LUTI modelling in the Netherlands: Experiences with TIGRIS and a framework for a new LUTI model

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This paper presents the use of the Dutch LUTI model TIGRIS in the planning process. TIGRIS is a long-term, incremental, time-based interaction and allocation model for land use, mobility, congestion and accessibility. In TIGRIS accessibility is described as a location factor for land-use that generates mobility. This increased mobility leads to congestion and changes in accessibility, and afterwards to new changes in land use. The model is used for regional and national forecasting, and follows a learning-by-doing approach.
In this paper four applications of TIGRIS are described with a focus on assessing impacts and the role in the planning process.
Because TIGRIS was originally developed as a sketch planning model with limited detail and the calibration on the basis of empirical data was rather limited, a new version, TIGRIS XL, is currently being developed.

1. Introduction

Since the fundamentals of transport modelling were developed in the 1950s there have been significant changes in emphasis. The earliest studies were predominantly concerned with the provision of road capacity, reflecting growing automobile usage throughout the world. Nowadays, the environmental impact of transport, pricing measures to reduce automobile usage, and the effects of new rail infrastructure on the housing and labour markets are at the centre of most transport studies (see for the history of travel demand modelling Bates, 2000).

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The change in emphasis towards broader research questions calls for an integrated approach of transport and the physical environment.
In all transport studies, the modelling of supply encompasses in some way the response of the transport system to a given level of demand. Supply responses include highway infrastructure, public transport services, parking lots and public transport modes. The modelling of demand herein contains a procedure for predicting which travel decisions people would wish to make, given the generalised costs of alternatives. These decisions include choice of time of travel, route, mode, destination, and trip frequency. The traditional approach of transport modellers is to keep land use fixed, while studying the choice of destination, mode or travel route.
In these types of studies, land-use planning is an important starting point: traffic flows are a result of the spread of housing, facilities and infrastructure. The reverse is also true: the presence or absence of infrastructure has an impact on the pattern of land-use development. For example, new transport infrastructure (both road and rail) will attract new activities in its vicinity. These, in turn, will generate new traffic. This is one particular form of "induced demand" (Hills, 1996) and may partly offset the benefits of increased accessibility.
There has been some debate in both urban economics and transport economics about the extent to which changes in land use and demographic composition and changes in the transport system can be separated, as transport changes may give rise to land-use changes. Nowadays, a general consensus seems to have been reached among geographers, transportation planners and economists that transportation and land use are too strongly interrelated to be separately considered (cf. Southworth, 2001; Badoe and Miller, 2000; You and Kim, 1999; and, Sasaki, 1990). This section covers land use transportation interaction (LUTI) models, that establish an explicit link between the two elements.
A LUTI model consists of two interacting sub-models of land use or location and transport; such that inputs from the transport model are inputs into the land-use model. The land-use model describes the behaviour of households, land developers and firms, and predicts urban development as a result of the locational choices of households and firms and land supply by land developers (see also the review of Wegener, 1998). The urban region considered is generally represented as a set of discrete sub-areas or zones. The modelling of travel demand is considered in the transport model, determining the number of trips – and sometimes mode and route choice – based on the location of activities that result from the land-use model. Although in theory travel has always been viewed as derived from the demand for activity participation, in practice it has mostly been modelled with trip-based rather than activity-based methods (for a discussion of the weakness and limitations of trip-based models we refer to McNally, 2000). LUTI's are no exception to this. Transport itself is sometimes modelled either as exogenous or endogenous in which case the results of the land-use model are in turn fed back into the transport model.
Differences between existing LUTI's result from different assumptions underlying the land use and/or transport modules as well as differences in detail: the number of zones, land use categories, transport modes, types of households, dwelling types, and number of sectors considered. Besides differences between the LUTI models there are common elements in the state-of-the-art LUTI models. As general characteristic of the LUTI models the following elements can be mentioned:

- The variety in basic theories for integrated land-use & transport modelling has diminished throughout the years and nowadays almost all 'state of the art' models rely on discrete

choice theory to explain and forecast the behaviour of actors such as residents or firms ;
- Another common element in most of the models is that they represent both activities and the space where they are located. The reason for doing so is the difference in the duration of urban processes as house construction or moving of residents;
- In LUTI models the focus is on the distributive impact of infrastructure measures rather than on their generative impacts. In other words the focus is on the redistribution of employment instead of the generation of employment;
- All of the LUTI models in the study are predictive models and not optimising models.
- The location of households and service activities can be explained much better than the location of industrial activity;
- The power of LUTI models in estimating the inter-regional location impacts of transport measures is much less than that of estimating the impact on intra-regional location decisions. The inter-regional element can be improved by integrating a LUTI model and a regional economic model.

