National Technical University of Athens
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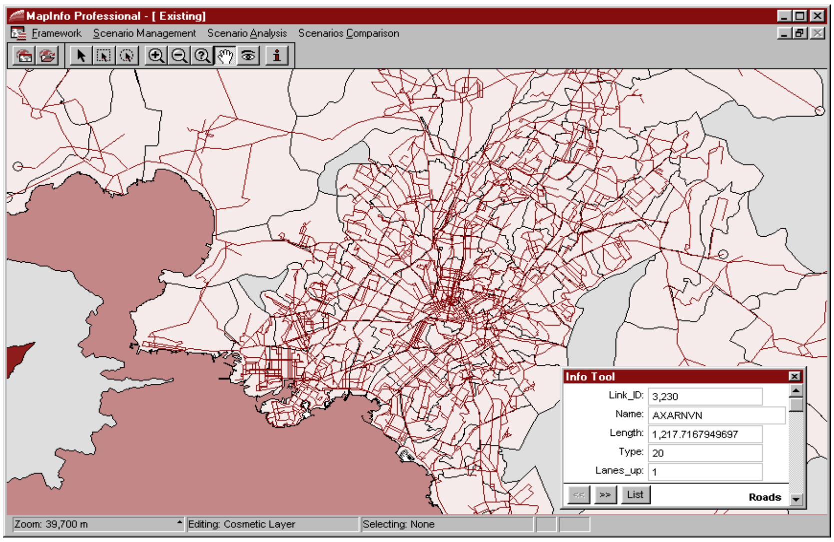
A GIS-Based Decision Support System for Planning Urban Transportation Policies



Overview

The tool is a Decision-Support System (DSS) integrated in a Geographical Information System (GIS) for the analysis and evaluation of urban transportation policies. The objective of the tool is to assist transport administrators to enhance the efficiency of the transportation supply while improving environmental and energy indicators. It involves realistic representation of the multi-modal urban transportation network and provides estimates of road traffic, energy consumption and pollutant emissions, and evaluates the implications of urban traffic policies.

The uniqueness of the tool lies in combining transport network and travel demand database management, GIS utilization for policy definition and result presentation, traffic simulation and analysis, energy consumption and pollutant emission modelling, evaluation of environmental impacts and scenario comparison into a seamlessly integrated package. The tight integration of these elements provides the new approach and qualifies the tool as a user-friendly DSS.

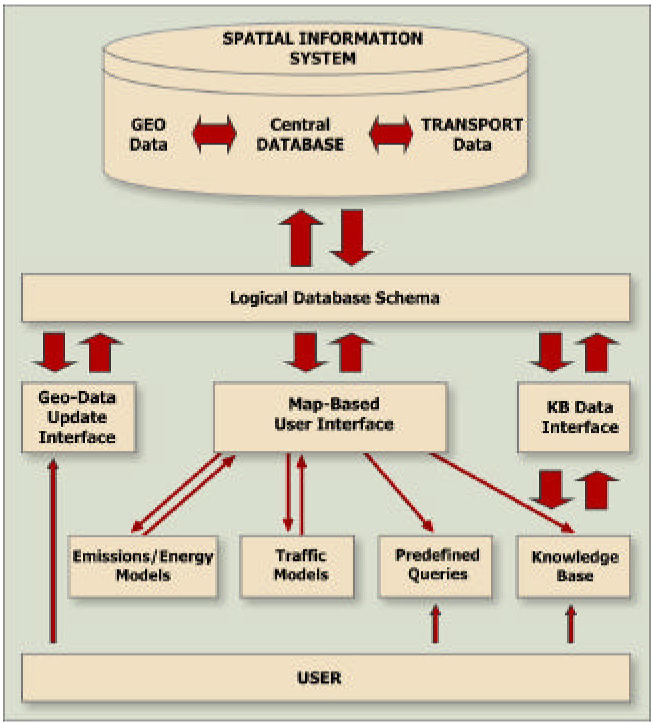
Architecture

The DSS was implemented within the operating environment of MapInfo GIS that serves as a central repository for the basic data, as an intermediate storage space for each scenario parameters, as well as for providing the user interface.

