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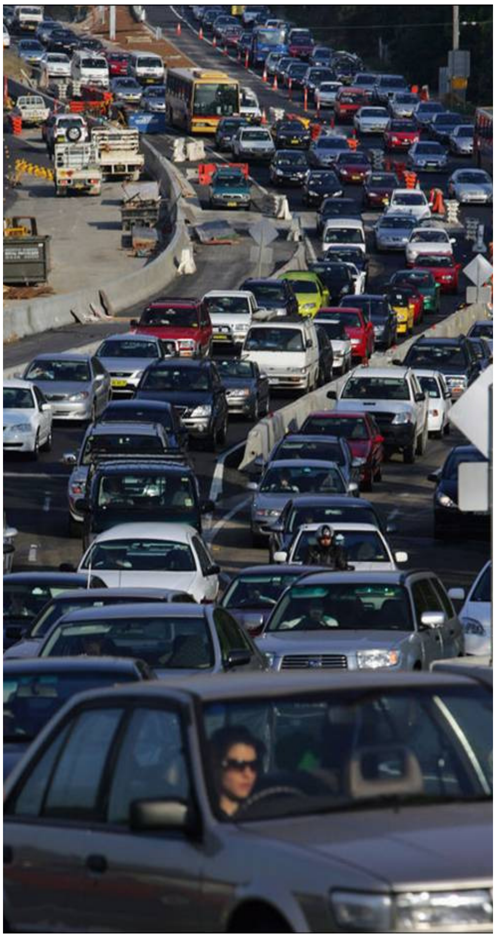

Travel Demand Management :

a comparative analysis between the cities of Groningen and Liege (Belgium)

Possible transfer of TDM measures from Groningen to Liege

Master Thesis

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August 31st 2008

To all those who have helped me and supported me, I would like to say a big

THANK YOU

This thesis has taught me a lot, and brought me to meet many people. So, …

In Groningen,

I would like to particularly thank my supervisors, Mr Paul Ike, Professor at the RijksUniversiteit Groningen and Chairman of the Planning Department, and Mrs Femke Niekerk, Professor at the RijksUniversiteit Groningen, for the advice they provided me all along these 6 last months, for their availability, and for their support.

I also would like to thank Mr Rob van Vliet, project leader of the Regiotram, and Menno Oedekerk, planner at the municipality of Groningen, who have taken time to meet me and give useful and relevant information.

My thanks also go to Mr Gerard Tolner, planner at the municipality of Groningen, for its reading work and its accurate remarks.

In Liege,

My first thanks go particularly to Mr Jean-Francois Leblanc, mobility counsellor of Liege, and to Xavier Bruyère, Road System Research Department in Liege, for the time they have devoted to my work and for the amount of pertinent information they have provided.

I have also to thank Mr Dominique Vanduyse, Head of the Studies and Planning Department at the Ministry of Equipment and Transport, and its assistant Mrs Hélène Cornet, for having answered my questions.

Finally, my last thoughts go to my near relations. My parents and my grand-mother who have done a long-term job, supporting me from afar since my arrival in Groningen, and my friends, here in Groningen, who were present in the best moments as in the worst ones. A special thank to Maarten for its "basic" Dutch and its support. Without forgetting my boyfriend, who had to endure sometimes my temper, sometimes my humour, all along this year. He was a good listener and advisor.

To all, again

DANK U **THANK YOU** **MERCI**

Abstract

Title : Travel Demand Management : a comparative analysis between the cities of Groningen and Liege (Belgium)

Subtitle : Possible transfer of TDM measures from Groningen to Liege

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Supervisors : Dr. P. Ike and Dr. F. Niekerk

Abstract : This master thesis takes place in the broader debate concerning the paradigm shift that occurred in transport planning these last decades, namely the shift from the "demand-led" towards the "management-led" transport paradigm. This shift has been mainly caused by the incapacity of the classical "four stages" model to satisfy the always growing mobility demand and to preserve the environment and public health. These observations have pushed policy-makers to develop new, more sustainable solutions. It is in this context that the concept of Sustainable Transport System is born ; the Travel Demand Management (TDM) being one of its main components.

This work aims at drawing a list of TDM measures that are in application in Groningen and that could be transferred to the Liege context to improve its transport system.

In that perspective, a practical analysis of the transport system of both studied cities has been carried out : the context within which they have developed has been described, the main elements constituting their respective transport networks have been identified, and the TDM measures in application in both cities have been evaluated. This analysis has put to the fore numerous differences between the transport system of Groningen and the one of Liege. These ones do not facilitate transfer possibilities between the two cities. However, a list of TDM measures that carefully takes these differences into account has been drawn. These measures concern (1) the improvement of the public transport services, (2) the development of a coherent parking policy, and (3) the promotion of bike use. In fact, the major shortcomings that Liege is facing in each of these three issues have been pointed out and efficient solutions have been looked for in the Groningen's experience. These solutions have been largely detailed.

Finally, some additional recommendations regarding the scope of this thesis and the possible practical implementation of the results in Liege have been formulated.

Keywords : Sustainable Transport System, Travel Demand Management, TDM measures transfer, Mobility Management & Traffic Management, Transport Network Analysis, Transport Policy, Alternative Transport Modes

Titel : Travel Demand Management : een vergelijkende analyse tussen Groningen en Luik (Belgie)

Ondertitel : Mogelijke overdracht van TDM-maatregelen van Groningen naar Luik

Auteur : Catherine MALOIR

Begeleiders : Dr. P. Ike en Dr. F. Niekerk

Samenvatting : Deze scriptie plaatst zichzelf in het brede debat over de paradigmaverandering die de afgelopen decennia plaats heeft gevonden in de transportplanning. De verandering waarover gesproken wordt is de verschuiving van een "demand-led " naar een "management-led" paradigma. Deze verschuiving wordt met name veroorzaakt door het gebrek van het "vier stappen model" om te kunnen voldoen aan de altijd groeiende vraag naar mobiliteit en milieubescherming. Deze constatering heeft beleidsmakers ertoe gedwongen om duurzamere oplossingen te ontwikkelen. In deze context is het Sustainable Transport System ontwikkeld, waarvan Travel Demand Management (TDM) een van de voornaamste componenten is.

Het doel van dit document is om een lijst met TDM-maatregelen op te stellen die in Groningen gebruikt worden en die in Luik gebruikt zouden kunnen worden om daar het transportsysteem te verbeteren.

Om dit te realiseren is een praktische analyse van het transportsysteem van beide steden uitgevoerd: er wordt beschreven in welke context elke stad zichzelf ontwikkeld heeft, de belangrijkste elementen waaruit de respectievelijke transportnetwerken zijn opgebouwd worden geïdentificeerd en de TDM-maatregelen in beide steden worden geëvalueerd. Deze analyse heeft veel verschillen tussen de transportsystemen van Groningen en Luik naar voren gebracht. Deze verschillen zorgen ervoor dat een overdracht van bestaande maatregelen niet mogelijk is. In plaats daarvan is er een lijst met TDM-maatregelen opgesteld die nauwkeurig rekening houdt met deze verschillen. Deze maatregelen omvatten (1) de verbetering van het openbaar vervoer, (2) de ontwikkeling van een coherent parkeerbeleid en (3) het bevorderen van het gebruik van de fiets. De belangrijkste tekortkomingen die Luik heeft op het gebied van deze drie punten worden geïdentificeerd en er worden efficiënte oplossingen aangedragen, gebaseerd op de ervaringen in Groningen. Deze oplossingen worden gedetailleerd beschreven.

Tot slot zijn wat aanvullende aanbevelingen met betrekking tot het onderwerp van deze scriptie en de mogelijke praktische implementatie van de resultaten in Luik geformuleerd.

Titre : Travel Demand Management : Une analyse comparative entre les villes de Groningue et de Liège

Sous-titre : Possibilités de transfert de TDM mesures de Groningue vers Liège

Auteur : Catherine MALOIR

Promoteurs : Dr. P. Ike et Dr. F. Niekerk

Résumé :

Ce mémoire se situe dans le débat relatif au changement de paradigme qui est survenu dans la planification des transports ces dernières décennies, à savoir le passage du "demand-led " au "management-led" paradigme. Ce changement a été principalement causé par l'incapacité du traditionnel "modèle en quatre étapes" à satisfaire la demande en mobilité sans cesse croissante et à préserver l'environnement et la santé publique. Ces observations ont poussé les responsables politiques à proposer de nouvelles solutions, plus durables. C'est dans ce contexte que le concept de Sustainable Transport System* est né ; le Travel Demand Management* étant une de ses principales composantes.

Ce mémoire vise à proposer une liste de TDM mesures en application à Groningue et qui pourraient être transférées à Liège pour améliorer son système de transport.

Dans cette perspective, le système de transport des deux villes étudiées a été analysé : le contexte dans lequel elles évoluent a été décrit, les principaux éléments qui constituent leur réseaux de transport respectif ont été identifiés, et les TDM mesures qui y sont en application ont été évaluées. Cette analyse a mis en évidence de nombreuses différences entre le système de transport de Groningue et celui de Liège. Celles-ci réduisent les possibilités de transfert entre les deux villes. Une liste de TDM mesures qui prend prudemment en compte ces différences a néanmoins pu être établie. Ces mesures concernent (1) l'amélioration des services de transport publics, (2) le développement d'une politique de parking cohérente, et (3) la promotion du vélo. Concrètement, les points faibles que connaît Liège dans ces trois domaines ont été épinglés, et des solutions efficaces ont été recherchées dans l'expérience de Groningue. Ces propositions ont été largement détaillées.

Finalement, quelques recommandations quant à l'envergure du sujet traité dans ce mémoire et à la possibilité d'appliquer les résultats obtenus à Liège ont été formulées.

* Ces termes sont généralement traduits par "Système de Transport Durable" et "Gestion de la Demande en Déplacements" (GDD)

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Glossary

This glossary provides extra information on the terms which are employed all along this master thesis. In fact, all the terms which are written in *italic* in the text are defined in the glossary. This process allows firstly, to lighten the text, and secondly, to provide to the reader a broad vision on the typical Travel Demand Management terminology.

The definitions which are provided here are a compilation of information found in different reference documents. The main source of information is the Travel Demand Management Encyclopedia edited by the Victoria Transport Policy Institute. When it was necessary, the definitions were completed by additional information collected in more specific documents (e.g. EPOMM, European Platform on Mobility Management ; MAX project, Definition and Categorisation of Mobility Management Measures ; MOSAIC and MOMENTUM projects, Mobility Management in Urban Environment ; SMILE ; the gateway to Sustainable Mobility, COST transport actions ; …).

Alternative Work Schedules (also called *Variable Work Hours*) include the following work alternatives :

- *Flextime* : employees are allowed some flexibility in their daily work schedules
- *Compressed workweek :* employees work fewer days, but the daily work schedule is longer
- *Staggered shifts* : work schedules shifts are regularly staggered to reduce the number of employees arriving and leaving a worksite at one time. This has a similar effect on traffic as flextime, but does not provide to individual employees as much control over their schedules.

Bicycle facilities refer to the various improvements which are realized to favour bike use and bike flows. This includes for example facilities such as :

- *Secure or non-secure bike parking facilities*
- *Special bike signs system* what allows an easy and quick reading of bike signals, and provides a good indicators system to guide efficiently bikers through urban area.
- *Adapted traffic lights and circulation rules* such as *right turn on red* (wherever possible, right-turning cyclists do not need to wait for a traffic light), s*imultaneous green traffic lights* (wherever possible, cyclists are given simultaneous green lights in all four directions of an intersection), *diagonally cross the intersections* (to cross the intersection, cyclists are allowed to cut diagonally across the intersection during one green light), *priority to bike in traffic lights* (during a complete light's sequence, cyclists have two green lights in the time that cars get only one), etc.

- *Wheeling ramps* : sometimes it is necessary for cyclists to use existing bridges or subways equipped only with stairs. Wheeling ramps may be added to one or both sides of stairs to facilitate the climbing of stairs.
- *Bike and pedestrian bridges* : narrow bridges exclusively reserved for pedestrians and bikes crossings. This provides a short cut and safe alternative to these road users.
- *Limited one-way streets* : adapted circulation plan within which on certain roads bikers are allowed to use streets in both directions while cars are only allowed to go through one direction. This allows the bikers to use the shortest way between two points (no itinerary constraint) and also to slow down car traffic since car drivers have to be constantly cautious to bikers.
- *Roundabouts* : more and more intersections are being converted into roundabouts to reduce, among other things, the number of cycling accidents. Cyclists in the roundabouts have the right of way over turning motor vehicle traffic.
- *Bubbled bicycle lanes* : these are separate waiting zones for bicycles which have been created at many traffic lights. In these lanes, cyclists wait in front of the cars. Consequently, they are less exposed to exhaust and they can start more quickly, what better accommodates motorists who wish to turn.
- *Public Bike System (*also called *Bike sharing facilities*) : to provide convenient rental bikes intended for short (less than 5 kilometres), utilitarian urban trips. A typical public bike system consists of a fleet of bicycles, a network of automated stations (also called *points*) where bikes are stored, and bike redistribution and maintenance programs.

Bus Rapid Transit (BRT) is a broad term given to a variety of transportation systems that, through improvements to infrastructure, vehicles and services, attempt to use buses to provide higher quality and cost-effective transit services than ordinary bus lines. Ideally, the goal of such systems is at least to approach the service quality of rail transit while still enjoying the cost savings of bus transit. A BRT system should include most of the following features : exclusive right-of-way lanes (or bus lanes), frequent, high-capacity and high-quality vehicles (that are easy to board, quiet, clean and comfortable), an integrated fare system and a good modal integration. Moreover, to be successful, BRT system also has to be supported by marketing (e.g. public transport campaigns, educational programs, …) and customer services (e.g. mobility centres, pre-trip and during the trip traveller information system, …).

*Car free zones (*also known as *auto-free zones* and *pedestrian zones*) are areas of a city or town in which car traffic is prohibited.

Carsharing refers to automobile rental services intended to substitute for private vehicle ownership.

Commuter financial incentives include several types of incentives that encourage alternative commute modes. These are among others :

- *Parking cash out* : commuters who are offered subsidized parking are also offered the cash equivalent if they use alternative travel modes.
- *Travel allowances* : financial payment provided to employees instead of parking subsidies. Commuters can freely use this money to pay for parking or for another travel mode.
- *Transit and rideshare benefits* : free or discounted transit fares provided to employees.
- *Reduced employee parking subsidies* : commuters who drive must pay some or all of their parking costs (parking pricing).
- *Tax and other government policies* that support such strategies.

Express commuter bus services (also called *express regional buses*) refer to fast bus services that connect efficiently urban areas to the regional surrounding areas.

Intelligent transportation system (ITS) is a system of hardware, software, and operators that allow better monitoring and control of traffic in order to optimize traffic flows. In fact, ITS allows to monitor traffic flows through the use of sensors and live cameras or analyzing cellular phone data travelling in cars (floating cellular data) and in turn to reroute traffic as needed through the use of various traveller information means.

Land use and zoning policies covers a variety of factors such as density, accessibility and connectivity, functions mix, and site design. These land use factors affect largely traveller behaviour by affecting the distances that need to be travelled between destinations, and the relative efficiency of different modes.

*Light Rail Transit (LRT) (*also called *trams* or *trolleys)* is a form of urban rail public transportation that generally has an intermediate capacity and speed between heavy rail and metro systems and traditional bus systems. The term is used to refer to modern tram systems with extensive priority signaling at intersections that mostly operate in private rights-of-way separated from other traffic (at least 30% of its route) to maximize travel speeds and minimize congestion delay.

Park & Ride consists of parking facilities located at transit stations, bus stops and highway onramps, particularly at the urban fringe, to facilitate public transit and rideshare use (carpooling and vanpooling in which vehicles carry additional passengers).

Parking management refers to strategies that result in more efficient use of parking resources, including sharing, regulating and pricing of parking facilities, more accurate and flexible parking requirements (parking standards reflect the parking demand and costs at a particular location, taking into account geographic, demographic, economic and management factors), use of fringe parking facilities (park and ride facilities), improved user information, and incentives to use alternative modes.

Parking pricing means that motorists pay directly for using parking facilities. Parking pricing may be implemented as a TDM strategy (to reduce vehicle traffic in an area), as a parking management strategy (to reduce parking problems in a particular location), to recover parking facility costs, to generate revenue for other purposes (such as a local transportation program or downtown improvement neighbourhoods), or for a combination of these objectives.

Pedestrian facilities refer to the set of facilities which exist in urban areas to improve walking trips. These are for example extensive pedestrian areas/streets, large and good quality sidewalks, numerous pedestrian crossings, adapted pedestrian-oriented traffic lights, … These facilities have to be made easily accessible by creating location-efficient, clustered, mixed land use patterns, with good road and path connectivity, and pedestrian-oriented buildings.

Pre-trip travel information service allows travellers to access a complete range of real-time multimodal transportation information at home, work, and other major sites where trips originate. Information on road network conditions, incidents, weather, and transit services, are conveyed through these systems to provide travellers with the latest conditions and opportunities in order to plan their travel. Based on this information, the traveller can select the best departure time, route and modes of travel, or perhaps decide not to make the trip at all.

Real-time traveller information system refers to the package of information concerning available parking spaces, road closures or accidents, … which are dispatched to traveller via means such as parking messages, diversion and alternative route messages, radio/internet/TV traffic announcements, warning signals, public transport information, …

Rideshare matching (or *ridematching*) *services* refers to services which help travellers to find travel partners to practice ridesharing (car- or vanpooling).

Ridesharing (also called *carpooling*) is the shared use of a car by the driver and one or more passengers, usually for commuting. When travelers do not use their own car but rented vans (often supplied by employers, non-profit organizations or government agencies), this activity is called *vanpooling*. Ridesharing contributes largely to reducing the number of vehicles at peak hours, what reduces congestion.

Road Pricing means that motorists pay directly for driving on a particular roadway or in a particular area. Road Pricing has two general objectives: revenue generation and congestion management. There are many different types of road pricing. The most commonly used are road tolls, congestion pricing (variable time and space road tolls according to the congestion level intended to reduce peak-period traffic volumes), cordon area tolls (fees paid by motorists to drive in a particular area, usually a city centre), high occupancy toll lanes (high occupancy vehicles lanes that also allow use by a limited number of low occupancy vehicles if they pay a toll).

Shuttle service (or *city buses services*) refers to public transport system operating at frequent intervals on a short route, often between two locations without (or with few) intermediate stops. This service is often associated with a P+R facility, to transfer people from the car park (where they let their car) to the city centre.

Speed reduction refers to various strategies which aim at reducing traffic speeds. Reducing traffic speeds tends to improve walking and cycling conditions, increase safety, reduce air and noise pollution, encourage more compact development, and reduce total automobile travel. These strategies include traffic calming, but also maximal speed limit reduction, speed enforcement improvement, signage improvement, traffic light synchronization optimization.

Taxi service refers to for-hire automobile travel supplied by private companies.

Traffic calming refers to various design features and strategies intended to reduce vehicle traffic speeds and volumes on a particular roadway. Chicanes, speed tables, roundabouts and street trees are common examples of such strategies. Traffic calming projects can range from minor modifications of an individual street to comprehensive redesign of a road network.

TDM marketing strategies investigate the types of transportation services people want, identify barriers to alternative modes, and promote use of efficient transport options. Specific TDM marketing activities are surveys, (un)targeted marketing campaigns, alternative transport modes promotion, educational programmes, design and diffusion of user guide manuals, …

Telework(ing) is a general term for the use of telecommunications (telephone, fax, email, websites, video connections, etc.) to substitute for physical travel. That includes for example telecommuting (employees work from home rather than a central office), teleconferencing (use of live video connections as a substitute for physical meetings), Internet-shopping (for shopping, banking, etc.), telelearning or telestudying (teachers and students use telecommunications as a substitute for physical meetings), …

Traffic signal control is a measure which favours bus flows at traffic lights crossroads by, for example, giving to buses longer green lights than to cars. This measure is especially used to restrain car use and increase public transport modal split in urban areas.

1

INTRODUCTION

1.1. CONTEXT OF THE RESEARCH

1.2. GOAL OF THE RESEARCH

1.3. RESEARCH QUESTIONS

1.4. RESEARCH METHODOLOGY

1.5. RESEARCH STRUCTURE

1.1. CONTEXT OF THE RESEARCH

Cities are nowadays facing increasing problems such as congestion, air and noise pollutions, degradation of urban life quality, ... due to the rising use of cars. In the developed countries as well as in the developing ones, the car dependency is growing. Cities all over the world are thus confronted to a big challenge : dealing with their congestion problems as well as limiting the environmental pollutions.

To understand the current problematic situation known by the majority of urban areas regarding transportation issues, it is necessary to understand the evolution that have known the transport planning practices during the last five decades. The end of the Second World War stood out the beginning of the automobile era. Consequently to the success that met the car industry, new infrastructures and parking facilities were needed to satisfy the increasing demand for personal mobility. The large amount of new infrastructures which were build during the 1950s and 1960s, particularly the construction of main roads and boulevards, have drawn the urban structure that cities still have nowadays. This period was characterized by the car ownership primacy as well as by a logical decline of public transport use. Two decades ago, this traditional **"demand-led" transport paradigm** was not considered as an appropriate solution anymore. This one was hard to justify economically, socially and environmentally. It was thus necessary to find another solution to the endless building of new infrastructures, a more sustainable one. In this context, in the late 1980s transport planning process knew a paradigm shift from the extension of roads capacity towards the management of the travel demand, also known under the name **"management-led" transport paradigm.** Since this period, the key word of transport planning became the management of the existing infrastructures and networks. In practice, that means that governments (national, regional, local authorities) had and still have to find appropriate solutions to solve, or at least limit, transportation problems according to the specific conditions of each urban area. In this task, numerous instruments aiming to manage the travel demand were developed and implemented, and have led to more or less good results. The set of possible tools in this field is really rich and continues to grow.

In the Netherlands, this paradigm shift from demand-led to management-led transport planning happened at the end of the 1980s with the publication of the Tweede Structuurschema Verkeer en Vervoer (SVV II). Indeed, until the publication of this document, the previous policy documents on transportation were supply-oriented, and largely favoured the construction of, and planning for, new infrastructures. In contrast, the SVV II policy document, published in 1988, aimed at avoiding mobility growth by forcing as many citizens as possible into public transport (to avoid kilometres travelled by car). In this goal, a broad package of measures was formulated, including "push" and "pull" measures such as road pricing, improvement of public transport, promoting cycling and mobility management. The package also included a restrictive land-use policy, the so-called ABC-policy. "With this visionary national policy document, The Netherlands positioned itself as a European front-runner with regard to transport demand management" (ECOMM, 2007). This trend was pursued until 2000 when a new contrasting transport policy was published, the "Nationaal Verkeers- en Vervoersplan" (NVVP). This document acknowledges that the Dutch government has failed in his task to reduce mobility. Moreover, since this year, mobility is not seen anymore as something that we have to reduce imperatively but, on the contrary, as something that we have to promote. The core message of this policy is the focus on the needs of the citizen to be mobile. So, the NVVP embraces mobility as a social need. Its main objective is to accommodate travel needs in an accurate manner, having a more neutral attitude towards the different transport modes (i.e. favouring not only public transport trips but also car trips when this mode is more appropriate). In this task, the National Government has a more modest role in meeting of transport needs. Its mission is mainly to provide sufficient infrastructures (by favouring a more efficient use of existing infrastructures, or in some extreme cases, by building new infrastructures) while minimizing as much as possible the adverse effects of transport (NVVP, 2001). Mobility was thus fun again ! Then, the most recent policy document (Nota Mobiliteit, 2004) modifies a little bit this message by stating that mobility is an (economic) must that has to be facilitated, but not always and not in an unlimited way (Bouwman and Linden in Linden and Voogd, 2004, p.282).

Besides this broad national paradigm shift, the local authorities of the city of **Groningen** have decided to follow another evolution. So, in the 1950s and 1960s the right-of-way principles[1] had dominated transport policy and planning in Groningen (as in many other European cities). The spatial planning of that time aimed at increasing the private-car capacities of the inner city considerably and at deconcentrating the urban functions of the inner city (Bratzel, 1998, p.185). However, the city has known a radical transport shift through the 1970s. Indeed, around 1970 a significant change occurred in the perception of the role of transport in Groningen. Students and young left-wing local politicians rejected the 1969 master plan for demolishing buildings and extending the capacity of road infrastructure in the city. New discourses on transport issues emerged. Since that time, the city has experimented a shift from given the priority to roads construction to the integration of environmental considerations into transport policy and planning. This integration was materialized through the implementation of two new policies. The first influential policy was published in 1972, when the local left-wing government decided to put more emphasis on the environmental quality and on the quality of life in the city centre, e.g. through lower acceptance levels of noise and air pollution and through improved conditions for pedestrians. The next significant change, and probably the most widely known, came in 1977 with the implementation of the Traffic Circulation Plan. This plan resulted in an extensive restructuring of traffic in the inner city. Its two main consequences were a significant decrease of the number of cars in the inner city, and a rapid increased of the use of public transport and softer modes of transport (walking and bicycling). These two early main changes were quite revolutionary for that time. They have, without any doubt, played the biggest role in the improvement of the liveability and mobility in the inner city. Presently the city is often designated as one of the best example of the compact-bike city, with a great percentage of trips made by bike and enjoying of a great bike network. In this respect, the city has been recognised as being a pioneer in the development of sustainable transport policy (Hansen C., 2005, p.4). However, despite this drastic improvement of the mobility in the inner city, the city experiences growing congestion and pollution problems on its ring. This is due to the fact that the city represents a big concentration of jobs and services that attracts a growing part of people from the North Netherlands. Actually, half of the people who work in Groningen live in the outskirts of the city or in the regional area (Kramer, 2003, p.1). Since the major flows of commuters are coming from outside the municipal boundaries, the solution to this problem has a more regional dimension. This asks for a wider vision of mobility issue and for an inter-municipal coordination. In that perspective, the national government has designated 6 urban networks to form the so-called “nationaal stedelijk netwerk” (VROM, Nota Ruimte 2006). The region Groningen-Assen is one of these 6 networks.

[1] Here, the ‘right-of-way’ principle is used as a phrase to describe, what seemed to be the ruling philosophy of the 1960s in particular, that new roads through cities and towns had priority, and a right, over the maintenance of old buildings and neighbourhoods (Hansen, 2005, p.4)

In **Belgium**, like in the Netherlands, large infrastructure works were conducted in the post War period. These works were particularly of a large extent in Belgium, which led the country to develop one of the densest road network in the world (14,5 km. per 1 000 inhabitants in Belgium in comparison to 10 km. per 1 000 inhabitants for the European average[1]). This period was characterised not only by the building of the main highways junctions between cities but also by the construction of the so called "urban highways" penetrating up to the urban densely populated areas. These urban expressways have radically changed the environment and the structure of many Belgian cities. These large-scaled works ended in the mid of the 1980s. Then, in 1989 the regionalisation of public works and transport led to a drastic diminution of the public budget for road infrastructures. Rather logically, this budgetary reduction has made impossible the building of new infrastructures, the maintenance of the existing roads being made even sometimes problematic. At the municipal level, the actions led by the local governments came down during a long time mostly to maximise the space available for cars and transport in general, as an answer of the rising demand for travel, without paying lots of attention to the urban quality of life. In Wallonia, this trend is challenged since 1998, when the regional government edited its "charte de mobilité communale" (municipal mobility charter) (Région Wallonne, 1998). In response to the rising pollution and congestion problems that knows the majority of the Walloon cities, "the public authorities try henceforth to adapt the development of the road infrastructures by dealing with the flows into a more strategic way and better adapted to the needs. The objective is to assure the efficacy and efficiency of all transport modes as well as of the future economic development while respecting the environment. [In practice, that means that the Walloon Region] induces municipalities and the bus public transport company (TEC group) to undertake actions together, through concrete projects, to improve the mobility of the citizens and the exploitations conditions of the public transport. […] The Walloon region commits itself to financially and technically help the municipalities which would carry out a transport study aiming at the improvement of its mobility management, [in other words, the preparation of Plan Communal de Mobilité – PCM (municipal mobility plan)" (Charte de mobilité communale, 1998).

Consequently, the city of **Liege**, like many other Walloon cities, implemented its own PCM in 2004. The key principles laid down in this mobility plan find their origins into the "Plan de Déplacement et de Stationnement - PDS" (Displacement and Parking Plan) which was published in 1999. At that time, the local authorities of Liege started to become aware to the rising mobility problems that appeared in the city. This plan was therefore commissioned to find solutions that could improve the mobility, and thus also the life quality, in the city. The proposed strategy rests on the development of a multimodal concept. Indeed, this plan acknowledged already 10 years ago the need to vary the transport supply in the city by providing other attractive alternatives to car users (i.e. to improve the quality of public transport services and to favour the use softer transport modes). Moreover, the PCM of Liege is largely integrated into the strategic vision for the development of the city, namely the "projet de ville 2007-2015" (city project). But, despites this plan, the city of Liege is nowadays facing important congestion problems (fig.1.1) and other related difficulties (air and noise pollutions, safety problems, flight of the citizens from central areas to the uncongested rural areas, …). To deal with these problems, it is primordial that the local government reacts by implementing appropriate measures. Within this perspective, the main idea of this thesis is to "steal" some of the successful transport measures which were implemented in the city of Groningen and to adapt and transfer them into the Liege context.

[1] Le Soir, « Priorité à la route : stop ou encore ? » 03/05/2008

Fig.1.1. Congestion problems in the city of Liege

Source : MET, 2001, p.11, drawn by Pierre Kroll

1.2. GOAL OF THE RESEARCH

The ultimate goal of this study is a proposal to transfer Travel Demand Management measures from Groningen to Liege with the objective of highlighting new possible alternatives which would improve the mobility in this latest city.

This goal can be subdivided into three steps :

1. **Analysis of the transport network of Liege and Groningen** : In a first time, a general description of the physical, socio-economic, institutional and policy context within which evolve both cities is provided. Then, this contextual presentation will serve as background information in the analysis of the transport network of both cities. This analysis is carried out in three times : (1) a description of the urban structure of both cities, (2) a transport supply analysis, and (3) a travel demand analysis.
2. **Evaluation of the Travel Demand Management (TDM) measures implemented in both studied cities and classification of their transport system** : In a second time, the TDM measures which are implemented in both cities will be listed and evaluated (in terms of the impacts they have on the actual transport system). Then, on the basis of the set of TDM measures that each city has chosen to develop, their transport system will be classified according to five contrasting transport planning approaches.
3. **Transfer possibilities of TDM measures from Groningen to Liege** : Finally, on the basis of the previous results, the expected outcome is a list of TDM measures which are in application (or are planned) in Groningen and which could be transferred and adapted to the Liege context to improve its current transport system.

1.3. RESEARCH QUESTIONS

To attain the goal described above, the study will answer the following research questions :

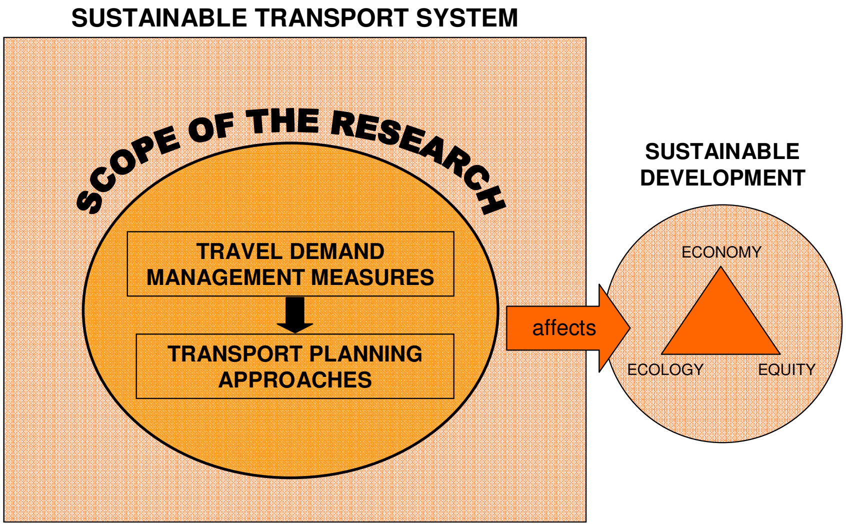
- What is a Sustainable Transport System ? And what is the importance of the Travel Demand Management in the achievement of such a system ?
- On the basis of a transport network analysis, what are the main characteristics (strengths and weaknesses) of the transport network of Liege and Groningen?
- What is the role played by the Travel Demand Management in the transport policy of each studied city ? To which extent the concept of Travel Demand Management is integrated into the daily transport planning practices of the cities ?
- How can we classify the transport system of both cities, on the basis of the set of TDM measures that each city has chosen to develop ?
- Which lessons can be learned from Groningen to improve the transport system of Liege, taking into account the similarities and differences which exist between the two cities as well as the characteristics of the Liege transport system ?

1.4. RESEARCH METHODOLOGY

SCOPE OF THE RESEARCH

According to the time and the means assigned to carry out this master thesis, it would have been impossible to study the complete transportation system of both cities. Indeed, although the concept of "Sustainable Transport System" is briefly tackled in this study (point 2.6.1), the fuzzy and *fourre-tout* nature of this concept, the numerous components that this concept comprises, and the strong interrelations that transport owns with other planning fields makes its total analysis impossible. For this reason, this work does not seek to deal with all the dimensions of the complex sustainable spectrum. Rather, the scope of the study is restrained to the evaluation of the Travel Demand Management measures implemented in both studied cities ; the management of the travel demand being nowadays the most important component to achieve a sustainable system of transport (fig.1.2).

Fig.1.2. Scope of the research



Author : C. Maloir

However, it is really important to keep in mind that this study, due to its scope limitation, only focuses on one component of the broad urban transport system, namely the management of the demand to travel. To be efficient, the results of this thesis have to be coordinated to other actions (e.g. environmental protection, social equity, health issues, …) and integrated into a more global strategic vision.

CHOICE OF THE STUDIED CITIES AND TRANSFER DIRECTION

The choice to study the cities of Liege and Groningen was motivated by various reasons.

The **first one** lies in the similarities shared by the two cities. In fact, two main factors are comparable between Liege and Groningen : the number of inhabitant living in the municipalities and the social and economic functions that are present in both cities (e.g. university city and many high schools, scientific and high technology poles, various cultural activities, …).

The **second reason** that has favoured the choice of Liege and Groningen is linked to the "maturity degree" of their respective transport system. So, while the concept of Travel Demand Management is still in its beginnings in Liege, the long-lasting experience of Groningen in this field makes interesting the transfer of practices between the two cities. Moreover, mobility issue was recently acknowledged by the local population and authorities of Liege as a priority to be dealt with. Therefore, solutions are looked for to effectively improve the transport system of the city. This changing context is thus highly favourable to new innovative ideas.

A **third reason** that has justified the choice of these two cities lies in the fact that the city of Liege is about to develop a new tram line, a public bike system, and park-and-ride facilities ; elements that already exist (or are planned) in Groningen. The experience of Groningen in regard to these projects could thus be of precious help to increase the success chances of the Liege projects.

Finally, the **last reason** that has played a role into the choice is personal. Indeed, the fact that I commuted first, and lived then in Liege has considerably helped me to understand the transport problems that the city is currently facing, as well as the causes of these problems. Identically, I live in Groningen for one year what allows me to better understand the transport system mechanisms of the city. Finally, the fact that I lived and studied in both cities allows me to meet more easily the local planners to discuss of transportation issues.

From what was stated above, it is logical that the transfer that will be proposed in this thesis will be limited to one direction, from Groningen to Liege.

RESEARCH DATA

In order to achieve the objectives set above, several data sources were needed.

Firstly, the data concerning the theoretical framework were collected through the literature review of several reference books and in articles of scientific journals.

Secondly, to conduct the two case studies, the data needed consist for their main part of secondary data that have been gathered around throughout this study.

Case study of Liege :	Case study of Groningen :
- The data used to describe the socio-economic context of the municipality of Liege were found for their major part in the demographic statistical yearbook 2007 of the city and in its “projet de ville 2007-2015” (city project). - The data concerning the transport system analysis and the transport projects of the city were largely found in the “Plan de Déplacement et de Stationnement de Liège” (Displacement and Parking Plan) published in 1999 and in the “Plan communal de Mobilitié” (municipal mobility plan) published in 2004.	- The data concerning the socio-economic context of the city were mostly found in the statistical yearbook 2007 of the Municipality. - The information concerning the transport system of Groningen and future transport projects were largely found in the municipal mobility plan “stad in beweging 2007-2010”, in the document “traffic and transport policy for the city of Groningen (progressive)” published in 2006 by the municipality for the occasion of the ECOMM conference (European Conference on Mobility Management), and in the Regiotram project public in May 2008.

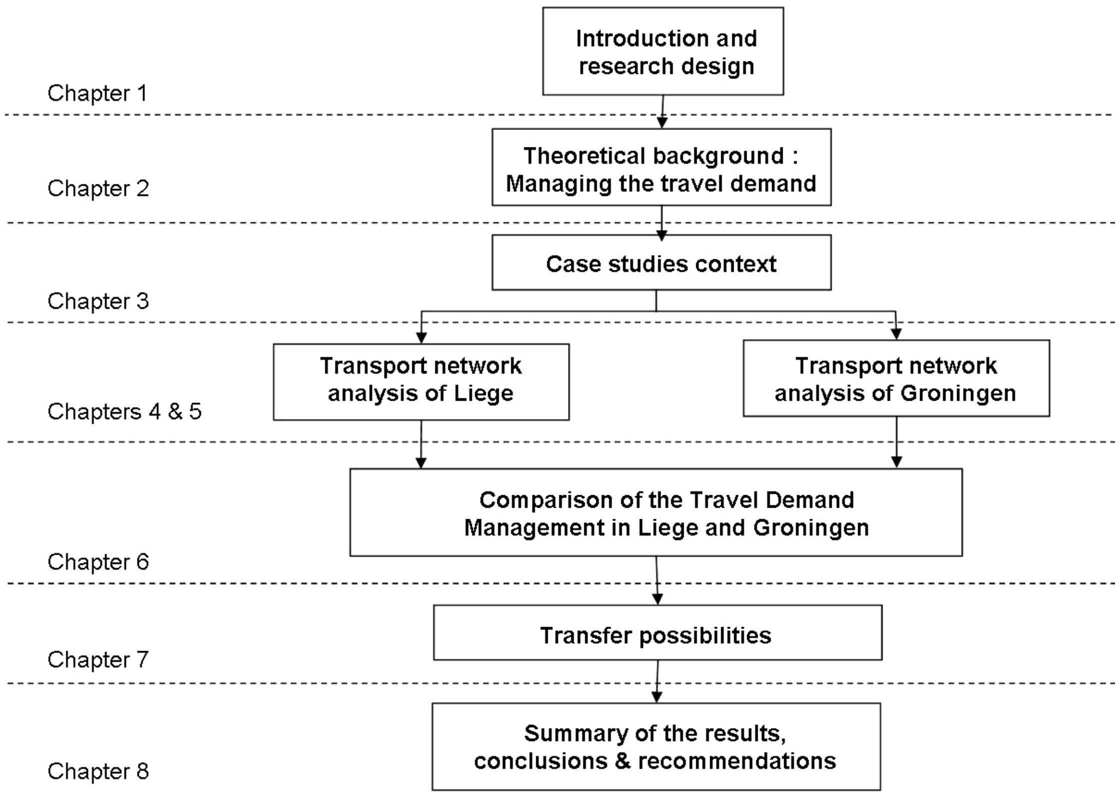
Moreover, some interviews were conducted in both cities to complete and/or precise the information provided by the secondary data. These interviews consisted of semi-structured questionnaires which were submitted to different actors directly concerned by transportation issues in the two studied cities (i.e. urban mobility advisors, transport project managers, …)

1.5. Research Structure

This study is composed of eight chapters which are described as follow (fig.1.3) :

1. **Introduction** : general idea of the research including the context within which the research is implemented, the goal of the research as well as the research questions to which the study has to answer, and the methodology which is followed to conduct the study.
2. **Theoretical framework** : description of the evolution that the transport planning practices have experimented throughout these last decades, focusing on the shift from the “demand-led” towards the “management-led” transport paradigm. The measures implemented to manage the demand to travel are at the core of the research. This first chapter sets the framework within which the practical comparison study will fall.
3. **Case studies context** : general description of the physical, socio-economic, institutional and policy context of the city of Liege and Groningen.
4. **Transport network analysis of Liege** : this analysis is carried out in three steps : (1) a description of the urban structure of the city, (2) an analysis of the transport supply, (3) an analysis of the travel demand. This analysis highlights the strengths and weaknesses of the transport system of Liege
5. **Transport network analysis of Groningen** : the same three-steps analysis than for the case of Liege is carried out.
6. **Travel Demand Management in Liege and Groningen** : firstly, the TDM measures which are in application in both cities are evaluated and compared. Then, on the basis of the set of TDM measures that each city has chosen to develop, the transport system of both cities is classified according to five contrasting transport planning approaches.
7. **Transfer possibilities of TDM measures from Groningen to Liege** : On the basis of the previous results, the expected outcome of this chapter is a list of TDM measures that are in application in Groningen and that could be transferred and adapted to the Liege context to improve its transport system.
8. **Conclusions and recommendations** : Finally, this last chapter summarises the results which were obtained all along this research, relates these results to the research questions asked in the introductory chapter and provides some recommendations for the future actions.

