TOWARDS SUSTAINABLE MOBILITY: ECONOMIC AND SPATIAL EFFECTS OF INCREASING GOODS TRAFFIC

(Project MD/DD/01)

SYNTHESIS

1. Title and summary

The network of this project consists of 3 research teams: **UFSIA** (Department of Transport and Regional Economics), **FUCAM** (Group Transport & Mobility) and a co-operation between **UCL** (Department of Geography) and **UFSIA** (Department of Transport and Regional Economics).

UFSIA research team:

Promoters:	Prof. Dr. H. Meersman
	Prof. Dr. E. Van de Voorde
	Prof. Dr. A. Verhetsel
Research assistant:	Drs. T. Pauwels

UCL/UFSIA research team:

Promoters:	Prof. Dr. I. Thomas
	Prof. Dr. A. Verhetsel
Research assistants:	Drs. P. Arnold (1/4/97-30/9/98)
	J.-P. Hermia (7/10/98-30/11/00)
	S. Hoebus (1/1/98-31/12/98 part time)
	K. Molenberghs (10/1/00-31/7/00)
	Drs. T. Vanelslander (1/9/99-31/12/99)

FUCAM research team:

Promoters:	Prof. Dr. M. Beuthe
	Prof. Dr. B. Jourquin
Research assistants:	F. Degrandsart (1/10/98-30/11/00)
	C. Koul à Ndang'ha (1/9/98-30/9/00)

The project of the research team, made of researchers of UFSIA, UCL and GTM-FUCAM is to analyse the impacts of freight transports in a spatial and multimodal framework. As transports are made over a non-uniform space, it is indeed necessary to take into account the characteristics and the density of infrastructure and of the supplied transport services. Furthermore, one should also take into account the mode choices which are made and which determine to a large extent the external effects of transports. The qualifications of the team members indeed permit to approach these problems by different ways.

As a result of the co-operation, the following is pursued:

(1) the provision of policy support concerning freight transport;
(2) the consolidation of scientific and financial investments in the 'Transport and Mobility' Impulse Programme (1990-1995);
(3) the strengthening of the Belgian research building and supporting 'centres of excellence'.

2. Objectives

2.1. What was at stake?

Freight and passengers transports are the source of many negative impacts on society. These are matters of serious concern because they threaten the sustainable economic development of Belgium and Europe, as well as of the whole world. These effects of transports not only reduce the real productivity of our economies, but raise serious questions about their capacity to keep functioning unchanged and about the future welfare of the populations. Thus, it is important to identify and measure all these negative effects: the pollutants, noise, accidents, time lost on congested networks, damages to the roads. It is also crucial to investigate the available means for limiting these impacts in order to permit a sustainable economic development and a growing welfare of the populations.

On the one hand, mobility of goods as well as of persons is a necessary condition for economic growth, wealth and welfare. On the other hand it generates negative external effects which might hamper economic activity and harm well being. This duality makes the design of policies, which reduce the external effects of freight transport without impeding economic welfare and economic growth, a hard task. It can only be successful if one has a clear insight in all the factors and mechanisms which have an impact on freight transport, on the negative external effects resulting from freight transport and on the complex network of relations between freight transport, passenger transport and economic activity.

This project has taken up the challenge to gain more insight into this complex relation between freight transport and welfare. It has used the knowledge and experience of the three teams involved. The UFSIA team has investigated, on the one hand, how companies and shippers of goods choose a transportation mode (road, rail, inland navigation or combinations) and how this choice can be influenced . On the other hand, it has looked into the question of how freight mobility has an impact on (regional) economic growth. The UCL/UFSIA team has analysed the role of infrastructure for sustainable freight mobility. FUCAM has developed a very detailed virtual network (NODUS), which makes it possible to identify the different streams of commodity flows, and the costs generated by freight transport on this network. The combination and integration of the research of the teams results in a better understanding of the complex interrelation among freight transport, infrastructure, costs (external and internal) and economic growth.

2.2. The goals

The ultimate objective of the project is to get a good grip on the complex relation among freight transport, external effects, infrastructure and economic growth. Within the project each team had its own targets which were necessary for reaching that final objective.

