The ISHTAR Suite: a decision support tool for urban planning and air quality management

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Abstract

The ISHTAR Suite is an innovative software tool that integrates several models for the simulation of the effects of transport and land use policies on the urban environment, population health and artistic heritage. Starting from the simulation of the effects of the postulated measure on the citizens behaviour in terms of daily movements, the suite calculation path goes through the modelling of transport, vehicles safety and emissions of pollutants and noise, pollutants dispersion and noise propagation, exposure to pollutants, noise and accidents and related risk assessment, monuments degradation, ending up with a specific tool for the overall comparison of the alternative scenarios in terms of cost-benefit or multi criteria analysis. The high spatial and temporal flexibility maximises the Suite applicability, from local short-term actions to widespread long-term policies. The software modules are integrated by a Suite Manager that controls the tools execution by means of dedicated software 'connectors', and is linked to a User Interface, a suite Database and a commercial Geographic Information System. The ISHTAR Suite and its specific modules are being tested in the seven cities involved in the FP5 EESD Programme ISHTAR Project: Athens, Bologna, Brussels, Graz, Grenoble, Paris and Rome, with the analysis of very different measures and policies.
Keywords: integrated software, models suite, policies assessment, urban planning, transport systems impacts.

1 Introduction

Worldwide cities face common challenges concerning their quality of life: degradation of the urban environment, significant risks for citizens' health,

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traffic congestion causing stress and economic inefficiency, progressive damage of the artistic and monumental heritage. Additional difficulties derive from the lack of integrated tools that allow cities to make balanced decisions on a wide range of issues. In this context the European Commission funded in 2001 the ISHTAR Project (Negrenti et al. [1]). The Project aims at building an Integrated Suite of software models for assessing the impacts of various types of urban policies and actions on the quality of life of citizens, and in particular on traffic congestion, air quality, citizens health and conservation of cultural heritage.

The ISHTAR Project (Negrenti et al. [2]) has several scientific and technological objectives:

• The integration of a large number of software tools and the creation of specific modules for the simulation of key processes such as transport behaviour and its direct impacts on the urban environment.
• The achievement of a high spatial and temporal flexibility in the use of the tool, for maximizing the possibilities of application from local short-term actions to widespread long-term policies.
• Development of specific modelling areas such as the representation of policies effects on citizens' behaviour, the integrated 24 hours simulation of traffic emissions, noise and safety, the microscopic analysis of air pollution effects on health and monuments.

The exploitation of the models suite has begun within the Project with the application of the tool to the analysis of measures tested or planned in the seven involved cities: Athens, Bologna, Brussels, Graz, Grenoble, Paris and Rome.

2 Methodology

2.1 Integration of a relevant number of modelling tools

The ISHTAR Suite is based on a high number of software tools whose aim is the modelling of various aspects of the impact analysis of short-term actions and long-term policies. Standard models suites normally include only a few of those models. It also represents a strong enlargement of the applicability area, since with this kind of 'multi-impacts' suite the users is able to analyse in an integrated and 'coherent' way the various aspects of 'global' urban policies, without having to perform separate studies relying on different input information providing very likely less credible conclusions. The wide scope of applicability offers the potential of easing the cooperation between different departments in municipal authorities: in fact the tool will be of interest for various activities of planning and assessment in the transport, environment, health and artistic heritage sectors.

2.2 Evolution of modelling techniques in crucial impact areas

The scientific core value of the ISHTAR Suite is largely linked to a few crucial modelling developments on which the accuracy and the significance of the results deriving from the Suite application strongly depend. These areas of 'modelling development' can be summarized as:

a) prediction of the effects of citizens' reaction to postulated measures.
b) improvement of the modelling of vehicle emissions, particularly concerning the consideration of speed variability along the network links, and the spatial-temporal distribution of 'cold-emissions' depending on the representation of trip origins (e.g. parking places).
c) development of an urban road safety model, which can take into account the variable flow and speed levels in the network and the adverse factors such as the presence of intersections.
d) detailed estimate of pollution effects on citizens' health based on the analysis of population groups movements during the day and the temporal-spatial maps of air pollution and noise.