Fig.1.3. Research structure



2

MANAGING THE TRAVEL DEMAND, AN IMPORTANT COMPONENT OF A SUSTAINABLE TRANSPORT SYSTEM

2.1. INTRODUCTION

This first chapter sets the framework within which the practical comparison study will fall. In fact, the goal of this chapter is to describe the evolution that the transport planning practices have experimented throughout these last decades, focusing on the shift from the “demand-led” towards the “management-led” transport paradigm.

Since the 1950s, the amount of people living in cities has continuously increased. As a consequence, cities have rapidly developed. The ongoing growing urban extension and the associated rising demand to travel have required the development of new transport infrastructures. The apparition of the automobile and the freedom that it procures to drivers have played a crucial role in the rise of mobility needs. The large-scale works that were conducted at that time to satisfy travel needs have largely influenced the current spatial structure of cities. The planning practices that prevailed at that time were dominated by the classic four stages model, which called most of the time for an expansion of roads capacity.

This ‘predict and accommodate’ model dominated the planning decisions until the 1980s. Then, its credibility collapsed. Its incapacity to satisfy increasing mobility demand and to preserve the environment and public health has obliged the policy-makers to develop new, more sustainable solutions.

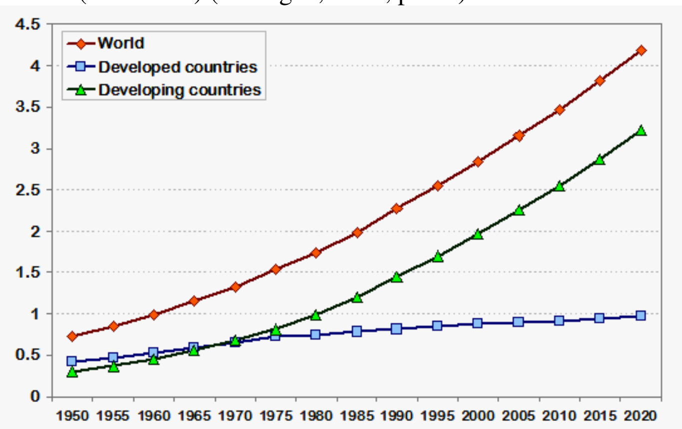
It is in this context that the concept of Travel Demand Management is born. The goal of the planning practices associated to this new transport paradigm is to make change travel behavior in order to increase transport system efficiency. In that respect, the use of alternative transport modes is largely favored, while car use is not forbidden but limited to certain trips (e.g. rural areas badly served by public transport). The measures implemented to manage the demand to travel are at the core of this research.

2.2. URBANIZATION AND URBAN FORMS

The amount of people living in cities has continuously increased since the 1950s. The global urban population has more than tripled between 1950 and 2005, to reach 3.15 billion of inhabitants (fig.2.1), and this **wave of urbanization** is only at the beginning of its expansion.

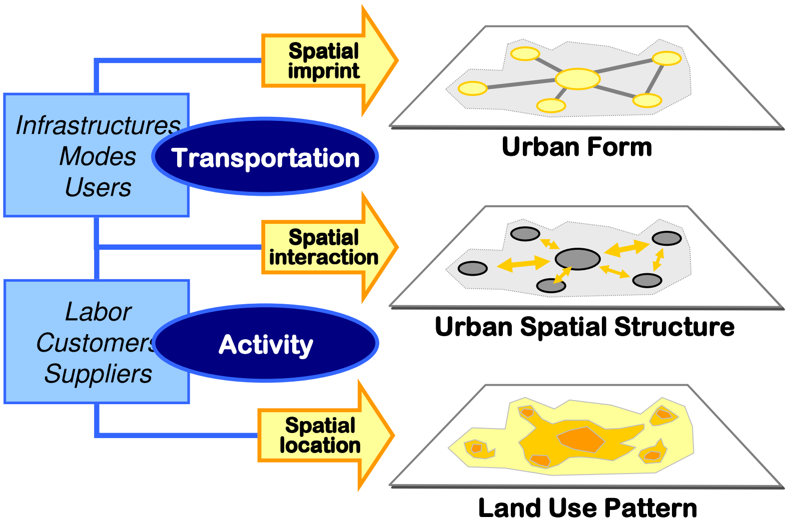
Indeed, although the population is still growing in cities of developed countries, this rate is quite low compared to the urban development known by cities of developing countries. The urban population of these countries will account for 93% of a 2 billion increase in the global urban population between 2000 and 2030 (Rodrigue, 2006, p.171).

Fig.2.1. World Urban Population, 1950-2005 with Projections to 2020 (in billions) (Rodrigue, 2006, p.171)



As a consequence of the urbanisation phenomenon, cities are facing an increasing development of new activities (housing, commercial and industrial) and of transportation infrastructures. These two components of the urban environment are closely linked : transportation infrastructures support accessibility and mobility demands of population of new developed areas (demand side) and, on the other hand, they also guide the development supply by creating new accessible areas (supply side) (Berke and al., 2006, p.228) (fig.2.2). Consequently, a good coordination between land use and transport planning is an indispensable condition to develop well-served urbanised areas and efficient urban transport systems.

Fig.2.2. Relation between transportation, activities locations and urban spatial structure



Source : Rodrigue, 2006, p.172

However, notwithstanding the importance that have land use and transport planning on the spatial structure of cities, several other variables also deeply influence urban structure. So, the spatial structure of each urban area is characterised by its land use patterns, its transport network, but also by a complex and unique combination of the other geographical, historical, social and economic factors.

Despite this complexity, many planners and geographers have developed models and conceptual frameworks that describe the major forms and structures of cities. One of these models consists in classifying the diverse **spatial structures** that present cities into four categories (fig.2.3). This classification is based on their level of "automobilisation", which is the most discriminatory factor.

Type 1 - Completely motorized network : "These cities are characterized by low to average land use densities, this automobile-oriented city assumes free movements between all locations. Public transit has a residual function while a significant share of the city is occupied by structures servicing the automobile, notably highways and large parking lots. Most activities are designed to be accessed with an automobile. This type of urban structure requires a massive network of high capacity highways to the point that urban efficiency is based on individual transportation. Secondary road converges at highways, along which small centres are located, notably nearby interchanges. This system characterizes recent cities in a North American context where urban growth occurred in the second half of the twentieth century, such as Los Angeles, Phoenix, Denver and Dallas".

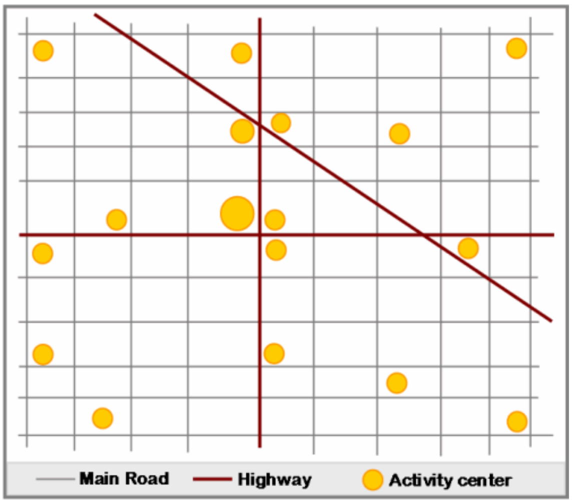
Type 2 - Weak centre : "these cities are characterized by average land use densities and a concentric pattern. The central business district is relatively accessible by the automobile and is the point of convergence of the transit system, which tend to be under-used and requiring subsidies. The urban area cannot be cost effectively serviced with the transit system, so services are often oriented along major corridors. In many cases, ring roads favoured the emergence a set of small centres at the periphery, notably at the convergence of radial lines, some of them effectively competing with the central business district for the location of economic activities. This system is often related to older cities, which emerged in the first half of the twentieth century, such as Melbourne, San Francisco, Boston, Chicago and Montreal, and were afterwards substantially impacted by motorization".

Type 3 - Strong centre : "the cities having a high land use density and high levels of accessibility to urban transit. There are thus limited needs for highways and parking space in the central area, where a set of high capacity public transit lines are servicing most of the mobility needs. The productivity of this urban area is thus mainly related to the efficiency of the public transport system. The convergence of radial roads and ring roads favours the location of secondary centres, where activities that could no longer able to afford a central location converge. This system characterizes cities having important commercial and financial functions and having grown in the 19th century, such as Paris, New York, Shanghai, Toronto, Sydney and Hamburg".

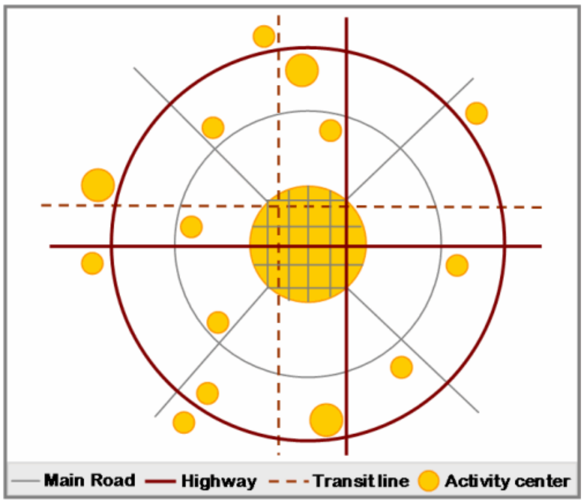
Type 4 - Traffic limitation : "the urban areas that have efficiently implemented traffic control and modal preference in their spatial structure. Commonly, the central area is dominated by public transit. They have a high land use density and were planned to limit the usage of the automobile in central areas for a variety of reasons, such as to preserve its historical character or to avoid congestion. Through a "funnel" effect, the capacity of the road transport system is reduced the closer one gets to the central area. Public transit is used in central areas, while individual transportation takes a greater importance in the periphery. […] Several cities are implementing this strategy, namely through congestion pricing, as it keeps cars from the central areas while supporting the bulk of the mobility in the suburbs. This system typifies cities having a long planning history favouring public transit, particularly in socialist economies. London, Singapore, Hong Kong, Vienna and Stockholm are good examples of this urban transport structure" (Rodrigue, 2006, p.177-178).

Fig.2.3. Four main types of urban spatial structures

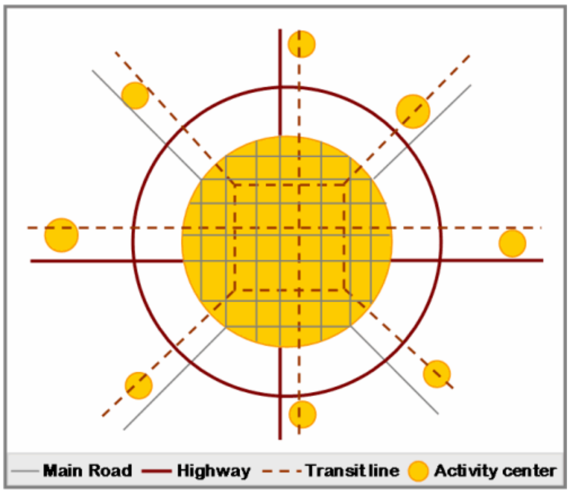
Type I - Completely Motorized Network



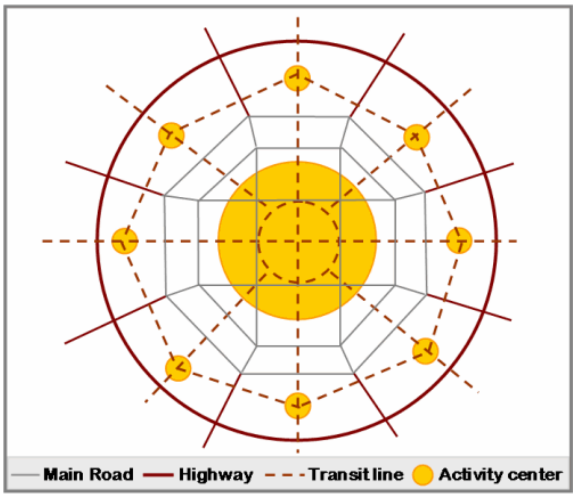
Type II - Weak Center



Type III - Strong Center



Type IV - Traffic Limitation



Source : Rodrigue, 2006, p.178

This classification of urban spatial structures will be used to characterize the transport system of Liege and Groningen (chapters 4 and 5). Indeed, according to the organisation of their own urban transport networks, the transport system of each city shares a more or less large number of similarities with these four urban structure models.

2.3. TRANSPORTATION NETWORK AND TRANSPORTATION IMPRINT

Before going further in this work, it is important to firstly clarify a few key concepts that will be used later on in the following chapters : transport network, transport system, transport supply and transport demand. Networks, systems, supply and demand are terms that are widely used in many fields of study, such as economy, finance, geography, etc. This allows many fundamental economic theories to be applied in the transportation field.

A **transportation network** consists of all the individual transport infrastructures which exist in a determined area. Any transport network is constituted of two types of elements: a set of points (or nodes) and a set of line segments (or arcs) connecting these points (Sheffi, 1985). Usually, an analysis of a transport network contains two fundamental constituents : the transport supply analysis and the transport demand analysis.

A **transport(ation) system** has a broader meaning than a transportation network. This term includes not only the physical (road and rail) network, but also other system components such as stations and vehicles or else traveller information and services organisation. Both the journey itself and the pre-trip planning take place within a transport system (Rodrigue, 2006).

The **transport supply** is the expression of the capacity of transportation infrastructures and modes, generally over a geographically defined transport system and for a specific period of time. Therefore, supply is expressed in terms of infrastructures (capacity), services (frequency) and network forms. The number of passengers, volume (for liquids or containerized traffic), or mass (for freight) that can be transported per unit of time and space is commonly used to quantify transport supply (Rodrigue, 2006).

The **transport demand** (or travel demand) is the expression of the transport needs. Similarly to transport supply, it is expressed in terms of number of people, volume, or tons per unit of time and space. A distinction must be made concerning the potential and realized transport demand. While the first one would be the amount of traffic if transport costs were negligible, the realized demand is a subset of the potential transport demand since it corresponds to the traffic that actually takes place, namely in view of costs (money and time) between the origins and the destinations (Rodrigue, 2006).

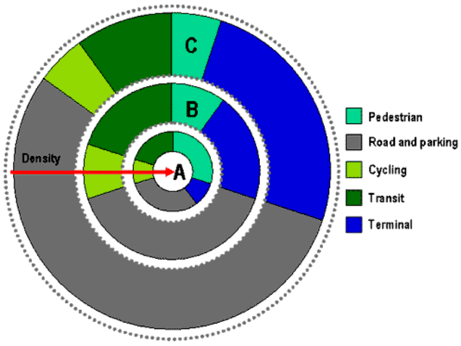
These two latest elements, in accord with the conventional economic theory, are interrelated and continually changing towards an equilibrium. This one is reached when the quantity of transportation the market is willing to use at a given price and the quantity being supplied for that price level are equal. However, several factors, specific to the transport field, conplexify this simplistic relationship. Usually, transport demand varies in time and space while transport supply is fixed. Therefore, in the case of a demand lower than the supply, transit times are stable and predictable, since the supply is able to satisfy the demand. On the other hand, when transport demand is higher than the supply, congestion problems appear and are combined to significant augmentation in transit times and higher unpredictability level.

These concepts will be used to perform the analysis of the transport network of Liege (chapter 4) and the one of Groningen (chapter 5).

In parallel to the physical extension faced by urban areas, the **spatial imprint of urban transportation network** is also growing according to the increasing mobility needs within and around cities. Indeed, as J.P. Rodrigue (2006, p.176) has developed in his book “the geography of transport systems” : “The amount of urban land allocated to transportation is often correlated with the level of mobility. In the pre-automobile era, about 10% of the urban land was devoted to transportation which were simply roads for a traffic that was dominantly pedestrian. As the mobility of people and freight increased, a growing share of urban areas is allocated to transport and the infrastructures supporting it. Large variations in the spatial imprint of urban transportation are observed between different cities as well as between different parts of a city, such as between central and peripheral areas.” Similar variations can also be observed between continents. The consumption of space by road infrastructure is of about 30% in the United States, between 15% and 20% in Western Europe (depending of countries), while this figure only reaches 10% on average in the developing countries (e.g. 6 % on average for Chinese cities) (Servant, 1996, in Camagni, 2002, p.203 and Rodrigue, 2006, p.177).

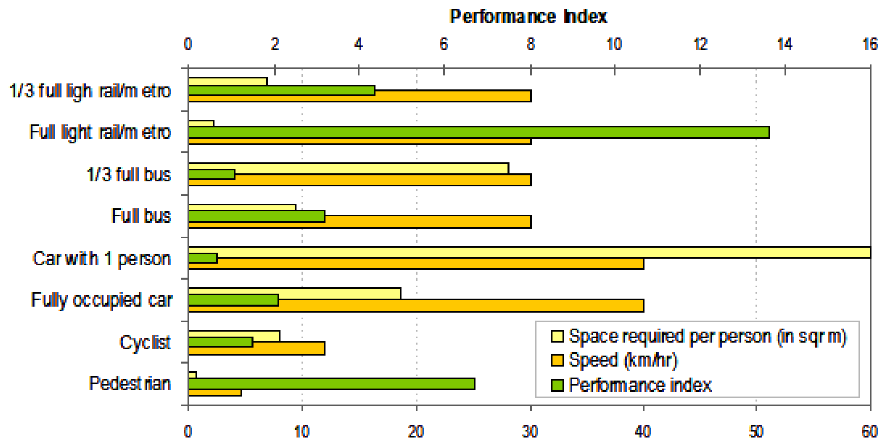
These variations in the spatial imprint of urban transportation network can be better understood by subdividing the total spatial imprint according to the different modes of transportation. The spatial extension of every transport mode varies according to a number of factors. The most important factor is the density (fig.2.4) since it dictates the spatial extension of each transport mode for every virtual “density ring” around the central area.

Fig.2.4. Rings of density and associated modal spatial importance (Rodrigue, 2006)



Further, each transport mode has unique performance and space consumption characteristics (fig.2.5). The most relevant example is the automobile, which consumes on average 10 times more space than public transport. This extensive requirement for space is largely explained by the space required for parking (98% of the car life!). Consequently, a significant amount of urban space must be allocated to accommodate the automobile, especially when it does not move and is thus economically and socially useless. The city of Los Angeles is often used as a good (or bad) example of car oriented city since 70% of the land use is reserved to the automobile ! Consequently, Los Angeles is one of the most car oriented city in the world.

Fig.2.5. Performance of Urban Transport Modes



Source: data from R. Tolley and B. Turton (1995) Transport Systems, Policy and Planning, New York: Longman, p. 184. in Rodrigue, 2006

2.4. URBAN MOBILITY AND TRAVEL BEHAVIOUR

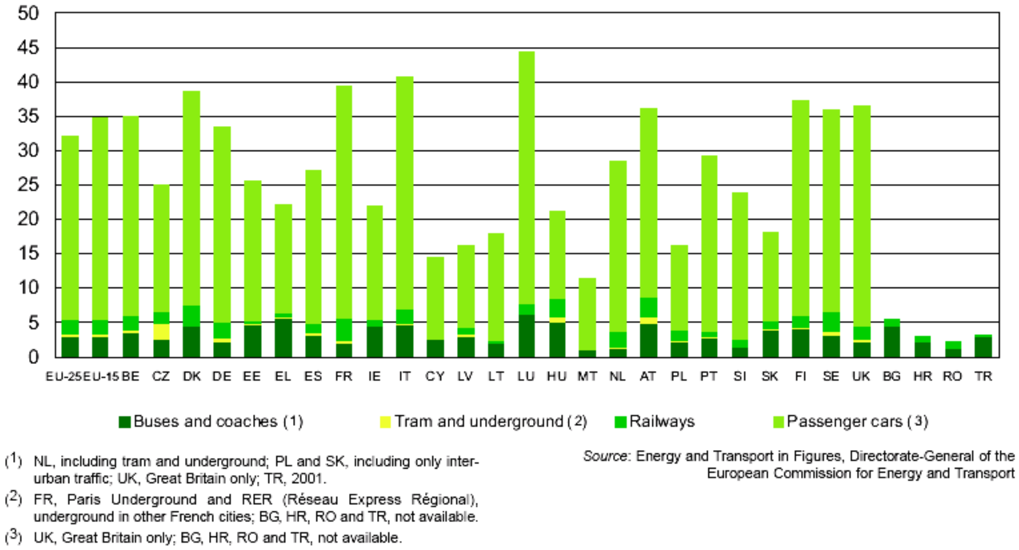
The rapid urban development that have known cities all over the world implies increased quantities of passengers and freight moving within urban areas. During the same period, the technologic improvements that has known transportation field have allowed faster movements. However, rather than using this speeding up of vehicles to diminish the travel time, people have preferred travel further. Consequently, the current travel time has remained the same than at the beginning of the 20^{th} century, approximately 1,2 hours per day, whereas the covered distance has been lengthened (Banister, 2006; Deakin, 2006; Duranton, 2006; Kahn, 2006 in Banister, 2008, p.79). In fact, the daily distance travelled on average by an European citizen (from the EU-15) increased from 16,5 km to 35 km between 1970 and 1996 (Ubbels and al., 2004, p.10).

The evolution of **urban mobility** can be subdivided into three main phases. These phases are associated to the three general eras of development that have experimented the cities of developed countries : the walking/horse era from approximately 1800s to 1890s, the transit era from 1890s to 1920s and the automobile era since the 1920s and which still dominates nowadays majority of cities. The entrance in this last era has had a determinant role on the present shape and extension of cities. Only a short time after the diffusion and commercialisation of automobile, this mode of transport dominated all the other ones. A mark of this domination was the general disappearance of tram lines from urban areas in the 1960s. The freedom and flexibility that cars procured to people allowed them to go living in less densely populated areas, the fringe of the city. That was the start of the urban sprawl phenomenon. This new way of life was responsible of the decline of public transport, cycling and walking. Indeed, while public transport was not capable anymore to serve efficiently these lowest density areas, the rise of distances to cover have made impossible a large amount of trips which were made by bike or on foot (Banister, 2008, p.79).

A recent study entitled “Consumers in Europe - Facts and figures” published in 2007 by Eurostat has brought to the fore two major trends that characterize the whole evolution of the

European **travel behaviour**. Firstly, "the total passenger transport demand keeps on growing : in 1995, 5 034 billion passenger-kilometres were performed by the various transport modes. Five years later, this figure stood at over 5 600 billion and in 2003 at 5 828 billion" (Eurostat, 2007, p.12). Secondly, in addition to the increasing demand for travel, it has also been observed that there is a large modal slip disequilibrium between the different transport modes. So, while each European travelled on average 11 730 kilometres along the year 2003 (excluding air and sea trips), more than 75 % of this distance were covered by car ! The car is largely the most widely-used mode of transport in every Member State (fig.2.6).

Fig.2.6. Average daily distance travelled per inhabitants in the EU (in kilometres/day) in 2003 (Eurostat, 2007, p.14).



In reaction to these transport changes that negatively impact the quality of life and the mobility in urban areas, actions and measures which dissuade car use and which make increase the attractiveness of the other environmentally friendly modes of transport (i.e. public transport but also bicycle and walk) must be undertaken. Certain of these measures are developed in more details throughout the chapters 2 and 6.

2.5. URBAN TRANSPORT PROBLEMS

As Joe Ravetz wrote in his book 'City Region 2020' : "mobility is the basis for modern lifestyles, and transport is the 'maker or breaker' of cities. But the transport system is also breaking local and global limits, and future trends are set to bring the system itself to a halt" (2000, p.87). Indeed, the extension of the transport systems has today achieved its limits. Transport systems are not capable anymore to satisfy the growing mobility requirements. Consequently, the advantages brought by the car ownership and the high mobility of goods and people are now counterbalanced by the **apparition of new[1] urban problems**.

[1] All the transport problems that cities presently know are not new ones. Some of these problems are ancient (e.g. congestion in Mediterranean cities like in Roma or Athena). Nowadays, urban areas are thus facing a worsening of their old transport problems and to apparition of new ones linked for the largest part to the car ownerships and the associated new way of life it has favoured.

The most notable urban transport problems are pointed by J.P. Rodrigue in his book 'the geography of transport systems' (2006, p.191). They can be summarized as follow :

Transport problems	Causes
Traffic congestion and parking difficulties	Inadequacy between increasing transport infrastructure demand and limited supply Increasing demand for parking space has led to a problem of space consumption, particularly in central area
Public transport inadequacy	Demand fluctuation in time (peak hours) and in space (urban vs. rural areas) has led to either over or under used of public transport
Difficulties for pedestrians	Intense traffic has impaired the mobility of pedestrians and vehicles Lack of consideration for pedestrians in the physical design of facilities
Loss of public space and pubic activities	High traffic has impeded social interactions and street activities (such as markets, agoras, parades and processions) which disappeared or moved to shopping malls
Environmental impacts and energy dependency	Air and noise pollution generated by higher circulation has seriously impacted the quality of life and even the health of urban populations Rise of energy consumption by urban transportation has led to a higher dependency on petroleum, and thus on the countries who hold it
Accidents and safety	Growing traffic in urban areas is linked with a growing number of accidents and fatalities, and a growing feeling of insecurity to use the streets
Land consumption	Transportation infrastructure consume a large part of cities, and that is particularly true for the automobile
Freight distribution	Globalization and the materialization of the economy have produced growing quantities of freight moving within metropolitan areas, which diminishes the available infrastructure capacity for the other modes. Cities can establish logistics strategies to mitigate the variety of challenges faced by urban freight distribution.

Remark : This list does not classify the transport problems according to their importance. The nature and the extent of the transport problems depend logically of the specific local conditions of each urban area.

The table above highlights that urban transport problems are related to several dimensions. However, most of them are **linked with the dominance of the automobile**. This observation has been at the origin of numerous debates. Many scholars from diverse educational arenas (geographers, planners, sociologists, ...) have called into question the global impact of car use and car ownership. They have asked themselves about the advantages of the car-oriented cities which were the symbol of modernity and freedom since the 1950s, while nowadays these cities are facing huge problems.

Moreover, the dimension of the debates was widen to cover concerns like social equity, economic efficiency and environmental protection. These dimensions, forgotten (or avoided) in the past, will play a more and more determinant role into the decision making process.

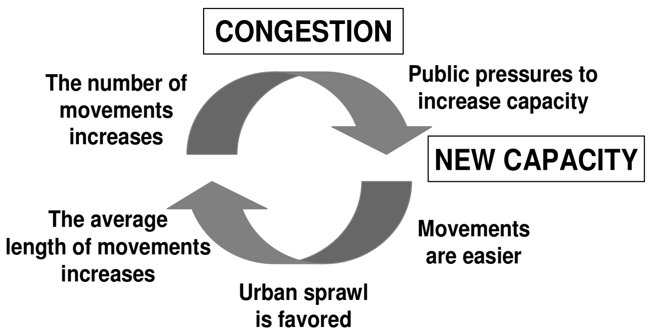
2.6. From the traditional 'demand-led' transport paradigm

The end of the Second World War was the beginning era of the largest car industry expansion. The new process of mass production, the technological innovations and the numerous advantages offered by car ownership explained the dramatic growth experienced by car industry in this period. In consequence, the demand for new roads also increased radically, in parallel to the growing car ownership. It was the **'gold era' of motorways constructions**. Highways were constructed, streets were enlarged, and parking lots were set, often disrupting the existing urban fabric. The present structure of cities is a direct heritage of this period. This time was dominated by traffic engineers who developed methods to objectively assess priorities in road building schemes. Years of practise and empirical analysis have resulted in the **classic four stage model**[1] (Bouwman and Linden in Linden and Voogd, 2004, p.184). This model provides a zone wise analysis of the trips followed by distribution of the trips, split the trips mode wise based on the choice of the travellers and finally assigns the trips to the network. This process contributes to understand the impacts of future transport networks developments on the traffic flows and trips as well as the influence that have people in terms of transport choices on the flows of the network (Mathew and Rao, 2007). "Since the most common prediction of the modelling is that present capacities will be unable to cope with traffic growth, the tendency has been to produce planning solutions that call for an expansion of capacity. This has been referred to as 'predict and accommodate'. It is the solution that has typified so much urban transport planning from the 1940s to the 1980s. It has given rise to the enormous expansion of highway construction that reinforces the dominance of the automobile" (Rodrigue, 2006, p.237).

Notwithstanding the success that knew this approach during the first decades following the Second War period, its credibility gradually collapsed in the late 1980s and 1990s. Two main factors explain its fading success.

Firstly, this strategy of creating new roads to compensate the lack of it is paradoxically the major responsible for congestion[2] problems in urban areas (fig.2.7). Indeed, instead of diminishing the traffic flows, offering new road capacity makes the displacements easier and thus favours new flows, which finally reinforces the congestion phenomenon and thus leads to an always increasing demand for new capacity.

Fig.2.7. The vicious circle of congestion
(Source : Rodrigue, 2006)



[1] The classical transport model is composed of four separate but interlinked sub-models, that together simulate the complex land-use interaction process. This process is used to estimate the number of trips (trip generation), to allocate these trips to particular destinations (trip distribution), to determine what transportation mode will be used in each of these trips (modal split), and to estimate the route that will be taken on the street network for each mode considered (traffic assignment). Although the fundamentals of this model are still valid in contemporary mainstream transportation modelling, the model process has received some considerable improvements which allow for example better forecasts for travel demand and for route choice (Bouwman and Linden in Linden and Voogd, 2004 ; Berk et al., 2006).

[2] Congestion occurs when transport demand exceeds transport supply in a specific section of the transport system. Under such circumstances, each vehicle impairs the mobility of others (Rodrigue, 2006, p.193).

The transport planning problems that faced the English government at the end of the 1980s is a good illustration of this congestion circle : "A series of studies indicated that Britain could not physically, economically or socially accommodate the 1989 Department of Transport forecasts of a 110% increase of traffic (Department of Transport, 1989). Even a road building programme of an inconceivable vastness would fail to stop congestion getting worse". (Ubbels, 2004, p.22). The vicious congestion circle can also be expressed in terms of mobility and accessibility. Where locations are viewed as fixed in space, each mobility gain is automatically translated into an accessibility improvement as both the costs per kilometre and the costs per destination are reduced. On the other hand, where mobility improvements induce the movement of destinations (i.e. to a more remote location or a location accessible solely by car), mobility gains can be translated into accessibility losses, which is an undesirable transport policy outcome. Enhanced mobility is valued in policy terms only to the extent that this increases accessibility over the long term (Levine and Garb, 2002, p.180).

Moreover, in addition to this impossibility of satisfying the predicted demand, a **second crucial factor** occurred : the growing awareness of motorised traffic's global environmental impacts, and the negative effects that it implies on public health. Transport systems are responsible for 23% of energy-related greenhouse gas emissions, and are increasing at a faster rate than any other energy using sector (Intergovernmental Panel on Climate Change, 2007). The rising mobility is also linked to a range of health problems including poor urban air quality, road injuries and fatalities, and reduced physical activity. The World Health Organization released a Charter on Transport, Environment and Health in 2003, and stated that "we are concerned that current patterns of transport, which are dominated by motorized road transport, have substantial adverse impacts on health". These environmental and societal considerations have been a key driving force in the transport policy debate.

The failure of 'demand-led' transport approach to satisfy increasing demand for mobility and to preserve the environment and the public health has obliged the policy-makers to develop new better-adapted solutions. This is in this context that the concepts of Sustainable Transport System and Travel Demand Management were born.

2.7. ... TOWARDS THE 'MANAGEMENT-LED' TRANSPORT PARADIGM

2.7.1. SUSTAINABILITY, SUSTAINABLE TRANSPORT SYSTEM AND SUSTAINABLE TRANSPORT PLANNING

During the 1980s, the decrease of life quality in urban areas combined with the rise of environmental impacts awareness have led many scholars to question themselves about the choices that cities had to make to evolve differently, or in accordance with the Bruntland report, towards a more sustainable outcome. According to the report, a **sustainable development** means " a development that meets the needs of the present generation without compromising the ability for future generations to meet their needs" (Brundtland Commission, 1987). The concept does not solely focus on environmental issues but encompasses three general policy areas : economic sustainability, environmental sustainability and social sustainability, also called the three pillars of sustainability.

Moreover, as transport systems strongly influence (and are influenced by) all these three sustainability dimensions (fig.2.8), it is thus logical that the sustainable concept was also adapted and applied at the transportation field (Litman and Burwell, 2006).

Fig.2.8. Transportation impacts on sustainability

ECONOMIC	SOCIAL	ENVIRONMENTAL
Accessibility quality	Equity/fairness	Air pollution
Traffic congestion	Inequity of impacts	Climate change
Mobility barriers	Mobility disadvantaged	Noise pollution
Accident damages	Human health impacts	Water pollution
Facility costs	Community cohesion	Hydrologic impacts
Consumer costs	Community liveability	Habitat and ecological loss
DNRR	Aesthetics	DNRR

(DNRR = Depletion of Non-Renewable Resources)
Source : Litman and Burwell, 2006, p.5

Consequently, during the 1990s, diverse definitions of a **Sustainable Transport System** were proposed. Amongst these ones, the Transportation Research Board's Sustainable Transportation Indicators Subcommittee recommends the definition selected by the European Council of Ministers of Transport in 2004 (TRB, 2008)[1] because of its broad scope, which encompass all the three sustainability pillars discussed above.

According to this definition, "a *Sustainable Transport System* :

- Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy.
- Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise".

Before going further, a remark has to be made concerning the difficulties to integrate the concepts of sustainability, sustainable development and Sustainable Transport System into daily practices. Indeed, although the need to evolve differently seems widely acknowledged,

[1] Originally developed by the Canadian Centre for Sustainable Transportation

the practical way of achieving this sustainable state is still quite uncertain and contentious. Indeed, while it is generally accepted that sustainable development and sustainable transport imply finding a proper balance between (current and future) environmental, social and economic qualities (OECD, 1996 ; Litman, 2003 and WCED, 1987 in Steg and Gifford, 2005), it is less clear which environmental, social and economic qualities should be guaranteed or balanced. Similarly, although various attempts have been made to decide upon a list of sustainable transport indicators (example of sustainable transport indicators list, see appendix 1), a key set of indicators that adequately reflects environmental, social and economic qualities have not been identified yet (Steg and Gifford, 2005). Ideally, theoretical conceptions and operationalisations of Sustainable Transport System indicators should be developed, first by clearly defining what a sustainable system of transport is, and then by deriving significant performance indicators that would allow us to measure the sustainability of a transport system. For this, many performance indicators have been derived from current practices (e.g. in transport plans and policies). Unfortunately, the development of indicators, in the majority of the cases, was not based on an explicit definition of a sustainable system of transport. This lack of precise definition has posed problems into the evaluation of the impacts that have these recent practices on the sustainability level of the transport system (Gilbert and Tanguay, 2000, in Steg and Gifford, 2005).

The application of the sustainability concept to the transport arena was not without impact on the transport planning. The achievement of a Sustainable Transport System requests a deep review of the traditional **transport planning** practices.

- Sustainability requires more comprehensive and integrated planning. Because transportation activities have so many impacts related to sustainability (fig.2.8), it is important to identify strategies that help achieve multiple objectives, and avoid those that solve one transportation problem but exacerbate others (win-win solutions). That involves a more comprehensive analysis of impacts (including consideration of indirect and cumulative impacts) as well as a broader range of contemplated solutions.
- Sustainability requires adequate stakeholder involvement to allow diverse perspectives and preferences to be incorporated, what contributes to take more equitable transportation decisions by giving disadvantaged groups more involvement in decisions that affect them
- Sustainability tends to support transportation planning and market reforms that result in more diverse and economically efficient transportation systems, and more compact land use patterns that reduce automobile dependency. These reforms help increase economic efficiency, reduce resource consumption and harmful environmental impacts, and improve mobility for non-drivers.

However, as already mentioned in the introduction, this research does not seek to analyse all the dimensions of the complex sustainable spectrum. Indeed, the fuzzy and *fourre-tout* nature of this concept, the numerous components that this concept comprises, and the strong interrelations that transport owns with other planning fields make its complete analysis impossible. For this reason, the scope of this study is restrained to the evaluation of the Travel Demand Management measures implemented in both studied cities ; the management of the travel demand being nowadays the most important component to achieve a sustainable system of transport (fig.1.1).

2.7.2. TRAVEL DEMAND MANAGEMENT (TDM) AND ASSOCIATED CONCEPTS

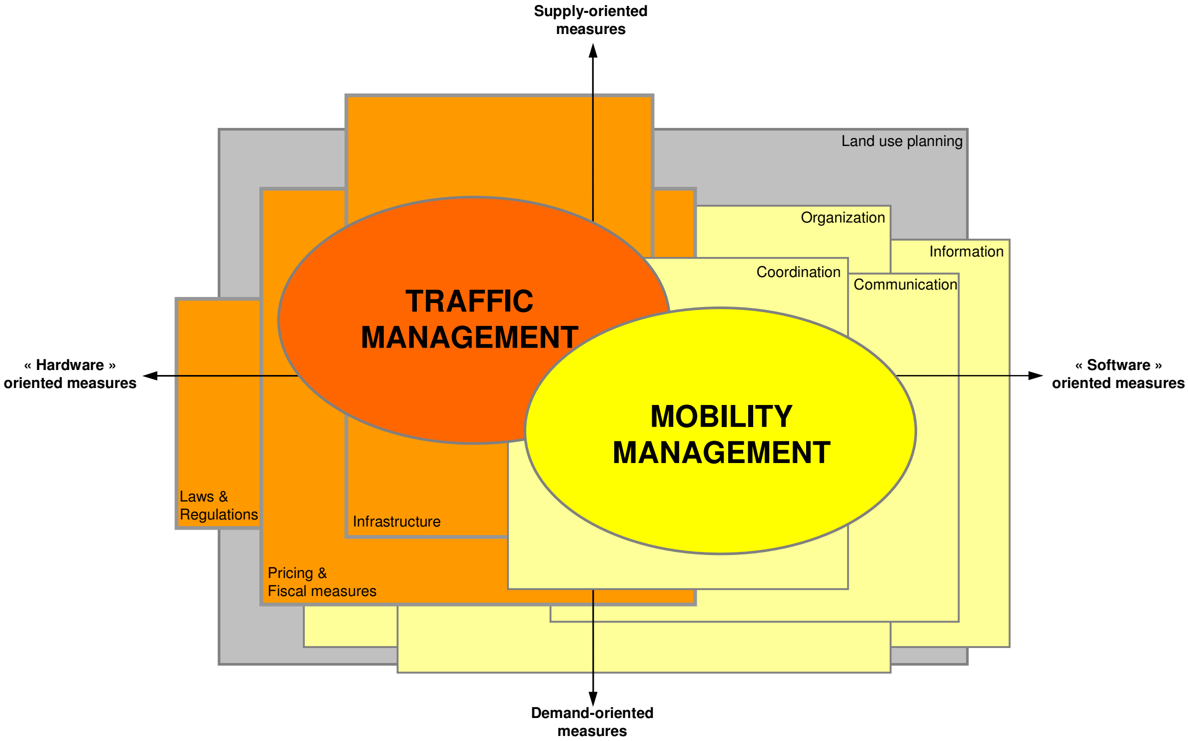
The management of the mobility (in contrast to demand-led approach) is rather a new concept for many cities which have only started recently to care about their congestion problems and associated pollutions. The sense of urgency to solve these problems which exists now in numerous urban areas has led to a fast and anarchic development of practices dealing with traffic congestion. Moreover, the management of the mobility strongly depends of the specific conditions of each urban area and was thus implemented differently according to the local environment of each city (not only natural environment of cities but also their political climate, economic situation, existing transport networks, …). These two raisons explain chiefly the mishmash existing in this field between concepts such as Congestion Management, Travel Demand Management, Mobility Management, etc.

