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Titel:

GIS-based Transport Infrastructure Planning and Evaluation

Abstract:

Transport planning is a stepwise, hierarchical, iterative, and political process taking account of different transport related, economic, social and environmental aspects, and involving a number of experts in the fields of transport, environment, housing, social affairs and economy. Nowadays increasing concern is given to environmental impacts. In the last decades a number of sophisticated models and software tools have been developed to support transport planning, however, each tool focussing on specialised aspect of the overall transport planning task (e.g. transport models, assessment tools) and requiring deep inside software knowledge of IT-experts. The main objective of the ongoing project presented is the development of such a missing comprehensive unified planning tool which should take account of an integrated database, easy-to use metaphors-based user interface, a strictly modular software structure and - as the major achievement - a close coupling of transport and environmental models within one system. The paper presents the outline and envisaged functionality of such a prototype and demonstrates how open GI systems can help to develop and implement such a comprehensive software tool.

Key words: Planning tool, metaphor-based interface, GIS; environmental models

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GIS-based Transport Infrastructure Planning and Evaluation

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1. INTRODUCTION

Transport planning is a stepwise, hierarchical, iterative, and political process. Typically, this process entails the following steps: identifying needs for new or upgraded transport links; calculating transport flows and evaluating congestion; assessing environmental, social and economic impacts of infrastructure projects using different evaluation techniques; selection of appropriate projects to be implemented. All these tasks are linked to each other in various, often iterative, ways.

Traditionally, transport planning was seen as a specialised, technical planning field to provide infrastructure as a pre-condition for economic development and social security, mainly focussing on the development, improvement and expansion of highway and motorway systems (Holz-Rau, 1996). This narrow view on transport planning is more and more substituted by a wider interdisciplinary integrative approach of transport planning combining different transport related, economic, social and environmental issues. In turn, this integration increases data requirements that must be taken into account by transport planners and also increases demands on data quality and availability. Moreover, data exchange between different organisations becomes of growing importance.

In that, the role of the planner will change from the technical engineering side towards a more process oriented moderator, who co-ordinates different planning steps and contributions of different institutions involved and who has to promote the planned projects against the political and public side (Neumann, 1997). The growing importance of project promotion in particular in case of huge infrastructure projects such as motorways or high-speed rail lines is indispensable for the conciliation of different competing demands and views on the spatial development between different organisations, institutions and lobbies. In consequence, this co-ordination and conciliation requires quick and comprehensive data and information availability.

In practice, the planning steps are performed by a number of institutions, offices, or consultants, each of them using their own databases, modelling tools and expertise. All of them are confronted with at least two major problems that delay response times in the planning process:

- Driven by the need for more and better IT-support in planning processes towards so-called Spatial Decision Support Systems (SDSS), software vendors have developed systems with increasing complexity including numbers of add-ons, patches and tools, that finally had led to 'over featured' systems. This complexity has reached a level, at which only a small number of functions available can actually be used. Many software products have been developed without taking user demands into account. User interfaces tend to be confusing and complicated, in consequence usability and utility is often bad (Craig, 1991; Nielsen, 1993).
- The required data exist in various, often incompatible data formats and are maintained at several organisations. Even in case of identical formats, sharing data might be problematic since different users have different views on real world objects. These different views of the world has led to different semantics of data (e.g. transport and environmental planners have different understandings of the geo-object 'road').

Due to theses difficulties the use of information from GIS analysis and transport / environmental models is limited to a small number of persons. This means that existing data often cannot generate value for those who should profit from it. Since domain experts like planners are often novice GIS users they depend on GIS experts. That is one of the reasons why planning processes become unbearable lengthy and intransparent.

However, to enable these people as novice GIS users to take advantage from the direct use of GIS, user interfaces have to be developed in a way that they can be interpreted and used correctly by 'non-GIS-experts'. Therefore user interface designers have to identify the specific requirements for the use.

The 'VUGIS' (='Verkehrs- und Geoinformationssystem') project aims to develop a comprehensive planning tool (VUGIS, 2000) taking account of the shortcomings and obstacles mentioned. It will combine typical planning problems such as evaluating proposed network alignments or measures in the outline planning stage. It will enable the planner to review and edit spatial data, to define planning alternatives (scenarios), to calculate transport flows in transport models, to evaluate environmental and social impacts using dispersion models, to use GIS based analytical functions and to display or print results in tabular or graphical form. All functionalities should be assisted by an easy-to-use integrative user interface. The main objective of the tool is to evaluate impacts of proposed transport infrastructure projects at an early stage in the planning process.

This paper outlines the envisaged objectives, model structure and user interface of the VUGIS prototype to be developed and concludes with a description of the three case studies to be implemented.

2. OBJECTIVES OF THE VUGIS PROTOTYPE

Facing the tendencies raised above, from a planning practice perspective, there is need for a unified software system that

(i) enables the planner to handle heterogeneous data sources (viewing, managing and converting data),
(ii) combines existing stand-alone transport planning support tools, in particular the combination of GIS tools with transport and environmental models, and
(iii) is characterised by an easy-to-use user interface with which the user needs not to take care of data formats or underlying model specifications and thus provides services instead of demanding deep technical knowledge.

Existing similar approaches already combine GIS and transport models (e.g. TransCAD, see Caliper Corporation, 2001) or land-use and transport models (e.g. PROSPECTS project, see Pfaffenbichler and Emberger, 2001). Other approaches focus on land management systems (e.g. MEDUSAT, see Joerin, 2001). The commercial VERUM transport modelling software package (Rosinak & Partner, 2001) also offers additional modules for evaluating environmental impacts (emissions, noise) centered around the core transport model, but all modules are implemented in separate software solutions, and there is only a loose coupling with GI systems (import / export functionalities to ArcInfo). The MOBILE research project also set up a modelling system combining transport modelling capabilities with environmental models in a modular fashion (Hilty et al., 1998) using object oriented programming techniques. The disadvantage of this approach is that no unified user interface is given but that the user first has to select and arrange the modules he wants to apply from the 'toolbox' offered.

