

# Co-creation of Sustainable Smart Cities

## Users, Participation and Service Design

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**Abstract**—The starting point of this paper is to develop new ubiquitous and participative services for sustainable urban planning using mixed reality and other relevant technologies. To support communication between stakeholders, we have created a demo service that can be situated in public places such as interactive displays, designed for community content sharing, close to people flows in cities. It can also be used in public planning events as well as anywhere with personal devices. The service combines visualizations and virtual environments by mixing panoramic imaging and architectural drawings of future urban plans, and includes user-centred interactions such as questionnaires and commenting tools. In this paper, we focus on social issues and the implications of this kind of services, especially trying to understand user values, needs and preferences in participative urban planning service. Political decision makers, city officials and citizens participated in this research to clarify how they perceive the new digital concepts, and how these digital services should be designed and offered for users to support public participation and collaboration in future urban planning projects. Important changes in urban planning would be to increase information and communication and present more alternatives at the early stages of projects. According to the different stakeholders involved in this research, informing the public how their feedback has been taken into consideration and developing real-time feedback channels would enhance participatory urban planning.

**Keywords**—participatory design; mobile mixed reality; ubiquitous services; urban planning; user experiences.

### I. INTRODUCTION

Urban planning has traditionally been perceived as a complex process. It includes different stages and multiple stakeholders, and it is not very understandable for lay people. Law defines urban planning process and it consists of certain phases, which require acceptance of stakeholders and decision makers. In Finland, statutory status of urban planning and land use ensures involvement of all citizens and other stakeholders who live in the target area. It guarantees any stakeholder the right to see the materials and to leave feedback before any decisions. According to the Land Use and Building Act, citizens are able also challenge the decisions if necessary. However, cities and communities have recently started to pay more attention to making the urban planning processes more participative. Negotiation between different stakeholders and considering citizens' needs and preferences has become more important. In Finland, for instance, besides the official process the

stakeholders can also be involved at earlier phase of planning process in order to get deeper understanding of target area. The participatory or co-creative approach which engages citizens and other stakeholders is beneficial in many ways. Co-creation and co-design benefits have been associated to improving processes of idea generation and decision-making and promoting co-operation and creativity. In addition, they have impact on improving users' satisfaction and building trust or loyalty over the long-term [1].

Especially when urban planning ideas are presented and tested already in the early stages, the projects are more likely to proceed smoothly, in a good spirit and are not in danger of being delayed or halted as a result of political or social resistance. When possible problems in the planning can be detected already at the early stages, the result can be qualitatively better in many ways. There is also a possibility of minimizing economic risks when there is no need to make costly changes afterwards, when it is noticed that something went wrong in planning [1].

There is a wide range of different kinds of participatory urban planning tools, methods and technologies in the practice in different countries and cultural contexts [2][3].

Increasing participation demands developing easy-to-use services that are situated in places where people notice them and can be used anytime and anywhere users want to use them. In this paper, we focus on exploring qualitatively how different stakeholders, especially citizens and political decision makers perceive ubiquitous, mixed reality technologies as a part of future participatory urban planning. We are interested in how different technology concepts using any device and any location could open up and make the urban planning process more visible, easy-to-access and understand. Moreover, we study what kind of devices, applications, locations and situations would support users to participate in urban planning. Consequently, we are interested in how to find urban planning solutions that enhance co-operation and take into consideration user values such as maintaining the quality of living environments, clean nature and the protection of historic buildings.

To understand different stakeholders' views, we have conducted 13 interviews among political decision makers responsible for urban planning in local government and city officials. These interviews shed light on different stakeholders' expectations towards participatory urban planning service and contributed to our first urban planning service demo, which is presented in this paper. In addition, we have conducted user studies in a small local community,

where several environmental urban planning projects are taking place. These projects include, for instance, supplementary construction, green design and planning of noise barriers. Through interviews, demos and case pilots we aimed to gain an understanding of how users perceived this kind of participatory mixed reality services in real urban planning projects and how to develop the service further for large-scale participatory projects.

