The Open Geospatial Consortium (OGC®)

Request For Quotation

And

Call For Participation

In the

FUTURE CITY PILOT PHASE 1 (FCP1)

Annex B: Technical Architecture

RFQ Issuance Date: 5 Febraury 2016

Proposal Due Date: 4 March 2016

Table Of Contents

List of Figures

Annex B: FCP1 Architecture

1 OGC and Smart Cities

Urban residents make up 54% of the global population[1], and that percentage is growing rapidly. Effective integration of human, physical, and digital systems operating in the built environment holds the promise of improving the quality of life for urban residents, improving the governance of cities and making cities prosperous, inclusive, sustainable and resilient. Location is a primary method for organizing urban information and services, and communicating about location requires standards. An OGC White Paper[2] addresses an open information technology standards framework that is critical to achieving the benefits of spatial communication for Smart Cities.

Figure 1 A Smart City uses location as an organizing principal to benefit residents, visitors, and businesses of all types. (Graphic from Steve Liang, University of Calgary)

When organized using the concepts of space and time, information about cities can be the basis for many powerful services, analytics and decision-making. Realizing these benefits depends on effective communication of location information. That communication happens when platform, system and application developers agree on location data encodings and spatial software interfaces. Even simple point location queries and responses require agreement on the naming and ordering of many parameters.

The OGC White Paper provides the beginnings of a spatial information framework for urban spatial intelligence based on open standards such as OGC CityGML, IndoorGML, Moving Features, and Augmented Reality Markup Language 2.0 (ARML 2.0). A spatial information framework provides the basis to integrate GIS features, imagery, sensor observations and social media in support of city governance and services.

Open standards from OGC, ISO and other standards organizations meet the need for interoperability, efficiency, application innovation and cost effectiveness. They have been developed over the last two decades by industry, government, NGO and academic partners. Many of the most important standards are widely implemented by vendors and solution providers.

---

[1] http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/

[2] https://portal.opengeospatial.org/files/?artifact_id=61188

This paper provides critical guidance on how to plan and implement open spatial standards architectures that guide deployment of interoperable information system components. It discusses open standards for mobile location communication, 3D urban models, building information models, indoor navigation, augmented reality, and sensor webs. It also gives Smart City system architects insight into how changing computing paradigms, particularly the widespread use of XML and the rise of RESTful programming, figure into Smart City planning.

2 Introduction

2.1 Purpose and Background

The purpose of this Request for Quotation and Call for Participation (hereafter referred to as RFQ/CFP) is to solicit proposals in response to a set of requirements for the Future City Pilot Interoperability Program (IP) initiative.

The OGC, on behalf of the project sponsors, will provide cost-sharing funds to partially offset expenses uniquely associated with the initiative, thus the solicitation is for quotations from bidders wishing to receive cost-sharing. However, not all proposals are expected to seek cost-share funding. OGC intends to involve as many participants in the initiative as possible; to the extent each participant can enhance and/or contribute to the initiative outcomes.

Human, natural, and physical systems interact in space and time, and the digital systems in cities will become increasingly diverse and numerous, with many owners. Cities thus need an open, vendor-neutral standards platform for communicating spatial and temporal data. Many of the longstanding technical boundaries separating indoor, outdoor, underground and atmospheric information have been overcome. The Future Cities Pilot will show how cities can begin to reap the benefits.

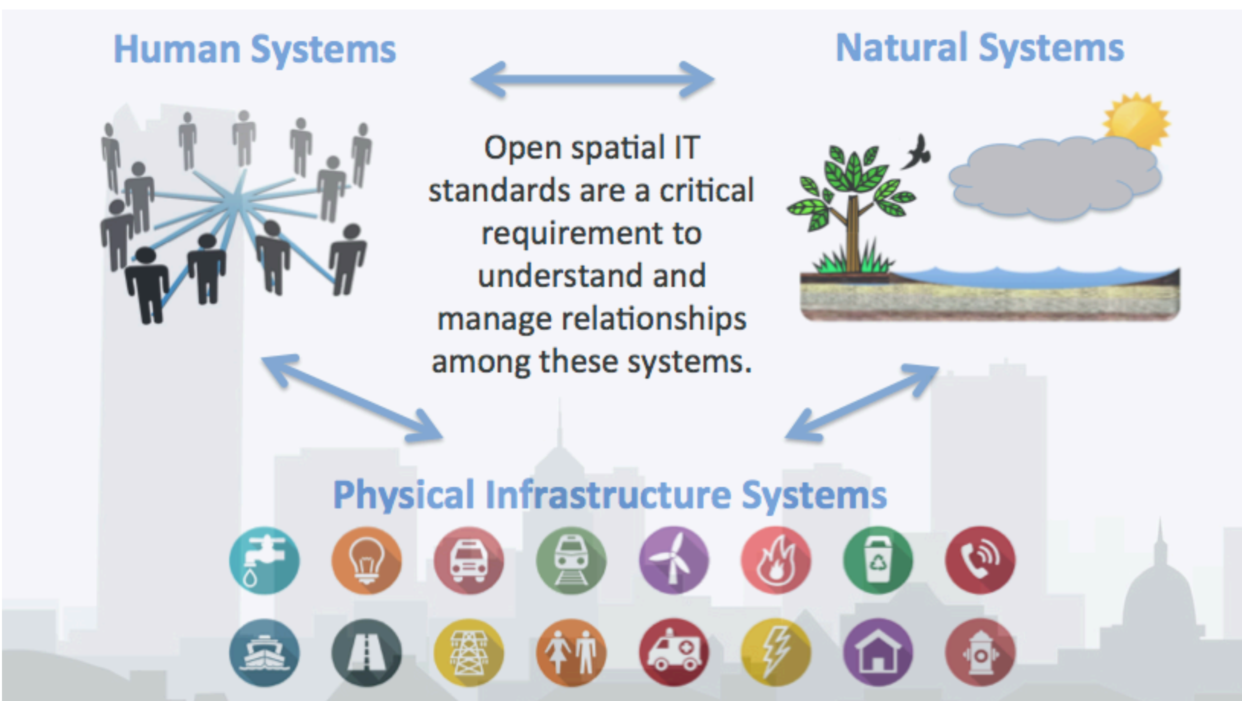


Figure 2: Relationship between Human, Natural and Physical Infrastructure systems

OGC and other standards organizations have made recent progress in fields such as city modelling, indoor navigation, citizen science and the Internet of Things. bSI is extending its BIM Standards to encompass infrastructure and other elements of the built environment. bSI and OGC collaborate in areas such as urban and infrastructure modelling and indoor/outdoor navigation.

The first Future Cities Pilot (FCP1) brings together visionary sponsors to help define activities that meet cities' spatial information requirements. All requirements, lessons learned and results will be shared among participants and made available to the public and cities everywhere. Hosting cities will benefit from OGC/bSI-led workshops for scoping and requirements-collecting, introductions to vendors and developers with commitment to open systems, public demonstration and leave-behind solutions. Sponsoring organisations will benefit from the opportunity to directly work with municipal personnel and understand their cities' requirements first hand. Solutions to current urban challenges may act as forerunners for solutions in rural environments. In addition, results will guide future standards development.

An important aspect of OGC initiatives such as the FCP1 initiative is that vendors, developers, administrators, and subject domain experts are brought together to learn from each other and collaboratively solve interoperability problems, which arise in the course of developing geospatial data architectures and information exchange using OGC and other standards. Equally important in this collaborative framework is the identification of potential factors, barriers or considerations that while not directly under investigation, may/will have impact upon the technology applied, data used and decisions made by both the first responder community and the industry technology provides.

This document describes the detailed requirements and initial system architecture for standards and technology to guide the design, development, testing, demonstration, and documentation of components, data, services, encodings, protocols and systems for the first Future City Pilot (FCP1) initiative.

This initiative is organized as an Interoperability Pilot as defined within the OGC Interoperability Program. The Program is described here (http://www.opengeospatial.org/ogc/programs/ip) and the policies and procedures governing its initiatives are defined here (http://www.opengeospatial.org/ogc/policies/ippp).

The key objectives of the FCP1 are:

- Develop and document the making of a draft city models from available data sources, to support the main scenarios of the pilot.
- Prepare initial specifications, profiles, Best Practices, and demonstration designs that demonstrate serving IFC using OGC WFS
- Prepare initial profiles, Best Practices transforming IFC to CityGML and CityGML to IFC
- Prototype capabilities that will associate sensor readings (hydrological sensor, air quality sensors, weather information) or other aggregated indicators (e.g. building information, energy performance indicators) to elements in the City Models. Aggregated data can come from a variety of models and data sources.
- Investigate the inclusion of Crowd Sourced (VGI) data into City Models
- Make aggregated data available through interoperable OGC web services.
- Visualize the sensor readings and indicators in a comprehensive way that is useful for urban and city planner and decision makers.
- Prepare engineering reports to document prototype capabilities and results demonstrated in a realistic scenario
- Plan and conduct a final demonstration using the pilot scenario

- Develop as part of the Engineering Report, potential factors, barriers or considerations that while not directly under investigation, may/will have impact upon the technology applied, data used and decisions made by both the first responder community and the industry technology providers

2.2 About This Document

Section 2 provides a detailed description of pilot requirements and deliverables.

Section 3 describes the pilot architecture, presented according to the Reference Model for Open Distributed Processing (RM-ODP), ISO/IEC 10746. An RM-ODP architecture is described by way of five viewpoints. Four viewpoints are included in this document and the fifth will be developed in the course of Pilot execution.

- The ***enterprise viewpoint*** explains the business reasons for this project, who should be involved, and what should be done in simple terms. It is intended primarily for high-level decision makers.
- The ***information viewpoint*** lists and briefly describes the encodings and information models most applicable for the system, based on the scenario and associated use cases (e.g. first responder groups) described in the enterprise viewpoint.
- The ***computational viewpoint*** similarly describes a basic set of components (including web services) and other interfaces/protocols most applicable for this initiative, based on the use cases, but stopping short of "wiring the system together".
- An ***engineering viewpoint*** is prepared to show how various components of a system architecture would fit together. This represents a conceptual model of the system architecture, not at the level of detail needed for a physical implementation, but rather a template that should be as platform-neutral as possible.
- A ***technology viewpoint*** is concerned with the deployed system, describing hardware, software and data to be used. For this FCP1 initiative, a technology viewpoint will be developed in the course of pilot execution.

2.3 Acronyms

FCP1	Future City Pilot Phase 1
ISO	International Organization for Standardization
IEC	International Electrotechnical Commission
LOD	Levels of Detail (feature of CityGML) (5 levels)
SWG	Standards Working Group
DWG	Domain Working Group
VGI	Volunteered Geographic Information
UPR	Urban Planning Rules
MVD	Model View Definition

IoT	Internet of Things
BIM	Building Information Modeling
SME	Subject Matter Expert
3DIM	OGC's 3D Information Management Domain Working Group

3 FCP1 Functional Requirements

The objective of the OGC pilot project is to demonstrate how use of open data sets, CityGML data and IFC data together can provide stakeholders with information, knowledge and insight which enhances financial, environmental, and social outcomes for citizens living in cities. CityGML is an open data model and XML-based format for the storage and exchange of virtual 3D city models. Industry Foundation Classes (IFC) are the open and neutral data format for openBIM.

