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This document presents the design, implementation and results of the user evaluation – cycle 2 for all applications. Quantitative, qualitative and role-based results are presented.
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DISCLAIMER

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Executive Summary

The enhanced ICT tools developed by urbanAPI aim to offer new opportunities for the development of both urban management intelligence as well as tools for decision-making support at three levels of urban governance from neighbourhood to city region level, thereby addressing the key dimensions of the management of urban complexity.

In response to these ambitions, evaluation of the tools provided by the pilot cities (Vienna, Bologna, Vitoria-Gasteiz, and Ruse) offers critically important insights for the future development of these and related ICT tools supporting urban governance. According to respondents the 3D Scenario Creator (3DSC), has high potential, although in some respects it remains immature. To fully respond to city expectations and successfully compete with other tools already in use, it needs further development in respect of user friendliness, and training to fully understand and exploit all the application functionalities. For this reason, even if there is great appreciation of the potential envisaged in the tool and there is the desire to adopt the 3D Scenario Creator in the future, at the current stage of development it is difficult to commit to it. The Rule Editor is well appreciated, mostly for the additional functions available in respect to similar tools. Whilst its functionality is considered good, the workflow is complicated even for an expert user.

The Mobility Explorer application is considered to have high potential to improve mobility analysis. However, at present, it cannot express all its functionalities and cannot be used alone, rather integrated with traditional mobility evaluations, due to difficulties in data availability and completeness. The Mobility Explorer tool is considered useful mostly for internal use involving domain experts such as planners and policy makers, and less for interacting with citizens. None of the cities can be sure about the possibility to adopt the tool at present, however, there is a strong interest in it. Similarly there is a very positive attitude towards the possibilities of Urban Development Simulator to support urban management, even if it is considered at a too early stage of development to make secure statements, the respondents seem to consider it quite probable to be adopted in the near future.

Evaluation of the tools and consideration of their impact in a wider context beyond that of the four pilot cities is also critically important in defining the future development path for ICT enabled urban governance. Integrated urban management is the key to unlocking and managing urban complexity in which two principal requirements are identified. First enhanced effective communication and collaboration between planning agencies critical to the creation of the information and intelligence necessary to manage the city. Secondly effective deployment of this intelligence in the policy model focused on decision-making regarding the future form of the city as the operational focus of urban governance.

urbanAPI tools are strategically located in relation to both these requirements enhancing both communication of information and intelligence between planning agencies, and at the same time addressing strategically important components of the policy model. Integrated management aims to secure, on the basis of the procedural requirements of the policy model, four fundamental outcomes essential to the delivery of effective decision-making including:

1) collection of information and intelligence
2) analysis
3) visualisation/simulation
4) explanation

Collection of intelligence is supported by the bottom-up engagement of stakeholders in the specification of policy objectives and the assessment of plan attributes, both substantially enabled by visualisation (3DSC) of problem specification and alternative proposals for problem resolution. Analysis of alternative courses of action in urban development is critically dependent upon the fullest understanding of the spatio/temporal patterns of socio-economic activity in the urban environment in relation to the spatial form of the city. The representation of these relationships (ME) and the insights provided into collective urban behaviours is considered a fundamentally important advance in urban planning and management supported by smart city enabled technology. This application opens the possibilities to realise deep understanding of environmental and social dynamics in securing public support and in urban areas, critical to the delivery of sustainable development.

Visualisation and simulation combined (UDS) provides the opportunity to view the future form of the city, its vision for development, and assess the socio-economic and environmental impacts of alternative urban futures. On this basis explanation essential to effective and democratic decision-making is realised, and communication of the alternative urban development paths to all stakeholders to secure necessary political mandates for plan adoption is provided.

The impacts of urbanAPI tools must be considered in the above context, and the strategic positioning of these tools in relation to these critical components of decision-making recognised as highly significant. Clearly conclusions in the evaluation process recognised the need for further development of these applications, but the strategic importance of the functioning of these tools, working in combination in an integrated manner, in relation to the decision-making process must also be recognised and endorsed as a basis for timely and well positioned RTD investments in the future development of ICT enabled urban governance.

The challenge then is how to generalise these ICT solutions, to support adoption by other cities. Based on the urbanAPI development experience it is found that the fundamental needs of participatory planning, collaborative decision-making and support to policy making processes remain the same for different cities. For instance, the urbanAPI tools can be applied to other cities as they provide an efficient way to analyse city data and visualise the future city model that helps in identifying planning issues and securing public support. Accordingly, lessons learned from the commonalities in requirements, support to participatory planning and policy making processes and comparative assessment of the applications developed in the differing project case study city contexts, can form the basis for the future development of generic ICT tools that can be utilised in the majority of the 400 plus cities of Europe with populations over 100,000, as well as other smaller cities and towns throughout Europe.

1. Introduction and Objectives

Cities are transforming and seeking to harness the full benefits of ICT enabled 'urban governance' (Montgomery *et al,* 2003, Ruble *et al,* 2001, Eckhardt and Elander, 2011). These benefits are sought in order to manage the complexity of urban systems in responding to political objectives supporting sustainable urban development, ensuring an appropriate balance of socio-economic and environmental objectives defined in respect of land use management, and full engagement with urban stakeholder communities in this process (Davies *et al,* 2012, Poplin, 2011, Hanzl, 2007, Misuraca, Reid and Deakin, 2011).

For instance, forms of engagement with stakeholders by the state have evolved from an emphasis on top-down hierarchical models towards networked models, from steering and directing society to contextual steering and incentive provision (Rhodes, 1997, Pierre and Peters, 2000). An important driving force in this transformation concerns the information overload arising from the complexity of urban systems management, experienced in both political and technical management. This has reinforced the understanding that traditional planning methodologies are to some extent out-dated, and has highlighted an increasing need for tools to support the involvement of the public in decision-making, and to assist in citizen assessment of the impacts of policy-making, creating enhanced intelligence, and applied to both the management of urban complexity as well as enhancement of e-democracy (Felt and Wynne, 2007). This is recently reported by Khan Z et al 2014a and is something similar to overall objectives of the urbanAPI project..

The urbanAPI project

urbanAPI aims to develop ICT enabled tools supporting city governance and adapted governance models particularly addressing stakeholder engagement and citizen participation in the planning process, in order to enhance sustainable urban policy development and delivery. These tools aim to provide planners and policy makers with the information they need to better understand participatory and collaborative planning scenarios and expose the socio-economic and environmental impacts associated with alternative options for territorial development. Such information provides necessary stimulus for creating conditions in which the political mandate as a critical basis for more effective management, is secured (Yigitcanlar, Velibeyoglu and Baum, Khan *et al,* 2014). The main stakeholders addressed in the urbanAPI project relate to three different interest groups: i) planning authorities interested in software solutions and application in their cities, ii) policy makers interested in content communication and means to intervene in the urban development process, and iii) others including 'ordinary citizens', laypersons with respect to methodology, but experts in local issue identification and specification of alternative development solutions.

(Khan Z. et al 2014a) presented a detailed overview of ICT-enabled participatory planning in the context of urbanAPI project. The urbanAPI toolset aims to provide advanced ICT-based intelligence in relation to three urban planning contexts and spatial scales as depicted in Figure 1. First, urbanAPI directly addresses the issue of stakeholder engagement and citizen participation in the planning process at neighbourhood scale, by the development of enhanced 3D scenario creator (3D SC) visualisation of neighbourhood development proposals. This 3D SC application enables end users to access and propose amendments to planning proposals using an interactive visual interface via the web. Second, at the city-wide scale, urbanAPI develops a Mobility Explorer (ME) application, a mobile phone location based application using mobile phone location data that permits the visual representation, and analysis of population distribution and movement patterns across the city which assists planning agencies to explore space attractiveness and carry out mobility analysis. Finally, urbanAPI develops Urban Development Simulator (UDS) for city-regions, addressing multiple urban planning challenges including visualisation of planning interventions and assessment of the impact of alternative proposals for urban expansion (and/or shrinkage) in the peri-urban area, and the optimum distribution of residential, employment and associated services. These solutions are applied on four EU cities: Vienna, Bologna, Vitoria-Gasteiz and Ruse as indicated in Figure 1.

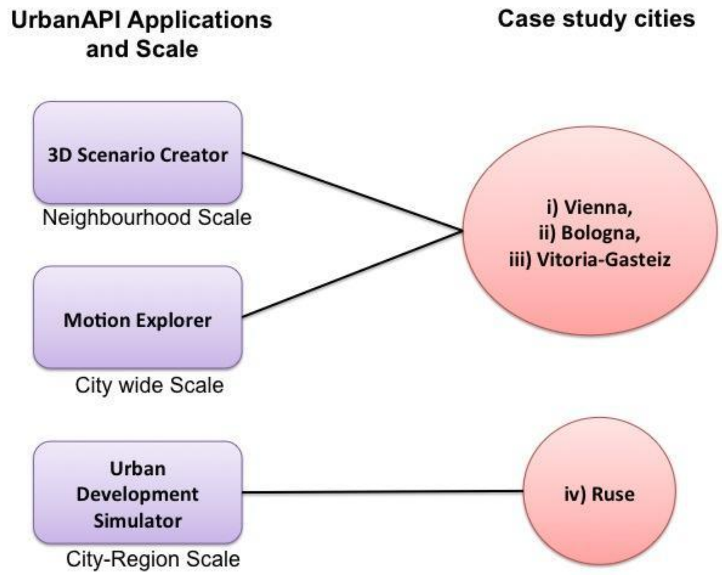

Figure 1: urbanAPI application scales and cities

The fundamental driving force behind the development of the urbanAPI ICT toolset was the state of the art literature and the need for ICT innovations in participatory urban planning, policy making and decision making. However, these findings were further strengthened by the development of additional user specific requirements by the public administrations of the case study cities (Khan *et al,* 2014, Khan and Ludlow, 2013). Most of the cities are participating in up to two different applications that aim to explore the potentials of the applications in relation to context specific socio-economic, environmental and territorial characteristics, governance structures and practices, and furthermore to define potential commonalities as a basis for the development of generic ICT applications (Khan *et al,* 2014). Figure 1 also depicts city participation in the different urbanAPI applications, defined according to local policy priorities.

User Evaluation

In the urbanAPI project, user evaluation refers to validation of the end-to-end outcomes of the urbanAPI applications against the stated and implied objectives and city specific application requirements of the project. The overall aim identified in the Criteria Indicators and Metrics (CIM) (Khan, Ludlow and Rix, 2012, Khan, Ludlow and Caceres, 2013) based assessment methodology (Khan, 2013) is to validate functionality, usability and relevance of the applications and identify benefits and overall impact of the application. This user evaluation was planned for both development cycles of the project (Anon., 2011). In cycle 1 major evaluation focus was on *functionality* and *usability* and results are documented in (Khan, 2014). In this document cycle 2 evaluation planning and summary of results are presented.

The cycle 2 evaluation aims to assess the usability, benefits and to some extent on functionality to derive overall expected impact of the urbanAPI tools for urban planning and city administrations. Overall the user evaluation enabled the evaluation stakeholders to contribute in validating the following policy making and participatory planning objectives:

- *direct mechanism through questionnaire for evaluation of qualitative and quantitative aspects of the implemented system to establish trust in the solutions;*
- *analysis of application specific results for different types of stakeholders and sharing of experiences and lessons learned.*

In addition, the following ICT and policy modelling objectives are also verified in both user and technical evaluation:

- *usability study to analyse the impact of the planned 3D user interface elements and other GUIs designed (e.g. ME, UDS, Rule Editor) for different applications;*
- *functional capacity of the applications based on the available technology and data; and,*
- *effectiveness of urbanAPI tools in a policy making cycle.*

In general, the evaluation of each application consists of three main activities: i) *Preparation* – i.e. designing evaluation with specific criteria, indicators, test scenarios and questionnaire; ii) *User evaluation* – i.e. implementing or carrying out the actual evaluation; and iii) *Reporting* – i.e. documenting the evaluation outcomes as described in detail in Deliverable D5.2 – User Evaluation Cycle 1 (Khan, 2014).

User evaluation cycle 2 is performed at the end of the project where it is expected that the urbanAPI tools have been fully developed based on the city requirements (Deliverable D2.1 – User Requirements Definition (Khan *et al,* 2014, Khan and Ludlow, 2013)) and feedback from User evaluation cycle 1 (Deliverable D5.2 (Khan, 2014). All the data limitations and application specific technology issues are presented in Deliverable D5.3 – Technical evaluation report (Khan *et al,* 2014).

2. User Evaluation Design for Cycle 2

Evidence from recent surveys of European city engagement in ICT enabled urban management and governance, and a broader spectrum of smart city related initiatives demonstrates that with, notable exceptions of innovatory progress, currently there is only limited evidence of the positive impacts of ICT-enabled innovations on urban management and city governance systems (Relhan, Kremena and Rumana, 2011). It is reasonable to argue that the ICT driven revolution remains in its infancy, and that progression towards a more mature status, and wider acceptance by European cities, can only benefit from further research to identify a more comprehensive vision of its effective application, particularly where a clear user defined requirement is established. It is precisely this sort of ambition that is addressed by the urbanAPI project (Khan *et al,* 2014a) and assessed by carrying out two user evaluation cycles. The conceptual frame for the project is based upon the understanding that urban administrations throughout Europe face common challenges in responding to the desire for a more participatory democracy, in order to define the basis for urban economic vitality, social inclusion and environmental sustainability. The commonality of the drivers of urban transition including global economic instability, demographic and migratory evolutions, 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.

Based on the experiences and lessons learned in cycle 1 evaluation (Khan, 2014), the overall evaluation design process was improved (Khan, 2013) and following steps were followed, as depicted in Figure 2 and briefly detailed below:

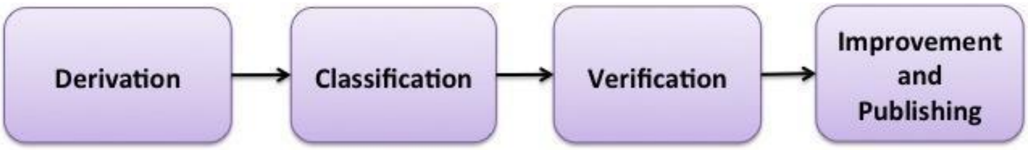

Figure 2: Evaluation design process

Step 1: Derivation of new questions and mapping to criteria and indicators identified during cycle 1. These questions included aspects not covered in cycle 1 evaluation e.g. features which were not fully implemented in cycle 1 development and/or were not implemented up to certain level of satisfaction/acceptance by evaluators.

Step 2: Classification of questions for technical (i.e. IT expert) and city stakeholders. In order to facilitate different types of stakeholders all evaluation questions classified into functionality related questions which can be answered by more technical (e.g. IT expert) evaluators, and usability, benefits and overall effectiveness related questions, which can be answered by domain experts such as urban and transport planners and policy makers. Also, a subset of generic benefit and usability related questions were derived for citizens participation in 3D SC's web based component.

Step 3: Verification with technical partners and city stakeholders to identify any limitations and gaps in draft evaluation design and associated questions. This step also aligned training needs for final urbanAPI products. A rigorous verification process was necessary to identify known limitations (e.g. data granularity, no feature implementation due to resource limitation etc), which can be documented prior to evaluation implementation for further improvements.

Step 4: Improvement of evaluation questions and then publishing through a new web interface for online evaluation with the objective to get qualified responses with some qualitative feedback. Such a qualified response helps to know why an evaluator responded to a certain question in a specific way that will help in deriving overall impact assessment and evaluation conclusions.

Step 5: Repeat step 1 to step 4 for all urbanAPI applications applied in selected case study cities.

urbanapi

SEVENTH FRAMEWORK PROGRAMME

3. Application-Specific User Evaluation

Each urbanAPI application is designed to capture specific aspects related to planning and policy development and hence provide certain characteristics attractive to different city administrations. Use of specialised software tools as well as skills are applied in the development of these applications. Below we present the overall evaluation responses by cities representatives, received for three urbanAPI applications with the objective to critically analyse evaluation results assessing their effectiveness for participatory planning, decision making and policy making processes, as discussed in detail in chapter 5.

As different types of evaluators participated in the evaluation process, it was necessary to analyse overall positive and/or negative responses based on role types to assess level of satisfaction and trust on the urbanAPI tools. Therefore, the following sections also present role-based analysis of user responses with the objective to see overall positive and negative role-based perception about urbanAPI tools.

In order to better understand evaluation results, these are presented using visual charts (bar and radar charts). Please note that these charts are mere visual representation and information presented in these charts should not be associated with any statistical assessment technique. Colouring scheme for usability and benefits (e.g. green for positive outcome and orange/red for negative) and behavioural analysis (role/expertise types) charts in this document can be interpreted as depicted in Figure 3.

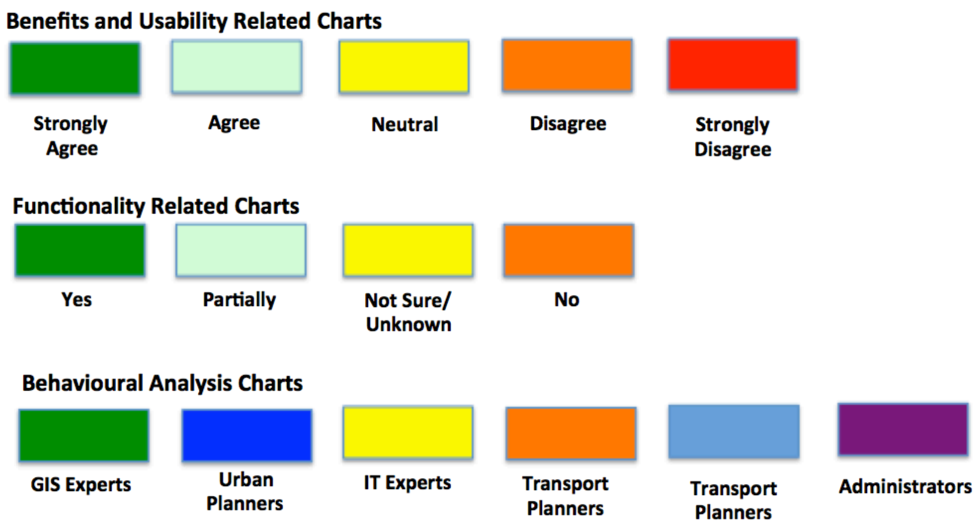

Figure 3: Colouring Scheme for Charts

3.1. 3D Scenario Creator

This application attempts to help in presenting (visualising) urban development plans with the help of 3D scenarios that support the negotiation process for urban development projects. In addition, interactive control of planning interventions and – on the fly – presentation of the new visual effects created by changes in the urban plans help citizens to understand alternative development proposals. Such 3D visualisation is intuitive and stimulates citizens' interest in policy making. urbanAPI 3D SC applications enable public administrations to virtually represent planning scenarios to policy makers and citizens, inviting feedback by providing 3D navigation through aerial and ground views. Allowing interactive modifications of alternative proposals (e.g. buildings: size, height, shape, surface, location; landscape: adding, removing and changing; underground structures: tunnels, pipes, etc; street furniture: lamps, benches, posts etc; and, green infrastructure: trees, etc) helps stakeholders to understand the proposed actions, hence promoting bottom-up policy development and decision making. urbanAPI 3D SC applications provide the capability to process data rich 3D models imported in different formats including CAD, GIS databases, selected elevation views and textured information. However, these applications heavily rely on the city specific 3D data which often does not exist and is expensive to generate.

Below we present the evaluation results and analysis of 3D SC scenarios for Vienna, Vitoria-Gasteiz and Bologna. The evaluation covers benefits, usability and functionality aspects of 3D SC.

The analysis of evaluation results provide reflections on the implemented features and suitability of current state of tools for the case study cities. As these tools can be used by users with different domain expertise, behavioural analysis of evaluator responses is performed to compare and see overall functional suitability and effectiveness of these tools from different users' point of views.

3.1.1. Vienna

Vienna evaluation exercise started from September 17, 2014 and several stakeholders representing different departments of Vienna city administration participated in urbanAPI application evaluation. Below we summarise results of the evaluation using different bar and radar charts. Please note that these charts are used only as a visual technique to get an overall idea about evaluators' positive and negative response to evaluation questionnaire. For detailed qualitative responses please refer to chapter 4 and annexes.

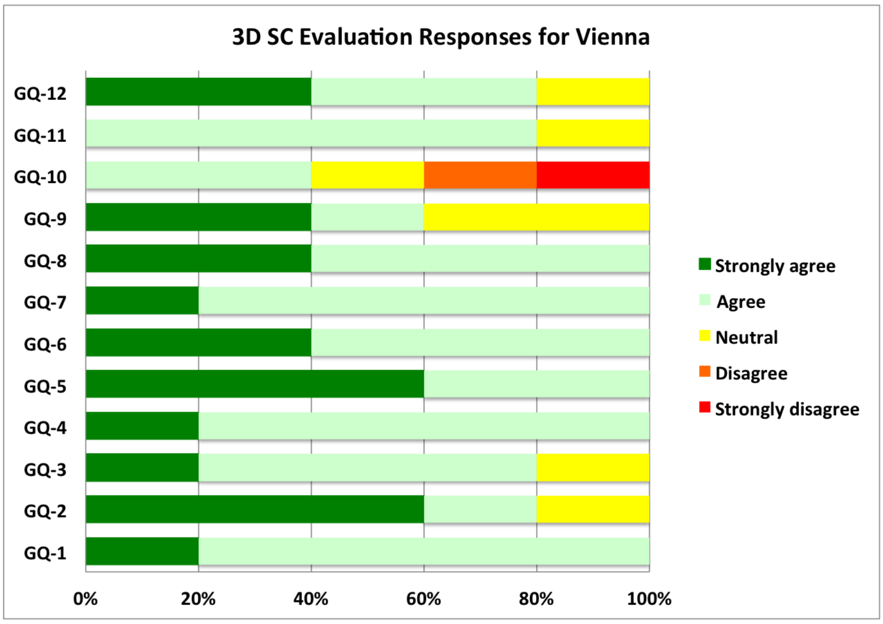

Figure 4a: 3D SC Evaluation Responses for Vienna

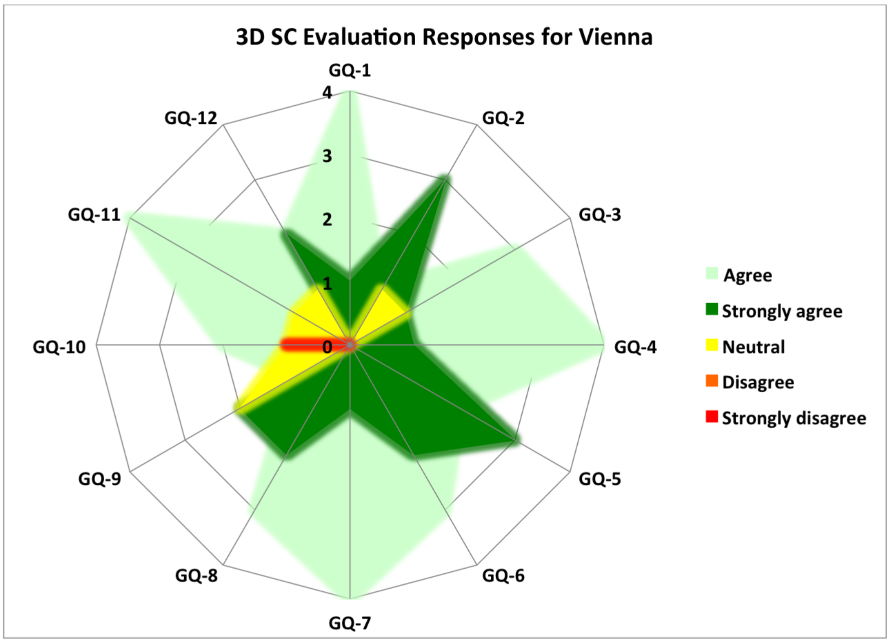

Figure 4b: 3D SC Evaluation Responses for Vienna

For Vienna total five (05) expert users from different planning departments participated in evaluation exercise. The aforementioned claims are substantiated by Vienna evaluators and their positive responses to questions GQ-1 to GQ-8 where 35% strongly agreed, 60% agreed and 5% were neutral (Figure 4a and Figure 4b). This shows that users consider the application, amongst others, useful for the following purposes:

1) Planning and visualising future development scenarios,
2) Facilitating communication with the public and helping them understand the impact of neighbourhood rehabilitation projects,
3) Enabling wider public participation, and
4) Helping experts in decision and policy-making.

