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Towards a GIS-based system for roads and transport planning in Norway

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Content

Abstract

Since 1999, SINTEF have been developing GIS-tools for ArcView for use in roads and transport planning. There have been developed tools to generate, analyse and present geographic data concerning transport modelling, cost-benefit analysis and environmental calculations. With the latest module developed, the user can construct horizontal- and vertical road geometry by giving the parameters from the Norwegian streets and roads design manual. All modules are converted to work with ArcGIS 9. This paper will give a short presentation of each module developed, and share some thoughts about what have to be done to make the modules more like a complete and integrated system for roads and transport planning.

1. Introduction

Transport planning is a complex process, where the main challenge is to study what kind of impact changes regarding the transport system makes for authorities, owners, users and other objects affected. The process involves collection, production, analysis and presentation of geo-referenced information of many kinds. In Norway, making tools for analysing matters within the sector of transport planning have traditionally been initiated and funded by the Norwegian Public Roads Administration (NPRA). The NPRA has also played a leading role in administering road databases and map data relevant to the transport planning process. Most of the tools developed by the NPRA were initiated long before GIS was commonly in use by the specialist environment both in the NPRA and among consultants and researchers. The introduction to GIS was in most cases made by adding low-functionality map viewers to the different applications, mainly for the purpose of presenting results of calculations. The use of ArcView and ArcGIS was first introduced by users wanting to do further analysis on geo-referenced data as completive studies to the existing applications. The idea of making ArcView and ArcGIS rapidly grew when the first tests of making extensions to ESRI products were executed. The main applications used in impact assessment studies soon got own extensions for collection, production, manipulation and presentation of input and output data.

2. Overview

In Norway, roads and transport planning mainly focus on three basic analyses. The demand modelling is done in strategic multimodal transport models. The cost-benefit analysis is done in EFFEKT and the environmental analysis is done in VSTØY/VLUFT (Figure 1).

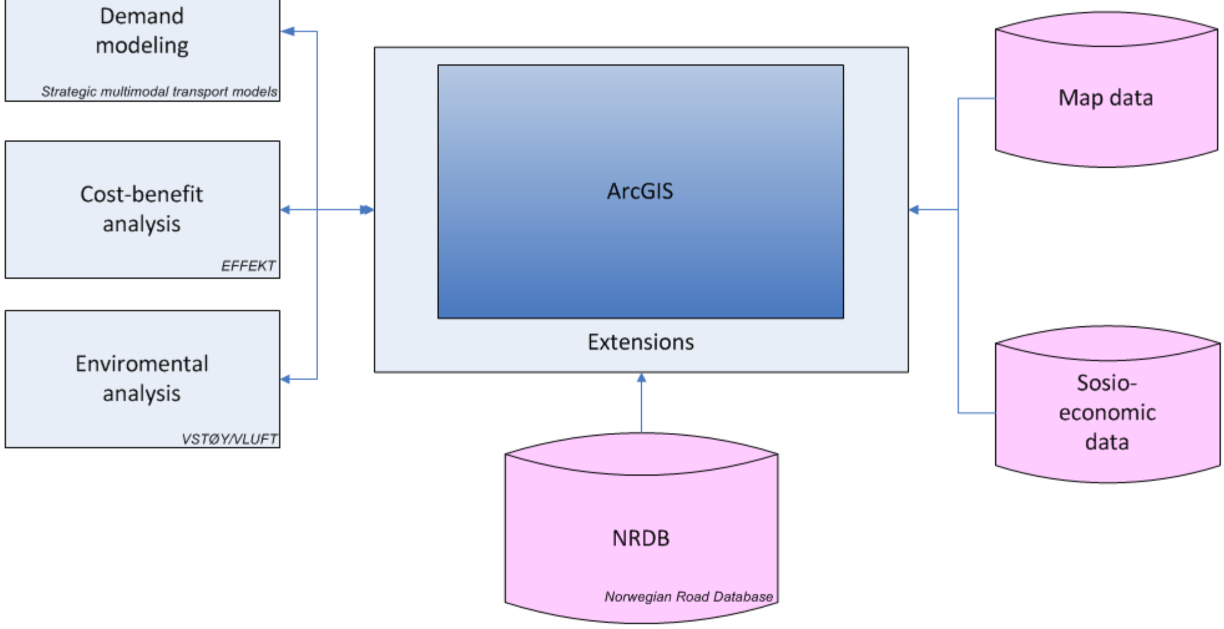

Figure 1 Overview of the data systems and the databases in road and transport planning.