Based on the review of existing similar approaches, the main objective of the VUGIS project is to develop an easy-to-use, integrative and comprehensive planning tool which can be applied by transport planners without consulting GIS-experts to evaluate environmental, social and economical impacts of proposed transport infrastructure projects at an early stage in the planning process at the local and regional level. Being aware of existing approaches mentioned above, the focus of the VUGIS prototype will be on the integration of GIS, transport and environmental models within one software system under one comprehensive user-interface.

To achieve this goal, a homogeneous and windows-based user interface will be developed, which bundles a number of analysis and presentation functions, which in traditional transport planning processes are usually being outsourced to consultants or split into several software applications. The aspired functionalities to be implemented can be subsumed under five levels ranging from relatively low to high complexity:

- Supplying heterogeneous thematic data
- Visualisation and overlay of all data relevant for transport planning processes
- Applying GIS-analysis (e.g. buffering, intersecting, dissolving)
- Generation of basic transport-related information by transport models (e.g. transport flows, congestion, average travel times)
- Simulation of likely environmental impacts of proposed projects by applying environmental models (e.g. emissions, immissions, land cover)

The system will not evaluate the need of new transport infrastructure, but will assess different planning alternatives and scenarios with respect to their environmental, social and economical implications. In that, the system should enable the planner to define and evaluate different planning options and scenarios.

The user interface should be intuitive in that it does not require deep knowledge or experience in GIS, transport or environmental modelling, but knowledge from the planning domain. For this reason it will be based on metaphors from the planning domain that will be implemented as 'icons' or 'commands' in the shell system.

3. SYSTEM ARCHITECTURE

As Albrecht et al. (1997) argue, it is essential that an envisaged spatial (environmental) modelling system such as the VUGIS prototype must fulfil the following criteria to be useful for practitioners as well as for scientific applications: The system should be easy to use with (i) a *visual* windows-based user interface and (ii) *interactive* capabilities for scenario development. It should be (iii) *dynamic* in that the approach implemented includes feedback loops and time parameters and it should be (iv) *spatial* including abilities for spatial manipulation and presentations. A (v) *model database* should be established managing all data required, keeping track of the scenarios developed and recording histories and versions of analysis. Moreover, the system should be (vi) an *integrated* system in that spatial modelling and analysis tools should be closely coupled with spatial modelling packages, and finally the system should be (vii) *generic* in that it operates as a toolbox independent of the domain or operating system used.

It is planned to follow these recommendations for the development of the prototype. The internal structure of the tool will be based on five key elements (Figure 1):

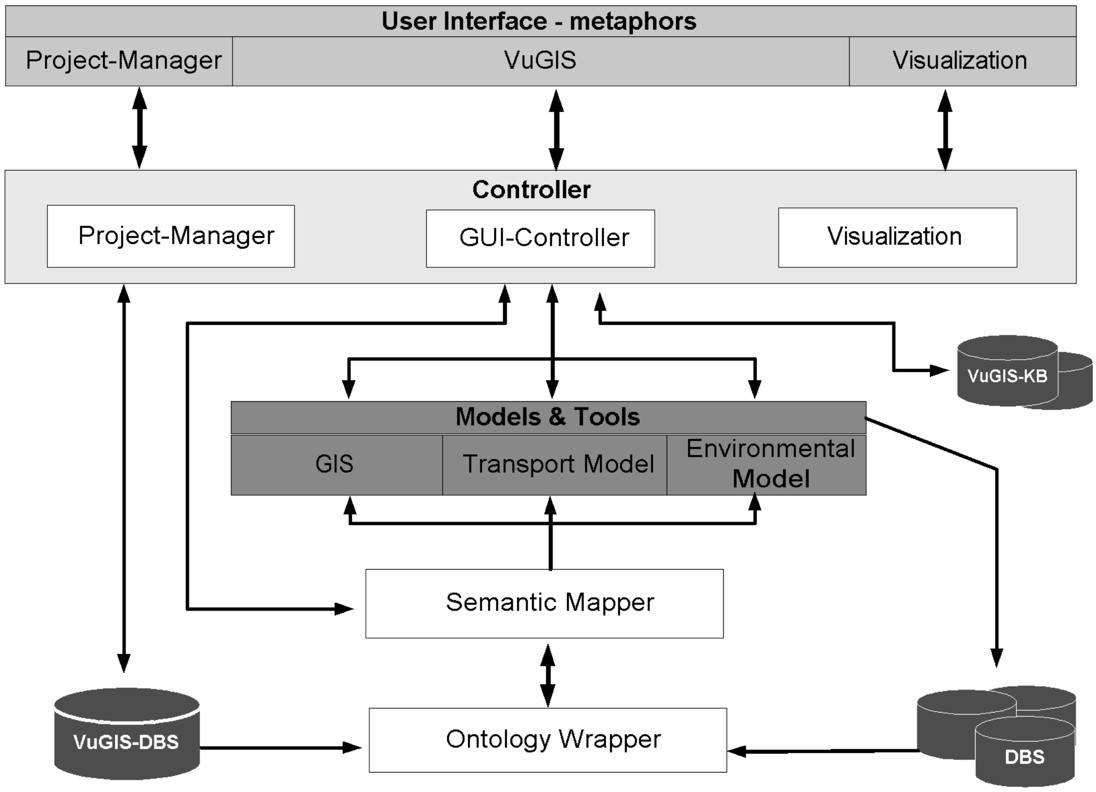

Figure 1. System architecture of the VUGIS prototype

1. A metaphor-based *user interface* to interact with these tools. The metaphors are directly deduced from technical terms and procedures in the planning practice to enable the user to communicate in his familiar planning language. The user interface is divided into components for project and scenario management, for VUGIS-analysis options and for visualization purposes.
2. The user interaction will be interpreted by the *controller* components. The VUGIS knowledge-base (VUGIS-KB) interprets the metaphors and sends the corresponding commands back to the controller.
3. A set of commercially available and self-developed *analysis and modelling tools,* which are set up to interact with each other to derive additional planning information and to evaluate impacts of proposed transport infrastructure projects.
4. A *semantic mapper* library consisting of interfaces which automatically identifies and solves schematic and semantic differences between the data and which facilitates in combination with the ontology wrapper the data to the other system components.
5. A *spatial database* containing heterogeneous sets of data stored in commercially available GIS including all data relevant for transport planning. The data are derived from various data sources, organisations, and institutions and are maintained in their proprietary formats.

