4D in City Transformations

Systems, Processes and Actors

Tim Johansson

Luleå University of Technology

ISSN: 1402-1757  ISBN 978-91-7439-532-7
4D IN CITY TRANSFORMATIONS
SYSTEMS, PROCESSES AND ACTORS

Tim Johansson
Luleå, November 2012
Abstract

The city of Kiruna is facing the challenge of relocating a large proportion of the existing city centre as a consequence of the subsidence caused by underground mining activities. This relocation includes urban residential areas, industrial areas, offices and spaces such as parks and infrastructure. There are a number of challenges in such a city transformation process which require the active participation of the public in the urban planning processes. A big challenge is the stakeholder management since there are stakeholders who share responsibility for the decision-making for the urban plans of the city transformation. The sharing of decision-making has led to a situation where plans are only accepted through discussions and consensus. Much of the planning content is related to time and space which means that 4D models, being 3D planning models linked with schedules, are suitable for enhancing the understanding of the time dimension of planning content, as well as their status. Therefore it is hypothesised that:

“4D visualization enhances the opportunity to create transparent, accessible and understandable plans for stakeholders to support communication with urban planners.”

The idea of such a support system is that the stakeholders can monitor how the planning content and the planning stages including the realization evolves over time. To investigate how such a planning support system can be realized, the following research questions were defined:

RQ1. What are the most important aspects to be communicated in a city transformation process?
RQ2. How can urban planning information be visualized and communicated to stakeholders to support a transparent decision-making process?

RQ3. What are the requirements of a planning support system to manage such a process?

The city transformation in Kiruna was used as a case study involving the first three steps of a 5 step system research approach. The most important aspects of the city transformation were understanding the forces of transformation, the complexity of the problem to solve (its wickedness), stakeholder values, planning stages and alternatives and the planning regulations controlling the decision-making process. Two main challenges was identified: first, the stakeholders’ power and interests change over time. Second, current methods of communicating the planning proposals do not encourage the public to participate in the city transformation process. The urban information can be visualized to support the accessibility of plans by the public, enhancing the opportunity to share ideas and remarks and support collaborative design and decision-making. Adding a time dimension can help the understanding of (1) the transition from an original state to a new planned state and (2) the spatial consequences of an urban transformation process over time and the dynamics of urban planning under re-development.

The case study showed that the traditional communication of urban plans through open exhibition and documents did not provide an efficient method of dissemination and receiving information, especially between the public and urban planners. Therefore, as an answer to the third research question, a planning support system (PSS) was proposed that could support iterations, visualize plans and status, visualize the planning content adapted to different stakeholders and support two-way asynchronous communication all in a simple, easy-to-use interface to encourage the public to participate in the urban planning process. A first prototype of the communication platform was created based on Google Earth and Facebook, including time-space visualization of urban planning information and the support of two-way asynchronous communication for collecting geo-referenced public opinions. A generic model of urban planning processes was also developed to describe the relationship between stakeholder, design and process more deeply. It was concluded that a PSS must support process, design and stakeholders in order to be efficient. The model was tested against the regulatory framework of the Swedish Planning and Building Act. The development of a generic PSS collaboration hub was proposed that supports the different levels of urban planning processes in a city.
Contents

ABSTRACT ...................................................................................................... III

CONTENTS ....................................................................................................... V

PREFACE ....................................................................................................... VII

1 INTRODUCTION ........................................................................................ 1
  1.1 Background and motivation ............................................................. 1
  1.2 Objective and aims ........................................................................... 3
  1.3 Research questions ........................................................................... 4
  1.4 Scope and limitations ....................................................................... 4
  1.5 Thesis layout .................................................................................... 5
  1.6 List of publications ........................................................................... 6

2 RESEARCH METHOD ............................................................................. 9
  2.1 Introduction...................................................................................... 9
  2.2 Research design .............................................................................. 10
  2.3 Case study description .................................................................... 15
      2.3.1 Interviews ........................................................................... 16
      2.3.2 Archival data ...................................................................... 18
      2.3.3 Observations ....................................................................... 18
      2.3.4 Data analyses ...................................................................... 18

3 THEORETICAL FRAMEWORK ........................................................... 21
  3.1 City transformations ....................................................................... 22
      3.1.1 Transitions and transformations ......................................... 22
      3.1.2 Sustainable development .................................................... 23
  3.2 Urban planning issues as wicked problems .................................... 24
      3.2.1 Definition of wicked problems ........................................... 24
      3.2.2 Managing wicked problems ............................................... 26
  3.3 Stakeholders ................................................................................... 27
      3.3.1 Mapping and managing stakeholders .................................. 27
      3.3.2 Decision-making ................................................................ 28
  3.4 Swedish planning regulations ........................................................ 28
      3.4.1 Introduction ........................................................................ 28
      3.4.2 The Swedish Planning and Building Act ........................... 29
      3.4.3 Building permits, demolition permits and site improvement
            permits............................................................................... 31
4D IN CITY TRANSFORMATIONS

3.5 Systems for the support of the urban planning process ................. 33
  3.5.1 Planning support systems ..................................................... 33
  3.5.2 Spatial decision support systems ........................................ 34
  3.5.3 Public Participatory Geographical Information Systems ... 35
  3.5.4 4D modelling systems ..................................................... 36

4 RESULT AND ANALYSIS OF APPENDED PAPERS ....................... 39
  4.1 Time-geographic visualization of stakeholder values: A case study
      of city relocation ........................................................................ 39
  4.2 A Communication Platform to Support Decision-Making in the
      Kiruna City Relocation Process .................................................... 41
  4.3 Development of a 4D Public Participation GIS to Improve the
      Communication of the City Transformation Processes ............... 42
  4.4 Cross-paper analyses ............................................................. 44

5 PROPOSED MODEL ........................................................................ 47
  5.1 Introduction ............................................................................ 47
  5.2 The Swedish PBA from a stakeholder-process-design perspective  49
  5.3 Comprehensive planning ....................................................... 49
  5.4 Detailed planning ................................................................... 52
  5.5 Building permit ....................................................................... 53
  5.6 Integration of comprehensive planning, detailed planning and
      building permits ........................................................................ 54

6 CONCLUSIONS ............................................................................ 55
  6.1 Addressing the research questions .......................................... 55
  6.2 Contributions made ............................................................... 58
  6.3 Validation and generalization .................................................. 59
  6.4 Suggested further research ...................................................... 59

REFERENCES ................................................................................. 61
A research process is full of exciting moments but also hard work. During my own work I have several of people to thanks for this thesis. I believe that a good thesis cannot be done with a lot of people supporting the work. I would therefore address my thanks to the following groups:

Firstly, the planning department at the municipality which helped me and let me stayed for my data collection period during mainly may 2011. The time that you spent on me really helped me understand the fundamental problems within urban planning transformation.

Secondly, the colleges in Enschede which gave me the opportunity to stay at University of Twente, it truly developed my capabilities as researcher as well as gave me memory for life. I’m glad that was able to participate both in the local football team as well as research activities. Special thanks Timo Hartmann for helping me to arrange my stay and supported my research with great ideas and remarks, as well as having great parties.

Third, my colleagues at Luleå University of Technology. This thesis would not be possible without you. Thanks for scrutinizing my work and encourage me to develop my research further. Special thanks go to Kristina Laurell-Stenlund, which helped me a lot during my first year as researcher. Furthermore, Thomas Olofsson and Rogier Jongeling thanks for always supporting my work with good ideas and remarks. I truly learned a lot from you both in the scientific as well as other fields. I really appreciate that you always gives a helping hand once I need it.
Finally, I would like to thank my family, especially mum and dad for always encourage my work.
INTRODUCTION

In this chapter, the background and the motivation for this research are explained, followed by the objective, aims, research question and scope and limitations. Finally, the outline of this thesis and the list of publications are presented.

1.1 Background and motivation

Currently, there is a consensus among scientists and politicians that the world is moving in an unsustainable direction (Yang, 2010). Since cities are seen as the drivers for the development of European regions (Rotmans et al., 2000), social, economic and environmental values need to be strengthened in order to fulfil the agenda of sustainability (Carmona et al., 2002). The social and political processes of urban transformations include many actors representing different views and interests (Friedman, 1986). These actors’ views are often diverse and conflicting due to different aims and objectives. Due to the strong social dimension, urban planning has always been a difficult task to carry out (Geertman and Stillwell, 2003).

The complexity of public financed projects can be exemplified by the cost estimations of infrastructure projects for building railroads, highways, tunnels and bridges. These projects often show cost overruns due to the long lead times from decision to actual building until the construction is completed. These delays are caused by unsatisfactory openness, democracy in planning and decision-making (Flyberg et al., 2003, 2004). To avoid such a situation, Flyvberg, (2005) called for increased accountability through transparency and public control. Public control, here, means enhancement through transparency to increase collaboration. Ultimately, this allows other actors to evaluate and
criticize the forecasting of projects by giving them insight regarding project information. So, collaboration enhances the transparency of the democratic processes between different stakeholder groups in public-financed urban transformation projects. Stakeholders need to collaborate in an iterative process to build trust and understanding of each other’s requirements and needs (Rittel and Webber, 1973; Healey, 1997; Flyvberg, 2005).

The development of a sustainable city is strongly dependent on the involvement of the public, social organizations and private enterprises in the urban transformation (Steinmann et al., 2004). To generate new insights, new ideas and new artefacts, the different and often controversial points of view need to be shared with the involved stakeholders (Arias et al., 2000). Methods and tools allowing the exchange of information and knowledge between stakeholders are therefore needed to enhance the collaborative nature of the design and decision-making processes of urban transformation (Barton et al., 2005).

The internet offers an easily accessible platform for collaboration. Integrated web-based GIS platforms using two-way synchronized communication have already been demonstrated, where an exchange of plans provided a high degree of access for the wider public, along with the potential for sharing ideas and remarks (Wu et al., 2010; Rinner and Bird, 2009). These qualities are essential to increase the public involvement and contribute to empowerment and trust, both for local planning authorities and for the urban planning process (Stern et al., 2009). Additionally, web-based technology can help the general public, who in general are not professional planners, to increase their participation in the urban transformation process (Rinner et al., 2008; Barton et al., 2005; Shen and Kawakami, 2010; Ghaemi et al., 2009; Rinner and Bird, 2009; Pettit, 2005; Stern et al., 2009; Hall et al., 2010).

Planning support systems (PSS) are intended to support planning at several spatial scales in the public sphere by integrating visualization and communication tools. However, the usage of the technology is poor despite the apparent benefits that a PSS could provide. In fact, very few PSS developed by researchers are finally adopted in practice to support planners and decision-makers in urban planning (Geertman and Stillwell, 2003 and 2004). Currently, most PSS lack the functionality to support the urban transformation process from the following perspectives:
First, there is a lack of knowledge regarding temporary objects in urban planning processes. No standards or best practice exist on how past, present or future activities should be visualized in time and space.

Second, current PSS are focused on problems found mainly in a narrow design domain for a specific phase. The process perspective is missing, which results in tools and methods for coordination of activities that are not implemented. As a result, the urban transformation process is not transparent to the involved stakeholders.

Third, the public are often considered as a homogenous stakeholder group whereas stakeholder management theories claim that groups should be categorized and managed according to interests and power. Hence, better knowledge of how heterogeneous groups such as the public can be categorized and managed in urban planning processes is needed.

Using these three perspectives leads us to the starting point of this research. It will be at the intersection of stakeholders, the process and the design of urban transformations. The PSS is ultimately seen as an opportunity for establishing a virtual planning platform supporting multiple stakeholders with different needs and requirements in the planning and realization of urban transformations. Hence, the PSS supports the integration of processes, stakeholders and design elements in space over time.

1.2 Objective and aims

The objective of this research is to extend the knowledge of urban planning by linking stakeholder, design and process management with time-space visualization, so-called 4D modelling.

The aim of the research is to create guidelines and knowledge for practical implementation of process modelling and 4D visualization to support the communication of planning of urban transformation with heterogeneous stakeholder groups.
1.3  Research questions

The research questions are based on the hypothesis that:

*4D visualization enhances the opportunity to create transparent, accessible and understandable plans for stakeholders to support communication with urban planners.*

Three research questions are addressed to investigate the hypothesis.

**Research Question 1**

*What are the most important aspects to be communicated in a city transformation process?*

The purpose of RQ1 is to identify information that is of importance in order to reach an overall understanding of a transformation process. Here, we investigate both spatial information and also information that is linked to the decision-making.

**Research Question 2**

*How can urban planning information be visualized and communicated to stakeholders to support a transparent decision-making process?*

The purpose with RQ2 is to investigate how to communicate with different stakeholders with a variety of interests, power and needs. The communication and visualization of the urban planning information needs to be adapted for different stakeholder groups.

**Research Question 3**

*What are the requirements of a planning support system to manage such a process?*

The purpose of RQ3 is to identify how this kind of information should be managed by a PSS.

1.4  Scope and limitations

The scope of this research is to investigate how 4D visualization can support stakeholder management in urban planning processes, with the intention of...
creating transparent urban planning processes on a comprehensive and detailed planning level. The goal here is to serve and manage stakeholders using adapted views and communication channels of spatial information.

The scope is limited to studying planned urban transformations as defined in the Swedish Planning and Building Act.

1.5 Thesis layout

This thesis consists of the following 6 chapters:

Chapter 1, Introduction: This chapter presents the background and motivation of this research. It is followed by an examination of the objectives and aims and the research questions. Finally, the scope and limitations of the research are outlined.

Chapter 2, Research method: First, the generic research process, research methods and data collection approaches are explained. Second, the methods used for each appended paper are examined. Finally, the overall research design is presented, a design that uses a combined system development and case study research approach.

Chapter 3, Theoretical framework: This chapter explains the theoretical basis of the 4D visualization and collaboration approach with theories of decision-making, rational and wicked problems, stakeholders, urban planning and, finally, Planning Support Systems.

Chapter 4, Results and analysis of appended papers: First, each of the appended papers is summarized and examined. Then, the findings related to weakness between designer and stakeholders processes are presented, based on a cross-paper analysis.

Chapter 5, Proposed model: Findings of the cross-paper analyses and the appended papers are combined into a proposed triangle model. First, the triangle is used to examine the challenges in three main levels of planning. These are the comprehensive planning, detailed planning and building permit from a design, process and stakeholder perspective. Finally, a collaboration hub is proposed to decrease the impacts of problems between the design process, stakeholder management and formal process.
Chapter 6, Conclusions: The main findings of this research are presented, using the research questions as a basis to examine how well they are answered in this thesis.

