

## MARS in Asia

### How a model can help and influence decision makers

*Günter EMBERGER, Nikolaus IBESICH*

(Dr. Günter Emberger, Institut für Verkehrsplanung & Verkehrstechnik, Technische Universität Wien,  
Gusshausstrasse 30/2, A-1040 Vienna, Austria, [guenter.emberger@ivv.tuwien.ac.at](mailto:guenter.emberger@ivv.tuwien.ac.at))  
(Dipl.-Ing. Nikolaus Ibesich, Institut für Verkehrsplanung & Verkehrstechnik, Technische Universität Wien,  
Gusshausstrasse 30/2, A-1040 Vienna, Austria, [nikolaus.ibesich@ivv.tuwien.ac.at](mailto:nikolaus.ibesich@ivv.tuwien.ac.at))

## 1 INTRODUCTION

The overall objective of modelling should be to help decision makers in a way J.D. Sterman put it: “The goal of modelling and of scientific endeavour more generally, is to build shared understanding that provides insight into the world and helps to solve important problems” [Sterman 2000].

The Institute of Transport Planning and Traffic Engineering (TUW-IVV) is working in the field of land use and transport modelling for now more than 10 years. As part of the Asia Pro Eco project SPARKLE, TUW-IVV developed the MARS (Metropolitan Activity Relocation Simulator) flight simulator (MARS FS). The central idea of SPARKLE is the transference of existing European research in the field of transport policy-making to South East Asia. One concept within SPARKLE is to provide technical training to local planners and decision-makers on how to use scientific and logical approaches to formulate a sustainable land use and transport policy. This training is done through seminars in Bangkok and Hanoi and six three-day-workshops in Thailand, Laos, Cambodia and Vietnam. These events are supported by adapted and translated guidance manuals and by using the MARS FS, which was adapted to Asian conditions.

This paper explains the idea behind the MARS FS and shows how the MARS FS is used for training purposes within the SPARKLE context. It explains in brief the structure of the MARS land use and transport model and in more detail the handling and output interpretation of using the MARS FS application.

## 2 THE “TYPICAL” DECISION MAKING PROCESS IN LAND USE AND TRANSPORTATION PLANNING

The “typical” decision making process was explored in detail within the EU-project PROSPECTS [PROSPECTS 2000-2003]. It consists of the following steps:

1. Identification of objectives / setting targets
2. Identification of possible instruments and combinations of instruments (strategies)
3. Assessing and appraising of the outcome of the instruments/strategies against the objectives/targets including identification of barriers to implementation
4. Can the objectives/targets be met?
  - If yes → strategy found – implementation of strategy
  - If no → go to step 2

Within the above-described decision making process, the MARS model/flight simulator is used to assess the impacts on land use and the transport system of either a single instrument or a set of instruments combined to a strategy. As can be imagined to assess impacts of a wide set of instruments a complex model (= MARS model) is necessary. On the other hand, transport planners and decision makers want to have a simple tool to test easily and explore the impacts of their strategies. For this reason the MARS FS was developed.

## 3 MARS LAND USE AND TRANSPORT MODEL

MARS is an integrated strategic and dynamic land-use and transport (LUTI) model. The basic underlying hypothesis of MARS is that settlements and activities within them are self-organizing systems. Therefore MARS is based on the principles of systems dynamics [Sterman 2000] and synergetics [Haken 1983]. The development of MARS started in the year 2000. A comprehensive description of MARS can be found in [Pfaffenbichler 2003]. Recently the model has been transferred to another software basis called Vensim®.2