This paper is structured as follows: Section II describes how the possibilities of mixed reality technologies have been experienced in urban planning. Section III describes the ubiquitous mixed reality concepts we discussed with different stakeholders to involve them to participative urban planning service design. Section IV describes the political decision makers' and city officials' views on participatory urban planning concepts. Section V addresses the environment project and goes into detail about the citizens' feedback on participatory urban planning service demo. Finally, in Section VI we present conclusions and our future work.

## II. THE ROLE OF MIXED REALITY SERVICES IN URBAN PLANNING: SOME EXPERIENCES

Different technological approaches such as virtual reality, mirror worlds and mobile augmented reality have been experimented on for aiding public participation in urban planning [2][3][4]. Immersive visualisation tools help users to understand what is being proposed and planned as many non-experts have difficulties to understand maps and plans [5][6]. Technological barriers to participatory urban planning and e-government are coming down, particularly at the local municipal level, and there are new opportunities for public engagement based on local needs and capacities [8]. Design of interactive systems can affect citizen participation in local governance and urban planning. The interactive systems should be flexible and versatile and enable participatory design approach, which goes beyond professional design projects and allows users to suggest further adaptations. New types of user interaction and technology design solutions should be considered to encourage citizens and other stakeholders to participate [9]. There are several recent examples of this. A prototype of a mixed reality application supporting a range of devices for a collaborative multimodal interaction was developed by Wagner et al. to enable group of participants to create a vision of urban projects. The stakeholders and users involved in the urban planning project had various backgrounds ranging from local urban planning specialists to other stakeholders such as members of local commerce. Mixed reality visualizations proved useful in enriching the available repertoire of representations and enhancing stakeholders' understanding of urban situations. 3D visualizations, videos and sounds helped to express and co-construct their ideas. Sound was perceived also an important element in urban planning, but a more complex medium in the participatory process [7].

Web-based solutions provide good support for the traditional methods used in the participatory urban planning process. These applications are especially suitable for acquiring local knowledge; they are an easy and inexpensive

way to reach large and diverse groups of respondents. Noujua et al. noticed that there are also challenges related to the web-based participation; for instance that it may produce shallow information and the participation may be quite random [11].

A smartphone augmented reality system for urban planning was tested with 18 members of the public. The objective was to test if a smartphone augmented reality system would increase the willingness of the public to participate in urban planning events and if the participation was actually increased. The aim was also study qualitatively how the public perceived the smartphone augmented reality system in urban planning. The results of the study show, as expected, that the younger members (the 18–25 age group) of the test groups were more familiar with smartphone technology and saw the system as easy-to-use. Only the youngest age group showed an increase in willingness participate in urban events if the smartphone augmented reality system was used in the events. However, the study could not show any evidence that the actual participation in urban planning events would have increased because of the use of the smartphone-augmented system [4].

Increasing participation requires time and resources from all stakeholders. From city officials' and other planning professionals' point of view seeking citizen involvement via web based and mixed reality services does not necessarily decrease the workload, and the professionals need to be strategically prepared to manage new flows and ideas coming from citizens [4].

## III. UBIQUITOUS MIXED REALITY CONCEPTS FOR URBAN PLANNING

In the beginning of the interviews with political decision makers, city officials and companies, we introduced four ubiquitous mixed reality concepts for urban planning. The examples helped in figuring out the idea of new visual approaches to community planning and aimed to facilitate feedback and ideas related to the different approaches.

### A. Mixed reality mobile tools

We described possibilities of visualizing urban planning solutions with smartphones and tablet devices. The idea is for users to be able to move around the surroundings under development and see merged virtual 3D objects and a camera view on a handheld device (Fig. 1). Moving in real environment and utilising mobile augmented reality (AR) solutions, which integrate virtual information into physical environment, help users to perceive scales and sizes related to the existing buildings and surroundings when virtual building objects will be located in their intended locations. The demonstrated mobile mixed reality tool for architectural sites has been described and evaluated in earlier studies [8][9][10]. Current trend in mobile devices supports the idea of utilising on-site AR solutions. Smartphones have advanced processors and cameras, they utilise large displays and tablet devices are already commonly used.