1.6 List of publications

Appended papers:

**Paper 1: Time-geographic visualization of stakeholder values: a case study of city relocation**

Written by Tim Johansson and Kristina Laurell-Stenlund and published in the proceedings of the 6th Nordic conference on construction economics and Organization. Tim Johansson’s contribution was first to formulate the fundamental problems associated with the current stakeholder methods, which was carried out with Kristina Laurell-Stenlund. They also developed the idea of combining the stakeholder power-interests matrix with the time-geographic perspective to analyze stakeholders over time. Finally, the data collection was carried out by Tim Johansson, the transcriptions of interviews by Kristina Laurell-Stenlund and the analysis of the content by both authors. The writing was divided between the two authors.

**Paper 2: A communication platform to support decision-making in the Kiruna city relocation process**

Written by Tim Johansson and Rogier Jongeling and published in the proceedings of the 2011 EG-ICE workshop. The idea of developing a communication platform for a city relocation process was developed together by the first and second author. Creation of the theoretical framework and communication requirements platform was mostly realized by Tim Johansson under Rogier Jongeling’s supervision. Finally, Tim Johansson wrote the paper and the second author reviewed its language and content.

**Paper 3: Development of 4D public participation GIS to improve communication of city transformation processes**

Written by Tim Johansson, Timo Hartmann, Rogier Jongeling and Thomas Olofsson and published in the proceedings of the 2012 construction research congress. Tim Johansson formulated the main idea regarding the 4D public participation GIS. Feedback and improvements was given by the other authors. The theoretical framework was created by the first and second authors. Data
collection and analyzes were carried out by Tim Johansson. The writing was mainly shared between Tim Johansson and Timo Hartmann.

**Technical paper 1: BIM i infrastrukturprojekt: Kartläggnings av VDC-användning i Sverige**

Report in Swedish covering the use of virtual design and construction in infrastructure projects and published as a technical report. The study was suggested by Rogier Jongeling who helped the author to select relevant cases. Tim Johansson’s contribution was the creation of the interview guide, carrying out the interviews and the data analyses. The paper was written by Tim Johansson.

**Technical paper 2: The REVITAPLAN Triangle**

Written by Tim Johansson and Timo Hartmann and published as a technical report. The triangle model was developed iteratively by the authors, who jointly formulated the problem domains between the stakeholders, design and processes. The paper was mostly written by Tim Johansson.
2 RESEARCH METHOD

This chapter describes the scientific methods and the research design used.

2.1 Introduction

The research process

Research is a “systematic, intensive study directed toward fuller scientific knowledge of the subject studied” (Nunamaker and Chen, 1990). Ackoff (1972) argued that science is not possible to define, since the meaning of science changes while it develops. Within this process, questions are answered, problems are solved and methods used to answer the research questions posed (Ackoff, 1972). Ultimately, the purpose is to extend the current body of knowledge, to facilitate a learning process and to explain and construct a reality. It is often an organized, data-based, critical investigation of a specific problem (Sekaran, 2002).

Patel and Davidsson (1994) claimed that the research process is about identifying the problem, establishing the state of the art through a literature review, selecting methods for the research design, carrying out the investigation, analyzing and then reporting. Popper (1979) identified the following steps in the research process: formulate or generate hypothesis, collect data, explore the data, model then implement/monitor and sell the solution. Therefore, the process can vary due to the qualitative and/or quantitative nature of selected methods but also according to the kind of research being carried out e.g. basic and/or applied research, scientific or engineering research, evaluative or more development driven research.
Data collection and research methods

The research process is heavily influenced by the selected data collection and research methods. Selected methods impact the content of the different steps of the research process. As a result, the selected research methods influence the results and validity of the study (Fellows and Liu, 2003).

Methods are often classified as quantitative and qualitative. Quantitative methods are more formalized and structured to include experiments, mathematical modelling and statistical compilation of questionnaires, often resulting in quantitative data answering research questions of the type how many, how wide etc. In contrast, qualitative methods are more explorative and seek to identify aspects and understanding of specific systems by asking the questions how and why (Backman, 1998).

2.2 Research design

This research falls under the category of explorative applied research, where knowledge is used to develop solutions to problems of immediate concern. The following research strategies and methods for data collection were considered:

Case study research: "An empirical inquiry that investigates a contemporary occurrence within real life context, especially when the boundaries between phenomenon and context are not clearly evident." (Yin, 2009)

The case study method is used to examine phenomena in natural settings, using multiple methods of data collection to gain information from one or more people, groups or organization (Benbasat, 1987). It is a research strategy that focuses on understanding the dynamics of the present in a single environment. The researcher can either use a single case or multiple cases. Often, a variety of data collection methods are used to evaluate case studies e.g. archival data collection, interviews, questionnaires and/or observations. The observations can be of a qualitative and/or quantitative nature. Case study research is used to provide descriptions of phenomena, test a theory or generate new theories (Eisenhardt, 1989).

Individual interviews: are a verbal interchange, often performed face-to-face. The researcher tries to elicit and engage the respondent in order to collect knowledge, beliefs or opinions. The strength of this method lies in the fact that it provides opportunities to explore the meaning of the question, to elicit a
direct response to the question being asked and to clarify misinterpretations instantly. However, this method has weaknesses in that it can include possible errors in the interpretation, there is the potential for interviewer's bias and the successful collection of the data is strongly dependent on the skill of the researcher (Woksepp, 2007).

**Ethnographic research:** comes from the disciplines of social and cultural anthropology. An ethnographer spends a significant amount of time in the field where they immerse themselves in the organisation that they are examining. The researcher studies the organisation and tries to explain the observed phenomena from a social and a cultural context (Myers, 1999). Ethnographers focus on understanding experiences and social behaviours. It is, therefore, a method suited to study the work processes of project organisations (Hartmann et al., 2009). Hence, ethnographic research is appropriate for gaining rich insights into the organisational, social and human elements of information systems and application (Harvey and Myers, 1995; Hartmann et al., 2009).

However, the presence of ethnographers makes it difficult to examine the uncertainties caused by the research project (Fellows and Liu, 2003). Thus, the presence of a resident researcher is the main difference between the case study research method and the ethnographic research method. In contrast to the case study method, data are mainly collected from direct observations (Myers, 1999).

**Action research:** is an established method, used in social and medical sciences since the mid-twentieth century. In the late 1990s, it began to grow in popularity for application to scholarly investigations of information systems. The method is grounded in practical action, where the aim is to provide solutions while carefully diagnosing the problems. In this way, highly relevant research results are produced. The method is based on the assumption that complex social systems cannot be reduced. It is only possible to understand interactions between organisations and information technologies, in the context of a whole entity. The action research process is described in Figure 2-1.
The action research process is conducted in a client environment and contains the following steps: (1) diagnosing; (2) action planning; (3) action taking; (4) evaluating and (5) specifying learning (Baskerville, 1999).

The main difference between case study research, ethnographic research and action research is that, in the latter, the researcher is involved as a participant in the implementation process. Hence, action research has two objectives: first, to diagnose the system thus identifying problems and second, to contribute to the development of the system to solve the problems. As a consequence, the action researcher obtains in-depth understanding of the studied subject, which is a strength of the approach. However, the weakness of the method is the potential risk for lack of objectivity, since the action researcher shares the responsibility of handling the results with the client organisation. Also, generalization of the result to other situations may be difficult (Benbasat, 1987).
The use of a combination of case study, ethnographic and action research methodologies is common. The system development research method (Nunamaker and Chen 1990; Chiasson and Dexter, 2001) is a special case of action research using case studies to collect data (Baskerville, 1999). A project-centric research method that combines ethnographic observation of project practitioners in action research implementation cycles on information systems was proposed by Hartmann et al. (2009), see Figure 2-2.

![Figure 2-2: Combination of ethnographic observation and action research implementation cycles of information systems, by Hartmann et al. (2009)](image)

The research method selected in this research is an action research methodology applied to system development research (Nunamaker and Chen, 1990; Chiasson and Dexter, 2001). The system development research includes the following steps:

1. Evaluate weaknesses with the current way of communication
2. Define requirements and functionalities of a communication platform
3. Build a prototype platform
4. Observe and evaluate use
5. Develop new theories/models based on observation and evaluation of usage.

Steps 1 – 3 of the research method are described in this licentiate thesis. The research questions, data collection and results can be found in the appended papers. A single case study of the city transformation of Kiruna was selected as a basis of the first cycle of investigation, because case studies are suitable when studying complex processes (Yin, 1994). The following research questions (RQ) was formulated using the case study context:

**RQ 1**: *What are the most important aspects to be communicated in a city transformation process?*

**RQ 2**: *How can urban planning information be visualized and communicated to stakeholders to support a transparent decision-making process?*

**RQ 3**: *What are the requirements of a planning support system to manage such a process?*

Data collection consisted of interviews and archival data with the aim of understanding the challenges of participation and communication with different stakeholder groups. The link between data collection methods, appended papers and research questions is presented in Table 2-1.

*Table 2-1: Research questions, data collection methods and appended papers*

<table>
<thead>
<tr>
<th>Research question</th>
<th>Data collection</th>
<th>Appended paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Literature review</td>
<td>Paper 1</td>
</tr>
<tr>
<td></td>
<td>Interviews</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Literature review</td>
<td>Paper 2</td>
</tr>
<tr>
<td></td>
<td>Archival data</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Literature review</td>
<td>Paper 3</td>
</tr>
<tr>
<td></td>
<td>Interviews</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Archival data</td>
<td></td>
</tr>
</tbody>
</table>
The case study was complemented with a literature survey, covering theories such as stakeholder management, urban planning, participatory planning system, decision-making and virtual reality in iterative steps during the research and is included in the appended papers 1 – 3. The theoretical framework was used in the interpretation and analysis of the data collected in the case study.

2.3 Case study description

The underground mining activities in the area surrounding Kiruna are causing deformations that are spreading in the direction of the city centre. This process started in the 1960s, once a new underground mine was established. The first residential area was relocated in the 1970s. In contrast to previous relocations, the future city transformation is much more widespread. The deformation zone is moving towards the city centre which need to be relocated within the next 40 years. A city deformation map is shown in Figure 2-3, showing the constraints for different areas by illustrating when each area will require relocation. There are 313 apartments, the city hall, cultural buildings, parts of highway E10 and the railway that will be affected in the next decade (Kiruna kommun, 2012).

Figure 2-3: A city deformation map, showing three border lines that define areas that will need relocation before 2013, 2018 and 2023.
The selection of Kiruna as a case study was based on the unique opportunity to study a city transformation, which is going to take place over a relatively short time. This makes the process more visible and clear compared to urban transformations in other cities which take longer and cover a greater area. Furthermore, the urban planning is being carried out by a relatively small organization which makes the data collection easier. Direct contact with the city architect and the project manager and other staff at the planning office is possible on a daily basis. Observations were also made during several planning meetings. These contacts and observations made it possible to select suitable respondents for interviews as well as gaining access to and understanding archival data, such as reports, models, spatial data, city plans and illustrations. In summary, the case offered a good opportunity to obtain data from a variety of sources about an actual urban transformation.

The selected case was also a part of the larger research project "Nya Giron" which is funded by European Union regional research fund. Nya Giron is a multidisciplinary research project financing different research groups from Luleå University of Technology and the municipality of Kiruna.

2.3.1 Interviews

Individual interviews were carried out mainly with the staff of the planning department within the municipality of Kiruna. Complementary interviews were carried out with the mining company LKAB and the municipality-owned company Tekniska verken.

The interviews aimed to reveal the urban planners view of the city transformation. An interview guide was developed including interview questions regarding factors influencing change processes described in the change kaleidoscope developed by Balogun and Hope Hailey (1999), covering time, scope, preservation, diversity, capability, capacity, readiness for change and power as well as specific questions regarding stakeholder values. Supplementary questions were asked about communication and decision-making, which were linked to the previous questions, but from a stakeholder perspective. The interview questions were based on the following seven categories:
1. The first category covered the respondent’s background, with the aim of identifying past experience.

2. The second category examined the state of urban planning in order to identify the pros and cons of the current process.

3. The third category aimed to cover the organizational structure and the capability and readiness of applying new information and communication technology (ICT) tools for urban transformation.

4. The fourth category contained questions about the main stakeholders values and possible conflicting aims of the city transformation. The stakeholders that were interviewed were representatives of the municipality, the energy company Vattenfall, the Swedish transport administration Trafikverket and the mining company LKAB.

5. The fifth category included questions regarding the interests and power structure of the main stakeholders.

6. The sixth category covered communication and decision-making, in order to create a picture of the communication flow between the planners and stakeholders. A stakeholder map was constructed and used to obtain information about:

   - The stakeholders most frequently communicated with
   - Forms of communication
   - Demand of communication in different steps in the planning process

7. The last section contained questions regarding whether the respondent wanted to add something to the previous questions asked or add something they felt was missing and of relevance to the researcher.

The result was a description of problems in the city transformation from a stakeholder perspective by the professional planners. Furthermore, the
interviews were also used to identify the needs and requirements of the communication and visualization platform developed later.

2.3.2 Archival data

Archival data were mainly used for three purposes:

1. To create a stakeholder map by using public data from the municipality website. The stakeholder map shows the configuration of power and interests in the city over time and gives information on how the municipality communicates and makes decisions about urban plans. The stakeholder map was also used in the interviews to change or add missing stakeholder groups.

2. Archival data were used in the analyses of different subprojects in the city transformation. It included critical decisions, activities and different urban transformation processes. It was presented as a time line of how different stakeholders acted over time in relation to their power and interests.

3. GIS and 3D models were used to establish the first prototype of the 4D model of the city transformation. Later, this 4D model was integrated into a web-based VR interface.

2.3.3 Observations

The author took part in a large number of formal and informal planning meetings over a one month stay in Kiruna. These were documented as notes, which were later analyzed and re-written.

The author also participated in a number of meetings within the Nya Girion project. As a result, suggestions for improvements were obtained from other researchers and planners in the Swedish transport administration and the municipality regarding the early visualization prototypes and concepts.

2.3.4 Data analyses

Interviews and archive data were analyzed using the qualitative data analysis tool Nvivo (QSR N6, version 2002). The following categories were created:

1. Need for improvement in the communication and decision-making with external stakeholders in general.
2. Demand for enhanced communication of design and plans with visualization applications.
3. Demand for visualization of transition process in time and space.
4. Requirements and possibilities for the organization to improve communication using visualization applications.

