URBAN MODELLING AND VISUALIZATION TOOLS FOR URBAN TRANSPORTATION SYSTEMS – EXAMPLES FROM TWO LIVING-LAB PROJECTS IN GOTHENBURG.

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Abstract:

Purpose: Within transport projects there is a growing demand for urban modelling and advanced visualization methods. This paper reflects upon visualizations techniques used in two transdisciplinary projects studying implementation of transport solutions in Gothenburg. Involvement of many stakeholders and efficient dialogue tools were essential to support communication in the transdisciplinary environment. *Sendsmart* and *Go:Smart* projects (2012-2014) aimed at developing and testing innovative sustainable solutions for urban transportation with a focus on freight (*Sendsmart*) and passenger transport (*Go:Smart*). They were developed as an important municipal attempt to create better conditions for sustainable urban travel in the city.

Research Approach: Both projects turned out to become a living laboratory for visualization implementation and engaged groups of key stakeholders from the academia, industry, city of Gothenburg, and the regional and national organizations. These practice-oriented projects were focused on development of new solutions and testing them in reality. This study presents reflections from a research-by-design process and available rich, documented material from the projects (meeting notes, workshop notes, monthly reports, films). Even if, *SendSmart* nor *GoSmart* were not part of municipal planning process, they were focused on early implementation phase of new approaches in the city transport planning. Integration of users was essential and the user perspective was the only one brought into research discourse.

Findings and Originality: In both projects methods and tools were developed in forms of demo visualizations and films, simulation models - scenario development and evaluation (decision support systems: Urban Strategy combined with *Visum*), image supported discussions (*Urbania*) maps and 2D visualizations as a basis for discussion. These tools are perceived as extremely helpful to support communication in the complex environments and were very useful as an input to the workshops. However, an iterative procedure would have been needed to further let the participants' opinions and suggestions lead to new visualized concepts. A need to simulate both in macro and micro scale was recognized. Challenges to further deal with are lack of detailed data for traffic simulation in advanced models, problems with different source data aggregation and a high demand for specifically qualified expertise in building simulation models. It is beneficial to put efforts into developing an integrated model for freight and passenger transport within transdisciplinary projects.

Research Impact: This paper underlines the necessity for a critical collaborative exchange and research needs to be fostered and disseminated in order to enhance and promote the usable knowledge and application of visualization methods and technologies. Their potential in addressing critical transportation issues of today, as well as promoting innovative approaches to meet society's transportation needs of the future often requires a discussion within a broader, multidisciplinary context of technology development in the areas of simulation and modelling

Practical impact: Paper addresses the importance of using visualization for communication in transportation projects.

Keywords: transportation modelling, visualization tools, sustainable urban mobility

Introduction

In the current environment of rapid global change, the role of transportation and mobility in cities become even more important. The emphasis is laid on the steering transport policy towards sustainable mobility. There are many constraints in modelling sustainable freight and passenger transport. The large majority of cities have not found yet the adequate solutions to help optimise the urban movements of goods. The urban passenger mobility is considered as one of the major challenges for the future (Little et al., 2014). Some cities have already faced the challenge by introducing different targets of information and education campaigns to raise awareness and change attitudes towards public transport. Sweden is one of the countries characterised by the greatest migration to cities in Europe (European Union, 2015). Innovative urban mobility solutions involve a number of barriers (Strömberg et al., 2015). At first, urban mobility management operates in the fragmented environment represented by lack of holistic approach to achieve synergies between different modes of transport. At second, decisions are often based on 'public actions' and do not sufficiently address collaboration with the private sector in order to achieve urban mobility goals. Moreover strategic urban and transportation planners lack operational and accessible tools to better understand consequences of policy and planning measures.