### 3.1 Mars – Overall software system

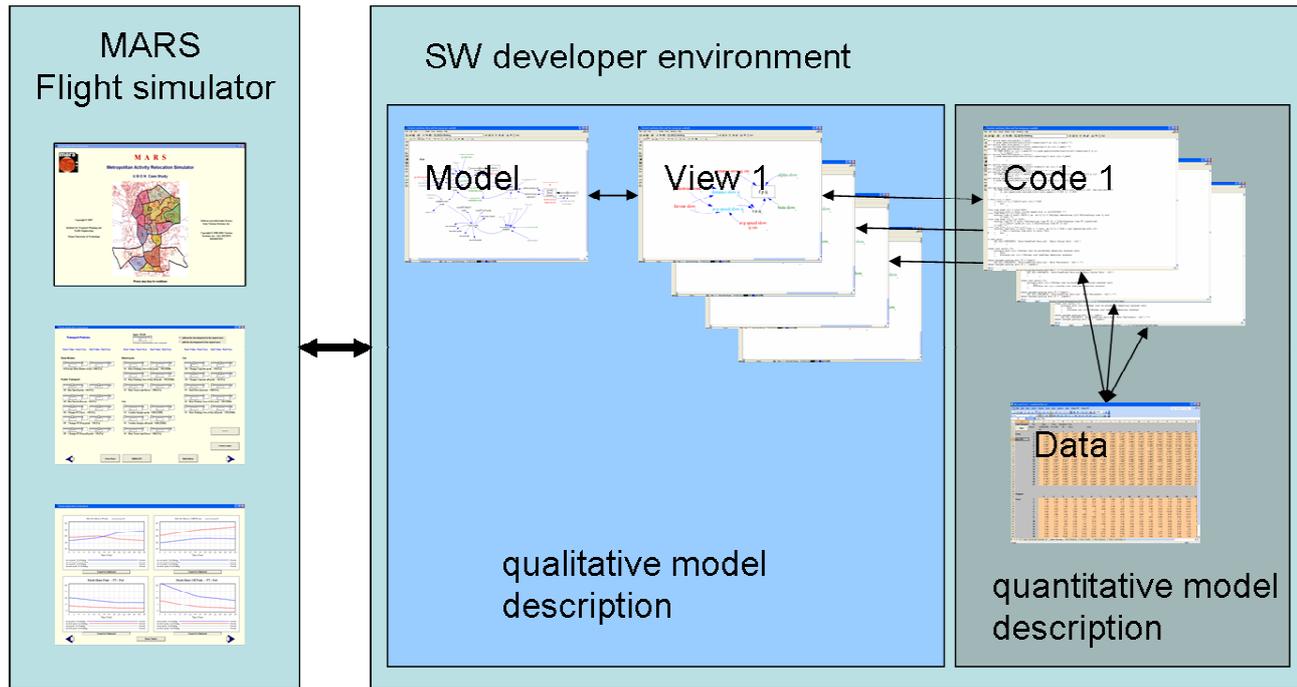
In Graph 1 the overall software system of the MARS model is shown. As can be seen the system consists of two main parts:

- the MARS flight simulator (left hand box) and

<sup>1</sup> Simplified version - for a comprehensive description of the decision making process please see [May, et al. 2003], page 11.

<sup>2</sup> Vensim® is a visual modelling tool that allows you to conceptualize, document, simulate, analyze, and optimize models of dynamic systems. Vensim® provides a simple and flexible way of building simulation models from causal loop or stock and flow diagrams. By connecting words with arrows, relationships among system variables are entered and recorded as causal connections. This information is used by the Equation Editor to help you form a complete simulation model. You can analyze your model throughout the building process, looking at the causes and uses of a variable, and also at the loops involving the variable. When you have built a model that can be simulated, Vensim® lets you thoroughly explore the behaviour of the model [Ventana-Systems 2003].

- the MARS software developer part (right hand box)



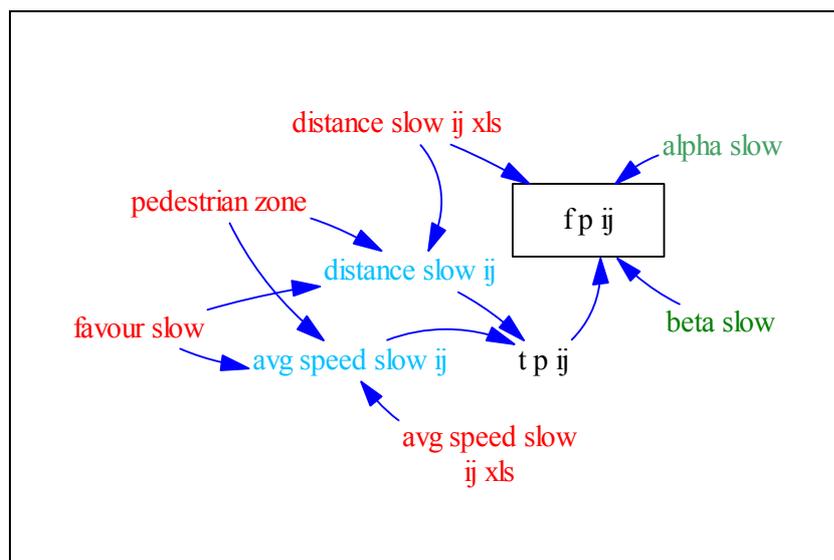
Graph 1: MARS – flight simulator – software system overview

### 3.2 SW-Developer environment

The SW developer part of the MARS model is using the Vensim® programming environment. Not going into too much detail it can be said that within this environment different abstraction levels are combined and linked together as depicted with the arrows in Graph 1 right hand side.

The top level called “Model” is the level where all information of the underlying “problem” is tied together. More information regarding the transport planning and land use planning issues implemented within MARS can be found in [Pfaffenbichler and Shepherd 2002, Pfaffenbichler 2003]. Information about land use and transport related applications of MARS can be found in [Pfaffenbichler 2001, Emberger, et al. 2003].