Moreover, 13% strongly agreed, 46% agreed and 26% responded neutrally to GQ-9–11. These responses indicate that most users consider the application to be user-friendly and intuitive with ample training material provided.

Based on the lessons learned from user evaluation cycle 1 (Deliverable D5.2 - User evaluation report - cycle 1), it was decided that functionality will be assessed and evaluation questions will only be answered by expert users who have necessary IT background and familiarity with functional requirements (Deliverable D2.1 - User requirements definition). From Vienna, for functionality related questions one expert user with necessary IT background and knowledge of Vienna functional requirements, found the application satisfactory with 86% positive responses such as tools to compare distance between objects, aerial and pedestrian views, reporting and export functions. Detailed responses are included in Annex-1.

Figure 5 indicates role-based evaluation analysis. There were mainly two types of evaluator roles participating in the evaluation. Both types responded with more than 82% to agree or strongly agree. And, minor difference appeared in the responses between neutral, disagree and strongly disagree. Main difference was that GIS experts also responded as strongly agree to nearly 40% of questions. This may be attributed to familiarity of GIS experts in loading, manipulating and visualising geo-spatial data in other GIS tools that helped in understanding and performing necessary operations using Admin tool and web based component of the 3DSC application.

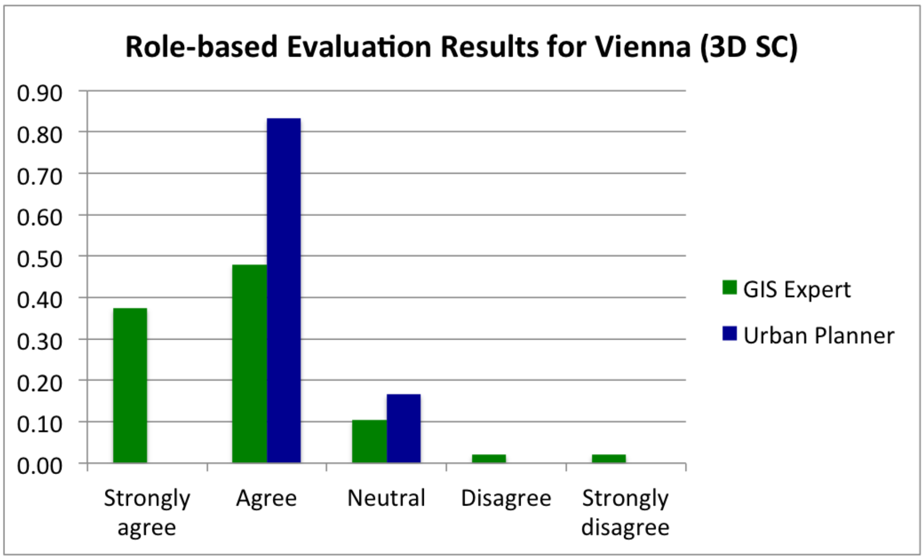

Figure 5: Role-based Evaluation Results for Vienna (3D SC)

3.1.2. Vitoria-Gasteiz

Vitoria-Gasteiz evaluation exercise started from September 8, 2014 and several stakeholders representing CEA of Vitoria-Gasteiz participated in urbanAPI applications evaluation. Below we summarise results of the evaluation using different bar and radar charts. Please note that these charts are used only as a visual technique to get an overall idea about evaluators positive and negative response to evaluation questionnaire. For detailed qualitative responses please refer to chapter 4 and Annex-1.

For Vitoria-Gasteiz five (05) users participated in the evaluation process. Overall responses indicate that 3DSC application is still behind in meeting specific local needs and scenarios. This may be attributed to lack of high quality 3D data that effect on the overall usability and adoption of the application for participatory planning, though a lot of functionality was implemented. One of the major concerns was that not all 3DSC component are web based and hence limit collaborative working between different city administration departments. Consequently, responses were mostly negative in the local city context, with 4% strongly disagreeing, 47% disagreeing, 33% neutral and just 16% agreeing to the benefits-related questions (GQ-1 to GQ-8). The responses are shown in Figure 6a and Figure 6b. Overall the users considered the application to be a useful tool for communicating proposed urban rehabilitation plans to different users including colleagues from different city departments and citizens and acquiring their feedback but require high quality data and capabilities supporting informed decision making.

The negative responses can also be attributed partly to some reluctance to the adoption of ICT tools for urban planning which are not functionally complete, visually non-intuitive and/or not fully compliant to city management processes, complex and difficult to use for different stakeholders including citizens. That is, it is important for the city administration to have mature and easy to use ICT tools, especially, where it is expected to have citizen participation. For example, they found the visualisations to be lacking realism, i.e. the 3D images lacked detail and texture. However, both depend upon the quality and detail level of 3D datasets available. In case of Vitoria-Gasteiz, there was a lack of detailed 3D texture data for selected neighbourhoods. In Vienna where such a detailed 3D dataset was available, the evaluation results are different and more positive. Moreover, the lack of calculated impact assessment was also pointed out, even though the capability to visually analyse plans was appreciated. Calculated impact assessment could not be performed because there are no reliable models available to do the same.

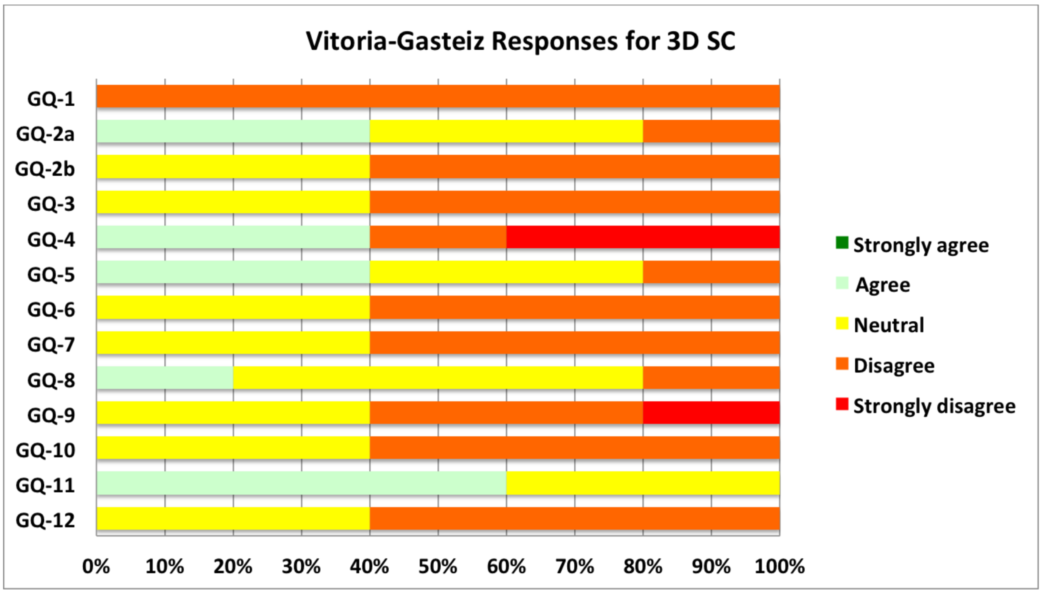

Figure 6a: Vitoria-Gasteiz Evaluation Responses for 3D SC

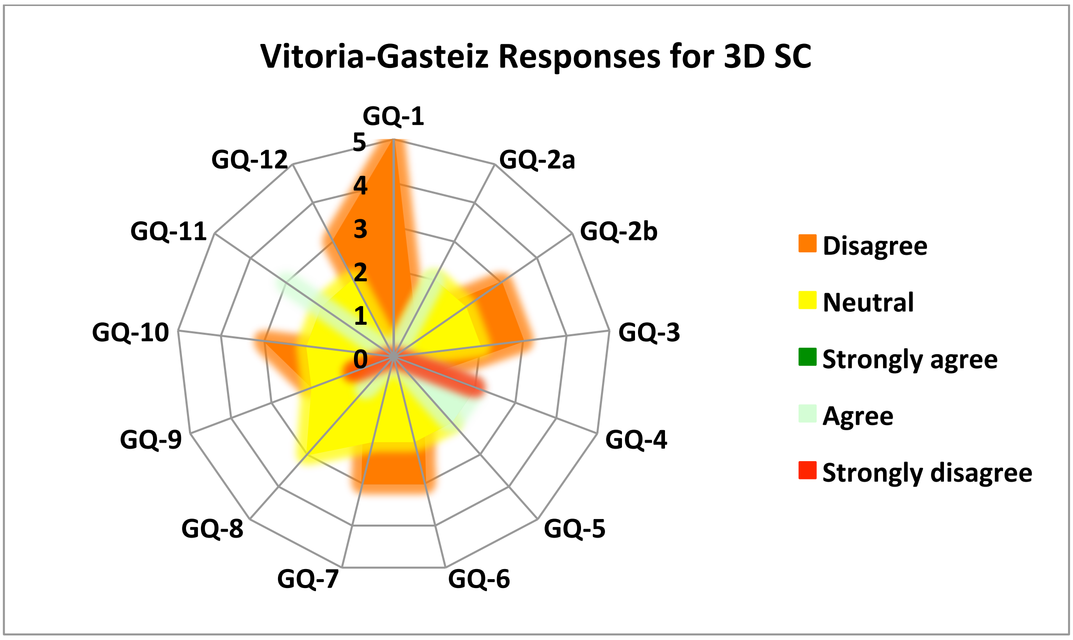

Figure 6b: Vitoria-Gasteiz Evaluation Responses for 3D SC

Usability was also a concern (GQ-9 to GQ-12) for users as 7% strongly disagreed, 33% disagreed, 4% were neutral and only 2% agreed that the application was user-friendly. The need for detailed local language support was also pointed out. Overall functionality-related questions got positive responses with 51% replying yes, 20% finding the functionality partially acceptable and 26% unsure. Only 3% users said that the required functionality did not exist (Figure 7a and Figure 7b).

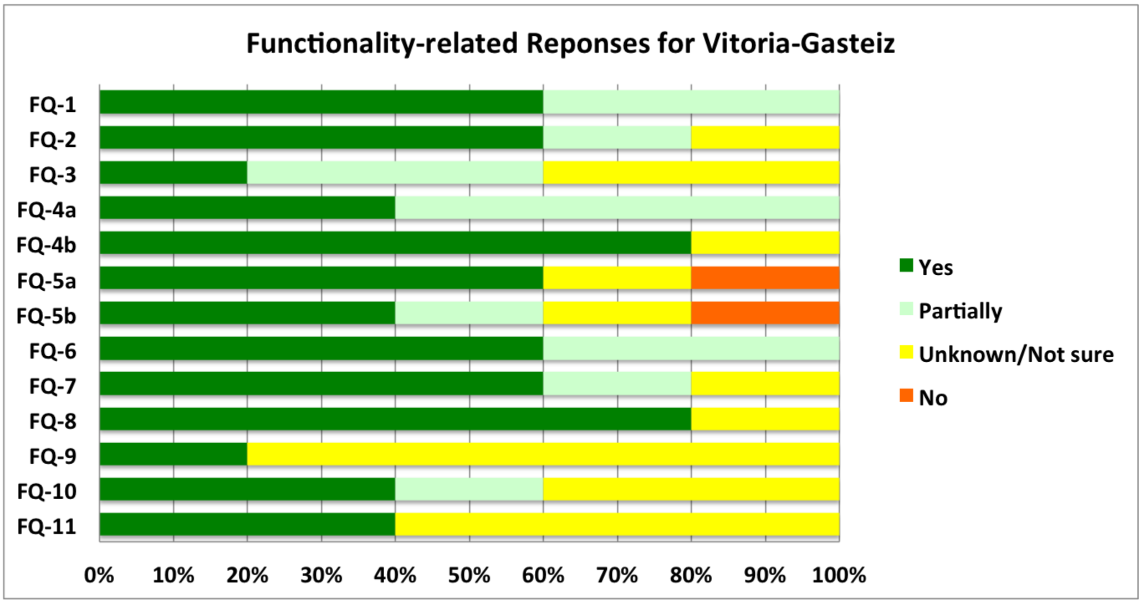

Figure 7a: Functionality-related Responses for Vitoria-Gasteiz

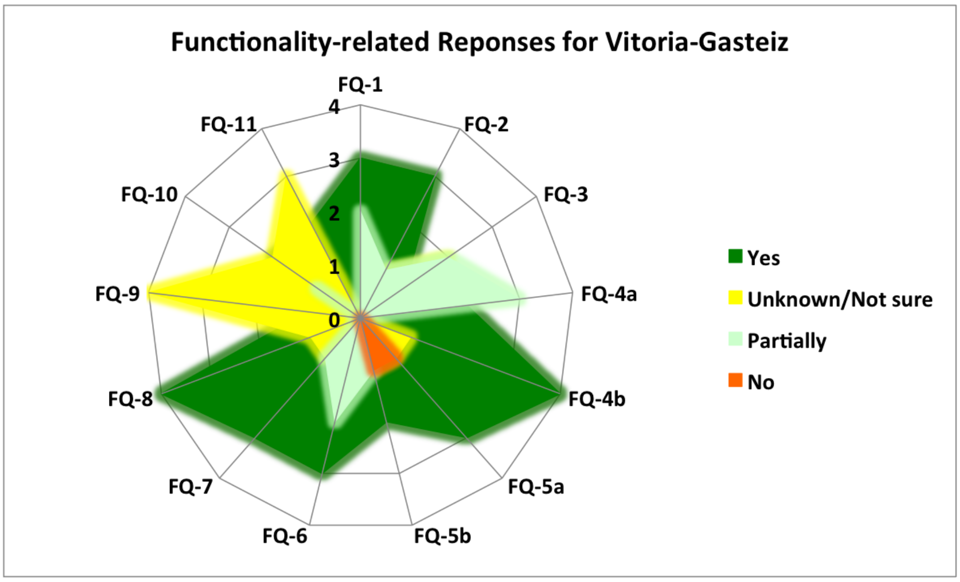

Figure 7b: Functionality-related Responses for Vitoria-Gasteiz

Users appreciated the application's ability to:

1) the ability to edit and update a 3D scene,
2) the ability to integrate different data layers in a 3D scene,
3) the ability to accurately visualise 3D objects in a 3D scene,
4) the ability to generate a 3D abstract model from 2D data,
5) the ability to allow expert users to create 3D scene and suggest improvements,
6) the ability to allow citizens to provide feedback and suggest improvements,
7) the ability to visually compare different 3D scenarios for the same neighbourhood,
8) the presence of a web interface to share 3D scenes between experts and citizens, and
9) the ability to allow experts to analyse a 3D scene or selected objects based on specified conditions such as the height of objects.

Figure 8 indicates role-based evaluation analysis. There were mainly three types of users participated in the evaluation. Only GIS experts and policy makers response was 15%-22% as agreed but majority responses were neutral and indicating disagreement. It is interesting to see that GIS experts had less disagreement than other two types and this may be attributed to GIS experts ability to handle spatial data and experience of using different GIS tools. This suggests that 3D SC can be difficult for domain experts to operate and would require technical IT knowledge and comprehensive training.

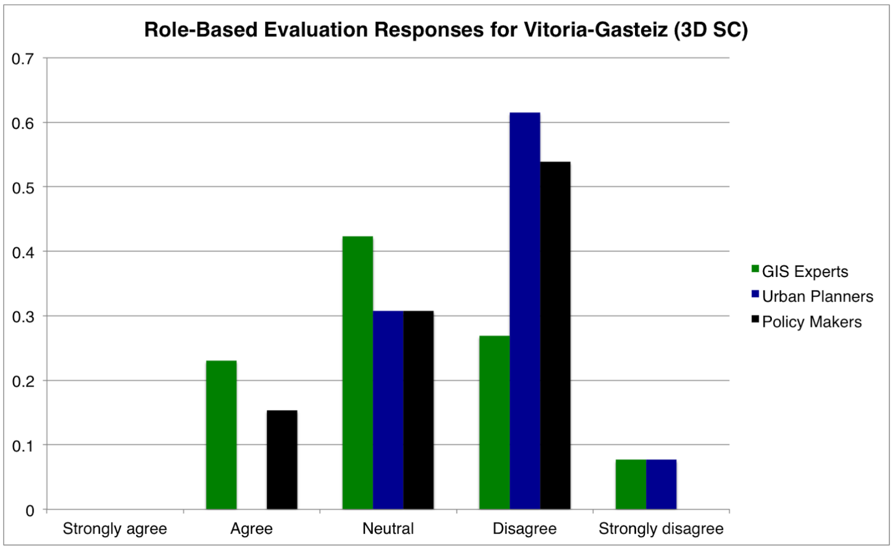

Figure 8: Role-based Evaluation Responses for Vitoria-Gasitez (3D SC)

The above analysis is further supported by the following role-based responses for functionality related questions for 3D SC as depicted in Figure 9. GIS experts found most of the intended functionality of the application as compared to other types of users. This may be attributed to less user-friendly operations of overall 3DSC application which may require additional technical support for domain experts or other stakeholders to understand and perform various operations using 3D SC application. Nevertheless, the overall ratio of yes and partially is high (approximately 70% to 80%) as compared to not sure or no responses which are mostly answered by urban planners and policy makers.

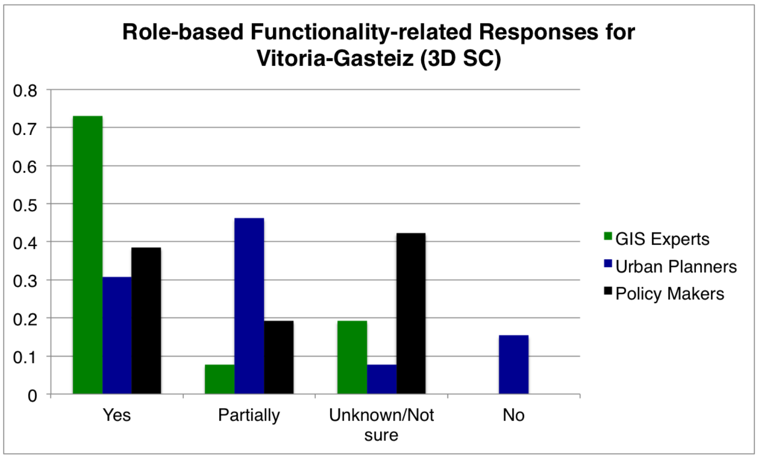

Figure 9: Role-Based Functionality-related Responses for Vitoria-Gasteiz (3D SC)

3.1.3. Bologna

Bologna evaluation exercise started in October 2014 and several stakeholders from Bologna city administration participated in urbanAPI application evaluation. Below we summarise results of the evaluation using different bar and radar charts. Please note that these charts are used only as a visual technique to get an overall idea about evaluators positive and negative response to evaluation questionnaire. For detailed qualitative responses please refer to chapter 4 and Annex-1.

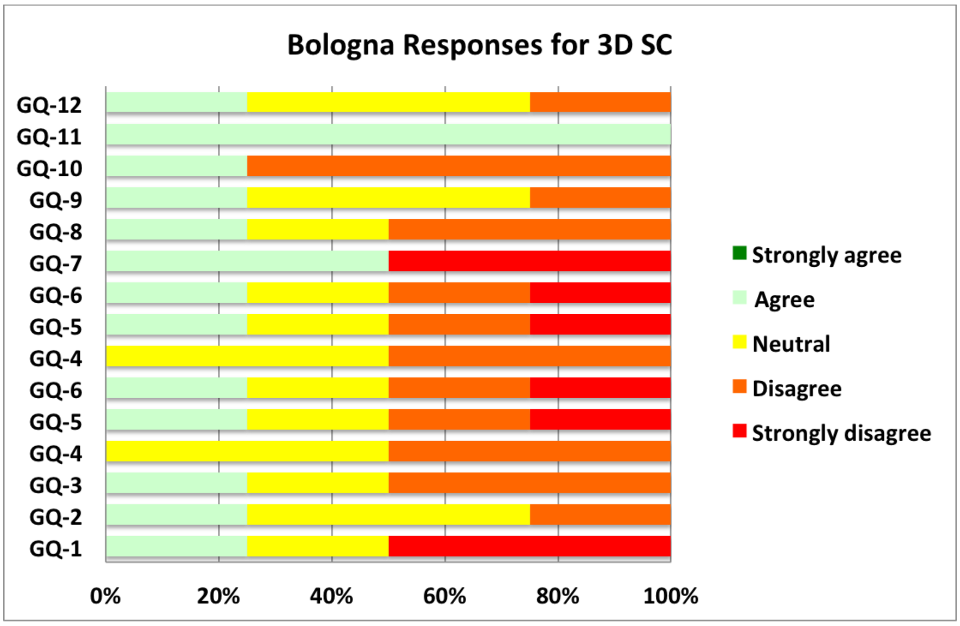

Figure 10a: Bologna Responses for 3D SC

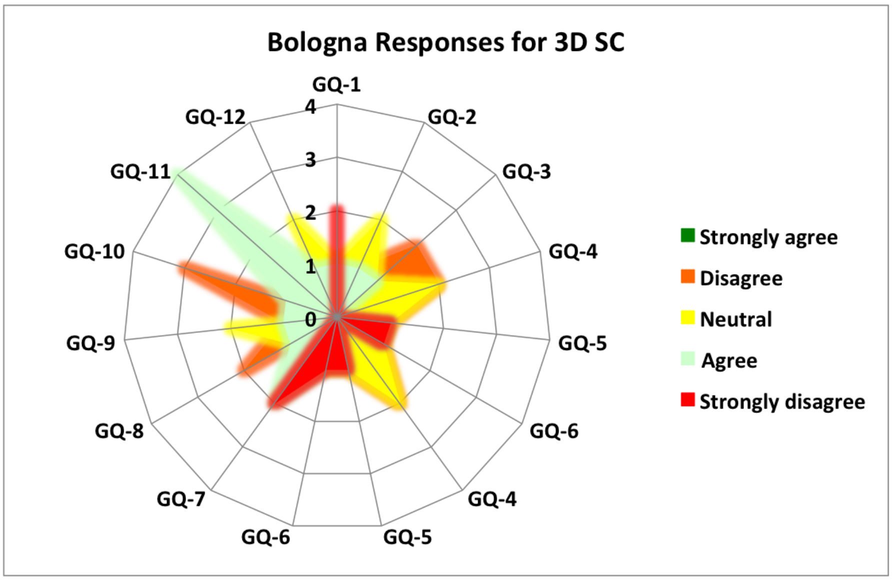

Figure 10b: Bologna Responses for 3D SC

In the case of Bologna four (04) users participated in the evaluation process. The responses, shown in Figure 10a and Figure 10b, were not highly positive for benefits-related questions (GQ-1 to GQ-8; 23% agree, 30% neutral, 30% disagree and 18% strongly disagree). Users were mainly concerned about the level of detail of the visualisations (building textures, street furniture e.g.

benches, fountains, flower beds etc.) due to which the neighbourhood was difficult to recognise. However, this depends on the availability of detailed and high quality 3D data of the neighbourhood. In the case of Bologna this data was not available. Despite having necessary capabilities implemented for Bologna scenarios in 3DSC, users found 3D scenes difficult to relate to local neighbourhoods. Users also found the usability of the tool just about satisfactory (GQ-9 to GQ-12; 44% agree, 25% neutral, 31% disagree). They indicated that the tool was well-documented. However, they found it difficult to navigate the visualisation using the mouse and also highlighted the need for more training. Local language support was also missing.