In the Netherlands, some years ago a major study of the structuring effects of infrastructure was carried out: the STRUWIN study (Borgman, Jorritsma, 1995). Part of this study included the development of a LUTI model for the Netherlands: TIGRIS. TIGRIS stands for: Transport Infrastructure - Land Use Interaction Simulation. AVV - the Transport Research Centre of the Ministry of Transport, Public Works and Watermanagement - has ownership of the model.

The development of TIGRIS started at the beginning of the 1990s. Initially, the idea was to calibrate TIGRIS on the basis of empirical data. This, however, proved to be impossible. As an alternative, therefore, in the first version of TIGRIS, equations were defined which describe the relationship between land use and transport on the basis of the results provided by a round table of experts (including relationships from the traditional gravity transportation model as a submodel). Since then, the model has been considerably enhanced on the basis of validation exercises in four major application studies. Also, the zoning system has been considerably extended, now comprising 345 zones corresponding to those of the Dutch National Model System (HCG, 2000).

TIGRIS has now been applied in four case studies: Randstadrail, the KAN (Knooppunt Arnhem - Nijmegen) area, the LHA (Leiden – Haarlem – Amsterdam) area, and Randstad Urbanisation beyond 2030. While Randstadrail and KAN area mainly deal with the impact of infrastructure on land use, LHA and Randstad Urbanisation are designed to evaluate various urbanisation options in general and try to find some optimum variant.

In this paper the four applications of the TIGRIS model are described with a focus on assessing impacts and the role of the model in the planning process. Before starting the description of the applications, we provide a global description of the main trends in Dutch transport and spatial planning policy in Section 2. Section 3 describes the theoretical foundation of TIGRIS. Then we discuss the four TIGRIS applications related to the planning process in Section 4. This section ends with a short evaluation of the applications and the use of the LUTI model TIGRIS in the planning context. Section 5 presents an international technical evaluation of the model with respect to the TIGRIS model and an inventory of the ‘LUTI-modelling’ requirements of the clients of the Transport Research Centre. This section also describes a framework for a new LUTI for the Netherlands, TIGRIS XL. The paper ends with conclusions in Section 6.

2. Planning in the Netherlands

Main trends in Dutch national transport policy in the past 25 years

The Netherlands is one of the most densely populated countries in the world, counting about 16 million inhabitants. The centre of urbanisation is in the western part of the country near the North Sea (about 7.5 million people). The “Randstad”, comprises the four largest cities of the country (Amsterdam, Rotterdam, The Hague, Utrecht) and is ring-shaped with a “green belt” in the central area. The country has an advanced road transport system, a dense and frequently served public transport network, and high bicycle use compared to many other European countries (Salomon et. al., 1993).

In the sixties and seventies of last century, prosperity and car ownership increased swiftly. At first, the policy was to build new roads to cater for increasing mobility. Many motorways of the current trunk road system were built in the seventies and eighties, leading to huge reductions in travel times and substantially improved accessibility to the Dutch regions. But at the end of the seventies it became clear that simply meeting the demand for car travel was not the best way to go (v/d Hoorn et. al, 2003).

At the end of the eighties, care for the environment reached a peak, both internationally and in the Netherlands, when reports like the Bruntland report "Our Common Future" were published (World Commission, 1987). This led to the “National Plan for the Environment” (NMP), discussed in Parliament in 1990. The Second Transport Structure Scheme (SVV2) and the “Supplement to the Fourth Policy Document on Spatial Planning” (VINEX) were both co-ordinated with the National Plan for the Environment.

The main objective was a "sustainable society", catering for the needs of current generations without endangering those of future generations. SVV2 formulated very specific, quantified targets. To achieve these targets it was - among other things - necessary to contain the expected 70% increase in car mobility under the “business as usual” scenario for 2010 to 35%.

Both “pull” and “push” measures were advocated. Pull measures make the alternatives to the private car more attractive (public transport, bicycle, ridesharing, etc.). Push measures make the private car less attractive (through pricing measures, parking measures, etc.).

A few years later, the progress of SVV2 was evaluated. It was very clear that many high ideals presented in SVV2 were far from being reached. Although substantial investment in infrastructure for the public transport system had been carried out, the timetables and service levels had hardly improved. Also, the “push” measures were lagging behind. Car use and congestion grew much more than "planned". The environmental objectives for CO2 reduction were not being met, particularly because freight transport by road might double till 2010. Cost increases of infrastructure projects led to a funding shortage, while the public transport deficits continued to cause concern. Societal support for SVV2 was not strong enough, and the Ministry could partly blame itself for this (v/d Hoorn et. al., 2003).

