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This deliverable defines the requirements for the development of UrbanAPI tools and applications for different scenarios of Vienna, Bologna, Vitoria-Gasteiz and Sofia.
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016	Zaheer Khan (UWE)	rfc	Master document with changes and comments	23-02-12
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023	Ivan Filipov (ASDE)	rfc	Section 9.2 – Public Motion Explorer requirements for Sofia City	28-02-12
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037	Wolfgang Loibl (AIT)/ Venco Bojilov (ASDE)/David Ludlow (UWE)	rfc	Full Section 9 is under development due to potential involvment of city of RUSE for urban growth simulation. Basic scenarios have been produced and are under discussion.	25-09-12

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Version	Reviewer	Comment	Date
001	Cristina Garzillo (ICLEI) and Thorsten Reitz (FH-IGD)	Managed and Coordinated by QA Leader – Paola Mauri (AEW)	23-04-2012

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About this Document

This document specifies the user requirements of the UrbanAPI system. It reports on the six-month activity of the workpackage *WP2: Requirements Gathering and Stakeholder Engagement* of the UrbanAPI project and is *Project Deliverable D2.1 – Requirements Definition*. The document has been produced by the collaboration of the workpackage WP2, the participants of the workpackage have all duly contributed to the activity of the workpackage and the production of this document and all the requirements are endorsed by the city partners as the conclusion of the deliverable. City planners, urban and transport planners, city administrations, policy makers, ICT developers with interest in urban governance, policy modelling and citizens participation can benefit from this document.

Please note that Section 9 of this document is being revised due to potential involvement of city of Ruse in the project for urbanAPI appilcations.

1 Introduction

Urban planning aims to manage the territory in order to address the key political concerns of European citizens, including climate change, greenhouse gas emissions, uncontrolled urban sprawl, urban health and biodiversity loss etc. However, this presents major challenges for urban planners and politicians as cities are extremely complex systems, and the various drivers of change, impacts and responses are strongly interrelated, support, alter or compete with each other.

Indeed the effective governance of the cities and city regions of Europe today is fundamentally undermined by this urban complexity, whereby the high degree of interconnectedness and multiple interactions between socio-economic and environmental factors in a territorial context create major barriers to the effective implementation of sustainable urban development.

ICT enabled governance of cities offers substantial opportunity for the application of enhanced intelligence in urban management, to overcome barriers to sustainable development. This can be achieved by enhanced assessment of urban complexity, improved decision-making support, all facilitating the delivery of more sustainable compact cities. Moreover the wider potential of ICT enabled urban governance is evident in the ability to simultaneously achieve effective management of the complexity of the city, and engage citizens in defining their urban futures.

The UrbanAPI tools will provide advanced ICT-based intelligence in three urban planning contexts. First, directly addressing the issue of stakeholder engagement in the planning process by the development of enhanced virtual reality visualisation of neighbourhood development proposals. Second, at the city-wide scale, developing mobile (GSM) based applications that permit the analysis and visual representation of socio-economic activity across the territory of the city, and in relation to the various land-use elements of the city. Finally, developing simulation tool applications in the city-region context addressing multiple challenges in responding to the simultaneous demands of both expanding city populations for certain European cities, and declining and frequently ageing populations elsewhere.

The essential first step in the development of the UrbanAPI tools is the definition of user requirements, and the prime purpose of this document. The reason for this focus on user requirements is that the UrbanAPI applications collectively provide vital decision-making aids for urban planners in the management of the territory, as well as for the associated responsibilities in political negotiation, and wider stakeholder engagement regarding the future development of the territory. These applications are highly specific not only to the planning related role they perform, but also to the specific context of the city and the system within which they are designed to operate. It is only, therefore, with the detailed engagement of the end-user's of these tools, and their knowledge of the context and systems specifics of their application and that useful products can be developed.

This document therefore provides, following a general overview of the challenges facing urban planning and policy from a user's perspective (section 2), a full analysis of the methodological process for requirements management (section 3), a review of the stakeholders involved in the process (section 4), and an overview of the case study cities and UrbanAPI applications to be developed (section 5). Sections 6 to 9 of the document provides detailed specifications of the requirements for each of the 4 application cities in relation to their selected UrbanAPI applications. Finally, section 10 reviews the common requirements arising from each of the 3 applications proposed, and section 11 addresses the issue of requirements validation and acceptance.

2 Urban Planning and Policy: user perspectives

2.1 User-defined solutions – urban sprawl

As indicated above ICT innovation applied to urban governance appears to offer significant opportunity to improve decision-making and deliver more sustainable cities. However, it is well-established that unless a user-defined framework and requirement for the development of ICT solutions is provided, the solutions offered will not fully meet the needs of the end-user. Accordingly is necessary to examine in more detail user needs, which are explored below with reference to the challenges of managing cities to minimise urban sprawl and its associated environmental, economic, and social impacts.

Apart from wealth, health and happiness, the ideals of the good life and quality of life are often equated with maximum person mobility and car ownership facilitating life in the green suburban environments surrounding Europe's cities. These aspirations provide important drivers for the sprawling urban area, which is arguably the antithesis of sustainable urban development.

Indeed the evidence for the unsustainable nature of Europe's sprawling cities abounds. Car based transport growth associated with the sprawling cities of Europe is a main driver of the growth of transport related greenhouse gas emissions. In 2005 transport emissions accounted for almost 20% of greenhouse gas emissions in EU25. Road transport is responsible for 93% of all transport emissions and urban transport accounts for half of these emissions. The correlation between the expansion of urban land use and the growth of transport related greenhouse gas emissions is very strong, much stronger than for other factors including population growth and GDP.

Furthermore, it is not just the issue of urban sprawl as a driver of greenhouse gas emissions that raises cause for concern, but also the connection between sprawl and a variety of other environmental impacts in the urban area. For example, car based urban transport growth associated with the sprawling cities of Europe is a prime driver of not only greenhouse gas emissions, but also associated pollutants (Green Paper on Urban Mobility (EC, 2007). Urban transport accounts for 70% of pollutants and 40% of GHG emissions), driving climate change and impacting adversely on human health in the urban area. Emphasis in the analysis of urban challenges and their causality, from a sustainable development perspective is therefore given to the interconnected nature of the challenges in the city, which reflects the ecosystems perspective on the city.

Key political concerns with climate change, greenhouse gas emissions, poor air quality and biodiversity loss etc are all fundamentally related in the land-use - transport - environment nexus, in which the complex interrelationship between land-use planning, transportation planning and associated environmental impacts are critically related to the nature of urban form, and in particular the extent to which the urban area is more sprawling or more compact.

These, universally complex interactions between the drivers of change in the urban environment, including land-use and transport planning, the resulting sprawling urban form, and the environmental impacts resulting from these interactions are illustrated in Figure 2.1: Policy Model - Urban Change Drivers and Impacts.

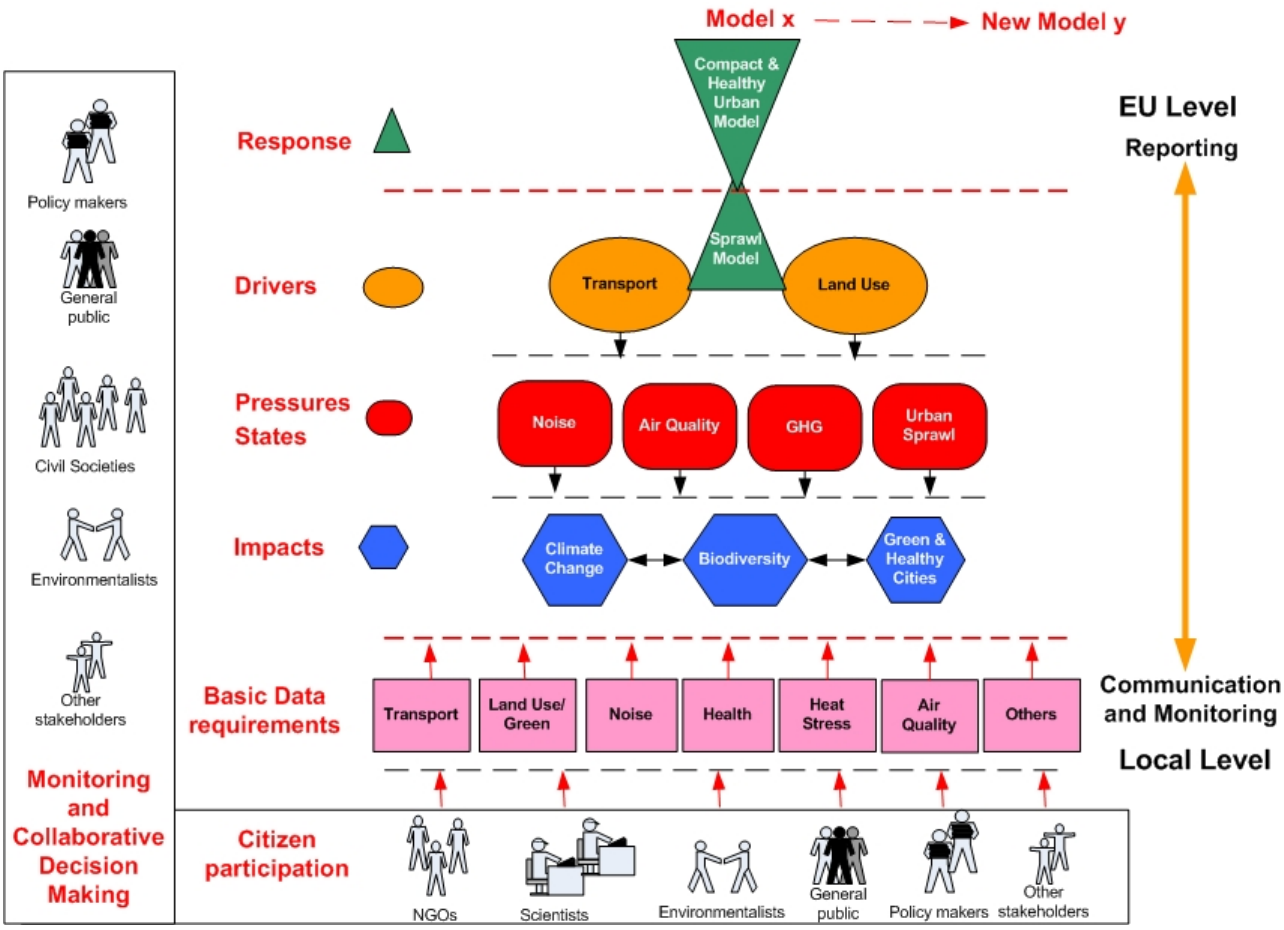


Figure 2.1: Policy Model - Urban Change Drivers and Impacts [9]

2.2 win-win opportunities – policy integration

The challenges of urban management are substantial, however set against these charges the opportunities for sustainable urban development in prising open this complexity are great. Appropriate policies to address the growth of transport related emissions in the context of the land-use - transport - environment nexus can not only secure the win-win possibilities for positive impacts on climate change, but also effectively address other environmental and social priorities without limiting the economic growth of the city.

This political opportunity to ensure that climate change adaptation and mitigation is consistent with, and promotes healthy and economically viable urban communities, underpins numerous initiatives over the past decade to secure integrated urban management, recognising that is more effective solutions must be based on better land use policies as part of an integrated and holistic policy response.

These principles are well illustrated by the example of urban sprawl impacts. Critical to the formulation of appropriate policies for the management of urban sprawl is the understanding provided by the Green Paper on Urban Transport (EC Com (2007) 551 final) [12] that the low density environments created by urban sprawl including dispersed home, work and leisure facilities result in increased transport demand that cannot be effectively satisfied by collective transport solutions. In other words sprawl cannot be fixed by investment in public transport alone, and effective solutions must be based on better land use policies as part of an integrated policy response. Such integrated policy responses inevitably demand collaboration between numerous sectoral agencies at the local level.

Equally, collaboration is required between the levels of government from local to EU levels. This is evident from examination of the widespread failure of local governments to prevent ever greater sprawling of cities. Evidence from the European Environment Agency urban sprawl report indicates that EU infrastructure investments conflict with and thereby undermine local policy initiatives to contain sprawl. Consequently coordination and collaboration is required, and urban planning can no longer be considered just a local or national issue, but that its impact on climate change make it also a matter where EU has clear responsibility to act in cooperation with the local and regional levels of governance. Neglect of this reality furthermore threatens to undermine the achievements of other climate change policies.

Indeed, a principal issue undermining the integrated approach to policy formulation and implementation is the lack of connectivity in both vertical and horizontal policy dimensions, in no small part due to the fragmentation of information and intelligence essential to support integrated policy definitions and policy implementation.

For example, at the local level agencies addressing the management of urban regions to contain urban sprawl have a critical need to integrate data across the sectoral domains of land-use and transport. However, given their distinctive departmental identities, the prime sources of information and data, information management and decision support tools developed for land-use and transport policy analysis are typically not interoperable. Active communication and data integration not only between sectoral agencies at the local level, but also between the levels of governance from local to EU, is critical to the attainment of the policy objectives for urban areas.

These horizontal and vertical dimensions, not surprisingly, also define the prime lines of communication and connectivity between sectoral agencies at the local level, as well as between levels of governance in a vertical perspective, all essential to the development of an integrated policy response. These dimensions for the engagement of agencies in the planning process, thereby provide the structuring principles for policy integration and for the policy implementation model, and are identified in Figure 2.2: Implementation Model - Structuring Principles, below.

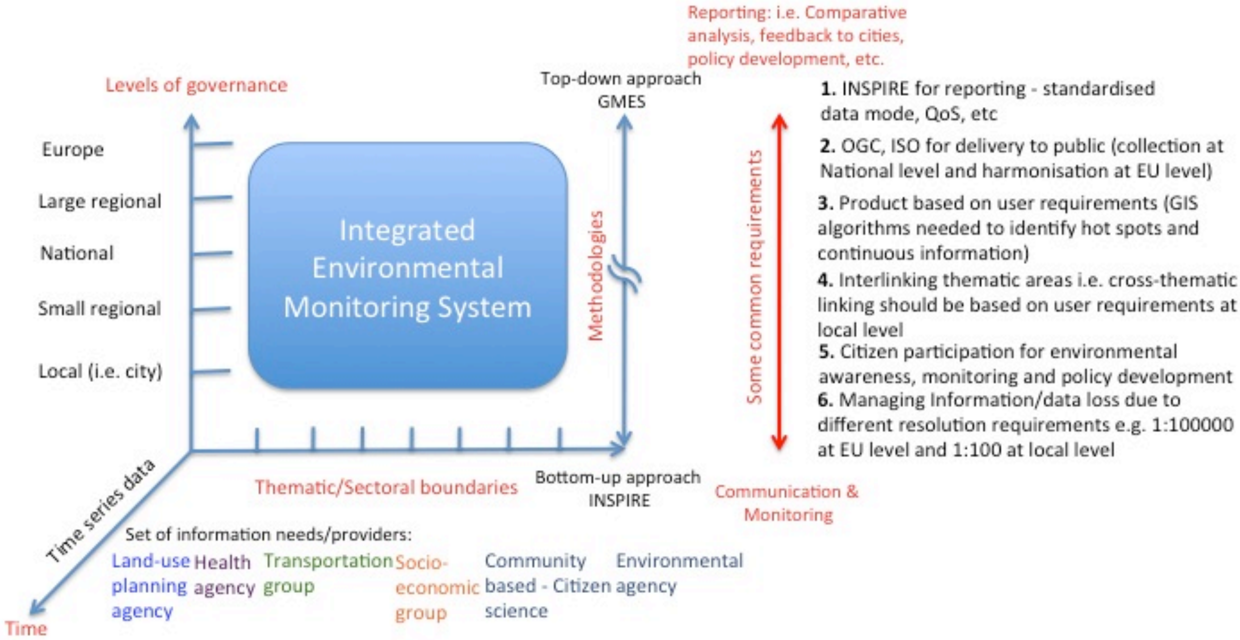


Figure 2.2: Implementation Model - Structuring Principles [10]

2.3 Integrated urban management – new governance models

Looking forward the structuring principles for the policy and implementation models identified above, offer the basis, according to the necessary interactions between planning agencies, to provide the essential user-defined building blocks for full deployment of ICT applications to secure more effective integrated urban governance.

This model aims to provide a consistent framework and context to systematise the information flow from data collection to assessment and policy support. The end user defined policy model of integrated urban monitoring and management thereby offers the opportunity for the development of a data model to which improved integrated intelligence can be applied and thereby address deficiencies in policy responses. From a technology perspective the development of new methodologies for information acquisition and increase of computing capacities to unprecedented levels opens new fields for monitoring and assessment with high information flow and capacity to manipulate it.

However, these structuring principles are developed in response classical models of urban governance which emphasise, centralised, hierarchical, top-down perspective mobilising departmental defined implementation and one-dimensional solutions. Transformational governance critical to the realisation of sustainable development, and stimulated by the demands arising from the management of urban sustainability, advocates a new synthesis of expert governance fully articulated with bottom-up stakeholder and citizen engagement to inform decision-making. Transformational governance and the principles of sustainable urban management are redefining and transforming the nature of urban governance highlighting the need for bottom-up process and effective stakeholder engagement in relation to the conflicting views at the community level.

This new governance approach provides additional emphasis on networks of enabling, influencing, mobilisation, coalition and relationship building, between multiple stakeholders at multiple levels, characterised by the following components:

- Linking territories to networks which cross multiple boundaries, with sometimes highly mobile and globalised social-economic groups;
- Multifunctional policy agendas for urban planning relating to energy and carbon, food, leisure, ecology, business park, retail park etc.;
- Multilevel decision making where strategic and local objectives need to be coordinated;
- Multi-sector working, which aims to realise the potential and added value from a wide range of stakeholders and 'communities of interest'.

Accordingly the demands of new governance have challenged existing governance systems, different sectoral agencies speaking different "languages" with different incentives, to respond to agendas which are multi-functional, multi-level, multi-agency, and intergenerational. As a consequence sectoral agencies are able to not only generate more information, but also new intelligence applied through the whole policy cycle from capacity building, to analysis, strategy, implementation and evaluation.

The necessary translation of new governance principles to urban planning processes and structures lies at the heart of the concept of 'strategic policy intelligence' [13]. Strategic policy intelligence provides a conceptual framework response to the new governance model and which translates governance priority into urban planning principles and their associated information demands including:

- Exchange of technical information from different sectors;
- Application to the policy cycle, with stages including survey, analysis, strategy, implementation and evaluation;
- Anticipatory governance through foresight and future studies, systems thinking and strategic planning.

Building on these foundations the ICT enabled innovations offer planners, new information and intelligence, new decision-making tools to meet these challenges, and new means of fully engaging stakeholders in the development process. ICT enabled innovations thereby facilitates this process of transformation, and simultaneously drives further the transformation process, supporting interactions actions between actors, enabling changes in policy-making, and thereby driving change in regulatory and governance processes.

2.4 Governance and UrbanAPI

The new governance of cities is a collective effort requiring joint initiative between planning and management agencies from EU to local level, clear coordination between a variety of agencies at the local level, as well as critical inputs from all stakeholder groups including citizens. In this context, the enhanced ICT tools proposed by UrbanAPI offer the potential to provide urban planners with the tools and intelligence needed to actively manage the urban environment. These tools aim to provide planners with precisely the information they need to fully expose the socio-economic and environmental impacts associated with alternative options for territorial development and thereby create conditions in which the political mandate and the basis for more effective management is secured, essential to sustainable development.

In relation to the above, UrbanAPI provides ICT enabled innovations for city governance and adapted governance models to support new stakeholder engagement and citizen participation, in order to enhance sustainable urban policy development and delivery.

The conceptual frame for the project is also based upon the understanding that urban managers throughout Europe face common challenges in responding to the desire for a more participatory democracy, in order to define the basis for securing urban economic vitality, social inclusion and environmental sustainability. The commonality of the drivers of urban change including global economic instability, demographic and migratory change, as well as climate change offers a major opportunity for the development of common solutions grounded in effective citizen and wider stakeholder engagement in the planning process.

UrbanAPI directly addresses these potentials for the development of common models of policy formulation and implementation in respect of both information generation and management, as well as stakeholder engagement, thereby supporting the potential for widespread application in the cities and regions of Europe.

UrbanAPI will provide a toolset that enables the city planning authorities to effectively use interactive simulation and visualisation instruments, and will additionally facilitate direct participation of stakeholders and citizens. These proposed generic ICT applications will be built from a set of common libraries for data integration, policy modelling, simulation and visualisation, to be easily adapted to changing requirements by integration of the relevant data sets, to inform the practitioners and gather feedback from the public.

The convergence of technologies evidence in the ICT sector furthermore enables the delivery of applications to different platforms, ranging from smart phones to web browsers and specialist equipment. In comparison, ICT applications for urban planning and public participation as used today often include a heterogeneous range of static and dynamic web pages, interest-forums, participatory GIS-systems, planning tools and simulation models. In addition, many innovative approaches are described in scientific publications – often originated from (and addressed to) the academic sector, but are not yet easy to use in policy making. One reason for this is that public participants in urban governance processes usually are not willing to observe simulations for hours, to orient themselves in relation to complex cartographic products or use special equipment to experience results. Making these applications available to the public requires on the one hand simplification in the simulation concept, and on the other hand enhancement of visualisation techniques.

2.5 Scope of the system

2.5.1 Policy Making and public participation objectives

The UrbanAPI applications address a number of the objectives in relation to policy making and public participation including improved predictions of urban development and societal trends, assessment of impacts of policy measures, in order to achieve a more efficient implementation of government policies. In addition the applications support public participation in the urban planning policy making process, and enhance the transparency of planning consequences at the local scale. Measures taken to meet these objectives include informing the public about proposed planning decisions, to enable citizens to discuss, reflect and select planning alternatives, and to support stakeholders in understanding the effects of planning interventions on urban development at the local scale.

2.5.2 ICT and Policy Modelling objectives

The UrbanAPI applications also address a number of ICT and policy model modelling objectives including development of an object-oriented meta-model for the creation of policy making domain models, including a model of geometric (topological, multiple representations/scale) and functional relations (feedback, conflicts); the design and implementation of a toolkit for rapid development and deployment of participative policy making applications; and the creation of a family of domain-specific rule languages enabling urban planning domain specialists to define policy models and their requirements, to integrate required data sets and to define the presentation of content to be delivered.

2.6 UrbanAPI applications at different urban scales

The **UrbanAPI** applications will be brought as common toolsets to four cities serving as test cases addressing different spatial scales in the multi-level governance setting of urban environments:

- urban quarters, addressing issues concerning the neighbourhood level,
- the urban core, addressing the citywide level, and
- City regions focused on all spatial and functional relationships, addressing the entire planning region.

The proposed **UrbanAPI** toolset and the applications will make use of the vast data resources – geospatial and statistical datasets – related to urban planning, by integrating smart ICT technologies to promote sustainable planning policies by engagement with the public through ideas and visions that address alternative urban planning perspectives and new city development proposals. Local initiatives will be encouraged to participate within the planning process, to contribute to the appropriate solutions and understand and finally endorse the expected impacts on environment and citizens.

2.6.1 UrbanAPI application 1: 3D VR

Neighbourhood scale: Creative participatory urban planning using a 3D scenario creator

Maps – as 2D-visualisations of proposed changes in an urban environment – are often judged as too abstract by lay persons, who do not have the experience required to create a mental representation of a future environment. Describing the general effects and the depicting the visual impact of urban development plans as realistically as possible with the help of 3D scenarios will support the negotiation process for urban development projects. Virtual and augmented reality visualisations depict the consequences of spatial planning processes in a virtual or real world environment. Interactive control of planning interventions and – on the fly – presentation of the new visual effects released through changes in zoning and finally building help the citizens to experience these impressions.

The 3D expression is interpreted rather as architectural presentation of the urban development, which do not exhaust the citizens, interests and policy making participation. In addition to the architectural image perception people is hardly interested in a lot of additional urban parameters, such as:

- Transport capacity and transport bottlenecks;

- Air, noise, chemical pollutions;

- Urban services availability (i.e. medical, police, school, communications);

- Disaster exposure and disaster prevention.

In this context the UrbanAPI shall present the parallel capability of multiple coded layers presentation in complex with 3D presentation (e.g. Figure 2.3) of buildings and green zoning. All those virtual parameters presentation shall be available both for actual infrastructure and for multiple planned scenarios of key urban parameters' layers combinations.

Virtual representations of planning decisions seem to be the most convenient and understandable solution for presenting spatial planning alternatives to the public. Allowing interactive modifications of alternatives helps stakeholders to understand the proposed actions and to endorse the anticipated impacts.

This deployment of the UrbanAPI system will employ a relatively coarse client-side simulation model, but requires high-quality 3D geodata and rich interaction elements, especially to provide feedback on planning in various forms. For this scenario, the 3D web client as well as the mobile app client is to be used.

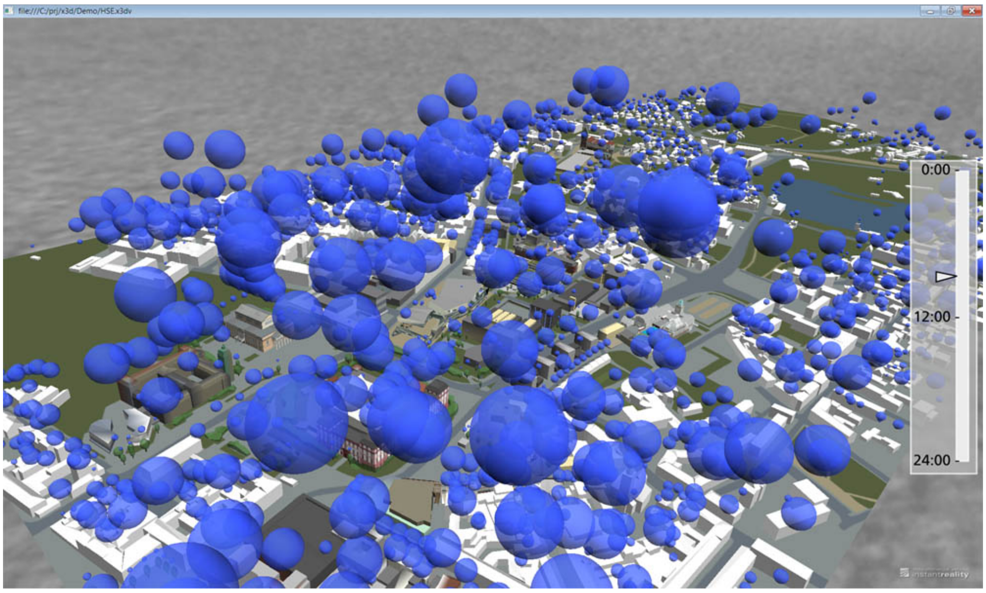


Figure 2.3: Real-time energy consumption [Courtesy: FH-IGD, UrbanAPI DoW]

2.6.2 UrbanAPI application 2: Public Motion Explorer (GSM)

Citywide scale

Exploring acceptance of urban infrastructure by Mobile Communication Device Locator

Urban planning urgently requires information regarding the population distribution and mobility patterns for various land uses. One aspect is to gain information concerning the provision of transportation infrastructure supporting the diurnal population movements within the cities according to policy objectives to reduce private car traffic, or by observing the volume of traffic flows. Another aspect could be to observe the populations preferences for certain open spaces – parks, nearby forests or recreation areas and public open spaces including pedestrian areas and playgrounds.

In today's world, wireless mobile communication devices are creating new dimensions of interconnectedness between people, places, and urban infrastructure. Mobile communication services allow the exploration of passive or active communication traces turning out as human sojourn and activity patterns. In the open space context discussed here, the communication device locator will indirectly provide indications about features and characteristics which attract and deter the population's engagement with the facility. In collaboration with the residents, deterrents to attractiveness will be identified to enhance the appreciation and use of urban environments. (Figure 2.4 below provides a coarse presentation of the sojourn/ activity pattern in an entire city. Interactive visualisation, zooming functionality and including city layout data and intersection of the geospatial content will deliver more useful information.)