The data analysis was carried out using a grounded theory methodology perspective developed by Glaser and Strauss (1967) and Glaser (1992), where new categories were developed from analyzing the data within the categories created from theory. Once the analyses were finished, requirements and functionalities for the first prototype were developed.
3 THEORETICAL FRAMEWORK

This chapter describes the theoretical framework upon which this thesis is based, see Figure 3-1

Figure 3-1: The theoretical framework.
3.1 City transformations

3.1.1 Transitions and transformations

Both of the terms “transformation” and “transition” have their roots in system theory (Shove and Walker, 2007). Transformation normally refers to an act, process or instance of transforming. It is defined as the passage from one system state to another, see Figure 3-2 (Yang, 2010).

Transformation is defined here as a continuous process between two system states in time. It is a process that aims to be well-planned, driven by endogenous forces e.g. policy, economic growth, governance. Transition, on the other hand, is a non-linear change process, mainly driven by exogenous factors such as fundamental changes in the political or economic system, such as an energy crisis or climate change. Transition is not about the re-orientation or change of an existing trajectory, instead it is more about creating a new one. Consequently, it is considered as more of a turning point and radical change from one state to the other (Yang, 2010).

*Figure 3-2: Transformation is a continuous process (the blue curve), while a transition is seen as a point shift, Yang (2010).*
The relationship between globalization and urban transformation has become an important element in urban studies over the last few decades. The local effect on the urban environment is discussed in the light of globalization processes and their implications on the economic, cultural and political spheres. Globalization is nowadays seen as an important aspect in the understanding of urban changes (Melchert, 2005).

Globalization is a result of a global economy where supply chains transform raw material to commodities on a global market. Through this mechanism, the supply of raw materials, processing of raw materials, production of components, assembly of products and distribution of finished products are integrated into a global interdependence (Knox, 1997). The link between urbanization and the global economy was explored in detail by John Friedman in 1986 in the article “World Cities Hypothesis” (Friedman, 1986). The economic force of globalization generates demands for transformations of metropolitan areas (Friedman, 1986; Melchert, 2005; Rotmans et al., 2000). However, the rapid urbanization and growth of megacities (Yang, 2010) has highlighted sustainability issues within society (Campbell, 1996).

3.1.2 Sustainable development

Currently, there is a consensus among scientists and politicians that the world is moving in an unsustainable direction (Yang, 2010; Rotmans et al., 2000). If cities are to be the driving forces of a more sustainable development of European regions (Rotmans et al., 2000), social and environmental values need to be strengthened within the transformation process and aim for more sustainable concepts such as green cities, eco-cities and the like (Carmona et al., 2002). However, the economic, social and environmental values in urban planning often conflict, see Figure 3-3. Planners face the problem of balancing environmental values whilst promoting economic growth of cities and advocating social justice (Campbell, 1996).
The involvement of a growing number of organizations, institutions and actors in the urban planning process results in more conflicting aims and objectives, thus increasing the complexity of a problem to which there are no objective solutions, only better or worse alternatives. The term “wicked problems” is used to explain the nature of the problems often found in city transformation projects, such as the location of new highways, railroads and building projects (Whelton and Ballard, 2002). The next section describes the characteristics of wicked problems.

3.2 Urban planning issues as wicked problems

3.2.1 Definition of wicked problems

The term “wicked problem” originates from a paper entitled “Dilemmas in a General Theory of Planning”. It was published in Policy science in 1972 by Horst Rittel and Melvin Webber, both urban planners at the University of Berkley (Ritchey, 2011). Problems were defined in two categories, as either being tame or wicked. Tame problems are those that are well-defined and it is
therefore possible to objectively evaluate the solution (Rittel and Webber, 1973). For this category, the end or goal of the problem is already prescribed or apparent. As a result, it is possible to provide a solution by appropriate means (Whelton and Ballard 2002). Normally, solutions are found using a linear problem solving method, often called the waterfall method, consisting of gathering data, analyzing it, then formulating and implementing a solution, Figure 3-4.

![Figure 3-4: Traditional method of problem solving applied to tame and wicked problems](image)

In contrast to tame problems, wicked problems are ill-defined. As a consequence, it is not possible to objectively evaluate the solution (Rittel and Webber, 1973). These ill-defined problems are usually too complex to solve using a rational systematic process (Whelton and Ballard 2002). Instead, the process of problem solution changes between understanding the problem and proposing a solution. Rittel and Webber (1973) characterized wicked problems as follows:

1. There is no definitive formulation of a wicked problem.
2. Wicked problems have no stopping rule.
3. Solutions to wicked problems are not true-or-false, but good-or-bad.
4. There is no immediate or ultimate test of a solution to a wicked problem.
5. Every solution to a wicked problem is a “one-shot operation” because there is no opportunity to learn by trial-and-error; every attempt counts significantly.

6. Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.

7. Every wicked problem is essentially unique.

8. Every wicked problem can be considered to be a symptom of another problem.

9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem’s resolution.

10. The planner has no right to be wrong.

### 3.2.2 Managing wicked problems

DeGrace and Stahl (1998) presented a three-step model to tackle wicked projects:

1. First, recognize that this is a wicked project. If the project is in need of satisfying participants who do not agree on fundamental issues about the project, then it is definitely a wicked project.

2. Second, see if the project can be tamed, something that is not easily done with a wicked problem. This demands executive support for a clear problem definition that all participants should agree on.

3. Third, use adaptive processes. Wicked problems are resolved through discussion, consensus, iterations so changes in solutions should be accepted as a normal part of the process.

In summary, city transformations are normally dependent on wicked problems as part of the urban planning processes. Within an urban planning context, these problems require a close and iterative collaboration with the involved participants. In the next part, we define these participants as stakeholders and examine how they can be mapped and managed.
3.3 Stakeholders

3.3.1 Mapping and managing stakeholders

City transformations include several projects with a large number of stakeholders. These are groups or individuals that have interests, rights or ownership in properties that are, to a greater or lesser degree, affected by the transformation. These stakeholder groups can contribute to, or interfere with and prevent, the realization of an urban project. Stakeholders are all, directly or indirectly, actively or more passively engaged in the decision-making process (Walker et al., 2008).

Different and often controversial points of view can contribute to the shared understanding among stakeholders of a project and generate new insights, ideas and artefacts (Arias et al., 2000). Johnson and Scholes (1999) argued that a stakeholder’s relative importance should be classified according to their interests and power, related to the specific organization. They created a stakeholder map in an attempt to explain how different stakeholder groups should be managed in relation to power and interests, Figure 3-5.

![Power-interest stakeholder map (Johnson and Scholes, 1999)](image)

Realizing change in the urban environment and sustainable development is strongly dependent on the involvement of stakeholders such as the public, social organizations and private enterprises within a region or city (Steinmann...
et al., 2004). This is one reason for using public administration and why stakeholder groups should be engaged in participatory spatial planning (Tress and Tress, 2003). Märker and Volkmar (2000) argued that there is interest in authorities improving their participation procedures in order to avoid the situation where projects are hindered, delayed or even stopped due to trials, legal judgments and public pressure, thus causing economic loss. The weakness of public participation can be related to the questionable comprehensiveness of explanations of plans, the sometimes selective invitation of stakeholder groups and finally the generally low level of public participation (Märker and Volkmar, 2000).

3.3.2 Decision-making

Formalised decision-making can be regarded as mental processes that result in the selection of a course of action chosen from several alternatives (March, 1994; Forman and Selly, 2001). Within rational decision theories, the decision-making process is often decomposed into a number of steps starting with 1) definition of the problem, 2) determination of the requirements and goals of the solution, 3) identification of alternatives that will solve the problem and 4) evaluation and selection of the best alternative. Normally alternatives are compared, using some kind of decision support mechanism, to the established requirements and goals of the solution. Schade et al. (2011) proposed a support tool applicable to decision-making in a structured design process, where design alternatives consisting of both objective and subjective evaluation criteria could be evaluated. March (1994) argued that within rational decision-making theories, alternatives are compared in terms of the extent to which their expected consequences are thought to serve the preference of the decision-maker. Sager (1999) claimed that planners often present their recommendations as the result of a rational choice process.

3.4 Swedish planning regulations

3.4.1 Introduction

There are several laws affecting urban planning in Sweden. Examples include the Road Law and the Railroad Construction Act, the Planning and Building act and the Environmental Code. The Swedish planning system for roads, railroads and land-use has several phases. Usually, the public interest is high on the agenda in the early phases whilst individual interests become more important the more detailed the project plans become. Consultation at the beginning covers a wide spectrum of interested parties while later, only the
stakeholder groups that are directly affected by the project outcome are consulted, Figure 3-6.

Figure 3-6: Outline of the Swedish planning process for infrastructure and land-use

The next section describes the regulations regarding the use of land in Swedish municipalities.

3.4.2 The Swedish Planning and Building Act

The following section is taken from the Swedish Planning and Building Act (PBA). The text has been simplified to some extent and some of the paragraphs have been removed. For a more detailed description of the Swedish planning regulations, the reader is recommended to read (http://www.boverket.se/). PBA consists of the three central planning stages in the planning of city transformations: comprehensive planning, detailed planning and building permits.
**Comprehensive planning**

The regulation states that:

*Each municipality shall prepare an up-to-date comprehensive plan, covering the entire municipality. The comprehensive plan shall provide guidance for decisions about the use of land and water areas and on the development and preservation of the built environment. The comprehensive plan is not binding on authorities or individuals.*

The plan specifies the land-use in a municipality including the specific national interests. The time horizon for the plan is 20 – 40 years.

**Regarding consultation:**

*The comprehensive plan shall record public interests subject to the provisions and the environmental issues and risk factors that warrant attention when decisions are made on the use of land and water areas. In this context, national interests of the Environmental Code shall be specified.*

Consultation with stakeholders happens with the purpose of improving the planning to enable insight and influence. Preparation of a consultation report is mandatory, presenting the results and proposals from the consultation.

The County Administrative Board, affected municipalities and individuals that have a vested interest in the proposal are also consulted. Here, the County Administrative Board’s primary function during the consultation is to safeguard and co-ordinate the public interests.

**Detailed planning**

The regulation of land-use and of building within a municipality is exercised through detailed development plans.

*The examination of the suitability of a site for development and the regulation of the design of the built environment are carried out through a detailed development plan for new continuous development; a new individual building, the use of which will cause a significant impact on surroundings; or a built environment, which is going to be altered or preserved.*

The detailed development plan needs to consider existing buildings, property rights and affected real estate.
Theoretical Framework

The detailed development plan shall indicate and set the limits of:

- Public spaces such as streets, streets, squares and parks;
- Development districts for, inter alia, built-up areas, sports grounds, leisure centres, graveyards, construction of traffic, water supply, sewerage and energy facilities as well as restricted areas and safety areas;
- Water areas for, inter alia, yachting marinas and other public leisure facilities. The plan shall specify the use and design of public spaces of which the municipality is in charge.

The time horizon for detailed plans is at least five years and not longer than fifteen years from the day when the decision to adopt the plan comes into force. Different areas of the plan may have separate implementation periods.

The detailed development plan may determine that building permits will not be granted until certain conditions have been fulfilled such as water supply, the demolition or construction of certain buildings etc.

**Building permits, demolition permits and site improvement permits**

A building permit is necessary in order to erect a building, make an extension to a building, use or adapt a building’s purpose, make alterations to buildings.

Demolition permits are granted if the building is not covered by prohibition against demolition in the detailed development plan or it ought to be preserved due to historical, cultural, environmental or artistic reasons.

Site improvement permits ensure that changes do not contravene a detailed development plan or area regulations, prevent or obstruct the affected area’s use for building, result in inconvenience to the users of e.g. defence constructions or involve disturbance to the environment.

A Building Committee examines an application for a permit (building permit, a demolition permit or a site improvement permit). Applications are normally made in writing and accompanied by the drawings, specifications and other relevant information needed for the examination.
The Building Committee shall also inform affected stakeholders, if the permit deviates from a detailed development plan or if it will be carried out within an area which is not covered by a detailed development plan and is neither a complementary measure nor specified in area regulations.

A building permit, a demolition permit or a site improvement permit will cease to be valid, if the measure has not been put into practice within two years and completed within five years from the date when the permit was granted.
3.5 Systems for the support of the urban planning process

3.5.1 Planning support systems

Planning support systems, PSS, consist of a wide diversity of geo-information tools developed to support urban transformation at any particular scale within a certain planning context (Geertman and Stillwell, 2004), see Figure 3-7.

![Figure 3-7: The planning process supported by a formal computation desktop PSS (Batty, 1995)](image-url)
PSS differs from decision support systems, computer models and optimization techniques in that they are not structured. Instead, they are often loosely coupled assemblies of computer-based systems, which aid urban planners to handle and manage their planning problems. For instance, a specific planning action within a planning department can use a transportation model, cost-benefit analysis software, qualitative tools and GIS. A PSS has the potential to offers all these types of techniques, which can be linked to specific planning actions in specific planning domains (Brömmelstroet and Schrijnen, 2010).

GIS is often an important part of a PSS because of its geo-processing, visualizing and modelling abilities. A GIS system is a general purpose system, offering tools for storing, manipulating, analyzing and presenting all types of geographically referenced data (Geertman and Stillwell, 2004; Maantay and Ziegler, 2006). Traditionally, GIS is used in for geospatial analysis in urban planning (Drummund and French, 2008).

PSS also consists of traditional tools for economic and demographic analysis and forecasting, environmental planning and land-use modelling. Other technologies such as expert systems, decision support, such as multi-criteria analyses and group decision support systems can also be a part of a PSS.

### 3.5.2 Spatial decision support systems

Spatial Decision Support Systems (SDSS) are a special kind of PSS. These systems are designed to support decision-makers in solving complex and semi-structured spatial problems. An SDSS is composed of four parts:

- The acquisition and management of spatial data
- The representation of geographical objects and their spatial relationships
- Carrying out spatial analysis
- The creation of map-based outputs

The system provides a framework for integrating a database management system with analytical models, graphical display and tabular reporting capabilities coupled with the expert knowledge of the decision-makers (Geertman and Stillwell, 2003 and 2004), see Figure 3-8.
PSS and SDSS have much in common. However, a PSS is generally regarded as a more holistic system, supporting planning practice with a variety of planning instruments. GIS is a tool which can be used as a component in both SDSS and PSS (Simão et al., 2009; Brömmelstroet and Schrijnen, 2010; Geertman and Stillwell, 2004)

Many studies have shown that the implementations of PSS in daily planning practice is nor according to expectation, particularly in the early planning phases (Brömmelstroet and Schrijnen, 2010). This could be related to the lack of communication between the PSS developers who, in general, focus on technical issues and potential PSS users (Brömmelstroet and Schrijnen, 2010). The tools do not readily fit the changing needs of the planning profession since they are too generic, complex and incompatible with most planning tasks, being oriented towards technology rather than problems (Geertman and Stillwell, 2003 and 2004). They are also incompatible with the management of less formal and unstructured information (Brömmelstroet and Schrijnen, 2010).