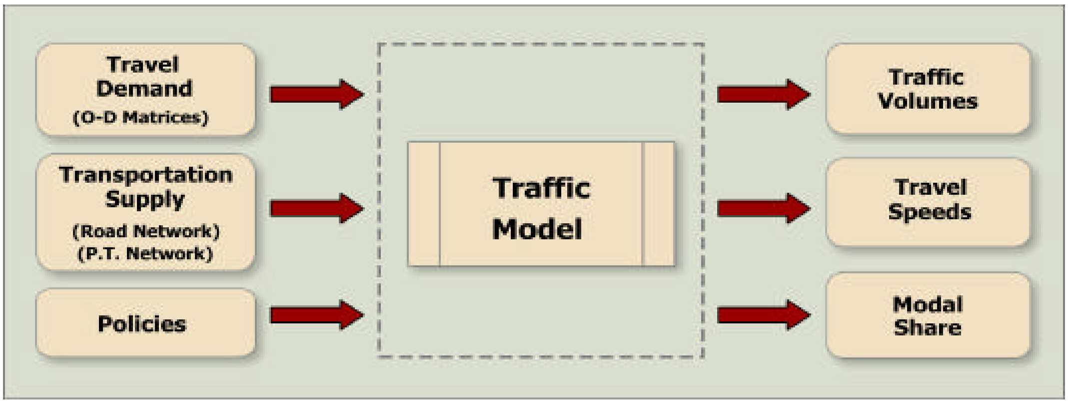
It was implemented according to a three-step schema that involves (a) the database, (b) a number of mathematical models for traffic assignment as well as for emission and energy consumption estimation, and (c) the user-interface for creating "what-if?" scenarios and presenting model results through appropriate thematic maps, figures and diagrams

GIS Database

The GIS database is the heart of spatial and operational information system and provides the central storage system and allows communication between the various sub-models. It is organized on the basis of the road network map. Each link has as attributes topographic (e.g. nodes UTM co-ordinates, total length), toponomastic (street names), physical (traffic directions, number of lanes), transport (road typology by means of speed-flow curves) and



Architecture of the decision support system



The structure of the traffic model

transit (description of public transport lines and corresponding frequencies) information. Traffic demand characteristics are expressed in terms of origin destination matrices of person trips and corresponding demand function for each transportation mode involved. This requires the definition of a suitable zoning of the entire urban context. GIS-integrated models use these data to estimate and reproduce traffic behaviour and characteristics, and calculate pollutant emissions and energy consumption. These may be aggregated over the whole area or broken-down into sub-areas (e.g. municipal boundaries, zones), or even a spatial grid for reference and comparison.

Traffic Modelling

Road traffic is simulated using a deterministic model that solves the user equilibrium assignment problem with capacity constraints. The representation of the multi-modal transport problem is based on the simultaneous elastic demand-traffic assignment concepts. Such a model allows the estimation of traffic patterns (volumes, speeds, travel cost, etc.) on each link or the road network as well as the share of total travel demand serviced by each mode. The later allows the representation of changes in demand, which occur as a direct result of changes in the costs experienced on the road network.

