Faculty of Engineering and Faculty of Architecture of the University of Porto

MASTER IN ENVIRONMENT PLANNING AND URBAN PROJECT

A DIFFERENT PERSPECTIVE OF PLANNING:

TRANSIT - ORIENTED DEVELOPMENT

Ana Elisabeta Dragutescu

Degree in Urban Planning

by the University of Architecture and Urbanism "Ion Mincu" Bucharest

Submitted to the Faculty of Engineering of the University of Porto, in partial fulfilment of the requirements for the degree of Master in Environment Planning and Urban Project

THESIS ELABORATED UNDER THE SUPERVISION OF:

Álvaro Fernando de Oliveira Costa

Professor at the Faculty of Engineering of the University of Porto

Porto, 2006

To Alex, Alina and my parents,

for their absolute support, sacrifice and friendship…

ACKNOWLEDGEMENTS

This study has had a long, sometimes sore conception over a period of one year and it would not have been concluded without the generous support and kindness of the people from behind the scene who will be brought to the spotlight in the following lines.

I would like to extend my loving thanks to my future husband, Alex Strazzaboschi and my parents for the untiring support and belief in me along these years of intense study and for the painful odyssey I put them through by getting on the airplane and leaving them behind over and over again. Without them I wouldn't have moved past the first page.

My special gratitude to my supervising teacher for all the fruitful discussions held mostly on Saturday afternoons and to my special friend Ana Sousa, the secretary from the Environment Planning Department. Without their help and fully understanding of certain circumstances this thesis would not have been completed.

I would also like to thank Mr. Robert Cervero, Professor of City and Regional Planning at the University of California at Berkeley, for promptly answering to my requests and for providing key inputs for the study even though he has not got any knowledge of who I am.

I owe a considerable debt to Metro do Porto SA for kindly providing me with important data that were invaluable to the completion of this research.

My special thanks to my small Romanian world from Porto, Alina Petrescu, Diana Matei Roxana Ciuperca, Victor Stanila, Cezarina and Andrei Mardare, Virginia Trandafir, Andrei Bunghez and Laurentiu Bucalau for finding time for friendship and illuminating discussions. Thank you to all the "new entries" in my life, either Portuguese, Brazilians or from Thailand who left behind them smiles, good thoughts and a lot of support along the way.

SUMMARY

One of the challenges that the continuous growing city has to face is how to manage the continuous sprawl and the inherent demand for travel. Transportation is a well acknowledged element of shaping the city and of determining an area's development potential, due to the accessibility thus resulted.

Consequently, the development of the urban form is constantly influenced by the market's response to the improved technology of public transportation resources fighting against growth of automobile ownership and the expansion of the highway system.

One of the many strategies recommended to help turn around this dangerous tendency of increasingly car dependency, is the promotion of an operational public transport system and an intensive development around its stations. The New Urbanism movement embraced the concept of Transit-Oriented Development. The emergence of this concept re-evaluated the development models and reconsidered the design and the importance of the relationships between transport – mainly public transport - and land use.

Transit Oriented Development (TOD) is a planning approach that calls for high-density, mixed-use business/neighbourhood centres to be clustered around transit stations and corridors. TOD is considered a "smart growth" strategy, because it both tackles the issue of where growth should occur from a regional "sustainability" perspective and it also coordinates land use and transportation, to see that both land and infrastructure are used efficiently.

An increasingly number of areas has flirted with the idea of Light Rail as an evolving attitude to become both a people-moving and a community-building strategy. The Metro provides the city with the next opportunity to systematically capitalize on public transport, to attract major development.

The success of light rail along defined corridors can be attributed to its modern, often futuristic vehicles, perception of reliability, quietness, ease of access, climatic controls and environmentally friendly nature. Its close association with land use integration will be the most important issue in determining the emergence and the success of any TOD, as it will be disclosed in the case study. Basically, light rail appears as a trendy new way to travel around our cities, compared with the car.

This study describes the integrated framework of the Transit-Oriented Development, practical issues and elements involved in the relationship born between land development and the public transport system. In combination with cautiously planned mixed land-use, the Metro system can be a powerful tool to help shape growth. Land use became thus a significant factor in decision-making for new Metro projects investments as transportation and land use are inextricably linked.

To emboss and extend the insights gained from the theory, a case study will be carried out in order to offer a rich set of perspectives on the challenges and potentials of implementing and developing a light rail corridor and its surrounding areas.

Even if the impacts of TOD vary by time and circumstances, the potential benefits of TOD are social, environmental, and fiscal.

By capturing the opportunities and benefits that a transit-oriented development might bring in the territory, a further stage could be achieved by outlining the potential, the challenges and the barriers that such a development type implies. This could lead not only to improved mobility options, but also to enhanced linkage between land-use planning and transportation system design. It is this synergic impact of treating land use or site design as “transportation” strategies that provide the forward motion for this study.

RESUMO

Um dos desafios que a cidade em contínuo crescimento tem que enfrentar é o modo de administrar a sua contínua expansão e a inerente exigência de deslocação de um lugar para o outro. O transporte é um elemento bem conhecido que configura a cidade e que determina o potencial de desenvolvimento de uma área, devido ao aumento de acessibilidade que proporciona.

Portanto, o desenvolvimento da forma urbana é constantemente influenciado pela resposta do mercado aos avanços tecnológicos dos recursos de transportes públicos lutando contra o crescimento do numero de automóveis e a expansão do sistema rodoviário.

Uma das muitas estratégias recomendadas para combater esta perigosa tendência de aumento contínuo da dependência do automóvel, é a promoção de um sistema operacional de transportes públicos e um desenvolvimento intensivo à volta das suas estações. O movimento *Novo Urbanismo* abraçou o conceito de Desenvolvimento Orientado pelo Trânsito (Transit-Oriented Development). A emergência deste conceito reavaliou os modelos de desenvolvimento e reconsiderou o desenho e a importância dos relacionamentos entre transportes – principalmente transportes públicos - e os usos da terra.

O Desenvolvimento Orientado pelo Trânsito (TOD) é uma abordagem de planeamento orientada para centros de negócios/habitação de alta concentração e uso misto que vão ser aglomerados em torno das estações e ao longo dos corredores. TOD é considerado uma estratégia do “crescimento inteligente" porque coordena os usos da terra e dos transportes, de modo a que tanto a terra como a infraestrutura sejam eficientemente usadas.

Cada vez mais áreas consideram a ideia do Metro Ligeiro como uma atitude de desenvolvimento para se tornar numa estratégia de deslocar pessoas e construir a comunidade. O Metro fornece à cidade a oportunidade de sistematicamente aproveitar os transportes públicos, para atrair maior desenvolvimento.

O sucesso do Metro Ligeiro ao longo de alguns corredores definidos pode ser atribuído aos seus veículos modernos, à sua percepção de fiabilidade, silêncio, facilidades de acesso, climatização e à sua natureza amigável com o ambiente.

A sua associação com a integração do uso da terra será a questão mais importante na determinação do surgimento e do sucesso de qualquer TOD, como se vai abordar no estudo de caso de caso. Basicamente, o Metro Ligeiro aparece como uma maneira nova de viajar nas nossas cidades.

Este estudo descreve a estrutura integrada do Desenvolvimento Orientado pelo Trânsito, as questões práticas e os elementos envolvidos no relacionamento nascido entre o desenvolvimento da terra e o sistema de transportes públicos. Em combinação com o planeamento atento dos usos misturados da terra, o sistema de Metro pode ser uma arma poderosa para ajudar a configurar o crescimento urbano. O uso da terra tornou-se assim um factor significativo na tomada de decisão para novos investimentos de projectos de Metro e vice-versa.

Para estender as introspecções ganhas da teoria, será realizado um estudo de caso como objectivo de oferecer um grupo rico de perspectivas sobre os desafios e os potenciais de realização e desenvolvimento de um corredor de Metro ligeiro e das suas áreas adjacentes.

Apesar do impacto de TOD variar de acordo com o tempo e as circunstâncias, os potenciais benefícios de TOD são sociais, ambientais e fiscais.

Ao capturar as oportunidades e benefícios que um Desenvolvimento Orientado pelo Trânsito pode trazer ao território, uma nova etapa pode ser alcançada destacando o potencial, os desafios e as barreiras que esse tipo de desenvolvimento implica. Isto pode conduzir não só a opções melhoradas de mobilidade, mas também a uma melhor ligação entre o planeamento dos usos da terra e o dimensionamento do sistema de transporte. É este impacto sinergético do tratamento do uso da terra ou desenho dos locais como estratégias de "transporte" que providencia um impulso a este estudo.

LIST OF TABLES

LIST OF FIGURES AND PHOTOS

TABLE OF CONTENTS:

01

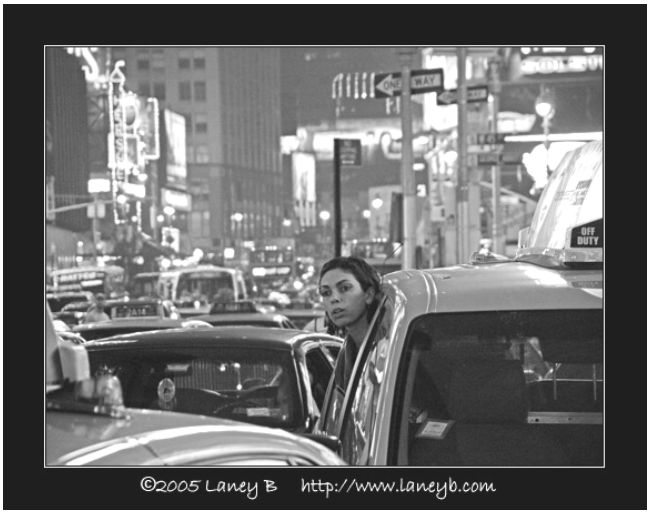
INTRODUCTION AND RESEARCH DESIGN

The contemporary urban life is widely perceived as a ceaseless and mobile interchange at different scales, spreading the frustration of sprawl development patterns.

A new tendency in shaping the metropolitan growth, labelled “smart growth” reveals more efficient land use and transportation patterns.

“Smart growth” is more than just a catchphrase, is the tool for revitalizing existing urban areas. It helps drawing the line of “no further development” and reducing thus car dependency. Transit-Oriented Development became thus an imperative topic in the smart growth debate.

This 1st chapter represents a brief introduction that seeks to provide a brief overview of Transit-Oriented Development as a theoretical concept and as a tool in shaping “smart growth” for the city.



1.1. INTRODUCTION TO TRANSIT-ORIENTED DEVELOPMENT

- **State of the art**

An introspective glance into the contemporary city reveals powerful and dynamic patterns of conception and a ceaseless and mobile interaction between different scales of urban life. Rapid growth and fast developments have been the outcomes of a continuous flow of movement and exchange in the city.

Sprawl and lack of open space produced real concern between planners, as the main reasons of increasing income inequality, providing job uncertainty, diminishing housing affordability, or creating long distance commutes and environmental problems. Finally, urban decline is aggravated during this urban development and growth process.

This sprawling tendency of the urbanised areas, require transport systems with high capacities to face the growth of travel demand. Transportation is a well acknowledged element of shaping the city and of determining an area's development potential, due to the accessibility thus resulted. Consequently, the development of the urban form is constantly influenced by the market's response to the growth and improved technology of transportation resources. But the growth of automobile ownership and the expansion of the highway system still represent a basis cause for most of today's urban problems.

How, then, can we imagine the complexity of the system that interlinks and supports the city and the urban life? According to various researchers, sprawl is the problem, congestion is the most tangible result of its materialization and smart growth is the solution.

- **Smart Growth, a broad-spectrum solution**

Smart Growth refers to development principles and planning practices that create more efficient land use and transport patterns, maximizing the potential of the already existing urbanized areas. It includes numerous strategies that result in more accessible land use patterns and multi-modal transport systems. It is an alternative to sprawl (Littman, 2005). And it does not signify "no growth at all".

This study tries to explore the potential of smart growth planning. Lying upon a different conceptual model of integrated thinking, it emphasises practical issues and elements involved in the relationship born between land-use development and transportation system.

One of the challenges that the continuous growing city has to face is how to manage the demand for travel. The transportation area is a sector where major technological jumps occur periodically and sometimes unforeseen. Researchers have analyzed thus the options of planning developments oriented towards an integrated approach of land-use and transportation, laying emphasise on public transport.

There is always a critical synergy between transport and land use, since the access they provide and other resources make the adjoining land valuable and support its development at higher densities. Meanwhile higher densities within the neighbouring land will support transit trips by attracting consumers close to the stations, stops and terminal.

It is widely admitted the importance of high densities and mixed land-use in the city's expansion, and also the interconnection between demand and supply of public transport as an active element in the dynamics and the structure of urban system. If well designed, this kind of corroboration helps developing different locations in the city. Hence these types of investments can be used to support the regeneration of the existing area.

Technological advances and scientific steps forward brought new capabilities. The New Urbanism movement embraced the concept of Transit-Oriented Development Transit-Oriented Development (TOD) – as a mean of promoting smart growth and providing quality of life, as an integrated development around public transport facilities (light rail, railway, interchange nodes) - could be considered a viable solution to combating uncontrolled growth and encourage the relation between transportation and land-use.

- **TOD - a more focused solution**

The study takes a narrower approach, referring to Transit – Oriented Development mostly at and around light rail metro stations.

Many claim that TOD holds the answers of solving sprawl problems through smart-growth developments. TOD has been considered a model for integrating land use with

transportation as a growing number of communities have pursued Light Rail Transit and integrated transportation and land use strategy to help revitalize the cities (Calthorpe 1993; Cervero 1998; Newman and Kenworthy 1999).

An increasingly number of areas has flirted with the idea of Metro Rail as an evolving attitude to become both a people-moving and a community-building strategy. High-speed trains became the solution for transportation crisis. Metro Rail investments represent significant opportunities for the development of public transport system, thereby aiming to reduce reliance on automobile trips. The motivation and support for Light Rail Transit has turned over from a simple alternative way to provide transportation to being a significant issue of the public transport expansion (Compin, 1999; Shaheen, Rodier, Finson, 2003).

Transit-Oriented Development's concern in bringing some fresh air around transit nodes by constructing and redeveloping the area is seen as the most probable solution in fighting car dependency in the crowded city.

The attempt to concentrate urban forms around public transport nodes is difficult to achieve, but it will bring changes to urban living and work activities.

1.2. RESEARCH OBJECTIVE

The objective of this study is to summarize the state of practice for TOD by performing an ample literature review and by conducting an eloquent case study.

The elements for promoting coordination of land use and transportation planning are to be addressed in order to outline patterns of land-use development that support public transport ridership and pedestrian activity.

This research builds upon significant studies related to Transit-Oriented Development, on current practice experiences and future potential, considering and evaluating the impacts and benefits of this concept, possible constraints and obstacles to be overcome and recommended procedures for achieving it.

1.3. METHODOLOGY

This study will cover the main aspects of TOD's opportunities and obstructions towards a successful relation between land-use and transportation planning around public transport stations. Many facets of these relationships will be addressed. They are to be examined, explained, evaluated, and documented in order to delineate a cost-effective public transportation investment.

Based upon a combination of literature review and an analysed case-study, the study will provide the state of art and practice for the Transit-Oriented Development.

It will also seek to understand how changes occurred over time, how different typologies adapted to different locations and how travel behaviour adjusts to the new transit and land development.

The research will be mainly divided in two major issues:

The theoretical part will review the body of literature concerning the effects of transit and land-use interaction by summarizing most of the relevant literature on Transit-Oriented Development concept.

Literature review will help providing a "place-setting" of this concept, in order to determine what is known and what still lies under the lines of uncertainty. Reports, articles and books are relied upon in revealing the most important features of Transit-Oriented Development and also some of the subtle underneath aspects that still hold back the developers and the transit agencies. In order to develop this study in a broad manner and to ensure that significant knowledge is incorporated, available information will be assembled from numerous sources.