### 3.5.3 Public Participatory Geographical Information Systems

The benefits of public participation in urban planning are widely documented (Al-Kodmany, 1999; Halvorsen, 2003; Lane, 2005; Stern et al., 2009). Participation helps the public to feel a stronger sense of commitment, increases their own satisfaction, builds trust and creates realistic expectations of the
outcomes (Al-Kodmany, 1999; Brody et al., 2003). If key stakeholders are involved in the early stages, it is possible to create a sense of ownership of the content of the plans (Brody et al., 2003). Hence, earlier and greater public involvement increases the likelihood of success (Wu et al., 2010). Brody et al., (2003) explained that early participation makes it possible to avoid potential long-term conflicts, because stakeholders feel responsible for the plan’s content in relation to planning policies. Involvement and public participation at an early stage uses time and adds cost. However, this upfront investment can pay off, at a later stage, when it comes to agreements on policy and implementation. Additionally, individuals and organizations bring valuable knowledge and innovative ideas regarding their community, which can increase the quality of the adopted plans (Brody et al., 2003).

Web-based techniques for public participation allow people to participate anytime and anywhere. Public Participatory Geographical Information Systems (PPGIS), Community Information Systems (CIS) and Public Participatory Spatial Decision Support Systems (PP-SDSS) are all examples of concepts for describing and allowing the two-way exchange of planning information and knowledge in order to support collaborative design and decision-making (Barton et al., 2005). A web-based two-way exchange of plans provides a greater accessibility for the wider public, along with a potential to allow the sharing of ideas and remarks. These are qualities that are essential for increasing the public involvement and contribute to empowerment and trust, both for local planning authorities and the planning process (Stern et al., 2009).

### 3.5.4 4D modelling systems

The use of 4D visualization in public participation is a new application and requires high quality 3D models in order to provide a clear visual representation of time and scheduling aspects (Stellingwerff and Kuhk, 2004). 4D visualization combines 3D models with time-related data and has the potential to visualize past, current and future scenarios plans, process and activities; it has been extensively used to visualize construction plans (Koo and Fischer, 2000; Jongeling and Olofsson, 2007; Hartmann et al., 2010).

Visualization of urban planning is limited to 2D and 3D representations of existing or new designs and plans. However, transitions take place in time when an urban area changes from its original state into a new planned state. Intermediate activities and incremental changes need to be visualized, to better grasp the social and spatial consequences of an urban transformation process.
(De Vries et al., 2009). Such an approach to visualize the change over time and space was presented by Pak and Verbeke (2010) who used a virtual environment to represent, communicate and analyze urban development projects. 4D models were used to map the changes of different zones in Brussels with opportunities to leave comments on geo-referenced place markers. De Vries et al. (2009) presented a prototype system for the modelling and visualization of a dynamic plan for urban areas that were to be redeveloped. However, De Vries et al. (2009) and Pak and Verbeke (2010) did not provide a clear method of how to visualize the status of current and planned activities. A development activity, as such, is complicated and includes many status levels and sub-activities. However, the current 4D modelling prototypes can only show one plan at a time whereas there is a need to visualize many kinds of urban plans with different statuses simultaneously, to support communication of complex city transformation processes with the public.
RESULT AND ANALYSIS OF APPENDED PAPERS

This chapter presents an analysis of the results from the three appended conference contributions.

4.1 Time-geographic visualization of stakeholder values: A case study of city relocation

The first paper investigates how the influence of different stakeholder groups in a city transformation process varies over time. A simple stakeholder management model is presented considering the time-space aspect, see Figure 4-1. The power and interest model (1) by Johnson and Scholes (1999) is combined with the time-geographic perspective (2) by Hägerstrand (1953), to create a power-interest-time cube (3), where changes over time can be visualized with the trajectories shown in (4).

The model was used to examine the stakeholder groups in the city transformation of Kiruna. From a timeline of important activities in the city transformation based on secondary data and interviews, the actions and values of different stakeholders involved were analyzed. The trajectories of the key players were drawn in the cube. As an example, the energy supplier Vattenfall had initially both a great interest and power (influence) in the city transformation process, which later changed when their main project was completed.

The conclusion is that the power and interests of different stakeholders change over time in a city transformation process. It also shows that it is important to continuously map the power and interest of different stakeholder groups.
Hence, to support communication and decision-making, information about future activities in both time and space need to be disseminated to all stakeholders. This is a major challenge when the power-interest map is continuously changing. Therefore, time-space information needs to be created, shared and used in a simple and efficient way to handle the different stakeholder’s values, power and interest.

Figure 4.1: Showing the process of merging the stakeholder matrix with the time-geographic perspective into the power-interest-time cube.
4.2 A Communication Platform to Support Decision-Making in the Kiruna City Relocation Process

The second paper investigates important principles in establishing a communication platform to support decision-makers in urban planning. Two perspectives were used: the problem solving perspective and the decision-making perspective. The rational problem solving approach (i.e. the waterfall method) includes a number of steps to reach a solution which can be evaluated from a list of criteria. The second perspective emanates from the definition of wicked problems and proposes a more non-linear and iterative process, since it is not possible to define a unique solution, only better or worse alternatives.

The wicked projects perspective is used to identify problems, requirements and goals that involved stakeholders can agree on. Here, collaboration and discussion between stakeholders is fundamental in order to create a common picture and a list of criteria for the future developments of the city. Rational decision-making can be based on established criteria using indicators that evaluate the performance of urban planning alternatives.

The following principles and requirements for a communication platform supporting the city relocation process are considered to be important:

1. **Understanding of plans:** the visualization should explain and create a common picture of requirements and goals, alternative solutions as well as consequences. A suitable communication platform is the creation of 4D models of prospective time and space plans.
2. **Collaboration & communication:** these support participation and engagement among the stakeholder groups. It is important to have accessibility, usability, interactivity and traceability in order for the involved parties to communicate effectively with each other.
3. **Evaluation of alternatives:** it is impossible to find the optimal solution within urban planning, therefore alternatives can be found through comparisons between alternatives and project requirements and goals.
4. **Design iterations:** adaption of information management towards redesign through discussion, consensus and iterations accepted as a normal part of the process.

It was concluded that the recent development of information technology, such as Google Earth and social networks e.g. Facebook and Twitter, has produced a
great number of opportunities to create a communication platform. However, it is unclear how these tools and services should be integrated to support the communication processes and decision-making in urban transformation processes.

4.3 Development of a 4D Public Participation GIS to Improve the Communication of the City Transformation Processes

In the third paper, a 4D public participation GIS platform was developed in a system development research process. The objective was to:

1. Evaluate weaknesses in the current methods of communication
2. Define requirements and functionalities of a communication platform
3. Build a prototype platform
4. Observe and evaluate use
5. Develop new theories/models based on observation and evaluation of usage

Steps 1 and 2 were analyzed using a case study where 10 urban planners were interviewed. The interviews focused on understanding the communication between the municipality and external stakeholder groups. The most difficult stakeholder group to communicate with was the public. The following weaknesses were also found:

- plans were scattered and hard to understand
- alternatives were not communicated properly so that the public could participate

As a result, we set up three requirements for the development of a prototype 4D Public Participation GIS (4D PPGIS) communication platform within a city transformation context:

1. Time-space urban planning information must be available and clear for the public to comprehend.
2. The communication platform must support two-way asynchronous communication for collecting public opinions and proposals.
3. The user interface, operations and management of the platform must engage the public in participation in the urban planning process.
A prototype 4D PPGIS based on the requirements was then created using the Google Earth API and Facebook, see Figure 4-2.

**Figure 4-2:** Showing the comprehensive plan and six phases of detailed planning.
4.4 Cross-paper analyses

In the first paper, insight regarding the importance of stakeholder management was evident. Also, the continuously changing stakeholder relationships over time added to the complexity of city transformation processes. Hence, effective and integrated communication processes are important to ensure that different stakeholder groups feel that their perceived values, requirements and views are taken into account during the urban planning.

The result of paper 1 leads to paper 2. Values and requirements can only be transferred when there is close communication between stakeholders and urban planners (Davis et al., 2006). Previous research have shown that virtual reality can provide a tool to provide a common picture and explain the content of planning proposals (Roupe, 2009; Johansson, 2010). The result of such a process should finally lead to transparent and well-balanced decisions regarding land-use. City transformation is about the changes in land-use over time. Stakeholders need to understand the status of the urban plans in different phases. Time-space modelling (4D-CAD) was a technology developed in the 1990s (Wang et al., 2004; Collier and Fischer, 1995) subsequent studies of its use have shown that it can be of benefit to the communication of project plans to both professionals and non-professionals involved in the building process (Hartmann, 2010 and 2011; Mahalingam et al., 2010). 4D modelling is essentially a VR technology, visualizing activities in time and space, making it suitable for creating a more comprehensive picture of urban plans than the current mix of planning documentations, sketches and schedules.

This conclusion in papers 1 and 2 leads to paper 3 and the development of an experimental 4D PPGIS, using the Google Earth visualization engine and Facebook as an interface for the communication of urban design plans. The visualization should be able to cover past, current and the future states of urban plans in different detail and at different scales. The result of the communications such as comments, suggestions for improvements etc. should be able to be connected in time and space. However, the prototype has a number of limitations, especially regarding the relationship between design proposals, the urban planning process and stakeholder management:

First, the prototype only supports setting status levels on current activities. However, 4D models at a city scale should also be able to represent historic as well as future activities. Stakeholders can invest in activities to support the
realization of future plans and learn from the outcome and experience feedback of historic plans and activities.

*Second,* a better connection between the support system and the underlying planning process is needed. The system needs to be a support for the individual project in the urban planning as well as a support for the coordination of all projects. *Third,* the underlying design models used to generate the design proposals need to be transferred and published on the web-based support system through an authorizing publication system.

*Fourth,* according to the theory, the way in which stakeholder groups should be treated depends on their power and interests. Therefore, the system should support different views and exchange of information with different stakeholder groups. To conclude, the urban planning process is dependent on three key components which are closely interrelated: (1) the process, (2) the design (urban plan) and (3) the stakeholders involved in the city transformation. In table 1, three scenarios are presented where an urban project fails to satisfy one of the key components.

*Table 4-1: Relationships between process, stakeholder and design components.*

<table>
<thead>
<tr>
<th>Project fails to:</th>
<th>Reaction</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage stakeholders and analyze their power and interest.</td>
<td>Unsatisfied stakeholders delay, hinder and stop planning process</td>
<td>Demands from stakeholder result in a change of design and formal processes.</td>
</tr>
<tr>
<td>Identify and monitor process constraints.</td>
<td>Permissions to realize possible designs are delayed or not accepted by public authorities.</td>
<td>The requirements of the formal process are not fulfilled, the result is a restart of the formal process.</td>
</tr>
<tr>
<td>Fulfil the design requirements.</td>
<td>Unsatisfied stakeholders. Result is that the plan is not approved.</td>
<td>A new design is needed. Design, stakeholder engagement and formal processes need revision.</td>
</tr>
</tbody>
</table>
5 PROPOSED MODEL

In this chapter, the proposed model is presented based on the results of the cross-paper analyses and the theoretical framework.

5.1 Introduction

The cross-paper analysis in the previous chapter listed the design, the process and the stakeholders as important components in urban transformation projects:

- the stakeholder component includes the public, groups, organizations, members or systems who affect or can be affected by the process component
- the process component consists of activities and decision gates including regulatory constraints that are necessary to fulfil in order to reach the goal of the urban process
- the design component includes documents such as descriptions, analysis, models of city plans, buildings and infrastructure in different states including “as proposal”, “as planned”, “as built” etc.

These components interact and need to be managed in any urban planning process. Therefore, a planning support system needs to include tools to manage the stakeholders’ involvement in the process, the evolutions of plans, designs, analysis, reviews of the urban transformation over time and the flow of information along with feedback to and from design and stakeholders, see Figure 5-1.
1. **Stakeholder - process**: The connection between stakeholders and the process component is two-fold. Stakeholders initiate urban processes in order to fulfil needs and requirements. Urban processes also need to involve and engage stakeholders to allow for proposals and feedback from both public and private interests.

2. **Process - Design**: Urban processes schedule activities for the development of design components. However, design components can also trigger urban processes such as in the case of the process of granting a building permit.

3. **Design - Stakeholder**: Urban design components need to be shared with involved stakeholders such as the public, neighbours and other affected organizations. The information flow must be two-way allowing the collection of comments and feedback on the design components from involved stakeholders.

*Figure 5-1: Components of urban transformation processes.*
5.2 The Swedish PBA from a stakeholder-process-design perspective

The Swedish Planning and Building Act (PBA) regulates three levels of urban processes, as described in chapter 3: comprehensive planning, detailed planning and building permits. These urban processes have different components regarding stakeholders, process and design and different patterns regarding the interaction between these components. There now follows a proposal of how the three levels of urban processes can be described from the process-stakeholder-design perspective.

5.3 Comprehensive planning

Figure 5-2 shows the urban planning model for a comprehensive plan. The model consists of three parts: planning content, stakeholders and the planning stages. The urban planner is placed in the middle, managing the planning stages, plan content and stakeholders.

Figure 5-2: Planning content, stakeholders and planning stages in comprehensive planning
Figure 5-2 shows that the urban planner needs to ensure the following flows (1 – 3) occur such that:

1. The stakeholder understands the plan content and that their response is integrated into the plan (1). Stakeholders need to be informed of planning contents and the current status of on-going activities (3). The comprehensive planning stages are dependent on clear communication of plans with stakeholders.
2. The plan content is finished on time to support the planning stages.
3. Stakeholders are aware of the planning stage and engagement in order to fulfil the requirements and response needed for decision-making.

A successful comprehensive plan is dependent on the coordination of the planning stages with the stakeholder matrix. For example, land and water use are important issues affecting a certain group of stakeholders whilst the development of the built environment and understanding of environmental effects involves other groups of stakeholders.

These steps are important within all planning stages because:

- Consultation with stakeholders at the beginning of the comprehensive planning stage ensures that needs and requirements can be integrated in the plan.
- Once the plan content is finished, the planners are obligated to have an exhibition to gain approval and to get feedback from stakeholders.
- Political support is necessary to gain approval for the plan by the municipal council.