According to the guidelines of the OpenGIS consortium (OGC, 1998), the overall system is set up in a strictly modular fashion, i.e. each component is clearly defined to fulfil one specific task in form of a separate procedure with clearly defined input and output interfaces. With this, it will be possible to exchange or replace selected components later on if necessary. Moreover, it will also be possible to add new components.

4. DATABASE

The common spatial database is the basis for the overall system in that it stores all data relevant for transport planning for the case studies and provides these data to the tools implemented. The data are derived from various sources, organisations, and institutions and are maintained in their proprietary formats. The database comprises the fields of transport planning, landscape planning, ecology, economy, socio-economic data, and settlement and man-made environment. According to recommendations of Hensel (1976), Ortúzar and Willumsen (1990), Kollarits (1997) and Rindsfüser and Ruhren (2000), the following items will be accessible in the database:

Transport networks, socio-economic data, land use and land coverage, ground, surface and water sheds, relief and topography, biotopes, restricted and environmental protected areas, real estate, ownership, climatic conditions, recreation areas, tourists facilities and points of interest, raw materials, deposits

This specification should not be seen as a closed list but it will be possible to add or remove certain data and adjust the database to specific user needs if necessary.

5. SEMANTIC MAPPER AND ONTOLOGY WRAPPER

Interoperability means the creation of open interfaces to enable data exchange in different formats. This challenge is subject of the OpenGIS specifications (OGC, 1998). However, the term ‘open systems’ is not limited to the mere idea of data transfer (Bishr et al., 1999). Moreover it relates to thematically aspects that are necessary to be considered to enable semantic interoperability. For example, a road can have different semantics for different domains. For landscape planners it means to divide biotopes or forests. From the transport planners’ point of view its function is to connect different locations. These dissimilar views of the world have lead to different data models. Ontologies have to be described to arrive at interoperability between these views of the world. So ontologies are defined specification of the conceptualisation (Gruber, 1993). The goal is the mathematical description of the semantic of specific data and related terms. These descriptions can be employed for the translation or mapping between various semantics that finally enable thematic interoperability. The ontology wrapper keeps the common ontology of the underlying database, generates objects from the database and adds meta-knowledge to the objects. These objects are offered to the semantic mapper that has knowledge about the data models which correspond with the model and GIS components.

6. MODELS AND TOOLS

The core components of the system are the models and tools implemented. Their applicability is tied to the spatial database and controlled via metaphors of the user interface. The models and tools interact with each other in two different ways: (i) direct interactions between two (or more) models using interfaces, or (ii) indirect interaction via database.

In the first case, a model passes data, parameter and information from its output interface directly to the input interface of another model; in the latter case, all results will be written in a specified format into the common database, from which they are accessible by other models. If it is necessary to convert the format of the requested data before data exchange, the requesting model will not directly access the database but the GIS is used for data preparation and conversion in an intermediate step.

6.1 Role of GIS

The GI system plays a crucial role. GIS is used to visualise, analyse, edit and maintain the spatial database. If necessary, the GIS converts the proprietary data formats into the required formats and forwards the data to the transport and environmental models by which they were requested. The GIS is also responsible for preserving coherence, topology and completeness of the database and to perform further analysis (e.g. overlay operations). All requests to the database forwarded by the GIS will then be facilitated by the semantic mapper which translates the metaphors used in the user interface into the selection codes required by the database layers.

For the prototype, ArcGIS Version 8.1 (ESRI) will be implemented as the commercial GIS platform. After a comprehensive analysis of commercial available GIS the following three criteria had been the main driving forces for choosing ArcInfo: (i) supported data exchange formats, (ii) programming possibilities (*O*pen *D*evelopment *E*nvironment – ODE) including possibilities to define object features, and (iii) availability among the VUGIS consortium. In particular criterion two, possibilities and restrictions for programming, was decisive, since ArcInfo seems to have only little restrictions in that respect compared to other commercial GI systems. However, in its modular structure it will be possible to exchange the underlying GIS modules by other GIS, when they are able to fulfil all the requirements.

6.2 Transport model

Generally speaking, the main task of transport models is to forecast movements of people (and goods) for individual motorised and public transport subject to travel demand and transport infrastructure supply to evaluate the impacts of proposed infrastructure projects.

Based on this characterisation, the transport model is used here to put dynamics into the system. Several scenarios of transport infrastructure developments (e.g. introduction of new roads or public transport lines) that are implemented in the database can be run to evaluate the impacts on transport flows, link loads, congestion and travel times.

The main benefit of incorporating a transport model into the prototype is to derive basic planning information on transport patterns in the case study regions as such. At the same time these patterns serve as a starting point for the environmental models in that the data generated by the transport model are the main input for evaluating environmental impacts. In detail, the outcomes of the transport model will be:

Traffic flows between transport analysis zones, link and turn loads for private and public transport, number of passengers at stops for public transport, accessibility of destinations for private and public transport, average travel times, shortest paths, generalised costs.

Similar to the implementation of the GIS, it is not planned to developed a self-written transport model but to utilise a commercially available transport forecasting and planning software. For the prototype, this software will be VSS (HHS, Aachen), because it is already used in the case study regions (see Section 9).