Having the investigated literature as a background, the research will try, further on, in accordance with the goals outlined above, to focus on some practical issues relating to land use development and transport system. These issues could be summarised as it follows:

- *An integrated framework of land-use and transport system* – physical dimension (land-use and design guidelines, densities, types of functions), modelling patterns of travel (travel times, accessibility levels, transportation options) and the use of networks to improve urban mobility;
- *Social dimension* – studying the human behaviour - trip destinations, reasons for moving and trip-changing - as a response to the integrated developments that provide a certain area with high density functionality, improved public transport facilities and reduced car dependency.

To provide a more comprehensive understanding of the relation between land-use and transportation, a case-study will be presented and analyzed. Through the practical part of the study, empirical evidence will be provided that public transport and land-use relationships are important.

This kind of approach wants to expose an "on-ground" project which is able to plead for application of higher densities, both residential and commercial, in strong relation with the public transport facilities as part of the Transit-Oriented Development process. The case study can offer a rich set of standpoints and challenges for implementing TOD.

The case-studies will be conducted following a number of steps:

- Preparation of a "study plan";
- With the basis on the review of background materials that will be completed in the first part, several types of data collection and interpretation will be carried out – field visits for site analysis, revision of reports and newspaper articles, revision of existing regulation and planning framework;
- Diagnosis and alternatives for the studied area.

1.4. STRUCTURE OF THE STUDY

The study is structured into five parts, as it follows:

The **first chapter** represents a brief introduction aiming to provide a brief image of the area of Transit-Oriented Development concept as a "smart growth" tool for the city.

The **second chapter** is dedicated to literature review. The principal aim of this literature review is one of "place-setting" - to establish what we know and what we don't know about Transit Oriented Development, bringing together a theoretical knowledge. By identifying existing knowledge gaps, it is hoped that areas where additional research and study are most needed can be looked into.

The **third chapter** explores, relying upon the literature review, the configuration and the parameters that influence the location and the functioning of such a complex system of transport and all the other land uses. The main forms and definitions, tools and techniques of Transit-Oriented Development will be described and analyzed along this chapter.

The **fourth chapter** brings in discussion a certain case study, trying to emphasize what factors account for the success or failure of such a Transit Oriented Development.

The **fifth chapter** which incorporates the concluding chapter will take into account the preceding discussions. The ways this complex spatial development brings new trends in the city transport facilities and orients them towards sustainable transport systems will be look into.

02

LITERATURE REVIEW

Many researchers claim that Transit-Oriented Development hold the answers to solving the answers of sprawl, thus it became a significant matter of debate for planning, transportation, urban development and other related fields.

This chapter gives an in-depth look at an old concept through the review of a new and continuously resurgent body of literature.

- **Literature Review Structure**

This section briefly summarizes most of the relevant literature concerning the characteristics, the potential and the barriers of the Transit-Oriented Development concept. The aim of this literature review is to establish the base knowledge and knowledge gaps for further development of the study, coming in touch with key issues of the main categories of the concept.

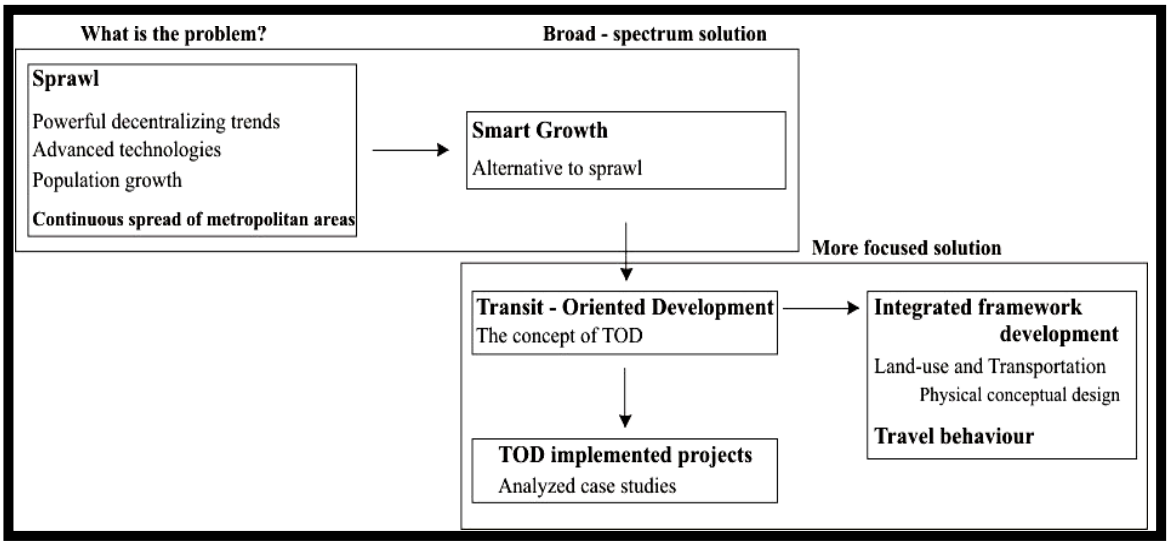
The bibliography does not intend to be complete, due to the scarcity of academic literature about this concept. Therefore, the literature review relies upon empirical studies drawn out of the researchers' experience, rather than on academic debates. Therefore, most of the literature used in preparing this review consists of a series of comprising guiding reports, articles and books as well as implemented projects statements.

Investigators have emphasized within their work various terms and various definitions used in describing best Transit-Oriented Development. Broad discussions were developed over an integrated framework of land use and transportation planning, over the design principles of TOD and also about the most significant factors that determine diverse travel behaviours within urban communities that foster TOD developments.

The review is divided into two main topics:

- The theoretical concept of Transit-Oriented Development;
- The current state of practise – guides through modern TOD.

Table 1 – Variables used in literature review and as base for study framework



2.1. SMART GROWTH AS A SOLUTION FOR SPRAWL

Metropolitan areas of today will continue to spread. Networked infrastructure and technical evolution allow cities to sprawl. This evolutionary tendency forces the city to imagine how the space and scale must be reshaped and the configuration changed.

Fig.1– Manchester traffic jam (photo:www.manchesteronline.co.uk)

The past years of urban decentralization and the mobility it develops cannot be supported by the future years. There is a wide range of literature that relate to urban sprawl, but this review has primarily focused on the interconnection between the sometimes uncontrolled urban spread of land-uses and the resulted increased automobile dependency. Due to low financial tasks – taxes and prices – for cars, automobile usage is put to advantage over public transport. An alarming increase in car ownership per person has been detected in the last years of research and statistics.

Starting with 1990, usage of automobile augmented as almost every member of a family owns a car. The average car ownership rate is of 0.40 cars per person in the European Union countries, with an increase of 30% in the last years (ECMT Report, 2002). Research carried out clearly emphasized that urban travel choice is guided mostly by the fact that "commuting and leisure trips by car have lengthened, the number of short trips by car substituting for walking have increased whilst congestion is encountered more frequently" (ECMT, 2002). Dispersion of urban land use over large areas leads to longer commutes thus increased car-dependency causing traffic congestion, poor air quality and finally urban decay. There can be easily noticed a closed circle between sprawl and car usage, since large areas of development require high level of automobile dependency.

Sprawl development is mainly characterized by dispersed, low-density and large scale developments as well as automobile – oriented transportation (Littman, 2001).

At the same time it contributes to a range of social disorders for urban populations left behind. In response to these trends, communities, public interest groups and levels of government have begun to develop smart-growth solutions to revitalize our cities, promote more compact and transit-oriented development, and conserve open space

Many authors refer to today's urban and suburban corridors as hazardous developments, uninspired streetscapes and poor connectivity. (Calthorpe 1993; Loukaitou – Sideris 1993; Cervero, Ferrell and Murphy, 2002).

This wide concept of sprawl is focused, exploring the effects that advanced technologies, globalization, increased automobile and population affluence have over the continuous spreading metropolitan area.

The density at which the city should develop is considered as a key issue for planners. This encouraged the emergence of the "smart growth" movement as a solution to sprawl and Transit – Oriented Development as widely assumed of being a model of planning smart. There is still considerable debate over the implications and the merits of smart growth seen as an efficient integration of land-use and transportation patterns.

The main elements that characterize the two forms of urban shape are compared in Littman's work as it follows:

Table 2 - Smart Growth and Sprawl (source: Littman, T. - *Evaluating Criticism of Smart Growth,* "Smart Growth," VTPI, 2005; SGN, 2001)

Smart Growth		Sprawl
Infill development	**Growth Patterns**	Urban periphery development
High - density ; Clustered activities	**Density**	Low density; Dispersed activities
Human scale: smaller building, blocks and roads; attention to detail since people experience landscape closer as pedestrians	**Scale**	Large scale: larger buildings, blocks, wide roads; less detail since people experience landscape at a distance as car drivers
Local; Distributed; Smaller;Walking access	**Services**	Regional; Consolidated; Larger; Automobile access
Multi modal transportation; Land-use patterns that support walking, cycling and public transport	**Transport**	Automobile - oriented transportation; Land-use patterns weakly suited for walking, cycling and public transport
Highly connected roads; Sidewalks and paths allowing more direct travel by motorized and non-motorized trips	**Connectivity**	Hierarchical road network with many unconnected roads and walkways; Barriers to non-motorized trips

2.2. STATE OF PRACTICE FOR TOD

2.2.1 Transit Oriented Development as an integrated framework

- **The concept**

A number of guiding principles and normative approaches have been advanced in designing Transit - Oriented Development. Even though the literature regarding TOD is new, the concept is rather old. Researchers have analyzed over the years and within a large amount of literature the importance that high densities and mixed land-use have in the city's expansion, and the interconnection between demand and supply of public transport as an active element in the dynamics and the structure of urban system.

Within the quite extensive literature that continues to expand, Peter Calthorpe has pioneered the concept and the thinking on how to design best Transit – Oriented Development with his provocative book *The Next American Metropolis: Ecology, Community and the American Dream* (1993).

From that moment, the literature began to see this concept as a real solution in providing smart growth, turning this study in one of the most frequently cited.

Along the years, the idea of Transit – Oriented Development was viewed and described in various manners, in terms like "transit villages", "transit-supportive development" or "transit-friendly design". Some authors use the term TOD in a different manner, referring to "transportation – oriented development" – bus, rail or light rail developments (Lefaver, 1997). Nevertheless, TOD has attracted significant interest as a tool of smart-growth planning.

The concept of TOD also varies in form in different locations. In the United States the concern for smart growth has been primarily brought by the New Urbanism movement and led to the idea that transit villages should borrow at high levels the design and the planning principles of the European cities. "*In Europe, a transit station often represents more than a collection/drop-off point*" (Cervero, Ferrell and Murphy, 2002). It rather functions more as a centrepiece for community building – an organizing platform for creating "*compact, mixed-use community centred around the transit station that, by design, invites residents, workers, and shoppers to drive their cars less and ride mass transit more*" (Bernick and Cervero, 1997).

Meanwhile, in the European territory, the researchers called for the emergence of the ideal of territorial cohesion and global competitiveness. The attempt is to invest in transport infrastructure at a trans-national scale in order to create some form of TOD (Hague, 2004). Nevertheless, the United Kingdom approved at national level Transit-Oriented Development principles and moved to creating projects based on transportation led growth corridors. The projects were gathered under a different term though: Transport Development Areas (RICS Report, 2000).

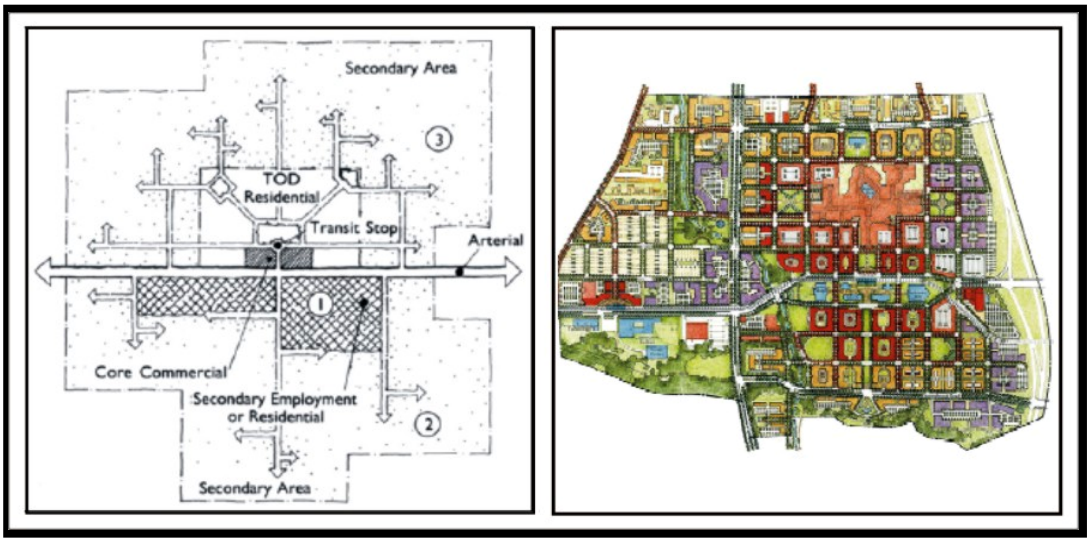


Fig. 2 – Conceptual design for TOD (Source: Calthorpe, 1993)

- **State of practice**

Due to the shortage of important academic literature, the review is more focused on a fair amount of guiding reports and articles, than on academic debates over different aspects of this concept.

Many claim that Transit – Oriented Development holds the answers of solving sprawl problems through smart-growth developments. TOD has been considered a model for integrating land use with transportation (Calthorpe 1993; Cervero 1998; Newman and Kenworthy 1999). Therefore, during the past years, TOD has become a highlighted topic for transportation, planning and development fields.

Transportation and land use are inextricably linked. The accessibility that transportation provides, makes the adjoining land valuable and also supports its development at higher densities: commercial development stretches out along highway and public transport corridors, new subdivisions pop up and congregate at interchanges after new transport systems arise. On the other side facet, lies the idea that higher densities within the neighbouring land of the public transport stations will support trips, attracting consumers close to the transportation facilities.

This review also contrasts the positions held by three notable urban planners, Genevieve Giuliano, Robert Cervero and John Landis as an important debate concerning the synergy of public transport and land-use development.

Giuliano argues that the connection between transportation and land-use started to weaken. Little justification is therefore found in public massive investments oriented towards transportation system – light rail or rail transit - or in balancing jobs and housing. This could only achieve minor change in the urban form. Strategies designed to reduce automobile travel by changing land use patterns are doomed to fail. As a consequence, price strategies are preferred to land use strategies. (Giuliano, 1995).

In response to this argumentation, the two authors stated that the connection between transportation and land use still greatly matters and makes a difference "*because there remains considerable elasticity in the relationship"*. It is truly believed that Transit – Oriented Development remains an answer to diminishing the car dependency, therefore land use initiatives remain an important tool for managing transportation demand (Cervero and Landis, 1995).

In a descriptive attitude, rather than an analytical one that prevails over the body of literature, it is revealed the clear growing importance of this type of urban development, providing performance oriented definitions for it. Knowledge in this field is supplied through comprehensive descriptions of the state of practice, of the implementation tools, concluding with the benefits of Transit-Oriented Development and the obstacles that its achievement has to meet. It is widely admitted the potential that TOD owns. Higher densities are expected to reduce the need for long distance travel, thus development patterns shape travel patterns (for example Cervero, Ferrell, Murphy, 2002; Beltzer and Autler , 2002).

Even if the definitions of TOD vary in scope and specificity from one work to another, most of them share some common features. They all are defined as station hubs, from functional and symbolical point of view, with tapered densities within easy-walk distances from the public transport station. The presence of a major public amenity playing the role of a gathering point is inevitable. High concern for mixed land-use - shops, services, restaurants, hotels - that provides trip generators and for intermodal seamless connectivity, is a major concern. Central, as a significant gain of the implementation of Transit-Oriented Development is the livable, active community that is provided with high quality life (Cervero, Ferrell, Murphy, 2002).