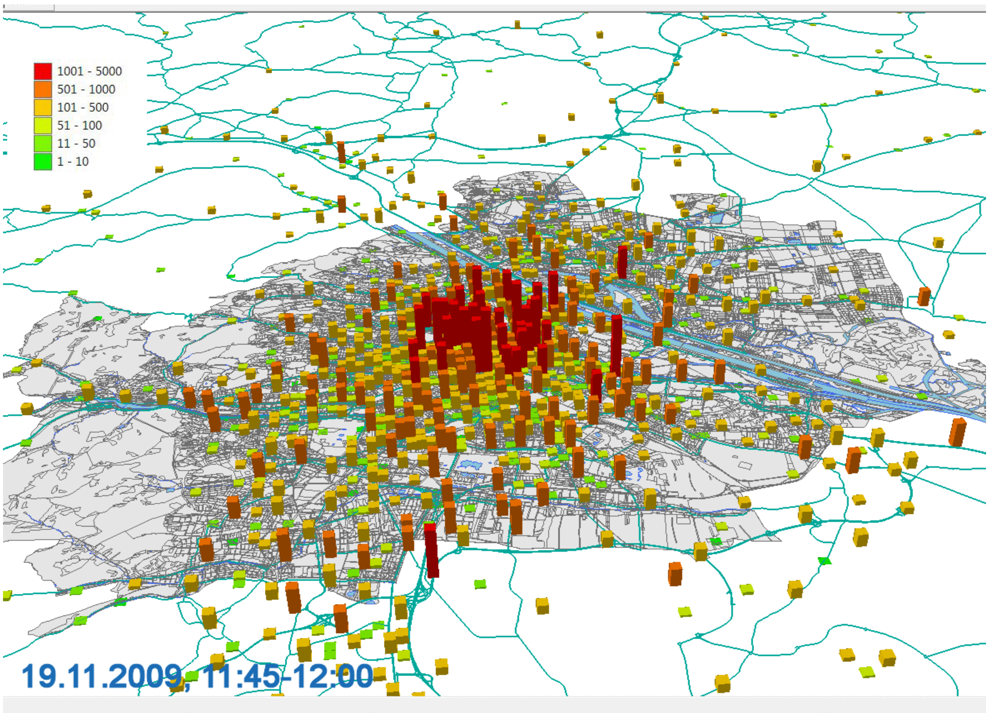


Figure 2.4: Mobile device subscriber distribution in the Vienna Region – noon sojourn/activity pattern at 19/11/2009, active subscribers attached to a GSM station, aggregated to 250x250m raster cells (Courtesy of AIT: geocoding and visualization based on A1 GSM traffic test data)

This application will mostly use specific visual analysis capabilities, as well as some custom optimization algorithms to interactively assess the impact of optimizations in urban infrastructure. The application will make use of the 2D/3D Web mapping client within the UrbanAPI system for full public access to the sojourn/activity distribution maps over time, to explore the sojourn/activity dynamics. It also provides a good data basis for advanced GIS analysis.

Opinion polls of the local population and the visitors of the web maps can provide further information about the features of the public space which they find more attractive than others, thereby supporting city authorities in making public space more attractive for residents. It is expected that the combination of the new data with existing polling and census data will provide new insights.

2.6.3 UrbanAPI application 3: Urban Simulation

Cityregion scale: Interactive city region development simulation addressing urban growth and densification with interactive planning interventions

Cityregion development simulation helps to understand the large scale consequences of spatial planning decisions in a complex urban system, including representation of socio-economic activity across the territory in relation to various land-use elements of the city. Interactive control of proposed planning interventions and associated impacts generated by these interventions assists the public interactively engaging in the planning processes and contributing to planning decisions. Detailed and easy understandable information about planning decisions and full transparency about the expected impacts will support the negotiation activities during a participatory planning process and will finally increase public commitment to these decisions.

The proposed application makes use of an agent based model, simulating land use- and land use density change in an high resolution cellular landscape (e.g. 100x100 m grid spacing) which permits the allocation of new infrastructure by hand to observe the urban development effects, triggered through planning interventions. Client- and server-side simulation components are part of the application. The standard visualisation shown below (Figure 2.5) refers to dynamic land use maps which will be enhanced.

The main deployment platform will be the MultiTouchTable, as a client device for integrating interactive planning interventions to control the simulations. This application refers to a rather complex policy model taking account of simulation results, based on a wide range of data sets and planning policy specifications.

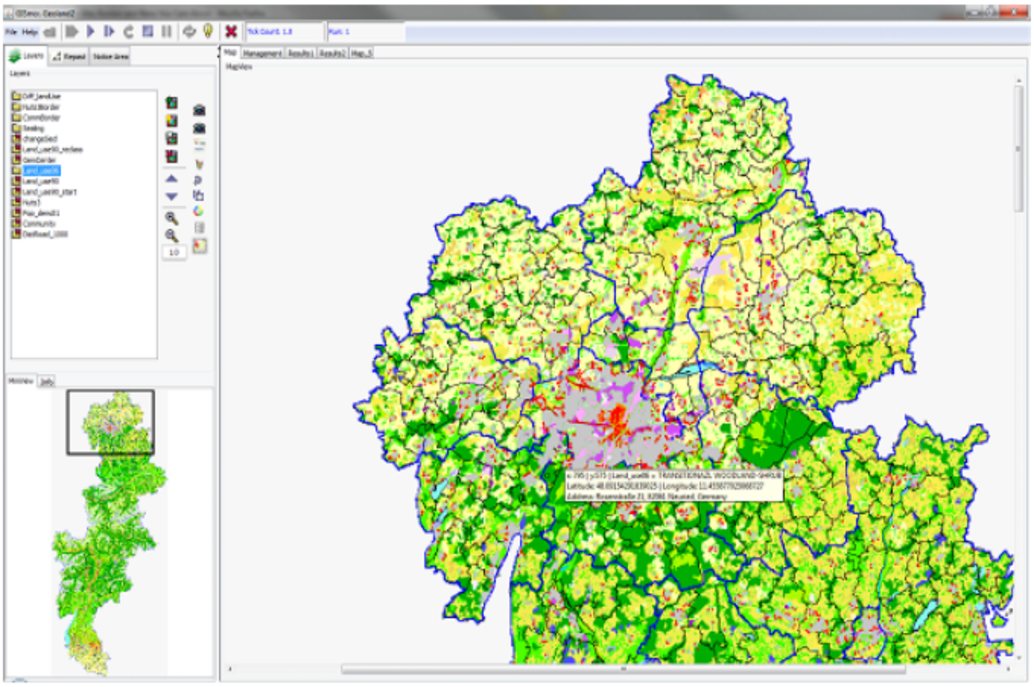


Figure 2.5: Visualising urban growth simulation: MASGISmo application of the Munich-Verona transect; current GUI (courtesy: Ernst Gebetsroither, AIT)

3 Methodological process for requirements management

One of the main building blocks for the development of the UrbanAPI toolset and applications is to apply a generic and precise requirements engineering methodology. Main aim here is to use a generic and common process to engage with all partner city stakeholders for requirement gathering and validation. In the following sections we briefly introduce the overall methodology for requirements development and subsequently requirements change management strategy.

3.1 Overall methodology for requirements gathering and stakeholder engagement

City administrations may have different local policy objectives and urban development needs and priorities. In order to develop requirements based on the actual local needs and policy objectives, a unique requirements development methodology is introduced that consists of following main components, as depicted in Figure 3.1:

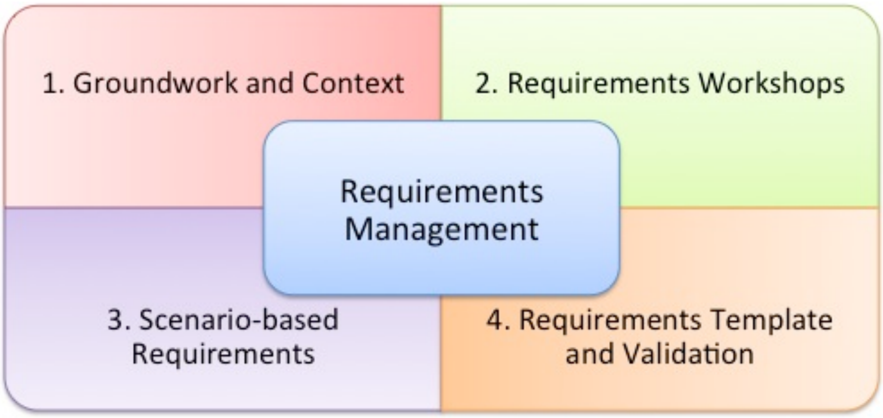


Figure 3.1: WP2 Methodology Components

1. Groundwork and context
2. Requirements Workshops
3. Scenario-based Requirements
4. Requirements Specification Template and Validation
5. Requirements Management

3.1.1 Groundwork and Context

Groundwork and Context is used to elicit basic requirements and establish basic understanding of the city needs, policy goals, problems and limitations in order to prepare and effectively participate in the requirements gathering workshops. From our point of view, *groundwork* is referred to *identification of stakeholder goals, conflicts, scope of the system and boundaries, associated risks, alternative scenarios.* Similarly, *context* is referred to *rationale for development – policy driven, customer or market driven, system interfaces, etc.* In order to establish groundwork and context a questionnaire is prepared. A detailed template of the questionnaire can be accessed from Annex-II. This questionnaire is distributed to city partners for their input before the requirements workshops. Mainly the questionnaire covers 'what' and 'why' type of questions and in order to perform a structured requirement gathering and analysis exercise, it is divided into the following categories:

- Organisation Objectives

This category of questions aims to identify objectives, goals and high level requirements that are relevant to local needs and can bring benefits to the municipality/organization in various forms.

- Organisation Future Needs

These type of questions aim to indicate high level system requirements, its functions, features, scope, interfaces, policy and standards compliance, challenges, expected outcomes and their measurability.

- Existing System and Current Problems (if exists)

These questions attempt to find out the limitations in the existing system if they exist and required interface with the new applications.

- Stakeholders and/or System Users

These questions attempt to identify major stakeholders and their roles.

- Acceptance Criteria

These questions help in identifying the measurable success indicators once the system has been developed.

- Assumptions and Issues

These questions aim to identify any known issues and assumptions taken for the development of the system.

3.1.2 Requirements Workshops

On the one hand groundwork and context questionnaire help to elicit basic requirements and establish basic understanding of the issues and needs of the city. On the other hand, requirements workshops are used as a mechanism to have face-to-face meeting and engagement with local city stakeholders. In addition, these workshops help to gather more detailed requirements, to analyse and discuss directly with the local city stakeholders and acquire more detailed understanding of the local policy issues and urban development goals. Each workshop report/minutes provide insights into discussions and issues from users perspective e.g. policy needs and technical perspective e.g. data availability.

3.1.3 Scenario-based Requirements

In order to have a common requirements development approach, scenario-based requirements and design approach is adopted. An operational scenario is an instance of a transaction/operation/task with data handling (create, read, update, delete operations) described in a user-language without including technical and/or implementation details. A scenario refers to a concrete narrative, or walkthrough, that describes the hypothetical use (i.e. one future possibility) of an UrbanAPI application. A scenario may include information: who uses the system, what are their roles and what they are trying to achieve – objectives and goals; indicates what is needed in the system and why is it needed; indicates the user-system interaction and context in which the user works with the system; indicates users constraints and limitations; indicates what is regarded as successful outcome of using the system. Scenario based design is useful to derive use cases and analyse and specify user requirements. Scenarios are developed for each application based on the needs of each city as presented in section 6, 7, 8 and 9.

3.1.4 Requirements Specification Template and Validation

As a structured approach, a common template for requirements definition is defined and used to elicit, analyse, specify and validate city requirements. This template includes application based scenario, user needs and goals, local stakeholders, functional and non-functional requirements. Each functional and non-functional requirement is further detailed to acquire common understanding of the requirement statements, changes and traceability and validation by the requirement owners. Section 6, 7, 8 and 9 represent the practical examples of the template.

3.1.5 Requirements Management

The requirements as documented in this document represent the views of the UrbanAPI applications as established by the requirements gathering and stakeholder engagement activity at the outset of the project. In particular, it explains the common understanding between the IT/developer and the user community about the goals of the design and development process.

The requirements definition thus should not be considered frozen or rigid for the full lifecycle of the UrbanAPI project development. In order to be compliant with the agile development methodology of the UrbanAPI project, it will be a good requirements practice to allow controlled evolution of requirements due to various reasons including for example: some requirements may still be hidden, changes in city environment and new political priorities, requirements contradictions revealed at design or implementation stages, etc.

The workpackage 3 provides management infrastructure for the UrbanAPI project [Deliverable D3.1 – Infrastructure and Quality Guidelines] where Redmine management tool is used to manage the requirements. Each requirement will be issued a ticket number that will improve the traceability of the requirement to design, implementation and also facilitate testing and evaluation. Furthermore, it will facilitate to manage requirements changes based on the evaluation of the cycle 1 implementation of the agile methodology adopted fort he development of the UrbanAPI project.

3.2 Requirements development process

The requirement development process, as depicted in Figures 3.2 and 3.3, initiated with the basic introduction of the UrbanAPI toolset and demonstration of three applications (section 2). City partners indicated their preferences of the applications based on their political priorities and needs. A rigorous plan to practically implement the requirement gathering methodology was discussed at the Kick-off meeting with well defined short deadlines.

For groundwork and context development a questionnaire was prepared (Annex-I) and cities were required to provided policy goals, objectives, issues, requirements etc. The responses to questionnaire provided introduction to basic requirements of cities for specific applications.

Then a requirement workshop was conducted in each city to elicit and analyse requirements and have face-to-face engagement with local stakeholders. These workshops provided more detailed insight into to the city needs and development requirements and lead to development of scenario based requirements specifications and requirements validation.

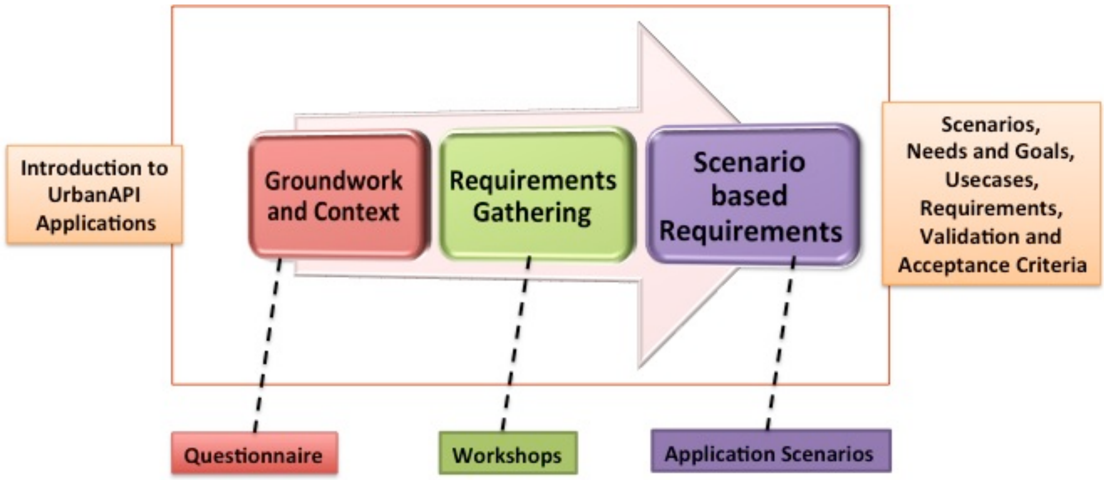


Figure 3.2: Overall Requirements Development Process

Figure 3.3: Requirements Development Planning and Timeline

3.3 Requirements change management strategy

As UrbanAPI project adopts an agile development methodology where two cycles of system (application) development and evaluation will be carried out. The evaluation results of first cycle may introduce new requirements and/or changes in the original requirements. To cater for these changes, the changing requirements shall be reviewed and an annex to requirements document will be released when necessary. This annex will use the requirement specification template (Annex-I) where each requirements possesses specific attributes to indicate changes, traceability, approval and acceptance criteria as depicted in the practical examples of requirements definition in sections 6, 7, 8 and 9. Rationale for change and its impact on the system will be documented. Also, these new requirements and/or changes will be managed using ticketing system in the Redmine management tool [Deliverable D3.1 – Infrastructure and Quality Guidelines].

4 Stakeholders

UrbanAPI stakeholders refer to an individual or an organisation or any legal entity that have vested interest (i.e. financial, technical, knowledge, policy etc) in the outcomes and/or success of the project. Stakeholders can be individuals who are involved in the development of the system (i.e. operators, developers or maintenance staff) or use (i.e. functional or operational beneficiaries) the system or who are mainly interested in the outcome of the project (political or financial beneficiaries). In UrbanAPI project, stakeholders play a key role in deriving requirements for the development of tools and applications, data provision and validating the outcomes of the project. Figure 4.1 depicts a high level stakeholders diagram from UrbanAPI perspective where local city stakeholders are at the centre of the project development process. This includes city municipality and various planning and IT departments, policy makers, citizens, etc. They are supported by technology and domain experts i.e. IT experts 3D application experts, GIS experts, urban planners, transport planners, architects, developers etc. Stakeholder board consists of European organisations and city networks that have research objectives similar to the UrbanAPI project and are interested in the outcomes of the project development and applications. Stakeholder board not only aims to link UrbanAPI development from local to regional and European scale and provide expert opinion but also to evaluate the outcomes of the project applications. General public are the indirect beneficiaries of the project outcomes. Public participation in urban and transport planning initiatives using UrbanAPI tools and applications can facilitate bottom-up collaborative decision making processes.

Figure 4.1: UrbanAPI Stakeholders: A Simple View

The above stakeholder diagram is further populated with more concrete stakeholders by using the 'Onion Model' approach and indicates political beneficiaries, functional beneficiaries, normal operators and support operators [22]. Using the structure of product onion model [22], Figure 4.2 depicts detailed relationship of stakeholders for UrbanAPI project. Each circle in the onion diagram denotes a subset of entities relevant to the development of the project, for example, specific roles (as 'actors' in UML Use cases) such as Policy Experts, Domain Experts and IT Experts in *'The System'* circle.

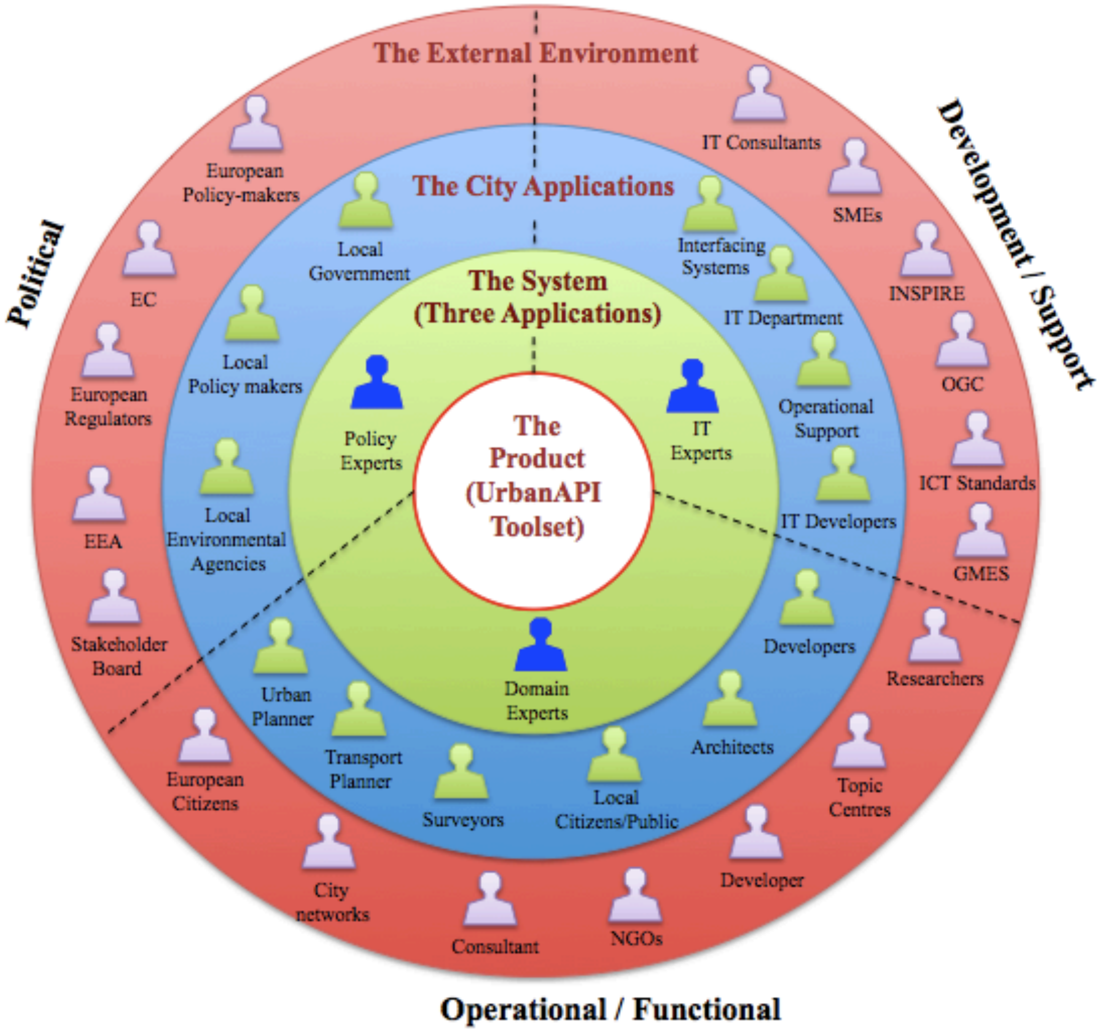


Figure 4.2: Representing UrbanAPI Stakeholders using Onion Model

The UrbanAPI stakeholder onion diagram consists of four concentric circles:

a) *'The Product'* is the inner circle referring to the UrbanAPI Toolset that provides basic functionality for the development of the UrbanAPI applications.

b) *'The System'* refers to the three applications of UrbanAPI that includes the UrbanAPI Toolset and its human operators, local policy or domain specific regulations and standard operating procedures, etc.

c) *'The City Applications'* refer to 'The System' plus any human beneficiaries (e.g. primary and secondary stakeholders).

d) *'The External Environment'* refers to 'The City Applications' and any other stakeholders (e.g. Tertiary stakeholders).

In UrbanAPI, we classify stakeholders into the following three categories adopted from [23]. This classification is performed to maintain consistent use of stakeholder roles in different work packages (e.g. WP2 and WP5) of the UrbanAPI project. All stakeholders can be financial benefiaries and the posposed stakeholder categories are:

1. Primary stakeholders

These are end users who will actually operate the software application to visualise specific scenarios e.g. urban planners, transport planners, architects, surveyors, IT operators, developers and maintenance operators etc.

2. Secondary stakeholders

This category refers to the functional beneficiaries e.g. those who will consume system output in their work but do not actually operate the system e.g. architects, transporters, real estate, construction/developers, SMEs/executives, transport/urban planners, general public, etc.

3. Tertiary stakeholders

This category refers to functional or political beneficiaries of the information generated by the system for strategic planning and decision-making e.g. local government, policy-makers, regulators, general public, etc.

5 Case study cities and UrbanAPI applications

UrbanAPI ICT tools will be developed with the application cities of Vienna, Sofia, Vitoria-Gasteiz, and Bologna. Local initiatives in the four urban regions working in this project will be encouraged to participate within the planning process, to contribute to the final solutions and understand and finally accept the expected impacts on environment and habitants. Based on the toolset, adapted urban planning applications will be created, deployed, evaluated and used to support policy makers, planners and stakeholders at different governance and spatial levels (urban quarter level, municipal level, urban region level).

Each application developed in one city context will be paired with another similar application in another and different city and national context, where different socio-economic, environmental and territorial characteristics, as well as governance structures and practices will be evident. At the same time it is evident that the drivers of change influencing the development of European cities, including the governance and management of urban areas, have common global and pan-European origin. Therefore lessons will be sought from the comparative assessment of the applications developed in the differing city contexts that will form the basis for the future development of generic ICT tools that can be utilised in the majority of the 500 cities of Europe with populations over 100,000, as well as other smaller cities and towns throughout Europe. The following table indicates the combination of UrbanAPI application scenarios for different cities. These application scenarios are selected based on the local city development priorities, different socio-economic, environmental and territorial characteristics and governance structure. At the moment only Sofia is participating in the urban growth simulation application.

	3D VR	**Public Motion Explorer**	**Urban Growth Simulation**
Vienna	2	1	
Bologna	1	2	
Vitoria-Gasteiz	1	2	
Sofia		2	1

6 Requirements development: Vienna

The city of Vienna, with 1,700,000 inhabitants, can be considered as the smartest city of the world as claimed in a recent study [1]. According to Thomas Madreiter, head of Municipal Department 18, '*for Vienna smart city means enhancing the quality of life of citizens and increased quality of economic site' that can be achieved by implementing long-term intelligent path into the future of the city mainly focused on areas: demographic development, environment, administration, energy and mobility* [1]. Vienna is committed to adopt best urban planning practices by applying contemporary ICT methods and tools for the sustainable development into the future of the city and to enhance public engagement to raise awareness in urban planning issues. The Urban Development Plan (Stadtentwicklungsplan - STEP) is an important tool for the urban development and identifies future development areas. Similarly, the Traffic and Transport Master Plan identifies sustainable mobility strategies.

Vienna has long recognised the critical importance of effective communication with citizens in respect of urban planning issues. There are already public participation using discussion meeting and technology such as 'aspern urban lake side' that is currently one of the largest urban development site in Vienna [2] and augmented reality smartphone application 'Flugfeld/Seestadt Aspern' [3].

Vienna has a very advanced ICT-infrastructure, supporting planning and public participation and has a wide range of data sets (e.g. coverage area of 414 km^2) related to building, planning, environment, economy, quality of life and citizens' views: spatially explicit data (land use and coverage, zoning and building heights) at block scale or finer, orthophotos and airborne laser scan data as well as statistical data on demography, socioeconomic characteristics and various others at block to census unit level.

Vienna has been actively using 3D applications to support this communication by planners, and is now seeking to extend this application so that all citizens can benefit as well. These new applications will enable citizens to more fully participate in urban planning decision-making, and in addition the applications can enhance internal communications between different departments of the municipality that need to collaborate in the urban planning decision-making process. 3D VR application can also be useful for assisting in the integration of new development proposals in the urban environment and the visualisation of alternative design and architectural possibilities. In addition shadow analysis, providing a visual representation of sun exposure times and visibility analysis, supporting the assessment of the visual impact of new development in the historic city centre are potential scenarios for the 3-D VR application.

The second UrbanAPI application being pursued by Vienna is the Public Motion Explorer (GSM) application. This application provides entirely new sources of information concerning socio-economic activity in the city based on mobile phone data. Specific information offered includes population density at various locations at various point of time to identify usage and attractiveness of specific places. Furthermore, travel behaviour analysis by exploration of day-time traffic flow provides a better insight in diurnal public mobility and traffic behaviour in the city at different hours of the day. This information can also be used to analyse patterns of use of specific modes of traffic by different age groups to identify social biases and hence results in increasing the efficiency and effectiveness of urban mobility. Finally the GSM-data shows the real behavior of a very large sample in a high spatial and temporal resolution at reasonable costs. This is an appreciated extension to the existing polling (small sample, but good for investigating motives and modes) and counting data (very precise information for one junction or edge, but no information about origins and destinations).

In the following sections we investigate scenario based system requirements for the above applications.

6.1 Scenario: 3D VR

Scenario A: Investigating architecture of future of city projects in architectural competitions

Mr. Seidler works for the Urban Planning department of the city of Vienna. A new urban development area shall be developed. As usual an architects' competition has been held. As a result, Mr. Seidler gets a number of drafts (as digital 3D-data) from the architects. He would like to use an information system that can take architectural design data as an input and visualise 3D architectural model over city map and other socio-economic elements. Further, he would like to see visual effects and impact on the city if certain variables in architectural data are modified. This would help Mr. Seidler in comparing and contrasting various architectural design options for the development of architectural project and measuring its impact on the city.

Mr. Seidler loads 3D VR application using multi-touch table or he can connects his desktop/computer to the architecture and planning competition website using his web-browser. On the first screen he gets various options and text explaining what he can do. One of the options 'Architecture of Future' catches his attention. He selects this option and enters in to the system. A new screen is loaded and on the right side of the screen a context sensitive help guides Mr. Seidler by showing the steps he needs to follow to visualise his architecture project. Following these steps, he clicks on the select data from the 'control panel' menu. Then he selects data from a data source (e.g. his computer) and clicks on the load data button and then a dialogue box shows that data loading is in progress. After a couple of seconds his architectural project data is loaded in the system. As soon as project data is loaded, he gets a hierarchical view of project data elements in the leftside window whereas the visual representation of the architecture is shown in the major right side window (i.e. workspace). The help dialogue box shows that he is in editing mode. Then from the control panel he loads the city map and selects a specific area of the city where the the new architectural construction would take place. Then in next step he clicks on the 'run project' from the control panel and a new window is loaded with 2D/3D map visualising the new architecture and its visual impact on the selected area (quarter/district). Mr. Seidler can choose to navigate around with an aerial view to visualise the new development impact. Mr. Seidler can also annotate different points on the visual screen such as possiblity of new developments etc. He stops the 'run project' mode and goes back to 'editing' mode.