Figure 1. On-site augmented reality solution

**B. Interactive public screens**

The other approach presented was interactive public screens with mixed reality and advanced control methods features (Fig. 2). The screen shows areas under development, and new digital visualizations are embedded into the views. One or several users can manipulate the views and community plan options using their gestures or the touch screen input method. Other users can watch and discuss the views at the same time. Gesture recognition would be implemented with the help of depth camera sensors or handheld control devices. On the other hand, utilisation of personal smartphones as a second screen device could also be applicable method in the public screen approach. This kind of public screens can be located next to the area under development, in shopping centres or in municipal office buildings.



Figure 2. Interactive public screen in urban planning.

**C. Multiuser design tables**

Thirdly, the users can explore and co-create urban planning solutions using interactive and multiuser design tables. The tables can be a combination of tangible objects or 3D printed building models, projected information and camera recognition systems. The users are able to browse different urban planning options or manipulate objects on a table, and they can receive more information using, e.g., pointing, touching or gestures.

The user moves and indicates building options using AR markers on the table. A tangible 3D table-top system in which physical objects on a table can be recognized has been developed [10]. The same kind of table-top systems in urban planning includes the *Spatial Design Table* and the *Bionicle*

*Table* [11][12]. They both enable 3D visualizations showing how different buildings look in their environments.

**D. Web-based service with panoramic visions**

One concept developed for participatory urban planning is web-based open service, which can easily be used with personal devices as they run on web browsers of different devices such as tablet devices and PCs. The user-centric service mixes panoramic imaging and architectural drawings of future urban plans, and includes user-centred interactions such as questionnaires and commenting tools so that citizens can participate and comment on timely issues, such as future urban planning, construction of green walls and urban gardening, and sustainable energy solutions. Fig. 3 is a screenshot of the web-based urban planning service, which visualizes sound barrier plans between a highway and a field. Left side includes map information of the area and how the sound barrier is located. The right side visualizes the sound barrier plans and its future construction phases embedded in panoramic images of surroundings.

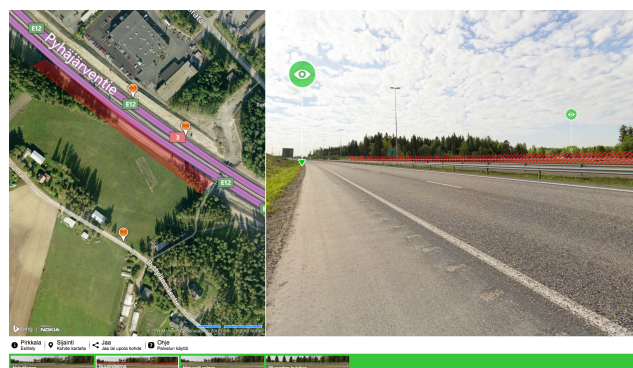


Figure 3. Web-based service with mixing panoramic imaging and architectural drawings of future urban plans and including user-centric feedback tools

**IV. POLITICAL DECISION MAKERS’ AND CITY OFFICIALS’ VIEWS ON THE PARTICIPATORY URBAN PLANNING CONCEPTS**

In the interviews with political decision makers we discussed how to increase the awareness of citizens’ opportunities to participate in planning of their living environment and how to increase real interaction with other stakeholders. The political decision-makers were selected from all the parties presented at these boards. The participating political decision-makers were both experienced and new decision-makers who were in their first term on the Board of Governors. They represented both genders and as members of environmental or technical boards they were in a central role in organizing services related to urban planning. The political decision-makers were selected from all the parties presented at these boards.

A common concern was that people are not aware of the general process, they lack of information on the channels for interaction and participation and at which phase they have an opportunity of commenting and providing feedback. Active citizens who acquire knowledge are well informed about the future urban projects of their communities and their

possibilities to contribute, but for the average citizen the statutory planning process is unfamiliar. In many cases, citizens do not realise that anything is going until before actual building begins in neighbourhoods and at that point it is too late to contribute. In addition it became clear, that recent participatory methods in urban planning are not suitable for all. As digital services may be unfamiliar to older generations, public urban planning events are tied to a certain time and place and in Finnish context situation is such that especially busy working generations and young people are easily left out. Encouraging young people and working families to participate in urban planning events is challenging.