Key challenges

- One of the key technical challenges identified, and one that has significant potential for future application, is to enable interoperability between CityGML and IFC data sets. This will support future accessibility of data on built environment performance.
- Explore what data is already available from the cities (the urban services: collection and street cleaning, lighting, drainage, public roads, parks and gardens, transport and telecommunications networks, telephone, electricity, water and gas), for example if there is already a CityGML or if one can readily be created from existing data to an appropriate level to achieve the desired pilot outcomes.
- A combined unified view of the various city services.
- How do you collect IFC data about facilities, floors, spaces, systems and components in the buildings?
- integration of building model (IFC) and CityModel (CityGML) according to 2 different schemes, which may be addressed or not by use cases:
- for exterior (up to LOD3)
- for exterior + interior (at LOD4), when the use case requires it.
- Identifying what attributes about the facilities, floors, spaces, systems and components is needed for analysis in order to achieve the outcomes and create a City Model View Definition (MVD). The pilot can potentially link existing data from a number of sources to demonstrate how this can be delivered.
- Connecting to real-time data on performance may include Internet of Things (IoT) data from the build environment, including movement sensors, temperature and temperature change, energy and water use. At pilot stage there may be potential to demonstrate gathering and use of data from relevant sensor technologies without the need for sensor installation.
- Urban planning rules control: Urban planning authorities have to instruct application for permit to build coming from BIM contractors, and check the conformance with urban planning rules. The use of BIM model in IFC should become a regulation for significant buildings.

4 Deliverable Requirements

Del #	Name / Type	Funded
D1	FCP1 Engineering Report (ER) (also send to BuildingSMART International relevant Room) The overall engineering report also includes the orthogonal or cross cutting items. And relevant Change Requests.	Yes
D2	Recommendations on Mapping IFC/CityGML to 3DIM Engineering Report (ER) (also send to BuildingSMART International relevant Room) and relevant Change Requests	Yes
D3	Recommendations on Serving IFC via WFS to WFS Engineering Report (ER) (also send to BuildingSMART International relevant Room) and relevant Change Requests	Yes
D4	Recommendations on use of TJS (aggregation of non real-time administrative data as sensor information) in 3DIM and SWE environment and relevant Change Requests	Yes
D5	Demonstration Script and Final demonstration materials (slide presentation and related video materials) and relevant Change Requests	No*
D6	Urban planning rules checking using WPS to WPS SWG Engineering Report (ER) and relevant Change Requests	Yes

* we welcome fully in-kind proposals and we are seeking additional sponsorship to fund these deliverables.

4.1 Documentation Deliverables

4.1.1.1 FCP1 Architecture Engineering Report (ER)

This (overal) Engineering Report shall describe the overall architecture of the systems developed and deployed during the Pilot (including the transversal topics), analyze lessons learned, and summarize technical results of the project, and relevant Change Requests.

4.1.1.2 Recommendations on Mapping IFC / CityGML to 3DIM Engineering Report (ER)

This Engineering Report shall describe recommendations for mapping and transforming IFC to CityGML and CityGML to IFC as well as other recommended practices developed or realized during the Pilot. The ER will also highlight gaps in the standards, as they are identified during the pilot and reported to the relevant working groups within the OGC and bSI.

The pilot will look into conversion at

- LOD2 (simple structure of building)
- LOD3 (detailed architectural structure of building)
- LOD4 (indoor structure)

4.1.1.3 Recommendations on Serving IFC via WFS to WFS Engineering Report (ER)

This Engineering Report shall describe recommendations for serving IFC using WFS as well as other recommended practices developed or realized during the Pilot. <link to previous work done>

4.1.1.4 Recommendations on use of TJS (aggregation of non real-time administratve data as sensor information) in 3DIM and SWE environment

This Engineering Report shall describe recommendations for using TJS to "aggregate" non real-time administratve data as sensor information as well as other recommended practices developed or realized during the Pilot.

4.1.1.5 Demonstration Script and Final demonstration materials (slide presentation and related video materials)

This report shall describe the scenario and use cases employed as a basis for guiding the development of technical solutions during the project. The document will also document the various actors, components (services, data, clients, devices, gateways, routers, etc.) that are deployed and the interconnection and interaction mechanisms for demonstration purposes. The report shall also identify and document the content produced as outcomes and used in support of the project demonstration.

4.1.1.6 Recommandation on Rules validation Engineering Report

This Engineering Report shall describe recommendations for validating against urban rules, validating with human verification and how validated data is added to existing 3D City Model/database.

4.1.2 FCP1 Component Deliverables

Del #	Name / Type	Funded
C1	Web Feature Service (WFS) serving IFC Feature Layers	No*
C2	Sensor Observation Service (SOS) for In Situ Sensors	No*
C3	Sensor Observation Service (SOS) / WFS for "aggregated data"	No*
C4	Client rendering IFC from WFS	No*
C5	Urban planning rules checking	No*
C6	Transformation of IFC to and from CityGML as a service component	No*

* we welcome fully in-kind proposals and we are seeking additional sponsorship to fund these deliverables.

4.1.2.1 Web Feature Service (WFS) serving IFC Feature Layers

The WFS shall be deployed to provide IFC as features as a layer.

4.1.2.2 Sensor Observation Service (SOS) for In Situ Sensors

The SOS shall be deployed to provide discovery of and access to current and historical observations from fixed and mobile sensors that are indexed by location and time, as well as by features of interest.

4.1.2.3 Sensor Observation Service (SOS) for "aggregated data"

The SOS shall be deployed to provide discovery of and access to current and historical observations from "aggregated data" coming from a variaety of sources.

4.1.2.4 Client rendering IFC from a WFS

The desktop client shall provide the capability to integrate and process, display IFC data.

4.1.2.5 Urban planning rules checking

A process that validates incoming models against urban planning rules, identifies rule violations and provides an initial validation report.

4.1.2.6 Transformation of IFC to and from CityGML as a service component

A service that transformas an incoming IFC dataset and transform it into CityGML and vice-versa a service that takes incoming CityGML and transforms it into IFC.

5 Enterprise Viewpoint: Context, Scenario, and Use Cases

5.1 Context of FCP1

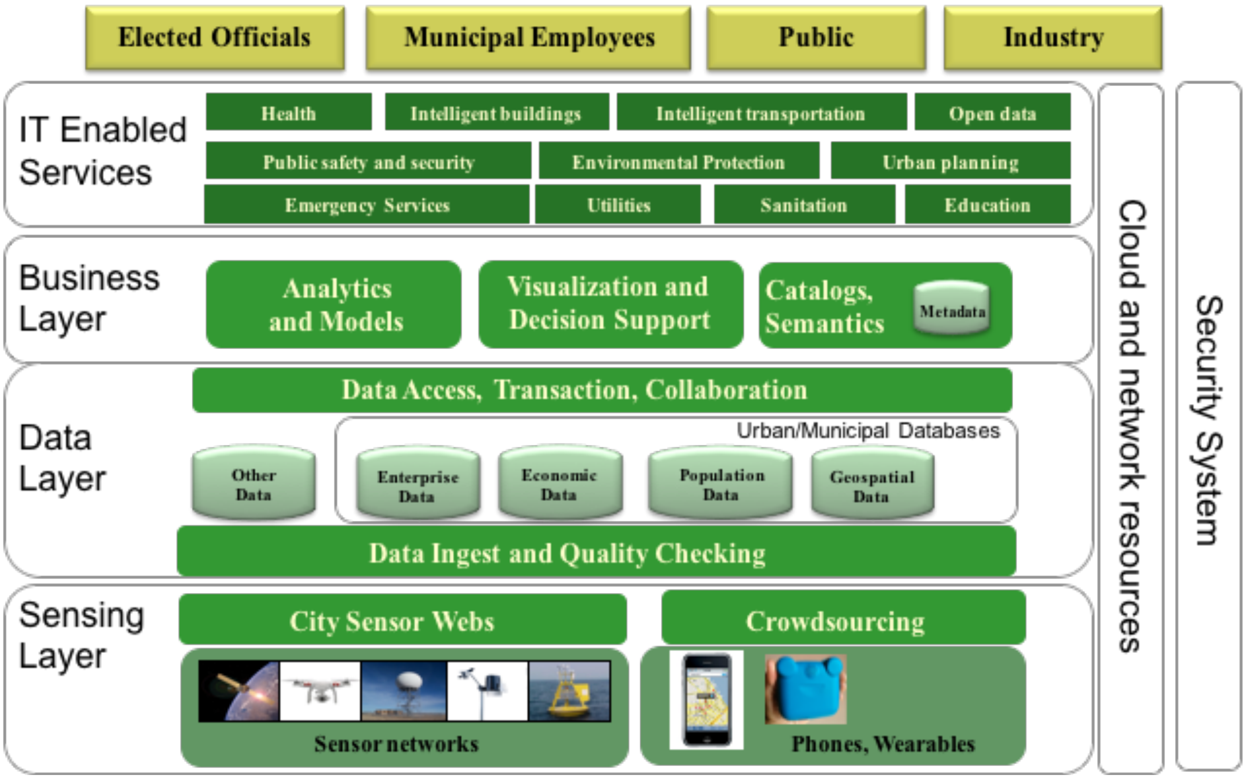


Figure 3: JTC1

ISO/IEC JTC 1 (Joint Technical Committee 1) created a Study Group to review Smart City topics. The Study Group was a short-term group that has now completed its report. The report is posted for the JTC 1 Plenary that will occur in November 2014. One recommendation by the SG 1 is to create a new JTC 1 Special Working Group to continue the work. Figure 15 from the JTC 1 report shows potential relationships for SDO coordination on Smart City Standards model. The JTC 1 SG 1 Smart Cities report includes these spatial items:

- Facilitating Instrumentation, Analysis, Decision-Making, and Automation
- Geospatial Information
- GIS (Geographic Information System)

5.2 Operational Context

5.2.1 FCP1 Scenarios

Use case vs Scenario	Link sensor information	Urban planning rules control	urban services and model CIM	Dynamizers	Semantic Int[truncated]
Urban Planning	X	X		X	X
Unified urban services	X		X	X	X
Social Services	X			X	X

5.2.1.1 Urban Planning

Urban planning authorities have to instruct application for permit to build coming from BIM contractors, and check the conformance with urban planning rules (UPR). The use of BIM models encoded in IFC will become mandatory for important building projects.

The proposed building project (provided as a BIM and encoded in IFC) should be:
- validation against urban rules planning (this process should be automated)
- validation with human verification; the analyst should be able to view the building project within the existing 3D model of the city.

Once the project has been validated and realized, the BIM data needs to be added to the exiting 3D City Model or database, according to local city rules, with mappings to the various LODs. The provided BIM data should also be stored with links between the geospatial data (at feature level) and BIM data.

5.2.1.2 Unified urban services

Urban services (collection and street cleaning, lighting, drainage, public roads, parks and gardens, transport and telecommunications networks, telephone, electricity, water and gas) are often kept in separate systems, that are difficult and expensive to connect to each other (each connection is a 'one-of' and hard to repeat). Unifying the existing and future information for each of the different areas, included within urban services, using standards-based interoperable web services will give the city the ability to do 'cross urban service' analyse and visualize the results in a 3D environment that helps the decision makers of the city.

5.2.1.3 Social Services

Fuel poverty and provision of adult social services are important to all local authorities. It is felt that part of the solution to improving adult social services and addressing fuel poverty issues lies in ensuring that the built environment is age friendly and well maintained: a better understanding of the energy efficiency of the housing is required.

A lot of data is available on the performance of homes, as is open geo-demographic data, but there is a need for more specific data on individual homes and the link to household need, and potentially to real-time data on performance to identify need for increased or urgent care of those at risk and to improve social outcomes.