Surprisingly in Gothenburg, like in the most cities, urban freight transport plays a minor role in transport planning procedures (Lindholm, 2010), even if, the role of urban freight in city transport is significant and unsustainable impact of urban freight compared to passenger transport is growing. The environmental impact of urban freight is bigger when compared to passenger modes. Moreover, the classic focus on city planning policy does not fully include goods, and there is low priority for urban freight in local planning procedures. Municipality regulations put in place to organize the traffic of delivery trucks, but essential freight activities in the city are resulted from the logistic decision making process and cannot be restricted by governments due to constitutional principles of freedom of circulation and freedom of trade(Dablanc, 2007). Visualization tools are perceived as having strong potential to support communication in complex and transdisciplinary environments (Senbel & Church 2011, Brown& Kyttä 2014, Billger et al 2016). However, the remaining challenge involves accessibility and management of the large amounts of data, design of visual-analytical tools to explore multi-faceted geospatial data and generate knowledge (Pack 2010).

The aim of the paper is to reflect upon use of visualization tools for development and testing urban mobility solutions in two transportation projects in Gothenburg: *Go:Smart* discussing passenger transport and *Sendsmart* developed for transport of goods. These two projects have been an attempt to create better conditions for sustainable urban travel, addressing urban challenges like road crowdedness, congestion, noise and accidents; i.e. a reduced trips with fossil-fuel vehicles, an increased share of travel by collective transport and demonstrate how new business models and partnerships can reduce emissions (noise, CO_2) and promote new "mobility services". Visualization as a work package in both projects played a unifying role having the objective of visualizing both the different activities in both projects as well as the aggregated results of both projects.

In this paper it is acknowledged that critical research needs to be associated with the effective application of visualization to transportation systems projects. Visualization has become an essential part of internal and external communication and used as support in the development phase of the project. The visualization work package played an important role in the living labs/field studies in both projects separately, and played a unifying role when presenting results of both projects in the simulation tool Urban Strategy and the final movie. The paper identifies particular challenges in the presented transportation projects in Gothenburg that visualization effectively addressed: communication of the project (in order to aggregate results from living labs, upscaling); collaboration among various stakeholders (different background and domains of experts); working with high complexity of issues; data integration and a broader, multidisciplinary context of technology development in the areas of simulation and modelling.

Literature Review

Urban planning processes involves many stakeholders and efficient dialogue tools are essential to support communication in the transdisciplinary environment, where urban modelling and visualization are perceived very beneficial (Senbel & Church 2011, Brown& Kyttä 2014, Billger et al 2016). Digital tools cover multiple learning styles (Kolb, 1999) since they engage through images, text and interactivity. Such tools therefore have the potential of bridging the distance between planners and citizens (e.g. Bailey et al., 2011), and to contribute to a shared spatial language among involved actors (Pelzer & Geertman, 2014).

In visualization studies, there is an increased focus on collaboration and implementation. Visualization tools typically consist of a 3D city model or map involving different levels of interactivity. Of these, 3D models seem to have the greatest potential for citizen empowerment, but combining several digital tools might be even more effective (Senbel & Church, 2011). 3D-visualisations are not suitable for all situations and one problem is to understand which visualization tool to use in which situation and how to optimize it. Challenges for implementing visualization tools are usually connected to organizational aspects, such as ownership, allocation of resources for maintenance, competence and access to tools and technology (Billger et al., 2016). Misinterpretation of data may be a problem, and various trends for visualization and ways of analysis is another challenging factor. How to best represent the proposed object at different stages in the building design process is a fundamental problem (Brown, 2003). Verbal and visual communication differs and there are specific problems to handle when using visualization as a communication tool, i.e. the expression of the images, level of abstraction, the use of verbal explanations connected to visualizations, and symbolism versus realism (Lange 5, Neto 2003).

Within the transport sector studies have shown that advanced visualization methods encouraged the public to participate in the planning process, which illustrates the ability of appropriate visualization techniques to communicate efficiently (Cheu et al., 2011). However, accessibility and management of the large amounts of data we in the society is seen as a problem. For example, there is a need to design visual-analytical tools to explore multi-faceted geospatial data and generate knowledge out of this (Pack 2010). More transportation references: (Garrick et al., 2005; TR, 2007).

