Transportation System Analysis

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1. Traffic and transport: a system description

1.1 Introduction

Transport and traffic are of essential importance for the economic and social functioning of modern societies. One way or another, 10 to 20 per cent of national time and economic activity is linked to transport.

From an historic perspective, administrative and military purposes led to extensive transport and traffic facilities. The gradual specialisation in the production of specific goods subsequently led to the emergence of important trading routes. This kind of specialisation continues to this day and leads to the transportation of raw materials and workers over ever-longer distances. There has been a dramatic increase in the transportation of goods and people over the last century and a half. In the cities, primitive forms of public transport existed from 1840, but the introduction of the automobile created a huge breakthrough starting around 1890. Motorised transport enabled the spatial separation of daily activities such as living, working, shopping and social-recreational activities.

The strong growth in transport and traffic has created a number of serious problems. Congestion jeopardises the accessibility of important economic and social centres. The human environment is affected by interference, especially from motorised traffic. Traffic accidents cause human suffering and social disruption. Transport emissions harm the natural environment.

Governments are now faced with the problem of developing policies that safeguard the economic and social advantages of transportation, but that also minimise the harmful effects of transportation. The multitude of interactions between the various components of transportation systems and the society in which they are imbedded makes for extremely complex political deliberations.

To get an idea of the relationship between the various aspects of the transport system and the way in which policies can influence this system, we begin this chapter with a system description of the policy areas that relate to traffic and transport. The system description was formulated by Egeter en van de Riet\textsuperscript{5} within the framework of the Questa project. This project was instigated to provide back up for the formulation of a traffic- and transport policy for The Netherlands. In this chapter we shall illustrate how the system diagram that evolved from the Questa project also helped formulate the Mobiliteitsplan Vlaanderen (Mobility Plan Flanders)\textsuperscript{ii}

The terms transport and traffic will be frequently used in the coming text. There is an important difference between these two concepts. Transport refers to the transfer of goods and people from one place to another. When we use the word transport the

\textsuperscript{5} Notes refer to the list of references at the end of the text.
emphasis is on the purpose of a trip, i.e. the linking of a certain origin to a destination. The transport of goods and people requires vehicles and infrastructure. The word *traffic* is used to describe the actual movement of vehicles across the infrastructure.

### 1.2 Policy areas in the traffic and transport sector

The policy area of traffic and transport is populated by a variety of actors. These actors operate at different scale levels (the international, national, regional and local scale levels) and in specific policy areas or markets. Policy areas are markets where there is an interaction between participants both on the demand side as on the supply side of these markets. The relevant areas are:

- the travel market
- the transport market
- the traffic market

The *travel market* is the market where the demand for activity and the supply of activity opportunities in space and time create travel patterns.

The travel market deals in possible interactions between geographically separated locations. These interactions have a dimension of space and time determined by the spatial allocation of locations for activities and the time sequence of these activities. Before undertaking a trip, every transport consumer weighs the utility of linking two geographically separated locations against the costs involved.

Therefore transport consumer perceptions also influence the travel market. Each transport consumer makes his own choice, and perceptions regarding the advantages and disadvantages of each choice are different for different consumers. The average assessment of the advantages and disadvantages can also change, depending on the supply of information, changes in attitudes, etc. The output of the travel market consists of a set of travel patterns: the allocation of trips between activities, in space and time.

The *transport market* is the market where the demanded travel pattern and the supply of transport options come together in a transport pattern that assigns passenger- and goods trips to vehicles and transport services.

Travel patterns (the output of the travel market) can also be seen as the demand side of the transport market: the demand for vehicles to transport passengers and goods. The supply side represents the available supply of vehicles and services for each trip (organised according to space and time) and the perception of trip opportunities (the assessment of quality, availability, costs, etc. by the transport consumer). The output of the transport market comprises a set of transport patterns: an assignment of passenger- and goods trips to vehicles and services.
This is again a market in which individual consumers make decisions based on individual choice-behaviour; especially the evaluation of the supply side of the transport market and the process of weighing the pros and cons of demand and supply vary strongly per individual. Developments in society also change attitudes amongst transport consumers. This can lead to a change in priorities when people consider their options.

The traffic market is the market in which the required transport patterns are confronted with the actual supply of infrastructure and their associated traffic management systems, (for example Dynamic Traffic Management (DTM), information systems, traffic light controls), resulting in the actual use of the infrastructure in the form of a traffic pattern.

Transport patterns (the output of the transport market) can also be seen as the demand side of the traffic market: the demand for infrastructure for vehicles and transport services. The supply side consists of the available traffic infrastructure including all its components, for example traffic management systems. The output of the traffic market consists of a set of traffic patterns: the assignment of vehicles and transport services to the infrastructure.

