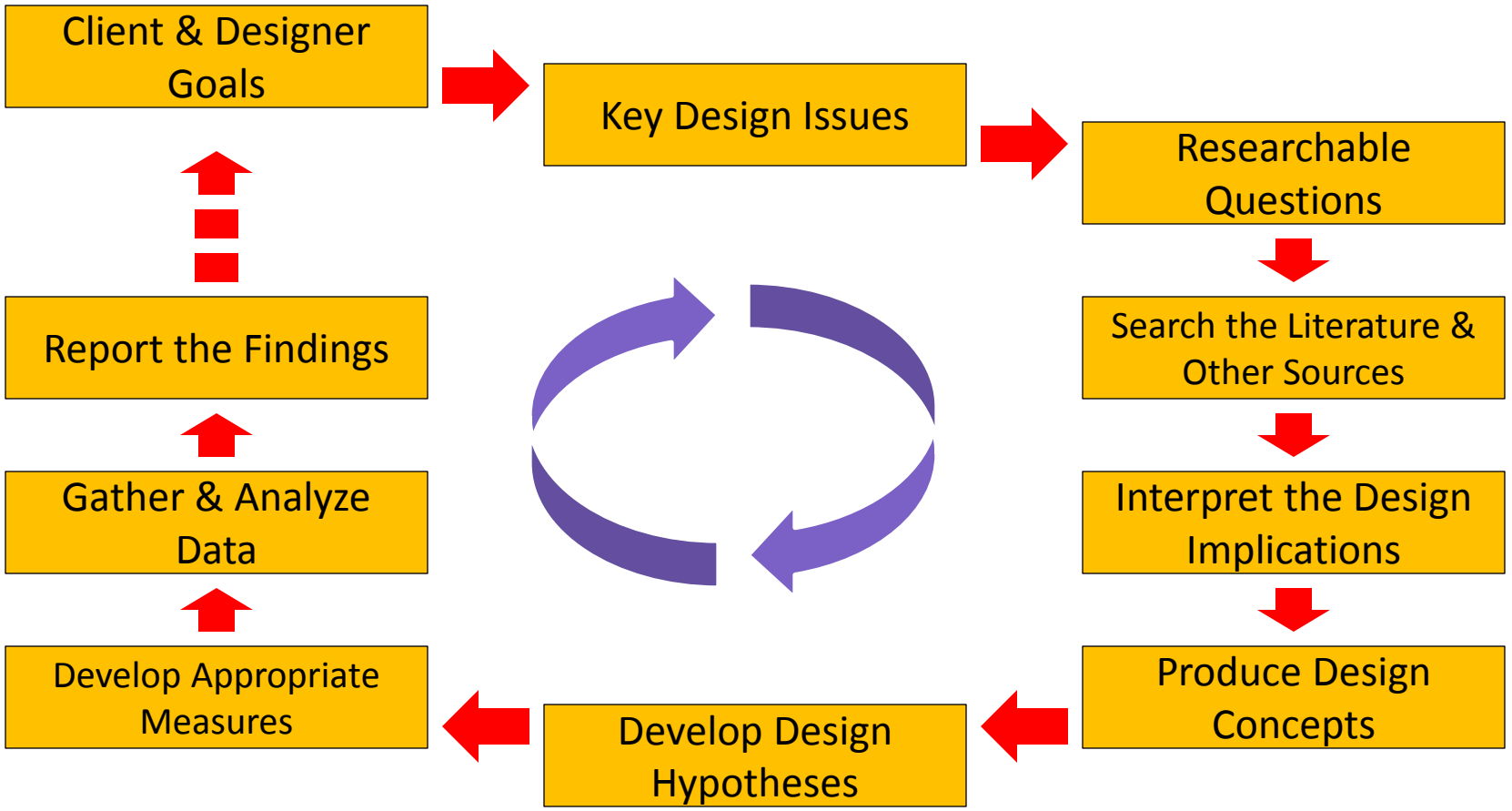
Pronovost (2010)

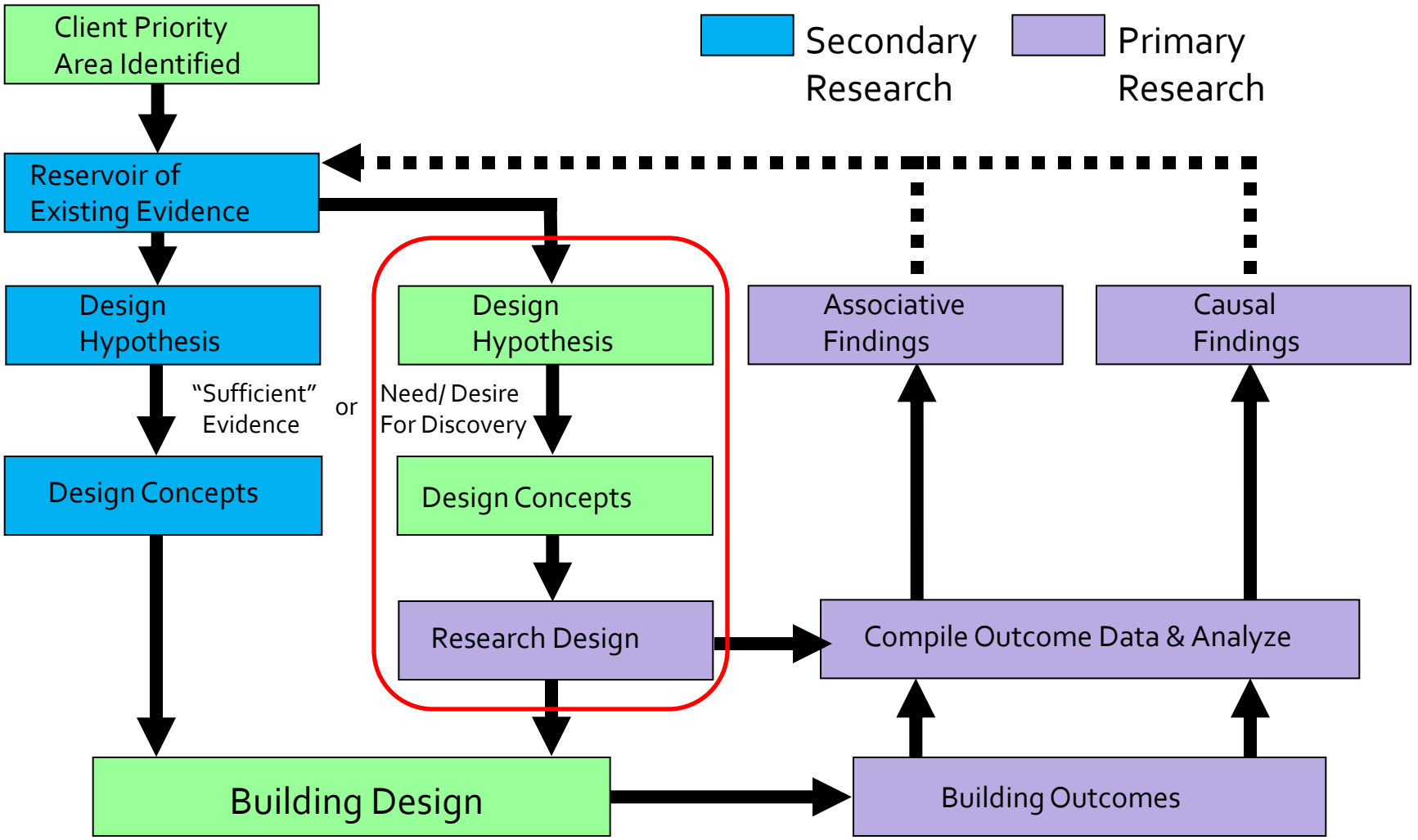
Proven Healing Environment Outcomes & Top Research Priorities*:

- 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);
- **enhanced operational efficiency and productivity*;**
- 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





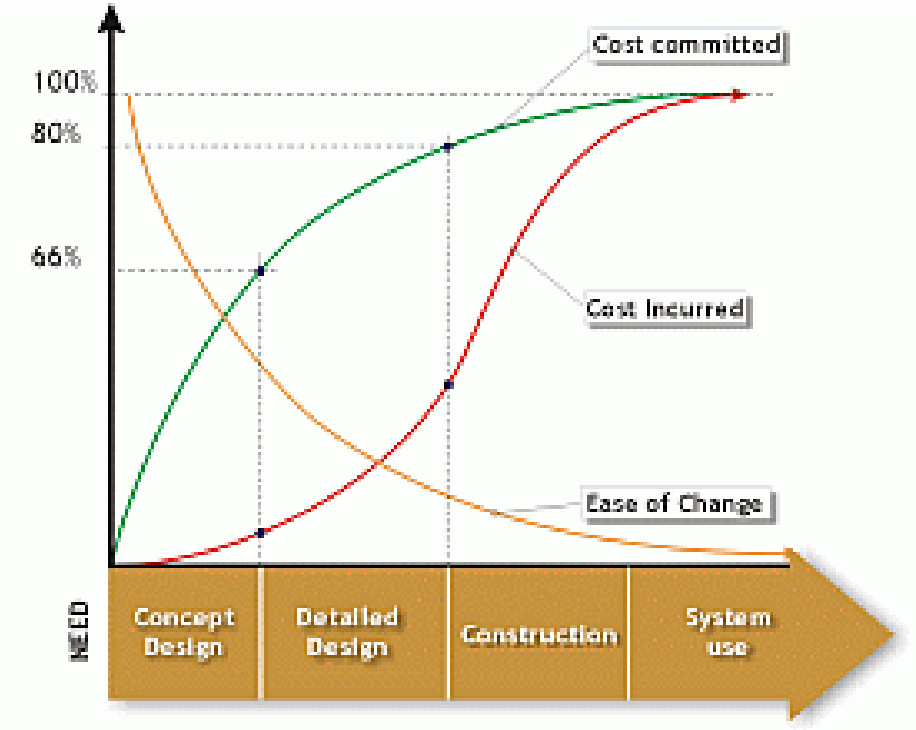
	TASK	ACTIVITY
1	**Identify the client's goals**	Note most important and facility-related global and project-based goals
2	**Identify firm's goals**	Understand firm's strategic, project, and evidence-based design objectives
3	**Identify the top 1-3 key design issues**	Narrow the possible choices; work on high impact decisions
4	**Convert design issues to research questions**	Reframe statement of design issues to become research topics
5	**Gather information** • *Benchmark examples* • *Literature sources* • *Firm's studies & data*	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

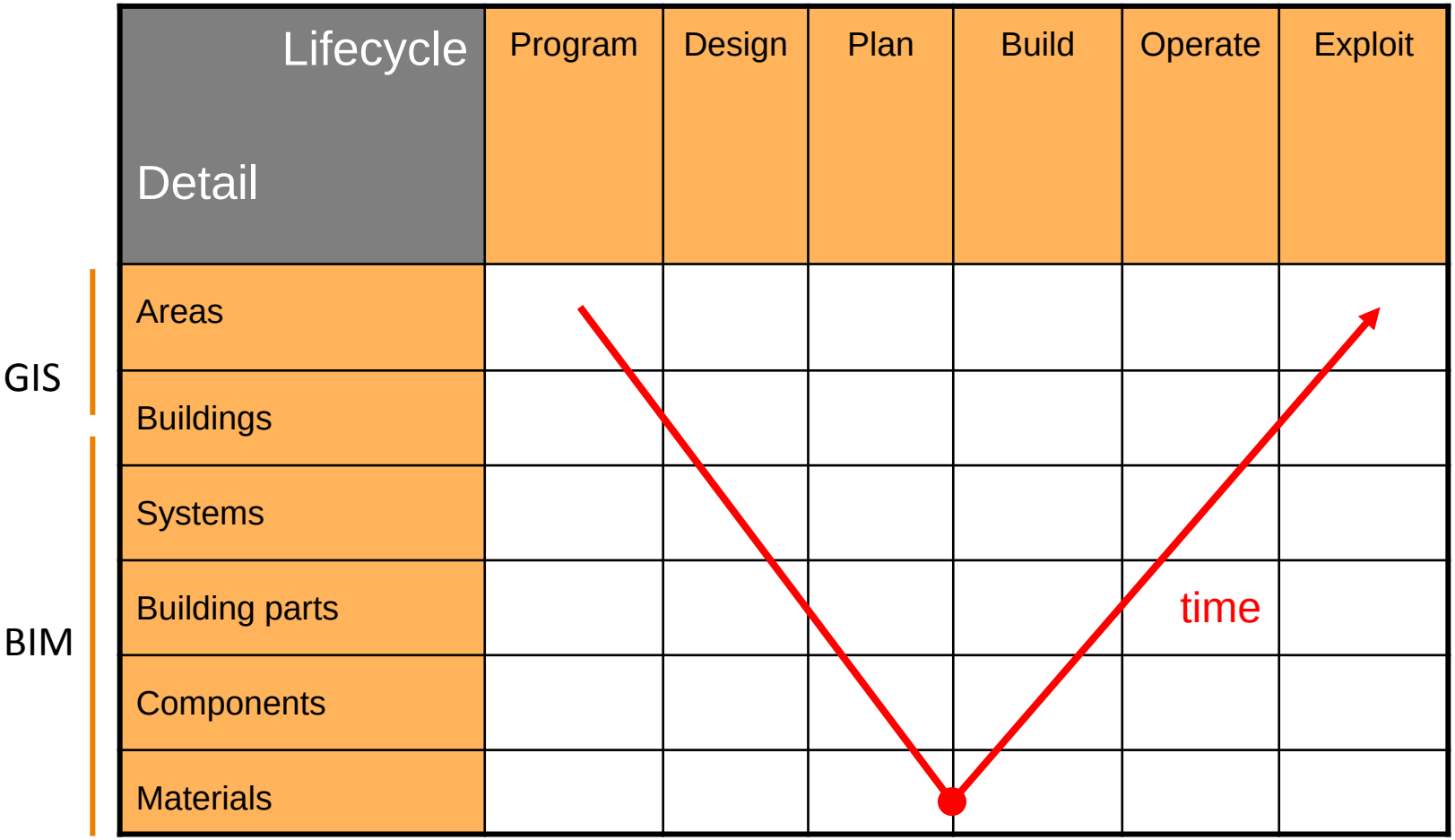
- From ideas & sketches to building blocks (concept design)
- Form building blocks into departmental layouts/floor plans
- From floor plans to detailed designs

Adding detail and information as the design progresses

Iterative process, capturing & storing information (enriching)



BIM approach (top down & bottom up)

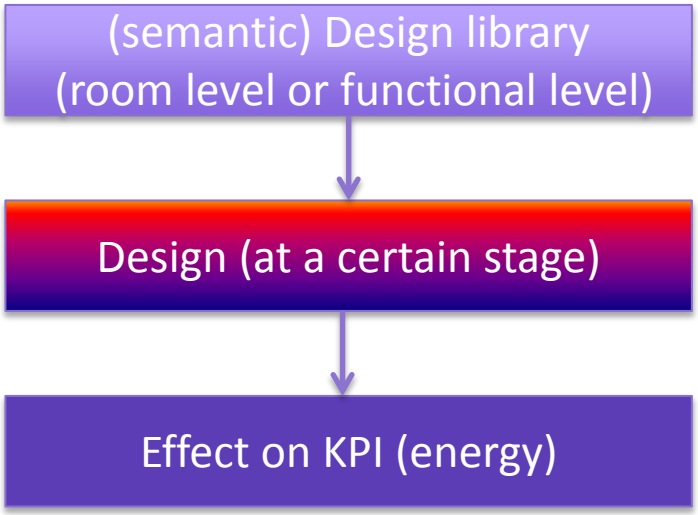


In an ideal world…..