These analyses utilize the same road network and some of the same road data managed by the Norwegian Road Database (NRDB). Other important data in this system are map data and socioeconomic data. There have been developed extensions and functionality for ArcGIS (ArcMap) for all three analyses. These extensions, which currently have been migrated to work with ArcGIS 9, all make great contributions to raising the user experience of working with the main applications used in analysis. ArcGIS is currently regarded as the dataflow hub which connects the input and output data for the applications. These are described in the next section.

3. What have been developed?

3.1. Extension for line construction

The first stage in road planning is often sketching alternative road routes in a map. The sketches are the input data to the analyses of transport and cost-benefit and environmental studies. Traditionally the road planning at this level has been too detail-oriented for the purpose. The idea was to develop an extension in ArcMap to easily sketch new roads. With a minimum of effort the transport planner can construct centre lines in ArcMap with functions for calculating curvature in the horizontal- and vertical plane. The generated curves can be the basis in transport network scenario-encoding or as input to the calculation of driving speed which is a variable in the calculation of time costs in the cost-benefit analysis. There has been developed a pilot that consists of an ArcGIS extension and a geometry module[1]. The geometry of the road is generated based on the dimensioning requirements given in the Norwegian road manual[2]. The input data needed in the application is a road network from NRDB and contour lines of the landscape. To sketch a new centre line the user has to give a line-name and a dimensioning class for that specific road type. The dimensioning class gives the geometry module a set of parameters for example the minimum clothoid or the maximum gradient of the road. The user is then ready to sketch a line by setting out angle-points in the map. The geometry module needs at least three points to generate curvature. The generated curves are symbolized with green colour if they satisfy the dimensioning requirements and red if they are outside the limitations (Figure 2).

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[1] The geometry module is developed by the company Road Solutions, Norway.

[2] Håndbok 017 Veg- og gateutforming.

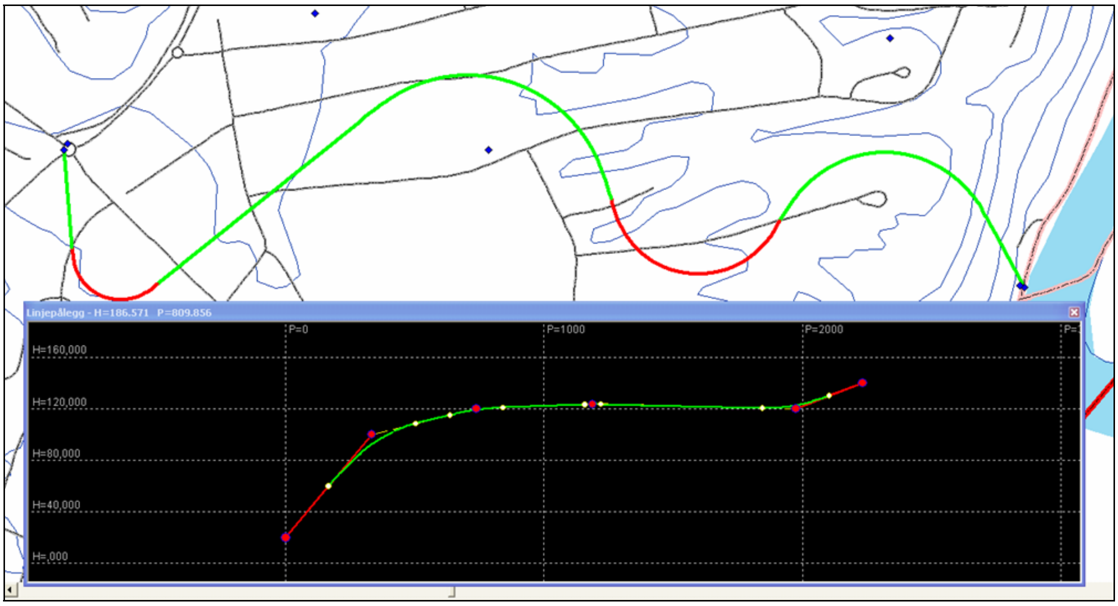

Figure 2 Generated curvature. Red curves do not satisfy the dimensioning requirements in the dimensioning class. Blue points are angle points given by the user. The vertical projection is presented in the black window.