Since the inception of SVV2, Dutch society had shifted to more liberal and right-wing viewpoints. In the new National Plan for Transport (in Dutch: NVVP), there is no longer a negative connotation associated with car use and mobility. The essential political creed of the NVVP is that mobility is allowed and is part of a modern society. However, the user should pay the full costs for the privilege (including all social and environmental costs). For transport issues there are no simple one-sided solutions, such as only building roads or only improving

public transport. A balanced policy package is needed. The most important components are: (i) better use of existing infrastructure and improvement of the alternatives for the car (ii) road construction where bottlenecks remain and (iii) pricing policy in the form of "variabilisation" (replacement of fixed car charges by charges dependent on use) and differentiation. Concretely, a "kilometre charge" is being proposed, using a sophisticated electronic toll collection system.
The key points are:

- The central position of needs and desires of the citizen. Choices made by individuals and companies are respected, provided that users pay for their choices;
- A business-like, non-ideological approach: instruments are used according to their effects;
- Infrastructure is the carrier for spatial developments;
- There will be more room for public-private partnerships;
- Decentralise everything that can be, centralise whatever is necessary. Regional mobility funds will be set up.

Traditionally the Netherlands has a rather strict land use planning with a heavy involvement of central government, both financially and in a regulatory sense. The main objectives were a sufficient supply of new houses without endangering the Green Heart region and other natural areas through uncontrolled sub urbanisation. There has also been an increasingly closer interaction between land use and transport policy: what are the most suitable locations to plan spatial programmes in a congested transport network? What impact has the presence or absence of infrastructure on the pattern of land-use planning?

3. The TIGRIS model

TIGRIS model
TIGRIS is a long term, incremental, time-based interaction and allocation model covering the following aspects: land use, mobility, congestion and accessibility. The model is used in a 'modelling as learning' – concept for *ex ante* evaluations (AVV, 1997).
TIGRIS consists of a set of a number of submodels or 'processes', which are run successively year by year (output year x = input year x+1). In TIGRIS 'accessibility' is known as a location factor for land use that generates mobility. This mobility leads to congestion and changes in accessibility, and afterwards to new changes in land use. Figure 1 shows the interactions in TIGRIS (Eradus et. al, 2002).

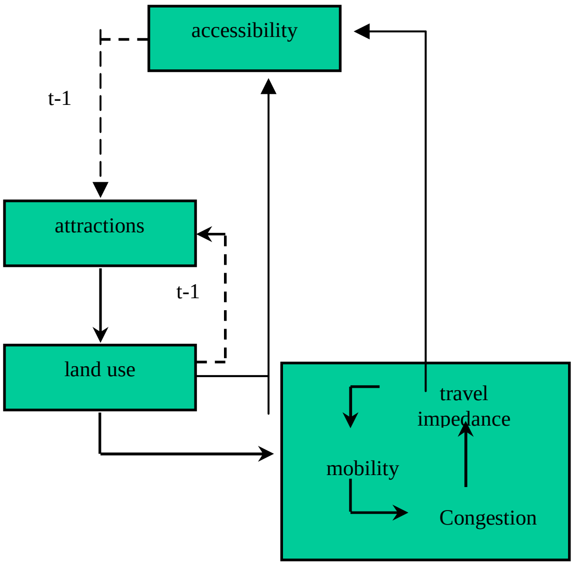

Figure 1: Interactions in TIGRIS

Submodels in TIGRIS

The *attractiveness* of a zone is subdivided in attractiveness for living purposes and attractiveness for working purposes (Figure 2). The attractiveness is dependent upon the accessibility of a zone. The attractiveness for living is determined by the number of (vacant) dwellings in the zone and something called 'living quality' (e.g. close to beautiful nature areas). This latter variable is comparable to a dummy variable and is designed to take into account the fact that some areas are more (or less) attractive than others. The attractiveness for working purposes is determined by the existing jobs and the developed employment capacity in the zone.

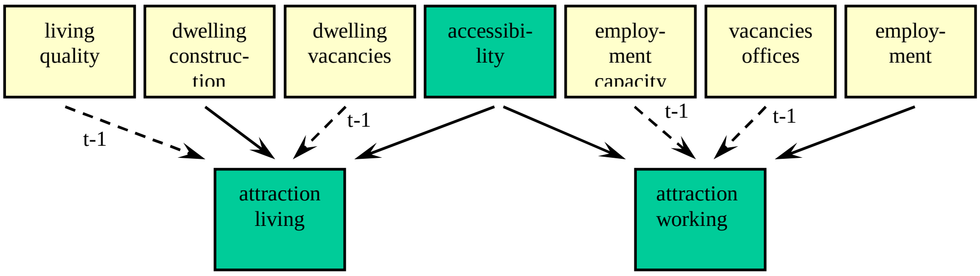

Figure 2. Attractions submodel

Land use is characterised by the number of dwellings, available employment capacity, population, jobs and amenities per zone (Figure 3). Land use is determined by autonomous national and regional developments, and the migration of people and firms. Migration is determined on the basis of attractiveness of a zone and the distance to competing zones. Dwelling construction per zone is determined on the basis of demand and a user-specified minimum and maximum number of dwellings. The same applies for the number of available jobs, calculated on the basis of the number of employed people and user-specified minimum and maximum number of office locations and industrial sites.