This project delivers an open

To aid designers in making a

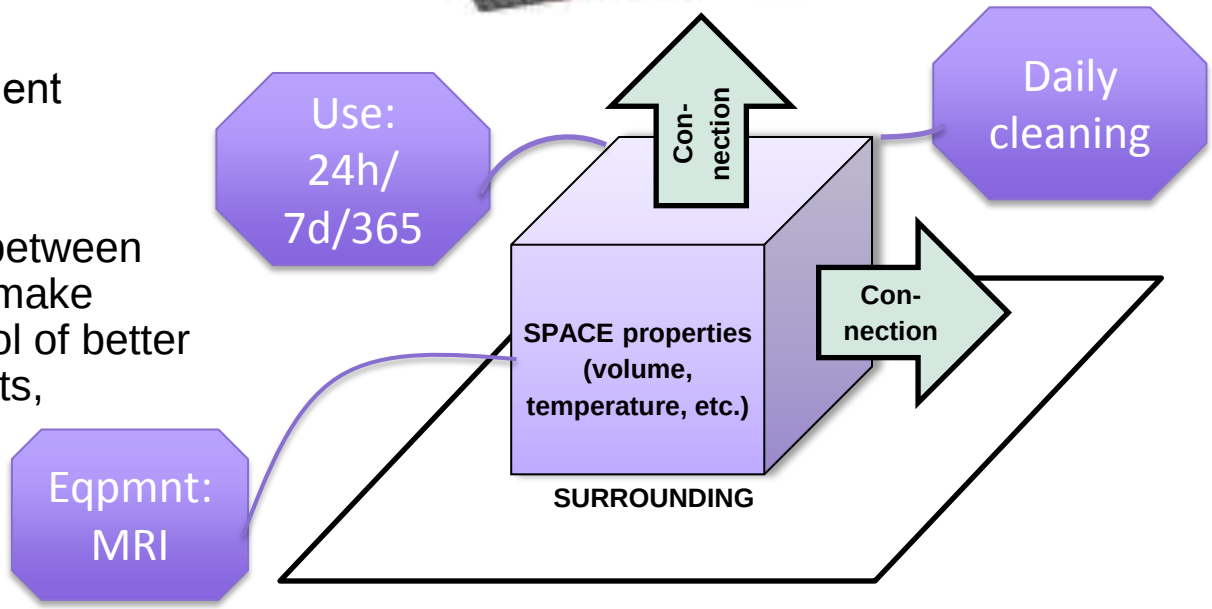
And showing the



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)



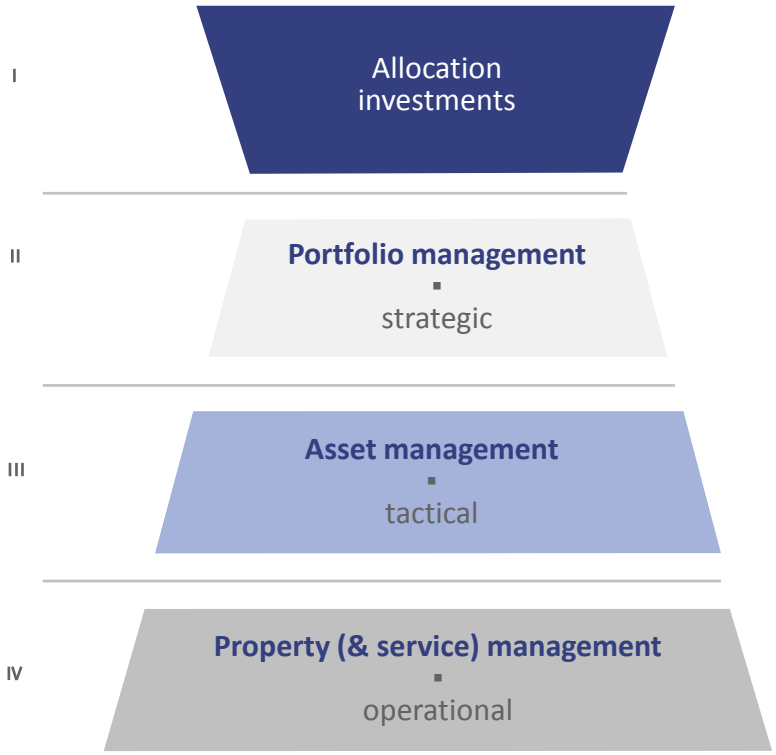
DESIGN DECISION-SUPPORT SYSTEM

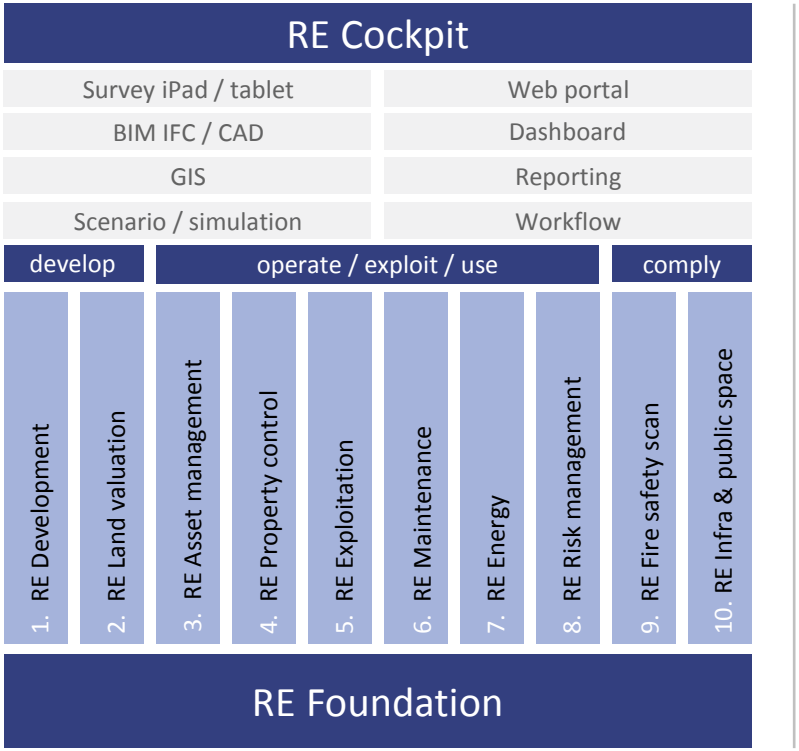
TARGET GROUP: HOSPITAL COMMUNITIES

Streamer
European research on energy-efficient healthcare districts

Real estate information management

Real **E**state + **I**nformation **M**anagement





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?