3.2. Transport modelling

The transport models available in Norway are developed for different needs; there are strategic, tactical and operational models in use. In this paper, we will be focusing on the strategic regional transport models, named RTM – Regional Transport Model. This model has been widely adapted to the dataflow described in this paper, while other models use parts of the established flow. RTM consist of all main public transport infrastructure in Norway. Roads, railroads, bus and boat routes are among the transport networks included. The zone structure consists of over 13.000 zones, and the total model is divided into 5 regions, to make the management of the models easier. RTM is based on Citilabs Cube, a transport modelling framework application. Managing models of this substantial size demands a good overview of data that makes input and output data to the transport model calculations. This is important both from a user interface perspective and to assure that preparation of data meets the quality standard defined in the model. All datasets that are input data to the transport model are geo-referenced in different ways:

- By coordinates
- By key index referring to a polygon administrative area
- By road reference index (consists of county index, municipal index, road category, road type, road number and parcel number. Also consists of metering values to indicate starting and ending point of link)

To help users prepare data for transport modelling purposes, there has been developed an ArcGIS extension. The extension handles several procedures:

- Dataset management
- Storage control
- Import and export of special format text files
- Creation of node-link structures from networks imported from NRDB, which handles segmentation of resulting network by specific predefined options
- Manipulation of networks
- Creation of public transport line networks
- Other special spatial procedures used to generate data from official national datasets