6.3 Environmental models

Environmental models are used to assess likely impacts of proposed transport infrastructure projects with respect to environmental and social aspects. The choice and the design of the environmental models implemented (Figure 2) follow the ones implemented in the SPARTACUS project (LT et al., 1998). They will calculate energy/fuel consumption, greenhouse gas emissions (CO_2) and other gas emissions, traffic noise, land take as well as exposure of population to noise and air pollution and impacts of transport infrastructure on open space, biotopes and land take on a raster basis.

These sub-models partly refer to information provided by the GIS (land take), are directly derived from the transport model (greenhouse and other gas emissions, traffic noise) or refer to further processed outcomes of the transport model (e.g. exposure of population to air pollution and to traffic noise). However, the latter sub-models are raster-based sub-models, i.e. the outcomes provided by the transport model must be converted into a raster representation beforehand. Figure 3 exemplary displays the interplay between the transport and environmental models when simulating the exposure of population to air pollution.

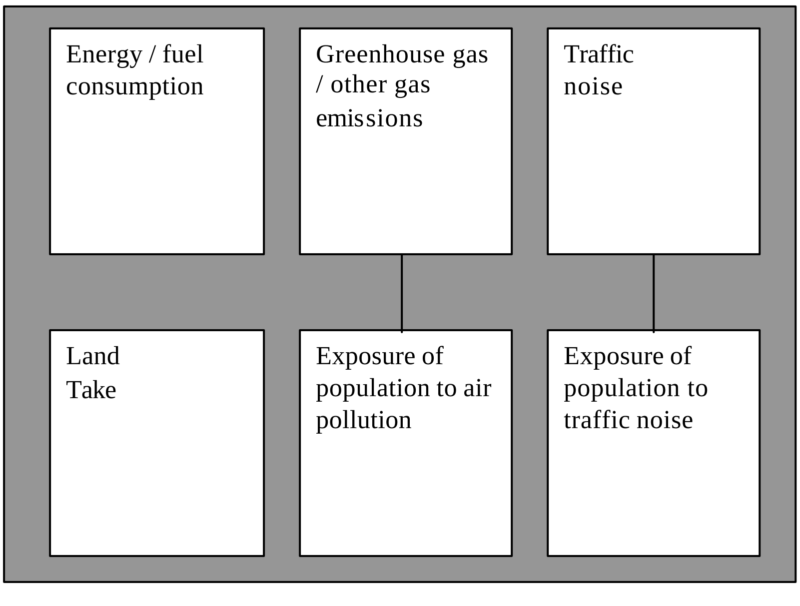

Figure 2. Environmental sub-models available

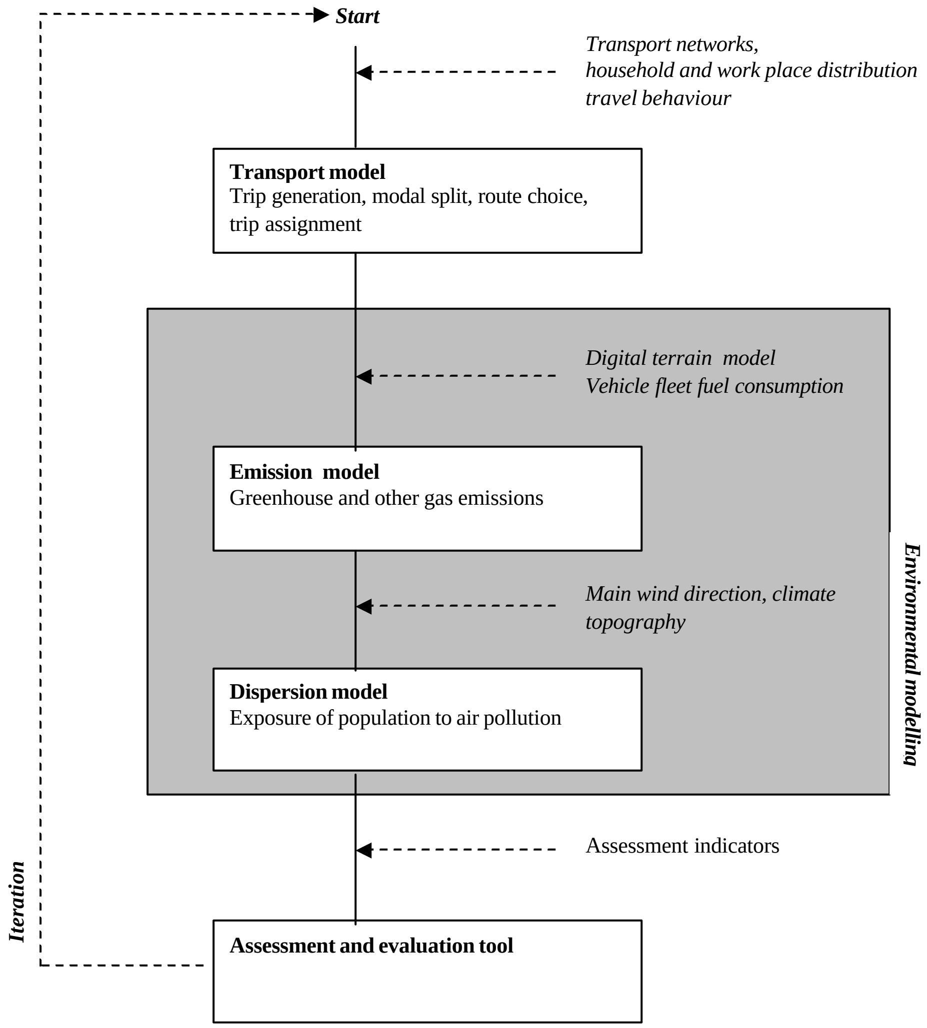

Figure 3. Interaction between transport and environmental models

The transport model will simulate traffic flows and link loads based on the current transport network(s), the spatial household and work place distribution and the observed travel behaviour. Using additional information on relief provided by the GIS and assumptions on vehicle fleet fuel consumption, the emission model will simulate greenhouse and other gas emissions. Despite the fact that most of the commercial transport models nowadays available are also able to calculate such emissions, in the VUGIS prototype this calculation will be moved into emission sub-models since the transport models calculate emission per link, where the exact alignment of the link is neglected, so that information on spatial emission sources is not available. In turn, calculating emissions in environmental models enables to locate these sources and so provides important spatial information required for the calculation of exposure of population to emissions. The calculation of exposures in the dispersion model is based on a raster or grid cell representation of the sources of emissions and is subject to the main wind direction, relief and general climatic patterns. In a last step this exposure is eventually assessed using certain sets of indicators. If desired, it is possible to iterate this evaluation process using different assumptions on proposed transport projects or on travel demand and travel behaviour.