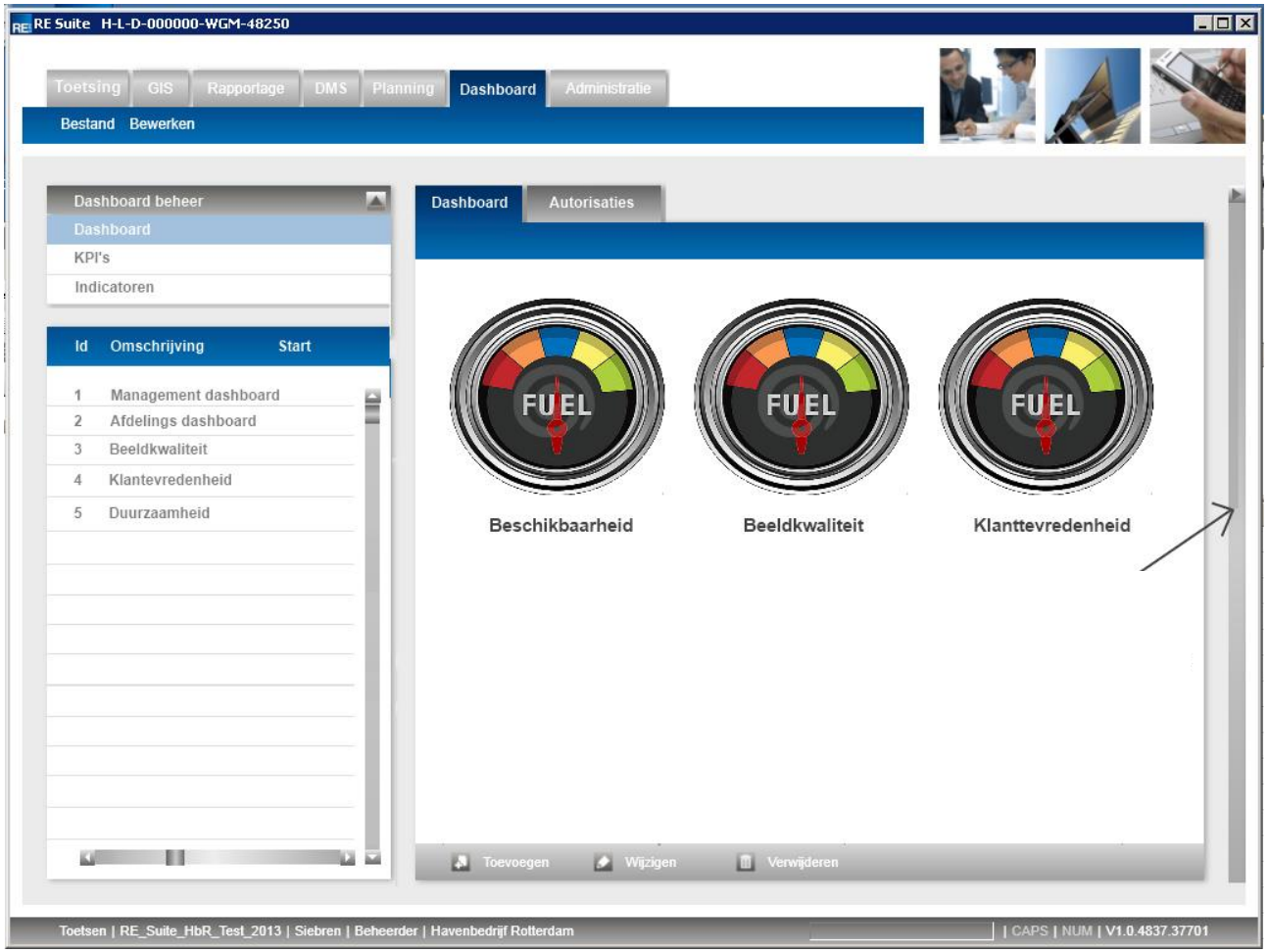
- Cost saving
- Resolving the lack of insight
- Ensure adequate understanding of the actual situation
- Gaining time for analysis
- Gaining insight in the analysis results for making correct assessments and decisions

How to come to a solution?

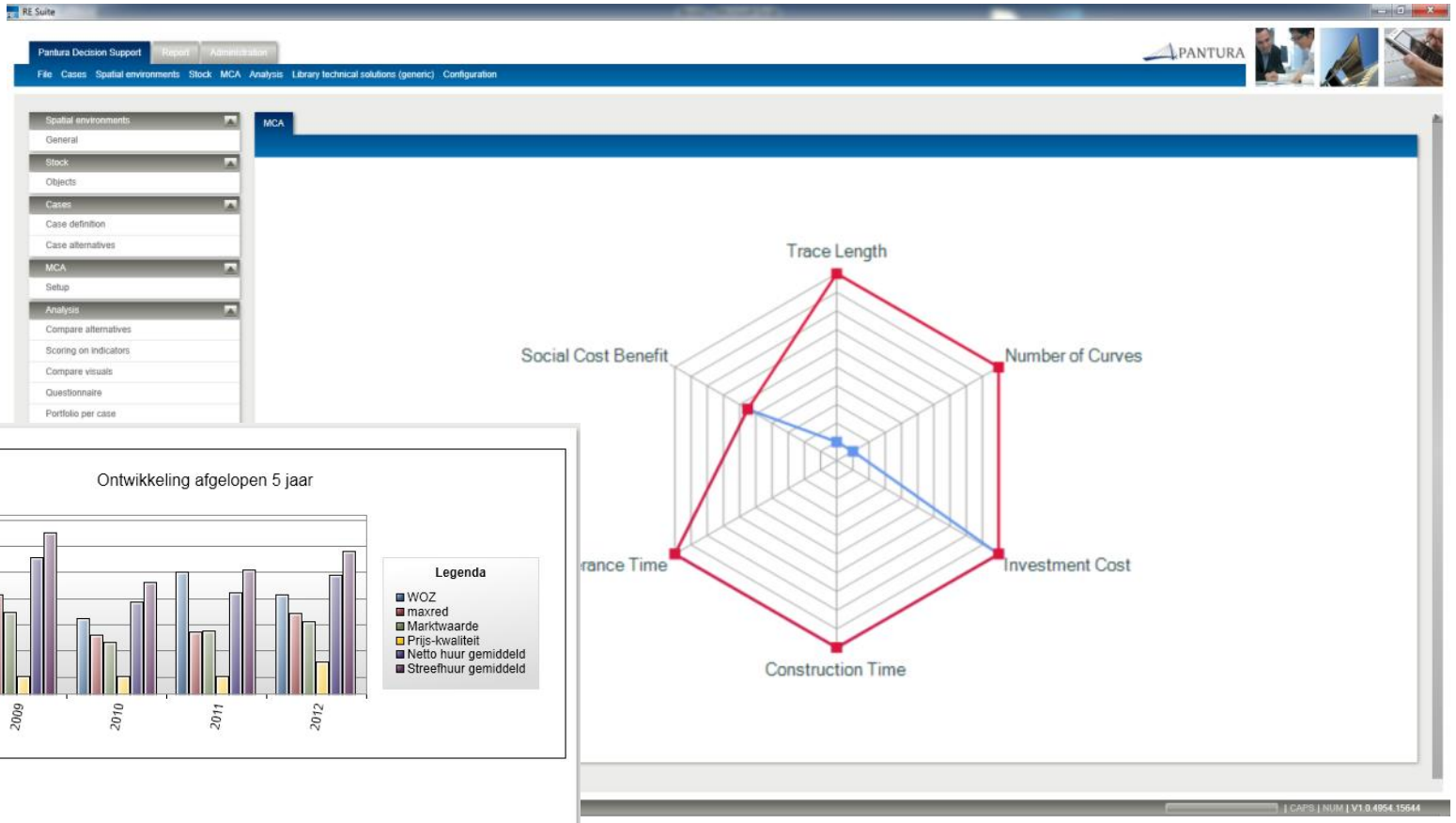
- Reasoning based on the existing information systems
- Gradual transition towards new systems
- Making use of existing data
- Enriching the existing data
- Transforming these data into relevant information
- Ensuring the sustainability of data
- Retaining the support within your organisation

