



**LiRa Pilot 4:
Light Rail, Long term
(modal split) impacts**

Final Draft Report

Commission by:

LiRa: The International Network of Light Rail Cities

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Executive summary

In this summary, first a general overview will be given of the results of Pilot study 4 of “LiRa: the International Network of Light Rail Cities”. Then, practical guidelines on the central aspect of the study will follow. At the end, there is a section with "good practices".

A Overview

- 1 Pilot 4 study of the LiRa project focuses on the following question: ***is a light rail system attractive enough to offer a serious alternative to travelling by car and cause a substantial modal shift of passengers in favour of public transport?*** Answering this question with findings from the literature and empirical evidences of case-study cities has enabled us to assess concrete proposals helping in the implementation of a new light rail scheme in the view of inducing an increase of the modal split for public transport.
- 2 The term "light rail" is used for various kinds of transport techniques, ranging from a modern but conventional tram sharing important parts of its itinerary with the cars to a system using mainly or exclusively dedicated lanes, and having only a limited number of crossings at level. It is clear that the ability of such systems to attract patronage, reduce traffic congestion and increase the modal split of public transport depends heavily on the characteristics of the light rail considered (operating speed, comfort, accessibility of the rolling stock...), and their variability makes the comparisons between studies difficult to achieve. ***In the LiRa study the term light rail represents every quality rapid transport system, that operate on a regional scale.***
- 3 Pilot 4 has consisted of reporting guidelines for local authorities who consider to develop a light Rail project : it is based on a literature review and three case studies carried out in Nantes, Karlsruhe and Brussels. These guidelines focus on :
 - the forecasting of the modal split that can be produced by such a transport system
 - the possible ways of influencing the modal split by the conception of the Project and by the accompanying measures.

B Case study results

4 Three case-study cities have been selected: Nantes, Brussels and Karlsruhe. According to the available data in each city, the impact of the light rail system regarding the modal split has been studied following one or several complementary angles :

- **before and after analysis** how is the modal split affected by the implementation of a new light rail scheme on a given corridor ?
- **with and without analysis** what are the differences in modal split between corridors served by a light rail scheme and those that are not ?

The following tables summarise the main findings from the case studies.

The case study approach has been completed by a large literature review aiming at identifying the expectations associated with new public transport schemes.

Table 1. Characteristics of the LR service

	Nantes	Karlsruhe	Brussels
✓ <i>Design</i>	<ul style="list-style-type: none"> Modern urban tramway network operated mainly on segregated lanes 	<ul style="list-style-type: none"> Dual system rolling stock (LR and heavy rail links without interchange) Regional system serving the city centre using conventional tramway tracks 	<ul style="list-style-type: none"> Pilot line connected with the Brussels urban PT network To be integrated in the LR network project that will be operated mostly on the existing rail infrastructure network
✓ <i>Date of implementation</i>	<ul style="list-style-type: none"> 1985 : first LR line 1994 : second LR line 	<ul style="list-style-type: none"> 1992 : first line 	<ul style="list-style-type: none"> 1994 : pilot line
✓ <i>Network length</i>	<ul style="list-style-type: none"> 3 LR lines : 36 km of lines (to be increased to 45 km by the end of 2005) 	<ul style="list-style-type: none"> 4 regional and 6 urban LR lines : 300 km of lines, to be extended 	<ul style="list-style-type: none"> Pilot line : 27.2 km (network to be extended) Total project : 300 km

Table 2. Before and after comparison

	Nantes	Karlsruhe	Brussels
✓ <i>PT usage</i>	<ul style="list-style-type: none"> significant impact on the total PT use, at the city level : 1984-1986 (line 1) : + 19 % 1992-1994 (line 2) : + 6.3 % 	<ul style="list-style-type: none"> significant impact along the corridors served : Karlsruhe - Bretten (1992-1997) : + 600 % Karlsruhe - Wörth (1996-1998) : + 94 % Karlsruhe -Pforzheim (1996-1998) : + 129 % 	<ul style="list-style-type: none"> significant impact along the corridor served by the pilot line : + 154 % (1993-1997)
✓ <i>LR modal split</i>	<ul style="list-style-type: none"> 1980-1990 : increase of the car modal split and stagnation of the PT modal split, despite the opening of the first LR line 1990-1997 : reduction of the car modal split and increase of the PT modal split, thanks too the opening of the second LR line and appropriate accompanying measures 	<ul style="list-style-type: none"> evidences of modal shift in favour of PT : Karlsruhe - Bretten line : 40 % of LR customers are former car users Pforzheim - Karlsruhe – Wörth line : 20 % of customers are former car users 	<ul style="list-style-type: none"> pilot line : no noticeable impact at the Brussels scale. Data not available at the corridor level. Simulation results for the whole LR network project : PT market share for trips going to the Brussels Capital Region : <ul style="list-style-type: none"> in 1991 without LR : 38 % in 2005 without LR : 32 % in 2005 with LR : 45 %

Table 3. With and without comparison

	Nantes	Karlsruhe	Brussels
✓ <i>PT usage</i>	<ul style="list-style-type: none"> Public transport use and walking are much higher within the city than in periurban areas 57 to 78 % of the inhabitants are PT users (regular or irregular) ; the higher percentage is found in the sectors that are the best served by the LR 	<ul style="list-style-type: none"> On the line Karlsruhe– Bretten, LR has appeared as much more successful than heavy rail 	<ul style="list-style-type: none"> availability of value attributed by line '26' users to different characteristics of the service (stated preference survey) : availability of values of different elements of public transport services by trip purpose (IRIS Plan)
✓ <i>LR Modal split</i>	<ul style="list-style-type: none"> the market share of PT is slightly higher along LR lines than along bus corridors offering a similar level of service 	<ul style="list-style-type: none"> LR or regional railway lines have a market share of 50 % ; for most successful routes, the market share rises to 67 % 	<ul style="list-style-type: none"> Before the implementation of the LR network: for home-to-work trips less than 30 km, the car has the greatest market share; for other trips PT have the greatest market share. The objective of the LR network is to counterbalance this trend
✓ <i>Car travelling context</i>	<ul style="list-style-type: none"> People living along LR lines and in situation of modal choice are much more likely to use the LR line for their home-work trips if they do not have a reserved car park at destination 		<ul style="list-style-type: none"> The use of PT is highly dependant on the difference in door-to-door travel time between cars and PT, hence on road congestion Simulation results show that car parking restrictions and / or road pricing are likely to induce a modal shift from car to PT

C Guidelines for implementing a new light rail scheme

In this section, conclusions in the form of guidelines to local authorities who consider developing a light Rail project are presented.

Why Light Rail ?

- 5 According to a recent survey of over 45 existing and planned light rail (or busway) public transport systems worldwide¹, ***the reduction of traffic congestion is the most common and the most important objective for constructing a new transit system.*** This suggests either an increasing concern about congestion or an increasing confidence about the ability of a new public transport system to deal with it.

Among the other objectives often cited are:

- the improvement of the public transport
- the improvement of the environment
- the stimulation of development.

The fulfilment of these objectives should imply an increase in the patronage of public transport, which may in turn have an impact on the modal split between public and private transport. This would also lead to reductions in emissions.

- 6 However, although the expectations associated with new light rail systems are high, ***the underlying mechanisms leading to the fulfilment of these objectives appear to be not well known*** by the promoters of these systems.
- 7 Moreover, there is evidence from the United States, Britain and France that ***the expected impacts of a new light rail system were often more important than the operational ones are actually.***

In most French cities having implemented a new light rail system, the market share of the car has continued to increase, despite the building of the light rail. In Britain and in the United States, few operational systems seem to have met their objectives. Indeed,

¹UTOPIA survey, Macketts & Edwards (1998)

when looking at traffic forecasts before and after the opening of a new system, it is clear that a gap may exist between the expectations and the reality.

8 To reduce as much as possible differences between forecasting and reality, it is recommended to pay a particular attention to the following items :

- **Define adequately the area to consider in the impact study** : Classical socio-economic evaluations investigate the modifications of patronage inside of the corridor being considered. **Take into consideration network effects** which are the modifications that may appear on the network outside the corridor being considered, as a result of the modifications of infrastructure within this corridor. These network effects include :
 - route modifications at the level of the study area ;
 - potential demand : additional trips (which did not exist in the former network configuration) being travelled through the corridor ;
 - induced effects : economic modifications which may appear from the interaction between generalised cost of location and generalised cost of transport (the new infrastructure project may induce inhabitants and companies movements).

- **Define and take into account in the models the adequate accompanying measures** that represent a key success factor of any public transport scheme. A new light rail system alone without adequate accompanying measures is unable to produce a significant modal shift in favour of the public transport.

- **Choose the adequate forecasting model** : transports models continuously evolve, as new impacts or developments are accounted.
 - As a minimum, make use of a **four steps classical multimodal model** able to consider the road congestion impact on the modal choice; in that case be aware that a four step classical model is only able to carry out short term forecasting ;
 - To carry out long term forecasting, take into account that transport and land-use have to be considered as an integrated and mutually dependant system. It is now generally accepted that transport policies alone will not achieve a sustainable level of fuel consumption and emissions. It is intended that transport and land-use have to be considered as an integrated and mutually dependant system. Make use of **integrated land-use – transport models** such as MEPLAN or TRANUS ;

- prefer disaggregate transport model versus aggregate transport model for analysing users behaviour².
- **Make an adequate use of forecasting procedures** and check the validity of hypotheses or input data in forecasting models³:
 - **consider the potential changing in politico-economic context** between designing and implementing a new light rail scheme which is likely to affect the validity of the hypotheses used as basis of the forecasting exercise ;
 - **elaborate a market study independent from potential pressure of politicians or policy makers** to produce a scheme that seem more attractive that it is actually.

Light Rail and modal split.

From the literature review and the Pilot 4 case studies, it has appeared that a good LR supply is able to induce a sensitive reaction in term of public transport demand.

9 Public Transport project design

Behavioural models show that the difference in door-to-door travel time between public transport and car alternatives, and hence the road congestion level, are crucial in the modal choice decision. This characteristic is well confirmed by the LiRa literature research and the results of the Pilot 4 case studies.

Success factors in this respect are the following.

- **Make sure the LR service is competitive with the private car in term of commercial speed** : 20km/h may be successful for urban lines (Nantes) while there is a need for higher speed such as 50 km/h on interurban corridor sub urban lines (Karlsruhe-Bretten line) ;

² Aggregate transport demand models have been used until the early 1980s, despite the awareness of several deficiencies in the conventional methodologies. Only then, discrete choice models like stated preference models, based on the behaviour of individuals, have started to be considered as a serious modelling option.

³ Transport forecasts are based on socio-economic forecasts that sometimes reflect the expected effect of economic and regional policies, whose success may actually depend on other uncontrollable factors like international trade and cooperation. Errors in forecasting these global indicators have been found to be at the root of the problem of mistakes for the planning variables at the local level.

- **Take care that the headway (related to frequency) does not induce a disproportionate penalty** on the door to door LR travel time. As LiRa Pilot 4 case studies confirm that :
 - on short distances or at the urban level, the appropriate frequency is 1 vehicle every 5 minutes to 10 minutes like in Nantes ;
 - on longer distances or at the interurban level, the frequency can be reduced to 3 vehicle per hours: see Karlsruhe and Brussels case studies ;
- **Reduce the number of interchanges or improve the level of service at the interchange stations.** The more successful LR usage to city centre destination in Nantes and Karlsruhe confirms this item as well as the impact on LR ridership of the diversion to the city centre of the Karlsruhe-Wörth line in 1998 and the value attributed by the Brussels line 26 user to one additional direct vehicle.

10 Customer related features

Some additional factors related to the user comfort appear to be preponderant as well. Recommendations are the following:

- **Pay attention to a harmonious integration of fare:** they are recognised as a factor of success, e.g. in Nantes and Karlsruhe. Karlsruhe case study shows the impact on LR ridership of integrated fare implementation on the Karlsruhe-Wörth line in 1997. In Brussels, it is advised to complete the fare integration (only achieved for trips inside the Brussels-Capital Region) for all trips ;
- **Take care of a satisfactory operation schedule:** the Karlsruhe LR system is operated from 4h30 am to 1h00 am and to 3h00 during the week-end. One of the most important inconvenient of line 26 in Brussels is that it is not operated during evenings and week-ends ;
- **Be aware of the importance of the comfort of the rolling stock :** on short distance (urban level), favour a **higher capacity of standing** passengers than **comfortable seats** ; on middle-long distance more and more comfortable seats are of importance; **Boarding at level rolling stock accessibility** is also a successful characteristic already fulfilled in Karlsruhe and on the new vehicle series in Nantes ;
- **Mind the importance of the quality of the information provided to the user :** three characteristics are of main importance :

- **Timetables** have to be **easy to understand and to remember** : scheduled timetables (fixed headway) are the most successful in that term; the experience of Karlsruhe show the positive impact on the LR ridership resulting from the implementation of scheduled timetable in 1993; it is also recognised that in Brussels it would contribute to improve the level of service of line 26.
- **LR origine-destination routes** have also to be **easy to understand and to remember** : (see the example of the North and the South network of London), the right compromise has to be found in the network configuration between lines linking all possible origin-destination pairs without connection and more efficient and more clear network organisation inducing connected trips.
- **The access way and the connection route to the stations and platforms has to be clearly indicated.**

11 LR image

The Pilot 4 case studies have also pointed out the importance of the image of the mode.

- **Make LR mode popular** by the way of marketing methods and using perception surveys: In Nantes, it has been reported that the “modern” image of the tram can explain the higher success of LR and that several people now consider the bus as being “old fashion”; In Karlsruhe 70 % are satisfied or very satisfied of the service; in Brussels, line 26 is better and better perceived.

12 Transport accompanying measures

The impacts of a new light rail scheme itself in terms of reducing car use and traffic congestion are generally very limited in scale. Therefore adequate accompanying measures are required :

- **Use LR as a transport policy tool** : accompanying measures should be used and optimised as push factor, complementary to the pull factor constituted by the LR supply to enhance the effectiveness of reducing car use. Accompanying measures, resulting of the Pilot analyse are the following :
 - **Reduce the car parks capacity within the city** (on street and off street policies): the success of LR in Nantes is partly due to the limited capacity of parking. Additionally, a survey carried out in Nantes has shown that people who are in situation of modal choice are much more likely to use LR services for their

home-work trip if they do not have a reserved car park at their destination. In this regard, it is envisaged to limit car park availability in Brussels in areas that are well served by PT.