The second level called “View” is a place where a single thematic issue of the underlying problem (e.g. the calculation of generalised costs or the development of population over time, etc...) is represented in an intuitive understandable syntax. This level is used to describe the structure of a thematic issue and shows the existing cause-effect relations between model entities in a qualitative way. An example of a thematic issue (generalised cost calculation for slow mode users) in view mode is given in Graph 2:



Graph 2: Generalised costs for slow modes in graphical view

Within a view, the different colours used help the user to identify different types of variables. Red variable names indicate external inputs, such as the distance between traffic zones (distance slow ij xls) or the average speed (avg speed slow ij xls). The light blue

colour is used to depict where and how policy instruments (distance slow ij and avg speed slow ij) influence the variables calculated within MARS. Generalised costs are stored for slow mode users between different zones in the variable f p ij.

The next level is the so-called “Code”-level where the mathematical formulations of all the cause-effect-relations depicted in the “View”-level have to be specified.

Table 1 shows the corresponding code to Graph 2:

<pre>alpha slow= 0.206 beta slow= 0.695 distance slow ij xls[i,J]= GET XLS CONSTANTS('Data\CaseStudy Data.xls','Slow Distance','c5') pedestrian zone[i,J]= GET XLS CONSTANTS('Data\CaseStudy Data.xls','Slow Pedzone','c5') favour slow[i,J]= GET XLS CONSTANTS('Data\CaseStudy Data.xls','Slow Favslow','c5') distance slow ij[i,J]= IF THEN ELSE(Time&lt;startyear[favslow], distance slow ij xls[i,J], distance slow ij xls[i,J]*(favour slow[i,J]-pedestrian zone[i,J]*policy profile[favslow]/200) )</pre>	<pre>avg speed slow ij xls[peak]= GET XLS CONSTANTS ('Data\CaseStudy Data.xls','Basic Scalar Data','b12') avg speed slow ij xls[opeak]= GET XLS CONSTANTS(Data\CaseStudy Data.xls','Basic Scalar Data','b13') avg speed slow ij[i,J,ToD]= avg speed slow ij xls*(1+(favour slow[i,J]/2+pedestrian zone[i,J]/2)* policy profile[favslow]/100) t p ij[i,J,ToD]= (distance slow ij[i,J]/avg speed slow ij[i,J,ToD])*60) f p ij[i,J,ToD]= IF THEN ELSE(distance slow ij xls[i,J]&gt;10 , 0 , alpha slow*t p ij[i,J,ToD]*EXP(beta slow*distance slow ij xls[i,J]))</pre>
---	---

Table 1: Friction factor for slow modes in text view

Finally, to complete the system, problem specific data (in the case of MARS in EXCEL file format) has to be linked to the code. In the MARS case the problem specific information contains data describing the land use and transport system of the city. E.g. as mentioned before the distance between two zones – variable distance slow ij xls.

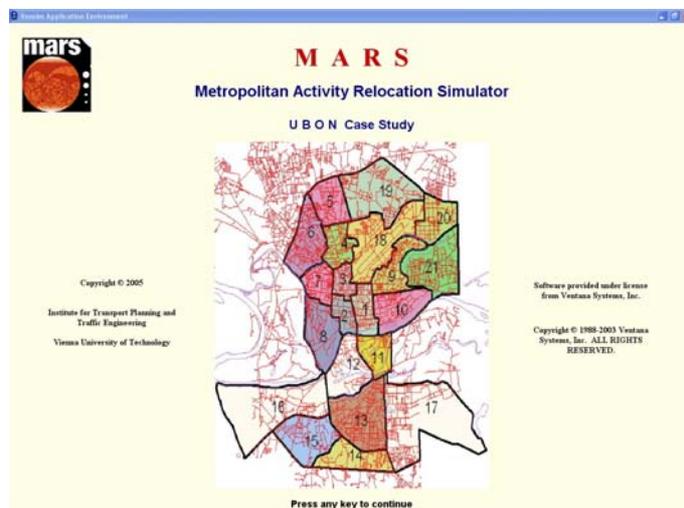
What is important to mention here is that all these different abstraction levels and city specific data is linked together within the VENSIM® environment. This linkage is useful if one wants to communicate the “problem” on different abstraction levels for different groups of people such as politicians, transport planners or software developers.

#### 4 MARS APPLICATION – FLIGHT SIMULATOR

The MARS model was intentionally designed to be a “white box” model, but as every model, over time it became more and more a “black box” model. The complexity of the MARS model was increased over the last five years significantly so there was a need to make it useable and user-friendly for a certain group of stakeholders, the transport experts working at local authorities. Fortunately, the VENSIM® programming environment includes an extension called VENSIM APPLICATION to develop a graphical user interface for the existing MARS model. This feature was used to implement a user interface that reflects the needs of decision makers and enables them to operate and run the MARS model for their own specific purposes with a relative short settling-in period of less than 20 minutes.