- The goals of the UFSIA-team were fourfold:
  - to study the external effects generated by freight transport;
  - to analyse the factors that affect the choice of freight transport modes and how changes of these factors, such as costs, will change the behaviour of shippers and companies;
  - to quantify the impact of internalising the external costs on freight transport and on the mode choice;
  - to start research on the impact of freight transport on economic activity.
- Within the UCL/UFSIA research group two goals were set. The first was to produce a spatial evaluation of goods transportation networks in Belgium. This evaluation is realised in terms of form, connectivity, accessibility and localisation and this for different types of networks (roads, railways and waterways). The second goal was the conception of an optimal localisation model for the goods transhipment platforms.
- GTM's work followed three main steps. Firstly, the further development of the NODUS software to facilitate and improve the empirical investigations which are necessary to assess sustainable transport solutions; secondly, its use for modelling the Belgian freight transport networks inserted in the trans-European networks; thirdly, the analysis with this model of a number of transport policies, and, particularly, the pricing policy of marginal external cost internalisation. Such an analysis demanded naturally a review in depth of the literature on the external effects and their valuation.

The above goals were complementary, which facilitated co-operation and the exchange of data and results. This means that the output of one group can be used as the input for another group.

2.3. The underlying interests

A distinction can be made between three kinds of interests.

(1) To provide policy support concerning freight transport

Each research team has the ultimate goal to provide policy tools. As will be discussed in detail in section 3, the UFSIA group aims to evaluate the effect of policy measures on the mode choice in freight transport (for example on the basis of a quantitative simulation tool). The interest of the UFSIA/UCL research group is to develop a measure that is applicable to the current spatial-

economic situation as well as possible future situations (with changes in demand for and supply of transportation capacity (with infrastructure in particular)). GTM-FUCAM quite naturally focuses its efforts on the continued development of the virtual network analysis and its associated software NODUS.

(2) The consolidation of scientific and financial investments in the 'Transport and Mobility' Impulse Programme

The research groups used the Multimodal Interregional Model (MIM) which was developed under the 'Transport and Mobility' impulse programme. The MIM was to be re-evaluated where necessary and linked to a more detailed network, NODUS.

(3) the strengthening of the Belgian research building and supporting 'centres of excellence'

At the start of this project of sustainable mobility the research teams were already actively present in the international research world (e.g. participation in European research programmes, research collaboration with Eastern European research teams, invitations from CEMT,...). This position is further enhanced by the project, as it also devotes specific attention to the European transport network. The development of a pan-European network that incorporates both private and social costs allows one to study sustainable mobility internationally. As regards the European Union, we were thus able to obtain a clearer insight into the impact of Belgian and European measures aimed at fighting the negative effects of increasing goods traffic. The methodology employed in this project was to be made extendable to a broader European context. Also, the presence at national and international conferences is encouraged. In 1998, the UFSIA researchers were co-operating in the organisation of the 8th World Conference on Transport Research in Antwerp. There is also an important involvement in the 9th World Conference, to be organised in Seoul (Korea) in 2001.

3. Activities and results

Designing policies for sustainable mobility can only be successful if one has a clear understanding of the factors that affect the behaviour of all the agents involved in transport. This project has focused its attention on freight transport. In order to be able to quantify the external effects generated by freight transport and to design policies to reduce negative external effects, the following elements needed to be investigated:

1) given the actual infrastructure and the actual mode choice, what and how big are the external effects of freight transport;
2) how can the infrastructure be adapted to guarantee freight flows with a minimal amount of externalities;
3) how can freight flows be shifted from socially expensive modes to socially less expensive modes (or combinations of modes);
4) how can freight flows be re-routed towards socially less expensive routes.

Answering these questions requires research on mode and route choice, on optimal changes of and investment in infrastructure, and a fairly detailed network model to quantify the freight flows and the external effects. The research teams have each used their specific knowledge and expertise to solve the above questions.

3.1. UFSIA research team

3.1.1. The activities of the UFSIA research team

The activities of the UFSIA research group can be divided into 4 categories: formulating definitions, a literature review, the analysis of available transport data and modelling the mode choice.