Compared to other stand-alone emission and propagation models (e.g. the vehicle and engine emission modelling software provided by EPA (2001)) the models implemented here are less sophisticated in its underlying mathematical structures and data requirements, but in turn are closely coupled with GIS and the transport model and are applicable not only at a micro scale but also on local and regional levels.

7. USER INTERFACE

The ergonomic deficits mentioned in Chapter 1 (e.g. 'over featured systems' or 'learnability') and the rapidly growing importance of geographic information on the other hand have led to intensive efforts by the GI industry for the development of improved geographic information technologies. Nevertheless, current systems allow only the usage of a small portion of the actual functionality. Because of the complexity and the ergonomic deficits and the fact that GIS is mostly intended to be used by GIS experts, today's GIS are usually not accessible to end-users in administration, planning, decision making or even less for citizens (European Commission, 1998). This realisation of growing functionalities and an increasing variety of user communities led to a new attention within the GIS community to better user interfaces in the early 90s (Standing, 1993).

To enable more people to take advantage from the direct use of GIS, user interfaces have to be developed in a way that they can be interpreted and used by 'non-GIS-experts'. Metaphors within user interfaces help to make the software accessible to a broader field of users (Carroll et al., 1988; Kuhn and Frank, 1991). They allow the users to communicate with the system in their own familiar language. Ideally they allow an intuitive use of the system. It is one of the objectives of the prototype to be developed to enable people from the transport planning domain to take advantage of GIS for their planning tasks. Therefore metaphors have to be derived.

7.1 Metaphors for user interfaces

The professional employment of metaphors for user interfaces is a well-tested method for user interface design (e.g. the introduction of the desktop metaphor by Smith and Harslem (1982)). Metaphors allow the user "to understand one thing in terms of another, without thinking the two are the same" (Sweetser, 1990). To understand a system functionality the user develops a mental model that reflects the system. Experiences in using the system alter the model, which again serves as guidance for future uses. If the user interface is metaphor based it makes the user believe, that the system is similar to something he already knows. Metaphors also represent complex operations that might be far away from the user's understanding but nevertheless offer adequately use of the models (Standing, 1993). So metaphors are meant to communicate with the user and to link the mental models of the software developer and the future user.

In common GI systems, the use of metaphors is already widespread in commands to describe space and spatial analysis (Standing, 1993) (e.g. a typical GIS metaphor is the map metaphor (Kuhn, 1991)).

There is a number of publications on how to derive metaphors (Carroll et al., 1988; Madsen, 1994; Rauterberg and Hof, 1994; Alty and Knott, 2000). Proposed methods for the design of metaphors range from choosing them from a set of already commonly known metaphors, using interviews, market feedback or observations of domain experts. However, in the domain of human-computer interaction (HCI) it is commonly accepted that the first phase of an user interface design process is the conceptual design with its functional specifications resulting from task analysis. It incorporates the user's mental model of the high-level use of the system. This includes the definition of objects and their properties, which a user will have to know in order to use the system (Foley and van Dam, 1982). The description of these objects and functionalities requires a mapping from the user's familiar domain to the computer domain. These mappings are metaphors.

However, one element in metaphor design is frequently missing, the thorough understanding of the problem domain (Wilson and Rauch, 1992). Hence, to increase the likelihood of good metaphors, domain experts have to be involved in the creation process, because only they have the control over their domain knowledge and can access the prospects of success. Therefore a participatory metaphor design process following Erickson (1990), Marcus (1993) and Madsen (1994) seems to be the most promising way for metaphor selection or design.

Once the metaphors have been derived they can serve as high-level commands in the user interface. A sequence of low-level operators that accomplish the corresponding task has to be found. A translation between these two levels of abstraction requires an exact analysis of the users workflows and tasks. Therefore methods from task analysis and requirement analysis have been employed to create a conceptual model including entity types like actors, documents, actions and processes as well as simple planning tasks.

7.2 Task analysis

Task analysis in general is the study of workflow, tools, language and general culture of users (Figure 4). Finding metaphor candidates is a central part and outcome of task analysis (Kuhn, 1996). As part of the paradigm of user-centered design, task analysis is commonly applied in other domains, but not very common in the GIS domain (European Commission, 1998). In general the purpose of task analysis is to simplify the remaining stages of user interface design. It includes 'the process of identifying a complete description of tasks, sub-tasks and methods required to use a system, as well as other resources necessary for users and the system to cooperatively perform tasks' (Gabbard and Hix, 1999: 53). The most common approaches of task analysis are related to software design lifecycles. The resulting models of task analysis give a top-down decomposition of users tasks, interdependencies, relation, task order and sequences (e.g. *H*ierarchical *T*ask *A*nalysis - HTA) and enable the understanding of task semantics (Gabbard and Hix, 1999). In that manner they can serve as a source for the specification of objects, methods, information and services required from the system.