In the following sections, this user interface is introduced by going through a typical task a transport planner has to deal with in his daily business.

##### 4.1 Introduction



The MARS FS application is designed to support decision makers to assess case study specific transport and land use strategies. The MARS FS is a simple to use push button interface for the MARS land use transport model. The application uses a set of commands to give users simplified access to the model. To the user, the MARS FS appears as a series of buttons, menus, or a sequence of screens allowing him or her to use and analyze the MARS model in a straightforward and meaningful way. [Ventana-Systems 2003]

Decision makers can themselves tryout their policies and see the consequences immediately.



To navigate through MARS FS you have to operate the appropriate buttons, just like in any other Windows® application.

When opening the MARS FS the first screen you see is the area of the case study with its zones (Graph 3). This screen gives you an impression how the underlying city looks like and how it is split up in zones.

The main menu (**Fehler! Verweisquelle konnte nicht gefunden werden.**) lets you choose to review the model structure, to simulate the model or to request help how to operate the MARS FS.

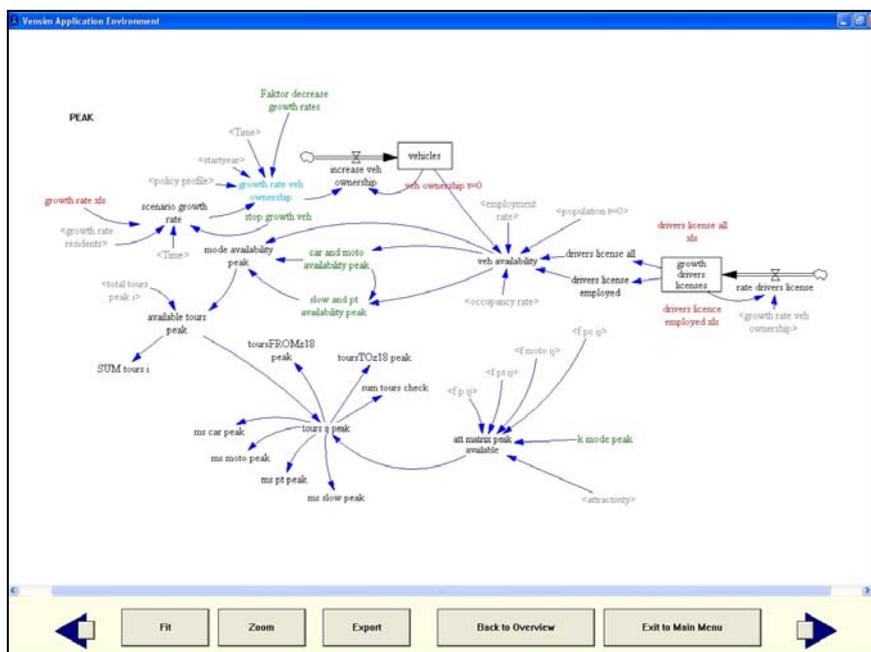
The Help pages cover the most urgent matters, e.g. how to review the model, how to simulate with different policies and how to use the output pages. Every graph, table or document window in the application can be exported to the clipboard for further use.

## 4.2 Review of the model structure

The button “Review Model Structure” leads the user to a section of MARS FS where he can explore the model inherent cause-effect relations. To be able to do so two different ways are offered:

### 4.2.1 View mode

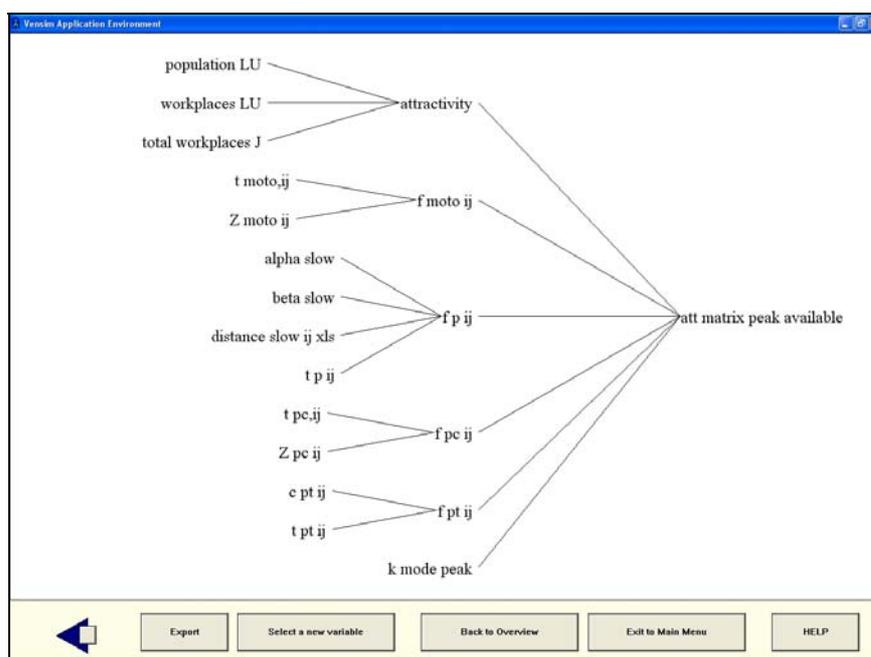
The model is split up into different views, which in turn depict specific thematic issues within the land use transport system. To review the model structure with the MARS FS application, you can go through every single view, and zoom in and out as necessary (Graph 4).



