# Using 3D Urban Information Models to Aid Simulation, Analysis and Visualisation of Data for Smart City Web Services (i-SCOPE)

Martin Ford[1], Scott Cadzow[2], Debbie Wilson[3], Peter Parslow[3], Federico Prandi[4], Raffaele de Amicis[4]
(1) GiStandard Ltd, Hamilton, UK
(2) Cadzow Communications Consulting Ltd, Sawbridgeworth, UK
(3) Ordnance Survey, Southampton, UK
(4) Fondazione Graphitech, Trento, ITALY

**Abstract.** The purpose of urban planning and management has always been to ensure that urban environments are safe and comfortable for current and future citizens. Through the iSCOPE project, 3-D Urban Information Models support the development of interoperable services for energy efficiency, environmental monitoring and the inclusion of aged and disabled citizens. Using open standards, the project integrates existing technology to create data, service and application layers. This paper describes how the existing technologies are integrated and identifies areas where further work is required. The 3-D Urban Information Models provide powerful analytical and decision support tools as well as facilitating the simulation of Smart City concepts. However, the range of data available and the power of the analytical tools can create unforeseen risks to the privacy of citizens, therefore Smart Cities must have powerful and comprehensive data protection policies to ensure that the privacy of citizens is safeguarded.

**Keywords:** Smart city, Geo-spatial, Security, Privacy

## 1 Introduction

In 2012, 50% or more of the population in every EU country live in non-rural areas (urban or intermediate regions, Eurostat, 30 March 2012). The continuing growth in city (non-rural) populations poses a challenge for services and infrastructures which need to grow at an equal rate in order to support rising demand. These increased populations will create new economic opportunities and social benefits for the cities in which they live.

To ensure that our cities can support the population demands, they must become smarter through improved utilisation of the resources available. This paper describes how geospatial technologies can be used to support the development of Smart Cities.

## 2 Smart Cities

Cities can be considered as living, breathing entities, exhibiting many of the stages of growth, maturity and death characteristic of living beings. At present we have a limited understanding of the requirements of creating and building such entities. However there are many techniques that can be used to help us support this understanding. Development of these techniques is the aim of the European Smart City project.

The vision of a Smart City is to improve how we navigate increasingly more complex environments and ensure that our urban environment is safe and comfortable for current and future citizens. The development of Smart Cities also promises to realise new economic opportunities and social benefits.

At the root of Smart City thinking is to view a city as a repository of data and information centered on a specific geographic location. The geography enriches the landscape by providing the pathway to historic, economic and social data. Indeed almost any kind of data can be tied to a location, and it is the richness of such integrated data that can make a Smart City greater than the sum of its parts.

In support of this vision, techniques are being developed that use geospatial data to support environmental monitoring and energy consumption as well as improved inclusion and mobility of aging and disabled citizens. This is being carried out in the i-SCOPE project and this paper covers the contribution of i-SCOPE to the smart city.

## 3 i-SCOPE

### 3.2 i-SCOPE - Project Objectives

i-SCOPE is an ICT PSP project that aims to deliver interoperable Smart City services through an Open Platform for urban ecosystems. The Smart Cities objective for energy control and climate impact reduction aims to prove to citizens that their quality of life and local economies can be improved through investments in energy efficiency and reduction of carbon emissions. This objective has been developed from a wide range of European and international strategies and policies. These include:

- COM(2006)105, 8.3.2006 – A European Strategy for a Sustainable Competitive and Secure Energy
- COM(2007)1, 10.1.2007 – An Energy Policy for Europe
- EC, 2011: A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy

- EEA, “Cities – Investing in Energy and Resource Efficiency”, 2011
- EEA, 2010: The European environment – state and outlook 2010. Synthesis.
- OECD, 2011: Green Growth Strategy Synthesis Report.
- TEEB, 2010: The Economics of Ecosystems and Biodiversity.
- UNEP, 2008: Green Jobs: Towards decent work in a sustainable, low-carbon world.
- UNEP, 2011: Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication
- European Wind Energy Technology Platform;
- European Photovoltaic Technology Platform;
- Euracoal;
- OECD Round Table on Sustainable Development;
- EU Global Energy Efficiency and Renewable Energy Fund (GEEREF);

The contribution of i-SCOPE is to develop smart services to improve decision-making at urban planning and city management levels, with particular regard to issues related to energy efficiency and noise levels as well as citizen inclusion and mobility. These will be based on basic geospatial information about urban pattern and its morphology. Thus i-SCOPE will provide tools to allow Europe to measure and meet the Smart Cities objectives.