In the editing mode, he changes some properties of the data fields (e.g. new/edited values such as height, colour, orientation etc) and uses different drawing tools to make visual changes in the architectural design and again runs the project from the control panel to see the visual impact. In editing mode he can also select another area on the map of the city. He can also choose measuring tool from the control panel to examine the height of a selected object and compare with neighbouring buildings e.g. how much higher the suggested high-rise is as compared to the church-tower next door. Having already selected the tool he can also measure the distance of the main entrance to the next tram stop.

In the end he wants to make his project publically avaialble either to a restricted circle of users for instance to disuss the project or proposed changes with the developers and politicians or he may want to share the project publically. This sharing of the project will allow others to make/recommend changes/modifications in order to enhance the architecture and/or surroundings. He also wants to be notified for any such recommendations and/or modifications.

Scenario B: Performing shadow analysis of new urban developments/constructions

Ms. Sofia works for the Urban Planning department of the city of Vienna. She is responsible to analyse the impact of shading of new urban developments on immediate neighbourhoods (i.e. neighbour buildings) in the City of Vienna. Her aim here is to detect movement of shadow of buildings and/or new building constructions/developments over time on the neighbouring buildings. This would help her to perform shadow analysis over time to detect implications of two hours shadow policy.

Ms. Sofia might use multi-touch table and starts the 3D VR application. She can also access the application from her home using a web-browser. An automated wizard is initiated and on the first screen she is offered a few options supported by tooltips. As she is mainly interested in performing shadow analysis of a new building/development in an urban area, she selects the 'shadow analysis' option and clicks on the Next button. On the next screen she can view the 2D/3D map of city of Vienna. She zooms in on a specific area on the city map by using control panel options and can see urban environment (i.e. buildings, roads, trees) in more details. She clicks on a specific empty space and a dialogue box appears that shows the coordinates of that location with additional land use information. She first clicks on the 'Copy' button and then clicks on the Next button. In case, she is not interested in that specific location she can click on the Cancel button and reselect another location. She can repeat this activity until she selects the right location. On the next screen she is asked either to select an existing object from the city data/map or to load data about new building/development/installation. She loads the data from her local system (or remote webservice address) and system confirms when the data is fully loaded as an object in the system. She can always select this new object and change its properties such as height, width, structure, etc. From the control panel she clicks on the update project and new building/development is integrated with 2D/3D map.

Now she clicks on the 'perform shadow analysis' button from the control panel and a new screen appears which requests start day time and end day time (can also be categorized in summer, winter, spring, autumn) to run simulation of shadow movement during that time and its projection on the neighbourhood (buildings/installations etc). She can view the simulation in an helicopter view to get better visualisation and analyse the shadow impact on the neighbourhood/buildings.

After she has performed the simulaiton, she may select the newly loaded object and change some of its properties such as height, orientation etc and restart the simulation. At the end she would like to export the final updated object values/settings with its coordinates and simulation results. She can also generate a report which indicates how long the selected object is in the shade of the new building and vice versa. Similarly, this report may inlcude other measurements such as how many percent of selected object (e.g. a park) is in the shade at every full hour. She may also like to share the final simulation results on the web in order to get feedback and comments from others. She would like to be notified for any feedback.

6.1.1 User needs and goals

The need to have 3D visualisation tools was realised about 10 years ago in the urban development projects near Vienna centre in order to avoid effects of new developments on the historic city centre and to continue maintaining the UNESCO world heritage status. Since then 3D visualisation has been one of the priorities for urban planning and as a result now Vienna has 3D database in CityGrid format [4]. This data is being used for different applications for example, a 3D visualisation system 'zacturn' developed by a private company 'z-koor' [5] has three prototypes installed at different places of the city for public use. Using this system, entire city can be explored/navigated (past, current and future possibilities) in 3D and five detailed applications on different urban development projects are accessible to general public. These applications are functional, robust but not appropriate for engagement with large number of public (i.e. over 2 million). Further, these applications are static and would require more dynamic feature such as loading new data and visualising new possibilities not only for general public but also for experts like urban planners and architects. Vienna aims to support open access to data [6] and open urban planning involving citizens. UrbanAPI 3D VR application can take one extra step to make 3D visualisation available to wider audience via web based access mechanisms and smart phones in order to have wider public participation in planning issues with frequently updated 3D city data at low maintenance cost. Further, it will provide the opportunity to experts to visualise and evaluate the impact of a project on the city with efficient use/release of human resources of Surveying/IT department to perform other tasks.

6.1.2 Local stakeholders

Following departments of the municipality of Vienna are the main stakeholders of the UrbanAPI tools and applications.

1. Department of City Development and City Planning (MA18)

Department representatives:

Helmut Augustin, Head of the Coordination Unit for GIS, MA 18

Wolfgang Dvorak, head of section public relations and knowledge management, MA 18

Angelika Winkler, head of the Section Traffic Planning, MA 18

Johannes Gielge, head of the Section Urban Research and Space Analysis, MA18

2. Department of Technology and Communication (MA14)

Department representatives:

Wolfgang Nagl, IT Consultant Department of technology and communication MA14

Rainer Haselberger, telematics, MA 14

3. Department of Surveying (MA41)

Department representatives:

Lionel Dorffner, head of the Section 3D Technologies, MA 41

4. Citizens of Vienna

6.1.3 Indicative Use cases[1]

[Where E=Essential, D=Desirable, O=Optional]

Use cases for Scenario A:

UC ID	Name/Description	Importance
UC_1.1_A	Stakeholder(s)/Architect(s) load city and architectural data into the system	E
UC_1.2_A	Stakeholder(s)/Architect(s) visualise new architectures in 2D/3D	E
UC_1.3_A	Stakeholder(s)/Architect(s) annotate different architectural elements	E
UC_1.4_A	Stakeholder(s)/Architect(s) change the values of different architectural elements and can make changes visually	E

[1] Detailed use case descriptions for all scenarios have been included in Annex-IV and restricted to project partners use only.

UC_1.5_A	*Stakeholder(s)/Architect(s) share different visual elements/points of the architecture and get feedback*	*D*
UC_1.6_A	*Export images and visualisation results*	*E*
UC_1.7_A	*Stakeholders use a measuring tools*	*E*

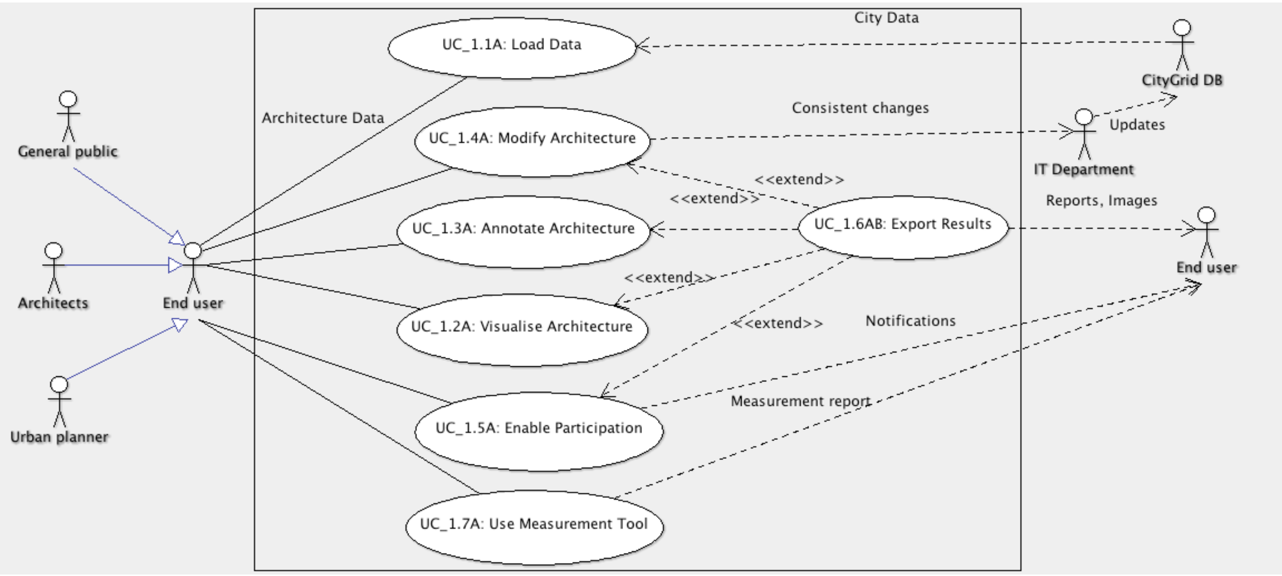


Figure 6.1: System Level Usecase diagram for Scenario A

Use cases for Scenario B:

UC ID	*Name/Description*	*Importance*
UC_1.1_B	*Stakeholder(s)/Urban Planners(s) access and load city data/map from CityGrid 3D DB*	*E*
UC_1.2_B	*Stakeholder(s)/Urban Planners(s) selects/loads a construction object*	*E*
UC_1.3_B	*Stakeholder(s)/Urban Planners(s) perform visual simulation of Shadow analysis*	*E*
UC_1.4_B	*Stakeholder(s)/Urban Planners(s) modify construction object properties*	*E*
UC_1.5_B	*Stakeholder(s)/Urban Planners(s) share simulation with others and get feedback*	*D*
UC_1.6_B	*Export images and visualisation results*	*E*
UC_1.7_A	*Stakeholders use a measuring tools*	*E*

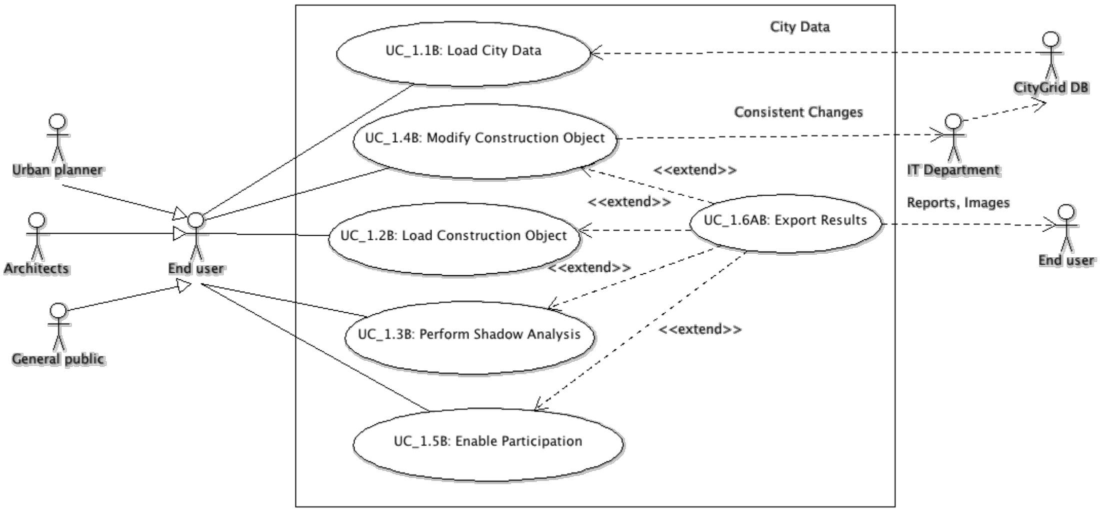


Figure 6.2: System Level Usecase diagram for Scenario B

6.1.4 Requirements definition[2]

6.1.4.1 Functional requirements

Req ID	Description	Importance
FR1.1.1	A framework should be defined to enable secure and mutual exchange of city data.	E
FR1.1.2	Data conversion should be very limited. If data conversion is needed then it must be applied to complete urban model in order to maintain consistency.	E
FR1.1.3	Common data models, data transformation and solutions should be provided to architects and planners to prepare and participate in architectural competitions.	E
FR1.1.4	Software should be able to compute shadow situation at city sites.	E
FR1.1.5	System should be able to determine the impact of any interaction (i.e. changes to data values, building models, etc) by a user.	E
FR1.1.6	Application should be user-friendly and all personnel with administrative previleges/role should be able to use it without much difficulty.	E
FR1.1.7	Application must conform to Municipality IT standards and administrative policies including existing user roles/rights etc.	E
FR1.1.8	Software must adopt multi-tier architecture by using an application server to avoid direct access to database by end-users.	E
FR1.1.9	Software should adopt platform (hardware/software) requirements such as operating systems, application servers, databases, web browsers etc.	E
FR1.1.10	Software should be able to visualise and evaluate the impact of an urban	E

[2] Detailed requirements specifications (according to the template in Annex-I) for all scenarios are included in Annex – V and is restricted to project partners use only.

	development project on the city.	
FR1.1.11	*Software should be able to provide automated workflow (for example wizards) for different scenarios (for example supporting data loading and performing shadows and visibility analysis of new constructions).*	*E*
FR1.1.12	*End users must be able to export visualisation screen images as well as 3D visualisation model as a whole.*	*E*
FR1.1.13	*System should allow import and export functions to be compatible with existing system.*	*E*
FR1.1.14	*Software should be able to load architecture data from 3rd parties.*	*E*
FR1.1.15	*Software must be intuitive and have high usability.*	*E*
FR1.1.16	*System should allow easy way to make changes in data values and visual objects.*	*E*
FR1.1.17	*System should be accessible via web and other touch-screen devices.*	*E*
FR1.1.18	*System should allow to add annotation and comments on visualisations.*	*E*
FR1.1.19	*System should have a measuring tool to measure the heights and distances between selected objects.*	*E*
FR1.1.20	*Common guidelines for achitects (especially for data formats) to participate in architecture competitions should be provided.*	*D*

6.1.4.2 Non-functional requirements

Req ID	***Description***	***Importance***
NFR1.1.1	*Any application running inside Municipality premises should not have remote connection with the outside world.*	*E*
NFR1.1.2	*There should be a detailed description/documentation of the workflow explaining the transformation of the raw 3D data and city data into refined outputs.*	*D*

6.2 Scenario: Public Motion Explorer (GSM)

Scenario A: Exploring diurnal population distributions through mobile phone data.

Urban planning consultant Mr. Huber, working for the community of Vienna, is responsible for exploration of intra-urban accessibility and attractiveness. He is in need for information on public motion patterns to assess acceptance of urban environments to get hints, where attractiveness – or accessibility has to be improved. .

Mr. Kurt Huber wants to get an idea about the population distribution patterns within the city during workdays and weekends: how many people are staying at which day time in which district and/or which area. Mr. Huber is keen on detailed information about sojourn patterns in the densely built up areas during day and night hours as well as in recreation areas during weekend hours.

On work days (average) he needs population density data (map and table) for 0:00, 5:00, 6:00, 7:00, 8:00, 9:00, 10:00, 12:00, 14:00, 15:00, 16:00, 17:00, 18:00 19:00, 20:00 and 22:00 o´clock. At the weekend for 10:00 and 15:00 o´clock.

He knows that the available mobile phone location data show some uncertainties depending on the allocation algorithms, expecting location information based to a large extent on antenna coordinates, or on weighted cell coordinates attached by the respective mobile device and to a small extent on GPS-coordinates from hand held devices. That is why some quality evaluation is necessary e.g. assessment of the spatial accuracy and user behaviour (e.g. is there less night population because people turn their mobile phones off? etc).

As the data are a new information source and the application of these data is a test case he will be careful regarding interpretation on derived location patterns, but he is fond of using data on motion patterns, where, until now, no information was available.

Mr. Huber calls a website providing a tool to explore mobile phone event data through interactive maps: he can decide whether he wants to get mobile phone subscriber densities for certain spatial aggregates like census districts or for larger Vienna / Lower Austrian district areas or raster cells. He can further select hours and week days to explore the changes of population distributions during the day.

A diagram function allows depicting the diurnal variation of the population distribution for the selected spatial aggregate during work days and weekends. He can select different points (parks, malls, buildings, etc) on the diagram for annotations and can export simulation images for later use. For the O-D-matrices (and the further functionalities) the population distributions for the spatial aggregates will be averaged for work days applying data from Tuesday to Thursday; for weekends the data will be averaged taking Saturday and Sunday patterns. (Data for one regular week and 2 weekends will be applied). At the end of the simulation, he can export simulation data visualisation results in a predefined format.

Scenario B: Extracting day-time specific origin-destination matrices of workday traffic

Mrs. Maier, working for the traffic planning department in Vienna, is responsible to increase effectiveness and efficiency of the public transportation system. She requires information on public motion patterns aiming in daytime-specific origin-destination matrices which allow exploring the necessary transportation capacities along certain origin-destination relations during certain time ranges.

Mrs. Mayer needs intra-city and extra-city origin-destination matrices containing the total traffic – the public and the private car traffic. Matrices will be generated for specific hours of work days, covering begin and end of major commuting,

Mrs. Maier is used to working with Matrices in this layout:

Night / Day	spatial reference unit A	spatial reference unit B	spatial reference unit C	…
spatial reference unit A	236	1200	957	…
spatial reference unit B	…	…	…	…
spatial reference unit C	…	…	…	…
…	…	…	…	…

The question she has in mind is: where do people live (=sleep = 0:00 o´clock) and where do they work (= 10:00). This is especially important for designing the transport system.

At the weekend the question is, where do they live (=5 o´clock) and where do they spend their spare time (= 10:00 and 15:00). This is especially important for improving the attractiveness and accessibility of public and/or open space.

Mrs. Mayer is aware of the possibilities to get certain time-specific information of traffic loads along certain relations. She knows that the information is actually data on travelling collectives aggregated on spatial reference units.

It is quite a hard task to decide which spatial reference unit is most suitable for the above mentioned purposes. To get a deeper understanding on that, she drew the following map (Figure 6.3):

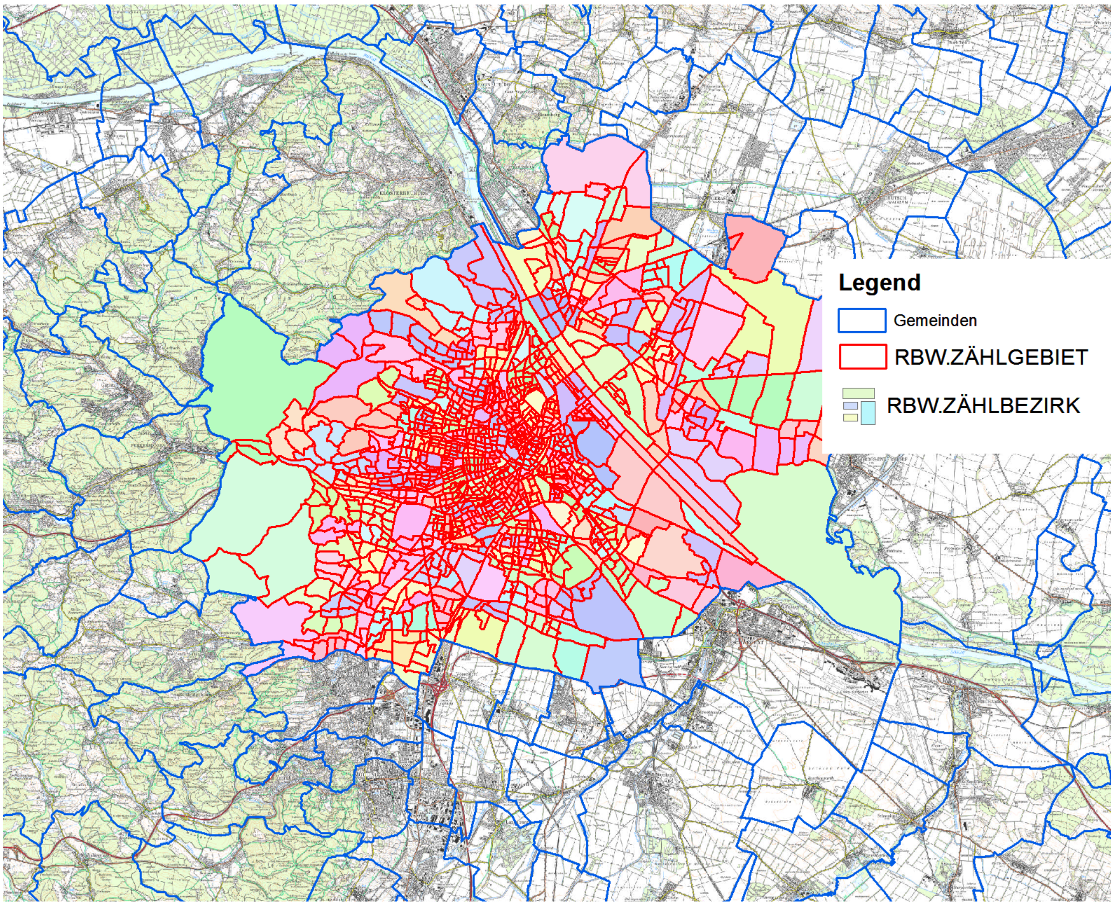


Figure 6.3: An example of different spatial reference units at different scales

Mrs. Mayer comes to the conclusion that the best compromise between a handy matrix, properly populated cells and a good spatial resolution is to take “Zählbezirke” for the inner urban areas, “Zählgebiete” for the outer urban areas and “Gemeindegrenzen” outside the borders of the City of Vienna. This also ensures a high level of compatibility to the “Verkehrszellen”.

Especially, when performing some analysis in the metropolitan area context Mrs. Mayer would prefer using raster cells.

In addition to that she needs some “special zones” like Mariahilferstraße, Gürtel, Flughafen Schwechat, etc because these locations are of extraordinary importance but still not properly represented by the statistical spatial reference units.

However she knows that the available mobile phone location data show some uncertainties depending on the allocation algorithm such as the degree of accuracy of the location data depends on the density of the mobile phone antenna network in the city.

Additionally she knows, that these data reflect just a subset of the total traffic, as only a part of all travellers within the city are subscribers of A1 mobile communication services, and that these shares may differ between areas and perhaps between time ranges, as A1 covers a specific socio-economic and age compartment of the population. The data along certain relations will be compared with traffic counting data at certain sections with single mode traffic and multi modal traffic (e.g. bridges) to calculate the ratio of the traffic members and the total car drivers/passengers, covered by the A1 mobile phone data provider. These rations allow estimating the moving population numbers within the city of Vienna.

Scenario C: Extracting trip chains through path-time diagrams based on mobile phone data

Mrs. Maier, also wants to get some information on trip chains, travelling time, on stops between and if possible on traffic mode selection for a sample of the travelling population within Vienna.

She knows that it might be hard to find reliable answers to these questions with the help of mobile phone location data. Mrs. Maier knows that the accuracy of the results depends much on the accuracy of the location information and that exploration of travelling behaviour based on mobile phone data is a first experiment. To her it is important to have a proper feasibility study on that, so that she knows how reliable the results are.

This task will be carried out with a sample of work day travel data: a set of (anonymous) single users – starting from selected origins in and outside Vienna will be tracked by using the "time stamps" and "location stamps" of the mobile phone log data. Therefore mobile devices that are turned on for a long period of time at a stretch are selected. A set of trip chains will be extracted and documented through path-time diagrams. Exemplary types of travellers will be grouped regarding travel distance, travel speed, travel mode and sojourn pattern during the daily trips.

In addition, the following explorations must be carried out to assess the usability and suitability of the GSM data to be a basis for evidence based decision making for the municipality of Vienna.:

- A1 Mobile has 42% of the market share with about 5 million subscribers in Austria. Intuitive visualisation of the overall population-distribution versus early morning A1 subscriber distribution can be performed. As A1 covers a specific socio-economic and age compartment of the population, the residential population numbers can be compared with the mobile phone subscriber numbers observed during the early morning hours including socioeconomic and age class data of the residential population to examine the shares covered in different areas. This may help to identify and document the (area specific) social bias and age bias of A1-subscriber distribution against the overall population distribution.
- Vienna traffic and population behavior survey data, provided through Vienna municipality, can be integrated into the investigations to increase the knowledge about biases occurring in the A1 subscriber distribution and motion data.
- Traffic modes can be explored for selected routes where single modes can be identified.
- Traffic modes and changes can be explored through the path-time diagrams considering (changing) travelling speeds described as slopes of the travel sections within the diagrams.
- Mobile phone location accuracy can be explored for test areas and (as far as possible) through additional information from the data provider.

6.2.1 User needs and goals

The Urban Development Plan (Stadtentwicklungsplan - STEP) and the Traffic and Transport Master Plan are important tools for the urban development and identify sustainable mobility strategies. One of main objective of transport planning in the city is to keep the distance short and shift to public transport from private traffic mode. A recent study [7] indicates that 'the Vienna's traffic infrastructure has developed significantly for last 15 years that now about 69 per cent of people's everyday journey is covered by public transport, bicycles or on foot'. But the demand for more attractiveness for public recreational places and sustainable traffic infrastructure always remains there for Vienna citizens as well as tourists.

Likewise, information about daily population distribution in different districts and attractiveness to recreational places can provide major indicators for urban development and public transport improvement and planning. The existing data on mobility behaviour (e.g. poll data) and use of public space have limited reliability with respect to motion patterns and stops[3]. In addition to that they are not representative at the level of small spatial units which makes it difficult for the urban and transport planners to take planning decisions. Therefore, city of Vienna's main goals here are to get information from additional sources about real mobility behaviour of citizens that can be used to: i) compare and contrast to existing polls, statistics and modelling results, ii) get better insights in mobility and traffic behaviour of the citizens , iii) get information about the attractiveness of selected areas; and iv) use as an evidence to improve transport and urban planning initiatives in the city. This information permits the targeting of areas of attraction within the city, the opportunity to obtain a full understanding of the basis for this attraction, and accordingly to create urban and transport planning responses. Hence, in UrbanAPI project, the city of Vienna is interested to investigate the potential of using mobile phone GSM data (A1 Mobile) to visualise and analyse sojourn population distribution and diurnal public motion patterns that can potentially be used to achieve the above goals. For Vienna, the above UrbanAPI application will have a major impact – which could be attributed to change in existing business model, cost savings and evidence based updated data and information for planning purposes. Traffic infrastructure planners would also be interested in development of GSM application in city - region context (functional urban area) for 'new network philosophy' i.e. importance of mobility with reasons.

6.2.2 Local stakeholders

Following departments of the municipality of Vienna are the main stakeholders of the UrbanAPI tools and applications.

[3] On the other hand pools are surely the best source to learn about the reason why and how people travel; counting traffic is the the best source to lean about the amount of traffic that flows over a special segment or junction.

1. Department of City Development and City Planning (MA18)

Department representatives:

Helmut Augustin, Head of the Coordination Unit for GIS, MA 18

Wolfgang Dvorak, head of section public relations and knowledge management, MA 18

Angelika Winkler, head of the Section Traffic Planning, MA 18

Johannes Gielge, head of the Section Urban Research and Space Analysis, MA18

2. Department of Technology and Communication (MA14)

Department representatives:

Rainer Haselberger, telematics, MA 14

3. Citizens of Vienna

6.2.3 Indicative Use cases[4]

[Where E=Essential, D=Desirable, O=Optional]

Use cases for Scenario A, B and C:

UC ID	*Name/Description*	*Importance*
UC_1.1	*Preprocess Mobile Phone Service providers' GSM data*	*D*
UC_1.2	*Stakeholder(s)/Planners (s) visualise diurnal population distribution in the city*	*E*
UC_1.3	*Stakeholder(s)/Planner(s) generate Origin Destination Matrices*	*E*
UC_1.4	*Performing Travel behaviour Analysis*	*D*
UC_1.5	*Import new GSM data*	*O*
UC_1.6	*Export images and visualisation results*	*E*
UC_1.7	*Extrapolate GSM data to map on the overall population*	*E*

[4] Detailed use case descriptions for all scenarios have been included in Annex-IV and restricted to project partners use only.