(1) Formulating the definitions

Within this part of the research, an overview of the relevant definitions and terminology was gathered. The analysis can be found in: T. Pauwels (1998), Aspecten van de vraag naar goederenvervoer: modale keuze en modale uitsplitsing, Hoofdstuk 2: De vraag naar modi in het goederenvervoer: theoretische achtergrond, p. 19-31.

(2) Literature review

The literature review gives an overview of empirical papers which study aspects of the demand for freight transport, with an emphasis on the demand for transport modes. The publications are categorised in several topics and judged on their contributions and shortcomings (T. Pauwels (1998), Modale keuze en modale uitsplitsing in het goederenvervoer: een literatuuroverzicht, p. 1-34). Parallel with the literature review of the empirical papers, a description has been made of the frequently used models in the literature (T. Pauwels (1998), Aspecten van de vraag naar goederenvervoer: modale keuze en modale uitsplitsing, Hoofdstuk 3: De vraag naar modi in het goederenvervoer: modelmatig, p. 32-48). Finally, conclusions are formulated.

(3) A critical analysis of the transport statistics, with a special emphasis on origin-destination data.

An overview was made of the existing statistical material of freight transport on the Belgian infrastructure. Road transport, rail transport and inland navigation were all taken into account. The focus was on the data that were useful in the analysis of mode choice in freight transport. The data that give an indication of origin and/or destination are mentioned in the overview. Drawing on the data that were immediately available, synoptic tables were constructed (national, import, export and transit) for the years 1996 and 1997. Conclusions were formulated in relation to reliability and usefulness (T. Pauwels (2000), Het goederenvervoer in België: een kritische analyse van de transportstatistieken, met een specifieke aandacht voor herkomst-bestemmingsdata, p. 1-71).

(4) Modelling the mode choice in freight transport

(4.1) Aggregated research

An econometric analysis was made of the mode choice. The analysis used the freight flows between Belgian districts ('arrondissementen'), which means that only national transport was investigated. The data refers to the year 1989 and were obtained from the NIS (National Institute of Statistics) and the NMBS (National Railway Company). The year 1989 is the last year for which comparable, detailed data are available. We refer to the final report of the previous Impulse Programme Transport and Mobility, De Brabander, G., Meersman, H., Gentil, G., Pauwels T. en E. Van de Voorde, Eindverslag (Voortgangsverslag nr. 5). Module B2: Ontwikkeling Modules "Generatie" en "Modal Split" voor goederenverkeer voor Multimodaal Interregionaal Model (MIM): BijlageI: Korte bespreking van de empirische resultaten betreffende de modale uitsplitsing, UFSIA-SESO, Antwerpen, december 1995; Van de Voorde, E., Winkelmans, W. (et al), Aspecten van havencompetitiviteit, Finaal onderzoeksrapport (GOA 1995-1998), p. 169-174, 2000 and a forthcoming paper by Meersman and Van de Voorde on mode choice in freight transport.

(4.2) Company-specific research

The choice of mode is a procedure carried out on the level of the company (producer of goods, forwarding-agent...). It is therefore useful to do the research also on this level, next to that of aggregated research. Especially the effects of internalising the external costs play an important role.

(4.3) From company-specific research to aggregated results

The results from the aggregated research and the company-specific research are linked and confronted. Finally, an interface is built which helps to design and evaluate nation-wide policies starting from individual choice behaviour.

3.2. The UCL/UFSIA research team

3.2.1. The activities of the UCL/UFSIA research team

In order to come near to reality, an evaluation has to combine a qualitative approach with a quantitative study. That is the reason why a joint approach was opted for. The basic analysis is quantitative, through stable indicators (indicators of form, accessibility,…), of which the mathematical construction is directly inspired by the literature review that was effected for the fields of transportation networks, network forms and accessibility indicators. This was followed by a qualitative approach, founded on the major results that were obtained through the calculation of synthetic indicators.

At the heart of this program, the principal theme of which is sustainable mobility, our approach was meant to be spatial. The major concern was to stress the inequalities existing within a territory, specifically Belgium, and especially for accessibility. In the same way, the study of the network forms is intrinsically related to the characteristics of the purified space.