By providing better accessible information, easier ways for participation and open communication awareness and a general understanding of the nature of the planning process could be increased.

Another concern was the state of planning when involvement of different stakeholders usually happens. Too mature, detailed plans and quality of materials were seen as the main problems from both the decision-makers' and citizens' point of view. Decision makers would like to have information on new projects at an earlier stage when planning has not yet reached a high level of maturity. They noted that they often face a situation where they can only accept or reject a proposal. There is a demand for alternative design solutions, a discussion of the impacts of different solutions and for a better illustration of the overall picture. Materials were also complained of as being too complicated and difficult to understand, not only from the decision makers' point of view, but even more by average citizens. Also, the amount of material is often huge and that makes it almost impossible to go through all the information to get an overview and a clear understanding of the wider impacts of the project. The situation is the same with the citizen. That easily leads to uncertainty and resistance among the citizens, which may result in an increased number of complaints and a longer time for processing.

Open communication between different stakeholders was seen as a way to enhance real co-operation and participation, which would help the discussion to resolve the problematic issues already at an early stage of planning. The numbers of complaints are assumed to decrease if different viewpoints can be taken into account as early as possible.

Different concepts of participatory mixed reality tools (described in Section III) were presented for the interviewees. Participants were asked for feedback and to evaluate the possible impacts of the use of such tools. All the concepts were seen as interesting and the possible impact for urban planning process was seen positive. Use of public tools would enable more flexible and diverse ways for stakeholders to participate in commenting on the plans. It would make communication more effective when the information can be brought among people flows. Scalability of tools was also seen as positive.

Of the presented technology approaches, the decision-makers and city officials prioritized lightweight, web-based mobile solutions. Other presented solutions, such as the interactive design table and public screens, were also seen as

viable in the long run. They were seen as suitable for large urban planning projects and as tools for both decision-makers and citizens. Interactive public screens were seen as effective attention grabbers and information channels: they were considered a good way of spreading knowledge of urban planning projects. However, screens were seen as less suitable for collecting feedback and ideas from the general public. It was assumed that people would be hesitant to use a technical device that was for public use. The actual participation and feedback would happen via a personal mobile or other personal device, or in a more closed facility organized by the city or community. User interfaces that recognize gestures were seen as better suited to public spaces than touch screens. Touch screens in public use were perceived as uncomfortable especially because of hygienic reasons.

Even if the need for easy-to-use, light and adaptive visualisation tools was recognised, a concern was how the tools will be adopted. Ability and willingness to take new technical solutions into use were seen as challenging.

Another concern that was raised in discussions with decision makers was that, due to new tools, the amount of data is likely to be increased and for that reason new tools and methods are also needed to handle and analyse all that data effectively and to produce readable reports. Even now the amount of information and material is often great, especially in the case of larger planning projects, and a lot of effort is needed to go through all that material.

Considering the earlier experiences of mixed reality technologies in urban planning and the feedback from political decision makers and city officials, we developed a service demo, which is an open urban planning service. It can easily be used with personal devices as they run on web browsers of different devices such as tablet devices and PCs. The service mixes panoramic imaging and architectural drawings of future urban plans, and includes questionnaires to acquire local knowledge. In the next Section, we describe how the demo was used in a local environment project and how citizens perceived use of this kind of service in urban planning. The interviews with political decision makers helped us to clarify what kind of technologies and what kind of user features would suit best for participatory urban planning. We have used this information in designing of our participatory urban planning demo. In the next Section, we will describe how we used this demo as a part of an environment project and how users responded to it.