Firstly, it is necessary to precisely define the meaning and the scope of the "Travel Demand Management" concept before developing the diverse instruments which are used in practice to manage this demand to travel. In this work, the concept of **Travel Demand Management** (TDM)[1] (also called congestion management or transportation demand management) is used in its broadest scope, as described in the Transportation Demand Management Encyclopedia of the Victoria Transport Institute : "the Transportation [or Travel] Demand Management refers to various strategies that change travel behavior (how, when and where people travel) in order to increase transport system efficiency and achieve specific planning objectives. […] TDM treats mobility as a means to an end, rather than an end in itself. It emphasizes the movement of people and goods, rather than motor vehicles, and so gives priority to more efficient modes (such as walking, cycling, ridesharing, public transit and telework), particularly under congested conditions. It prioritizes travel based on the value and costs of each trip, giving higher value trips and lower cost modes priority over lower value, higher cost travel, when doing so increases overall system efficiency".

Before broaching the TDM measures itself, a distinction must be made between the concepts of Travel Demand Management and Mobility Management. While the TDM Encyclopedia and other literature consider the concepts of "Travel Demand Management" and "Mobility Management" as equal, these terms are differentiated in this research, considering Mobility Management as only an element of the concept of Travel Demand Management. The framework provided by the User Manual Guide conceived in 1999 in the frame of the European projects MOMENTUM and MOSAIC is used to illustrate this distinction. In accordance with this framework, the concept of Travel Demand Management is subdivided into two main categories of measures : **Mobility Management** measures and **Traffic Management** measures. These two measures groups can be positioned into a two-axis graph, each of the axis representing one dimension of transport planning (fig.2.9).

[1] Although the concept of "Travel Demand Management", as its name underlines, is mainly demand-oriented, it is not only limited to demand-oriented measures but also includes several supply-oriented measures (e.g. park-and-ride facilities, bus and bike lanes, traffic flows management). The measures that are covered by the concept of Travel Demand Management are defined in more details in the following sections.

Fig.2.9. Mobility Management in relation to Traffic Management



Source : Mobility Management – User guide, 1999, p.11

The first dimension concerns the nature of the measures ; each measure being more or less demand- or supply-oriented. **Demand-oriented** character of the measures refers to the implementation of measures that support and encourage travellers behaviour changes towards a rising use of sustainable transport modes (i.e. public transport, cycling and walking) or of shared vehicles (i.e. ridesharing). In comparison, **supply-oriented** measures focus on optimizing use of road and parking capacity by influencing traffic flows for all transport modes. Such measures involve the efficient and safe distribution of vehicles over limited space and time.

The second dimension represents the "hardness" of the measures. The "**hardware"** oriented measures refer to the construction and regulations side of transport planning which are considered obligatory to the user (e.g. road infrastructure building, tax and pricing schemes, transport policies, …). The "**software"** orientated measures places more the emphasis on the organisation and services. They influence human mobility behaviour through information, communication, organisation, and coordination, what has become increasingly important in today's society.

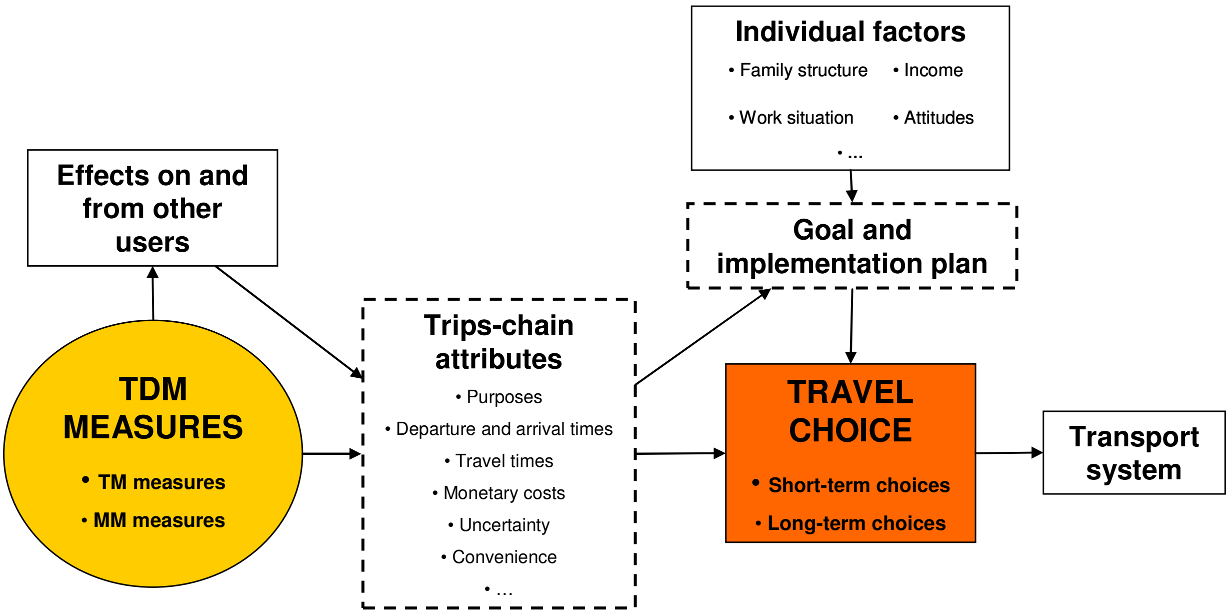
In respect to this framework, the different European actors concerned by transport concerns have agreed on the following definition of the Mobility Management concept: "Mobility Management is a demand orientated approach to passenger and freight transport that involves new partnerships and a set of tools to support and encourage change of attitude and behaviour towards sustainable modes of transport. These tools are usually based on information, communication, organisation, co-ordination and require promotion" (European Union, Mobility management – user guide, 1999). Individual mobility needs is at the core of MM measures. Consequently, to serve at best population mobility needs, such measures result most of the time in the development of "customized" services, tailored for example to serve specific target groups (e.g. young or elderly people, disabled, …) or for particular trip purposes (e.g. for commuting, shopping, transport of goods, …). In many cases, the implementation of MM measures do not require large financial investments since they mainly use existing infrastructures, and they may give rise to a high benefit-cost ratio. However, soft measures alone are rarely sufficient to significantly improve the transport system of an urban area. Studies on the effectiveness of MM measures have proven firstly that, to have larger impacts, MM measures must rather be considered as a support to enhance the effectiveness of harder measures (European Union, MAX project, 2006), and secondly, that one of the key success factors of the implementation of MM measures is the use of incentives or disincentives to encourage a change in travel behaviour (Meyer, 1999, p.591).

To sum up, the reference framework of this research is called Travel Demand Management. All the measures which are part of this framework can be classified into two main categories, Mobility Management and Traffic Management measures, depending on whether there are more supply- or demand-oriented and whether they are more hard or soft.

2.7.3. CONCEPTUAL FRAMEWORK OF TDM MEASURES

Since the concept of Travel Demand Management and the other related concepts have been defined, it is now possible to specify whether and how the TDM measures affect people's travel options. To this end, T. Gärling and other searchers have proposed a conceptual framework which compile the whole factors, including TDM measures, that influence the travel choices (Gärling et al., 2002) (fig.2.10).

Fig.2.10. Conceptual framework of Travel Demand Management (TDM) measures



Source : Gärling, 2002, modified by C. Maloir

In this framework, they hypothesize that choices concerning travel options are determined by two main factors[1] : the trip chain attributes, and the goals and implementation intentions of households.

[1] Other factors such as situational ones (weather, time of the day, workdays or week-end days, …) also influence the travel choices of people. However, since TDM measures have a limited (or no) influence on these additional

The first factor which determines travel choice lies in the packages of **attributes describing trip chains** (purposes, departure and arrival times, travel times, monetary costs, uncertainty, and convenience). A delicate research issue in the evaluation of such attributes lies in the evaluation of the effects that the others users of the transport system have on these attributes. “This is important since these other users are likely to respond to TDM measures in such a way that the travel options for a target user are changes over and above the effects that a particular TDM measure (or combination of measures) would otherwise have” (Van Lange et al., in Gärling et al., 2002). Then, the second factor which strongly influences travel choice is **the goals and implementation intentions** that households form over time. These goals can in fact be assimilated to the needs and desires that people strive to satisfy. People decide on goals and implementation intentions on the basis of trips chains attributes evaluations, as well as of several other static factors including family structure, incomes, work situation, and attitude (e.g. environmental concern). Implementation intentions consist of a plan for how to achieve the goals given the choice options. In making plans, households consider a wide range of possibilities. These possibilities are not only short-sighted, such as staying at home, using new communication means, changing attributes of trip-chains (e.g. modes, destinations, departures times), etc., but can also include longer-term strategic changes such as moving to another residence or changing work place or hours. Moreover, all these possibilities are not evaluated simultaneously. “Choices among these possibilities are likely to be made sequentially over time such that some are tried out and evaluated before other ones, starting with less costly changes and continuing with more costly ones” (Gärling et al., 2002).

In this conceptual framework**, TDM measures** are assumed to affect specific trip-chain attributes. These attribute changes are supposed to both directly and indirectly affect people’s travel choices. In the second case, people indirectly react to attribute changes by adjusting their goals to the changing trip-chain attributes. So, for instance if local authorities introduce road pricing, car drivers will experience increased travel cost. Individual factors, such as incomes, are assumed to affect whether or not a goal is set to reduce travel costs, i.e. those who can afford to pay the increased travel costs are less likely to set the goal of reducing them than those who cannot afford the costs. Thus, in the case of the increased travel costs are perceived as necessary to reduce, the person will set the goal of reducing them. So, in this second case, TDM measures change trip-chain attributes, which, in turn, encourages setting goals to counter such changes.

The theoretical considerations which were developed in this section will be used in chapter 7 to understand and evaluate the effects that have, or should have, TDM measures on people’s travel behaviour in the cities of Liege and Groningen.

2.7.4. TDM MEASURES AND TDM STRATEGIES

The large variety of existing **Travel Demand Management measures** makes their complete inventory very difficult. For this reason, two choices have been made : firstly, the TDM measures were classified into two broad categories, according to their rather supply- or demand-oriented[1] nature, and secondly, it is only the TDM measures which are the most

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factors, we have decided not to develop them in this thesis. For more information on this subject, see Gärling et al. (2002) and related literature.

[1] This classification was not always easy to carry out. While some measures are clearly supply- or demand-oriented, others have an impact on both the supply of transport and the demand to travel. This is for example the case for the “land use and zoning management”. By planning the locations and designs of new developments, land use and zoning policies influence the travel demand, but they also impact on the road network supply since

representative of each category which were listed. The list[1] of measures[2] which is proposed below will be used as a reference list in chapter 6 to practically analyse the measures which are in application in both studied cities.

SUPPLY-ORIENTED MEASURES
Roads traffic operations
- Intelligent traffic system (ITS)
- Real-time traveller information system
- Speed reduction and traffic calming
Improvement of transport choices
- Bus rapid transit and express commuter buses
- Light rail transit (tram and trolleybus)
- Park-and-Ride facilities and shuttle services
- Bicycle facilities
- Pedestrian facilities
- Carsharing
- Train services
- Taxi services

DEMAND-ORIENTED MEASURES
Land use and zoning management
Traveller information systems
- TDM marketing (TDM promotion campaigns)
- Pre-trip travel information services
- Rideshare matching (or ridematching) services
Economic measures
- Road pricing
- Parking pricing
- Commuter financial incentives
Administrative measures
- Alternative work schedules (in coordination with companies)
- Car free zones
- Parking management
Telework(ing)

Sources : O'Flaherty, 1997 ; Gärling, 2002 ; TDM Encyclopedia, Victoria Transport Policy Institute

Usually, the implementation of one of these measures has modest effects on urban transport systems. Most individual TDM measures only affect a small portion of total trips, but the impacts of these measures are cumulative and synergistic (the total impacts are larger than the sum of the individual impacts). To deal efficiently with transport issues, urban authorities must set strategic transport goal(s) according to the urban context and the nature of the transport problems that they have to deal with. These goals take the form of comprehensive **TDM strategies**, which are in fact packages of complementary TDM measures.

There are many different TDM strategies with a variety of impacts. According to the goal that urban authorities have set, they will for example rather favour the improvement of transportation options available to consumers, or reduce the need for physical travel through more efficient land use, or develop transportation substitutes, or combine these possibilities. The application of such strategies can often affect a more significant portion of total trips and thus provide larger total benefits. It is therefore important to plan and evaluate integrated TDM strategies rather than individual measures (TDM Encyclopedia, Victoria Transport Policy Institute).

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each new development has to be connected to the existing road network, what increase the total road capacity. This classification is thus rather indicative, giving a first insight on the main impacts that has each TDM measure.

[1] The list of TDM measures which is proposed in this work was constituted on the basis of information gathered through different scientific articles and websites focusing on Travel Demand Management (e.g. O'Flaherty, 1997; Gärling, 2002 ; TDM Encyclopedia, Victoria Transport Policy Institute)

[2] Each of these measures is defined in the glossary proposed at the beginning of this work

2.7.5. TRANSPORT PLANNING APPROACHES

The transport system of each urban area, characterised by its set of TDM measures, is particular to its place. However, these systems of transportation can be classified into some broad categories. In this goal, C. O'Flaherty proposes in his book "Transport planning and traffic engineering" a classification of the different urban transport systems according to five contrasting transport planning approaches (fig.2.11). The below description of these approaches are largely inspired by O'Flaherty's book.

STRATEGY 1 : DO-MINIMUM APPROACH

At its extreme this approach assumes that traffic congestion, road accidents, and environmental degradation are inescapable features of modern-day life and, if left to itself, human ingenuity and self-interest will ensure that congestion will become self-regulating before it becomes intolerable. In term of TDM measures, that means no measure.

Congestion is associated with stop-start driving conditions which reduce fuel efficiency and increase air pollution, raise the cost of freight movement and distribution, hinder bus movements (thereby making car trips more attractive) and increase the number of accidents.

Drivers who regularly encounter recurring congestion on main roads in urban areas try to find another itinerary driving through adjacent non congested neighbourhoods to reach their destination. This alternative to congested roads imposes considerable environmental hardships and social and economic costs on person living in those areas. Recurring congestion also encourage the flight of inhabitants from the crowded and polluted inner city towards rural areas, which reinforce the suburbanisation phenomenon.

For all these reasons, to let congestion find its own level without constraints would have the effect of causing irreversible long-term damage to both urban and rural areas and would ultimately reinforce car-dependent lifestyles, which is totally in opposition with the Sustainable Transport System objectives.

STRATEGY 2 : THE LAND USE PLANNING APPROACH

This approach assumes that the control of land use is to a large extent the key to control both the demand to travel and its impact upon environment.

As already mentioned, land use planning and transport planning are closely interconnected. So, by implementing land use control measures (e.g. limiting the spread of cities, promoting high density urban development or mix of functions, ...), the needs to travel by car are reduced and the distances travelled shortened. However, initiating land use changes is not something that is easily done. Consequently, this approach is often accompanied by Traffic Management measures that aim at increasing the competitiveness and attractiveness of urban centres and at promoting the other travel modes. These measures consists for example in limiting parking places in central area and developing park-and-ride parking facilities at the outskirt of the city, in implementing priority measures that promote the use of public transport and softer transport modes, in establishing car-free zones in central areas, …

STRATEGY 3 : THE CAR-ORIENTED APPROACH

As already written before, the post-World War II era was characterised by very rapid developments in respect of the growth and usage of the private car. For the cities which decided to promote this transport mode (the majority of them), there was an urgent need to carry out transport plans which provide more and bigger roads as well as a huge number of parking places in and about town centres. Face to this "car supremacy" context, public transport lost its competitiveness. Indeed, cities who adopted the car-oriented approach have seen strongly decline their public transport system.

Cities that have adopted approaches which favour the private car put considerable emphasis on the hierarchy of their road network. The road hierarchy concept was a major feature of transport plans in the 1950s in the United-States[1]. This concept allows to clarify and prioritize the transport functions served by various types of roads. In this goal, roads were divided into three main functional groups :

- Arterial roads which are those for long-distance high-speed through-vehicle movements and therefore which provide minimal access to adjacent frontages
- Local roads and streets whose main function is to provide access for frontages and thus, whose design and traffic management is intended to discourage through traffic
- Collector roads are the intermediate group, which are intended to provide for both shorter and through-vehicle movements and frontage access

Moreover, this approach also often includes the implementation of road traffic operations tools which provide motorists with real-time information regarding congested locations and times, and improve traffic flows with the aid of traffic control technology.

STRATEGY 4 : THE PUBLIC TRANSPORT-ORIENTED APPROACH

With this approach, the main objective of cities is to improve the quality and quantity of road and rail public transport services. This objective is normally associated with demand-oriented measures such as land use, economic, administrative and improved traveller information services measures which encourage the usage of public transport.
Advocates of transport-oriented plans emphasise that public transports, whether they are road- or rail- based, are more energy efficient, emit less airborne pollutants, minimise the amount of land used for transport (including parking) purposes, and generally result in better physical environments in urban areas. They also favour the remaining of activities in central areas as well as the pedestrianisation. However, public transports can be competitive only if they guarantee regular, predictable and reliable services at a reasonable cost, performed by safe and comfortable vehicles.

Rail systems are more effective to service densely populated cities with relatively long journey-to-work distances along radial corridors with congested roads which are central-oriented. Because of the high costs of rail building, making the full use of existing rail infrastructures is the key to ensure the success of this transport mode.

Concerning the **buses**, since these ones do not request particular road infrastructures, bus network and itineraries are also easier to change and to adapt to the demand. Three main strategies which favour the use of buses over private cars in urban area can be implemented :

[1] Although this concept of road classification was implemented in the United States, it is now also largely used in Europe to prioritize road networks of European urban and/or rural areas.

- Managing land use and zoning policy by locating large traffic generators at sites which are capable of being well served by buses (see strategy 2)
- Improving bus services via the development of *bus rapid transit* (including bus lanes and pre-emption bus signals, high-capacity, frequent and high-quality vehicles, integrated fare system and good modal integration) of *express commuter bus services*, or via the construction of *park-and-ride facilities* at the fringe of large urban areas
- Using traffic restraint measures such as *parking management* or *traffic signal control* to make car travel and parking more difficult in urban areas and thus discourage car use.

In addition to these measures, softer measures such as the organisation of campaigns promoting public transport or the implementation of services providing information about routes, waiting times, and timetables that remove uncertainty and inform (actual and potential) public transport customers are also very important. Much effort is currently being placed on providing customers with real-time information displayed via Internet, in the buses and trains and at bus stops and stations. Moreover, the implementation of integrated fare system (or "travelcards"), which allow the customers to change from one rail system to another, and from bus to rail and vice versa without the need for re-ticketing, is also a critical factor to encourage the use of public transport.

STRATEGY 5 : THE DEMAND MANAGEMENT APPROACH

Among all the already presented approaches, this one is the most extreme in term of managing the demand to travel. In practice transport plans and strategies that correspond to this approach tend to promote anti-congestion measures to reduce the pressure on the road system. These measures can be for example the ones proposed in strategy 4 (i.e. to improve public transport services or to implement traffic restraint measures). But, in addition to the previous strategy, this fifth approach also supports the implementation of TDM measures which influence pre-trip travel choices. These are for example the implementation of *pre-trip travel information services*, the promotion of *ridesharing* activities which favour high-occupancy vehicles at congested locations and times or *alternative work schedules* and *telework* which respectively shifts travel from congested peak hours or reduces the amount of trips.

More far-reaching proposals include the use of *road pricing* mechanisms based on the concept that road users who contribute to congestion are a cause of additional costs to society. If they were to be charged for these costs, some would travel at different times, by different routes or by different means, and congestion would therefore be reduced.

These five transport planning approaches and the TDM measures that they involved are summarised in the following table (fig.2.11)

Fig.2.11. TDM measures used to support each transport planning approach

TRANSPORT PLAN. APPROACHES →	Do-minimum approach	Land use planning approach	Car-oriented approach	Public transport-oriented approach	Demand management approach
TDM measures	X	Land use control measures + TM	Road hierarchy + TM	**Rail** MM **Bus** TM + MM	TM + MM

MM = Mobility Management measures – TM = Traffic Management measures
Author : C. Maloir

TRANSPORT PACKAGING

The five contrasting strategies described above are only an oversimplified categorisation of the reality. In practice, transport plans for urban areas have not been developed following solely one of these strategies. Rather, each urban area being a unique set of particular "ingredients", it is thus normal that their transport plans are a combination (or package) of these five strategies, carried out to meet the needs of the specific environment within which the urban area is located.

The combination of information that will be provided along the transport network analysis of Liege (chapter 4) and Groningen (chapter 5) and by the evaluation of the TDM measures that have been implemented in both cities (chapter 6) will allow to classify the transport system of each city according to these five transport planning approaches.

2.8. IN SUMMARY

This chapter has related the evolution that transport planning practices have experimented throughout these last decades.

More specifically, it has focused on the paradigm shift that occurred in transport planning in the 1980s. The causes of this shift have been elaborated, and the new "management-led" transport paradigm has been described.

This chapter has provided the theoretical framework within which the practical comparison study will take place. This practical analysis is carried out in the five following chapters. The goal of the next one is to describe the context within which Liege and Groningen evolves.

3

CONTEXT OF THE TWO STUDIED CITIES : LIEGE AND GRONINGEN

3.1. INTRODUCTION

This chapter starts the practical analysis of the two case studies. The analysis will fall within the scope of the theoretical framework elaborated in the previous chapter. So, the concepts which were defined and presented in chapter 2 will serve as reference concepts for the following chapters.

The goal of this third chapter is to describe the context - the physical, the spatial repartition of the population, the socio-economic, the administrative, and the policy contexts - within which the cities of Liege and Groningen have developed. This first preliminary study may seem rather far from the core subject of this research, namely the analysis of the transport system of both cities. However, a transport network is not an independent variable of the urban environment. It both depends of and influences the other contextual factors which constitute this environment. Thus the early description of these factors is a preliminary and indispensable step to the analysis of any transport system.

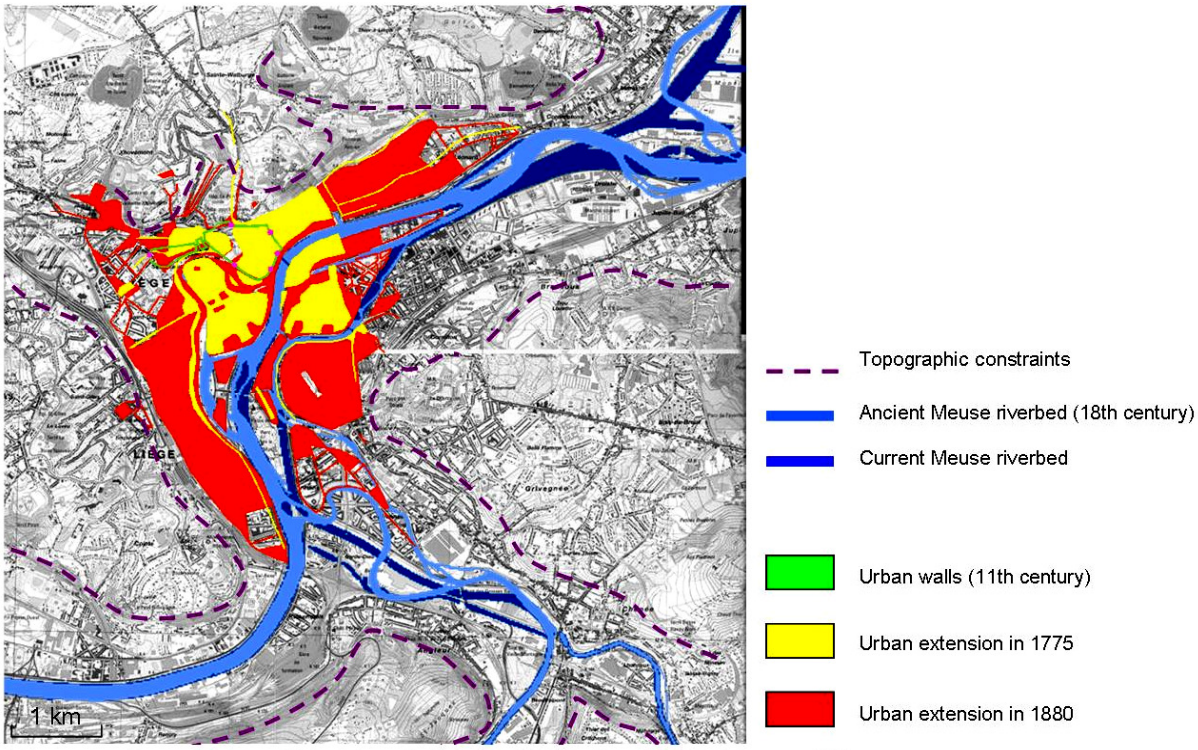
3.2. PHYSICAL CONTEXT

The general situation of any urban area and the physical context within which they have been developed plays a predominant role in the location and extension choices which were made. In that respect, the first section of this chapter provides information about the general situation of Liege and Groningen as well as about the physical factors which have influenced the urban development of both cities.

The city of Liege, located in the heart of the Euregio Meuse-Rhine and at the crossroad of many national and international highways, enjoys a privileged central location. However, this particular location is also the source of important passengers and trucks flows. These flows put an extra pressure of the urban transport networks of the city. The management of the automobile flows is thus an elementary condition if Liege wants to safeguard the quality of its urban environment.

The topographical and hydrological factors of the Liege region have highly influenced the development of the city. Because of the steep slopes which encircle the city, the first urban development cores were limited to the lowest part of the Meuse valley (fig.3.1). For the same reasons, roads and railways were also mainly constructed in the valley, following the weakest slopes to connect the plateaus to the city-centre.

Fig.3.1. Urban development of Liege in relation to its physical environment

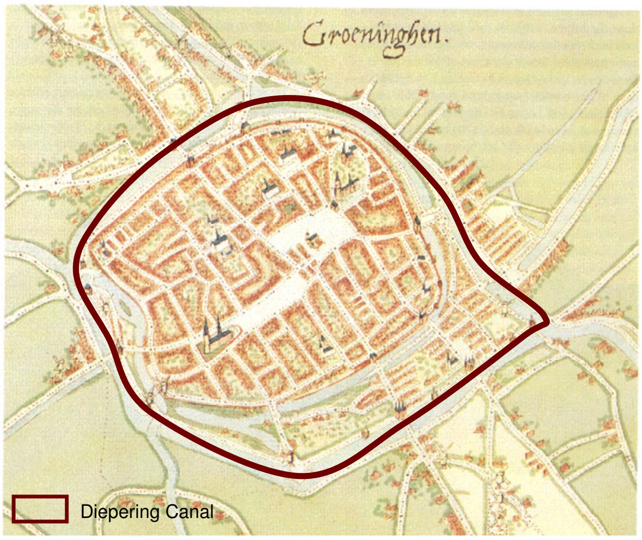


Sources : vector layers : city-promotion / topographic map : IGN
Author C. Maloir

The city of Groningen, as the only medium-size city of the North region of The Netherlands (about 180 000 inhabitants), alone polarises an area of more than 40 kilometres of radius (more than half a million people). This privileged situation explains the strong regional function that the city plays for the economic and social dynamisms of the north-eastern part of the country. Indeed, the city offers about 120 000 jobs and owns many facilities (like schools, hospitals, sport and cultural centres, etc.)

Due to the absence of relief of the region, the only physical factor which has guided the development of Groningen has been the hydrologic one. Indeed, as many Dutch cities, Groningen has numerous canals and waterways cutting through the urban area. The historical city centre is defined sharply by the "diepenring" ("diep" means canal in the dialect of Groningen) that encircles an area of approximately 1 sq km (fig3.2) (Hansen, 2005, p.11).

Fig.3.2. Historical map of Groningen – 16th century
(http://web.inter.nl.net/users/springelkamp/gronhist.html)



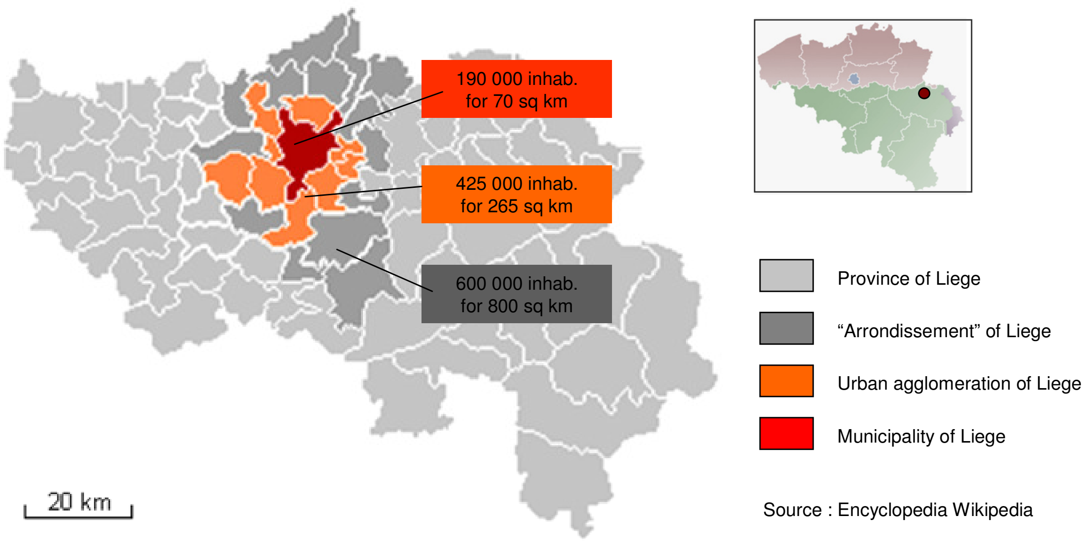
3.3. PERIMETER OF THE STUDY AND POPULATION SPATIAL REPARTITION

Secondly, the spatial repartition of the population in and around cities influences strongly the travel needs and traffic flows. So, this section describes firstly the spatial entities which delimit each study area. Every official administrative entity is characterised by its spatial extension and its inhabitants number. Then, this information is used to compare the spatial repartition of the population living in and around the cities of Liege and Groningen.

Presently, the **municipality of Liege** (equal to the city of Liege) (in red in fig3.3) is composed of many former communes that were aggregated in 1977, at the time of the municipal merger policy, to form the present entity. This territory covers approximately 70 sq km and has 190 000 inhabitants. The municipality of Liege and other adjacent municipalities form the morphologic agglomeration of Liege (in orange in fig.3.3) which covers about 265 sq km and has about 425 000 inhabitants. Finally, the large agglomeration of Liege, also called the "arrondissement" of Liege, which can include rural zones, has approximately 600 000 inhabitants (in dark grey in fig.3.3) who live in an area of about 800 sq km.

This figures highlights one of the main characteristic of the population repartition of and around Liege ; the number of inhabitants living in the peripheral area (400 000) is approximately two times bigger than the inhabitants number living into the city of Liege (190 000). This disequilibrium between central area and its periphery can be mostly explained by the suburbanisation of the urban citizens (Ville de Liège, PDS 1999). This migration has direct consequences on the travel length and time of this population as well as on the worsening life quality in the urban agglomeration due to the importance of the transit traffic in this area.

Fig.3.3. The municipality of Liege and its larger administrative entities

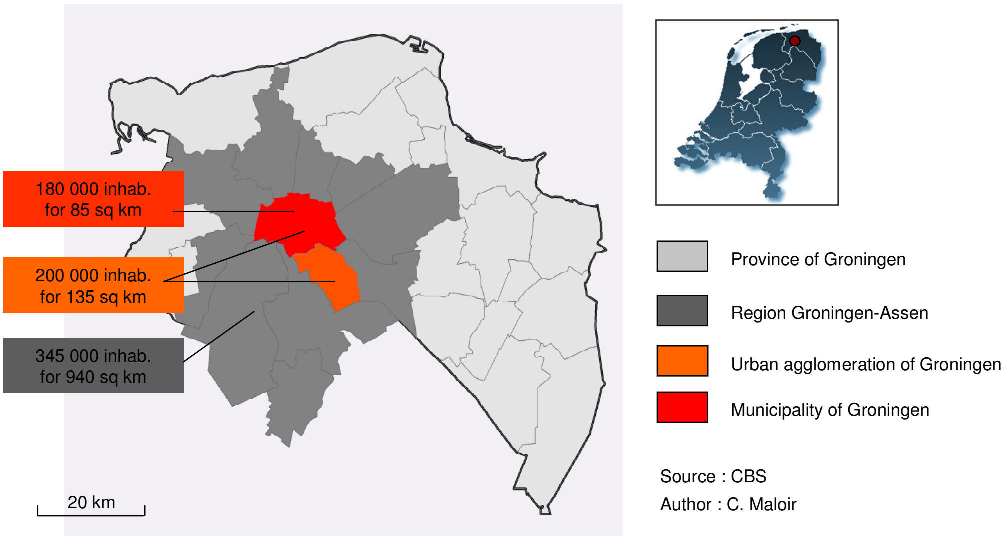


Moreover, to deal with transport issue, the research consultancy which has carried out many mobility plans for the city of Liege has subdivided the urban agglomeration of Liege into three perimeters on the basis of the land use patterns, the structure of the existing urban transport network, the urban traffic flows and the topography (fig.4.1).

These delimitations do not fit with the administrative boundaries described above but they are better adapted for the study within the transportation field. These three zones correspond roughly to the heart of the city or city centre (about 1,6 sq km) (P1), the densely urbanised zone (P2) which corresponds mainly to the bottom of the Meuse valley, and the surrounding area (P3) which includes all the main highways interchanges of the agglomeration as well as the peripheral economic and residential poles. The majority of the documents presented in this work are based on this territorial delimitation.

Like the city of Liege, the **municipality**[1] **of Groningen** ("gemeente" in Dutch) was formed by the merging of smaller municipalities. The Groningen municipality (in red in fig.3.4) has about 180 000 inhabitants and covers approximately 85 sq km. These figures are really close to the ones of the municipality of Liege.

Fig.3.4. The municipality of Groningen and its larger administrative entities



However, the population densities of the surrounding areas around both cities are critically different. While about 600 000 inhabitants are "concentrated" into the 800 sq km of the large agglomeration of Liege, this number of inhabitants corresponds to the population of whole the province of Groningen (in light grey in fig.3.4), namely about 2330 sq km. This observation conveys lower population densities in the rural areas around Groningen, although the population density of the municipality of Groningen is similar to the one of Liege. This sharp[2] boundary that exists between urban and rural areas, also observable for many other Dutch cities, is partly due to the model of compact urban development which is applied in the Netherland for more than 30 years. Another striking difference between Liege and Groningen is the extension of the urban agglomeration of both cities ("agglomeration urbaine" in French, "Grootstedelijke agglomeratie" in Dutch). While the one of Liege has a spatial extension of 235 sq km, the one of Groningen reaches only 135 sq km (including the municipality of Groningen (in red) and the one of Haren (in orange) in fig.3.4). Considering that the delimitation of these morphological entities are based on inhabitants number and building

[1] The city of Groningen ("stad" in Dutch) is often (wrongly) assimilates to the municipality. In reality, the municipality of Groningen covers the territory of the Groningen city but also some villages and hamlets located around the city.

[2] Although this boundary between urban and rural areas is still stronger in Dutch cities than in many other European cities, urban extensions projects (e.g. Blauwstad and Meerstad projects in Groningen) that cities have experimented these last decades have made this dichotomy between city and countryside less and less sharp.

density thresholds[1], these figures are indisputably proving that the densely urbanised environment extent far beyond Liege municipal boundary, while the municipality of Groningen represents the majority of its urban agglomeration (since the only other municipality which is part of the Groningen agglomeration is the one of Haren).

This difference of population densities between the surrounding areas of Liege and Groningen has significant impacts on the traffic flows which exist in and around the two cities. This will be developed in more details later in this work.

Until the late 1990s, the transport plans (like the other planning plans) which were carried out in the Netherlands were designed at the municipal scale rather than at the urban agglomeration scale like it is the case in Liege. Indeed, although the urban agglomeration is an officially recognised entity, its use is really uncommon. In the context of Groningen, the common goal of these municipal plans was to promote Groningen as a compact and complete city.

However, besides the municipality and the urban agglomeration, a third larger spatial entity was recently defined and promoted by the national government. The reasons of this scale change are set out in the last National Spatial Strategy : "the Netherlands is developing into a network society and a network economy. On the one hand, individualisation continues to progress ; on the other hand, all those individuals are increasingly closely interconnected in numerous networks. This development also has major consequences for spatial planning. There is more and more coherence between the various cities and urban areas. The government applauds this development towards [the concentration] of urbanisation and infrastructure into national urban networks, economic core areas and major transport axes as much as possible. […] Partnerships between such networks expand the support base of public facilities and services and open up opportunities for optimal use of the scarce space. To respond to this trend, the national government has designated 6 national urban networks[2] ("nationaal stedelijke netwerken" in Dutch). The development of these networks is a high priority" (VROM, Nota Ruimte 2006). The region Groningen-Assen (in dark grey in fig.3.4), which was created in 1999, is one of these 6 national urban networks. The region covers 12 municipalities, which represents 447 000 inhabitants and a spatial extension of 1100 sq km (Regio Groningen-Assen, Regiovisie 2030). The goals pursued by the region Groningen-Assen are twofold : to strengthen the economic position of the region at the (inter)national scale and to protect and reinforce the qualities of the regional territory, which are the combination of towns and countryside with a rich variety of landscapes, living and working environment. To achieve these goals, the regional committee has designated four regional projects : the cooperation regarding business parks, the Regiopark project (protection and valorisation of landscape), the initial landscape investments and the management of mobility,

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[1] The urban agglomeration is defined as an administratively adjusted morphological zone (or continuous build-up area) in which most activities, jobs and public facilities are located. Although the criteria and the limit values vary largely from one country to another, two criteria are present in all the definitions : the inhabitants number and the maximal distance between buildings (continuity of the build elements) (CBS ; INS ; Donnay and Lambinon, 1997 ; Vliegen, 2003)

[2] A national urban networks is defined as an entity of larger and smaller cities, including the open spaces in between. The cities and centres that comprise these networks complement and reinforce each others' strengths, so that they have more to offer together than they do as individual cities. It is explicitly not the intention that a new tier of government be created for the national urban networks. The partnerships between the local and regional governments within the networks are completely voluntary, flexible and pragmatic. The national government expects that the municipalities will draw up agreements on how they will shape the concentration policy, in consultation with the provinces and the urban regions (VROM, Nota Ruimte 2006)

which includes the Kolibri network development (Regio Groningen-Assen, Regiovisie 2030). This last project will be developed in more details in chapter 5.

3.4. SOCIO-ECONOMIC CONTEXT

Then, to be able to understanding and satisfy the travel needs of a certain population, a good knowledge of the main characteristics of this population is needed. For that, this third section presents socio-economic variables which characterised the population living in both studied cities. However, due to the large number of available socio-economic data, the study was restrained to the variables which (should) have the biggest impacts on the travel behaviour of the population living in both cities. These factors are the evolution of the inhabitants number living in the two urban areas, the age repartition of the present population, the number and structure of the households residing in the two cities, as well as the unemployment rate and motorisation rate of these households.