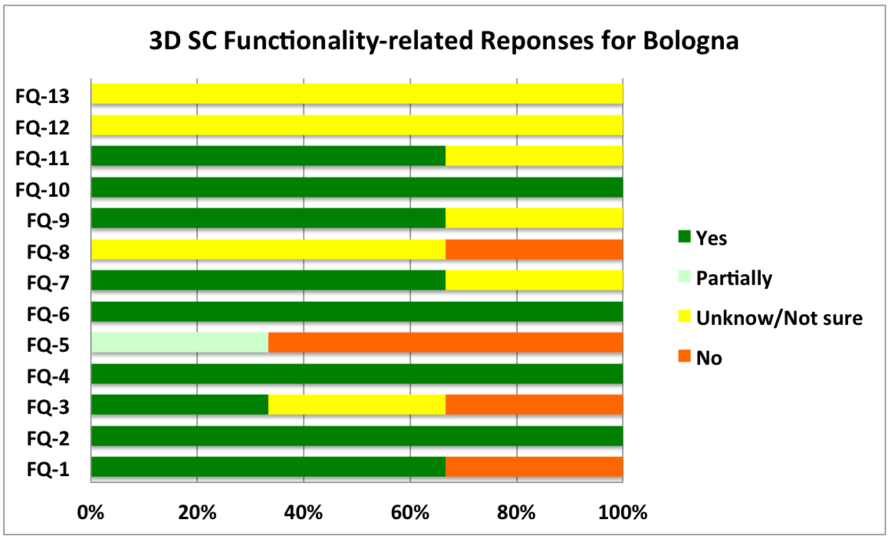

Figure 11a: Functionality-related Responses for Bologna (3D SC)

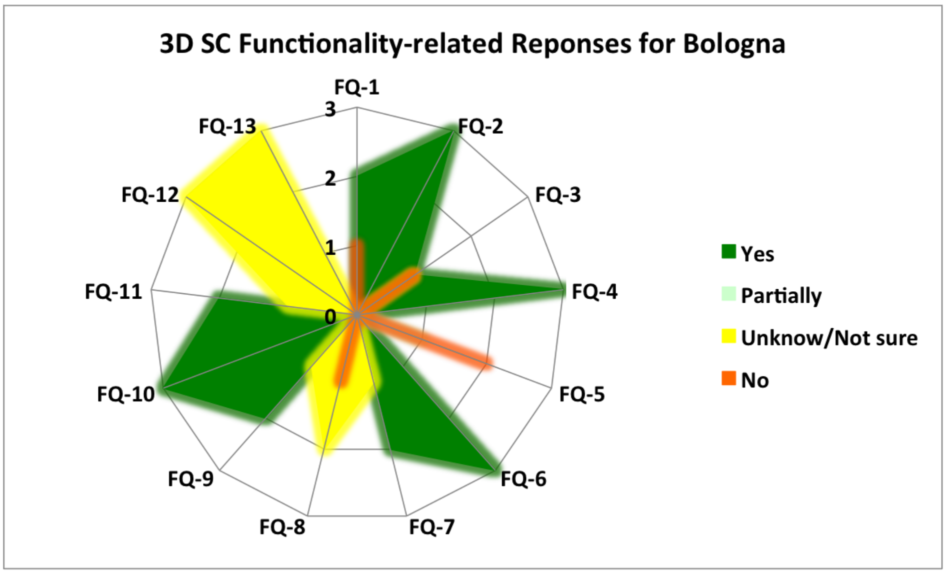

Figure 11b: Functionality-related Responses for Bologna (3D SC)

Functionality-wise users were mostly satisfied with the application as 54% answered yes, 3% were partially satisfied, 31% were not sure and only 13% answered no as shown in Figure 11a and Figure 11b. They were unsure of some of the functionality as it was not covered during training such as exporting the 3D visualisations. Also, some incompatibilities were identified between 3D SC Admin tool (also Rule Editor) and existing IT platform (hardware/software) in the municipality that resulted in unsure responses.

Three different types of users participated in user evaluation of 3DSC as shown in Figure 12. As compared to administrators, urban planners showed more disagreement to benefits or usability of the application. This may be attributed to lack of quality of Bologna 3D scenes, ability of non-IT users in preparing or designing 3D scenarios in 3DSC application and putting them on web for sharing with different stakeholders. GIS experts on the other hand responded over 20% agreement but about 38% neutral to overall effectiveness of the 3DSC application.

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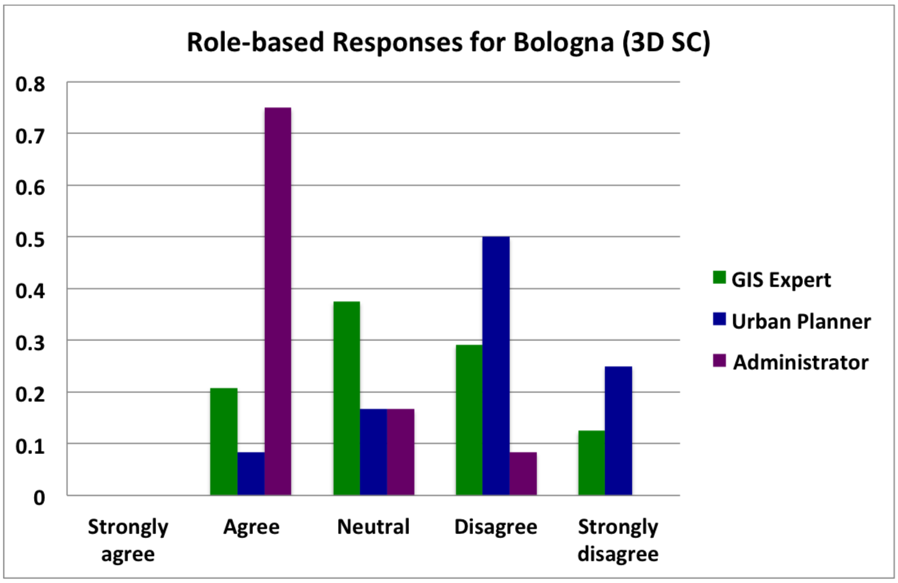

Figure 12: Role-based Responses for Bologna (3D SC)

Figure 13 depicts role-based responses for functionality related questions for 3D SC. Overall both GIS experts and Urban planners found 50%-61% expected functional aspects, respectively. Both answered 30% unsure about potential benefits which may be attributed to either evaluators couldn't apply these features on Bologna data or the quality of functional features was not up to their expectation.

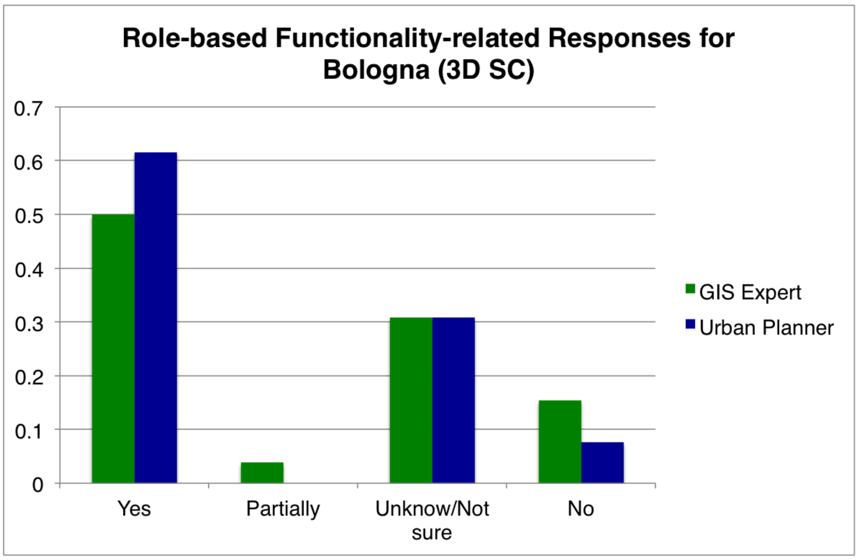

Figure 13: Role-based Functionality-related Responses for Bologna (3D SC)

3.2. Rule Editor

Rule Editor is one of the main components of the 3DSC application. This component was evaluated separately from 3DSC admin tool and web based component. Representatives of all city partners participated in the evaluation of Rule Editor with the objective to assess its functional suitability and usability. Below we summarise results of the evaluation using different bar and radar charts. Please note that these charts are used only as a visual technique to get an overall idea about evaluators' positive and negative response to evaluation questionnaire. For detailed qualitative responses please refer to chapter 4 and Annex-1.

The evaluation covers benefits, usability and functionality aspects of Rule Editor. The analysis of evaluation results provides reflections on the implemented features and suitability of current state of tools for case study cities. As these tools can be used by users with different domain expertise, behavioural analysis of evaluator responses is performed to compare and see overall functional suitability and effectiveness of these tools from different users' point of views.

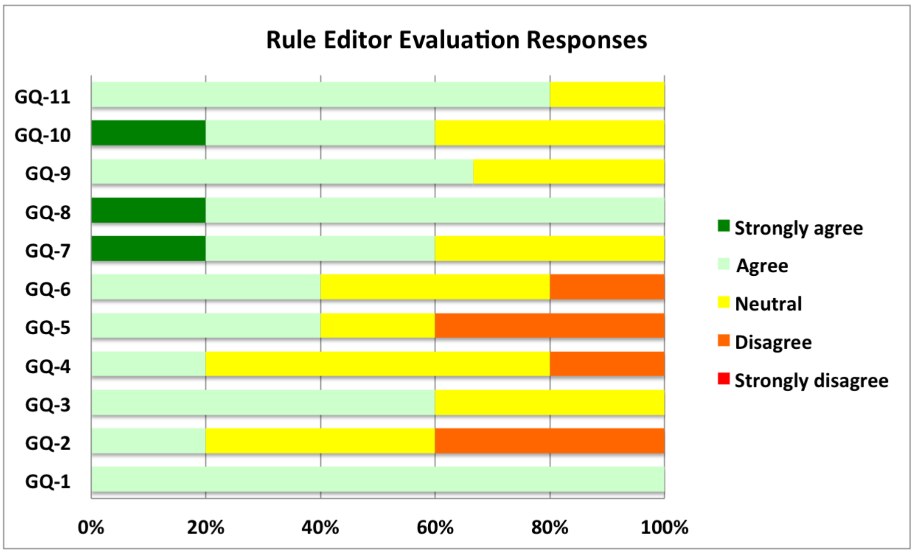

Figure 14a: Rule Editor Evaluation Responses

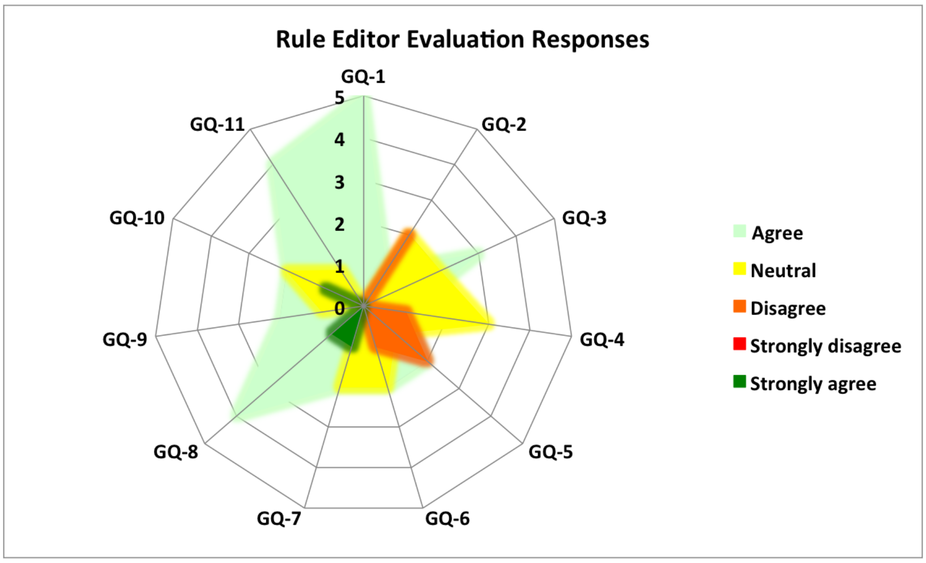

Figure 14b: Rule Editor Evaluation Responses

Based on the evaluation results of user evaluation cycle 1 (Deliverable D5.2 - User evaluation report - cycle 1), it was decided that expert users from participating cities would evaluate rule editor. So, total five (05) users participated in the evaluation of rule editor from all cities; one from Vienna, one from Vitoria-Gasteiz, two from Bologna and one from ASDE/Ruse. The evaluation questionnaires targeted two key areas: usability and functionality. The responses, shown in Figure 14a and Figure 14b, were mostly positive for usability-related questions (GQ-1 to GQ-11; 5% strongly agree, 51% agree, 29% neutral and 11% disagree). Aspects of the application appreciated by users included:

1) useful recipes for performing various tasks,
2) good error-reporting and tracing,
3) user-friendly interface for configuring various recipes,
4) user-friendliness for domain experts without a computer science background,
5) promoting reusability by allowing recipes to be applied to various use cases and applications,
6) support for various logical operations allowing users to create complex and flexible queries.

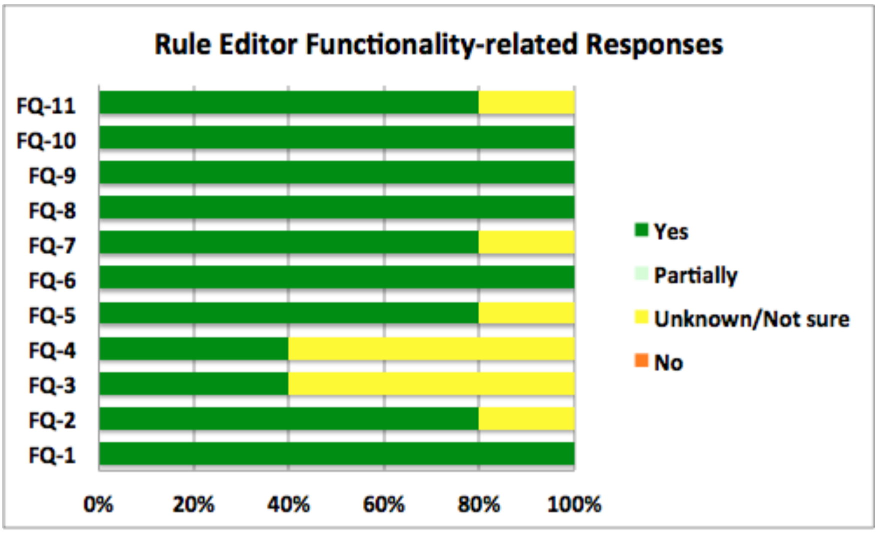

Figure 15a: Functionality-related Questions for Rule Editor

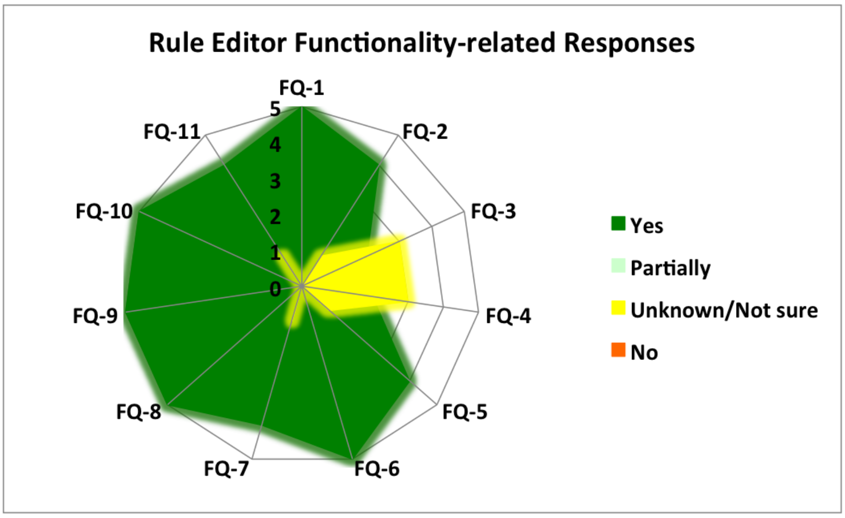

Figure 15b: Functionality-related Questions for Rule Editor

Figure 15a and Figure 15b show that as with usability, responses to functional questions were also mostly positive (FQ-1 to FQ-11; 82% yes and only 18% unsure). This shows that rule editor possesses necessary functionalities derived from user requirements definition (Deliverable D2.1). As there were no explicit requirements raised by cities, it was difficult to test functional completeness of the tool, for example, customised rules, different and complex logical operators etc. The unknown/not-sure responses may be addressed by better, more targeted training methods and practices. The evaluated functionality included:

1. the ability to modify the height of objects automatically according to the terrain model,
2. the ability to create composite rules containing several steps,
3. the ability to flexibly divide the terrain model into several parts,
4. the ability to extrude a 2D footprint to 3D,
5. the ability to automatically select specific objects meeting certain criteria via rules, and
6. the ability to colourise specific objects meeting certain criteria via rules.

The overwhelmingly positive responses can be attributed to the level of expertise and previous knowledge about rule editor. This also indicates that evaluators consider this tool useful for expert users who have GIS, data management and IT background. However, due to existence of other advanced tools which can perform similar functionalities or provide advance features it seems difficult to adopt this tool in its current form. Some comments from users are included below:

1) *"The rule editor itself is user friendly. However the whole workflow is much harder to learn."*
2) *"It is user friendly for skilled users, otherwise a training about it is needed."*

Figure 16 depicts role-based analysis of user responses for Rule Editor. Mainly two types of users participated. Overall response of GIS experts is about 60% as 'strongly/agree' as compared to urban planner's less than 40% response as 'agree'. The figure also indicates that about 55% responses of urban planner were 'neutral' and this may be attributed to not finding clear benefit or having any usefulness of the tool in local applications. In contrast, GIS experts response was just over 21% as 'neutral' and this may be attributed to seeing the potential of the rule editor in preparing and processing 3D city data for different scenarios but still not sure about its overall effectiveness as not many complex operators are implemented and lack of designing and enacting customised recipes. Also, Rule Editor is used as a desktop component of Admin Tool and different stakeholders cannot directly share and work collaboratively on newly prepared 3D city scenarios which indicates need of an online version that is accessible via web. All these factors may have contributed to overall neutral and disagree responses.

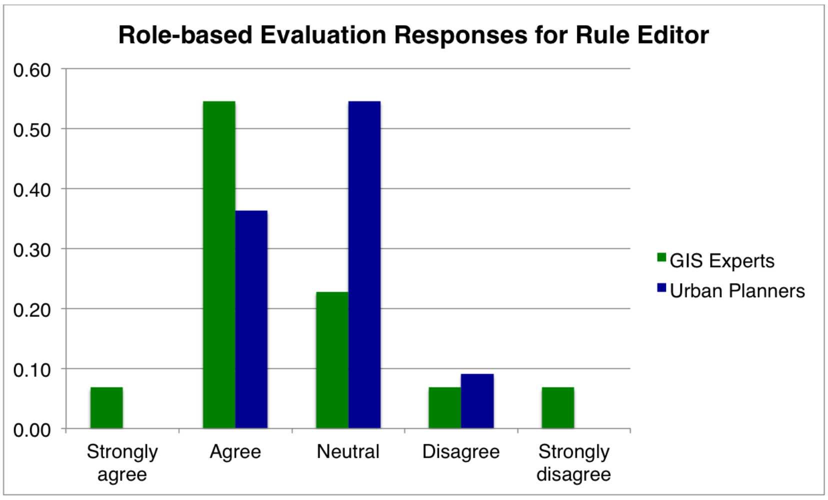

Figure 16: Role-based Evaluation Responses for Rule Editor

Figure 17 depicts role-based analysis of functionality related questions for rule editor. Here both GIS experts and urban planners were able to perform requested functionality and hence positive results range from 80% to 90%, respectively. Some of the functionality could not be tested e.g. due to compatibility/installation issues of 3D SC admin tool on Bologna PCs and/or complexity of tool or less clarity in performing specific operations, and therefore 9% to 20% responses were 'unsure'. It is important to mention that only functional aspects identified in Rule User Interface Elements (Deliverable D3.3) were evaluated.

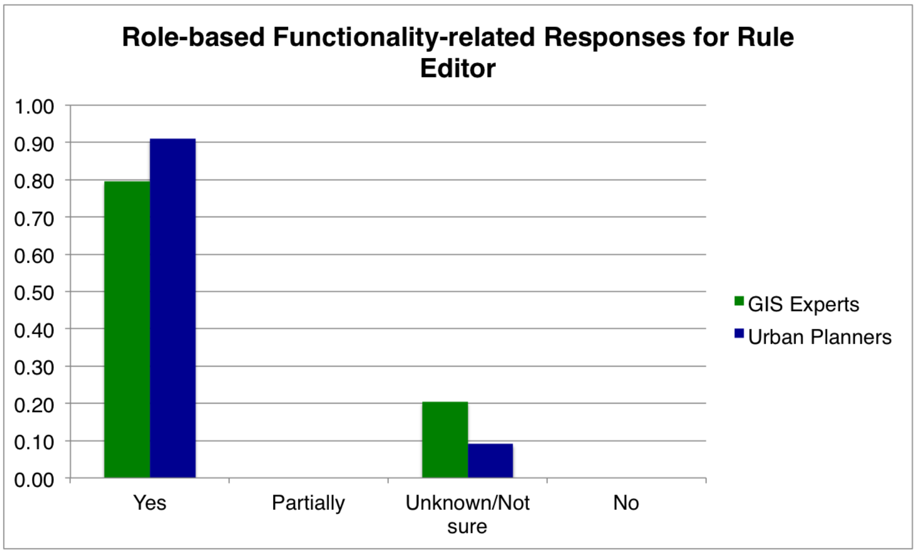

Figure 17: Role-based Functionality-related Evaluation Responses

3.3. Mobility Explorer

This application helps urban planners to acquire information regarding the population mobility patterns associated with various land uses. This information helps planning agencies to manage public and private transportation within the cities according to policy objectives. For example, movement patterns between specific urban districts during specific times (day/night) generate origin-destination matrices. The ME application also helps to observe citizen mobility in relation to all land use features, for example open spaces – parks, shopping areas etc. The overall concept of using mobile phone location data to represent spatio-temporal population distribution and motion patterns can be utilised for multiple applications including: environment analysis e.g. effect of air pollution or noise on the general public; capacity planning of public traffic infrastructure etc.

The real challenge for the ME application is acquiring high quality fine-grained mobile phone location data from mobile service providers. The quality and fine granularity of given information within mobile phone location is not always suitable to analyse and generate useful and complete results. For example, in some small to medium size cities like Vitoria-Gasteiz the distribution of mobile phone cell towers is not dense enough to map the population density patterns e.g. in 500m grid cells at certain time of day/night.

Below we present the evaluation results and analysis of ME scenarios for Vienna, Vitoria-Gasteiz and Bologna. The evaluation covers benefits and usability. For Vienna functional aspects are also tested. The analysis of evaluation results provide reflections on the implemented features and suitability of current state of tools for case study cities. As these tools can be used by users with different domain expertise, behavioural analysis of evaluator responses is performed to compare and see overall usefulness of these tools from different users' point of views.

