I-Scope–Interoperable Smart City Services through an Open Platform for Urban Ecosystems

Raffaele de Amicis, Giuseppe Conti, Daniela Patti, Martin Ford, Pietro Elisei

(Raffaele de Amicis, Fondazione Graphitech, Via alla Cascata, 56/C, 38123 Trento–Italy, raffaele.de.amicis@graphitech.it)
(Giuseppe Conti, Fondazione Graphitech, Via alla Cascata, 56/C, 38123 Trento–Italy, giuseppe.conti@graphitech.it)
(Daniela Patti, CEIT Alanova, Concorde Business Park 2/F, A-2320 Schwechat-Austria, d.patti@ceit.at)
(Martin Ford, GiStandards LTD, 1 Swift Bank Hamilton Scotland-UK, martin@gistandards.eu)
(Pietro Elisei, Regione Lazio, Via C.Colombo 212, Rome-Italy, pietro.elisei@urbasofia.eu)

1 ABSTRACT

The latest generation of 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. UIM can be used by local governments to:

- Improve decision-making on issues related to urban planning, city management, environmental protection and energy consumption based on urban pattern and its morphology.
- Promote inclusion among various users groups (e.g. elder or diversely able citizens) through services that account for barriers at city level.
- Involve citizens at wider scale by collecting geo-referenced information based on location-based services at urban scale.

Based on interoperable 3D UIMs, i-SCOPE delivers an open platform on top of which it develops, within different domains, three 'smart city' services. These will be piloted and validated, within a number of EU cities that will be actively engaged throughout the project lifecycle. The services will address:

- Improved inclusion and personal mobility of aging and diversely able citizens through an accurate city-level disable-friendly personal routing service that accounts for detailed urban layout, features and barriers.
- Optimization of energy consumption through a service for accurate assessment of solar energy potential at building level.
- Environmental monitoring through a real-time environmental noise mapping service, by leveraging citizen's involvement will who act as distributed sensors city-wide measuring noise levels through their mobile phones.

All smart services will be based on already available technologies which will be integrated, deployed and made publicly available from a "3D smart EU cities" portal. Potential trust, privacy and data security risks and vulnerabilities, i.e. due to localisation of people, are integral part of the project and will be explicitly addressed.

2 INTRODUCTION

The term "smart city" has been introduced as a liveableness qualifier for urban environments, where advanced technology, tipically based on web-services and web-applications, are made available to the community through latest communication infrastructures (integrating both wired and wireless technologies) delivering "smart" functionalities that can simplify citizens' life or facilitate take-up of new business models by companies, in the context of houses, offices and public places. The scope of smart cities has been further extended through the introduction of advanced mobility management solutions, dealing with both transport infrastructures and information/monitoring systems. Last, but certainly not least, smart city services are being developed to address environmental monitoring and energy efficiency issues. This is affecting not only the energy retail market, where utilities can benefit from smart grid technologies, but also the building construction sector, where the design of low-environmental impact buildings can significantly benefit from more efficient services optimising heating, air-conditioning or power consumption.

The European Commission, within the so-called Digital Agenda, is paying significant attention to smart cities, as technologies associated to smart cities can bring to an improved knowledge-based economy, to better social inclusion and, in more general term, to a more livable environment. The technological and societal evolution required by the concept itself of smart city can act a flywheel that can help Europe

maintain a leading position at the global stage. Several research programmes, initiatives, projects and pilots, are being promoted within Europe and beyond.

The overall ambition is not only new technological but, most notably, societal in that smart cities will have to change the way people interact with others and with the urban environment itself. This is why i-SCOPE (Interoperable Smart City services through an Open Platform for urban Ecosystems), the project presented within this paper, has -among its founding principles- the integration betweemn the "real" city with its "virtual" counterpart, made of ubiquitous and pervasive services for improved mobility, inclusion, energy efficiency. Such a co-existence of real and virtual cities is hyielding a new articulated ecosystem, where citizens' life are closely integrated with urban-level IT services, giving birth to what is often referred to as the "hybrid city".

Moreover, in i-SCOPE different issues, transcending the mere technological domain, are being tackled, including apsects dealing with social and environmental issues. Indeed in i-SCOPE each technological solution is not considered as an achievement "per se", but it engineered following an open-innovation, user-driven approach, with the ultimate goal of promoting a so-called "humane city".