2.2.2 Influences of TOD on Travel Behaviour

The design of urban communities which favours reduced car dependency to walking, cycling and pedestrian friendly developments is seen as an effective strategy for the city, while travel behaviour is an important feature in shaping travel patterns as accurate as possible.
There are three elements that the studies rely upon in evaluation of travel behaviour:

Fig. 3 – Variables involved in travel behaviour study

These three elements also interact with other important features that add valuable information to the final appraisal of travel behaviour. Thus, researchers have been trying to figure out how the purpose of the trip, the personal attributes and the characteristics of the residential environment might influence the modal choice and distances travelled.

Socioeconomic and personal characteristics remain important in travel behaviour when residential environment is taken into account. Of these personal characteristics, car ownership is by far the most important variable in the process of explaining modal choice (Dielman, Dijst and Burghouwt, 2001).

Research has also shown that land use and transport provision factors are very important in determining both demand for travel and the chosen modes.

Transit – Oriented Developments aim to increase transit ridership, walking and cycling in the detriment of automobile usage. Higher densities and mixed land-use may decrease both work and non-work automobile trips.

This way, public transport systems could amortize its investments.

The combination of density, diversity and the supply of public transport reduce automobile usage. Studies on this subject show that Transit-Oriented Development brings beneficial effects to society such as increased public transport ridership (Cervero, 2004).

However, all the benefits and most of all congestion relief get to a noticeable degree, only if TOD's consequence is in convincing people to make the switch from private car to public transport system. Surveys on this subject showed that the average number of residents from Transit-Oriented Development that use public transport is five times bigger than the residents from another part of the city (Cervero, 1995).

2.3. "ON – GROUND" PROJECTS OF TOD

Case studies represent the "on-ground" projects that have already been put together. They help the policy research as they are analysed and evaluated, providing a significant "zoom in" of the key issues on the ground. Most of the cited literature provides a special chapter of case studies, as a presentation of a more focused, grounded context.

The quality of the projects, measured based on the functional outcomes is considerable important in declaring a project successful or not. Within the literature, projects are analysed under different lights and different approaches. In order to improve them, different issues are addressed and stressed out.

Some of the studies develop a critical attitude to the patterns by which a project is declared successful or unsuccessful. "The actual outcomes or functional aspects of a project" are rarely compared in order to establish its achievement. Only the simple fact that the project was built is not enough. Barriers have to be taken into consideration (Beltzer and Autler, 2002).

Transit-Oriented Development has gained and continues to gain a stable place in most of the United States' urban planning approaches -almost 100 TODs of various shapes and sizes currently exist across the United States.

Most of the examples of TOD start with a vision and proceed to develop the execution through aggressive and inclusive station area planning, backed up by supportive zoning, infrastructure enhancements, and fiscal policies that reward smart growth investments. The lessons learned from the already built case studies are instructive. Atlanta, Puget Sound (Seattle) and San Francisco Bay Area, and also Toronto, are perhaps some of the more classic examples of TOD-style developments and integrated transport solutions. It is, though, widely recognized by the researchers that the Bay Area of San Francisco is a leader in promoting good planning and transportation concepts (Cervero,2004).

In Europe, the emerging regional transport strategy for South East England, Northern France, the conurbation of Lille, Copenhagen - with a long history of integrated land use/transport planning - perceive the 'public transport hub' as one of the reinforcements for the planning policy framework. Therefore, all signs indicate that this pro-TOD attitude will continue in years to come.

The literature shows that a fair amount is known about the inputs of Transit–Oriented Developments. There is, though less known about the outcomes. The complexity and constrains of the development and implementation processes of TOD still rely on case-study experience in order to advance knowledge and understanding.

Fig. 4 – TOD in Lyon and Zurich (photo: http://public-transport.net)

Fig. 5 – San Francisco Bay Area Rapid Transit District (photo: http://linemag.org/)

03

CONFIGURATION AND PARAMETERS

At the convergence of the city's trends, there is a sensible market for a new form of walkable, mixed-use urban development around light rail or rapid bus stations.

"These transit-oriented developments have the potential to provide residents with improved quality of life and reduced household transportation expenses while providing the region with stable mixed income neighborhoods that reduce environmental impacts and provide real alternatives to traffic congestion" (Belzer and Autler, 2002).

Relying upon the literature review, the 3rd Chapter describes the configuration and the parameters that influence the location and the functioning of such a complex transportation system and all the land-uses that suround its stations. The main forms and definitions as well as tools and implementation techniques of Transit-Oriented Development will be portrayed along this chapter.

3.1. DEFINING TRANSIT-ORIENTED DEVELOPMENT

- **Beyond the concept**

"Historically, transit helped foster community, just as the automobile helped undermine it. The reason is that when most people took transit, they normally walked from their homes to the bus or streetcar stop. Other people from the neighbourhood were doing the same, and as they walked at the tram stop they met face to face. Since commuters tend to be creatures of habit they saw many of the same people each day. They met, talked, and got to know each other. They found a shared interest in the well being of the neighbourhood. Transit itself was part of that well being. Often shops and maybe a bar or cafe opened near the shop, and a mini-community developed around it.
All these influences helped a neighbourhood become a community" (Weyrich and Lind, 1996)

3.1.1 What is Transit – Oriented Development?

- **Focus on definition**

During the past decades Transit-Oriented Development represented a fundamental rethinking of the consumer preferences and for the location of uses or transportation strategies. As a mean of promoting smart growth, TOD infuses vitality and lifestyle choices.

In most of the cases Transit – Oriented Development emerged as a consequence of the important makeover of tram into the sophisticated and modern light rail system. This transportation system is designed to keep people away from their own cars in the favour of public transport use. Meanwhile, a fundamental rethinking of the public transport surrounding area became a real concern.

What is Transit-Oriented Development anyway?

There is no unanimously accepted definition of TOD, as the continuous shifts in consumer preferences, employer location strategies and transportation planning values must be considered. Situated at the convergence of these three important elements of the city, Transit-Oriented Development relies upon the potential built up by their synergy.

Typically, the definition of TOD is following a straight descriptive line based upon the mix of uses, the densities and the vicinity of public transport. (**Fig.6**)

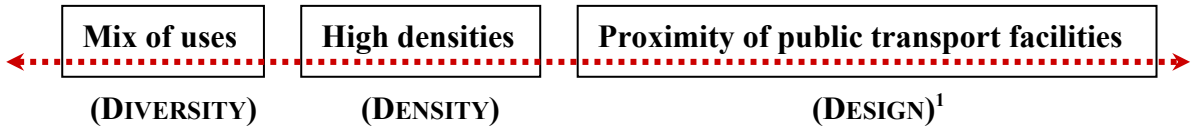
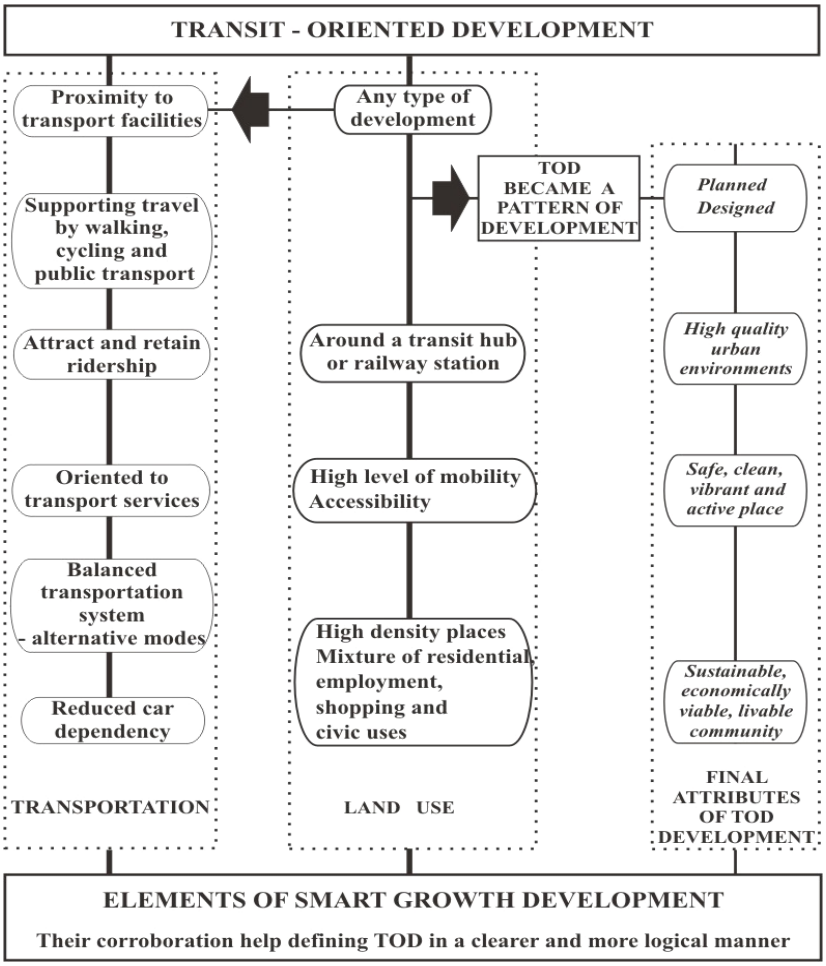


Fig. 6 – Key elements in defining TOD, in a descriptive approach

There is no generally accepted definition of Transit – Oriented Development. Nevertheless, the definitions of TOD share some common traits as seen in the following table. Stakeholders and agencies provide different definitions that particularly concern their area of intervention. Some of them emphasize high density and mixture of uses, while for others the alternative public transportation system weights more to the disadvantage of the mass diffusion of automobile. Most of them strive for a high quality sustainable environment and a livable, active community .

Table 3 – Shared elements in defining TOD



[1] Bernick, M., Cervero, R., *Transit Villages in the 21st Century*. McGraw-Hill, 1996 - The “three D’s”

Known as one of the successful stories of TOD in San Francisco, Bay Area Rapid Transit (BART) illustrates Transit – Oriented Development as it follows:

"Moderate to high-density development, located within an easy walk of a major transit stop, generally with a mix of residential, employment, and shopping opportunities designed for pedestrians without excluding the automobile. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use."(Cervero, 2004)

- **Concerns in the defining process**

Mainly, the definitions focus on the physical form of the territory. Cervero's "three Ds" - density, diversity and design – became important "pillars" in telling the story of Transit-Oriented Development. Although suitable built form is a significant element when referring to TOD projects, that alone is not sufficient in the process of constructing TOD.

The physical characteristics exposed above proved to be unsatisfactory in drawing an eloquent image of the final results of the project. The difference lies in the way that these physical forms, once built, lead to an appropriate functional integration. This functional integration should be an active synergy of transportation and surrounding developments.

Their only construction is not a necessary and sufficient cause for declaring a project a successful one. Considering some performance criteria that could help evaluate the project functionality and the outcomes, may thus successfully complete the spectrum of physical elements. The typical descriptive definition may be improved by the performance criteria and may lead the projects to the point of comparing them on a scale of success instead of simply building or not building them.

- **Performance criteria**

A clear vision of what Transit-Oriented Development wants to achieve is compulsory. Focusing only on physical qualities might block out TOD from creating locations that function differently from other conventional developments.

There is no novelty in the emergence of the performance criteria, but turning them into planning tools may become a challenging issue. Different studies emphasise quite similar measurable point of reference that increase the purely descriptive definition of TOD (Dittmar and Ohland, 2004; Beltzer and Autler, 2002).

1. Efficiency of location – Due to the progress of technology – computing and GIS – researchers were able to perform new tasks in estimating the efficiency of TOD location.

A number of factors like income, household size, residential density, transit quality and frequency, quality of pedestrian environments and neighbourhood retail have been analysed. The researchers developed a mathematical algorithm focused on automobile ownership and usage and also on household expenditures.

In a simpler statement, location efficiency is about turning driving from a necessity into an option and about placing homes in the proximity of public transport system. Homebuyers are encouraged to choose a location-efficient neighbourhood through financial mechanisms.
Therefore, **location efficiency** is about:

- Residential density;
- Pedestrian friendly environment;
- Public transport accessibility – location, frequency and quality.

2. Choice – More than form, Transit-Oriented Development involves function. The theory of choice is thus needed for generating the idea of a good life. The abundance of choice means everybody can get what they need or what they want.

The incontestable advantage that rich mix of choices brings is represented by the possibility of creating a wider range of options. Options to live in different housing types, options to shop other than one would shop at an auto-oriented retail centre, options to get around on foot, by bicycle or by public transport, enhancing the mobility of either seniors or children. Building relying upon the principle of choice, therefore expanding options is one of the issues that Transit-Oriented Development is referring to.

The increase of options relies on the diversity of housing types, on a broad spectrum of affordable housing options, on the diversity of retail – limited by the market area and the desire of the residents - and last but not least, it relies upon the diversity of public transport choice.
Therefore, **choice** is about:

- Providing housing choices;
- Expanded mobility;
- Shopping diversity.

3. Value capture - As seen in the chart below, transportation is the second-highest household expenditure; therefore a successful Transit-Oriented Development could mean a substantial economic value capture.

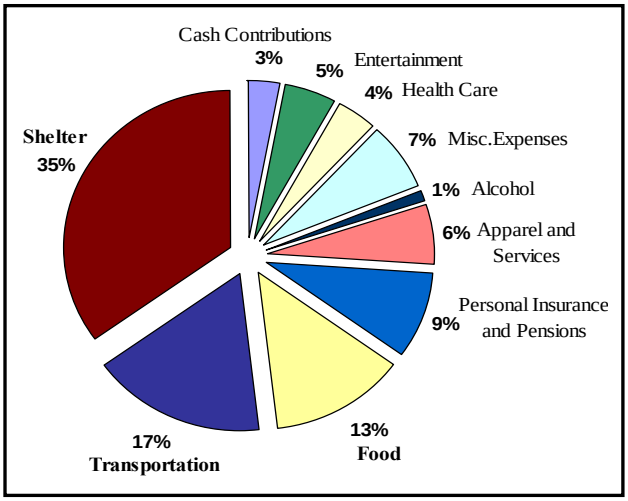


Fig.7 – Medium household expenditures (source:Bernstein, S., *Moving Towards TOD-An emerging view of a Performance-Based System)*

Value capture is an issue that comes like a benefit of location efficiency, directly translated into savings for individuals – either local residents, or at regional and national level. Capturing value should be a key objective for TOD, leading thus to an affordable life for individuals. Researchers stressed the relation regarding automobile expenditures over public transport usage, both at individual level and at public spending level – usually, residents of denser, public transport – rich areas presented a lower level of expenditure for transportation than their equivalents living in auto-dependent areas. The question, though is not only how to reduce the spending on car dependency, but also how to capture the value of the saving.

A recent study in the United Kingdom used a case study in order to determine the economic, social and environmental value of a proper urban design. The study provided a variety of benefits – like potential increased land values, enhanced regeneration of the area or reduced running costs - designing an useful framework of involved stakeholders and short-term or long-term values that each of them might capture from the project (Dittmar and Ohland, 2004).

Therefore, value capture is related to:

- Reduced individual and community expenditure on transportation.

4. Place-making – Attention has to be paid for turning the places attractive and pedestrian-friendly. Urban design is no exception from the rules that make a Transit-Oriented Development successful. It draws together the many strands of place-making into the creation of beautiful places with their own distinctive identity.

Key aspects in developing a quality urban design are defined, as it follows. They provide good thinking principles in turning an area into a healthy and friendly pedestrian environment.

Table 4 – Key aspects of Urban Design (source: *Dittmar and Ohland, 2004*)

Places for people

Places must be safe, comfortable, varied and attractive, distinctive, providing variety, choice and fun, becoming thus used and esteemed. Vibrant places offer opportunities for meeting people, playing in the street and watching the world go by.

Enrich the existing

New developments should enrich the qualities of existing urban places, complementing its setting. This applies at every scale - the region, the city, the town, the neighbourhood, and the street.

Make connections

Places need to be easy to get to and be integrated physically and visually with their surroundings. This requires attention to how to get around by foot, bicycle, public transport or the car.

Work with the Landscape

Places that strike a balance between the natural and man - made environment and utilize each site's intrinsic resources - climate, landform, landscape and ecology - to maximise energy conservation and amenity.