In the goal of lightening the text, all the figures sources which are used in this section are not mentioned. In fact, the majority of the data which are used in this section were found in the demographical statistics yearbooks of both municipalities (Ville de Liège, demographical statistics yearbook 2007 ; Gem. Groningen, statistical yearbook 2007). When it is not the case, the sources are given in the text.

EVOLUTION OF THE POPULATION

The two cities are both characterised by an increase of their total number of citizens. The **city of Liege** has known a large rise of its population until the 1900s. Then, the amount of citizens in the city has decreased slowly (excepted in 1977 when the city has "won" about 100 000 inhabitants because of the municipal merger policy). This population diminution is mostly explained by the suburbanisation[1] of the urban citizens towards the surrounding less populated areas. That is only since the year 2002 that this trend has been again reversed with a gain of about 6 000 inhabitants during these last five years. This arrival of newcomers is mainly due to the actions of urban renovation and the support to housing projects which were undertaken by the local government. If the population evolution of the next years follows this trend, the city of Liege should have about 195 000 inhabitants in 2010 and more than 200 000 in 2020.

Similarly to Liege, the number of inhabitants in the **city of Groningen** has never stopped growing (excepted during the 1970s), from about 30 000 inhabitants in the early 19th century until more than 180 000 inhabitants presently. According to the population prognosis's, Groningen should reach 183 000 inhabitants in 2010 and almost 206 000 inhabitants in 2021. To satisfy this future growth of population, local authorities have decided to increase the housing stock of the city. This is made in two ways : firstly, via projects of intensification and urban renewal in the city-centre; and secondly via the construction of new residential areas at the outskirt of the city.

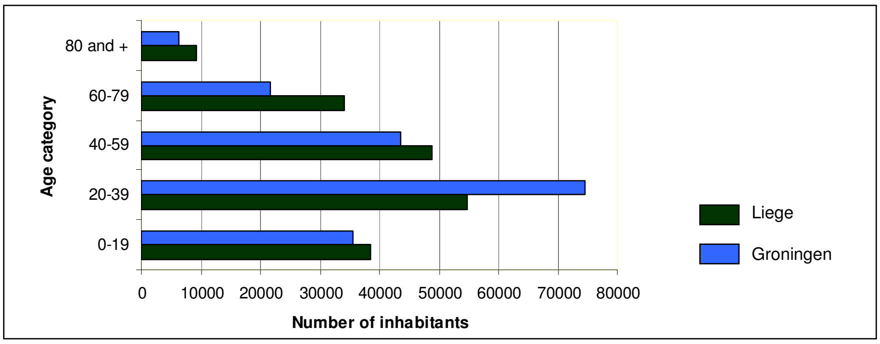
[1] According to the report of the demographical statistics of the city of Liege (yearbook 2003, p.10), the two major causes mentioned by the citizens to leave the city are "the desire to become an owner" (17 %) and the "too much urban nuisances and the lack of green and peaceful areas" (17%). The job (11%) and the need to have more space are also two other important reasons (9%)

Since each person has specific travel needs, the increase of the citizens number living in an urban area contributes to the general augmentation of the travel demand in this area. Consequently, the local authorities must take account of the population forecasts in their transport projects to be capable to provide a transport supply which is adapted to the future transport demand.

AGE REPARTITION OF THE POPULATION

By studying in more details the demographic profile of the inhabitants of the two cities, a difference in the age reparation of these populations can be highlighted (fig.3.5). While the group of the 60-79 and the one of 80 and more which are particularly important in the city of **Liege** (with 23% of the total population against only 15% in Groningen), it is the group of the 20-39 which is largely predominant in **Groningen** (41% of the total population),

Fig.3.5. Population repartition by age category



Sources : municipality of Groningen, statistic yearbook 2007 / city of Liege, demographical statistics, yearbook 2007
Author : C. Maloir

The young character of the Groningen population can be easily explained by the large number of students who live in the city. In fact, the city has more than 47 000 students[1] spitted up into the Rijksuniversiteit (RUG), the Hanzehogeschool (HHG) and other HBO institutions (higher education level). However, all these students do not live in Groningen ; half of them live out of the municipality boundaries. The fact that Groningen is a student city has large impacts on the transport system of the city. For example, to satisfy the students travel demand, the transport supply must be adapted to the student mode of life (modal split, schooldays schedules, …). It must also allow to the students who commute from the surroundings areas to easily access to the city, especially in the morning and the evening of weekdays.

In the case of Liege, although the city has also an important number of students (25 000 registered at the university and in other higher education institutions), the age repartition figures render rather an aging population. This observation can be mainly explained by the emigration of the young families with children that left the city-centre to live in more rural areas. Since the elderly population does not have the same travel needs or the same modal preferences as the young one, the transport system has to take this demographic characteristic into account. As an example, elderly people travel on different days and at different times of a day than students or workers. Most of them also prefer travelling on foot or by public transport.

[1] The statistics about the population, especially the student population, have to be carefully interpreted because of the misinformation concerning the actual population living really in the city. Indeed, there is always a more or less large difference between the official registered population and the actual one. This difference is particularly huge concerning the student population because of the large numbers of students living in cities without being registered as an inhabitant of the city (i.e. about 7000 students flats lodged non-registered students in Liege)

On the basis of these observations, one can say for both cities that when local authorities implement new transport projects and policies, they must imperatively take account of the demographic profile of the inhabitants living in the municipality. By doing so, the transport supply would better satisfy the travel demand of the local population.

HOUSEHOLDS NUMBER AND HOUSEHOLDS STRUCTURE

The number and the structure of the households living in an urban area have also a certain influence on the travel habits of these households. Indeed, according to the small or large size of households, individuals have different travel needs and preferences.

In the case of **Liege**, the municipality accommodates about 100 000 households and has known a raise of 4 500 new households between the year 2002 and 2007. Comparatively, the municipality of **Groningen** has about 88 000 households and has known an increase of 2 000 new households during the same period. The evolution of the households number in Liege between the year 2002 and 2007 is thus over two times bigger than the one of Groningen during the same period. Furthermore, it also appears that 83 % of the 4 500 new households of Liege are one-person households.

Generally speaking, by looking at the current households composition in both municipalities, one can notice that the proportion of one-person households is really important (54 % of the total part of the households in Liege and 44 % in Groningen) and the number of families with children is quite low. In fact, this large quantity of small households is largely constituted by old widowed persons and by young active single workers. These two "extreme" population subgroups present fundamental differences in their mobility profiles, which also have to be included in the preparation of the current and future transport plans.

UNEMPLOYMENT RATE

Based on the data that have been collected, it was not possible to make a direct comparison between the households incomes of the two studied cities. However, an idea of the financial situation of households can be provided by comparing the unemployment rate in the two municipalities.

In the municipality of **Liege**, the unemployment rate is of 31 %. This figure is the second highest unemployment rate of Belgium (after Charleroi), and is really higher than numerous other European cities (e.g. higher than all the middle and large size cities of France, the Netherlands and Germany) (Urban Audit, 2004). In comparison, the unemployment rate in the municipality of **Groningen** is only of 12 %. That is a little bit higher than the unemployment rate in a big amount of other Dutch cities, but that is still really lower than in the surrounding countries.

The large difference which exists between the financial situation of the households living in Liege and Groningen strongly constraints the budget that these households are able to allocate to transport. In other words, this difference in households incomes has large impacts on the mobility profiles of the households living in both cities.

MOTORISATION RATE

Finally, a comparison must also be made between the motorisation rate of the households living in both studied cities.

The rate of car ownership in the municipality of **Groningen** is clearly low, with 54 cars per 100 households against 80 cars per 100 households in the municipality of Liege. This observation is particularly true in the city centre of Groningen where the average of car ownership falls to 31 cars per 100 households (Gem. Groningen, ECOMM 2006 ; Ville de Liège, PCM 2004). However, the motorisation rate of **Liege** is relatively low in comparison to other Belgian cities. Indeed, in terms of cars per 100 inhabitants, the car ownership in Liege is only of 38 cars per 100 inhabitants (like in Charleroi and Namur), while the municipalities of Brussels or Hasselt for example reach respectively 83 and 47[1] cars per 100 inhabitants.

Several empirical researches have proven that the motorisation rate of households is highly correlated to their incomes. So, the non-motorisation is generally not the result of a choice but rather of a financial constraint. The population age and the supply of the public transport services have also a large influence on the motorisation rate of households.

3.5. INSTITUTIONAL CONTEXT

Fourthly, since the administrative structure and the competences of the different authorities levels are characteristic to each country, their institutional frameworks are also an important component of the understanding of any urban transport system. This section tries thus to describe basically the mechanisms and regulations which govern the transport systems at the urban areas level in The Netherlands and in Belgium.

Belgium administrative structure has known a perturbed history. The Belgian Constitution has known since the 1970s many successive reforms. The country has evolved from an unitary state towards a decentralised state (regionalisation process of 1970) to finally become in 1993 a federal state, created as a common answer to the claims of cultural autonomy of the Flemish and of economic autonomy of the Walloon. Since this latest reform, the political competencies are divided between the federal (national level, the regional level (regions and communities), the provinces and the municipalities, forming a three-tiered[2] system of administration. The competences of the regions, provinces and communities are exclusive. That means that each constitutive entity is totally responsible for its particular competencies, depriving the State government of every intervention form.

In general[3], the federal state is competent in all the national interest fields, such as the defence and international affairs, the social security, the taxation system, the economy, the telecommunication and many important semi-federalised competencies (such as scientific researches or education). At the regional level, the communities are bound to persons (competencies related to cultural activities, education and assistance to individuals), while the

[1] What is surprisingly high in an urban municipality where the bus services are free (INS, 2002)

[2] Whilst the State and the Regions clearly have different areas of responsibility, from a legal and a constitutional position they share the same level of authority and are considered equal (same unique level).

[3] In the reality, the distribution of the competencies between the three authority levels is not as clear as described above. Many exceptions and particularities exist. However, these are out of the scope of this study. For more information about this subject, see http://www.crisp.be/Wallonie/fr/mode_emploi_fr.html

regions have authority on fields which are broadly associated with their territory. Their authorities and competencies are rather limited, their main task being the supervision of the municipalities in areas such as public works and transport, land use planning and conservation, environment and water policy, housing policy, agriculture policy, economy, energy policy and lower government employment policy. Each region (excepted for Brussels) is divided in a number of provinces, which have a limited power too. Finally, at the lowest level, municipalities are responsible for local matters and have to respect the framework established by the higher authority levels.

Although Belgium is a federal state, the national government is responsible for many of the traffic and transport legislations and the control and funding of the autonomous public companies, i.e. the railways company (National Society of the Belgian railways - SNCB) and the air control company (Belgocontrol). However, the regions having competence for most infrastructure (all roads, urban and regional public transport, land use planning), that makes them a key player in transport policies. In this context, municipalities, which are largely constrained by the framework set by the national and regional level, meet difficulties to draw up their local transport policy. Indeed, it is clear that in such scattered competencies, urban traffic and transport policy needs a lot of co-ordination with the Regions and Federal government, as well as with the other planning fields (www.leda.ils.nrw.de).

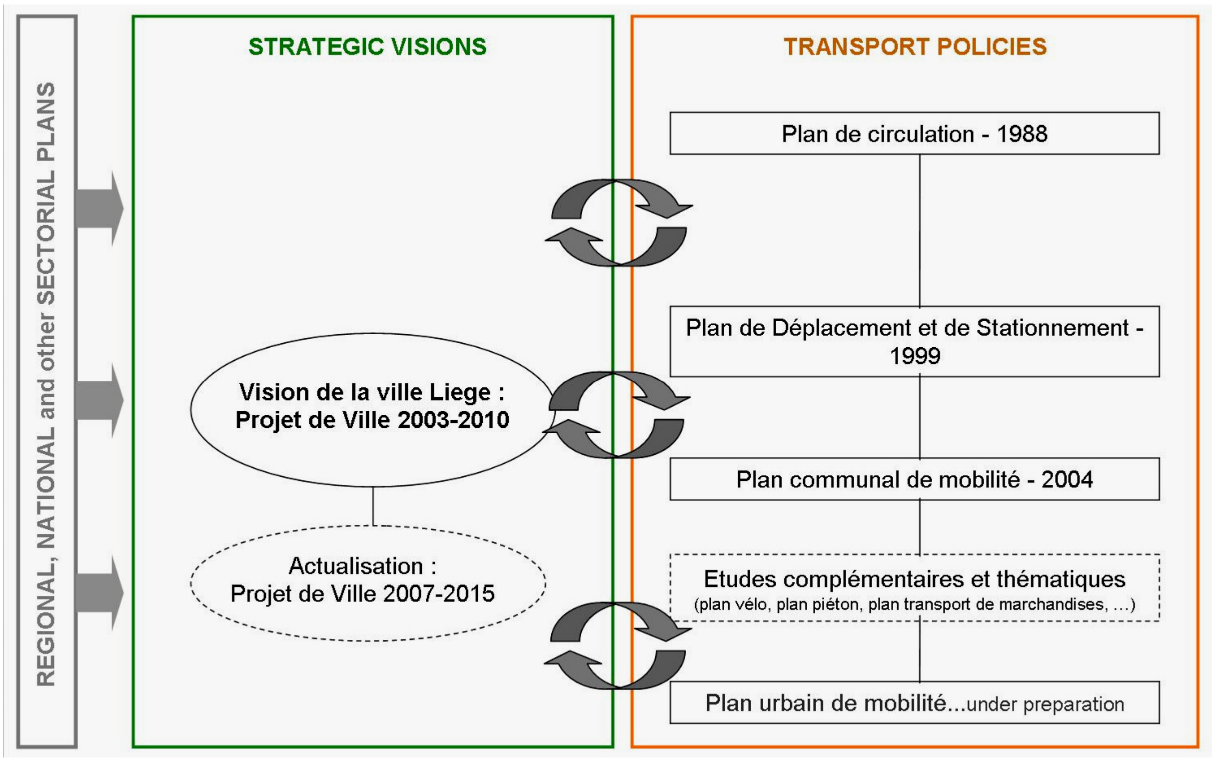
In contrast to the perturbation that has known Belgium, the overall **structure of the Dutch administrative system** has remained essentially unchanged since the middle of the 19th century. "In the 1848 constitution, a decentralised unitary state was articulated for the Netherlands, providing for relative autonomy for local and provincial governments within a framework and conditions set by the central government. […] These bodies form a three-tiered, hierarchical system of administration for the country (ECMT, 2001, p.27). In this context, the national government is responsible for regulation on transport, land use, environment, fiscal affairs and on various requirements and standards. Provinces, the intermediate level of power, are competent for regional public transport and land use, as well as to supervise the municipalities actions (via budget and granting supervisions). Finally, municipalities have a lot of decision power in local planning, land use, mobility and transport planning and have thus consequently an important role to play regarding sustainable development policies (www.leda.ils.nrw.de)

The transport planning arena conforms to this system. As set out by the Second Traffic and Transport Structure Scheme of 1990 (SVV2), overall responsibility for urban transport planning is under the responsibility of the Central Government. The national transport policy is defined and developed by the Ministry of Transport, Public Work and Water Management ("Ministerie van Verkeer en Waterstaat" - V&W). On a regional level, the provinces co-ordinate transport policy. However in some cases, regional entities, created by the Act Regions of 1993, handled in practice most of the second-tier responsibilities for transport policy as well as other areas. Once the mandate of these regions has expired in 2003, the regional responsibilities were transferred for their main part to the municipal level, decreasing the role of the provinces into the transport planning decision-making. This is in line with the plan to decentralise the government responsibilities for transport, which started in 1996 with the VERDI Accord and were reinforced in 2000 by the following national transport policy (The National Masterplan for Traffic and Transport – NVVP). In this decentralisation context, "generally speaking, municipalities have, within the limits and guidelines set by the national government, considerable freedom to develop their own transport policy, to design their road network and to introduce traffic measures" (www.leda.ils.nrw.de). This administrative organisation in the process of decentralisation requires a well-developed system of coordination between the three levels of the transport authorities as well as between the transport authorities and those responsible for spatial planning and environmental affairs, as well as economic and fiscal concerns (ECMT, 2001, p.31)

3.6. POLICY CONTEXT

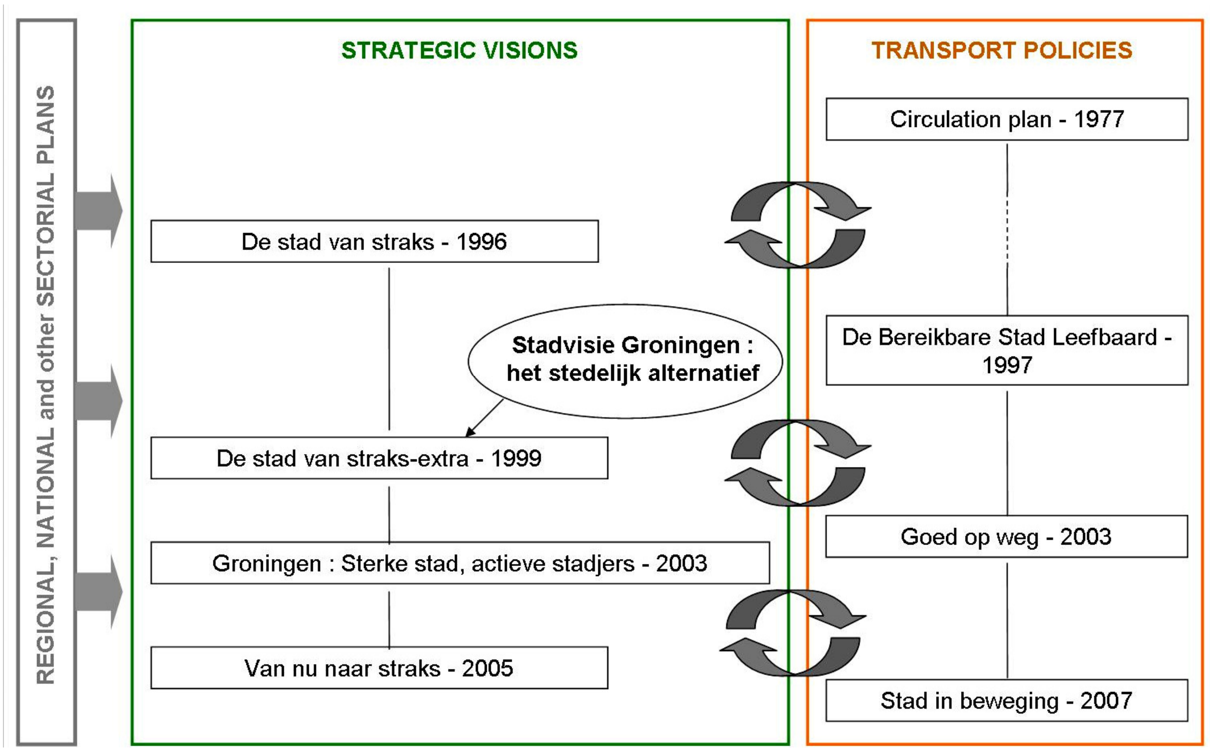
Finally, the goal of this last section is not to provide a detailed analysis of the policy documents which were published in Liege and Groningen, as this would ask for extra researches and would be quite far from the central subject of this thesis. Rather, this section is limited to a simple presentation of the successive transport policy documents which were implemented in the two cities. The strategic documents which have influenced and still influence the transport policies are also included in this presentation. No explanation concerning the content of these documents is supplied here ; the policy key documents, relevant for this thesis, will be detailed latter in the following chapters. So, the two following documents (fig.3.6 and 3.7) serve as reference document to retrace the history of strategic and transport policies in both cities. They will be particularly useful for the following chapters to situate any document in its broader policy context.

Fig.3.6. Successive strategic and transport policy documents of the municipality of Liege



Author : C. Maloir

Fig.3.7. Successive strategic and transport policy documents of the municipality of Groningen



Author : C. Maloir

3.7. In summary

The information which were provided all along this chapter are summarised for each of the two cities in the following table :

	LIEGE	GRONINGEN
Physical context	topographical and hydrological constraints	Hydrological constraint (diepenring and other canals)
Perimeter of the study and spatial repartition of population	Municipality of Liege and urban agglomeration of Liege Due to massive suburbanisation : number inhab. in the peripheral area is 2X bigger than in the city (municipality)	Municipality of Groningen and region Groningen-Assen (urban network) Due to compact development model : concentration of the inhab. into the city (around already developed area)
Socio-economic context		
Population evolution	Rising inhabitants number	Rising inhabitants number
Age repartition	Aging population	Young population (student city)
Households number and structure	Numerous one-person households	Numerous one-person households
Unemployment rate	Relatively high (and higher than other Belgian and European cities)	Relatively low (but a little bit higher than in other Dutch cities)
Motorisation rate	Relatively high (but lower than other Belgian cities)	Relatively (really) low
Institutional context	Low freedom and decision power of municipalities, constrained by the framework set by national and regional levels	Large freedom and decision power of municipalities (decentralisation process)
Policy context	See figure 3.6	See figure 3.7

This chapter has highlighted the contextual elements that have influenced the development choices made in term of transportation in both studied cities. Due to the narrow links that exist between context and transport development choices, the elements above described will be regularly referred to in the two following chapters, which will analyse the transport networks of Liege and Groningen.

4

TRANSPORT NETWORK ANALYSIS OF THE CITY OF LIEGE

4.1. INTRODUCTION

This fourth chapter deals with the study of the transport network of the city of Liege and of its surrounding area.

As already mentioned in chapter 2, any transport network analysis consists at least in two steps : the analysis of the transport supply and the analysis of the transport (or travel) demand. In accordance with that, the study of the Liege transport network is organised as follow :

- A first part depicts the spatial structure of the city
- A second part analyses the supply in transport per transport mode, in terms of infrastructure and services.
- And a last part analyses the travel demand (needs) of the population per transport mode.

Many of the information which were provided in chapter 3 will be frequently used all along this analysis to explain the choices which were made in the municipality in terms of transportation infrastructures development or to understand the travel behaviour and modal preferences of the population living in Liege or commuting to Liege.

Before starting the analysis in itself, a remark has to be made concerning the presentation order of the two cities. It was decided to begin with the transport network analysis of the city of Liege, rather than the one of Groningen. The main raison of this choice is linked to the "maturity degree" of these two transport networks. If the mobility management is a recent notion in Liege (urban mobility has been recognised as important for only a few years), urban mobility management is a top priority of the city of Groningen for more than 30 years.

In the goal of lightening the text, all the figures sources used in this chapter are not mentioned. In fact, the majority of the data which are used in this chapter were found in the Displacement and Parking Plan of Liege (Plan de Déplacement et de Stationnement) published in 1999 and in the municipal mobility plan of 2004. When it is not the case, the sources are given in the text. Moreover, these data are completed by information collected through interviews which were conducted with different actors acting in the field of transportation in Liege.

4.2. URBAN SPATIAL STRUCTURE AND TRANSPORT OBJECTIVES OF THE CITY

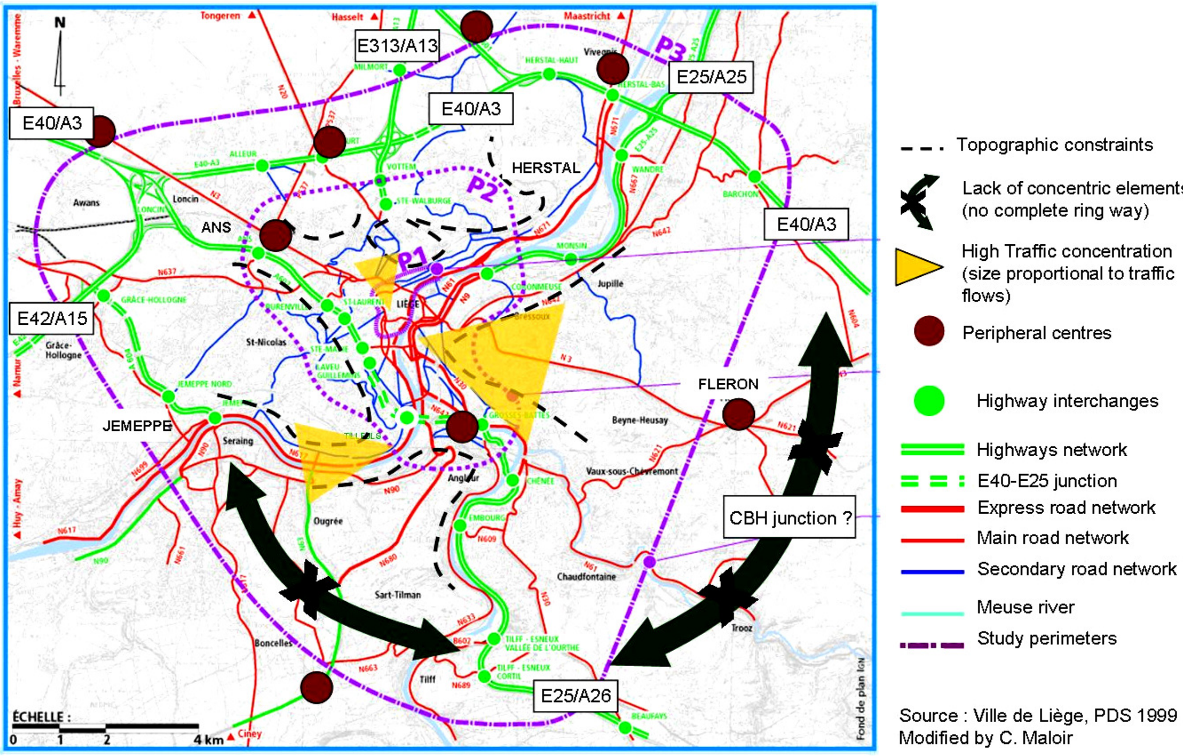
As it was already mentioned in the previous chapter (see section 3.2), the development of the Liege city in general, and its transport network layout in particular, were largely constrained by two natural factors : a ramified hydrological network and a steep relief. Indeed, while the water crossings (bridges, tunnels,…) are delicate zones because of the high traffic concentration in these places, the topography is a strong technical constraint for the network layout.

In consequence to these natural constraints, the main road network of the **agglomeration of Liege** (P3) is characterised by a dense radial structure converging through the city-centre (fig.4.1). The lack of concentric elements[1] intercepting this radial network (lack of complete

[1] The recent realisation of the highway junction between the A25 and A40 offers new possibilities to bypass the city-centre. But, nevertheless this sizeable improvement, still a too large part of the traffic continues to cross the

ring encircling the city) and the high capacity offered by the highways and numerous interchanges[1] favour the access by car to the city-centre. Indeed, everyday there are on average almost 200 000 vehicles rushing into the city-centre via this "funnel-shape" road network. This leads to high congestion at peak hours, as the city is not able to cope with such traffic flows.

Fig.4.1. Road network structure and accessibility to the agglomeration of Liege

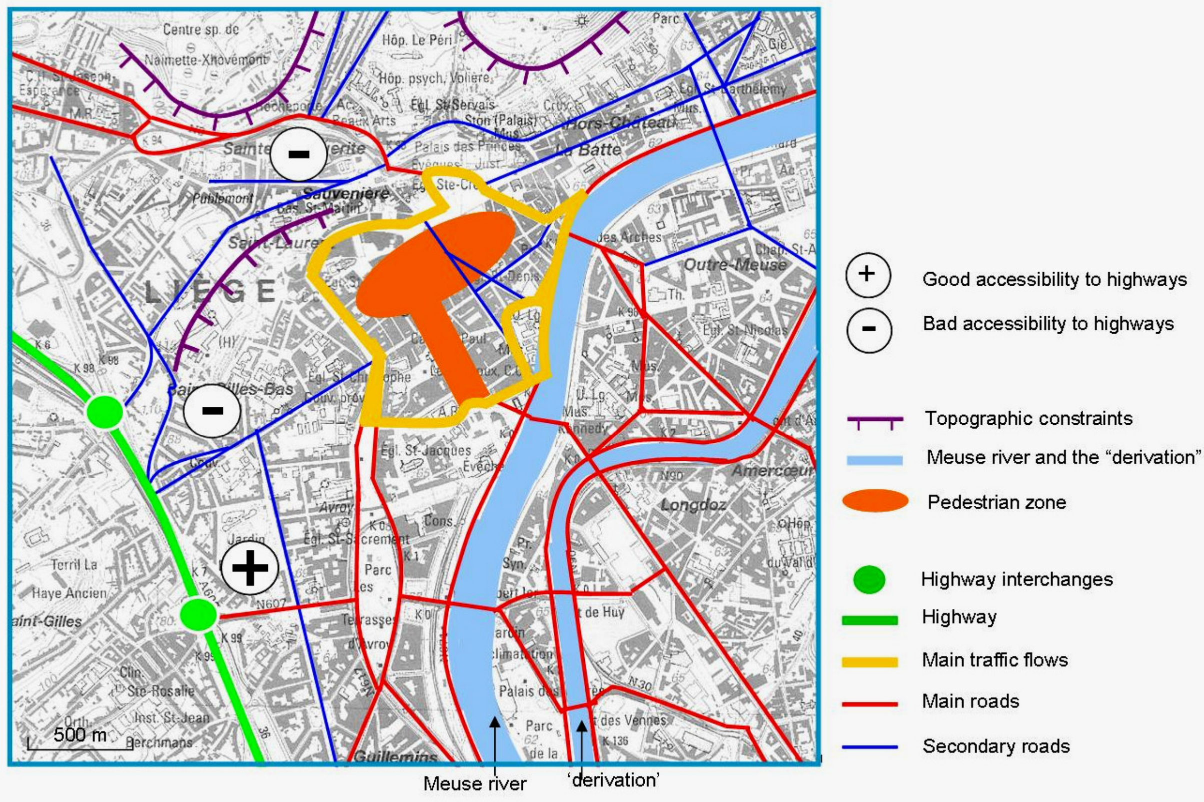


At the city centre level (P1), water and topography also constrain the access to certain parts of the city-centre or make the displacements difficult from one neighbourhood to another. Moreover, the density of the urban fabric and the narrowness of certain streets (especially in the historical heart of the city, which is also the most attractive area) make the mobility still more difficult in some parts of the city. Consequently, the organisation of the circulation in the inner city was planned taken into account of these factors, using the banks of the Meuse, its ancient riverbed (embanked to become the main boulevards of the city) and the bridges to structure the traffic flows (in yellow in the fig.4.2).

central area of the city, causing many congestion problems. Moreover, the rising demand for travel makes this new highway connection already almost saturated. Other measures/options must thus be considered.

[1] The city of Liege is served by about twenty interchanges, which are used daily on average by 550 000 vehicles. This interchanges network, although making sometimes more difficult the management of the traffic flows, is above all a formidable asset for the city because it permits a efficient redistribution of the traffic on the access network (cahier du MET, May 2005, p.24).

Fig.4.2. Road network structure and accessibility to the city-centre of Liege (P1)



Source : topographic map IGN
Author : C. Maloir (based on map from PSD Liege 1999)

This concentric model, characterised by a strong city-centre within which a (too) large part of the traffic flows coming from all the agglomeration converges, is a major cause of the degradation of urban quality of life, and consequently of the massive flight of housing and commercial activities towards the outskirt of the city. This suburbanisation phenomenon explains the emergence of secondary centres at the periphery of the city, notably at the convergence of radial lines, some of them effectively competing with the central area for the location of economic activities (fig.4.1). The characteristics named above are typical of the second model of urban structure, namely the “**weak centre**” model (fig.2.3). Moreover, as a consequence of the emergence of these new attractive poles, the freedom of decision of the local government has been strongly reduced. Indeed, in such a situation the local authorities have to take into account this new potential choices of location, being aware that if they implement too extreme urban policies (in the field of transport, that would be a strong pricing politicy), the ones constrained by these policies will be inclined to leave the city for these peripheral centres. The new measures have thus to be carefully evaluated before being implemented.

In this context, all the actors concerned by the mobility issue in Liege agreed in 2004 in the “Plan Communal de Mobilité - PCM” (municipal mobility plan), which is mainly based on the “Plan de développement et de Stationnement - PDS” (Displacement and Parking Plan) published in 1999 on three main development axis for the city (Ville de Liège, PCM 2004, p.23) :

- To improve the **quality of life** in the urban area by restructuring the circulation flows which currently transit needlessly via local neighbourhoods roads.

- To reinforce the **attractiveness** of the city centre by strengthening its commercial, economic and cultural functions via the revitalisation of its urban centres and the integration of new projects in the existing urban environment.
- To assure the high **accessibility** of the city by promoting a good multimodal accessibility and safe for everybody.

To reach these goals, the mobility plan focuses on attaining a balanced utilisation of the different transport modes according to their particular strengths and weaknesses. This equilibrium will be achieved by stopping to privilege the accessibility to the city only by private cars, but rather by developing multimodal concepts less consumer of public space and more respectful of the environment. Concretely, these objectives require the development of a different and better mobility supply and also the management of the travel demand, that in all the urban agglomeration of Liege (Ville de Liège, PCM 2004, p.23).

Moreover, the objectives of the mobility plan of Liege, like many other sector-based or regional plans, are coherent with the strategic vision for the city : the "Projet de Ville". This plan, published in 2003 and updated in 2007, fixes the major development orientations that the city has to follow until the year 2015. These ones can be sum up in five strategic objectives (Ville de Liège, Projet de Ville 2007-2015, p.8) : To improve the life quality in the city, to improve the economic sector, to limit poverty and social inequalities, to protect the environment by reducing the greenhouse gazes, to increase the number of inhabitants.

4.3. TRANSPORT SUPPLY ANALYSIS

A transport network analysis is usually constituted of two components. The analysis of the transport supply is the first one. Concretely, this section focuses on the supply in transport, per transport mode, in terms of infrastructures and services. This analysis is carried out at two different spatial scales, at the agglomeration level (including the adjacent municipalities and the highway network, P3) and at the city level (limited at the Liege city centre, P1). In some cases, the intermediate scale of the densely urbanised area (P2) is also considered. This analysis allows to provide a first insight of the main characteristics of the Liege transport network. It concerns, for example, the general structure of the road network, the space dedicated to each transport mode, the supply for transport facilities, or the quality of the different transport services.

4.3.1. ROAD NETWORK SUPPLY

As already mentioned in chapter 1, the road infrastructures network of Liege, like in many other Belgian and European cities, was mainly build during the 1950s, 60s and 70s. The highways and urban boulevards which were constructed at that time still constitute the backbone of the current transport system of the city. In parallel to these large road works, the actions which were undertaken by the local authorities these last decades have aimed to maximise the space available for cars and transport in general in the urban area, as an answer of the rising demand for travel. The current road network supply of the city and agglomeration of Liege is thus mainly the result of the works which were realized all along the second part of the 20th century.

At the agglomeration level (P3), the capacity offered by the highway network and by the numerous interchanges allowing to reach the city is really high. However, this high capacity is justified by the very high traffic flows which exist on these roads. More details on the causes of these flows are provided in section 4.4.1.

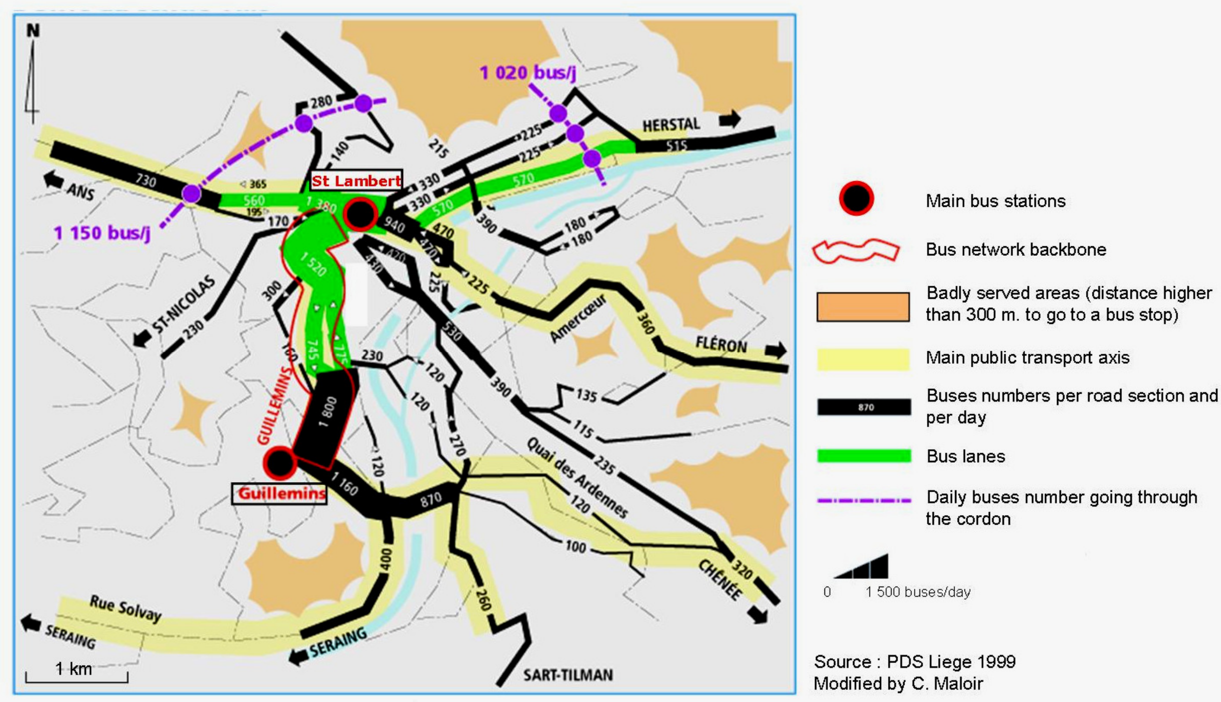
Then, concerning the supply of the road network **at the densely urbanised level** (P2), a quantitative analysis of the numbers of vehicles penetrating into the city centre and of the diffusion of these flows through the urban road network allow to understand a part of the congestion problems causes in the city, the other part being explained by the nature of the urban traffic demand (see section 4.4.1). Firstly, although the traffic flows are well-balanced between the different parts of the city, there is a real general **inadequacy** between the high flows capacity of the highways and interchanges and the restricted capacity of the urban road network. This capacity difference has important harmful effects on the urban circulation. Indeed, the urban road network is often saturated (especially at peak hours), what penalizes the totality of the transport modes. This situation is thus extremely harmful for the quality of the public transport services, the buses being stopped in the traffic jams. Secondly, the important traffic flows coming from the highways interchanges is spread through the urban fabric without a real **hierarchy**. The lack of an efficient traffic management damages highly the life quality of the neighbourhoods which are continuously crossed by these flows (in yellow in fig.4.4). A restructuration of this transit traffic on the main roads would allow a more efficient diffusion of the traffic through the city, what would be beneficial for the overall mobility of the city, as well as an improvement of the urban living environment in the harmed neighbourhoods.

4.3.2. PUBLIC TRANSPORT SUPPLY

The **rail network** of the agglomeration of Liege is really dense. However, even if the rail transport supply is high (with about twenty railway stations in all the agglomeration), the number of trips made by train is actually small. Indeed, although the train frequency (two trains per hour per line on average) is enough for the long distance trips (regional and national trips), this train frequency is far too low to be efficient for agglomeration trips (trips within the agglomeration of Liege).

The structure of the **bus network** presents essentially a radial structure, converging through two main poles (the central Saint Lambert square and the outlying Guillemins station) which are linked together by a high quality bus network (fig.4.3). The supply for bus trips is actually really high in the city centre of Liege (perimeter P1 extended to the Guillemins station). Several main roads of the network are frequented by more than 1000 buses a day (1800 buses on the main boulevards of the city, that means 2 buses per minute at peak hours).

Fig.4.3. Bus network supply in the city centre of Liege



But, nevertheless this high buses supply and the existence of special buses facilities in certain area of the city (bus lanes see fig.4.3), the commercial speed[1] of buses is really low[2] and irregular in the urban area. In fact, at every moment of the day (even at peak hours), the speed of car trips is higher than the one of bus trips ! Consequently to this observation, why people would choose to travel by bus when they have the possibility (financial possibility or age to have a permit licence) to travel by car ?

4.3.3. Bike supply

The use of bike to travel in the city of Liege is really rare. The inadequacy of the current road network, that make bike use highly dangerous, and the lack of adapted bike facilities have made its use obsolete. However, since recently, there is a real will from citizens and local politicians to "reintroduce" bikes in the city. More details about the measures that will be implemented to promote bike use are provided in the section concerning "bike demand" (section 4.4.3).