Knowledge building in the dialogue process is prevented by insufficient feedback and follow up (SOU, 2012). Preconditions for a successful process also contain a good learning situation. For increased knowledge building in sustainable urban development, David Kolb's (Kolb, 1999) learning model 'Experiential learning' supports the use of games and visualization. Since gaming and visualization engage through images, text, and interactivity, they enable possibilities to reach a broader group and cover more learning styles than a text or a lecture. According to Brommelstrout and Schrijnen (2010), a meaningful use of planning support systems requires the combination of these learning styles, ideally including all four. They also point out the importance of that a visualization tool in itself is not enough, but that a mediator is required in order to design a meaningful use of the tool.

Studies of the usability of visualization tools refer to different stages of tool development. Only a few are tested in real processes. At later stages, prototypes of new tools or combinations of existing tools are evaluated, again mostly in simulated settings. Very few studies focus on the implementation of visualization tools in real planning processes (Brown & Kyttä, 2014).

Research Approach

Sendsmart and *Go:Smart projects as a living laboratory for visualization implementation*

This paper reflects upon the usefulness of various visualizations techniques in two transdisciplinary projects studying implementation of transport solutions. Literature studies indicate great potential of visualization to be used in the dialogue process, however, there are very few studies of implementation in real planning. Neither *SendSmart* nor *GoSmart* project considered as "ordinary" planning processes, which usually are directed by the city council. However, they focused on early implementation phase of new approaches for transport planning in the city. These practice-oriented projects were focused on development of solutions and testing them in reality, not on developing particular scope of research. Integration of users were essential and the user perspective was the only one brought into research discourse. One important limitation was a lack of possibility to evaluate the visualization activities due to limited time of two years to run a project. Thereby, this study presents reflections from a research-by-design process. Documented material from the project (meeting notes, workshop notes, monthly reports, films) and collected reflections were used in this study.

Sendsmart and *Go:Smart* projects (2012-2014) aimed at developing and testing innovative sustainable solutions for urban transportation with a focus on freight (*Sendsmart*) and passenger transport (*Go:Smart*). 19 partners involved in *Sendsmart* project and 14 in Go:Smart project were selected from the academia, industry, city of Gotheburg, and the regional and national organizations. At the beginning visualization was formally considered a separate work package in each project but it turned out to become a one mutual work package for both projects (Fig.1).

An overall major challenge addressed in the *Sendsmart* project was to find both technical solutions for sustainable urban transportation as well as "soft solutions" developed within cooperation between different actors. The goal was to create logistic proposals that are commercially viable. An important part of work was to create a synergy between the authorities and business, so that developed proposals and solutions were analysed and based on broad knowledge and experience. *Sendsmart* included 2 living labs, one field test and one theoretical study.

The overall major challenge for *Go:Smart* based on the sustainable personal transportation was to find a useful, flexible, affordable and reliable alternatives to private cars, as well as a possibility to convert commuting vehicles to mainly electric. The project also addressed conflicts for commuting related to increased traffic, noise and security risk. Another challenge addressed was a risk for unprotected travellers as cyclists and pedestrians. *Go:Smart* Included one living lab and two field tests. The *Ubigo Living Lab* was developed and used in Go:Smart as a travelling broker service and tested for over six months by involved 71 households.

Fig. 1. Illustration of SendSmart and GoSmart projects: urban challenges like crowdedness, congestion, noise and accidents are addressed (illustration: Jackie Forzelius).

In both the *Go:Smart* and *Sendsmart* project, visualization was from the start designed mainly to support the participation of stakeholders involved in the development process, raising the understanding of the project and illustrating its impact. Use of visualization techniques was considered to be essential part of the project, but methodology was reshaped when compared to original plan, articulating the needs raised during the process and partly by selecting other visualization tools. Visualization techniques were used to effectively address communication of the project (in order to aggregate results from living labs, and upscaling), collaboration among various stakeholders (different background and domains of experts), working with high complexity of issues, and data integration and a broader, multidisciplinary context of technology development in the areas of simulation and modelling.