2.3 Realisation of integrated specific modules inside the suite

The ISHTAR Suite is globally aiming at the highest flexibility of use: this is particularly reflected in some of the tools. The choice of building an 'Integrated Transport Module' which makes use of different models, having complementary characteristics in terms of applicability field, is of particular significance. Also relevant is the consequence of this flexibility in transport modelling: the downstream models (emission, noise, safety, exposure models) will have to be flexible in their input characteristics in order to give the proper accuracy whichever transport model is used in a given analysis. This implies the use of 'advanced' emission, noise and safety models capable of treating flexible input information. The suite includes a module dedicated to the direct impacts of traffic: emissions, noise and accidents. This module is based on such common and flexible traffic input. Also the module dedicated to the overall evaluation of the policy scenarios includes parallel elements: in this case a Cost Benefit Analysis tool is complemented by a Multi criteria Analysis software.

2.4 Space and time total flexibility

Among the crucial characteristics of the ISHTAR Suite, a total flexibility in space and time plays an essential role. The starting point for the achievement of this goal was the realization of the so called '24hours capability': traffic flows, vehicles speed, emissions, noise levels, pollution levels are calculated (when needed) hour by hour thanks to the characteristics of the citizens behaviour, transport, emission, noise and dispersion models that have been selected or developed. This flexibility enhances the scope of applicability of the tool that can be used for both short term scenarios and measures having a longer time horizon (months, year).

3 Project results

The ISHTAR Suite (Negrenti et al. [3]) was built over the following software modules including one or more software tools. The modules exchange a number of data, schematically represented in Figure 1.

The regional sectoral analysis mirrors the national one, with few exceptions only. In fact, the PM_{10} emissions in material handling and industrial processes, in Puglia, are higher than the share at national scale. Also, Liguria, Campania, Calabria, Sicilia e Sardegna have pronounced shipping emissions, compared with the shipping share in national emissions.