The rapid technological evolution, which is characterizing all the disciplines involved within the wide concept of smart cities, becomes a key factor to trigger true user-driven innovation. For this reason, i-SCOPE is making a substantial effort to maximise user-driven innovation by involving, from the earliest stages of the project, citizens, public officers, high-tech entrepreneurs, administrators, decision-makers. This way an bottom-up research process based on open the innovation system, is being promoted within three key research domains: 1) inclusive routing, to facilitate personal mobility of diversely-abled citizens; 2) solar impact analysis, to promote energy savvy planning policies; 3) crowdsourced environmental monitoring, to be able to use citizens and mobile IT technologies (i.e. smartphones) as distributed sensors of environmental information.

3 OBJECTIVES

The objectives of i-SCOPE are manifold. First of all i-SCOPE will eliver an open-source toolkit based on 3D Urban Information Models (UIMs), developed according to the principles of service-oriented architecture, and based on use of open standards from the Open Geospatial Consortium (OGC). The toolkit will be released as open source solution ready to be deployed by city administrations. The toolkit will include services capable to create 3D urban models from raw data such as surface models (e.g. LIDAR), terrain models and building floor plans according to the OGC standard CityGML.

The toolkit will include smart services that will be used to:

- Improve decision-making in planning processes and policy design at city-regions management levels, with regard to issues related to energy efficiency and noise levels, based on urban pattern and its morphology.
- Promote inclusion and mobility of differently-abled people and elderly users through guiding technologies, based on use of mobile IT devices (e.g. smartphones) that can help them overcome barriers at city level and that support them during their daily urban trips.
- Involve citizens at wider scale in the collection of real-time location-based information at urban scale with particular attention being paid to mapping of noise. It should be noted that the third domains has clear policy implications in that creating technology capable to deliver real-time noise mapping can help city achieve the requirements of the Environmental Noise Directive (END) (2002/49/EC). The Directive, which clearly expresses the importance of the participation of all involved citizens, among other obligations, enforces Member States to provide strategic noise maps on a regular basis (5 years) as of 2012, for major roads, railways, airports and agglomerations (>250k inhabitants), using harmonised noise indicators. These maps can be used to assess the number of people annoyed and sleep-disturbed respectively throughout Europe, to address issues emerged during each assessment period, and to create action plans for said target areas. The approach pursued by i-SCOPE is in line with Article 9 of the Directive which states that citizens must be provided with clear and accessible noise maps, disclosing areas exceeding value limits.

The aforementioned smart city services will be tested within a variety of real network ecosystems available in the cities involved in the project, ranging from city-wide sensor networks (as in the case of the city of Velletri, Italy), to large scale regional optic fibre networks (in the case of Trento and Lazio Region, Italy), to mobile location based services.

Due to the nature of the technology being developed, which heavily relies on location based services and tracking of the users' position, i-SCOPE will pay significant attention to the development of trustable, secure privacy schemes to ensure the highest level of protection of users' information. This is necessary since such a set of real-time, location-based mobility services poses significant security and privacy issues (due to traceability of people's location, actions, travel plans etc). The i-SCOPE project shall ensure that the privacy of users is respected whilst providing protection of the data at the core of the system and the interaction of users with that data in line with the data protection laws.

Furthermore i-SCOPE aims at providing a significant contribution to standards in the domain of smart city services, through contribution to extension and wider adoption of the OGC standard CityGML as key enabling open standard for 3D smart city services. With specific regard to this, i-SCOPE has the following goals:

- Promoting establishment of a common "Urban Information Model" (UIM) based on CityGML within a network of cities in Europe of relevant critical mass, and to create specific applications on top of these UIMs. It is worth noting that the outcomes of the project will neither be isolated nor stand-alone. In contrast, the adoption of a common standard (i.e. CityGML) ensures that applications realized in City A can be transferred and utilized in City B. This represents an important asset of the project and an essential factor to facilitate cooperation within the cities.
- Accelerate the uptake of CityGML as the reference standard to support simulation at urban and regional level, by integrating or extending existing open platforms in several EU cities. In practice this will done by making combined use of existing mobile technologies, location based services, sensor networks, high performance networks and 3D technologies and by integrating them into a comprehensive software suite that can deliver novel services to tourists, local residents, businesses and and public administrations.
- Extend the core CityGML open standard, through a formal submission to the OGC consortium, to define specific CityGML Application Domain Extensions (ADE) relevant to the pilots selected, specifically in the domain of inclusive routing, solar energy assessment and noise mapping.
- Promotion of a number of targeted awareness activities to accelerate the uptake of CityGML as the reference standard to support urban-scale smart services, sustainable planning and simulations.