An understanding of the planning stages, stakeholders and planning content is important for a successful comprehensive planning process. Therefore, an analysis of existing comprehensive plans for Kiruna from 2006 to present was carried out. The results are presented in Table 5-1. The documents describe the current conditions and future scenarios, with some maps appearing in more than one document. Urban planners face the challenge of making these documents understandable to both the stakeholders and the decision-makers.
**Table 5-1:** Summary of documents included in comprehensive plans from 2006 until present.

<table>
<thead>
<tr>
<th>Data</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comprehensive plan</strong></td>
<td></td>
</tr>
<tr>
<td>Aerial images</td>
<td>~100</td>
</tr>
<tr>
<td>Maps</td>
<td>~60</td>
</tr>
<tr>
<td>Pages</td>
<td>~230</td>
</tr>
<tr>
<td><strong>Environmental impact assessment</strong></td>
<td></td>
</tr>
<tr>
<td>Aerial images</td>
<td>~60</td>
</tr>
<tr>
<td>Maps</td>
<td>~70</td>
</tr>
<tr>
<td>Pages</td>
<td>~150</td>
</tr>
</tbody>
</table>

Urban planners also need to integrate feedback from different stakeholders into the comprehensive plan. The collected feedback from the consultations on the comprehensive plan in Kiruna are listed in Table 5-2.

**Table 5-2:** Summary of stakeholder feedback on the comprehensive plan

<table>
<thead>
<tr>
<th>Stakeholder Groups</th>
<th>Consultation 1</th>
<th>Consultation 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual stakeholders(Public)</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>Local Stakeholder groups</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>Political Parties</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Local planning institutions</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Regional stakeholders</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Country stakeholders</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>52</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

The amount of feedback from the public group is considered as low. This is also supported by the interviews with the urban planners. The lack of stakeholder engagement in the early stages can be detrimental to the downstream process since stakeholders can appeal against the plan during the detailed planning stages.
5.4 Detailed planning

Figure 5-3 shows the proposed model from a detailed planning point of view. The detailed planning phase in Sweden consist of four stages: program consultation; plan consultation & feedback; review and exhibition; approval, control and acceptance. In contrast to the comprehensive planning, the land-use regulations are legally binding.

---

Figure 5-3: Detailed planning

In the first planning stage, the program consultation phase, the urban planner collects opinions and ideas from the stakeholders in order to create a strategy and to define requirements for the plan. In the second stage, a plan is created for the specific area showing the outlines of the city blocks, building
regulations and use of public spaces. The plan is reviewed and put on display for several weeks. The plan is then either approved or not by the municipality council. Regional and government authorities then control the plan and, if no additional appeals are made, the plan is finally accepted.

5.5 Building permit

In Figure 5-4 the building permit process is shown.

Figure 5-4: Building permit

The building permit planning stage consists of application and registration, acknowledgement and environmental control, consultations with neighbours, decision and feedback. In this phase, neighbours are more important than the general public compared to the earlier urban planning processes described. Since the drawings and descriptions are provided by the building permit applicant, the role of the urban planner is different than in other planning stages. The support system should support the client rather than the urban planner. The support system can include a web-interface where the client can...
upload files and where both the client and the urban planner can validate the content using a common interface.

Neighbours have access to the support system using a special login so the urban planner can share the model or drawing created by the client. Furthermore, this information can be checked by a responsible planner within the municipality.

5.6 Integration of comprehensive planning, detailed planning and building permits

A stakeholder collaboration hub is proposed that integrates stakeholders and a variety of plans, at several stages, with a variety of plan content. This provides the right stakeholders with right plan at the right time with a time-space context. The main purpose of this is to increase the number of suggestions from individual stakeholders groups, as they are able to leave feedback anywhere, anytime via the collaboration hub, see Figure 5-5.

Figure 5-5: Collaboration hub is defined with a number of stakeholders.
6 CONCLUSIONS

In this chapter, the research questions are answered, there is a discussion of the contributions made, an examination of the research validity and generalization and a direction for future research is proposed.

6.1 Addressing the research questions

This research is based on the hypothesis that: “4D visualization enhances the opportunity to create transparent, accessible and understandable plans for stakeholders to support communication with urban planners.” Based on this, three research questions were formulated, which are answered in this chapter.

RQ1: What are the most important aspects to be communicated in a city transformation process?

From the literature review, we conclude that communication in a city transformation is dependent on the following:

- **Transformation forces**: It is necessary to understand the endogenous forces driven by, for example, policy, economic growth and governance. These forces are the inputs to the transformation process that create an external demand for the city.

- **The wickedness**: A city transformation includes several projects that have a wicked character. Stakeholders should recognize the characteristics of the wicked problem and use adaptive and iterative processes. Communication should support this pattern.
Stakeholder demands and values: Values and demands, i.e. the problem definition, need to be communicated early and be identifiable in planning proposals.

Planning stages and alternatives: The different planning stages require different strategies regarding stakeholder communication and collaboration. The communication of planning alternatives need to consider involved stakeholders power and interest. Performance indicators can be used to support the understanding of the impact of different alternatives.

Planning regulations and decisions: Stakeholders need to understand the planning regulation controlling the decision-making process. This is fundamental in order to be able to leave meaningful feedback and remarks about the planning proposals.

The single case study revealed two main challenges in city transformation of Kiruna. First, stakeholders power and interest change over time. For instance, the decision-makers are dependent on the project, i.e. they change according to the power and influence they have in the project. This is difficult to communicate and understand for the public. Second, current methods of communication of planning proposals do not encourage the public to participate in the city transformation process. Hence, public values and views becomes difficult to evaluate and consider in the urban planning.

RQ2: How can urban planning information be visualized and communicated to stakeholders to support a transparent decision-making process?

The literature showed a number of techniques to enhance communication and visualization with the public and other stakeholders. Improved public participation was essential and leads to four identified benefits. First, it helps the public to feel a stronger sense of commitment. Second, it creates a feeling of ownership that increases the likelihood of success. Third, it can avoid long-term conflicts. Fourth, it collects innovative ideas and valuable knowledge from individuals and organizations. Planning support systems and visualization can support this further by:

- Improving the accessibility of the plans to the public;
- Enhancing the opportunity to share ideas and remarks;
- Supporting collaborative design and decision-making.
Conclusions

Adding a time dimension to the visualisation of plans can support:

- Visualization of the transition from an original state into a new planned state;
- Presentation of the spatial consequences of an urban transformation process over time
- Visualization of the dynamic of urban planning under re-development

The single case study indicated that a majority of the public was not aware of the ongoing planning process of the city transformation. A planning support system enhanced by 4D visualization can help stakeholders to understand the process and also to communicate their demands and feedback in due time in democratic planning of city transformations.

RQ 3: What are the requirements of a planning support system to manage such a process?

From the literature review and the case study, the following requirements for a planning support system were identified:

- **Support Iterations**: Support for iterations and change of the planning content as support for an adaptive and democratic process.
- **Visualize plans and status**: Make the stakeholders aware of the status of plans, the planning stages and type of plan.
- **Visualize the planning content**: Show the visualization of different land-use and building environment proposals combined with performance indicators to understand the outcome of the proposals.
- **Stakeholders views**: Adapted views according to stakeholder requirements, scales and time horizons, power and interests.
- **Support of two-way asynchronous communication**: To collect public opinions and proposals and give feedback.
- **Simple user interface**: Easy to use interface to engage the public in participating in the urban planning process.

These requirements are mostly related to the end-user experience the interfaces in the support system. However, the system also need to keep track of design data and planning information as well as information coming from stakeholders.
4D IN CITY TRANSFORMATIONS

6.2 Contributions made

Four main contributions were made in this thesis.

1. A dynamic stakeholder management model was integrated in the urban planning process. Here it was shown that stakeholders’ power and interests vary over time. A model was developed to visualize the changes in power-interest over time as trajectories in a cubic stakeholder management model. The existing stakeholder matrix only focuses on static conditions. The cube model can be used to investigate stakeholders' change in power-interests in different projects over time as a mean to understand the changing roles of decision-makers.

2. A communication platform, based on the wicked problem perspective, was designed to guide rational decision-making by incorporating the following features in the requirements: understanding of plans, collaboration & communication, evaluation of alternatives, support for design iterations. These features were used to propose a conceptual communication platform including 4D visualization and social media to provide collaboration and communication functions. The main contribution consisted of adding the 4D visualization to support the process perspective of urban planning.

3. A first prototype of the communication platform was realized based on Google Earth and Facebook including:

- Time-space visualization of urban planning information.
- Support of two-way asynchronous communication for collecting geo-referenced public opinions.

It was concluded that 4D visualization of the urban planning process offers opportunities for the public to better understand a city transformation proposal, an understanding that is vital for increasing the level of participation, engagement and credibility.

4. A generic model of urban planning processes was developed, as described in chapter 5, to examine the relationship between stakeholder, design and process more deeply. It was concluded that a PSS must support process, design and stakeholders in order to be efficient. The
model was tested against the regulatory framework of the Swedish Planning and Building Act including comprehensive plans, detailed plans and the process of granting building permits. This gave a better understanding regarding the scale and level of details in the planning content, the various planning stages and the different management of stakeholders. The development of a generic PSS collaboration hub was proposed to support the different levels of urban planning processes in a city.

6.3 Validation and generalization

This thesis is based on a single case study and only stages 1 – 3 of the system development method was carried out. As a result, validation and the generalization of thesis are low and only applicable to Swedish conditions. However, in respect of known knowledge, the result of interviews and observations in the single case study and the theory in the literature review appear to be in agreement. The result so far is promising enough to carry on with last steps in the system development method.

6.4 Suggested further research

The next step of this research is to develop the prototype platform further to support the planning model proposed in chapter 5. Once this is achieved, steps 4 and 5 can be carried out in the system development method consisting of:

1. Evaluate weakness with the current way of communicating
2. Define requirements and functionalities of a communication platform
3. Build a prototype platform
4. Observe and evaluate use
5. Develop new theories/models based on observations and evaluation of usage.

The further research is proposed to be carried out using the city transformation of Kiruna as case involving the public and the urban planners as main stakeholder groups in the study.
REFERENCES


Analysis of online public participatory GIS applications with respect to the differences between the US and Europe


Paper I
Successful construction projects include stakeholder management. However, it still is difficult to communicate stakeholders’ interest in the early planning processes of complex building projects due to different stakeholder groups and their conflicting values. The question of how city relocation processes are influenced by stakeholder values is investigated in a case study. Secondary data from municipality public information and two in-dept interviews made it possible to analyse stakeholder’s action and their values in a city relocation process over time. A time-interest-power model is developed from the analysis. A city relocation project will be influenced by stakeholder’s power and interest. However, power and interests are influenced by the perceived values for the different stakeholders. Therefore, communication is important in order to identify values and needs of the many stakeholders in the city relocation processes. One problem for the decision makers is the development of good communication channels especially with the citizens.

KEYWORDS: city relocation, stakeholder values, time-geographic perspective

INTRODUCTION

Previous studies have shown that stakeholders actively engaged in construction projects may positively or negatively affect the result of the project (Olander & Landin, 2008). Identifying stakeholders by mapping and visualising their influence on project management processes may have a significant impact on the success of projects as well as on project management according to Walker et al. (2008).

A model for analyses of city relocation processes and their influence by stakeholder values with a time-geographic perspective is argued to be of interest for project management. With a city relocation process we describe the complexity of city planning processes ongoing parallel with design and construction processes conducted by actors. Stakeholders influence is investigated in terms of interest and power followed by a discussion of methods for analysing stakeholder values with a time-geographic perspective. Data has been collected within a case study to develop the model discussed in the final section of the paper.

INTERESTS AND POWER

Stakeholders can be identified with different theoretical perspectives. However, these perspectives are in some sense conflicting with each other. One perspective is based on stakeholder roles. Winch (2002, p 67) suggest that stakeholder groups should be described as
internal and external stakeholders depending on their relation to the project or organization. According to Winch (2002) internal stakeholders have an active role in the construction project acting as clients, financiers and users on the demand side. External stakeholders on the other hand, act as architects, engineers, contractors and materials suppliers, on the supply side. The research presented by Walker et al. (2008) supports this view by describing how upstream, downstream and external stakeholders may influence internal stakeholders, i.e. project teams. Upstream stakeholders include end users and paying clients organisations. Downstream stakeholders include suppliers and subcontractors. External stakeholders are all groups that in one way or another will be influenced of and by the project (Walker et al., 2008).

Another perspective is when identifying stakeholder groups based on their power influence on the project or organisation. Chinyio and Akintoye (2008) argue that it is important to quickly identify key stakeholders in the early phase of a construction project, i.e. those stakeholders with high power and urgency. Power can be recognized more easily by identifying the one who will authorize a certain key decision, because the urgency of stakeholders changes (Chinyio & Akintoye, 2008). Johnson and Scholes (1999) argue that stakeholder’s relative importance for organisations should be investigating by stakeholder groups’ degree of interest and power related to the specific organisation. Olander (2006) investigated stakeholders’ relationships focusing on roles by identifying their level of power and interests.

Johnson and Scholes (1999) presented a power interest stakeholder map which can be seen in Figure 1. This approach is an attempt to explain the influences of different stakeholders within in a project in relation to interests and power, e.g. a stakeholder high interest and power are defined as key players. Stakeholders with high interest but with a low power impact need be informed of the progress and activities of the organisation or project. Stakeholders with low interest and low power are of minor interest but stakeholders with low interest and high power need to be taken care of. Olander (2006) argued that one problem with the approach is that the scale is limit to either low or high power and interest values.

Figure 1: The power-interest stakeholder map. Source: Johnson and Scholes (1999).

For all groups it still is important to investigate if their level of power and interest change over time due to activities related to the specific categories.

Even more complicated are the questions regarding city relocation processes and how the various numbers of related and complex construction projects performed during different
time periods are influenced by stakeholder values. According to Freeman (1984) and Mitchell et al. (1997) some stakeholders have a strong influence on society, i.e. legitimate demands and power to use their values when putting pressure on politicians and private and public organizations. Hence analysing changes of stakeholder impact over time, needs a time-space dimension and we suggest a further investigation of how to analyse stakeholder values with a time-geographic perspective.

STAKEHOLDER VALUES: A TIME-GEOGRAPHIC PERSPECTIVE

The value concept in construction is in general described in terms of quality referring to product, services, functions, etc. which fulfil the client’s needs and requirements according to Wandahl et al. (2007). Saxon (2005) defines value as it is what you give in relation to what you get and it is personal and not an objective fact. Wandahl et al. (2007) argue that values are principles by which we live. Hence, values are visualized by the individuals’ habits and manifested in society by people’s attitudes presented by Banyard and Hayes (1994: 378-399). According to Barrett (2007) stakeholder values should be managed and balanced in the building processes. Managing stakeholder values also gives an understanding of the business concept according to Saxon (2005). Public construction clients have described their values of public building project for cultural activities, i.e. Houses of Culture (Laurell-Stenlund, 2010). These values were generally described as human beings expectations grounded in personal beliefs, social norms and rules developed in society or related to specific groups, i.e. they are culturally conditioned.