4.3.4. Parking supply

Besides the analysis of the road network and of the public transport supply, the study of the parking supply in and around the city centre (P1 and P2) is also a factor which plays an important role on the travel behaviour of people.

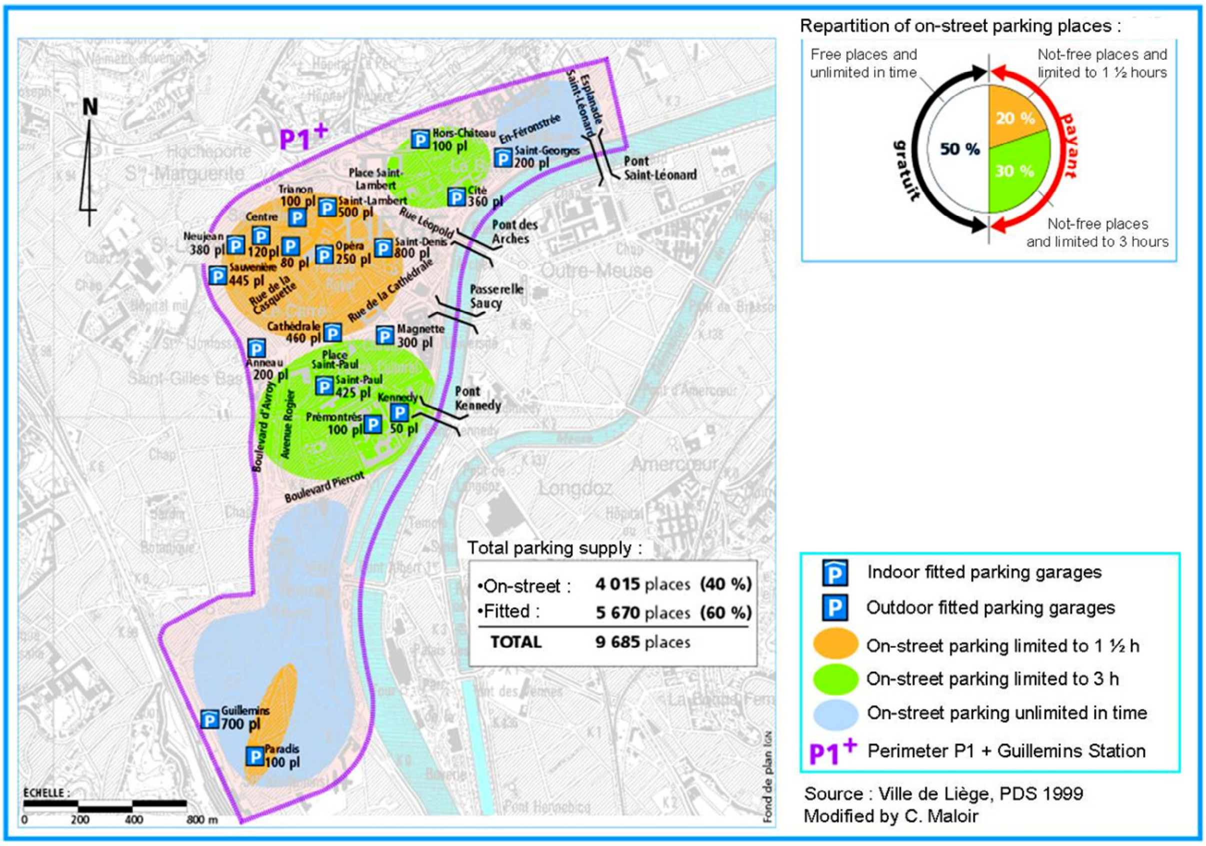
The parking supply **in the city centre** of Liege (perimeter P1 extended to the Guillemins Central Station) reaches the 10 000 parking places. On these 10 000 places, about 40 % are on

[1] The commercial speed of a bus is the average speed of the bus for a section of the route, i.e. the distance between origin and destination points divided by the time, including the time taken for all the stops, the regular stops (for passengers movements) as well as the unexpected ones (due to traffic jams, traffic lights or obstacles). (Ville de Liège, PSD 1999)

[2] In the municipality of Liege, more than 3 bus trips on 4 are characterised by a commercial speed of less than 15 km/hour (Petit, 2001, p.63)

streets. Half of these on-streets parking places are free and unlimited in time ! (fig.4.4) With so many free parking places without time limitation, the rotation of street parking cars is not dynamic enough, what is harmful for the economic and commercial activities of the city. Moreover, nevertheless the price rising of the metered parking places since 2003, on-street parking fee is still so low (1 €/hour and free between 12:30 and 13:30 PM and after 18:00 PM) that it does not dissuade the parking on-street. By comparison, parking on metered street places in Groningen costs 1,80 €/hour and this fee is in application from 9:00 AM to 10:00 PM from Monday to Wednesday and from 9:00AM to midnight from Thursday to Saturday. Moreover, besides these on-street parking places, the other 60 % of fitted parking places (indoor parking garages and outdoor fitted parking places) offer good potentialities to park in the city-centre of Liege (fig.4.4). However, the cost of these parking places (sometimes five times higher than street parking places) and the lack of security of these places explain their low occupancy rate.

Fig.4.4. Parking supply in the city centre of Liege



The same observations can be made about the **densely urbanised zone (P2)**. Indeed, on the 14 000 parking places located in this area, 93% are on-street parking places and only 3% are not-free and limited in time (400 parking places). These ones are located in the most commercial streets, where the car rotation rate is higher.

As a first conclusion, one can say that the major problem of the parking policy in Liege is thus not a problem of insufficiency of parking places but rather a problem of management of these places (limited parking time, pricing, incoherency between on-street and fitted parking places). Further observations will be added when the demand for parking will be tackled (section 4.4.4)

4.4. TRAVEL DEMAND ANALYSIS

The demand to travel is the second main component that constitutes a transport network analysis. The travel demand is the expression of the transport needs of a population living in a particular area. This section focuses therefore on the travel demand of the population of Liege (including the population living in the city centre as well as in the agglomeration), presented per transport mode. Moreover, this section goes further into the analysis by comparing the current travel demand with the existing transport supply. The balance between demand and supply allows to highlight the capacity shortcomings of the Liege transport network. The projects that are planned to deal with these shortcomings are also presented in this section.

Finally, before starting the analysis itself, a remark has to be made concerning the demand for parking places (section 4.4.4). This section makes the distinction between short-term and long-term parking users. But it does not deal specifically with the parking demand of the inhabitants living in the municipality. These ones represent however a significant part of the parking demand for on-street places. It must be mentioned that, besides metered street parking, special yearly parking cards can be obtained by the Liege residents for free. This resident card was introduced to assure to citizens cheap parking close to their residence. This system is essential to sustain the attractiveness of the city and to attract newcomers to live in Liege. For the same reasons, such a resident card system is also in application in Groningen (one card costing 40 € per year per inhabitant).

4.4.1. ROAD NETWORK DEMAND

The strong suburbanisation phenomenon that has known the city of Liege these last decades has had huge consequences on the traffic flows of all the urban agglomeration. Indeed, in accordance with the theory of the congestion vicious circle (fig.2.11), the spatial spreading of the population has for consequence an increase of the travels length and of the travels number. In consequence, the daily traffic flows on **highway network** between peripheral areas and city centre (or other peripheral areas) are really important, what causes some traffic management difficulties around the city. In terms of vehicles, in 1998, these highway flows represented on average 330 000 vehicles per average weekday (24 hours), which has not generated congestion problems yet. But, since this period, traffic flows have strongly grown. Indeed, between the year 1998 and 2007, highways traffic flows have known a yearly augmentation of more than 2 %, reaching the 400 000 vehicles per average weekday (Ville de Liège, commission spéciale mobilité, février 2008). Consequently, the current capacity of highways and interchanges is not high enough to satisfy the current (and still increasing) demand. Extra measures are needed to solve this capacity shortage.

In this context, the solution which was chosen in the mobility plan of the city is to build a **new CHB highway junction** long 12 kilometres to the east of the city, between the actual E25 and E40 highways (fig.4.1). This project, although highly expensive[1], harmful for the local population and environment[2] and in total opposition with the principle of stopping new roads

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[1] The CBH project, it is the construction of a 12 km highway junction, but also of 6 new interchanges and 3 viaducts. According to the engineers of the Ministry of Equipment and Transport, "CBH would be the most spectacular of our highways junctions". The total cost of the project (excluding maintenance costs, …) is estimated at 400 millions of Euros (Lamarche, 2008).

[2] The construction of this junction would necessitate the expropriation of many inhabitants (and would harm the living environment of many others). Moreover, this junction would be build crosswise a Natura 2000 zone, a veritable green hearth located at only 10 kilometres of the city.

construction, has received lots of supports. Firstly, this new junction would finalize the actual uncompleted ring way, what would allow too many cars which actually transit uselessly by the centre, to bypass it. Moreover, many studies have shown that this new highway junction would diminish the general pressure on the highway network. Finally, this new junction would also strongly reduce the traffic flows of the Meuse river banks. Ideally, this traffic diminution along the Meuse valley, if supported by measures favouring bus flows (and the construction contract is written in that way, assuring that for every euro invested in the highway construction, one euro will be invested in the public transport network (compensation principle)), could be really favourable to the development of a high quality public transport services in the urban area of Liege. However, all the arguments advanced here above are highly controversial[1] and this project is (still)[2] under discussion.

The demand for road travel **in the urban area** must also be discussed. However here, it is not the quantitative aspect of the demand which is problematic but rather its nature. On the basis of a qualitative analysis of the actual traffic of the densely urbanised zone of Liege (P2), three traffic categories can be identified : the intern traffic (or local traffic), the exchange traffic, and the **transit traffic**[3]. While the two first traffic categories are necessary for the economy of the city, the transit traffic is completely useless and even harmful for the city. Unfortunately, this last one represents 40 % of the total traffic of the city (fig.4.4). This situation can be partly explained by the suburbanisation phenomenon which touched the city these last thirty years. During this period, large institutions (like the hospital centre and the university) were transferred from the city towards its periphery, and many out-of-town large shopping centres have been located at the city's edge. Presently, these poles of activities contribute to the major part of the traffic flows, going in and out of the city (Petit, 2001). The emergence of these secondary poles of activities, encouraging greatly private car use, has changed profoundly the intensity and the travel behaviour on the road network. As an example, it is common that a person living in the East of the city works in the West, and reversely. Due to the radial structure of the road network and the lack of concentric elements intercepting this structure (section 4.2), this person, like many others, will go through the city to go at work (idem for all the other daily activities). These flows explain the important traffic of transit which daily cross the city of Liege. Consequently, the overall mobility in the city is slowed down. Some bridges are constantly under pressure and local transit even develops in many neighbourhoods around the city centre, what directly impacts the life quality of these areas (fig.4.5).

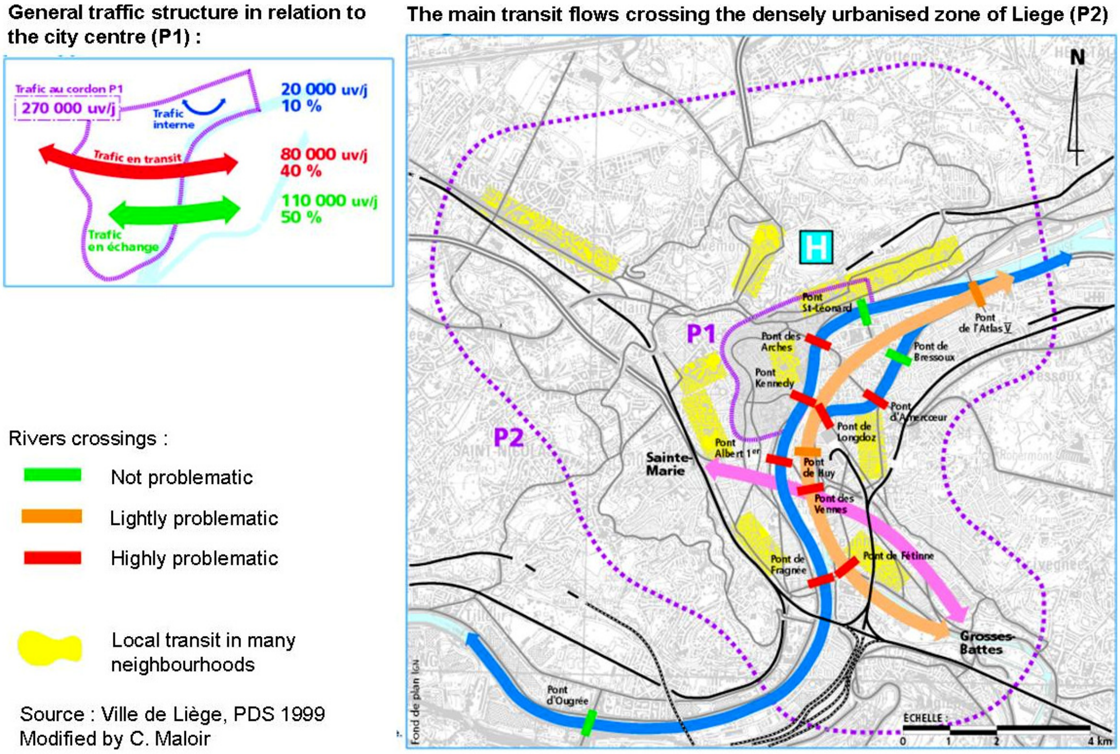
[1] As an example, a study has concluded that only 2,7 % of the traffic that would use the CBH junction would be transit traffic, the largest extent of this traffic being local traffic. In addition, this new junction would not involve a diminution of the pressure on other highway junctions. At the opposite, the CBH junction would at long term even attract more traffic than presently (Lamarche, 2008).

[2] Indeed, as the Walloon Minister of Transport has declared : "we are waiting this highway project since 30 years". In other words, this project dates from before the oil crisis and the climate warming issue. The question is to know if this project is still adapted to the present situation and needs.

[3] - Intern (or local) traffic : The complete course of this traffic (origin and destination points, and route between these two points) is totally inside the limits of the studied zone.

- Exchange traffic: The origin or the destination of this traffic is out of the studied area.
- Transit traffic : The origin and the destination of this traffic are out of the studied zone. So, the transit traffic goes through the studied zone without stopping in this zone (com. de Liege, PCM 2004).

Fig.4.5. General structure of the traffic and transit traffic problems in Liege



These observations mean that a change of displacement habits, such as the modification of itineraries (via the management of these transit flows) or the use of other transport modes, would allow to eliminate a large number of useless cars from the city centre, and thus solve a part of the congestion problems that the city presently knows. These measures are elaborated in more details in chapters 6 and 7.

A last remark must be made concerning the **intern traffic** in the municipality. Although this traffic only accounts for 10 % of the total traffic of the city (fig.4.5), some studies concerning the travel habits of the inhabitants of the municipality of Liege have proven that more than 50 % trips made by cars cover distances shorter than 5 kilometres. Yet, for such short distances, other modal alternatives like walk, bike and bus would be perfectly conceivable (Petit, 2001, p.59). By making these alternative modes more attractive (safer, faster, more comfortable, cheaper,…), a part of the intern traffic which presently contributes to the congestion problems of the city could be avoided.

4.4.2. PUBLIC TRANSPORT DEMAND

The demand to travel by **train** is directly proportional to the railway transport supply. Thus, with an extensive railway network, but a too low train frequency, the demand to travel by train is quite high at the regional level (with 28 000 travellers a day on average in the main station of Liege Guillemins), but is really low in the agglomeration (with less than 500 travellers a day). The train only accounts for 2% of the total trips made in the agglomeration of Liege.

On the contrary, the travel demand for **buses** is relatively high, with about 180 000 travellers a day in the agglomeration (PDS Liege 1999). However, the frequency rate of bus trips is highly unstable throughout **time** and **space**. Indeed, the bus modal split represents only 10 % of the total trips made in the agglomeration on a 24 hours basis, but it can reach 20 % during the morning peak hours. Moreover, by analysing the spatial repartition of this demand, it can be observed that the bus trips are highly concentrated in the inner-centre (P1 extended to zone included the Guillemins train station) (fig.4.3). These inner city trips account for two third of the total bus activity in the urban agglomeration. This high demand for buses in the central area can be mostly explained by the socio-economic profile of the urban population and the low car ownership characteristic to many cities. Indeed, the living population in Liege is composed of a large number of students and of an ageing and poor population (chapter 3). Most of these people do not use the bus services by choice but because they have limited incomes and/or are not allowed to drive (no licence permit). To move, they do not have other choices than walking (only for short distances) or to use the bus, and that nevertheless the slowness of buses in the city centre (see public transport supply, section 4.3.2). Finally, and against all expectations[1], the bus use in Liege (and in the entire region) has experienced a strong growth since the year 2000. This occurred without any changes concerning the socio-economic profile of the population living in the city. Therefore, other causes must be considered to explain this recent success (e.g. the recent improvement of bus services and its promotion, the rise of fuel price, the people awareness to environmental issue, …). For the moment, however, the real causes of this augmentation of the bus frequency rate have not yet been thoroughly analyzed and understood.

This last observation highlights one thing. Nevertheless the low commercial speed and recurrent delays that are characteristic of bus trips in the city of Liege, the bus trips demand is growing. That puts into the fore the high potential that bus services represent to serve urban population. Consequently to these results, local authorities have decided to improve considerably the quality of bus services in the city. Different projects exist. However, all of them agree on the fact that the improvement of bus services will necessarily request a strong restructuration of the current bus network and the implementation of measures that give larger priorities to bus flows, while restraining car flows. Concrete measures to improve bus services are proposed in chapter 7.

4.4.3. BIKE DEMAND

Although the number of trips made by bike in the city is presently really low, several surveys conducted among the local population have shown that there is a real high latent demand to use bikes more extensively. To satisfy this demand, the city got in 1998 a new bike itineraries plan. This plan aims at improving the urban bike network. In that perspective, it points out the roads (and bridges) which have to be built or adapted to assure continuous, fast and safe trips to bikers. The plan also plans the development of additional bike facilities as well as the creation of bike services (e.g. bike itineraries folders, promotion campaigns, educational programmes, …). Many actions planned in this plan were implemented these last years (e.g. development of bike itineraries, *bike traffic lights*, *limited one-way streets,* promotion campaigns, …), but the remaining efforts required to supply safe and fast movements to bikers are still numerous.

Moreover, recently the local authorities have decided to make of the bike use a top priority for the city. In this perspective, a new project of rental bike system should be developed by 2009 to complete the current bike supply. This project consists in developing a network of bike stations covering as well the inner city as the surrounding neighbourhoods of the city. More details about this rental bike project are provided in chapter 7.

[1] On the basis of a diagnostic of the bus travel demand realised in 1998, the future expectations were rather pessimist concerning the evolution of the demand to travel by bus (Ville de Liège, PDS 1999).

4.4.4. PARKING DEMAND

The supply characteristics for parking in the **city centre of Liege** (perimeter P1 including the Guillemins Station), i.e. numerous free (or cheap) on-street parking places, influence directly the demand to park.

Firstly, the **quantitative analysis** of the parking demand in the city centre of Liege (P1) induces two observations. On the one hand, the occupation rate of the on-street parking is quite low in the morning (occupied mostly by residents) but is saturated during the day (mostly workers and shoppers) and still high in the evening (mostly for leisure activities). In contrast, the occupation rate of the fitted parks is really low in the morning and in the evening and is only medium during the day. This first observation explains that at 3:00 PM, for example, about 2 500 parking places are free in the fitted parks while in the same time, the streets are totally saturated, with almost 450 vehicles illegally parked (PSD Liege 1999). This saturation state of streets is penalizing for the citizens which find hardly a parking place when they come back home from work. On the other hand, the rotation rate of on-street parking is really low, as well for places with unlimited parking time as for limited parking time ones. Daily, 35 % of the parking users exceed the permitted parking time and 75 % of vehicles are without parking tickets or exceed the ticket time. The lack of regular control by the police explains this situation (PSD Liege 1999). Therefore, since 2003, the city has intensified the parking control, hoping by this action to limit the number of parking offences.

Secondly, the **qualitative analysis** of the parking demand has allowed to get more information on the parking duration and time. The result is that the majority of parking places are occupied by long-term users. In general rule, these users are commuters who “squat” the parking places for the whole duration of their working day. This situation leaves only a few parking places available for the mid- and short-term users, however the most economically useful for the city. Consequently, most of them choose to park illegally (e.g. on pedestrian crossings, bus stop areas, …), what among other things harms the general urban mobility and the safety of pedestrians.

These observations are similar for the **densely urbanised area level (P2).**

As a general conclusion, one can say that the lack of available parking places on street (though fitted parks are far from being full) and the low rotation rate of these places are responsible for the high rate of illegal parking activity in and around the city centre. This situation is highly harmful for the quality of life of urban area as well as for the general attractiveness of the city.

4.5. IN SUMMARY

The goal of this fourth chapter was to carry out a complete analysis of the Liege transport network. It was structured as proposed in the theoretical framework, namely a first analysis of the transport supply, followed by an analysis of the travel demand. Moreover, the urban structure of the city was preliminarily described.

This analysis has allowed to provide a detailed overview of the elements that constitute the current transport network of Liege. The main points that have emerged are listed in the following table :

TRANSPORT SUPPLY		**TRAVEL DEMAND**
- High capacity of highways and numerous interchanges BUT uncompleted ringway - Capacity inadequacy between highways and urban network - Bad hierarchy of the urban road network	**Road**	- Really high demand, and still increasing - High transit traffic and intern traffic
- Well-developed rail network capacity & good train frequency for regional/national trips - Well-developed bus network & high bus frequency BUT low bus commercial speed and unreliable PT services (delays)	**Public transport**	- Low train demand for intercity trips but in the national average train demand for regional/national trips - High bus demand (especially at peak hours), and in augmentation since recently - Bus demand concentrated in the city-centre
- Low supply for bike network and bike facilities BUT …in improvement	**Bike**	- Rare bikers but real latent demand
- Very high parking supply - Bad parking management	**Parking**	- Unequal occupation rate between on-street and fitted parking places - High illegally parked cars - Low rotation rate (many long term users)

To sum up : (1) the large space dedicated to roads around and in the urban area of Liege explains rather logically the high number of cars and the important transit traffic that currently exist in the city ; (2) the high demand for bus trips, nevertheless the low commercial speed and unreliability which characterise this transport mode, highlights the large potentialities that could have buses to partly solve transport problems ; (3) the poor development of the bike network and facilities explains the rarity of its use. However, a real latent demand seems to exist for this travel mode ; (4) nevertheless a high parking places supply, the absence of a real parking management policy makes the current parking situation highly problematic.

The information provided in this chapter will serve as basis information further in this work, firstly to evaluate the importance that plays the concept of Travel Demand Management in the transport planning practices of Liege (chapter 6), and then, to define the TDM measures that could be transferred from Groningen to Liege (chapter 7).

The next chapter will analyse the transport network of Groningen. Like for the Liege case, the goal of this analysis is to highlight the main characteristics of the transport system of the city.

5

TRANSPORT NETWORK ANALYSIS OF THE CITY OF GRONINGEN

5.1. INTRODUCTION

In the goal of conserving a certain coherence between the transport network analysis of the cities of Liege and Groningen, this chapter follows the same three-steps organisation that the previous one, namely the description of the spatial structure of Groningen, the analysis of its transport supply and the analysis of its travel demand.

The information which are provided in this chapter also try to be as much coherent as possible with the ones provided in the case of Liege. However, this coherence is limited by the quantity and the nature of the information which have been collected in both cities.

Like for the case of Liege, all the figures sources which were used in this chapter are not mentioned in the text below. In fact, the largest part of the information were collected in the mobility plan of the city "stad in beweging 2007-2010" and in the document "traffic and transport policy for the city of Groningen (progressive)" published in 2006 by the municipality of Groningen for the occasion of the ECOMM conference (European Conference on Mobility Management). When the information was found in a different document than the two ones mentioned above, the sources are given in the text. Moreover, these data are completed by information collected through interviews which were conducted with different actors acting in the field of transportation in Groningen.

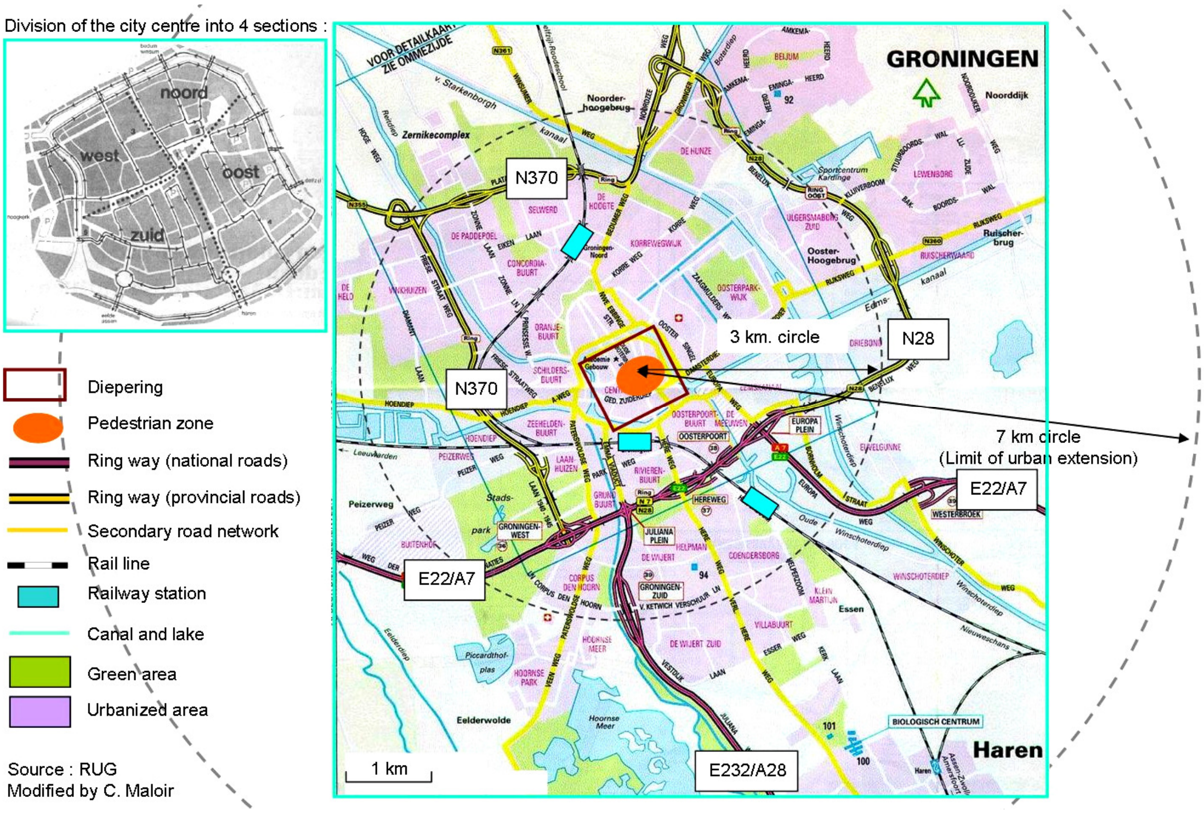
5.2. URBAN SPATIAL STRUCTURE AND TRANSPORT OBJECTIVES OF THE CITY

As it is mentioned in chapter 3 (section 3.2), the first limitation to the extension of the city were the **fortification wall** and the **Diepering** which encircled the urban enclosure until the mid 19th century (fig.3.2 and 5.1). At that time, the local authorities decided to destroy the wall which was a constraining obstacle to the growth of the city. However, although the wall was broken up, the canal is still present and strongly structures the current urban organisation of the city (www.grunn.nl). Indeed, the transport infrastructure inside the urban area of Groningen is built up around the Diepenring. The inner city has a narrow and old network of streets, while the Diepenring itself is flanked on both sides by an inner ring road. Then, at the end of the 20th century, a second structuring element was constructed around Groningen : the **ring way** (fig.5.1). In fact, this ring way was completed in different parts, from 1970 (southern ringroad) to 1986 (eastern junction). The ring connects the urban road network of Groningen with the regional and national infrastructure network. It was constructed to satisfy the rising motorised traffic flows that experimented the city at that time. It totally encircles the central area of Groningen. The system ring way and interchanges allows an efficient management and distribution of the traffic flows around the city. Moreover, this circular structure allows to stop motorised traffic upstream of the central area of the city. Actually, this is done by concentrating the car drivers on multimodal platforms (fig.5.5) and then by encouraging them to use alternative transport modes (like city buses or train) to access to the city centre.

In addition to these two physical barriers, in the late 1970s the local authorities have taken two important decisions concerning the developments of the city. These decisions have had a determining role on the urban organization of Groningen. Its current structure still owns numerous traces from the choices which were taken at that time.

The first important development choice which was made was the implementation of a new **circulation plan** for the inner city in 1977. The traffic in the inner city was extensive restructuring. The inner city was divided into four sections, and the boundaries between these sections may not be crossed by private cars. Instead cars have to use the inner ring road as the shortest way to move from zone to zone. But public transport (including taxis), cyclists and pedestrians can cross freely the sector boundaries. Other supportive measures were also implemented, e.g. the pedestrian area was expanded and the cars were totally forbidden in certain central areas (fig.5.1) (Gem. Groningen, an integrated town planning and traffic policy, 1992, p.11). Although these measures were largely criticised in the first years following the reform (especially by the shopkeepers of the city centre afraid to lose their clients), it was proven that in the long term this plan has led to a great success : the improvement of the shopping climate in the city centre, an enhanced quality of public spaces, an increase in the number of visitors, and also a remarkable increasing use of public transport and softer transport modes (walking and bicycling) associated to a significant decrease of the cars number in the inner city. According to Gerrit van Werven, a senior city planner, this plan was not only intended to be an environmental programme, but also an economic initiative which has boosted jobs and business in the city (www.globalideasbank.org). Indeed, following this success, at the end of the 1980s the shopkeepers themselves “pressured” for a large extension of the pedestrian zones.

Fig.5.1. Urban structure of Groningen



However, the promotion of public transport and softer transport modes would not be possible without the deep coordination between transportation policy and spatial planning. Indeed, such a circulation plan would not be efficient without an adapted town planning. So, the second choice of urban development which has largely impacted the general structure of Groningen was the **compact city policy**. This model of urban organisation promotes a careful and restricted location of diverse activities (e.g. mixed land use, ABC policy1, interdiction to

[1] More information about the ABC policy, see Linden and Voogd, 2004, chapters 13 and 14

develop peripheral secondary centres to protect the commercial activities of the city-centre and the attractiveness of the central area) and does not allow urban extensions situated at more than 7 kilometres[1] from the Grote Markt (city centre). As a result of this policy, 78 % of the residents live and 90 % of the employees work within a 3 kilometres circle around the Grote Markt (fig.5.1) (Gem. Groningen, ECOMM 2006). The compactness of the city, the high density of its urban fabric and the shortening of the distances to cover, also favour the use of public transport and softer transport modes in the city.

These two main development choices had not only large consequences on the physical structure of the city. By promoting softer transport modes, these measures have also influenced deeply the transport system of Groningen as well as the travel behaviour of its citizens. More details about this topic are given further in this chapter (sections 5.3 and 5.4).

Since this period, all the actors concerned by the future development of Groningen have agreed upon two **central goals** for the city : to strengthen the economic position and the central function of Groningen for the northern region ("hoofstad van het noorden") and at the same time to improve the quality of life in the city. These goals were laid down in the different structure plans of the city. The **traffic and transport policy**, as the other planning fields, has developed its own objectives which come within the scope of these strategic goals. Its two main missions are (-2010, Stad in beweging 2007, p.3) :

- To assure the good **accessibility** of the city to reinforce the attractiveness of Groningen and to sustain its economic development
- And to sustain the **liveability** of the city by restricting car traffic (in a selective way[2]) and by stimulating alternative transport modes, such as public transport and the bicycle

The task for the city is thus to reach a delicate balance between accessibility and liveability.
The local authorities use **various instruments** to achieve this goal. In addition to the town planning policy described above, the most influential instruments are the creation of special facilities for environmentally-friendly transport alternatives (e.g. bike and bus lanes, fast connection and prioritisation to limit travel time, bike parking, multimodal platforms to improve the complementarity between transport modes, etc) and the implementation of a traffic management system that leads to a restriction of private car traffic. This can be achieve by using more efficiently the existing roads, in opposition to create new ones (e.g. via a better traffic lights coordination on main roads or via the construction of P+R facilities coordinated with city buses). A second solution is to concentrate car traffic on only a few main roads (e.g. by limiting the speed to 30 km/hour in residential areas). Finally, the most direct mean for local authorities to restrain car traffic is the implementation of restrictive parking policy. (Gem. Groningen, an integrated town planning and traffic policy, 1992, p.6-11).

This list of instruments is of course not exhaustive. A more detailed list is presented in chapter 6 dealing particularly with Travel Demand Management measures.
By the many elements which are mentioned above, it seems clear that the urban structure of Groningen corresponds in a large extent to the latest model, namely the "**traffic limitation"**

[1] 7 kilometres, what equals to 20-30 minutes in bike travel time, is considered the upper limit above which the travels by bike become to long and are replaced by the use of a motorised vehicle (public transport or car) (Stad in Beweging, 2007, p.6)
[2] The city of Groningen makes the distinction between the useful and not-useful car traffic. Car traffic which is economically necessary, such as for example for delivering goods, are example from restrictive measures. In the other hand, non-essential car traffic, such as commuter traffic, is restricted as much as possible (Van nu naar straks, 2005, p.37)

model (fig.2.3). Indeed, this model is characterised by the implementation of traffic control and modal preferences (favouring public transport and softer transport modes while limiting private car uses), a high land use density (compactness of the urban fabric), a strict and clear hierarchy of the road network and the presence of many interchange places (multimodal platforms). It must also be mentioned that this kind of urban structure requires a long planning history. The urban organisation of Groningen is in line with these features.

5.3. TRANSPORT SUPPLY ANALYSIS

Like for the Liege case, the analysis of the transport network of Groningen also starts by an analysis of the supply in transport, per transport mode, in terms of infrastructures and services.

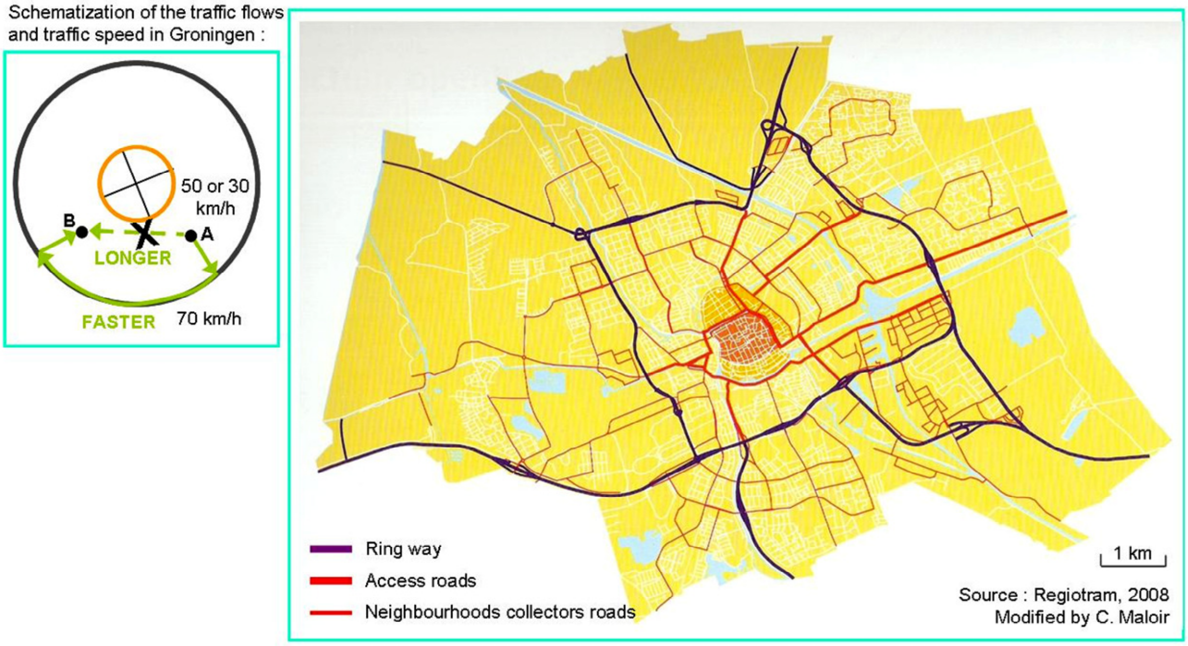
5.3.1. ROAD NETWORK SUPPLY

As early mentioned in chapter 1, the road network of Groningen was mainly build during the 1950s and 60s. Then, in the 1970s the city has experimented a radical shift from the right-of-way principles towards the integration of environmental considerations into transport policy and planning. Since this period, the mobility objectives for Groningen are to improve the liveability of the urban environment of the city and its accessibility.

In this context, the local authorities have favoured since the 1970s the use of public transport and softer transport modes **in the city centre** to improve the quality of life of the urban area.
To improve the liveability of the city, the choice was made to stop the extension of roads capacity. Instead of that, the priority was given to the restructuration of the existing urban network. The circulation plan of 1977 played a major role in the reorganisation of the network ; other plans and measures have followed and reinforced the measures taken in 1977. Actually, the capacity of the current road transport system decreases through a "funnel" effect as moving from the peripheral ring way towards the inner city. Based on the map below, three main roads levels can be identified : the ring way, the access roads which link the ring way to the diepering (secondary ring around the city centre), and the neighbourhood collectors roads (fig.5.2). The map makes it clear that Groningen has a diffuse network of neighbourhoods collectors. The traffic intensity of these roads is reasonably high, while the traffic on the roads serving these neighbourhoods is relatively much lower. To protect the overall life quality of the neighbourhoods, traffic on these latest roads has to be sustained as low as possible (Gem. Groningen, ECOMM 2006 ; Gem. Groningen, stad in beweging 2007-2010).

This strong hierarchy of the network allows an efficient control of the traffic flows through all the urban area. As a first example, the measures which were implemented in the urban area constrain so much cars flows that it is presently longer (in distance and time) to go by car from a point A to a point B by using the neighbourhood roads than to take the ring way (fig.5.2). In addition to constrain cars flows, the actual roads organisation also gives the priority to public transport and bikes, what makes them faster than cars. Indeed, when in 10 minutes a car covered an average distance of 1,6 km, in the same time a bike covers an average distance of 2,4 km ! (gem. Groningen, 2006a)

Fig.5.2. Roads network structure in Groningen



However, although the measures taken since the 1970s have had really positive effects on the liveability and the mobility in the central area of Groningen, the city nowadays knows growing congestion problems on its **ring**, what impacts negatively the accessibility of the city. More details on the causes of these congestion problems and the solutions which are planned to solve these problems are provided in the chapter “road network demand” (section 5.4).

