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Planning and Research of Policies for Land Use and Transport for Increasing Urban Sustainability

Project Funded by the European Comission under the Energy, Environment and Sustainable Development Thematic Programme of the Fifth RTD Framework Programme

PROPOLIS

Planning and Research of Policies for Land Use and Transport for Increasing Urban Sustainability

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Authors:

Kari Lautso, Klaus Spiekermann, Michael Wegener, Ian Sheppard,
Philip Steadman, Angelo Martino, Roberto Domingo, Sylvie Gayda

Project Co-ordinator:
Kari Lautso
LT Consultants, Finland

Partners:
IRPUD Universität Dortmund, Germany/
Spiekermann & Wegener, Urban and Regional Research
ME&P Marcial Echenique and Partners, United Kingdom
UCL University College London, United Kingdom
TRT Trasporti e Territorio, Italy
MECSA Marcial Echenique y Compañía, Spain
STRATEC, Belgium

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Foreword

PROPOLIS is a research project within the Fifth Framework Programme of the EC. It belongs to the Thematic Programme "Energy, Environment and Sustainable Development" and it's Key Action "City of Tomorrow and Cultural Heritage". DG Research and national organizations from six countries – Finland, Germany, UK, Belgium, Italy and Spain – have funded it. The project started on 1.1.2000.

The objective of PROPOLIS was to research, develop and test integrated land use and transport policies, tools and comprehensive assessment methodologies in order to define sustainable long-term urban strategies and to demonstrate their effects in European cities.

The project objectives, for the most part, have been achieved. The project has further developed the comprehensive approach for the assessment of sustainable urban development. Also, new methodologies and tools have been developed and successfully applied for analysing potential urban transport and land use policies and their impacts in the project's seven case cities of Helsinki, Dortmund, Naples, Vicenza, Inverness, Bilbao and Brussels.

The message from the project is clear. The results show that with the growing traffic volumes the sustainability of our cities is environmentally and socially deteriorating despite local plans designed to improve the situation. Only radical actions can maintain the current level of sustainability. The land use and transport subsystems must be viewed as a whole. The sustainability of this entire system can be improved by offering better public transport services while restricting car use and providing supportive land use policies. Following these lines will, as demonstrated in the seven PROPOLIS case cities, simultaneously enhance the environmental and social dimensions of sustainability while being also economically efficient – improve our cities of tomorrow.

I want to express my special gratitude to all consortium partners and research team members for their hard work and patience, all the local authorities involved for their help and guidance, and to Dr. Eric Ponthieu, Scientific Officer of EC, for his constructive and responsive attitude and actions which have helped and encouraged us in our work.

Helsinki, February 2004

Kari Lautso

Co-ordinator of PROPOLIS

Abstract

PROPOLIS is a research project within the Fifth Framework Programme of the EC. It belongs to the "Energy, Environment and Sustainable Development" Thematic Programme's Key Action "City of Tomorrow and Cultural Heritage". DG Research and national organizations from Finland, Germany, UK, Belgium, Italy and Spain have funded it.

The objective of PROPOLIS was to research, develop and test integrated land use and transport policies, tools and comprehensive assessment methodologies in order to find sustainable long-term urban strategies and to demonstrate their effects in European cities.

A set of indicators was developed for measuring the environmental, social and economic dimensions of urban sustainability. Values for these indicators were calculated using advanced urban land use and transport models and new GIS and Internet based modules developed during the project. A decision support tool was used to evaluate the sets of indicator values in order to arrive at single aggregate environmental, social and economic indices describing the alternative policy options. To include the long-term land use effects, a time horizon of 20 years was used. In close contact with Client-Partners and international networks the system was used to systematically test and analyse policy options in 7 European cities using three different types of land use and transport models.

The main innovation of the project is the integrated and comprehensive but still transparent approach undertaken. Secondly, the approach applied has also produced innovative policy recommendations based on the system's ability to forecast the indicator values into the future and to take into account the long-term land use effects.