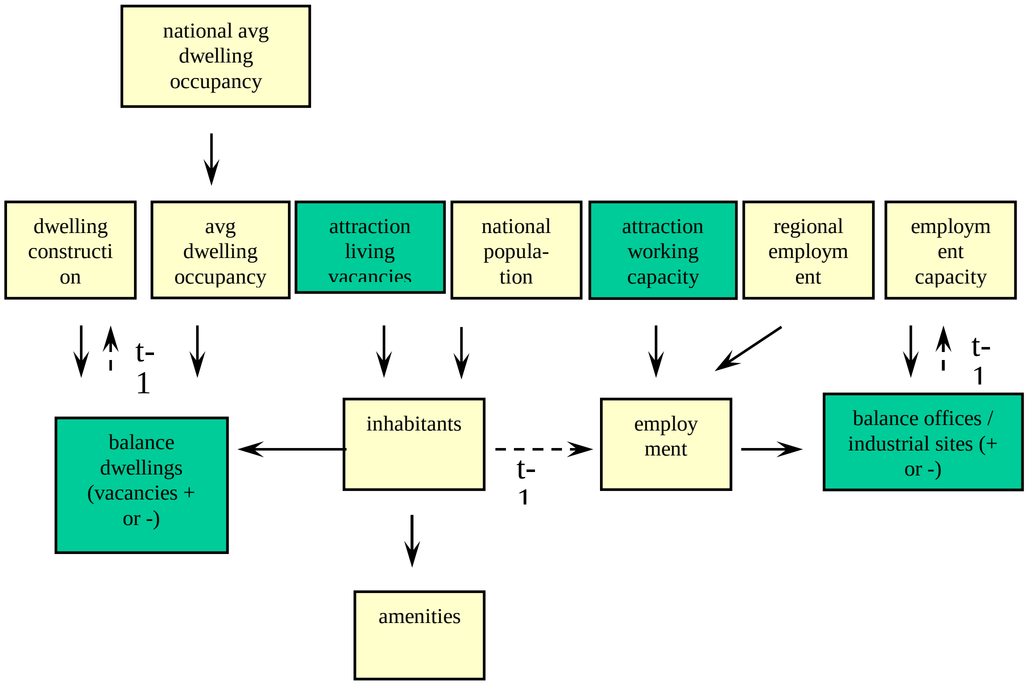

Figure 3 . Land-use submodel

Mobility is calculated in terms of flows by transport mode (car and public transport) between zone pairs. First, car ownership is determined by zone. This is partly dependent on the difference in travel impedance between car and public transport to other zones, the total demand for travel and national economic development. For every zone, an attractiveness measure is derived from the various land uses (amenities, inhabitants, jobs). For every type of land use there is a weighting factor. Next, for every zone the travel production to other surrounding zones is calculated, depending upon population and car ownership (figure 4).

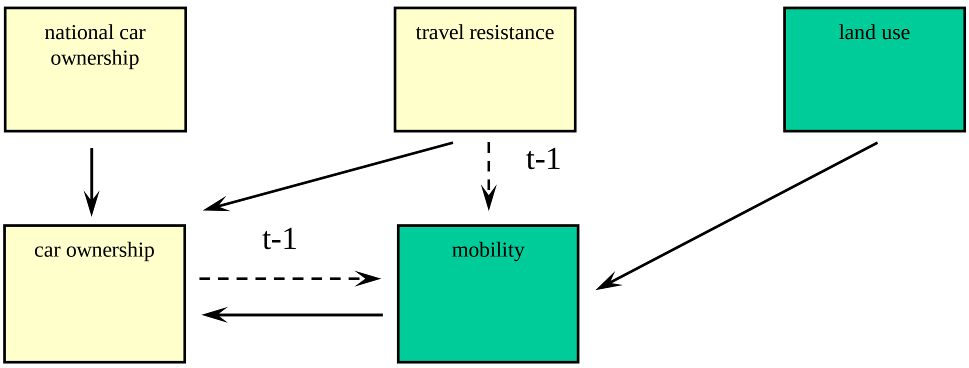

Figure 4. Mobility submodel

Congestion (volume/capacity ratio) is determined per road section and direction. The volume is determined by the number of journeys over the route element, corrected for factors like peak shares, commercial vehicle shares and a factor for ‘rat running’(alternative routes and shortcuts). The capacity per route is given initially, but can be changed by policy measures specified by the user (figure 5).