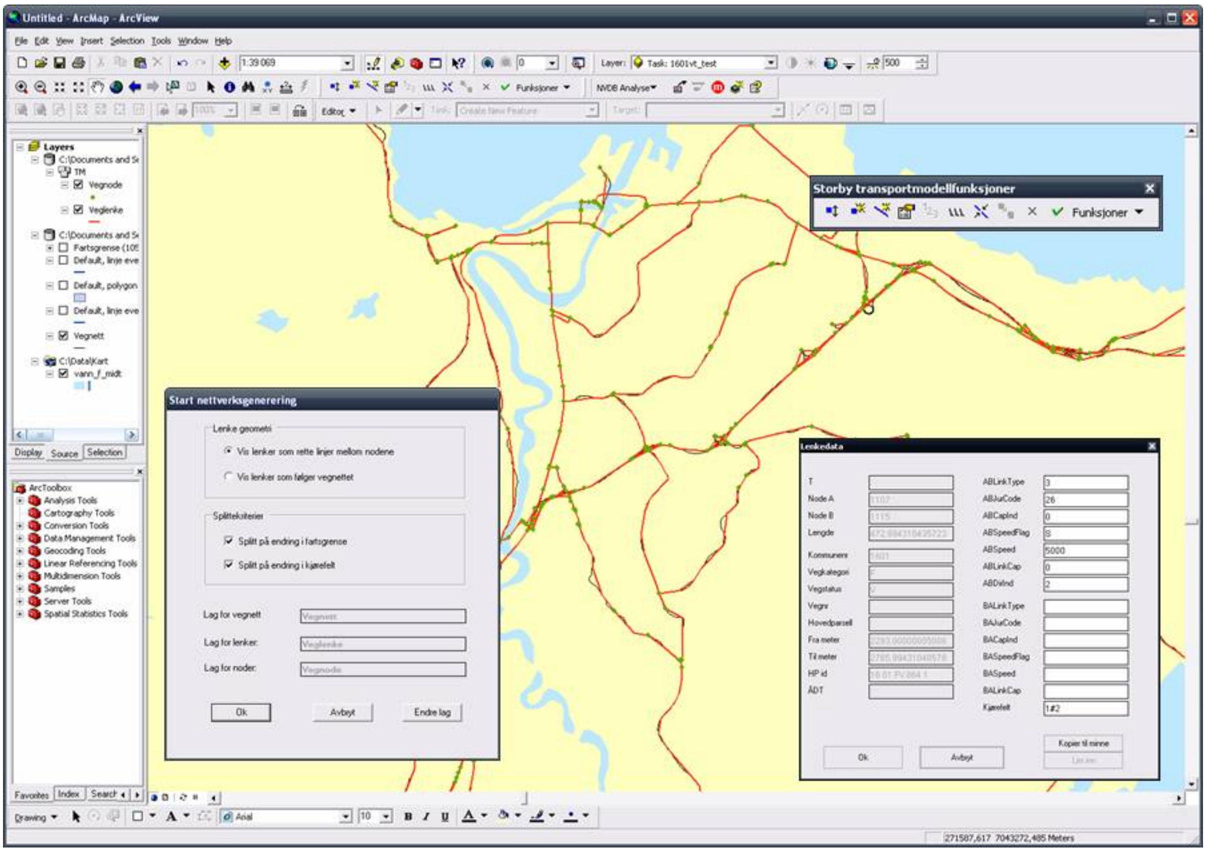

Figure 3 Screenshot from working with extension for transport modelling

Creation of datasets from scratch often starts with importing datasets from official national datasets, for example from NRDB. Based on official data, a node-link structure is created, following pre-defined national rules. Based on demographic data and administrative boundaries, the user can generate centroids for referring the zone level to the transportation network. The public transport infrastructure is then based on the physical network, and routines for creating lines are partly predefined and partly user-input driven. After adding special attributes to network that the transport model needs, the user exports the files to Cube and calculates the traffic volumes on the transport network links. When the calculation has finished, the user can import results from the transport model to ArcGIS to study results, do additional analysis and produce presentations.

3.3. *Environmental studies*

For analysing environmental impacts of infrastructural changes, the NPRA has developed an analysis tool named VSTØY/VLUFT. This application calculates noise and air pollution from road traffic. The application is based on Microsoft Access, and the calculations follow national guidelines and directives for doing such analysis. The calculations are based on road networks, traffic volumes and houses and buildings of different types that are exposed to environmental impact caused by road traffic. Preparing and creating input data for the environmental application is a demanding process. The road network is complex in urban areas, and the model uses several attributes from NRDB to create a node-link network with attributes. In addition, there are also many other types of data regarding buildings and their attributes that has to be collected and controlled to make the best input dataset for the calculations.

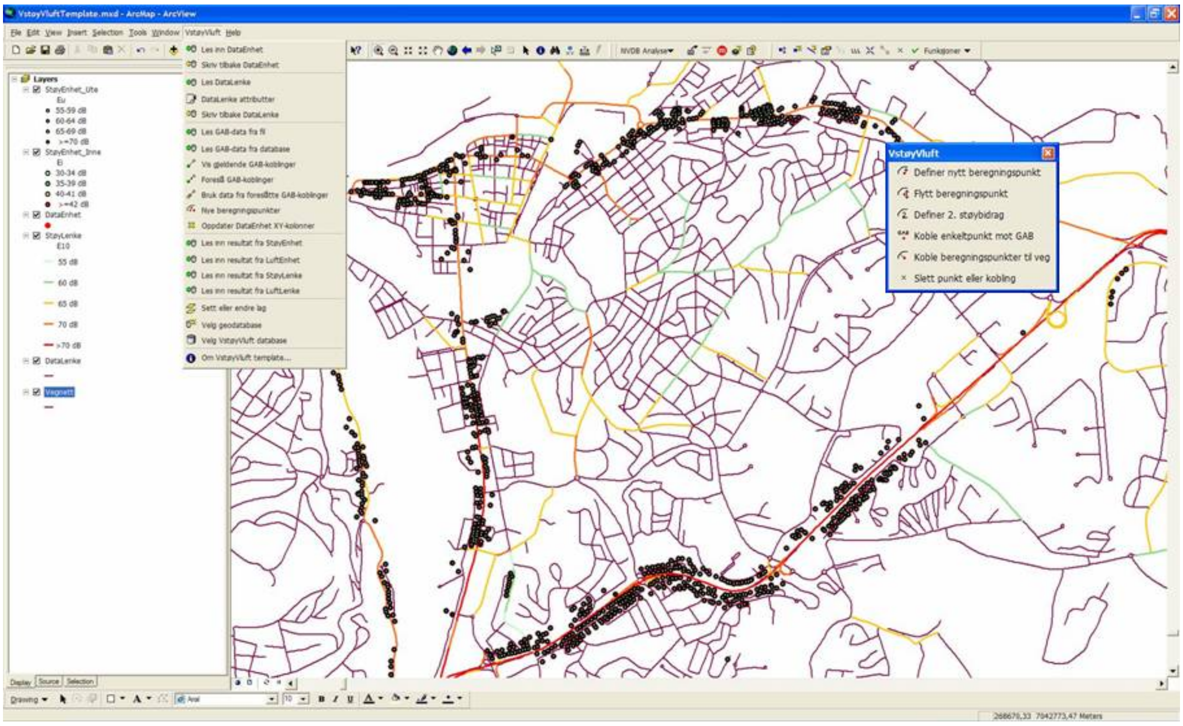

Figure 4 Screenshot from working with extension for ArcGIS related to environmental studies.