The results show that, with growing traffic, the environmental sustainability deteriorates in all case cities compared with the current situation if no actions are taken. The trend is unlikely to change even if city specific reference scenarios, including local investment programmes, are adopted. Also, the social sustainability tends to deteriorate.

The aim of PROPOLIS was to find policies that could simultaneously improve all three dimensions of sustainability compared with the reference solution and, if possible, even improve the current level of sustainability. This goal was reached in most of the case cities using the same type of package approach combining pricing, investment and land use policies. This indicates that the approach could be transferable and similar strategies could work also in other European cities.

The local investment plans, normally consisting of an investment programme for both public transport and road investments, performed in the right direction but could not maintain the current level of sustainability. The various elements of the programmes were often found to encourage development towards opposing goals. Investment programmes should be designed to be consistent with the general goals set for the transport-land use system.

Different car pricing methods were able to produce positive results. However, their effects on land use have to be separately assessed as the balance of services and vitality of different areas may change too much.

Also public transport policies, increasing speed and service and reducing fares, worked well. However, also here special attention has to be paid to the land use effects and to their possible contribution to city sprawl. Although intended to decrease travel demand they could in the long-term lead to increases in private car use.

Regulating car speeds had positive effects on traffic accidents, as intended, but the policy was not enough to compensate for the effects of the worsening opportunity, accessibility and air pollution related indicators. Thus, speed policies should be adopted on a case-by-case basis.

Different types of individual land use policies did not have significant positive effects on the overall sustainability indices. However, land use policies could successfully be used locally and to support the changes in demand caused by the car pricing and public transport policies.

Best results were achieved by using policy combinations, i.e. push and pull measures consisting of car pricing policies and simultaneous improvements of public transport through reduced fares and better speed and service. The combination produced cumulative positive results and the negative land use effects of the individual policies could be avoided.

Adopting the above policy packages lead to a 15-20% reduction in CO2 emissions, a 8-17% reduction in traffic accidents and often to at least small reductions in exposure to noise and pollutants and in the total time spent in traffic. In addition, the accessibility to the city centre and services was improved. The socio-economic benefits varied but were typically 1000 – 3000 euro/inhabitant for the assessment period. Searching and defining more optimal local levels for the actions could further improve the results, as demonstrated in some case cities.

The PROPOLIS research has demonstrated that a complete urban policy programme should be evaluated both policy by policy and as a whole. A good urban policy programme consists of co-ordinated elements that work together to produce cumulative long-term effects that attain a balanced set of environmental, social and economic goals. These elements may include:

- Combination of car and public transport pricing policies reflecting the external costs caused and with differentiation between peak and off-peak hours as well as congested and non-congested areas
- Targeted transport investment programmes meeting the changes in demand caused by the above policies and especially responding to the increased demand for better public transport speed and service
- A land use plan supporting the new need for people to live near central areas, in satellite cities or along well served public transport corridors, and the people's increased need and opportunity to use public transport

PROPOLIS has demonstrated that in typical European cities this type of strategy is likely to improve all dimensions of urban sustainability compared with the continuation of existing policies and, in best cases, increase the current level of sustainability – improve our cities of tomorrow.

Executive summary

The PROPOLIS approach

The objective of PROPOLIS is to research, develop and test integrated land use and transport policies, tools and comprehensive assessment methodologies in order to define sustainable long-term urban strategies and to demonstrate their effects in European cities.

PROPOLIS views urban sustainability from three perspectives – environmental, social and economic. Each of these dimensions is divided into themes and each theme comprises a set of indicators. Indicators under each dimension and its themes are used to measure the state of sustainability for a set of policy options. In addition to indicators, a set of background variables is defined to help understand and illustrate the different impacts of the tested policies.

Indicator values are based on integrated land use and transport model outputs which are further processed with tools developed for disaggregation of data, economic evaluation, decision-making support and presentation of results.