The aim of the project is to demonstrate how Smart City web services and mobile/web applications can be rapidly developed using existing Open Standards (OGC/ISO/CEN, INSPIRE, W3C).

iSCOPE’s objectives are to:

- Improve inclusion and personal mobility of aging and diversely able citizens through an accurate city-level disable-friendly personal routing service which accounts for detailed urban layout, features and barriers.
- Optimise energy consumption through a service for accurate assessment of solar energy potential at building level.
- Improve environmental monitoring and assessment using real-time noise measurements collected via citizen’s mobile phones.

These objectives must be delivered securely, safely and with full regard to the privacy of citizens.

### 3.2 Smart city data architecture

The approach taken in i-SCOPE is to view a city as a layered geographic entity. The base layer is the topographical model of the physical environment. Subsequent layers can be added, limited only by the availability of knowledge. To a large extent cartographers have been using this process for centuries. However, digital geospatial technology allows us to massively expand the volume and number of datasets that can be layered and, with the immense processing power now available, build new capabilities from the datasets that we have now or in the future.

i-SCOPE integrates open source technologies and existing services and applications developed by the project's partners. This creates a comprehensive toolkit promoting interoperability through the use of OGC and other open standards for data exchange and services. In turn this allows the independent development and deployment of functionality provided by different web-services. Pre-existing technologies that were not available as individual services will be incorporated in the project's service layer to ensure compliance with the overall schema.

Figure 1 provides the overview of the project architecture.

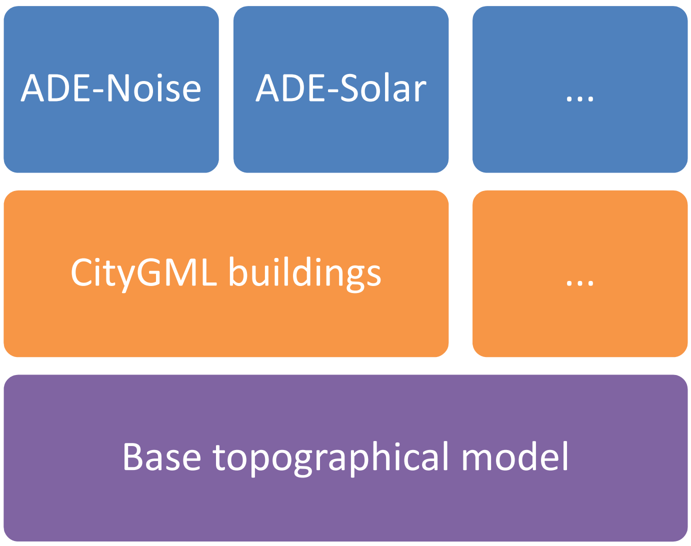


**Figure 1.** Simplified architecture for smart city data modeling

On top of i-SCOPE's open platform, various 'smart city' services are being developed within different domains. These will be piloted and validated in the EU cities identified in Figure 2.