5.2.2 Use Cases

The following use cases describe typical roles, activities, and objectives to be addressed by cities in the FCP1 and are more technical in nature. These scenarios are examplar and gives the particpants insight into the varius scenario's that are present in today cities. The Use Cases will be refined, generalised and implemented in the course of design, testing, and demonstration phases. The activities in this initiative will be performed according to the plans set forth in the Concept of Operations, contained in Section 4 of Annex A to this RFQ/CFP. Deliverable requirements are provided in Section 5 of the RFQ/CFP Main Body.

5.2.2.1 Use Case 1: Link sensor information to components of the City Model

Overview	
Title	*Fuel poverty and provision of adult social services*
Description	Fuel poverty and provision of adult social services are important to all local authorities. It is felt that part of the solution to improving adult social services and addressing fuel poverty issues lies in ensuring that the built environment is age friendly and well maintained: a better understanding of the energy efficiency of the housing stock in the Borough, including the Council's own existing housing (comprising 23,000 homes) and those of the Peabody Trust, is required. If RBG can collect data about both Peabody Trust's and its own housing, including performance (energy), internal room temperatures and dampness, and link it with demographic/socio-economic data, it could help RBG be more proactive and able to make more strategic interventions to improve health and quality of life for its vulnerable citizens. A lot of data is available on the performance of homes within England , as is open geodemographic data , but there is a need for more specific data on individual homes and the link to household need, and potentially to real-time data on performance to identify need for increased or urgent care of those at risk and to improve social outcomes. Collecting and storing data about housing stock (existing and in development) and presenting it through a prototype navigation, search and reporting application is the focus of the FCP1. The primary data sets will be in CityGML and IFC.
Actors and Interfaces	- Urban Planning Staff / analyst - City Model administrator - Property owners
Initial Status and Preconditions	Input data: - city model in IFC and CityGML - temperature and dampness measurements
Basic Flow	
Step 1: collect city model information (IFC, CityGML) Step 2: associate temperature and dampness reading to model	

Step 3: analyze performance data and reporting for decision making Step 4: Collecting and storing data about housing stock
Post Condition
Alternative Flow(s)

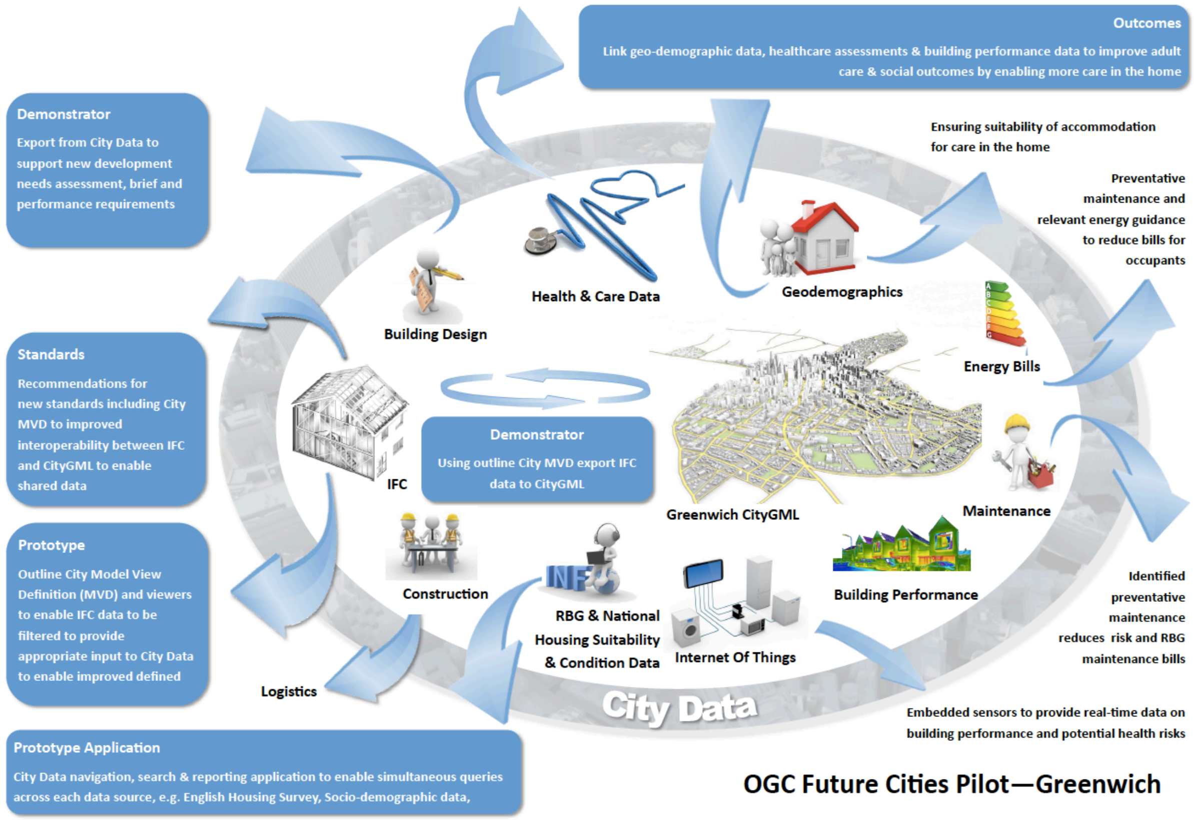


Figure 4 Problem Statement: How can we make more timely interventions and improve the condition of housing to reduce fuel poverty and improve adult health care services in the home

5.2.2.2 *Use Case 2:* Urban planning rules control

Overview	
Title	Inserting a new BIM project (IFC) into a City model (CityGML) and checking urban planning rules
Description	Urban planning authorities have to instruct application for permit to build coming from BIM contractors, and check the conformance with urban planning rules (PLU). The use of BIM model in IFC should become a regulation for significant buidlings The proposed project (provided in BIM IFC at LOD200) should be: - validated against a set of urban rules planning

<table>
<tr><td></td><td>- validated with human verification; the analyst should be able to view the project within the existing 3D model of the city.

Once the project has been validated and is realized, the BIM data need to be added to the exiting 3D City Model / database, according to the (emergent) French IGN CityGML profile (Ref3DNat), with mapping to LOD2 and 3. The provided BIM data should also be stored; links between created geospatial data (at feature level) and BIM data should be created.</td></tr>
<tr><td>Actors and Interfaces</td><td>• Urban Planning Staff / analyst
• City Model administrator</td></tr>
<tr><td>Initial Status and Preconditions</td><td>Input data:
- cadaster information for parcel on which building is planned + PLU zone
- urban planning rules for the designated area (as introduced below)
- BIM model (IFC) of the intended project (at LOD200)
- existing CityModel on the area of interest (CityGML profile, according to Ref3DNat recommendations, in LOD2 – or 3 in close future – with textures)
- other geospatial data available on the area of interest (BD topo, as necessary, e.g. for roads, parcel and buildings)</td></tr>
<tr><td colspan="2">Basic Flow</td></tr>
<tr><td colspan="2">1- Loading of the BIM project (link to the appropriate parcel, and location)
2- Automatized validation of urban planning rules; the application checks the BIM project against a set of rules, identifies rule violations and provides an initial report.
3- Visualisation of the project by the analyst and interactice verification (simple request on the model); based on the initial report done in step 2, final report is done.
4- Integration of the BIM model into a geospatial infrastructure (according to National 3D profile)
5- Visualisation (and final verification) of the updated 3D City Model

<u>Note</u> : As PLU rules address external geometry of building (apart from floor surface), it is recommended to evaluate the rules on the basis of a 3D CityGML LOD3 model of the building, as defined in RefNat, capturing the outer 3D geometry of the buidling.</td></tr>
<tr><td colspan="2">Post Condition</td></tr>
<tr><td colspan="2">- Final report and identification of infringed rules
- Updated City Model with links to BIM data sources (at feature level)</td></tr>
<tr><td colspan="2">Alternative Flow(s)</td></tr>
<tr><td colspan="2">This flow may be runned as described in “basic flow” or in another order.</td></tr>
</table>

Annexes:

1- This case will be demonstrated with Rennes Metropole, partner city of IGN, on a BIM project provided by the city of Rennes (in Bruz, south-west suburb of Rennes). CityModel will be made available at LOD2 level (textured) – with terrain and buildings.
2- Example of urban planning rules (PLU) (2D and 3D rules) (see Appendix B)

The French Local Urban Plan (PLU) describes constraints that regulate the urban development, notably through tri-dimensional constraints that new buildings must respect. These rules, which vary according to

PLU zone, address setbacks and prospects to public roads or neighbor buildings. The proposed example rules to be checked in the IP are provided and explained in the joint Appendix.

Requirements:

- Input of contextual data : CIM in CityGML and CityGML/ Ref3DNat, Roads (BD Topo – Shape or GML), Parcels (BD Parcellaire - – Shape or GML)
- Proposal of interface / standard / protocol for urban rule submission (TBD)
- Provision of converted BIM model in CityGML Ref3DNat LOD3 and LOD2
- Evaluation of the OGC web services (such as WFS) for this demonstrator, when applicable

Note :

IGN COGIT[3] Lab has developped an open-source library[4] for the evaluation and simulation of PLU urban rules. This library is not necessary to the development of the IP demonstrator, but might be of interest. The key focus of this use case is not the modelisation and simulation of the urban planning rules, but the integration of various urban data that are required for checking these rules, including CIM and BIM/IFC model.

5.2.2.3 Use Case 3: urban services management system based on a model CIM

Overview	
Title	Implementation of urban services management system based on a model CIM (City Information Modelling) for the entire city of Sant Cugat del Vallès
Description	The application adapted to urban services will unify existing and future information for each of the different areas included within urban services (collection and street cleaning, lighting, drainage, public roads, parks and gardens, transport and telecommunications networks, telephone, electricity, water and gas) in a single database, with the objective in acheiving the following functions: - Build a 3D model of the city using CityGML. - Inventory of all the parts which compromise urban services, and the different sections (sewer system, street lighting...) with a minimum LOD 300. - Immediate updating of management and elements. - Allow open data with citizens to share information of public interest. - Share information with other departments. - Speeding up the process of opening and closing events, establishing criteria to simplify the process. - Fault indicators in each of the services. - Indicators showing completed works, those in progress and future scheduled works. - Statistical data of different types - Forecast investment and energy consumption in the area of

[3] http://recherche.ign.fr/labos/cogit/accueilCOGIT.php

[4] https://github.com/IGNF/simplu3D

	maintenance, etc. - Improved planning and work brigades. - Improve communication between council and sub contractors. To complement the model CIM and to ensure that future works and services in public highway can be integrated directly into the model, a statement which defines the conditions that must be met by future projects using BIM will be created.
Actors and Interfaces	**City of Sant Cugat del Vallès** (Both politicians and technicians responsible for the management and maintenance of the city) **IDP Ingeniería y Arquitectura Iberia S.L.** (Technical team for the CIM System Implementation) **Companies supplying services** (FECSA ENDESA , TELEFONICA , SOREA , natural gas, etc.) Sub contractors Citizens of Sant Cugat del Vallès Hardware and software companies
Initial Status and Preconditions	Cartographic, topographic and cadastral information existing on GIS Various applications which appear on the database of the different services QGIS; SQL, mavix 2.0 Other information in office and microstation Collateral information which is currently not held
Basic Flow	
PHASE I - Advice and study for implementation - Define study areas - Dialogue with third parties - Study of alternatives and selection of software - Implementation action plan **PHASE II -** Implementation Management System - Creation of the new information model - Installation and launching of management platform - Editorial Handbook operating system to supplement the **CIM Execution Plan** (CEP) - Editorial specification type	
Post Condition	
Final report and identification of infringed rules Updated City Model with links to BIM data sources (at feature level)	
Alternative Flow(s)	
A generic flow has been proposed but depending on the urban service selected and/or the proposed output it might change therefore.	