Mix Uses and Forms

Stimulating, enjoyable and convenient places meet a variety of demands from the widest possible range of users, amenities and social groups. They also merge different building forms, uses and densities.

Design for Change

New development needs to be flexible enough to respond to future changes in use, lifestyle and demography. This means designing for energy and resource efficiency; creating flexibility and introducing new approaches to transportation, traffic and parking.

5. Financial Return – All investors involved in a Transit-Oriented Development project expect some type of return from their investment. While the public investment may not yield for an immediate profit, the private sector is another issue. No private sector project is built without the assurance of a rapid financial return.

Therefore, planning for TOD requires a clear understanding of the types of return that each of the participants expect. Under the condition that each of the participants agrees with an acceptable rate of return, a mixed-use strategy may thus become a more effective option for the developer.

At the same time, financing smaller increments is considered of different development elements, as the risk involved is thus spread among them.

For that reason, all TOD projects should also be evaluated in terms of profit and should include:

- Higher taxes revenues for local governments and for transport agencies;
- Higher return on investments for the developer;
- Shorter commutes and higher accessibility for employers.

6. Balance of the tension between place and node - A public transport station plays both the role of “node” in the regional transportation network, and the one of “place” for the local community. The tension between the two elements is a distinction first studied by the Dutch professors Luca Bertolini and Tejo Spit. It acts first like an access point for transportation users and at the same time as an active, vibrant, pleasant place to live, shop or work in.

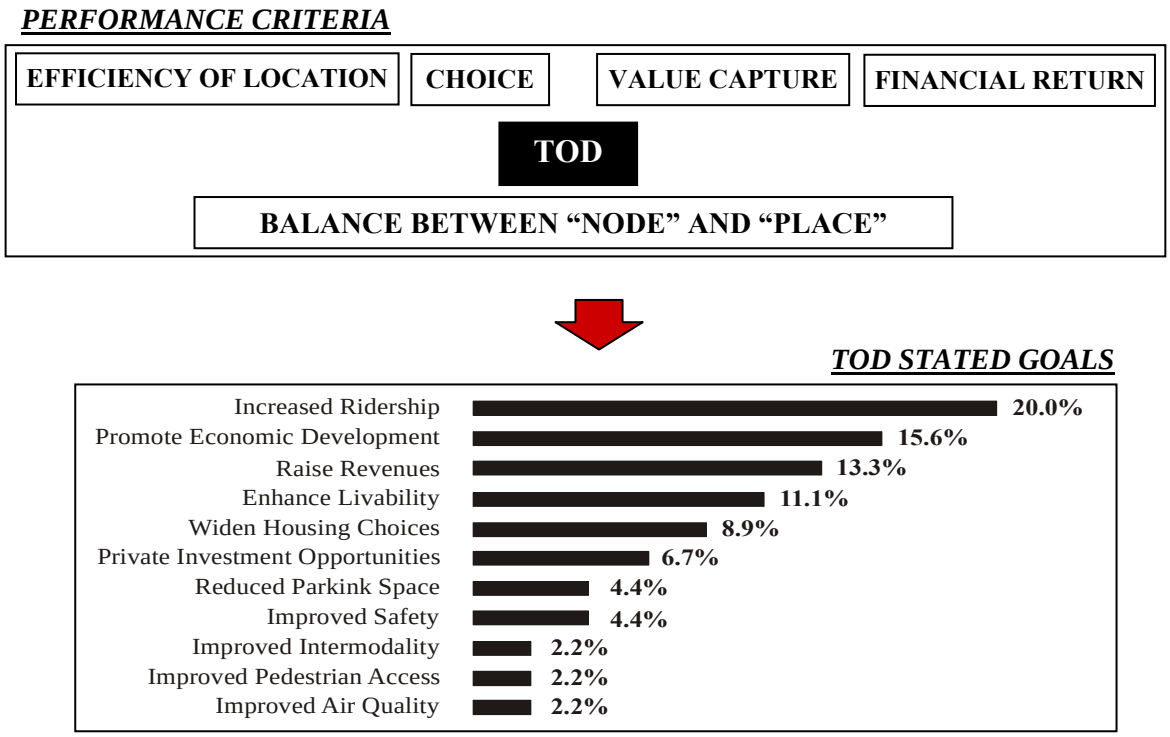
The multitude of actors and goals to be found in any TOD project makes integration of node and place extremely difficult.
Transit-Oriented Development must deal with the tension between node and place. That is, it must balance the transportation functions of the site with issues of place making and livability.

Many of the shortcomings of TOD projects can be better understood when those projects are viewed through the lens of place and node. There is not necessarily a single correct way to balance these two roles; however, achieving the best possible outcomes in any given case requires an understanding of the way in which this tension shapes projects and forces trade-offs (Belzer and Autler, 2002).

3.1.2 Goals and Objectives of TOD

Following a similar line of argument as the chapter above, it became important for the development of the study to capture the main goals and objectives of Transit – Oriented Development. Because there is a wide spectrum of definition approaches, TOD's objectives may be differently prioritised depending on the achievements that every involved stakeholder aims. There is a common ground though as TOD ought to reach a complex functional integration of public transport system and the surrounding developments, as well as the synergy among all its uses.

Table 5 – The connection between the performance criteria needed to define Transit – Oriented Projects and some of the goals stated in the TOD projects by involved stakeholders (Source: Cervero et al., 2004)



Other possible goals may emerge during the process. They are associated with each of the actors involved in the projects. Some of the goals might conflict and become incompatible. If they are to be reconciled, they must be carefully balanced and strategically defined. Increased ridership remains at the top of the list as the most as the "essence of what is happening". The next group of goals promotes financial issues.

Other goals aim the improvement of transportation system performance in order to sustain the neighbourhood's vision and values.

Some of the tension encountered during the process of goals statement might be as a result of the non-balanced situation of the "place – node" issue. In order to achieve a successful and a quality project, it should start with a clear vision and a well-stated mission. The rest of the work and the efficient objectives that the project is wanted to accomplish should flow from these elements. Consistent with the mission statement and also coping with the performance criteria, the objectives address the top priorities of the project.

3.1.3 Typologies of TOD

- **Is a TOD typology needed or general solutions fit all contexts?**

The process of generating and implementing Transit – Oriented Development must be designed with the concern for the forceful complexity that each situation might develop. There are many ways to state the definition for TOD with common elements though: a mix of uses at high densities within walking distances from public transport stations; but places that stand for this kind of development are sites with sophisticated and diverse characteristics.

Therefore, a tendency to force a one-size-fits-all solution onto the different types of sites is not appropriate. The types of projects that might be appropriate in older neighbourhoods close to downtown are different from those that might work in newly growing areas, even with similar density goals (Dittmar and Ohland, 2004).

Transit – Oriented Development projects are categorized according to the context of the area they are located in and they analyze the level of densities, the level of land-use mix and the public transport services. There has been, thus created a typology containing five categories. First mentioned in *The New Transit Town: Best Practises in Transit – Oriented Development* (Dittmar and Ohland, 2004), this deliniation was further regarded as a starting point for defining TOD's typology.

As already stated above, there is neither a generally accepted definition for TOD, nor generally accepted goals. Therefore, sometimes, the attempt to force one set of solutions is not recommended: different types of locations are provided different types of transportation systems. Just because a TOD project works in one location, does not ensure its unconditioned success elsewhere.

Delineating these typologies connected to the context of development will lead to the implementation of the most appropriate script for each one of them. This kind of approach, together with the performance criteria, help the research to establish if a TOD is really the answer for a certain area. The new tendencies in planning that aim to personalize every solution and to develop the capacity to accommodate demand lead the research to an inherent distinction between these different types of transportation areas.

As seen below, important land-use parameters of development are defined in order to provide sufficient residential and services densities that will support high-quality transportation services.

Table 6 – Typology of Transit – Oriented Development (Source: Dittmar and Ohland, 2004)

TOD type	Transportation	Land-use
URBAN DOWNTOWN	Primary transfer point for various public transport modes	Diversity of functions and uses – O***ffice Centre, Leisure, Housing, Retail***
URBAN NEIGHBOURHOOD	Medium access to downtown Subregional Circulation Transit – friendly corridor – ***Rapid Bus or Light-rail***	Moderate to high density housing Commerce situated along central street or cross-roads
SUBURBAN TOWN CENTRE	Connection through the traditional radial system – High accessibility to Downtown Subregional Hub	Important job centre 24-hour location - ***Office Centre, Leisure, Housing, Retail***
SUBURBAN NEIGHBOURHOOD	Rapid access to a Suburban Centre or Downtown ***Light-rail or Rapid Bus line***	*Residential, Neighbourhood Retail* *Local Office*

Even if the general tendency is to strictly classify Transit-Oriented Development, locations and public transport systems significantly vary regarding their suitability for TOD. Therefore, the following types of locations are considered leading elements in defining and differentiating the role that any TOD project plays within the surrounding area.

Table 7 – Land-use **c**haracteristics of TOD typologies (Source: Sam Adams, *BLOG: To "TOD" or not to "TOD"?*)

Urban Downtown

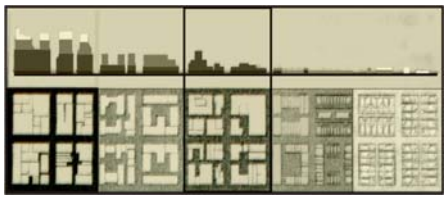
- Minimum residential density - 100 units per hectare – there is no maximum limit;
- Height of buildings – 4 to 30 stories;
- 100% site coverage;
- Ground floor office/retail required.

Urban Neighbourhood

- Minimum residential density - 35 units per hectare, up to 75 units per hectare;
- Height of buildings – 3 to 10 stories;
- 85% site coverage;
- Ground floor office/retail required.

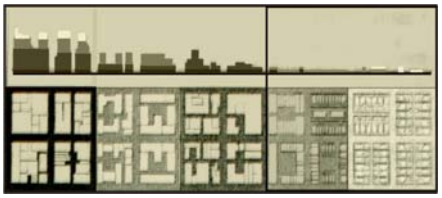
Suburban Town Centre

- Minimum residential density - 75 units per hectare – there is no maximum limit;
- Height of buildings – 2 to 20 stories;
- 90% site coverage;
- Ground floor office/retail required.



Suburban Neighbourhood

- Minimum residential density - 25 units per hectare, up to 50 units per hectare;
- Height of buildings – 2 to 5 stories;
- 75 -80% site coverage;
- Ground floor office/retail optional.



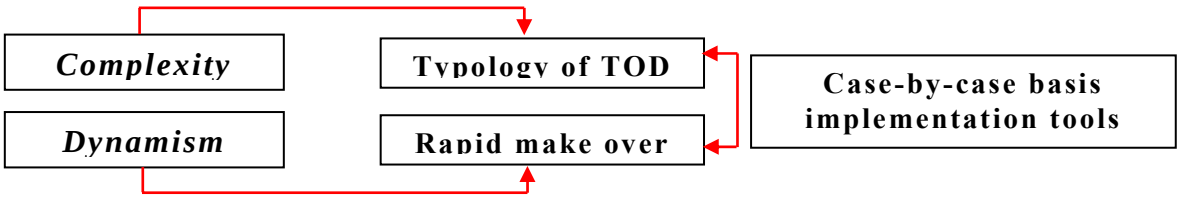
3.2. BEYOND THE IMPLEMENTATION ISSUES

3.2.1 An integrated design framework of the urban form of TOD

3.2.1.1 Planning for urban complexity and uncertainty

Space, under the form of physical city, is considered an object that must be rationally handled. In the discourse of today's city planning the target is to cope in a realistically manner with the considerable complexity of the present and with the significant uncertainty of the future. Most of the Transit-Oriented Development projects still lay under the incipient mark of experiments. Their target is a simultaneous negotiation between physical, social, political and financial requisites leading, no doubt, to an inherent complexity of the TOD implementation process.

Retail and services dynamics, consumer's behaviour as well as working or non-working trips tell the story of the complex and dynamic system that implicates the context of Transit-Oriented Development planning and implementation. This presumes an interaction of multiple known existing forces as well as the emergence of new incoming forces as a result of the latest technologies and competition. The synergy that TOD requires between its mixture of uses and functions, linking all the parts together into a well-functioning system, remains still difficult to achieve. The developers and the actors involved in the process may not succeed in the end to maximize the potential synergies of the project even if they don't get discouraged by the uneven and partial integration of the mixed-use land and the transportation facilities. Consequently, TOD involves more complexity and dynamism, greater uncertainty and even higher costs than other forms of development.



Fi.g 8 – Characteristics of TOD projects implementation

This way, transportation and land-use planning process must deal with these characteristics of the urban system, designing and implementing Transit – Oriented Development on a case-by-case basis, using zoning as the standard tool that provides land regulations and further help for the implementation process.

3.2.1.2 Zoning as an instrument to implement TOD

The transportation system is the most important infrastructure division of a community. The influence that transportation has on the land-use patterns and on the rate of growth helps shaping the urban form and the transportation demand and modes.

Transit – Oriented Developments should operate as gateways into the transportation system. TOD's design and functional interdependency is vital to encourage or discourage people from using the system. The critical synergy between public transport and land-uses must be fully coordinated and exploited.

Transportation resources make the adjacent land valuable and support its high density development, while these densities bring riders close to the stations, representing trip generators for the area. If well designed, this interdependent development may lead to a successful TOD project.

Zoning must establish, in a macro-vision level of the future, which are the elements involved in designing a functional TOD and also the way they will be successfully integrated down to the parcel level. Zoning delineates land uses, sets heights, densities and sizes. It also contains explicit regulations concerning other details like parking spaces or street standards.

Along the years, planners realized the deficiencies of the traditional single-use zoning stressing their inflexibility for mixed-use and mixed-housing development, their exclusionary nature. In such a sprawling and "modern" urban landscape flexible and inclusionary zoning approaches that use unified development codes are needed.

A lot of time and effort must be invested while planning and implementing a Transit-Oriented Development project. It represents rather a mixture of technical, operational and place-making challenges that relies upon overlay or special zoning districts. Transit-Oriented Development is designed to achieve several key public objectives. In an idealistic view, a project should have its unique identity, attracting the users with its characteristic features and the manner in which the transportation services are provided.

As part of this customized zoning, the worry is the quality of the on-site development with a growing emphasize on setting the stage for transportation supportive and walking distances development. Thus, zoning codes may be used to encourage Transit-Oriented Developments. These regulations govern the proper development of TOD projects.

First, as TOD projects tend to allow higher densities in the proximity of public transport hubs, regulations concerning the amount of development are necessary. They also govern the type of development for the project, as mixture of land - uses are looked for. Their spatial disposal next to the public transport facilities enables their use within easy walk-access.

The TOD project represents both a challenge and an opportunity. Zoning regulations help innovative urban design guidelines to be outlined in the search for compatibility and a functional relation between mixed land – uses and public transport. A key feature in creating a transport – supportive development is the designation of uses that are the most supportive for public transport – banks, professional businesses, retail stores, offices, child-care centres, etc.- trying to exclude the ones that may be harmful for this kind of development. Allowed uses always depend on the type of the TOD project.

If it's designed on a larger scale, then regional trip generators may be implemented. But if, on the contrary, the project is designed at the neighbourhood scale, these kind of large-scale trip generators are apt to be forbidden from developing.

Zoning reveals challenges for creating an original and creative design with regard to three main topics: ***active pedestrian-friendly streets, density and intensity of buildings, careful integration of transit*** (Dittmar and Ohland, 2004).