As in the two markets above, the traffic market also needs to take into consideration the individual differences in the evaluation of demand and supply and changing behaviour, since they influence the outcome of the evaluation process.

Figure 1  Arrangement of the travel, transport and traffic markets

Figure 1 illustrates the relationship between the three markets. Note that the time dimension plays an important role. Some submarkets react very swiftly to changes (take, for example, actual ('real time') traffic management in the traffic market), while other markets show great inertia, as, for example, the spatial layout in the travel market.
Figure 1 clearly shows that the demand for transport is a derived demand. Transport does not derive its usefulness from the trip itself (with the possible exception of some recreational trips) but from the activities that are made possible through the availability of transportation.

1.3 Using the system diagram to formulate transportation policy

The 3-markets model can be used to formulate transportation policy. We will show how it was used in drafting the Mobility Plan Flanders. This Plan includes recommendations towards sustainable mobility.

1.3.1 Sustainable mobility

The concept of Sustainable Development was introduced in 1987 in a United Nations report (the so-called Brundtland report). In this report, Sustainable Development was defined as development that provides for the needs of the current generation without endangering the ability of future generations to provide for their needs.

<table>
<thead>
<tr>
<th>Foundations Sustainable Development</th>
<th>Five Policy Objectives Sustainable Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1: Economic concerns</strong></td>
<td>• Accessibility</td>
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<tr>
<td>- Economic well-being</td>
<td>• Transportation equity</td>
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<tr>
<td>- Employment</td>
<td>• Safety</td>
</tr>
<tr>
<td>- Productivity</td>
<td>• Liveability</td>
</tr>
<tr>
<td><strong>2: Social concerns</strong></td>
<td>• Care for nature and environment</td>
</tr>
<tr>
<td>- Equity</td>
<td></td>
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<tr>
<td>- Health and safety</td>
<td></td>
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<tr>
<td>- Quality human environment</td>
<td></td>
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<td><strong>3: Ecological concerns</strong></td>
<td></td>
</tr>
<tr>
<td>- Exhaustion natural resources</td>
<td></td>
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<tr>
<td>- Pollution air, water, soil</td>
<td></td>
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<tr>
<td>- Biodiversity</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2  Policy objectives Sustainable Mobility Flanders

The initial emphasis centred on concerns regarding current consumption levels of natural resources and their possible negative impact on the quality of life of future generations. In other words, there was a desire to think of the needs and rights of future generations. This was followed by a growing realisation that not only future generations deserve consideration, but that also within the present generation all people without exception deserve a decent quality of life. Sustainable development aims to achieve an optimal balance between economic, social and ecological targets in all areas of human activity.
These three targets are also called the foundations of sustainable development. In the Mobility Plan Flanders five policy objectives were derived from these three foundations. These five policy objectives are shown in Figure 2.

- The first objective concerns economic development and it aims to guarantee permanent accessibility of important economic nodes and gateways. Capacity problems on the various transport networks lead to increased and unreliable travel times.

- The second objective is to guarantee access to the transport system for all citizens. The aim of this objective is to achieve social development in its broadest sense by minimising transport inequality between the various social groups.

- The third objective aims to increase traffic safety on the Flemish roads. Traffic accidents cause great personal suffering and have large social consequences and high costs.

- The fourth objective, that of liveability, is concerned with the quality of life within communities. This relates to matters such as hinder from traffic noise, vibrations, odour and light. Also of importance are use of space, landscape fragmentation and visual degradation of town and country.

- The fifth objective aims to reverse environmental damage. The carrying capacity of the natural environment is exceeded by traffic emissions, the consumption of non-renewable fossil fuels is excessive and the biodiversity of ecosystems is under serious threat.

1.3.2 Influencing mobility

Figure 3 identifies the important aspects for the sustainable development of society and it shows where policy opportunities lie.

1.3.2.1 Opportunities in the travel market

Influencing the need for travel ("volume measures")
One could try to change the spatial pattern of living, working, shopping and recreation by emphasising the advantages of spatial proximity. This implies that the planning stages of new residential areas and of the arrangement of urban areas attend to a better balance between the number of jobs created and the actual size of the active population in these areas.

Structuring the timing of trips can also reduce mobility. Peak time traffic causes network overload and obliges dimensioning that remains underused in the off-peak hours. Options
that influence the timing of trips include enhanced flexibility of working hours, the introduction of shorter working weeks and the encouragement of teleworking.