- **Implement Park & Ride facilities** : Nantes and Karlsruhe have both developed park & ride: Karlsruhe LR success is partly due to park & ride: 10 000 park & ride users, 4.6 % of line 1 and 6% of line 2.
- **Reorganise the urban and interurban public transport services and provision of right of way** : the level of service of LR is highly dependent on the level of service of the overall PT supply in the whole transport system area. Ensure a good coordination of every mode within the whole transport area; in Karlsruhe, in 1994, a new passenger transport authority gathering the municipalities and the regional administrations has been created and is responsible for the fare structure and the timetables of the whole transport system.
- **Develop the attractiveness of the LR stations**. Notably in Karlsruhe, buses were removed as soon as LR was implemented and were reorganised as “feeder lines” to serve the area more densely; in Brussels, several stations of line 26 have been improved in this respect.
- **Restrict the capacity of the road network** : the main objective is to share more equitably the public space between every user category i.e. increasing the space devoted to PT lines (segregated lanes), 2 wheels users and pedestrians. It aims to improve the commercial speed of public transport; in Nantes and Karlsruhe the building of dedicated lanes for PT lines has been facilitated by the building of new bypass roads infrastructure projects.
- **Road pricing could be envisaged as a efficient tool affecting the modal split** : this measure which has been simulated in the land use transport model of Brussels reveals that the modal shift from car to PT is even more efficient if the revenue of car tolling is used to subsidise PT alternatives.

13 Land-use related accompanying measures

Transport policies and investments are implemented on the basis of transport planning and operation and therefore their evaluation is linked to performance in terms of transport operations.

However, transport policies and investments may have wider economic effects than only at the corridor level or within the areas that they are designed to serve, but also at a larger spatial and temporal dimension. It is therefore required to carry out in-depth researches in order to evaluate the socio-economic impacts stemming from transport policies and investments.

A consensus is emerging that it is necessary to **co-ordinate land use changes with transport measures** in order to achieve an environmentally and economically sustainable transport system. In the Brussels case the Land-use Master Plan was conceived simultaneously with the Transport MASTER Plan and was inspired by the Dutch ABC method “The right business in the right place”

Some additional guidelines in this respect:

- **Define the accompanying measures reinforcing the concentration of activities:** in addition to the here above mentioned transport accompanying measures, socio-economic accompanying measures enabling to control the location of housing and employment activities within the transport system area.
 - On one hand, positive land-use effects from Light Rail can be observed; LiRa Pilot 3, notably presents the case study of London Docklands where the Light Rail network is considered as a structuring framework for development.
 - On the other hand, negative impacts could be observed too: in Brussels, for example, land-use transport simulations studies have confirmed the expectations that there is a high risk that the increasing accessibility along the corridors served by the LR network could induce a relocation of households in the suburbs, where the land is cheaper, and increasing the phenomena of the urban sprawl.

D Good practices

Infrastructure design and operation

If your aim is....

To increase the use of PT services...

Important aspects are :

- Provide a good LR level of service in term of travel time, frequency and number of interchanges in order that it is competitive with the door-to-door private car trips ;
- Ensure a good coordination of the LR service with the whole transport area: fares, timetables,... ;
- Pay attention to the service to the users : integrated fares, long operation schedule, services information provision and readability ;
- Be aware of the importance of the comfort of the rolling stock: number of seats, boarding at level rolling stock,... ;
- Use marketing methods to let LR mode become very popular.

Transport planning

If your aim is....

To reduce the car use...

Important aspects are :

- Use LR as a transport policy tool ;
- Define appropriate accompanying measures :
 - Reduce car parks capacity ;
 - Implement Park & Ride facilities ;
 - Reorganise the urban and interurban public transport services and provision of right of ways ;
 - Develop the attractivity of the LR stations ;
 - Restrict the capacity of the road network ;
 - Road pricing can also be envisaged as an efficient tool.

Integrated Land-use Transport planning

If your aim is....

To serve a sustainable development...

Important aspects are :

- Use LR as a integrated land -use - transport – environment policy tool ;
- Define appropriate accompanying measures ;
- Control the location of household and employment activities within the transport system area ;
- If necessary, reinforce the concentration of activities.

Modelling issues

If your aim is....

To carry out long term forecasting...

Important aspects are :

- Define adequately the area to consider in the impact study, take in consideration network effects ;
- Define and take into account in the models the adequate accompanying measures ;
- Choose the adequate forecasting model :
 - As a minimum, make use of a four steps classical multimodal model ;
 - To carry out long term forecasting, make use of integrated land-use – transport models ;
 - Prefer disaggregate transport model versus aggregate transport model for analysing users behaviour ;
- Make an adequate use of forecasting procedures and check the validity of hypotheses or input data in forecasting models :
 - Consider the potential changing in politico-economic context ;
 - Elaborate a market study independent from potential pressure of politicians or policy makers.

Chapter 1 Introduction

This chapter will first describe the backgrounds of the project. Then, the central theme of the project is addressed, providing the objective of Pilot 4. Approach and project design follow. The structure of the report concludes this introductory chapter.

1.1 Background : LiRa

'LiRa: the International Network of Light Rail Cities' is an Interreg IIc-project, which is co-financed by the European Union/NWMA. The main goal of the project is to exchange ideas and knowledge and conduct research about Quality Rapid Transit systems, operating on a regional scale, ultimately leading to the drawing up of Action Programmes and Guidelines. The project started early 2000 and will continue until the beginning of 2001. In the project, 11 European partner regions from the four countries of the NWMA region (North -Western Metropolitan Area) work together. The regions taking part are:

- City Region of Haaglanden (the Netherlands);
- Province of Noord-Holland (the Netherlands);
- Province of Limburg (the Netherlands);
- Province of Gelderland/KAN-region (the Netherlands);
- Greater Manchester Passenger transport Authority (United Kingdom);
- East Lancashire Partnership (United Kingdom);
- Cardiff County Council (United Kingdom);
- Ministry for the Walloon Region (Belgium);
- Ministry of the Flemish Region (Belgium);
- City of Kaiserslautern (Germany).

These regions are all working on the implementation of Light Rail systems; their systems are in various stages of completion.

One of the main parts of the overall LiRa project is carrying out pilot studies. Four of these more specialised detail-studies are carried out, treating subjects that bear the interest of the LiRa partners:

- Pilot 1: Comparison of exploitation models;
- Pilot 2: Light Rail versus heavy rail;
- Pilot 3: Light Rail, economic impact and real estate development;
- Pilot 4: Long term (modal split) impact.

The results of the pilot studies are valuable input to the Action Programme that is the final component of the overall LiRa project.

This report covers ***pilot 4***.

1.2 Objective of Pilot 4

Pilot 4 study of the LIRA project addresses a very fundamental question : **Is a Light Rail system attractive enough to offer a serious alternative to travelling by car and cause a substantial modal shift of passengers in favour of public transport ?** Answering this question with findings from the literature and empirical evidences of case-study cities have enabled us to discuss and to assess concrete proposals helping in the implementation of a new Light Rail scheme in the view of inducing an increase of the modal split for public transport.

The term "Light Rail" is used for various kinds of transport techniques, ranging from a modern but conventional tram sharing important parts of its itinerary with the cars to a system using mainly or exclusively dedicated lanes, and having only a limited number of crossings at level. It is clear that the ability of such systems to attract patronage, reduce traffic congestion and increase the modal split of public transport depends heavily on the characteristics of the Light Rail considered (operating speed, comfort, accessibility of the rolling stock...), and their variability makes the comparisons between studies difficult to achieve. ***In the LiRa study the term Light Rail represents every quality rapid transport system, that operate on a regional scale.***

Pilot 4 has consisted of reporting guidelines for local authorities who consider to develop a Light Rail project : it is based on a literature review and three case studies carried out in Nantes, Karlsruhe and Brussels. These guidelines focus on :

- the forecasting of the modal split that can be produced by such a transport system
- the possible ways of influencing the modal split by the conception of the Project and by the accompanying measures.

This report contains the results of the project. The pilot group that monitors the study consists of representatives of:

- City R. of Haaglanden (Germany)
- GMPTE Manchester (United Kingdom)
- East Lancashire Partnership (United Kingdom)
- Walloon Region (Belgium)
- City of Kaiserslautern (Germany)

1.3 Approach and project design

Four main phases of the pilot can be distinguished. For each of them, an overview of the activities carried out is described here below.

Phase 1 : Literature review

A wide literature review has been made on Light Rail experiences in Europe and America with the aim to propose a list of relevant case studies to be analysed in depth. An intensive use of the UITP library has been done during this phase .

Phase 2 : Case studies

After consulting the pilot group about the result of the first phase, the selection of the case studies started, resulting into the choice for Nantes, Brussels, Karlsruhe and Den Haag⁴. According to the available data in each city, the impact of the Light Rail system regarding the modal split has been studied following one or several complementary angles :

- ***before and after analysis*** how is the modal split affected by the implementation of a new Light Rail scheme on a given corridor ?
- ***with and without analysis*** what are the differences in modal split between corridors served by a Light Rail scheme and those that are not ?

⁴Note that Den Haag was subsequently deleted.

Phase 3 : Interview of the marketing managers of the Light Rail services

The consultant has been in contact with the marketing managers of the Light Rail services to discuss the best interpretation of the results and the lessons to be deduced and to validate the methodological conclusions.

Phase 4 : Development of guidelines and recommendations

The outcome of the three first phases has been integrated in the present report containing guidelines and recommendations for local authorities who consider to develop a Light Rail Project.

1.4 Structure of the report

The report is structured as follows:

- **Chapter 2** deals with the conceptual framework, based on the literature review. It mainly addresses the following topic : *What are the expectations to be associated with new urban public transport systems and their impacts?*
- **Chapter 3** focuses on the models and methods for calculating impacts, including recommendations.
- **Chapter 4** provides with a summary of the case studies (Nantes, Brussels and Karlsruhe). For each of the cities, the city and Light Rail systems are described and a number of aspects are investigated of which the main topics are the potential impacts of Light Rail implementation and the potential impacts of the accompanying measures. The full description of the case studies is available in appendix.
- **Chapter 5** focuses on guidelines for a successful implementation of Light Rail.

Chapter 2 **Conceptual framework**

2.1 Introduction

Pilot 4 study of the LIRA project addresses a very fundamental question: ***Is a Light Rail system attractive enough to offer a serious alternative to travelling by car and cause a substantial modal shift of passengers in favour of public transport?***

Before answering this question, we must acknowledge what Light Rail does mean. ***In the LiRa study the term Light Rail comprises all quality transport systems that operate on a regional scale.***

In accordance with this, in the literature, the term "Light Rail" is used for various kind of transport techniques, ranging from a streetcar sharing most of its itinerary with the cars to a system using mainly or exclusively dedicated lanes and having only a limited number of crossings at level. Many old European streetcar systems are progressively and continuously upgraded to "Light Rail" by the building of right-of-ways and tunnels (Brussels, Bielefeld, Frankfurt, Hanover,...), therefore the border between a Light Rail and a streetcar is not easy to define. Even when we focus on the new systems that have been opened in Europe or in North America during the last twenty years, we detect a great variability in their characteristics :

- light automated metro, totally segregated from road traffic : Lille (VAL), Toulouse, Detroit People Mover ;
- reuse of disused railway lines with on-street extension of the network to the city-centre : Manchester, Croydon, Kassel ;
- modernisation of old suburban railways and extension of the line to the city-centre in new tunnels : Valencia, Bilbao, Newcastle upon Tyne ;
- mixed-operation of railway lines where conventional (heavy) trains share their tracks with Light Rail vehicles that are extended to the city-centre via the conventional streetcar network : Karlsruhe, Saarbrücken ;
- modern urban tramway with (generally) low-floor vehicles and dedicated lanes on an important part of their itinerary, and sometimes tunnels or underpasses: Grenoble, Nantes, Lille (Mongy), Sheffield, Rouen.

It is clear that the ability of these systems to attract patronage, reduce traffic congestion and increase the modal split of public transport depends heavily on the characteristics of the Light Rail (operating speed, comfort, accessibility,...), and their variability makes the comparisons between studies difficult to achieve.

2.2 Analysis of expectations with new urban public transport systems

One way to identify the anticipated impacts of new urban public transport systems is to examine the objectives underlying their development. The Urban Transport Operations and Planning using Intelligent Analysis (UTOPIA) project⁵ has studied these objectives. The overall purpose of the UTOPIA project was to collect experience about the decision process addressed in the selection of the most appropriate form of urban public transport technology on a regional scale (metro, Light Rail, guided bus and so on), with a view to incorporating the expertise into a decision-support system to provide advice to those making such decisions.

Most often, for more than one project on two⁶, it appears that the main objective underlying the development of a LR system is the **reduction of traffic congestion**. This suggests either an increasing concern about congestion or an increasing confidence about the ability of a new public transport system to do deal with it.

It should be noted that reducing traffic congestion is not mentioned as an objective for the following Light Rail systems :

- London Docklands Light Railway (London) : the objective was rather to promote the urban development of the Docks area.
- Metrolink (Manchester and Newcastle-upon-Tyne) : the building of a Light Rail was viewed as a consequence of the need to take action to deal with heavy rail lines in serious need of investment .

⁵ Mackett and Edwards (1998), "The impacts of public transport systems : will the expectations be met ?", Transportation Research A, Vol. 32 n° 4.

⁶ but not for the older existing system

- Toulouse : the motivation of the building of a Light Rail system was to reduce the deficit of the public transport company, by operating a more efficient mode of transport⁷.

Among the other objectives mentioned :

- *improve public transport*
- *stimulate development*
- *serve the city-centre better*
- *improve the environment*

It is clear that, with the exception of *stimulate development*, the fulfilment of these objectives implies an increase in the patronage of public transport, which may have an impact on the modal split between public transport and private car. It should also favour positively the environment, by a diminution in emissions, as a consequence of the reduction in traffic congestion.

Hence, it appears that public transport companies have clear expectations related to the operation of Light Rail systems. However, it has to be mentioned that UTOPIA has revealed that ***the underlying mechanisms leading to the fulfilment of these objectives appear to be not well known by the promoters of these systems***.

2.3 Analysis of impacts resulting from urban public transport systems development

It stems from the literature review that, although reducing car use and traffic congestion is one of the main purpose of building a new Light Rail system, the evidence is that, in general, such impacts are very limited in scale.

It stems from the UTOPIA survey that :

- reductions in car use or congestion have been observed as a result of building the new systems in Atlanta, Baltimore (metro), Memphis and Miami (metro and Light Rail).
- in contrast, no such reduction has been found for the Adelaide and San Jose systems.

⁷ Rosalie Hill (1995), "The Toulouse Metro and the South Yorkshire Supertram : a cross cultural comparison of light rapid transit developments in France and England", Transport Policy vol. 2 n° 3.

- in Manchester, it is estimated that 1,32 million car trips per annum have been removed from the road, however there is no evidence that this is the result of the opening of the Light Rail: traffic has fallen by approximately 1,5 % along the corridor served by the new line, however similar declines have also been recorded in other corridors.
- in Calgary, an increase in traffic speed was observed in some places, but this may be due to the reduction in the number of buses, widening of a bottleneck on the highway and upgrading of signal coordination.
- There is evidence of switching from the car to the new system in Sheffield and Toulouse.
- Reductions in air pollution have occurred in Miami (metro and Light Rail), Sacramento and Essen.
- There are few examples of major impact on urban development cited in the UTOPIA survey.