Choice and utilization of visualization

Visualization became a unifying essential part of communication internally and externally in both projects. It has been used as support for the development of the projects , evaluation, display on the effects of solutions proposed and tested in the different living labs/field tests, and for generalization and further development of ideas. The need, as well as, the understanding of the potential for visualization increased during the project. Thus, the choice of methodology has broadened compared to the original plan. In both projects different goals lead to different choice of methods and tools:

A. Demo visualizations and films - Film was used as a way to communicate the project's content and concepts externally and internally, and to demonstrate and evaluate different solutions (use and production of short animated movies with different levels of photorealism)
B. Simulation models - scenario development and evaluation (decision support systems: Urban Strategy combined with *Visum*)
C. Image supported discussions (*Urbania*) maps and 2D visualizations as a basis for discussion (e.g. to show the capacity of the city depending on the different transport solutions)

A. Demo visualizations and films

In *Sendsmart* project one film was produced to present the project as a whole, and another to demonstrate the difference in sound between using fossil fuel driven garbage trucks and electrical ones. The garbage truck film was made using a photorealistic 3D-model of the urban environment and a realistic auralization where a combination of synthetic and recorded sound was used (Forssén et al 2013). In *Go:Smart*, films were made for different living labs and field test. One film was to

Fig. 2. Images from 3 films, *Sendsmart Garbage Trucks*, *Geofencing* and *the Electrical Buses Scenarios.*

attract to the *UbiGo Living Lab* users and to communicate the content of this subproject. Another was used to present the geofencing concept tested in a field study. Thus, the objective of these films were primarily to communicate the content and raise interest for activities in the project. While, the third production had the aim of giving input to discussions potential uses for electrified vehicles. A series of film sequences visualizing rather photorealistic examples of future scenarios for usage of electrical buses in sensitive environments, such as narrow streets with cafes, indoor shopping malls and residential areas. It was used as an input in 2 focus group evaluations. Finally, a series of illustrations (fig. 2) and a 6 minutes film were made to present the results of both projects. These illustrations were used separately for presentations and also to frame the story throughout the film, in between them simulations and film sequences were added.

All films apart from the *SendSmart Garbage Trucks* were visualized and animated by the project visualizer, Jackie Forzelius, who was an intern in the project during the first year and after that an employee. The *Sendsmart* film was made by students and Jackie worked in the same project team as a commissioner.

The production of the *Ubigo Go:Smart* film and the *SendSmart* films represented similar processes. Project partners participated in a workshop were engaged in the first draft's work out. The core of the project and the main messages were defined. After that, the visualizer/s and the project management worked jointly on the script and story board. The visualizers finalized the film.

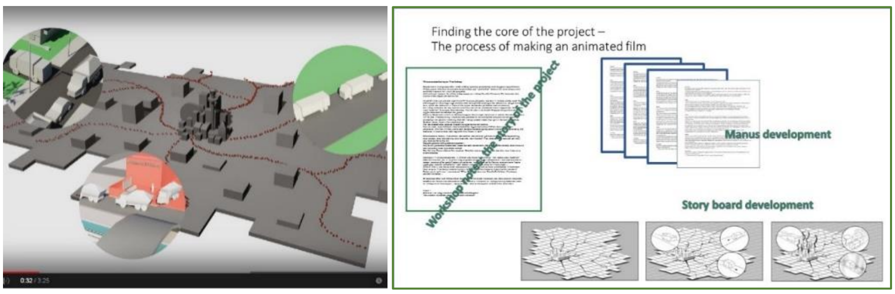

Fig. 3. Visualizations in *Sendsmart* project a) an image from the film introduction, b) illustration of the film production.