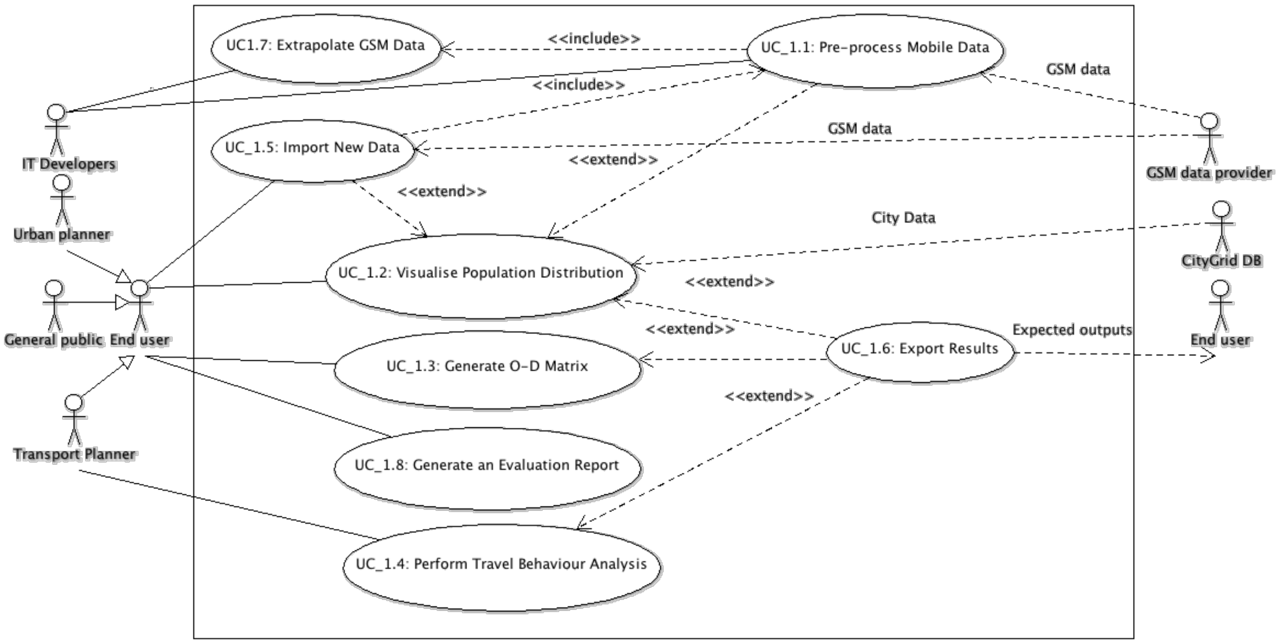


Figure 6.4: System Level Usecase Diagram for Public Motion Explorer Application

6.2.4 Requirements definition[5]

6.2.4.1 Functional requirements

Req ID	*Description*	*Importance*
FR1.2.1	*System must be able to show population density for selected spatial aggregates during weekdays and weekends.*	*E*
FR1.2.2	*System should be able to segregate mobile patterns when mobile phones are in buildings and outside buildings.*	*D*
FR1.2.3	*System should consider other sources of data e.g. smart phone GPS data, polls and surveys etc for calibration with GSM data.*	*D*
FR1.2.4	*System should be able to identify social biases in terms of population distribution and mobility behaviour.*	*E*
FR1.2.5	*System should be able to accommodate O-D Matrices for special zones which are not represented by spatial reference units.*	*E*

[5] Detailed requirements specifications (according to the template in Annex-I) for all scenarios are included in Annex – V and is restricted to project partners use only.

FR1.2.6	*System should be able to accurately capture and show real end-to-end distance coverage by selected indviduals for origin-destination matrices.*	*D*
FR1.2.7	*System should be able to show and generate matrices based on the number of people moving from one zone to another.*	*E*
FR1.2.8	*System must provide intra-city and extra-city origin destination matrix acquired from diurnal day-time mobility patterns.*	*E*
FR1.2.9	*System must be able to generate origin-destination matrices including information about trip-chain, travelling time, traffic mode selection from mobility behaviour of selected group of individuals.*	*D*
FR1.2.10	*System should be able to distinguish slow motion traffic due to congestion (e.g. at peak hours) from padestrians and/or bicycle riders.*	*D*
FR1.2.11	*System should be able to accommodate specific spatial reference units at different scales for origin destination matrices and maps.*	*E*
FR1.2.12	*System should be able to statistically extrapolate the GSM data to the whole population.*	*E*
FR1.2.13	*System should allow to add annotation and comments on visulisations.*	*O*
FR1.2.14	*System should allow import and export functions.*	*E*
FR1.2.15	*Software must be intuitive and have high usability.*	*E*
FR1.2.16	*Software should adopt platform (hardware/software) requirements such as operating systems, application servers, databases, web browsers etc.*	*E*
FR1.2.17	*Software must adopt multi-tier architecture by using an application server to avoid direct access to database by end-users.*	*E*
FR1.2.18	*System should be able to assess the quality of spatial accuracy and user behaviour.*	*E*

6.2.4.2 Non-functional requirements

Req ID	***Description***	***Importance***
NFR1.2.1	*Application must conform to Municipality IT standards and administrative policies including existing user roles/rights etc.*	*E*
NFR1.2.2	*Application should be user-friendly and all personnel with administrative previleges/role should be able to use it without much difficulty.*	*E*
NFR1.2.3	*System should be accessible via web and other touch-screen devices.*	*E*
NFR1.2.4	*There should be a detailed description/documentation of the workflow explaining the transformatioin of the raw GSM and city data into refined output.*	*E/D*

7 Requirements development: Bologna

Bologna is pursuing UrbanAPI solutions for both urban planning as well as environmental objectives. The aim is to communicate more effectively with citizens by visualising future development and potential impacts and to enhance public engagement for quick feedback on planning initiatives. Bologna will participate in the development of both 3D- VR and Public Motion Explorer (GSM) applications.

In Bologna, the San Vitale District is located in the eastern part of the city and covers both central and peripherical areas. Due to his wideness, the district shows heterogeneous oddities and problems. The central part is one of the anciest of the city whereas the peripherical area is located around one ancient Roman route which led to the capital of the West Roman Empire, Ravenna.

The central part of the district will be part of a rehabilitation and mobility plan and will provide the context for the development of the 3D-VR application, where proposals are seeking to create new public spaces in order to connect the district with the urban core, and thereby enhancing the local sustainability. Implementation of the initiative requires public participation to raise awareness of the benefits of the scheme that will be supported by the dynamic visualisation potential of the 3D-VR application.

The San Vitale Distric is considered to be the main area of application for 3D-VR and it will be applied for the rehabilitation of the central area of the San Vitale district. This area will be involved in a municipality project ("Di nuovo in centro"), which aims to intervene on the mobility system, and will also be the master plan for a wider project ("Ambiente Vitale") that aims to increase the number of public and green spaces.

This area has a great population density (192962 m^2, 3370 citizens, density 17736 /km^2). Piazza Aldrovandi is a market square in this area and this part of the area is very popular as many streets have highly educated and social population. An important commercial activity is centred around some of the main streets (Via San Vitale, Via Petroni) and deals mainly with food and catering. Many of them are run by immigrants. The closeness to the University district plays a vital role in such activities.

Another important characteristic of this area is the high involvement of the citizens in the public interventions: there are many citizen committees and cultural associations which usually organize many events dealing with the welfare of the district.

Bologna has a wide range of data sets [16][17] related to building, planning, environment and economy: spatially explicit data (land use and coverage, zoning and building heights) at block scale or finer, orthophotos and airborne laser scan data as well as statistical data on demography, socioeconomic characteristics and various others at block to census unit level.

What is needed now is a more sophisticated tool to manage the traffic flow in the city center: GSM data application suits to the Municipality plan [14] which aims to intervene with very important structural changes in the mobility system of the city center. This application is thought for the most important mobility project promoted by the municipality ("Di nuovo in centro") [15], which aims to intervene severely on the mobility system in the city centre.

Bologna's wide city centre (400 ha) involves many business activities [18]. Despite the growth, the city remained centripetal-oriented: citizens and other actors usually cenverge into the very central part of the city for their activities (both for business and for free time). The city centre has about 51000 (the whole city has 377000). Mobility analysis estimated 550000 daytime inhabitants, 181000 of them in the city centre (more than a threefold of the residents). The three main streets of the city centre are Via Indipendenza, Via Rizzoli and Via Ugo Bassi: this area is called "T-Zone" from the shape drawn by the cross of these streets. Strong measures against traffic congestion have already been taken for this area: day accesses with motor vehicles are 23500 (9500 autos, 14000 motorcycles).

The whole city centre has traffic restrictions either, but still has many day accesses with motor vehicles (48000 autos, 16700 motorcycles). People who access daily to the city centre with public transportation are 199000: 77000 of them access to the T-Zone. Citizen who lives in the city centre may ask for a special permission which enable them to access the city centre with cars: citizens with such permission are 38138. The goal to be achieved with GSM application is to observe and analyse people tracks inside the city centre, especially in the T-Zone, to reduce noise and air pollution and help starting a new mobility plan.

In the following sections we investigate scenario based system requirements for the above applications.

7.1 Scenario: 3D VR

Scenario A: Performing analysis of new urban rehabilitation in S. Vitale District

Mario Rossi works for the Urban Planning Department of the city of Bologna. The department is deeply involved in a plan about the rehabilitation of a part of the San Vitale district. This area is located in the central part of the city and will be subject to an experimental plan which aims to rehab the city-districts considering all the different aspects of urban living.

Mr. Rossi loads 3D VR application which is installed in his computer or he can connect his desktop/computer to the municipality website using his web-browser. On the first screen he gets various options and text explaining what he can do. Options are related to the main objects which have been identified as the most important ones for the rehabilitation of the district. Mainly these options are:

- Waste collection,
- Green areas such as park, plant, tree and garden, etc
- Car parking spaces,
- Street/Public space benches
- Bike sharing and racks
- Junction boxes,
- Traffic markings and road sings,
- Pedestrian ways,
- Open spaces for bars/restaurants, and
- Public street lighting.

As he is mainly interested in improving waste collection, he starts with the option “Waste collection”. All the options are in a window beside the screen, just as a palette. On the right side of the screen a context sensitive help guides Mr. Rossi by showing the steps he needs to follow to visualise his changes in the spaces normally occupied by different garbage cans.

Following these steps, he clicks on the city maps of the district. He zooms to a street. He selects a garbage bin located on the 3D street maps. The left side window/panel contains all the editing options he can apply to this object. He decides to eliminate it from the street.

Mr. Rossi decides to intervene on other options which are listed in the main left side window panel. For example, he selects "Green" option. The subset of this option has two other options, such as "Trees" and "Plants". He selects the second option and as a result on the right side of the screen a new palette window opens that show different types of the plants. Mr. Rossi drags one plant into the 3D screen and places on the location from where he earlier removed the garbage bin. Mr. Rossi also wants to insert a tree into the street. He again goes to the left panel and selects "Trees" option and as a result on the right side of the screen a new palette window opens showing different tree objects. He tries to drag one of the tree objects on the roadway but it doesn't work. A help box indicates that trees can not be planted on roadways and suggests other nearby places to plant the tree. He again drags the tree on a little garden beside the street and everything works fine. During the visualisation he can take high resolution screenshots. Mr. Rossi pauses the visualisation run mode and he starts annotating different points on the visual screen such as possibility of new developments etc. Then he save the changes these changes and can export visualisation results in different formats.

In the end he wants to make his project available to selected group of colleagues (or general public) and allow other colleagues involved in the project to make/share changes/modifications. He also wants to be notified for any such recommendations and/or modifications. So he gets (e.g. via an email) an XML file that includes all the changes or annotations performed by a citizen on the shared project. Using the analysis tool of the 3D VR application he can load and analyse these XML files and get statistics of the most occurred changes operated by the citizens.

Scenario B: Performing analysis of new sustainable moiblity in S. Vitale District

Luigi Verdi works for the Mobility Department of the city of Bologna. The department is deeply involved in a plan about the sustainable mobility in the city centre, which deeply involves a part of the San Vitale district. This area is located in the central part of the city and will be subject to an experimental plan which aims to rehab the streets from the point of view of a new pedestrian and bicycle mobility.

Mr. Verdi loads 3D VR application which is installed in his computer or he can connect his desktop/computer to the municipality website using his web-browser. On the first screen he gets various options and text explaining what he can do. Options are related to the main objects which have been identified as the most important ones for the rehabilitation of the district (see Scenario A). A new mobility option is included in them.

He chooses the option "Street routes" and starts tracing a route with his mouse. This route is thought as one of the most important routes for vehicles and pedestrians. He wants to try to choose another route for vehicles, and points an annotation on the designed route just up to an important and troublesome crossing.

He draws another route as he thinks it could be the best pedestrian route from the University district to the District library. He finds on the way that many pavements in the arcades need to be rehabilitated and points out using annotation on these places.

In the end he wants to make his project available to selected group of colleagues (or general public) and allow other colleagues involved in the project to make/share changes/modifications. He also wants to be notified for any such recommendations and/or modifications. So he gets (e.g. via an email) an XML file that includes all the changes or annotations performed by a citizen on the shared project. Using the analysis tool of the 3D VR application he can load and analyse these XML files and get statistics of the most occurred changes operated by the citizens.

Scenario C: Visualising and interacting with new urban rehabilitation plan of the S. Vitale District

Luisa Bianchi is a citizen of the San Vitale central district. She heard about the new plan of rehabilitation of her district and wants to have her say. She goes to the public participation website and is presented with a short text and some images explaining what can be done on this site. Also, a news stream is presented, highlighting projects, comments and suggestions recently added. The Municipality promotes a 3D application on the website, and a demonstration is planned: the involvement of the citizens is expected, and they can try to modify some aspects of the district. The Municipality collects all the data about the changes done by the citizens through this application and will publish a statistic of the most required changes.

Mrs. Bianchi connect from home to the Municipality website. In the page of her district she finds a link to the 3D application. She connects to the application. On the first screen she gets an 3D image. Under the image are 2 options: “Info” and “Enter”. In the first one she gets some information explaining what she can do with the application and some basic instructions.

In the second one she enters in to the system. A new webpage is loaded. On the right side of the screen a context sensitive help guides Mrs. Bianchi by showing the steps he needs to follow to visualise her changes. Following these steps, she clicks on the city maps of the district. She zooms to a street. She starts with the option “Pavement”. She identifies a damaged part of the street pavement and clicks on it. On the right side of the screen a new palette window opens: the option in it is “Repair”. She drags it into the damaged path. A new repaired path is shown.

Mrs. Bianchi stops the visualisation run mode, as she aims to close the window with the 3D application. A window appears and asks her to save the changes in order to let the Municipality see them. She saves the visualisation results and changes made in an XML format for further analysis by the Municipality technicians.

7.1.1 User needs and goals

The need to have 3D visualisation tools was realised in order to accomplish one of the most relevant plan of the municipality for the rehabilitation of the city center. Rehabilitation is referred not only to the buildings, but aims to change the living style of the citizens and to ensure them a more healthy and sustainable life in the district.

The city center is one of the oldest and widest medieval area in Europe. The municipality aims to develop attractiveness for the tourists. Also, it must quickly take measures to reduce air and noise pollution in order to eliminate congestion of streets due to traffic and parking places and to rehab some streets which suffer from the overcrowding due to their closeness to the University.

The 3D-VR tools enable the planners to visualise all the changings which are going to be introduced in the district, to try different solutions regarding, waste collection system, public spaces, green areas or just green spots, increasing spaces for benches, bike-sharing racks and bike racks, street lighting, new traffic markings and signs and rehabilitation of the pedestrian ways.

It makes also possible to track the possible predestrian or bicycle routes and to make annotations on the points which need to be rehabilitated or developed.

Implementation of the initiative requires public participation to raise awareness of the benefits of the scheme that will be supported by the dynamic visualisation potential of the 3D-VR application. UrbanAPI 3D VR application can take one extra step to make 3D visualisation available to wider audience via web based access mechanisms in order to have wider public participation in planning issues with frequently updated 3D city data at low maintenance cost.

7.1.2 Local stakeholders

Following stakeholders are the main beneficiaries of the UrbanAPI 3D tool and applications in Bologna:

1) Giovanni Fini (Environment and Energy Sector)
2) Milena Naldi (President of San Vitale District)
3) Enzo Scudellari (Maintenance Sector)
4) Cleto Carlini (Sustainable Mobility Sector)
5) Inti Bertocchi (Housing Sector)
6) Andrea Minghetti (Territorial Information System Department)
7) General Public
8) Cultural Associations and citizens Associations of San Vitale District
9) Bologna citizens

7.1.3 Indicative Use cases[6]

[Where E=Essential, D=Desirable, O=Optional]

Use cases for Scenario A:

[6] Detailed use case descriptions for all scenarios have been included in Annex-IV and restricted to project partners use only.

UC ID	Name/Description	Importance
UC_2.1_A	Stakeholder load city data and objects used for rehabilitation into the system	E
UC_2.2_A	Stakeholders visualise rehabilitation area in 2D/3D	E
UC_2.3_A	Stakeholders annotate different selected elements/points on the city map	E
UC_2.4_A	Stakeholders manage changes related to the values of different rehabilitation objects	E
UC_2.5_A	Stakeholder share different proposed rehabilitation changes and get feedback	E
UC_2.6_A	Export images, rehabilitation project and visualisation results	E
UC_2.7_A	Perform statistical analysis of received XML data from public participation	E

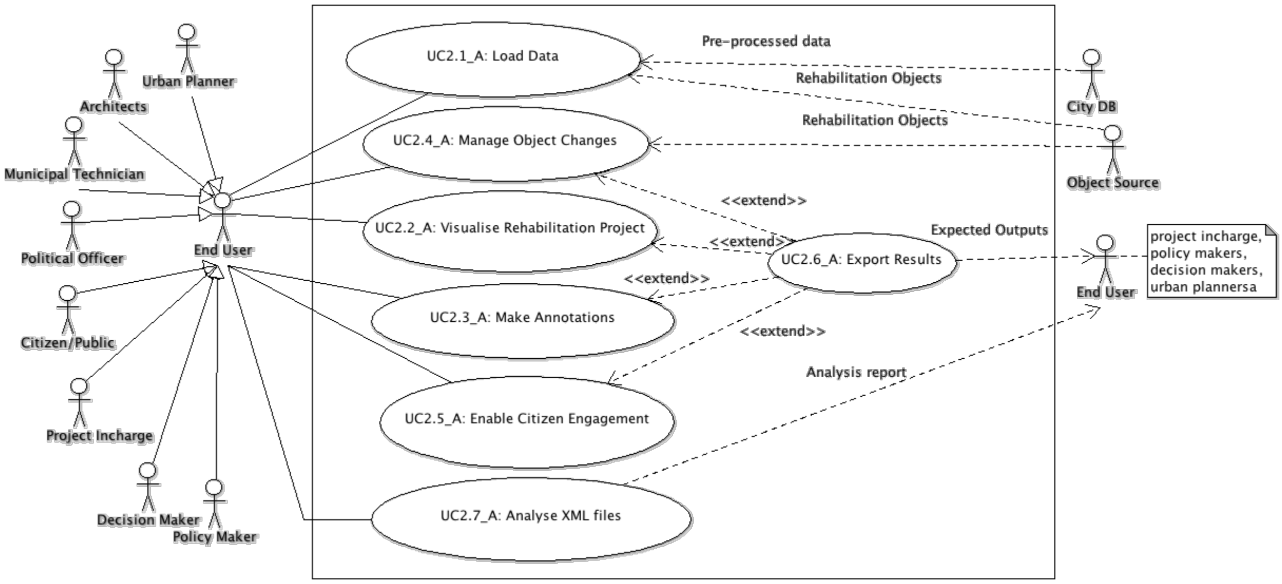


Figure 7.1: System Level Use cases for Scenario A

Use cases for Scenario B:

UC ID	Name/Description	Importance
UC_2.8_B	Stakeholders visualise rehabilitation area in 2D/3D	E
UC_2.9_B	Stakeholders draw different routes on the city map	E
UC_2.10_B	Stakeholders annotate different selected points on the city map	E
UC_2.11_B	Stakeholder share different proposed rehabilitation changes and get feedback	E

UC_2.12_B	*Perform statistical analysis of received XML data from public participation*	*E*

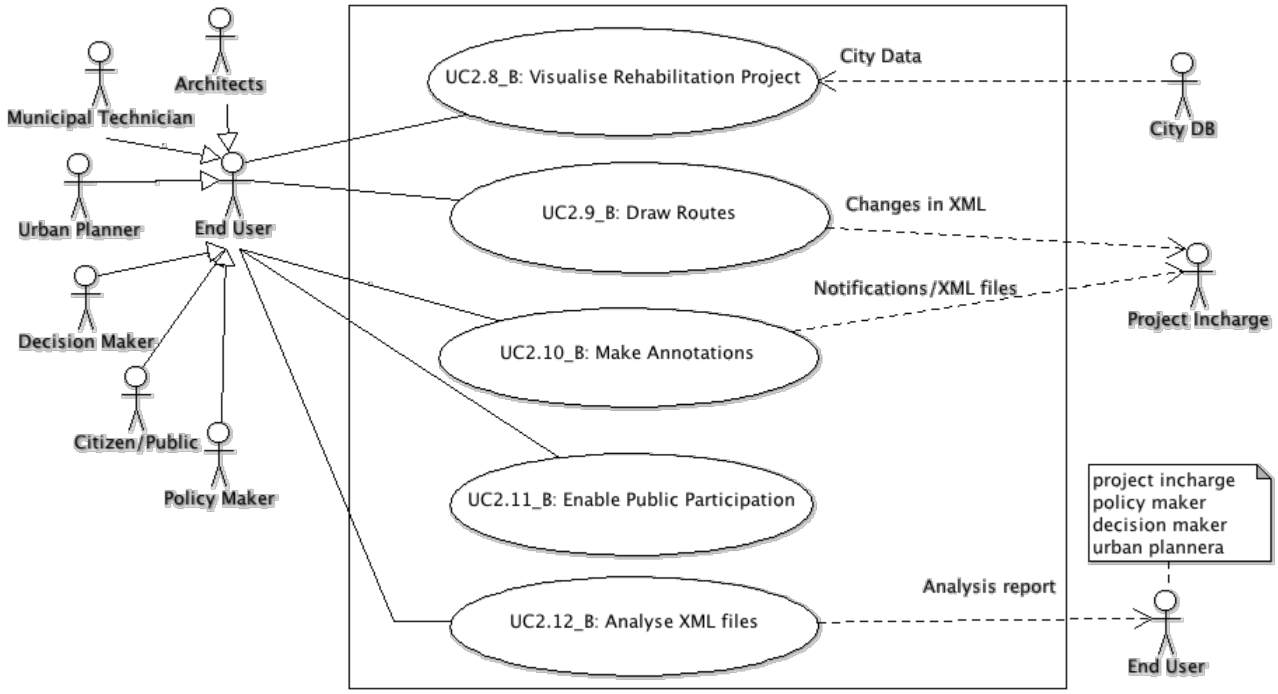


Figure 7.2: System Level Use cases for Scenario B

Use cases for Scenario C:

UC ID	*Name/Description*	*Importance*
UC_2.13_C	*Enable public participation by sharing different proposed rehabilitation projects*	*E*
UC_2.14_C	*Stakeholders visualise rehabilitation area in 2D/3D*	*E*
UC_2.15_C	*Stakeholders make changes with different rehabilitation objects*	*E*

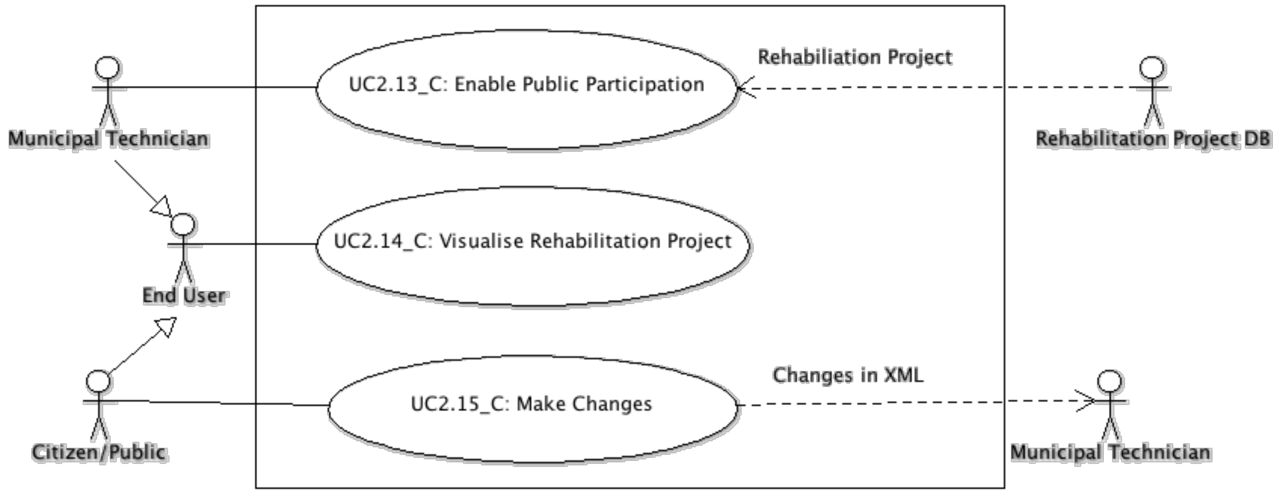


Figure 7.3: System Level Use cases for Scenario C

7.1.4 Requirements definition[7]

7.1.4.1 Functional requirements

Req ID	*Description*	*Importance*
FR2.1.1	*A framework should be defined to enable secure and mutual exchange of city data.*	*E*
FR2.1.2	*Common data models, data transformation and solutions should be provided to planners to participate in the planning process.*	*O*
FR2.1.3	*System should be able to determine the impact of any interaction (i.e. changes to data values, objects, etc) by a user.*	*E/D*
FR2.1.4	*Application should be user-friendly and for all users.*	*E*
FR2.1.5	*Software should adopt platform (hardware/software) requirements such as operating systems, application servers, databases, web browsers etc.*	*E*
FR2.1.6	*The Municipality should provide only an external link to the application.*	*E*
FR2.1.7	*End users must be able to export visualisation screen images, changes in XML and 3D visualisation model as a whole.*	*E*
FR2.1.8	*Software must be intuitive and have high usability.*	*E*
FR2.1.9	*System should be accessible via web, multi-touch tables, tablets and smart phones*	*D*
FR2.1.10	*System should be produce a XML (or similar format) file when the user saves*	*E*

[7] Detailed requirements specifications (according to the template in Annex-I) for all scenarios are included in Annex – V and is restricted to project partners use only.

	changes.	
FR2.1.11	*The produced XML (or similar format) file containing changes made by the user should be geographically referred.*	*E*
FR2.1.12	*An Administrator profile should be activated.*	*E*
FR2.1.13	*The Administrator profile should manage and change the objects selected for the rehabilitation of the district (Green areas, parking places, etc.).*	*D*
FR2.1.14	*System should produce a statistical report of the most occurred project model changes received in XML format*	*E*
FR2.1.15	*System should allow easy way to make changes in data values and visual objects.*	*E*
FR2.1.16	*The application should show reconstructed buildings (vector construction of facades, street view system, etc.)*	*E*
FR2.1.17	*System should allow to make changes, add annotation and comments on visualisations.*	*E*

7.1.4.2 Non-functional requirements

Req ID	***Description***	***Importance***
NFR2.1.1	*The application should enable the 2D and 3D surfing.*	*O*

7.2 Scenario: Public Motion Explorer (GSM)

Scenario A: Exploring population distribution in the historic centre of Bologna by mobile phone location data

Traffic planning consultant Luigi Stradivari working for the Comune di Bologna, is responsible for exploration for traffic planning policies within the City. He is in need for information on population distribution patterns to explore effects of the LTZ (Limited Traffic Zone) as traffic planning instruments in the urban environment.

Mr. Stradivari wants to observe the diurnal population distribution patterns and to compare them between the parts of the centre of Bologna to explore the effects of the LTZ. He knows that the available mobile phone location data show some uncertainties depending on the allocation algorithms, expecting location information based to a large extent on antenna coordinates, or on weighted cell coordinates attached by the respective mobile device and to a small extent on GPS-coordinates from hand held devices.

As the data are a new information source and the application of these data is a test case he will be careful regarding interpretation on derived location patterns, but he thinks this tool will be surely improved in the future.

Mr. Stradivari calls a website that provides a tool to explore the mobile phone data through interactive maps of the city, with particular attention to the center of the city. He can decide if he wants to explore the density of mobile subscribers for some territorial aggregates like cells magnitude of the census (from polygons, aggregating pixels). He can also select the hours and days of a week to explore the changes in population distribution during the day (every 30 minutes or more).

A diagram function allows depicting the diurnal variation of the population distribution in the defined spatial aggregates during work days and weekends and allows print outs to compare different areas with different (or no) traffic reduction policies.

The population distributions for the spatial aggregates will be averaged for work days applying data from Tuesday to Thursday; for weekends the data will be averaged taking Saturday and Sunday data. (Data will be taken for one regular week and 2 weekends in tourist off-season, as well as one regular week in tourist high season.)

Scenario B: Analysing the results and comparing them to other data available by the Municipality

Mr. Stradivari is working with the received mobile phone data available throught the application*. H*e realises that the application is very useful for the traffic planning, but he needs further informations about the population-distribution and the mobility in the central area of the city. He needs to integrate in the system the census data and other data from survey and traffic monitoring *that* he is able to get from the Statistical Department and the Mobility Department.

Mr. Stradivari analyses the data about the subscribers he received from TIM. The company holds 35.7% of the market share (source: AGCOM, Annual Report 2011). He loads the programme to visualise the public mobility behaviour using received GSM data. A tool on the toolbar allows him to import statistical datas about the population distribution (.xls format, shape format) and data about the Mobility sector (.xls format, shape format).