3.3.1. Vienna

Vienna evaluation exercise started from September 17th, 2014 and several stakeholders representing different departments of Vienna city administration participated in urbanAPI application evaluation. Below we summarise results of the evaluation using different bar and radar charts. Please note that these charts are used only as a visual technique to get an overall idea about evaluators positive and negative response to evaluation questionnaire. For detailed qualitative responses please refer to chapter 4 and Annex-1.

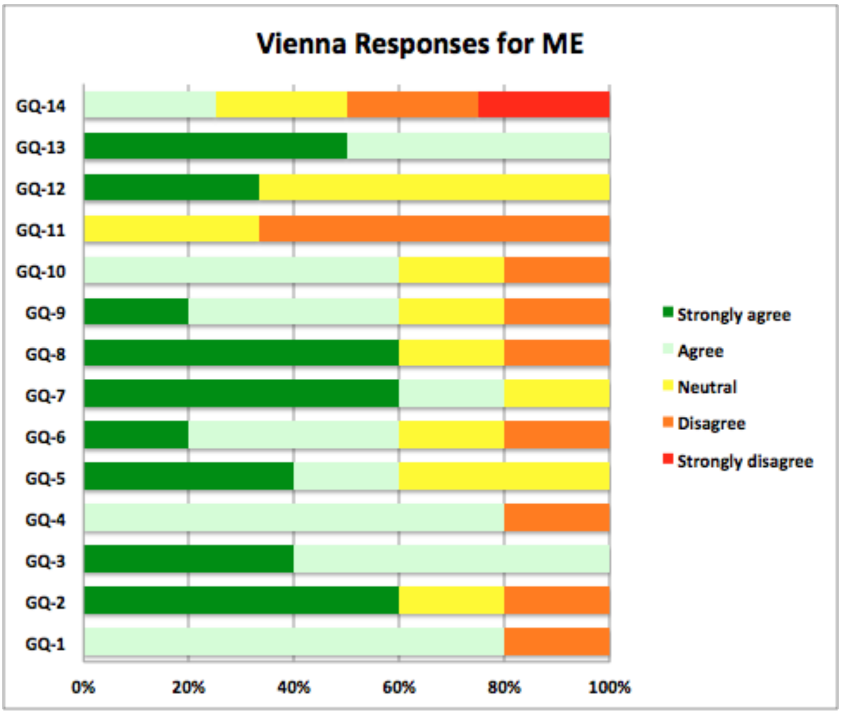

Figure 18a: Vienna Evaluation Responses for ME

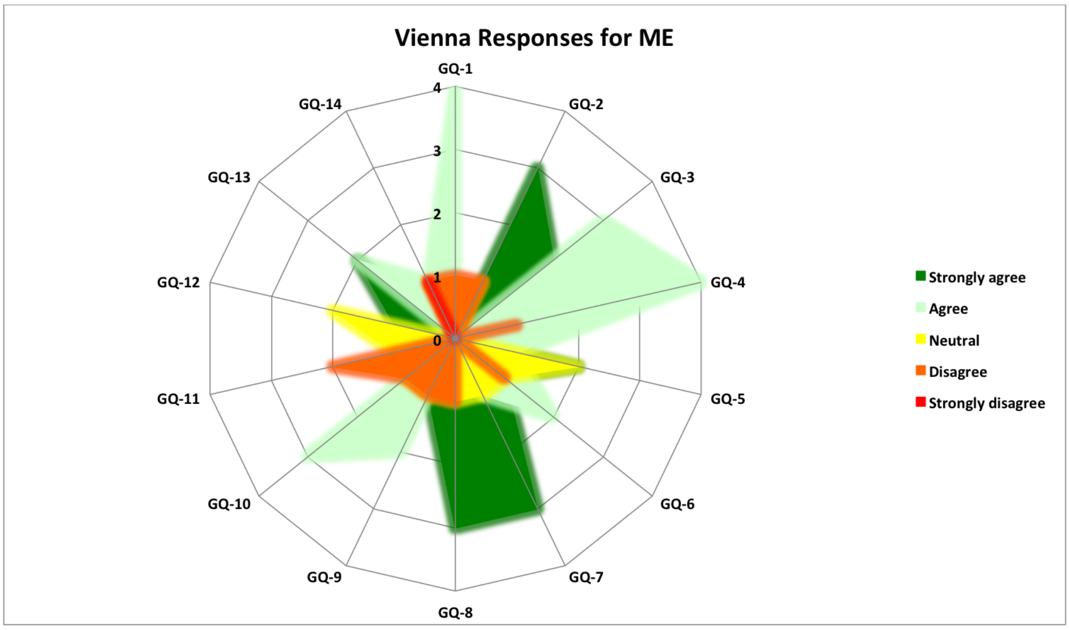

Figure 18b: Vienna Evaluation Responses for ME

For the Mobility Explorer Figure 18a and Figure 18b show that responses were mostly positive for benefits-related questions (GQ-1 to GQ-9; 33% strongly agreed, 38% agreed, 16% neutral and 13% disagreed). The application was considered beneficial for the following purposes:

1) Providing useful information for evaluating planning decisions,
2) Efficiently visualising city population distribution,
3) Efficiently visualising population mobility patterns,
4) Efficiently enabling passive public participation in transport planning,
5) Enabling evidence-based decision-making and policy development,
6) Calibrating and replacing other means of gathering public mobility data, and
7) Better understanding diurnal population distribution and mobility patterns in the city.

Users had some concerns with regards to the usability of the applications (GQ-10 to GQ-14; 12% strongly agreed, 24% agreed, 20% neutral, 16% disagreed and 4% strongly disagreed). Users found the interface fairly straightforward, though it was recommended that the GUI should provide more helpful hints. Moreover, the interface was not available in the local language, which also resulted in negative results.

In terms of functionality one expert user found the application satisfactory. Overall response was positive i.e. 20% and the functionality was found to be partially satisfactory 40%. There were 10% unsure and 30% responses were negative. Functionality that was found useful related to the visual representation and analysis of mobility patterns. However, some limitations were identified, mainly in the data export functions of the application.

Figure 19 depicts role-based analysis of user responses for Vienna ME application. Four types of users participated and following figure indicates variation in responses by different types of domain experts. Urban planners, GIS experts and IT experts responded positively by agreeing to overall benefits and usability of the ME application i.e. about 62%, 79% and 72%, respectively. This may be attributed to the expected benefits or utility of new source of data that can be combined with other available data to generate new models and information for decision making. In contrast, Transport planners showed relatively low agreement (approx. 14%) but high degree of disagreement and neutral stance (approx. 54% cumulative response) which may be attributed to the technological limitations of the application e.g. lack of more accurate position information, mode of travelling, transport type, mobile phone cell tower/infrastructure dependency, over/under-subscription to one cell server provider, lack of gender and demographic information, etc.

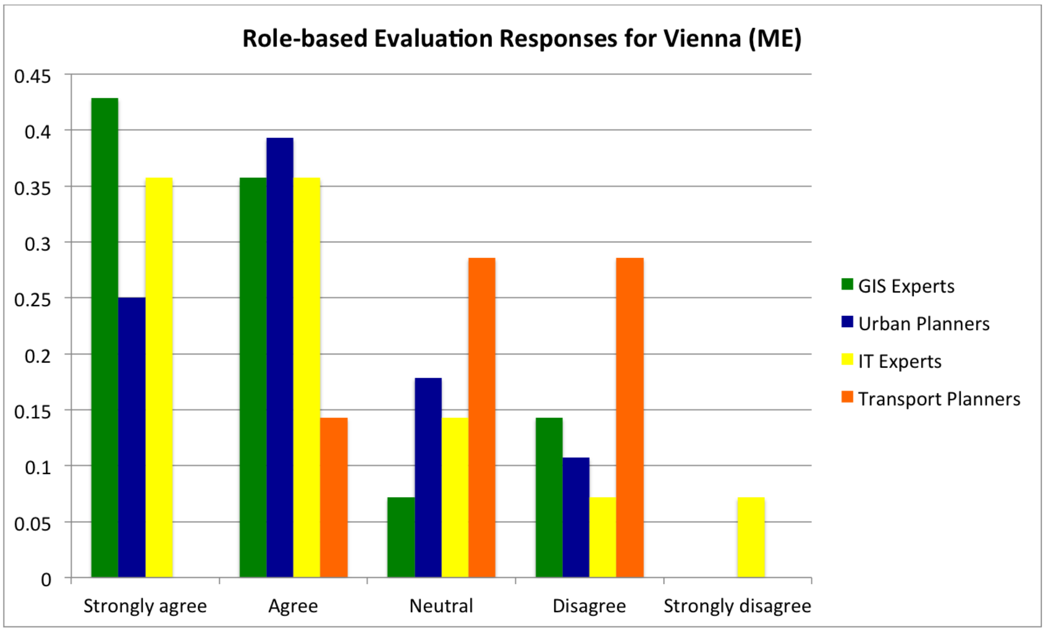

Figure 19: Role-based Evaluation Responses for Vienna (ME)

3.3.2. Vitoria-Gasteiz

Vitoria-Gasteiz evaluation exercise started in late September/ early October, 2014 and several stakeholders representing CEA of Vitoria-Gasteiz participated in urbanAPI application evaluation. Below we summarise results of the evaluation using different bar and radar charts. Please note that these charts are used only as a visual technique to get an overall idea about evaluators positive and negative response to evaluation questionnaire. For detailed qualitative responses please refer to chapter 4 and Annex-1.

In the case of Vitoria-Gasteiz 6% of the users strongly agreed, 36% agreed, 28% were neutral, 25% disagreed and 3% strongly disagreed to benefits-related questions (GQ-1 to GQ-6). The responses are shown in Figure 20 and Figure 21. The users appreciated the application's potential to act as a calibration source for other data. The negative results can partly be attributed to the fact that the application's capability to analyse mobility behaviour could not be demonstrated for Vitoria-Gasteiz. This is because the density of cell towers in the city is too scarce to track the movements of anonymised subscribers. Users also pointed out that the application did not show street-level mobility behaviours. Again, this was due to the lack of detailed data provided by Telefonica.

Another feature that users found lacking was that the application does not overlay the population distribution data with other kinds of data such as facility locations, housing densities etc. They also suggested that the application should include other sources of data to analyse the population distribution and mobility patterns of people. This data could include public transport data, for example. However, these factors are highly dependent on the availability of fine-grained GSM data and density of cell towers in Vitoria-Gasteiz.

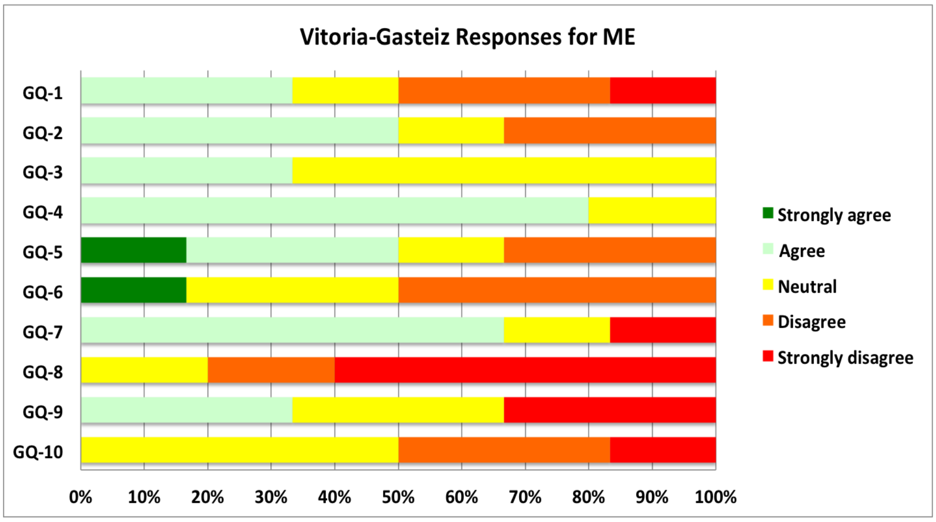

Figure 22: Vitoria-Gasteiz Evaluation Responses for ME

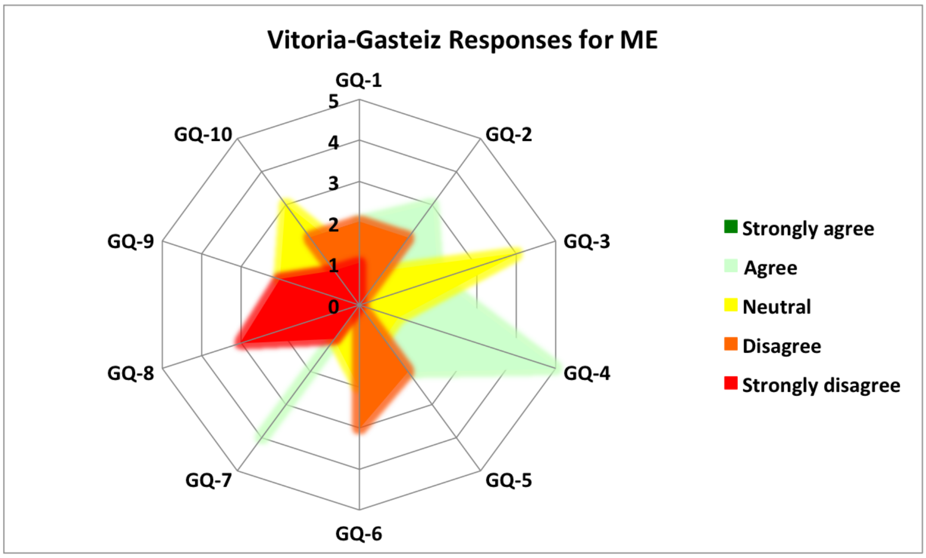

Figure 23: Vitoria-Gasteiz Evaluation Responses for ME

In terms of usability the responses were also mild (25% agree, 29% neutral, 13% disagree and 29% strongly disagree. The users found the interface intuitive and easy to learn but lacking in local language support. Some improvements in usability could still be made though e.g. intensive user interaction within selected cells, download features etc. No functionality-related evaluation was carried out for Vitoria-Gasteiz as no new features had been developed for it during cycle 2 due to lack of new GSM data.

Figure 24 depicts role-based analysis of user responses for Vitoria-Gasteiz ME application. Four types of users participated and the following figure depicts variations in responses which indicate effectiveness of the ME application for different types of domain experts. GIS experts and Policy maker roles agreed to a reasonable level of satisfaction for overall benefits and usability of the application i.e. 50% and 40% respectively in contrast to Urban planner and Others type of evaluators who showed 30% agreement. Urban planners indicated high level of disagreement (about 80%) which may be attributed to the fact that in its current form ME didn't prove to be a useful application for local planning. This is mainly due to low density of cell tower, limited available GSM data and coarse grained data, small city size and large size of grid cells for application. Others type (mobility expert) of users indicated 50% neutral response that can be attributed to the fact that ME application itself has high potential to perform population distribution and mobility patterns as demonstrated for Vienna application but couldn't be applied for Vitoria-Gasteiz due to above limitations.

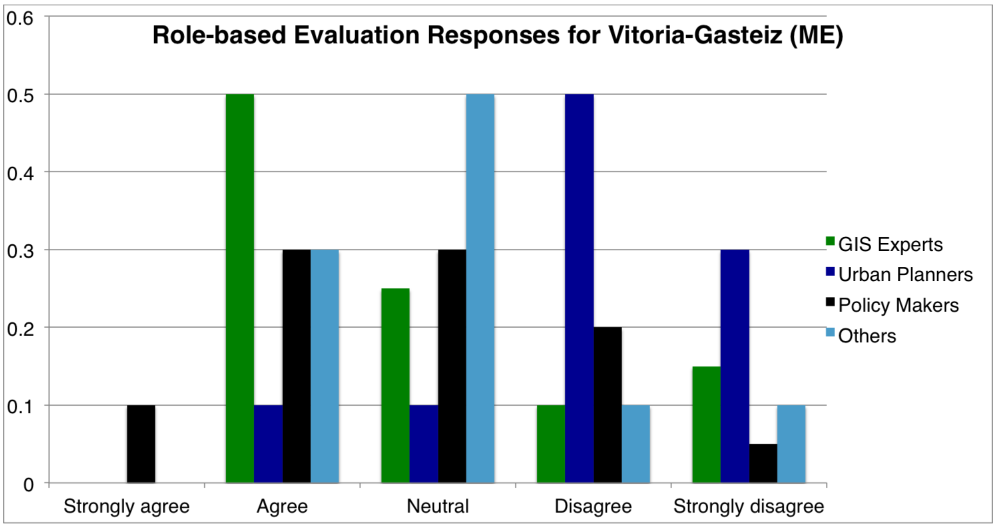

Figure 24: Role-based Evaluation Responses for Vitoria-Gasteiz (ME)

3.3.3. Bologna

Bologna evaluation exercise was carried out in October 2014. Several stakeholders representing Bologna city administration participated in urbanAPI application evaluation. Below we summarise results of the evaluation using different bar and radar charts. Please note that these charts are used only as a visual technique to get an overall idea about evaluators positive and negative response to evaluation questionnaire. For detailed qualitative responses please refer to chapter 4 and Annex-1.

For the Mobility Explorer four (04) users from Bologna participated in the evaluation. The results are shown in Figure 25a Figure 25b. Users found the application to be mostly satisfactory (GQ-1 to GQ-8; 9% strongly agreed, 72% agreed, 16% neutral and only 3% disagreed). They appreciated the following aspects of the application:

1. Usefulness for evaluating planning decisions.
2. Efficient visualisation of city population distribution and mobility patterns.
3. Enabling evidence-based decision-making and policy development.

The users also found the application interface to be user-friendly and intuitive. The only significant concern was the unavailability of local language support at the time. There was no functionality-related evaluation for cycle 2 as no new functionality was developed during cycle 2 due to lack of new GSM data.

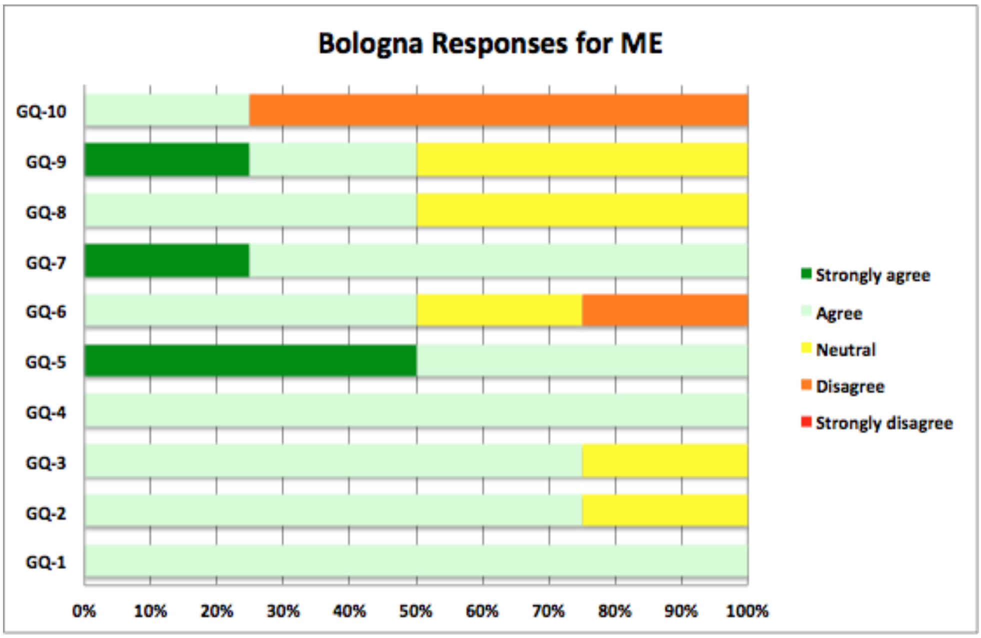

Figure 25a: Bologna Evaluation Responses for ME

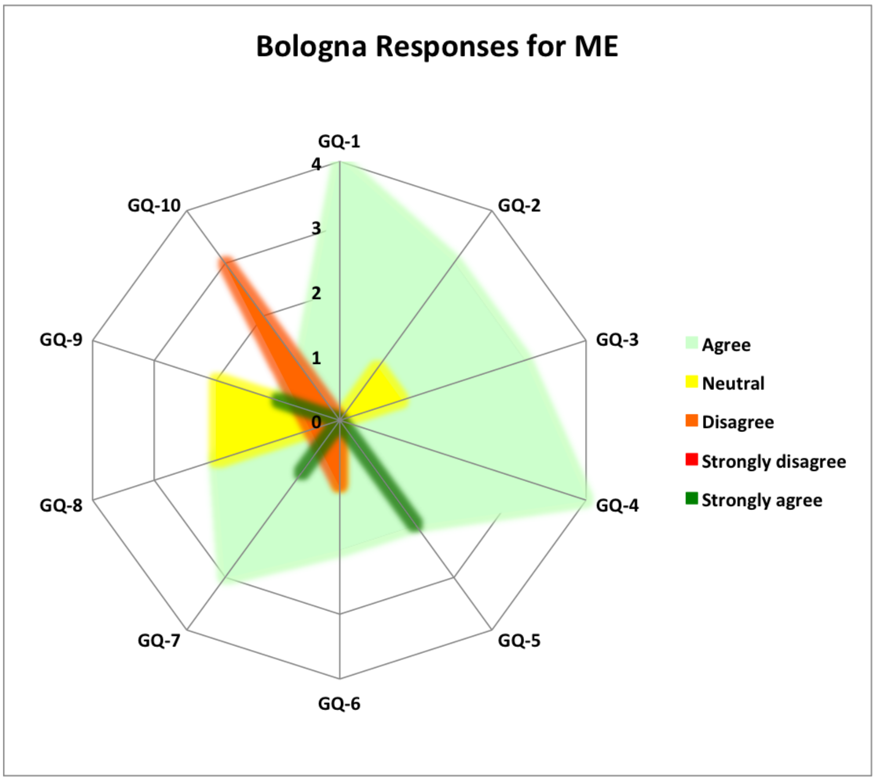

Figure 25b: Bologna Evaluation Responses for ME

Figure 26 depicts role-based analysis of user responses for Bologna ME application. Three types of users participated and the following figure depicts more or less similar responses by different types of users. Administrators, GIS experts and Urban planners indicated high level of agreement to overall effectiveness of the application for city of Bologna i.e. about 90%, 64% and 70% respectively. All neutral and disagree responses can be attributed to lack of fine grained data availability without which it is difficult to extract mobility patterns and fine grained population distribution and perform other socio-economic analysis for Bologna city.