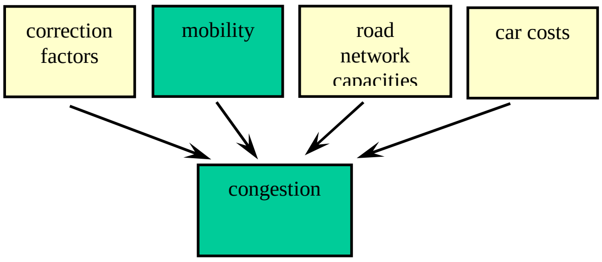

Figure 5.Ccongestion submodel

Travel impedance is determined between any two zones. First, impedance per mode is calculated. Next, a general travel impedance is calculated between a combination of zones. The latter can be corrected for parking restrictions in the origin or destination zone (figure 6).

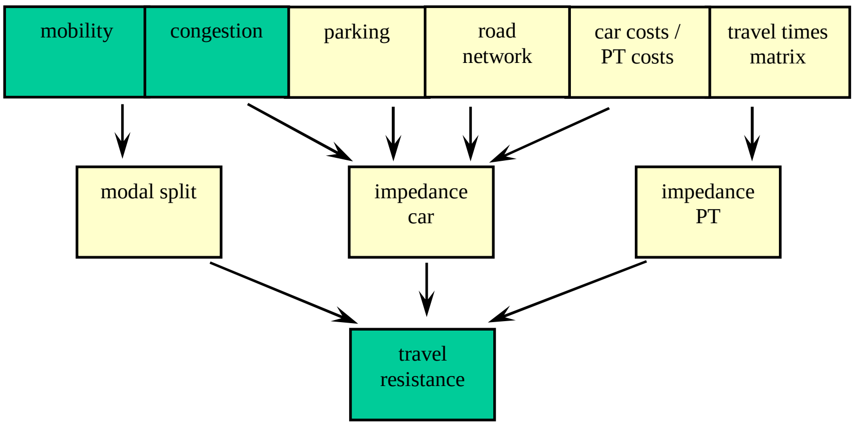

Figure 6. Travel impedance submodel

In general, the concept of accessibility of a zone is made operational as the amount of activity around a zone, weighted by the distance to that zone: the more there are activities within reach, the more accessible a zone is. Accessibility is distinguished into accessibility for, respectively, amenities, population and jobs (Figure 7).

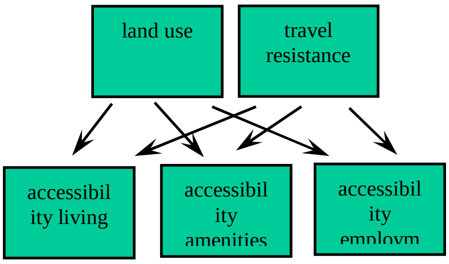

Figure 7. Aaccessibility submodel

Effect/factor matrix

In TIGRIS we distinguish the following effects: land use (population, jobs and amenities), attractiveness (attractiveness for living, working and recreational purposes), mobility, degree of infrastructure use (congestion, trip resistance) and accessibility. The value of the effects is determined using (the value of) particular factors. For example accessibility is calculated using trip resistance, weighted by population, employment and amenities.

The effect/factor interactions can be represented in the effect/factor matrix. There are also a number of iterative feedback-loops, for example to model congestion, whereby particular variables act both as a factor and effect.

Input and output

TIGRIS requires a lot of input. So far, every TIGRIS study has been unique: for every study area one has to make a new model. In general, three types of data are required (AVV, 2001): socio-economic data at national level (population trend in the Netherlands in the period 2010-2020), zone and infrastructure data in the base year (year of validation) and scenario-related data which describes the spatial plans (where do we build and how much?) and infrastructure plans between base year and future year of the application. Table 1 presents the data for TIGRIS applications in more detail.

Table 1. Data needs for TIGRIS applications

data national level base year	zonal level + infrastructure base year	national, zonal level + infrastructure forecasting year
car ownership	**zonal data**	**national level**
variable costs for car	car ownership	car ownership
public transport costs	inhabitants	variable costs for car
parking costs	jobs	public transport costs
inhabitants	no. of houses	parking costs
jobs	no. of vacant houses	inhabitants
average house occupancy	vacant office buildings / industrial estate	jobs
	living quality	average house occupancy
	data infrastructure	**zonal level**
	network + network characteristics	no. of houses
	LOS matrix public transport	no. of jobs (industrial / office)
		parking costs
		data infrastructure
		network mutations
		public transport measures

A TIGRIS simulation generates a lot of output in dBase format. This provides much flexibility and many possibilities to analyse the results. For the main analysis purposes, some standard formats have been pre-defined. TIGRIS generates maps (connection with ArcView) and graphs:

- Maps: car ownership, population, congestion, mobility, employment, dwellings, accessibility (example: Figure 8);
- Graphs: population, employment, travel by car / public transport, passenger- kilometres by car / public transport, average trip length by car / public transport.