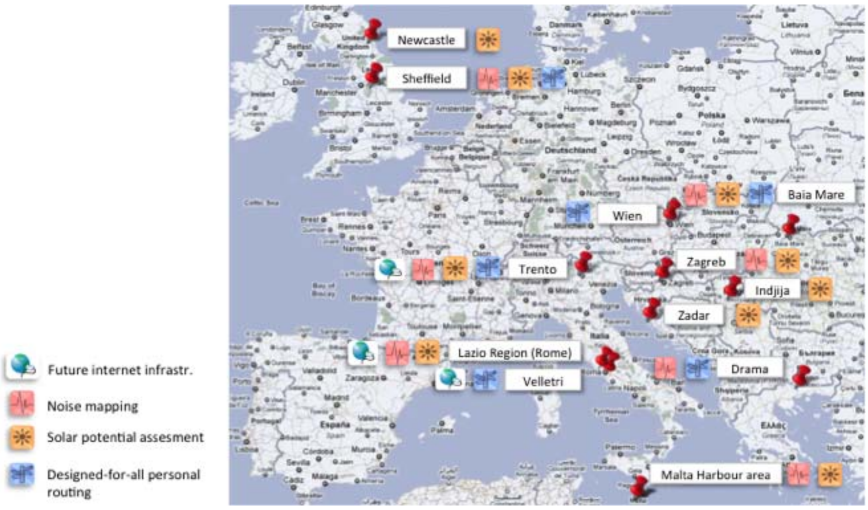


**Figure 2.** The locations of the various pilots planned within i-SCOPE

### 3.3 3-D Urban Information Models for analysis, visualization and simulation

Advances in computing capabilities and the increasing accessibility of new applications allow us to collect and visualise a wealth of information though mobile technologies. In turn this allows us to understand our urban environment in ever increasing detail. The ability to undertake multi-dimensional simulation analysis using data sourced from both traditional data producers (government, research and industry) and by citizens themselves is allowing new relationships and insights to be identified. Also the ability to present geo centric information to citizens and policy makers spatially in 2D and 3D via mobile and web applications offers exciting new ways to engage and change or optimise behaviour.

The latest generation of interoperable 3D Urban Information Models (UIM), created from accurate urban-scale geospatial information, can be used to create smart web services based on geometric, semantic, morphological and structural information at urban scale level.

The structure of the 3D UIM is outlined in Figure 3 and the succeeding sections of the paper provide details about each layer, highlighting the technical components already available, areas where further development is required, and the integration required for each component.

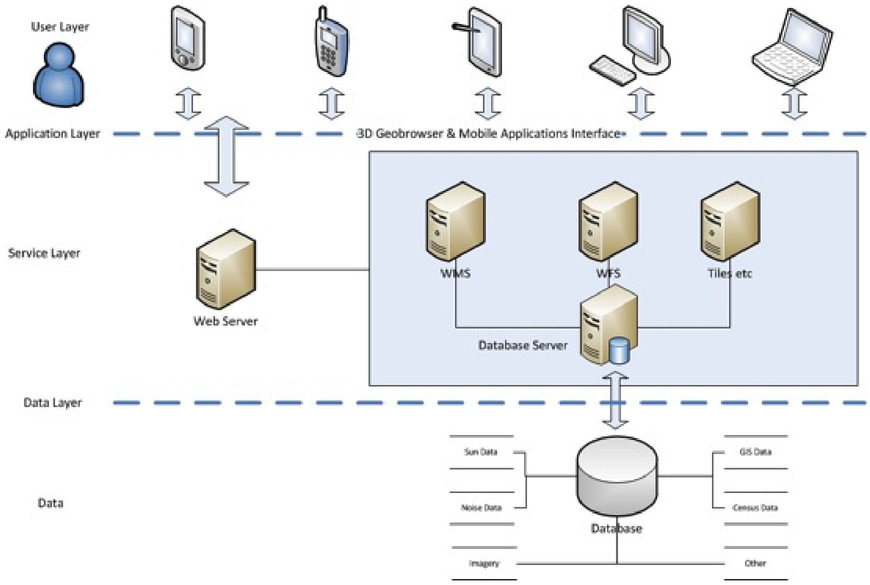


**Figure 3.** System architecture for i-SCOPE demonstrator

### 3.3.1. Data layer

i-SCOPE will significantly rely on CityGML which is the open standard for interoperable encoding of 3D Urban Information Models. The CityGML standard is being developed by the Open Source community. In practice, i-SCOPE requires the development of an extension to the core standard. It will also require the creation of two Application Domain Extension (ADEs) and the extension of a third one (on noise) of the current CityGML. These developments will extend the modelling capabilities of CityGML making it compliant with the requirements of the three scenarios tackled by the project:

- Solar Potential Mapping
- Noise Mapping
- Differently-abled-friendly routing

### 3.3.2. Service Layer

The service layer will require integration of a number of pre-existing technologies, provided by a range of the project's partners. These include integration of the BRISEIDE (www.briseide.eu) platform along with the processing services required. The toolkit is currently undergoing extensive testing in several pilots across Europe and provides services to access spatio-temporal data both in terms of data access and data processing.

i-SCOPE will also extend the routing algorithm developed by BRISEIDE. This is based on OpenStreetMap available datasets and it can be exposed as an OpenLS service. Additionally in i-SCOPE the new service will provide a routing algorithm that will be friendly to people with disabilities. For example; the dataset will provide information on ramps to get on the pavement after crossing a street. The routing algorithm will use this dataset to provide the person using the i-SCOPE service with routes that:

- Require lesser effort to get from point A to point B;
- are the quickest in terms of time
- are the shortest in terms of overall length
- always accounting for the requirements of disabled people.