Experiences of new Light Rail systems in France suggest that their opening may boost public transport patronage, however the impact on the modal split is not clear:

- In Grenoble, the number of journeys on the whole urban transit network has increased by 40 % between 1985 and 1992, following the opening of two new tram lines (in 1987 and 1991), and a significant increase of the market share of public transport has been recorded, however this rise was not accompanied by a decrease of the market share of the private car⁸ :

Year	Market share for trips heading to the city-centre			
	Walking	Two-wheels	Private car	Public transport
1985	36 %	4 %	42 %	18 %
1992	30 %	4 %	43 %	23 %

Source : Morel and Gaillardot (1998)

- In Rouen, the new *Metrobus* has been opened in December 1994. After one year of operation, the number of journeys on the whole urban transport network had risen by

⁸ Pierre Morel and Hubert Gaillardot, "Bilan de la politique de déplacement et du tramway de Grenoble", Transports Urbains n° 98, janvier - mars 1998.

27,2 % while the increase of distance travelled by the public transport operator had been limited to 12.4 %. Between 1983 and 1996, the average number of daily trips using the public transport network has risen by 17 %, but the market share of public transport has diminished (from 11,2 % in 1983 to 9,3 % in 1996) following a stronger increase of car use⁹.

- In Nantes, the market share of the car has fallen from 59 % in 1990 to 57 % in 1997 following the extension of the tramway network. A satisfaction survey has shown that 16 % of the tram users did not use the public transport network before the opening of the tram, and that 39 % of users own a car¹⁰.

Hass-Kau *et. al.*¹¹ point out that "European cities which operate significant Light Rail networks have gained more public transport passengers over the 10-years period 1986 - 1996 than cities which rely only on buses. (...) Yet the fact remains that in the majority of cases most of the growth in public transport has resulted from greater numbers of existing passengers rather than making substantial inroads into car use."

2.4 Traffic forecasts and observed traffic

There is evidence from the UTOPIA survey that new public transport systems are expected to affect travel demand, the environment and urban development. However, when questioning the network officials, the expected impacts of a new Light Rail system seem to be more important than the operational one have had. Actually, few of the operational systems seem to have met their objectives¹².

When looking at traffic forecasts before and after the opening of a new system, it is clear that a gap may exist between the expectations and reality. According to Mackett and Edwards (1998), there is clear evidence from the United States of proposals for rail-based schemes in which the forecast levels of patronage were well in excess of what actually

⁹ Raymond Hue, "Bilan et impact du métro de Rouen", Transports Urbains n° 98, janvier - mars 1998.

¹⁰ Gérard Lefèvre, "Le tramway de l'agglomération nantaise : résultats d'une évaluation a posteriori", Transports Urbains n° 98, janvier - mars 1998.

¹¹ Hass-Klau C., Crampton G., Weidauer M. & Deutsch V., "Bus or light rail : making the right choice. A financial, operational and demand comparison of light rail, guided buses, busways and bus lanes", Environmental & Transport Planning, 2000.

¹² Mackett and Edwards (1998), *op. cit.*

occurred. Actually, the Light Rail of Saint-Louis is the only North-American system which has recorded a patronage higher than the a priori forecasts :

	Forecast		Actual			Actual		
	Year	Patronage	Year	Patronage	% difference	Year	Patronage	% difference
Washington (metro)	1 977	569.6	1 986	411.6	- 28 %	1 993	526.6	- 8 %
Baltimore (metro)	1 980	103.0	1 987	42.6	- 59 %	1 991	45.2	- 56%
Miami (metro)	1 985	239.9	1 988	35.4	- 85 %	1 992	48.4	- 80 %
Buffalo (Light Rail)	1 995	92.0	1 989	29.2	- 68 %	1 995	29.0	- 68 %
Pittsburgh (Light Rail)	1 985	90.5	1 989	30.6	- 66 %	1 992	31.3	- 66 %
Portland (Light Rail)	1 990	42.5	1 989	19.7	- 54 %	1 995	24.0	- 43 %
Sacramento (Light Rail)	2 000	50.0	1 989	14.4	- 71 %	1 995	23.0	- 54 %
Miami (people mover)	1 981	41.0	1 988	10.8	- 74 %	1 992	9.5	- 77 %
Detroit (people mover)	1 985	67.7	1 988	11.3	- 83 %	1 992	8.8	- 87 %
Saint-Louis (Light Rail)	1 994	17.0	1 994	44.4	+ 161 %			

Source : Mackett and Edwards (1998). Patronage expressed in thousands of passengers on a weekday.

In the United Kingdom, traffic forecasts were underestimated in Manchester, but overestimated in Sheffield and Newcastle-upon-Tyne.

	Forecast		Actual			Actual		
	Year	Patronage	Year	Patronage	% difference	Year	Patronage	% difference
Manchester Metrolink	1 996	35.7	1 995	43.5	+ 22 %	1 996	44.5	+ 25 %
Sheffield Supertram	1 996	70.7	1 995	7.8	- 89%	1 996	18.7	- 74 %
Newcastle (Tyne and Wear)	1 985	219.1	1 985	208.9	- 5 %	1 996	126.9	- 42 %

Source : Mackett and Edwards (1998). Patronage expressed in thousands of passengers on a weekday.

The authors point out that the forecast exercise is much easier to achieve for Light Rail systems like in Manchester and Newcastle than for the other networks, since these new systems are replacing old conventional railway lines for which previous patronage data were available.

Chapter 3 **Forecasting issues**

When considering the discrepancies between forecasted and observed patronage of new Light Rail systems, we may ask ourselves what are the reasons explaining these differences : are the forecasting procedure inadequate or biased, or are they simply badly applied ?

3.1 Modelling approach

The gap between patronage forecasts and reality may stem from the analytical method used. Indeed, the assumption that there will be fewer cars on the road follows from the modelling approach used (Mackett and Edwards, 1998). These are largely discussed in the literature, however we must bear in mind that transport models evolve continuously, as new impacts or developments are accounted for.

Definition of the catchment area of the infrastructure project

The difference between traffic forecast and observed traffic may occur because the modelling and evaluation framework that is often used as part of the development process usually ignores the latent demand for car use and so is liable to predict higher levels of patronage on the new system, and greater reductions in car use than will be the case (Mackett and Edwards, 1998).

The development of a new infrastructure in a corridor induces a reduction of the generalised cost of transport in the corridor. Classical socio-economic evaluations investigate the modifications of patronage resulting from modal shift or change of route in the corridor. However classical evaluations do not consider **network effects** which are the modifications that appear on the network outside the corridor being considered, as a resulting of the modifications of infrastructure within this corridor. The network effects include:

- **route modifications** : because the generalised cost of going through the new infrastructure is smaller than the generalised cost of the former usual route.

- **potential demand** : the decreased generalised cost of transport enables the emergence of a potential demand, in terms of additional trips (which did not exist in the former network configuration) being travelled through the corridor; the accessibility improvement due to the project will make possible the completion of trips which constituted a non satisfied potential demand before the implementation of the project. The economists did not find really an agreement about the methods which enable to evaluate this potential demand in term of volume and geographical structure¹³. The impact in term of traffic is generally aggregated as traffic volume modification between pairs of geographical zones as determined for the needs of the evaluation¹⁴.
- **induced effects** : economic modifications appear from the interaction between generalised cost of location and generalised cost of transport : the new infrastructure induces inhabitants and companies movements. It is here question about the impacts generated by the implementation of the project on the nature and the volume of activities in the proximity of the project. These impacts can be classified into two categories :
 - o the impacts which result from the improvement of accessibility generated by the project : improvement of the economic situation for the local companies, improvement of the household incomes, increasing attractiveness of the local investment,...
 - o the impacts due to the valorisation of the local potentialities which are not directly linked to the improvement of accessibility; for example, the improvement of the image of the region in consideration.

Modelling of the accompanying measures of the infrastructure project

Accompanying measures represent a key success factor of any public transport scheme. A new Light Rail system alone without adequate accompanying measures is unable to produce a significant modal shift in favour of the public transport. Accompanying measures have to be considered in the forecasting models.

Model choice

On one hand, the taking into account of land-use effects in transport models is relatively recent, and the mechanism that links the new public transport to the generation of economic development is still not clear. Research in this field has been started in the United States, following the finding that urban expressways became over-congested long before the

¹³ The stated preferences survey method seems to be the more adapted method to evaluate this type of impacts.

¹⁴ This zones can be more or less wider and enable respectively less or more precise analysis of the impacts in consideration

forecasted date¹⁵. It is now generally accepted that transport policies alone will not achieve a sustainable level of fuel consumption and emissions. It is intended that transport and land-use have to be considered as an integrated and mutually dependant system.

To carry out long term forecasting, it should be taken into account that transport and land-use have to be considered as an integrated and mutually dependant system, the use of **integrated land-use – transport models** such as MEPLAN or TRANUS is advised.

As a minimum, for shorter term forecasting, a **four steps classical multimodal model** is recommended to consider the road congestion impact on the modal choice.

On the other hand, aggregate demand transport models have been used until the early 1980s, despite the awareness of several deficiencies in the conventional methodologies. Only then, discrete choice models (based on the behaviour of individuals) have been considered as a serious modelling option¹⁶.

3.2. Forecasting procedures

Another possible explanation for the discrepancies between forecasts and reality is a bad application of transport models, or an inadequate choice of the model to apply.

In North America, Mackett and Edwards argue that planners are under pressure from politicians to produce a scheme that seem attractive, particularly if it is paid for either by the national government or by a local tax that has popular support. According to Pickrell (1990), much of the funding comes from the Federal Government, and such support is based on a share of the total predicted outlays, which are based on forecasts which have been shown to be optimistic in terms of success for the system.

In addition, transport forecasts are based on socio-economic forecasts that sometimes reflect the expected effect of economic and regional policies whose success may actually depend on other uncontrollable factors like international trade and cooperation. MacKinder and Evans (1981) found that errors in forecasting these global indicators were at the root of the problem of mistakes for the planning variables at the local level.

¹⁵ Putman, "Integrated urban models", Pion, 1983.

¹⁶ Ortuzar and Willumsen, "Modelling Transport", second edition, John Wiley and sons, 1990.

In Sheffield, following delays caused by lengthy legal procedures and changing eligibility rules for government funds, the Supertram has been opened in an economic and social climate very different from that on which the evaluation was predicated and public opinion was sought. Evaluation of the scheme also failed to take into account the substantial costs which have been associated with disruption to business and movements by both private and public transport during the construction phase¹⁷.

Such experiences show the importance of using adequately forecasting procedures and checking the validity of hypotheses or input data in forecasting models. It is therefore advised to consider the potential changing in politico-economic context between designing and implementing a new Light Rail scheme which is likely to affect the validity of the hypotheses used as basis of the forecasting exercise and to elaborate a market study independent from potential pressure of politicians or policy makers to produce a scheme that seem more attractive than it is actually.

¹⁷ Hill (1995), *op. cit.*

Chapter 4 **Case-studies**

It has been identified in the literature review that beside classical modelling and evaluation procedures analyses, there was a need for more comprehensive before-and-after studies to identify the impact of new public transport systems. Pilot 4 has been incorporating an important case studies component, as all other LiRa Pilot Studies. Although Light Rail is not a widely utilised concept yet, valuable interesting practical experiences exist throughout Europe.

Pilot 4 has focused as much as possible on case-studies for which widespread data are available on the *behaviour of individuals regarding their mobility* : household surveys, population census, satisfaction surveys towards the perception of public transport, and so on. This approach is well suited for the LIRA study, since any error coming from a model misspecification can be avoided by studying the factors affecting the behaviour at the individual level. Furthermore, the findings should be more easily transferable from a city to the others, since the underlying mechanisms affecting the behaviour of individuals regarding their mobility decisions are assumed to be quite similar throughout the NWMA study zone.

The choice of the case cities will be presented in Section 4.1. Sections 4.2 to 4.4 provide with a summary of the case studies. For each of the cities, the city and Light Rail systems are described and a number of aspects are investigated of which the main topics are the potential impacts of Light Rail implementation and the potential impacts of the accompanying measures. The full description of the case studies is available in appendix. Section 4.5 focuses on the main case studies aspects with a cross-cases summary.

4.1 The choice of the case cities

The selection of case aims to cover deliberately *several kinds of Light Rail systems* running for some time, from a conventional tram network to a new, modern interurban tram-train . The objective of this choice is to get a broader view on the impacts of a Light Rail line according to its own characteristics and performances.

In June 2000 Stratec and Holland Railconsult have performed a quick scan of the Nantes, Karlsruhe, Brussels and Den Haag transport systems. It has revealed that these cases fulfil the criteria described here before. Note that Den Haag was subsequently deleted.

These case studies description will use the same structure :

- A Background: introduction, description of the city and transport system;
- B Accompanying measures;
- C Before and after analysis: how is the modal split affected by the implementation of a new Light Rail scheme on a given corridor ?
- D With and without analysis: what are the differences in modal split between corridors served by a Light Rail scheme and those that are not ?

However the sub structure of this section can be different for each case study according to the information available case by case.

4.2 Nantes

A Background

The Nantes Region is constituted by the District of Nantes¹⁸ (21 municipalities) and the periurban area which consists of 23 independent municipalities.

Since 1994, the Nantes Region possesses a complete Ring Motorway, which plays an important role in the mobility in the area. Indeed, the District of Nantes is crossed by two rivers : the *Loire* (East-West orientation) and the *Erdre* and the *Sèvre Nantaise* (North - South orientation) and except the Ring Motorway, only three bridges allow the crossing of the Loire River.

The urban public transport network is operated by SEMITAN (*Société d'Economie Mixte des Transports de l'Agglomération de Nantes*). In 1999, SEMITAN was operating two tramway lines, for a total of 26 km¹⁹, 57 bus lines (ca. 600 kilometres of lines) and a shuttle boat on the Erdre River.

¹⁸ The Agglomeration of Nantes is organised as a "District", i.e. an inter-municipality organisation in charge of several competences : transport policy, environment policy, land-use planning, housing policy, education and research.

¹⁹ a third line has been opened on August 28, 2000, as well as a new extension of line 1 to the West of Nantes.

The network has a radius shape, i.e. most lines are directed towards the city-centre : there are only a few lines providing direct relations between the outskirts of the town without serving the city centre.