5.2.2.4 Use case 4: Dynamizers - Supporting dynamic/time-dependent properties for semantic 3D city models

Overview	
Title	*Supporting dynamic properties for semantic 3D city models*

Description	CityGML is a useful and important source of information for different types of simulations (environmental simulations, disaster management, training simulators). Simulation specific data can be represented by specific features and properties within the city models. Further, the results of simulations can be fed back to the original 3D city models for thematic enrichment and data fusion by data from different disciplines. In most of the simulations, time-dependent properties play an important role. Such properties may either represent evolution of the city (slower changes); for example, change of the real property value of a building, change of ownership over time. They may also represent highly dynamic properties (comparatively faster changes); for example, variations of thematic attributes such as changes of physical quantities like energy demands, temperature, and solar irradiation levels. The variation may also be with respect to spatial properties such as change of a feature's geometry, both in respect to shape and to location (moving objects). The variation may also be according to the specific sensor or real time data. Such time-dependent and dynamic properties are not supported in the current version of CityGML. They only allow storing all such attributes as static values. The research work on 'Dynamizers', supporting such dynamic properties within CityGML is already progressing and is intended to be a part of CityGML version 3.0.
Use case scenarios	Below are some of the use case scenarios which will be highly benefitted by the proposed concept of Dynamizers: **1. Energy simulations** There are several studies/applications intended towards city-wide estimation of the energy demands of buildings. One such project 'Energy Atlas Berlin' includes all data from the Solar Atlas Berlin including the rating of the suitability of all individual roof surfaces for each of the 550,000 buildings in Berlin for the production of photovoltaic and solar thermal energy. It also integrates methods for energy demand estimation (heating energy, electrical energy and warm water) and assessment of the energetic retrofitting possibilities on the individual building level (so far, for all residential buildings only). As shown in Figure 1, the authorities may explore the energy demand of individual buildings for different months of a year. However, such values can be stored within standards such as CityGML as static values only. The current version of CityGML does not allow to store such values varying with respect to time. In this application, one attribute for each month is explicitly modeled. Dynamizers would allow to model and define such time-dependent values within CityGML.

Fieldname	Value
_____ESTIM...	_HEAT_DEMAND_
Jan_kwh	18119
Feb_kwh	15255
Mar_kwh	12232
Apr_kwh	5969
May_kwh	1918
Jun_kwh	440
Jul_kwh	0
Aug_kwh	6
Sep_kwh	1977
Oct_kwh	6926
Nov_kwh	13938
Dec_kwh	18829

Figure 1: Visualization of estimated heat demand values of a building in Berlin

2. Solar Irradiation analysis

There is an ongoing work in TU Munich for the development of a tool, which automatically calculates insolation values for wall- and roof surfaces of buildings, stored in the CityGML data model. Furthermore the results are used to accumulate the original data with suitable attribute aggregations. The sky view factor (SVF), which indicates the amount of visible sky from an observation point, is calculated as well as the monthly and yearly insolation value of roofs and walls with respect to the surrounding three dimensional topography, whereby the global insolation value is assumed of being composed of a direct and diffuse irradiance component. All surfaces of a building are sampled into points in a regular pattern to generate a basis for the calculations. Consequently each point represents a specific mount of surface area. Using a simplified algorithm the sun positions are calculated for specific points in time. Afterwards the positions are represented as simple point objects just as the building points. The hemisphere, which is used to calculate the SVF and the diffuse irradiation, is approximated by a set of uniform spread points.

For each building point a line of sight is generated to each hemisphere and sun point. These three dimensional lines are checked for 3D-intersections with the surrounding topography to determine shadowed areas at the considered points of time. Based on the computed information on shadowed areas monthly and a yearly insolation values are computed using a simplified transition model with respect to the exposure of each surface. The transition model contains some parameters, which can be used to calibrate the calculated irradiance values to particular climatic properties. Afterwards the calculated SVF and insolation values are aggregated and saved as generic attributes in the original CityGML data file.

Figure 2 illustrates visulaization of solar irradiation analysis for buildings for different months in a year.

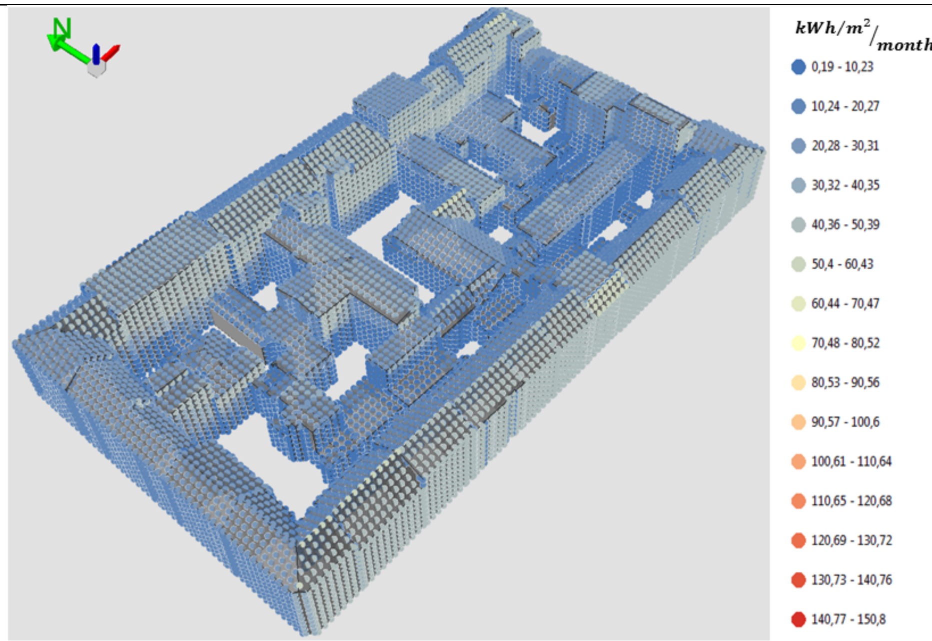


Figure 2(a): Solar irradiation results in January

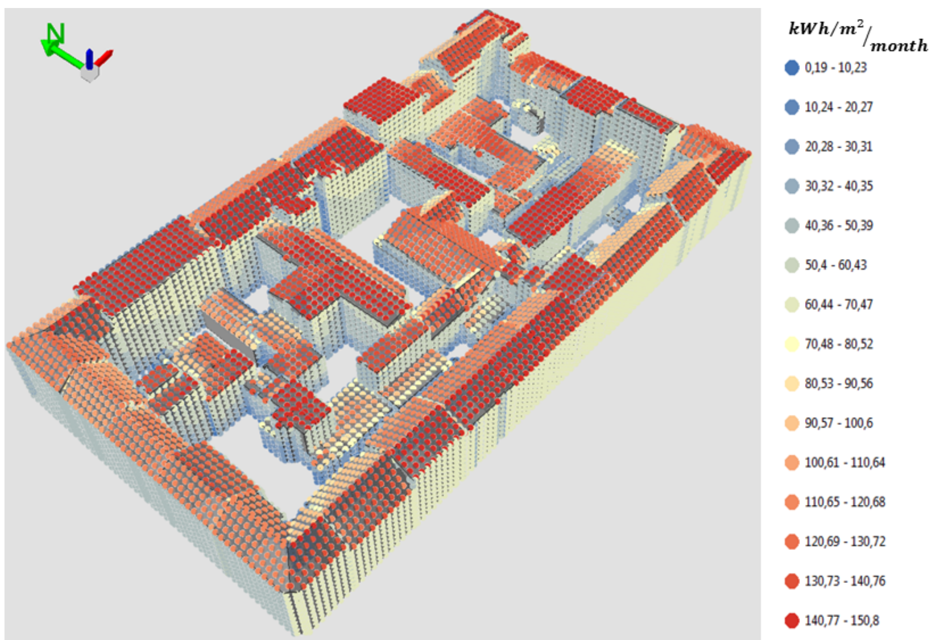
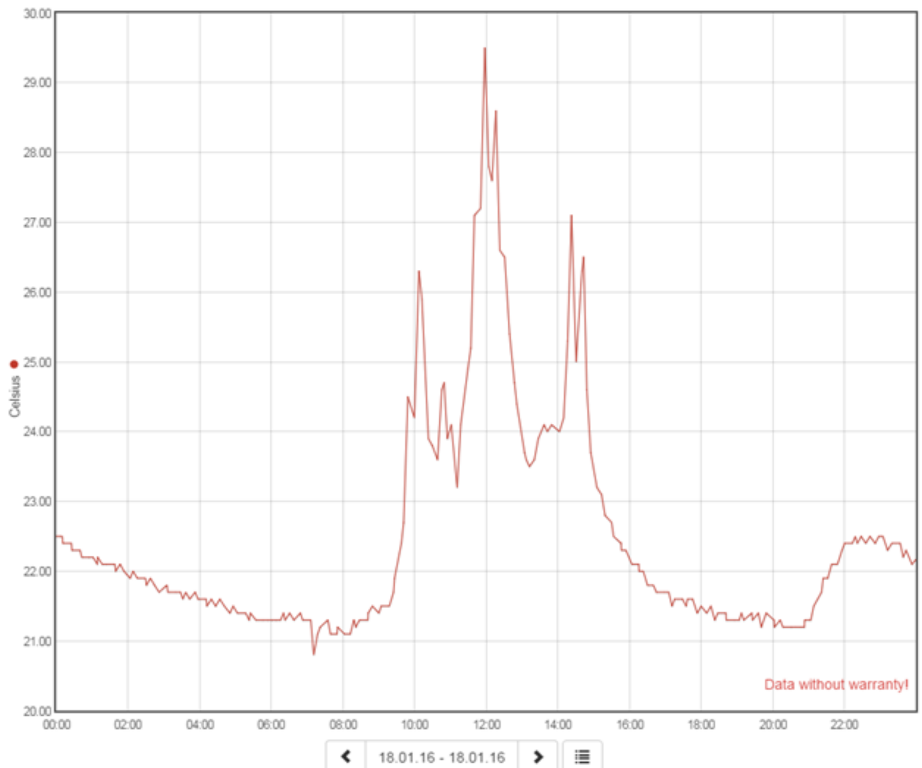


Figure 2(b): Solar irradiation results in July

3. Real time sensor integration

With the help of OGC Sensor Web Enablement framework, the sensor web infrastructures can be realized in an interoperable way. It permits integration of various sensors such as Smart Meters with semantic 3D city models. The sensors and their metadata can be defined using SensorML, the observations can be defined using Observations & Measurements (O&M) format. Utilizing sensor services such as Sensor Observation Service (SOS), the real-time observations from such sensors can be retrieved and integrated with standards such as CityGML. Figure 3 below shows a screenshot from a running SOS

	instance. It is a visualization of hourly values from a sensor measuring temperature of a room in a building for a day.  Figure 3: Temperature variation in a room of a building for a day The concept of dynamizers would allow modeling such timeseries for representing hourly/monthly/yearly values within CityGML.
Actors and Interfaces	☐ Urban Planning Staff / analyst ☐ City Model administrator ☐ Property owners
Initial Status and Preconditions	Input data: - city model in CityGML - information/values from different sources/sensors as per required use cases
Basic Flow	
Post Condition	
Alternative Flow(s)	