Figure 8. Example of spatial and infrastructure maps (mutations inhabitants and congestion)

Field of application of TIGRIS

TIGRIS can be used both at a national and regional level. In the policy cycle of the Ministry of Transport, TIGRIS is most suitable at the start of the planning process. This implies that at

the national level TIGRIS can be used for long-term forecasting studies, problem analyses, strategic vision and strategic policy packages in the field of interaction between spatial and infrastructure planning; in other words, it is suitable for strategic discussions about the national transport policy (NVVP). The TIGRIS model can calculate *global* consequences of spatial and/or infrastructure measures. The model contains limited detail. The model is effective in supporting scenario discussions. During a phase in the planning process that requires more detail, a sectoral (transport) model is used.
At the regional level TIGRIS is suitable for strategic discussions about (large) infrastructure projects and regional spatial and transport planning (province). So far, TIGRIS has only been used in studies of the Ministry of Transport, both at a national and regional level.

4. TIGRIS applications related to the planning process

So far TIGRIS has been used for 4 major studies, since the prototype was launched in 1997. These studies presented the impacts of spatial planning on mobility and infrastructure and the impacts of mobility and infrastructure on spatial planning. For every study a new TIGRIS model has been built. The base year of every TIGRIS model is validated according to the mobility characteristics of the Dutch Model System.
The Ministry of Transport commissioned all four TIGRIS applications. The scope of all of these studies was regional. In this section, the role of the applications in the Dutch planning process is examined.
RandstadRail (1997): The first application of TIGRIS in a concrete planning context has been for the ‘RandstadRail’ project, comprising the development of a light rail system in the ‘South Wing’ of the Randstad. The main objective of this study was to test the TIGRIS prototype. The study did not have an explicit role in the planning process of RandstadRail (AVV, 1997).

Prior to this study, DHV, a major Dutch engineering consultant had made the forecasts for the official RandstadRail policy documents, using a classical transport model. The objective of the TIGRIS study was to add an extra dimension by including the feedback from transport infrastructure to land use development (AVV, 1997).
Leiden Haarlem Amsterdam (LHA, 1999): Until 2005 the national spatial policy is set out in the ‘Supplement to the Fourth Policy Document on Spatial Planning’ (Vierde Nota op de Ruimtelijke Ordening Extra, VINEX). In 1998 the government suggested to continue the current spatial policy until 2010. This means that a reconsideration of the starting points of the national spatial policy will start in the period after 2010 (AVV, 1999b).
At the same time the government acknowledged that these starting points were too weak for four areas in the Netherlands because of the complexity of the spatial problems in the medium and long term. These four areas needed an integrated area-based approach. One of these areas is the corridor area defined by the cities Leiden, Haarlem and Amsterdam (LHA).
The goal of the project is to find out the effects of the isolated position of (dwelling) locations related to mobility. In the study three urban planning concepts are defined, two public transport scenarios and two road infrastructure scenarios. Besides there was a difference in the role of the government: 100% regulation of the location of new dwellings by the national

government or 50% regulation. In the project nine of the 24 (3x2x2x2) scenarios were calculated with the TIGRIS model (AVV, 1999b).

Arnhem Nijmegen (KAN, 1999): KAN is the corridor area defined by the cities of Arnhem and Nijmegen in the east of the Netherlands. In the coming years a strong spatial and economic development is expected there. In the 'Regionaal Structuurplan (RSP)' document of the KAN area policy choices are transformed in a spatial housing and working programme. To solve future accessibility problems, the regional government (KAN) and the public transport companies made a public transport master plan, in which a light rail system is incorporated (AVV, 1999a).

The Minister of Transport, Public Works and Water Management asked the regional government (KAN) for a forecasting study, with a focus on the capacity and the quality of public transport in the KAN area. Depending on the results of this study the minister will decide, in accordance with the MIT rules (programme for implementing transport policy), whether the project will go forward to the planning study phase or not.

In this study, TIGRIS has been used as a part of the MIT forecasting study. The set-up of the MIT forecasting study asked for the mobility and infrastructure impacts of spatial planning and the spatial planning impacts on mobility and infrastructure in the KAN area in 2010 (AVV, 1999a).

Besides the evaluation of two light rail systems related to the spatial planning an important objective of the TIGRIS application was to investigate the interaction (and competition) between the KAN area and the Randstad.

Randstad urbanisation beyond 2030 (2000): At the end of 2000, two national documents were expected: the national transport plan (NVVP) and the national policy plan for spatial planning (Vijfde Nota op de Ruimtelijke Ordening). TIGRIS is used to give a contribution to the discussion around these documents (AVV, 2000).

Randstad Urbanisation beyond 2030 deals with two main questions. The first question relates to the consequences of a continuing demand for space for living and working in the Randstad region (the highly urbanized western part of the Netherlands). Which part of the green areas in the Randstad should be preserved against the rising tide of urbanisation? The second question is whether a high-speed (MAGLEV type) rail ring connecting the four largest cities would be able to transform the Randstad into a single cohesive metropolitan area (AVV, 2000).