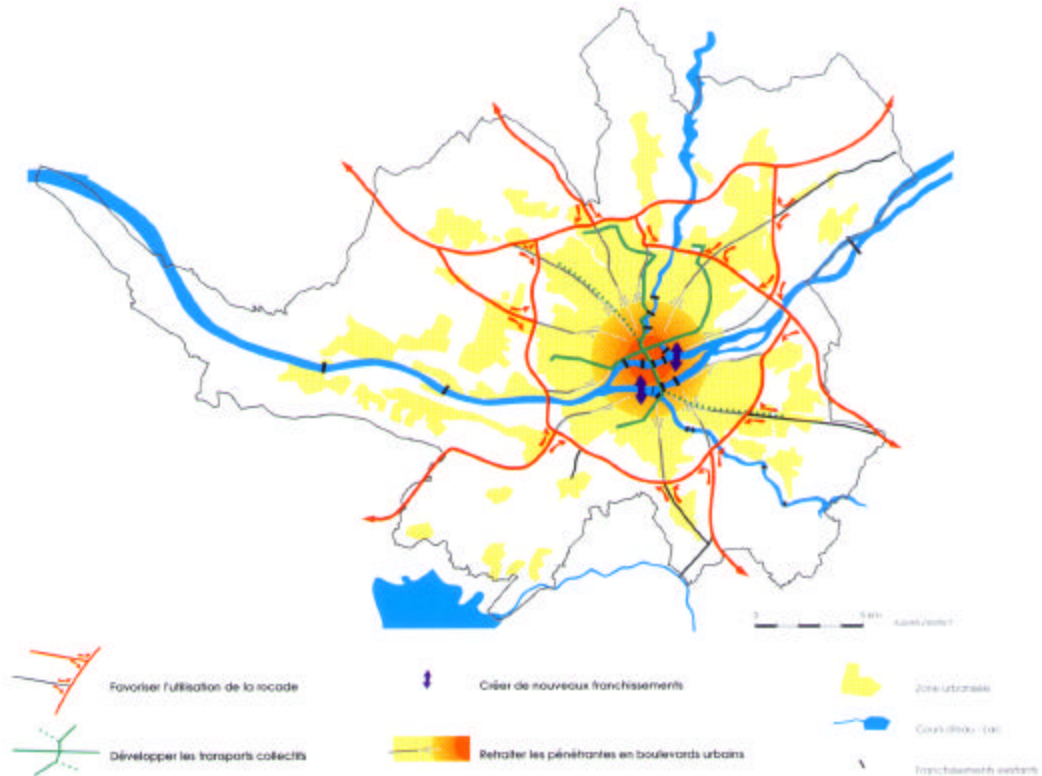
The District of Nantes is equipped with 85 km of conventional railway lines, that converge to the city-centre. The *Plan de Déplacement* was planning to convert two existing heavy rail lines into Light Rail lines, with the creation of about 20 new stops and the building of ten or so park-and-ride facilities near these stations. Furthermore, the extension of tram line 1 on conventional SNCF tracks is also envisaged.

Although none of these projects have been achieved yet, they are still considered in the future *Plan de Déplacements Urbains 2000-2010* currently under discussion.

According to the District of Nantes, fares are lower than those of other similar French cities are, especially regarding passes for schoolchildren and students. Since January 2000, and for a two-year trial period, SEMITAN tickets are also valid on SNCF trains within the District of Nantes. In addition, a common fare structure has been existing between SEMITAN and ATLANTIC networks since 1994 : passengers of ATLANTIC buses can purchase a combined ticket or a pass that allows the use of SEMITAN trams and buses.

B Accompanying measures

During the nineties, the building of the second tramway line was only a part of a more comprehensive plan to improve mobility in the District of Nantes. This "*Plan de déplacements de l'Agglomération Nantaise*" has been adopted in 1991 by the District's authorities. Its main objective was to promote the complementarity between all transport modes (public transport, private car, two-wheels and pedestrians), in order to let them move in harmony and increase the quality of life within the city. It is therefore impossible to study the effects of the tramway on the mobility in Nantes without taking into account the other actions that have been engaged in this field.



Five key actions have been defined in the *Plan de Déplacement*:

- **Terminating the Ring Motorway around the city, and promoting its use** : The Ring Motorway around Nantes has been completed in 1994. With 42 kilometres, it is the longest Ring Motorway in France²⁰. Although it connects the major motorways to Nantes, it should be primarily seen as an urban infrastructure (90 % of its traffic has the origin and/or the destination within the District). With over 40 000 vehicles per day (both ways) in most parts of its itinerary, the Ring Motorway is by far the most intensely used highway in the District.
- **Building new bridges on the Loire River rather than broadening existing ones** : We must point out that the Ring Motorway has added two new bridges on the Loire River to the three existing ones in the city-centre; therefore, many car users were no longer obliged to travel through the city-centre for crossing the river. Although the completion of the Ring Motorway has stimulated car use, it also gave the potential to reduce the traffic in the city centre.
- **Rebuilding the major highways entering the city centre** : The construction works related to the building of the tram have been seen as an opportunity to reshape the

²⁰ with the exception of the Paris Region

road system, mainly in the city-centre and during the building of the second line : reducing the number of lanes dedicated to cars, building of new pedestrian areas or "urban promenades", improving of the urban landscape, transforming "urban motorways" into urban roads, and so on... aiming to a better quality of life and a better sharing of the public space between every road users.

- **Promoting the use of public transport by the building of park-and-ride stations along the tramway lines, and interconnecting light (tram) and heavy rail lines :** Several locations offer "de facto" park-and-ride facilities (two along line 2, and three along line 3). Six new park-and-ride facilities have been built along the tramway lines, of which five are located along line 2 and offer a total of 1245 car spaces. In the future, it is planned to build 10 new park-and-ride stations near the new tram lines, of which 6 along the new line 3.
- **Promoting the use of two-wheels and walking :** The District of Nantes has undertaken the building of 226 kilometres of pedestrian routes (*continuités piétonnes*) and 570 kilometres of two-wheel routes (*continuités deux-roues*). In 1998, 160 km of pedestrian routes and 210 kilometres of two-wheel routes were already equipped.

C Before and After analysis

Individual mobility has increased over the past twenty years : in 1980, the average number of trips per day and per inhabitant was 2.72 within the SIMAN²¹ perimeter ; in 1997, the household survey has shown that it has increased to an average of 3.6 daily trips, whatever the mode.

- **Modal split :** The modal repartition as revealed by the 1997 household survey is the following²² : per day and per inhabitant, 2.07 trips by private car, 0.86 walking trips, 0.53 trips by public transport and 0.14 two-wheel trips.
During the eighties, despite the **building of the first tramway line**, car use has severely increased (+ 56 % of daily trips per person between 1980 and 1990). The rise in public transport use was less important (+ 21 %), and the use of two-wheels has collapsed (- 42 %). Consequently, **the modal split of the private car has severely increased**, while the modal share of public transport has been maintained at the same level. Therefore, it may be argued that, at the level of the whole city, the opening of the first tram line had no effect (or, at least an insufficient effect) to

²¹ The SIMAN perimeter consists of 19 out of 21 municipalities that now compose the agglomeration of Nantes : during the eighties, public transport was organised at that scale instead at the District level at the present situation.

²² The notion of "main mode" has been used to obtain the modal repartition (i.e. a long journey in public transport followed by a short hop on foot is not counted as a trip on foot)

counterbalance the trend of increasing car use, despite the commercial success of the tram.

During the period 1990-1997, corresponding to the **opening of the second tram line**, the rise in **the number of daily trip by car has been slowed down** (+ 6 % in seven years), while the use of public transport has continued to increase at a pace similar to the eighties (+ 15 % in seven years). The increase in car use has been proportionally smaller than the increase in public transport use, the market share of two-wheels has been maintained, and an increase of the market share of walking has been recorded. Consequently, the market share of the car has been diminished. **This may be attributed to the opening of the second tramway line in combination with the related accompanying measures considered in the “Plan de Déplacements”** : building of pedestrian and two-wheels routes, and diminution of the space dedicated to the private car in the city-centre.

- **LR usage** : In **1985**, the tram was representing **14 % of the boardings** on the SEMITAN network. In **1994**, after the whole opening of line 2, this figure has risen to **40 %**. In **1999**, shortly before the opening of the third line, **42 % of the boardings** have been done on a tram. In **November 1989**, there was nearly **60 000 daily boardings on the line 1**. The average numbers of tram boardings per working day are **now respectively 65 000 for line 1 and 95 000 for line 2**. The tram represents only 13.5 % of the output of kilometres supplied by the SEMITAN.
- **Public Transport usage** : The opening of the first tramway line has stimulated the patronage of the whole urban transport network : when comparing 1984 to 1986²³, the number of trips has increased by 19.2 % and the number of boardings²⁴ by 26.4 %. The impact of the **opening of the second line** on the SEMITAN's ridership is less important : between 1992 and 1994²⁵, the number of trips has been increased by 6.3 % and the number of boardings by 7 %. This lower impact may be explained by a more difficult economic context.
- **LR perception** : Satisfaction surveys were done in 1993. They have shown that 16 % of the tramway users did not use the bus network before the building of the tram, 39 % of them have a private car at their disposal, 31.5 % of them claim that the quality of public transport is an essential element for the choice of the location of their home or flat. After the building of line 1, the tram has been perceived as an *“urban tool” for the improvement of the quality of life within the city*, beyond the traditional “transportation function” of the tramway : in 1993, before the opening of the first line, only half of the inhabitants of Nantes were in favour of the tram; today, after the building of the

²³ i.e. one year before and after the operation of the whole line

²⁴ We differentiate 'trips' and 'boardings', since one trip may require one or several connections

²⁵ before its opening and after the operation of the whole line

second line, 95 % of them are in this case. **The 'modern' image of the tram contributes to explain the higher success** of this mode. Similarly, it has been reported that several people now consider buses as being 'old-fashioned' since the tram has been introduced in Nantes.

D With and without analysis

It comes out from the French experience that, in general, cities that have invested in an efficient Light Rail network perform much better than other cities in the field of public transport use. With 152.8 trips by public transport per year and per inhabitant, Nantes is one of the French cities in which the use of public transport is the highest²⁶.

- **Modal split** : In the city, the structure of the public transport network and the location of activities are more suitable for other modes than the private car. The opposite phenomenon has appeared in peri urban areas. As a consequence, walking and public transport use is much higher in the District than in the periurban area. In the opposite, the market share of the car is more important in the periurban area than within the boundaries of the District.

The **market share** of Public transport **is much higher in the areas of the District of Nantes well served by public transport than in other areas or in peri urban areas**, less well served by public transport. The market share of public transport is by far the highest in the Centre and North District zones, both served by the second tramway line: while the market share of public transport is equal to **15.4 % for the whole District of Nantes**, it rises respectively to **21.3 and 23.9 % for the Centre and the North District** study zones. Concerning the **trips having their origin or destination in the city centre**, it appears again that the **North District** study zone has the highest public transport market share : **43.5 %** (whole District : 21.3 %).

The **market share** of public transport is **somewhat higher along the tramway lines** than along the bus lines (13 % for areas served by buses, and 19 % for areas served by the second tramway line). For a similar level of service, the **tram is more appreciated than buses**, in terms of **waiting time, travel speed and comfort** : 26 % of the tram users of the second line have said that they are very satisfied with the travel conditions (24 % for the first line)... while only 14 % of the bus users are in this situation.

²⁶ Only Lyons and Marseilles outperform Nantes : much larger cities both equipped with a heavy metro network.

Beyond the intrinsic characteristics of the public transport network, the conditions of travelling by car (and, in particular, the availability of a car park) are important in explaining the modal split. The **market share** of public transport **is much lower for people that have a reserved parking at their destination**. For instance, 88 % of people located along tram line 1 and having a parking at their workplace use their car to go to work (market share of the public transport for this segment : 8 %), while only 59 % of people living in the same areas having no reserved park space at their work use their car (market share of public transport : 31 %). Similar trends are also found for the second tram line and for bus corridors.

- **Public Transport usage** : The tramway network serves the city centre. Line 1 also serves small parts of the West and East zones, and line 2 serves the North zone and a small section of the South-West zone. Trams do not serve the other zones. The household survey has revealed that it is in the Centre and North District, which are the best served areas by the tramway network that the usage of the public transport is the highest : **78 % of interviewed people in the city centre** and **73 % in the North District** had used the SEMITAN network at least once during the three months preceding the enquiry. This percentage varies between **57 and 66 % for the other zones** that belong to the District of Nantes, and is lower than **36 % for peri urban zones**. Similarly, the number of daily trips in public transport per person is much higher in the Centre and North District study zones than elsewhere.

Evaluation studies have shown that **nearly 10 000 people per day use the car in combination with the tram** for their travel : 5 000 drivers and 5 000 passengers. This represents 4.6 % of the number of users for the first tram line and 6 % for the second line. The parking location of these park and ride users is for one third on one of the six existing park-and-ride facilities, for the second third on one of the existing 'de-facto' park-and-ride and for the last third on the streets along the tramway lines. It is to note that this success should be somewhat moderated : 20 % of the users of park-and-ride facilities did use the buses for the totality of their trip before the building of the tram. Therefore, the combination car + tram is has created a new competition for traditional bus services.

Recapitulation of the effects

Modal split

Before and After Analysis

- 1980-1990 : increase of the car modal split and stagnation of the PT modal split, despite the opening of the first LR line;
- 1990-1997 : reduction of the car modal split and increase of the PT modal split, thanks to the opening of the second LR line and appropriate accompanying measures;

With and Without Analysis

- the market share of PT is slightly higher along LR lines than along bus corridors offering a similar level of service;
- People living along LR lines and in situation of modal choice are much more likely to use the LR line for their home-work trips if they do not have a reserved car park at destination.

PT usage

Before and After Analysis

- significant impact on the total PT use, at the city level :
1984-1986 (line 1) : + 19 %
1992-1994 (line 2) = + 6.3 %

With and Without Analysis

- Public transport use and walking are much higher within the city than in peri urban areas;
- 57 to 78 % of the inhabitants are PT users (regular or irregular); the higher percentage is found in the sectors that are the best served by the LR.

4.3 Karlsruhe

A Background

The most famous feature of the Karlsruhe transport system is the dual-system rolling stock, able to circulate on heavy rail lines as well as on the traditional urban tram lines. The Karlsruhe Main Rail station is located about 2 kilometres far away from the city-centre. The ultimate aim is to link rural and urban areas enabling passengers to travel from their origin to the city-centre without any connection.

The successful concept of track-sharing by light and heavy rail vehicles in the Karlsruhe Region model consists of the following possibilities :

- a vehicle equally capable of using regional DB tracks and LR tracks in the urban area ;
- the building of new stops on existing heavy rail lines which can be served without extending journey times, thanks to the improved acceleration of LR vehicles ;
- the connection of DB tracks to the existing tramway system.

The first dual-system LR line has been opened in 1992, between Karlsruhe and Bretten (30 km east of Karlsruhe). Other projects were started or developed further and most of these have been implemented since 1996 :

- Karlsruhe – Wörth
- Karlsruhe – Pforzheim – Bietigheim-Bissingen
- Karlsruhe – Rastatt – Baden-Baden
- Bretten – Eppingen – Heilbronn
- Bruchsal – Menzingen / Odenheim

The philosophy was to make public transport as competitive as possible, by offering as many features of the car as possible :

- door to door travel time ideally has to be equal or less than the time needed by car for the same journey.
- few or no interchanges
- the comfort inside public transport vehicles should be a priority (no advertising, comfortable seats, lighting,...) ;
- high frequency, scheduled timetable, easy to remember (one tram or train every 10, 15 or 20 minutes) ;
- long operation schedule (from 4h30 to 1h00, or even 3h00 during the week-end) ;
- modern, attractive rolling stock (low floor for new series, large doors, good acceleration power,...)
- generalised fare integration (train, LR, urban trams, urban and regional buses) throughout the KVV area.