This PROPOLIS system is used to define and measure the effects of the policy options offering the most potential. The policy options are mainly based on a literature review and the partners' experience. Policy combinations have been successfully formed from the individual policy options in order to obtain cumulative positive effects.

State of the art of land use, transport and environment modelling

That urban land use and transport are closely inter-linked is common wisdom among planners and the public. However, the reverse impact from transport to land use is less well known: how the development of the transport system influences the location decisions of landlords, investors, firms and households is not clearly understood even by many urban planners.

One method to better understand this two-way interaction and to predict the impacts of land use and transport policies is mathematical modelling which simulates the location and mobility behaviour of firms and households in urban regions. The urgency of the environmental debate has renewed the interest in integrated models of urban land use and transport.

A number of integrated urban land-use transport systems are in use today. There are significant variations among the models with respect to overall structure, comprehensiveness and theoretical foundations, modelling techniques, dynamics, data requirements and model calibration. The number of real-world applications of integrated urban land-use transport models has increased steadily over the last two decades.

However, urban modellers have for a long time ignored ecological aspects of the processes simulated in their models. Existing land-use transport (LT) models are be-

ing augmented by environmental submodels to become land-use transport environment (LTE) models. Yet today there exist no full-scale urban LTE models in the world. The first efforts to extend LT models to LTE models have concentrated on environmental impacts of land use and transport and ignored the opposite direction, the impact of environmental variables on location decisions of investors, firms and households.

There are different approaches to incorporate environmental impacts and feedbacks into urban land-use transport models. Environmental submodels require a higher spatial resolution than zone-based land-use transport models. In PROPOLIS, the results of the land use models are spatially disaggregated for post-processing by the environmental submodels in the Raster module (see below).

PROPOLIS methodologies and tools

The analytical framework of PROPOLIS consists of the databases, models and tools of the PROPOLIS Modelling System.

Inputs to the modelling system are policy packages, GIS databases and model databases. Policy packages to be tested are transformed to 'model language' by changing some of the model parameters or the model database. GIS databases contain spatial data on zonal boundaries, road and public transport networks, land use categories etc. All land use transport models used are fully GIS-based, i.e. each model zone and each model link is represented in the GIS database.

In the modelling part, land use transport models are the driving engines of the system. In PROPOLIS there are three different land-use transport models, each somehow different with respect to theory, issues modelled and output generated. The land use transport models simulate the effects of the policies in terms of changing zonal activities such as population or employment and changing mobility pattern that result in different modal splits and different link loads.

A range of indicator modules receives the output of the land use transport models and calculates raw values of sustainability indicators.

Raster

The Raster module provides indicators for the environmental and social component of sustainability by introducing a disaggregate raster-based representation of space for those indicators that require a higher spatial resolution. In the Raster module the land use pattern within the zones is disaggregated to 100m x 100m raster cells using GIS information in order to permit the calculation of air quality, noise intrusion and other environmental indicators by raster cells. As the resident population of each raster cell is known –the percentage of population by zone and socio-economic group affected by environmental impacts can be calculated.

Economic evaluation

The backbone of the economic assessment is represented by the application of a complete Cost Benefit Analysis on the transport side, further integrated by other indicators accounting for the distribution of costs and benefits and the regional change in competitiveness induced by adoption of the policy. The assessment is performed by the Economic Indicator Module software tool, which provides a coherent set of indicators summed up in a synthetic Economic Index (EEEI), which represents the net present value of the savings per capita.

Assessment of sustainability

The assessment of sustainability takes place in the USE-IT module, where the indicator values are weighted and the importance of change is valued. The weighting and valuing process results in a single sustainability index for each dimension of sustainability. This index summarises a vast amount of data from e.g. the 100m x 100m raster cells. The module also makes the comparisons between policies easy and illustrative and can be operated through Internet, in case public involvement is needed.