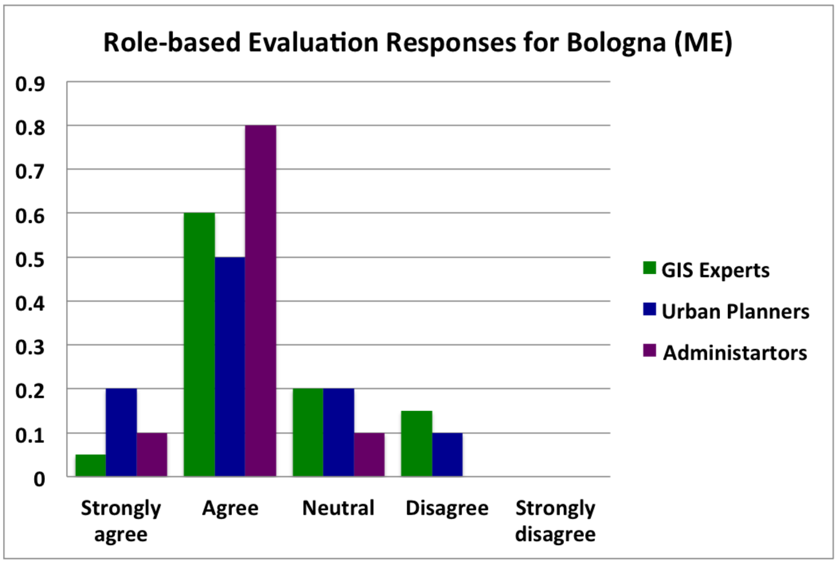

Figure 26: Role-based Evaluation Responses

3.4. Urban Development Simulator

This application can be applied to both city and city-region scales and helps in understanding the large scale consequences of complex spatial planning decisions including socio-economic activity in relation to land-use enlargement of the city. For example, in the urbanAPI application in Ruse the agent based model for simulating land use and land use density change in a 3D and high-resolution cellular landscape (e.g. 100x100 m grid) permits the allocation of new infrastructure by hand to observe the urban development effects, triggered through planning interventions. In addition, interactive control of proposed planning interventions and associated impacts generated by these interventions assists the public to engage in the planning processes and contributes to enhance planning decisions. Detailed and easily understandable information about planning decisions and full transparency about the expected impacts will support negotiation activities during the public participation process and will so increase public commitment to decisions.

Like the ME application, UDS is also highly dependent on the availability of historical data to train software agents and predict future behaviour. UDS allows the identification of urban development effects through historical dynamic land use maps and data and learning about interaction between various variables. It also explores land-use effects of population growth; alternative planning proposals; planning interventions e.g. major transport infrastructure etc. UDS also permits interactive exploration of planning policies and decisions i.e. what if analysis, and the simulation of the overall impacts.

Ruse based UDS evaluation exercise started late September 2014 and completed by end of October 2014 and several stakeholders representing ASDE and Ruse city administration participated in urbanAPI application evaluation. Below we summarise results of the evaluation using different bar and radar charts. Please note that these charts are used only as a visual technique to get an overall idea about evaluators positive and negative response to evaluation questionnaire. For detailed qualitative responses please refer to chapter 4 and Annex-1.

The evaluation covers benefits, usability and functionality aspects of UDS. The analysis of evaluation results provides reflections on the implemented features and suitability of current state of UDS application for Ruse. As UDS can be used by users with different domain expertise, behavioural analysis of evaluator responses is performed to compare and see overall functional suitability and effectiveness of these tools from different users' point of views.

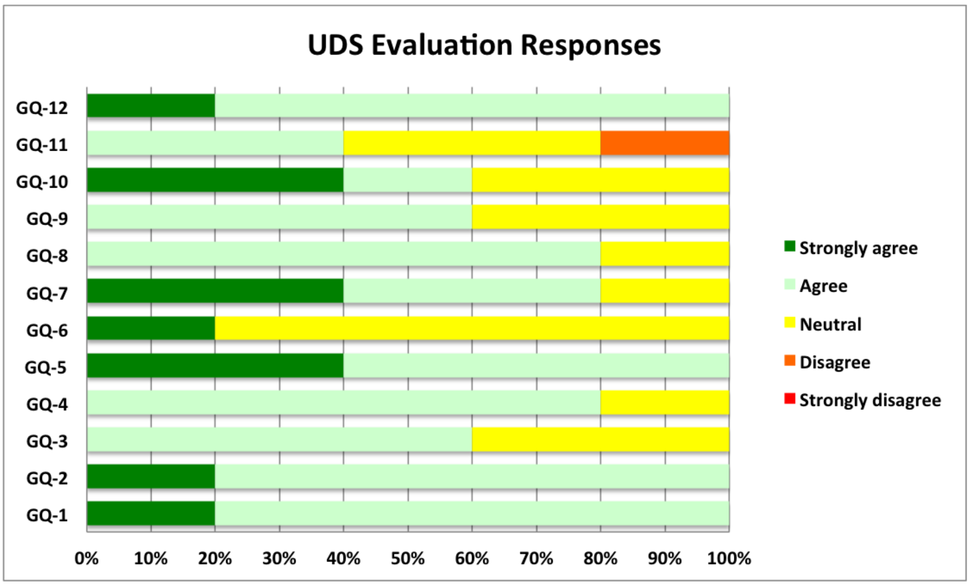

Figure 27a: UDS Evaluation Responses

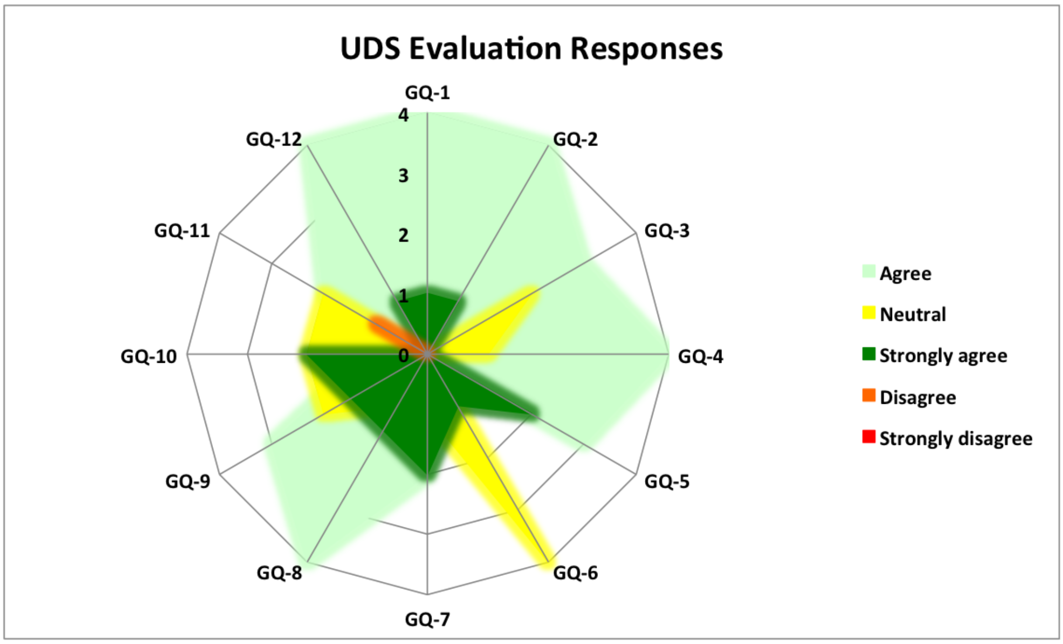

Figure 27b: UDS Evaluation Responses

For UDS a total of five (05) users responded. The responses, shown in Figure 27a and Figure 27b, were mostly positive to benefits-related questions (GQ-1 to GQ-9; 16% strongly agreed, 60% agreed and 24% were neutral). Users appreciated the application's usefulness for the following purposes:

1. identifying the effects of urban growth and shrinkage,
2. comparing its output with the Ruse Master Plan,
3. analysing the population shrinkage trend in the past and counterbalancing growth,
4. acquiring necessary information about possible future changes in population distribution and building distribution/development,
5. enabling public participation in urban planning initiatives,
6. providing sufficient evidence based on past data to initiate new urban development projects,
7. identifying evidence-based indicators for urban development and transport improvement and planning, and
8. exploring and investigating future urban development trends and their effects on energy consumption, emissions and spatial distribution of population and buildings of Ruse.

Moreover, the users also found the graphical user interface to be intuitive and easy-to-use. The availability of scenario-based video tutorials and their usefulness were also appreciated.

In terms of functionality the responses were also mostly positive (67% yes, 19% partially satisfied and only 15% unsure). The responses are shown in Figure 28a and Figure 28b. The evaluated functionality included the capability to simulate planning interventions, visualising and analysing their impact and import/export functions.

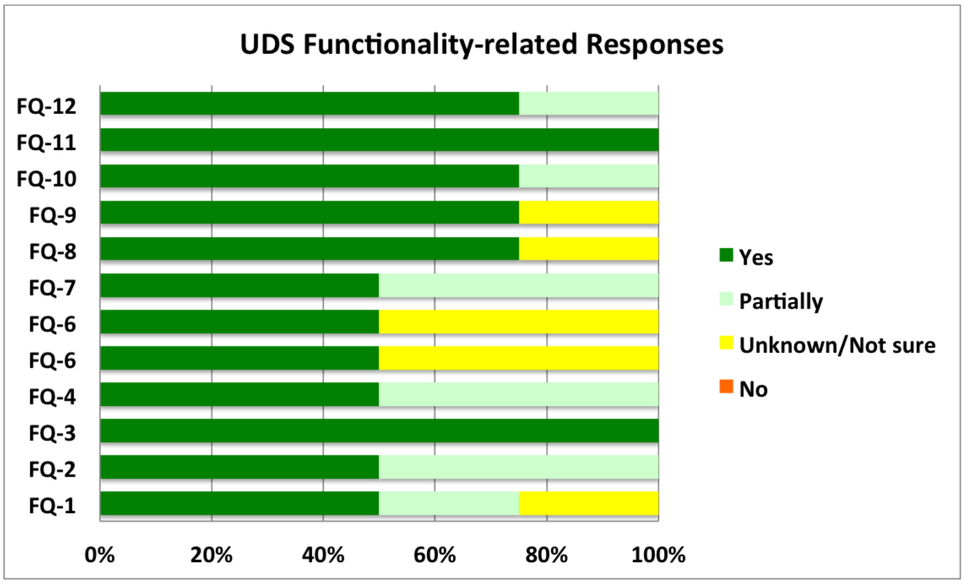

Figure 28a: UDS Functionality-related Evaluation Responses

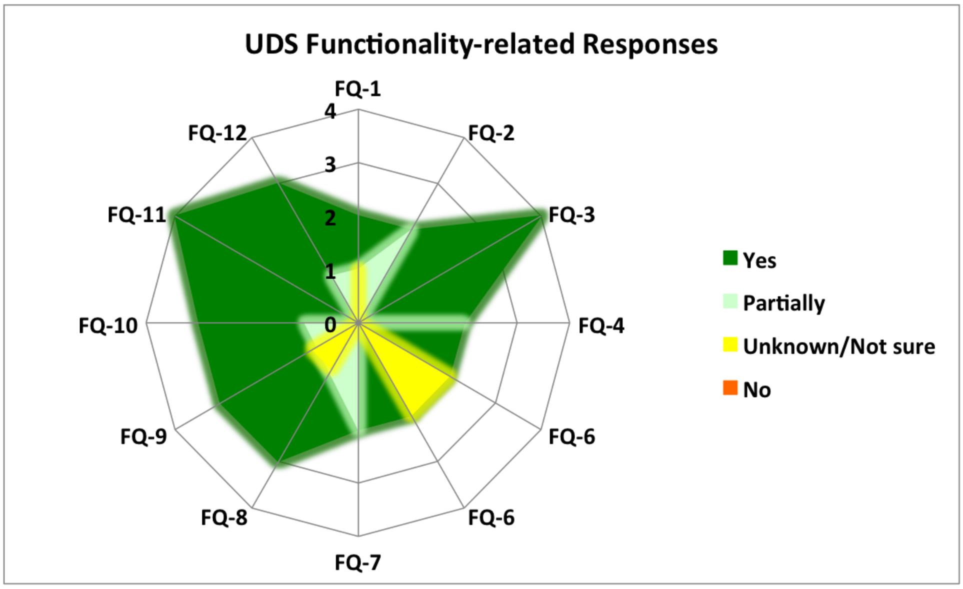

Figure 28b: UDS Functionality-related Evaluation Responses

The following list of features where two or more users responded as 'neutral' or 'disagree':

1. The UDS provides sufficient evidence based on past data (real data) on urban changes that can support decision making and policy making,
2. The analysis of the population shrinkage trend in past and counterbalancing growth shown in simulation option A is useful for experts,
3. The UDS graphical user interface is intuitive and easy to use,
4. The UDS provides sufficient help (e.g. context-sensitive help) to end users in understanding and using the application.

Users indicated that the simulator of urban development is too complex system and only context sensitive help/menus won't be helpful and hence require more detailed training and learning material such as tutorial videos. In addition, following list of functional features are responded as 'partial' by two or more users:

1. interactively introducing new spatial planning initiatives (master plan changes, zoning categories, etc),
2. allowing end users to define future actors' behaviour for the ex ante trend simulation,
3. comparing and contrasting environmental impacts (e.g. energy demand and CO2 emissions) of a specific urban planning intervention project e.g. population/building distribution
4. enabling stakeholders to view and compare suitability of a selected site/area for new housing settlements.

The major reason identified for all above limitations was by urban planners and administrators (policy maker) that such an application need a long period of testing of the simulator in different modes/scenarios that will allow validating overall simulation results.

Figure 29 depicts role-based analysis of user responses for Ruse UDS application. Four types of users participated and the following figure depicts more or less similar responses by different types of users. Administrators, GIS experts and Urban planners indicated high level of agreement to overall effectiveness of the application for city of Ruse i.e. about 67%, 92% and 68% respectively. However, Urban planners and Administrators showed about 32% neutral response in contrast to approximately 25% for Others (Engineer - Cadastre/GIS expert). Only GIS experts indicated about

8% disagreement. All neutral and disagree responses can be attributed to need of more time to validate simulation results and lack of fine grained data availability without which it is difficult to develop ex post land use and socio-economic behavioural patterns to derive ex ante simulation model. And, while UDS demonstrated its value and effectiveness by receiving high positive answers by specific types of users, it needs to be developed further to respond to concerns of users who responded approx. 32% neutral answers. In general, very low level of disagreement and high level of agreement to effectiveness of UDS application is revealed by all users.

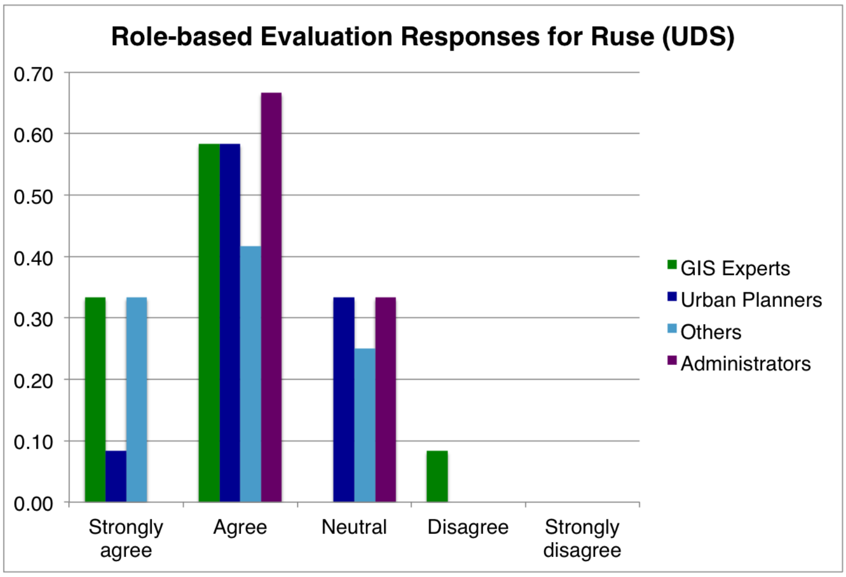

Figure 29: Role-based Evaluation Responses for Ruse (UDS)

Figure 30 depicts functionality related role-based behavioural analysis. GIS experts managed to perform all functionality related tasks (100%) as compared to Urban planners (approximately 22%). This difference may be attributed to level of pre-requisite skill-set to understand how to use UDS application and therefore Urban planners responded with approximately 41% partial and about 37% unsure answers. Similar to Urban planners, Administrators also answered partial (approx. 23%) and unsure (approx. 17%) results but about 59% answered yes. The level of uncertainty was for Others type of users was low and hence partial and unsure answers resulted in about 9% each as compared to about 82% answers as yes. In general, most of the functionality was found by most of the users but still some partial and unknown results indicate more training needs and or usability issues.

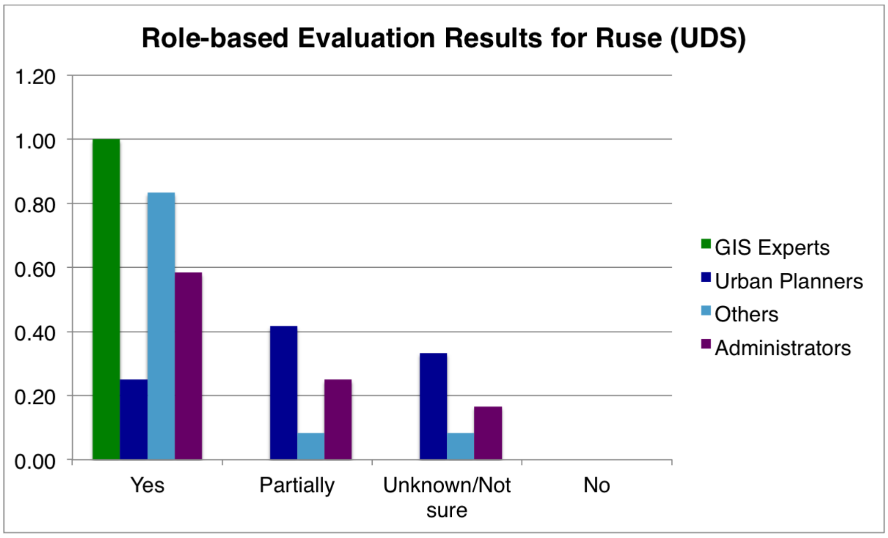

Figure 30: Role-based Functionality-related Evaluation Responses

3.5. External Feedback

In addition to the city-specific evaluation, some citizen and external stakeholders feedback was also carried out. For instance, a detailed evaluation by stakeholder board (members of different European organisations who are related to urban management domain) was carried out on 23rd September 2013 in Vitoria-Gasteiz, Spain. The detailed evaluation results are presented in D5.2 - User evaluation report - cycle 1. These results identify strengths and potential opportunities for improvement in the urbanAPI applications for wider applicability in other European cities.

In addition, a joint event 'Smart Green Cities' was organised with EC FP7 URBAN-NEXUS project on 1-3 April 2014, in Bristol, UK. urbanAPI project was presented and its applications were demonstrated in this event under the 'smart city management tools' theme. This provided an excellent opportunity to engage with over 80 urban experts and other stakeholders including, land use planners, ICT experts, social science researchers and political representatives from all over the Europe and beyond. This was the first opportunity for the URBAN-NEXUS community to directly interact with the urbanAPI application developers and investigate potential application opportunities for urban planning and policy making. The overall experience of engaging with domain experts was very stimulating and productive. In particular discussions with both protagonists and sceptics regarding the use of ICT tools to enhance participatory urban governance i.e. citizen participation and political and planning processes were both positive and thought provoking. urbanAPI developers were able to get direct feedback on their applications during the application demonstration sessions. In order to capture participants feedback more formally, a "lightweight" evaluation was prepared to get more qualitative feedback using the online evaluation portal. Participants found the application of these tools useful for expert users and suggested usability improvements for adoption by cities and citizens.

For urbanAPI case study cities a light-weight evaluation exercise for 3D SC web component was prepared for local city stakeholders who were not directly involved in the project. Overall participation level was low but the feedback was mostly positive. Results indicate that the application is intuitive and easy-to-use and is an effective tool for communicating with the public, raising awareness and policy and decision-making. Responses are included in Annex-1.

3.6. Conclusion

Overall the purpose of user evaluation cycle 2 was successfully fulfilled due to the following factors:

1) we could assess the overall functional suitability and effectiveness of urbanAPI tools for four different cities;
2) many important lessons were concluded that helped in defining future research and innovation directions.

For 3D SC it was found that the application was considered useful overall, especially for communicating urban rehabilitation plans to citizens. However, an important factor identified for this was the usability of the application; more specifically the realism (i.e. quality of 3D models) with which the 3D models were presented. Quality of 3D models is important for cities because it helps citizens orient themselves within the virtual environment by identifying key landmarks. The lack of realism hindered this ability and thus made it difficult for Vitoria-Gasteiz and Bologna city stakeholders to consider this tool effective, in its current state, in their local planning processes. Realism, in turn, depends on the availability of detailed 3D data for the city. In the case of Vienna where this high quality 3D data with high level of details (LOD) was available, users appreciated that usefulness of the application. In the case of Bologna and Vitoria-Gasteiz, where this data was not available, users registered their reservations about the lack of realism. This suggests investment by cities in developing high quality 3D city model for cities as this was not the objective of 3D SC. Moreover, the rule editor, meant to be used only by experts to pre-process the data, was also appreciated as being useful as well as mostly user-friendly. This may be attributed to the detailed level of training provided to end-users. However, this tool is less likely to be adopted due to its limited number of implemented features and availability of other similar GIS tools. Also, adoption of these tools by city administrations requires changes in existing IT infrastructure (e.g. upgrading hardware/software etc) and acquisition of high quality data (e.g. 3D or GSM in case of ME) which is highly dependent on the required monetary investments, and often is highly dependent on cities future digital agenda and priorities.

The ME application development for three different European cities derive important lessons and conclusions. As this novel way of collecting population distribution and mobility patterns data was new for cities, several requirements were considered as feasibility study with the objective to identify strengths and limitations in this approach. Results indicate that GSM based data does not provide extremely useful output for small size cities in detecting population distribution and mobility patterns due to low density of mobile cell towers. Among others, location accuracy is also an expected feature which requires more complex and expensive methods (e.g. antenna/cell tower triangulation) to be implemented by mobile service providers. For ME, users appreciated the simplicity of the interface and user-friendliness with which the application presented the population distribution and mobility patterns. However, for the mobility patterns to be identified, detailed GSM data is required that shows citizens connecting to different cell towers as they travel throughout the city. Again, in the case of Bologna and Vitoria-Gasteiz, this data was missing from mobile service providers due to privacy and security concerns. Thus, the usefulness of the application could not be demonstrated for these cities. However, users from Vienna, where the full functionality of the application could be demonstrated, the users indicated relatively high satisfaction with the application outcome.

The UDS was reported by users as being very useful as well as user-friendly. The various functionalities provided by the application were also greatly appreciated. A number of features were dropped due to lack of required data for city-region scale. End users identified a lot of potential for the UDS application especially to accommodate cross-border (Bulgaria-Ruse/Romania-Giurgiu) urban development simulation. Though the overall results of UDS evaluation for Ruse were positive, UDS was only applied on one city and it is difficult to generalise results based on the above results. Users also indicated the need to have longer assessment period to validate simulation results, which cannot be done within the urbanAPI project timeframe.

The behavioural analysis charts depict quite useful results. One important conclusion that is derived is that most of the applications indicated that expert users (with IT background e.g. IT Experts and GIS Experts) found most of the functional aspects and could relate them to overall benefits. In contrast, domain experts (urban planners, administrators, policy makers, transport planners) mainly assessed the application from the perspective of overall suitability of applications outcomes for planning processes. These behavioural analysis results indicate where future research and development efforts needs to be spent i.e user engagement, training, functional and usability improvement etc.

4. Qualitative Evaluation and Results

The aim of this final section of the questionnaire response assessment is to analyse from qualitative perspective - information concerning the general acceptance of the application tools and the potentials for the toolset to support policy processes in the city pilots. The qualitative method used in this section aims to offer empirical support to the quantitative analysis based on the Likert scale and undertaken for the application development requirements specified by the partner cities (see Chapter 3).

4.1. Questionnaire Response Assessment

The questions were formulated on the basis of identified city needs, specified in the urbanAPI Stakeholder Board meetings, urbanAPI city requirements workshops, and urbanAPI user evaluation cycle 1 report. The same respondents that completed the quantitative analysis (3.1 to 3.4) were requested to provide their overall opinion on the application tools, whether the tools meet city needs and expectations, support different stakeholders in city management, are compatible with available resources, and if they will be adopted for city management in the near future. Responses were provided via online evaluation portal, and retrieved in a formatted spread sheet as a basis for synthesis.