Today, the network counts about 300 kilometres of railway and LR lines, and 60 dual-mode vehicles for a total of over 200 vehicles. Six urban tram lines and four regional LR lines are in operation in Karlsruhe. It is planned to extend further the network.

The urban LR (tram) network is operated by VBK (Verkehrsbetriebe Karlsruhe). LR lines are either owned by AVG (Abtal-Verkehrs-Gesellschaft), a regional railway operator, or by the Deutsche Bahn. (DB). LR services are operated by AVG, while on some lines regional and inter-city "heavy" rail services operated by the DB still exist.

The basic frequencies of urban tram lines are 10 minutes (with overlapping lines in the city-centre sections, the resulting frequency is often 5 minutes or less). On the regional network, the basic frequency is 20 minutes.

This case study focuses on two lines :

- Karlsruhe Marktplatz - Bretten Gölshausen (line S4)
- Pforzheim - Karlsruhe - Wörth (line S5).

B Accompanying measures

When creating and expanding the LR network, the objective of the operators and the municipality of Karlsruhe was to increase the share of public transport against growing car traffic. The philosophy to reach this target was to make public transport as competitive as possible, by offering a the best comfort but **not by forcing car-drivers with restrictive measure**. It has to be mentioned that politics in Karlsruhe never have been following a black and white scheme "public transport yes, car traffic no". Indeed, Karlsruhe is considered as a rather car-minded city. **Accompanying measures have been very few** :

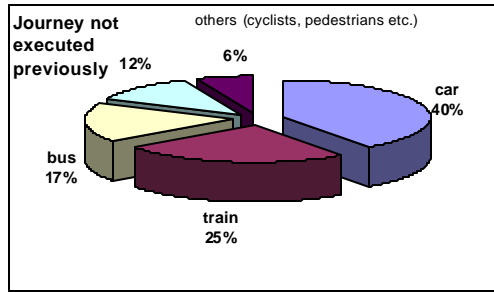
- **Increase the commercial speed of public transport** : Measures have been taken to improve the fluidity of the movement of trams and LR vehicles : generalisation of segregated tracks²⁷, and priority scheme giving priority to tram and LR vehicles against car traffic²⁸.
- **Development of the attractiveness of the LR stations** : Another noticeable feature of the Karlsruhe model is the removal of buses as soon as a LR service is introduced. Instead, bus lines are reorganised as "feeder lines", to serve the area more densely without duplicating the LR service.
- **Development of park & ride stations** : Capacity of park-and-ride facilities has been increased.
- **Building of a bypass road** : These measures aiming to give priority to tram and light LR services have been made possible thanks to the building of a new bypass road at several locations.

C Before and After analysis

In the *Corridor Karlsruhe-Bretten*, the opening of the LR has induced 12 % of new trips.

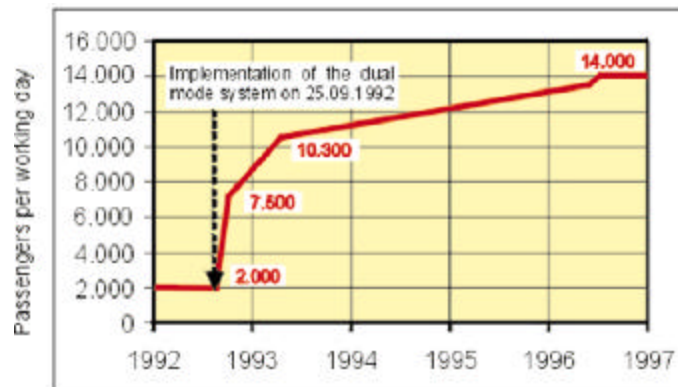
²⁷ up to 80 % of the urban network

²⁸ 80 road junctions have been equipped during the late eighties or the early nineties



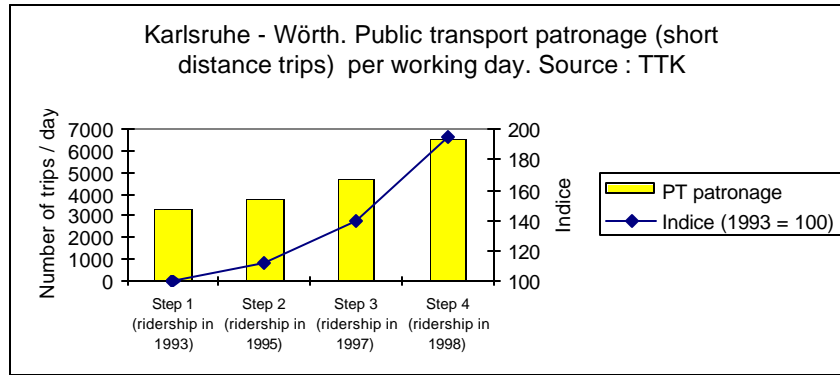
(source : TTK)

- Modal split** : In the *Corridor Kalsruhe-Bretten* : 40 % of the passengers of the line were former car drivers but now leave their car at home (or at one of the park-and-ride facilities). Only 25 % of LR users were previous DB-trains users. In the *Corridor Kalsruhe-Wörth* : 20 % of the users of the Karlsruhe - Wörth line were previous car users.
- Public Transport Usage**: In the *Corridor Kalsruhe-Bretten*, Following to the introduction of the LR, the ridership of the line Karlsruhe - Bretten has dramatically increased : while there was only 2000 trips per working day prior to the opening of the LR line, this figure has risen to over 10 000 less than one year after its opening.



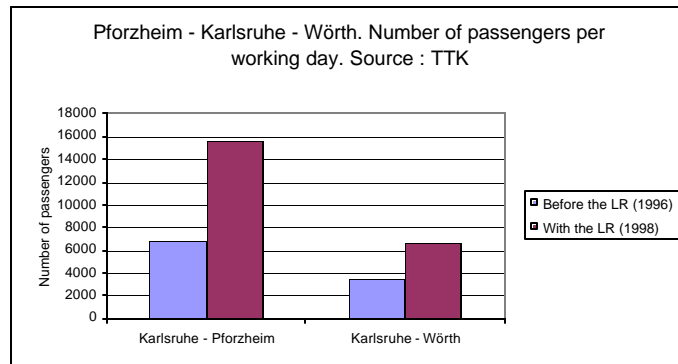
Karlsruhe - Bretten. Evolution of the number of trips per day. Source : TTK

In the *Corridor Kalsruhe-Wörth*, the level of service of the line Karlsruhe-Wörth has been increased in three steps : In **1994** *scheduled time tables* have been implemented, in **1995** *fare integration* has been applied and in **1997** the *diversion of the LR line via the city centre of Karlsruhe* has been completed. It is interesting to note that, although the diversion of the line via the city-centre has resulted in the most important increase in patronage, every improvement in the service has been accompanied by a greater ridership.



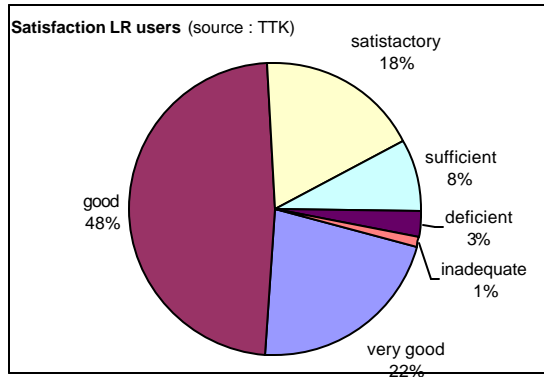
Between 1993 and 1998, the supply²⁹ has been increased by 81 %, while the demand has risen by 95 %. If we focus on the last step (diversion of the LR line via the city-centre), the supply has risen by 43 % and the demand by 53 %.

In the *Line Karlsruhe-Wörth*, **the introduction of the LR line into the city-centre, combined with an increase in frequencies** has resulted in an **augmentation in the total ridership in the two corridors** : + 129 % on the corridor Karlsruhe – Pforzheim and + 94 % on the corridor Karlsruhe – Wörth.



- **LR perception** : A satisfaction survey done on the line Karlsruhe - Wörth has shown that passengers are pleased with the LR service : 70 % of the LR users are satisfied or very satisfied by the service, while only 4 % of them think that the service is inadequate or deficient. In addition, it has been found that 20 % of the users of the Karlsruhe - Wörth line were previous car users

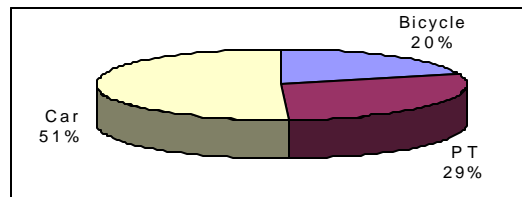
²⁹ in term of number of PT journeys supplied during one day (Monday to Friday, school day)



D With and without analysis

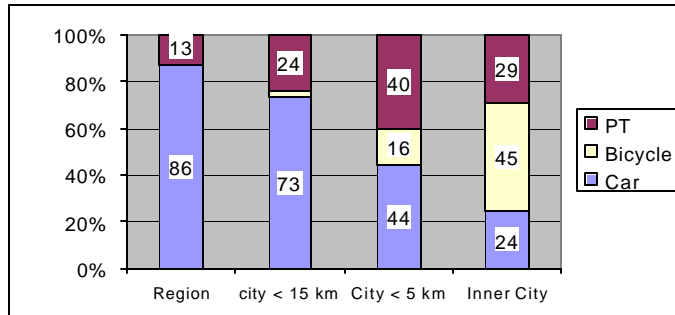
- Modal split** : The market share of public transport in the city of Karlsruhe is 17 %. However, for longer distance trips operated by LR or regional trains, an average modal split of 50 % in favour of public transport is reached, and very successful routes even manage to have a modal split of 67 %. On average, people who live within the catchment area of the LR network make between 400 and 450 trips per year by public transport.

For trips having the city-centre of Karlsruhe as destination, the market share of public transport is equal to 29 % (car : 51 %)



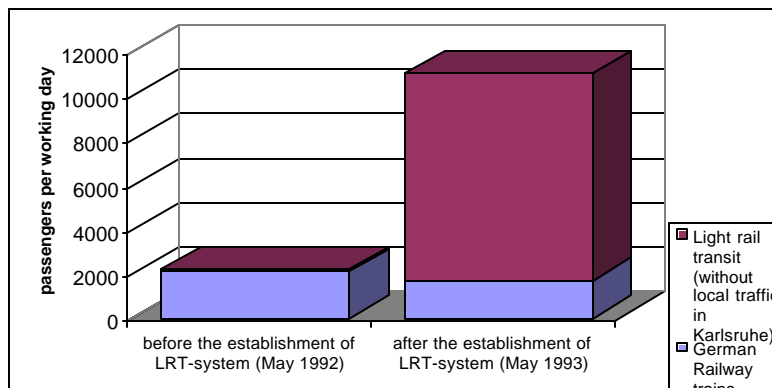
Traffic with destination Karlsruhe inner city (working day).
Source : TTK

The PT market share is much higher for trips starting from the inner city or close neighbouring suburbs (less than 5 km, and lower for longer journeys).



Traffic with destination Karlsruhe inner city, sorted by origin.
Source : TTK.

- Public Transport usage** : In the *Line Karlsruhe-Bretten*, during the first years after the opening of the LR line³⁰, a DB heavy rail service has been operated parallel to the LR. The total patronage of the DB service has decreased slightly, as a consequence of the new LR line, although the total ridership on the corridor Karlsruhe – Bretten³¹ has increased dramatically



(Source : TTK)

Recapitulation of the effects

Modal split

Before and After Analysis

- evidences of modal shift in favour of PT :
 Karlsruhe – Bretten line : 40 % of LR customers are former car users. Pforzheim - Karlsruhe – Wörth line : 20 % of customers are former car users

With and without Analysis

- LR or regional railway lines have a market share of 50 % ; for most successful routes, the market share rises to 67 %

³⁰ before its extension to Heilbronn

³¹ Light Rail + heavy rail

PT usage

Before and After Analysis

- significant impact along the corridors served :
Karlsruhe – Bretten (1992-1997) : + 600 %
Karlsruhe – Wörth (1996-1998) : + 94 %
Karlsruhe-Pforzheim (1996-1998) : + 129 %

With and without Analysis

- On the line Karlsruhe – Bretten, LR has appeared as much more successful than heavy rail

4.4 Brussels

A Background

As a consequence of the decline of accessibility of the Brussels-Capital Region, the authorities have been stating a priority for the improvement of the public transport network in order to reduce the usage of the car. The IRIS plan has shown that the Brussels urban sprawl can be dealt with a consistent set of actions of which the main one is the implementation of the RER, a regional commuting service between the Brussels region and its periphery.

The RER consists of new regional public transport LR services over distances from 10 to 40 km from the centre of Brussels³² on the existing star-shaped rail network. The RER services will be operated on the existing railway tracks converging to Brussels, with characteristics quite similar to those of the existing metro which is very much appreciated by the population. The main advantages of these RER services can be summarised as follows, in comparison with the characteristics of a normal train: for the same ticket price, a better commercial speed due to the characteristics of the LR equipment (acceleration and deceleration, door opening, quicker boarding and alighting), a higher frequency, a higher number of stops and a higher capacity.

³² The IRIS plan had notably pointed out that the public transport supply serving the Brussels Region, at the morning peak, was perceived as quite good by people travelling inside the Brussels Region and by travellers commuting over distance of more than 40 km to the Brussels Region.



As a pilot project of the LR mode, since 1993, the operation of the line '26' has been modified in order to convert it from a railways operation mode to a LR operation mode³³.

The frequency has been increased to three vehicles per hour, with a good connection with urban public transport.

Line '26' is a loop line linking Halle to Vilvoorde (and less frequently, Mechelen) that traverses the East of Brussels. It serves Huizingen, Beersel, Moensberg, St Job, Boondael, Delta, Mérode, Meiser, Evere, Bordet and Haren.

B Accompanying measures

Recently, on behalf of the Minister of Transport, a RER high level group has been created, of which one mission has consisted of examining and discussing which accompanying transport measures have to be taken and how and when to implement them.

The objectives of the accompanying measures are :

- firstly to induce a modal transfer from the private car to the public transport in the whole RER area as a reinforcement of the implementation of the new LR services ;
- secondly, to favour the urban concentration and hence avoid the negative consequence of the urban sprawl because of its negative effect on modal split in the longer term : public transport can only be efficient where households and working places are concentrated.

The following section provides a brief description of the measures which are investigated. Moreover, the impact of tolling the road access of the Brussels region has been examined but appears as not politically acceptable at the moment in Belgium.

- **control of the urban sprawl and protection of the housing area** against the traffic nuisances : Simulations³⁴ project show the qualitative aspects of the possible impacts,

³³ Operating the line has evolved from a railway-type logic (the fullest possible train service which requires passengers to adapt their time of travel to train timetables, with not all trains serving the same route) to a LR-type logic (simpler line, good connections with urban public transport and frequent services).