- Thus, data evolution instead of data revolution

Software application to display Key Performance Indicators

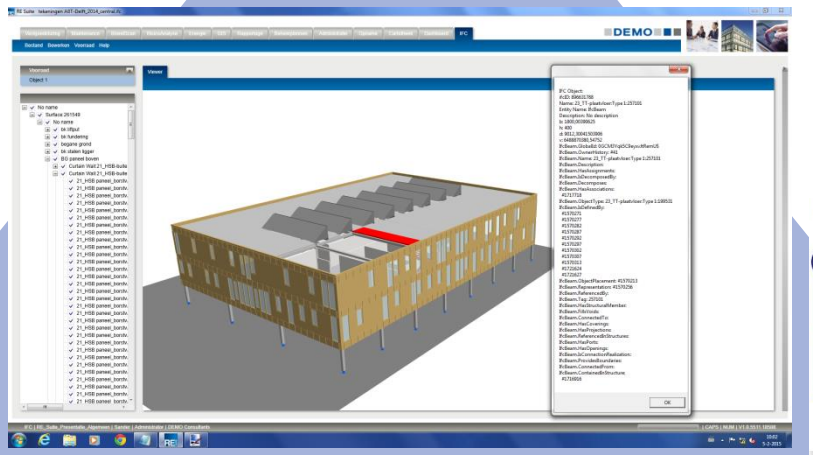


Software application to display Key Performance Indicators



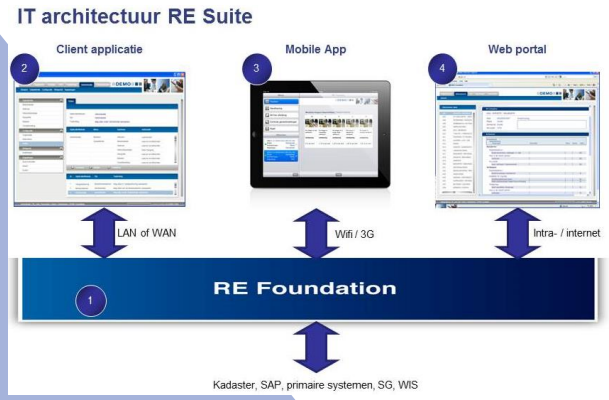
Integrating software applications for building and energy management

Building control system



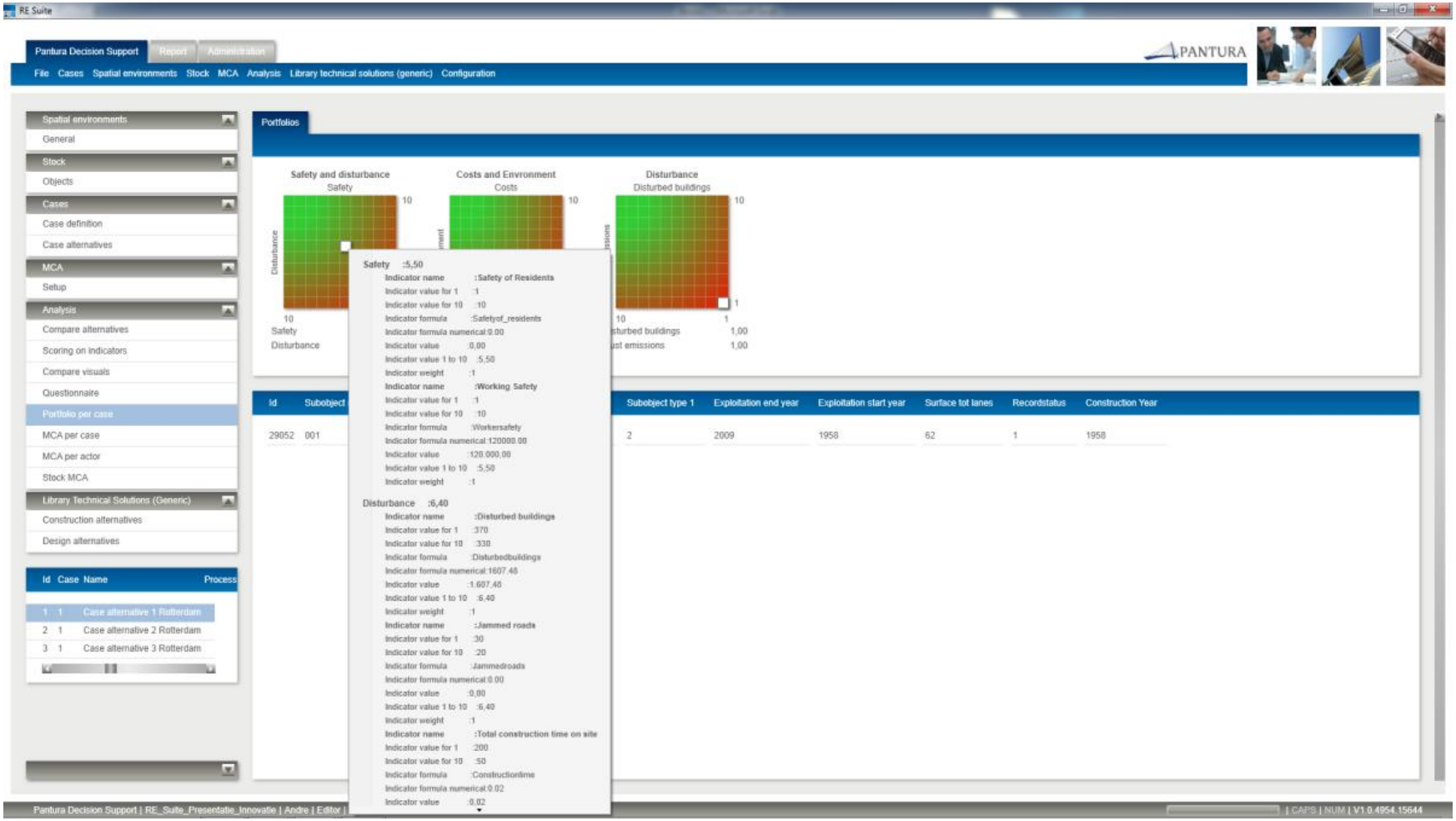
Office building in BIM IFC open standard