5.2.2.5 Use case 5: Overcoming Semantic Heterogeneity for Smart Cities

Overview	
Title	Overcoming Semantic Heterogeneity for Smart Cities : A Case Study of Solar Potential Analysis for Singapore
Description	With open formats available for geospatial data, exchange of data across different platforms no longer poses a critical challenge. Spatial data can be exchanged in the formats of CityGML, IndoorGML, LandXML, IFC, and others, or through web services such as WMS, WFS. What poses a challenge however is the conceptual and terminological differences that exist between the diverse data sources and services. In the smart cities context for instance, building design data can come from Building Information Models (BIM). Topography information can be obtained from city models in the format of CityGML, and legal property boundaries can be provided in LandXML. These data sources represent different aspects of a building, namely design, physical and legal, and these data are developed based on different domain knowledge (e.g. AEC industry, surveyors). Different domain background knowledge causes conceptual and terminological differences when data and services are fused. Conceptual and terminological difference is referred to as semantic heterogeneity. To achieve a seamless integration of spatial data and services, the issue of semantic heterogeneity must be overcome. The domain knowledge inherited in the data and services must be made explicit and formal so that applications using a variety of computer systems can work together. When semantic heterogeneities are overcome, various resources including geometries, files, images, can be linked and pulled together seamlessly for specific applications. What is required, therefore, is an enhanced metadata structure tailored to the kinds of data encountered in urban applications. We propose to provide a solution to this problem, in the first instance using the specific example of solar insolation (irradiance averaged over time) data as the application. Insolation analyses are an important study for smart cities, as modern buildings often aim to deploy maximum solar photovoltaic and thermal power systems, and optimize building design for ambient lighting and solar radiant heat gain. To perform the required analyses, appropriate algorithms and a large variety of building and environmental datasets are required. For instance, from BIM models, the buildings' geometry and materials can be obtained to calculate incident, shadowed and reflected solar radiation. From CityGML models, the usage and function of a building can be determined. If a building is for habitation, lighting and thermal loads due to radiant heat gain must be considered. Legal boundaries from LandXML describe building ownership and may provide energy demand information. In our proposed pilot study, a solar analysis study will be performed as a real world case. From this pilot, it is expected that best practices will be created and prototype metadata structures (ontologies) will be developed whereby

	computer systems will be able to do reasoning and inference based on formal sets of rules and definitions relating all relevant geospatial entities. Using the ontologies, the computer systems will mitigate the problems caused by semantic heterogeneities and will seamlessly link various resources required for the solar energy analysis case study.
Actors and Interfaces	City modeller
Initial Status and Preconditions	3DIM Ontologies CityGML, IFC and LandXML
Basic Flow	
Post Condition	
Alternative Flow(s)	

5.3 Enterprise Components/Context

Access and processing of geospatial information for smart cities is achieved in a serviceoriented architecture using open standards as shown in the figure below. The OGC services are grouped in the figure and discussed in the following sections.

5.3.1 Geospatial Services Architecture

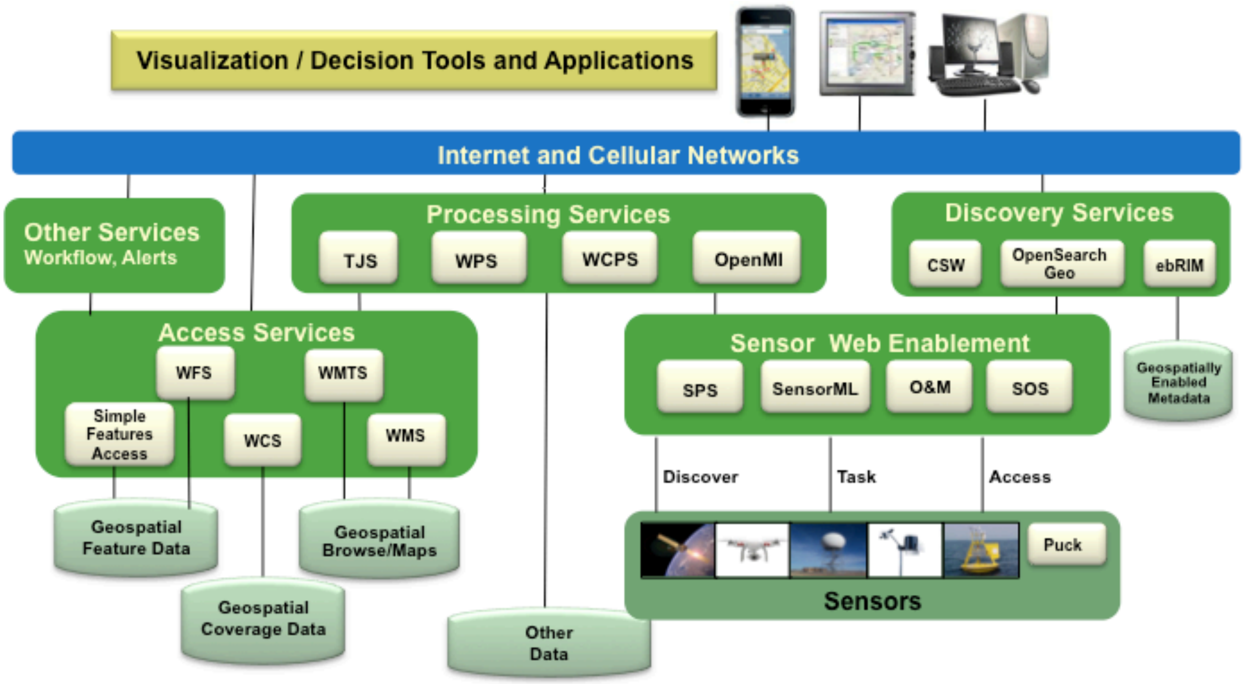


Figure 5 OGC Services Architecture for interoperable access and processing of geospatial information for decision support

The following Viewpoints describe architectures, components, services, protocols and encodings to be addressed during the FCP Pilot.

6 Information Viewpoint

6.1 Overview

The information viewpoint is concerned with the semantics of information and information processing. It defines conceptual schemas for geospatial information and methods for defining application schemas. The conceptual, or base, schemas are formal descriptions of the model of any geospatial information. Application schemas are information models for a specific information community. Applications schemas are built from the conceptual schemas. Information encodings then define the content of messages by which system components exchange information

6.2 OGC and Other Information Models and Encodings

This section identifies specific standard information models, schemas, profiles, and/or encodings that are applicable to the information exchanges expected to play a role in the Pilot project. This is a representative list, but additional standards may be identified in the course of the initiative.

Information Standards:

- Geographic Markup Language
- Observations and Measurements
- SensorML
- OWS Context
- Sensor Networks: Sensor Network Reference Architecture (SNRA)
- CityGML
- IFC
- IndoorGML

6.2.1 Geographic Markup Language (GML)

The OGC Geography Markup Language (GML) is an XML grammar for expressing geographical features. GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet.

6.2.2 Observations and Measurements (O&M)

The OGC and ISO Observations and Measurements (O&M) conceptual model (OGC Observations and Measurements v2.0 is also published as ISO/DIS 19156) provides for the exchange of information describing observation acts and their results, both within and between different scientific and technical communities. The standard also provides XML schemas (GML application schemas) for observations, and for features involved in sampling when making observations. O&M is an essential dependency for the OGC Sensor Observation Service (SOS) Interface Standard.

6.2.3 SensorML

The OGC Sensor Model Language (SensorML) standard provides a robust and semantically-tied means of defining processes and processing components associated with the measurement and post-measurement transformation of observations. This includes sensors and actuators as well as computational processes applied pre- and postmeasurement. SensorML is one of several implementation standards resulting from OGC's Sensor Web Enablement (SWE) activity.

6.2.4 OWS Context

The OGC Web Services Context Document (OWS Context) encodes a set of configured information resources (service set) to be passed between applications primarily as a collection of service invocations. OWS Context is developed to support in-line content as well. OWS Context supports use cases such as the distribution of search results and the exchange of a set of resources such as OGC Web Feature Service

(WFS), Web Map Service (WMS), Web Map Tile Service (WMTS), Web Coverage Service (WCS) and others in a '*Common Operating Picture*'. Additionally OWS Context can deliver a set of configured processing services (Web Processing Service (WPS)) parameters to allow the processing to be reproduced on different nodes.

6.2.5 Sensor Networks: Sensor Network Reference Architecture (SNRA)

ISO/IEC 29182-1:2013, Information technology -- Sensor networks: Sensor Network Reference Architecture (SNRA) -- Part 1: General overview and requirements
http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=45261

The purpose of the ISO/IEC 29182 series is to

- Provide guidance to facilitate the design and development of sensor networks
- Improve interoperability of sensor networks
- Make sensor networks plug-and-play, so that it becomes fairly easy to add/remove sensor nodes to/from an existing sensor network

Part 1 as referenced here provides a general overview and the requirements for the sensor network reference architecture.

The following diagram shows two sensor networks connected to a backbone network or other entities. Gateways provide sensor networks with connectivity to other networks through access networks.

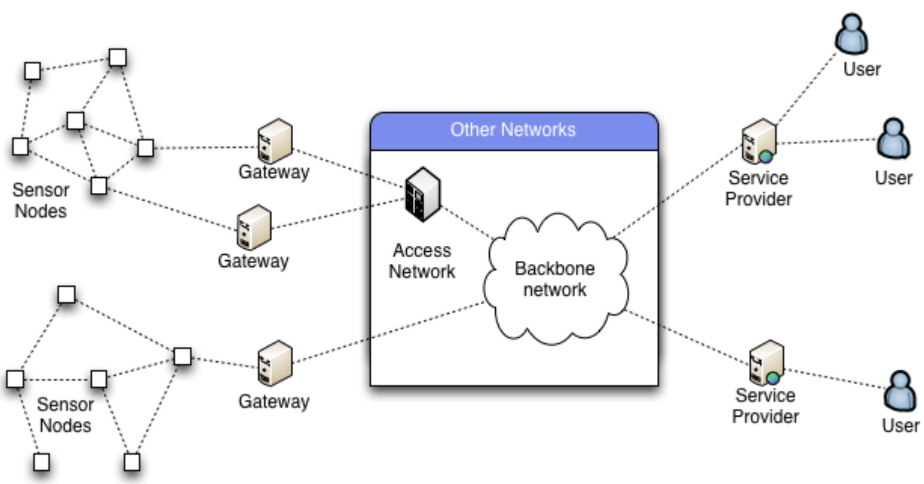


Figure 6: Sensor Network Connectivity

6.2.6 CityGML

The City Geography Markup Language (CityGML) is a new and innovative concept for the modelling and exchange of 3D city and landscape models that is quickly being adopted on an international level. CityGML is a common information model for the representation of 3D urban objects. It defines the classes and relations for the most relevant topographic objects in cities and regional models with respect to their geometrical, topological, semantical and appearance properties. Included are generalization hierarchies between thematic classes, aggregations, relations between objects, and spatial properties. In contrast to other 3D vector formats, CityGML is based on a rich, general purpose information model in addition to geometry and graphics content that allows to employ virtual 3D city models for sophisticated analysis tasks in different application domains like simulations, urban data mining, facility management, and thematic inquiries. Targeted application areas explicitly include urban and landscape planning; architectural design; tourist and leisure activities; 3D cadastres; environmental simulations; mobile telecommunications; disaster management; homeland security; vehicle and pedestrian navigation; training simulators; and mobile robotics.