³⁴ Brussels case study of the ESTEEM project – DGTREN 1998

i.e. the importance of accessibility for people and firms and their desire to relocate when a more efficient transport system is set in operation. The RER is restructuring the socio-economic space in the perception of people.

For the households, residential location is spatially distributed in function of their jobs but is highly sensitive to the land value of the zones ; the compromise found between transport cost (encouraging centripetal movements) and land cost (encouraging centrifugal movements) depends on the type of household. When transport costs decrease (taking into account not only home -to-work trips but also home-to-shop and service trips) families already strongly dispersed tend to disperse even more because they consume much space ; for them the locations minimising the sum of transport and land costs move further from the centre. Single persons have the opposite reaction : already highly concentrated in space in the Region, they tend to localise themselves even more in the Region although they diffuse towards the boundaries of the Region. Non-active people, very slightly concerned by the economic system, move very little tending also to concentrate in town.

For the induced tertiary activities which give more importance to accessibility than the households, location is distributed in function of the households that induce them (mainly families). The decrease of transport costs puts more distance between them and these households so that they are able to locate in spatial points central to larger markets, i.e. the central areas of the Region. It is clear that the RER encourages commercial and service development downtown.

- **parking restrictions in the RER area** : The availability of car parking has a major influence on the choice of means of transport. Some studies suggest that levels of parking can be more significant than levels of public transport provision in determining means of travel, even for locations very well served by public transport. Car parking also takes up a large amount of space in developments and reduces densities.
- **restrictions of capacity of the road access to the Brussels Region and creation of HOV lines** : this measure, based on successful experiences of promoting public transport in Spain and USA, has been proposed and examined by the RER high level group as an accompanying measure to be realised since the beginning of the implementation of the RER. It aims :
 - o to compensate the public transport accessibility improvement of Brussels by an equivalent reduction of the road accessibility in order to avoid the acceleration of the urban sprawl.
 - o to maintain the dissuasion impact of the level of congestion of the access of Brussels in order to maximise the modal shift to the RER

- o to make use of the road lanes left , notably on the motorways, to operate new quick bus services in complement to the RER services
 - o to make use of the free flow lanes to encourage car-pooling by allowing high occupancy vehicle to drive on it.
- **increase of the commercial speed of the buses on the urban part of the inter-urban public transport network** : the RER High Level Group has defined five motorways RER bus axes in complement with the RER network as a competitive service ensuring a commercial speed at least equal to the car speed and a good reliability of the time schedule. Moreover, the RER High Level Group has determined measures to ensure the traffic fluidity for the public transport on the axes served by the Regional buses such as segregated bus or tramways lanes (bus overtaking lane or bus lock, one reversible direction segregated lane, segregated lane, traffic light remote control, priority at the traffic light) or public transport access measuring out. These measures has to be included in a larger set of measures such as the provision of information at the public transport stops, improvement of the waiting conditions, increase of the frequency, improvement of the accessibility of the buses, provision of parking,...
 - **development the attractivity of the RER stations** : the RER High Level Group has identified the following aspects to be investigated in the development of the access to these stations, by order of priority :
 - o the pedestrian accessibility, in terms of minimising the walking distance, comfort, safety for local pedestrian access to the station, people coming from two wheels parks, from the public transport stops, from “park and ride” and “kiss and ride” car parks. A particular stress has to be put on direct access to the platforms in order to reduce walking distances ;
 - o the two wheels accessibility in a radius of 5 kilometres ;
 - o the public transport accessibility in a radius of 10 kilometres ;
 - o the car accessibility for car passengers ;
 - o the car accessibility for car drivers ;
 - o the optimisation of the connections from platform to platform between modes.

C Before and After analysis

A detailed evaluation of the Line ‘26’ have been conducted by Stratec on behalf of the Federal State Administration in January 1997. This evaluation has been carried out with a goal to improve the existing infrastructure in order to increase the users’ satisfaction travelling inside the Brussels Region as well as between the Brussels Region and its periphery. The main results of the operation of the line ‘26’ are quite encouraging.

- **Modal split** : Line '26' is the Pilot line of a LR network at the Brussels-Capital Region scale. There is no data available at the corridor level and no noticeable impact on the modal split at the Brussels scale. The information available hereafter concerns the mobility of the Brussels Region and does not fully focus on the line '26' user behaviour. However, we can assume that the general modal choice behaviour observed in the Brussels Region can be applied to the line '26' users, as far as the line '26' users are not a particular segment of the Brussels users from the point of view of their socio-economic characteristics. Simulation results based on household surveys provides with the effect of the whole LR network project. PT market share for trips to the Brussels Capital Region would increase from 38% in 1991 to 45% in 2005. Without LR network implementation, PT market share for trips to the Brussels Capital Region would decrease to 32% in 2005.
- **LR usage** : In 1993, 1588 travellers were travelling every day by the line '26's stations. In 1997, there were 4 047 travellers. That means a corresponding **increase of 164 % since 1993**. Since two out of three trains per hour are diverted by Etterbeek Station, the volume of line '26' users' * kilometres has significantly increased: **+ 35 to 38 % between November 1994 and January 1997**. Despite the supply has increased, the average train occupancy rate has quite reached the level of 1994 in 1997.

The results of the evaluation of line '26' are positive and show the potential success of the Brussels RER in term of patronage attractivity.

It has to be noted that the line '26' can not really be considered as a full LR regional service yet :

- line '26' is not operated in the evening and in the week-end ;
- improvements have to be done concerning the connection with other public transport in some stations notably ;
- fully integrated fares have to be achieved between SNCB and other inter-urban public transport operators ;
- a fully regular frequency of 3 trains by hour every 20 minutes can not be obtained at the moment because two trains out of three are serving an additional station (Etterbeek station).

However, it has to be mentioned that even if the increase of the line '26' patronage is notable, this increase is marginal at the scale of the whole railways trips to Brussels: the market share of line '26's stations was only representing 2.3% of the total of travellers who have travelled by one of the 29 Brussels railways stations.

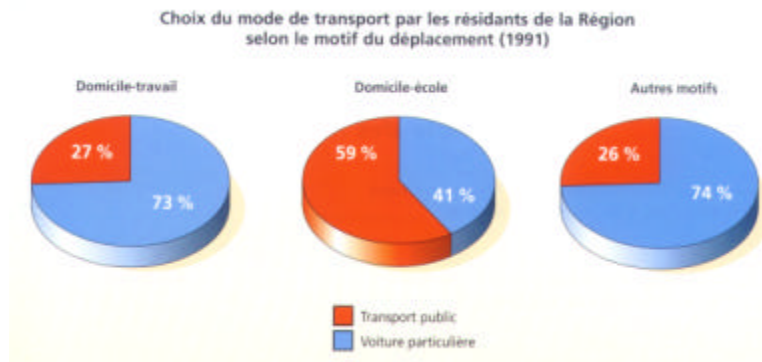
- **LR perception** : the most frequented stations are Merode, Boondael, Saint-Job and Delta :

- o Both Merode and Delta are very well connected with the Brussels metro: both SNCB and STIB stations are integrated in the same building.
- o In Boondael and St-Job stations, tram and bus stops have been re-developed and are easily accessible from the line '26' platforms.

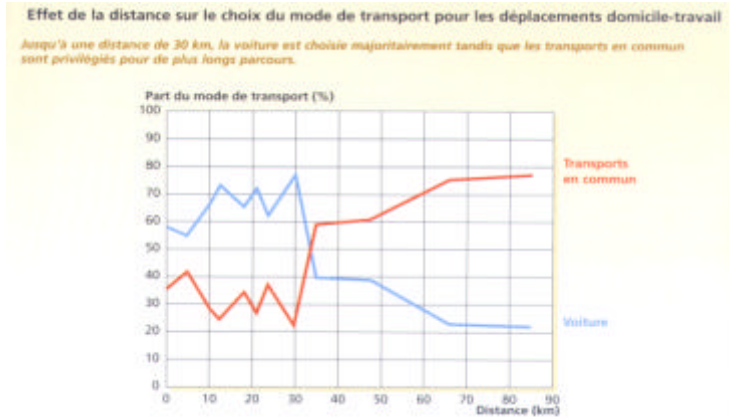
The survey has revealed that Line '26' is better and better perceived by the users but some improvements have still to come: Beersel, Haren and Meiser are not protected from the rain and are perceived as unsafe.

D With and without analysis

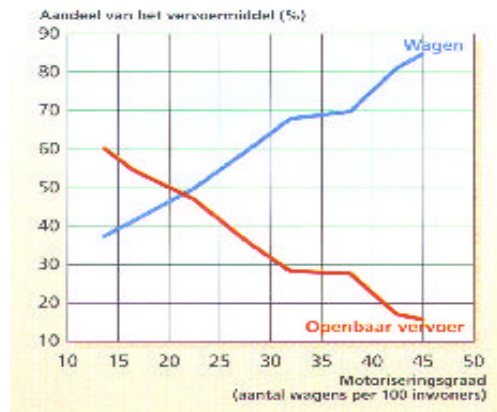
- **Modal split** : the behaviour models, conducted for the needs of the IRIS plan, have demonstrated that the variation of the modal split between private car and public transport is mainly explained by the following parameters.
 - o *travel purpose* : In proportion, the most important public transport users are students going to school. Public transport is not globally used more for regular home to work trips than for non regular or less regular other trips



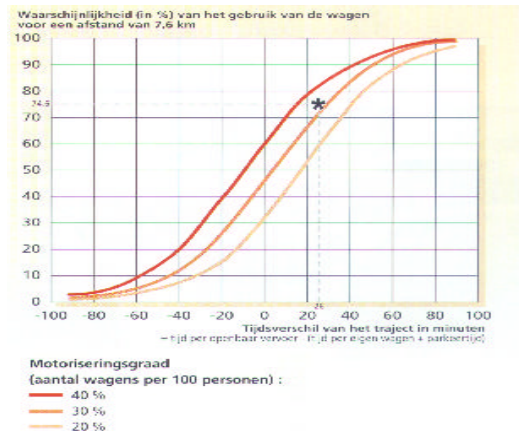
- o *distance travelled* : The following figure shows the impact of distance on modal choice in the case of home to work trips. It clearly shows that until a distance of 30 km there is a major choice for the car since the public transport is preferred for longer trips.



- o *car ownership rate* : The figure here after shows the impact of car ownership rate on modal choice. As high is the car ownership rate, as high is the market share.



- o *respective travel times and speeds by public transport and by private car*. The figure here before shows the elasticity of the modal split to the difference of travel time between private car and public transport and the elasticity of the modal split to the car ownership rate for a travelled distance of 7.6 km and hence the role of the increasing of road congestion in the modal choice



Other investigations³⁵ concerning analysis of mobility behaviour have notably point out that :

- o Public transport is more satisfying on longer distance partly due to the less important relative penalties generated by waiting time and walking time.
- o Public transport can be very well appreciated and used if it allows to reduce the users door to door travel time.

Some interesting conclusions of a stated preference survey on parking facilities choice close to workplaces in Brussels are summarised below³⁶ : **parking restriction could induce a modal transfer** from car to public transport, but to very different extents, according to whether the public transport service is improved or not, compared to the current situation.

Tolling the road access of the Brussels region has been examined³⁷. Key issues are the following :

- o **tolling at the gates to Brussels or on the ring induces a shift from private car to public transport.** It also induces a slight decrease of the total length travelled by all mechanised modes : households and services are locating closer to each others in order to reduce their travelling and accessibility costs ;
- o tolling at the gates of Brussels also facilitates an increase in the average speed on the whole road network of the study area. **Attracting more**

³⁵ which has been carried out in the ESTEEM³⁵ project

³⁶ Study conducted by STRATEC on behalf of the Brussels-Capital Region, in February 1993 as a part of a larger study on parking facilities management in the Brussels-Capital Region

³⁷ as a case study of the EUROSIL (European Strategic Intermodal Links is a research project financed by the TRANSPORT R&D Programme of the European Commission, DG TREN). The primary aim of the case study is to assess the efficiency of this set of tolling scenarios, in terms of impacts on the modal split and of alleviation of the road congestion. As a second aim, the study is also investigating spatial impacts due to tolling implementation.

commuters onto the public transport network benefits to the remaining road users ;

- o lowering public transport fares contributes to the general improvement of the road network conditions.

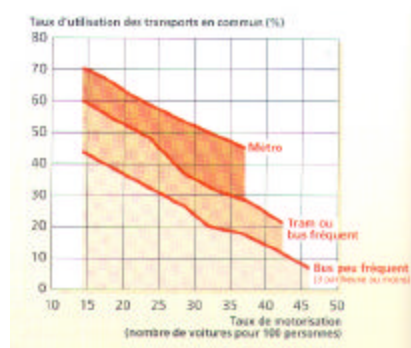
- **Public transport usage :** In 1994, as a consequence of the modification of the Line '26' services, conflicting customer reactions led the SNCB to conduct a stated preference survey aiming to determine whether it would not be more expedient to return to the pre-1994 situation. Resulting key aspects in term of LR frequency, connection with other public transport modes and comfort are described hereafter.
 - o *Frequency* : Users travelling from the North to the South of the line (and vice versa) were strongly in favour of maintaining a frequency of three shuttle trains per hour. Indeed, in their view the loss of one direct train per hour could only be offset by a fare reduction of 0.26 EURO per trip³⁸ which is about 30 % of the price of their ticket.
 - o *Organisation of the network* : Workers travelling into the city via Line '26' plus the metro accorded very little importance to the provision of one direct train service per hour (0.02 EURO per journey). They were satisfied with the good metro link. Workers travelling to Etterbeek and Quartier-Léopold on Lines 26 and 124 accorded very great importance (0.66 BEF per journey) to the provision of a service of one direct train per hour
 - o *Comfort in term of access to the station* : Students travelling to Etterbeek via Delta, followed by a walk of over 500 meters, accorded very great importance to the provision of a service of one direct train per hour. The provision of one direct train would, in the view of these users, be worth a price rise of 0.28 EURO per journey.

At the level of the Brussels Capital Region, the public transport route choice model based on revealed preference carried out in the IRIS plan provides with relative values of different elements composing the door to door travel time by public transport by trip purpose. The characteristics and the level of service of the LR services defined as the regional metro service which is intended to be implemented in the Brussels metropolitan area can be compared to the ones of the so called metro mode.

- o *Frequency*: The penalties attributed by the Brussels public transport users by purpose classes show the importance of a good frequency. It also points out that waiting time is perceived as a bit less unpleasant than in-vehicle time by home to work travellers. On the contrary, for other trip purpose waiting time is less favourable than in-vehicle time.