Most approaches of task analysis follow well-defined methodologies that are described by Kirwan and Ainsworth (1992) and Hackos and Redish (1998). Most methodologies and principles do hardly differ from other approaches, e.g. represented by Wixon and Holzblatt (1990), Beyer and Holzblatt (1998), Jarke and Bui (1998), Tawbi and Souveyet (1999), Rolland and Prakash (1999) and Carroll (2000). All of them stress out the necessity of contextual proceeding and the need to get insights in the users language and thoughts. Typically methods for task analysis are interviews, surveys, observation, scenario engineering, narrative methods and workflow diagrams.

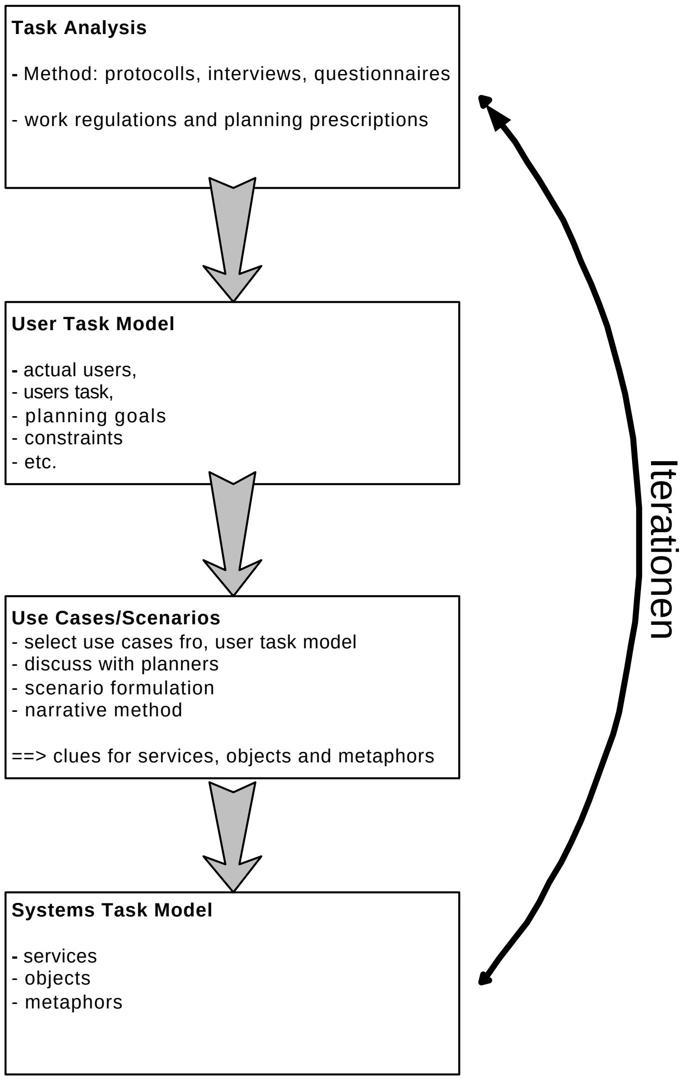

Figure 4. From task analysis to system design (Möltgen and Kuhn, 2000)

A task is defined as something to fulfil a specific mission (Sheridan, 1997). In transport planning a mission could be the construction of a new road. The task is to work out a legal planning basis, e.g. a legal binding plan. Sub-tasks in this sense can be the preparation of maps or the examination of environmental impacts. The accomplishment of a (sub-) task requires low-level user action, e.g. employing overlay commands within a GIS.

Because the targeted people of the VUGIS prototype are not GIS-experts, the task analysis performed here is not aiming at understanding certain GIS-commands, but it is rather to identify services and information the system has to provide to support the planner in solving his planning task. Doing so, all domain tasks had to be enumerated, independently whether they can be done with the GIS or not (Jeffries, 1997).

The outcome from task analysis is the abstract definition of what the system should do, what the potential user interaction can be, and what data structures and relations are underlying those interactions.

Consequently this requires information about

- potential planning tasks,
- what information are needed,
- what information are generated,
- which objects are being produced within the workflow,
- who is involved in the planning process,
- how did the user solve the problem up to now,
- which workflows can be supported by computer use,
- are the users more casual, occasional or rather daily users,
- assumptions that define the context of the planning steps.

For the design of metaphors the developer has to consider the functional specification, which is the result of the task analysis. The developer tries to create a concept from the user's point of view to show what can be done and what objectives lie behind it. On this basis one can try to find metaphors (Preim, 1999). In that way the metaphors can simplify a GIS user interface for the transport planner by eliminating commands and replacing them by more general concepts.

Exploiting the HTA method (Kirwan and Ainsworth, 1992), a users' conceptual model of the software can be designed. The HTA produces a hierarchy diagram which illustrates objects, operations, sub-tasks, instructions and constraints for the users planning task – the so-called *User Task Model* (Figure 5). One branch of the diagram in Figure 5 is then called a *Use Case*.

For the refinement of the overall *User Task Model*, the analysis of different configurations or instances of a *Use Cases* as seen from different experts seems a promising step. As exemplarity, the generation of a conflict map for the area of biotopes is presented in Figure 6 as a detailed *Use Case*.

Based on textual analysis of interviews and descriptions of the domain experts, the narrative method (colouring verbs, objects etc.) is used to analyse the Use Cases in order to get candidates for objects, services and also metaphors that should be implemented in the user interface of the prototype. Table 1 shows a comparison of objects and services and metaphors derived from an expert interview.