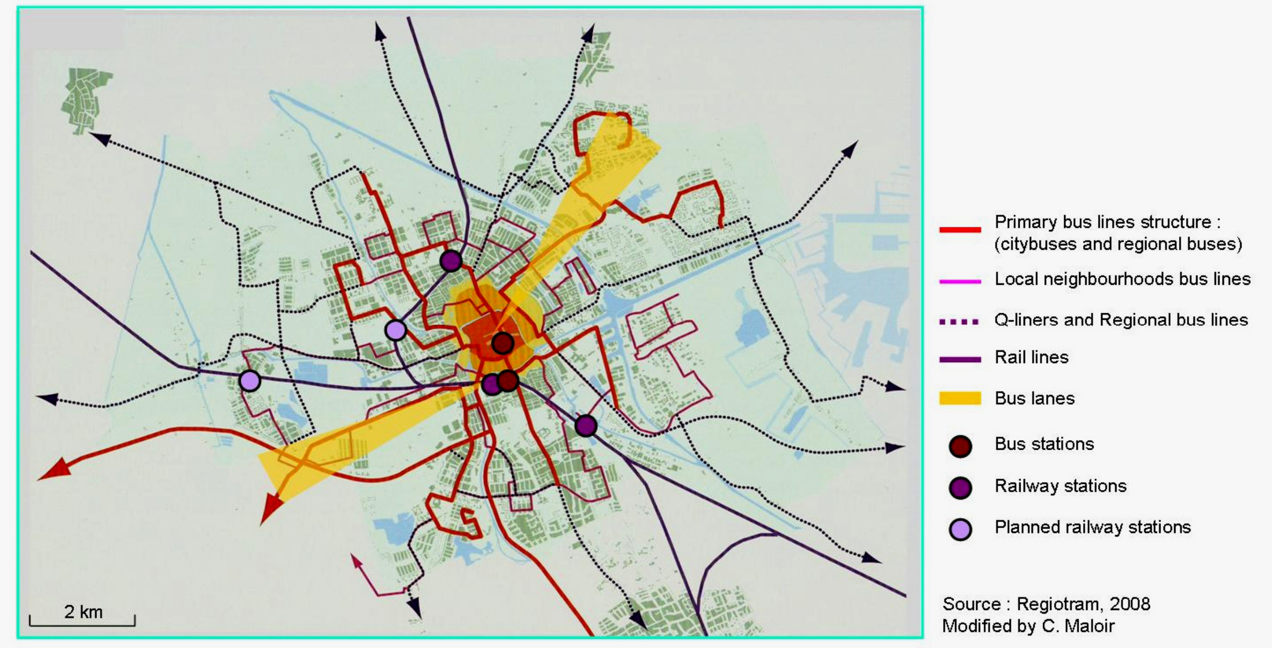
5.3.2. PUBLIC TRANSPORT SUPPLY

A good public transport supply is a key element in the achievement of a liveable and accessible city and region (Gem. Groningen, Stad in beweging 2007-2010, p.10). For that reason, the local authorities have decided long ago to favour the development of train and bus services. The 1977 circulation plan and the compact city policy discussed above are main proves of this political will to prioritize public transport, as well as softer transport modes (see bike supply in section 5.3.3.).

So, in consequence to the numerous improvements that received the public transport supply throughout the successive traffic and transport policies, Groningen has presently a really dense **public transport infrastructure network**. This network can be subdivided into two categories : the commuter net and the collector net. The commuter net ensures that Groningen is well connected to the region by means of the train, the Q-liner[1] (or express regional/commuter buses) and the regional buses. In the city, this net consists of a number of urban lines to the suburbs. In the other hand, the collector net serves rural areas and, in the city, provides access to local neighbourhoods (fig.5.3) (Gem Groningen, ECOMM 2006).

[1] The “Q” means Quick and Quality. So, the Q-liner bus lines are fast and comfortable buses which connect urban areas (long-distance bus trips). They can achieve really high commercial speed because the number of bus stops is small and in some cases, these buses are allowed to use the extra lane on highways (e.g. Q-liner Assen-Groningen uses the A28 highway to go faster) (www.arriva.nl)

Fig.5.3. Public transport network structure in Groningen



Moreover, in addition to this dense infrastructure network, public transport also enjoys high quality facilities.

Concerning **train services facilities,** Groningen has three railway stations (fig.5.3). The Central Station is located in the South of the inner city. All the rail lines meet there and the station is connected with a bus station. Then, the Northern Station, which is really smaller, only represents approximately 6 % of the total train passengers of the city. Its main mission is to serve the northern neighbourhoods of the city. Finally, in October 2007, the new Europapark Station was opened in the south-east of the city in relation to the new real estate project Europapark[1]. The current location of the station is temporary ; it will move to its definitive location by the year 2010.

However, what makes the strength of the Groningen public transport is its **high quality bus services**, also called BRT for *Bus Rapid Transit* (or HOV in Dutch for Hoogwaardig Openbaar Vervoer). The main elements which constitute the BRT are :

- Bus stations : Groningen has two important bus stations, one at the Central Station and one on the Grote Markt, in the heart of the city (fig.5.3).
- Bus lines : the bus lines network of Groningen is constituted by three buses categories : the regular urban bus lines which serve all the urban area of Groningen, the Q-liners and regional bus lines which connect Groningen to other surroundings urban areas, and the citybuses which connect the P+R facilities to the city centre. A strength of this bus system is the complementarity which exists between all these bus lines. So, an urban bus is no longer necessary where a regional bus is already operating. This coordination allows to offer better bus services, with high bus frequency, accessibility and reliability.
- Bus lanes : in addition to the various part in the city which are exclusively reserved for bus and bike flows, Groningen has two main bus lanes : one long of 1,6 km to ensure optimum circulation from Kardinge to the Grote Markt, and one long of 3 km from

[1] Europapark project is a mix land use project of 43 hectares, combining working, housing and entertainments facilities. More information in this project : www.europapark.groningen.nl

Hoogkerk to the Central Station[1] (fig.5.3). These two high quality bus lines offer a fast connection between peripheral areas and central area of the city.

- Bus priority signals : buses are equipped with a system enabling them to influence traffic lights. This favours the bus traffic flows and prevents long delays.
- Park-and-ride locations : presently, five P+R facilities are located around the city centre of Groningen, along the ring way (fig.5.5). From these parking locations, people can park their cars and quickly travel to the city centre via a citybus or other regular bus lines.
- Modal integration : bus services are coordinated with walking and cycling facilities, rail network, taxi services and P+R facilities.
- Integrated and clear fare system : bus tickets are coordinated with train tickets and P+R parking tickets, what allows free or discounted transfer between different transport modes. Moreover, the utilisation of "eurokaartjes" for bus tickets (only tickets of 1, 2 or 3 Euros) provides a really clear fare system.

Some of these elements will be discuss in more details in chapters 6 and 7.

Consequently to the development of such high quality bus services, bus use provide some significant advantages compared to car use (e.g. buses are faster than cars along certain roads, buses are cheaper than cars and suppress parking problems, …), especially in the inner city of Groningen where the car flows have been strongly restricted.

5.3.3. BIKE SUPPLY

For the same reasons than the ones that have encouraged the local authorities to favour public transport use, choices were made to prioritize bike trips in the city centre of Groningen. So, for more than twenty-five years Groningen has had a consistent **transport policy** aiming at encouraging the use of the bicycle and discouraging the use of the car for short distances. In this task, the combined effects of the 1977 circulation plan and the compact city policy have provided the fundamental elements for the establishment of an urban environment perfectly adapted to bike use : the circulation plan has provided security and rapidity to bikers, while the compact city model has limited the length of intercity trips. The fig.5.4 highlights the importance that bikers attach to trips length, since the intensity of bike traffic strongly decreases with the lengthening of the distances to be covered to reach the inner city.

Besides these policies, the local authorities of Groningen have also invested a lot of money into the development of bike infrastructure along these last three decades. So, Groningen presently enjoys of a really dense **bike network** (fig.5.4). This one is constituted of 192 kilometres of bicycle paths or lanes[2], with 120 kilometres have been build in the last twenty-five years. In addition to be dense, this network is also of a high quality, with about 80 % of the cycling infrastructure asphalted (Gem. Groningen, ECOMM 2006).

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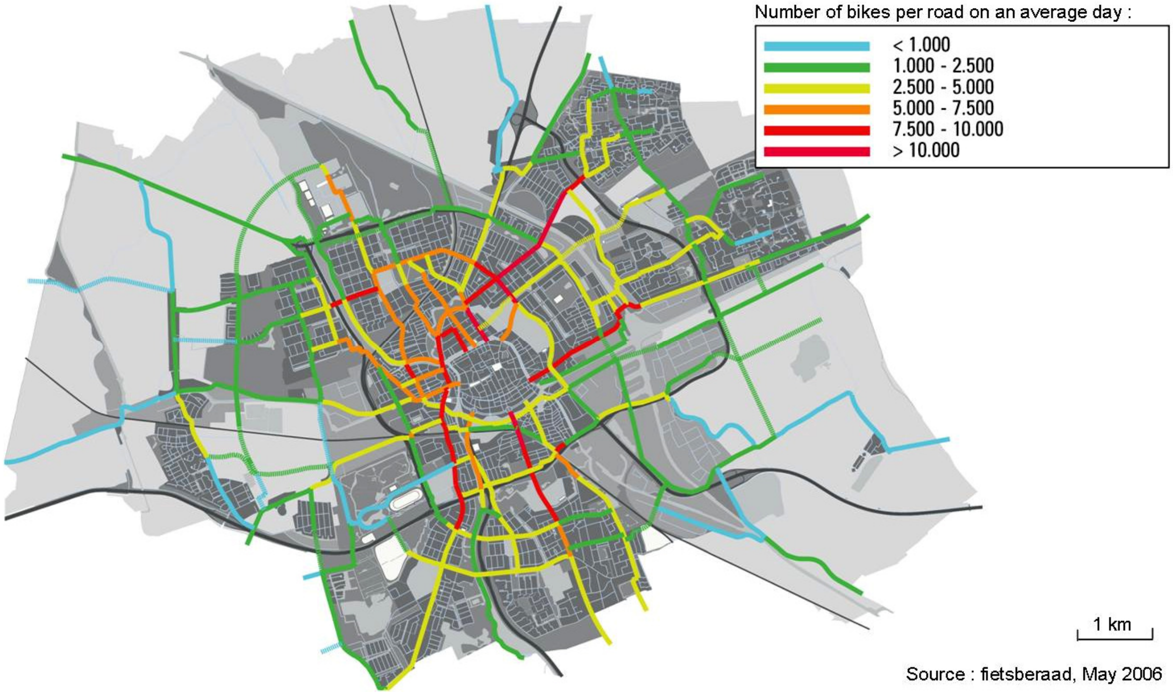
[1] The second bus lane which links the P+R Hoogkerk to the city centre is still under construction. Presently, the two first kilometres are operational, and the last kilometre would be build in the year 2010-2011.

[2] Bike paths and bike lanes are both bikeways, i.e. a facility that is provided primarily for bicycle travel. What differentiates these two terms is their situation in relation to the road. The bike lane is a portion of the roadway that is delimited by striping, signing, and pavement markings, while the bike path (also called sidepath) is adjacent to the roadway, completely separated from the motorised circulation. In Groningen, a bicycle path has been developed along all the city's most important access roads (Gem. Groningen, 2006a ; Bicycle Transportation Institute : www.bicycledriving.org)

The bike network is subdivided into primary and secondary routes. Primary routes must be safe and ensure that the cyclists have to cross as little motorised traffic as possible, while secondary routes connect residential areas to the primary bicycle routes.

Fig.5.4. Intensity of the bike traffic on an average day on the main bike roads in Groningen



However, to promote bike use, the existence of an extensive cycling network is not enough. To make the bike more attractive, the city of Groningen has developed numerous **additional bike facilities** such as *bike parking facilities*, s*pecial bike signs system, adapted traffic lights and circulation rules, wheeling ramps, bike and pedestrian bridges, limited one-way streets roundabouts*, *bubbled bicycle lanes,* etc. (see glossary for definitions of these terms).

Consequently to these numerous successive bike improvements, the bicycle offers now many comparative advantages to the car. Its main advantage is its speed, since the bicycle is on average 30 % faster than the car for intercity trips ! (SMILE website)

But, nevertheless the current high quality supply for bike in Groningen, the local authorities continue to give the priority to the bike supply improvement into present and future urban plans because, as Mr. van Werven (senior city planner of the Groningen municipality) has declared, "We don't want a good system for bicycles, we want a perfect system" (Global Ideas Bank). All the measures which are planned for the next three years are summarised in the bike policy of the city "Stap Op! fietsmaatregelen 2007 – 2010" (see the gemeente Groningen website for the detailed programme).

5.3.4. Parking supply

In respect to the strategic goals pursued by the municipality, the local authorities commit themselves to provide a high accessibility to the city centre for only economically necessary traffic (commercial traffic, transport of goods and shoppers) and, in the same time, to protect the liveability of the urban environment. The parking policy of Groningen supports the achievement of these goals by containing measures which restrict the unnecessary traffic flows in the city-centre.

To describe the parking supply of Groningen, the municipality can be subdivided into three spatial areas : the inner city (limited by the Diepering), the neighbourhoods located around the inner city, and the peripheral area along the ringway.

The parking supply **in the city-centre of Groningen** is of about 2 600 spaces, 35 % of these places are on-street parking places while the other 65 % are spread into the city centre into parking garages (fitted parking places) (fig.5.5). This repartition between on-street parking and fitted parking places is quite similar to the one of Liege. However, there are two big differences between the parking supply of both cities :

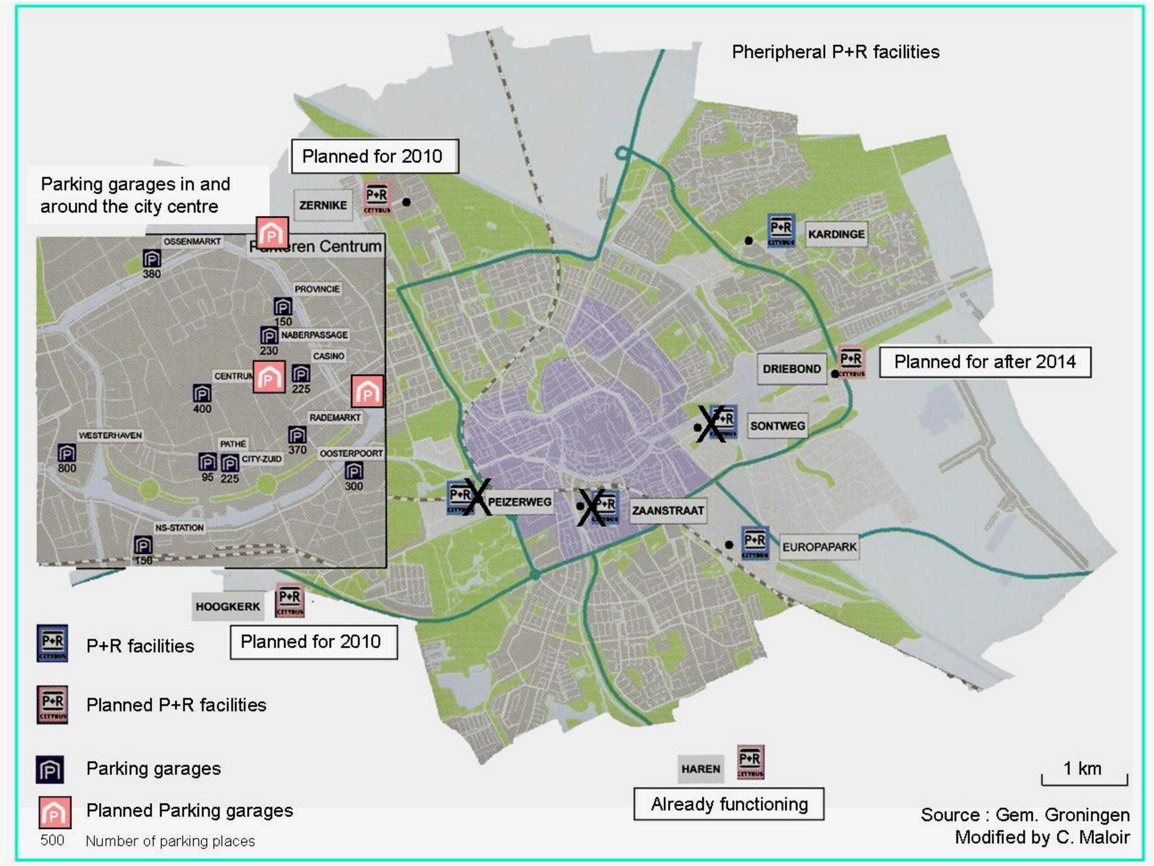
- The **total number of parking places in the city centre** (on-street and fitted parking places) : there are approximately 10 000 parking places in the city centre of Liege (about 1,6 sq km). In comparison, in the city centre of Groningen (1 sq km), the number of parking places is of 2 600. By comparing these figures per surface unit, there are about 6 250 parking places/sq km in the city centre of Liege, for only 2 600 places/sq km in Groningen. So, per surface unit, the parking places supply in the city centre of Liege is almost 2,4 times higher than in Groningen.
- The **parking fees** : the on-street parking places in the city centre of Groningen are really expensive (1,80 €/hour) and have all a maximum time limit (1 hour or ½ hour for places located at the edge of the pedestrian area). Besides the on-street parking places, the parking garages places do not have a time limitation and are cheaper (approximately 1,50 €/hour). In comparison, half of the on-streets parking places in the city-centre of Liege are unlimited in time and free and the other half is not free but the parking ticket is much cheaper than to park in a garage (fitted parking places).

These observations highlight the different character of parking policy of both cities. While in Liege, nothing seems to be done to limit car numbers into central area and to restraint long on-street parking, the parking policy of Groningen clearly tries to limit the number and duration of parking in the city centre. However, not to impact negatively the attractiveness of Groningen, this policy of car restriction into the central area of the city has required the development of an attractive parking alternative at the edge of the city centre (see below).

Secondly, **in the neighbourhoods located around the city centre,** there is metered street parking. This parking functions well to reduce the parking pressure in neighbourhoods surrounding the centre. The fee is also 1,80 €/hour. In comparison to the fee for metered on-street parking in Liege (1 €/hour), parking fees in Groningen are here also higher.

Finally, **at the periphery of the city**, the local authorities of Groningen have developed P+R facilities along the ringway and public transport lines to serve these parking areas. The first P+R was built in 1988. Since that time, additional P+R facilities were built at strategic locations close to the ringway (fig.5.5). These peripheral parks were developed to encourage car drivers to park their car into peripheral areas and then to use the public transport to access to the city centre rather than to go to the city by car.

Fig.5.5. Parking supply in and around the city of Groningen



However, to make this alternative attractive, the sole development of new parking places is not sufficient. This is a complete and complex package of measures which is needed to make P+R facilities successful. All these measures will be developed in more details in chapter 7.

5.4. Travel demand analysis

Then, like in the Liege case, this transport supply analysis is completed by an analysis of the travel demand. This section focuses on the travel needs of the Groningen population (including the population living in the municipality as well as in the surrounding region), presented per transport mode. Moreover, the balance between travel demand and transport supply allows to highlight the current capacity shortcomings that the transport network of Groningen is facing. The projects that are planned to deal with these shortcomings are also presented in this section.

5.4.1. Road network demand

The volume of traffic flows **in the city centre** of Groningen is directly linked to the choices which were made since the 1970s to limit the construction of new infrastructure and to constrain car trips in the central area. Presently, there are congestion problems in the city, mainly at peak hours. However, the transport policy of the city does not aim at solving these congestion problems, what would have for only consequence the rise of vehicles number in the city. Rather, the present transport policy aim at favouring the use of others transport modes (i.e. public transport, bikes), by improving the infrastructure and services supply for such modes. The improvements can be for example simply the increase of the commercial speed or of the comfort of public transport, and also an extension of *bike lanes* network. But, these measures can also focus on providing better alternatives for car in the outskirt of the city as well as into the city. These ones are for example the development of *park and ride facilities* or the implementation of a *parking management* policy.

These measures will be developed in more details in chapter 6. At this point, let us only remember **one essential thing** : to be efficient, a transport policy must not only focus on one transport mode (as it too often the case), but must be inscribed in a broader reflection covering all the transport modes as well as the interactions they have together.

The strategy implemented in Groningen can be related to the "push and pull factors" system[1] which is part of the national transport policy. So, since the transport policy of Groningen does not penalize car use but aims to offer transport alternatives better than car, the transport policy led by Groningen favours the pull factors rather than the push ones. The local authorities have made this choice to continue to attract as many people as possible in Groningen rather than to make them flee because of too constraining car measures. However, in other cities and other contexts, it is the push factors which are largely favoured. It is for example the case in London where local authorities have implemented fuel taxes and road pricing measures.

Besides the light traffic problems that exist in the city centre of Groningen, its **ring way** presently knows more serious traffic problems. These ones are mostly explained by the role of regional economic centre that Groningen plays for the whole north-eastern part of the Netherlands. Presently, the city daily welcomes 160 000 people who come to work, study or shop in Groningen, what equals almost the number of inhabitants living in Groningen. So, everyday the city sees thus its population almost double between 7-9:00 AM and 4-6:00 PM (regular work and school schedules). The congestion problem, highlighted in the section 5.3.1, is due to the fact that 75 % of the 160 000 daily commuters come in Groningen by car ! (Gem. Groningen, 2008). This difference between the car modal split of the inner city traffic and commuting traffic leads to the conclusion that effects of transport policies and plans which were implemented in Groningen from an environmental perspective have largely been located inside the urban area (Hansen, 2005, p.14). These figures provide a first picture of the traffic flows that daily come to and go out of Groningen. Moreover, in addition to be unequally spread over time, congestion problems are also unequally spatially located. In reality, congestion problems are for their main part located on the southern part of the ring, on the A7/E22 highway junction (fig.5.1). In fact, this junction is part of the national highway network (while the other ring roads are provincial roads). The national character of this part of the ring explains the extra traffic which transit on it (and, to a large extent, which does not stop in Groningen, what is useless for the economy of the city).

According to the recent evolution of commuters flows (an average progression of 4-5 % per year), congestion will still grow in the following years. If no measures are taken, the southern part of the ring will be totally saturated by 2020 (Gem. Groningen, 2006c).

[1] The "push and pull" factors were initially used in human migration sciences. In this context, push and pull factors are those factors which either forcefully push people into migration or attract them. A push factor is forceful, and a factor which relates to the country from which a person migrates. A pull factor is something concerning the country to which a person migrates. It is generally a benefit that attracts people to a certain place (EPOMM website). If we adapt these definitions to transport world, a push factor is a factor which forces people to change their mobility habits, while a pull factor is a factor which favours the change of people travel preferences by offering to them other attractive transport solutions.

To solve these congestion problems, and because the accessibility of Groningen is a top priority of the city (section 5.2), decisions were taken to increase the capacity of the ring way to satisfy the present and future evolution of motorised flows. Depending on the circumstances, three alternatives are conceivable : to add extra lanes to the existing highways, to build bypass structures or to build roads on a higher level on poles.

5.4.2. PUBLIC TRANSPORT DEMAND :

The analysis of the **demand for train trips** in Groningen is pretty similar to the one done for the Liege case. So, according to the relative small size of the city and the high quality of bus services which exists in Groningen, the use of train for intercity trips is really insignificant. However, at the regional scale, modal split of train is more important. Indeed, with more than 31 000 passengers on an average workday in 2004, the train accounts for almost 6 % of the total trips made in the region of Groningen (trips made from the region towards the city of Groningen) (Gem. Groningen, ECOMM 2006).

Then, the analysis of the **bus trips demand** highlights really large difference between the bus modal split in urban area and at the regional scale. Indeed, while the bus modal split in the city of Groningen only represents 4 % of the total trips made on an average day (24 hours), it represents 14 % of the total trips made from the surrounding region towards the city of Groningen. This low bus frequentation rate in the city is not explained by the bus services supply in itself, which is really good in the city centre, nor by the socio-economic profile of the inhabitants, since a large part of them are students and are thus normally more prone to use public transport. It is rather the large success that meets bike for intercity trips that mainly explains the low modal split of buses in urban area.

So, because more than 60 % of the trips are made by bike in the city centre of Groningen, it is really difficult for bus services to compete with it, even when the bus supply is of a high quality, as it is the case in Groningen. However, for longer distance trips from outside the city, bike modal slip falls to 5 % because of the too long distance to cover. Consequently, trips which can not be made by bike are made by car (75 %) or by public transport (20 % with 14 % of them made by bus and 6 % by train) (Gem. Groningen, 2006a).

In this context, local authorities have decided to sustain the present quality of the urban bus supply, and to focus the largest part of their present and future efforts on the development of an efficient regional public transport network, called the **Kolibri network**. Three reasons have motivated this choice. Firstly, this new public transport network must provide a high quality alternative to the car. Secondly, the development of this network answers to the need to create inter-municipal collaborations in the context of the national urban networks development. So, the Kolibri network must be the bearer of the spatial and economic development of the region Groningen-Assen. Finally, the Kolibri must increase the accessibility of the cities of Groningen and Assen since it must be connected to the (inter)national public transport network and the high-speed rail lines (Gem. Groningen, Stad in beweging 2007-2010 ; Gem. Groningen, ECOMM 2006).

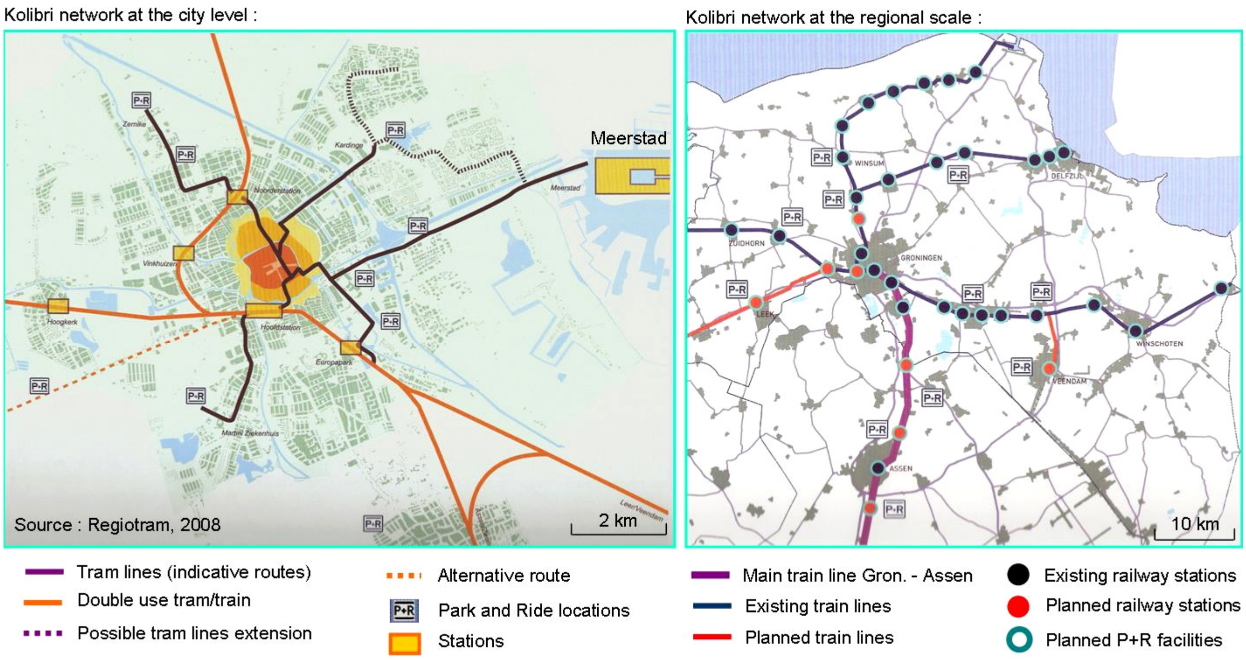
Concretely, the Kolibri network is constituted of 3 main components (Regiotram, 2008) :

- The improvement of regional public transport (new trains and (express) regional buses, interconnective bus and railway schedules, higher frequencies)
- The development of P+R facilities, at the outskirts of the Groningen and in surrounding municipalities

- The development of high quality public transport services in the city (tram lines and BRT lines).

In a first time, the extension of the Kolibri network will be **limited to the city of Groningen**. So, by the year 2014 the first tram line should operate between the Central Station and the Zernike complex (educational and scientific centre)[1]. Then, if the first tram line is successful, four additional tram lines should be constructed by 2020. These lines would connect the Central Station to Kardinge, to Meestrad, to Europapark, and to the Martini hospital (fig.5.6). Moreover, all these tram and bus lines should be directly connected to P+R facilities located along the ring way of the city, what will allow efficient intermodal transfers. So, to satisfy the future demand, the current P+R supply would be reorganised in the next years : three of the five existing P+R facilities would be suppressed and replaced by new P+R facilities (fig5.5) (for more information, see parking demand section 5.4.4) The construction of the Europapark railway Station is also part of this network. Moreover, in the next years the construction of the Vinkhuizen railway Station should also reinforce the current rail network.

Fig.5.6. The Kolibri public transport project



Then, if the project meets a large success in the city of Groningen, the Kolibri network would be **extended through the entire region**. Tram and fast buses lines would be developed to connect more efficiently the areas around Groningen to the city. Moreover, in addition to new tram and bus lines, the Kolibri also plans the development of new P+R facilities located in the municipalities around Groningen (regional coverage of P+R facilities[2]), as well as the construction of new train lines and railway stations (fig.5.6), but these latest elements are still uncertain.

[1] The final decision concerning the route of this first tram line is not yet known. Some alternatives are in fact possible. Therefore, detailed studies are carried out and discussions are organised between all the persons concerned by the tram project to find a common agreement concerning this tram line route.

[2] The P+R facilities located in the municipalities around Groningen are called “origin” P+R (or “herkomsttransferia” in Dutch) ,in opposition to the “destination” P+R (“bestemmingstransferia”) located in the municipality of Groningen, along its ringway.

5.4.3. BIKE DEMAND

As mentioned above, bike trips presently accounts for 60 % of the total trips made in the municipality ! Groningen was awarded "Number One Bicycle City" of the world in 1993 by the leading American magazine Bicycle and "Bicycle City" in 2002 by the Dutch cyclist organisation Fietsersbond. In comparison, cycling accounts for 36 % of total trips number in the municipality of Utrecht, 32 % in Amsterdam, and 22 % in Rotterdam (gem. Rotterdam, Rotterdam fietst ! 2007-2010).

The large success of bike in Groningen results from a combination of many favourable factors. Indeed, the dense cycle network and numerous bike facilities that have been developed in Groningen over the years (see section 5.3.3) form one of the best cycling environment for bikers in the world. Moreover, the compactness of the urban structure, the absence of topographical constraint, and the relatively large proportion of young people surely constitute a favourable ground for an extensive use of bikes. Furthermore, the fact that bicycle is deep-rooted into the Dutch culture has also favoured the diffusion of this transport mode.

In this regard, Mr. van Werven has rightly declared that "we [inhabitants of Groningen] do not ride bicycles because we are poor ; people here are richer than in England. We ride them because it is fun, it is faster, it is convenient" (Global Ideas Bank).

In the latest traffic and transport policy, local authorities have decided to continue to give high priority to bike trips. The expected situation for the next years/decades in Groningen is to maintain the situation in which one trip on two in made by bike, and this despite the city's growth and the increased distances to the suburbs (Gem. Groningen, ECOMM 2006).

5.4.4. PARKING DEMAND

The demand to park in and around the city centre of Groningen is largely conditioned by the parking supply (section 5.3.4). So, commuters and visitors who want to go to the city for working, shopping or other urban activities have the choice between three parking possibilities, according to the time they plan to spend into the city and the money they are ready to pay to park (Gem. Groningen, stad in beweging 2007-2010, p.19) :

- For a short parking time, they can park their car **on-street in the centre,** but the number of these parking places is limited and the maximal parking time too (max. 1 hour).
- For a longer parking, they can use the diverse **parking garages** which are located in and close to the city centre (fig.5.5).
- However, for long(er) and cheaper parking, the combination **P+R – citybus** (fig.5.5) provides a really attractive alternative since the parking is free and the citybus return ticket costs only 2 € for all the occupants of the car (max. 5 persons). Moreover, the citybus services assure a fast and reliable transfer to the city centre[1].

This third option has met a large success since the opening of the first P+R in 1988. In 2006, 1,3 millions of passengers used the citybus services and, every year, users number knows a growth of 5 to 10 % (Gem. Groningen, ECOMM 2006). Since the P+R-citybus system is

[1] Expected for the P+R Zaanstraat where a different pricing system has been implemented : citybus ticket is free but parking ticket is not free. This pricing difference is due to the close location of this parking to the city centre. The fact of requiring money to park rather than to take the bus is a efficient mean to dissuade drivers to park in this parking and to reach the city centre on foot for free.

successful and that this parking alternative largely contributes to provide good accessibility to the city centre while guarantying the safeguard of the liveability of the city, the local authorities have decided to restructure and to extent the supply of P+R facilities to satisfy the rising parking demand. So, by the next years, the three P+R facilities Peizerweg, Zaanstraat and Sontweg will be suppressed because they are too close to the city centre, what has impact on the general urban flows and on the quality of the urban environment. These three parks will be progressively replaced by new P+R facilities (fig.5.5). These new parks will be located further away from the urban area to limit as much as possible the penetration of car into the city. Another factor of their location choice is that they have to be situated as close as possible to the ringway (or to one of the highways junctions) to assure a high accessibility by cars to the parking areas. The location of the two P+R facilities Zernike and Driebond will also be connected to the future tram network, what will increase the transfer speed and quality from the P+R to the city centre.

Moreover, in addition to these extra P+R facilities, the number of parking garages places will also be largely increased in and around the city centre to answer to the expected future visitors parking demand. So, at least three additional parking garages will be constructed : the CiboGa garage (1 250 places), the Damsterdiep garage (540 places), and the garage beneath the new Groningen forum (460 places).

As a conclusion, one can declare that the parking management system of Groningen helps largely to the realisation of the two strategic objectives for the city, i.e. accessibility and liveability. The choices made by the local authorities to develop (so early) P+R facilities and to implement a dissuasive pricing policy have largely favoured the diminution of unnecessary car flows in the city. The future developments will continue on this way, by extending P+R facilities and parking garages supply as the parking demand rises. So, the on-street parking places number will still stay limited.

5.5. In summary

The goal of this fifth chapter was to carry out a complete analysis of the transport network of Groningen. It has followed the same three-steps structure than the one carried out for Liege.

The main results that have been gathered all along this analysis are presented in the following table :

TRANSPORT SUPPLY		**TRAVEL DEMAND**
- Complete ringway - Good urban road hierarchy - Limited road capacity in the city centre	**Road**	- High demand on the ringway, and in augmentation - Limited in the city centre
- Well-developed rail network capacity & good train frequency for regional/national trips - Well-developed bus network and high quality bus services	**Public transport**	- Low train demand for intercity trips but high train demand for regional/national trips - Relatively low bus demand for intercity trips (balanced by bike trips) but high bus demand for regional/national trips
- Extended bike lane network - High quality bike network and facilities	**Bike**	- Low for long distance trips - Really high demand for intercity bike trips
- Dissuasive parking pricing - Large parking supply at the periphery of the city (P+R facilities + city buses) and low supply in the city centre	**Parking**	- Low for on-street parking places - High for parking garages and in P+R parking facilities, and in augmentation

To sum up : (1) in term of car use, the policy conducted by the local authorities of the city is clear. Car flows have to be facilitated around the city, on its ringway, but have to be largely constrained on the urban road network. The fact to restrict car flows in central area has allowed to improve the supply for the other transport modes ; (2) the analysis has highlighted the high quality of bus services, and (3) the remarkable success of bikes for intercity trips ; (4) the local authorities of Groningen have also implemented a dissuasive parking policy that restricts long-term parking in central areas, while providing attractive parking facilities at the edge of the city. This parking policy is thus in line with the aforesaid objectives.

Like the information provided in the Liege transport network analysis, the information gathered in this chapter will serve as basis information for the following chapters.

6

TRAVEL DEMAND MANAGEMENT IN LIEGE AND GRONINGEN

6.1. INTRODUCTION

The goal of this chapter is to compare the role that plays Travel Demand Management in the transport policy of Liege and Groningen. The information which were provided all along the transport network analysis will be extensively used in this chapter.

This comparison is conducted in two steps. Firstly, the list of TDM measures which was proposed in the theoretical chapter (section 2.7) is used as a reference list to evaluate the TDM measures that are in application in both cities. This first evaluation will allow to determine to which extent the concept of Travel Demand Management is integrated into the daily transport planning practices of the cities. Secondly, the five transport planning approaches which were presented in the theoretical chapter (section 2.7) are used to classify the transport system of both cities. In fact, on the basis of the set of TDM measures that each city has chosen to develop, their transport system will be classified according to these five approaches.

6.2. EVALUATION OF THE TDM MEASURES IMPLEMENTED IN LIEGE AND GRONINGEN

This section makes use of the reference list of TDM measures which was proposed in section 2.7 to practically evaluate the TDM measures which are in application in both case studies.

Concretely, each TDM measure has been evaluated according to its level of development as following :

- "-" means that the measure is not developed in the relevant urban area, or that the measure is "wrongly" developed and leads to bad results
- "0" means that the measure is developed but in a limited extent, and thus that its effects on the travel demand is also limited in the relevant urban area
- "+" means that the measure is extensively developed and plays a crucial role in the management of the travel demand in the relevant urban area

Fig.6.1. Evaluation of the development level of TDM measures in Liege and Groningen

SUPPLY-ORIENTED MEASURES	LIEGE	GRONINGEN
Roads traffic operations		
-Intelligent traffic system (ITS)	0	0
-Real-time traveller information system	0	0
-Speed reduction and traffic calming	0	0
Improvement of transport choices		
-Bus rapid transit and express commuter buses	-	+
-Light rail transit (tram and trolleybus)	-*	-*
-Park-and-Ride facilities and shuttle services	-	+
-Bicycle facilities	-	+
-Pedestrian facilities	+	+
-Carsharing	0	0
-Train services	0	0
-Taxi services	0	0

* Planned measures

DEMAND-ORIENTED MEASURES	LIEGE	GRONINGEN
Land use and zoning management	-	+
Traveller information systems		
-TDM marketing (TDM promotion campaigns)	0	0
-Pre-trip travel information services	0	0
-Rideshare matching (or ridematching) services	0	0
Economic measures		
-Road pricing	-	-
-Parking pricing	0	+
-Commuter financial incentives	0	0
Administrative measures		
-Alternative work schedules (in coordination with companies)	0	0
-Car free zones	0	+
-Parking management	-	+
Telework(ing)	0	0

Author : C. Maloir

This first evaluation allows us to have a wide vision on the set of TDM measures that have been implemented in each city, as well as to highlight the strengths and weaknesses of the cities in managing the travel demand.

A first **rough analysis** of the set of TDM measures which were implemented in each of the two studied cities allows us to put forward several observations :

- Both cities have developed as well supply-oriented as demand-oriented TDM measures.
- The number of (limited and extensively developed – symbols "X" and "-") TDM measures which were implemented in Groningen (10 supply-oriented and 10 demand-oriented meas.) is higher than the one in Liege (7 supply-oriented and 8 demand-oriented meas.), and that either for the supply- as for the demand-oriented measures.
- TDM measures that are extensively developed ("X") are really more numerous in Groningen (8) than in Liege (1).
- Concerning the supply-oriented measures, while the authorities of Liege seem to have developed undifferentially measures aiming at improving traffic flows as well as measures favouring the use of other transport modes (especially walking), the authorities of Groningen seem to have chosen to implement preferentially measures focusing on the improvement of alternative transport modes supply.
- The same observations can also be made concerning the demand-oriented measures. While the local authorities of Liege have implemented some of the TDM measures, without real preference for a particular measures category, the authorities of Groningen have made the choice to concentrate more specifically their efforts on the management of land use and on the implementation of economic and administrative measures.

Then, a **finer comparison** between the TDM measures which were implemented in Liege and in Groningen allow us to underline the strengths and weaknesses of each city with respect to the management of the travel demand. So, in the case of **Liege**, the TDM measures evaluation highlights the numerous pedestrian facilities that exist in the city. However, Liege suffers from the absence (or the limited development) of many other TDM measures : a lack of efficient and fast bus services, the absence of park-and-ride facilities, a poor development of bike network and facilities, a bad integration of land use planning into transport practices, the absence of road pricing and a bad management of the parking facilities. Then, the evaluation of the TDM measures which are in application in **Groningen** puts to the fore the high quality of the supply for alternative transport modes (i.e. public transport, cycling and walking). Moreover, this evaluation also underlines the importance that have the land use and zoning policies and the parking policy (i.e. parking pricing and parking management) in the transport system of the city. Concerning the missing elements, the local authorities have chosen not to implement road pricing measures. Neither has the city (yet) developed light rail transit services.

As a result of these two analysis, some concluding remarks can be provided. Firstly, on the basis of the TDM measures evaluation which were implemented in Liege (a few measures extensively developed and many measures gaps), one can say that the concept of Travel Demand Management is still (too) rarely integrated into the daily transport planning practices of the city. Conversely, the high number of TDM measures which were implemented throughout these four last decades in the city of Groningen conveys a totally different transport planning policy, which largely acknowledged the importance of implementing TDM measures to evolve towards a more Sustainable Transport System.