Graph 4: MARS FS – review model structure

### 4.2.2 Causes Tree mode

Another way to review the relationships between the model variables is to use the Causes Tree function. Here a tree-type graphical representation is created showing the causes of the chosen model variable (Graph 5). By clicking on a variable name, the causes tree can be expanded until the final cause is reached.



Graph 5: MARS FS – Causes Tree

### 4.3 Simulation of the model

The core of the MARS FS is the simulation set up screen (Graph 6). On this screen, all implemented transport policy instruments are represented with so-called “sliders”. For example in the upper left corner, there is a slider headed “slow modes”. Here the user has the possibility to test the impacts of a policy favouring the slow modes (pedestrianisation of the city centre zones). To set up a scenario the user can either pick up the slider with the mouse and moves it to the desired numerical value or keys in a target value in the box below the slider.

This has to be done for a start year (in this case for the year 5 of the simulation as shown with the number on the right hand side of the slider) and for an end year (in the shown example year 20 of the simulation). After the entered end year, the level of the instrument stays constant for the rest of the simulation period. Of course, it is also possible for the user to vary the values for the start and the end years between 0 and 30.

There are different policies for each mode implemented within the MARS model and can be simulated using the MARS FS:

#### Slow Modes

If you think of implementing pedestrian zones or bicycle lanes; you can input how much of the zone will be pedestrianized. This will also lengthen the distance to or from the parking place.

#### Public Transport

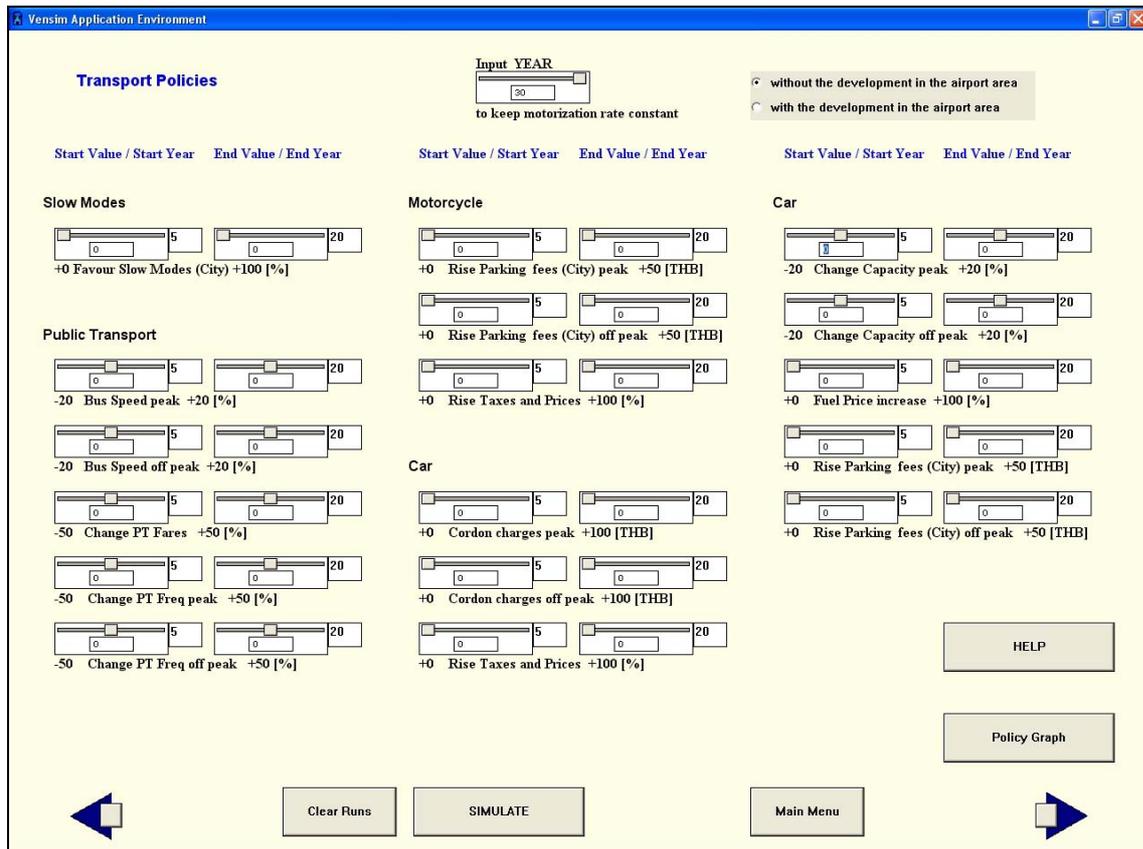
Decrease or increase bus speeds, bus fares or the bus frequency.