After loading necessary data, he examines the subscriber shares covered in different areas comparing them with the residential population numbers and to perform an intuitive visualisation of the overall population-distribution versus TIM subscriber distribution.

The traffic behavior survey data, provided through the Mobility sector, can be integrated into the investigations to increase the knowledge about biases occurring in the TIM-subscriber distribution and motion data.

The application also allows Mr. Stradivari to compare, analyse and combine the received data with city maps and represent it in an intuitive way. Mr. Stradivari can also export the final visualisation on different file formats (jpg, mpeg, and shape).

7.2.1 User needs and goals

This application is thought for the most important mobility project promoted by the municipality ("Di nuovo in centro"), which aims to intervene severely on the mobility system in the city centre. The Community of Bologna has decided to reduce the motorized traffic within the historic city centre. Therefore some policy instruments have been applied to encourage alternative mobility – e.g. by establishing a Limited Traffic Zone (LTZ) in the historic centre (starting in the North-East University quarter as test case). Bologna possesses one of the largest historic town centres in Europe, creating often conflicting demands for the conservation of its cultural heritage while serving its role as a major shopping centre for the region.

A report of Mobility Sector indicates that the car traffic in the LTZ decreased constantly and gradually since access data transmission has been enforced. On the other side a strong increase of motorcycle traffic is noticed and despite the decrease of traffic cars, air pollution and noise pollution have to be reduced. The existing data on mobility behaviour (e.g. poll data) and use of public space have limited reliability and are not representative at the level of small spatial units which makes it difficult for the urban and transport planners to take planning decisions.

The city envisaged that the Public Motion Explorer application can provide an effective way of testing alternative mobility proposals for the city centre including the pedestrianisation of certain localities. The application can, for example, determine the attractiveness of areas by the time spent in any given and the number of people using that area at specific times and seasons.

In addition, socio-economic and demographic characteristics can be interpolated with GSM aggregates, to estimate additional information about the substantial student population of the city and their use of the city centre.

Hence, in UrbanAPI project, the city of Bologna is interested to investigate the potential of using mobile phone GSM data (from TIM) to visualise and analyse sojourn population distribution and diurnal public motion patterns that can potentially be used to achieve the above goals.

7.2.2 Local stakeholders

Following stakeholders are the main beneficiaries of the UrbanAPI GSM tool and applications in Bologna:

1) Giovanni Fini (Environment and Energy Sector)

2) Chiara Caranti (Environment and Energy Sector)

3) Piero Lovisolo(TIM Mobile Wireless Network Service Layer & Messaging)

4) Enzo Scudellari (Maintenance Sector)

5) Cleto Carlini (Sustainable Mobility Sector)

6) Andrea Minghetti (Territorial Information System Department)

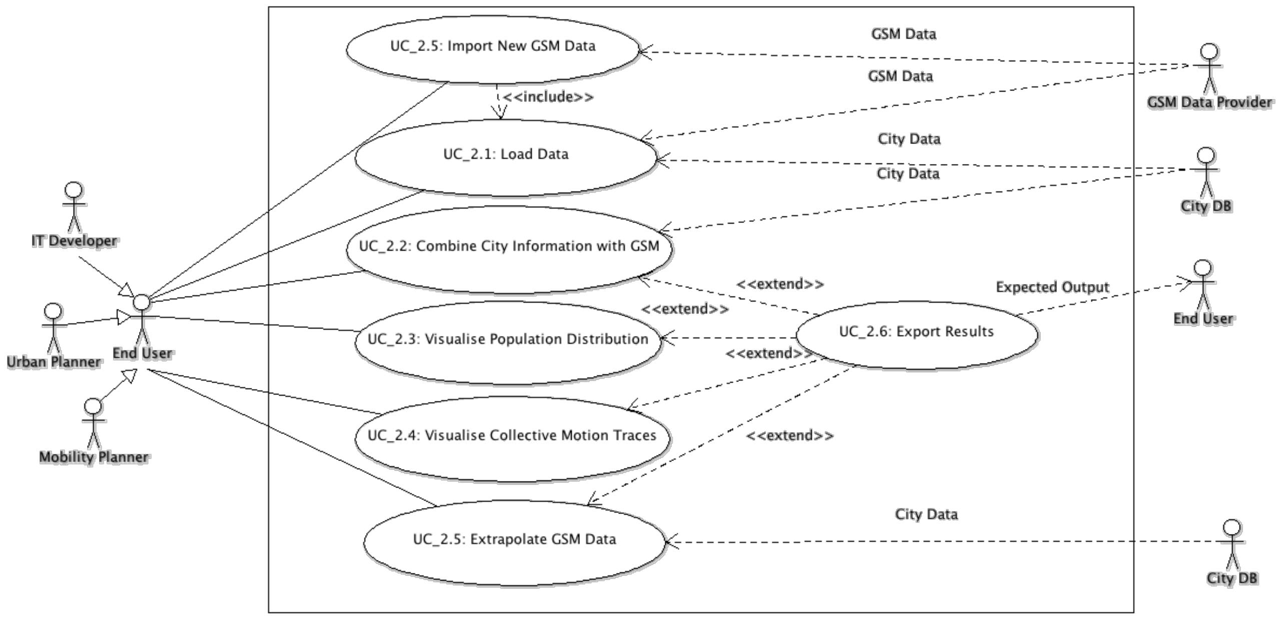
7) Marisa Corazza (Statistics Sector)

7.2.3 Indicative Use cases[8]

[Where E=Essential, D=Desirable, O=Optional]

Use cases for Scenario A and B:

UC ID	Name/Description	Importance
UC_2.1	*Loading the GSM data*	*E*
UC_2.2	*Enabling planners to combine GSM data and visualisation results with other data provided by the city (cartography, orto-photos, statistical data provided by Statistics and Mobility Department*	*E*
UC_2.3	*Stakeholder(s)/Planners (s) visualise diurnal population distribution in the city*	*E*
UC_2.4	*Stakeholders visualise motion traces*	*O*
UC_2.5	*Import new GSM data*	*E*
UC_2.6	*Export images and visualisation results*	*E*
UC_2.7	*Extrapolate GSM data to map on the overall population*	*D*



[8] Detailed use case descriptions for all scenarios have been included in Annex-IV and restricted to project partners use only.

Figure 7.4: System Level Use cases for Public Motion Explorer Application

7.2.4 Requirements definition[9]

7.2.4.1 Functional requirements

Req ID	Description	Importance
FR2.2.1	System must be able to show population distribution for selected spatial aggregates during weekdays and weekends.	E
FR2.2.2	System should consider other sources of data such smart phone GPS data, polls, surveys and census data for calibration with GSM data.	E
FR2.2.3	System should be able to statistically extrapolate the GSM data to the whole population.	D
FR2.2.4	System should allow import and export functions.	E
FR2.2.5	End users must be able to export visualisation screen images as well as visualisation model as a whole reusable format for statistical and spatial analysis.	E
FR2.2.6	End user must be able to export tables and charts with the results obtained by the application.	E
FR2.2.7	Software must adopt multi-tier architecture by using an application server to avoid direct access to database by end-users.	E
FR2.2.8	Software should adopt platform (hardware/software) requirements such as operating systems, application servers, databases, web browsers etc.	E
FR2.2.9	System should allow to add annotation and comments on visualisations.	O
FR2.2.10	System should be able to identify social biases in terms of population distribution and mobility behaviour.	D
FR2.2.11	System should be able to show public motion traces between different zones during weekdays and weekends.	O/D

7.2.4.2 Non-functional requirements

Req ID	Description	Importance
NFR2.2.1	Application should be user-friendly and for all users.	E

[9] Detailed requirements specifications (according to the template in Annex-I) for all scenarios are included in Annex – V and is restricted to project partners use only.

NFR2.2.2	*There should be a detailed description/documentation of the workflow explaining the transformation of the raw GSM and city data into refined output.*	*D*

8 Requirements development: Vitoria-Gasteiz

The Municipality of Vitoria-Gasteiz (276.8 km^2) is arranged in concentric circles, the most central of which contains the city itself, which is surrounded by the Green Belt. This is a narrow, asymmetrical, semi-natural green area. The transition between this first circle and the second is immediate. In the latter, there is a large agricultural area dotted with 64 small rural villages, hills covered with natural vegetation, water courses and riverbanks. The third circle envelops the mountainous terrain dominated by forestry and livestock uses and the landscapes to which these give shape, owned mainly by the City Council.

The city of Vitoria-Gasteiz, European Green Capital 2012 [19], has 1,091ha of public green areas and nearly 100% of the citizens of Vitoria-Gasteiz live within 300m of open public zones and green spaces. Such a green network extends over the entire city and interconnects an excellent offer of gardens, parks, avenues, boulevards and plazas, linking these to the Green Belt and the surrounding countryside. Moreover, the fact that the Green Belt surrounds the urban area completely, guarantees the presence, tangibility and accessibility of nature in each of the city's districts. It is important as it allows nature to integrate in the city, improves biodiversity and fosters the leisure, education and environmental awareness of its inhabitants.

Proposals for the implementation of an Interior Green Belt are now under development, as the embryo of an urban green infrastructure system in Vitoria-Gasteiz [20]. Based on it, the urban green will extend and branch out. In the same way as the configuration of the region is concentric, the green infrastructure would also follow a concentric arrangement, formed by several main spaces in the form of different belts -Interior Green Belt, Peri-urban Green Belt, Agricultural Belt and the Upland Ring- linked by means of radial axes that would act as ecological corridors.

The work on the main spaces and on the connecting axes, through naturalisation actions and environmental enhancement of different kind, both in the urban space and in the region, will contribute to the consolidation of a stable ecological system that will increase the ecological resilience of the municipality, improve the environmental quality of the city and, in short, improve the health and welfare of our citizens.

The refurbishment needed to implement the Interior Green Belt will take into account all the thematic fields that are affected by the urban green infrastructure project including:

- Mobility management: measures are proposed in order to reduce traffic volumes and promote sustainable mobility.
- Increase of biodiversity and biocapacity rates, and creation of biodiversity corridors that facilitate the ecological connection along several creeks than run down the mountain range area in the south to the main river in the north of the city.

- Water management: it is planned to carry out a number of actions intended to improve sewage treatment and to restore the ecological and hydrological functionality of the water systems: aquifer, creeks and rivers, wetlands, stormwater management, etc.
- Energy: the installation of systems for the production of renewable energy within the urban fabric (such as photovoltaic plates), the introduction of systems for the reduction of energy consumption, and the introduction of a new lighting system, according to Starlight criteria, will improve efficiency and energy saving.
- Actions to improve the public space and increase its attractiveness and accessibility.

The first implementation area of this urban green infrastructure will start by the so called Interior Green Belt. Formed by four main urban axes, it constitutes a pilot area where integral transformations "from grey to green" will take place. At the same time, this will work as a reference of environmental integration to be extended throughout the whole city.

According to this challenge, Vitoria-Gasteiz finds the 3D VR application as a great tool to visualize the new proposals and scenarios, in order to give support to more effective coordination between the different departments involved in the project at the City Hall, as well as reinforcing engagement with the public and other urban stakeholders. Furthermore, it will be very useful to foster political consensus and to communicate the project to the citizens and receive their contributions.

The other main challenge that Vitoria-Gasteiz is facing at the present time is the implementation of the Sustainable Mobility and Public Space Plan (SM&PSP) [21]. As a pedestrian-scale compact city, Vitoria-Gasteiz has a long track record in developing and implementing policies for achieving a sustainable city that offers a high quality of life for its citizens. For many years the City has had a strong commitment towards environmentally-friendly (and healthy) mobility through ongoing investment in pedestrian areas and cycle lanes.

In Vitoria-Gasteiz, over 80% of the City's inhabitants are employed within the municipal boundaries and walking is the most popular means of travel. Still, the proportion of journeys of less than 5 km by private car has been increasing over recent years, from 31% in 2002 to 36% in 2006. In order to reverse such a negative trend, the SM&PSP, based on a process of intense public participation, aims to minimise the dysfunctions caused by the high use of private cars. The SM&PSP seeks to transform the public space to enable non-motorised transport modes to recover a leading role.

SM&PSP seeks to reverse the upward trend in the use of the private car and to establish a new public space and mobility scheme to minimise the dysfunctions caused by the high use of motorised modes, especially the private car, and to improve sustainable mobility modes.

Reorganising mobility networks from a new urban cell (superblock) is a key element of the SM&PSP. This strategy classifies the roads in a core network for road traffic (perimeter of the superblock) and pedestrian-priority streets (inside the superblock). This scheme dissuades private car traffic by limiting both access and on-street parking inside the specified home-zones. This will also lead to the improvement of public transport and will promote short-distance modes such as cycling or walking through a safe and functional approach. The initiative aims to make Vitoria-Gasteiz a livable and vibrant city through a new shared space scheme.

Inner streets become a preferential environment for pedestrians, cyclists and service, emergency and residents' vehicles, being transformed into unique sections with roadways and sidewalks at the same level, and set out as low-speed zones. On-street parking is gradually being reduced and freight distribution is subjected to a new form of management. This scheme is being applied to the whole city, starting with the city centre and the medieval district, as well to every urban district where redevelopment is undergoing.

A Pedestrian Mobility Master Plan is currently under development. The aim is to ensure that all the communications nodes, installations and public spaces come within the reach of citizens who travel on foot. This way, a satisfactory level of accessibility to services and day-to-day activities is guaranteed. Consequently, the dependence of the population on motor-driven mobility is reduced. Work is currently underway to define in greater detail a number of actions to be undertaken within the central superblock with the financing from the URBAN programme (16.6 million € for the period 2007-2013).

The implementation of the new super-blocks mentioned earlier, included in the SM&PSP, will allow Vitoria-Gasteiz to return 70% of the space currently dedicated to vehicles to pedestrians. The new urban unit generated with an approximate average dimension of 400x400 m obliges private vehicles and public transport to circulate around the perimeter of the city, while within the "super-blocks" only local residents' traffic and the restricted distribution of goods will be permitted.

These actions will have a drastic influence on improving the quality of life of the inhabitants of the city, on mobility modes, on the level of services, on the public space, on local commerce, on acoustic quality, etc. Public Motion Explorer application will allow us to explore and visualize human and activity patterns and collective motion traces. It will be also very useful to detect centres of attraction and rejection into the city in order to help urban planners to act on them. Furthermore the application would be a tool to verify the efficiency of the actions that are carried out in the public space.

In the following sections we investigate scenario based system requirements for the above applications.

8.1 Scenario: 3D VR

Scenario A: Interdepartmental coordination in the draft of proposals for the Interior Green Belt as an urban green infrastructure system.

Urban planners of the Town Hall of Vitoria-Gasteiz are working on the planning and implementation of one of the Mayor´s most important project: The Interior Green Belt (IGB). As an integral urban transformation project, planners are in the need of reaching technical consensus and complex coordination amongst the different municipal departments, concerning all the aspects related to improve urban space functionality and quality in order to implement the first steps to an urban green *infrastructure system: mobility, accessibility, biodiversity, biocapacity, water management, energy consumption and production, pollution (air, noise, lighting), etc.*

To do that, they use a 3D VR tool that allows them to work on the planning of different scenarios that go "from grey to greener". The tool will also allow them to share the viability of these scenarios with other technical personnel and to interact and get feedback from them.

The application runs on the municipal intranet without installing any component in the computers of the technical personnel. These can see the design of the IGB in the current condition of development and propose modifications depending on the different variables that each of the departments handles.

This way, the *Department in charge of Water Management* studies the permeable pavement in the new section, the application helps them to calculate the water volume of run-off in different raining scenarios and this way they decide what capacity new sustainable drainage systems must have. They are also able to evaluate the amount of stormwater that will be released from going to the traditional sewage system to the natural depuration system.

The *Parks and Gardens Department* visualizes the state of the project to short, medium and long term in different scenarios corresponding to different epochs of the year and with different vegetable species. This way, they can decide which are the most appropriate species for each of the streets, according, for example, to shelter/shadow, biocapacity, biodiversity and management criteria and indicators.

The *Architecture Department* identifies the main buildings to be rehabilitated. They set a list of green factors that can be introduced in order to improve energy consumption and production, as well as increase biodiversity and biocapacity rates. The application helps its visualization in the urban scenario and shows the quantification of the new rates.

The *Public Space Department* plans a new distribution for the different modes of mobility, including the reduction of the on-street parking in order to increase public space for pedestrians. The application helps to calculate the changes of uses in the new section. Following to this, they also realize a new type urban lighting could be more efficient, and the application is also capable of visualizing the energy savings that this change will mean in the set of the streets.

<u>Example</u>: On the first screen various options are shown and text explaining what can be done. Selecting the chosen option they enter in to the system. A new screen is loaded and on the right side of the screen where a context sensitive help is found guiding trough the steps needed to visualise the specific layers of the project. Following these steps the project data is loaded in the system. As soon as project data is loaded, data elements are given and the visual representation of the project is shown in the major right side window (i.e. workspace). Then from the control panel the city map or a specific area of the city where the new lights system would take place, can be loaded. In next step, 'running project' from the control panel a new window is loaded where the impact on energy saving on that area is showed.

Once reached the technical agreement, urban planners trace the main scenarios of the project that are in conditions to be presented to the political officers, as they have the last word to launch the project.

Scenario B: Political consensus in the draft of the Interior Green Belt project as an urban green infrastructure system.

The planners of the IGB are in the need of political approval by consensus with the *representatives of all the political groups in the council. For it, they use the 3D VR tool that allows to visualize the project and to explain what kind of improvements the transformations will mean to a hearing that is less accustomed to working on 2D.*

They organize a meeting to join together the technical personnel and the politicians. The pilot area appears on a great screen in a very visual way. The application generates a 3D scenario of the present stage of the IGB, where changes are introduced and explained by layers of the different elements and new green functional features that make up the whole project. The main options or viable scenarios are shown. This allows the political representatives and their technical advisers to take a "virtual walk" along the projected tracing in order to realize the improvements, interacting with the system of a tactile way on the screen.

Hereby, it is possible to realize visual comparisons in different suppositions. The representative of the party A wants to compare the current situation with a future offer to detect the strong and weak points of the improvement.

The representative of the party B wants to compare the post-project situation in the short term (with little development of the vegetation) and in the medium or long term (with a complete development of the vegetation). This way he discovers that, though the intermediate situation is not fully attractive, it is worth waiting a time to reach the complete development of the action.

In the same demonstration, they are observing the changes produced so much in the aesthetics of the environment as in the management of the different variables depending on the different possibilities that the technicians raise as viable.

Hereby, the meeting has a great success and they are capable to obtain consensus in the design of de IGB combining technical, environmental, economic and aesthetic aspects, as the reached solution satisfies the requirements of all the stakeholders.

Scenario C: Citizens cooperation in the draft of the Interior Green Belt project as an urban green infrastructure system.

Ana is a person highly engaged with her city and accustomed to the use of new technologies. She has heard in press that the Town Hall has got a pre-design of refurbishment for a series of streets with ecological criteria and that they look for the contributions of the citizenship so she decides to explore the project.

The IGB project has been uploaded to the municipal website in order that the citizens could know the project and do their contributions to it, without having to install any component in their habitual browser.

This way, Ana does the first exploration of the whole tracing by means of a virtual walk along the streets. The walk is so simple and easy to operate that she can handle it with her mouse.

Through the virtual walk along this pilot area, she gets to learn more about what an urban green infrastructure system can mean when applied to her city: biodiversity, biocapacity, water management, sustainable mobility aspects, etc., when coming together can make up a more healthy, sustainable and resilient urban life.

In the course of this walk, she also realizes little details that could be improved. For example, she finds a pedestrian crossing that has been placed close to a roundabout when it could be better a few meters removed from the crossing. So she adds an annotation in the matter from the pop up menu.

On the other hand, Ana belongs to the *User group of the bicycle* and, as an expert in the field, she creates a PDI collection with the black spots around the tracing for the cyclist safety. She wants to transmit it to the Town Hall in order for them to study an improvement of the signposting.

Ana wants to add a contribution to the webpage on a similar project of an Australian city that she found in the web some time ago. Then, she writes a text with a link to the recommended site that she sends across the suggestions box.

All these contributions come to the technical team. They study all of them to reject those that are unviable and to integrate those that they consider of interest up to coming to the final definition of the IGB.

Ana´s evaluation of the project will be most useful in terms of public participation. Through visual information citizens can reach a full understanding of the project, become more aware and more sensible to environmental and urban improvements, and finally give support to public investments on these matters.

8.1.1 User needs and goals

Vitoria-Gasteiz is used to apply IT in urban planning design. But technicians have realized that the tools they use have little versatility to compare scenarios and to communicate results. Currently, Vitoria-Gasteiz cannot create 3D cartographic models of future plans in an automatic way (we just can create 2D maps). It has been done at some time in a manual way but it is not repeatable and carries a lot of time and work. UrbanAPI 3D VR application will provide the opportunity to experts to visualise and evaluate the impact of a project on the city with efficient use of human resources. Also it would be a very visual way of communicating the designs to the policy makers.

Furthermore, Vitoria-Gasteiz aims to open urban planning involving citizens and this application can take one extra step to make 3D visualisation available to wider audience via web based access mechanisms in order to have wider public participation in planning issues with frequently updated 3D city data at low maintenance cost.

Therefore, the aims that are looked by this application are the following ones:

1. Urban planning, design and management modelling. 3D visualization as a tool for the development of multiple planned scenarios of key urban parameters´ layers combination, in order for us to:
    a. Visualize and measure the different parameters variation in each scenario
    b. Compare and evaluate the different proposals
    c. Favour the integration of all the different parameters´ layers when planning and designing for the improvement of urban scenarios (High)
    d. Identify complex problems and better solutions
    e. Etc.
2. Avoiding conflicts on urban planning, design and management scenarios: Support of decision making processes in the design of street refurbishing projects. Decision makers are technical staff working in the municipality and political leaders who have the last word in these issues.
3. Improving communication between citizens and decision makers, and increasing support and participation in urban transformation processes.

8.1.2 Local stakeholders

Following stakeholders are the main beneficiaries of UrbanAPI tools and applications in Vitoria-Gasteiz:

- Urban, environment or GIS municipal technicians:
    - Rebeca Dios. Landscape and Urban Planning, Architect. Environmental Studies Centre.
    - Asier Sarasua. GIS, Bicycle Mobility, Environment. Environmental Studies Centre.
    - Juan Carlos Escudero. Mobility, Bicycle Mobility, GIS, Environment. Environmental Studies Centre.
    - Ane Itziar Velasco. Environmental and Landscape Planning. Environmental Studies Centre.
    - María de Santiago. Mobility, GIS, Environment. Environmental Studies Centre.
    - Roberto González. Environment, Dissemination, Public Participation. Environmental Studies Centre.
    - Eduardo Rojo. Urban Design, Public Space Design, Architect. Public and Natural Space Service, Town Hall.
    - Iñigo Arnaiz. Urban Design, Public Space Design. Public and Natural Space Service, Town Hall.

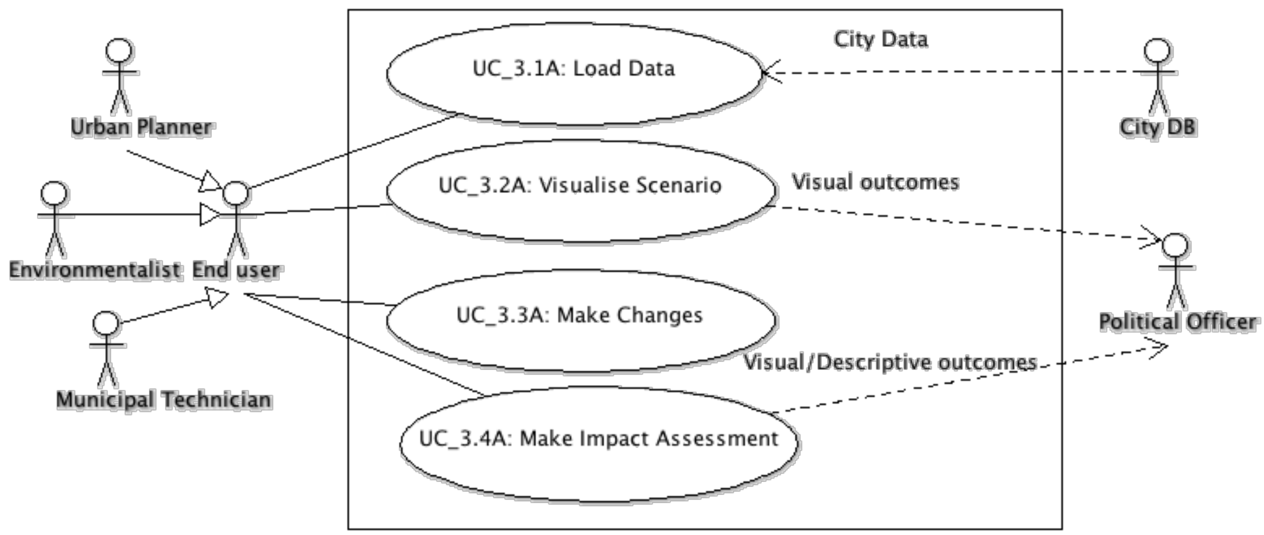
    - Other municipal technicians.
- Municipal Department Directors
- Political officers:
    - Mayor.
    - Councilors.
    - Municipal Department Directors.
- General public: citizens and associations.

8.1.3 Indicative Use cases[10]

[Where E=Essential, D=Desirable, O=Optional]

Use cases for Scenario A:

UC ID	*Name/Description*	*Importance*
UC_3.1_A	*Stakeholders load city and urban infrastructure data into the system*	*E*
UC_3.2_A	*Stakeholders visualise new urban scenarios in 2D/3D*	*E*
UC_3.3_A	*Stakeholders make changes for different elements (using visual tools and/or editing variable values) of the new urban section (distribution of uses, facades, urban materials – pavement and furniture, infrastructures and services, green features, etc)*	*E*
UC_3.4_A	*Stakeholders can visualise the variable changes in the urban model and generate output (visual, tabular or graphs, etc) for impact assessment*	*D*



10 Detailed use case descriptions for all scenarios have been included in Annex-IV and restricted to project partners use only.