This is summarised in Figure 4.

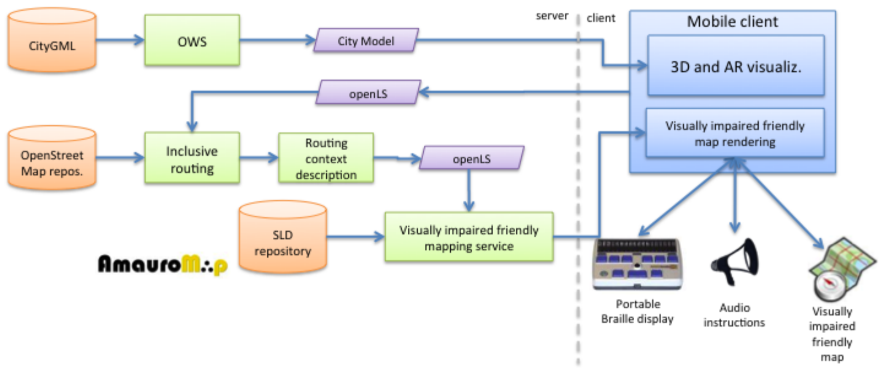


**Figure 4.** The various components and interfaces which will be used within the i-SCOPE inclusive routing pilot

Specifically i-SCOPE will integrate a tool to generate 3D city models based on existing geodata. This process can provide the best results when using high resolution and high accuracy surface models such as LiDAR-produced datasets. In addition, it combines data such as terrain models and floor plans to produce as much a realistic effect as possible. This technology will be customized and adapted to i-SCOPE's requirements in order to operate as a web service. To achieve this, a software layer will be developed around the initial standard application enabling it to provide interoperable access to simulation functionalities via a WPS (Web Processing Service).i-SCOPE will also integrate existing noise simulation technology, currently developed on top of Oracle and ESRI technology. To do so a WPS component will be developed to ensure interoperable communication with noise simulation software as an interoperable web service.

i-SCOPE will use services based on geographic information systems (GIS) extended with algorithms that can create semantic spatial descriptions automatically. The spatial description derives from vector data so that large-scale mapping is possible. This method makes it possible to describe the shape of crossings, blocks, etc. in a standardised way. The semantic and the automated generated textual description of the urban space is created on the server with GIS methods in the background or directly running within.

The basic geographic data is open data from the "OpenStreetMap" project. OpenStreetMap data has been created by its community, is free to download, contains a great variety of attributes and is kept up-to-date in a satisfying way. In addition, the geodatabase is prepared to add more exact data, for example data provided by the local community governments. As a first sample the City of Vienna will provide data as a test region.

i-SCOPE provides a service for calculation of sun potential and production of solar irradiation maps. In order to achieve this the "r_SUN" function – module of GRASS will be customized and integrated in the platform's functionality by creating a WPS interface. Interoperable access to the "r_sun" functionality will be provided through a Web Processing Service

### 3.3.3. Application layer

The web client will be based on 3D Geobrowser, to access and manage geographical information according to OGC standards.

The 3D Geobrowser allows for user interaction with large 3D geo-referenced environments. Operators can refer to an extremely wide range of heterogeneous multi-source, multi-dimensional, time-varying information sources, including GIS maps, aerial or satellite images, morphology of the terrain data

Within i-SCOPE the 3D Geobrowser will be extended to provide support for CityGML's Level Of Detail 2 (LOD2). A further extension is required to allow for interactive visualisation of time varying data (e.g. noise or solar simulation) on top of the 3D urban model. Further limited development is required to customise the graphical user interface.