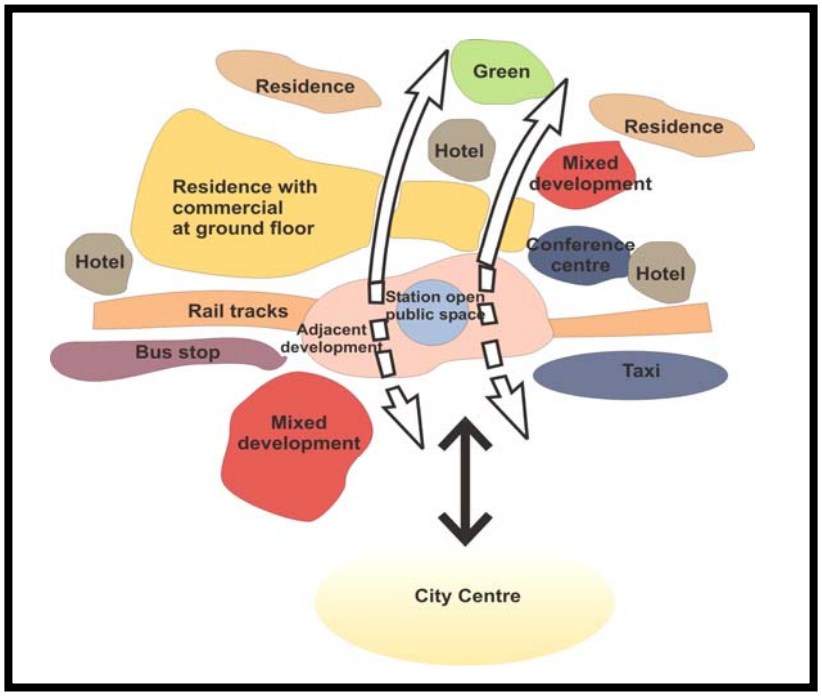


Fig. 9 – An example of integrated framework of transportation and land-use (source: ARUP, *Intermodal and Terminal Access Study, 2001*)

Active, walkable streets help to maintain human activity and also to generate more use of the transportation system. A walkable and active street should rely upon the proper development and coordination of many urban elements, such as: land–use, streets and sidewalks patterns, placement, size and orientation of buildings, fenestration, parking issues and last but not least, a careful integration of transportation facilities. It stresses a walkable scale, integrating different housing types and commercial uses, as well as the building of neighborhood centers with community uses.

Careful integration of public transport facilities – The way the integration of public transport is addressed is an essential element in strengthening the bond between the transportation service and the area that it serves.

The platforms of the transportation facilities - simple stations or more complex interchange nodal points – as well as the immediately surrounding area are perceived to the scale of the project as 'gateway zones'. In the search for an intimately connection between transportation and all the other mixed uses, normally this "gateway zones" should be the suppliers of the highest level of public transport integration.

The station itself embodies more than a collecting/drop-off point, thereby careful and detailed planning is needed for them to provide a high-level quality design for the streetscapes and the buildings adjacent the station.

Because of their need to fulfill both place and node functions, TOD projects require all their component parts – the transit system, station access routes (buses, taxis, cars, bicycles, and pedestrians infrastructure), and the surrounding development – to interface with each other. (Belzer and Autler, 2002).

Transit – Oriented Developments must rebalance this tension between node and place, thus it needs to achieve a functional integration between public transport and the adjacent uses. It is a noticeable attitude of complain between actors involved in TOD projects concerning the carelessness of transportation actors. "They run the trains and no more" (Belzer and Autler, 2002), showing little interest in the stations and their surroundings seen only as passing-through nodes.

The sustaining elements of these desirable goals are revealed and discussed further in this study.

- **Mixed Land-Use**

Land–use and densities **-** The mixture of uses is the fundament stone in designing liveable streets and it leads to an immediate complex of effects like efficiency of location, expanded mobility and increase of choices, both housing and commercial or services.

There is an obvious fact that unique identity is searched for every place. Therefore, the choice of uses that are to be implemented should not be similar in every project, but rather to define a general and desired mix that is to be embedded further on.

Zoning becomes thus an important tool for defining permitted activities, for limiting their spreading area or their location. For designing what it was called above an active, pedestrian-friendly street, uses that might generate pedestrian activity are thus to be implemented primarily at the ground floor of the buildings. Depending on the type of the TOD project at least 50 percent of the ground floor area should be occupied with service and retail spaces while residential uses should come secondary.

The mixture of uses does not come as a result of an accidental disposal, nor does their density. The key to create transport-supportive land-uses is to designate uses and to define regulations that permit or require certain densities that will encourage the further usage of public transport. The issue of density is one that gives shape to the project.

A Transit-Oriented Development is a project that fosters intensive developments, with stress on regulations to establish minimum densities by offering density bonuses in exchange for the provision of transit facilities or other urban design features (Legal Research Digest, 1999).

Transportation nodes encourage more concentrated patterns of development, rather than dispersed ones. That implies mixture of uses and high densities – the two most important characteristics of TOD. In order to insure a successful implementation for this type of development programs, key issues are to be considered, as it follows.

Through *sequential development controls* (Legal Research Digest, 1999), during the implementation process both residential and non-residential uses of the site are emphasized. A multi staged-growth might be required not to allow residential developments to occur on a broad area before non-residential uses occupied their places.

These non-residential uses can be attracted and controlled through *financial and regulatory mechanisms* to physically implement in certain areas of the site.

Finally, carefully planned *urban design guideline**s*** are needed to establish a high degree of compatibility between the uses and also to stimulate the pedestrian activity.

***Streets and sidewalks patterns* –** Streets are essential features in Transit-Oriented projects and all their elements require thus special interest.

Standards for public streets are mentioned in many regulatory papers. What is of great significance is that streets and sidewalks should be designed to offer quality and comfortable walking. The internal streets of the project must supply good connectivity inside, as well as outside the projected area, providing a good flow within the networked city.

Inside Transit-Oriented Developments, the well-known traditional hierarchy of streets is usually abandoned in favour of a new system mostly based on a functional equality between the streets.
A conceptual framework of narrow streets is designed to provide what is called “traffic calming” by minimizing the speed of automobiles and also their number. Consequently, pedestrians will benefit more from the streetscape development, becoming thus the primary parameters of the urban form equation.

***Placement, size and orientation of buildings* -** As a powerful weapon in shaping the urban streetscape form, the placement of buildings makes a significant difference between traditional, conventional zoning and TOD projects. This approach, known also as the ‘form-based zoning’, seeks to establish regulations for the building form rather than, or better, in addition to land-use regulations.

Form-based codes typically contain regulating plans that identify which type of building standards apply to which block frontages; building standards that set basic parameters for building height, setbacks, roof design, and fenestration; and architectural and streetscape standards (APA, 2006).

There are two important issues to be addressed in order to draw the guiding lines of TOD projects streetscape. They are strongly related with TOD’s main purposes of providing higher densities and more active, pedestrian friendly streets.

First of all, "build–to" lines are established rather than minimum setbacks from the property line, bringing buildings as close as possible to the streets.

This way the variation of building placement is avoided by creating a street wall with building frontages set on the property line. (Dittmar & Ohland, 2004). Pedestrian activity is thus generated and automobiles are forced out from the fore – ground to the rear of the buildings.

Second, for developing high densities, building frontages and lots sizes are reduced. Also, entrances provided with colonnades or wide windows might be required for stimulating pedestrian activity.

- **Transportation**

Traffic and Parking – Traffic and parking represent a significant approach in the exposing of TOD elements.

Transit-Oriented Developments fight for turning public transport into a convenient and attractive manner of motion. Planning traffic and parking for conventional non mixed-use land developments is, from far, not as challenging as the type of development discussed in this study. Consequently, there are special issues to be addressed in order to develop this integrated development of transportation and mixed land-use. It cannot emerge and develop any successful TOD and no public transport benefits can be achieved without an interrelated approach between attractive, well-designed mixed-use developments and the transportation facilities. Both transportation facilities and the surrounding land uses are their own traffic and parking generators.

Parking is a sensible problem in the matter of TOD planning and requires careful treatment. "Rail transit has always had a schizophrenic relationship with parking". (Cervero, *TCRP Report 102*, 2004). Balancing the notions of pedestrian accessibility and dense, mixed-use communities with the need for station area parking is often a difficult task.

Restrict, rather than Require - Typically, planning requirements that ensure sufficient parking spaces facilitate by all means the usage of automobile, thereby reducing the odds for commuters to opt for public transport trips. Therefore, regulations may need to restrict off-street parking rather than require a minimum number of off-street parking spaces.

Parking must be configured without dominating or becoming an obstruction to pedestrians' free motion. Parking areas should be set away from the pedestrians' routes, behind buildings.

Large areas of asphalt parking detract from the walking quality of the environment, discouraging pedestrian mobility and also reduce the probability that commuters will choose the public transport.

Charging - Charges for parking became a significant parameter in determining a person's travel behaviour, as prices paid might reduce the demand for parking spaces with 10 to 30 percent. Together with the existence of appropriate and well-designed streets and highways, and with the traffic fluency, parking represents the biggest problem at the end of the trip.

High expenses and limited parking area are issues that influence in high degree the choice of the transportation mode. No fees and plenty of parking unquestionably encourage car dependency.

Internalizing the trips – Channelling development linked to the expansion of public transport into locations help to identify an appropriate urban form for transportation - one that discourages low-density sprawl and encourages high densities. It is vital to stress the complexity of this process because Transit – Oriented Development aims to increase internal trip capture rather than external trips that occur between single land-use types of development.

Trips can be internalized within neighborhoods, prompting residents to walk to convenience shops instead of driving outside the neighborhood. The presence of on-site eateries, retail shops, and consumer services free people from the need to solo-commute since they need not feel stranded during the midday without a car (Cervero 1996).

The paradoxes of connection and disconnection in the contemporary city have major implications over the concepts of territoriality and temporality. Thereby, acting with care in combining and developing the synergy between land uses in TOD projects can reduce the scale and length of non-working trips, thus reduced automobile usage.

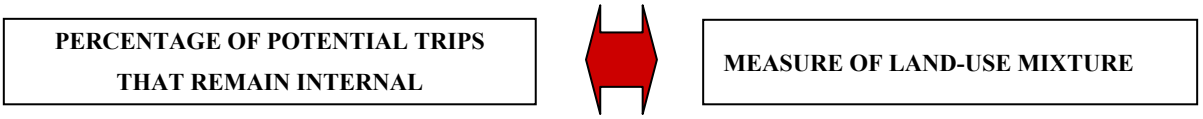


Fig. 10 – For designing a successful TOD a strong relation must be developed between the mix of uses and the ability to internalize trips

- **Mixture of Uses and Transportation facilities – places of seduction**

Urban design is important. Making a place is a challenging action and extreme care needs to be taken to design a human-scale environment, providing thus comfort, pleasantness and attachment to the place.

If the public transport station is more than a collection/drop-off point or a transportation-shift point, then it rather should play its active role of centrepiece for the area. “By design, it invites residents, workers, and shoppers to drive their cars less and ride mass transit more.” (Bernick and Cervero, 1997)

The challenge of designing TOD projects is present in every step taken. Physical design features came as essential consequences of the above analyzed elements:

- *Mixture of land-uses* – retail commerce, services, restaurants, hotels, child-care centres – as 24 hours a day / 7 days a week trip generators, promoting travel efficiencies - trip-end consolidation and more balanced, bi-directional travel flows. (Cervero, Ferrell and Murphy, 2002);
- *High - densities areas* – “like wedding cakes” (Cervero, Ferrell and Murphy, 2002) - within short distances;
- *Intermodality and seamless connections* – in the attempt to reduce car dependency, concern for giving efficient and if possible seamless connectivity;
- *Accent on livability, attractive landscape* – The walking distance and the chosen mode of transport are strongly affected by the walking environment;
- *Parking and traffic management* – reduced free and ample parking spaces in order to discourage single-occupant driving.

There is a large amount of Transit-Oriented Development projects that kept improving their performances from the first generation that failed to realize their potential in place making.

Defining and planning a successful place seems always to present some intangible elements and the challenge is even bigger as the TOD projects have an increased importance in getting the job done right as to have benefic impact on the project itself, on the public transport, on the surrounding areas and the community of public transport users.

3.3 IMPACTS AND BENEFITS

3.3.1 The Chain of Benefits

During the past decade, Transit-Oriented Development has turned into a significant planning tool for promoting smart growth, for fighting sprawl and as an antidote to traffic congestion. If successful, TOD generates the development of the area where implemented, speeds up the transition of places suffering from slow commercial advancement, contributing to the design of a more sustainable urban form. TOD supports public transport usage and also induces walk and bicycle trips to and from public transport station as well as to and from the uses surrounding the station.

There is a wide body of literature arguing about the impacts and benefits that TOD implementation might engender. Most of the research conducted was realized regarding two of the most important features of impact analysis: impacts of TOD over travel behaviour – ridership – and shifts in property value. But, except of these issues, little research has been conducted in order to establish and measure the outcomes of TOD. The study will also develop concern on travel behaviour and land use value.

The actual challenge in measuring TOD's outcomes resides in the *attribution* concept (Cervero and al., 2004). There is still limited knowledge to clearly delineate how much from the traffic congestion, property value, increased ridership, open-space consumption or increased economic development turn over can be attributed to TOD and not to other factors. **Table 8** exposes benefits delimitated as primary and secondary as well as an association to public sector – the society in large - or private sector – benefits associated to individuals, businesses or property owners.

Table 8 – Classes and Recipients of TOD benefits (Source: Cervero et al., 2004, 120, Table 7.1.)

	CLASS OF BENEFIT	
MAIN RECIPIENT OF BENEFIT	PRIMARY BENEFITS	SECONDARY BENEFITS
PUBLIC SECTOR	1. Increase ridership and profits	A. Less traffic congestion and reduced automobile related costs
	2. Provide joint development opportunities	B. Increase social capital and public involvement
	3. Revitalize neighbourhoods	C. Reduce sprawl - conserve open space
	4. Provide economic development	D. Reduce road expenditures and other infrastructure expenses
		E. Increase property tax revenues
PRIVATE SECTOR	5. Increase land-value, rents and real-estate performance	F. Increase retail sales
		G. Increase access to labor groups
	6. Increase housing opportunities	H. Reduce parking costs
		I. Increase pedestrian activity

→ Arrows represent primary benefits and/or secondary benefits that influence secondary benefits.

3.3.2 Travel Behaviour and Ridership in TOD

3.3.2.1 Relating land-use and transportation to travel behaviour

People need to meet mobility, therefore they place demand on the public transport system. Meanwhile the capacity of transportation systems is not being expanded proportional with the growth in travel demand, and traffic congestion has reduced the capability of transportation systems to provide the required accessibility and mobility. Land use, urban form, travel choices and travel distances put an important cumulative pressure on most aspects of travel demand, having the users manifest certain travel behaviour.

The scope of Transit-Oriented Development is to reduce automobile dependency based on the integrated relation between high-density mixture of land-uses and the public transport system. Travel behaviour features are important in understanding the link between these issues that are trip-generators in this type of development. The question is whether the environment and the transportation mode actually influence travel behaviour and how neighbourhood can be actually designed in order to reduce automobile use.

Planners have engaged certain estimations of trip generation variables or other travel behaviours based on alternative development patterns in order to prove that population density, mixture of land-uses, employment location, parking, transportation opportunities and the distances length do indeed influence travel behaviour.

The means that urban form and the public transport system influence travel behaviour can be organized in various ways far beyond any simplistic attitude regarding this relationship.

The behavioural impact analysed in this sub-chapter on modal choice of travel is related to personal individual attributes and the characteristics of the environment around the public transport facilities together with the motivations for shifting places.

Consequently, the key factors related to travel behaviour analysis and the variables used for their description are sorted out as it follows in **Table 9** and further on in the study they will be described in a broader spectrum.