The opinion of respondents are based on their specific expertise and their knowledge of the city processes and are analysed considering the following factors:

1) possible applications within the urban context, and
2) opportunities offered within the pilot cities policy model.

Responses are provided with reference to the city-partner context and reflect the personal opinion of respondents, and the results are evaluated qualitatively in the framework of cities expectations. All original evaluation responses are presented in Annex-1. In addition, Annex-2 presents a summary of the different policy processes in Vienna, Vitoria_Gasteiz, Bologna and Ruse.

4.2. 3D Scenario Creator and Rule Editor

Three cities partners participated in the evaluation, including end users from Vienna (5), Vitoria-Gasteiz (5) and Bologna (4).

Q1 – Do you think that the analysed urbanAPI tools meet users (policy makers, planners, citizens) needs and consequently respond to your expectations, compared to other similar and/or traditional tools already in use in your municipality?

1) Vienna - Only one respondent is negative on this point, the common view is that the tool provides access to many different user-groups, however for some processes there is a need to go further (shadow analysis and calculation of effected areas).
2) Vitoria-Gasteiz – There is some reservations on the tools effectiveness, and expectations are not completely met as the respondents were mostly interested on the possibility to calculated environmental impacts. In addition quality of 3D models was not good as compared to other visual tools such as Google Street View which were considered more realistic and user friendly.

3) Bologna – The tool, even if it has a high potential, does not, in it's current form respond completely to city expectations (difficult to recognise the different part of the city, difficulties in navigation), it seems still quite complicated and compared with similar tools, already in use in the city, doesn't add value to participatory processes.

Q2 – Are urbanAPI tools capable to effectively involve a broad range of wide segments of stakeholders including citizens in urban planning?

1) Vienna – In principle the tool can reach broad range of stakeholders, but it is not so suitable for citizens. Some web-based 3D solutions should be restricted.
2) Vitoria-Gasteiz – Criticisms concern user friendliness, speed and detail, and concluded that technology alone, unsupported by a good promotion plan, is insufficient to foster participatory processes.
3) Bologna – The main criticism concern difficulties in using the tool, with further work required to involve effectively different stakeholder categories, and some training is necessary to use the applications available in the portal.

Q3 – Is local government ready to make full use of interactive tools like urbanAPI tools in planning and communication activities, in other words are the urbanAPI tools sustainable in your city or in your specific department considering personnel qualifications, technological and staff resources?

1) Vienna – Basically yes, however there is a long way to go to reach a full use of interactive tools.
2) Vitoria-Gasteiz – The city already use a tool to foster public participation in urban master plan development. The city has the necessary resources and qualifications to support it.
3) Bologna – At the moment the resources in the municipality are not sufficient to support and adopt the 3D Creator, especially as similar tools are in use and it is not easy to find more financial resources for fixing the urbanAPI tool with available databases and software.

Q4 - On the basis of above statements, do you think that one or more urbanAPI tools will be adopted by your city now, or in the near future, for one or all of the following reasons: effectiveness, cost saving, time saving?

1) Vienna – It is possible to adopt the tool, but no decision has been taken.

2) Vitoria–Gasteiz – At the current stage of the application, it is very difficult to show and demonstrate the applicability of the urbanAPI 3D SC to the decision makers.
3) Bologna – At the moment it is very unlikely that our city will adopt the urbanAPI tool because of budget restrictions and difficulties identified above.

4.2.1. Rule Editor

The city partner representatives also responded to the Rule Editor questionnaire, and generally they are well qualified to provide sound feedback, as they have a good knowledge of the tool, having been familiar with it during the project implementation and are fully aware of their city needs and policy making demands.

Generally the functionality of the tool was considered good but the workflow complicated even for an expert user. The advantages in relation to existing tools are mostly the potential of new features. The tool will be used internally and citizens will interact through the portal, which is a great opportunity. The capability of the cities, in terms of technology, expertise and resources varies, and financial issues linked to the crisis are crucial. On this basis the adoption of the tool is considered a good option, however probably not in the near future.

4.2.2. Conclusions

The 3D Scenario Creator, according to respondents opinion has high potential, however, in some respects it needs further development to fully respond to the city expectations and successfully compete with other tools already in use. Mainly, it needs development in respect to user friendliness, as users/stakeholders need training to fully understand and exploit all the application functionalities. The comparison done with tools not designed for planning (Google Street), means that more effort has to be done to inform end-users on 3D SC functions. Local governments generally have the qualifications necessary for running the tool, but they should adapt to the new tool to their local existing databases and integrate it with similar tools already in use. This is not always possible for financial reasons, and a common view is that the full use of interactive tools is not going to happen so soon. For this reason, even if there is great appreciation of the potential envisaged in the tool and there is the desire to adopt the 3D SC in the future, at the current stage of development it is very difficult to demonstrate its effectiveness to decision makers.

The Rule Editor is very well appreciated, mostly for all the additional functions available in respect to similar tools. Whilst its functionality is considered good, the workflow is complicated even for an expert user. Nonetheless there is a great opportunity for this application as the tool is intended to be used internally by expert users and this doesn't require any interaction with citizens or general users.

4.3. Mobility Explorer

Three cities participated in the evaluation, including Vienna (5 users), Vitoria-Gasteiz (6 users) and Bologna (4 users).

Q1 – Do you think that the analysed urbanAPI tool meets users (policy makers, planners, citizens) needs and consequently respond to your expectations, compared to other similar and/or traditional tools already in use in your municipality?

1) Vienna - The ME tool is a promising prototype and basically meets user needs, mostly the transport community, not so much the citizens. There are still some bugs such as spatial resolution and a limitation in fully exploiting available data. It can be used to augment the information the municipality already has and to validate information from other sources.
2) Vitoria-Gasteiz – At the present stage of development the ME tool can be used as a complement to traditional tools not a substitute, however it has high potential for the future.
3) Bologna – The tool is very promising and will be definitely useful for analysing mobility patterns when fully developed. At present it can be used only as an integration of traditional tools.

Q2 – Are urbanAPI tools capable to effectively involve a broad range of wide segments of stakeholders including citizens in urban planning?

1) Vienna – Yes with respect to domain experts, not to citizens mostly because a number of issues are still open about user interface and its usability, and because citizens are not usually so interested in large scale urban problems.
2) Vitoria-Gasteiz – ME can involve different stakeholders like planners or policy-makers but not the citizens.

3) Bologna – The ME tool is regarded as a tool for an internal use. Yet it can suit bottom-up participatory processes, but improvements need to be done in respect of visualisation.

Q3 – Is local government ready to make full use of interactive tools like urbanAPI tools in planning and communication activities, in other words are the urbanAPI tools sustainable in your city or in your specific department considering personnel qualifications, technological and staff resources?

1) Vienna – Considering personnel qualifications and technological resources there is no problem, the problem is the will.
2) Vitoria-Gasteiz – The department is ready in respect of qualifications and technical resources, but at this stage of the tool development is not ready to use it.
3) Bologna – There are no objection in the use of the ME tool as regards qualifications and technology, the problem can arise in relation to personnel resources to hire and train.

Q4 - On the basis of above statements, do you think that one or more urbanAPI tools will be adopted by your city now, or in the near future, for one or all of the following reasons: effectiveness, cost saving, time saving?

1) Vienna – Possible but no decision taken.
2) Vitoria-Gasteiz – More information should be provided on costs and work time needed to take any decision.
3) Bologna – Even if there is a quite positive attitude in respect to the ME tool adoption in the future, at the moment no commitment can be made.

4.3.1. Conclusions

The application has high potential to improve mobility analysis. However, at present, it cannot express all its functionalities and cannot be used alone but as an integration of traditional mobility evaluations. The is because of the difficulty in data availability and functional completeness. The ME tool is considered useful mostly for internal use involving domain experts such as planners and policy makers, less for interacting with citizens. In the three pilot cities there is a similar situation, no problems about personnel qualification or technology, but perplexity in using the tool at this stage of development or difficulties in allocating staff to it. Data availability can be an issue. None of the cities can be sure about the possibility to adopt the tool now, however there is a strong interest in it.

4.4. Urban Development Simulator

One city partner, Ruse, participated in application of the UDS tool with five (05) representatives.

Q1 – Do you think that the analysed urbanAPI tools meet users (policy makers, planners, citizens) needs and consequently respond to your expectations, compared to other similar and/or traditional tools already in use in your municipality?

- Ruse – Generally there is a very positive attitude towards the possibilities of the tool to support urban management. It is seen useful mostly for specialists and policy makers, less for citizens.

Q2 – Are urbanAPI tools capable to effectively involve a broad range of wide segments of stakeholders including citizens in urban planning?

- Ruse – The tool is addressed mostly to planners and policy-makers, however the involvement of citizens can be a very good opportunity.

Q3 – Is local government ready to make full use of interactive tools like urbanAPI tools in planning and communication activities, in other words are the urbanAPI tools sustainable in your city or in your specific department considering personnel qualifications, technological and staff resources?

- Ruse – Not easy to respond, it is at too early a stage of development.

Q4 - On the basis of above statements, do you think that one or more urbanAPI tools will be adopted by your city now, or in the near future, for one or all of the following reasons: effectiveness, cost saving, time saving?

- Ruse – There are many good reasons for the adoption to the UDS application, timing and cost reduction, larger participation in planning decisions.

4.4.1. Conclusions

Generally there is a very positive attitude towards the possibilities of UDS to support urban management, even if it is considered at a too early stage of development to make secure statements, the respondents seem to consider it quite probable to be adopted in the near future.

5. Discussion, Lessons Learned and Impact

In this chapter a critical discussion and analysis of the overall lessons learned and impact from results provided in the context of a broad perspective on city requirements for integrated urban management and the opportunities created by ICT enabled governance tools are presented. First we present generic city governance requirements and then potentials for smart cities governance. Then urbanAPI tools assessment and impact in the context of policy modelling, participatory and evidence based planning and commonalities in cities' requirements to develop common solutions is elaborated. This is followed by reflection on urbanAPI tools development and recommendations for future. Then data specific and methodological lessons are presented.

5.1. City governance requirements

To provide a fuller understanding of the evaluation results (above) as a basis for assessment of their effectiveness and impact, it is important to set the urbanAPI tools and their evaluation in a wider context of the policy model, integrated urban management and smart city governance. These urbanAPI tools fit nicely in various stages of policy making process, integrated urban management and smart city governance.

The policy model specifies territorial decision-making procedures as the basis for inter-agency collaboration and forms the fundamental driving force of urban territorial governance. This governance model is in the process of transformation in response to structural weakness of the policy model in meeting the substantial demands of integrated assessment, and inter-agency collaboration as a basis for integrated urban management. Transformational urban governance is also promoted in response to the dynamic of ICT innovation in tandem with social innovation, supporting the potentials for co-production of urban plans and redefining the opportunities for enhanced bottom-up engagement in the decision-making process. Smart city governance in this manner promoted by ICT enabled innovation aims to enhance the functioning of the policy model supporting integrated urban management and facilitating inter-agency collaborations to deliver territorial decision-making.

Fundamentally the effective governance of the cities and city regions of Europe today must address 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 specification and implementation of sustainable urban development. This interconnectedness and complexity of the urban environment can only be effectively managed via integrated urban management processes which aim to address the gaps between sectoral policies, between planning and implementation, for which responsibility is often split between different departments and stakeholders, between resources available and required, and between administrations and functional urban regions, where competition between municipalities often exceeds collaboration.

5.1.1. Integrated urban management

Integration also entails linking different administrative levels, departments and sectors together in order to ensure problems are approached in a holistic way and solutions chosen do not negatively affect others. Integrated management is a way to improve the consistency and coherence between different policies, from a socio-economic and environmental perspective, and a means to maximise the effectiveness of those policies within available budgets. It can also offer greater transparency in policy development and encourage a greater public involvement and acceptance. The integrated management of urban environments implies tackling related issues together such as urban management and governance, integrated spatial planning, economic wellbeing and competitiveness, social inclusion, and environmental stewardship. In this context an integrated approach is permeated by a holistic management that is not bound to a specific sector or level within the local authority, which covers the political and operational organisations as well as the stakeholders and actors in the territory.

Local governments must therefore liaise effectively with other levels of government in the promotion and implementation of sustainable urban governance. Such vertical communication between levels of governance, combined and connected with horizontal communication between sectoral responsibilities at the local level defines the essential dimensions of the necessary communication frameworks to support integrated urban governance and planning of cities at the local level.

Failure to integrate policy is widely evident however, and can be attributed to a variety of factors including notably, organizational and procedural barriers between sectoral planning agencies responsible, for example, for land-use, transport and environment, in a horizontal perspective primarily at the local level, and in a vertical perspective poor communication between agencies responsible for policy development at local, regional, national and EU levels. A prime casualty of the lack of connectivity in this policy model is the fragmentation of the information and intelligence essential to support integrated policy definitions and policy implementation.

The sectoral planning agencies at the local level, identified above, are typically repositories of a vast amounts of data, specified in relation to land use characteristics, transportation modes, as well as socio-economic and environment monitoring data. However, this information and intelligence is contained in sectoral departmental agency structures that inhibit cross-sectoral information flows. Accordingly this information is frequently not available as a collective integrated resource to inform planning decision-making and urban governance. These failures of communication and coordination between government agencies, and indeed between urban stakeholders, underpin the demand of the policy-making community for integrated urban management frameworks, as well as the demand for new assessment methodologies and decision-making tools to support urban and regional governance.

5.1.2. Operational policy model

Vertical and horizontal communication, in combination with planning and management processes, define the essential template of user requirements from which ICT tools and methodologies can be developed. Planning and management processes are operationalised in the policy model which identifies a cyclical sequence of decision-making stages which in combination realise territorial decision-making. The relationship between inter-agency communication and the policy model is mapped in terms of the flows of information and intelligence from the nested hierarchy of collaborating planning agencies from local to EU level in a vertical perspective, combined with inter-sectoral information and intelligence flows in a horizontal perspective at the local level. These flows of information and intelligence are essential to support planning and management processes and related decision making operationalised in the policy model.

Furthermore, it is evident for the policy model analysis what information and intelligence is used and required by which organisation/actors, for what purpose, at what time and thereby identify the information and intelligence management relationship between these organisations/actors. This data model provides the basis for the development of ICT enabled tools and methodologies to support the plan making and decision taking process.

5.1.3. Transformational governance

Intensifying socio-economic challenges for cities countered by the adoption of sustainable development as a political and technical response framework, have promoted the emergence of new forms of integrated urban management, supported by innovative forms of engagement with stakeholders and collaborative decision-making. These governance and managerial transformations are in many ways a reaction to the shortcomings of classical models of urban governance that emphasise the expert top-down perspective mobilising departmentally defined implementation and frequently ineffective one-dimensional solutions.

The core principles of sustainable urban management highlight the need for effective stakeholder engagement and public consultation in relation to the complex of tensions at play within a multiple system of interactions and often conflicting views between the three pillars of sustainable development (economic, social and environmental). These emerging forms of “transformational governance”, as an alternative to traditional approaches, are viewed as critical to the realisation of sustainable development, requiring a new synthesis of expert governance fully articulated with bottom-up stakeholder and citizen engagement to inform decision-making (co-production).

Urban planners have also recognised the need for new information processing and decision making support tools that both assist in the analysis and management of urban complexity, as well as tools that support bottom-up engagement critical to transformational governance. Such tools create new information and intelligence, as well as new means of engaging stakeholders effectively in the development planning process. The sustainable city would appear to be increasingly dependent upon the opportunities created by ICT innovation to unlock the full power of this new urban governance.

5.2. Potentials for smart city governance

In response to the above demands (5.1) for more effective planning tools new opportunities are arising in the application of enhanced ICT driven intelligence to urban management, securing more effective governance of cities, and the delivery of more sustainable cities. In particular ICT enabled urban governance supports the production of an effective basis for the assessment of urban complexity, and decision-making support. In fact ICT enabled urban governance offers a significant new potential to simultaneously achieve more effective management of the complexity of the city, as well the engagement of citizens in defining their urban futures. The key elements of the dynamic of the rapid evolution of ICT smart city tools and methodologies, as presented here provide a further necessary basis for assessment of the utility, impact and potential future development of the urbanAPI tools. In this context beyond the assessment of the specific tools developed in the project, it is important to reflect on two additional considerations:

1) need for integration between tools and their function to support integrated management;
2) need to seek commonalities, common solutions and common tools that can respond to the demands for urban governance to meet the challenges of the common global drivers of change that impact on all cities.

Following this review a full assessment of the urbanAPI tools can be provided and the next steps requirement in tool development are specified as recommendations for further research and development.

5.2.1. Co-production and collaborative planning

The European Innovation Partnership on Smart Cities and Communities Operational Implementation Plan (2013) identifies key trends in relation to the current and future evolution of smart city governance and ICT enabled urban policy formulation. The report emphasises that integrated planning and management involves spatial, temporal and technical coordination of diverse policy areas and planning resources to achieve defined goals using specified (financial) instruments. Its success requires the comprehensive and early involvement of all governmental and non-governmental players, private sector, and citizens. It is particularly challenging as it involves managing long-term planning perspectives and short term actions, addressing domains as diverse as transport, energy, ICT and beyond – in both existing (retrofit) and new urban territory. Current approaches are insufficiently agile to cope with a more entrepreneurial approach and to respond to the pace of change in demography, societal expectations, and technology. This requires technical planning capabilities, co-production of the plan with more inclusive participatory and consultation processes, and greater collaboration within and across traditional policy and administrative boundaries within and between cities and communities.

5.2.2. Scalable design and multi-criteria toolkits

Integration of scalable design and multi-criteria is one of the key actions needed in creating future low carbon cities. Co-creation platforms including specified sub-platforms, decision tools (simulation, visualization/virtualization, open data/information platforms) and living labs in order to increase the level of awareness, increase inhabitants' involvement in planning and implementation process, activate social communities.

The goal is to develop a toolkit for existing and new close to zero energy buildings and districts that integrates and connects different assessment, solutions and design tools and, in addition creates different "views" for results and visualizes them. The platform also enables multi stakeholder analyses of cities as integrated ecosystems. The purpose of the toolkit is to give a more holistic view and solution of the different perspectives of city/district design.

This integrated toolkit should enable multi-stakeholder analyses of different spatial and domain perspectives as integrated ecosystems. Integration/creation of digital platforms for integrated multidisciplinary collaborative design and planning involves co-simulation and optimization of complex interactions in different domains, virtual environments for viewing and commenting designs, e-learning applications, user-oriented cognitive data visualisations. Interoperability with operational systems actually in use is essential for take-up. To evaluate the decisions made in the city strategy it is essential to assess and measure the performance of cities and districts. The goal is to develop an integrated holistic auditing tool by collecting and fine-tuning existing auditing tools/systems and decide on what to measure to be used for evaluation in cities. All developed tools should be scalable in such way that both big and small cities can use them easily. Tools need reliable data (reference open data).

5.2.3. Citizen Focus

Planning and management approaches at the city-level need to be agile enough to respond to the needs of various stakeholders and holistic enough to capture synergistic benefits across departmental silo's. The focus concerns governance mechanisms enabling a holistic planning approach, tangible for all relevant stakeholders and citizens. Securing long-term commitment from stakeholders and balancing long-term objectives with short-term actions is a key challenge when implementing smart city initiatives. Key needs in this context include the need for defining long-term goals, and stimulating and managing the dynamics of entrepreneurship in smart city initiatives involving public partners, private partners and citizens.

Industries, civil society, and different layers of government must work together with citizens to realize public interest at the intersection of ICT, and urban governance. Much has already been done to engage citizens for mobility, energy efficiency, sustainability and related topics – though individual entrepreneurs, rather than larger-scale industry and government are often the drivers. There are also many ICT platforms for crowd funding and collaboration. Likewise, citizens are already creating apps and services to help cities solve problems. Two core project types are identified as organizing principles:

1) projects that create an enabling environment for citizens to solve the problems they identify. Additionally, projects that help the most successful citizen-led projects scale in a city;
2) projects that facilitate conversation between stakeholders, where citizens' voices are not only heard, but instrumental in solution design, allowing for better results and creating faster and more targeted improvements.

5.2.4. Stakeholder engagement platforms

Community insight and engagement is vital to solve challenges like minimising energy consumption, reducing waste or ensuring efficient movement around cities. Without proper support from citizens solutions may not be implemented. Engaging people has many dependencies: culture, motives, trust, capability, availability, enablement, etc. These vary by nation, by city and further by local groups. In order to best motivate citizens or incentivise behavioural change, cities benefit from deeper understanding of who their citizens are and what they need and want.

Doing this well requires a three-step approach: first a good understanding of society; from which to engage efficiently and effectively; and then motivate appropriate action. Done well, this builds capacity and resilience in society, ensures the efficacy of policy-funded services, and can help meet policy goals (like the EU 20/20/20 targets for energy and climate change). Effective engagement, innovation and societal progress are increasingly realized in networked environments. Stakeholder platforms and other forms of collaboration between government institutions, SME's, international businesses, NGO's and citizens are developing, supported or enabled by modern ICT infrastructures and may serve a variety of purposes including:

1) Co-creation – Conduct workshops where citizens from various target demographics join service providers in creating an idea to solve a problem
2) Concept validation – Conduct user studies with concept sketches and word documents to learn early how citizens feel about the proposed solution
3) Usability - Conduct user studies with early prototypes or sketches showing the mechanisms for a solution to understand how usable the solution is for different types of users
4) Feature requests – Enable citizens to request new solutions, with voting and curatorial mechanisms to identify the most requested 'features'.

5.2.5. City Information Platforms

The goal is to unleash the full creative potential of cities to meet societal challenges through the full deployment of modern ICT infrastructures. New models of collaboration and co-creation in cities can be stimulated through the realisation of city platforms, where stakeholders of all kinds form "living labs". Cities presently hold their data in multiple silos within each department of each agency that operates in the city (and indeed those related agencies in regional and national Departments). This data is of variable quality and is also inconsistently captured between departments, and across agencies. The more progressive cities have started to open up their data sets to encourage developers to use the data in more innovative and value-added ways. However, open data alone will not deliver significant advance as value must be extracted from a number of available data sources, including:

1) department databases
2) open data of multiple agencies
3) social media data
4) urban sensor data (machine-to-machine / IoT)
5) commercial data

To significantly improve services, increase efficiency, and deliver ambitions of real-time operations it is necessary to work with all these data sources – particular to each service area. This requires consideration of issues including data quality, security, structure, inter-dependencies, time-based matters, governance rules etc. This requires also a new model to deliver sustainable value and requires new ICTs, as well as alignment between departments and across agencies; and between leadership, business operations and IT functions. The direction of improvement is very clear but currently the approach and methods differ considerably, and there is limited collaboration between cities. The goal is to increase the uptake of cities to exploit the value available from a common core logical design for an interoperable city information platform (or platform types).

5.2.6. Big Data for planning and management

The goal is to support the implementation of data driven planning and management approaches in developing and implementing smart city projects. Data-driven planning and management strategies can contribute to planning and management strategies at the city level which are agile enough to respond to the various opportunities and needs of stakeholders arising in the city. The flow of data and information arising from a broad variety of ICT-driven technologies offers ample opportunities for optimising, assessing and communicating progress in implementing smart city policies. Examples can be found with regard to capturing big data on mobility and electric transport, energy systems, smart metering, environmental sensing and control and data and information from peer-to-peer applications and social media. As yet, the most imminent aspects related to implementing this action concern opening up databases which are currently in use by public services and city departments.