The cumbersome matter is how city relocation processes are influence by stakeholder groups over time at different locations. Out of this point of view we suggest a time-geographic perspective as one way of developing a model for analyses of stakeholder values including time and space.

Time-geographic builds on a holistic approach of how projects are fulfilled by the resources that the actors have access to and constraints they experience (Hägerstrand, 1985; Thrift, 2005). With a time-geographic perspective we analyse resources and constraints for activities in time and space, which are considered inseparable parts of the time-space dimension. The time-geographical view of the world combines the view of objectivity in natural science with the social science view of subjectivity (Hägerstrand, 1976). The approach has become a foundation of different forms of analysis such as innovation diffusion studies (Rogers, 1962/2003) as well as everyday life in households (Ellegård & Wihlborg, 2001).

Our view on the time-geographical analysis is on the actors’ roles, arrangement of resources and constraints in time-space. The use of time and space is fundamental for all social and natural scientific processes, but still not commonly integrated as an explicit precondition for scientific analysis. Hägerstrand’s ambition was to create a notation system for making processes (irrespective of whether they were human or non-human) visible in the time-space.

As a geographer his starting point was the map as a horizontal illustration with time added as a dimension emerging vertically above the map, and he thereby developed the now classical illustration of time and place (Figure 2).
We suggest that the time-space notation system (Figure 2) could be used to analyse processes in time and space. In the time-space trajectories, e.g. different actors’ movements, can be illustrated. By identifying stations in time-space, location for specific activities and the relation between them can be illustrated (Hägerstrand, 1953).

In Figure 3 individuals actions are illustrated by defining two stations indicated by $S$, which may be for example a home and a school (Hägerstrand, 1970). The thick line $f$ is a trajectory of an actor, leaving $S_1$, visiting $S_2$ and returning to $S_1$. The two stations visualised in Figure 3 could also describe trajectories in virtual spaces, e.g. movements between interest and power.

In Figure 4 the space is presented as an interest-power stakeholder map (Johnson & Scholes, 1999) illustrate movements between stakeholders’ interest and power with a time perspective. By illustrating different actions or activities in a time-space dimension the change between interest and power should be possible to visualize, see Figure 4. There may be many reasons for the outcome in time-space, but they all fall back on the basic issue of who was actually in possession of the time-space when a specific process took place, i.e. who has the power and who is able to influence on the action.
RESEARCH METHOD

Our research method, a case study, is based on Yin (1994) arguing that case studies are suitable when studying complex processes in general. The case study was chosen based on its possibilities to include different types of data collection and analysis methods within one single case.

Case selection
Our case is the city relocation processes taken part in Kiruna which is causing changes in the urban environments by phasing out and the creation of new urban areas. The city relocation in Kiruna is complex causing high pressure on several construction processes taking part during a long time period.

The selected case is a part of a study within the Nya Giron project which is a European Union research financed project for the relocation of the city of Kiruna. The project is a multidisciplinary project consisting of a research cluster with six different research groups from Luleå University of Technology and the Municipality of Kiruna. Focus area of the project is sustainable development within infrastructure and urban environments. The aim of the projects is to create sustainable and innovative technical solutions which include environmental, economical and social aspects for the relocation in Kiruna.

Secondary data
Data has been collected by using secondary public data from the municipality. This was mainly public information data collected from the website of the municipality and it was sorted and analysed by the authors.

Interviews
Interviews were carried out with the project leader and the town architect, representing the municipality’s interest in the city relocation. By selecting the project manager for the first interview and the town architect for the second, we were able to get a broad picture and deep description of the overall planning processes. The selection of the respondents is based on our view that the project manager represents the municipality as a client of a city relocation
The town architect represents the construction professionals within the public administration organisation, with a professional architectural knowledge and the city planning administration. The interviews were performed in a semi-structured way, recorded and transcribed.

Data analyses
From the secondary public information data, a timeline with critical decisions, activities and processes was developed. The activities were also verified by the interviews following a qualitative data analysis method described by Miles & Huberman (1994). The power-interest stakeholder map (Johnson & Scholes 1999) was used in the development of the analysis model with a time-geographic perspective. Key stakeholders were first identified by analysing the official webpage of the municipality. We then made a stakeholder map by identifying different stakeholder groups that we thought were relevant to investigate suggested by Johnson & Scholes, (1999) and Walker et al. (2008). Mapping the stakeholders also lead to our decision to analyse one stakeholder group and their relation with other stakeholders when developing an analysis model.

We developed our interview guides based on stakeholders’ interest in the city relocation process as well as on their power to act within these processes. When we developed the interview guides we treated the municipality as one single organisation representing one stakeholder group. Based on this view we developed the interview questions from factors influencing change processes described in the change kaleidoscope developed by Balogun and Hope Hailey (1999), e.g. time, scope, preservation, diversity, capability, capacity, readiness for change, power; as well as on questions specific regarding stakeholder values. Our purpose with collecting data from the two respondents regarding these change factors was to ensure that we got a satisfactory description of the city relocation processes and the factors influencing this process out of one stakeholder perspective, the municipality’s, see Appendix were the interview guide is summarized.

The transcribed data files together with secondary data files were exported to the qualitative data analysis tool NVivo (QSR N6, version 2002) for further analysis. NVivo allowed us to create categories from theory with focus on one stakeholder: the municipality, the change processes and on stakeholder values. We analysed the data from the interviews and secondary data by coding the data into the categories. The data analysis was performed with a grounded theory methodology perspective developed by Glaser and Strauss (1967) and Glaser (1992) where new categories were developed from analysing the data within the categories created from theory.

A STUDY OF CITY RELOCATION

In this section the analysis of the city relocation processes is presented after giving a short introduction to the city and the need of city relocation.

City history
Due to rich ore deposits in the northern part of Sweden, the company LKAB has come to a critical point in their activities. After more than hundred years of mining activities, together with their mining technology the company has reached deep ore deposits stretching under the central city of Kiruna. People have been living in the area over 6000 years. The Lappish culture and the Finnish culture have been together as long as we know. The first settlers and mineworkers came during the 1600-century. However, Kiruna or Giron the Lappish name of
the city, is a young city, once built on wealth created by the mining activities in Kirunavaara together with the first company directors’, Hjalmar Lundbohm, visions and efforts of creating a modern ideal city. The city, just 100 years old, was built on the foot of the mountain with a special street system hindering the cold winds to blow thru the city. Some buildings are also specially mentioned for their architecture, e.g. the church at Kiruna, which was voted Sweden’s most beautiful building in 2001 and the City Hall, which got the Kasper Salin price for Sweden’s most beautiful public building in 1964.

**Need of a city relocation**

In 2004 the mining company LKAB informed the municipality with a formal letter. It was important for the company to continue their future mining activities and that these activities would affect the city and its buildings. Continuing the exploration of the ore funding, if possible, solutions of moving critical blocks in the city as well as developing the city into a new direction are a must. The public administration received the letter and handed over the question to the politicians according to the project manager:

“It was the start of our journey. The first thing we noticed [the public administration] was that we needed the opinions from the politicians and their view on Kiruna. That is, we needed a program for the city with the politicians’ values that we, the public administration, could relay on.” Project manager 20101116.

**Results of analyses of stakeholder influence and values**

A time liner is presented in Figure 5 showing different milestones and construction processes related to a city relocation process in Kiruna. Milestones are defined as important activities and decisions that have or will be carried out by the different stakeholders.

Figure 5: Construction activities and decisions and processes with milestones of a city relocation project
Stakeholders as decision makers and informants

By analysing activities performed within the Kiruna case, i.e. city relocation processes consisting of different activities, stakeholders’ involvement in the activities and their power of making decisions have been analysed. The results from the analysis show that stakeholders have different roles in the city relocation process closely related to their power and influence in accordance with previous studies. Key players are in the position of decision makers for all kinds of activities related to the city relocation processes. Stakeholders with high power and lower interest in one specific activity or construction project, still have the power of giving their approval to the decisions made, i.e. stakeholders that should be kept satisfied need to be satisfied due to their power position in the city relocation project, and thus they put a pressure on the decision makers. Stakeholders that need to be kept informed, e.g. interest groups. Interest groups do not have any power of putting a direct influence on the decision makers, however their interests in specific activities taking part in the city relocation process is very strong. This interest gives the interest groups a specific influence. The decision makers need to consider this influence by informing the interest groups before the decisions are made. Finally stakeholders with low power and low interest, in our case the citizens with no interest in specific activities and construction projects performed in the early phases of the city relocation process.

Our analysis has resulted in defining the role of key players as decision makers; keep satisfied is developed into approval; keep informed is developed into comment and minimal effort is developed into ignore.

Shift in level of power and interest over time, due to stakeholder values

Figure 6 illustrated our results from the analysis of stakeholders’ interest and power over time within the time-interest-power stakeholder map.

Figure 6: Results from analysis of stakeholders interest and power over time within the time-interest-power stakeholder map.

In Figure 6 the green colored trajectory is one example of how a stakeholder can change role. The example illustrates the process of the energy company. This is related to that the company already finished their construction process in the city relocation. A possible shift in
power and interests is a reasonable outcome. In order to manage city relocation process there is need of managing the different stakeholders’ right in relation with time. In that process communication is vital in order to satisfy and inform stakeholder groups.

From initial analyses of stakeholder groups and their values over time, we can see that there is a shift in their level of power and interest in the city relocation process. The municipality expressed that they initially had a plan of saving the city by moving the city to the new location. Firstly the municipality thought it was possible to keep the main infrastructure, such as the railway and the main road and only move the buildings. After the mining company found new ore deposits, this no longer was an option. The municipality had to develop new infrastructure solutions in the community by initiating sanitary sewer construction processes. Studies of how it should be technical possible to move valuable buildings were accomplished resulting in very expensive solutions and in some cases also technical impossible. One argument from an architectural perspective has also been that some of the identified unique buildings are close connected to the place were they are built. Thus moving for example the City Hall should make the building less attractive.

We can see that traditions from early years still live imbedded in the city articulated by the municipality’s vision of developing the “new” city influence by the spirit of the first company directors’. Hjalmar Lundbohm, visions and efforts of creating a modern city. The municipality is acting as a decision maker. The municipality makes the decisions regarding the infrastructure and rebuilding public houses, influenced by the mining company’s power of exploring the land resources.

**DISCUSSIONS AND CONCLUSIONS**

An analysis of stakeholder power and interest, driven by values within a time-geographic perspective has been presented. The time-power-interests stakeholder model is used to visualize and explain how different stakeholders’ interest and power change over time. This approach connects stakeholder’s interests-power with time and space relationships.

Our main conclusions are that when relocating a city, stakeholder roles influenced by their power and interest are not only related to specific activities and construction processes, they are also related to stakeholder values. Thus, it is important to make these values transparent for the decision makers through proper communication. One of problem discovered for the decision makers in the case study is the development of good communication channels especially with the citizens. Little feedback was found from this group in the secondary data. The potential benefits of including these stakeholders groups are therefore high.

To support communication and decision making processes needs information of future activities, both in and time and space, to be disseminated to all stakeholders. This is a major challenge in the city relocation project studied, where the power-interests map is continuously changing over time. Therefore time-space information needs to be created, shared and used in a simple and efficient way to handle the different stakeholder’s values, power and interests.
REFERENCES


APPENDIX

Questions to project manager and town architect
Interviews with project manager and town architect were conducted on the 16th and 17th November 2010 and took approx. one hour.

Presentation of the respondent
What is your profession and what are your working tasks in the municipality? For how long have you been working for the municipality? How your professional career does looks like?

The planning processes
Describe your image of the planning processes in Kiruna as it looks today. What is good and what is less good.

The organization structure of the planning office
Describe the organization of the planning office. What is good and what is less good in current structure? In what ways does relocation of the city influences the organizational structure?

City relocation and its stakeholders
Describe the different change forces of the municipality? What is the value of the city relocation for the municipality? For a successful relocation change, which are the main internal and external stakeholders within the municipalities, which interests should be reviewed, expressed, adapted, agitated? Show mindmap. Kiruna Kommun (municipality), LKAB (mining company), Trafikverket (Swedish transport administration), Vattenfall (power company). Describe how you perceive the different stakeholders change forces behind the city relocation. Describe how you perceive the value of the city relocation for different stakeholders

Power configuration between different stakeholders
Who has the legitimate power in the municipality? How much acting space has the municipality to pull and push the transformation? How do you perceive the responsibility distribution between the municipality and the other stakeholders? Is it a dividing line between how you want to influence and how you can influence and how do you handle that. Describe how your own organisation and other stakeholders influence you. What are the main difficulties for your work within planning for a new Kiruna.

Questions regarding visualization model
In what way do you think visualization can be used for decision making and communication? What are the challenges in that? How do you think that virtual models can be used to support visualization in decision making and communication? What are the difficulties to use a variety of visualization in the city relocation? Do you have any ideas about how the planning can be improved? What kind of feedback do you get for such ideas within the organisation? Your response/responsible/relations to colleagues/acting space.
Paper II
A Communication Platform to Support Decision Making in Kiruna City Relocation Process

Tim Johansson, Rogier Jongeling
Luleå University of Technology, Sweden
johtim@ltu.se

The city of Kiruna in Sweden needs to be relocated due to mining related subsidence which is affecting major parts of the urban environment. Using 4D modelling environment for visualisation of urban planning can support the communication and decision making between the different stakeholders. This paper identifies principles from the definition of wicked problem and rational decision making theory in order to create a communication platform to support the city relocation process. A combined approach consisting of Google Earth for visualisation of 4D plans combined with social networks for enhanced communication and participatory urban planning is suggested to be the main ingredients of the communication platform.

Introduction

This paper investigates principles of importance in establishing a communication platform to support decision making in urban planning of the relocation of the city Kiruna. The city needs to be relocated due to mining related ground subsidence which is affecting major parts of the urban environment. The affected areas will gradually be replaced during the coming years with new build-up areas, therefore there is a growing demand of rapidly developing new plans for land-use. Two main points of departure have been used to classify urban planning, the wicked problem perspective which is affecting the overall decision making process on the macroscopic level and theories of rational decision making which is used as a support on the microscopic level e.g. to support the different iteration steps within the overall decision making process. To be able to support the planning of the city relocation in Kiruna, time and space needs to be connected. One approach is usage of 4D models which combines 3D models and schedules in an integrated environment (Jongeling, 2006). Hartmann, et al (2007) conclude that 4D models can be used (within construction management) to improve understanding about construction sequences, support of the master schedule, team communication and visualization support for the client and public in large construction projects in urban areas.