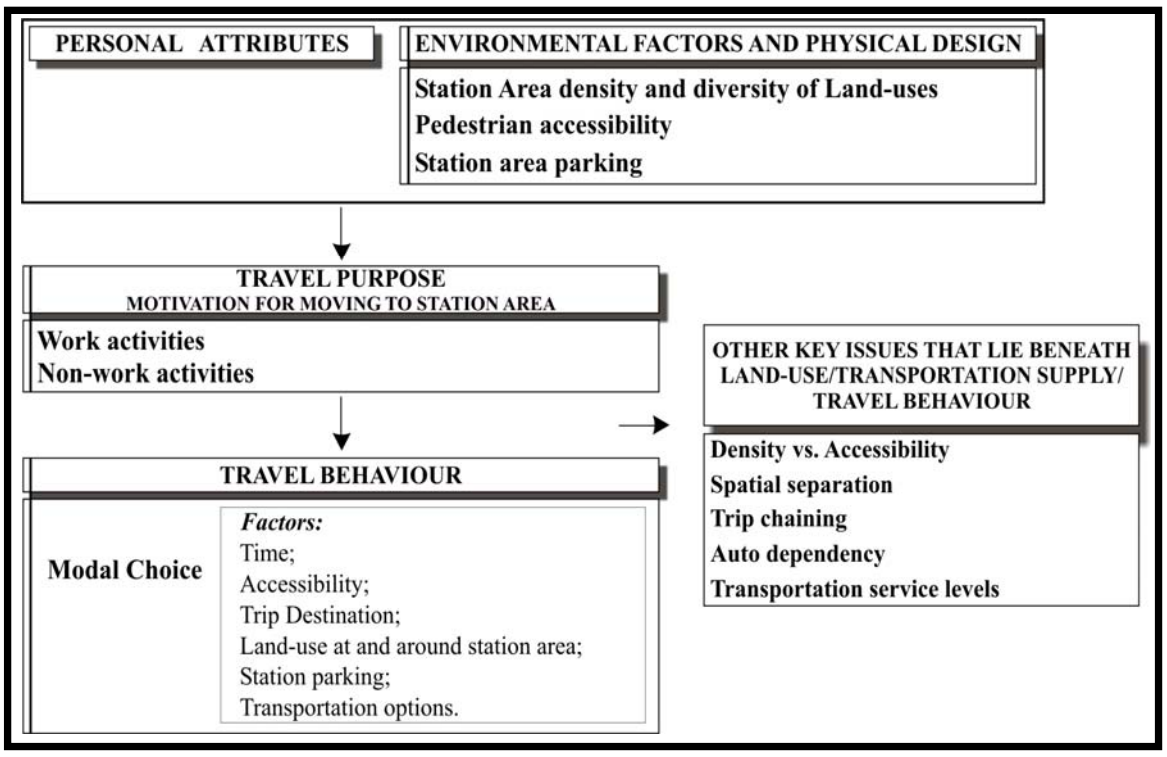
Even so, with continuously improving research on these issues, the understanding of human travel behaviour remains poor under several aspects.

General estimations conclude that there is still a big gap of knowledge concerning the relationship of land-use, transportation and travel behaviour. Some of the pieces are missing from this relationship while some of them don't fit together.

Not only that the state of knowledge regarding land-use / public transport relationship is growing, but also the personal attributes and values – cultural, political and social – that emphasize travel behaviour continue to evolve.

Therefore, given the extended period of time involved in surveying travel behaviour of TODs, many influential factors should be considered when evaluating the changes: demographic shifts, income changes, market trends, prices, technology and even shifts in tastes or preferences (Crane, 1999). Consequently, **Table 9** will summarise the essential factors of influence in the analysis process related to travel behaviour.

Table 9 – Variables used in the travel behaviour analysis (Source: adapted after Dieleman, Dijst and Burghouwt – *Urban Form and Travel Behaviour: Micro-level Household Attributes and Residential Context*, 2001)



Based on research models of public transport ridership, the users possessing different personal values are likely to use public transport **if** the time benefit is increased compared to travelling via highways using the personal automobile, **if** there is a pedestrian friendly activity, **if** limited vehicle availability is involved. Work or non-work activities are important to be individually discussed as different trip-generators.

Physical design factors and streetscapes do show some influence on travel behaviour, but they are less influential on modal choice than the provided transportation service levels. This suggests an important variation between individuals, some of them placing value on these kind of elements, while others may remain unresponsive to them.

3.3.2.2 Elements to be considered in travel behaviour appraisal

This evaluation effort is intended to facilitate a more comprehensive understanding of travel decisions within Transit-Oriented Development areas. According to numerous investigation sources, TOD residents have higher rates of public transport usage comparing to other sites in the city or other adjacent areas. Residents living near public transport stations are five times more likely to use public transport as an average resident of the same city. There are some elements (**Table 9**) though, that these public transport commutes depend on in order to establish the travel behaviour of users. It is obvious that household attributes and the physical environment develop a strong relation with the users' modal choice.

Personal and household attributes **–** As important elements of personal attributes, the income level, car ownership, household composition and education must be taken into account and carefully evaluated (Dielman et al., 2002).

Among these parameters, car ownership has the strongest influence on modal choice, as expected. Possessing a car reduces the expectancy of public transport as a choice of transportation especially in a moment when the percent of trips realized by car is close to 90. Studies show at higher densities though, a greater ability in meeting everyday needs without a vehicle, avoiding thus higher costs and the inconvenience of parking space requirement.

Also important in considering travel behaviour is the household type, number of employed people in the house and whether they are with or without children that need to be dropped off to child care centres or schools on their parents' way to work. (**Table 10**)

Table 10 – Household Characteristics of Station Areas Surveys (Source: R.Cervero – *Travel Characteristics of TOD in California*)

***Female* (%)**
***Age* (%)**
Over 50 yrs; 36 to 50
18 to 35; Under 18
***Race* (%)**
African American; White
Asian; Other
***Occupation* (%)**
Office/Professional; Craftsman/Labourer
Sales/Service; Not employed; Other
***Workplace* (%)**
Away from home
Work at Home
***No. of people in HH* (%)**
1-2 persons; 3-4 persons; 5+ persons
***Ratio of drivers to vehicles* (%)**
<1 vehicle/driver; 1 vehicle/driver; >1 vehicle/driver
***Approximate income* (%)**
***Primary reason for moving to site* (%)**
Housing quality; Transit access; Cost of housing

Environmental factors and physical design – As stated above, the level of ridership in Transit-Oriented Developments is higher than the one in the traditional developments, but the simple existence of this type of urban form does not guarantee a large increase in public transport usage. Environmental design - the mixture of uses, their density and diversity, accessibility, provision of public transport services and parking - show high correlation with modal choice, in fact the highest after the variables involving car ownership. Therefore the properties of the environment have a high impact on ridership.

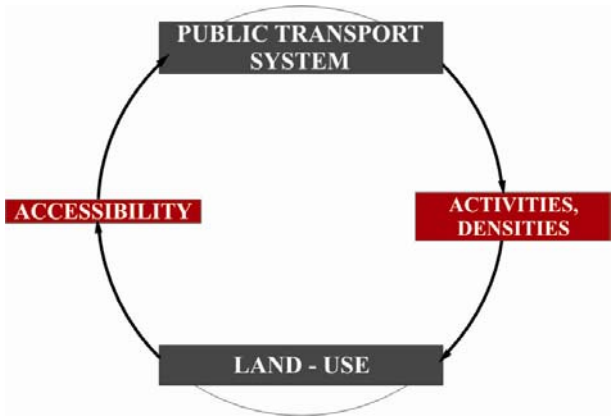


Fig. 11 – The Land-use / transport feedback circle (Source: After Wegener and Furst, *Land-Use Transport Interaction: State of the Art*, 1999)

- **Density of land-uses** – The link between land-use density and travel behaviour has been the subject of extended studies. Some research emphasizing mixture of land-use and area design found no effect on travel behaviour, while some other studies have estimated substantial impact – on a more complex basis than intuitive – of a strong relationship between urban form and travel.

Density, in a simplistic approach of the concept, reduces spatial separation and brings everything closer together. Researchers sustain that a mixture of uses like residential, commercial, services and offices are most favorable to increased public transport ridership and that a successful Transit-Oriented Development feature land-use arrangements that produce all-day and all-week trips, such as entertainment complexes, restaurants, and other mixed uses (Cervero et al, 2002).

There is more to the relationship between mixture of land-use, urban form and travel behaviour that can be described with a simple explanation about combined densities alone.

Due to the observed implications that spatial separations have on use and choice of public transport, non-uniform densities should be shifted for the benefit of public transport ridership by gathering high densities at and around stations. If well designed, the TOD project brings together complementary land-uses in terms of meeting travel needs and the other way round, in terms of placing the needs closer together.

A balanced land-use development may thus reduce trip-motives placing jobs opportunities close to housing. Even so, it is possible that not all members of a community to choose jobs close to their homes, but, nevertheless the opportunity to reduce commute and traffic still stands (Kuzmyak, Pratt and Douglas, 2003).

Retail and services placed within walking distances from residence areas, workplaces and station areas are subjects of mixed land-use and integrated design that generate prospects both for work and non-work trips within reach with subsequent effects on travel behaviour and modal choice.

- **Accessibility** – As seen above, mixture of uses is benefic to a successful TOD, but good pedestrian accessibility both within and surrounding the station area is also important if users are expected to walk.

Accessibility as commonly defined consists of an activity element providing the motivation or needs satisfaction of being in or reaching a place, and a transportation element providing the means of getting there. (Kuzmyak, Pratt and Douglas, 2003)

Accessibility is generated by compact land-use and also by the manner that complementary uses are placed near to each other.

The concept of creating accessible communities and neighbourhoods, accompanied by a mixture of land-uses is aiming to encourage local trips on foot or by bicycle without discouraging automobile usage.

A network of streets is necessary to provide pedestrians, bicyclists and automobiles the possibility to interact safely and efficiently. Stations with poor pedestrian access fall short of the integrating potential into the adjacent areas (Caltrans report, 2002).

Travel purpose – Motivation for motion -Travel demand cannot predict with high accuracy the response of the marketplace to major transportation and land use changes. But, developers that provide goods and services are still expected to re-locate their establishments from highly independent areas to larger clusters with high levels of accessibility.

Meanwhile, consumers are expected to go for activities situated within immediate vicinity rather than dispersed locations at the regional scale.

As for taxpayers, they are expected to fund sites with increased level of public transport services needed to support the new land use patterns and induce significant numbers of new riders.

These types of land-use and transportation policies lead to the change of travel price, either for all modes - placing job and residence locations closer together, or for different modes – reducing automobile travel speeds and improving sidewalks with facilities for pedestrian access, thus increasing the price of auto travel relative to walking.

Therefore, the response of travel behaviour to these land-use and transportation policies should be modelled as a function of prices, income, land-use variables – work or non-work activities which affect prices -, and "taste" variables which go for different attitudes toward travel across individuals.

- **Work vs. Non-work activities** - Since non-work activities began to gain significance in the past years, an understanding of work and non-work type of activities needs to be incorporated in the research. As Transit-Oriented Development is expected to induce more pedestrian trips and to increase public transport ridership, the benefit aims accessibility to employment and non-work places gathered in compact, mixed-use locations. Even with such an overwhelming development, non-work trips have still been little discussed in research on travel behaviour compared to work trips.

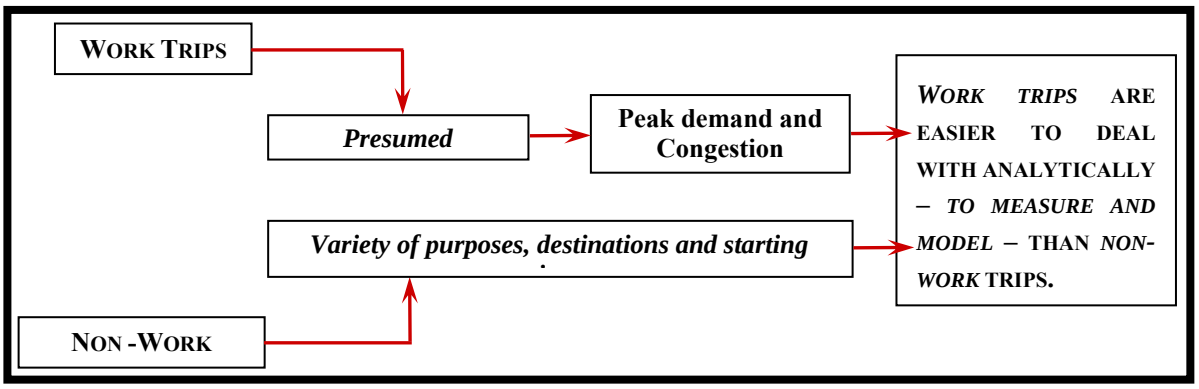


Fig. 12 – Work trips versus non-work trips (Source: after Nelson, Niles and Hibshoosh, 2001)

Non-work travel is thus more complicated to analyze and to be used in modeling travel behaviour due to its various purposes and to everyday alterations, being considered a more flexible trip generator.

Non-work activities also generate stops in the trips from home to work or from work to home, therefore they are suited to be located in Transit-Oriented Development station areas. It is also important to know which are the main activities that generate the non- work travel. The largest four categories of non-work trips are: shopping, family and personal business, social and recreational and eating out (Nelson and Niles 2001).

Table 11 – Trip Purpose as Percentage of All Person Trips, 1995 (Source: Nelson, Niles and Hibshoosh, 2001).

Trip Purpose	*Percentage*	*Destination Flexibility*
Work and Related to Work	**18**	Somewhat inflexible
Shopping	**21**	Flexible
Family and Personal Businesses	**15**	Somewhat inflexible
Out to Eat	**8**	Flexible
Social / Recreation	**10**	Flexible
Other friends, doctor, school, church)	**28**	Somewhat inflexible

Considering that in 1995 these trips represented 54 percent of all trips, beside work trips they are important in order to outline the functioning of TOD and to further improve the location of uses, density and diversity. The automobile still dominates as a mode choice both for work and non-work trips among station area residents, about 80 percent of he trips being realised by car.

Due to the fact that most of the non-working trips length are short ones, walking, light rail and bus usage, cycling and even taxi services could become alternatives of motion. However, the surveys results show a wider extent for the usage of personal automobile both for wok and for non-work trips. There is still a long road ahead of the Transit-Oriented Development before car dependency will decrease in favour of increased public transport ridership.

Marketing approaches, activity patterns and travel mode choices suffer a continuous transformation in time, therefore prospecting the future, a trend of increasing public transport is expected, enhancing the benefits of implementing TOD.

Final Key Issues concerning travel behaviour

- **Density and Accessibility - Structures that influence travel behaviour**

Transit-Oriented areas are high density developments in the proximity of a public transport station, fully characterized by centrality of place, mixed land-uses, above average public transport supply, higher parking costs and diminished car dependency. (Kuzmyak, Pratt and Douglas, 2003).

A person’s daily activities are likely to meet an enhanced fulfillment in high-density mixed land-use development that is also a nodal point for public transport services providing faster connections. The person’s needs will be thus satisfied with the minimum expenditure of time and resources.

The impact of travel behaviour on the relation between having land-uses closer together along with the associated public transport infrastructure is stronger than considering only density as an influential factor.

Hence, accessibility is not only determined by gathering land uses, but also by placing complementary uses close to each other, developing thus an integrated relation between density and diversity of activities.

Different research techniques have been applied, and different types of explanatory variables were included in the researches in order to establish the effects of density, diversity and site design on trip rates and modal choice of transport. An important study over the influential aspect of density, mixture of uses and accessibility on travel behaviour was developed by Kara Kockelman at the University of California. Three key dimensions of the urban form were emphasized:

- Intensity – represented by **Accessibility Indices** as a number of activity opportunities described by the easiness of reaching them;
- Land-use Balance – represented by the **Entropy Index** as the variability of uses and the relative balance among the uses;
- Land-use Integration - represented by the **Dissimilarity Index** as the degree of mixture at the pedestrian scale.

Under a more mathematical formulation the three elements were defined as it follows:

Table 12 – Formulae for Kockelman Urban Form Variables (Source: Kockelman, 1997)

Accessibility = Σ *j Aj* / *f(tij)*, with Aj = attractiveness of zone j and tij = travel time zone i to j
Entropy = Σ j (Pj x ln(Pj)) / ln(J), Where Pj = proportion of land in the jth use type
Dissimilarity Index = Mix Index = Σ S k 1/K Σ S i^8 X_{ik} / 8, Where K = Number of actively developed hectares in tract, and Xik = 1 if central active hectare's use type differs from that of neighboring hectare (Xik = 0 otherwise).