5.2.7. *City Visualisation*

The complexity of city systems can be daunting to understand for city engineers, let alone the general public. The ability to present layered information on city systems in an intuitive fashion using modern technologies is quickly developing. Technologies can be used to engage city residents for value-adding purposes including urban planning, urban mobility, public security, environmental management, energy (and other resource) usage, waste management and the like. The availability at the city level of numerous sources of data combined with the plotting these data at various geographical levels (from street-level up to city level or even regional levels) provides policymakers, entrepreneurs and citizens with a rich source of information.

ICT enables city governments in communicating and engaging broad stakeholder groups in their planning and management policies regarding city development. The focus is on smart visualisation tools supporting communication on city governance issues, peer-to-peer-tools and social media to engage large, informal groups into city development and governance. The goal is to support cities in communicating and engaging broad stakeholders groups, most importantly citizens, in their integrated planning and management policies. It is one of the enabling tools to collect opinions, address stakeholder interests and to secure long-term support and involvement.

5.2.8. *Urban Simulation and Planning*

Cities can benefit greatly from quantified assessments and scenario exercises. These tools can help to better understand the impacts of policies and implementation strategies under different context conditions. This can cover a broad array of topics such as land use and urbanization, investments, energy saving and production, mobility plans, resource efficiency and variable socio-economic aspects. Pending issues relate to questions as to whether and how urban policies will contribute to an energy efficient and sustainable city, how to inform stakeholders on complex system interdependencies or how to arrive at smart decision-making. Urban simulation and planning models to capture the dynamics and impacts of urban development, including socio-economic aspects, offer a common approach and methodology which can be used among cities to assess in a quantified way the effects of planning policies and implementation strategies on energy, mobility, socio-economic aspects and urban development.

5.3. urbanAPI tools – assessment and impact

This section critically reflects on the evaluation results from the following perspectives (Khan Z et al 2014a) which are central to the user requirement and the project objectives:

1) policy modelling process
2) participatory and evidence based urban planning;
3) commonalities in ICT tool requirements

5.3.1. Policy modelling process

The generic policy model (Figure 31) depicts a cycle representing different stages of the policy-making process (boxes). This generic policy model has been verified in relation to the urbanAPI pilot cities (see Annex-2) where substantial commonality in the specification of the policy model in the pilot cities was identified in accordance with the provisions of the generic model identified in Figure 31.

The planning policy development process depicted in the figure begins with the “issue Identification” stage (evaluation) that collects domain specific data e.g. socio-economic and environmental data relevant to the issue of urban development, etc. either by evaluations, opinion polls, or ICT technologies e.g. sensor nets, etc. for issue identification. From a top-down policy making perspective issues may be identified by planning agencies using, for example, the ME or UDS applications to identify key development issues, or from a bottom-up perspective, using the 3DSC application to engage stakeholders and support crowd sourcing of issues and priorities.

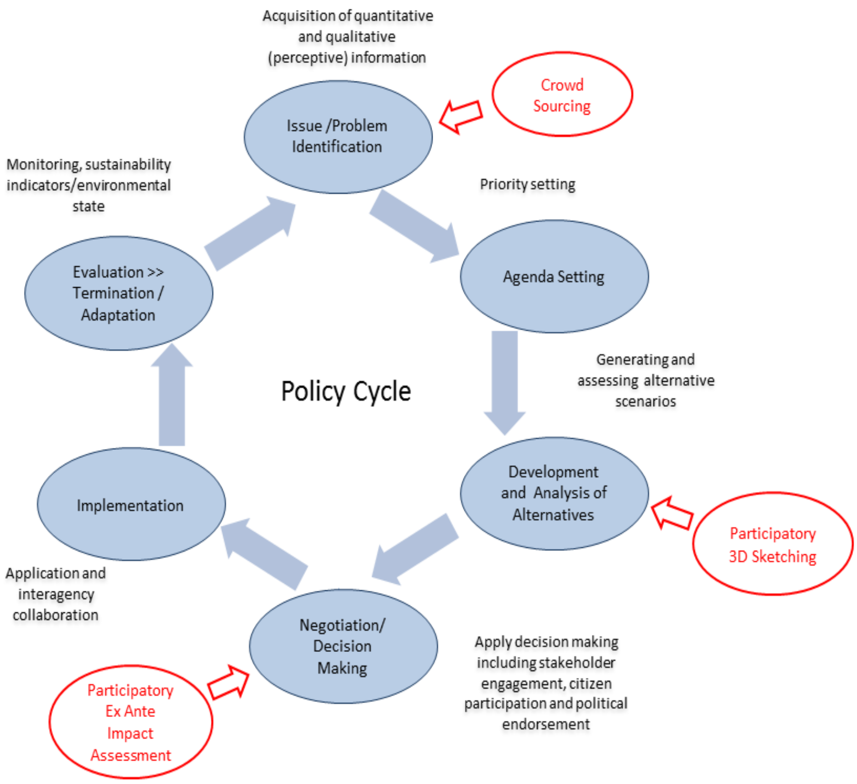

Figure 31: Generic Policy Model - Planning Policy Development

The next stage of the policy-making process – "agenda setting stage" aims to set priorities for the following stages. The stage concerns the formulation of a coherent planning strategy, specified by urban planners in respect of a variety of policy objectives, that address the issues identified in the first stage, and which proposes a plan of action over a period of time (typically five to ten-year period) to resolve these problems. Again all three urbanAPI applications support this stage by facilitating the development of alternative scenarios including proposals and suggestions by stakeholders.

The "development and analysis stage" utilises data gathered at the "issue identification" stage and based on the priorities set up in the "agenda setting stage", and provides an assessment of the territorial impacts, in respect of socio-economic and environmental variables associated with the solutions to the issues to be resolved by the plan. Here participatory 3-D sketching (3DSC) supported by ME driven impact assessment and simulation offers significant added value in co-production of the plan.

In the “negotiation/decision-making stage” urban planners provide a proposition for future development of the urban territory universally subject to public and wider stakeholder consultation fundamental to the political acceptance of the plan, following which a political commitment is made by elected officials of the municipality to the implementation of the plan.

Implementation of the plan (“implementation stage”) over the plan period of several years involves commitments by a variety of public agencies acting in concert to secure the objectives of the plan in order to respond to the problems identified at the evaluation/analysis stages and to provide a framework for private investment in the development of the urban area. Again all three urbanAPI applications support stakeholder co-production of the planning proposals, and furthermore the identification of public preferences and new issues which can be addressed in future planning policy cycles.

The “evaluation stage” is focused around monitoring of the implementation of the plan to identify the extent to which the plan is achieving the objectives defined by the policies of the plan, and where it is failing to fully meet the policy objectives of the plan, and so provide a basis for reformulation of the plan in the subsequent iteration of the policy cycle, where the process is repeated in a cyclical manner in order to assess and improve policy implementation.

Based on the urbanAPI evaluation we can conclude that ICT tools substantially assist in transforming policy making and decision making processes by engaging with various stakeholders including the public at all stages of the policy development cycle, to acquire feedback and influence policy and decision making. At the same time, the cycle 2 evaluation results indicate that these tools need further development to be fully exploitable in the public domain. Nevertheless, this offers expectation that new features can be added to existing urbanAPI tools, usability can be improved and additional tools can be developed or integrated to fill “gaps” at other stages of the policy making process e.g. social networking, crowd sourcing at “issues Identification” stage. In addition, an integrated workflow based approach can assist in more effectively utilising outcomes of previous policy development stages at the next stage as proposed in (Kraemer, Ludlow and Khan, 2013). This would result in semi-automated data collection and analysis for policy and decision-making.

5.3.2. *Participatory and evidence based urban planning*

urbanAPI applications support both passive and active stakeholder engagement that assists in securing the evidence necessary to make bottom-up and more democratic planning decisions. The 3DSC application promotes active participatory planning where end users can participate via web browser (due to X3DOM technology) to identify urban issues for a specific planning proposal e.g. by adding annotations, placing visual objects at specific locations such as street furniture, new infrastructures/buildings, etc. This application helps city administrations in raising awareness by communicating planning issues to the public with the objective to empower them in the identification and debate on local issues. Though there are potential benefits identified, 3DSC needs to be developed further to fulfil variety of city needs.

From a different perspective the ME application actively supports the identification of the evidence base for urban planning in defining the spatio-temporal patterns of socio-economic activity in the city and relating the use to the spatial structure of the urban area. This provides unique and highly significant insights into collective behaviours in the urban environment essential to the pursuit of evidence-based urban planning. Population distribution and mobility patterns are identified by using mobile phone data and presented through a web-based visual interface. The visualisation results can be exported to other statistical and spatial tools for further analysis and impact assessment. In urbanAPI, ME is considered highly relevant and beneficial source of information. However, quality of mobile data varies from one city to another and needs further investigation to develop generic ME application.

The UDS application supports both active and passive participation. The passive participation is based on the ex post model calibration by using historical city data and/or citizen participation to develop behaviour rules and use these rules for ex-ante trend simulations. The active participation element is based on online evaluations conducted on the planning interventions and results are used to calibrate simulation models.

5.3.3. *Commonalities in ICT tool requirements*

The conceptual frame for the project is 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 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 based on the development of generic ICT applications and methodologies, 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 of the tools developed in the cities and regions of Europe

In various ways top-down and bottom-up urban planning and policy making needs vary from one city administration to another making it difficult to capture and develop all the required features in the respective IT tools, often resulting in failure of developing generic software solutions. Nonetheless the identification of the common elements that do exist in city IT tools requirements can support the development of common features and the development of lower-cost products compared with bespoke software development.

The urbanAPI application development follows a structured requirements development methodology where over 50% of commonalities are identified at various stages of a policy-making cycle/process (Khan *et al,* 2014). However, specialised data is required for the development of these applications which often does not exist in the required quality and format and hence necessitates data harmonisation and pre-processing to ensure successful delivery of these tools.

Preliminary analysis derived from the urbanAPI CoReS method application (Khan, Ludlow and Rix, 2012) indicates that nearly 50% commonality exists between two or more city requirements for the 3DSC application. These common requirements include usability aspects such as need for 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. This conclusion suggests that generic tools and services can be developed which can be exploited in fulfilling the specific needs of a wide range of city administrations in Europe, and globally. At the same time requirements individually derived from cities also indicate new potentials which can be developed to enhance functional features and improve the overall functionality of the 3D SC application.

In a similar fashion to the 3DSC application, there exist about 60% commonalities between two or more city requirements for the mobility explorer (ME) application. These requirements include usability aspects such as need for intuitive user interface; visualisation of aggregated population; indication of places attractive to the public; extrapolation of results to the overall city population; identification of social biasing; visualisation of motion traces between city districts/zones; intra-city and extra-city origin-destination matrices and travelling mode; accessibility using different platforms; importing new mobile phone data and exporting results in common formats; integration of ME data with data from other sources e.g. GPS, evaluation information, city administration IT standards compliance; and workflow documentation. Based on the above findings we can conclude that generic tools can be developed to a substantial extent, and more specific requirements from cities can add value to these common capabilities for city tailored solutions.

5.4. urbanAPI tool Development and Recommendations

Based on the experiences of the urbanAPI project and user evaluation results, the following recommendations are considered appropriate:

5.4.1. Recommendation 1: 3DSC

3DSC and visualisation tools offer major potential for creation and innovation enabling cities to meet societal challenges. Exchange of ideas and experience and room for experiment are needed, to understand how these new “organizing principles” work and how they can be enhanced, to see what works and then bring successful ideas to broader scale, applicable in different urban contexts. Development recommendations include:

1) Develop as explanatory application
2) Develop as interactive co-production application
3) Develop at different scales (local, citywide, city region)

4) Develop as component of platform (Toolkit)
5) Support to cities in acquiring high quality city data
6) Provide calculated impact assessment based on planning interventions

5.4.2. Recommendation 2: Mobility Explorer

The mobility explorer offers exceptional potential to secure unique understanding of the spatial and temporal dimensions of urban socio-economic activity mapped against the spatial structure of the city. Numerous development opportunities exist including necessary integration of urban management information and analysis (cross departmental/multi-scalar), with a focus on management of urban complexity. Priority should be given to the city-wide context – further developing urbanAPI mobility explorer RTD, focused on the key EU political priorities concerning the containment of urban sprawl and the creation of the compact city. Development recommendations include:

1) Develop for different temporal and scale specifications
2) Develop generic interfaces to import/export new GSM data
3) Develop to specify data according to gender/ demographic/ socio-economic class/vehicle mode etc
4) Develop modelling functionality – model mobility data in relation to alternative spatial environments
5) Develop socio-economic and environmental impact assessment functionality
6) Develop common standards/interfaces for communication to other planning agencies (different scales and levels)
7) Develop as component of platform (Toolkit) - integrate with other data

5.4.3. Recommendation 3: Urban Development Simulator

The urban development simulator, and more generally simulation of the future form of urban development is a critically important complement to the mobility explorer. Modelling of urban environments to optimise socio-economic and environmental impacts, as delivered by the mobility explorer are necessary pre-conditions for sustainable urban governance. However, the future orientation of urban planning, considering options for territorial development over 10 – 20 years, demands joint development between the mobility explorer impact assessments and simulation. Development recommendations include:

1) Develop for planning proposals at all scales in relation to planning development constraints
2) Develop simulation of alternative development options and socio-economic/environmental impacts assessment
3) Develop simulation based on interactive planning interventions
4) Develop in respect of long-term regional development vision

5.4.4. Recommendation 4: Integration

New ICT methodologies and decision-making tools, in accordance with the Shared Environmental Information System (SEIS) (Høebíček, J. and Pillmann,W. 2009) and other related initiatives such as EU Digital Agenda 2020, must be based on the requirements of the new governance models, and as a consequence an entirely new paradigm of integrated urban governance is required in order to provide a consistent framework and context to systematise the information flows from data collection to assessment and decision-making support. Development recommendations include:

1) Develop analysis of key integration gaps – in relation to requirements of policy model
2) Develop data harmonisation and integration solutions – in relations to data sources from variety of local, national, EU and open data repositories
3) Develop intra and inter cities process harmonisation solution
4) Develop assessment of requirements for integration of all governments levels (EU to local)
5) Develop as component of platform (Toolkit) - integrate data and application functionality

5.4.5. Recommendation 5: Commonalities

ICT enabled urban governance solutions should be built upon the analysis of commonality of user requirements, and a model of a common fully interoperable information space (Høebíček and Pillmann, 2009). In this information space all agencies, at all levels of governance, and all stakeholders have equal access to information and intelligence necessary to secure the sustainable management of the city-region. Development recommendations include:

1) Develop general principles considering modular frameworks for urban governance
2) Develop common land use - transport territorial impact assessments as strategic city-wide tool
3) Develop common socio-economic and environmental indicators monitoring system linking local to EU level

5.4.6. Recommendation 6: Research

Despite the evident dynamic and future orientation of all of the above, at the city level there is only limited evidence of the direct effects of ICT-enabled innovations on city governance systems, and in many respects this revolution is still in infancy. Clearly more research, particularly at the pan-European level, is required. Development recommendations include:

1) Develop research to define the most effective tools and methodologies to support ICT enabled participatory urban governance
2) Develop research linking EU (ICT), ESA (Copernicus), EEA (urban atlas), and member state (JPI Urban Europe) as co-ordinated focus on ICT enabled urban governance
3) Development research to apply urbanAPI tools to other cities to discover new requirements and challenges which could not be identified during this project

5.5. Data specific issues and lessons

One of the lessons learned is that the urbanAPI applications are dependent on specialised city data to develop the required features. Often this data is not compliant to INSPIRE specification and is not available in the required quality and so necessitates data harmonisation and pre-processing. Detailed lessons learned with respect to data collection from cities are presented in Deliverable D2.2 – Data Collection, and data pre-processing, harmonisation and integration in Deliverable D4.1 – Integrated and Harmonised Data.

Data plays a crucial role in the development of urbanAPI applications. Three main issues require special consideration to deal with application specific data which can be useful for the development of similar ICT tools and applications. These issues are:

i. *Application specific data requirements:* Identifying the data requirements at an early stage based on application requirements specification helps in identifying which particular features can be implemented. This also helps in identifying alternate sources of data which can be utilised.

ii. *Data availability and accuracy:* Collecting the required data is often challenging as storage formats vary from one city database to another and often there is no metadata available. Furthermore, the required data is not always available. This requires comprehensive data analysis, cleansing, harmonisation and integration so that data can be used for application development. For example, lack of availability of 3D data for 3D SC application requires the construction of new 3D models using 2D city data. Similarly, historical socio-economic and urban development data (e.g. taxation, lot prices, etc) at city-region scale for the development of UDS application is either limited or not available in the required format (e.g. language, resolution, district unit et). Also, mobile phone data from various providers contain fine to coarse grained information and often may not be able to provide required information for ME application for case study cities due to privacy and security constraints.

iii. *Cost of application specific data:* Not all the data is freely available and may only be accessed on payment. For example, mobile phone location data for the ME application is acquired from mobile data provider companies which often charge for such data. This limitation may be exploited by investigating co-production and innovative partnerships between public-private organisations.

5.6. Methodological lessons

The project adopted different methods for requirements management (CoReS), application development (SCRUM) and evaluation (CIM2). In this section we reflect on the lessons learned from the application of these methodological approaches.

5.6.1. Process oriented perspective

Structured processes need to be applied at various development stages of the urbanAPI tools and applications due to the complexity of the urbanAPI applications and involvement of various stakeholders. These processes include:

urbanAPI tools and Application specific Requirements development process: Due to the applied nature of the urbanAPI project a rigorous requirements development process was applied that consisted of the following activities: i) background and context, ii) requirements workshop, iii) scenario development and requirements specification, iv) requirements validation, and v) requirements management. This process resulted in defining detailed user requirements and commonalities in those requirements which provided the basis to develop urbanAPI tools for different cities. This process and detailed requirements are documented in (Khan and Ludlow, 2013, Khan, Ludlow and Loibl, 2013).

Data collection process: A structured data collection process ensures that necessary data elements have been collected, analysed and transformed for application development. In the urbanAPI project a hybrid data collection process is applied on the basis of identified data requirements using a top-down approach i.e. using existing application prototypes, and a bottom-up approach i.e. using cities application feature requirements. Detailed data collection process is presented in Deliverable D2.2 – Data Collection.

Software development process: Agile software development process proved to be useful to secure regular stakeholder engagement for feedback on developing application features. This is evident by carrying out two development cycles in urbanAPI project.

Evaluation process: A comprehensive user and technical evaluation using Criteria, Indicators and Metrics methodology (Khan *et al,* 2014, Khan, Ludlow and Rix, 2012, Khan, Ludlow and Caceres, 2013, Khan, 2014) was applied to secure usability, functionality, benefits, relevance and impact of urbanAPI applications. The overall evaluation process is documented in detail and accessible from (Khan, 2013, Khan, 2014).

Stakeholder engagement process: The iterative nature of the software development process necessitates engagement with urbanAPI stakeholders, mainly city administrations and external bodies e.g. stakeholder board organisations who are not directly involved in the development of the project but have vested interest in the outcomes and are willing to oversee overall project progress and provide technical input. Regular meetings and online feedback mechanisms are utilised to secure feedback from such stakeholders.

5.6.2. *Criteria Indicators and Metrics Methodology*

Using the CIM2 methodology - Deliverable 5.1 – Assessment Methodology (Khan, 2013), selected sets of questions were directly derived from the user requirements specification and mapped to different criteria derived from ISO25010 standard. These questions were refined and prioritized by going through a thorough user consultation process. Traceability matrices from requirements to evaluation ware provided in each city evaluation reports, which indicate which user needs and requirements aspects are covered in cycle 1 evaluation. The overall approach mostly followed for the evaluation was to provide training material (videos) two weeks in advance. Also, hands-on training sessions were conducted so that the evaluators could understand specific functionality and learn how to use the applications and then respond to specific questions. Based on the experience it is wise to say that this training based evaluation approach was successful to the extent that evaluators got first-hand experience of using and getting better understanding of the specific functionalities these applications can support. It is understood that without training sessions it would have been difficult to fully understand the functionality and especially how to perform a specific operation. The results reflect positive evaluation responses for the aspects covered in the hands-on training sessions. However, it is found that training needs vary from one city to another and more comprehensive approach is needed to train and build capacity of end users during cycle 2 (Khan, 2014).

The above results (chapter 3-4) prove that the overall agile project development methodology was useful and resulted in identifying challenges for the different urbanAPI application when applied in cycle 1 and cycle 2 evaluation. Among other benefits, the online evaluation portal for urbanAPI applications proved to be really useful as it allowed evaluators to record their evaluation results in their own time after testing the application features. This also helped evaluation team to manage the evaluation process and compile evaluation results.

6. Conclusions – Integration and Impact

The enhanced ICT tools developed by urbanAPI aim to offer new opportunities for the development of both intelligence sources as well as tools for decision-making support at three levels of urban governance from neighbourhood to city region level, thereby addressing the key dimensions of the management of urban complexity. At the same time the project provides a simplified language of communication between different stakeholder groups (3D virtual reality, visualisation and simulation-based communication) developed on a common platform of communication between the different levels of governance including local (virtual reality), citywide (mobile based GSM data) and city region (simulation), thereby addressing the state of the art in relation to the necessary collectivity of city governance.

urbanAPI ICT methodologies and decision-support tools, are provide support toward SEIS and other related initiative such as EU Digital Agenda 2020. In addition, based on the requirements of the governance paradigm of integrated urban governance, provide a step towards a consistent framework and context to systematise the information flows from data collection to assessment and decision-making support. These new models of governance and management in support of sustainable development require greater stakeholder engagement, partnership between stakeholders, and integration of information and analysis (cross departmental/multi-scalar), with a focus on management of urban complexity, including management of the peri-urban (interface urban and rural), where key challenges for urban planning include issues concerning the containment of urban sprawl and the creation of the compact city.

In response to these ambitions the pilot city (Vienna, Bologna, Vitoria-Gasteiz, and Ruse) evaluation of the tools provided critically important insights for the future development of these and related ICT tools supporting urban governance. According to respondents the 3D Scenario Creator, has high potential, although in some respects it requires further development. To fully respond to city expectations and successfully compete with other tools already in use, it needs further development in respect of user friendliness, and training to fully understand and exploit all the application functionalities. For this reason, even if there is great appreciation of the potential envisaged in the tool and there is the desire to adopt the 3D Scenario Creator in the future, at the current stage of development it is difficult to commit to it. The Rule Editor is well appreciated, mostly for the additional functions available in respect to similar tools. Whilst its functionality is considered good, the workflow is complicated even for an expert user.

The Mobility Explorer application is considered to have high potential to improve mobility analysis. However, at present, it cannot express all its functionalities and cannot be used alone, rather integrated with traditional mobility evaluations, due to difficulties in data availability and completeness. The Mobility Explorer tool is considered useful mostly for internal use involving domain experts such as planners and policy makers, and less for interacting with citizens. None of the cities can be sure about the possibility to adopt the tool at present, however, there is a strong interest in it. Similarly there is a very positive attitude towards the possibilities of Urban Development Simulator to support urban management, even if it is considered at a too early stage of development to make secure statements, the respondents seem to consider it quite probable to be adopted in the near future.