Figure 8.1: System level use cases for Scenario A

Use cases for Scenario B:

UC ID	*Name/Description*	*Importance*
UC_3.5_B	*Stakeholders visualise new urban scenarios in 2D/3D*	*E*
UC_3.6_B	*Stakeholders visualise and compare different (or multiple) urban design options simultaneously in 2D/3D*	*D*
UC_3.7_B	*Stakeholders annotate different urban elements*	*E*

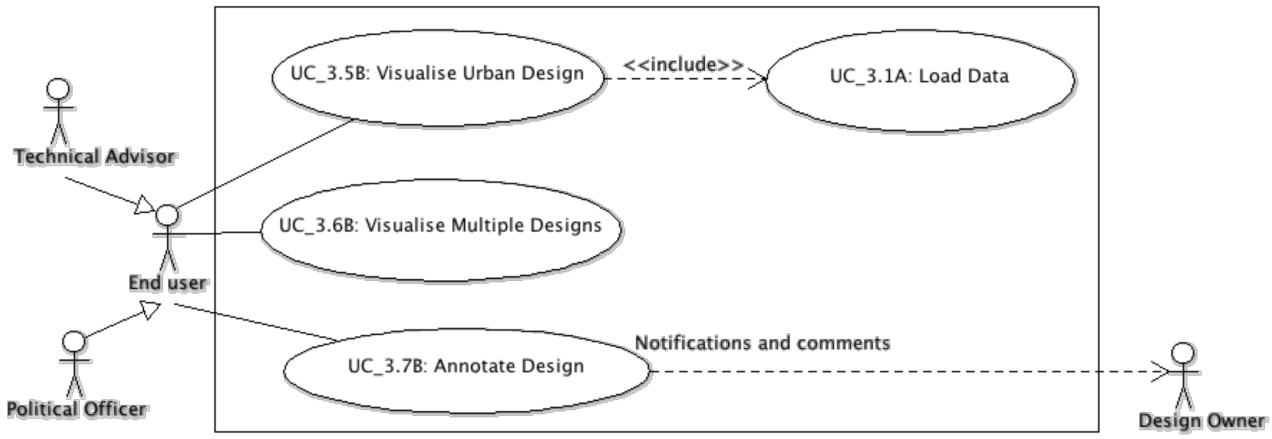


Figure 8.2: System level use cases for Scenario B

Use cases for Scenario C:

UC ID	*Name/Description*	*Importance*
UC_3.8_C	*Stakeholders visualise new urban scenarios in 2D/3D*	*E*
UC_3.9_C	*Stakeholders visualise different (or multiple) urban design models in 2D/3D*	*D*
UC_3.10_C	*Stakeholders annotate different urban elements*	*E*
UC_3.11_C	*Stakeholder share visualisation with others and get feedback*	*E*

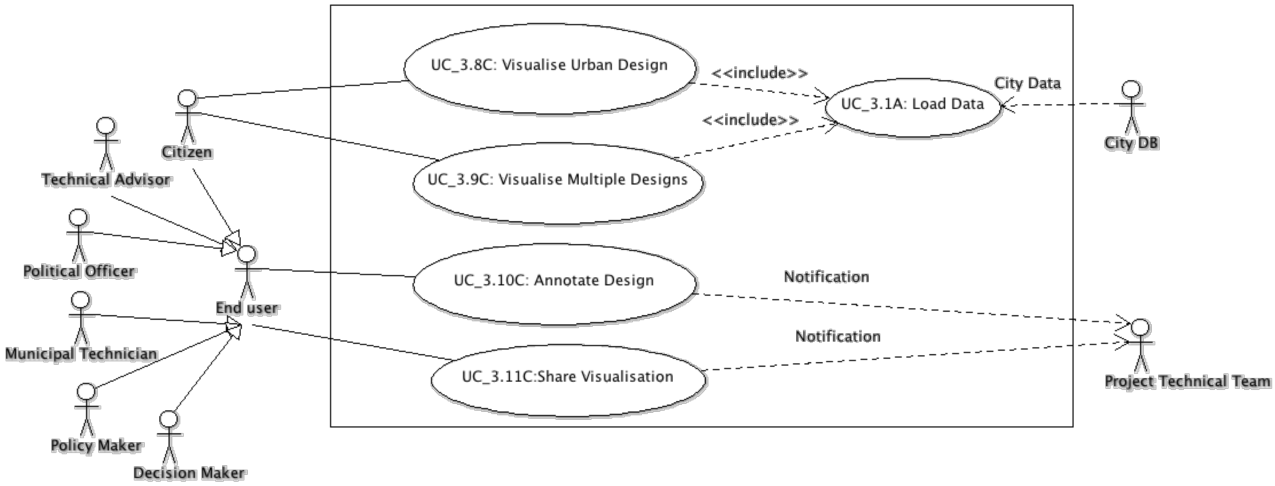


Figure 8.3: System level use cases for Scenario C

8.1.4 Requirements definition[11]

8.1.4.1 Functional requirements

Req ID	Description	Importance
FR3.1.1	System must be able to load the cartographic data (dwg, dxf) from the municipality database for different visualisation scenarios	E
FR3.1.2	System should be able to integrate all the different parameters layers when planning and designing for the improvement of urban scenarios.	E
FR3.1.3	Application should be able to visualise and evaluate the impact of city development projects through virtual reality simulations.	E
FR3.1.4	System should allow easy way to make changes in data values and visual objects.	E
FR3.1.5	System should be able to determine the impact of any interaction (i.e. changes to data values, building models, etc.) by a user.	E
FR3.1.6	System should be able to make clear cartographic representations of variables such as water related aspects, effect of proposals in the biodiversity improvement, mobility issues, people vs. services density, etc.	E
FR3.1.7	System should be able to allow access to citizens and politicians who can use these applications and suggest improvements.	E
FR3.1.8	8 End user must be able to export tables and charts with the results obtained by the	E

[11] Detailed requirements specifications (according to the template in Annex-I) for all scenarios are included in Annex – V and is restricted to project partners use only.

	changes of values.	
FR3.1.9	*End user must be able to export visualization screen images as well as 3D visualization model as a whole.*	*E*
FR3.1.10	*System should be reusable for applying scenarios in future pilot areas.*	*E*
FR3.1.11	*Software should also be accessible on touch screen devices.*	*D*

8.1.4.2 Non-functional requirements

Req ID	***Description***	***Importance***
NFR3.1.1	*Application should be deployed and accessible on the municipal intranet.*	*E*
NFR3.1.2	*Application must be available or linked on the Municipality website.*	*E*
NFR3.1.3	*Application should be user-friendly and all personnel with administrative privileges/role should be able to use it without much difficulty.*	*E*
NFR3.1.4	*Application must conform to Municipality IT standards and administrative policies including existing user roles/rights etc.*	*E*
NFR3.1.5	*Software must be intuitive and have high usability.*	*E*
NFR3.1.6	*Any application running inside Municipality premises should not have remote connection with the outside world.*	*E*
NFR3.1.7	*Application must have multilingual support.*	*O/D/E*

8.2 Scenario: Public Motion Explorer (GSM)

Scenario A: Evaluation of the efficiency of the Sustainable Mobility and Public Space Plan (SM&PSP) implementation

The *Public Space Department* of the Town Hall of Vitoria-Gasteiz has taken first steps of the SM&PSP by the implementation of the first superblock: Sancho el Sabio. Other actions have also been started in the implementation of the main central superblock. As pilot areas, planners want to find out how these urban transformations have influenced or changed the mobility means and the use of the public spaces in these areas.

The GSM data could be useful to perform comparison with the previous data available from other sources in order to evaluate, as for instance, the following aspects:

- How much have human activity and mobility patterns changed?

- What are the new itineraries and spaces most preferred by citizens, and what mobility mode they use?
- Which are the new centres of attraction or rejection for public use and for mobility?

Identifying the relation between those new patterns and the urban transformations that have been carried out can verify the efficiency of the Plan, and can help to improve its future implementation.

Scenario B: Site suitability analysis for a landmark

The *Public Space Department* of the Town Hall of Vitoria-Gasteiz is thinking to place a commemorative monument of the European Green Capital as a reminder for the future. There appears the doubt of the location since the idea is to fit it in a place with very much step and stay in order that it could be enjoyed by most of the citizens as well as on the part of the visitors.

In order to choose the best location they resort to the application Public Motion Explorer that operates on the urban core segmented in cells. The technical team formulates to the application a series of questions:

- Which is the city cell that has more traffic of people?
- Which is the city cell in which there is the larger number of stays?
- How these two values (traffic and stays) change throughout the time: working days versus public holidays, different times of the year?

The application determines three streets of the city that have a lot of traffic as well as two points of meeting where people stand there a long time. Then, technicians ask to the application: What is there nearby? The system returns the points of interest in different buffers of 50/100/200 meters.

The following question that the technicians ask is how many people live nearby and, once again, the system returns the population who lives in the tree buffers.

With all the compiled information and with the orto-photography as a reference, technicians finally decide to locate the monument in a square in which there are no architectural relevant elements but that has a high index of stay and is in a densely populated zone.

Along this process, a technician notices that one of the streets with persons' major traffic, according to the system, does not have a high index of stay but it represents a point of rejection. Again, he asks to the application what is nearby and who lives nearby. The application identifies a high number of small local retailers and banks in the zone but it highlights the absence of places of stay.

Since there are also many children and an empty lot, he proposes the construction of a playground to strengthen the attractiveness of the area.

Scenario C: Selection of improvement actions in pedestrian streets

Inside the actions derived from the Sustainable Mobility and Public Space Plan, there appears the improvement of a series of streets to foster the pedestrian mobility. The Plan has a short budget and a wide list of streets with hanging actions on improvement so that the budget does not reach for all the streets.

The technical team decided to use the application Public Motion Explorer that operates on the urban core segmented in cells. It will be useful to help in arrangement the actions in order to generate a prioritized list.

They search with the application which are the most followed routes by the citizens. The technicians ask to the tool to estimate the time travel in each of the selected routes. With the information of the time, they establish a threshold below which they suppose that the distance is realized by foot.

Now, they are capable of doing the selection to improve those streets that have more pedestrian traffic.

8.2.1 User needs and goals

In Vitoria-Gasteiz, in the present time, pedestrian and cyclist appraisals are carried out with an annual periodicity, which prove to be insufficient to properly characterize the pedestrian displacements and the public space usage by the citizens. Public Motion Explorer application will provide the opportunity to obtain an approach to these information trough GSM data.

Furthermore, Vitoria-Gasteiz has a long track record in improving the quality of public space. A set of actions have been derived from the Public Space Plan and the key point is the implementation of the "superblock" model that is expected to return 70% of the space currently dedicated to vehicles to pedestrians. Public Motion Explorer application might be a very good tool to assess the efficiency of these actions.

Therefore, the aims that are looked by this application are the following ones:

1. Improving our knowledge about the source-destination points and routes of people in their daily activities, in order for us to improve the mobility means used by those citizens (public transport, bicycle lanes, walking lanes, roads).
2. Analysing the impact that the actions for the improvement of the public space cause on its appropriation by the citizenship.
3. Testing new tools for the analysis of public space use and their possible application in the evaluation of the effectiveness of the measures derived from the Sustainable Mobility and Public Space Plan.
4. Support of decision making processes in the design of street refurbishing projects. Decision makers are technical staff that works in the municipality and political leaders who have the last word in these issues.

8.2.2 Local stakeholders

Following stakeholders are the main beneficiaries of UrbanAPI tools and applications in Vitoria-Gasteiz:

- Urban, environment or GIS municipal technicians:
    - Rebeca Dios. Landscape and urban planning, architect. Environmental Studies Centre.
    - Asier Sarasua. GIS, bicycle mobility, environment. Environmental Studies Centre.
    - Juan Carlos Escudero. Mobility, bicycle mobility, GIS, environment. Environmental Studies Centre.
    - Ane Itziar Velasco. Environment planning. Environmental Studies Centre.
    - María de Santiago. Mobility, GIS, environment. Environmental Studies Centre.
    - Roberto González. Environment, dissemination, public participation. Environmental Studies Centre.
    - Eduardo Rojo. Urban design, public space design, architect. Public and Natural Space Service, Town Hall.
    - Iñigo Arnaiz. Urban design, public space design. Public and Natural Space Service, Town Hall.
    - Other municipal technicians.

8.2.3 Indicative Use cases[12]

[Where E=Essential, D=Desirable, O=Optional]

Use cases for Scenario A:

UC ID	***Name/Description***	***Importance***
UC_3.1_A	*Stakeholders load city and GSM data into the system*	*E*
UC_3.2_A	*Stakeholders visualize diurnal population distribution in the city*	*E*
UC_3.3_A	*Stakeholders visualize collective motion traces*	*E*
UC_3.4_A	*Stakeholders generate origin destination matrices*	*E*
UC_3.5_A	*Stakeholders combine GSM data and visualisation results with other levels of city information (cartography, orto-photos…)*	*D*
UC_3.6_A	*Stakeholders perform comparative analysis using visualisation results of two or*	*D*

[12] Detailed use case descriptions for all scenarios have been included in Annex-IV and restricted to project partners use only.

	more different time stamps	
UC_3.7_A	*Stakeholders perform travel behaviour analysis*	*D*
UC_3.8_A	*Export images and visualisation results*	*E*

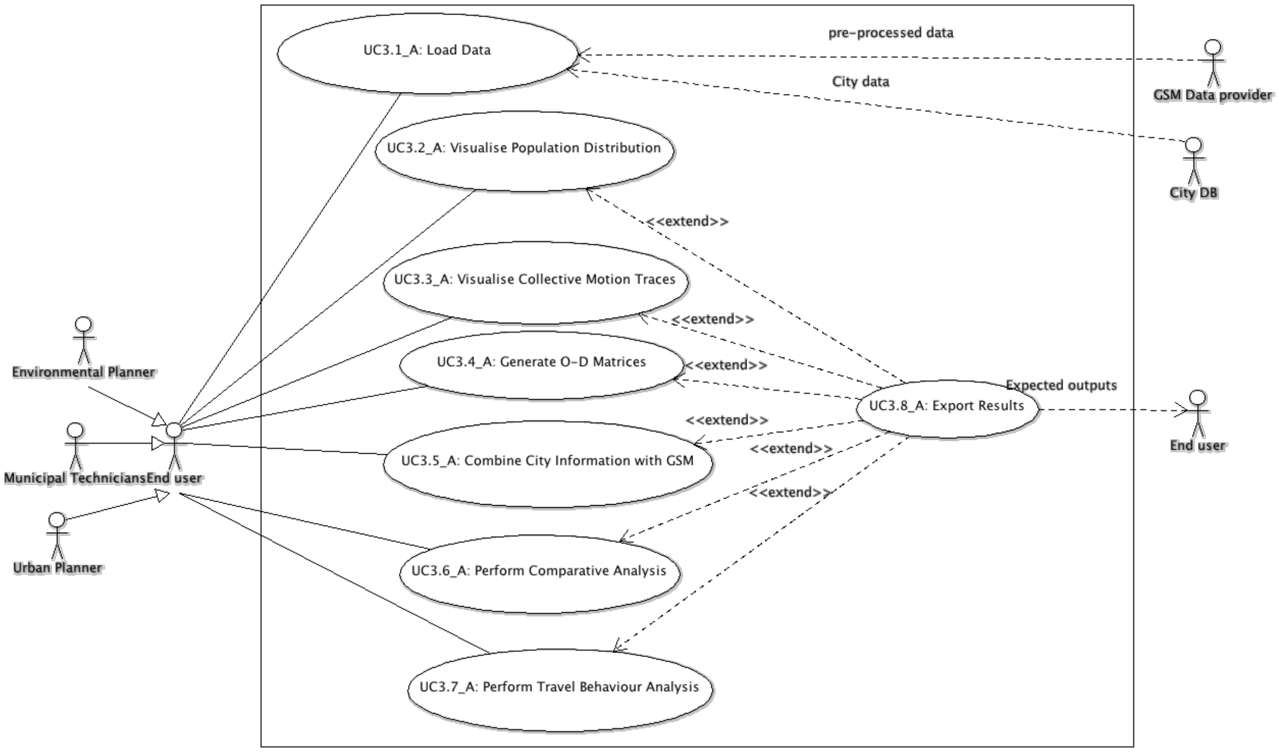


Figure 8.4: System Level use cases for Scenario A

Use cases for Scenario B:

UC ID	*Name/Description*	*Importance*
UC_3.9_B	*Stakeholders load city and GSM data into the system*	*E*
UC_3.10_B	*Stakeholders visualize diurnal population distribution in the city*	*E*
UC_3.11_B	*Stakeholders combine GSM data and visualisation results with other levels of city information (cartography, orto-photos...)*	*D*
UC_3.12_B	*Stakeholders perform comparative analysis using visualisation results of two or more different time stamps*	*D*
UC_3.13_B	*Export images and visualisation results*	*E*

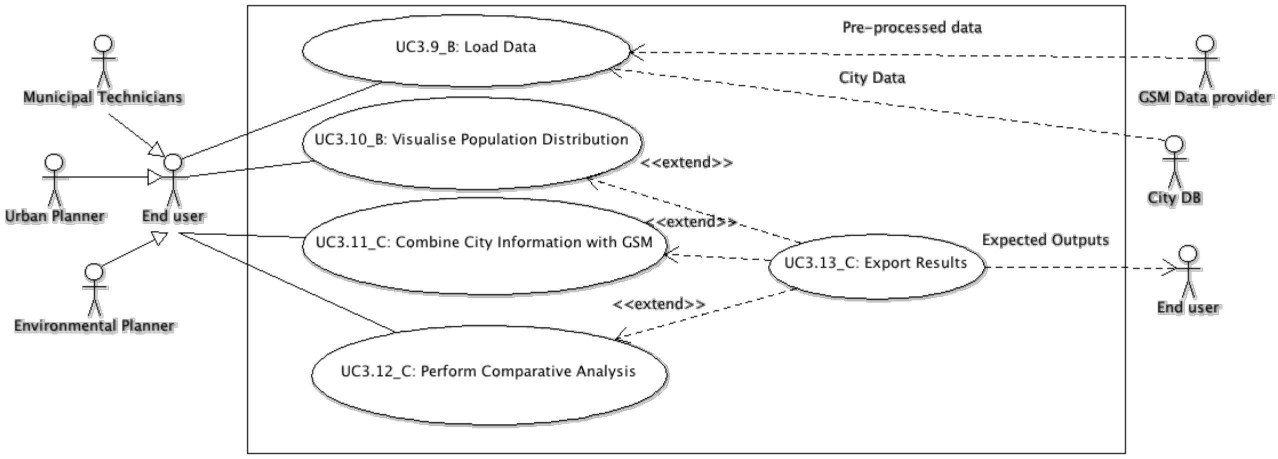


Figure 8.5: System Level use cases for Scenario B

Use cases for Scenario C:

UC ID	*Name/Description*	*Importance*
UC_3.14_C	*Stakeholders load city and GSM data into the system*	*E*
UC_3.15_C	*Stakeholders visualize collective motion traces*	*E*
UC_3.16_C	*Stakeholders generate origin destination matrices*	*E*
UC_3.17_C	*Stakeholders combine GSM data and visualisation results with other levels of city information (cartography, orto-photos…)*	*D*
UC_3.18_C	*Stakeholders perform comparative analysis using visualisation results of two or more different time stamps*	*D*
UC_3.19_C	*Stakeholders perform travel behaviour analysis*	*D*
UC_3.20_C	*Export images and visualisation results*	*E*

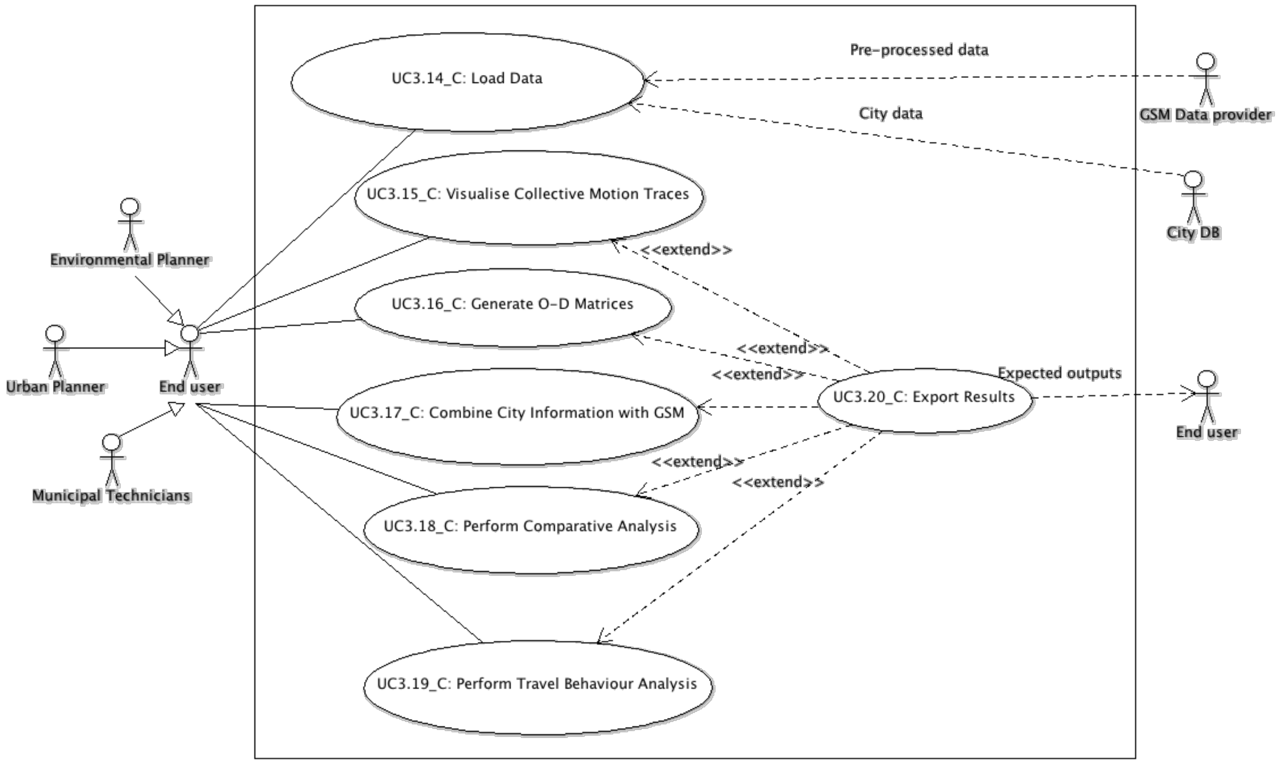


Figure 8.6: System Level use cases for Scenario C

8.2.4 Requirements definition[13]

8.2.4.1 Functional requirements

Req ID	Description	Importance
FR3.2.1	*System must be able to show population distribution for selected spatial aggregates during weekdays and weekends.*	*E*
FR3.2.2	*System should consider other sources of data e.g. smart phone GPS data, polls and surveys etc for calibration with GSM data.*	*D*
FR3.2.3	*System should be able to identify social biases in terms of population distribution and mobility behaviour.*	*D*
FR3.2.4	*System should be able to detect public in shops/recreational places within a cell but no doing anything to trigger an event.*	*D*
FR3.2.5	*System should be able to accurately capture and show real end-to-end distance coverage by selected individuals for origin-destination matrices.*	*E*

[13] Detailed requirements specifications (according to the template in Annex-I) for all scenarios are included in Annex – V and is restricted to project partners use only.

FR3.2.6	*System should be able to show and generate matrices based on the number of people moving from one zone to another.*	*E*
FR3.2.7	*System must provide intra-city and extra-city origin destination matrix acquired from diurnal day-time mobility patterns.*	*E*
FR3.2.8	*System should be able to distinguish slow motion traffic due to congestion (e.g. at peak hours) from pedestrian and/or bicycle riders.*	*D*
FR3.2.9	*System should be able to statistically extrapolate the GSM data to the whole population.*	*D*
FR3.2.10	*Ease of redoing with future GSM data.*	*E*
FR3.2.11	*End user must be able to export tables and charts with the results obtained by the application.*	*D*
FR3.2.12	*End user must be able to export visualization screen images.*	*D*
FR3.2.13	*System should be able to add, correlate and analyse other city information with GSM data.*	*D*

8.2.4.2 Non-functional requirements

Req ID	***Description***	***Importance***
NFR3.2.1	*Application has to be available on the municipal intranet.*	*E*
NFR3.2.2	*Application should be user-friendly and all personnel with administrative privileges/role should be able to use it without much difficulty.*	*E*
NFR3.2.3	*Application must conform to Municipality IT standards and administrative policies including existing user roles/rights etc.*	*E*
NFR3.2.4	*Any application running inside Municipality premises should not have remote connection with the outside world.*	*E*
NFR3.2.5	*Application must have multilingual support.*	*O*

9 Requirements development: Sofia[14]

Sofia is an historic city (old name – Serdika) and was founded seven thousand years ago. It is the second oldest city in Europe. Sofia's population is about 1,259,446, with overall territory 1349 km² and average population density about 933.6 people per km². City has about 98152 buildings and total dwellings are about 536629. In general, the public municipal property includes municipal administration buildings, publicly used property such as parks and gardens, as well as parts of underground or above-ground infrastructure, monuments of culture of local significance, and social and cultural institutions - municipal hospitals, polyclinics, kindergardens and schools. From socio-economic point of view about 642995 people are employeed under labour contract and overall unemployment rate (%) - according to labour force survey (NSI, RSO – Sofia) – is 6.6 by year 2010. Sofia Municipality is an administrative and territorial unit (More information from: http://www.sofia.bg/). The territory of the municipality also includes the areas of 3 towns - Bankya, Novi Iskar, Buhovo, and 34 villages. Their construction activities and development being coordinated with the construction plans of the capital, which were legally recognised in 1961. The capital includes 24 administrative and territorial districts and 34 mayor-led councils.

During April 2003 – December 2006, significant positive socio-economic changes took place in the country, whose strongest manifestations were observed in the city of Sofia and Sofia Municipality. Demand for new buildings increased and unemployment rate dropped to lowest levels. These developments led to increase the number of permanent residents and the projected demographic forecast of the 2003 Master Plan was about 1.3million population by year 2010. However, the unforeseeable situation and the increased level of 'motorization' created problems for transport system including public transport and private car parking etc. Also, number of violations of the regulatory framework were observed such as constructions in green areas and free spaces, during 2001 – 2006. These factors and changing socio-economic conditions resulted in the several studies of the amendment of the Master Development Plan. These studies took account of the new socio-economic conditions and direction, objectives and priorities in the development of Sofia Municipality as laid down in the District Development Strategy till the year 2015 and the updated Municipal Development Plan (2007-2013). The Master Plan of Sofia is one of the main instruments for realization of the strategic vision and aims of the development of the Sofia City-Region.

The basic principles of the spatial development of the territory include but are not limited to the following:

- Regional approach in the planning of the development of Sofia Municipality;

- Equitability of all types of ownership;

- Achieving balanced development of the compact city and the surrounding area;

- Sustainable development of the urbanized and the natural environment.

[14] Section 9 is currently being revised fully due to potential invovlement of city of Ruse from Balgaria for UrbanAPI applications.

These principles indicate limitations, formation, regulations and conservation objectives. This also lays down detailed spatial planning policy for development of central city area and surrounding areas (more information from: http://www.sofproect.com/). A more detailed regional development priorities and objectives can be found in [24]. All the above developments in Sofia and spatial planning policy indicate that the implementation of the UrbanAPI applications (3D VR, Public Motion Explorer and Urban Growth Simulation) can be effective in evidence based visualisation of population distribution and attractiveness to specific areas that can be shown as simulations of future urban growth and result in better policy and decision-making and territorial development as discussed in the following sections.

9.1 Scenario: Urban Simulation[15]

Scenario X - Pre-processing: Exploring population and workplace distribution changes linked to land use and transportation infrastructure layout as background for attractiveness and accessibility layer modeling and behavior rule development.

Chef Architect Office' staff of Sofia Municipality and the Urban planning chief expert Mrs Rafailova working for the community of Sofia, are responsible for modeling and exploration of intra-urban and extra-urban accessibility and attractiveness of Sofia. It is planned to run a simulation model which allows to explore the expansion of the city area and to identify the impacts on the area and the environment, which are different when alternative planning decisions are taken. The model shall support stakeholder integration and public participation in the planning process by allowing interactive planning interventions whose effects on the future spatial development shall then be-simulated on the fly.

The modeling tool applied will be an improvement and extension of an existing one as a completely new one would require much more resources as available. The modeling tool is an agent based simulation tool, which integrates people, households, and entrepreneurs as actors whose behaviour triggers spatial development. Intensive pre-processing work with necessary collaboration with municipality (e.g. data availability) will be needed to improve the model, to integrate new features, to adapt the agent classes and their behaviour to local characteristics. The scientists will provide some data sets regarding land use. In addition, city municipality will provide statistical data (if available for statistical entities below LAU2 level) as well as the legal planning framework information like the master plan, the infrastructure network and (narrative) future development concepts.

The pre-processing work refers to:

a) Preparation of retrospective and recent land cover layers, land utilization intensity layer and attractiveness/repulsion layers influencing actors' behaviour

b) Exploration of retrospective population, household and workplace distribution patterns,

[15] Section 9.1 is under development due to agreement on the required functionality and availability of the data for the development of simulation models.

c) Exploring the municipality choice probability and actors' behavior rules for local target area search

d) Exploring planning instruments and policies (legal planning framework, infrastructure…) and transfer into spatially explicit model input as serving as spatially explicit model input

a) Preparation of land cover layers, land utilization intensity layer and attractiveness/repulsion layers

Land use and infrastructure layout serves as physical planning framework and allows modeling landscape attractiveness layers and accessibility maps serving as attractiveness or repulsion layer for certain actor classes.

- **Land cover data** for entire Bulgaria are available for the years 1990, 2000 and 2006 (as vector maps) carried out within the CORINE Land Cover (CLC) project, following the CLC-guidelines, an example depicted in Figure 9.1. However, it may not be possible to compare the 1990- and the 2000-data due to changes in classification. The disadvantage of the CLC guidelines is the 25h minimum mapping unit, which means that all patches smaller than 25 ha are excluded when mapping land cover classes.
- But additionally Urban Atlas data (again a vector data set which includes roads and channels) are available for the Sofia urban region (http://www.eea.europa.eu/data,- http://bsdi.asde-bg.org/lccs.php; maps/data/urban-atlas/bulgaria), where no minimum mapping unit is defined. The mapping has been carried out applying SPOT data from year 2009, as well as LANDSAT-ETM (15 м), SPOT-5 (5 м), IKONOS-2 (1 м).
- AIT has already extracted a 5x5m land cover raster map for the larger Sofia urban area ranging from the northern to the southern mountain ridges by merging the 2009 Urban Atlas (UA) with the 2006 CLC vector data. (CLC data have been added to the urban atlas raster, for areas with no UA data coverage). This layer will serve as the urban region expansion model's cellular landscape.