6.3. CLASSIFICATION OF THE TRANSPORT SYSTEM OF BOTH STUDIED CITIES ACCORDING TO THE FIVE TRANSPORT PLANNING APPROACHES

On the basis of the information collected along the transport network analysis of Liege (chapter 4) and Groningen (chapter 5) and by the list of TDM measures that have been implemented in both cities (section 6.2), the transport system of each city can be classified according to the five transport planning approaches which were proposed by C. O'Flaherty in chapter 2.

In this goal, the characteristic elements of each of the five transport planning approaches are compared with the elements constituting the transport system of Liege and Groningen.

Firstly, the **DO-MINIMUM APPROACH** stipulates that traffic congestion, road accidents, and environmental degradation are inescapable features of modern-day life, and if left to itself, human ingenuity and self-interest will ensure that congestion will become self-regulating before it becomes intolerable. In this perspective, no measures are needed to deal with transport problems. Since **Liege** and **Groningen** have made the choice to implement TDM measures (at least some of them) to deal with transport issues, one can directly affirm that their transport systems do not correspond to the do-minimum approach.

Secondly, the **LAND USE PLANNING APPROACH** acknowledges that the control of land use is to a large extent the key to control travel demand. Concretely, the control of land use requests the implementation of land use control measures, which are often supported by additional Traffic Management measures.

The planning system in **Liege**, and in Wallonia in general, is acknowledged to be weak and non restrictive. As a consequence, the urbanised area of Liege has been extended outside of the municipal boundaries (urban sprawl), what was accompanied by a massive suburbanisation of the urban population towards the surrounding rural areas. Moreover, the city has been developed without a real coherence between road building projects and the other urban development projects, what leads nowadays to accessibility and mobility problems in the urban area of Liege. The only effort which was made related to land use management was the establishment of car free zones and streets in central area.

Conversely, land use management is a key concept of the transport planning system of **Groningen**, and of The Netherlands in general. In term of land use control measures, the compact city policy and the ABC policy have been largely responsible of the current shape and organisation of the city. These policies have played a major role in the limitation of the spatial extension of the city, in the promotion of high density urban development and mix of functions, and in the location choices of new companies according to their mobility profile. Moreover, land use policies have been largely supported by additional Traffic Management measures such as the implementation of an efficient parking management system (limitation of parking places and parking time in central area and parking pricing), the development of park-and-ride at the outskirt of the city, the implementation of the 1977 circulation plan that constrains car flows and gives priority to public transport and softer transport modes, and the pedestrianisation of central areas and streets. All these reasons allow us to say that the transport system of Groningen shares many of the elements which characterise this second approach of transport planning.

Thirdly, the **CAR-ORIENTED APPROACH** often corresponds to cities that have decided to promote the use of private car by providing more and bigger roads as well as a numerous parking places in and about town centres to satisfy the growing mobility demand characteristic of the post-World War II period. Cities that have adopted this kind of approach typically put considerable emphasis on the hierarchy of their road network. This approach also often includes the implementation of road traffic operations instruments which provide motorists with real-time information regarding congested locations and times, and improve traffic flows with the aid of traffic control technology.

The city of **Liege** is one of the many cities which has build extensive (highways and urban) road infrastructures and parking facilities through the post-war decades. The current transport policy still (too) largely favours the use of car. However, nevertheless this car-oriented transport policy, the local authorities of Liege have not implemented adequate measures to control and guide car flows. Consequently to the bad hierarchy of the urban road network and the inadequacy between the capacity of highways and urban roads, the city presently suffers from recurrent congestion problems and of important transit traffic in local neighbourhoods, what impact negatively the life quality of these areas.

In the case of **Groningen**, this situation was avoided by the early decisions which were taken by the local authorities since the 1970s to limit as much as possible the use of car in the city centre and to favour alternative modes of transport. In this task, the extension of the urban road network was limited and the network was highly hierarchized to allow an efficient management of the traffic flows trough the urban area.

In addition, both cities have developed certain road traffic operations tools such as intelligent traffic system or real-time traveller information system to optimize and fluidify traffic flows.

Fourthly, the **PUBLIC TRANSPORT-ORIENTED APPROACH** concerns cities that have carried out transport plans which aim at improving the quality and quantity of road and rail public transport services. The measures favouring public transport are normally associated with demand-oriented measures such as land use, economic, administrative and traveller information services measures which encourage the use of such transport mode.

In both studied cities, the public transport network is quite well-developed and the frequency of trains (at least for regional/national trips) and buses is rather high. However, a big difference must be underlined between the public transport services quality of Liege and Groningen. In fact, public transport services in **Liege** are not really reliable (delays, unplanned strikes, …) neither comfortable (noise, seats quality, …). Moreover, the commercial speed of buses is really low in the city centre, and that nevertheless an extensive network of bus lanes and bus pre-emption signals. Conversely, **Groningen** enjoys high quality public transport services, reliable, comfortable and fast (faster than cars in the city). Moreover, extra measures have also been implemented to support public transport use. The compact city and ABC policies described above are two of these measures. The design of car free zones and of a dissuasive parking policy, coupled with the development of park-and-ride facilities at the outskirt of the city and shuttles services are also elements that have played an important role into the quality improvement of public transport services of Groningen.

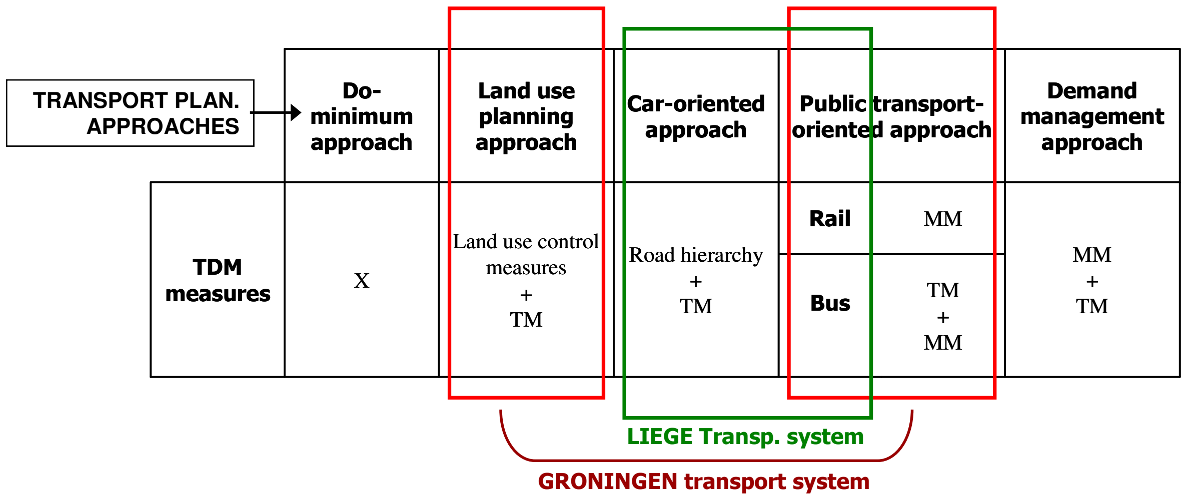
Finally, the **DEMAND MANAGEMENT APPROACH** refers to transport plans which promote anti-congestion measures to reduce the pressure on the road system, but also more Mobility Management-oriented measures which influence pre-trip travel choices. The anti-congestion measures refer to measures such as improving public transport systems or implementing traffic restraint measures which were already presented in the previous approach (see above). However, the particularity of this approach lies in the implementation of measures such as *pre-trip travel information services*, *ridesharing* activities, or *alternative work schedules* and *telework,* in the goal of influencing pre-trips choices.

In that respect, although local authorities of both cities have started to implement some actions of this kind, **Liege** and **Groningen** are still quite far from a real extensive use of these alternative travel means. However, considering the enormous improvements that have experimented new communication technologies these last decades, their use to provide extra information to traveller (via Internet, mobile phone, …) or as a substitute to travel (telework) should know a growing success in the next future.

To sum up, if the transport system of Liege and the one of Groningen should be classified according to these five transport planning approaches, one can state that (fig.6.2) :

- The high capacity of the highways and urban road network of Liege (although this last one is badly hierarchized) is characteristic of the **car-oriented approach**. However, the relative numerous measures that urban authorities have undertaken in the goal of improving the **public transport services quality** of the city these last years (e.g. new railways station, bus lanes extension, bus pre-emption signals, traveller information services, …) places the transport system of the city between the third and fourth approach of transport planning. According to the TDM measures that local authorities will decide to implement in the following years, it will be possible to know which of these two transport planning approaches the city will follow, car-oriented approach if the local authorities decide to prioritize measures which improve traffic flows, or public transport-oriented approach if the city continues to improve and promote its public transport services.
- The strong land use planning system that has developed the city of Groningen, coupled with the numerous measures improving alternative transport modes and restricting car use (at least in the city centre) position clearly the city in an intermediate position between the **land-use planning** and the **public transport-oriented approach**.

Fig.6.2. Classification of the transport systems of Liege and Groningen according to the five transport planning approaches



This second evaluation put clearly to the fore the lack of an efficient land use management of the city of Liege, as well as the relative poor extension of public transport services and related measures in comparison to the ones implemented in Groningen.

6.4. CONCLUDING REMARK

The goal of this chapter was to compare the role that plays Travel Demand Management in the transport policy of Liege and Groningen. In that task, two evaluations have been carried out. The results of the first evaluation has underlined the weak integration of the Travel Demand Management concept into the transport planning practices of Liege, while this concept is deeply integrated into the ones of Groningen. The second evaluation has highlighted another difference between the two cities : while the transport system of Liege is characteristic of the car-oriented approach, and shares some similarities with the public transport-oriented approach, the transport system of Groningen occupies an intermediate position between the land-use planning and the public transport-oriented approach.

These results will be used in the next chapter to define which of the TDM measures that are in application in Groningen could be useful to transfer to Liege.

7

TRANSFER POSSIBILITIES OF TDM MEASURES FROM GRONINGEN TO LIEGE

7.1. INTRODUCTION

This chapter closes the practical part of this thesis. Its aim is to draw a list of TDM measures that are in application in Groningen and that could be transferred to the Liege context to improve its current transport system.

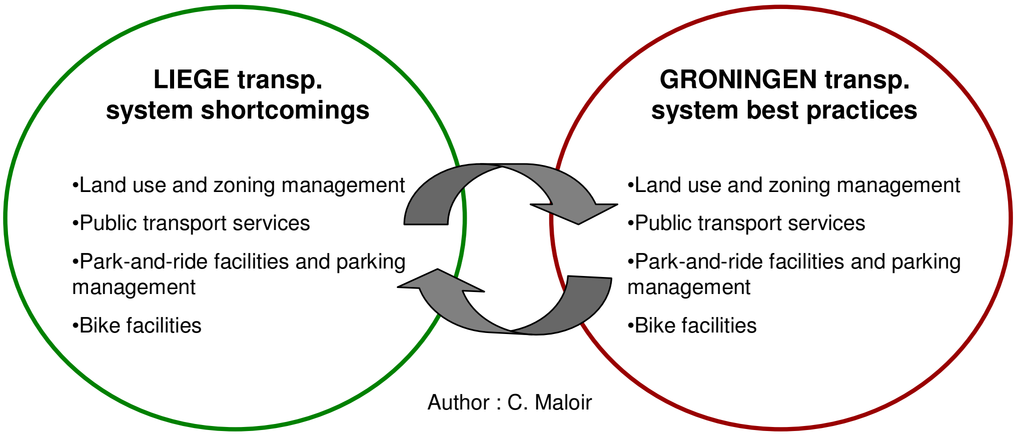
The information that is used to achieve this goal is a combination of the results that were provided all along the chapters 3, 4, 5 and 6. In fact, the conclusions of this chapter are generated on the basis of all the information that were collected in this work. They take into account factors such as the similarities and differences which exist between the two cities, or the characteristics of their urban transport systems.

Concretely, the TDM measures that could be usefully transferred between Groningen and Liege are selected. Then, each of these measures is discussed in more details.

7.2. CHOICE OF THE TDM MEASURES

The results that have been obtained along the previous chapter (fig.6.1 and 6.2) allow to define which of the TDM measures that are in application in Groningen could be usefully transferred to Liege in order to improve the transport system of the city[1]. However, the time assigned for this work has obliged to focus on the transfer of only a few specific measures. Consequently, the TDM measures which will be developed in this chapter are the ones which correspond to the biggest strengths in the transport system of Groningen and the biggest shortcomings in the transport system of Liege (fig.7.1).

Fig.7.1. Matching between Liege transport system shortcomings and Groningen transport system best practices



As it was mentioned in chapter 2, the implementation of individual measure has only limited effects on the transport system of an urban area. To deal efficiently with transport issue, measures have to be coordinated into a comprehensive TDM strategy. Moreover, many

[1] We are conscious that other measures than the ones proposed here could also be implemented in Liege. For instance, the implementation of road traffic operations measures would maybe have better results on the transport system of Liege than promoting bike use, since Liege has a high capacity road network and some obvious problems to control its traffic flows. However, the scope of this study is limited to the transfer of TDM measures from Groningen to Liege. Thus, although the transfer of other measures implemented in other cities should be interesting to study too, it falls out of this study scope.

researches carried out in the field of Travel Demand Management have concluded that to be efficient, "TDM strategy should include a balance of improved travel choice and incentives to reduce automobile travel" (TDM Encyclopedia, Victoria Transport Policy Institute). So, any improvement of travel choices, either a specific transport mode or a combination of different modes, will only be successful if extra measures are taken to restrain car traffic. The reverse is also true. To provide incentives to diminish car traffic without improving the supply for other modes would have limited effects since no attractive alternatives to car is available.
In this case, we are lucky in the sense that the four elements transferable from Groningen to Liege aim as well at improving travel modes as at reducing car use. These four measures are thus complementary and can be part of a coherent TDM strategy.

A last remark concerning the land use and zoning management has to be made before starting the analysis in itself. As land use planning and transport planning are closely interconnected, it was chosen not to develop the 'land use and zoning management' measure in a separate section. Rather, land use management will be integrated in the discussion of the three others measures.

To sum up, the following sections will successively analyse TDM measures that focus firstly, on the improvement of transport public services, secondly, on the development of a coherent parking policy, and finally, on the promotion of bike use, while regularly referring to land use planning instruments.

7.3. PUBLIC TRANSPORT SERVICES

The key to increase the quality of bus services is to make buses more attractive than cars, at least at certain times (e.g. at peak hours) or certain places (e.g. in city centre, along a particular corridor). On the basis of the information provided along the transport network analysis of Liege (chapter 4), it is possible to grasp the main factors that harm the bus services quality of the city : bad structure of the bus lines network, too low capacity of bus services in regard to the growing bus trips demand, and lack of measures that constraint car flows.

HOW TO EFFICIENTLY RESTRUCTURE THE BUS LINES NETWORK ?

The analysis of the public transport supply and demand of Liege has put into the fore several problems in regard to the organisation of its bus network. The core of this problem lays in the lack of hierarchy and of coordination that exist between the different bus lines which serve the city. So, a regional line can use the same urban roads and end at the same places than an urban bus line. This lack of hierarchy induces high concentration of buses at key areas of the bus network (such as at squares, boulevards,…). This situation is, for example, responsible of the high number of buses which daily use (sometimes uselessly) the main boulevards of the city to reach their destinations. Although these roads were equipped with bus facilities (bus lanes and bus pre-emption signals), such a concentration of buses causes recurrent congestion problems on bus lanes. As a result, the commercial speed of vehicles on these main roads, which represents the backbone of the public network of the city, is largely slowed down. Moreover, this situation does not only affect a few bus lines. On the contrary, since the majority of bus lines use these roads, it is the overall quality of the urban bus services that is harmed.

A strength of the bus network of Groningen that could be adapted to the Liege context is the **strong hierarchy of its public transport network** in general, and of its bus lines network in particular. The reorganisation of the bus lines of Liege according to either they serve main roads of urban areas, local neighbourhoods, or regional areas could be a first major improvement to the present situation. This reclassification should imply to rethink bus routes. This would allow to redistribute more efficiently the bus supply through the urban area, to avoid the current situation in which some neighbourhoods are uselessly served by too many bus lines while other ones are not served correctly at all (see bruin neighbourhoods in fig.4.3). This remark is also true for main boulevards, along which the bus flows have also to be reorganised. Ideally, bus flows should be concentrated on main roads/boulevards to enjoy of bus lanes and bus pre-emption signals in the goal of achieving a high commercial speed, but these flows have to be better balanced through the whole urban area to avoid the present congestion problems. Another alternative would be to develop a high capacity public transport service on these high-frequented roads (see below).

Moreover, **different design for different bus functions** would also improve the bus services quality. So, regional buses which have a different appearance than urban ones is something that is quite easy and cheap to implement and that can improve significantly the results of such a network restructuration, since people can actually see the difference between bus lines functions.

However, although this first alternative proposed to improve the bus services efficiency in Liege still stays quite cheap to implement in comparison to other more expensive and risky measures, the restructuration of bus lines is somewhat more difficult to implement than in Groningen. Indeed, in Liege the suburbanisation of households towards peripheral areas and the delocalisation of economic activities to secondary centres have largely **spatially spread and multiplied origin and destination poles** that have to be served by public transport. So, contrarily to Groningen were bus lines always end at the Central Square where a large number of the working, commercial and services functions are concentrated, bus lines in Liege have to be planned on the basis of the most attractive poles location. This polycentric urban pattern organisation involves a harder job of bus routes planning, but has also the advantage to allow certain bus lines to bypass the city centre to connect two places (e.g. a village located at the north-east of the city, and an industrial estate located at the north-west), which limits useless bus transit traffic in the city centre.

HOW TO DEAL WITH THE GROWING DEMAND FOR BUS TRIPS ?

The growing success that bus services experiment in Liege since the year 2000 has for consequences a higher occupancy rate of buses. However, this higher passengers number is not equally spread. This growth is higher for intercity bus trips than regional/commuter trips. As a result, the capacity of many urban bus lines is not high enough anymore, what leads to crowded buses and more and longer halts at bus stops. Since the bus network is not able to welcome additional vehicles (without causing congestion problems), another alternative should be found. In that respect, studies were carried out to define the best alternative to satisfy the growing bus demand. Accordingly to the objectives that are pursued by the city in term of mobility (section 4.2), local authorities have decided at first to **reinforce the existing bus network capacity** (e.g. by extending bus lanes and giving extensive priorities to buses at crossroads, roundabouts, …). However, considering the current evolution of bus demand, this alternative will not be sufficient at longer term. So, by the next ten (fifteen ?) years the city should know the **development of a “heavier” public transport system**. Due to the topographic and hydrological constraints and the highly dispersed urban development (and thus dispersed demand) that characterise Liege, the possible routes for this new transport mean were largely limited. Accessibility by car to sites, existing bus and train lines, and availability of space were also taken into account. On the basis of these factors analysis, two roads were selected : the first one along the Meuse Valley, between Jemeppe and Herstal, and the second one along the axis Ans-Guillemins Station-Fléron, to which secondary bus lines will be connected. Moreover, these new axis should be connected to the Guillemins Central Station and to the Saint Lambert square (the two nerve centres of the current public transport network) via a circular line[1] encircling the city centre (fig 4.1 or appendix … for more details on the tram lines routes). (Ville de Liège, PDS 1999, p.68).

In this case too, some lessons can be learned from the Groningen case. Indeed, since Groningen plans to develop its own regional public transport network, including high quality bus lines and tram lines, some elements of this network can be useful to take into consideration for the planning of the Liege project.

Firstly, the **choice of the public transport mean** is an indispensable primary step in any public transport project. This choice is often difficult and controversial, since every person who is concerned by the project (that includes citizens too) has his own vision on what is the ideal transport mean for "his/her" city, on the basis of its own personal values. So, factors such as noise and pollution can be determinant factors for a group of persons, while others rather value the cost and rapidity of a trip. In Liege, two alternatives were retained : the development of a *Bus Rapid Transit* service (BRT) or of a *Light Rail Transit* service (LRT, refereeing to tram and trolleybus)[2]. Although the last studies which were carried out show a preference for the tram, the final decision is not yet surely known. However, in the sake of clarity, the term "tram" will be used further in this work to refer to the future public transport line which will be developed in Liege.

Additionally, besides the choice of the public transport mean in itself, **many additional elements** have to be integrated in a project of such a scale to achieve results that come up to the invested money and energy. So, although the Kolibri network is not yet implemented in Groningen, it is interesting to compare the studies which were carried out in both cities concerning their future needs in public transport, more precisely the elements that were covered by each study. Such a comparison highlights the necessity to integrate the following elements into the Liege project. **Firstly**, the study concerning the Kolibri project has underlined the need to efficiently connect the new tram lines with the (regional and urban) bus lines and train lines. Especially the connection with the existing train lines is crucial due to the fixed nature of rail infrastructures, on the contrary to bus routes which can be easily adapted to changing needs. In that respect, in Liege the Guillemins Central Station is planned to be a key element of the future tram line. However, other railway stations located in the surrounding urban agglomeration should also be integrated into this vast project. To sum up, an extensive coordination between bus/tram/train could allow to reinforce the synergies

[1] This circular line plays many roles. Firstly, it would allow to improve the public transport services quality by decreasing the stops number between an origin and a destination. Secondly, this loop would also allow to serve the neighbourhoods of the right bank of the Meuse river. Finally, it will also multiply the connection points with the other bus or train lines, what would allow to spatially distribute travellers through all the urban area rather than concentrating them at only a few places (urbAgora, conference de presse du 22 juillet 2008)

[2] More information concerning the pros and cons of these two public transport alternatives are provided in the following sources : D. Hensher (2006), Sustainable public transport system : Moving towards a value for money and network-based approach and away from blind commitment. Transport Policy 14 (1) 98-102 and TDM Encyclopedia, articles "Bus Rapid Transit" and "Light Rail Transit" (www.vtpi.org/tdm).

between rail services and other public transport means, and also to increase significantly the general modal slip of public transport. **Secondly**, another component which was at the core of the Kolibri project's study is the integration between bus, tram and train lines with the P+R facilities. The development of P+R facilities is planned in Liege since some times (see section 6.4.3). However, although the mobility actors commonly agreed on the need to develop such facilities, the recent study carried out about the public transport mobility needs in Liege[1] does not take the future potential P+R facilities locations into account. That is a shame since both the tram and the P+R facilities need each other to efficiently work. Indeed, to be economically efficient, tram line requires 5 000 travellers per hour and per direction. Currently, along certain sections of the Flemalle-Herstal axis, the bus passengers number per hour and per direction reaches the 3 000 passengers (and even 3 500). The forecasts predict a natural growth (without any intervention) from 3 000 to 4 500 pas./hour per direction on this axis, what is not high enough to justify the development of a tram line. However, forecasts also predict that the figure of 7 000 pas./hour per direction could be reached if additional measures are implemented to actively support the use of public transport (Le Soir, "l'option tram validée", 18/04/2008 ; ACTP info, April-June 2008) (see the current bus passengers number along the two future tram axis in appendix 2). The development of P+R facilities, by concentrating travellers at a few spatial points, could bring (a part of) the additional passengers needed to make the tram viable in Liege. The reverse relation is also true. P+R facilities that are not well-served by public transport are doomed to failure, since no alternative is offered to drivers to access rapidly and comfortably to the city centre. **Finally**, as already mentioned many times, one of the big strength of the Dutch transport planning system is the strong coordination that exist between transportation and land use planning. Rather logically, the future urban development and urban renewal projects were also integrated into the study of the Kolibri network project. The best example of such coordination is the Meerstad project. This mega project of 4 000 hectares, combining housing (8 000 new dwellings are planned) and recreational activities, is located at about 8 kilometres from the city centre (eastern fridge of the city). This distance still allows to use bike as main transport mode (8 km being the average maximal distance that people accept to cover by bike). However, besides this bike alternative, the complex would also be connected efficiently to the city by tram (fig.5.6). This mixed supply of bike and tram should limit car use, even in that kind of "less compact" development. This kind of reasoning must also be increasingly integrated into transportation planning practices in Liege. One of the factors that should stimulate the integration between land use and transport is that, although such integration requires a more in-depth pre-project reflection, it was proven in many cases that the results of such efforts have paid off.

To conclude, any tram project should be above all an integrated and regional (i.e. urban agglomeration) project that would be the result of a deep comprehensive reflection concerning the future mobility needs of all an urban area, as it has been the case in Groningen for the planning of the Kolibri project. However, we must keep in mind that, although a well-planned project increases its chances of success, the largest part of the success of any project really depends on its actual implementation, on its good or bad integration into the wide urban environment (i.e. how the project works in practice, and how it interacts with the other urban elements), and on the support the project will receive from politicians and local population

[1] Study financed by the Walloon Region and realised by the Société Régionale Wallonne des Transports (SRWT- Regional Walloon Society of Transport). This study has compared diverse alternatives in terms of public transport services including factors such as commercial speed, vehicles frequency, and transport mode (bus, trolleybus or tram) and has estimated the total costs for infrastructures and vehicles that such investments would require.

(since it is the clients which will actually use the new public transport service). In that respect, Groningen has already experimented the failure of large dimensions projects such as the Kolibri due, among other reasons, to a political shift associated with a change of objectives for the city or to a large wave of protest from local population (most of the time due to their too late integration in the process).

HOW TO CONSTRAIN CAR FLOWS ?

Another major problem of the bus services in Liege, besides the bus lines structure and the limited bus services capacity, lies in the low commercial speed of buses. To improve this situation, local authorities have already agreed on the necessity to extent priorities given to buses. However, these kinds of measures, although indispensable, will not be sufficient to make considerably changes in traveller behaviour if not coordinated with an extensive set of measures restricting car flows. Knowing the long lasting orientation of the transport policy of the city favouring car flows, this is surely such anti-car flows measures which will be more delicate to implement in Liege.

Before focusing on car restraint measures, a first preliminary remark must be made concerning the **difference of spatial organisation** of the two studied cities. The spatial policy of Groningen has strongly favoured, and still favours, the concentration of functions into the central area while forbidding the emergence of peripheral poles. This situation sustains largely the attractiveness of the city. At the opposite, the city of Liege is surrounded by many peripheral (industrial and commercial) centres. In this context, people have the choice to go to the city centre or to one of these numerous centres. Unfortunately, people choose more and more often the second option, since peripheral centre offers the same products than the city, with the advantages of being more easily accessible and located out of the congested corridors, and offering extensive and free parking places. Face to this sharp concurrence, the attractiveness of the city is highly harmed, seeing its number of visitors decreasing. In such a weak position, the implementation of too constraining push measures (penalizing car flows) would still worsen the current situation. Therefore, yes, car flows have to be constrained in Liege, but in a well-thought-out and limited way.

By taking this preliminary remark into account, here below are some car restraint measures that were successfully implemented in Groningen and that could be transferred in Liege to improve, among other things, the quality of the bus transport services of the city.

A first possibility would be to implement measures which seek to efficiently **control car flows**. In that goal, Groningen's experience has shown that the combination of a strong road network hierarchy (coordinated with an adapted circulation plan) and of traffic calming measures leads to really good results. **Firstly**, it was proven that a strong hierarchy of a road network (in coordination with an adapted circulation plan) improves the general diffusion of the traffic in all an urban area, what is beneficial for the general mobility of a city, and thus also for bus flows. Therefore, the hierarchisation of the Liege road network could allow to take back the control of a large part of car flows which escape currently from any control, and to concentrate these flows on main roads. However, such a concentration of cars on main roads can also have the reverse effect. Indeed, if the roads capacity is not high enough to support this higher car numbers, it would cause congestion. Further studies should be carried out to know if the main roads of the Liege network are able to cope with higher traffic flows, and if yes, to which extent. **Secondly**, an adapted speed regulation (i.e. reduction of speed limit on local roads) combined with the implementation of traffic calming measures such as the increase of the number of speed tables, chicanes or roundabouts, or the use of cobblestones rather than asphalt for local road surface, are also a mean to constrain car flows. Such measures should be more extensively developed in Liege to slow down car flows, especially in areas where cars drive too fast. This would allow firstly to supply bus services that are faster than cars (at least in certain areas) and also to increase the general safety of weak users (i.e. pedestrians and bikers). In terms of impacts on car drivers, this combination of measures would imply that drivers should adapt their itinerary (often lightly) to the new circulation plan, and that they should adjust their speed and driving to the new obstacles and speed regulations. These changes would thus stay relatively minor for the drivers, and would not require a financial participation, what is advantageous in comparison to other more radical measures such as road pricing. The combination of road hierarchy and traffic calming measures seems thus a well adapted alternative to the Liege context.

Another possibility which has also proven its effectiveness in Groningen is the implementation of a **parking policy** that limits the number of parking places in the central area and imposes high costs for these rare places, while offering extensive (almost) free parking places in peripheral parking facilities (more details on this policy in section 7.4). This strategy could also be an efficient mean to decrease car numbers in Liege. Such a policy would limit congestion problems and would dedicate extensive space for buses, what would also improve bus flows.

The set of measures proposed in this section provides some ideas to improve the public transport services quality of Liege. This measures set was carefully constituted by taking into account on the one hand, the measures which have been implemented in Groningen and which have led to good results, and on the other hand, the Liege context and more especially the weak position that occupies its city centre. This last element has imposed to limit the transfer possibilities to measures that do not penalize too much car flows. The next section will follow the same reasoning to suggest ideas inspired by the Groningen's experience and adapted to the Liege context to improve its current parking policy.

7.4. PARKING MANAGEMENT

Parking policy is a key component of any urban traffic policy. However, such policy is not easy to implement. The variety of measures as well as the difficulty to predict effects of each particular measure (e.g. effects on traveller behaviour, indirect effects on other measures, synergic effects with other measures, …) make this planning task quite difficult. Moreover, to implement an efficient parking strategy, it should be plan for all an urban area (and not only at the city centre level, as it is too often the case), what increases considerably the factors that have to be taken into account.

In his paper "parking management – strategies, evaluation and planning", Todd Litman describes the paradigm shift that parking planning has recently experimented. The below table highlights the main differences between these two paradigms.

OLD PARKING PARADIGM	NEW PARKING PARADIGM
"Parking problem" means inadequate parking supply	There can be many types of parking problems, including inadequate or excessive supply, too low or high prices, inadequate user information, and inefficient management
Abundant parking supply is always desirable	Too much supply is as harmful as too little
Parking should generally be provided free, funded indirectly, through rents and taxes	As much as possible, users should pay directly for parking facilities
Parking should be available on a first-come basis	Parking should be regulated to favour higher priority uses and encourage efficiency
Parking requirements should be applied rigidly, without be applied if proven and widely accepted	Innovations should be encouraged, since even unsuccessful experiments often provide useful information
Parking management is a last resort, to be applied only if increasing supply is infeasible	Parking management programs should be widely applied to prevent parking problems
"Transportation" means driving. Land use dispersion (sprawl) is acceptable or even desirable	Driving is just one type of transport. Dispersed, automobile-dependent land use patterns can be undesirable

Source : Litman, 2008

So, while "the old paradigm assumes that parking should be abundant and free at most destinations and that parking lots should almost never fill, […] the new paradigm rather strives to provide *optimal* parking supply and price" (Lidman, 2008).

On the basis of the information provided in chapter 4 (network analysis of Liege), **the parking situation of Liege** can be synthesized as following : a really high parking capacity (as well in the inner city P1 as in the densely urbanised area P2), a shared division between the number of on-street and fitted parking places, and a pricing policy characterised by a high percentage of free on-street parking places and lower costs for not-free on-street parking places (sometimes five times lower) than for parking garages.

This brief description of the situation highlights the fact that the current parking problems experimented by the city are not related to the parking supply (i.e. too few places available), but rather to the management of this supply (i.e. available facilities are used inefficiently). Therefore, by relating the Liege parking situation with the aforesaid parking paradigm shift, one can said that the parking strategy which is currently in application in Liege is still largely "old paradigm"-oriented.

A deeper analysis of the information concerning the parking demand and supply in Liege (sections 4.3.4 and 4.4.4) allows to put one's finger on the major parking problems that the city is facing : recurrent saturation of streets while fitted parking are far for being full, low car rotation rates, and numerous parking offences.

At the opposite of the Liege case, **the parking policy of Groningen** is much more sophisticated (see chapter 5). Possible solutions to improve the Liege parking problems could thus be found in the Groningen's experience. Some of these solutions are developed in the subsequent parts of this section

HOW TO IMPLEMENT AN EFFICIENT PARKING PRICING POLICY ?

The adaptation of the present parking pricing policy of Liege would be a first good mean to deal with the first parking problem that the city knows, namely the unequal occupancy rate between the on-street and fitted parking places.

The first primary condition to deal with these problems is to implement a coherent pricing policy which would cover all the urban area of the city. Indeed, it is mainly the lack of coherence between the different parking supplies which has led to the current anarchic situation of Liege. Moreover, the pricing parking policy must also imperatively be coherent with the objectives set by the local authorities. Therefore, since the attractiveness of the city is a top priority, it is not conceivable to impose too high parking costs to park in central area, what would make fled visitors. A first mission for the local authorities should thus be to implement a pricing policy which would **improve the use of existing parking facilities** without harming the attractiveness of the city.

In that perspective, parking pricing policy which is in application in and around the city centre of Groningen, based on higher costs for on-street parking places than for fitted parking places, could be an efficient mean to achieve a better balance between the demand for on-street and fitted parking places in Liege. However, to achieve better results, such a parking costs change should be supported by a reinforcement of the security in fitted parking facilities, which is for the moment really problematic. In term of impacts on the drivers, the ones that faced with an on-street parking fee increase may switch to another transport mode or change their parking mode (Petiot, 2004). In the case of Liege, since the supply for other transport modes is not really attractive (yet) (i.e. slow commercial speed and regularity lack of public transport and poor development of bike network and facilities), drivers would rather react to a change in parking fees by modifying their parking habits. The expected result is that a significant percentage of drivers stop using on-street parking places to park in fitted parking facilities (at least while the distance that is imposed by the change in parking location to reach a destination is not valued by the driver as more costly than the extra costs imposed to park on street). This change of parking modes should allow to recuperate public space for the other road users (i.e. for public transport, bikers and pedestrians) and to increase available parking places for inhabitants. The implementation of such a parking pricing policy would thus be totally in line with the strategic goals pursued by the city. However, we have to keep in mind that the actual implementation of such change is conditioned by the possibility to conclude an agreement[1] between the local authorities, the parking managers, and the different actors who are concerned by the parking activity.

[1] As an example of such agreement, the local authorities of Liege have recently concluded an accord with the shopkeepers and parking managers to offer one hour of free parking in fitted parking facilities to clients of shops participating to the action. This action is beneficial for all the actors : for parking managers who fulfil their infrastructures, for shopkeepers who attract clients since they offer a comparative advantage in comparison to

Moreover, besides the transfer of parked cars from on-street to fitted parking places, **other parking alternatives can also be developed by companies and public institutions**, with or without the support of local authorities. Indeed, "companies [and public institutions] are pursuing a variety of strategies to manage car parking[1]. These are determined by a combination of site circumstances, transport options to site and company culture" (Department for transport of United Kingdom, 2008, p.44). In that respect, some creative initiatives have been developed in Groningen these last years. This is for example the case of the coordination agreement between the P+R Europark and the university hospital, supplying discounted parking costs to clients of the hospitals who use this parking, or the recent creation of a parking permit to use the university parking lots (permit deliverance only to employees who lives at a certain distance from the university site, who have a physical disability, or who need their car for commuting on a daily basis). This last measure is an initiative motivated by the university itself to force students and university staff to use bike and public transport rather than private car. The development of such alternatives has been multiplied throughout these last years. The fact of integrating companies and public institutions in the parking policy of the city should also be considered in the case of Liege. Indeed, such innovative parking initiatives could open the door to new possibilities to deal with parking issue.

Another key of the Groningen parking pricing policy is the **decrease of parking costs as we go away from the city centre to the periphery**. In liege, however, this alternative would only be possible on one condition. To protect the city centre from peripheral competitors, the rise of central parking places costs must obligatorily be accompanied by the development of an attractive parking alternative around the city (see below), served by efficient public transport services (e.g. tram line, see section 7.3). This peripheral parking supply, if well planned, should allow commuters and visitors to park outside the city centre and to access to the city centre in a relative short time (shorter than by cars) and for low costs (lower than to go to the city centre by car and to park there).

Finally, the success of pricing parking policy also depends on the compliance of drivers with the imposed parking costs. Next section deals in more details with this factor.

HOW TO DECREASE THE NUMBER OF PARKING METER VIOLATIONS ?

The success of any parking pricing policy depends largely on the drivers compliance level with the parking tariff constraints. Indeed, parking meter violation interferes in the expected results of pricing policy. In that respect, the choice to legally or illegally park is the result of a rational economic choice. "The driver assesses the expected illegal parking cost (taking into account the enforcement probability and the fine level) versus certain legal parking cost (taking into account the parking charge only). The calculus includes walking time from parking to final destination but excludes the travel demand context as traffic level or parking congestion. Then, the driver opts for the 'cheapest' alternative between illegal and legal parking. […] Consequently, it seems to be an accepted fact that an increase in the enforcement effort deters parking offence […], what is a key condition to ensure the efficiency of parking pricing" (Petiot, 2004). Fine increase can also be part of such an

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other shopkeepers, and for clients who benefit from one hour of free parking in the city centre. Such kind of agreement must be more frequently implemented in the future.

[1] For more information and concrete examples of such innovative parking strategies, see the article in the TDM encyclopedia titled "commuter financial incentives" (http://www.vtpi.org/tdm/tdm8.htm) or the "essential guide to travel planning" edited by the Department for transport of United Kingdom (http://www.dft.gov.uk/pgr/sustainable/travelplans/work/essentialguide.pdf)

enforcement effort. However, some researches have shown that the relation between fine increase and parking violation deterring is not systematic. Some researches have even reached the reverse conclusion, the fine increase boosting parking violation. Fine level should thus be cautiously set.

Since in Liege, every day it is 75 % of vehicles that are without parking tickets or exceed the ticket time (see section 4.4.4), more parking meter compliance controls is a key to decrease parking offences number. It would in term favour the change in drivers parking habits (towards fitted parking facilities) on one hand, and, on the other hand, increase the rotation rate per parking place. This last element would be really beneficial for the general economy of the city since it would allow to diminish the number of long-term users for on-street parking places and to reattribute these places to short- and middle-term users[1], which are in fact the most economically useful for the city. Moreover, more controls would also be beneficial for the general mobility of the city since it would diminish the number of double-parked cars and of cars parked on bus lanes that currently harms traffic flows, and more specifically, bus flows.

The **frequent parking controls** and **high parking violation fines** that are practised in Groningen (i.e. parking fine costs about 45 € n Groningen, against only 25 € in Liege), and the results that it has on the level of non-compliance parking, could be good lessons for the Liege case.

HOW TO PLAN AN ATTRACTIVE PERIPHERAL PARKING ALTERNATIVE (P+R FACILITIES) TO CENTRALLY LOCATED PARKING PLACES ?

In addition to parking pricing and parking enforcement effort, another alternative to solve parking problems of Liege would be to develop park-and-ride facilities at the edge of the city. This new peripheral parking supply would allow to stop commuters and long-length visitors upstream to central area, what would significantly decrease the number of cars in the city centre.

Nevertheless the high investments required by the development P+R facilities, the deep changes necessitated in travellers behaviour, and the high failure risk that P+R development represents (in comparison to the foresaid alternatives), the large benefits that it could create, if well planned, explain the success that this parking alternative has met worldwide these last years. These benefits are, among others :

- The decrease of parking demand in central area. That would allow to satisfy the parking needs of residents and short- and middle-term visitors, what would reinforce the attractiveness and economy of the city.
- The recovery of public space that would be reassigned to other functions, such as to lanes and/or facilities for buses and bikes, larger pavements for pedestrians, green and recreational areas, etc.
- The reduction of congestion problems, what would improve the general mobility (of all transport modes) in the city
- The improvement of the urban environment quality (reduction of air, noise, visual pollutions, higher safety, …)

[1] To favour short-term parking, in June 2004 the municipal council has taken the decision to reduce meter parking costs for parking of maximum 30 minutes to 0,10 Euros (Ville de Liege, www.liege.be).