CityGML is realised as an open data model and XML-based format for the storage and exchange of virtual 3D city models. It is implemented as an application schema for the Geography Markup Language version 3.1.1 (GML3), the extendible international standard for spatial data exchange issued by the Open Geospatial Consortium (OGC) and the ISO TC211. CityGML is an official OGC Standard and can be used free of charge.

6.2.7 IFC

The **Industry Foundation Classes (IFC)** data model is intended to describe building and construction industry data.

It is a platform neutral, open file format specification that is not controlled by a single vendor or group of vendors. It is an object-based file format with a data model developed by buildingSMART (formerly the International Alliance for Interoperability, IAI) to facilitate interoperability in the architecture, engineering and construction (AEC) industry, and is a commonly used collaboration format in Building information modeling (BIM) based projects. The IFC model specification is open and available.[1] It is registered by ISO and is an official International Standard ISO 16739:2013.

http://www.buildingsmart-tech.org/specifications

Because of its focus on ease of interoperability between software platforms, the Danish government has made the use of IFC format(s) compulsory for publicly aided building projects.[2] Also, the Finnish state-owned facility management company Senate Properties demands use of IFC compatible software and BIM in all their projects.[3]Also the Norwegian Government, Health and Defense client organisations require use of IFC BIM in all projects as well as many municipalities, private clients, contractors and designers have integrated IFC BIM in their business.

6.2.8 IndoorGML

This OGC® IndoorGML standard specifies an open data model and XML schema for indoor spatial information. IndoorGML is an application schema of OGC® GML 3.2.1. While there are several 3D building modelling standards such as CityGML, KML, and IFC, which deal with interior space of buildings from geometric, cartographic, and semantic viewpoints, IndoorGML intentionally focuses on modelling indoor spaces for navigation purposes.

7 Computational Viewpoint

7.1 Overview

The computational viewpoint is concerned with the functional decomposition of the system into components, which allow clients and servers to interact at interfaces. This viewpoint captures the details of the components and interfaces that form the building blocks of the target system without necessarily constraining either the technology platforms, overall system organization, or physical distribution of an implementation.

7.2 Service Layer Standards

This section identifies OGC Web service standards that handle data types, standards, and other geospatial information sources that may be involved in use cases and specified in the Enterprise Viewpoint. These standards represent services and protocols that may be applicable in operational contexts, which use or process information described in Section 6. As Web services, these standards typically rely in turn on fundamental Web standards such as HTTP. Below is a partial, representative list of standards; however, additional standards may be identified in the course of the initiative.

Interface Standards:

- OpenGIS ® Web Map Service (WMS)
- OpenGIS ® Web Feature Service (WFS)
- Catalog Service for the Web (CSW)
- Web Processing Service (WPS)
- Sensor Observation Service (SOS)
- SensorThings (candidate standard)
- 3D Portrayal Services (candidate standard)
- Table Join Server (TJS)

7.2.1 Web Mapping Service (WMS)

The OpenGIS® Web Map Service (WMS) Implementation Specification enables the creation and display of registered and superimposed map-like views of information that come simultaneously from multiple remote and heterogeneous sources.

When client and server software implements WMS, any client can access maps from any server. Any client can combine maps (overlay them like clear acetate sheets) from one or more servers. Any client can query information from a map provided by any server.

In particular WMS defines:

- How to request and provide a map as a picture or set of features (GetMap)
- How to get and provide information about the content of a map such as the value of a feature at a location (GetFeatureInfo)
- How to get and provide information about what types of maps a server can deliver (GetCapabilities)

7.2.2 Web Feature Service (WFS)

The OpenGIS® Web Feature Service (WFS) Implementation Specification allows a client to retrieve geospatial data encoded in Geography Markup Language (GML) from multiple Web Feature Services. The specification defines interfaces for data access and manipulation operations on geographic features, using HTTP as the distributed computing platform. Via these interfaces, a Web user or service can combine, use and manage geodata -- the feature information behind a map image -- from different sources.

7.2.3 Catalogue Service for the Web (CSW)

OGC Catalogue interface standards specify the interfaces, bindings, and a framework for defining application profiles required to publish and access digital catalogues of metadata for geospatial data, services, and related resource information. Metadata act as generalised properties that can be queried and returned through catalogue services for resource evaluation and, in many cases, invocation or retrieval of the referenced resource. Catalogue services support the use of one of several identified query languages to find and return results using well-known content models (metadata schemas) and encodings. Catalogue Service for the Web (CSW) refers particularly to the implementation standard incorporating an HTTP binding. Version 3.0 of this specification includes OpenSearch as an alternative query interface and template mechanism.

7.2.4 Web Processing Service (WPS)

The OGC Web Processing Service (WPS) Interface Standard provides a standard interface that simplifies the task of making simple or complex computational processing services accessible via web services. Such services include well-known processes found in GIS software as well as specialized processes for spatio-temporal modeling and simulation. While the OGC WPS standard was designed with spatial processing in mind, it can also be used to readily insert non-spatial processing tasks into a web services environment. It supports both immediate processing for computational tasks that take little time and asynchronous processing for more complex and time consuming tasks. Moreover, the WPS standard defines a general process model that is designed to provide an interoperable description of processing functions. It is intended to support process cataloguing and discovery in a distributed environment.

7.2.5 Web Processing Service (WPS)

The OGC Web Processing Service (WPS) Interface Standard provides a standard interface that simplifies the task of making simple or complex computational processing services accessible via web services. Such services include well-known processes found in GIS software as well as specialized processes for spatio-temporal modeling and simulation. While the OGC WPS standard was designed with spatial processing in mind, it can also be used to readily insert non-spatial processing tasks into a web services environment. It supports both immediate processing for computational tasks that take little time and asynchronous processing for more complex and time consuming tasks. Moreover, the WPS standard defines a general process model that is designed to provide an interoperable description of processing functions. It is intended to support process cataloguing and discovery in a distributed environment.

7.2.6 Sensor Observation Service (SOS)

The OGC Sensor Observation Service (SOS) Interface Standard defines a Web service interface which allows querying observations and sensor metadata, as well as representations of observed features. It also defines means to register new sensors and to remove existing ones, as well as operations to insert new sensor observations. The SOS implementation specification includes two protocol bindings: an HTTP URL-based key-value-pair (KVP) binding and a SOAP binding.

7.2.7 SensorThings (Candidate Standard)

The OGC SensorThings API (also http://ogc-iot.github.io/ogc-iot-api) provides an open and unified way to interconnect the Internet of Things devices, data, and applications over the Web. The OGC SensorThings API is an open standard, and that means it is non-proprietary, platform-independent, and perpetual royalty-free. Although it is a new standard, it builds on a rich set of proven-working and widely-adopted open standards, such as the Web protocols and the OGC Sensor Web Enablement (SWE) standards, including the ISO/OGC Observation and Measurement data model. That also means the OGC SensorThings API is extensible and can be applied to not only simple but also complex use cases.

At a high level the OGC SensorThings API provides two main functionalities and each function is handled by a profile. The two profiles are the Sensing Profile and the Tasking Profile. The Sensing Profile provides a standard way to manage and retrieve observations and metadata from heterogeneous IoT sensor systems. The Tasking Profile provides a standard way for parameterizing - also called tasking - of task-able IoT devices, such as sensors or actuators.

The Sensing Profile is in fact based on the OGC Sensor Observation Service and the Tasking Profile is based on the OGC Sensor Planning Service. The main difference between the SensorThings API and OGC SOS and SPS is that the SensorThings API is designed specifically for the resource-constrained IoT devices and the Web developers. As a result the SensorThings API adopts the REST principle, the efficient JSON encoding, and the flexible OData protocol and URL conventions.

7.2.8 3D Portrayal (Candidate Standard)

The purpose of this Standards Working Group is to progress the Candidate Web 3D Service Interface Standard v 0.4.0 document (OGC Doc. No. 09-104r1) and the Web View Service Discussion Paper (OGC Doc. No. 09-166r2) to the state of an integrated, adopted OGC standard (http://www.opengeospatial.org/standards/requests/130 and the 3D Portrayal Implementation Standards in https://portal.opengeospatial.org/files/61884). The SWG will achieve this objective by processing the comments submitted during the public comment period and ensuring that the candidate standard is consistent with the OGC baseline and business plan.

7.2.9 Table Join Service (TJS)

The OGC Table Join Service (TJS)[5] standard defines an interface for services that provide the ability to join attribute data stored in one database on a network with corresponding geometry (points, lines, or polygons) stored in another network accessible database.

Attribute data refers to data that can be mapped, but is not directly attached to and bundled with geographic coordinates. Attribute data uses an identifier, found in a framework key field, to indicate the geographic feature to which it applies.

Framework data refers to data that describes the positioning on the surface of the earth of a set of geographic features such as countries. Framework data must include a framework key field, an identifier that allows attribute data to be attached to an individual geographic feature.

For example, a table on one server may indicate the population of various cities, while a second server may contain the geometry that describes the cities' locations and boundaries. The TJS standard describes a set of interfaces for both servers that allows the city name to be used as the "common geographic identifier" in order to join the population data to its geometry, thus enabling mapping and geospatial analysis of the tabular data. An earlier draft of this standard was titled the "Geographic Linkage Service".

[5] http://geoprocessing.info/tjsdoc/Overview

8 Engineering Viewpoint

The Enterprise, Information, and Computation viewpoints describe a system in terms of its purposes, its content, and its functions. The Engineering viewpoint describes an initial design "solution" to problems posed by applying the information and computation elements of the architecture to the requirements of the use cases.

The pilot does not intent to use actual city data servered from services that are in production. It is expected that the participants will simulated the city infrastrcture (city data centers) in a sand box environment.

The following datasets will be made available during the pilot, in the simulated city data center:

- Greenwich
  - Property data – property level data which includes the address, the housing type, coordinates and unique identifiers (such as the UPRN), which allow linkage to other types of data. Currently available as spreadsheet and GIS formats (TBC
  - Housing performance data – surveyed, property level data which can be used as a proxy to predict performance. This includes attributes such as building age, construction type, insulation material etc. Also available as spreadsheet and GIS formats (TBC). It is thought that some in-situ property sensor data (temperature, dampness etc) will be made available. These are to be installed into homes through the course of the FCP, and are therefore not currently available.
  - Adult health & social care data – sensitive adult social care data, specifically for the 3500 population of the Thamesmead area within Greenwich. Option A is to make the data available under NDA, or option B would be to mock-up some representative sample data. Currently we are working with RBG to agree how to best take this forward.
- Rennes
  - BIM model (IFC, at LOD200) for a project on a parcel in Turquety allotment, city of Bruz in Rennes-Metrople
  - Textured CityGML model at LOD2 level on this area – with terrain and buildings
  - Constraint to be checked for this project and parcel, corresponding to the rules exposed in Appendix B
  - (IGN) road and parcel description from IGN databases (in Shape or GML)
  - (IGN) Ref3DNat constraints on CityGML for buildings
- Sant Cugat del Vallès (Barcelona), Spain
  - Cartographic, topographic and cadastral information
  - waste collection and street cleaning, street lighting, water supply, ICT infrastructure, sewage system
- Berlin (exemplar, open data)
  - http://www.businesslocationcenter.de/en/downloadportal
- Rotterdam (exemplar, open data)
  - http://www.rotterdam.nl/links_rotterdam_3d

The above mentioned datasets, made available during the pilot (and during the pilot period only), may be subjected to an Non Disclosure Agreement (NDA) between the participant and the data provider (NDA made available by the data provider).