The identified principles will be used to propose a communication platform which will be tested later during experiments together with the urban planning office in Kiruna, Sweden.

Stakeholders, decision making and communication

According to Rittel (1973), problems can be categorized in tame and wicked. Tame problems are well defined and have solutions that can be objectively evaluated. Wicked problems on the other hand are hard to define and have solutions that cannot be objectively evaluated. Examples of wicked problems are location of new highways, a new car design or project definition of a construction projects, Whelton & Ballard (2002).

DeGrace and Stahl(1998) presented an appropriate way of tackle wicked projects consisting of three steps:
Firstly, recognize that this is a wicked project. If the project is in need of satisfying stakeholders who do not agree on fundamental issues about the project, then it is definitely a wicked project.

Secondly, see if the project can be tamed which is not easily done with a wicked problem. This demands executive support, a clear problem definition that all stakeholders should agree on.

Thirdly, use adaptive Processes. Wicked problems are resolved through discussion, consensus, iterations and that changes in solutions should be accepted as a normal part of the processes.

Stakeholders are groups who have an interest or rights or ownership in the project and can contribute or be impacted by either the work or the outcomes of the project. The different stakeholders are all, directly or indirectly and actively or more passively engaged in the decision making process (Walker et al, 2008). By bringing different and often controversial points of view together it’s possible to obtain shared understanding among the stakeholders this can generates new insights, new ideas and new artifacts (Arias, et al, 2000). Steinmann, et al (2004) claimed that realizing change in the urban environment and sustainable development is strongly depending on the involvement of stakeholders such as citizens, social organizations and private enterprises within a region or city. This is one reason for the public administration and why stakeholder groups should be engaged in participatory spatial planning. Johnson and Scholes (1999) argue that stakeholder’s relative importance should be classified according to interest and power related to the specific organization. They presented a stakeholder map in an attempt to explain how different stakeholder groups should be managed in relation to power and interests, figure 1.

Figure 1: Power - interest stakeholder map, (Johnson and Scholes, 1999)

Formalised decision making can be regarded as the mental processes resulting in the selection of a course action among several alternatives, (March, 1994; Forman and Selly, 2001). Within rational decision theories the decision making process is often decomposed in a number of steps starting with 1) definition of the problem, 2) determine the requirements and goals of the solution, 3) identification of alternatives that will solve the problem, 4) evaluating and selection of the best alternative. Normally alternatives are compared using some kind of decision support against the established requirements and goals of the solution. Schade, et al (2011) proposed a support tool applicable to decision-making in a structured design process,
where design alternatives consisting of both objective and subjective evaluation criteria can be evaluated, March (1994) argued that within rational decision making theories alternatives are compared in terms of the extent to which their expected consequences are thought to serve the preference of the decision maker. Sager (1999) claimed that planners often present their recommendations as the result of a rational choice process. Realizing change in the urban environment and sustainable development is strongly depending on the involvement of stakeholders such as citizens, social organizations and private enterprises within a region or city, Steinmann, et al (2004). This is one reason for the public administration and why stakeholder groups should be engaged in participatory spatial planning, (Tress and Tress, 2003). Märker and Volkmann (2000) argued that there is an interest for authorities to improve participation procedures in order to avoid that the projects is hindered, delayed or even stopped due to trials, judgments and public pressure initiated by citizens causing economical losses for the society. Weakness in public participation can be related to that comprehensiveness of explanation of plans is often questionable, invitation of stakeholder groups is sometimes selective and finally that the level of participation activities among citizens is pretty low (Märker and Volkmann, 2000).

**Information modeling and visualization**

Virtual Reality (VR) offers a digital platform for communication of different plans (Johansson, 2010). VR can be used to obtain better understanding and accessibility of a common representation of a building project for participants despite educational or professional background (Dehlin and Olofsson, 2008, Roupe, 2009, Johansson, 2010). VR can be used to support communication and decision making among the different stakeholders. The different stakeholders have traditionally been supplied by 2D-drawings of plans, sections, elevations and artist impressions to communicate geometrical designs of urban planning projects (Podevyn et al, 2008). Democratic values could be supported in decision making by usage of VR-models which is related to a common reference obtained in the project among architects, planners, politicians and the general public. However, the platform needs appropriate management and technical input in order to reach the intended audience, (Podevyn et al, 2008). Geographical information systems (GIS) is used due to its spatial nature in almost all administrative levels from local to national – and supra-national (e.g. European union). Efforts have been done recent 30 years to improve GIS technically, methodologically and more recently in integrating it in mainstream IT software’s (Steinmann, et al, 2004). Virtual Globes such as Google Earth as well as other immerse worlds becomes more important not only for professional planners but also many private users are getting more interested in these tools which can increase stakeholders participation in urban planning (Zeile et al 2007; Pettit et al, 2011). Westholm (2002) identified that one problem with traditional communication procedures is that they don’t reach new citizens-groups. For these groups internet plays a secondary role and those parts of population who normally do not participate in planning procedures will not also not do so in internet supported procedures. Therefore more work is needed in communication of visualisation products to multiple audiences and the effective engagement of multiple stakeholders, (Pettit et al, 2011).

**Points of departure**

The proposed communication platform is based on a decision making model consisting of wicked projects perspective to explain the overall design process on a macroscopic perspective as well as using the rational decision making theory on the microscopic perspective e.g. to explain decision making in the different iteration steps within the overall planning process. From the principles of taming wicked projects we obtain:
1. Support the creation of common pictures using visualization to identify problem definitions, alternative solutions, etc that all stakeholders agree on.

2. Resolving issues through discussion, consensus, and iterations and that changes in solutions should be accepted as a normal part of the planning process

From theories of rational and formalized decision making process the following steps are proposed:

**Requirements and goals:** It is essential to establish goals for the future solutions. Here the so called "voice of the customer" from the different stakeholders needs to be translated into functional requirements that can be used to generate alternatives. The result often creates a multi-criteria decision problem of high complexity with partially contradictory goals. Here active participation in urban planning can help to identify interests and demands from a particular stakeholder group, (Tress and Tress, 2003).

**Generation of alternative solutions:** To be able to support decision making in the city relocation of Kiruna generation of different possible alternatives is a vital. The fundamental resource that the different stakeholders negotiate about is space (3D). The resource is getting more critical since time is constantly changing impact of space which is related to the expansion of damage zones. Therefore space (3D) and time (1D) needs to be integrated in order to obtain transparency and understanding of possible actions within different alternatives.

Managing the communication processes is strongly contributing to the success of a project. This process should be adapted to the information management e.g. by receiving and sending information about different alternatives to involved stakeholders. It’s important that the information is adapted in a variety of ways to meet the needs of the stakeholders. Knowledge about the consequences of different alternatives can only be collected through communication between the stakeholders. The city relocation is complex due to the large number of subprojects were the interests and power varies among stakeholders. This needs to be planned in relation to each other and demands transparency and prediction about the outcomes of future alternatives.

**Decision support:** Communication of the different alternatives increase the knowledge about the consequences of each alternative. These consequences needs to be divided between the different stakeholders involved in the project. Since the consequences and effect of different alternatives on the requirements and goals can be partially contradictory a mechanism for ranking the different criteria is needed. The criterion investment cost is one example, this is unclear in Kiruna due to the fact that the mineral law is not adapted to the extreme changes in space over a time.

**Requirements for the communication platform**

Based on decision making points of departure, identification of important principles and requirements for city relocation process are:

1. **Understanding of plans**, the visualization should explain and create common image requirements and goals, alternative solutions as well as consequences. A suitable communication platform is the creation of 4D models of prospective time and space plans.
2. **Collaboration & communication**, by support participation and engagement among the stakeholder groups. Here it’s important with accessibility, usability, interactivity and traceability in order to communicate effective with each other.

3. **Evaluation of alternatives**, it’s impossible to find the optimal solution within urban planning therefore alternatives is found through comparisons with other alternatives against project requirements and goals.

4. **Design iterations**, adaption of information management towards redesign through discussion, consensus and iterations accepted as a normal part of the process.

### 3.3 Proposal for a communication platform

**Understanding of plans:** Virtual Globes such as Google Earth offers an interactive, accessible interface to exchange of geodata via the web. This creates an enormous potential for presenting and communicating of spatial information. Spatial information can be connected with time properties (time spans) in order to create 4D models which is essential in the city relocation in order to visualize progression of different plans to increase the understanding among the different stakeholders. The user can in the interactive Google Earth environment place landmarks including reviews comments and create new simple geometries such as polygons and polylines. Figure 2 illustrates the application of a 4D model of in a planning scenario of the new belt road E10 around Kiruna.

![Figure 2: Shows the development status level in different time steps](image)

Figure 2: Shows the development status level in different time steps
Collaboration and communication: Collaboration and communication of the city relocation process especially can be managed in several of different way, see figure 3. Integration of virtual worlds such as Google Earth with social networks e.g. Facebook, Linkedin and Twitter could be one way to support the communication, (Bugs et al., 2010). This could possibly increase the engagement of the public and open up the communication between the different stakeholders and the decision makers. This approach will be further investigated in an ongoing case study, both design of the integration and possible collaboration and communication benefits using it.

![Figure 3: Presents an approach to combine social networks with virtual worlds such as Google Earth](image)

Evaluation of alternatives: The so called Smart Decision Making Framework (DMF) is proposed to be used as a decision support system, (Schade et al, 2011). Within Smart these goals are captured from the main stakeholders using the concept of Key Performance Indicators (KPIs). KPI evaluations are relative by nature since they base on the deviation of actually measured figures to initially set optimum figures for specific criteria. They can be formulated for objective as well as for subjective criteria. Smart DMF further proposes to discretely define the relation between the tolerance level for deviations and a respective dimensionless rating, using so called utility functions. To incorporate tolerances is necessary since goals are in praxis often conflictive in their effects on each other; therefore it is generally seldom possible to achieve all goals to 100% at the same time.

Discussion and Conclusion

A proposal for a public communication platform has been presented based on the wicked project perspective combined with rational decision theory. The city relocation of Kiruna consists of multiple wicked problems that can only be tamed through efficient communication, the creating of common goals and requirements, alternative proposals and finally support for decision making in iterative steps. The recent development of information technology, such as Google Earth and Social networks e.g. Facebook and Twitter gives a manifold of opportunities to create a communication platform, however it’s not clear how these tools and services should be integrated to the communication processes and decision
making. The information e.g. feedback from different stakeholders within the communication platform needs to be handled in the right way in order to support decision making. The feedback from the different planning alternatives needs to be validated and evaluated against common goals and requirements. Otherwise it will be difficult for the decision makers to objectively select the most suitable alternative. A decision support system like DMF is therefore suggested.

Action research will be carried out in order to create a 4D process model based on the requirements and the proposed communication platform. The process model will be created iteratively together with the urban planning office in Kiruna. In order to decrease the management of the communication platform, use of user-friendly technology and existing tools will be promoted due to the relatively low resources available at the urban planning office of Kiruna.

Acknowledgement

This work was performed within the GIRON project. The support from the European Regional Development Fund, the Swedish Transport Administration, Norrbotten County Council and Norrbotten County Administrative board is acknowledged.

References


J., Schade, Olofsson T., Schreyer, M. (2011): Decision-making in a model-based design process, Construction Management and Economics, Accepted for publication


Paper III
Development of 4D Public Participation GIS to Improve Communication of City Transformation Processes

Tim JOHANSSON\textsuperscript{1}, Timo HARTMANN\textsuperscript{2}, Rogier JONGELING\textsuperscript{1} and Thomas OLOFSSON\textsuperscript{1,5}

\textsuperscript{1}Department of Civil, Mining and Environmental Engineering, Luleå University of Technology, Luleå, 971 87, Sweden; email: johtim@ltu.se
\textsuperscript{2}Department of Construction Management and Engineering, University of Twente, P.O. Box 217, AE Enschede 7500, The Netherlands; email: t.hartmann@utwente.nl

ABSTRACT

Based on a case study of the city transformation of Kiruna we concluded that the information about the urban planning processes; (1) was scattered and hard to understand and (2) not communicated properly for the public to be able to participate. Here public participation geographical systems (PPGIS) and modeling of a project delivery timeline, also known as 4D, are possibilities to improve communication with stakeholders in urban planning and construction processes. As a result, we set up three requirements for the development of a 4D PPGIS communication platform. Firstly, time-space urban planning information must be available and understandable for the citizens to comprehend. Secondly, the communication platform must support two-way asynchronous communication for collecting public opinions and proposals. Finally, the user interface, operations and management of the platform must engage citizens to participate in the urban planning process. An experimental 4D PPGIS based on Google Earth and Facebook services was developed to visualize geo-referenced past, current and future urban activities and support public discussions regarding planning proposals. The prototype is currently being evaluated in the first iterative cycle of the information system development method.

INTRODUCTION

The city transformation of Kiruna is caused by ground subsidence due to iron ore mining activities underneath parts of the city. An incremental move of the existing city center is therefore necessary in the coming thirty years. As a result, the comprehensive and detailed urban plans are currently revised because of two main reasons. First, to change residential, commercial and industrial areas that are affected by ground subsidence to areas dedicated for mining. Second, to make sure that corresponding areas are replaced at new locations within the city. Use of public participatory geographic information systems (PPGIS) offers possibilities to support these planning processes by facilitating two-way communication online between citizens and planners. In recent years several PPGIS has matured and been developed to support the participation of citizens in urban planning. The technology offers an alternative to traditional public meetings in that they do not require in-person attendance (Rinner and Bird, 2009). Additionally, the technology facilitate citizens, which in general are not
professional planners, to expand their participation (Rinner et al, 2008; Barton et al, 2005; Shen and Kawakami, 2010; Ghaemi et al, 2009; Rinner and Bird, 2009; Pettit, 2005; Stern et al, 2009; G.B. Hall et al, 2010). However, there are lack of methods visualizing urban planning in time-space continuum to explain the current status of plans and future scenarios. Time-space visualization is in this context necessary for the understanding, engagement and participation of the public in urban planning. The paper is structured as follows: First, a description is given of the theoretical framework for PPGIS and 4D modeling. Second, the goal, objectives and limitation are introduced. Third, the method and the case study are presented. Fourth, based on the case study and theoretical framework, requirements are presented for a 4D PPGIS platform. Finally, an experimental 4D PPGIS platform is proposed based on the presented requirements.