## V. THE ENVIRONMENT PROJECT

We conducted user studies and participatory urban planning pilots related to real environment projects with our service demo in Western Finland. In this region, there are several large future urban planning projects planned related to public traffic and development of city and community centres. For instance, the international airport area is under lively development. Local media reports frequently on new urban plans, and in local government there are debates for and against different urban planning and environment projects. We conducted our first user demo in a small local community. We wanted to ascertain how to support citizens

and other stakeholders in involving them planning of the sustainability and quality of their living environments through digital services. We wanted to find out how our demo service suited this purpose, and how to develop it further, especially trying to understand user values, needs and preferences in participative urban planning. We first conducted a user study in a small village near the highway where a new noise barrier is planned to protect inhabitants from noise pollution. There are only town houses in this area, and residents of the village consisted mainly of families with children and older people. Our aim was to reach residents living near the noise barrier to respond to our inquiry, so we published an online questionnaire link in a municipal community web portal, community Facebook site and in a local newspaper. The query was available over a period of a few weeks in March and in April 2014.

*A. Citizens' feedback on participatory urban planning demo and devices*

In all 25 respondents (12 males, 13 females) completed the web-based questionnaire, which included both multiple choice and qualitative open-ended questions. Most of them belonged to the age group from 35 to 44 year olds. They were quite highly educated: 10 of them had a bachelor's degree, 6 of them had a Master's degree and two of them had the level of doctorate.

The survey included basic background information questions, and focused on topics such as clarifying requirements for a future community planning, perceptions on visualisation and participation services, and most preferred places and information channels and devices for utilising a future participatory urban planning service. Users were also asked to try out the web-based pilot service which mixed panoramic imaging and architectural drawings of the planned noise barrier near their homes. The demo illustrated noise barrier building stages and the area five and ten years later.

Fig. 4 shows how users would like to have access to participatory urban planning service. From the options given, users would most likely to use the service from municipal web pages. They also preferred mobile devices as a convenient way of using the services in the local environments. However, users reflected that they would quite unlikely to use it from a municipal service point. Also municipal public events and notices in public transport were quite uncertain or unlikely places to access and use these services. In open-ended questions, users reflected that it would be problematic to give their opinions in such public places, if they wanted to maintain their privacy. One respondent pondered that it would be most convenient to participate with a personal device on a couch at home and it would be more likely to increase the possibility of participating in a public planning event also, if the plans are easy to access with personal devices and they are related to one's own neighbourhood.

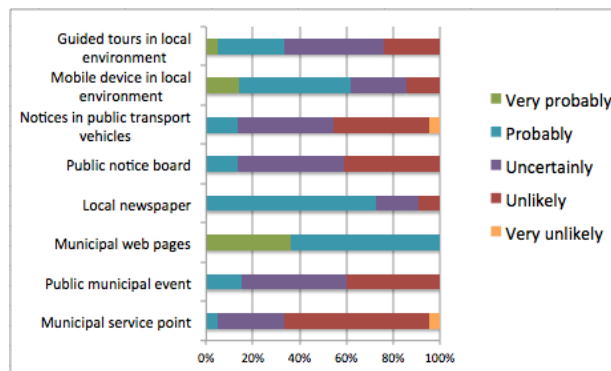


Figure 4. Where and with what devices users would you like to have an access to participatory urban planning service?

*B. Citizens' views on using participatory service in environment and sustainability related projects*

Fig. 5 provides an overview of the questionnaire responses to the question of presenting information related to municipalities' community planning and construction projects. Half of the respondents stated that impacts on the environment and showing alternative plans are very important. Also, explicit information on timetables and upcoming phases are at least as important to more than four fifth of the respondents. Only the need for visualising influences of seasons of the year was not seen as very important.

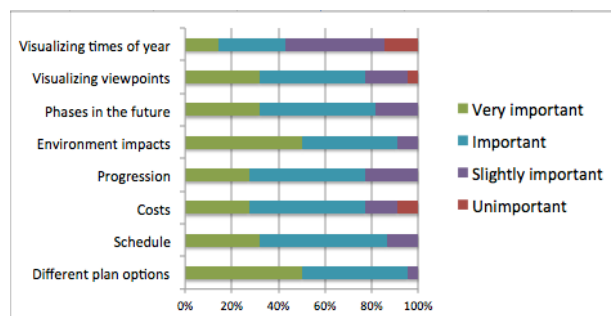


Figure 5. Importance of visualising and sharing different information on community planning projects through the participatory service.