The TIGRIS model has been applied to the Randstad in order to back up national policy options. The role of the TIGRIS exercise in the decision-making process is not totally clear. What is clear at that moment is that the application has delivered a contribution to the discussion about the MAGLEV option: policy attention to this issue has decreased (AVV, 2000).

Conclusions

Our experiences with TIGRIS so far have been overwhelmingly positive. Transport planning and land-use experts are learning about the interrelations between their respective fields. They are thinking about the development of infrastructure and land-use policy measures together, and the results are also being analysed in a joint effort. Although TIGRIS is a quite transparent LUTI model, analysing the results proved to be complex: why are the results as they are? In spite of this complexity the users of the model system think that its mechanisms are plausible - in spite of the fact that TIGRIS has its limitations concerning market segments

- and TIGRIS has made a valuable contribution to thinking around the issue. Another problem when evaluating the results was the interpretation of the (absolute) results. For example TIGRIS over-estimates the use of public transport. Other (sectoral and more complex) models will give other (more reliable?) results. How can we deal with this problem? In practice we use the TIGRIS model in scenario studies and analyse the changes between scenarios.
However, the explicit role of the results of the TIGRIS studies in the decision-making (planning) process is not clear. In particular, the LHA and Randstad Urbanisation 2030 studies have had – besides a lot of other studies – a role in the decision-making process around the national spatial planning document and the national transport policy document (SVV2/NVVP), but it is not clear what part of what study had influence in the process.

Table 2: 4 TIGRIS applications of the Ministry of Transport, national scale.

application	study	step in the planning proces
RandstadRail (1997)	The development of a light rail system in the 'South Wing' of the Randstad	no explicit step: testing prototype problem analysis
Leiden Haarlem Amsterdam (LHA, 1999)	Urbanisation and infrastructure concepts beyond 2020 in the corridor area defined by the Randstad-cities Leiden, Haarlem and Amsterdam	long-term forecasting study problem analysis strategic vision
Arnhem Nijmegen (HSOV-KAN, 1999)	The development of a light rail system in the corridor area defined by the cities Arnhem and Nijmegen in the east of the Netherlands	strategic vision strategic policy package
Randstad urbanisation beyond 2030 (2000)	Randstad urbanisation concepts beyond 2030 and the question whether a high-speed rail ring connecting the four largest cities would be able to transform the Randstad into a single cohesive metropolitan area	long-term forecasting study problem analysis

5. Evaluation of TIGRIS

Needs of the clients of AVV

As said earlier, the current version of TIGRIS has been used four times so far. After these applications the transport research centre of the Ministry of Transport (AVV) evaluated the TIGRIS model in two phases. First a project was started to make technical recommendations for improving the current version of the TIGRIS model. In this project a literature review of land use models (with respect to TIGRIS) was done, an inventarisation of data sources to calibrate the TIGRIS model in the Netherlands was made and preliminary research was carried out to incorporate a theoretical, economic foundation into the TIGRIS model. In the second phase an inventory was made of the 'LUTI-modelling' requirements of AVV clients.

Demands of AVV clients

A LUTI model should be capable of providing support to AVV clients in building a vision on spatial development and its interactions with the transport system. In discussions with AVV clients several policy issues were frequently mentioned:

- The structuring role of transport on the settlement pattern of residents and employment is important for assessing spatial development in line with the spatial targets and assessing the economic impacts of transport measures;
- The long-term impacts of transport policies on the transport network. E.g., measures to improve accessibility leads to locations of new activities, new activities leads to new transport demand and new transport demand leads to new congestion problems;
- The impacts of spatial policies on the transport system;
- The roles of non-government actors like residents or firms in spatial development. Government spatial development plans are not the only element influencing future spatial development. The preferences of other actors also influence spatial development.

Besides this the AVV clients are searching for land-use and transport interaction instruments in the scan or plan evaluation phase. The first tool (scan) should be fast and flexible: it should be possible to scan the global impacts of many policy measures within a short period of time. The second application requires more accuracy in the modelling results.

Furthermore transport demand is not only influenced by the number of people at a given location but also by the characteristics of the people (car ownership, age, etc). Improved information about the settlement behaviour of different types of residents will help to improve the transport demand projections.

One important policy issue that arises is: what are the economic impacts of transport policies? A traditional LUTI-model is normally strong in modelling the distribution of labour demand (within national/regional totals). The generative economic impacts (GDP growth or job generation) of transport policies are often modelled at a higher spatial resolution. A trade-off exists between model complexity/spatial detail/calibration on the one side and policy assessment limitations on the other side.

Besides these topics and questions there are more questions we cannot solve with the current TIGRIS version, such as: what are the effects of road pricing, related to land use planning? Moreover, clients want more reliable results: the results of a quick scan tool versus the results of a forecasting model.

The conclusion of the two-stage evaluation with respect to TIGRIS was that the current version of TIGRIS was too far removed from the state of the art and the questions of our clients at the present time.