Energy monitoring

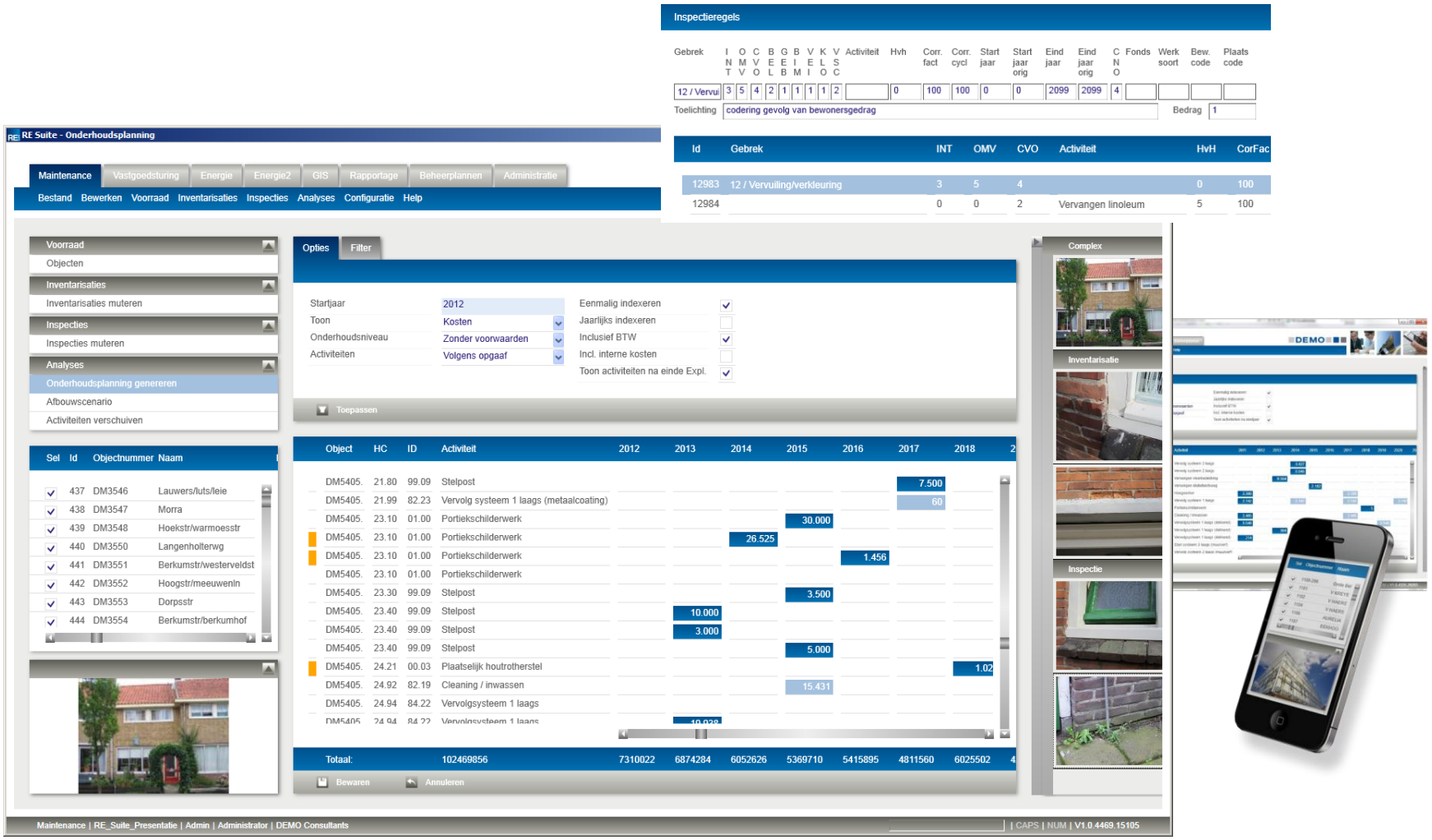


Real estate information management

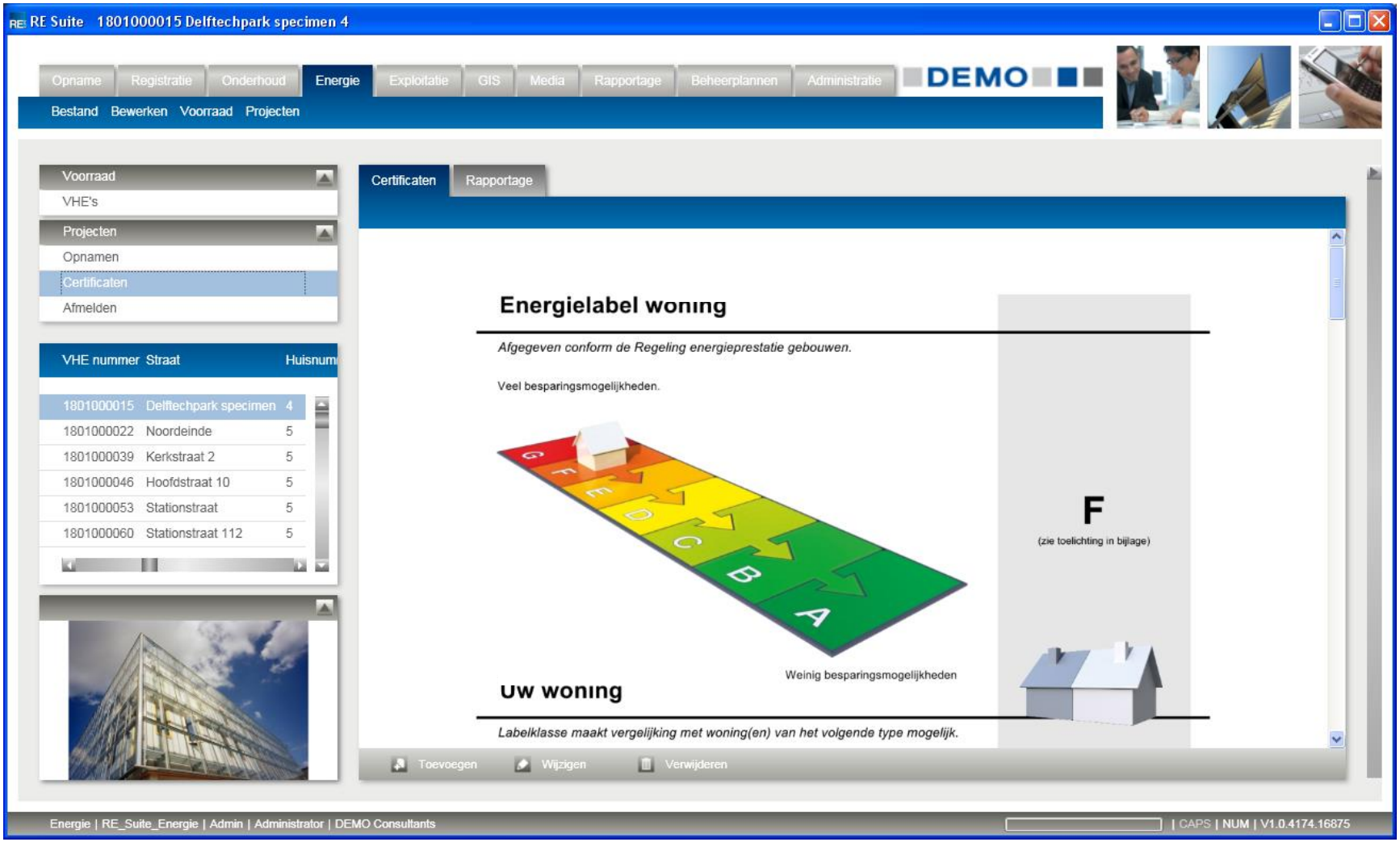
Software application for analysis of the underlying data