## 4. Simulation and its role in Smart City

It almost goes without saying that you cannot build a city simply to test a scenario. Therefore, one of the key roles of 3-D Urban Information Models can be to develop simulations to illustrate how Smart Cities can work. With the introduction of complex services, and in particular when those services are layered on other complex services as functional cores, the use of simulation to ensure everything works, and as a means to trial the service in front of its intended audience prior to live use, become essential for both fiscal care as well as for citizen care. There are several approaches to this. For example:

- Noise simulations can be calculated through a remote service, based on interoperable standard WPS. Using this any client (including commercial or open source GIS software) can perform noise simulations by invoking a smart service based on an interoperable protocol.
- The EU Directive 2002/49/EC on the assessment and management of environmental noise requires large cities in Member States to produce noise maps and action plans to curb noise pollution. Current efforts to comply with the directive are based on simulations rather than field measurements, based on statistical data for transport (air, train and large roads) and industry. By using measurement data collected by citizens as well as by traditional sensors, possibly in combination with statistical data (e.g. on urban traffic flows), these existing efforts can likely be improved upon and will certainly throw a different light on the actual situation.
- Simulated maps are by construction dated (typically 3years back), and they are in terms of averages over day, evening and night periods over a whole year. Real-time maps provide finer granularity in terms of time as well as space.
- Simulated approaches map the situation at 4m above the ground at each house's most exposed facade, while real-time noise mapping through mobile sensor networks provides a people-centric view on urban soundscapes: it allows measuring noise levels in the streets where people are.
- Further innovative aspects of the proposed real-time noise mapping framework are:
  - low-cost facilitation of wide-scale people-centric daily sound level measurements (in dB(A)) with hardware that is already out there;
  - immediate correlation with subjective experience and source identification through tags entered by users;
  - comparison of time slots, areas and more generally, citizens' experiences through map querying;
  - geographic visualization of measured sound levels and iterative creation of collective noise maps;
  - improved decision making by better understanding urban noise pollution through data that was not available before;
  - direct feedback from and to citizens, thus engaging citizens according to the paradigm of "people as sensors" and creating potential for awareness-building;
  - high density (in principle) of information on noise levels both outdoor (e.g. on streets) and indoor (e.g. metro).

## 5. The privacy and security dimension

Smart Cities are environments in which people live, learn, work and play. How they do that and how they interact with the Smart City allows the Smart City to learn about them. This implies that a Smart City can build up very detail models of the behaviour of citizens both as generalised communities and as individuals. The success of the Smart City then depends on the development of mutually supportive (symbiotic?) relationships between the city and the citizen.

A citizen looks to the city to provide a huge range of services, and has a reasonable expectation that in order to receive those services some personal data has to be shared with the city. For example in receiving education for children the education authorities in the city need to know the age, sex, religion and academic attainment (maybe even academic desires) of every child in the city. In giving this data to the city the citizen also has a reasonable expectation that the city will not divulge this knowledge to anyone who asks. The protection of such explicitly sought and delivered data can be protected by policies of consent and fair use, and by ring-fencing the storage. However a Smart City gathers significant volumes of data that may be linked to individuals when data mining tools and similar are applied to it. This PII revealing data is not obvious and may not be picked up when the Smart City's data designers conduct their Privacy Impact Assessments. Furthermore ring-fencing data is not a reasonable practice either as it leads to massive duplication, and this is almost always going to lead to inconsistencies.

Therefore, a Smart City has to have a data policy that determines how data is shared between different use cases.

The protection model in i-SCOPE, in common with other evolving web services, is policy based validation of security and privacy. In this model each interacting service exchanges its policy with regard to privacy and security attributes (e.g. identity of users, integrity and confidentiality of data) and when each party agrees them they create a privacy and security contract that binds their sharing of data. Any future interaction is then validated as complying to the contract allowing run time privacy and security protection to be given across the system.

## 6. Conclusion

3-D Urban Information Models provide an extremely powerful mechanism to deliver the vision of Smart Cities. The iSCOPE project is creating an infrastructure that will demonstrate how these models can integrate spatial data from a wide variety of sources to create tools for analysis, visualisation and simulation. As far as possible the project is integrating services and applications already developed by partners in the project. However, some further work is needed to ensure that gaps are filled and the objectives of both iSCOPE and Smart Cities are fully realised.

It is extremely important to reflect on the implications of the project for safety, security and privacy of the citizens of Smart Cities. Data can be synthesised and analysed in ways that cannot be anticipated by the data creators and developers of the system. Therefore it is imperative that a Smart City has a comprehensive data policy to determine how the privacy of citizens can be safeguarded.

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