Figure 3  The 3 markets with effects and policy opportunities

1.3.2.2 Opportunities in the transport market

Influencing modal choice

Although cars will continue to be an essential part of the transport system for the foreseeable future, there are possibilities to increase both the supply and the attractiveness of alternative modes of transport. Increasing the quality of the existing public transport system in terms, for example, of comfort, information and service can contribute to this end. The role of the existing collective transport system can also be enhanced by the introduction of alternative forms of community transport such as "dial-a-ride" busses. Stimulating car pooling or shared car-use can also have a positive effect on the modal split.
The extension of multimodal systems also needs attention. Creating efficient transfer options in multimodal nodes could reduce the use of the car. It must be noted, lastly, that there is scope for a substantial increase of goods transport by rail or water.

**Influencing transport-efficiency**

Policy in this area should aim to optimise the operation of vehicles both for passenger transport and for goods transport. Occupation levels for private cars are very low and should be increased. The development of logistic systems can lead to increased efficiency in the use of freight vehicles. Many goods trucks are empty or nearly empty on the return journey.

**Influencing mobility effects through technological improvements**

Technological means can help reduce the negative effects of growing mobility. Firstly, the introduction of specific measures towards less noisy, cleaner, safer and more economical vehicles could be stimulated. These measures are called "source-measures". Another development, namely radio-controlled vehicles, can enhance both the safety of car-systems and the capacity of the underlying infrastructure.

### 1.3.2.3 Opportunities in the traffic market

**Influencing traffic efficiency**

Traffic efficiency refers to the extent to which the potential capacity of the existing traffic system is exploited. Here, modern forms of Dynamic Traffic Management (DTM), usually based on telematics applications, are significant. Examples are the provision of dynamic route information (coupled with incident- and tailback detection systems), ramp metering and incident management (based on rapid intervention).

**The influence of improved infrastructure design**

Many of the measures that aim to increase sustainability of the transport system are based on improved infrastructure design.

Some measures are concerned with the layout of the entire traffic network. Accessibility is increased when the road network is classified into primary roads, secondary roads and local roads, as put forward in the *Spatial Structure Plan Flanders* (RSV). An intrinsically safer road network and increased liveability are achieved by harmonising form (cross section, speed regime, capacity) and function (connecting, collecting, providing access). The many dangerous passages of busy roads right through the centre of villages and towns in Flanders require special attention. Traffic networks also require built-in backup options (alternative routes) to deal with unexpected incidents and calamities. This also entails adjusting the layout of the entire network.

Many other infrastructure improvements, requiring local adjustments, can be mentioned. They include, for example: noise reduction measures; construction of so-called *eco-
corridors to mitigate infrastructure barrier-effects on fauna; the layout of residential areas in cities; security measures (effective lighting, for example); and the provision of adequate cycle- and pedestrian facilities.

1.3.2.4 Attitudes

The sustainable development of transport systems is only possible when the necessary measures are institutionally incorporated into society. Because the determining factor in this area is the attitude of society at large towards the attainment of sustainable targets, we summarise the possible measures under the heading of Attitudes.

The impact of pricing

When it comes to the thorny question of sustainability, it is not enough to rely on the selfless benevolence of citizens. Economic theory holds that consumers react to so-called incentives. An adequate pricing policy (for example, charges for car traffic) confronts consumers with the real costs of their travel behaviour. Besides the direct resource costs (vehicle purchase price, fuel and such like), car drivers should also pay for the damage caused to third parties and to the environment.

The impact of regulation and education

Besides economic incentives, we can use regulations to enforce desired consumer behaviour. Examples of such regulatory measures include the restriction of car access to particular areas, restrictive parking policies and the introduction of maximum speeds. These measures require sufficient funds for surveillance and enforcement.

Lastly, traffic education can play an important role in the increase of traffic safety while relevant information on transportation possibilities might enhance transportation equity. Education and information can also raise the awareness of the consequences of irresponsible behaviour.

Table 1 summarises the different traffic measures discussed in the preceding pages. It also shows what measure supports which policy objective. The specifications in the table are only indicative: when a measure affects a number of policy areas we have given only the most important ones.
Table 1  Relation between measures and sustainability objectives