4 THE PROJECT DESCRIPTION

4.1 Issue proposed and target users

i-SCOPE delivers an open source toolkit for 3D smart city services based on 3D Urban Information Models (UIM), created from accurate urban-scale geospatial information.

The smart services proposed address the following three scenarios:

(1) Improved inclusion and personal mobility of aging people and diversely able citizens.

(2) Energy dispersion & solar energy potential assessment.

(3) Noise mapping & simulation.

The targeted users of i-SCOPE are:

- Diversely-abled citizens needing customised routing instructions. Specifically, mobility impaired users or people with limited ambulation requiring barrier-free routing functionalities or visually impaired users who cannot read maps and need voice-based semantically rich routing instructions.
- City administrations that need to define policies in terms of heat dispersion and solar potential at urban level as well as experts/professionals/companies that need to have high precision solar potential assessment.

- City administrations needing to assess noise through simulation as well as existing mapping data in order to create noise maps according to EU Directive 2002/49/EC on noise. Citizens, who can access real-time data as well as accumulated maps on areas and time-scales of interest.

4.2 Usage

The typical use case of i-SCOPE starts with a differently-abled user, for instance with mobility constraints (e.g. a wheelchair user), who starts an App in their smartphone looking for a route that can guide them through the city along barrier-free routes. Directions are provided by the smartphone through an easy-to-use Augmented Reality interface.

Another differenty-abled users, with serious visual impairement, asks for a customised route that can guide them through the city. The smartphone in this case starts providing spoken, semantically-rich instructions describing the surrounding context in detailed manner. Additional feedback is also provided through a portable Braille displays connected to the smartphone via Bluetooth.

In a different scenario a city planner starts a 3D web application to create very high-resolution solar potential maps of the city. This is required to define new policies or incentive schemas at the city level. The solar potential map is created, through a specific web services, from an interoperable 3D model of the city. Professionals can also use the 3D web-client to access the 3D city and provide for a specific building information on a refurbishing project, for instance uploading relevant data, such as thermo images, regarding energy performance of a building. This is part of a compulsory procedure to obtain an certification on energy rating of the building.

In the last scenario a city administrator starts a 3D web application to access noise data being retrieved by citizens through their mobile phones. Users are used as remote sensors and the data generated by their smartphone through an ad-hoc App, can be used to generate 3D real-time noise mapping data. The system also allows accessing historical data regarding noise maps. Citizens can use the App to provide real-time measurements of noise levels in specific parts of the cities to file an official complaint for excessive noise exposure (e.g. due to vicinity of roadwork or entertainment venues).

4.3 Innovative features

From the aforementioned use cases it is clear that i-SCOPE features a number of innovative aspects. With regard to the first use case Most routing and navigation systems have been developed for vehicles. i-SCOPE smart routing service returns orientation and navigation information, customised to cater for diversely able users, providing:

- Automatic map-descriptions in words (e.g. for visually impaired users or in contexts where visual information cannot be accessed).
- Maps with larger fonts and/or mouse over acoustic descriptions.
- Navigation descriptions in easy to hear versions.
- Navigation directions provided in a format suitable for Braille displays.
- Information about the surrounding, i.e. streets (name of the street, lengths, type, crossings), landmarks (points of interest, orientation points) and areas (parks, squares).
- Navigation functionalities without distances (in meters) but based on landmark descriptions.
- Context awareness, through a “visual map in words” (automatically read aloud by the client) providing all the required spatial information.
- A visual map whose graphical appearance is adapted to the specific user requirements of visually impaired users.
- A simple button to invoke the “where am I?” function providing additional descriptions of the surrounding targeted to people with reduced orientation skills (e.g. elderly users).

When observing the second use case, dealing with solar potential mapping, i-SCOPE provides an improved solution, if compared to current solar assessment GIS (e.g. ESRI Solar Analysis), since it ensures a calculation based on real 3D layouts of buildings. Traditional applications instead calculate solar potential based on raster data that need to be created separately from existing terrain and, if available, merging

building information. Other online services (e.g. Photovoltaic Geographical Information System by JRC) is simply based on the position (lat/lon) and through manual specification of the roof layout (orientation, slope etc.). i-SCOPE solar assessment is based on accurate 3D georeferenced models of urban environment and therefore accounts for:

- Real layout of roofs and other structures (e.g. walls, slabs etc.).
- Correct positioning.
- Shadowing effects induced by adjoining buildings as well as vegetation, infrastructures (e.g. power line posts).