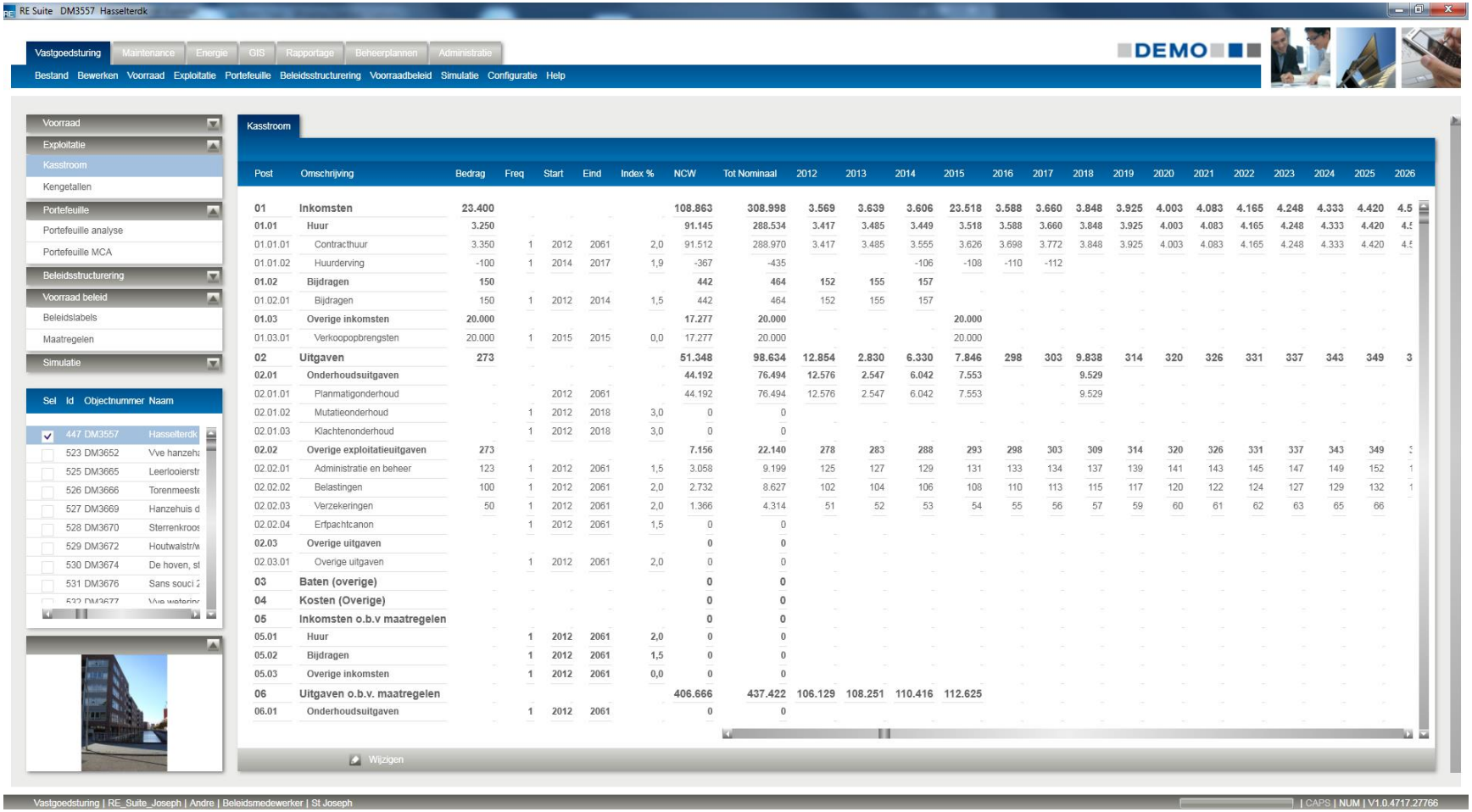
Software application for long-term building maintenance