#### Motorcycle

Change the fees for motorcycle parking and change taxes and costs for the purchase of a motorcycle.

#### Car

Charge cars and motorcycles if they enter the cordon, change taxes and costs of a car purchase, offer cars more or less infrastructure, which has influence on the speed, change the fees for car parking and change the prices for fuel.



Graph 6: MARS FS – input policies and scenarios for simulation

As soon as the desired policy levers are set, the simulation of the model can be invoked by pressing the “SIMULATE” button.

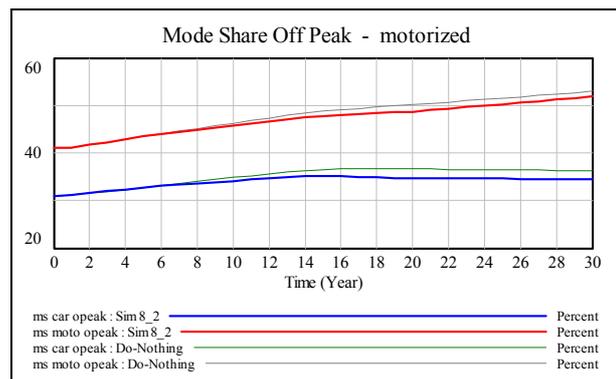
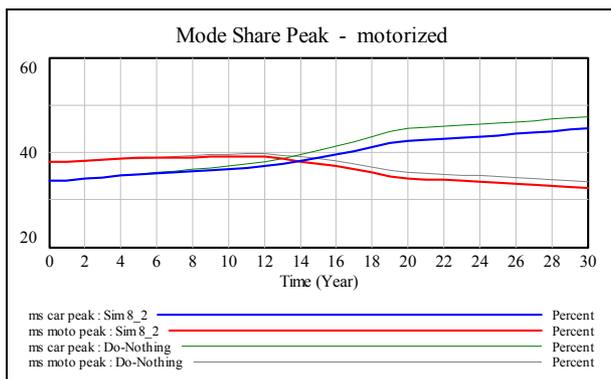
#### 4.4 Output

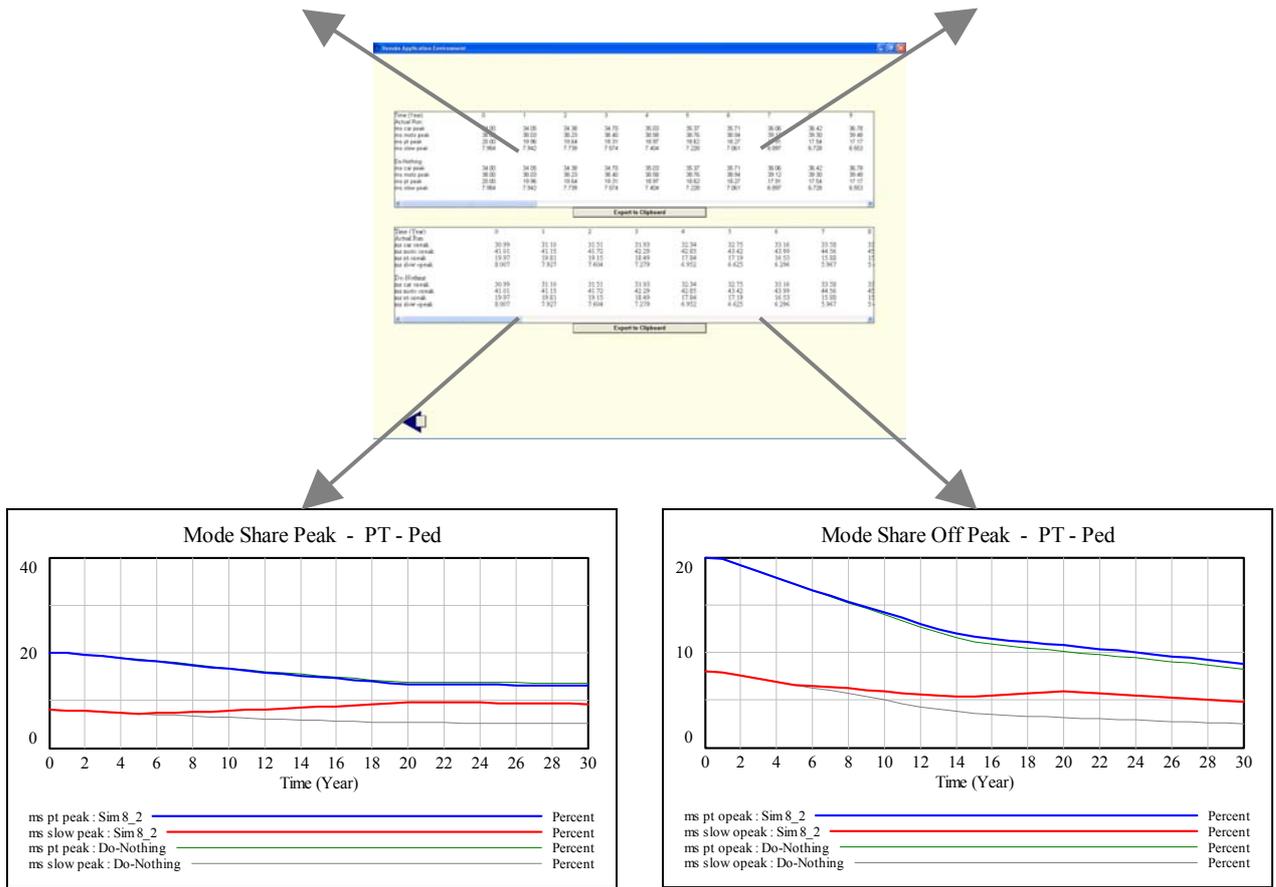
After the simulation (which takes about 20 seconds on a standard PC), the user can immediately switch between different output variables and formats. Within the existing MARS FS, the following variables are shown in graphs for a “do-nothing” scenario and the user defined “do-something” scenario:

- Mode share in peak and off peak
- Population, workplaces
- Total vehicle km motorized
- Average commuting distance motorized and non motorized
- Total CO2 emissions for car and motorcycle
- Average commuting speed per mode.

The simultaneous display of the “do-nothing” scenario and the “do-something” scenario shows the user the impacts of his tested policy instrument in a clear way.

Analyzing graphs is a good way to get the overall picture, you can see immediately if, for example CO2, increases or decreases. For the ones interested in absolute numbers, there is also option to present for every graph an according table (Graph 7).

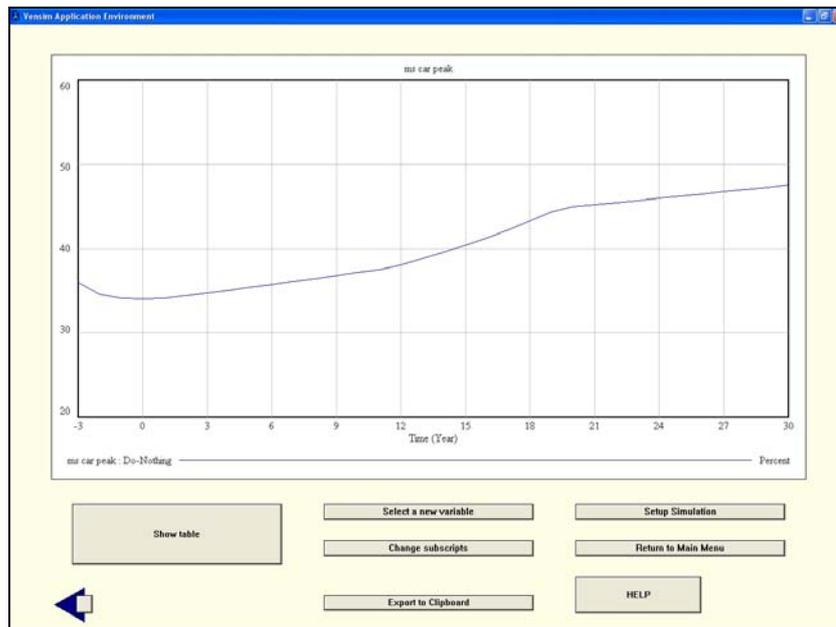




Graph 7: MARS FS – Output Mode Share

4.4.1 Individual Output

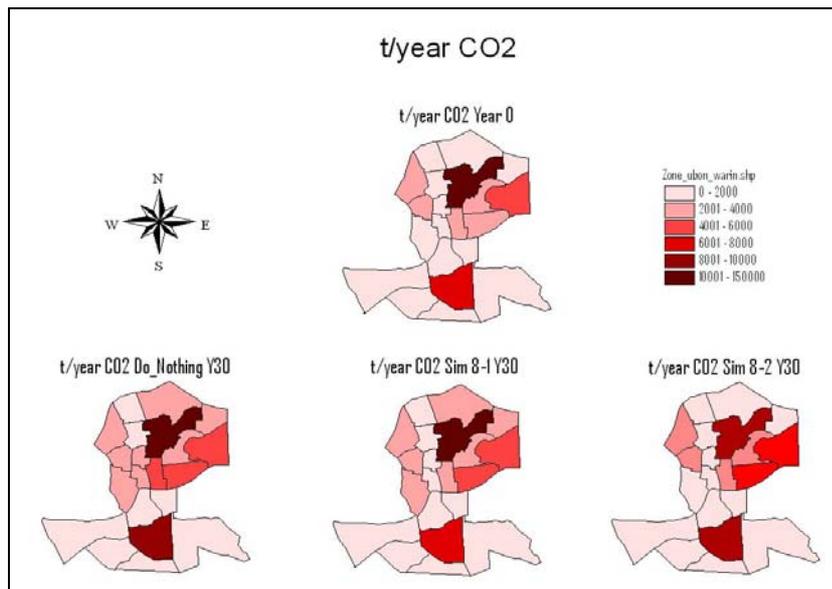
If the MARS FS user wants to go into even more detail of analyses, there is the possibility to choose from a list any variable within the model and display it as graph or as a table. This feature also enables the user to display and export information for a certain range of zones, for specific modes, or for specific trip purposes, etc. (Graph 8).



Graph 8: MARS FS – Individual Output

After simulation, MARS FS can be set up to export the values for a set of predefined variables in formats like dbase. These data can then be used in a GIS application to produce coloured maps or short movies to make it even simpler for decision makers to analyse the results (Graph 9)

## 4.4.2 GIS – Output



Graph 9: GIS output – example difference CO2 emissions “do-nothing” vs. “do something” in [t/year]

## 5 CONCLUSION AND OBSERVATIONS

Up to now, the MARS FS has been used as a decision support tool in two workshops in Thailand. More than 40 high and medium level decision makers took part in these workshops. The feedback was positive and encouraging. All users found it easy to navigate within the MARS FS application. During the debriefing session interesting questions and discussions arose regarding the implemented land use and transport interactions of MARS.

The causes-tree tool was found to be extremely useful to understand some of the behaviour of the model output, which was not anticipated at first. In that way, it increased the understanding of the complex interactions between land use and transport system over time.

The possibility for the participants to work interactively with the LUTI-model and test the outcome of single policy instruments provided them with knowledge about the impacts of each instrument individually. The opportunity to combine these individual instruments to strategies allowed them to explore synergetic effects of combining different instruments. Furthermore it was appreciated that all produced output can be viewed either as graph or as a table and that it is possible to export all information to other software packages to carry out more detailed investigations.