Unlike other solution all the aforementioned information is automatically calculated from a high precision UIM available in the interoperable standard CityGML. In turn as output the services delivers:

- Interoperable provision of solar maps through Web Coverage Service (WCS) or Web Map Service Time (WMS-T).
- Solar simulations can be calculated through a remote service, based on interoperable standard WPS. This way any client (including commercial or open source GIS software) can perform simulations by invoking a smart service based on an interoperable protocol.
- Finally i-SCOPE promotes an innovative scenario to support the update of data on heat dispersion from community of citizens and professionals. This information can be later accessed by city administration for planning or taxation purposes. City administrations can easily create maps to show how policies have contributed to improving energy efficiency in areas of the city.

Last but not least, the third scenario, dealing with noise mapping, has a distinct innovation flavour in that:

- Noise simulations can be calculated through a remote "smart" web service, based on interoperable standard Web Processing Service (WPS). This way 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 3 years 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

4.4 Technology

i-SCOPE integrates open source technologies and previously developed partner projects within a comprehensive toolkit promoting interoperability through the use of OGC and other open standards for data exchange and services. This allows for independent development and functionality deployment provided by different web-services. In i-SCOPE pre-existing technologies, wherever not available as services, will be wrapped by a service layer in order to ensure compliancy with the overall schema The following diagram provides an overview of the project architecture.

i-SCOPE will significantly rely on CityGML. This is the open standard for interoperable encoding of 3D Urban Information Models. Since i-SCOPE refers to Smart Cities CityGML and its extension according to the requirements of the project is the most prominent solution. The standard is being developed by the Open Source community under coordination of OGC. As previously mentioned, i-SCOPE requires extension of the core standard as well as the creation of two Application Domain Extension (ADEs) and the extension of a

third one (on noise) of the current CityGML. This will extend modelling capabilities making CityGML compliant to the requirements of the three scenarios tackled by the project:

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

i-SCOPE services will integrate 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 dataset, and it can 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 the 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.

i-SCOPE will also rely on integration of existing technologies. Specifically i-SCOPE will integrate a tool to generate 3D city models based on existing geodata developed by MOSS (a German company partner of the project), that can provide combine different data such as terrain models and floor plans to produce a realistic 3D city as CityGML. The technology will be customized and adapted to i-SCOPE's requirements in order to operate as a web service through a software layer that can 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 an WPS component will be developed to ensure interoperable communication with noise simulation software as interoperable web service. Similarly i-SCOPE will also deliver a service for sun potential calculation and production of solar irradiation maps by extending the "r_SUN" function – module of GRASS by creating a WPS interface.

i-SCOPE will also use services developed by partner CEIT that can create semantic spatial descriptions from GIS repositories. The spatial description derives from vector data so that a largescale mapping is possible. This method makes it possible to describe the shape of crossings, blocks, etc. in words and in a standardised way.

The project will also integrate noise level mapping technology based on NoiseTube, a technology initially developed within the scope of the FP6 project TAGora by Sony CSL in collaboration with Vrije University Brussels. The NoiseTube application for smartphones allows users to collect geo-located noise level measurements and share them in real-time. The NoiseTube server software, accumulates and stores all shared data and uses it to generate noise maps (as OGC KML files), user tag clouds and basic statistical noise information.

The web client will be based on 3D Geobrowser, developed by Fondazione Graphitech to access and manage geographical information according to OGC standards. This is a mature software, that currently supports exchange of map information in a totally interoperable manner; loading of CityGML models; access to processing features as WPS. The system is based on an enterprise level SOA designed to provide all the access, management and processing functionalities of multi-dimensional GIS and satellite data through OGC – OpenGIS Consortium compliant web services. Within i-SCOPE the 3D Geobrowser will be extended to provide support for CityGML at high level of detail.