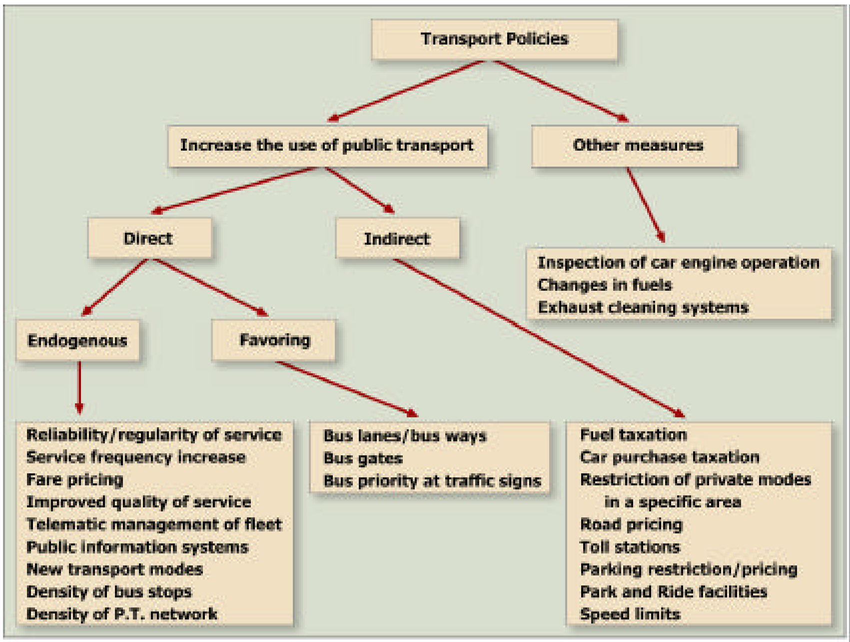
The behaviour of public transport users is modelled by using the concept of transit hyper-paths on a generalized network combining the road network (acting as walk links) and the public transport lines. As a result, the flow pattern of passengers at each public transport line including walking is estimated.

Emissions-Consumption Modelling

Fuel consumption and air pollutants' emission rates are estimated by appropriate models. They are based on proportional emission/consumption factors for each vehicle type in vehicle fleet involved and taking into consideration traffic volumes and link travel speeds provided by the traffic model. Results include not only the total emission level of each pollutant and the total consumption of each fuel type in the study area, but also averages by vehicle category and by link.

Policy Formulation

A characteristic of the decision support tool is that it pre-defines a number of "abstract" policies and incorporates them as "methods" into the system. These "methods" are algorithms and procedures for estimating impacts for each pre-defined policy type. An "abstract" policy becomes "application specific" by the user-definition of its parameter set and its geo-

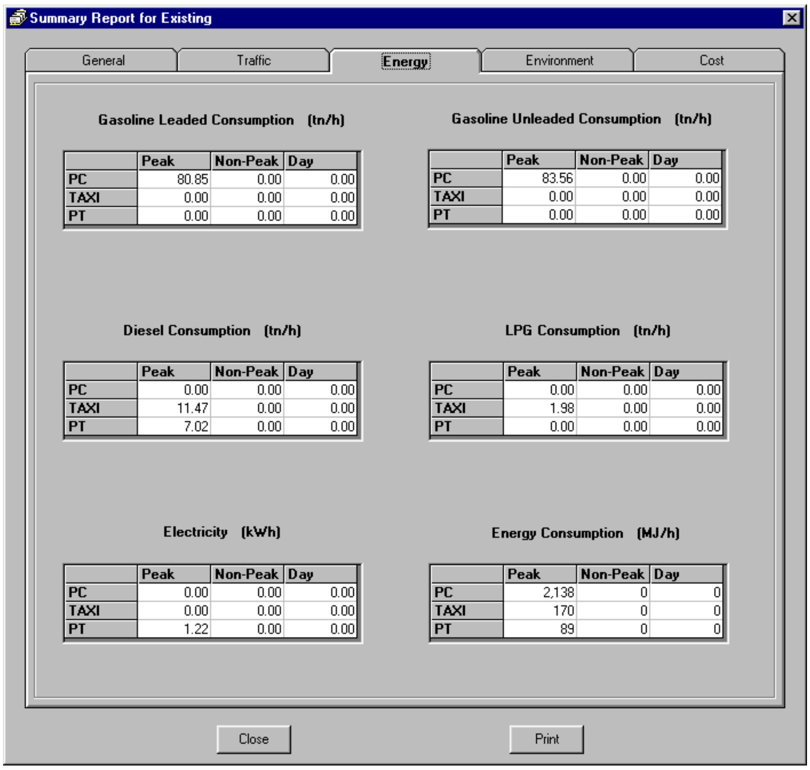


Hierarchy of policies handled by the DSS graphic domain. An initial set of policies that can be taken into consideration is given in the figure. The policies incorporated within the framework of the developed tool are mainly focused to the shift from private to public transport as a means of reducing fuel consumption and improving urban environment. In this case, the main aim is either to improve efficiency of the public transport and increase its competitiveness to private modes or to discourage the use of the private modes.