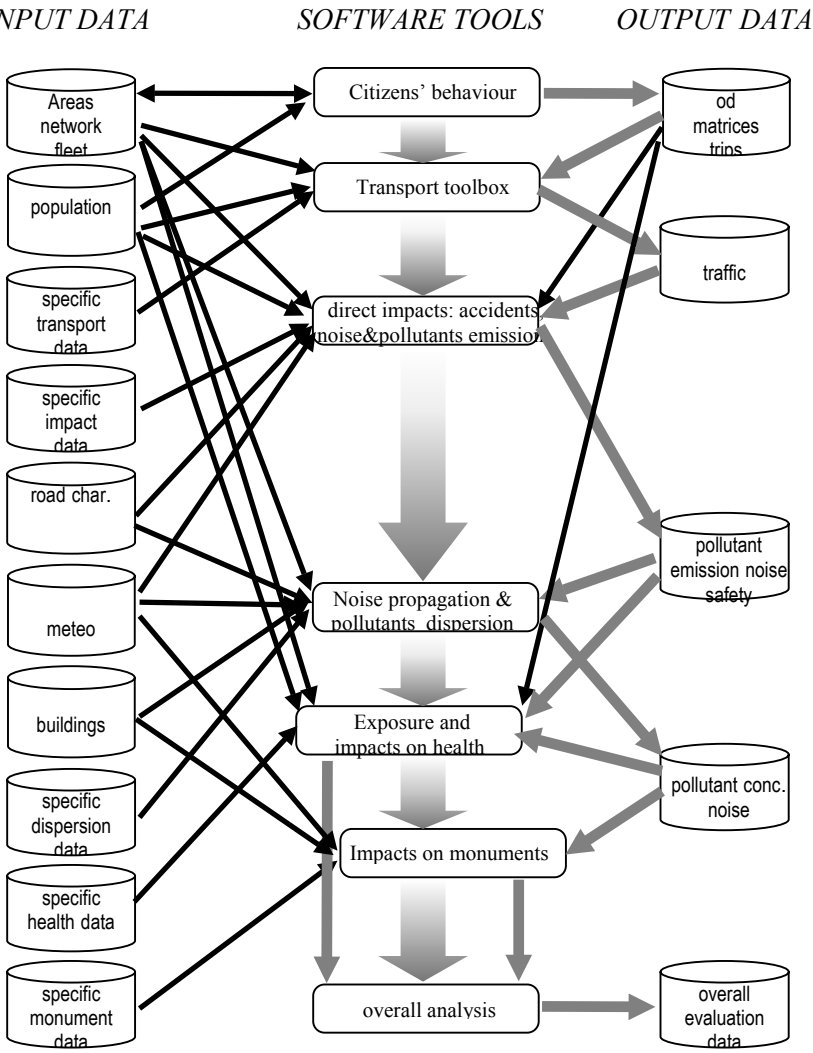

Figure 1: Main data flows and input-output data in ISHTAR suite.

3.1 The Cellular Transport Methodology

The Cellular Transport Methodology (CTM) is a completely new software tool developed by ISIS (Italy) that simulates the effects of policies and measures on

the behaviour of citizens in terms of movements, mainly producing the modified Origin-Destination matrices. This tool is considered as an 'ancillary element' of the suite because it is likely that the city teams wishing to use the ISHTAR software will already have a 'mobility demand model' or alternative techniques for estimating the modification of the trip matrices.

3.2 The transport toolbox

After an analysis of the available transport models, the VISUPOLIS model has been described as the best tool to integrate within the suite. This model, rather recent, has been developed by PTV (Germany) integrating VISUM and the innovative tool 'Metropolis' by Prof. A. De Palma from the University of Clergy Pontoise (F). However the potential users are free to continue to use their own traffic model (as most of the cities participating in ISHTAR Project). VISUPOLIS is going to be tested in the Paris case study. It is likely that a significant fraction of the future users of the suite will use the PTV software, while the majority of the user will have their own traffic model and will have to export the related output into the ISHTAR database.

3.3 The transport direct impacts module

The direct impact model chosen for the suite is TEE2004, developed by ENEA and ASTRAN (Italy). This tool is particularly flexible in terms of space and time, includes advanced modelling of kinematics and cold start effects on the emissions, and feeds several downstream suite elements by calculating the emissions of pollutants and noise and the occurrence of accidents. This tool is compatible with most of the traffic models output. In facts the large number of options about the description of vehicle kinematics, the definition of the local fleet at link level and the approach for estimating the fraction of cold vehicles should guarantee an easy coupling between TEE2004 and the upstream used traffic model.

3.4 Noise propagation and pollutants dispersion module

The pollutants dispersion can be calculated with one of the two tools provided by ARIA Technologies depending on the spatial and time scale. For urban scale and long term analysis the suite will rely on ARIA Impacts, while for meso scale and short term events ARIA Regional will be the future reference, not yet fully integrated in the suite. For the noise propagation the Soundplan software (by Braunstein & Berndt GmbH, Germany) has been integrated within the Suite. These software tools operate on a common and harmonised set of input data needed for representing the dispersion processes.

3.5 Exposure and impacts on health module

For assessing population exposure to pollutants and noise, a completely new software denominated TEX (Transport Exposure) has been developed by WHO

(ECEH office in Rome). Such a tool provides exposure of population groups in their residential areas or along the trips in the city network. The evaluation of the health risk related to the exposure to pollutants, noise and accidents is run with the H.I.T. software, also developed by WHO. This tool provides estimates of life years lost due to the effects of air pollution, noise annoyance and accidents effects.

3.6 Impacts on monuments

The air pollutants impact on monuments is simulated by a software purposely developed for ISHTAR by ENEA (Italy) and PHAOS (Greece). This software named MODA (Monuments Damage) can assess the loss of material or the deposition of crust and the money needed for maintenance. This module receives information from the air pollution software and gives useful output data to the module for the overall evaluation of the scenarios. The model can provide estimates of damage for specific monuments or for types of monuments and buildings.

3.7 Overall scenarios analysis tool

For the overall analysis of the policy scenarios two methodologies and software pieces are available: the Cost-Benefit Analysis and the Multi-Criteria Analysis. These tools gather the data from the upstream models (following the required aggregations) and give the results of the comparison of the scenarios developed. In any case the MCA takes into account the results of the CBA. Both of them are developed by TRaC – LMU (UK). This module needs the availability of a commercial software denominated LDW.