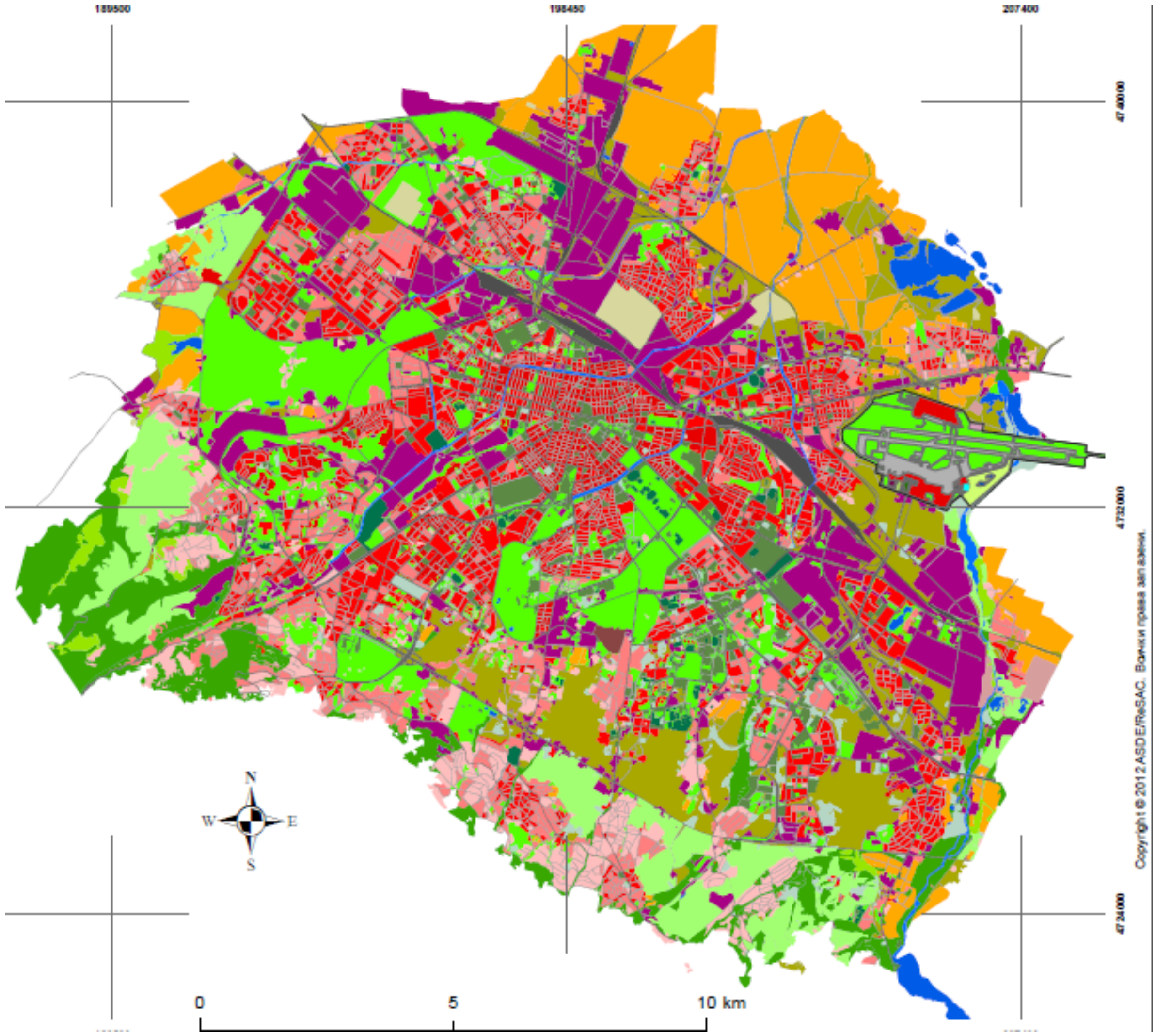


Figure 9.1: Sofia region land cover

- A new high resolution dataset - the 20x20m soil sealing layer - can also be provided by AIT in order to relate population numbers or workplace numbers to the built up land which allows to estimate to some extent land utilization intensity.
- A **land utilization intensity layer** shall be derived to be prepared for basic 3D visualisation allowing to distinguish between 1- to 2-story houses, multi-story houses and high rise buildings, giving the public audience a better impression of the area observed when zooming into the 3D landscape.
- **Land use density** is linked to population and workplace density and zoning conditions, thus data on workplace and population allocation as well on housing density and size are required to carry out such a density map which serves also as attractiveness or repulsion layer for different actor groups.

- **Landscape attractiveness / repulsion layers** will be derived out of land use maps by calculating either distance to certain land use patches (e.g. green spaces, forests, industry, main roads etc.) or the share of particular land use classes within a certain areal extent. If maps on (retrospective and recent) environmental quality on the region are available they can be used for further attractiveness pattern generation and finally for environmental future impact assessment.
- **Accessibility layers** will be derived as distance to certain infrastructure (highway exits, railway stations, workplace centres, urban cores, certain recreation areas) The final decision depends on tests and judgments of local experts

b) Exploring retrospective population, household and workplace distribution patterns within the urban region city since the last 10 to 15 years

Population and workplace distribution data (at least at municipality level) allow to explore allocation change patterns and statistically relate the change patterns to attractiveness and repulsion patterns for developing attractiveness/repulsion dependency functions to finally develop actor behavior rules. If the population structure cannot be divided into different socioeconomic groups, assumptions must be made to adapt the general behavior rules- to particular ones.

- **Population** distribution will be explored by applying data from the last census statistics (at least at LAU2 level) considering data from around 1990, 2000 and 2006 to match with the land use inventories stored as CORINE land cover. Further the urban atlas map and the European 1km GEOSTAT Population Grid 2006 developed by AIT (http://www.efgs.info/data/GEOSTAT_Grid_POP_2006_1K). For Sofia and surroundings urbanized area more detailed population allocation data for entities below LAU2 are appreciated for at least 2 time steps (in the best case 1990, 2000, 2006).
- **Education structure** data are required because of two reasons. On the one hand education is a proxy qualification having impact on business development, workplace evolution and employment attractiveness. On the other hand education is a proxy for economic welfare triggering affordability of residential areas and housing types. Other welfare related data are appreciated – e.g. regional tax payments per capita or regional GDP per capita. Such data are welcome if available at least for NUTS3 level.
- **Household size distribution** data are important for developing behavior rules - as smaller households have other demands than larger ones e.g. with respect to single family homes or town flats. Those shall be made available at LAU2 level – at least for NUTS 3 level such information is required. Household size changes must be estimated for the future based in prior evolution and if lacking, based on assumptions provided by the case study responsibles.
- **Workplace distribution** data should be made available at least at LAU 2 level. For Sofia and surroundings urbanized area a more detailed workplace allocation data are appreciated for at least 2 time steps (in best case 1990, 2000, 2006).

- **Aggregation level:** If data disaggregated to units below LAU2 level can be made available only for urbanized areas in only a part of the Sofia region, a detailed simulation can be carried out only for this part unless the simulation framework will suffer from incomplete population pattern and population dynamics presentation which will not allow top consider concurring places as mover or entrepreneur targets for residential or commercial areas.

c) Exploring the municipality choice probability and actors' behavior rules for local target area search

The location of each household and entrepreneur agent is performed by a search routine of two subsequent tasks: (1) municipality choice; and (2) local target area search. The regional and local attractiveness information for the agent's search has to be provided in advance.

- The ***municipality choice*** refers to the observation that certain municipalities are selected more often as destinations than others, assumed to be driven by certain regional attractiveness criteria. The preference of each agent for a certain destination municipality is controlled by regional choice probability distributions. They are derived in advance by developing multiple regression models, explaining increase of population / household- and company numbers (using workplaces as proxy for business start-ups) in the peri-urban municipalities with attractiveness variables. The municipality selection of the agents is conducted by the discrete choice of a municipality out of the agent classes' choice probability distribution. This leads, on the contrary, not to a random selection, but despite of performing randomly to a certain municipality selection priority and thus selection frequency,
  The main factors that may contribute to attractiveness and selection of a location can be driving time to economic centres, general economic and landscape attractiveness and the differences between the neighbouring regions, neighbouring land use, near distance open space land use share, and household or workplace density. These attractiveness criteria and behaviour patterns have to be explored in order to apply them to simulate future development

  The explanatory variables of the regression functions are typically:
  - number of people, households and workplaces per municipality in the start year,
  - Municipal social infrastructure condition (presence of schools, hospitals, security centers, public transport services), if data is available in similar scale.
  - average accessibility (travel time) to district centres and to the urban core,
  - average share of attractive land-use classes in the vicinity of the municipalities' settlements (percentage of open space, forest area etc.).
  - average share of repulsive land-use classes (poluted areas, degradated urban areas, criminal area, high natural risk areas, high industrial risk areas)

  This choice probability can be adjusted individually by exchanging the variables – e.g. taking new accessibility values as effect of new transportation infrastructure.

- ***Local attractiveness criteria:*** The calculation of local attractiveness is performed on a cell by cell basis, using a land-use raster and map algebra functions to estimate the share of more or less attractive land-use classes in each cell's neighbourhood. As part of these calculations Euclidean distances are estimated to the nearest patch of the land-use classes that serve as attraction or obstacle for location choice. The cell's population, household and workplace density is calculated by relating demographic and employment data to the underlying built-up area cells.

  Various cell layers serve as input to examine local attractiveness. A typical set of layers contains the following ones:

  - land-use layer with various classes: urban fabric-, infrastructure-, open space types.
  - distance to closest residential area, to closest industrial area;
  - distance to closest major road/motorway, to closest motorway exit;
  - population density per LAU2 sub unit;
  - workplace density per LAU2 sub unit;
  - zoning regulations: residential-mixed to industrial area
  - nature conservation areas.
  - cultural heritage areas;
  - education complexes, recreation and leisure areas, etc.

d) Exploring planning instruments and policies (legal planning framework, infrastructure…)

Here the major planning instruments and assumptions about future spatial development have to be investigated and to some extent transferred into the model framework. The Master Plan of Sofia is one of the main instruments for realization of the strategic vision and aims of the development of the Sofia City-Region. The Plan defines a set of aims with functional, spatial and environmental character, as well as specific objectives for each of the main functional systems – residence, employment, recreation, transport and technical infrastructure. Some of these issues addressing the more the urban region as the urban core will be considered as outline for future spatial development of the city region. Further assumptions regarding placement of large infrastructure will be part of two of the development scenarios.

Scenario A: general urban expansion simulations for the Sofia urban region and a sub-region

Chief Architect Office' staff of Sofia Municipality and the Urban planning chief expert Mrs Rafailova working for the community of Sofia, are responsible for modeling and exploration of intra-urban and extra-urban accessibility and attractiveness of Sofia. They are interested in the results of an urban region development simulation for the next 20 years which allows to explore the expansion of the city area and to identify the impacts on the area and the environment.

Two initial simulation assumptions are made:

1. A trend simulation is required which allows to apply the actors behavior patterns to the entire area to assess - "what will happen if the actors in the region response to the current planning framework as usual" for the region within the Sofia influence sphere.

2. A sub region simulation will be carried out for an area of interest considering the municipality sub-unit level and a resolution of 5 to 10 m making use of the behaviour patterns extracted from the first simulation focusing municipality choice frequencies and attracted population volume as part of the moving totals. For this sub-region focus a 3D-visualisation will be carried out to present the simulation results.

- ***Scenario A1: Simulation of the development of the entire urban area following the retrospective trends and considering the current master plan for the city region area***

The simulation based on the ABM will be carried out with a coarser resolution – e.g. 50 x50m in order to identify actors' behaviour, sharpen the behavior rules of the model's agents, serving as the actors who trigger spatial development: population, households and entrepreneurs.

The main objective is identifying and *s*imulating location decisions of households and business start-ups driven by regional attractiveness patterns under current conditions. When simulating the spatial development of the entire urban region, the overall trends can be understood and the municipalities as target areas which are in competition for new businesses and workplaces, new public investments like large infrastructure, better accessibility and finally new inhabitants can be identified as attractive or less attractive targets which allows then to select the appropriate attractiveness layers and develop the municipality choice probability functions.

Scenario A1 depicts the urban expansion, for entire Sofia city- region considering the basic spatial development framework related to the Master plan and defined in collaboration of scientists with urban planners familiar with the Sofia situation.

To carry out this scenario various steps are necessary (the annex shows some details on data and required variables):

- Analysing the prior legal planning framework (local planning power distribution, Master plan, traffic infrastructure development), the population development and the economic development of the Sofia greater urban region with respect to effects on urban development during the last 10 years
- Analysing land use and land use change during the last 10 years in the Sofia greater urban region
- Extracting attractiveness and accessibility criteria from prior land use and infrastructure distribution
- Analysing prior and current population (and workplace) distribution of the Sofia greater urban region
- Exploring the actors and defining actor groups triggering the urban development (e.g.

households by income and /or size characteristics, entrepreneurs starting small to larger businesses) based on statistical data for the agent simulation

- Exploring migration and business start up behaviour in the Sofia greater urban region with respect to the legal planning framework, to land use, infrastructure and thus accessibility and related attractiveness
- Extracting behaviour rules for the agent simulation related to actor groups based on prior population/employment as wel as land use state accessibility and attractiveness criteria by comparing the changes during the last decade
- Control simulations of the Sofia greater urban region for model calibration (adaptation of the behaviour rules)_
- simulation of prior urban development of the Sofia greater urban region starting from prior state to current state based on prior population and workplaces targeting future population (and workplace) distribution /density - growth

- **Scenario A2: Simulation of a sub-region development with high resolution and 3D visualization.**

As test bed for the sub-region simulation an area southeast of the municipality borders is selected: the ECOZONE Sofia East.

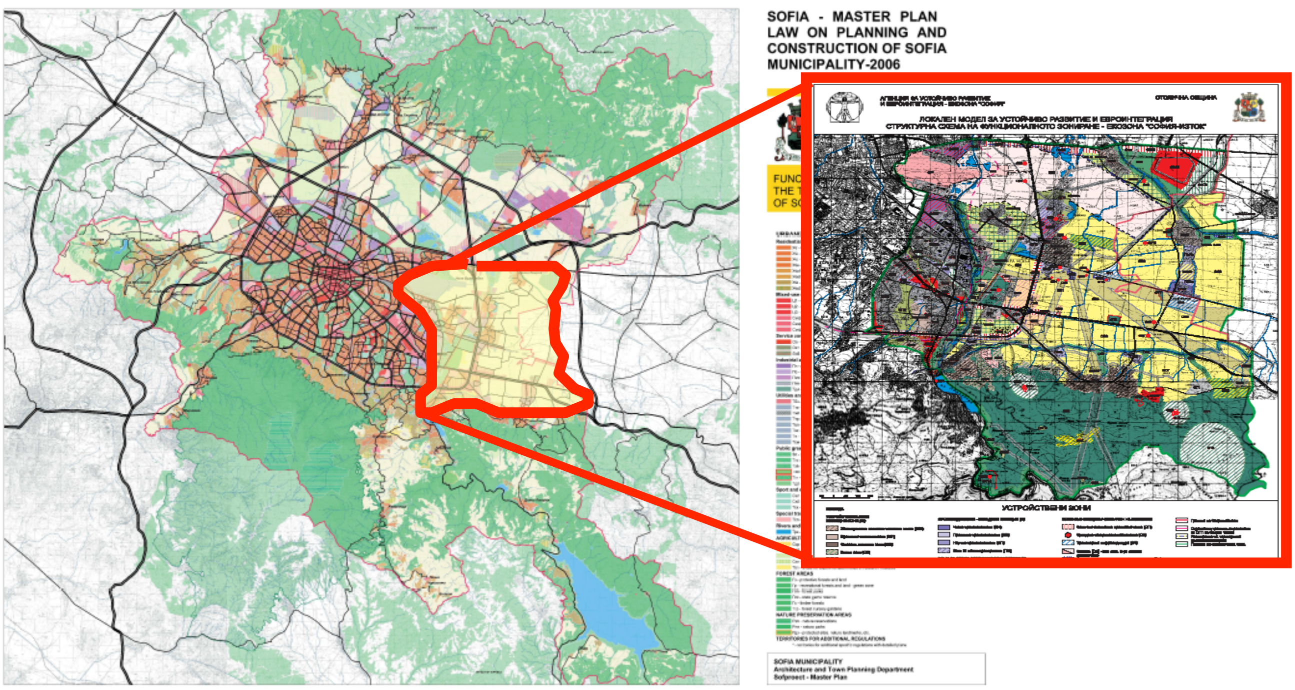


Figure 9.2: ECOZONE Sofia-East in Sofia Master Plan

The Municipality of Sofia has decided to develop an area in the south east outskirt of the city - ECOZONE Sofia East (Figure 9.2). The proposed application will make use of an agent based model, simulating land use- and land use density change in a high resolution cellular landscape (e.g. 5x5m or 10x10 m grid spacing – the high resolution helps to carry out proper 3D-visualisation). The 3D-visualisation is matter of current development and promises achieving an attractive, easy understandable simulation and exploration environment.

The high resolution urban expansion simulation for the sub-region will help understanding the consequences of different planning frameworks, by exploring actor behaviour as response on planning restrictions, on landscape quality and on general accessibility of central places. Interactive control of behaviour rules allows modifying the settling preferences, observing effects of different acceptance levels, reacting on changing attractiveness patterns.

The steps to model spatial development in the ECOZONE Sofia-East sub-region are the same as those for the entire city region: the city region results regarding actors' behavior, municipality choice – reduced to the sub-set of targets and reduced to a subset of potential movers / entrepreneurs voting for ECOZONE Sofia-East as future residence area or commercial. Some steps are not appropriate – the attractiveness layer generation, the behavior rule quantification as well as the simulation control run needs the entire cities catchment area.

The differences regarding the steps mentioned above refer to the sub-regional focus:

- Analysing the legal planning framework focussing on ECOZONE Sofia East
- Analysing the detailed prior and current population (and workplace) distribution focussing on ECOZONE- Sofia East
- Exploring migration and business start up behaviour in focussing on ECOZONE Sofia
- Simulations of future scenarios in the ECOZONE Sofia East area

The simulation results shall be presented in 2D and in 3D-mode allowing interactive control of view point and viewing direction.

Scenario B: New large infrastructure: Interactive planning interventions allowing participation and public involvement for urban expansion simulation

Chief Architect Office' staff of Sofia Municipality and the Urban planning chef expert Mrs Rafailova working for the community of Sofia, are responsible for modeling and exploration of intra-urban and extra-urban accessibility and attractiveness of Sofia. They are interested in testing effects of local planning interventions suggested by practitioners and by the public applying ECOZONE Sofia East as test bed. Three decisions on local infrastructure projects are made which may lead to particular environmental and population related impacts. The urban expansion model shall simulate the actors' responses on the new infrastructure to finally access the impacts to be expected.

Following the wishes of the Sofia planning department, the new large infrastructure simulation scenario is divided into 3 sub-tasks, each of them covering alternative local development assumptions.

- Scenario B1: introducing large infrastructure projects: airport and an attached industrial development area.
- Scenario B2: introducing a green development project: e.g. eco village & recreation zone – to be decided.
- Scenario B3: interactive placement of new infrastructure (transportation, industry) - continuing with scenario B2.

The main objective of this scenario with its sub-tasks is to modify the regional attractiveness patterns as consequence of the new physical conditions released by the large infrastructure development. The new attractiveness results leads to changes of the municipality choice probabilities which have to be quantified in advance before the simulation of the location decisions of households and business start-ups are conducted.

As the effects shall only be related to the ECOZONE Sofia East sub-region the changes in choice probabilities might be vague as the calculation lacks the entire region with all concurring target areas. It has to be discussed if this regional focus is useful or if considering the entire area leads to higher certainty. Nevertheless the scenario will work at last as demonstration task.

The model runs, to be carried out within these 3 sub-tasks shall refer to large infrastructure investments which either ignore provoking environmental stress or shall consider environment as a resource, worthy of protection.

Scenario B1: will be expected to have high economic and environmental impact. Depending on the allocation of the infrastructure site the area in the vicinity will be affected to a high extent. Additionally large scale effects may occur in terms of additional traffic load dispersed over the entire area, with some concentration near the infrastructure site.

Scenario B2: will be the antipode of B1 trying to show what green investments can release and what kind of impact – either positive or negative - can be expected compared to the B1 scenario.

Scenario B3: will be a special challenge as a new functionality shall be integrated into the simulation model: the interactive placement of new (transportation) infrastructure within the model's landscape. The user shall be able to sketch a new motorway which changes on the one hand accessibility but changes also on the other hand the environmental quality (noise, air pollution) in the vicinity of the motorway section.

The high resolution simulation results shall finally allow and support exploring local effects of these large infrastructure investment as planning intervention placed on the fly: on the one hand the response of the actors in terms of settling or occupation decisions – on the other hand the pressure on land resources and environmental quality.

The steps to model the spatial development triggered by large infrastructure in the ECOZONE Sofia-East sub-region are the same as those for the entire city region. What is different are the regional and local attractiveness criteria, affecting municipality choice patterns and local target search.

The differences regarding the steps mentioned above refer to the sub-regional focus:

- Modifying the attractiveness layers
- Estimating new municipality choice probabilities
- Simulations of future scenarios with respect to the new large infrastructure investments.

The simulation results shall be presented in 2D and in 3D-mode allowing interactive control of view point and viewing direction.

Scenario C: Post-processing: Exploring environmental and economic impacts of allocating new population and workplaces as general evolution or triggered by large infrastructure

Chief Architect Office' staff of Sofia Municipality and the Urban planning chief expert Mrs Rafailova working for the community of Sofia, are responsible for modeling and exploration of intra-urban and extra-urban accessibility and attractiveness of Sofia. The simulation results shall allow further exploration of impacts – locally, regarding the region and general. The city's representatives urgently need information on the changes in distribution of population, households and workplaces triggering the construction of buildings and triggering additional traffic load. This requires the exploration of the actor distribution as well as the changes in land use, in land utilization intensity, and in environmental stress.

The post processing work thus refers to the development of a basic impact assessment framework which allows extracting and introducing various data in, and out of the gridded model landscape – either as geospatial dataset or as aggregated numbers related to the entire city-region, to defined sub-regions or to single municipalities. Here we will concentrate on the peri-urban region in general; the urban core numbers will be extracted as far as possible,

The results require particular input data on economy including employment and income, on demography and social structure as well as on environmental conditions. Outcome can only be estimated as for as input ou data are available. Outcome can anly show in best case the spatial resolution and the thematic stratification of the input data.

Data to be extracted cannot exceed the stratification of the input data sets, but we will try to provide data extraction in the best possible way

- Population - totals
- households by size class, by income/education/wealth classes - depending on the input
- household personal motor cars usage and concentration, parking area availability – subject to the data avaialability.
- total number of employees

- total commuting and visiting traffic trips (estimation)
- change in environmental quality – additional area under pressure (estimation) (air, noise, groundwater/soil)
- nature area disturbance
- land use change by land use class

As far as regionally distinguished environmental data and economically data are available, these will be considered for impact analysis. Parts of the results exploration will be carried out within the simulation tool. Other parts can be explored after extraction of results. All layer related data can be extracted as raster files (in ASCII grid format). All table data are stored in a POSTGRE SQL database, which can be extracted as CSV- files.

9.1.1 User needs and goals

The Urban Development Plan of Sofia (Masterplan) is an important tool for the urban development and for the identification of sustainable mobility strategies. Actually the Traffic and Transport Master Plan of Sofia is partially outdated, partially undone (many roads and traffic exchanges are planned but not materialized), and specially because of parking areas crisis. In addition lot of other building initiatives has locally degraded the transport throughput of the existing infrastructure. The demand for more attractiveness for public recreational and business places and sustainable traffic infrastructure always remains there for Sofia citizens as well as for tourists.

The main challenges are to deal properly with:

- urban renewal ;
- urban sprawl;
- urban growths
- urban resilience - what results can be stated
- impact on natural and cultural environment
- impact on human behaviour and living status - is it acceptable or not
- Slow mode transports – questions – does it improve urban accessibility and reducing travel time, or not?

For all above items (except the last) common questions are valid - is every challenge realized in accordance with the Master plan or not; if not - is this because of problems with the Master plan or administrative and financial weakness? As a final results we need a discussion what to do – **a)** changing the Master plan implementation or goals, **b)** changing legal background or strengthening administrative capacity; and **c)** searching for financial, investors or citizens support;

Because of already surpassed norms of population concentration versus requested available place for social services and green areas - the Sofia municipality has oriented the city in the way of decentralization. The Metropolitan polycentric development goals are:

- **Alleviation of the overpressure to the core** city;
- **Enhancing the quality** of Sofia city environment;
- Partial **reduction of everyday commuting** by stimulating employment in smaller peripheral centres; groupings of settlements to share the social infrastructure costs;
- Respective **transportation economies** and CO2 reduction;
- **Better efficiency of public investments** for technical infrastructure, public transport inclusive, and social service in expanding peripheral settlements, using their present basic utilities **(investment optimisation)**;
- **Better efficiency of land use:** in the periphery - businesses needing more space at low price and easier connectivity with national road and rail network; intensified higher quality re-use of expensive land within the metropolis (**resources usage optimisation**);
- **Better living environment with more space and greenery at better price** - smaller scale housing in the peripheral settlements for families with children and aged people (cross pointing the transport problem);
- **Urban rehabilitation** and revitalization of abandoned zones and brown fields
- **Effective monitoring of the urban expansion plans**
- **Accessibility for everyone** to complex service centers;

The above polycentric topics have their economic and ecologic components

- **Promotion of sustainable growth and knowledge-based economy in the place of already collapsed production-based one**
- **Development and modernization of the transportation services, public, and business infrastructures**
- **Solving the traffic and parking problem ;**
- **Solving the waste treatment problem** by introducing an integrated waste management system
- **Improving of the social and technical infrastructure** including the city's supply chains and modes
- **Improvement of the living conditions and the quality of life, of buildings stock and - urban environment**
- **Preservation of the natural environment and greenery, the city open spaces and the city backup landscape (Hinterland)**

All above goals have to be investigated in retrospection, having in mind not only the actual status, but the historic development and if possible – the future prospects and predictions.

9.1.2 Local stakeholders

Following departments of the municipality of Sofia are the main stakeholders of the UrbanAPI tools and applications on city expansion modeling.

1. Chief Architect's office in Sofia Municipality

Petar Dikov, Chief Architect of Sofia

2. Department of City Development and City Planning "Sofproject" Master Plan **-** Sofia

<u>Department representatives:</u>

Georgette Rafailova , Chief expert – Public centers and social service

3. Department of Architecture and Urban planning

<u>Department representatives:</u>

Deliana Sechenska, Engineer; Urban infrastructure and transportation systems;

***<u>4. Sofia municipal Parliament</u>* -** *Sofia City council – as policy maker, and its key permanent commissions:*

- *Architecture, territory management and dwellings policy*
- *Finances and budgeting*
- *Ecology , crop lands and forestry*
- *Utility infrastructure*
- *Transport infrastructure and transport safety*
- *And others…*

<u>5. Ministry of Regional development and Public Works</u> – the UrbanApi tool can be used in the future development of Integrated Urban Rehabilitation and Management Plans (under Operatrional program – Regional Development).

<u>6. Sofia citizens and non-government organizations</u> – as stakeholders and beneficiaries of the city management policy – the Bulgarian Information Office for Earth Observation – GMES (BIOG)

9.2 Scenario: Public Motion Explorer (GSM)

Scenario A: Exploring diurnal population distributions through mobile phone data.

Urban planning chief expert Mrs Rafailova working for the community of Sofia, is responsible for exploration of intra-urban accessibility and attractiveness. She needs information on public motion patterns of the citizens in the city of Sofia to assess acceptance of urban environments, where accessibility has to be improved.

Mrs Rafailova wants to get information on the population distribution patterns within the city during workdays and weekends:

- how many people are staying at which day time in which district and/or which area.
- how many people are moving inside or outside Sofia, which day time, in which district and/or which area (commuting amount to be very important both in transport planning of key in/out routes, and related service infrastructure needs).

Mrs Rafailova is keen on detailed information about sojourn patterns in the densely built up areas during day and night hours as well as in recreation areas during weekend hours.

She knows that the available mobile phone location data show some uncertainties depending on the allocation algorithms, expecting location information based to a large extent on antenna coordinates (and their spatial density), and to a very small extent on GPS-coordinates from hand held devices.

As the GSM data are a new information source and the application of these data is a test case, she will be careful regarding interpretation on derived location patterns, but she is reluctant of using data on motion patterns, where, until now, no information was available.

Mrs Rafailova is also interested in the following both functionalities:

- calling a website providing a tool to explore mobile phone event data through interactive maps. She can decide whether she wants to get mobile phone subscriber densities for certain spatial aggregates like traffic cells, census districts or for larger Sofia / Great Sofia neighboring district areas. She is interested in selecting key hours and week days to explore the changes of population distributions during the day or the week.