The transport models mentioned above were suitably enhanced by a set of additional procedures for all policies discussed here. Modelling of the policies can be done by modifying on-the-fly the cost and demand functions of all transport modes affected.

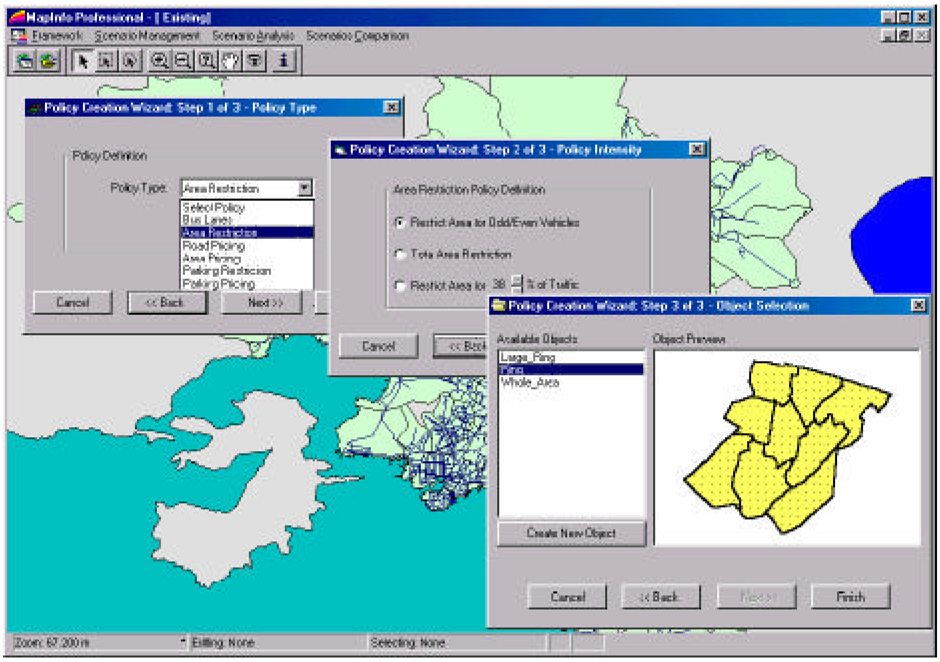
Operational Aspects

The operation of the DSS tool is based on the concept of scenarios. A scenario is defined in terms of an appropriate database that represents the transportation infrastructure of the study area at the starting point as well as a set of user-defined policies whose impacts will modify the database. User interaction with the DSS environment falls into three different functional groups, accessed via a hierarchical menu system; namely Scenario Management, Scenario Analysis and Scenario Comparison.