8.1 Previous work

8.1.1 OWS-4 (2006)

(Taken from the OWS-4 OGC Web Services Architecture for CAD GIS and BIM)

The full document can be found here: http://portal.opengeospatial.org/files/?artifact_id=21622

Bridging the worlds of AEC Workflows with the Open Geospatial Web Services Architecture will allow the varied data models and information flows concerned with Architectural Development and Building Operation together with administrative information infrastructure that is broader in scope. The fundamental pattern of the OGC's Architecture is the Publish-Find-Bind Pattern that permits diverse information sources in a multitude of formats, distributed around the internet, to be discovered and accessed by multi-purpose clients. This integration of information will have benefits to actors in both areas and will enable applications in other areas as well.

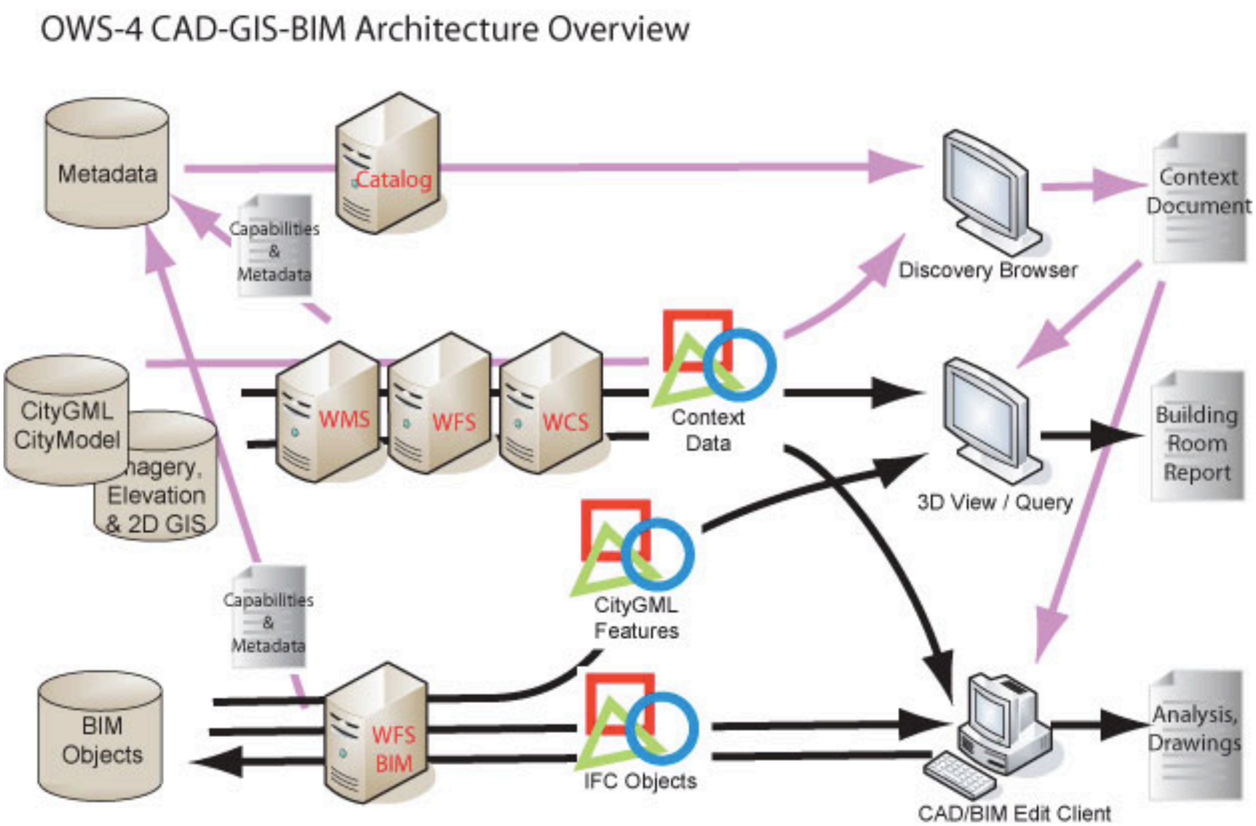


Figure 7: OWS-4 CAD-GIS-BIM Architecture Overview

The activities of the CGB thread resulted in the development of several new types of components that demonstrate the integration of BIM with Open Geospatial Service Architecture: A new type of Transactional Web Feature Service (WFS-T for BIM) that serves features from BIM in both IFC and CityGML; New client capabilities for three dimensional thematic viewing and analysis of building information in CityGML; New capabilities in BIM authoring clients that consume CityGML from WFS and images from Web Map services to allow the development of BIM in geographic context. The testbed also involved several interoperability experiments that stretched the capabilities of existing OGC services to support the new problems of serving CityGML through web feature services. This testbed also resulted in fruitful discussions between the primary custodians of IFC and CityGML concerning the useful overlap of these two means of representing places.

8.1.2 AECOO (2006)

http://www.opengeospatial.org/projects/initiatives/aecoo-1

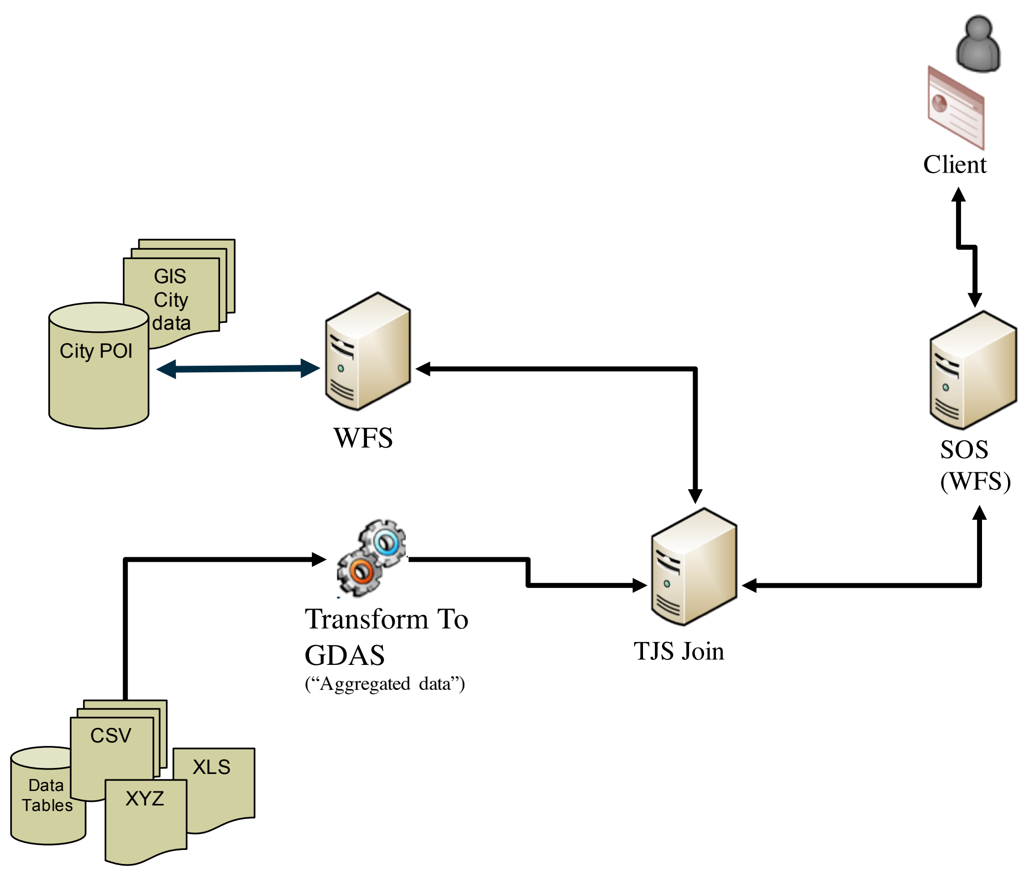
(Also references OGC OWS-4)

Effective design, construction and management of buildings and other capital facilities requires information exchange among all disciplines and professions that have a stake in the design, construction and operation of those facilities. The AECOO-1 Testbed looks at streamlining communications between parties in the conceptual design phase to get an early understanding of the tradeoffs between construction cost and energy efficiency. To that end, the project developed Information Delivery Manuals (IDMs) for quantity takeoffs and energy analysis needs, and used these to define subsets of Industry Foundation Classes (IFCs) needed in these analyses.

Summary of the Architecture, Engineering, Construction, Owner Operator Phase 1 (AECOO-1) Joint Testbed, OGC Document 10-003r1 Public Engineering Report
https://portal.opengeospatial.org/files/?artifact_id=37223&version=3

8.2 Wiring diagram

8.2.1 Serving "Aggregated data" using SOS



The above wiring diagram is purely indicative and exemplar.

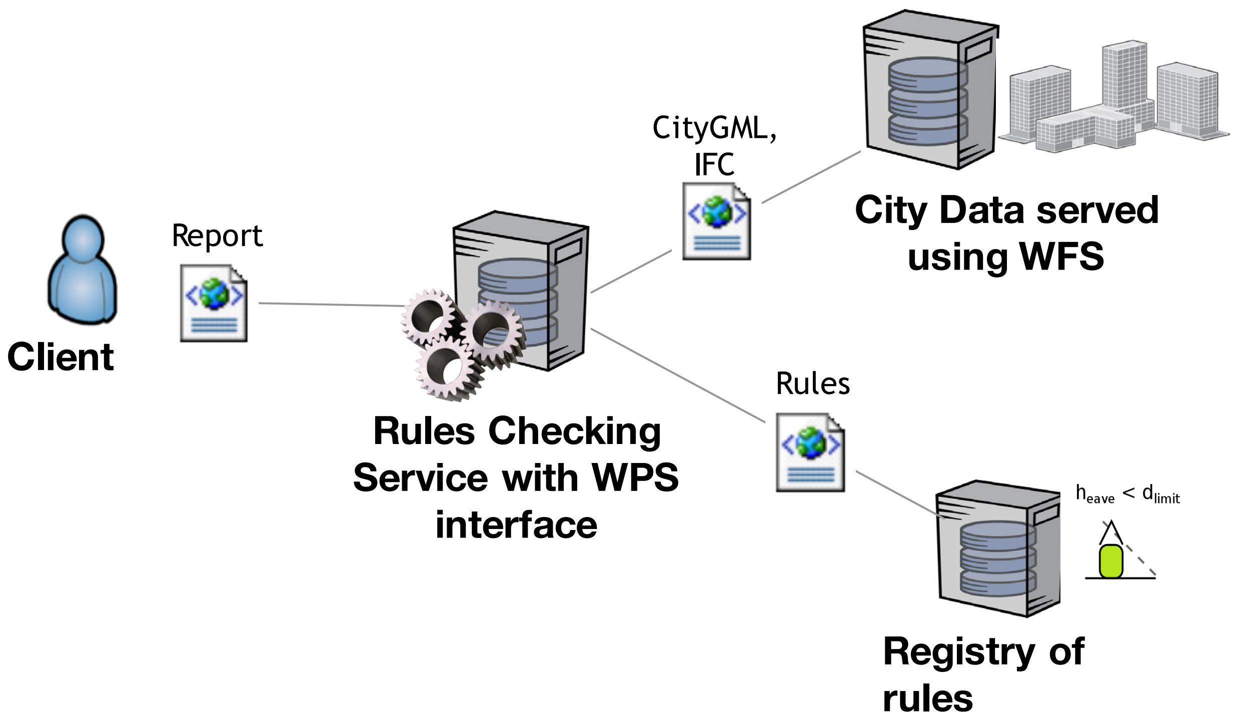
References:

European Location Framework, TJS implementation by Geonovum (Michel Grothe) and Geodetski inštitut Slovenije (Tomaz Zagar). https://portal.opengeospatial.org/files/?artifact_id=64962

Table Join Service Overview: http://geoprocessing.info/tjsdoc/Overview

Table Join Service FAQ: http://geoprocessing.info/tjsdoc/FAQ

8.2.2 Rules Checking Choreography Pattern



The use of WPS is recommended, but not required.