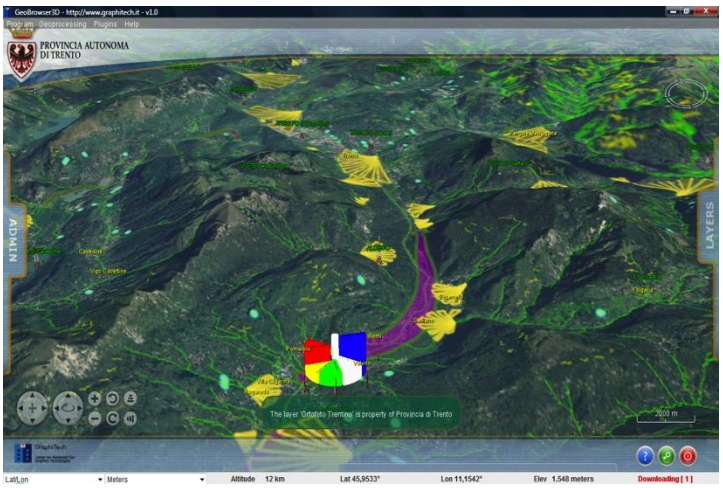

Figure 1: the 3D web-based GeoBrowser by Graphitech

5 CONCLUSIONS

i-SCOPE is facing very critical issues connected to the future quality of life and economic/financial performances of our cities and city-regions. Decision making processes, at local, regional and national scale, are more and more connected to the use of complex tools based on articulated and mult i-SCOPEs informative systems and related digital tools.

The three adjectives (smart, inclusive and sustainable) characterizing the EU2020 strategy request for major change in the way of defining the way of being competitive and at the same time keeping under control the unbalances connected to regional disparities, but even to look for more effective and efficient solutions in the se of digital data. In fact, this way, especially those connected to the definition of smart solutions for the economic growth of European cities, city-regions and major scale territories, is strictly connected to the proper design of an EU Digital Agenda (DA).

The i-SCOPE outcomes are to identify in set of tools, services and policies that will contribute to major horizontal tasks connected the EU digital Agenda (e.g. access of data owning to public sector information, and enhancing the EU innovation capacity), but, at the same time, the project's outcomes will affect and impact on the realms of a) interoperability and standards of spatial data, b) the research and innovation sectors and c) trying to propose effective solutions to major social challenges (e.g. ageing issues).

Moreover, the implementation of smart services in the urban realms could be one of the innovation to consider for town planner in order to understand and better design the new planning challenges determined by ICT inputs, solutions, opportunities. It is to consider that for many cities, and this is valid even for i-SCOPE pilot partners, "going smart" could be currently seen just as a slogan useful to be in a stream of EU investments. It is important to understand, in implementing i-SCOPE, which ICT solutions can really make the difference in terms of a) making planning instruments more effective and efficient (re-thinking the way of designing planning tools), b) moving the decision making process to a wider arena (communities matter), c) opening new opportunities for public and private spaces in the city (technology helps in exploiting hidden, until now, potentialities). i-SCOPE introduces services based on 3D data and technologies in the world of town planning, where decision making is literally and legally centred on 2D tools; this is definitively a frontier to consider, smart technologies based on use of 3D data. Smart services should not just focus on practical application (e.g. this part of cities is suitable or not for solar enegy tools…), but should be capable to contextualize the capabilities of facilitating practical application into a major urban strategic framework, if the smart cities services find the way to pass from the scale of 'solutions providers" to that of strategic organiser of cities potenitalites in terms of energy, noise, use of spaces, mobility, services to citizens and so on at urban and metropolitan scale, at this point we cann see them as vectors of innovation within the many contexts of urban planning.

Concluding, the many i-SCOPE outputs, from the more technological ones to the definition of indicators and frames for policies, will fall on different categories (from meta data modelling, definition of platform to the design of services and urban/territorial policies) that cannot bring to a synthesis if not faced in the context of a pluralistic and multi-faced governance based on the directive and directions given by the EU. The

questions connected to inter-regional/cross border use of data, those connected to the indications for the design of trans-national services (the market is definitively global), the other linked with the indication to provide for the design of policies and strategies (the EU should provide a soft creation of coherence among all national and local policies in order to avoid unbalances in use of funds and in the definition of policy principles) are just few examples that demonstrate how the i-SCOPE purposes cannot be solved at local or at national level, but required to be set up, experimented and implemented at EU scale through the implementation of a partnership including, public administration (cities and regions) SMEs and research centres.

6 ACKNOWLEDGMENTS

The project i-SCOPE has received funding from the EC, and it has been co-funded by the CIP-ICT Programme as part of the Competitiveness and innovation Framework Programme (http://ec.europa.eu/ ict_psp) under the objective identifier 5.1: Open Innovation for Internet-enabled services in 'smart' cities' (GA N. 297284). The author is solely responsible this work which does not represent the opinion of the EC. The EC is not responsible for any use that might be made of information contained in this paper.