3.8 Software integration

As important as the previous tools is the software developed by INRETS (F) for integrating the various tools in a Suite. The integration is made by a Software Manager that launches the so called 'software connectors'. The connectors are pieces of software that upload the data needed by the single tool in the appropriate format, launch the tool and then download the results of the run in the ISHTAR Suite Database making them available for other tools or for the output through the Geographic Information System (ARCGIS) used for managing geographic data. An overall scheme representing the integration architecture of the ISHTAR suite is reported in Figure 2.

3.9 Case studies

The suite is being tested with seven case studies involving the seven cities of ISHTAR project: Athens, Bologna, Brussels, Graz, Grenoble, Paris and Rome. These studies can be summarised as follows.

The Athens case study 'Attiki Odos' addresses the new roadway construction, Attica Periphery Road, which is assessed in terms of traffic, toll strategy and

pricing, and environmental impacts. The Bologna Provincial Authority case study concerns the evaluation of infrastructure scenarios for the city of Imola with reference of alternative road paths. The aim of the Belgian case study is to prepare the implementation of traffic banning measures in the Brussels area, according to the Plan Ozone of the Federal Government. In the Brussels case study the focus is on the population behaviour, the modelling of traffic flows and the effects of the measure on pollutant emissions. The Graz case study is based on the traffic and noise impact evaluation of a 600 m long new road tunnel causing a relevant local traffic rerouting. Grenoble case study is intended to monitor the effects of the installation of reserved lanes for public transportation and new traffic lights on boulevards with heavy traffic. The focus in this case is on traffic and emissions. Every September 22nd the city of Paris takes part in a car free day. This typical short term event can be modelled with the ISHTAR suite of modules. For this case the usage of the new traffic model Visupolis is planned. The results include emissions of pollutants and air pollution. The Rome large scale case study involves the Heaven Project area banning to the more polluting vehicles. In the northern part of the city centre a number of models of the suite have been used, from the locally available traffic model (Transcad) to the Overall Evaluation module.

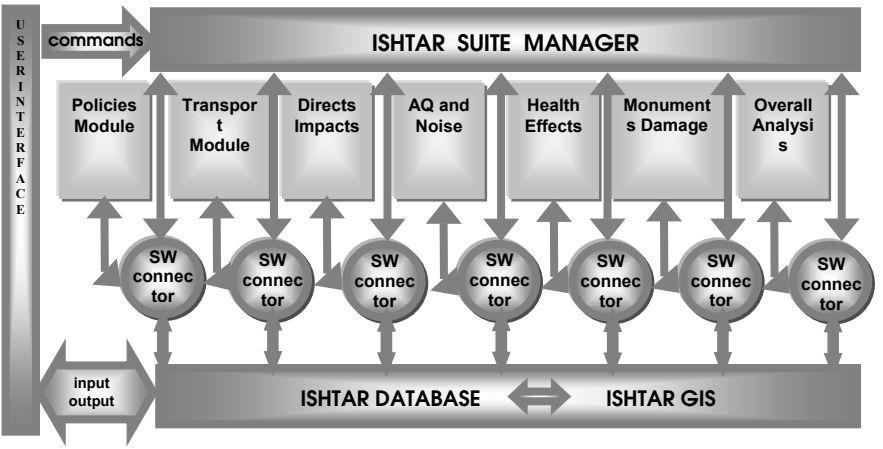

Figure 2: Integration architecture of the ISHTAR suite.

4 Conclusions

The ISHTAR Suite has the potential of becoming a reference tool for the future planning of urban policies in terms of traffic, environment, health, monuments protection (Negrenti and Hoglund [4]). The integrated tool will enhance cooperation among the planning departments of municipalities and will be of interest also for environmental agencies, consultants, transport companies, ministries. Project conclusion in May 2005 will be followed by a pre-commercialisation phase allowing the involved partners to transform a research

project result into a marketable tool or a software system for running calculation services. Along this phase an extensive demonstration activity in European cities is planned and is subject to negotiation at the time this paper is being finalised. Future users of the suite are expected in a fully international environment, having assessed the high interest by technical and scientific audiences worldwide (Negrenti [5] and Negrenti and Agostini [6]).

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