B. Simulation models - scenario development and evaluation
The Visualization Platform Urban Strategy (Pelzer & Geertman, 2013) was used to simulate and analyze scenarios. We integrated the Gothenburg traffic model in Urban Strategy and imported 2.5D data for Gothenburg to create a 3D model of the city. In this interactive 3Dmodell, we examined how different solutions affect the city's capacity, noise and air quality. In other words, what is the situation in the city on the private car traffic decreases, public transport increases, electrification increases, and we create smarter city logistics and construction logistics. We also simulated the effects of air and noise pollution in the growing city affected by different transport solutions. In addition to Urban Strategy, micro simulations were tested as a way to visualize the consequences of transporting tons from construction sites by barge instead of trucks. Micro simulations were created by Tyrens AB (partner in the project and active in the Visualization WP:s) with the software VISSIM. These were and based on calculations by Master diploma students at Chalmers.

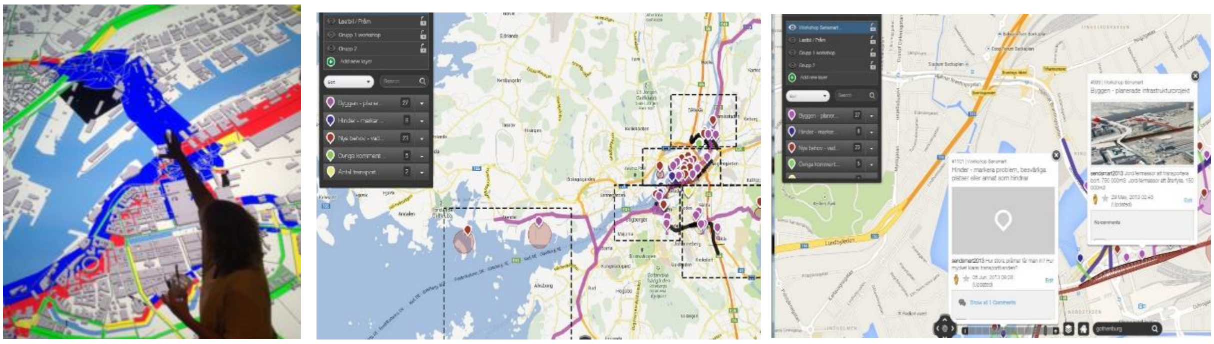

Fig. 3. Left and middle: Urban strategy visualization Right: Two views from the workshop with Urbania

C. Map-based supported discussions (*Urbania*)

The digital map-based workshop software Urbania has been used in *Sendsmart* as a basis for discussion and analysis of mass transport. *Urbania* is a prototype, lightweight visualization and collaboration tool designed to form a dialogue in urban planning, based on Google Maps. It allowed non-technical users to interact using a map with other users. They were asked to place symbols on the map to denote different areas and points on a map for further discussions. It was developed in the transdisciplinary project *Urban Games* commissioned by two partners[1]. It has earlier been tested in real planning processes by the Swedish Transport Administration and in citizen dialogue processes by the City of Gothenburg (Billger et al 2016).

In *Sendsmart*, a workshop involving 15 stakeholders was held discussing how to transport the clay and stone from the *Westlink* construction sites. There was a rigorous planning work done prior to the workshop. All information available on the construction sites, the amount of clay and stone, time plans and information of other large construction projects during a 10 year period were collected. Short text notes and images were “nailed” to the correlating locations on the map. This was too early in the planning process for having the locations for use of masses, thus the workshop was based on a few scenarios for the inner city. The endpoints of the routes were not important, they just made it possible to evaluate certain directions and point to problems and possibilities in the city center. In the workshop, the participants contributed with their reflections on the discussed issues that were nailed to the map. After the workshop, a pdf with results was distributed to the participants.

<u>Findings and reflections</u>
During the projects, a need for visualization evolved and increased in a different way that we initially planned. The importance of using visualization for communication turned out much bigger than we