- **Trip Chaining**

Trip chaining – or the linking of trips - is resembled with a diary travel and provides information of pedestrian trips, of routes choice and trip linking. It is believed that trip chaining influences other variables of decision regarding travel behaviour. Due to this fact, many researchers have tried to emphasize the role that trip chaining plays in travel behaviour. For instance, evidence was outlined that trip chaining determine mode choice (Jonnalagadda et al. 2001) or that high accessibility to retail and services is a significant motivation for trip chaining (Niles and Nelson, 2001).

Studies showed that there are gender difference in travel behaviour, as women link trips more than men – approximately 30 percent of work–to-home trips and approximately 45 percent of home-to-home trips involve two or more stops for women.

Identifying the best combination of uses within a Transit-Oriented Development is important and this relies very much upon a better understanding of users' trip chaining. An influential chain is generated having as basis the mixture of uses as well as their complementary location. The knowledge of their best combination and placement lead to increased efficiency for trip linking providing more time for customers and increase ridership and internal capture.

- **Auto Dependency**

Reduced auto dependency is one of the key factors aimed by Transit-Oriented Developments. If practical needs are located within easy access, walking becomes an option as well as public transport, carpooling or cycling. This inherent need for an auto, also termed as " auto captivity", still represents an important percent of mode choice (approximately 80 percent). Cervero found that there were high levels of public transport usage if both the origins and destinations were in reasonable close proximity to a station, but the densities and built environment were generally conducive to increased auto ownership and use, and reduced public transport options.

Final Remarks

Given the challenges of transportation and urban design planning, it is essential to understand the implications this kind of infill development has on users' travel behaviour in order to fully comprehend TOD's impacts on the community.

It is a fact that TOD demonstrated increasing rates of public transport usage than comparable surrounding areas or cities - residents living near public transport stations are five times more likely to use public transport as an average resident of the same city. But auto dependency also functions within high rates making the project vulnerable to traffic congestion problems. TOD users are more likely to use public transport if the time benefit is increased compared to travelling via highways using the personal automobile, if there is a pedestrian friendly activity, if limited vehicle availability is involved, but, they are less likely to use public transport if the trip involves multiple stops - "trip chaining", if highways provide god accessibility, if parking is free at their destination. All these elements are determinant issues in portraying travel behaviour.

3.3.3 Impacts on Land and Real Estate Market

If public transport investments bring benefits to the city, they can be easily identified through land and real-estate market indicators. TOD is time-saving and increased accessibility. Theory says that these benefits positively influence land value and market rents. Together with the ridership impacts stated and discussed above, land and real-estate indicators can be used to methodically monitor and measure the impacts and eventually the success of Transit-Oriented Developments.

The connection between enhanced accessibility of an area and the land values and real-estate rents is no doubt present among the theory of TOD impacts. “Good location” turns into an important parameter of the real-estate market equation: shops and other services more easily to be reached as well as reduced stress because of the public transport proximity.

Even though research in this area is various, the resulted evidence suggests that locations within easy access to public transport rapidly enhance land and real-estate values and rents. Usually a percent of 20-30% over the average market line has been recorded. Depending on the types of development, the rates might reach even higher levels, up to 40-50 percents more in TODs.

If once the neighbourhoods bordered or crossed by rail corridors were suffering of the continuous ascendancy of automobile usage and the increased surface of highways, today in the 21st century the wheel seems to be turning as light rail-served areas with residential and commercial properties within easy walk of stations became burning possessions.

Whether a parcel or a real-estate property belongs to a Transit-Oriented Development proved to be a less important matter in evaluating the impacts as the influence of the public transport station proximity might have. (Cervero et al., 2004). TOD location hasn’t been a specific data in the rent analysis and land values, but mixed-use infill within walking-friendly distances of a well functioning public transport network produced and supported healthy real-estate results.

Many indicators have been studied throughout the process of impacts evaluation, but they have been categorized in five main groups in order to ease the work: travel behavior, economic, environmental, built environment, and social diversity/quality impacts.

Also for developing efficient studies concerning the impacts and the benefits of a transit oriented development, some indicators have been defined as the usefulness for the process:

- Public transport ridership – studied in the previous chapter as TOD's impacts on travel behaviour;
- Streetscape – density, quality, pedestrian activity, safety;
- Land-use – quantity and quality;
- Transportation – functioning and number of mode connections at the stations, parking and traffic.

Impacts on value – impacts on residential and commercial properties

The impacts of light rail transit on real-estate properties have been already studied for a long time, almost for as long as these systems have been firstly implemented.

Even if not all the studies concerning public transport impacts have recorded first-rate benefits, most of them have. Impacts also vary by time and circumstances and it is because of these differences that the knowledge remains incomplete. Different and sometimes conflicting results have come out from the studies – some pointing the net benefits, some underlying the lack of obvious benefits or even the lower values concerning the residential properties that have been recorded.

But it is still widely acknowledged though that light rail implementation is favourable and encouraging for the residential and commercial real-estate market. Public transport and mainly light rail provide increased accessibility if the service is reliable, with high frequency and covers a large area.

These characteristics, together with the design elements at and around the station that determine its integration into the neighbourhood, significantly influence the residential values.

Estimations and research disclosed that homes located in a TOD area is sold 60% faster than one located in a non-TOD area due to the different rating that one is endowed (Cervero, 2004). In the same manner that public transport brings value advantages for the residential areas, it increases the value of commercial real-estate. Any commercial property value is at higher value appreciated if located near light rail route and public transport weighs greatly in the balance of choosing a location for a commercial surface to be implemented.

Impacts on intensity of development

Studies developed concerning the impacts of transit-oriented development, showed that light rail could develop benefits over the intensity of development. In order to acquire eloquent results the researchers conducted different types of approaches for analysing the area: light rail corridors as a whole compared to non-light rail corridors, or rail corridors divided into individual station areas and spaces between them examined as different parts of the same puzzle.

Even so, the results disclosed the fact that area where light rail is present and increases accessibility have a faster rhythm of development and growth. Station areas are like catalysts of development within a light rail corridor, “centres of economic activity and growth” (TCRP Report, 1996). Light rail station are capable to attract investments creating jobs and further opportunities to develop in a concentrated, mixed-use manner.

Building a general overview of the issue, light rail together with mixed-use station areas within walking distances usually generate healthy land and real-estate outcomes.

But, only light rail, is rarely sufficient to stimulate development and growth without proper zoning, infrastructure improvement and expansion and without other complementary initiatives. If so, proximity to public transport could provide any type of development – either residential or commercial and services – with property value gain and real-estate performances above the average market standards.

Transit-Oriented Development is a two way street regarding the impacts and benefits of its final urban form. This synergy developed between land-use and transportation provides the area with a range of benefits. Reliable and quality public transport confer value premium to residential and commercial properties, stimulating also the intensity of development at and around station areas while high-density mixed-use land provide users for light rail generating bidirectional flows and discouraging the use of cars. Even under these conditions the two elements are not self sufficient for generating growth without strong market forces and supportive policies.

04

CASE STUDY - PORTO METRO RAIL SYSTEM

Transit-Oriented Development has been embraced as a working strategy to deal with a wide range of planning objectives – from reduced automobile dependency to high-quality life standards. As relevant examples, case studies are essential for delineating the key principles of the Transit-Oriented Development approach.

The cities interested in implementing Metro Rail systems have greatly learned from the experience of early systems. In combination with cautiously planned mixed land-use, the Metro system can be a powerful tool to help shape growth.

This research will employ the case study of Porto for a better understanding of how light rail insertions can be meaningful to the city's development towards a transport-oriented concept.

By examining the "on-ground" development for the Metro of Porto, the study will succeed in moving forward beyond theoretical practices.

4.1 ELOQUENCE OF THE CHOSEN CASE STUDY

4.1.1 Relevance of Light Rail for the City - Porto Metro Rail System

Transit-Oriented Developments have increased in number during the last years, as a mean of promoting smart growth and providing quality of life for their users, as an integrated development around public transport facilities (light rail, railway, interchange nodes).

TOD has been embraced as a working strategy to deal with a wide range of planning objectives – from reduced automobile dependency to high-quality life standards. As relevant examples, case studies are essential for delineating the key principles of the Transit-Oriented Development approach.

By examining an "on-ground" development, the study will succeed in moving forward beyond theoretical lines.

Many European cities have concerted their efforts in reducing car dependency and integrate public transport with mixed land-uses. Zurich, Stockholm, Copenhagen, Freiburg planning strategies will be quoted in this chapter as examples that offer particularly striking lessons.

Table 13 – Zurich's strategies for overcoming automobile dependence (Source: www.istp.murdoch.edu.au)

TRAFFIC CALMING	FAVOURING ALTERNATE MODES	ECONOMIC PENALTIES	NON-AUTO DEPENDENT LAND-USES
ZURICH			
Regional traffic calming	Expansion of the light rail and heavy rail system and bike / pedestrian lanes.	Usual European fuel tax and registration.	Containment of growth.
* Extensive 30 kph zones * Development of selected transit malls and pedestrian zones. * Reclamation of traffic lanes for light rail.	* Careful timed coordination between services and modes. * Professional marketing and passenger information. * No extra road capacity, restrictions on parking. * Rainbow Pass for transit system.	* No congestion pricing. * High parking fees.	* Transit directed growth * New urban villages around the rail system. * Mixed land-use
FREIBURG			
Regional traffic calming, but extensively pedestrianised in city centre.	Strong commitment to light rail transit and bicycle infrastructure.	Usual European fuel tax and vehicle registration.	Corridors and nodes of transit-oriented development and no other growth.
* Extensive 30 kph zones. * All new streets in urban villages traffic calmed.	* Bus feeders strongly support the light rail system. * Little extra road capacity.	* No congestion pricing. * High parking fees.	* Urban villages around new rail stops. * Most internal movement within TOD on foot and bicycle. * Road penetration into TOD sites strictly limited. * Mixed use in centres.

Due to the strategy summarized in Table 13, Zurich managed to channel the city's development towards a city-building process, controlling car usage and achieving a spectacular increase in public transport services.

"Suddenly trams became popular in Zurich. We found it impossible to attack the use of the tram... People simply won't accept it", says planning consultant Willi Husler.

a.

b.

Fig. 13.a - Zurich fought the war against the car and won

Fig. 13.b - Freiberg is a city which has built a successful LRT and integrated land use around it

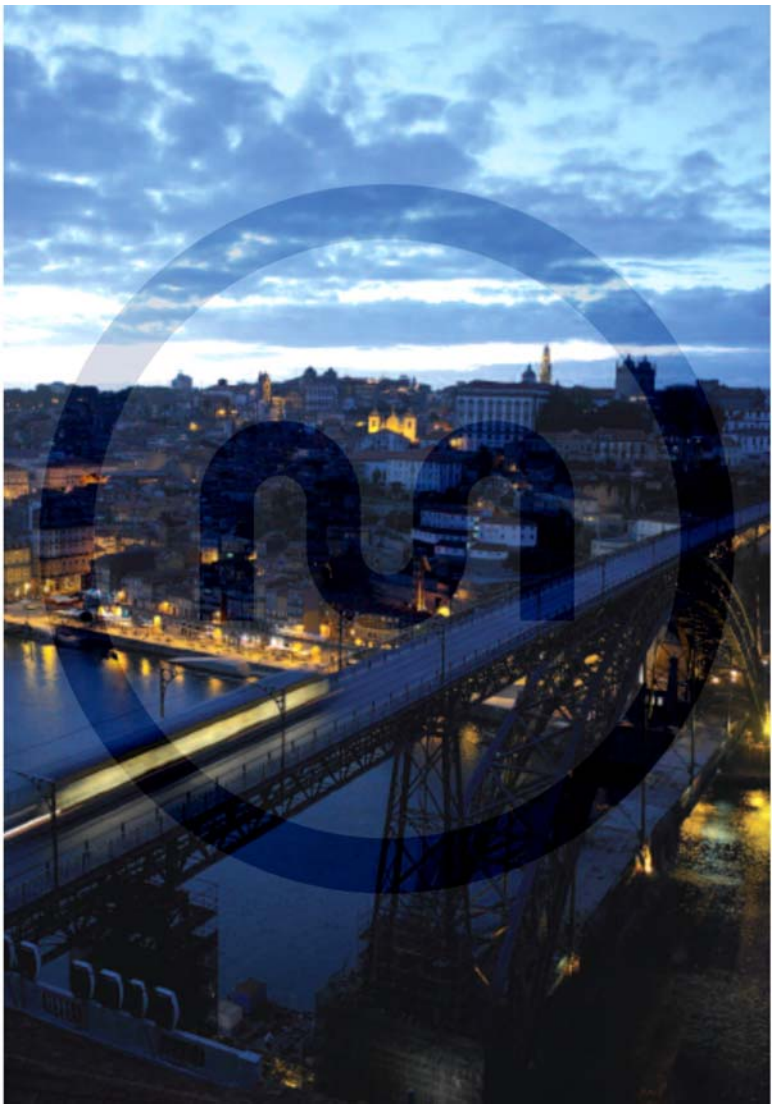
Restricted auto use has been achieved through mechanisms such as pedestrianisation of the city centre, area-wide traffic calming schemes (citywide speed limit of 30 km/h in residential areas) and more difficult, expensive parking. In the meantime expansion of public transport – especially Light Rail – has made the difference in transportation mode choice shifts.

Therefore, there is an obvious need the cities express regarding a viable affordable alternative to the automobile, enhancing thus mobility and promote land use trends that produce traffic reduced developments, turning the cities into desirable places to live and work. Light rail has continuously been cited as a mean of meeting these diverse set of goals.

This research will employ the case study of Porto for a better understanding of how light rail insertions can be meaningful to the city's development towards a transport-oriented concept. The analyze will focus on the possibility of integrating the Metro Rail System and the land-use developments situated within walking distances from its stations.

Porto is the second largest city of Portugal, being the core of the Metropolitan Area of Porto with fourteen municipalities – Arouca, Espinho, Gondomar, Maia, Matosinhos, Porto, Póvoa de Varzim, Santa Maria da Feira, Santo Tirso, S. Joao da Madeira, Trofa, Valongo, Vila do Conde, and Vila Nova de Gaia – with a total area of 815 km^2 and 1.256 million people.

During the last years, the Metropolitan Area of Porto had to face a severe decline of public transport usage – considering the 1988 to 1996 period, public transport trips decreased from 65% to 37% while automobile trips increased from 35% to 62%. There was a real threat beyond these figures to the competitiveness and business attractiveness of Porto and the embracement of the light rail concept came as an answer. The Light Rail System of MAP has emerged as a compulsory demand from the city in order to develop accessibility and life quality for its inhabitants.



The public Metro operator is ***Metro do Porto*** which is the public light rail transport company. Metro do Porto opened an initial segment of 9.3 km between Senora de Matosinhos and Trinidade in December 2002 of what will be an ultimate four-route, 70-km system of light rail connecting the city of Porto and all the other cities belonging to MAP, arranging it on grassy medians, high viaducts short tunnel segments, converted railroad rights-of-way and reserved space along existing streets (Bottoms, 9th National Light Rail Transit Conference, 2003).

Fig. 14 – The Metro crossing Luis I Bridge, from VN de Gaia to Porto

Associating speed and operational services to a strong element of urban and landscape renewal, the light rail of Porto is a complete turn-over on the way to quality and modernization.