Presentation

A strong focus on clear, graphical presentation of data runs throughout the tools developed in PROPOLIS. The model-specific tools use GIS and three-dimensional mapping techniques to show spatial variations and highlight patterns and trends in background variables. The fine resolution mapping in the Raster module pinpoints very localised effects and interactions whereas the Analysis and Presentation Tool facilitates rapid comparison between policies and between cities. The focus on graphical presentation helps to maximise productivity and to promote understanding throughout the PROPOLIS modelling and analysis process.

Policy testing using the PROPOLIS system

The PROPOLIS system has been used in the seven case cities of Helsinki, Dortmund, Inverness, Naples, Vicenza, Bilbao and Brussels. Three different land use and transport model types have been used (MEPLAN, Dortmund and Tranus) ensuring that the results are not model specific. All data used has been harmonised in order to produce comparable results.

The final list of policies tested in all case cities includes 17 individual policies and three policy combinations. In addition, each test city has a set of locally tested policies defined in co-operation with national authorities. The selection of the 17 common policies is mainly based on a literature review, the partners' previous experience and the preliminary tests made by LT. The definition of the combinations is based on the properties of the individual policy run results. The policies tested are grouped under the following themes: base scenario, investment policies, car pricing, regulation, public transport, land use and policy combinations.

Results: Approaching sustainable urban policies

PROPOLIS has maintained and further developed the general comprehensive approach and the methodologies, originally developed in the SPARTACUS project, for studying sustainable urban policies. Most of the conclusions previously made can now be confirmed, specified in more detail and supported by more case cities and new types of models used.

The PROPOLIS system produces large amounts of information, but it also makes possible a drastic stepwise aggregation of the data — down to three sustainability index values per policy based on the preferences of the user or client of the system. In this way also the transparency of the system is maintained.

The results demonstrate the types of policies, which are likely to give positive results and therefore merit further study. However, theoretical, methodological and data limitations mean that some care is required in their interpretation. Despite these reservations many of the results in different types of cities, in different cultures and achieved using different types of models point in the same direction, are understandable and confirm the underlying theoretical considerations.

The main concept for further research builds on the premises that urban transport and land use form one integrated environmental, social and economic system that interacts with the surrounding region without a clear border. Thus the urban system and the effects of alternative policies should be assessed by simultaneously studying the land use and transport systems and their interaction with the environmental, social and economic systems and with the surrounding region on which the urban system is dependent. Both short- and long-term effects have to be taken into account. Many of the methods developed in PROPOLIS merit further research. However, the PROPOLIS system even in its current state could be used for more detailed policy identification in the seven case cities for producing comparable and harmonised data from different types of European cities.

The results show that the environmental sustainability deteriorates in all case cities compared with the current situation if no actions are taken and even if city specific reference scenarios, including local investment programmes, are adopted. Also socially the majority of cities tend to deteriorate.

The aim of PROPOLIS was to find policies that could, in an ideal case, simultaneously improve all dimensions of sustainability compared with the reference solution and, if possible, even improve the current level of sustainability. This goal was reached in most of the case cities using a same type of approach. This indicates that the approach could work in other European cities, as well, and that the results could thus be transferable.

The local investment plans, normally consisting of an investment programme for both public transport and road investments, performed in the right direction. However, they were not enough to maintain the current level of sustainability. It was found that the elements of the programmes are often contradictory and encourage development to-

wards different goals. Investment programmes should thus be designed to be consistent with the general goals set for the transport-land use system.

Regulating car speed policies had positive effects on traffic accidents, as intended, but they were not enough to compensate for the effects of the worsening opportunity, accessibility and air pollution related indicators. Thus, instead of applying general speed reduction policies, the locations for speed reductions should be considered case by case.

Different types of individual land use policies did not produce significant positive effects. However, land use policies could successfully be used to support the changes in demand caused by the car pricing and public transport policies. Also locally the effects of adopting land use policies may be significant.

Different car pricing methods were able to produce positive results. However, their effects on land use have to be separately assessed.