[1] Partners within the research centre Mistra Urban Futures http://www.mistraurbanfutures.org/en

thought. Communication and agreeing on what the focus really was a crucial part of a collaborative project in order to create synergies with other businesses. Each partner had its own start point, its own agenda and its own goals. This was also necessary to defend the contribution of approx. 50% inkind, which was an initial condition for creating this kind of project. The goal of making animated short movies to support external and internal communication was reached. However, the surprising and most valuable contribution to the project was a production of animated movies and the way their helped the stakeholders to focus on the core of the project, despite the many agendas of each partner collaborating in the project. The films and especially the process of creating short animated films have been of great help to describe the core of the projects. Illustrations, clickable or animated series has also helped to maintain a group work.
Auralization of sound has given valuable input to the project, and been utterly important to create trustworthy scenarios for evaluating electrical vehicles (Forssén et al., 2013). From using visualizations for demonstrating new applications of electric buses, we learned that visualizations techniques were most useful as an input, people reacted immediately and it allowed to open up discussions. However, an iterative procedure was needed so changes and new suggestions could be visualized and evaluated over again. This way a fruitful dialogue and a common ground for co-creation between stakeholders was created.
We recognized the need to simulate both in macro and micro scale, giving both the big general overview (which also shows the synergies both between subprojects and between freight and passenger), and what the impact looks like in the small (e.g. how a garbage truck blocking a street, and generate congestion during rush hours, while during night work more smoothly - with the benefit of both the driver and the traffic situation in the city). However, there has been technical challenges to overcome with the tool simulation Urban Strategy. We had only one person in the project who was skilled enough to manage this complex system, the rest of us neither the time nor the competence to learn this during the project. It was fascinating to see the potential in the elaborations made, however more time would have been needed. Maps as base for discussions were an essential part of urban development dialogues, and this kind of digital tool like *Urbania* was the most helpful and powerful. It was convenient to prepare and compile all data in one web document and then add layers of information above this during the workshop.

Research and practical impact

It was challenging for the projects that some field studies /living lab activities were implemented later than planned. It was therefore difficult to assess the overall impact of all the measures implemented and to identify synergies between these measures. In addition, it was difficult to see how these can be linked to the passenger in the project *Go:Smart*. Efforts to develop a model for integrated analysis of freight and passenger transport is just started and will be further studied in new projects.
Furthermore, the data for freight was not refined enough to make use for scenarios in the inner city. The data in the Goteborg traffic model was only divided in under and above 3,5 tons, a large part of the freight transport in the city was distributed by smaller trucks.
Several applications for funding are filed for new collaborations projects involving the city of Gothenburg. New projects developed from *Sendsmart* and/or *Go:Smart* has been granted. One example is *CIVIC*, a JPI Urban Europe Project, managed by University of Amsterdam. The Swedish part is studying building logistics in Norra Djurgårdstaden. It is a practice-oriented project implementing and testing new solutions, where visualization is used for communication and a dialogue with stakeholders. Another example is *Data Fusion in urban planning and analyses*, a BIgData@Chalmers project involving City of Goteborg and several companies in series of workshops on big data visualizations, studies of traffic data, environmental data and health data.
The visualization results from *Sendsmart* and *Go:Smart* projects has led to at least 10 Invitations to talk at conferences, targeting both a scientific as well as a broader audience in urban development. Discussions has also started with the traffic office at Goteborg City on how to collaborate on using visualization tools for planning and in transdisciplinary projects.

Conclusion and Future Research

Critical collaborative exchange and research needs to be fostered and disseminated in order to enhances and promote the usable knowledge and application of visualization methods and technologies. Their potential in addressing critical transportation issues of today, as well as promoting innovative approaches to meet society's transportation needs of the future often requires a discussion within a broader, multidisciplinary context of technology development in the areas of simulation and modelling.

The main conclusion from the study is that, in order to provide planning and policy-making with an adequate knowledge base, it is necessary to develop urban modelling and visualization tools in transdisciplinary projects. This is useful not only for communication but also on agreeing on the focus in the crucial parts of collaborative transportation projects among different partners in the city. In the contexts of urban complexity it is important to simulate both in micro and macro level, giving an overview of synergies between subprojects, freight and passenger, day and night transport. The tools tested in the study can serve as a valid starting point for further development of such tools and methods used for practical applications in the city transportation planning. Finally, utterly important was to have an internal project visualizer on part time during the whole project period. It allowed to develop a profound understanding for the content and the complexity of these projects with all their sub projects, and communicating the results.

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