<table>
<thead>
<tr>
<th>Traffic Measures</th>
<th>Market</th>
<th>Type meas</th>
<th>Accessibility</th>
<th>Equity</th>
<th>Safety</th>
<th>Liveability</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>More efficient spatial organisation</td>
<td>Travel</td>
<td>volume</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved timing</td>
<td>Travel</td>
<td>volume</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved quality Public Transport (comfort, information, service)</td>
<td>Transport</td>
<td>modal split</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stimulate rail and water transport</td>
<td>Transport</td>
<td>modal split</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development multimodal systems</td>
<td>Transport</td>
<td>modal split</td>
<td></td>
<td></td>
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<tr>
<td>Extension collective transport (district, dial-a-ride, taxi, shared car, carpool ...)</td>
<td>Transport</td>
<td>modal split</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved transport efficiency</td>
<td>Transport</td>
<td>transport-eff</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Vehicles handicapped</td>
<td>Transport</td>
<td>technology</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Radio-controlled vehicles</td>
<td>Transport</td>
<td>technology</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Source measures (silent, clean, economical, safe)</td>
<td>Transport</td>
<td>technology</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved operation (DVM, incidentm, information, ramp metering, priority PT)</td>
<td>Traffic</td>
<td>traffic-eff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Lay-out road net (hierarchical, target groups, fall-back option, through roads)</td>
<td>Traffic</td>
<td>design</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Road design (noise pollution, maintenance, traffic calming devices ..)</td>
<td>Traffic</td>
<td>design</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Mitigation barrier-effect</td>
<td>Traffic</td>
<td>design</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Restrictive parking policy</td>
<td>Traffic</td>
<td>design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Adequate cycle and pedestrian services</td>
<td>Traffic</td>
<td>design</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential areas (Estate areas, location of industry)</td>
<td>Traffic</td>
<td>design</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Security in public areas</td>
<td>Traffic</td>
<td>design</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Institutional measures</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Pricing policy (road, parking)</td>
<td></td>
<td>attitudes</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Regulations, education</td>
<td></td>
<td>attitudes</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

1.4 Stakeholders on the mobility market

Many actors (also called stakeholders) are active on the three markets mentioned above. The tasks, responsibilities and competence levels, and especially the interests of these actors or stakeholders can differ greatly. The three-markets model can help identify the parties involved in the mobility debate.

Amongst the actors the following clusters can be identified:

- government and administration
- providers of transport- and traffic services
- project developers
- consultants
- lobby organisations
- the media
- citizens
Government
The specific tasks and responsibilities of governmental bodies at the European, national, regional and municipal level give them a very special place amongst the actors. Government is active in all three markets. In the travel market, governments play the role of regulating *planning actors*. It can, for example, take a steering role in the allocation of space by drawing up structural plans. The role of the authorities in the transport market will be that of *facilitator* of transport alternatives to the car. Governments can also act as *innovator* by introducing new transport systems into the market. The traditional *role* of the authorities in the traffic market is *to guard over the quality* of the infrastructure.

Roles
We have mentioned some of the roles that can be played by the various actors on the mobility market, namely that of planner, facilitator, innovator and that of guardians of quality. Other examples of possible roles are: the role of designer, the role of initiator and stimulator, the regulatory and enforcement role and the role of the lobbyist.

Actors in the travel market
On the demand side of the travel market we find the actors who claim space to carry out certain activities. Examples are actors from the private sector such as companies and families.

The supply actors are the parties that provide the physical space, such as landowners, and property developers. Trips also have a time dimension. Problems of access are largely caused by peak hour demand. A variety of actors play a role in determining the peak moments. Economic actors, the educational sector and a number of government departments have an important role as time planners. This relates to the setting and harmonising of opening- and working hours.

Actors in the transport market
The choice for a specific transport mode is made on the transport market. On the demand side of this market are employees, customers, students, holidaymakers, etc., who want to choose the most reliable and efficient mode of transport. These actors are organised in various groups such as the Cycle Federation, the Federation of Train-, Tram- en Bus users and the various motoring organisations. Social groups such as environmental organisations, senior citizens organisations etc. also influence the demand for specific modes of transport.

The supply of the transport market offers an arsenal of vehicles or it offers public or collective services. The suppliers in this sector are government agencies such as the national railway company NMBS and the national bus company De Lijn, but also private actors like taxi companies, tour operators, leasing companies, courier services, etc.
Actors in the traffic market

Users on the traffic market require a certain quality of the infrastructure. The demand side is composed of drivers, cyclists, pedestrians and users of public and collective transport. They are often organised in lobby groups. There are also lobby groups that make particular demands on traffic systems, usually motivated by the negative impact of traffic on the quality of life in their area.

The supply side is made up of producers and suppliers of materials and services, organised in lobby groups such as the FEBIAC (car- and bicycle industry). The supply of the infrastructure is usually a task of government. In Flanders this important task comes under the heading of the Department of Roads and Traffic. Local- and state police are also important actors in this area. They are charged with the enforcement of regulated behaviour, but they also perform the important task of promoting a steady flow of traffic.

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ii Ministerie van Vlaamse Gemeenschap [2001], Departement Leefmilieu en Infrastructuur, Mobiliteitscel, Ontwerp mobielieitsplan Vlaanderen (Concept Mobility Plan Flanders).