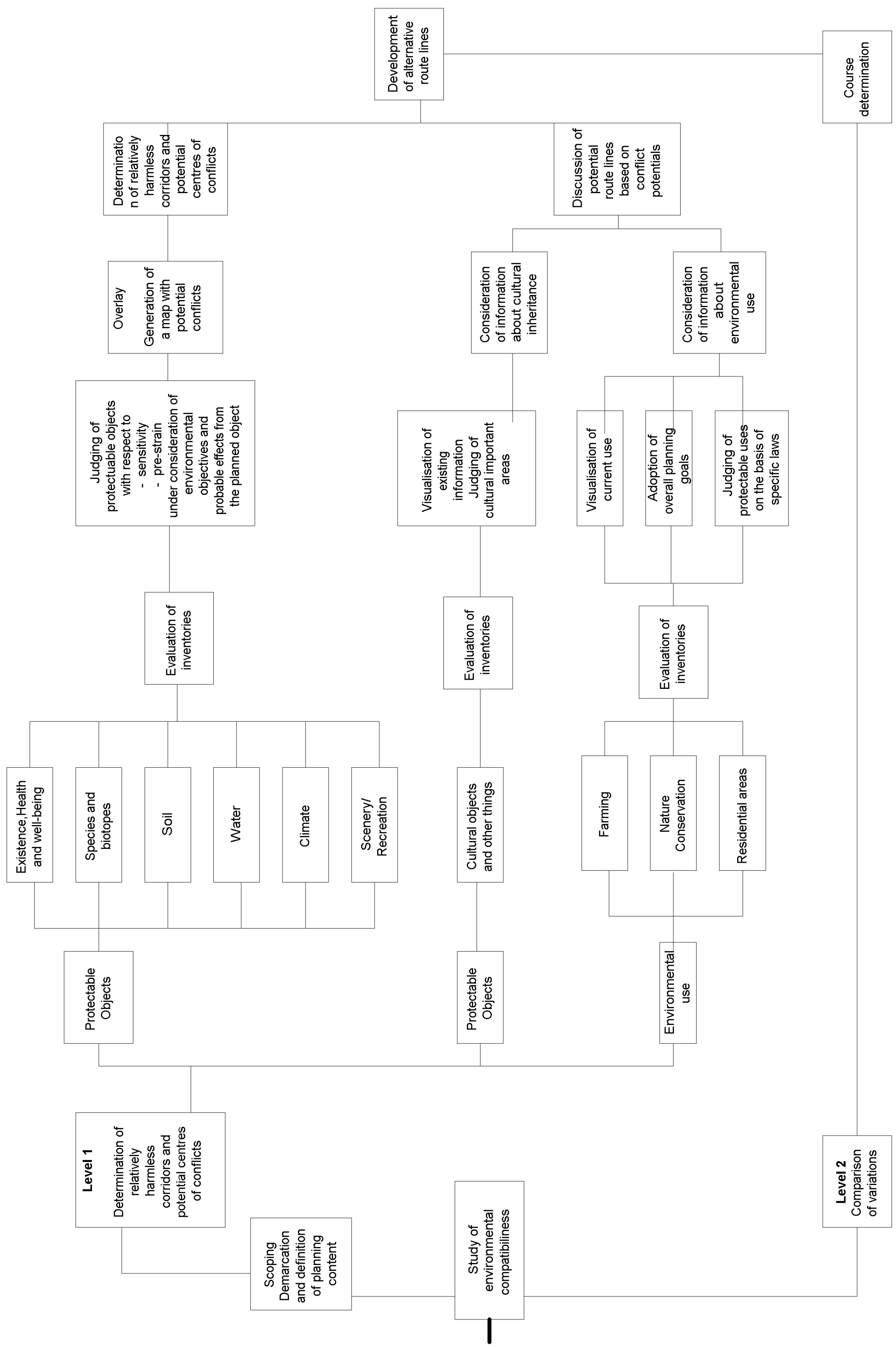

Figure 5. User Task Model (excerpt) (Möltgen and Kuhn, 2000)

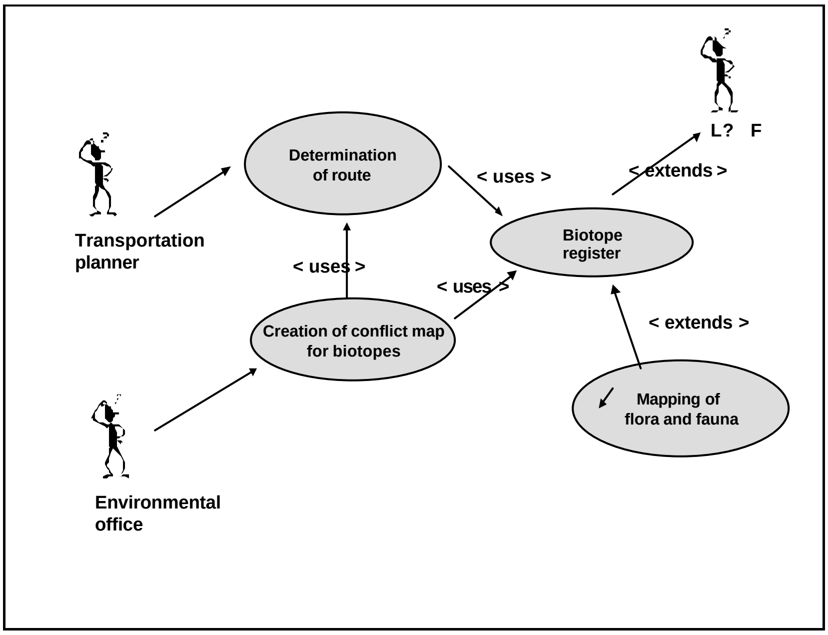

Figure 6. Use Case (Möltgen and Kuhn, 2000)

Table 1. Comparison of objects, services and metaphors (sample)

Objects	Services and metaphors
intended route	map creation
Map potential conflicts	Data check
fruit-meadow	Show
Hedges	superimpose
Shrubberies	
natural monuments	
Forest	
River	
out-dying plants	
bird hotbeds	

The phrases in the right column of Table 1 represent candidates for metaphors to be implemented in VUGIS in the user interface in form of ' icons' on the screen or commands in menus or list boxes.

The interaction with the system will be guided by the metaphors that represent the planners domain ontology. Figure 7 shows an simplified example of the command sequence to produce a map that presents conflicts with soil protection which can arise through the construction of a new road. Instead of knowing and choosing all these commands from GIS and transport/environmental models, the user can navigate in a menu where he can find familiar terms instead of all these commands. In Figure 7 the user can search in the '*conflicts*'-menu. It is divided in *social*, *economical* and *environmental* conflicts. The command '*soil conflicts*' will start an analysis that employs the GIS, the transport and the environmental model.