References:

OGC Testbed 10 Provenance Engineering Report , OGC 14-001

OWS-9 CCI Conflation with Provenance Engineering Report, OGC 12-159

OWS-5 GeoProcessing Workflow Architecture Engineering Report, OGC 07-138r1

OWS-5 Conflation Engineering Report, OGC 07-160r1

OWS-4 Topology Quality Assessment Interoperability Program Report, OGC 07-007r1

(To be published: City GML Quality Interoperability Experiment ER)

9 Technology Viewpoint

The technology viewpoint is concerned with the deployed system, describing the hardware and software components used. This architectural view will be developed during the course of this FCP1 initiative to describe the realized Pilot system and the contributions from Pilot participants that it comprises.

Appendix A: FCP1 Architecture References

Refer to the OGC website (http://www.opengeospatial.org/specs/?page=baseline) for the authoritative listing of adopted documents.

Note: Please contact the OGC Tech Desk if you need assistance in gaining access to these documents (techdesk@opengeospatial.org).

OGC Specifications and Supporting Documents Relevant to FCP1:

1) OpenGIS® Geography Markup Language (GML) Implementation Specification (version 3.0), available at: http://www.opengeospatial.org/specs/?page=specs
2) Geography Markup Language (GML) simple features profile (with Corrigendum), (OGC 10-100r3) http://portal.opengeospatial.org/files/?artifact_id=42729
3) OGC® Geography Markup Language (GML) — Extended schemas and encoding rules, Version 3.3 (OGC 10-129r1) https://portal.opengeospatial.org/files/?artifact_id=46568
4) OpenGIS® Web Map Service (WMS) Implementation Specification, version 1.1.1, available at: http://www.opengeospatial.org/specs/?page=specs
5) OpenGIS® Map Context Documents Implementation Specification, version 1.0, available at: http://www.opengeospatial.org/specs/?page=specs
6) OpenGIS® Web Feature Server (WFS) Implementation Specification, version 1.0, available at: ***http://www.opengeospatial.org/specs/?page=specs***
7) IFC Overview Summary available at: http://www.buildingsmart-tech.org/specifications/ifc-overview
8) IFC Release Summary http://www.buildingsmart-tech.org/specifications/ifc-releases/summary
9) xmlIFC release available at: http://www.buildingsmart-tech.org/specifications/ifcxml-releases/summary

Other OGC Specifications and Supporting Documents

10) OpenGIS® Abstract Specification Topic 11: OpenGIS® Metadata (ISO/TC 211 DIS 19115) May 2001, <http://www.opengeospatial.org/techno/abstract/01-111.pdf>
11) OpenGIS® Abstract Specification Topic 12: OpenGIS® Service Architecture (Version 4.3), Percival, G. (ed.), January 2002, < http://www.opengeospatial.org/techno/abstract/02-112.pdf>
12) OGC Cookbooks website: http://www.opengeospatial.org/resources/?page=cookbooks
13) OGC Interoperability Program Concept Development Policies and Procedures" (also available from http://www.opengeospatial.org/ogc/policies/ippp), Percivall, George. 2005

ISO Specifications

14) ISO 19101:2002 (Reference Model): http://webstore.ansi.org/ansidocstore/product.asp?sku=ISO+19101:2002
15) ISO 19107 (Spatial Schema) : http://www.isotc211.org/protdoc/DIS/ISO_DIS_19107_(E).pdf
16) ISO 19108 (Temporal Schema) : http://www.isotc211.org/protdoc/DIS/DIS19108.pdf
17) ISO 19109 (Rules for Application Schema) : http://www.isotc211.org/protdoc/DIS/ISO_DIS_19109_(E).pdf
18) ISO 19115 (Metadata) : http://www.isotc211.org/protdoc/DIS/ISO_DIS_19115_(E).pdf

19) ISO 19119 (Services) : http://www.isotc211.org/protdoc/DIS/ISO_DIS_19119_(E).pdf
20) ISO 19125-1 (Simple Features Access - Part 1: Common Architecture): http://www.isotc211.org/protdoc/DIS/DIS19125-1.pdf
21) ISO 19125-2 (Simple Features Access - Part 2: SQL option): http://www.isotc211.org/protdoc/DIS/DIS19125-2.pdf

Other Related Specifications:

22) Uniform Resource Identifiers (URI): Generic Syntax (RFC 2396) T. Berners-Lee, R. Fielding, L. Masinter, available at: http://www.ietf.org/rfc/rfc2396.txt
23) Extensible Markup Language (XML) 1.0, Second Edition, Tim Bray et al., eds., W3C, 6 October 2000. See http://www.w3.org/TR/2000/REC-xml-20001006
24) XML Schema Part 1: Structures. World Wide Web Consortium (W3C). W3C Recommendation (2 May 2001). Available [online]: http://www.w3.org/TR/xmlschema-1/
25) XML Linking Language (XLink) Version 1.0, DeRose, S., Maler, E., Orchard, D., available at http://www.w3.org/TR/xlink/

Related Supporting Documents:

26) Reference Model of Open Distributed Processing [ISO/IEC 10746]
27) ISO/IEC 29182-1:2013, Information technology -- Sensor networks: Sensor Network Reference Architecture (SNRA) -- Part 1: General overview and requirements.

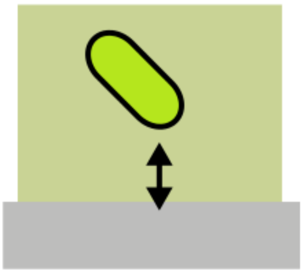
Appendix B sample urban planning validation rules

(from Règlement Littéral Rennes Metropole PLU (sept. 2013, zone UE), in the French language only)

Article 7: Recess with respect to the road alignment

The building or building parts must be located at lateral limit D_{min} from road alignment.

$$d_{road} > D_{min} \text{ m}$$



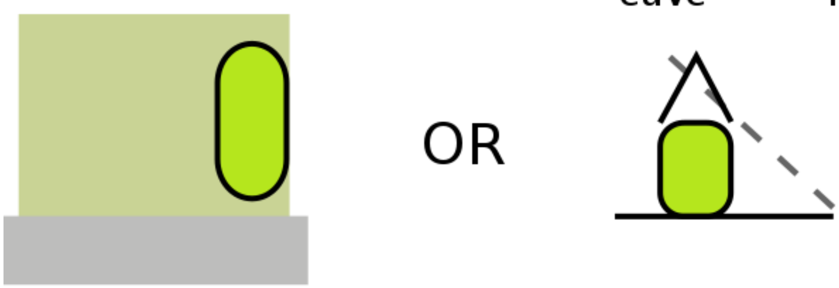
For example, $D_{min} = 4$ m

Recess with respect to the alignment on the separating limits

The buildings or building parts must be located at lateral limit from cadastral limits or in recess to this limit.

In case of recess of one or several lateral limits, buildings or building parts, except the traditional building projections, architectural elements and balconies, must be located at a distance greater or equal to the height at the eave.

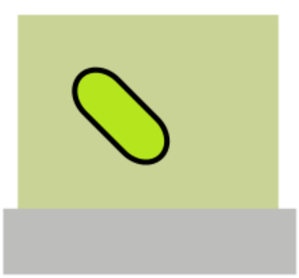
$$d_{limit} = 0 \text{ m} \qquad h_{eave} < d_{limit}$$



Footprint (Emprise au sol)

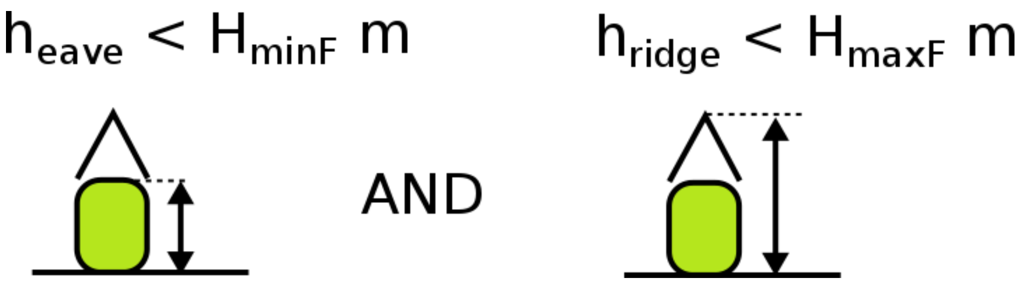
The footprint ration of all buildings, including annexed building part, shall not exceed a regulated limit ratio ($ratio_{max}$, e.g. 40%) of the total parcel surface.

$$area_{built} < ratio_{max} \text{ x } area_{parcel}$$



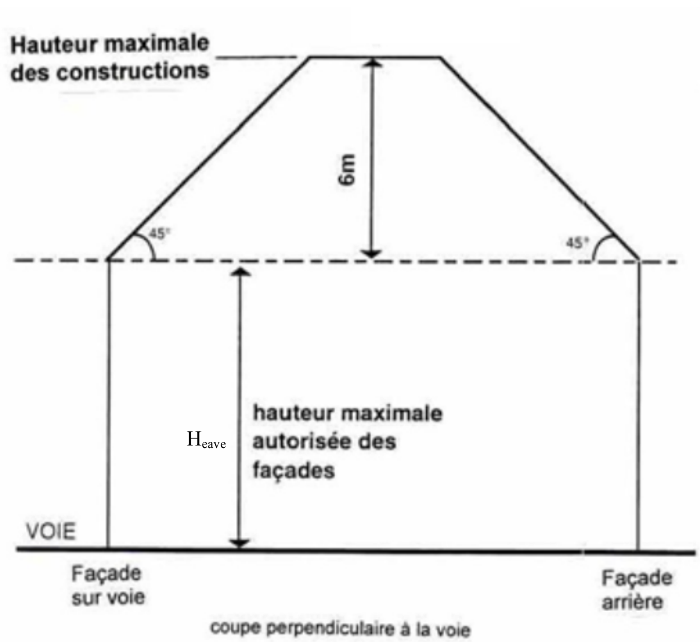
Maximum height of buildings

Maximal height of buildings at eave or parapet must be below H_{maxF} m (e.g. 20 m)
Total maximal height of buildings at ridge must be below: H_{maxB} m (e.g. 26 m, i.e. **6** m above eave - h_{eave}).



<u>Optional additional rule:</u>

L The building must be within a volume defined by a 45° angle from street and back façades of projected building.



Where (translation French to English) for terms in above figure:

- Voie : road
- Façade sur voie : Street façade
- Façade arrière : Back façade
- Hauteur maximale des constructions : Maximal height of facades
- Coupe perpendiculaire à la voie : Vertical cut view orthogonal to street