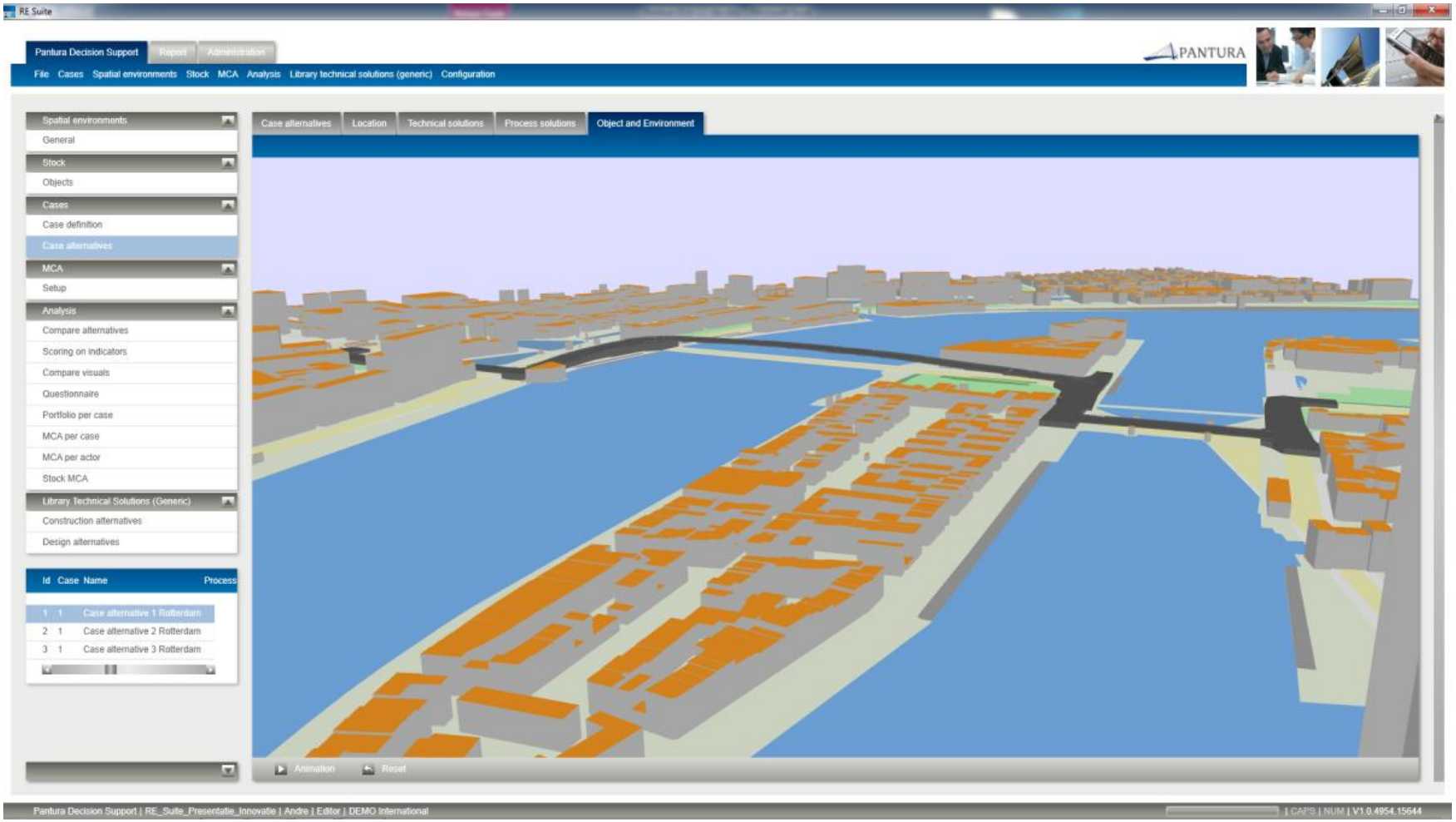
Software application energy labelling



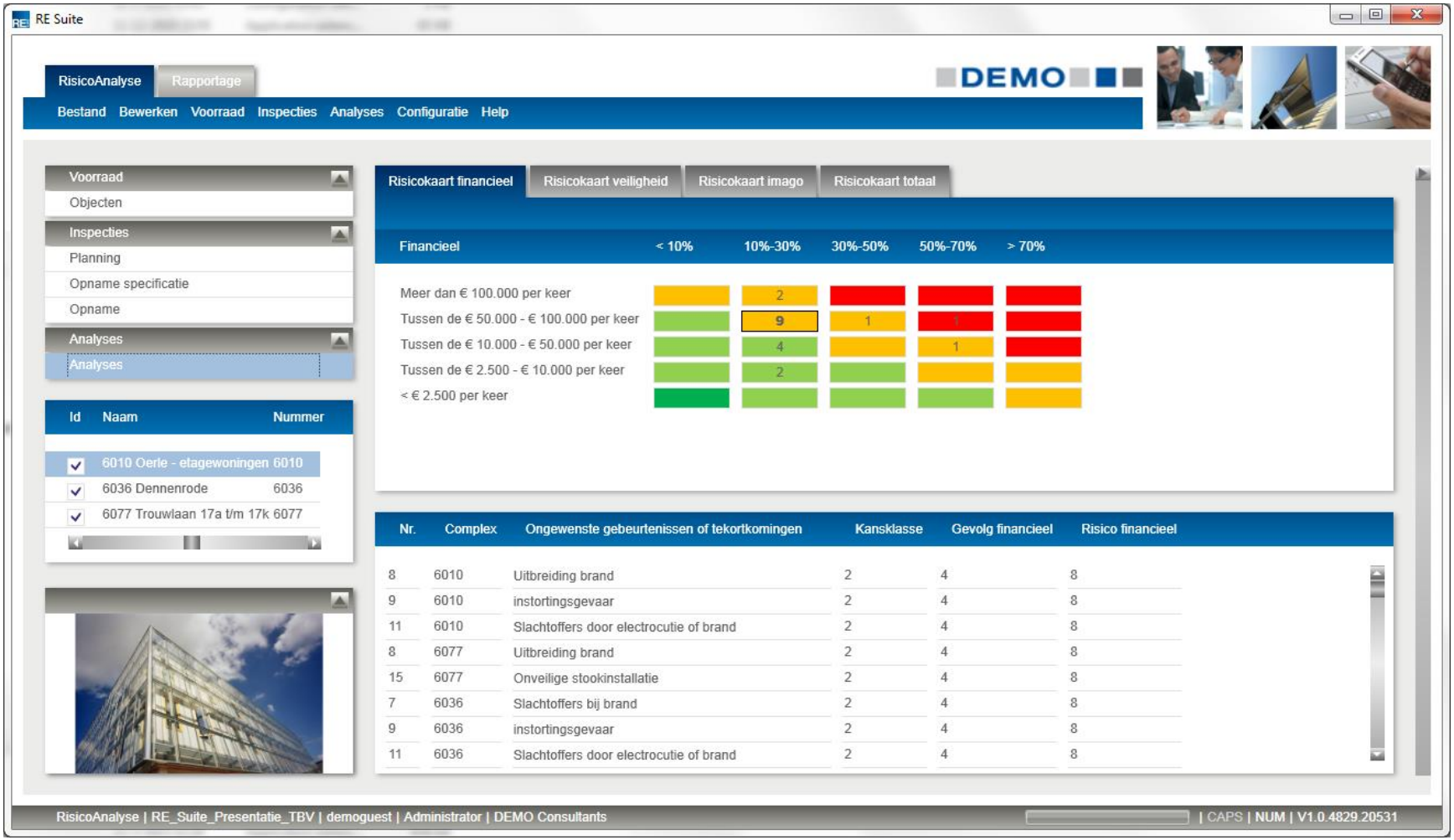
Software application for Life Cycle Cost



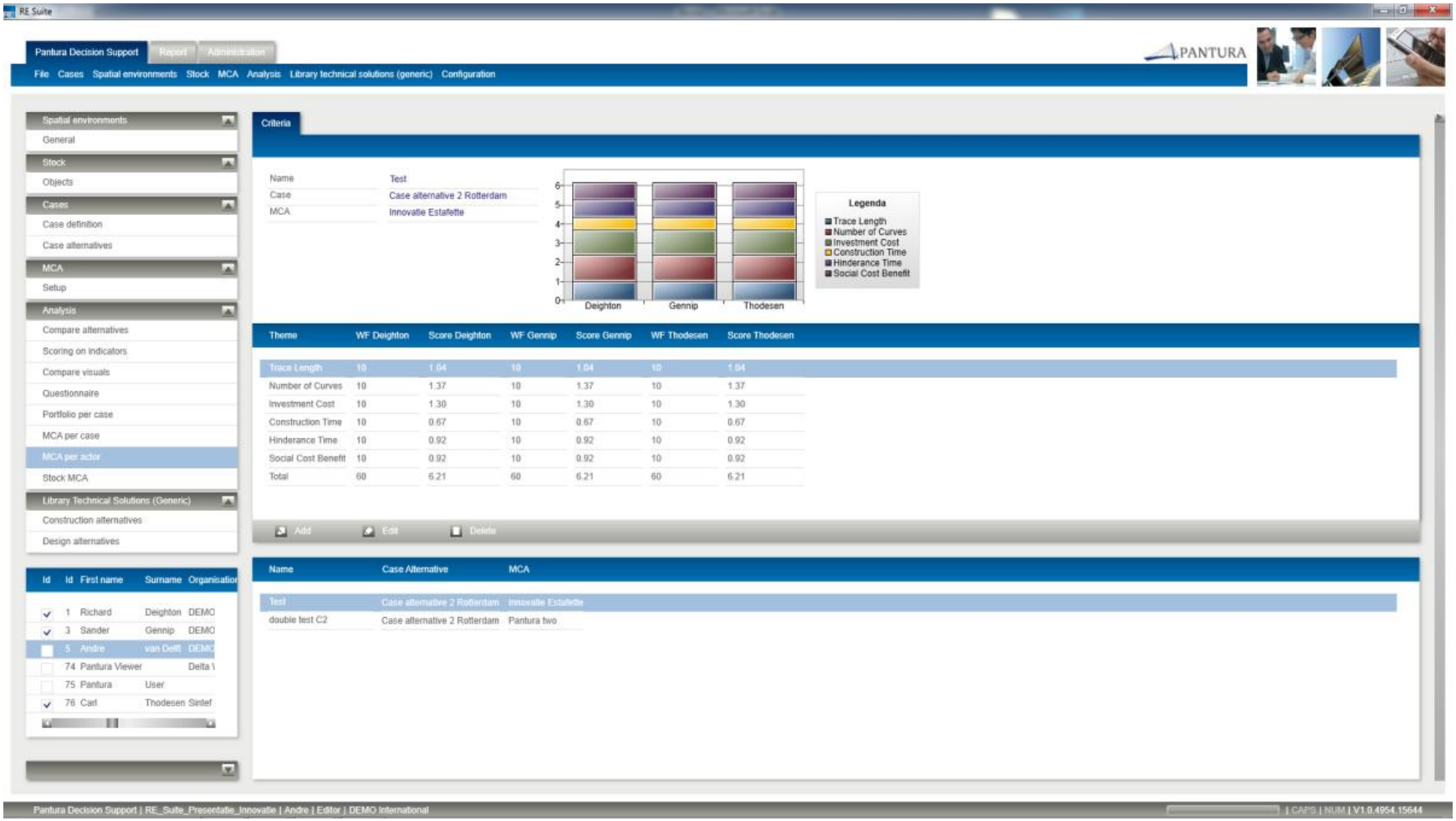
Software application for disclosing 3D GIS data



Software application for risk analysis



Multi-actor multi-criteria decision-support tool



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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