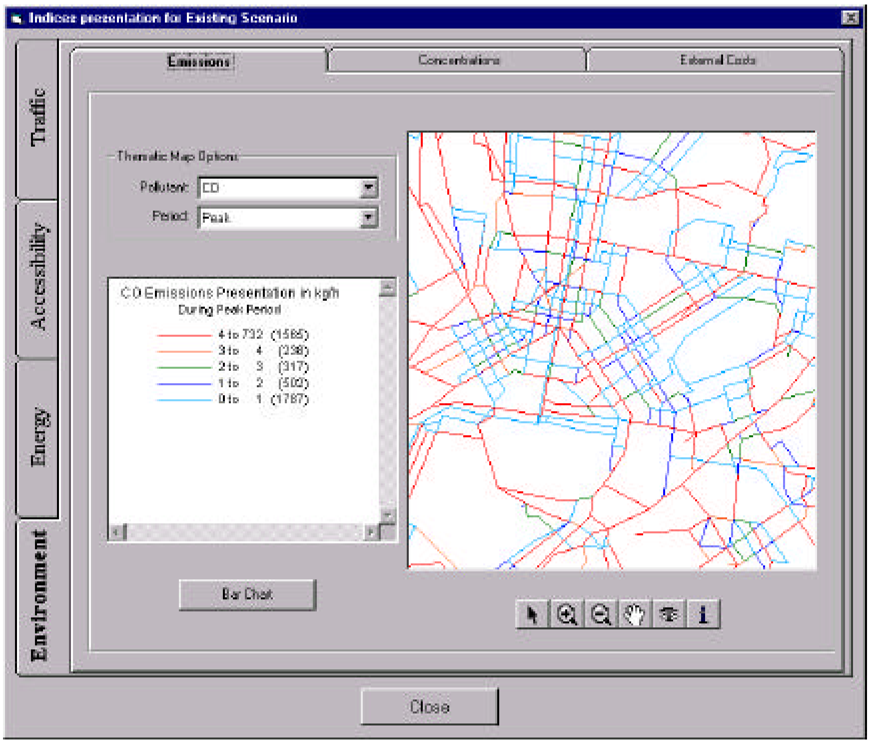
Summary report of energy consumption estimates

Scenario Management provides the user with capabilities to create a new or to edit a previously stored scenario and to define a set of policy measures to be examined. A "reference" or "zero-state" scenario is always present, serving as the basis for the creation of new scenarios. The definition of a new policy measure is carried out through interactive procedures based on sets of hierarchical popup dialog boxes which allow the user to specify the policy type, the geographical objects (road sections or sub-areas) upon which it is to be applied and policy-specific parameters. Alternatively, an automatic selection procedure is able to propose the objects, which fulfil a set of user-defined criteria. Safeguards have been incorporated into the policy definition module to ensure that user responses are valid. This form of user-interface is very flexible and is easily mastered by users even if they have little previous experience.



Using the DSS to define policies

Scenario Analysis corresponds to the analysis and presentation of computational results through appropriate thematic maps, diagrams and reports. The user can estimate the impacts of the set of policy measures included in the current scenario either by examining a summary report (on-screen or in hard copy) or via an interactive report which utilizes the capabilities of the GIS to produce diagrams, tables and thematic maps. Part of this detailed report can been seen in the figure where a screenshot of CO emission rates is presented. These report elements are dynamic in the sense that drill-down, zooming and output configuration is possible.



Interactive thematic map of emission estimates

Finally, **Scenario Comparison** permits the evaluation and comparison of alternative scenarios. The evaluation of each scenario is based on a number of traffic, environmental and energy indicators. A multi-criteria analysis, where each decision is based upon judging over appropriate weighed criteria is adapted for comparing user-selected scenarios. The user is allowed to define the number of indicators and weighting factors assigned to each one through appropriate dialogs.

Multicriteria Evaluation During Peak Period .

Indices Presentation for the selected Scenarios

Scenario	Existing	RestrArea1	RestrPark2
Average Private Vehicle Speed	0.299	0.307	0.395
Average Public Transport Speed	0.309	0.313	0.378
Average Vehicle Speed	0.299	0.307	0.394
Modal Share for Private Cars	0.35	0.347	0.303
Modal Share for Taxis	0.333	0.333	0.333
Public Transport Modal Share	0.307	0.311	0.383
Vehicle km	0.351	0.35	0.299
Passenger km	0.34	0.341	0.319
CO Emissions	0.376	0.367	0.257
VOC Emissions	0.365	0.356	0.279
NOx Emissions	0.348	0.347	0.305
PM Emissions	0.345	0.344	0.311
CO2 Emissions	0.363	0.359	0.278
Energy Consumption	0.363	0.359	0.278
External Costs	0.338	0.324	0.337
Index Weighted Sum	-2.497	-2.434	-1.669

Differences | Values | Graphs | Weights | Close

Scenario comparison module