A quick preliminary overview of the literature revealed that little was known about this subject, at least as far as commodity transport was concerned. For passenger transport, a relatively small number of publications was dealing with accessibility. It had to be investigated whether the methods used there were applicable to commodity transport. Furthermore, nowhere in the existing literature did anyone try to integrate demand for and supply of transportation capacity, so that research in this field would be entirely new. Neither could we find any intention to consider different modes next to one another. Most studies were unimodal. Finally, in most cases (for passenger transport), accessibility measurement was restricted to the use of distance (or a measure directly derived from it). We thought it would be interesting to consider direct costs as well, and if available, time and external costs data.

The first phase consisted of a literature review in the area of accessibility, in order to define relevant terminology to be used, and to determine (a) relevant measure(s) and their components. The spatial scope was restricted to the Belgian territory. The measure to be used was made suitable for expansion to a larger or another area. As far as the time considered was concerned, a restriction was made to the present and existing situation of infrastructure and activities. Expansion to possible future situations was kept as an option. Measures to be used primarily consisted of accessibility measures.

The next step consisted of the preparation of the data to be worked with, primarily the transportation networks for goods in Belgium. Besides the choice of the digitalisation type of the networks, it was thought useful to construct digitalised networks that are specific for the research undertaken, starting from the ones effected by the FUCAM team. Their networks were realised during the conception of the NODUS software.

The construction of networks with a simple structure, close to that of the topological network, permits the application of a large number of indicators. The choice of indicators is based upon a literature review that was meant to be as critical as possible, in order to select only those indicators that are most adequate for a spatial evaluation of transportation networks. As the literature directly linked to the subsector of transport named goods transport is quite limited in terms of volume as well as originality, we are principally relying on scientific publications that treat non-specific indicators for this subsector. In a next step, we will eventually adjust them to the own properties of the goods transport subsector.

Once base networks are constructed and different indicators are selected, it appears useful to complete our data base, starting from the lessons that the literature review teaches us. In this way, starting from a network that is close to a topological graph, we associate a number of data, which are the attributes of the arcs and nodal points on the initial network. The characteristics of the nodal points include their population – we treat nodal points where people are living – or their ‘administrative status’, and the

characteristics of the arcs (roads, railway tracks and waterways) include the maximum speed allowed on them, their number of lanes, the mean traffic they support, the possible presence of congestion, or an estimation of the time distance separating each pair of neighbouring nodal points. All these characteristics are evaluated for each nodal point and for each arc of the networks we have constructed. Next, they are encoded as variables – or attributes – within matrices that can be initialised in GIS computer packages or in tabulators.

After performing these steps preparing the data, we have moved to the full realisation of the principal objective. The spatial evaluation of the Belgian transportation networks is done using the indicators mentioned above, on the one hand for the form of the networks, and on the other for their accessibility. The latter is essentially measured for the nodal points that are contained within the networks, for the notion of accessibility is in a first instance related to distinct points within a limited space. The analysis is carried out in terms of accessibility, for the same indicators are calculated for different configurations of the road network. This permits us to measure the impact that is produced by the presence of congestion, variations in mean speed effected on the routes, and so of time distances. It also permits us to evaluate e.g. the effect that the finishing of the A8 motorway linking Brussels to Lille over Ath and Tournai can produce on the accessibility of the nodal points.

Existing material was used for the literature review (publications) and the calculation of the accessibility measure (economic and spatial data). An experiment (changing existing situations to situations that are suspected to come up in the future) was kept as an option. Field research (interviews with transportation specialists) for these evolutions or government measures was an option that has not been taken within the project, but will be undertaken by the Flemish government in the very near future.

The applications of the calculation technique chosen were made dependent on the availability of data. In the results section, it will be shown which data were available and suitable.

The main activity was to integrate the economic findings of the UFSIA part and the results of the FUCAM part. This way, actual as well as possible future situations have been considered and evaluated. The integration of the work of the UFSIA and FUCAM research groups asked for an efficient measure. A literature review was undertaken to determine the scope of the research activities and to decide upon a suitable measure. The literature review left us with a measure that was applicable to the current Belgian situation, a possible future situation (with changes in demand for and supply of transportation capacity (with infrastructure in particular)). The application was made for the current Belgian case: suitable data were collected and used as input for the measurement. Conclusions were drawn from these results.