Fig. 6 indicates respondents' feedback related to how well future visualization and participation tools are applicable for municipalities' environmental development domains. Their attitudes towards environment-related development activities were mainly very positive. Only playgrounds had one negative feedback, but on the other hand nine users stated that playgrounds fit excellently with future community planning services.

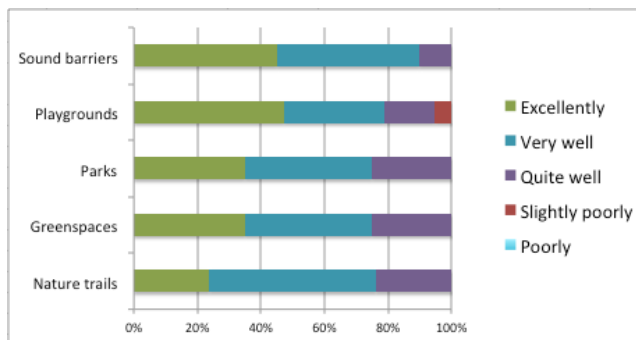


Figure 6. How well does the service suit different environment and sustainability projects?

The results of the survey were very much in line with the issues discussed with decision makers. In open-ended questions, urban planning information was complained of as being difficult to find, and the participation process is perceived as being too complex. Opportunities to interact and be heard were claimed to be challenging. Respondents requested involvement at an earlier phase of the planning process, more alternative solutions to be compared, clear timetables and information on how the process is progressing.

Respondents were mainly interested in the projects that are linked to their neighbourhood area, somehow reflect their everyday lives or projects that are supposed to have large, revolutionary influences not only geographical but also at the societal level. At present, the information on ongoing projects is sought from municipal websites and from the local newspaper, which are both listed as municipal official communication channels.

Participants were asked how the visualisation service succeeded in visualising the example case. In general, the service was found to be interesting, useful, and easy to use. The way the service visualises planning material was seen to be beneficial compared to traditional methods. Especially the possibility of viewing the target area from different viewpoints in a real environment was seen to be valuable. This feature also helps to locate plans, e.g., new buildings in the current surroundings and to illustrate the effects on the landscape.

## VI. CONCLUSION AND FUTURE WORK

The design of participatory urban planning services can have a great impact in developing smart and sustainable environments. To have optimal user-satisfaction, services should be flexible and adaptive and provide access to plans at any time and with any devices users prefer. Citizens in general are interested in commenting on and participating in urban planning projects, which are related to their everyday lives and their own neighbourhood. Urban places such as public interactive screens at transportation or municipal service points are good options in informing about future plans, however, users may be more hesitant to use them to give comments or feedback than to use their own, personal devices. Young people have been a little more active in

responding to on-line surveys, and interested in new technological approaches such as smartphone augmented reality, but it is still challenging to find a method to activate young people to participate and influence their living environments.

Moreover, in order to become effective, co-creative and influential, the service should be either specially designed for each relevant user segment and research theme or activate large numbers of users to comment and share their ideas. Important changes in urban planning would be to increase information, communication, collaboration and present more alternatives at the early stages of projects. Also, informing the public how their feedback has been taken into consideration in urban planning is important. Up-to-date information should be easy to find for instance under the same service.

In the next steps of our participatory urban planning service development project, we will pilot the demo in a large urban planning project to demonstrate green design and urban farming in a city centre. Furthermore, another important question to study further is how to consider and use this user feedback in decision making so as to plan and co-create user-centric smart cities and sustainable living environments.