The ArcGIS extension creates many types of input data to the environmental model, writes the data to the project database and analyses the results from calculations. The extension also holds functionality to manipulate attributes in road network and buildings. This is required when analysing future plans, as there is no official dataset that provides information about these actions. This job is part of the planning of the project that is being analysed.

In addition to curvature, the geometry module calculates the cross profile of the new road. So far the extension only presents the centre line and the edge line, but further development can take advantage of other options in the cross profile.

3.4. GIS and cost-benefit analysis

EFFEKT is the application for cost-benefit analysis of road and traffic projects. The application is based on a MS Access-database. EFFEKT is getting the transport networks from transport models, which consists of links and nodes. In addition to a transport network the application is in need of a route identification called road reference on each road link. This route ID makes it possible to collect road data from the national road database (NRDB). The route ID is also the key to present data from EFFEKT in a GIS-system. There are several reasons to present data from the cost-benefit analysis in a GIS-system. In a large database with thousands of road links and many attributes there is essential to check out the quality of the input data. When data is presented in a map the probability of finding errors is larger than looking at data in a table. It's also useful to present the results from the cost-benefit analysis in a map. It makes it easy to compare data from the cost-benefit analysis to data from the transport analysis or the environmental calculations. Additional analysis can also be done when you make the data available in a GIS, for example analysis of accessibility based upon data from EFFEKT. In EFFEKT there is functionality to write data (input data and results) into another database called effekt2ArcGIS. The data is generated at two levels: link-level and network level (sum of links). At the link level this function generates attribute data as absolute values and differences between alternatives. The function has selection criteria so the user can choose to work on different road types, areas or road functions. The user needs to choose cost plan, key field, the year of calculation and selection criteria. When the user activates the function it will calculate data at the given year and it will save the output data in the effekt2ArcGis.mdb. The user can add this database to ArcMap and choose one of the tables to present data. Chosen table can be connected to the transport network by using the Add Route Event-function.

4. Main benefits

The benefits of developing GIS-functionality for applications within transport planning that contains geo-referenced information are many. The main benefits are:

1. Improved user experience - the user can work in the same interface when obtaining and presenting data.
2. Improved quality of input and output data – presenting data in a map gives the user better overview and control on the dataset.
3. Improved dataflow - easy to compare data from different sources.
4. Increased opportunities when analyzing geo-referenced data – a GIS itself has built in powerful analyzing tools.

These benefits will lead to more efficient transport planning. Taking advantages of GIS as the dataflow hub make the transport planning better as a ground for decision-making.

5. Future plans

5.1. New types of data

Future plans involve examining what new types of data can be used in planning tools. As more and more data gets accessible, new areas of application will be developed. One of the main impacts will be relating the planning process to new data from the NRDB, and using other types of spatial data from governmental sources in Norway.

5.2. Further integration

A part of the dataflow between official databases, planning applications and ArcGIS is based on exchanging files via established file formats that have traditionally been used in the different applications. By basing future dataflow on GIS-based databases, both ArcGIS and the planning applications can use the same storage structures, and derive data needed to do calculations from these databases. This makes management of data a lot easier and more flexible. Even further integration will be studied, related to making ArcGIS the main user interface for working with different analysis related to transport planning. This means that the future system for transport planning purposes may consist of a central database which holds data related to all planning purposes and utilize external calculating components. The components may be implemented to fit the data storage and using ArcGIS as a common user interface.

5.3. New tools

Outside the established calculation models which hold official methodology, there is also a need to be able to utilize the built-in geoprocessing tools available in ArcGIS to do ad-hoc analysis. This analysis relates to official datasets and calculations, but will vary greatly depending on the type of project that is being analysed. This is a very important step that means that the user can use ArcGIS as a real tool for analysing challenges related to transport planning, with input from official methodology, local data sources and project-related challenges.