³⁸ The price of the journey varying between 0.74 EURO and 0.92 EURO for journeys within the Brussels Region

- o *Organisation of the LR network* : The network organisation appears as very important : each connection penalty has to be calculated as the sum of the penalties due to walking time, waiting time and mode boarding.
- o *Comfort in term of access to the station* : the model shows the importance of the access to the stations: one minute of in-vehicle time is better accepted than one minute walking, and this phenomenon is even more stressed for other trip purpose than home to work and home to school.
- o *Reliability* : It appears that there is a big preference for the metro or LR mode, and that without taking into account the travel time : this is probably due to the higher frequency and better reliability of this mode in comparison with other public transport modes.



Recapitulation of the effects

Modal split

Before and After Analysis

- pilot line : no noticeable impact at the Brussels scale. Data not available at the corridor level.
- Simulation results for the whole LR network project : PT market share for trips going to the Brussels Capital Region :
 - o in 1991 without LR : 38 %
 - o in 2005 without LR : 32 %
 - o in 2005 with LR : 45 %

With and without Analysis

- Before the implementation of the LR network: for home-to-work trips less than 30 km, the car has the greatest market share; for other trips PT have the greatest market share.
- The objective of the LR network is to counterbalance this trend
- The use of PT is highly dependant on the difference in door-to-door travel time between cars and PT, hence on road congestion

PT usage

- Simulation results show that car parking restrictions and / or road pricing are likely to induce a modal shift from car to PT

Before and After Analysis

- significant impact along the corridor served by the pilot line :
+ 154 % (1993-1997)

With and without Analysis

- a “Stated Preference” survey has shows the value that line ‘26’ users attributed to different characteristics of the service :
frequency, organisation of the network, comfort in term of access to the station
- models carried out for the IRIS plan has provided with the relative values of different elements of public transport services by trip purpose of which frequency, organisation of the network, comfort in term of access to the station

4.5 Case studies : cross-cases summary and concluding remarks

The following three tables summarise the case study findings. Then, cross-case conclusions will be drawn.

Table 1. Background

	Nantes	Karlsruhe	Brussels
A. Characteristics of the city			
Population	<ul style="list-style-type: none"> • 546 000 inhabitants in 1997 ; • increase of 9.4 % within the period 1990-1997. 	<ul style="list-style-type: none"> • 270 000 inhabitants in 1999 ; • 1 100 000 inhabitants in the whole transport system area. 	<ul style="list-style-type: none"> • 955 000 inhabitants in 1998 • decrease of 11% in 20 years ; • 2 750 000 inhabitants in the whole transport system area.
Population density	<ul style="list-style-type: none"> • 11 inhab./ ha ; • 50 inhab./ha in the city centre. 	<ul style="list-style-type: none"> • 15 inhab./ ha ; • 3.55 inhab./ha within the whole transport system area. 	<ul style="list-style-type: none"> • 59 inhab./ha ; • 6.9 inhab./ha within the whole transport system area.
Employment	<ul style="list-style-type: none"> • 226 400 jobs in 1990, of which 24.3 % located in the city centre. 	<ul style="list-style-type: none"> • 147 400 jobs in 1999. 	<ul style="list-style-type: none"> • 632 000 jobs in 1991.
Car ownership	<ul style="list-style-type: none"> • 1.16 car / inhab. in 1997 (0.9 car / inhab. in the city centre); • increase of 5.5 % within 1990 - 1997 ; • increase of 32.2 % within 1980-1997. 	<ul style="list-style-type: none"> • 0.53 car / inhab. in 1989 ; • increase of 30 % within 1978-1989. 	<ul style="list-style-type: none"> • 0.5 car / inhab. in 1999 ; • increase of 11 % within 1995-1999.
B. Characteristics of the LR service			
Design	<ul style="list-style-type: none"> • Modern urban tramway network operated mainly on segregated lanes. 	<ul style="list-style-type: none"> • Dual system rolling stock (LR and heavy rail links without interchange) • Regional system serving the city centre using conventional tramway tracks. 	<ul style="list-style-type: none"> • Pilot line connected with the Brussels urban PT network ; • To be integrated in the LR network project that will be operated mostly on the existing rail infrastructure network.
Date of implementation	<ul style="list-style-type: none"> • 1985 : first LR line ; • 1994 : second LR line. 	<ul style="list-style-type: none"> • 1992 : first line. 	<ul style="list-style-type: none"> • 1994 : pilot line.
Network length	<ul style="list-style-type: none"> • 3 LR lines : 36 km of lines (to be increased to 45 km by the end of 2005). 	<ul style="list-style-type: none"> • 4 regional and 6 urban LR lines : 300 km of lines, to be extended . 	<ul style="list-style-type: none"> • Pilot line : 27.2 km (network to be extended) ; • Total project : 300 km.

	Nantes	Karlsruhe	Brussels
C. Accompanying measures			
Car oriented	<ul style="list-style-type: none"> Terminating and promoting the Ring Motorway around the city Rebuilding the major highways entering the city centre : less space for cars, more space for PT. 	<ul style="list-style-type: none"> building of a new bypass road. 	<ul style="list-style-type: none"> parking restrictions in the RER area (to be implemented) ; restriction of the road access capacity (to be implemented) ; creation of HOV lanes (to be implemented).
PT oriented	<ul style="list-style-type: none"> Promoting the use of public transport by the building of park-and-ride stations along the tramway lines, and interconnecting light (tram) and heavy rail lines (to be implemented) ; generalised fare integration (only one fare zone for the whole LR network). 	<ul style="list-style-type: none"> priority given to LR and other PT services ; improving the attractivity of LR stations ; development of P&R stations ; generalised fare integration (train, LR, urban trams & regional buses). 	<ul style="list-style-type: none"> increase of the commercial speed on the urban and interurban networks (dedicated lanes, signal controlling...) ; improving the attractivity of stations ; Semi integrated fare (train, LR, urban trams & regional buses) within the Brussels Capital Region (no fare integration yet outside the Region).
Two-wheels and walking oriented	<ul style="list-style-type: none"> Building of two-wheels routes ("continuités deux roues"). 	<ul style="list-style-type: none"> Two-wheels park spaces at LR stations. 	<ul style="list-style-type: none"> Building of two-wheels routes ("itinéraires cyclables"). Control of the urban sprawl (to be implemented) ; Protection of the Brussels housing area (to be implemented) ; Measures concerning urban structures in order to reduce the need for motorised transport and to ease access to public facilities and educational institutions (ABC classification).
Land-use oriented			

Table 2. Before and after comparison

	Nantes	Karlsruhe	Brussels
PT usage	<ul style="list-style-type: none"> significant impact on the total PT use, at the city level : 1984-1986 (line 1) : + 19 % ; 1992-1994 (line 2) = + 6.3 %. 	<ul style="list-style-type: none"> significant impact along the corridors served : Karlsruhe - Bretten (1992-1997) : + 600 % ; Karlsruhe - Wörth (1996-1998) : + 94 % ; Karlsruhe -Pforzheim (1996-1998) : + 129 %. 	<ul style="list-style-type: none"> significant impact along the corridor served by the pilot line : + 154 % (1993-1997).
LR modal split	<ul style="list-style-type: none"> 1980-1990 : increase of the car modal split and stagnation of the PT modal split, despite the opening of the first LR line ; 1990-1997 : reduction of the car modal split and increase of the PT modal split, thanks too the opening of the second LR line and appropriate accompanying measures. 	<ul style="list-style-type: none"> evidences of modal shift in favour of PT : Karlsruhe - Bretten line : 40 % of LR customers are former car users ; Pforzheim - Karlsruhe – Wörth line : 20 % of customers are former car users. 	<ul style="list-style-type: none"> pilot line : no noticeable impact at the Brussels scale. Data not available at the corridor level. Simulation results for the whole LR network project : PT market share for trips going to the Brussels Capital Region : in 1991 without LR : 38 % ; in 2005 without LR : 32 % ; in 2005 with LR : 45 %.

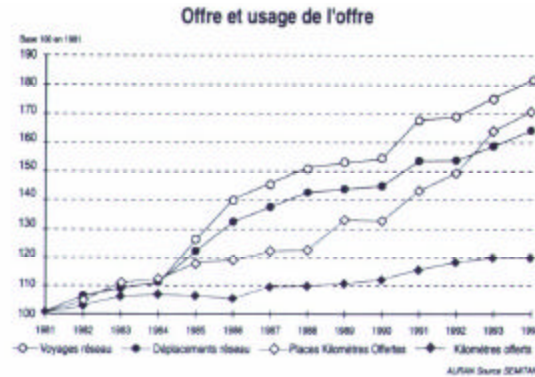
Table 3. With and without comparison

	Nantes	Karlsruhe	Brussels
PT usage	<ul style="list-style-type: none"> Public transport use and walking are much higher within the city than in periurban areas ; 57 to 78 % of the inhabitants are PT users (regular or irregular) ; the higher percentage is found in the sectors that are the best served by the LR. 	<ul style="list-style-type: none"> On the line Karlsruhe– Bretten, LR has appeared as much more successful than heavy rail. 	<ul style="list-style-type: none"> availability of value attributed by line '26' users to different characteristics of the service (stated preference survey) ; availability of values of different elements of public transport services by trip purpose (IRIS Plan).
LR Modal split	<ul style="list-style-type: none"> the market share of PT is slightly higher along LR lines than along bus corridors offering a similar level of service . 	<ul style="list-style-type: none"> LR or regional railway lines have a market share of 50 % ; for most successful routes, the market share rises to 67 %. 	<ul style="list-style-type: none"> Before the implementation of the LR network: for home-to-work trips less than 30 km, the car has the greatest market share; for other trips PT have the greatest market share. The objective of the LR network is to counterbalance this trend.
Car travelling context	<ul style="list-style-type: none"> People living along LR lines and in situation of modal choice are much more likely to use the LR line for their home-work trips if they do not have a reserved car park at destination. 		<ul style="list-style-type: none"> The use of PT is highly dependant on the difference in door-to-door travel time between cars and PT, hence on road congestion ; Simulation results show that car parking restrictions and / or road pricing are likely to induce a modal shift from car to PT.

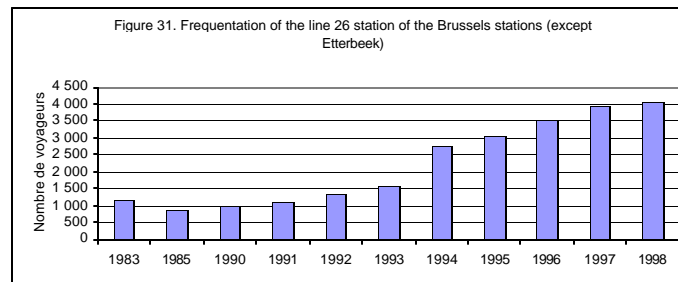
PT usage

Pilot 4 case studies have demonstrated that a good LR supply is able to induce a sensitive reaction in term of public transport demand. The figures given below are self-explanatory to show the impact of the LR introduction on public transport patronage.

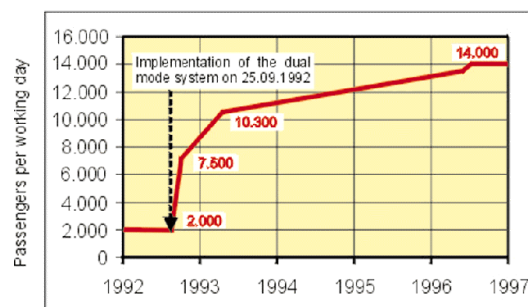
- **Nantes**³⁹ : The first line has been opened in 1985 and the second line in 1992.



- **Brussels** : The LR service operation of line 26 has started in 1994



- **Karlsruhe** : the dual mode system has been implemented in 1992



³⁹ Generally speaking, it has been shown that French cities having implemented a new light rail scheme during the Eighties or the Nineties have recorded an increase in public transport ridership of 20 to 40 %, at the level of the whole network - Pecheur P., "Penser la ville autrement avec le retour du tramway", Revue Générale des Chemins de Fer, Novembre / Decembre 1998.

Accompanying measures

Pilot 4 case studies have demonstrated that even if a good LR supply is able to induce a sensitive reaction in term of public transport demand, **it is not always able to generate by itself a significant modal transfer producing a significant reduction on the road traffic congestion.**

Of course LR is a necessary condition to achieve the objective of reducing the urban congestion but is it sufficient ?

It appears that there should be a certain level of benefit for the traveller (time or money) before he is willing to change his modal choice habits. If this level is not reached by the implementation of the LR project in itself, **accompanying measures** should be considered as a **push factor**, complementary to the **pull factor** constituted by implementing the LR services.

Indeed, when stating that European light rail-based networks have recorded an higher gain in public transport patronage than bus-based ones, Hass-Klau *et. al.*⁴⁰ argue that one possible explanation for this observation may be that "cities which operate light rail have a tendency to implement more effective car restraining measures, partly because light rail can help to develop the political consensus to adopt a more radical approach to car restraint than bus systems have allowed".

Several accompanying measures have been implemented in the reviewed case-study cities : in Nantes, the building of the second LR line was a component of a more comprehensive mobility plan, the "Plan de déplacement de l'Agglomération Nantaise", of which one of the objectives was to provide the complementarity between all transport modes (public and private). In Brussels, it is now widely accepted that accompanying measures concerning households and firms location are important. Simulations have shown that without an efficient control of the location reinforcing the concentration of the activities, the improvement of accessibility by PT as well by private car (resulting from the new LR service) will induce a sensitive impact on the relocation of activities, which can have a negative effect on the public transport market share in the long term. In Karlsruhe, only a few accompanying measures have been implemented and the success of Light Rail is not due to car restrictions.

⁴⁰ Hass-Klau C., Crampton G., Weidauer M., Deutsch V., "Bus or light rail : making the right choice. A financial, operational and demand comparison of light rail, guided buses, busways and bus lanes.", Environmental & Transport Planning, 2000.

More precisely, accompanying measure, as observed in the pilot 4 case-study cities, consist of :

- reduction of the car parks capacity (on-street and off-street policies) ;
- restriction of the capacity on the road network ;
- reorganisation of the urban and inter-urban public transport services ;
- provision of rights of way and other means giving the priority to surface public transport vehicles, in order to increase their commercial speed ;
- development of the attractiveness of the LR stations ;
- implementation of park and ride ;
- implementation of road pricing schemes.

It should be noted that it is very difficult to identify the impact of each isolated measure from real world observation (case-study approach), since many factors are interacting and changing simultaneously. For studying such questions, **modelling methods** are requested. However, as was pointed out in Chapter 3 and will be summarised in the following Chapter, special care should be taken for the design of such models to avoid misspecification.

LR Modal split

Long term modal split impacts include effects induced by the improvement of the city accessibility. The new LR service **induces a better accessibility of the city and its suburbs by Public Transport**. However, if the LR succeeds in attracting former car drivers and if no car-restraining measures are taken, there might also be a better accessibility of the city for cars, resulting from the diminution of car traffic. This phenomenon is likely to stimulate a new demand for car travel (induced trips), counterbalancing (at least partly) the benefits in term of modal split of the implementation of the LR scheme.