Evaluation of all the tools and consideration of their impact in a wider context i.e. beyond that of the three pilot cities is also critically important in defining the future development path for ICT enabled urban governance. As indicated above integrated urban management is the key to unlocking and managing urban complexity in which two principal requirements are identified. First enhanced effective communication and collaboration between planning agencies critical to the creation of the information and intelligence necessary to manage the city. Secondly effective deployment of this intelligence in the policy model focused on decision-making regarding the future form the city as the operational focus of urban governance.

urbanAPI tools are strategically located in relation to both these requirements enhancing communication of information and intelligence between planning agencies, and at the same time addressing strategically important components of policy model. Integrated management aims to secure, on the basis of the procedural requirements of the policy model, four fundamental outcomes essential to the delivery of effective decision-making including:

1) Collection of information and intelligence
2) analysis
3) visualisation/simulation
4) explanation

Collection of intelligence is supported by the bottom-up engagement of stakeholders in the specification of policy objectives and the assessment of plan attributes, both substantially enabled by visualisation (3DSC) of problem specification and alternative proposals for problem resolution. Analysis of alternative courses of action in urban development is critically dependent upon the fullest understanding of the spatio/temporal patterns of socio-economic activity in the urban environment in relation to the spatial form of the city. The representation of these relationships (ME) and the insights provided into collective urban behaviours represents a fundamentally important advance in urban planning supported by smart city enabled technology. This application opens the possibilities to realise deep understanding of environmental and social dynamics in the urban areas fundamental to sustainable development.

Visualisation and simulation combined (UDS) provides the opportunity to view the future form of the city, its vision for development, and assess the socio-economic and environmental impacts of alternative urban futures. On this basis explanation essential to effective and democratic decision-making is realised, and communication of the alternative urban development paths to all stakeholders to secure necessary political mandates for plan adoption is provided.

The impacts of urbanAPI tools must be considered in this context, and the strategic positioning of these tools in relation to these critical components of decision-making recognised as highly significant. Clearly conclusions in the evaluation process recognised the need for further development of these applications, but the strategic importance of the functioning of these tools, working in combination in an integrated manner, in relation to the decision-making process must also be recognised and endorsed as a basis for timely and well positioned RTD investments in the future development of ICT enabled urban governance.

The challenge then is how to generalise these ICT solutions, to support adoption by other cities. Based on the urbanAPI development experience it is found that the fundamental needs of participatory planning, collaborative decision-making and support to policy making processes remain the same for different cities. For instance, the urbanAPI tools can be applied to other cities as they provide an efficient way to analyse city data and visualise the future city model that helps in securing public support and identify planning issues. Accordingly, lessons learned from the commonalities in requirements, support to participatory planning and policy making processes and comparative assessment of the applications developed in the differing project case study city contexts, can form the basis for the future development of generic ICT tools that can be utilised in the majority of the 400 plus cities of Europe with populations over 100,000, as well as other smaller cities and towns throughout Europe.

Innovative forms of smart city policies and regulations are needed to identify commonalities and the potential for common tools that can respond to the city government's demands arising from common global drivers of change to enable large scale implementation and roll-out of smart cities. Cities need an adequate set of framework conditions in the field of policy and regulations in order to be able to take full advantage of the enormous opportunities arising in respect of ICT enabled urban governance. New governance concepts are required to coordinate and integrate smart city stakeholders – cities, businesses, and research organisations – within the change process so to identify strengths, weaknesses, opportunities and threats. Stakeholders need to jointly experience and learn with new forms of governance and policy concepts to further the process of becoming a sustainable, smart city.

Cities often focus on stand-alone smart cities projects. But experience shows that a strategic vision, backed by all stakeholders and supported by long-term policies and respective regulatory frameworks, is the basis for an effective and efficient change process. A detailed city or even nation-wide implementation plan including intelligent and innovative funding models is key for a coordinated approach. Alignment, both horizontally (between different policy fields) and vertically (between regional, national, EU actors), using a participatory approach, guarantees a holistic view and commitment to the smart-city process. Cities need to involve a broad range of policy fields and stakeholders and formulate an integrated smart city strategy. With clearly defined targets in mind (e.g. establishment of energy- and carbon-neutral districts), cities, regional/national authorities, and EU lawmakers need to work together, to identify what measures are required, what future research is needed, what political, administrative, technological and financial hurdles have to be eliminated, what regulations have to be put in place, or changed, in order to reach the goal? City authorities need to create frameworks for the deployment of integrated technologies, which allow for public-private partnerships between cities and industry, and the creation of innovative and stable business cases.

On the other hand, private companies are hesitant to invest in new technologies and infrastructure due to policy uncertainty. For instance, major stakeholders in a smart city implementation actions (e.g. energy utilities) face uncertainty in long-term investments in energy infrastructure as long as policy uncertainty regarding e.g. fossil fuels, carbon prices or feed-in tariffs prevails. A smart city strategy will need to account for these political, but also financial, uncertainties and present a suitable approach towards dealing with them. The need for long-term policies with clear targets, actions and strategic guidelines on EU, national, regional and city level will need to be addressed to enable private investors to support a Europe-wide deployment of smart city concepts. While most of this is not within the competency of cities, cities needs to highlight the needs for effective policy frames, notably on the basis of integrated planning and management, at all levels to avoid being locked-in to energy-inefficient / carbon intensive / fossil fuel based technologies and developments, which will be difficult and costly to change at later date.

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urbanAPI

SEVENTH FRAMEWORK PROGRAMME

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8. Annexes

8.1. Annex-1: Evaluation Questions and Responses

All questions are presented here and responses are in separate file named: annex_1_evaluation_responses.xlsx (confidential).

8.1.1. 3DSC Application

8.1.1.1. Vienna

GQ-1	1. The 3D SC effectively helps expert users to plan, create and visualise future neighbourhood models in 3D.
GQ-2	2. The 3D SC helps to communicate a proposed neighbourhood plan in 3D to different stakeholders i.e. expert users and citizens.
GQ-3	3. The 3D SC aids expert users and citizens in understanding the impact of the proposed rehabilitation of the neighbourhood.
GQ-4	4. The 3D SC web interface facilitates wider public participation in the planning process.
GQ-5	5. The citizen feedback using 3D SC web application helps in improving neighbourhood planning intiatives in the city.
GQ-6	6. The 3D SC presents an integrated view of (buildings, green, street furniture etc) plan of a neighbourhood that can help experts in decision making and policy making?
GQ-7	7. The 3D SC application demonstrates its usefulness to different stakeholders e.g. urban planners, policy makers, public.
GQ-8	8. The 3D SC helps in gaining useful insights for planning interventions at the local neighbourhood scale.
GQ-9	9. The 3D SC application graphical user interface is intuitive and quick to learn?.
GQ-10	10. The 3D SC application provides local language support to promote high operational feasibility.
GQ-11	11. The training material helps in understanding how to use the 3D SC?

GQ-12	12. The 3D SC application is accessible using multiple platforms.
FR-1	1. Does the 3D SC application provide tools to compare the height of selected objects?
FR-2	2. Does the 3D SC application provide tools to compare the distance between selected objects?
FR-3	3. Does the 3D SC provide an aerial (helicopter) view of the urban neighbourhood?
FR-4	4. Does the 3D SC provide an pedestrian (street) view of the urban neighbourhood?
FR-5	5. Does the 3D SC application produce a report with a summary of changes in the 3D urban model and their impact on the neighbourhood?
FR-6	6. Does the 3D SC web interface enables citizens to add annotations in the neighbourhood 3D model?
FR-7	7. Does the 3D SC application allow sharing a 3D visualisation with selected user groups e.g. selected departments or general public?
FR-8	8. Does the 3D SC application allow sharing a 3D visualisation with selected user groups e.g. selected departments or general public?
FR-9	9. Does the 3D SC application allow sharing a 3D visualisation with selected user groups e.g. selected departments or general public?
FR-10	10. Does 3D SC enable loading of new building architecture models (e.g. AutoCAD) in a selected neighbourhood scene?
FR-11	11. Does 3D SC perform visual impact assessment in neighourhood architectural competitions?
FR-12	12. Does visual shadow analysis indicate violation of 2 hrs shadow policy on neighbouring buildings?

FR-13	13. Does 3D SC allows exporting 3D Scenes in high resolution images?
FR-14	14. Does 3D SC allow exporting navigation (padestrian/aerial) video of a 3D scenario?
FR-15	15. Does 3D SC allows exporting 3D scenarios in resuable raw data format?

8.1.1.2. Vitoria-Gasteiz

GQ-1	1. The 3D SC effectively helps expert users to plan, create and visualise future neighbourhood models in 3D.
GQ-2a	2 (i). The 3D SC helps to communicate a proposed neighbourhood plan in 3D to citizens.
GQ-2b	2 (ii). The 3D SC helps to analyse a proposed neighbourhood plan in 3D by expert users.
GQ-3	3. The 3D SC aids expert users and citizens in understanding the impact of the proposed rehabilitation of the neighbourhood.
GQ-4	4. The 3D SC web interface facilitates wider public participation in the planning process.
GQ-5	5. The citizen feedback using 3D SC web application helps in improving neighbourhood planning intiatives in the city.
GQ-6	6. The 3D SC presents an integrated view of (buildings, green, street furniture etc) plan of a neighbourhood that can help experts in decision making and policy making?
GQ-7	7. The 3D SC application demonstrates its usefulness to different stakeholders e.g. urban planners, policy makers, public.

GQ-8	8. The 3D SC helps in gaining useful insights for planning interventions at the local neighbourhood scale.
GQ-9	9. The 3D SC application graphical user interface is intuitive and quick to learn.
GQ-10	10. The 3D SC application provides local language support to promote high operational feasibility.
GQ-11	11. The training material helps in understanding how to use the 3D SC.
GQ-12	12. The 3D SC application is accessible using multiple platforms.
FQ-1	1. Does 3D SC admin tool provide an intuitive and interactive graphical user interface for expert users to replace visual objects and update object properties in a 3D Scene?
FQ-2	2. Does 3D SC admin tool enable expert users to integrate different data layers in a 3D Scene and visualise different scenarios?
FQ-3	3. Does the system create virtual reality simulations 2D / 3D that combine all the factors introduced to the system as described in scenarios and use cases?
FQ-4a	4 (i). Does 3D SC accurately visualise 3D objects (i.e. orientation and geolocation of buildings, green spaces, streets and furniture etc) in 3D model of an urban neighbourhood area?
FQ-4b	4 (ii). Does 3D SC help in generating 3D abstract model from 2D city data?
FQ-5a	5 (i). Does 3D SC allow expert users to create 3D scenes and suggest improvements (i.e. visual and textual) at selected location in 3D scene?
FQ-5b	5 (ii). Does SC allow citizens to suggest improvements (i.e. visual and textual) in an existing 3D scene on the web?
FQ-6	6. Does 3D SC web component present visual comparison of different 3D scenarios

	of same neighbourhood area?
FQ-7	7. Does 3D SC provice web based interface to share 3D Scenes between experts and citizens?
FQ-8	8. Does 3D SC enable expert users to analyse 3D Scene or selected objects based on specified conditions such as height of the object?
FQ-9	9. Does 3D SC allows exporting 3D Scenes in high resolution images?
FQ-10	10. Does 3D SC allow exporting navigation (padestrian/aerial) video of a 3D scenario?
FQ-11	11. Does 3D SC allows exporting 3D scenarios in resuable raw data format?

8.1.1.3. Bologna

GQ-1	1. The 3D SC effectively helps expert users to plan, create and visualise future neighbourhood models in 3D.
GQ-2	2. The 3D SC helps to communicate a proposed neighbourhood plan in 3D to different stakeholders i.e. expert users and citizens.
GQ-3	3. The 3D SC aids expert users and citizens in understanding the impact of the proposed rehabilitation of the neighbourhood.
GQ-4	4. The 3D SC web interface facilitates wider public participation in the planning process.
GQ-5	5. The citizen feedback using 3D SC web application helps in improving neighbourhood planning intiatives in the city.
GQ-6	6. The 3D SC presents an integrated view of (buildings, green, street furniture etc) plan of a neighbourhood that can help experts in decision making and policy making?

GQ-7	7. The 3D SC application demonstrates its usefulness to different stakeholders e.g. urban planners, policy makers, public.
GQ-8	8. The 3D SC helps in gaining useful insights for planning interventions at the local neighbourhood scale.
GQ-9	9. The 3D SC application graphical user interface is intuitive and quick to learn.
GQ-10	10. The 3D SC application provides local language support to promote high operational feasibility.
GQ-11	11. The training material helps in understanding how to use the 3D SC.
GQ-12	12. The 3D SC application is accessible using multiple platforms.
FQ-1	1. Does 3D SC enable end users to navigate and zoom in/out in a 3D Neighbourhood Scene?
FQ-2	2. Does 3D SC admin tool allow expert users to add new 3D objects to 3D Scene?
FQ-3	3. Does 3D SC web component allow expert users and general public to add new object in a 3D Scene?
FQ-4	4. Does 3D SC admin tool allow expert users to select and edit an object properties from a 3D Scene?
FQ-5	5. Does 3D SC intelligently indicate where new 3D objects (e.g. buildings, street furniture) can and cannot be placed?
FQ-6	6. Does 3D SC provide web-based interface to share 3D Scenes between experts and citizens? And second question - Does 3D SC allow expert users and citizens to suggest improvements by annotating or adding/removing objects at selected location in 3D scene?
FQ-7	7. Does 3D SC help in generating 3D abstract model from 2D city data?

FQ-8	8. Does 3D SC web component notify the owner of the scenario about collaborative changes made to 3D Scene (e.g. via email)?
FQ-9	9. Does 3D SC application show effects of user changes to visual 3D Scene?
FQ-10	10. Does the 3D SC export high-resolution screenshots of the visualisations?
FQ-11	11.Does 3D SC allows exporting 3D Scenes in high resolution images?
FQ-12	12. Does 3D SC allow exporting navigation (pedestrian/aerial) video of a 3D scenario?
FQ-13	13. Does 3D SC allow exporting 3D scenarios in reusable raw data format?

8.1.2. ME Application

8.1.2.1. Vienna

IDs	Questions
GQ-1	1. The ME provides useful information for evaluating planning decisions.
GQ-2	2(i). The ME provides an efficient method to visualise city population distribution.
GQ-3	2(ii). The ME provides an efficient method to visualise population mobility patterns.
GQ-4	3. The ME enables effective passive public participation (i.e. not aware of their contribution) using mobile data in identifying public distribution and mobility patterns that can help in city transport planning.
GQ-5	4. The ME provides useful input for evidence-based decision-making and policy development.
GQ-6	5. The ME demonstrates its usefulness to different stakeholders including urban

	planners, transport planners and policy makers.
GQ-7	6. The ME application output complements other sources of data regarding population distribution and mobility patterns.
GQ-8	7. The ME enables planners to better understand variations in diurnal population distribution and mobility patterns in the city.
GQ-9	8. The ME application helps in identifying evidence-based indicators for urban development and public transport improvement and planning.
GQ-10	9. The ME graphical user interface is intuitive and quick to learn.,
GQ-11	10. The ME provides local language support to promote high operational feasibility.
GQ-12	11. The training material helps in understanding how to use the application.
GQ-13	12. The ME is accessible using multiple platforms.
GQ-14	13. The ME provides context-sensitive help bubbles to facilitate high operational feasibility.
Functionality-related Questions	
FQ-1	1. Does the ME application allow users to create animations for change of population density analysis at regular int1. Does the ME application allow users to create animations for change of population density analysis at regular intervals (e.g. 6:00, 7:00…)?
FQ-2	2. Does the ME application indicate in a two- dimensional matrix that show how many people are in a specific zone (RBW-IDs and special zones) at a certain time interval (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) during weekdays and weekends?

FQ-3	3. Does the ME application use surveys and polls to extrapolate the A1-data to the whole population?
FQ-4	4. Does the ME compare GSM data (day and night population) with resident numbers from the census and other existing socio-economic data?
FQ-5	5. Is the ME application able to identify visual clusters of people with homogeneous travel behaviour? (e.g. office workers, commuting between 7 to 9am, work in office quarters, return home between 4 and 6pm)?
FQ-6	6. Does the ME generate O-D matrices based on the total number of people moving from one zone to another at certain time intervals?
FQ-7	7. Does the ME application visually show diurnal mobility patterns?
FQ-8	8. Is information presented in O-D Matrices is sliced for specific time intervals during weekdays and weekends e.g. 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?
FQ-9	9. Does the ME application allow exporting high resolution images (visualisation path diagrams, aggregated maps) and data (O-D matrices) for information exchange in reusable format?
FQ-10	11. Does the ME application identify social biases using GSM data in space utilisation and mobility behaviour?
	If you answered no, partially or not sure to the previous question, please provide your reasons or suggest improvements you would like to see

8.1.2.2. Vitoria-Gasteiz

IDs	Questions
GQ-1	1. The ME provides useful information for evaluating planning decisions.

GQ-2	2. The ME provides an efficient method to visualise city population distribution.
GQ-3	3. The ME demonstrates its usefulness to different stakeholders including urban planners, transport planners and policy makers.
GQ-4	4. The ME output complements other sources of data regarding population distribution.
GQ-5	5. The ME enables planners to better understand variations in diurnal population distribution in the city.
GQ-6	6. The ME helps in identifying evidence-based indicators for urban development and public transport improvement and planning.
GQ-7	7. The ME graphical user interface is intuitive and quick to learn?.
GQ-8	8. The ME provides local language support to promote high operational feasibility.
GQ-9	9. The training material helps in understanding how to use the application.
GQ-10	10. The ME provides context-sensitive help bubbles to facilitate high operational feasibility.

8.1.2.3. Bolgona

IDs	Questions
GQ-1	1. The ME provides useful information for evaluating planning decisions.
GQ-2	2. The ME provides an efficient method to visualise city population distribution and mobility patterns.
GQ-3	3. The ME provides useful input for evidence-based decision-making and policy development.
GQ-4	4. The training material helps in understanding how to use the application.

GQ-5	5. The ME demonstrates its usefulness to different stakeholders including urban planners, transport planners and policy makers.
GQ-6	6. The ME application output complements other sources of data regarding population distribution and mobility patterns.
GQ-7	7. The ME enables planners to better understand variations in diurnal population distribution and mobility patterns in the city.
GQ-8	8. The ME application helps in identifying evidence-based indicators for urban development and public transport improvement and planning.
GQ-9	9. The ME application graphical user interface is intuitive and quick to learn.
GQ-10	10. The ME application provides local language support to promote high operational feasibility.

8.1.3. UDS Application

GQ-1	1. The UDS is a useful investigation tool to identify effects of urban growth/shrinkage and helps in comparing its output with Master Plan of Ruse.
GQ-2	2. The UDS provides useful insights for future urban planning initiatives for Ruse.
GQ-3	3. The analysis of the population shrinkage trend in past and counterbalancing growth shown in simulation option A is useful for experts.
GQ-4	4. The UDS results are effective in acquiring necessary information about possible future changes in population distribution and building distribution/development.
GQ-5	5. The UDS provides a useful mechanism (e.g. online survey) to support Ruse public participation in urban planning initiatives.
GQ-6	6. The UDS provides sufficient evidence based on past data (real data) on urban changes that can support decision making and policy making.

GQ-7	7. The UDS provides sufficient evidence based on past real data and ex ante/post simulations to initiate new urban development projects.
GQ-8	8. The UDS helps in identifying evidence-based (i.e. using real city data) indicators for urban development and transport improvement and planning.
GQ-9	9. The UDS application enables end users to explore and investigate alternative future urban development trends and their effects on energy and emission and spatial distribution of population and buildings for Ruse.
GQ-10	10. The UDS graphical user interface is intuitive and easy to use.
GQ-11	11. The UDS provides sufficient help (e.g. context-sensitive help) to end users in understanding and using the application.
GQ-12	12. The scenario-based video tutorials provided to understand and use UDS are useful and effective.
Show Functionality-related Questions	
FQ-1	1. Has UDS ex post simulation of Ruse able to inform inhabitants' settlement behaviour in city?
FQ-2	2. Does UDS allow end users to interactively introduce new spatial planning initiatives (master plan changes, zoning categories, etc)?
FQ-3	3. Does UDS integrate results of connected questionnaire using LimeSurvey as public participation for planning choices based on which new simulation results are generated and visualised?
FQ-4	4. Does UDS allow local experts to define future actors' behaviour for the ex ante trend simulation?
FQ-6	5. Does UDS compare and constrast environmental impacts (e.g. energy demand and CO2 emissions) of a specific urban planning intervention project e.g.

	popluation/building distribution?
FQ-6	6. Does UDS application allow expert users to change values of different causal parameters to see effects of energy demand or CO2 emission or spatial distribution of buildings?
FQ-7	7. Does UDS tool enable stakeholders to view and compare suitability of a selected site/area for new housing settlements?
FQ-8	8. Does UDS show differences of current master plan and the preferences of the citizens?
FQ-9	9. Does UDS allow exporting simulation scenes in high resolution images?
FQ-10	10. Does UDS allows exporting simulation results in resuable raw data format (e.g. csv, excel, shapefiles)?
FQ-11	11. Does UDS allow importing new urban data to calibrate development model and generate simulation?
FQ-12	12. Is UDS statistical analysis of past data useful for Ruse to perform extended analysis and visualisation?

8.1.4. Qualitative Questions and Responses

All questions are presented here and responses are in separate files named: annex_1_qualitative_responses.xlsx.

Do you think that the analysed urbanAPI tools meet users (policy makers, planners, citizens) needs and consequently respond to your expectations, compared to other similar and/or traditional tools already in use in your municipality?
Are urbanAPI tools capable to effectively involve a broad range of wide segments of stakeholders

including citizens in urban planning?
Is local government ready to make full use of interactive tools like urbanAPI tools in planning and communication activities, in other words are the urbanAPI tools feasible in your city or in your specific department considering personnel qualifications, technological and staff resources?
On the basis of above statements, do you think that one or more urbanAPI tools will be adopted by your city now, or in the near future, for one or all of the following reasons: effectiveness, cost saving, time saving?

8.1.5. Rule Editor Questions and Responses

IDs	Questions
GQ-1	1. The rule editor cookbooks contains useful recipes.
GQ-2	2. The rule editor interface is user friendly and easy to learn.
GQ-3	3. The rule editor provides adequate feedback when a rule is executed.
GQ-4	4. The rule editor allows the user to easily trace the source in case of an error.
GQ-5	5. The rule editor organises the various recipes in an intuitive manner.
GQ-6	6. The rule editor represents the various recipes in an intuitive manner (e.g. color-coded by function).
GQ-7	7. The rule editor allows configuration of recipes in a user-friendly manner.
GQ-8	8. The rule editor recipes are easy-to-understand for domain experts that do not have a strong computer science background.
GQ-9	9. The rule editor promotes separation of concerns between the recipes and the rest of the system (e.g. by allowing the system to be changed without requiring scripts to be changed).

GQ-10	10. The rule editor promotes reusability by allowing the recipes to be applied to different applications or use cases within the same domain.
GQ-11	11. The rule editor supports adequate number of logical operators
FQ-1	1. Does the rule editor allow users to specify data sources to process?
FQ-2	2. Does the rule editor allow the user to specify composite rules containing several steps?
FQ-3	3. Does the rule editor allow users to flexibly divide the terrain model into several parts via rules?
FQ-4	4. Does the rule editor allow users to create copies of objects to prevent modification by subsequent action recipes?
FQ-5	5. Does the rule editor allow users to raise or lower the height of buildings automatically according to the terrain model?
FQ-6	6. Does the rule editor allow users to extrude a 2D footprint to 3D by modifying its height?
FQ-7	7. Does the rule editor allow users to move objects form one layer to another via rules?
FQ-8	8. Does the rule editor allow users to select objects for further processing using rules (e.g. via conditions)?
FQ-9	9. Does the rule editor allow users to specify actions to take for selected objects using rules?
FQ-10	10. Does the rule editor allow users to colorise specific objects using rules?
FQ-11	11. Does the rule editor allow users to select objects having specific metadata properties using rules (e.g. via conditions)?

8.1.6. External responses (Urban-Nexus Dialogue Café, Vitoria-Gasteiz external participants for 3DSC)

All questions and responses are in separate files named: annex_1_external_responses.xlsx (confidential).

8.2. Annex-2: Planning Processes

Details of the planning processes are present in a separate file named: annex_2_planning_process.xlsx (confidential).