The tasks between UFSIA and UCL were divided in a way that UCL has concentrated on the network and its characteristics, whereas UFSIA has linked the network to the neighbouring activity zones.

3.3. The GTM-FUCAM research team: Activities and results

In the framework of the research network formed by UFSIA, the UCL Department of geography and the FUCAM Groupe Transport et Mobilité (GTM) in order to study the "Economic and spatial effects of increasing freight transports", GTM was in charge of the development of a multimodal network analysis of the freight flows in Belgium. The purpose of this research was to contribute a tool for assessing the socio-economic impacts of various investments and transport policies.

The approach taken by GTM was to continue the development of the simulation software NODUS that was used earlier for a set of case studies. This software is based on a detailed modelling of the trans-European networks of roads, rails and waterways as well as short-sea shipping lines. All transport operations are identified per mode and means (diesel train or electrical train, etc.), and their costs accounted for separately, including the costs of transferring from one mode or means to another. This set-up allows an analysis of intermodal solutions. By minimising the generalised cost of transport tasks, defined by a matrix of origins and destinations, the software finds the least costly solutions, which may very well be combinations of different modes and means. Since the parameters of the cost functions and the networks characteristics can be changed according to needs, it is possible to simulate what would result from an implementation of various transport policies, investment plans, and network organisations with specific constraints.

GTM's work program was then to continue the development of this software in order to facilitate its use and allow more complete analyses. Secondly, it was necessary to improve the detailed definition of the Belgian networks. Lastly, the software was to be used for a certain number of case studies, and in particular for an analysis of possible impacts of a pricing policy based on the internalisation of freight transport external effects.

For what concerns the software NODUS, a number of tasks were completed. NODUS was completely re-written to facilitate its use by external analysts and to make it available for various computing platforms: Windows, Unix, Linux, Open VMS. The program was completed for allowing the handling of terminal operations. The computing algorithms was revised in order to increase the computation speed. A comprehensive user's guide was written.

NODUS has been applied to study a set of problems. First, the problem of regulating the road freight flows across Switzerland, with the helpful co-operation of the Swiss Ministry of transports. This study showed how important was the impact of the Swiss restriction of 28 tons trucks on the trucking flows in that country. It allowed to compute also the levels of tolls that would be necessary to maintain the "statu quo" on the Swiss roads in case the limitation was cancelled.

Two cases concerning terminal operations, intermodality and the configuration of networks were studied: the rail "freightway" between Muizen (B) and Sibelin (F), and the planning of a hub-and-spoke network at the North-East of Paris. These analyses allow to determine a good definition of intermodal networks , and to forecast the transport flows they can attract.

After a thorough review of the Belgian freight networks definition, a number of simulations related to various plans of infrastructure investments were realised on the basis of forecasts and detailed matrixes of origins and destinations, which were built up by the consultants STRATEC and ADE. This work was done for the Walloon Ministry of transports in order to better assess the need of new infrastructures for freight transports.

On the basis of the preceding study, GTM was able to systematically estimate the direct and cross-elasticities of transport demand for different categories of commodity. These results, derived from appropriate simulations, are particularly interesting because empirical results on these important elasticities are very few. Moreover, the adopted methodology was an innovation in that field of research.

Finally, GTM has conducted an extensive review in the scientific literature of the available estimates of external costs of transports resulting from pollution, accidents, noise and congestion. The best available estimates were used for simulating the possible impacts of a marginal social cost transport pricing policy. It turned out that such a policy would induce a substitution of rail and inland waterway transports at the expense of road transport, with a sizeable decrease of various external effects and total social costs.

We should note also that, in the meantime, GTM continued researches in cost-benefit and multicriteria analysis of public investments. These researches were started in the framework of the previous SSTC-DWTC research program on Mobility. They were focused on the integration of risk into the decision making process and the computation of the risk premium which corresponds to the uncertain outcomes of projects.