Beside, relocation effects may arise : because people are making a compromise between transport costs and cost of the land, there is a risk that, if the cost of the land is cheaper outside the city, the gain of accessibility resulting from the new LR service will be consumed by people, through a change in their travel habits (new destinations, change in their location choices,...). For instance, according to the location of their job and to the land cost, they can decide to move in the periphery, in the neighbourhood of a LR station of a motorway entrance.

Hence, the improvement of accessibility is generating a change in the travel demand pattern :

- increase in the average length of trips ;
- increase in the average number of trip per day and per person.

This phenomenon has been observed in the past in many cities in Europe, such as Nantes and Brussels.

This does not mean that relocation effects should always be avoided : the objective of a light rail scheme may be to stimulate the economic development of a suburb or a declining area ; this was notably the case in Manchester (Metrolink extension to Eccles) or again in the Docklands area (London), where the LR network was considered as a structuring framework for development, as was noted in LiRa Pilot 3. This is in many cases a good justification for a new LR scheme.

However, we should bear in mind that, *from a modal split point of view*, the market share of the public transport is always the highest in central locations, because public transport networks are the more efficient in densely-settled areas (higher demand, thus better supply, in terms of frequencies and PT coverage). In this view, any trend favouring the urban sprawl or the spread of households and activities is likely to result in a greater market share for cars.

Chapter 5 **Guidelines for implementing a new Light Rail scheme**

In this section, conclusions in the form of guidelines to local authorities who consider developing a Light Rail project are presented.

5.1 Why Light Rail ?

According to a recent survey of over 45 existing and planned Light Rail (or busway) public transport systems worldwide⁴¹, ***the reduction of traffic congestion is the most common and the most important objective for constructing a new transit system.*** This suggests either an increasing concern about congestion or an increasing confidence about the ability of a new public transport system to deal with it.

Among the other objectives often cited are:

- the improvement of the public transport
- the improvement of the environment
- the stimulation of development.

The fulfilment of these objectives should imply an increase in the patronage of public transport, which may in turn have an impact on the modal split between public and private transport. This would also lead to reductions in emissions.

However, although the expectations associated with new Light Rail systems are high, ***the underlying mechanisms leading to the fulfilment of these objectives appear to be not well known*** by the promoters of these systems.

⁴¹ UTOPIA survey, Macketts & Edwards (1998)

Moreover, there is evidence from the United States, Britain and France that ***the expected impacts of a new Light Rail system were often more important than the operational ones are actually.***

In most French cities having implemented a new Light Rail system, the market share of the car has continued to increase, despite the building of the Light Rail. In Britain and in the United States, few operational systems seem to have met their objectives. Indeed, when looking at traffic forecasts before and after the opening of a new system, it is clear that a gap may exist between the expectations and the reality.

To reduce as much as possible differences between forecasting and reality, it is recommended to pay a particular attention to the following items :

- ***Define adequately the area to consider in the impact study*** : Classical socio-economic evaluations investigate the modifications of patronage inside of the corridor being considered. ***Take into consideration network effects*** which are the modifications that may appear on the network outside the corridor being considered, as a result of the modifications of infrastructure within this corridor. These network effects include :
 - route modifications at the level of the study area ;
 - potential demand : additional trips (which did not exist in the former network configuration) being travelled through the corridor ;
 - induced effects : economic modifications which may appear from the interaction between generalised cost of location and generalised cost of transport (the new infrastructure project may induce inhabitants and companies movements).

- ***Define and take into account in the models the adequate accompanying measures*** that represent a key success factor of any public transport scheme. A new Light Rail system alone without adequate accompanying measures is unable to produce a significant modal shift in favour of the public transport.

- ***Choose the adequate forecasting model*** : transports models continuously evolve, as new impacts or developments are accounted.
 - As a minimum, make use of a ***four steps classical multimodal model*** able to consider the road congestion impact on the modal choice; in that case be aware that a four step classical model only enable to carry out short term forecasting
 - To carry out long term forecasting, take into account that transport and land-use have to be considered as an integrated and mutually dependant system. It is now generally accepted that transport policies alone will not achieve a

sustainable level of fuel consumption and emissions. It is intended that transport and land-use have to be considered as an integrated and mutually dependant system. Make use of **integrated land-use – transport models** such as MEPLAN or TRANUS

- o prefer disaggregate transport model versus aggregate transport model for analysing users behaviour⁴².
- **Make an adequate use of forecasting procedures** and check the validity of hypotheses or input data in forecasting models⁴³ :
 - o **consider the potential changing in politico-economic context** between designing and implementing a new Light Rail scheme which is likely to affect the validity of the hypotheses used as basis of the forecasting exercise ;
 - o **elaborate a market study independent from potential pressure of politicians or policy makers** to produce a scheme that seem more attractive than it is actually.

5.2 Light Rail and modal split.

From the literature review and the Pilot 4 case studies, it has appeared that a good LR supply is able to induce a sensitive reaction in term of public transport demand.

Public Transport project design

Behavioural models show that the difference in door-to-door travel time between public transport and car alternatives, and hence the road congestion level, are crucial in the modal choice decision. This characteristic is well confirmed by the LiRa literature research and the results of the Pilot 4 case studies.

⁴² Aggregate transport demand models have been used until the early 1980s, despite the awareness of several deficiencies in the conventional methodologies. Only then, discrete choice models like stated preference models, based on the behaviour of individuals, have started to be considered as a serious modelling option.

⁴³ Transport forecasts are based on socio-economic forecasts that sometimes reflect the expected effect of economic and regional policies, whose success may actually depend on other uncontrollable factors like international trade and cooperation. Errors in forecasting these global indicators have been found to be at the root of the problem of mistakes for the planning variables at the local level.

Success factors in this respect are the following.

- **Make sure the LR service is competitive with the private car in term of commercial speed:** 20km/h may be successful for urban lines (Nantes)⁴⁴ while there is a need for higher speed such as 50 km/h on interurban corridor sub urban lines (Karlsruhe-Bretten line) ;
- **Take care that the headway (related to frequency) does not induce a disproportionate penalty** on the door to door LR travel time. As LiRa Pilot 4 case studies confirm that :
 - o on short distances or at the urban level, the appropriate frequency is 1 vehicle every 5 minutes to 10 minutes like in Nantes
 - o on longer distances or at the interurban level, the frequency can be reduced to 3 vehicle per hours: see Karlsruhe and Brussels case studies
- **Reduce the number of interchanges or improve the level of service at the interchange stations** The more successful LR usage to city centre destination in Nantes and Karlsruhe confirms this item as well as the impact on LR ridership of the diversion to the city centre of the Karlsruhe-Wörth line in 1998 and the value attributed by the Brussels line '26' user to one additional direct vehicle.

Customer related features

Some additional factors related to the user comfort appear to be preponderant as well. Recommendations are the following:

- **Pay attention to a harmonious integration of fare :** they are recognised as a factor of success, e.g. in Nantes and Karlsruhe. Karlsruhe case study shows the impact on LR ridership of integrated fare implementation on the Karlsruhe-Wörth line in 1997. In Freiburg, the introduction of an integrated pass in 1984 is reported to have caused an increase in PT ridership of 12 to 23 % (depending on the estimated journey frequency for travel cards) in one year time (Hass-Klau *et.al.*, 2000). In Brussels, its is advised to complete the fare integration (only achieved for trips inside the Brussels-Capital Region) for all trips ;
- **Take care of a satisfactory operation schedule :** the Karlsruhe LR system is operated from 4h30 am to 1h00 am and to 3h00 during the week-end. One of the

⁴⁴ Although this objective may seem difficult to reach in urban areas, it is by no ways impossible : the average operating speed is equal to 20,02 km/h in the Rouen's and Strasbourg's LR networks, and the difference in travel time between peak and off-peak periods is lower than 7 %. In Nantes, both LR lines 1 and 2 are close to 20 km/h. (Wu *et. al.*, 1997).

most important inconvenient of line '26' in Brussels is that it is not operated during evenings and week-ends ;

- **Be aware of the importance of the comfort of the rolling stock** : on short distance (urban level), favour a **higher capacity of standing** passengers than **comfortable seats** ; on middle-long distance more and more comfortable seats are of importance; **Boarding at level rolling stock accessibility** is also a successful characteristic⁴⁵, already fulfilled on the new vehicle series in Nantes ;
- **Mind the importance of the quality of the information provided to the user** : three characteristics are of main importance :
 - **Timetables** have to be **easy to understand and to remember** : scheduled timetables (fixed headway) are the most successful in that term; the experience of Karlsruhe show the positive impact on the LR ridership resulting from the implementation of scheduled timetable in 1993; it is also recognised that in Brussels it would contribute to improve the level of service of line '26'.
 - **LR origine-destination routes** have also to be **easy to understand and to remember** : (see the example of the North and the South network of London), the right compromise has to be found in the network configuration between lines linking all possible origin-destination pairs without connection and more efficient and more clear network organisation inducing connected trips.
 - **The access way and the connection route to the stations and platforms has to be clearly indicated.**

LR image

The Pilot 4 case studies have also pointed out the importance of the image of the mode.

Make LR mode popular by the way of marketing methods and using perception surveys: In Karlsruhe 70 % are satisfied or very satisfied of the service; in Brussels, line '26' is better and better perceived. In Nantes, it has been reported that the "modern" image of the tram can explain the higher success of LR and that several people now consider the bus as

⁴⁵ Beside the point of view of comfort, a study in Hannover has revealed that the average time needed for level boarding and alighting is about 25 % lower than if the platform and train entrances are not at the same level (cited in Hass-Klau *et. al.*, 2000)

being “old fashion”. Therefore, special care should be taken to modernise the image of buses or other lines that have not been converted to LR operation.

Transport accompanying measures

The impacts of a new Light Rail scheme itself in terms of reducing car use and traffic congestion are generally very limited in scale. Therefore adequate accompanying measures are required :

Use LR as a transport policy tool : accompanying measures should be used and optimised as push factor, complementary to the pull factor constituted by the LR supply to enhance the effectiveness of reducing car use. Accompanying measures, resulting of the Pilot analyse are the following :

- ***Reduce the car parks capacity within the city***(on street and off street policies): the success of LR in Nantes is partly due to the limited capacity of parking. Additionally, a survey carried out in Nantes has shown that people who are in situation of modal choice are much more likely to use LR services for their home -work trip if they do not have a reserved car park at their destination. In this regard, it is envisaged to limit car park availability in Brussels in area that are well served by PT.
- ***Implement Park & Ride facilities*** : Nantes and Karlsruhe have both developed park & ride: Karlsruhe LR success is partly due to park & ride: 10 000 park & ride users, 4.6 % of line 1 and 6% of line 2.
- ***Reorganise the urban and interurban public transport services and provision of right of way*** : the level of service of LR is highly dependent on the level of service of the overall PT supply in the whole transport system area. Ensure a good coordination of every mode within the whole transport area; in Karlsruhe, in 1994, a new passenger transport authority gathering the municipalities and the regional administrations has been created and is responsible for the fare structure and the timetables of the whole transport system.
- ***Develop the attractivity of the LR stations***. Notably in Karlsruhe, buses were removed as soon as LR was implemented and were reorganised as “feeder lines” to serve the area more densely; in Brussels, several stations of line ‘26’ have been improved in this respect.
- ***Restrict the capacity of the road network*** : the main objective is to share more equitably the public space between every user category i.e. increasing the space

devoted to PT lines (segregated lanes), 2 wheels users and pedestrians. It aims to improve the commercial speed of public transport; in Nantes and Karlsruhe the building of dedicated lanes for PT lines has been facilitated by the building of new bypass roads infrastructure projects.

- **Road pricing could be envisaged as a efficient tool affecting the modal split :** this measure which has been simulated in the land use transport model of Brussels reveals that the modal shift from car to PT is even more efficient if the revenue of car tolling is used to subsidy PT alternatives.

Land-use related accompanying measures

Transport policies and investments are implemented on the basis of transport planning and operation and therefore their evaluation is linked to performance in terms of transport operations.

However, transport policies and investments may have wider economic effects than only at the corridor level or within the areas that they are designed to serve, but also at a larger spatial and temporal dimension. It is therefore required to carry out in-depth researches in order to evaluate the socio-economic impacts stemming from transport policies and investments.

A consensus is emerging that it is necessary to ***co-ordinate land use changes with transport measures*** in order to achieve an environmentally and economically sustainable transport system. In the Brussels case the Land-use Master Plan was conceived simultaneously with the Transport MASTER Plan and was inspired by the Dutch ABC method “The right business in the right place”

Some additional guidelines in this respect:

Define the accompanying measures reinforcing the concentration of activities : in addition to the here above mentioned transport accompanying measures, socio-economic accompanying measures enabling to control the location of housing and employment activities within the transport system area.

- On one hand, positive land-use effects from Light Rail can be observed; LiRa Pilot 3, notably presents the case study of London Docklands where the Light Rail network is considered as a structuring framework for development.

- On the other hand, negative impacts could be observed too: in Brussels, for example, land-use transport simulations studies have confirmed the expectations that there is a high risk that the increasing accessibility along the corridors served by the LR network could induce a relocation of households in the suburbs, where the land is cheaper, and increasing the phenomena of the urban sprawl.

5.3 Good practices

Infrastructure design and operation

If your aim is....

To increase the use of PT services...

Important aspects are :

- Provide a good LR level of service in term of travel time, frequency and number of interchanges in order that it is competitive with the door-to-door private car trips ;
- Ensure a good coordination of the LR service with the whole transport area: fares, timetables,... ;
- Pay attention to the service to the users : integrated fares, long operation schedule, services information provision and readability ;
- Be aware of the importance of the comfort of the rolling stock: number of seats, boarding at level rolling stock,... ;
- Use marketing methods to let LR mode become very popular.

Transport planning

If your aim is....

To reduce the car use...

Important aspects are :

- Use LR as a transport policy tool ;
- Define appropriate accompanying measures :
 - Reduce car parks capacity ;
 - Implement Park & Ride facilities ;
 - Reorganise the urban and interurban public transport services and provision of right of ways ;
 - Develop the attractiveness of the LR stations ;
 - Restrict the capacity of the road network ;
 - Road pricing can also be envisaged as an efficient tool.

Integrated Land-use Transport planning

If your aim is....

To serve a sustainable development...

Important aspects are :

- Use LR as a integrated land-use - transport – environment policy tool ;
- Define appropriate accompanying measures ;
- Control the location of household and employment activities within the transport system area ;
- If necessary, reinforce the concentration of activities.

Modelling issues

If your aim is....

To carry out long term forecasting...

Important aspects are :

- Define adequately the area to consider in the impact study, take in consideration network effects ;
- Define and take into account in the models the adequate accompanying measures ;
- Choose the adequate forecasting model :
 - As a minimum, make use of a four steps classical multimodal model ;
 - To carry out long term forecasting, make use of integrated land-use – transport models ;
 - Prefer disaggregate transport model versus aggregate transport model for analysing users behaviour ;
- Make an adequate use of forecasting procedures and check the validity of hypotheses or input data in forecasting models :
 - Consider the potential changing in politico-economic context ;
 - Elaborate a market study independent from potential pressure of politicians or policy makers.

Literature

Literature

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