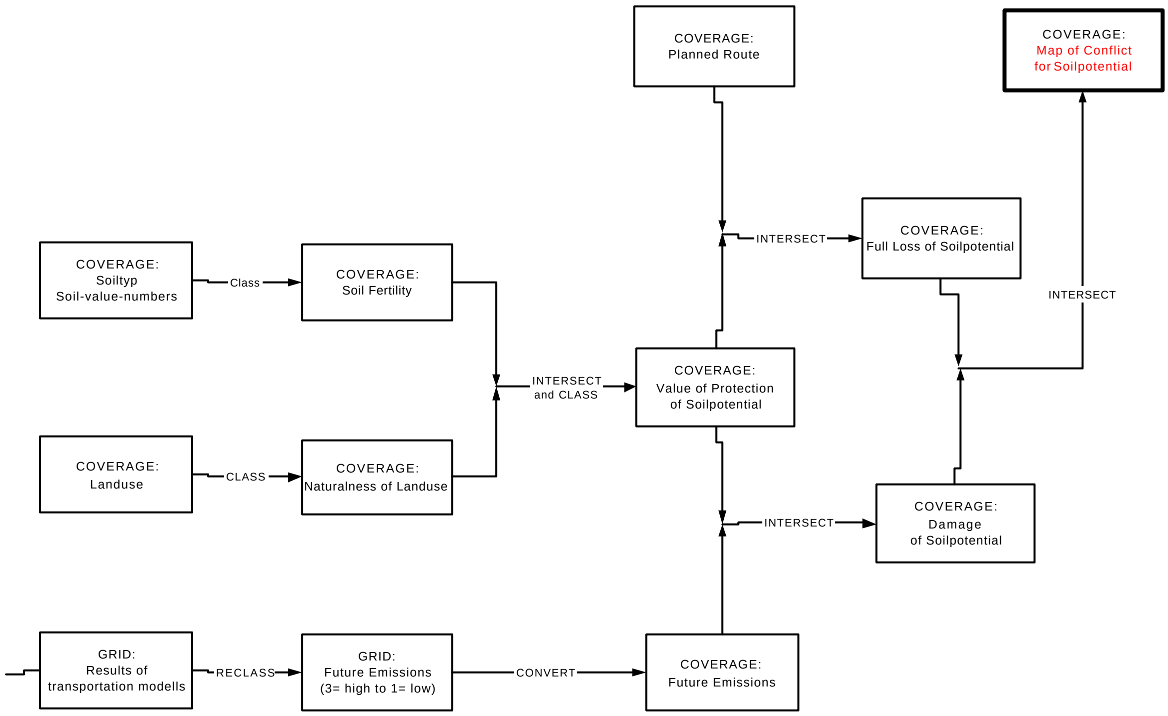

Figure 7. Typically command sequence in GIS

8. CASE STUDIES

The VUGIS prototype will be implemented for three case studies each representing a typical transport planning project (Figure 8). The choice of these examples took account of different scales and different planning missions, i.e. the case studies cover different spatial and thematically issues. The spatial scale ranges from a small local road project up to a major regional railway project. In detail, the three case studies will be:

1) The new construction of a major city road and the construction of a national motorway ramp in Hiltrop, which is a suburb of the city of Münster, which aims to improve accessibility of the southern suburbs of the city of Münster.
2) The new construction of a bypass road around the small town of Raesfeld in a rural area which is set up to relieve the local roads of transport flows.
3) The reactivation of a formerly closed important regional railway line between the cities of Münster and Neubeckum which mainly aims at strengthening public transport.

Thematically each case study (*Use Case*) has a slightly different focus as the first projects is dedicated to improve accessibility, the second mainly focuses on relieving local roads of traffic and the third is set up to strengthen public transport systems. Consequently, the *Use Cases* and the *User Task Models* of the three studies will have slightly different structures, however, the overall frame will look the same.

For these case studies the user will find capabilities to introduce a number of scenarios with respect to road alignments or time schedules for public transport systems. However, regarding the alignment issue, the level of detail implemented will be on a 'strategic level', i.e. the alignment is as fixed and detailed as possible, but is not as detailed as required for real road design.

Figure 8. Case Studies

The prototype will be implemented on the basis of these case studies to evaluate, simulate and represent environmental impacts of these typical transport projects. They are chosen to demonstrate that the software prototype will be able to support the assessment of different transport projects regardless of their spatial scale or thematic implications .

9. CONCLUSIONS

This paper presents the outline and structure of a comprehensive Spatial Decision Support System (SDSS) for the evaluation and environmental assessment of transport projects at an early planning stage comprising several GIS, transport and environmental modelling tools under one unified user interface. The advantages of such a prototype are the *comprehensive and unified database*, an easy-to-use, *metaphors-based user interface*, the *modular structure* according to the OGC-guidelines, and as the major achievement the *close coupling of GIS, transport and environmental models* in one unified system

During the development and implementation of the prototype special concern will be given to the derivation of the metaphors since they are seen as the base keywords for the design and establishment of an easy-to-use user interface.

Although the envisaged functionality of the prototype does not cover all tasks required in transport planning processes, the prototype will be open and flexible to be enhanced by additional modules, models and tools. In this, the prototype will not be a marketable software product but is rather meant to show how such a system could be specified and implemented and to show how metaphors in the user interface and the technique of semantic mapping could support transport planners in their daily work.

The project is not aiming at developing new sophisticated transport or environmental models, but the major achievement will be the development of a unified system closely coupling transport and environmental models by using latest open GIS techniques and metaphors design principles. In that the transport and environmental models may not represent the latest and most sophisticated models of their kind, but the benefit for planners will be to apply all these models within one system with an easy-to-use user interface.

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