-receiving a package of digital maps on mobile phone event data already sorted, coded and structured in some predefined layers of presentation both for given time/day, or statistically averaged for longer period (week, month, quarter year)

A diagram function allows depicting the diurnal variation of the population distribution for the selected spatial aggregate during work days and weekends. For the O-D-matrices (and the further functionalities) the population distributions for the spatial aggregates will be averaged for work days applying data from Tuesday to Thursday; for weekends the data will be averaged taking Saturday and Sunday patterns.

Scenario B: Extracting day-time specific origin-destination matrices of workday traffic

Mrs.Rafailova's colleagues, working for the traffic planning department in Sofia, are responsible to increase effectiveness and efficiency of the public transportation system. They require information on public motion patterns aiming in daytime-specific origin-destination matrices which allow exploring the necessary transportation capacities along certain origin-destination relations during certain time ranges.

Mrs. *Rafailova's colleagues* need intra-city and extra-city origin-destination matrices containing the total traffic – the public and the private car traffic - between the Sofia traffic model cells as well as the traffic crossing the Sofia borders. Matrices will be generated for specific hours of work days, covering begin and end of major commuting and shopping times: 7h, 9h, 12h 14h, 16h, 20h.

They are aware of the possibilities to get certain time-specific information of traffic loads depending on certain relations. They know that actually there is no reliable data on travelling collectives aggregated on the Sofia traffic cells and the districts outside Sofia, and they know that the available mobile phone location data show substantial uncertainties depending on the allocation algorithm, such as the level of accuracy of the location data depends on the density of the mobile phone antenna network in the city and the phone usage intensity.

Additionally they know, that these data reflect just a subset of the total traffic, as only a part of all travellers within the city (up to 50%) are subscribers of MTel mobile communication services, and that these shares may differ slightly between areas, as MTel covers a specific socio-economic and age compartment of the population. And in some more general extent the mobile traffic is not so intensive in the group of travellers in rush hours. Hence the relevance of mobile communication usage in identifying the travellers do not exceed the 5-10%, and a statistically sound presentation requires statistical averaging of data on many days, and even mounts

They also understand that as there is no systematic traffic counting data available, at certain sections with single mode traffic and multi modal traffic (e.g. bridges) calculating the ratio of the traffic members and the total car drivers/passengers, covered by the MTel mobile phone data provider, which intensively use their devices when travelling is technically impossible. Or such method's quality assessment requires a huge amount of statistically processed data.

Scenario C: Extracting trip chains through path-time diagrams based on mobile phone data

Mrs. Rafailova also wants to get some information on trip chains, travelling time, if possible on traffic mode selection for a sample of the commuting population within/outside Sofia.

This task will be carried out with samples of work day travel data: a set of (anonymous) single users – starting from selected origins in and outside Sofia will be tracked by using the "time stamps" and "location stamps" of the mobile phone log data. A set of trip chains will be extracted and documented through path-time diagrams. Exemplary types of travellers will be grouped regarding travel distance, travel speed, travel mode and sojourn pattern during the daily trips. Mrs. Rafailova knows that the accuracy of the results depends much on the accuracy of the location information, the intensiveness of the mobile telecom traffic, and that exploration of travelling behaviour based on mobile phone data is a first experiment with a limited authenticity of the result.

In addition, the following constraints of MTel data should be kept in mind in order to perform the above explorations and to assess the usability and suitability of the GSM data for city policy goals and sustainable planning needs:

- MTel has more than 50% of the market share with about 5,5 million subscribers. Intuitive visualization of the overall population-distribution versus early morning MTel subscriber distribution can not be performed because no early morning callback.
- There is no Sofia traffic and population behavior survey data. The only available data on the population behavior provided through Sofia municipality is a modeled data. It can be integrated into the investigations to increase the knowledge about biases occurring in the MTel subscriber distribution and motion data.
- Traffic modes can be explored for selected routes where single modes can be identified. Such exploration could be done for GPS and Smart phones only, i.e. for less than 3-4% of MTel users.
- Mobile phone location accuracy (except the GPS and Smart phones) is highly limited, requires position triangulation from at least 3 cell antennas, and can be explored for test areas and (as far as possible) through additional information from the data provider if any.

9.2.1 User needs and goals

The Urban Development Plan of Sofia (Masterplan) and the Traffic and Transport Master Plan are important tools for the urban development and identify sustainable mobility strategies. Actually the Traffic and Transport Master Plan of Sofia is partially outdated, partially undone (many roads and traffic exchanges are planned but not materialized because of lack of appropriate investments), and because of parking areas crisis. In addition lot of other building initiatives has locally degraded the transport throughput of the existing infrastructure. One of the main objectives of transport planning in the city is to keep the distance short and shift to public transport from private traffic mode. A recent study indicates that 'the Sofia's traffic infrastructure has degraded significantly for the last 20 years that now less than 50 per cent of people's everyday journey is covered by public transport, bicycles or on foot' [11]. For the commuting people, the public transport services are even less than 50%. The demand for more attractiveness for public recreational and business places and sustainable traffic infrastructure always remains there for Sofia citizens as well as for tourists.

Likewise, information about daily population distribution in different districts and attractiveness to recreational places can provide major indicators for urban development and public transport improvement and planning. The existing data on mobility behaviour (e.g. poll data) and use of public space have limited reliability and are not representative at the level of small spatial units which makes it difficult for the urban and transport planners to take planning decisions. In addition lots of legal limitations on poll data hampers its effective usage in urban planning. Therefore, city of Sofia's main goals here are to get information from alternate sources about real mobility behaviour of citizens that can be used to:

i) get better insights in mobility and traffic behaviour of the citizens which can indicate citizens' preferences to mode of transport for travelling, social biases and attractiveness to selected areas;

ii) use as an evidence to improve transport and urban planning initiatives in the city.

This information permits the targeting of areas of attraction within the city, the opportunity to obtain a full understanding of the basis for this attraction, and accordingly to create urban and transport planning responses. Hence, in UrbanAPI project, the city of Sofia is interested to investigate the potential of using mobile phone GSM data (from MTel) to visualise and analyse sojourn population distribution and diurnal public motion patterns that can potentially be used to achieve the above goals. For Sofia, the above UrbanAPI application will have a major impact – which could be attributed to changes in existing business model, cost savings and evidence based updated data and information for planning purposes. Traffic infrastructure planners would also be interested in development of GSM application in city - region context (functional urban area) to identify evidence-based planning needs for public and private transport infrastructure.

9.2.2 Local stakeholders

Following departments of the municipality of Sofia are the main stakeholders of the UrbanAPI tools and applications.

1. Department of City Development and City Planning: "Sofproect" Master Plan - Sofia

Department representatives:

Georgette Rafailova, Chief expert – Public centers and social service

2. Department of Architecture and Urban planning

Department representatives:

Deliana Sechenska, Engineer, Urban infrastructure and transportation systems;

3. Citizens of Sofia

9.2.3 Indicative Use cases[16]

[Where E=Essential, D=Desirable, O=Optional]

Use cases for Scenario A, B and C:

UC ID	*Name/Description*	*Importance*
UC_4.1	*Preprocess Mobile Phone Service providers' GSM data*	*O*
UC_4.2	*Stakeholder(s)/Plannes(s) visualise diurnal population distribution in the city*	*E*
UC_4.3	*Stakeholder(s)/Planner(s) generate Origin Destination Matrices*	*E*
UC_4.4	*Import new GSM data*	*O*
UC_4.5	*Export images and visualisation results*	*E*

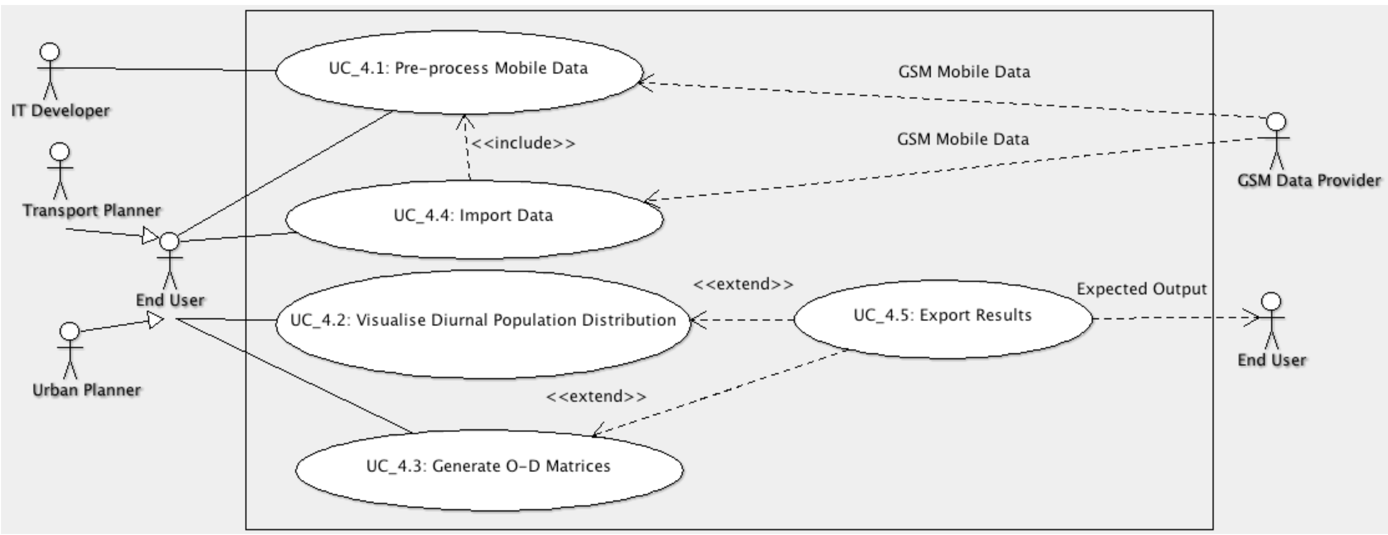


Figure 9.3: System Level Usecase Diagram for Public Motion Explorer Application

9.2.4 Requirements definition[17]

9.2.4.1 Functional requirements

Req ID	*Description*	*Importance*

[16] Detailed use case descriptions for all scenarios have been included in Annex-IV and restricted to project partners use only.
[17] Detailed requirements specifications (according to the template in Annex-I) for all scenarios are included in Annex – V and is restricted to project partners use only.

FR4.2.1	*System must be able to show population distribution for selected spatial aggregates during weekdays and weekends.*	*E*
FR4.2.2	*System should be able to consider other sources of data e.g. smart phone GPS data, polls and surveys etc for interpolation and calibration with GSM data.*	*O*
FR4.2.3	*System should be able to accurately capture and show real end-to-end distance coverage by selected individuals for origin-destination matrices.*	*D*
FR4.2.4	*System should be able to generate and show matrices based on the number of people moving from one zone to another*	*E*
FR4.2.5	*System must provide intra-city and extra-city origin destination matrix acquired from diurnal day-time mobility patterns.*	*E*
FR4.2.6	*System should be able to show mobility patterns at city-region scale (funtional urban area) and commuting from South, North, West and East.*	*O*
FR4.2.7	*System should allow import and export functions.*	*E*
FR4.2.8	*End users must be able to export visualisation screen images as well as visualisation model as a whole.*	*D*
FR4.2.9	*Software must be intuitive and have high usability.*	*E*
FR4.2.10	*Software should adopt platform (hardware/software) requirements such as operating systems, application servers, databases, web browsers etc.*	*E*
FR4.2.11	*Software must adopt multi-tier architecture by using an application server to avoid direct access to database by end-users.*	*E*
FR4.2.12	*System should be able to generate, show and edit O-D matrice of substantial dimension (e.g. up to 1000x1000 cells and even more).*	*E*
FR4.2.13	*System should be able to pre-process GSM data in Giga bytes or even better if can manage Tera bytes.*	*D*

9.2.4.2 Non-functional requirements

Req ID	***Description***	***Importance***
NFR4.2.1	*Application should be user-friendly and all personnel with administrative previleges/role should be able to use it without much difficulty.*	*E*
NFR4.2.2	*System output and operations interface should be accessible via web and other touch-screen devices.*	*E*
NFR4.2.3	*There should be a detailed description/documentation of the workflow explaining*	*E*

	the transformatioin of the raw GSM and city data into refined output.	

10 Common requirements

The aim of this section is to identify commonalities in application specific requirements defined by four cities (sections 6, 7, 8 and 9). These commonalities in requirements defintion, on the one hand, will help in identifying the technical capabilities required to solve local policy needs and enable ICT developers to implement generic funtionalities which could be applied in other European cities. On the other hand, these commonalities and variations will help planners and policy makers to identify common cities priorities and define framework/roadmap to align local level priorities with EU scale. The main criterion to identify the commonalities is to select a right level of abstraction i.e. higher the abstraction level, more common processes and functionalities are needed and vice versa. For example, use-case level or requirement defintion level can be used but in order to be more precise and concrete examples of common requirements of cities, here we focus on requirement definition level.

The following sections present the generic capabilities/functionalities in Urban API applications (3D VR application, Public Motion Explorer and Urban Growth Simulation) and map them to formal requiremetns (requirements IDs) from different cities in order to indicate which cities have common need of such capabilities.

10.1 Application 1: 3D VR

Capabilities/Functionalities	Vienna	Bologna	Vitoria-Gasteiz
Enable ease of use and application intuitiveness (e.g. easy aerial navigation (2D/3D) support, tools to make changes visually, etc)	FR1.1.6, FR1.1.15	FR2.1.4, FR2.1.8	NFR3.1.3, NFR3.1.5
Provide generic or common 3D data modelling and transformation guidelines	FR1.1.3	FR2.1.2	
Enable direct data accessibility and integration/synchronisation with city 3D Databases – A framework for internal exchange of city data	FR1.1.1	FR2.1.1	FR3.1.1
Use multi-tier architecture to access city DB	FR1.1.8		
Enable Public participation - Enable public to make changes to 3D visual model, annotate and leave comments (e.g. drawing a bicycle route)	FR1.1.18	FR2.1.17	FR3.1.7
Enable 3D Visualisation project sharing with public using different platforms e.g. web, multi-	FR1.1.17	FR2.1.9, FR2.1.16	FR3.1.11, NFR3.1.2

touch table, smart phones, etc			
Get feeback from public/stakeholders in a reusable format, e.g changes proposed in an XML format		FR2.1.10, FR2.1.11, FR2.1.12	FR3.1.7
Ensure limited data conversion or consistent data/model transformation	FR1.1.2		FR3.1.1
Easy to manage changes to visual objects: addition, removal, change of characteristics/properties	FR1.1.5, FR1.1.16	FR2.1.15	FR3.1.4, FR3.1.5
Ensure mapping to local spatial statistical units (zones/districts/census units etc)			FR3.1.2
Perform integration of 3D data with other city data e.g. census, transport network, etc.			FR3.1.2
Perform object change impact assessment visually and as a report e.g. dynamic changes to visual objects and its effect (e.g. socio-economic, environmental, etc).	FR1.1.5, FR1.1.10	FR2.1.3	FR3.1.3, FR3.1.5
Generate object change impact (e.g. statically representing changes) report	FR1.1.4	FR2.1.14	
Provide graphical tools to perform interaction and and object changes with the 3DVR application	FR1.1.5, FR1.1.6, FR1.1.15	FR2.1.4, FR2.1.8	FR3.1.5
Provide measuring tools (distance, height, etc)	FR1.1.19		
Support importing new data/objects/models (e.g. from existing system)	FR1.1.13	FR2.1.13	FR3.1.1
Provide export functionality (common format e.g. XML) to use data/model/results for statistical (excel, SPSS, etc) and spatial analysis (ArcGIS) etc which can be used by existing system.	FR1.1.12, FR1.1.13	FR2.1.7, FR2.1.10, FR2.1.11	FR3.1.8, FR3.1.9
Notify project incharge about any public participation activity via email		FR2.1.12	
Municipality IT department Application access (i.e. security) restrictions	FR1.1.6, FR1.1.7		NFR3.1.1, NFR3.1.2
Municipality IT department Software/platform compliance	FR1.1.9	FR2.1.5	NFR3.1.4
Municipality IT department policy compliance	FR1.1.7		NFR3.1.3, NFR3.1.4
Documentation – developers and users manuals –	FR1.1.20, FR1.1.6,		

training material	NFR1.1.2		
No remote connection is allowed if application if application is running inside the municipality network	NFR1.1.1		NFR3.1.6
Multi-language support			NFR3.1.7
Shadow situation/visibility analysis	FR1.1.4		
Semit-automated workflows for scenarios supported by user interactions	FR1.1.11		
Load data/models/architectures from 3rd party software	FR1.1.14		
Common guidelines fro architects	FR1.1.20		
Application hosted on an external server and municipality should provide an external link to the application		FR2.1.6	
Reusability of the application on other city districts and different objects/themes		FR2.1.13	FR3.1.10
Statistical report on most changes performed by users/public		FR2.1.14	
Show reconstructed buildings		FR2.1.16	
Enable 2D/3D surfing		NFR2.1.1	
Clear cartographic representation of differnt variables			FR3.1.6
Application deployment and accessibility from municipality intranet			NFR3.1.1
Application linked to municipality website			NFR3.1.2

The above table shows that there are commonalities between city requirements for the 3D VR application. Nearly 50% of the above characteristics or capabilities are needed by more than one city. Furthermore, usability aspects with visual aid; data synchronisation and integrity; public participation and ease of interaction with the application; accessibility of the application using different platforms e.g. web, smart phones; change impact assessment; importing new data and exporting results in common formats; and conformance to city administration IT policies are the most common functionalities required by all cities. In addition, individual specific requirements of cities indicate new capabilities which can be developed to improve the overall functionality of the 3DVR application. This suggests that based on these commonalities in city requirements, generic tools and services can be developed which can be adopted and further extended to fulfill specific needs of new city administrations.

10.2 Application 2: Public Motion Explorer (GSM)

Capabilities/Functionalities	Vienna	Bologna	Vitoria-Gasteiz	Sofia
Enable ease of use and application intuitiveness	FR1.2.15	NFR2.2.1	NFR3.2.2	FR4.2.9
Visualise aggregated population distribution during weekday and weekends	FR1.2.1	FR2.2.1	FR3.2.1	FR4.2.1
Identify where do people mostly spend their time – public spaces, parks, offices, homes etc	FR1.2.2		FR3.2.4	
Clustering based on common behaviour	FR1.2.2			
Extrapolate GSM data to map it to whole city population	FR1.2.12	FR2.2.3	FR3.2.9	
Analyse social biases using GSM and city data	FR1.2.4	FR2.2.10	FR3.2.3	
Identify and Visualise public mobility traces e.g. how many people in total daily move from one zone/district to another	FR1.2.5	FR2.2.11	FR3.2.6	FR4.2.4
Identify travelling mode – car, bicycle, padestrian, etc. (peak/off-peak hours)	FR1.2.9, FR1.2.10		FR3.2.8	
Generate Simple Origin-Destination Matrices for diurnal mobility	FR1.2.5, FR1.2.6		FR3.2.5	FR4.2.3
Generate complex multi-dimensional origin-destination matrices for diurnal mobility in different time slices, trip-chains, traffic modes etc	FR1.2.5, FR1.2.6, FR1.2.9			FR4.2.3, FR4.2.12
Investigate the location accuracy of GSM data and feasibility to identify accurate public mobiity patterns based on the data and events handled by GSM service provider	FR1.2.18			
Enable Public participation - Enable public to annotate and leave comments e.g. attractiveness of a place	FR1.2.13	FR2.2.9		
Enable Public Motion Explorer project	NFR1.2.3			NFR4.2.2

sharing with public using different platforms e.g. web, touch-screens, smart phones, etc				
Get feeback from public/stakeholders in a reusable format, e.g changes proposed in an XML format		FR2.2.9		
Diurnal daytime mobility patterns at city-region scale, intra-city and extra-city O-D matrices	FR1.2.8		FR3.2.7	FR4.2.5, FR4.2.6
Capacity to pre-process GSM data in Giga-bytes and Tera-bytes				FR4.2.13
No remote connection is allowed if application if application is running inside the municipality network			NFR3.2.4	
Ensure mapping to local spatial statistical units (zones/districts/census units etc)	FR1.2.5, FR1.2.11			
Perform integration of GSM data with other city data e.g. census, transport network, etc.			FR3.2.13	
Support importing new GSM data	FR1.2.14	FR2.2.4		FR4.2.7
Provide export functionality (common format) to use data/model/results for statistical (excel, SPSS, etc) and spatial analysis (ArcGIS) etc.	FR1.2.14	FR2.2.4, FR2.2.5, FR2.2.6	FR3.2.11, FR3.2.12	FR4.2.7, FR4.2.8
Multi-language support			NFR3.2.5	
Municipality IT department Application access (i.e. security) restrictions	NFR1.2.1			
Segregation of mobile patterns	FR1.2.2			
Use and integrate data from other sources (e.g. surveys, polls, GPS, etc)	FR1.2.3	FR2.2.2	FR3.2.2	FR4.2.2
Origin-Destination Matrices accommodating special zones (not represented in spatial statistical units)	FR1.2.5			
Municipality IT department Software/platform compliance	FR1.2.16	FR2.2.8		FR4.2.10
Use multi-tier architecture to access city DB	FR1.2.17	FR2.2.7		FR4.2.11

Municipality IT department policy compliance (e.g. Application access restrictions)	NFR1.2.1		NFR3.2.3	
Application is user-friendly and compliant to Municipality administrative access previledges	NFR1.2.2	NFR2.2.1	NFR3.2.2	NFR4.2.1
Documentation – workflow, data trasnformation documentation, developers and users manuals – training material	NFR1.2.4	NFR2.2.2		NFR4.2.3
Reusabiity or redoing the application with new data			FR3.2.10	
Application deployment and accessibility from municipality intranet			NFR3.2.1	

Similar to 3DVR the above table shows that there exist commonalities between city requirements for the GSM application. About 60% of the above capabilities are needed by more than one city. Furthermore, usability aspects with intuitive user interface; visualisation of aggregated population; indicating places attracted by public; extrapolation to reflect the results for overall city population; identifying social biasing; visualising motion traces between city districts/zones; intra-city and extra-city origin-destination matrices and travelling mode; accessibility using different platforms; importing new GSM data and exporting results in common formats; integration of GSM data with data from other sources e.g. GPS, polls; city administration IT standards compliance; and workflow documentation are the most commonly needed capabilities for the GSM application. This suggests that generic tools can be developed to facilitate wider adoptability of the GSM application where as more specific requirements from cities add value to these common capabilities.

10.3 Application 3: Urban Simulation

Only City of Sofia is participating in the Urban Growth Simulation application – please refer to section 9.1.

11 Requirements validation and acceptance

Requirements validation is an important aspect of the requirements methodology that ensures accuracy and reliability of requirements from the stakeholders and keeps requirements changes to a minimum level at the later stages of the system development stage. Therefore, the scenario based use cases and requirements are defined to understand the required system functionality and get it validated by the city stakeholders. Also, a requirement template is defined, as depicted in Figure 11.1

and detailed in Annex-I, requires city stakeholders (i.e. requirement owners) to explicitly *validate* each requirement statement, its *rationale*, *functionality* and *acceptance criteria*. These attributes for each requirement statement are completed at the time of development of requirements definition.

FRx.x.x: Requirement statement.

Attribute	Value	Attribute	Value
Scenario ID		*Use case ID*	
Requirement ID		*Owner/Responsible*	
Rationale		*Created By*	
Stakeholder		*Function*	
Version		*Assumption*	
Status		*Priority*	
Traceability		*Requirement Change*	
Approval status		*Means of validation*	
Requirement Validated by Owner/Responsible [Yes/No/With changes]			
Acceptance Criteria			

Figure 11.1: Template for Requirement Attributes

The *acceptance criteria* will be used to perform testing and validation of the system functionality in WP3 and WP5. Further analysis of the requirements reveals the feasibility for the implementation of specific functionality for a specific requirement and to satisfy the acceptance criteria. This feasibility study may either result in requirement scrubbing or proceed to design, implementation and testing/validation results in defining the *approval status* of each requirement statement. As soon as these requirements definitions are validated, these will be transferred in to the Redmine management tool for managing and tracing these requirements to various development stages as well as to get quick feedback from the stakeholders as discussed in section 3.1.5.

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Annexes

Annex-I: Template for requirement definition

Each requirement statement may follow MoSoCow method [8] to indicate need and importance to implement solution for the requirement. The following table shows the attributes for each requirement statement. e.g. A functionl requirement statement can be:

'System must be able to show population density in census cells during working days and peak morning hours between 7:30 am to 9:30 am.'

And associated with following attributes.

Attribute	Possible Values
Scenario ID	Refers the Scenario from which this requirement is initiated
Use case ID	Refers to the associated use case
Requirement ID	Unique identifier for traceability purposes e.g. FR[City number . Application number . Requirement number]. For example FR1.1.1 means city 1 (Vienna), Application 1 (3D VR) and Requirement number 1.
Owner/Responsible	Initiator and incharge of this requirement who will validate it / Contact person
Rationale	Justification for the requirement
Created By	Author of the requirement
Stakeholder	Potential stakeholders effected by this requirement
Function	Statement of the main functionality
Version	Version number starting from 1
Assumption	Any assumptions related to this requirement which can effect design and implementation stages
Status	Any one of these values {Original / Changed / Complete / In complete / Dropped}
Priority	Any one of these values {Essential / Desirable / Optional}
Traceability	Backward and Forward traceability (new requirment identification numbers)
Requirement Change	Reason for change in requirement and changed requirement ID
Approval status	The value of this attribute is set after analysing the technical feasibility of the requirement. Any one of these values supported by a justification statement should be provided {Initiated / Approved / Not-Approved}

Means of validation	Possibilities may include { Testing / Validation / Demonstration / Survey etc}
Requirement Validated by Owner/Responsible	This attribute is used to get Possible values include {Yes /No /With changes}
Acceptance Criteria	Indicators and standards that satisfy the Owner/Responsible's quality and functionality expectations for this requirement and gain acceptance of the final product.

Annex-II: Questionnaire for groundwork and context development

Questionnaire for groundwork and context development are accessible to project partners from the UrbanAPI intranet.

Annex-III: Requirement workshop reports/minutes

All requirement workshop minutes are accessible to project partners from the UrbanAPI intranet.

Annex-IV: Use case descriptions

All use case descriptions are accessible to project partners from the UrbanAPI intranet.

Annex-V: Detailed requirements definition

All requirements definitions are accessible to project partners from the UrbanAPI intranet.

Glossary

Context *of a system refers to the connections and relationships between the system and its environment.*

Funtional Requirements – *refer to the intended behavior of the system being developed. These include definition of things such as system calculations, data manipulation and processing, user interface and interaction with the application, and other specific functionality that show how user requirements are satisfied. Each FR will be assigned a unique id - FR 1.1.1, FR 1.1.2.*

Non-Functional Requirements - *also refer to quality requirements e.g. security, performance, reliability, usability etc. Sometimes, depending on the nature of the project and product, NFRs are also used as FRs. Each NFR will be assigned a unique id - NFR 1.1.1, NFR 1.1.2.*

Requirements Definition - *Application specific requirements (functional and non-functional) with the attributes – ID, created by, statement, rationale, owner, stakeholder, type, scenario, usecase, function, acceptance criterion, priority, version, assumption, status, means of validation, approval status, means of design verification, means of product verification etc.*

Scenario – *An operational scenario is an instance of a transaction/operation/task with data handling (create, read, update, delete operations) described in a user-language without including technical and/or implementation details. A scenario refers to a concrete narrative, or walkthrough, that describes the hypothetical use (i.e. one future possibility) of an UrbanAPI application. A scenario may include information: who uses the system, what are their roles and what they are trying to achieve – objectives and goals; indicates what is needed in the system and why is it needed; indicates the user-system interaction and context in which the user works with the system; indicates users constraints and limitations; indicates what is regarded as successful outcome of using the system.*

Stakeholders *refer to individuals or organisations who have vested interest in the success of the project. Stakeholders can be individuals who use the system and/or who are mainly interested in the outcome of the project. This section includes an Onion model for stakeholders – Beneficiaries – functional, political, purchasing, etc; operators, regulators, developers, public, experts, etc. Also, stakeholders are categorized into the primary, secondary and tertiary stakeholders.*

Urban API Applications *refer to three application at different levels of urban governance: i) 3D VR application at neighbourhood level; ii) GSM based mobility dynamics at city level; and iii) Urban Growth Simulation at city-region scale.*

Urban API Toolset *refers to set of generic tools that will be designed and developed in the UrbanAPI project to support the development of three urban applications.*

Use case - *A use case represents one possible functional process within a scenario. It indicates actions (performed by specific actors) that are required to achieve a specific goal. A use case can have multiple paths that can be taken by any actor at any one time. Use cases are depicted as a UML use case diagrams and each use case is described using a use case description template including Use Case Title, Functional Goal, Primary and other Roles, Happy Scenario, Variations or Exceptions, Preconditions, Description, Stakeholders, Qualities & Constraints.*