TIGRIS XL

Having assessed íts clients wishes, AVV decided to develop a new LUTI model: TIGRIS XL (RAND, 2002). Specifications of the model design of TIGRIS XL are as follows:

- TIGRIS XL has to be an incremental model. The model calculates yearly changes, with respect to the previous year (output year x = input year x+1). Within a year, there is no demand / supply equilibrium;
- In many LUTI models the relationship between the location of jobs and residents is hierarchical; “hierarchical” in this context means that either residence location choice is

strictly conditional on job location choice or job location choice is strictly conditional on residence location choice. In The Netherlands a one-sided relationship is less clear. Because of this TIGRIS XL assumes a non-hierarchical relation between location of jobs and residents;
- We pursue a Behavioural modelling approach for the demand side of the housing market;
- Supply side should be capable to address different levels of government involvement: spatial planning in the Netherlands is more or less regulated but may become more liberal in the future;
- We focus on the labour market modelling of the distribution of jobs;
- We use the National Model System as transport model. The consistency of the (transport) results with the other forecasting models of the Transport Research Centre will increase and the costs – through using an existing transport model – will decrease.

There is a clear difference in interest between the scientific challenge of a LUTI model development and the policy challenge. Often in the development process the focus is too strongly set on the scientific challenge. There is a risk that these models end up as state-of-the-art, but are not widely used. Therefore we focused on the most useful model for the client, rather than on designing the ‘best’ model ever. The main model requirements of TIGRIS XL are:

- A modelling approach focused on policy relevance (transport policies and spatial and housing policies). The model has to contribute to the analysis of regional (or national) transport / spatial policies;
- TIGRIS XL is actor based and based on economic/behavioural theory;
- A key requirement of the Transport Research Centre is that the model parameters should be calibrated on real world data. It is not intended to build a kind of modelling framework with expert judgement values for the parameters. This means that data availability sets serious constraints on the modelling options;
- TIGRIS XL is a linkage module model. The demography module addresses basic demographic developments. The land market is simplistic and excludes the role of the land-owner and project developers, is policy oriented and flexible towards very different land-use policies. The housing market model is a behavioural choice model, estimated according to a housing market survey. The labour market is calibrated on real world data in the period 1986 – 2000. The National Model system of AVV (transport model) is linked to the spatial allocation system (accessibility by logsums);
- The regional spatial level is consistent with the National Model System (NMS) subzone-level (1308 zones).

The TIGRIS XL model is much more disaggregated than the current version, in accordance with the wishes of the clients. The prototype of the model was completed in April 2004. The first case study with the model, a back-casting study, will start at the end of 2004.

6. Conclusions

Although TIGRIS has been used successfully four times, LUTI models are not often used in the Netherlands and the explicit role of the models in the decision-making (planning) process is not clear. Focussing on TIGRIS we can define the following reasons for this limited use. The main reason is that there were no explicit policy questions at the start of the TIGRIS model design. The main – technical – question in that period was whether it was possible to develop a LUTI model for the Netherlands. The questions of (policy) clients were not taken into account.

One reason why the current TIGRIS model is not often used is the unclear role of the TIGRIS studies in the planning process. Possibly this unclear role of the applications is related to the unclear position of the TIGRIS model itself. Because of the unclear role of the studies within the planning process, the studies did not involve much commitment. Another reason is the limited field of application. LUTI applications are related to transport planning and land-use planning. In the Netherlands transport planning is the responsibility of the Ministry of Transport, Public Works and Water Management, while land-use planning is entrusted to to the Ministry of Spatial Planning, Housing and the Environment: working together can be a challenge. A third reason we can mention is the complexity of analysing the results of a LUTI. Although TIGRIS is quite a transparent LUTI model, the modelling concept of TIGRIS is too advanced (!) for policy-makers: many policy-makers are not familiar with it. The last reason why LUTI models are not often used is the (forecasting) quality of the outcomes in relation to the costs, time and benefits of an application.

Because of all this, and because of the technical disadvantages of the current model, the Transport Research Centre of the Ministry of Transport is working on a new LUTI model: TIGRIS XL. It is intended to eliminate most of the described disadvantages by fulfilling the wishes of AVV clients. TIGRIS XL will be something more of a forecasting tool, connected to the current transport models of the Ministry of Transport (NMS). Thanks to this, the (forecasting) quality of the LUTI outcomes will increase. The role of these – proven – transport models in the policy cycle are clear. By connecting the land-use model and these transport models, the position of TIGRIS XL and the role of this model in policy practice will also increase. A tool with a greater forecasting dimension also means that more detail in the TIGRIS XL model framework is necessary. TIGRIS XL is a discrete choice model with specific types of persons and households.

But not all the disadvantages of the current TIGRIS model will be solved with the new model. The new model is less transparent, and analysing and understanding the results will be as complex as with the current model.

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