Also the tested public transport policies, increasing speed and service and reducing fares, worked well. In most cases they were environmentally, socially and economically feasible. However, also here special attention has to be paid to the land use effects and possible contribution to city sprawl.

Some measures intended to decrease travel demand could in the long-term lead to increases in private car mileage. This was especially the case in some public transport policies.

Best results are achieved by using policy combinations, i.e. push and pull measures consisting of car pricing policies and simultaneous improvements of public transport through reduced fares and better speed and service. The combination of public transport policies with car pricing policies produced cumulative positive results and the negative land use effects of the individual policies could be avoided or mitigated.

Adopting the above line of actions leads in the PROPOLIS case cities to a 15-20% reduction in CO2 emissions, 8-17% reduction in traffic accidents and often to at least small reductions in exposure to noise and pollutants and the total time spent in traffic. Also accessibility to the city centre and services is improved. The socio-economic benefits vary but are typically 1000 – 3000 euro/inhabitant (net present value). Searching and defining local optimum levels for the actions can further improve these results, as demonstrated in some case cities.

It is important to note that the optimum level of the pricing actions is city specific and that the optimum levels should be locally defined taking into account the cumulative effects of the individual actions.

The PROPOLIS research has demonstrated that it is insufficient to merely evaluate policies on a one by one basis. Instead a complete urban policy programme should be evaluated both policy by policy and as a whole.

A good urban policy programme consists of co-ordinated elements that work together to produce cumulative long-term effects that attain a balanced set of environmental, social and economic goals. These elements may include:

- Combination of pricing policies directed at car users, with differentiation between peak and off-peak hours, as well as congested and non-congested areas, with appropriate level of pricing of public transport fares
- Investment programmes supporting the changes in demand caused by the above policies and especially responding to the increased demand for better public transport speed and service
- A land use plan supporting the new need for people to live near central areas, in satellite cities or along well served public transport corridors and the people's increased need and opportunity to use public transport

This policy line is likely, as demonstrated by the PROPOLIS case cities, to improve all dimensions of urban sustainability in typical European cities compared with their reference scenarios or continuation of existing policies and, in best cases, increase the current level of sustainability - improve our cities of tomorrow. This can only be achieved through coordinated intervention of both local and national decision-making levels.

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Mauri Heikkonen	Ministry of Environment
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Administration de l'Equipement et des Déplacements de la Région de Bruxelles-Capitale (Administration of Equipment and Mobility of the Brussels-Capital Region)

Authors and Contact information

Authors

Name	Institution	Main research area
Lic. Sc. Kari Lautso	LT	editor, the PROPOLIS approach, policy testing and analysis
Prof. Dr. Michael Wegener	IRPUD/S&W	environmental feedback, the Dortmund model application
Dipl.-Ing. Klaus Spiekermann	IRPUD/S&W	PROPOLIS analytical framework, Raster application
Dr. Ian Sheppard	WSP	the analysis and presentation tools
Prof. Philip Steadman	UCL	Inverness application
Ing. Angelo Martino	TRT	Policy testing and analysis
M.Sc. Roberto Domingo	MECSA	Bilbao application
M. Ing. Sylvie Gayda	STR	Brussels application