## REFERENCES

- [1] M. Steen, M. Manschot, and N. De Koning, "Benefits of co-design in service design projects." *International Journal of Design*, vol. 5, 2011, pp. 53-60.
- [2] G. Rambaldi, P. A Kwaku Kyem, M. McCall, and D. Weiner "Participatory Spatial Information Management and Communication in Developing Counties." *The Electronic Journal on Information Systems in Developing Countries*, vol. 25, 2006, pp. 1-90.
- [3] M. Majale "Employment Creation through Participatory Urban Planning and Slum Upgrading: The Case of Kitale, Kenya." *Habitant International*, vol. 32, 2008, pp. 270-282.
- [4] M. Allen, H. Regenbrecht, and M. Abbott, "Smart-Phone Augmented Reality for Public Participation in Urban Planning" *Proceedings of the 23<sup>rd</sup> Australian Computer-Human Interaction Conference*. ACM, New York, NY, USA, 2011, pp. 11-20.
- [5] J. D. Salter, C. Campbell, M. Journey, and S.R.J. Sheppard "The Digital Workshop: Exploring the Use of Interactive and Immersive Visualisation Tools in Participatory Planning." *Journal of Environmental Management*, vol. 90, 2009, pp. 2090-2101.
- [6] S. R.J. Sheppard "Landscape Visualisation and Climate Change: the Potential for Influencing Perceptions and Behaviour." *Environmental Science & Policy*, vol. 8, 2005, pp. 637-654.
- [7] I. Wagner, M. Basile, L. Ehrenstrasser, V. Maquil, J-J. Terrin, and M. Wagner, "Supporting Community Engagement in the City: Urban Planning in the MR-Tent." *C&T '09 Proceedings of the fourth international conference on Communities and technologies*, ACM New York, NY, USA, 2009, pp. 185-194.
- [8] C. Skelton, M. Koplin, and V. Cipolla, "Massively participatory urban planning and design tools and process: the Betaville Project." *Proceedings of the 12<sup>th</sup> Annual international digital government research conference: Digital government innovation in challenging times*. ACM New York, NY, USA, 2011, pp. 355-358.

- [9] J. Saad-Sulonen, A. Botero, and K. Kuutti, "A long-term strategy for designing (in) the wild: lessons from the Urban Mediator and traffic planning in Helsinki" Proceedings of Designing Interactive Systems (DIS'12). ACM New York, NY, USA, 2012, pp. 166-175.
- [10] V. Oksman, A. Vääänen, and M. Ylikauppila, "Future Illustrative and Participative Urban Planning." Proceedings of CONTENT 2014, The Sixth International Conference on Creative Content Technologies, 2014, pp. 22-29.
- [11] J. Noujua and A. Jussila, "Exploring Web-based Participation Methods," Proceedings of the Tenth Anniversary Conference on Participatory Design (PDC '08), Indiana University Indianapolis, IN, USA, 2008, pp. 274-277.
- [12] E. Seltzer and D. Mahmoudi, "Citizen Participation, Open Innovation, and Crowdsourcing: Challenges and Opportunities for Planning", *Journal of Planning Literature*. Sage Publications, vol. 28, 2013, pp. 3-18.
- [13] T. Olsson, A. Savisalo, M. Hakkarainen and C. Woodward, "User evaluation of mobile augmented reality in Architecture", *Engineering and Construction*, 2012, pp. 733-740.
- [14] C. Woodward and M. Hakkarainen, "Mobile mixed reality system for architectural and construction site visualization". In *augmented reality –Some Emerging Application Areas*, Andrew Yeh Ching Nee (ed.), InTech, 2011, pp. 115-130.
- [15] P. Dalsgaard and K. Halskov, "Tangible 3D tabletops: combining tabletop interaction and 3D projection". Proceedings of NordiCHI 2012, ACM Press, 2012, pp. 109-118.
- [16] H. Ishii, et al., "Augmented urban planning workbench: Overlaying drawings, physical models and digital simulation." Proceedings of the 1st International Symposium on Mixed and Augmented Reality. IEEE Computer Society, 2002, pp. 203-211.
- [17] R. Nielsen, J. Fritsch, J. K. Halskov and M. Brynskov, "Out of the box – Exploring the richness of children's use of an interactive table". Proceedings of the 8th International Conference on Interaction Design and Children (IDC '09), ACM New York, NY, USA, 2009, pp. 61-69.