- The enhancement of the accessibility to the city

On the basis of diverse studies concerning the potential impacts that the development of P+R facilities could have on the city of Liege, the local authorities have decided for some years to develop their own “P+R network”. The location choice of the future P+R facilities was planned taking into account four main factors : the quality of the public transport services at the P+R site, the site accessibility by car, the land availability[1], and the financial factor. On the basis of the evaluation of these factors, 10 sites were selected to accommodate the future (short and long-term) development of P+R facilities (see map illustrating the location choices of P+R facilities in appendix 3).

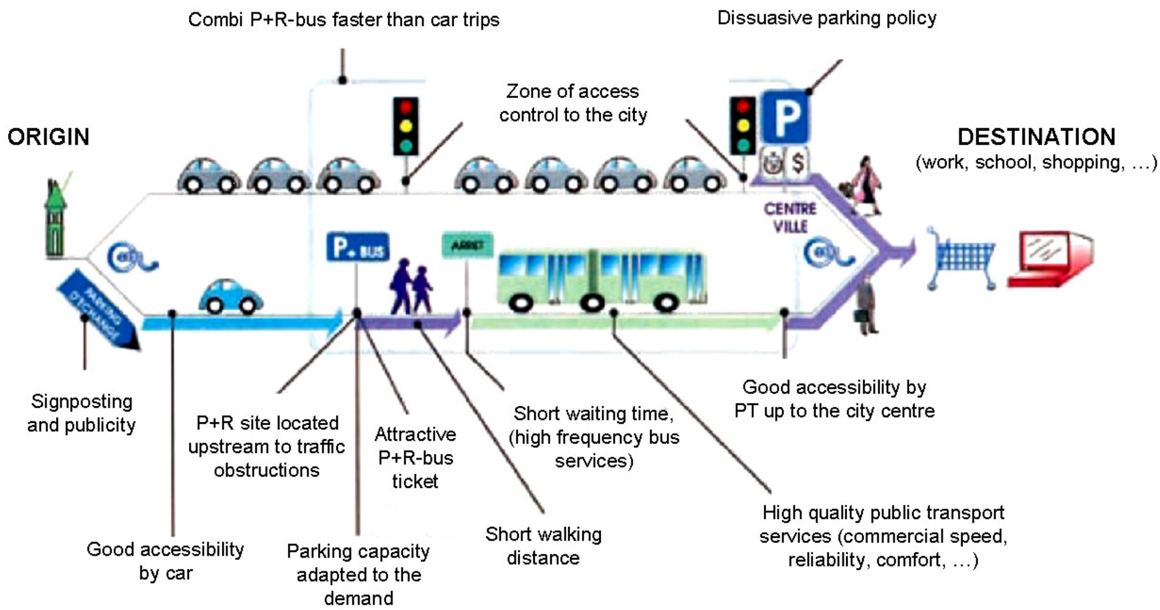
The development of P+R facilities is a delicate task since a park-and-ride is a multimodal platform that should effectively coordinate cars, bikes, and walking itineraries with public transport routes. Its planning must thus be the result of a comprehensive reflection including all transport modes, and carried out at the agglomeration level.

It is commonly acknowledged that numerous factors condition the success of P+R facilities (e.g. European technical committee on transportation, 2006 ; Victoria Transport Policy Institute, TDM encyclopedia ; Région Wallonne, 2005). These factors can be summarised into 10 points (fig.7.2) :

1. A **good location** assuring a good accessibility by car, located at the intersection point of many roads and upstream to traffic obstructions
2. An **available site** (with sufficient spatial dimensions) with a **good visibility**
3. **High quality public transport services** to reach the city centre
4. **Cheap** (or free) parking costs, coordinated with an **adapted parking policy** in the city centre
5. **Quick** and **comfortable transfer** between parking facilities and public transport (short walking distances, large pavements, high quality bus stops, …)
6. **Modal coordination** avoiding competition between modes going into the centre
7. **Secured** parking (sensation of security for people and vehicles)
8. **Land use coordination**
9. Good **signposting**
10. **User information** and **promotion**

[1] The factor “land availability” refers to the space available to develop a P+R site at a certain place. To be selected, a site must provide a potential parking supply which is high enough to satisfy the potential parking demand (evaluated on the basis of the current cars number on the considered axis).

Fig.7.2. Main factors conditioning the success of P+R facilities



Source : Transitec, dans Région Wallonne, 2005
Adapted by C. Maloir

Considering the long-lasting experience that the city of Groningen has with P+R facilities, the city of Liege could benefit from the Groningen's experience to implement its project of park-and-ride.

On the basis of the above list and of the information gathered in the chapter 5, it can be stated that the main strengths of the P+R services of Groningen are the high quality of the public transport services, the low parking costs and the adapted parking policy in the city centre, and the good signposting and publicity to promote P+R facilities use.

Firstly, the **quality of a public transport** is a vital condition for the car park to operate properly and to consolidate the attractiveness and productivity of this system (European technical committee on transportation, 2006). To be successful, a public transport must combine many factors. The main advantages of the city bus services in Groningen are its rapidity (city buses are faster than cars to reach the city centre), its reliability, and the high buses frequency (a bus every 5 or 10 minutes depending on the P+R). Such qualities must be imperatively part of the Liege P+R project. The prospective development of tram lines could serve the P+R sites in an efficient way. However, until the opening of the tram line, bus services should be deeply reviewed in coordination with the new locations of P+R sites.

Secondly, the **price required to use P+R services** is also a main determinant of the success of such parking option. In fact, two conditions must be met. Firstly, the costs that are required to use P+R facilities and shuttle services have to be set in such a way that using the combination P+R/shuttle is cheaper than going by car in the city centre and park there. Secondly, to be able to offer cheaper P+R/shuttle tickets than central parking tickets, the local authorities have to adapt the **parking policy of the city centre**, rising costs for central parking places. The city of Groningen has fulfilled these two conditions. At the opening of the first P+R facilities, the combination parking and bus services was offered for free. This choice was made by the local authorities to stimulate the change in drivers behaviour to use the new peripheral parking facilities. Such choice, although costly for the municipality, was considered as essential to assure the success of the P+R facilities. And indeed, the success came along quite quickly. Then, once drivers were used at this parking mode, local authorities have little by little increased the ticket cost (2 € for a return ticket for max. 5 persons per car), although being still largely cheap in comparison to parking fees in central areas. The P+R project of Liege should imperatively give a large attention to limit the ticket fees required to use P+R facilities and to adapt adequately the parking policy of the city centre. These two conditions are maybe even more important in Liege than somewhere else, since the transport policy set by the local authorities for many years has largely favoured car flows. In this car-oriented context, a change in drivers behaviour would thus request consequent efforts, as well from the municipality as from the drivers, the simple fact of (re)using public transport being already a big step for many of them. This reason justifies well the necessity that, to make the P+R alternative attractive, it should be supported by a tantalizing ticket cost (at least during the first months of the launching).

Finally, a factor which has also played a major role into the success of the P+R services in Groningen is the good **signposting** (e.g. road signals, billboards, traffic signs, …) and the extensive **publicity** (e.g. parking folders, parking campaigns, design of city buses, …) promoting the use of P+R facilities. Such promotional measures must also be imperatively considered at the time of the opening of the P+R facilities in Liege to make change drivers habits.

Moreover, in addition to the above factors inspired by the Groningen's experience, a last component typical of the Liege context should also be taken into account into the planning of the P+R projects of Liege : the **spread out spatial pattern organisation of the peripheral areas**, and the related increasing complexity of the origin-destination matrix. The relation between spatial pattern and P+R services is double. **Firstly**, the development of P+R multimodal platforms will concentrate the spread out traffic flows coming from the entire region at certain privileged spatial points. Therefore, due to the higher traffic that the P+R generates, congestion problems can appear on the roads connected to the P+R sites. For this reason, the development of any P+R facility should always imply the adaptation of the surrounding road network to the expected additional traffic flows. Moreover, it also highlights the necessity to develop P+R facilities upstream to the traffic obstructions, without what the accessibility of the P+R site would be harmed. **Secondly**, the polycentrism of employment and commercial poles is a main constraint to the development of efficient P+R services. The main difficulty of such a spatial spread out of functions lies in the transfer of commuters between P+R sites and employment sites. This factor adds an additional failure risk to the development of P+R facilities in Liege (in comparison to Groningen where all the functions are centrally located). To overcome this difficulty, extra studies and/or surveys must be carried out to have a better knowledge of the itineraries habits of travellers (origin-destination matrixes). Such studies would allow firstly, to increase the quality of the shuttle services supply (e.g. to increase the number of destinations served from the P+R sites, to coordinate shuttle services with fast urban bus services, …), and secondly, to increase the number of P+R users by satisfying the transport needs of more drivers.

The ideas provide in this section are useful elements to take into account to improve the parking policy currently in application in the city of Liege. This set of measures covers as well soft measures quite easy to implement, that do not required large investment or radical travellers behaviour change, as well as more radical measures such as the development of P+R facilities, which require higher investment, larger behavioural changes and higher failure risk, but that have also shown in many cases the large benefits that such development could have. This section has also put into the fore the strong interdependency that exist between the different developed measures, as well between parking measures, as with others categories of measures such as public transport improvement measures. Finally, this section has highlighted the importance to have a high degree of coherence between the implementation choice of TDM measures (i.e. pull measures versus push measures), the context within which are implemented these measures (i.e. compact versus sprawled urban development) and the strategic goals set by the city.

The next section will follow the same "question-answer" structure to suggest ideas inspired by the Groningen's experience to increase the current bike modal split in the city of Liege.

7.5. BIKE FACILITIES

Bike modal split increase could be the solution to deal with a large part of the problems that numerous cities face nowadays. "Increasing the number of journeys made by bicycle can be a real objective adopted by local authority officials in their quest for a less congested, less polluted, and less noisy city that makes better use of space and energy. Along with encouraging a greater share of the number of journeys made on foot and by public transport, it is certainly one of the most effective methods available to cities where better quality of life - a desire now shared by a growing number of citizens - is the aim"(SMILE, 2004, p.39). In addition, bike use is also really cheaper than any other motorised transport mode, what makes is use particularly well-adapted to low incomes citizens. In fact, this is really likely to be reinforced in the future considering the current energy crisis.

The city of Liege, like many other European cities, will tent to introduce bikes in the city. This project would be supported by the development of a **self-service *public bike system***. This system plans the supply of 300 bikes, split up into about 30 bike stations[1] spread through the urban area. However, the topography of the region has strongly limited the possible extension of the bike network. In fact, the bike stations should be located in the inner city, where the bike supply should be the highest, and in some of the neighbouring municipalities located along the Meuse valley. (see map of the bike stations network in appendix 4). Three kinds of stations should constitute this network : the stations that are close to the public transport poles (to assure a good connection with other transport modes), the stations close to urban poles that generate a high demand (e.g. university and schools, administrative centres, cinemas, …), and the stations located in the heart of the neighbourhoods. The goals pursued by this project are triple :

1. To "supply" a bike for urban inhabitants who do not possess a bike (mainly due to the lack of parking places on street and/or at home)

[1] These figures of 300 bikes and 35 stations correspond to a "critical size" (considering the spatial size and the inhabitants number of Liege). Under this size, the number of available bikes per station would be too low and the distances between the bike stations would be too high to provide an efficient bike supply at the urban area level. Ideally the distance between two adjacent stations should not be higher than 400 meters (300 metres in the city centre P1). Concerning the number of bikes, their number should vary between 3 and 40 bikes per station, according to the importance of the station (key role or secondary role in the bike network) (Ville de Liege, Commission spéciale mobilité, Feb.2008).

2. To make the city accessible by bike to visitors, by improving the quality and visibility of the bike itineraries and by decreasing the rising car pressure on the road network
3. To allow to inhabitants to occasionally use a bike for short distance trips (intercity trips or trips to/from the adjacent municipalities)

It term of management, to be attractive, Willy Demeyer, the burgmester of the city, and Jean-François Leblanc, the mobility counsellor of the city, have clearly expressed their will to provide rental bike services that are cheap. "Our requirement as regards to companies is that the first 30 minutes of renting will be supplied for free, and that bike use costs and yearly ticket costs will be really cheap (around 10 € a year)" (La Meuse, 10 juillet 2008). In term of costs, each bike would cost between 1 500 to 2 500 € to the municipality, or a yearly total investment of approximately 600 000 €. That represents a substantial investment considering the financial situation of the city and that the money that will be allocated to this project cannot be used elsewhere (for the improvement of public transport services for example).

Several critics have been formulated by different associations[1] against this project. The most commonly named concern :

- The weak development of the current bike network[2], what will force bikers to share the roads with cars, even in situations where the sharing of infrastructures is not secure. In these cases, bikers will be tented to drive on the pavements, what would increase conflicts with pedestrians.
- The absence of real educational programmes to prepare bike users to safely cycle in an urban environment that is still largely dominated by cars. These programmes should also include the education of car drivers that must know how to react to bikers (e.g. to review bike priorities, to learn to respect bikers, …).
- The pertinence of allocating yearly such an amount of money to a self-service bike system while so numerous basic bike improvements are still missing. The clear lack of bike parking facilities is a good example of such miss.

Many other critics could be listed. In fact, the opponents of the project agree on the following statements. This project, although well-thought, surely appears too early, in a context within which a global mobility policy is not yet implemented in practice. The implementation of such a public bike system, without having been preceded by measures that would have diminished significantly the car pressure on road (cars speed and cars number), would surely be doomed to failure. In that respect, these organisations have required the postponement of the project, until the Liege urban area will be ready to safely welcome bikers in its streets. They support the idea of an extensive bike use in the city, acknowledging that it is the faster travel mode under congested conditions, but they are convinced that to delay the project some years would lead to better results (GRACQ Liège, 2008). This remark highlights the necessity to progress slowly while dealing with mobility, without skipping important steps, and while being sure that all the elements of the transport system have been correctly integrated into the reflection.

[1] The critics have mainly emerged from two associations : the GRACQ Liège (Groupe de Recherche et d'Action des Cyclistes Quotidiens) and UrbAgora. The complete debate "pros and cons public bike system" is available on the website of both associations (www.urbagora.be/activites/compte_rendu_de_la_conference_sur.html).

[2] In fact, the bike itineraries plan of 1998 (see section 4.4.3) is now completed at approximately 70 %. However, in this 10 years period, the number of cars has also growth of 25 % in the city ! The objectives concerning bike that were decided 10 years ago are thus not adapted anymore to the current traffic situation of the city. For that reason, extensive measures favouring bike flows and protecting bikers have to be implemented to make possible the safe use of bike in the city (GRACQ Liège, 2008).

If we assume that the project will be delayed some years to allow it to develop in a more favourable biking context, the Groningen's experience allow to define which are the key elements that must be imperatively developed in Liege along these years so that the city is able to welcome an extensive number of bikers. Two of the elements that would make bike flows safer by decreasing significantly car pressure on the road network are the improvement of public services and the implementation of a dissuasive parking policy. These two measures were already developed in details in the previous sections of this chapter (sections 7.3 and 7.4). However, besides these measures, the long-lasting experience of Groningen in regard to bike policy allows also to highlight other elements that largely condition, or favour, bike use in city. These are the extension of bike network and bike facilities, the importance of the public and political support to favour bike use, and the development of complementarity between bikes and public transport services.

HOW TO EFFICIENTLY EXTENT THE BIKE NETWORK AND BIKE FACILITIES OF THE CITY ?

The first step of any programme aiming at increasing bike use should be the **reallocation of public space to bikers**. Indeed, the safety of bikes and bikers and the rapidity of bike flows can only be assured by extending the bike lanes network (at least on main roads), and by multiplying the spaces specially dedicated to bikes (e.g. *bike parking*, *wheeling ramps* and narrow *bike bridges*, …). Moreover, the efficient use of these bike infrastructures also necessitates **good information and clear itineraries to bikers** (e.g. information on cycling routes, bike itineraries folders, cycling signage, …). Considering urban road network capacity as a fixed variable (especially in the dense urban area where the extension of existing or the provision of new infrastructures is largely constrained by the built-up environment), the extension of space dedicated to bikes can only be achieved by restraining space presently used by the other transport modes. To be in line with the objectives pursued by the city, that means a reduction of space dedicated to cars (i.e. car lanes, on-street parking places). In the Groningen's case, bike roads were divided into two categories, primary and secondary roads, according to the importance and the function of the roads (i.e. higher traffic flows on arterial roads than on local collectors roads). The primary roads were equipped of separated and good quality bike lanes, assuring safety and rapidity to bikers. The lower traffic flows and lower speed of cars driving on secondary roads have allowed "lighter" bike investments. On these roads, speed regulations were slowed down in such a way that car and bike drivers can safely share the roads. This **hierarchic system** between main and secondary roads could be well adapted to the Liege case, to provide to bikers the space they need according to the roads they use. Moreover, this network restructuration task must be implemented without harming the attractiveness of the city. Therefore, every decrease of urban space originally dedicated to cars must be compensated by attractive alternatives that allow to reduce car numbers in central areas while sustaining the attractiveness of the city. Examples of such measures are, among others, the development of *P+R facilities* at the edge of the city (section 7.4), or else the promotion of *carpooling* activities.

HOW TO INCREASE THE CHANCES OF SUCCESS OF A PROGRAMME AIMING AT INCREASING BIKE USE ?

Besides the need of developing an extensive bike network and bike facilities, the success of a bike programme is also conditioned by additional factors. Indeed, as the Groningen's experience has shown, a growth in bike modal split inevitably requires extensive **support from the local population and politicians**.

On one hand, a significant increase in bike use is only conceivable if **supported by citizens**. Indeed, local authorities can take as many measures as they want to favour bike flows, if the demand from the locals to use bikes is absent, these new infrastructures will stay unused. In Groningen, the success met by bikes is partly due to the Dutch pro-bike culture and to the high awareness of citizens to environment and heath issues. Although such bike culture does not exist in Belgium, and that such awareness to environment matters was absent in Liege since recently, the rising pollution and congestion problems that occur in the city have made people more conscious to such problems. Environmental damages and life quality degradations are now more and more acknowledged by the Liege citizens. However, there is little chance that this awareness, alone, will be sufficient to make change their travel habits.

On the other hand, the will of local population to use bikes, if not **supported by elected representatives**, will also have poor effects. A successful bike programme requires many changes implemented by elected representatives. Considering the Groningen's experience, the present high bike modal split of the city has been achieved thanks to a long-lasting effort initiated in the late 1970s by local authorities to sustain the use of sustainable transport modes in the city. The measures which were taken to favour bike use throughout these last decades are numerous. Among others, we can mention the adaptation of bike and car flows regulations to favour bike flows (e.g. *bike traffic lights*, *adapted circulation rules*, *speed reduction*, …). These measures were associated with measures decreasing car pressure on roads (i.e. public transport improvement and dissuasive parking policy). Moreover, a big strength of Groningen was the strong integration that was created between the different planning fields. So, each decision related to transport issue must be in line with the objectives of the other land use planning fields, and reversely. Concretely, that means that any urban project, without exception, must make sure that bikers are integrated in their plans. Indeed, as Menno Oedekerk, planner at the municipality of Groningen, points out : "it is nowadays not possible anymore to plan a project without considering bikes and bikers. It has become more than an obligation, it is an automatism that is totally integrated into our daily planning practices". Just like considering the rising support of citizens for more sustainable transport modes, a change can also be noticed in Liege in the attitude of politicians in regard to bike use. Indeed, in a general way, while recently local authorities still dealt with traffic problems by systematically increasing spaces dedicated to cars, current practices seem to evolve towards the research of more sustainable solutions. The fact that the local representatives consider now bike as a real solution to deal with mobility problems is one of the proof of such change.

Thus, on the basis of these observations, we can state that in Liege there is a growing will, as well from citizens as from politicians, to "make things changing". In that respect, the number of studies which were carried out to find solutions to deal with the Liege transport problems is impressive. However, nevertheless the joint agreement of citizens and politicians concerning the need to use "better" transport modes, the actual implementation of such changes is still hesitant. The main factor explaining this hesitation seems to be linked to the impacts that such changes would have on travel behaviour, most people being not ready yet to modify their travel habits for the sake of sustainability.

HOW TO IMPROVE THE COMPLEMENTARITY BETWEEN BIKES AND PUBLIC TRANSPORT SERVICES ?

A last, more practical consideration should also be made concerning the integration of bike with the use of other transport modes. This last point is really important too since "the complementarity between bike and public transport allows to increase the services supply of the two transport modes, and thus their competitiveness in comparison to car. It profits as well to bikers, who can increase the distance they are able to cover, as to public transport providers, who enlarge their clientele" (Région Wallonne, 2005, p.17).

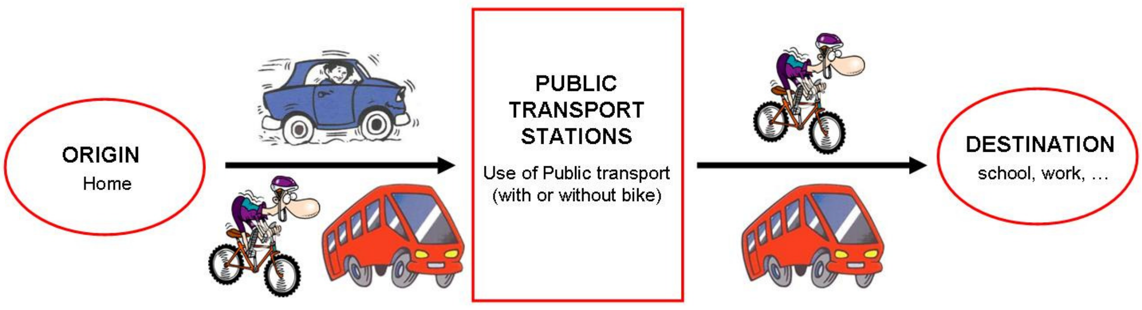
To allow a good complementarity level between bike and public transport, adapted alternatives should be proposed to bikers firstly, around the main public transport stations to safely park their bikes, and secondly, along the trip to allow to bikers to travel with their bikes.

Firstly, concerning the **supply of bike parking facilities**, the local authorities of Groningen have developed large parking facilities close to the main public transport stops (e.g. around the railway stations and the Grote Markt, at P+R locations, …). The most impressive example of such parking facility is the Stadsbalkon parking, which is located directly in front of the railways Central Station, close to the platform entrances. The parking was built in the underground in order to save space that could be use by other functions. This underground situation also allows to limit the visual impact that bikes have on the urban landscape, and to offer a protection to bikes in case of bad weather. This enormous space dedicated to bikes provides a free supply to park 4150 bicycles ! (Fietsverkeer, Feb.2007). The security of bikes parked in the parking facilities also plays an important role into the complementarity level that can be achieved between transport modes. In Groningen, many parking facilities are secure (guarded and/or monitored). Moreover, in the following years the local authorities have planned to extent the supply of secure bike parking facilities in order to favour such combination of transport modes. Conversely, bike parking facilities in Liege, either close to public transport poles or in elsewhere in city centre, are cruelly missing. The increase of parking supply must be a priority of the city to attract new bikers.

Secondly, considering the **loading of bikes into public transport**, although this practice is not implemented with buses (due to technical and security raisons), the loading of bikes in trains is a current practice, as well in Groningen as in Liege. A daily ticket, costing respectively 6 and 8 €, can be bought at stations by bikers to take their bike into trains.

The combination bike-public transport has met a large success in Groningen, especially with the students and workers who daily commute to the city. Many variants to this combination exist. The figure below (fig.7.3) illustrates the most frequent ones.

Fig.7.3. Examples of possible "bike-public transport" combinations



Author : C. Maloir

In fact, the choice to one variant rather than another depends mainly of the distances that have to be covered between the origin and the railway station, and between the station and the destination. A distance longer that 5 kilometres would mostly favour the use of car or bus, rather than bike.

Such combined trips bike-public transport are also conceivable in the Liege case. It could be an attractive alternative to car use. However, the potential success of this alternative will never be as high as in Groningen since the city of Liege is located in a hilly region, what makes some trips more difficult.

The ideas developed in this section are inspired by the long-lasting experience that the city of Groningen has in regard to cycling policy. In fact, this section has summed up the key elements that have been combined in Groningen so that the city was elected "Number One Bicycle City". Since the local authorities of Liege have recently decided to prioritize actions that favour bike use in the city, these elements are of a prime importance for the Liege case. So, besides the necessity to implement measures that aim at decreasing car pressure (cars speed and numbers), this section has pointed out the importance to develop bike network and bike facilities, to have a project that is supported by the local population and politicians, and to stimulate complementarities between bike and public transport services. The implementation of (some of) these measures should prepare the city of Liege to better greet its public bike system project, and the numerous bikers that such a system should attract.

7.6. IN SUMMARY

In this chapter, three TDM measures in application in Groningen have been selected to be transferred to Liege : (1) the improvement of public transport services, (2) the development of a coherent parking policy, and (3) the promotion of bike use.

The major shortcomings that Liege is facing in each of these 3 issues have been pointed out and efficient solutions have been looked for in the Groningen's experience. The tables here below summarize the results of that reflection :

(1) The improvement of public transport services

Liege shortcomings	Possible solutions inspired by Groningen
- How to efficiently restructure the bus network ?	- To restructure the bus lines network according to either they serve main roads of urban areas, local neighbourhoods, or regional areas - To use different designs for different bus functions
- How to deal with the growing demand for bus trips ?	- To develop a high occupancy public transport system - In coordination with additional elements : - to connect the new PT line(s) with the existing bus and rail lines - to connect tram/train/bus lines with P+R facilities - to reinforce the coordination between transport planning and land use planning

- How to constrain car flows ?	- To control car flows via :
	  - the restructuration of the road network (strong hierarchy)
	  - the adaptation of speed regulations
	  - the implementation of traffic calming measures
	- To implement a dissuasive parking policy (i.e. limited and expensive parking places in central area, and extensive cheap parking supply at the periphery)

(2) The development of a coherent parking policy

Liege shortcomings	Possible solutions inspired by Groningen
- How to implement an efficient parking pricing policy ?	- To use more efficiently the existing parking facilities (i.e. higher costs for on-street parking places than for fitted parking places) - To encourage companies and public institutions to develop new parking alternatives - To reduce parking costs as we go away from the city centre to the periphery (only if attractive P+R supply served by efficient PT services)
- How to decrease the number of parking meter violations ?	- To increase the number of parking controls - To set higher parking violation fines
- How to plan an attractive peripheral parking alternative to centrally located parking places ?	- To provide a high quality public transport services to serve the P+R sites - To assess cheap (or free) P+R-bus tickets, coordinated with an adapted parking policy in the city centre (high costs for central parking places) - To promote P+R facilities use via a good signposting and publicity

(3) The promotion of bike use

Liege shortcomings	Possible solutions inspired by Groningen
- How to efficiently extent the bike network and bike facilities of the city ?	- To reallocate public space to bikers, by reducing space dedicated to cars (only possible if attractive alternatives for car drivers) - To (re)structure bike roads network (i.e. hierarchic system between main and secondary roads) - To provide good information and clear itineraries to bikers
- How to increase the chances of success of a programme aiming at increasing bike use ?	- To be supported by local population (e.g. if sensitized to growing pollution and congestion problems) - To be supported by authorities (i.e. adapted cars and bikes flows regulations, measures decreasing car pressure on road, integrated planning)
- How to improve the complementarity between bikes and public transport services ?	- To supply bike parking facilities close to the main public transport centres - To allow to easily load bikes into public transport (i.e. space reserved to bikes and attractive ticket fees)

This chapter has closed the practical part of this work. The results summed up in the 3 above tables have achieved the goal pursued in this work, namely to draw a list of TDM measures that are in application in Groningen and that could be transferred to the Liege context to improve its current transport system.

However, in addition to these results, some additional recommendations must be formulated concerning the limitations imposed by the scope of this work, as well as the possible impacts that such results could practically have in Liege. It is the aim of the last chapter.

8

CONCLUSIONS AND FURTHER RECOMMENDATIONS

8.1. RESEARCH QUESTIONS AND ANSWERS

8.2. SCOPE LIMITATION AND HINTS FOR FURTHER RESEARCH ON THIS TOPIC

8.3. PRACTICAL APPLICATION OF THE RESULTS

8.1. Research questions and answers

This master thesis takes place in the broader debate concerning the paradigm shift that occurred in transport planning these last decades, namely the shift from "demand-led" towards the "management-led" transport paradigm.

The goal of this research was to draw a list of Travel Demand Management measures that are in application in Groningen and that could be transferred to Liege to improve its transport system. To reach this goal, five research questions have been formulated. The below sections try to provide complete and pertinent answers to these questions on the basis of the findings that has been gathered and analysed all along this work.

What is a Sustainable Transport System ? And what is the importance of the Travel Demand Management in the achievement of such a system ?

Various definitions of a Sustainable Transport System have been proposed these two last decades. In this research, it has been chosen to use the one selected by the European Council of Ministers of Transport (recommended by the Transportation Research Board's Sustainable Transportation Indicators Subcommittee, TRB, 2008). This definition is often used because of its broad scope that encompass all the three pillars of the sustainability concept.
According to this definition, a Sustainable Transport System :

- Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy.
- Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise".

Concerning the concept of the Travel Demand Management, the TDM Encyclopedia edited by the Victoria Transport Institute proposes the following definition : "various strategies that change travel behavior (how, when and where people travel) in order to increase transport system efficiency and achieve specific planning objectives. TDM treats mobility as a means to an end, rather than an end in itself. It emphasizes the movement of people and goods, rather than motor vehicles, and so gives priority to more efficient modes (such as walking, cycling, ridesharing, public transit and telework), particularly under congested conditions. It prioritizes travel based on the value and costs of each trip, giving higher value trips and lower cost modes priority over lower value, higher cost travel, when doing so increases overall system efficiency". This definition highlights the narrow links that exist between the management of the travel demand and the three aforesaid pillars. In fact, the Travel Demand Management is a major component to evolve towards a Sustainable System of Transport. Moreover, its role in transport planning is becoming more and more important worldwide.

ON THE BASIS OF A TRANSPORT NETWORK ANALYSIS, WHAT ARE THE MAIN CHARACTERISTICS (STRENGTHS AND WEAKNESSES) OF THE TRANSPORT NETWORK OF LIEGE AND GRONINGEN?

The chapter 3 has provided a general description of the physical, socio-economic, institutional and policy context within which both cities evolve. It has allowed to underline the similarities, but also the numerous differences that exist between the cities of Liege and Groningen. These information have played an important role in the analysis of the transport networks (chapters 4 and 5) to understand some of the choices that have been made in term of transportation in both cities, as well as the travel behaviour and modal preferences of the local populations.

The chapters 4 and 5 apply to the analysis of the transport network of Liege and Groningen, and of their surrounding areas. These two analysis have allowed to highlight the main characteristics, per transport mode, of the transport system of each studied city. It has put to the fore the large dissimilarities that exist in term of modal split between the cities, especially for intercity trips. Indeed, while the car is the favourite transport mode for agglomeration/regional trips in both cities, the decisions that were taken in Groningen since the 1970s have largely constrained car use in the city. Therefore, while car flows largely dominate in Liege, it is the bike that is "the queen of the road" in Groningen. Moreover, these analysis have also laid emphasis on the different transport policies that are pursued by the two municipalities. So, although the strategic objectives set by the transport plans of both cities are similar, big differences exist for instance in the instruments they used to actually deal with transport issues. The constraint degree of these policies regarding car flows, restrictive in Groningen vs. *laissez-faire* in Liege, is also one of these differences.

WHAT IS THE ROLE PLAYED BY TRAVEL DEMAND MANAGEMENT IN THE TRANSPORT POLICY OF EACH STUDIED CITY ? TO WHICH EXTENT THE CONCEPT OF TRAVEL DEMAND MANAGEMENT IS INTEGRATED INTO THE DAILY TRANSPORT PLANNING PRACTICES OF THE CITIES ?

This question was answered by the first evaluation performed in chapter 6. In fact, the TDM measures which have been implemented in both cities have been listed and evaluated (in terms of the impacts they have on transport systems). The results of this evaluation have allowed to conclude that the Travel Demand Management plays a highly different role in Groningen and in Liege. Indeed, in Liege, the few TDM measures that are actually used to deal with the travel demand underscores the derisory role that these measures play into the daily transport planning practices of the city. On the contrary, the numerous TDM measures that are in application in Groningen convey a totally different transport planning policy, which largely recognizes the importance of implementing TDM measures to evolve towards a more sustainable transport system.

HOW CAN WE CLASSIFY THE TRANSPORT SYSTEM OF BOTH CITIES, ON THE BASIS OF THE SET OF TDM MEASURES THAT EACH CITY HAS CHOSEN TO DEVELOP ?

C. O'Flaherty (1997) has proposed a mean to classify the urban transport systems according to five contrasting transport planning approaches. This classification is based on the elements that constitute the transport system of a considered urban area and on the set of TDM measures that have been implemented. This classification method was developed in chapter 2 and put into practice in chapter 6 to classify the transport system of both studied cities.

The results obtained from this second evaluation have highlighted the divergent nature of the elements that constitute the transport system of Liege and the one of Groningen. It has brought to the conclusion that the two studied transport systems correspond to different transport planning approaches. Indeed, the decisions in term of transport that have been taken in Liege throughout these last decades have largely favoured the access by car to the city. The current transport system of Liege corresponds logically to the car-oriented approach, although it also owns some typical elements of the public transport-oriented approach. In the case of Groningen, the strong land use planning system that has guided the extension of the city, coupled with the numerous measures that have been implemented to favour alternative modes of transport and restrain the use of car (at least in the city centre) have clearly situated the transport system of the city in an intermediate position between the land-use planning and the public transport-oriented approach.

WHICH LESSONS CAN BE LEARNED FROM GRONINGEN TO IMPROVE THE TRANSPORT SYSTEM OF LIEGE, TAKING INTO ACCOUNT THE SIMILARITIES AND DIFFERENCES WHICH EXIST BETWEEN THE TWO CITIES AS WELL AS THE CHARACTERISTICS OF THE LIEGE TRANSPORT SYSTEM ?

To answer this last question, it has been necessary to combine all the information that have been collected along the four previous chapters. It has allowed to define which of the TDM measures that are in application in Groningen could be useful to transfer to Liege to improve its transport system. These measures have been carefully selected by taken into account on the one hand, the context within which both cities have developed and the elements that constitute their transport systems, and on the other hand, the kind of measures that have been implemented in both cities. Moreover, the choice of transferable measures has also been guided by the projects that are planned in both cities (e.g. tram, P+R facilities, public bike system, …).

Considering the time assigned to carry out this thesis, the choice was made to focus on the transfer of only a few specific measures, namely the ones which correspond to the biggest strengths in the transport system of Groningen (that have led to good results) and the biggest shortcomings in the transport system of Liege. These measures concern (1) the public transport services, (2) the parking policy, and (3) the use of bike. In fact, for each of these three issues, the major problems that Liege is facing have been pointed out and efficient solutions have been looked for in the Groningen's experience.

The set of proposed possibilities is large. It includes as well soft measures, quite easy to implement and that do not required large investments or radical changes in travellers behaviour, as well as harder measures. These solutions, although quite different from one another, are all complementary and all in line with the goals pursued by the municipality of Liege. This is indispensable to draw an effective TDM strategy that could have large benefits on the general mobility and life quality of the city.

8.2. SCOPE LIMITATION AND HINTS FOR FURTHER RESEARCH ON THIS TOPIC

The scope within which this master thesis situates itself was limited by two dimensions.

Firstly, the time and means assigned to carry out this research has made impossible the complete study of all the components constituting a Sustainable Transport System. For this reason, it has been chosen to analyse solely one of these components, namely the Travel Demand Management. In that regard, it must be kept in mind that the results generated in this work must be placed into a broader context, including all the components of a Sustainable Transport system. They must be coordinated to other actions (e.g. environmental protection, social equity, health issues, …) and integrated into a more global strategic vision. Each isolated action could merely have limited impacts on a transport system, it is only the combinations of individual actions that could make significantly evolve a transport system towards a more sustainable state.

Secondly, this thesis has been limited to the TDM measures that could be transferred from Groningen to Liege. However, it is sure that other measures, from other cities, are also transferable to Liege. To extent the comparative analysis that has been carried out in this work to other urban areas would allow to increase the range of possibilities that could solve the Liege transport problems. Indeed, since the transport system of Liege is rather car-oriented, ideas could surely be found in the transport practices of other "car-oriented" cities that have implemented efficient means to manage car flows.

Finally, Mobility Management deserves a particular attention. The necessity to implement MM measures to support the development of harder measures (i.e. requiring larger investments and deeper travellers behaviour changes) has been mentioned several times along this work. However, it is essential to insist on the importance that MM measures have in the success of any transport project, especially because these measures are (too) often neglected in transport planning practices. This low interest of local authorities in MM is mostly due to the lack of physical presence and/or visual impacts of these measures (e.g. information diffusion or educational programmes vs. construction of parking facilities or road extensions) and the difficulties to evaluate their impacts (e.g. indirect effects between a public campaign and the changes it causes on travellers behaviour). Yet, MM measures are as much important - if not even more important - than harder measures. This statement calls therefore for a better understanding of the impacts of such measures. Additional researches would provide precious information on the way people should react, and are open-minded, to the idea to travel differently (e.g. by combining the use of several transport modes and by using alternative modes, by paying higher parking prices, …).

8.3. PRACTICAL APPLICATION OF THE RESULTS

Taking into account the numerous differences that exist between the two studied cities, the goal pursued by this master thesis has been achieved and a list of transferable measures has been proposed. However, it should be kept in mind that the gap between a theoretical list of possible transfers of TDM measures and the practical implementation of these measures is large. The impact that this work could practically have on the transport system and transport planning practices of Liege depends on various factors.

Firstly, the utility of this work is conditioned by the path that the urban transport system of Liege will take and by the development choices that the local authorities will undertake in terms of transport in the next future. In that respect, as it has been already mentioned, the local population and authorities of Liege have recently acknowledged the mobility issue as a priority to be dealt with. This changing context should thus be highly favourable to the implementation of new innovative ideas, such the ones proposed in this work.

Secondly, the "rough" implementation of the measures inspired by the Groningen's experience in Liege would not be sufficient. As it has been stated many times in this work, a successful transfer of measures from Groningen to Liege indispensably requires the adaptation of these measures to the Liege context. In that respect, several elements that differ between Groningen and Liege could jeopardize the success chances of transfer :

- The general **spatial organisation** of both cities - sprawled and polycentric in Liege *versus* compact and monocentric in Groningen
- Their **transport planning system** – weak, non-restrictive and isolated in Liege *versus* strong, restrictive and integrated in Groningen.
- The **budget** that the two municipalities have to cope with mobility – limited in Liege *versus* large in Groningen.
- The **interrelations between actors** involved in mobility issues – highly diverging opinions leading to "dead-ends" in decision-making in Liege *versus* actors aiming to achieve consensus in Groningen.
- The **integration of the population** and their **support** for transportation projects – low in Liege, but in progress *versus* long-lasting participative planning in Groningen.
- The **physical environment** characteristic of both cities – strong topographic and hydrologic constraints in Liege *versus* strong hydrological constraint, but absence of relief in Groningen.

Finally, in the implementation of any transport project, like in any other fields, the "zero risk" does not exist. However, it is possible to limit these risks by learning from its own previous errors or from others' errors. Groningen, due to the precursor role that the city has played in many transport fields, has been constrained to learned chiefly from its own errors. Reversely, the fact that the local authorities of Liege have taken a long time before seeking effective solutions to deal with mobility issues allows to the city to beneficiate from others' experience. These opportunities, if well used, can considerably increase the chances of success of the future transport projects that will be implemented in Liege.

To sum up, it will necessarily require time and large, in-depth efforts to improve the transport system of Liege. Time will tell us if the "good" decisions will be take to guide the mobility of the city (i.e. decisions leading to a more sustainable mobility and city), and if the local population will support these decisions.

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