PUBLIC PARTICIPATORY GEOGRAPHIC INFORMATION SYSTEMS AND 4D MODELING

The benefits of public participation in urban planning are widely documented (Al-Kodmany, 1999; Halvorsen, 2003; Lane, 2005; Stern et al, 2009). Participation supports citizens to feel a stronger sense of commitment, increase their user satisfaction, build trust and create realistic expectations of the outcomes (Al-Kodmany, 1999; Brody et al, 2003). If key stakeholders are involved in early stages, it is possible to create a sense of ownership over plans content (Brody et al, 2003). Hence, earlier and more public involvement increases the likelihood of success (Wu et al, 2010). Brody et al, (2003) explains that early participation makes it possible to avoid potential long term conflicts, because stakeholders feel responsible for the plans with content and planning policies. Involvement and public participation in an early stage add time and cost. However, this upfront investment can pay off, at a later stage, when it comes to agreements on policy and implementation. Additionally, individuals and organizations bring valuable knowledge and innovative ideas regarding their community, which can increase the quality of adopted plans (Brody et al, 2003). Web-based techniques for public participation allow citizens to participate anytime-anywhere. Public Participatory Geographical Information Systems (PPGIS), Community Information Systems (CIS) and Public Participatory Spatial Decision Support Systems (PP-SDSS), are examples of concepts for describing and allowing two-way exchange of planning information and knowledge in order to support collaborative design and decision making (Barton et al, 2005). Web-based two-way exchange of plans provides high accessibility for the broader public, along with possibilities of sharing ideas and remarks. Qualities that are essential to increase the public involvement and contribute to empowerment and trust, both for local planning authorities and the planning process (Stern et al, 2009).

The use of 4D visualization in public participation is a new application and asks for high quality 3D models in order to provide a clear visual representation of time and scheduling aspects (Stellingwerff and Kuhk, 2004). 4D visualization combines 3D models with time and offers possibilities to visualize past, current and future scenarios plans, process and activities and have been extensively used to visualize construction plans (Koo and Fischer, 2000; Jongeling and Olofsson, 2007; Hartmann et al, 2010). Within the field urban planning visualization of plans is still limited to 2D and 3D representation of existing or new designs and plans. However, transitions take place in time when an urban area changes its
original state into a new planned state. Intermediate activities and incremental changes need to be visualized, to better grasp the social and spatial consequences of an urban transformation process (De Vries et al, 2009). Such an approach to visualize the change over time and space was presented by Pak and Verbeke (2010) which used a virtual environment to represent, communicate and analyze urban development projects. 4D models were used to map the changes of different zones in Brussels with opportunities to leave comments on geo-referenced place marks. De Vries et al, (2009) presented a prototype system for modeling and visualization of a dynamic plan for urban areas that was redeveloped. However, De Vries et al, (2009) and by Pak and Verbeke (2010) doesn’t provide a clear image regarding how to visualize the status of current and planned activities. A development activity as such is complicated and includes many status levels and sub-activities. However, the current 4D modeling prototypes only includes one plan at a time whereas the need is to visualize many kinds of urban plans with different status to support communication with the public of complex city transformation processes.

GOAL, OBJECTIVES AND LIMITATION

The goal of the research project is to provide a communication platform for urban planners to communicate and receive feedback from citizens on urban plans. To fulfill the goal a number of objectives have been set-up:

1. Evaluate weaknesses with the current way of communication
2. Define requirements and functionalities of a communication platform
3. Build a prototype platform
4. Observe and evaluate use
5. Develop new theories/models based on observation and evaluation of usage

The steps 1-5 in the research process can be iterated depending on the outcome. This paper presents the first three steps in the research project.

METHOD

The overall research methodology is known as system development research process (Nunamaker and Chen 1990; Chiasson and Dexter 2001) and is a special case of action research (Baskerville 1999). A case study of a city transformation was selected as a base of the first cycle of investigation, because case studies are suitable when studying complex processes, (Yin 1994). The city transformation of Kiruna was selected because of its availability, stakeholder and time-space complexity and high pressure on urban planning processes. Data collection consisted of interviews and archival data with the aim to understand challenges in participation and communication with different stakeholder groups.

CASE DESCRIPTION

The city transformation is caused by iron ore mining activities, which causes ground subsidence. As a consequence, the existing city center needs to be relocated in the future. Existing affected residential and commercial areas need to be moved as they are transformed into mining area. The speed of the
transformation process is dependent on the mining production. As a result, a demand is created to revise the existing plans and to establish several new detailed plans. Therefore future demands and requirements of the citizens needs to be estimated along with physical conditions, survey e.g. ground subsidence and ground properties. Due to the dynamic development the coordination of the many activities in order to fulfill demands at different time steps becomes important. Hence, different plans on local and regional levels needs coordination in time and space during the whole of the city transformation process. Uncertainties in the process requires schedules that can be continuously updated.

INTERVIEW STUDY

The interviews focused on understanding the stakeholders relationships between the municipality and external stakeholders such as the public. The interviews covered questions regarding the urban planning process, the organization structure of the planning office, stakeholders within the city transformation, power relationship between the stakeholders and also how urban planners communicated with their stakeholders and how decisions were made. The questions were partly based on factors influencing the change processes for stakeholders, described by Balogun and Hope Hailey (1999), e.g. time, scope, preservation, diversity, capability, capacity, readiness for change and power. The purpose with the interviews was to explore the city transformation from a time-space, stakeholder and process point of view. The respondents and their characteristics are showed in table 1.

<table>
<thead>
<tr>
<th>Title</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chief of planning</td>
<td>Kiruna Municipality</td>
</tr>
<tr>
<td>Project manager</td>
<td>Kiruna Municipality</td>
</tr>
<tr>
<td>Chief architect</td>
<td>Kiruna Municipality</td>
</tr>
<tr>
<td>Urban planner</td>
<td>Kiruna Municipality</td>
</tr>
<tr>
<td>Urban planner</td>
<td>Kiruna Municipality</td>
</tr>
<tr>
<td>Urban planner(investment in land)</td>
<td>Kiruna municipality</td>
</tr>
<tr>
<td>Urban planner</td>
<td>Kiruna municipality</td>
</tr>
<tr>
<td>Traffic planner and engineer</td>
<td>Kiruna municipality</td>
</tr>
<tr>
<td>Technical Chief</td>
<td>Municipality owned contractor</td>
</tr>
<tr>
<td>Project manager</td>
<td>Mining company</td>
</tr>
</tbody>
</table>

In total 10 respondents working with the city relocation process were interviewed giving a broad picture and understanding of the different urban planning challenges from the involved stakeholder perspective. The interviews were recorded and coded using nvivo to categories such as design and visualization, time, urban planning organization, and external stakeholders. Requirements and functionalities of a communication platform were established based on the result of the interviews and then a first experimental prototype was developed.
RESULT OF INTERVIEWS

The result from the interviews and archival data revealed two main weaknesses in the current practice of urban planning of the city transformations:

Weakness 1: The information regarding the city transformation of Kiruna is too scattered for the public and the politicians to grasp. Aspects of the urban planning are related to time-space dependency, which today and can only be understood by combining several sources of information from maps and documents. For instance, color maps are used showing the planned progression of Kiruna in 5 year steps, including the relocation of industrial, residential and commercial areas. These kind of planning documents are often appropriate for communication with professional planners but are insufficient for non-professionals, such as the public and politicians. According to the project manager, benefits in the urban planning process can be obtained if the information in documents and plans can be integrated and visualized. For example, a plan developed to estimate the quantities of square meter of residential and commercial property that will be phased out in the next 10, 20 or 30 years is difficult to communicate to the public in traditional information channels, such as planning documents and maps.

“If we would be able to visualize the huge pile of papers including our ideas in a simple and good way our work would be much easier and efficient”
Project Manager - Kiruna municipality

Professional planners often face challenges in communication of planning information like the example given above. Furthermore, the communication of different alternatives adds to the complexity. Currently, the majority of the public do not read planning documents. They are generally hard to reach and do not attend publicly announced information meetings. The results are often that only a few citizens participate, which is usually the same group of people independent of project type. It is especially difficult to attract the younger generation to participate in urban planning projects. Visualization and social networking sites have been discussed to support the participation, by engaging the public with new technologies and methods, but so far not much has been done.

“A boring 2D map is often sufficient for communication with professionals, however a 3D visualization can make the plan more attractive to the public” Chief of planning - Kiruna municipality

Weakness 2: According to the professional planners a large share of the citizens are not aware of the activities in the city relocation process. Hence, they do not realize that there is an ongoing planning process that will determine how the city will be transformed.

“The municipality has problems with communicating the right information in time to the right people. If we can communicate the right information and be more transparent we can save valuable time in the planning process.” Traffic Planner - Kiruna municipality

Instead, the public is in general facing the facts too late in the process, sometimes as late as when the construction start. This can also be noticed in the participation, where the public tends to act very late in the process, often at a point when much of their ability to influence the project is lost.
REQUIREMENTS AND FUNCTIONALITIES

From these weaknesses we identified the requirements for the 4D PPGIS communication platform. As a result, the most important issues are addressed on how urban plans can be supported by visualization and public participation. The requirements are based on that the public needs to understand the transformation process in order to participate.

**Visualize past, now and the future:** A city transformation process consists of three phases past, current and future activities. Understanding and transparency of the process can only be obtained by understanding these phases. Visualization past gives traceability and acceptance for decisions. Showing the current phase illustrates when to act, for instance which plans are currently open for public participation, offering citizens to leave feedback and remarks for different proposals. Visualization the future gives an overview of the future planning activities and decisions. Currently this information is scattered in schedules, maps and documents, which is hard to integrate. The large number of sources of information, the dynamics and contextual complexity requires efficient methods to compile and visualize the information. Furthermore, the status of active plans needs to be visualized with different signs in order to get possible attention by the citizens.

**Visualize urban and local plans:** A city transformation is dependent on the comprehensive planning and detailed planning. The public needs good understanding of both types of plan in order to participate. Both types includes a variety of information and data to illustrate planning alternatives. This includes data and information such as text, temporal data, schedules, 2D raster and vector format, sketches and maps, 3D data and location data. A system should be able to represent detailed plans with a short horizon as well as overall long term plans in a seamless environment. The content, status and process of this plans is visualized in order to explain the urban planning process for the public.

**Comments referenced to time and space:** The two first requirements offer a potential increase of understanding of the 4D geo-references information. Once understanding of the process is obtained it is easier to communicate and leave feedback according the planning proposals. The communication made between citizens to citizens and to urban planners should be tagged by time and space. The feedback can then automatically be sorted in space and time and compared with the 4D geo-referenced data. Social networking sites can be used to engage and explain urban planning between the citizens and citizens and urban planners. The communication can be logged by project and time and citizens can get notifications about updates regarding projects that they find interesting.

**Functionalties and solutions:** Web 2.0 offers support to create customizes web applications, such as web based 4D visualizations (Pak and Verbeke, 2010). The web 2.0 applications works as programmable customizable platforms, often through the light weighted application programming interface (API) (Bugs et al, 2010), that are often freely accessibly (Rinner et al, 2008). As a result, programmers can combine these services into so called mashups that meet the requirements of specific users and applications (Bugs et al, 2010). Google Earth API provides an interactive interface to exchange geodata via the web, by linking 3D object models with KMZ maps (Lammeren et al, 2010). Individual
users can publish their own vector or raster data on top of the standard Google Earth layers of imagery and topographic information (Drummond and French, 2008). As a result, new opportunities emerge that can facilitate public participation during the entire urban planning process by the use of a 3D web-based platform, which offers seamless integration of VR with other traditional text and multimedia information channels (Wu et al, 2010; Drummond and French, 2008). Google Earth API and KML based models also offer the possibility to visualize time and space, which creates opportunities to visualize geometries on the 3D map in relation to their temporal futures. The build-in timeline function enables virtual time travel, where user can observe changes in aerial photos and user created 2D/3D models (Pak and Verbeke, 2010).

**EXPERIMENTAL PROTOTYPE**

Google Earth and Facebook API are selected as the two components within the experimental 4D PPGIS. The applications are chosen because they are relatively easy to program and customize. These applications are combined to create a 4D communication map shown in figure 1.

![Figure 1: Two different planning scales are showed (the yellow color represent planning of a residential area). First the comprehensive plan as a 4D model, including new areas and ground subsidence(red). Second the detailed plan process visualized by six different status levels.](image-url)
The 4D map provides possibilities for internet users to visualize comprehensive and detailed plans at any given scale, time and view. Consequences in time and space for different types of areas can be visualized. This will help the users to understand the impact on new and existing residential, commercial and industrial areas in the coming 30 years of the city transformation process. Both the comprehensive and detailed plans should be visualized and communicated, since the outcome is highly dependent on public participation. The detailed plans are active once the internet users are at a close distance, visualizing the proposal and the status of the local plan. This is illustrated in the lower part of figure 1, were the comprehensive and detailed plan of a residential area is visualized in six different phases. To support these phases a variety of information and data are needed such as text, illustration, sketches, maps and 3D models depending project phase. These kinds of spatial information are fully integrated within the platform. The main purpose of explaining and communicating urban plans is to increase participation, which in our prototype is based on multiple Facebook sites. The social networking site offers citizens a familiar user interface to engage each other to participate in urban planning. Urban planners can receive feedback and also communicate to groups of citizens that are interested in the same issues regarding comprehensive and detailed city plans. A link between Facebook and Google Earth is created in order to make the social networking debates easier to distinguish and understand for both for the urban planners and the citizens. This is obtained within the system by the “hot spot” menu, which consists of common links for views in 4D maps connected with a Facebook site.

CONCLUSION

The 4D visualization of the urban planning process offers opportunities for the citizens to better understand a city transformation. This understanding is vital for increasing level of participation, engagement and credibility. In order to visualize the process and increase participation we identified three requirements for a 4D PPGIS platform in a case study of the city transformation of Kiruna:

- Time-space urban planning information must be available and understandable for the citizens to comprehend.
- The communication platform must support two-way asynchronous communication for collecting public opinions and proposals.
- The user interface, operations and management of the platform must engages citizens to participate in the urban planning process.

A prototype 4D PPGIS based on the requirements was created using Google Earth and Facebook API. The prototype and has not yet been tested and further investigation of the use of 4D models in urban planning is going to be performed. The use and validation of the 4D PPGIS system in Kiruna is planned to be performed during 2012.

ACKNOWLEDGEMENT

The research work has been partly financed by European Regional Development Fund in the Nya Giron project.
REFERENCES