A minor point of criticism was the chosen list of pre-prepared indicators depicted in the graphs. Although there is a feature implemented, which enables the user to generate a graph or a table of every individual variable, users preferred to have a fuller set of pre-prepared graphs to click through. This will be improved before our next set of workshops held in Vietnam in March 2006.

Summing up, the MARS model is a land use transport interaction model, which can be used by experts to explore the interactions between these two systems. The modular and open structure allows adding on additional parts to the MARS model easily.

The MARS FS, as a graphical user interface, was assessed to be useful for easy access to the MARS model. The feedback from users at the workshops proved that the combination of the MARS model and the MARS FS is a useful tool to support the decision making process and encourages us to improve the software in future.

## 6 REFERENCES

- Emberger, G., May, A. D. and Shepherd, S. P.: Method to identify optimal land use and transport policy packages, Year.
- Haken, H.: Advanced Synergetics - Instability Hierarchies of Self-Organizing Systems and Devices, Springer-Verlag, 1983.
- May, A. D., Karlstrom, A., Marler, N., Matthews, B., Minken, H., Monzon, A., Page, M., Pfaffenbichler, P. C. and Shepherd, S. P.: Developing Sustainable Urban Land Use and Transport Strategies - A Decision Makers' Guidebook, Institute for Transport Studie, University of Leeds, 2003.
- Pfaffenbichler, P.: The strategic, dynamic and integrated urban land use and transport model MARS (Metropolitan Activity Relocation Simulator) - Development, testing and application, Beiträge zu einer ökologisch und sozial verträglichen Verkehrsplanung Nr. 1/2003, Vienna University of Technology, 2003.
- Pfaffenbichler, P. and Shepherd, S. P.: A Dynamic Model to Appraise Strategic Land-Use and Transport Policies, 2002.
- Pfaffenbichler, P. C.: Analysing the driving forces behind decision-making processes for the (new) location of businesses, Year.
- PROSPECTS: PROSPECTS - Procedures for Recommending Optimal Sustainable Planning of European City Transport Systems, 2000-2003.
- Sterman, J. D.: Business Dynamics - Systems Thinking and Modeling for a Complex World, McGraw-Hill Higher Education, 2000.
- Ventana-Systems: Vensim DSS Reference Supplement, 2003.