Contributors

Mr. Hannu Lehto	LT	USE-IT module
M. Sc. Virpi Pastinen	LT	economic analysis
M. Sc. Miia Lehmuskoski	LT	indicator development
Dr. Silvia Maffii	TRT	Economic analysis
Dr. Riccardo Parolin	TRT	Economic analysis
Arch. Silvio Angelini	TRT	Vicenza and Naples application
Arch. Carlo Andriolo	TRT	Vicenza application
Ing. Enrico Pastori	TRT	EIM Economic Indicator Module
Dr. Angel Gil	MECSA	Bilbao application
M.Sc. Sonia Padilla	MECSA	Bilbao application
M.Sc. Françoise Boon	STR	Brussels application
M.Ing. Nathalie Schaillée	STR	Brussels application
Mr. Steve Evans	UCL	Inverness application
Dr. Peter Rickaby	Rickaby-Thompson Ltd	Inverness application
Prof. Tomas de la Barra	Modelistica	Inverness application
M.Sc. Paavo Moilanen	Strafica	Helsinki application, policy runs
Timo Flieger	IRPUD	Dortmund application
Dipl.-Ing. Meinhard Lemke	IRPUD	Dortmund application
Dipl.-Ing. Björn Schwarze	IRPUD	Dortmund application
Dipl.-Ing. Carsten Schürmann	IRPUD	Dortmund application
Dipl.-Ing. Ahmed Talaat	IRPUD	Dortmund application

Contact information

Scientific Officer of DG Research

Dr. Eric Ponthieu,
European Commission
DG XII-D.1.4 (MO75 6/4)
Rue de la Loi, 200, B-1049 Brussels
tel. +32-2 2969945, fax. +32-2 2960588
e-mail: eric.ponthieu@cec.eu.int

The Consortium

LT Consultants Ltd (LT) – Co-ordinator
Heikkiläntie 7, 00210 Helsinki, Finland
Lic. Tech., M.Sc Kari Lautso – Co-ordinator
+358 9 615811, +358 400 411030, +358 9 61581430 (fax)
kari.lautso@ltcon.fi, http://www.ltcon.fi/

Universität Dortmund, Institut für Raumplanung (IRPUD)
August-Schmidt-Strasse 4 , 44221 Dortmund, Germany
Prof. Dr. Michael Wegener
since 01.02.2003:
+ 49 231 1899 441, + 49 231 1899 443 (fax)
mw@spiekermann-wegener.de
http://IRPUD.raumplanung.uni-dortmund.de/IRPUD/index_e.htm

Subcontractor to IRPUD
Spiekermann & Wegener, Urban and Regional Research (S&W)
Lindemannstrasse 10, 44137 Dortmund, Germany
Dipl.-Ing. Klaus Spiekermann
+49 231 1899 439, +49 231 1899 443 (fax)
ks@spiekermann-wegener.de,
http://www.spiekermann-wegener.de

WSP Policy & Research Unit (formerly ME&P)
49-51 High Street, Trumpington, CB2 2HZ Cambridge, United Kingdom
Mrs. Lynn Devereux
+44 1223 840704, +44 1223 840384 (fax)
lsd@meap.co.uk, http://www.meap.co.uk/

University College London, **Institution incorporated by Royal Charter (UCL)**
The Bartlett School of Architecture, Building, Environmental Design and Planning
Torrington Place 1-19 (Philips House), WC1E 6BT London, United Kingdom
Prof. Philip Steadman
+44 20 7679 1628, +44 20 7916 1887 (fax)
j.p.steadman@ucl.ac.uk,
http://www.ucl.ac.uk http://www.casa.ucl.ac.uk/ Centre for Advanced Spatial Analysis (CASA)

TRT Trasporti e Territorio srl (TRT)
Via Rutilia 10/8, 20141 Milan, Italy
Ing. Angelo Martino
+39 02 5741 0380, +39 02 5521 2845 (fax)
martino@trttrasportieterritorio.it, http://www.trttrasportieterritorio.it

Marcial Echenique y Compañía S.A. (MECSA)
C/Cristobal Colon 8B, 48990 Getxo-Vizcaya, Spain
Dr. Angel Gil
+ 34 94 430 4210, + 34 94 430 4204 (fax)
agil@mecsa.es, http://www.mecsa.es/

STRATEC S.A. (STR)
Avenue A. Lacomblé 69-71 box 8, 1030 Bruxelles, Belgium
Françoise Boon / Sylvie Gayda
+32 2 735 0995, +32 2 735 4917 (fax)
f.boon@stratec.be / s.gayda@stratec.be, http://www.stratec.be

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