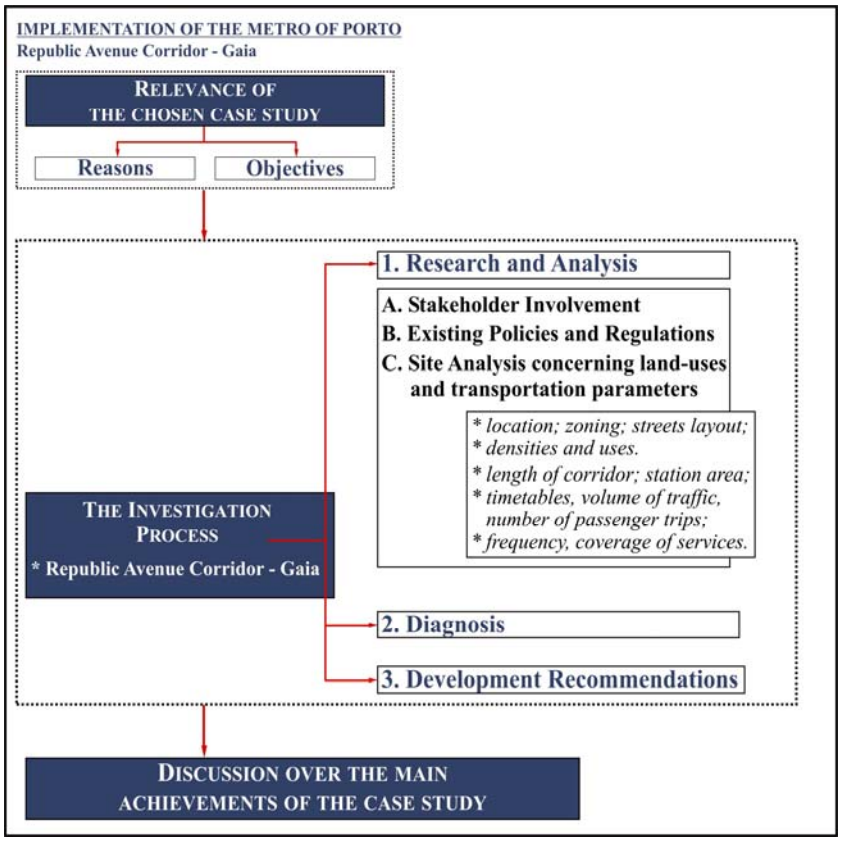
4.1.2 Framework of case study analysis

Implementation of high-density areas located within an easy walk around public transport nodes can increase and encourage usage of public transport. The aim of the case study is to explore the Metro rail system and the land-uses surrounding its stations, in order to delineate the relation born between them towards Transit-Oriented Development.

Several aspects are to be studied during the process of research:

- The extent and character of development at or around Metro Rail stations, with the accent on the distances between the station and the uses;
- The character and the intensity of the relationship born between the main elements of the projects - the Metro and the surrounding areas -, the process generating them and the recommended conditions conducive to the tools that can be used to encourage their integrated corroboration.

Table 14 – Framework of the presented Case Study



The formulation of the study strategy will include a discussion regarding involvement of stakeholders, existing policies and regulations specified in the Municipal Directory Plan for the areas to be studied, site and Metro network analysis, all leading to a holistic diagnosis and to the sketch of a possible development concept.

4.2 ANALYSIS AND EVALUATION

4.2.1 Stakeholder Involvement

Today's developments in the City of Porto involve many different actors, every one of them aiming their own wide range of concern. Local governments are responsible with the planning process, making the development possible while developers are responsible for generating profits for the lenders and investors. Building the public transport system becomes the task of the transportation agencies.

Stakeholder involvement is critical to the planning effort in order to direct the development of the process and the implementation of the project. For manufacturing a Transit-Oriented Development it takes a large number of actors and it is an obvious challenge to establish a coherent performance since the players tend to have different ideas, different goals, priorities and interests to the table.

On the **public** side of the issue, the main actors involved are the rail authority – giving zoning ordinances that allow mixed high-density developments at and around public transport stops - transportation agencies, neighbourhood planning agencies and other public organizations that target new developments along the light-rail corridor.

On the **private** side the stakeholders are the developers, building associations and firms, planning institutions that design, finance and coordinate most of what happens on the parcels at and around public transport stations.

Also important for the process are the non-governmental organizations and other community organizations sustaining cycling or pedestrianism as well as fighters for a sustainable development.

For the city of Porto, a city that seeks to reinforce itself around light rail, Transit-Oriented Development could be used to enforce the development of the whole corridor generated by the Metro. The process is still in the early stages and stakeholder definition and mobilization is essential for getting the job done.

As seen in **Table 15**, there are various actors involved in the Metro rail insertion and in the development of the area at and around the stations, often playing contradictory roles that need to be coordinated in order to facilitate de projects infill.

Table 15 – Framework of the stakeholders involved in the Metro insertion and the development of the territory

	PUBLIC	PRIVATE
TRANSPORTATION	***Ministry of Public Works, Transportation and Habitation*** **Intermodal Transports of Porto (TIP)** **Metro do Porto** → *Metropolitan Area of Porto* *STCP (Road public transport operator)* *The Portuguese State* *CP (Tha Portuguese Heavy Rail)* *Gondomar City Hall* *Maia City Hall* *Matosinhos City Hall* *Porto City Hall* *Póvoa de Varzim City Hall* *Vila do Conde City Hall* *Vila Nova de Gaia City Hall*	**TRANSDEV** **European Company for Public Transport Development**
TERRITORY	***Ministry of Environment, Territory Planning and Regional Development*** → *General Assembly of Territory Planning and Urban development* **Porto City Hall** → *Municipal Assembly of Urbanism (DMU)* *Study and Planning Cabinet (GEP)* **Gondomar City Hall** **Maia City Hall** **Matosinhos City Hall** **Porto City Hall** **Póvoa de Varzim City Hall** **Vila do Conde City Hall** **Vila Nova de Gaia City Hall**	**APOR** **The Agency for Porto Modernization** → *Porto City Hall* *Administration of the Douro and Leixões Harbors* *Sonae Turismo, SGPS, S.A.* *Lusomundo, SGPS, S.A.* *Mota & Company, S.A.* *RAR - Control Society (Holding), S.A.* *Sport Club of Porto* *Offices Association of Porto* *The foundation fo the Development of Vale de Campanhã*

The Metropolitan Area of Porto is going through significant changes within its mobility system. An appropriate transportation agency is needed in order to control where, when and if light rail and bus services are provided. This kind of agency is also the forefront of implementing TOD.

The insertion of light rail is expected to bring a shift and some fresh air in the Porto transportation system, therefore a functional reorganization for the public transport modes is required.

The road public transport operator – STCP – is to be seen as a users feeder for the light rail within the context of an integrated transport system. Thus, the STCP is supposed to develop an integrated and redrawn network that cooperates with the light rail.

The transportation developer and Porto Metro operator is TRANSDEV as the leading private passenger transport operator. This operator holds the exploitation of Metro until the 2009 with the prospective of reinforcement and extension of the operations.

The Group is active in two areas:

- Rail transport: operation of the Porto metro, participation in the metro construction consortium, and management of rail infrastructure maintenance company in a joint venture with Effacec (Empresa Fabril de Máquinas Eléctricas);

- Road transport: public bus transport group (TRP) acquired in 2002, operating regular routes around Braga, Coimbra and Porto, long-distance express services between the cities of northern Portugal and Lisbon, and international lines.

Given the complexity of the Transit-Oriented Development projects, an overall vision is needed in order to realize successful developments. The areas surrounding the Metro stations become thus places of high interest turning into cooperation zones between high quality mixed-use insertions situated within easy walk from the stations. Porto City Hall along with all the subordinated organizations – Municipal Assembly of Urbanism, Study and Planning Cabinet - must coordinate and facilitate the development.

The APOR agency - The Porto Development Agency - is an important partner that encourages synergies for public and private entities and promotes the requalification and modernization of the urban business structure of the city.

For a better understanding of what transit-oriented means and with a clear functional definition of what this type of project should accomplish, a new organization is needed to bring this product to scale in a way that increases housing affordability and transportation choice, revitalizes the city and urban neighbourhoods, generating durable public and private returns.

4.2.2 Existing Policies and Regulations

Existing land use policies in the city of Porto do not specifically endorse the concept of Transit-Oriented Development, but they do have explicit proposals mentioned within the urbanization plans that lead to a suitable approach for this type of urban development.

The State seeks to support projects that increase the benefits of existing investments in public transport that may contribute to stimulate private investments. The city of Porto promotes through the Municipal Directory Plan (PDM) - reviewed and approved with the Council of Ministers' Resolution no.19/2006 DR 25 03.02.2006 and the city of Gaia through the

Municipal Directory Plan that is under the revision process – the urban design, social concern and economic development regulations and policies.

The guiding principles and priorities addressed to in the PDM emphasize balanced land-use developments, that include the following objectives:

- Encourage quality development, enforcing the urban identity for the City of Porto - design of coherent and qualified urban texture, control of density and urban volumetric aspects;

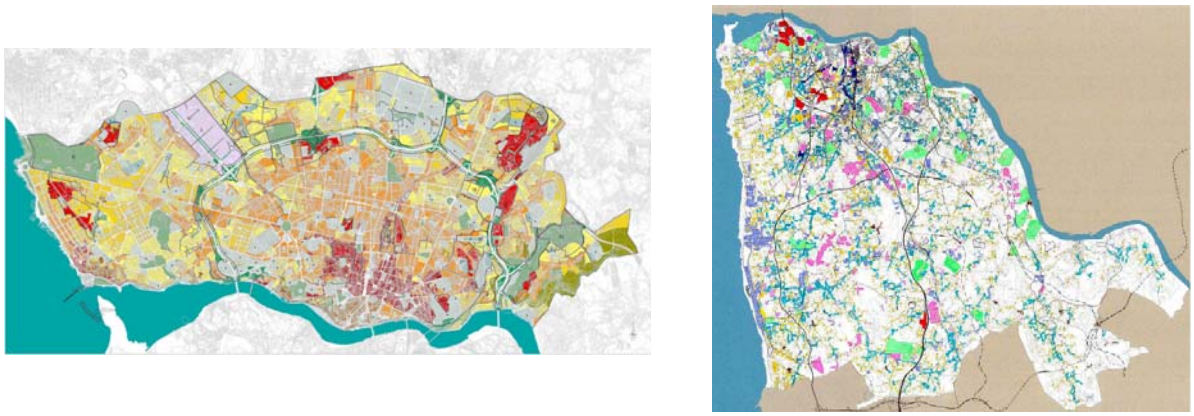


Fig. 15 – a. Conditioning Plan from the Municipal Directory Plan of Porto (Source: PDM Porto, www.cm-porto.pt) ;
b. Morfotipology of Territory Occupation from the Municipal Directory Plan of Gaia – Provisory version (Source: PDM Gaia, www.gaiurb.pt)

- Increase of transportation choices – rationalize the transportation system with concern towards the improvement of the urban intra–mobility, giving priority to public transport with a special reinforcement of the pedestrian mobility;

Fig. 16 – a. Hierarchy of street system from the PDM of Porto (Source: PDM Porto, www.cm-porto.pt);
b. Hierarchy of street system from the Municipal Directory Plan of Gaia – Provisory version (Source: PDM Gaia, www.gaiurb.pt)

- Provide housing opportunities;
- Enhance quality and character of communities – through public space re-qualification putting price on ecological, environmental and landscape elements, aiming the minimization of the environmental impacts;
- Make efficient use of existing and proposed investments – reduction of the urban asymmetry looking for equity of locations of the public investments, reinforcing the social and territorial cohesion;
- Reaffirmation of Downtown area seeking for liveability and attractivity;
- Make development decisions predictable, fair, and cost effective;
- Encourage community and stakeholder involvement in development decisions.

The Municipal Directory Plan covers the whole area of the city of Porto or the city of Gaia, consequently the two locations to be studied are under the incidence of the goals stated above.

Since TOD is not a specific goal for the urbanization plans, one objective of the case study is to identify specific approaches that could be changed or added in order to improve the regulations shape under which the city will be conceived.

In consistency with local land-use planning priorities, the extension of the Light Rail system in Porto and surrounding districts, will represent a fundamental step towards increased accessibility and towards the cooperation between public transport and other different functions of the city: commerce and services, leisure, jobs and public equipments.

The Metro of Porto plays an important role for the mobility conditions of the Metropolitan Area of Porto. For the Light Rail system of Porto, the year 2006 is going to be a year of analysis and work out for the Metro of Porto Development Plan. For the future period 2007-2013, Metro of Porto will look for an integrated development with others public transport options – railway and road transport.

Integrating Light Rail and its stations into the adjacent area demand local governments to involve with authority, for regulating and endorsing development. Quite an extraordinary effort is required from the authorities and their development plans, if they are to succeed in creating a functional integrated land-use – transportation system.

4.2.3 The Yellow Line(D) Metro system: São João Hospital – João de Deus

- ***"Travel on the Yellow Line"***

The case study analyzed in the following part belongs to the Yellow Line of Metro network. It is of great significance to establish some of its characteristics of this line in order to move forward with the study.

Fig. 17 – The metaphoric image of the Yellow Line (Source: www.metrodoporto.pt)

The Yellow Line of the Metro do Porto network began functioning in September 2005, bringing thus all the four lines to entry into service. The Yellow Line is the unquestionable king of the lines of the Metro do Porto network.

First of all due to the fact that it connects two of the most populous municipalities of the Metropolitan Area: Porto and Vila Nova de Gaia.

Together, the two cities sum 544,000 inhabitants, more than a third of the total population of the Porto Metropolitan Area. Second, the Yellow Line's route provides a direct north-south link that connects areas of high centrality and high densities.

Fig. 18 – The Yellow Line Route (Source: www.urbanrail.net)

As seen above, there is not only one station on the Yellow Line Route that cannot be associated to an important commuting point. From the north of the line to the south, it crosses paths with some of the most important entities of Porto and Gaia: São João Hospital, The Polytechnic Institute of Porto, the Portuguese Oncology Institute (IPO/Porto), the entire Asprela university campus (which accounts on its own for 30,000 commuters per day), the centre of Paranhos parish (the largest in the city of Porto), the Antas area and Costa Cabral Road, Marquês Square, Camões, Fonseca Cardoso and Faria Guimarães roads, the entire downtown area of Porto (via Trindade, Aliados and São Bento stations), connecting to two important railway stations - São Bento and General Torres - and the important services and commercial centre of Republic Avenue, in Gaia.

At Trindade station – the true 'heart' of the network, with its two levels and numerous access routes – the Yellow Line (D) interfaces with all the other lines of the network: the Blue (A), Red (B) and Green (C) lines and also with the Violet Line (E) currently under construction, which already provides a link to Dr. Francisco Sá Carneiro International Airport.

The connection between the city of Porto and the city of Gaia is made on the Luís I bridge reinforcing the upper platform and allowing the Light Rail and the pedestrians to cross the Douro River.

- ***Times and frequencies***

The yellow line operates with ***6 minute headways*** during peak periods of travel (7-20h) in the working days and Saturday also and ***10-15 minute headways*** during off peak hours (6-7 h and 20-01h) and also during Sundays and holidays.

Table 16 – Timetable for Line D (Source: www.metrodoporto.pt)

	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	24h	01h
Yellow Line (Line D) São João Hospital - João de Deus																				
Working days	10								6								10		15	
Saturdays	10								6								10		15	
Sundays / Holidays									10										15	

The journey time of the almost six kilometre-long Yellow Line, including the stoppage time at each station, is less than 20 minutes.

The studies developed by the Metro of Porto concerning the number of validations at the stations come as a support of the stated importance of the Yellow Line. After its opening in September 2005, there has been registered an average number of 81.384 daily validations (98.974 in working days) which signifies an increase of 115.6% against the previous period January-September 2005.

The benefits became more significant as the final section of the Yellow line was finished connecting the University Pole with the São João Hospital – which at present operates as the terminus point of this line. An important increase in the number of passenger will be noticed at the other extreme of the line, in Gaia, as the El Corte Inglés mall has opened at the end of May 2006 (Annual Report, Metro do Porto, 2005).

4.2.4 Republic Avenue in Gaia – Metro as a catalyst for the corridor development

In most of the cases Transit – Oriented Development emerged as a consequence of the important makeover of tram into the sophisticated and modern light rail system.

The implementation of the Metro in the Metropolitan Area of Porto developed a great asset: beyond the benefits brought to an increased mobility the route of the Metro represents also an excellent reason for investments in urban renewal. And this is exactly what it happened on the main urban avenue of Gaia: the Republic Avenue.

Republic Avenue is one of the potential subjects of transit-oriented makeovers, searching to propose a smart growth planning approach – with mixed-use places, walking distances, less automobiles and well-developed public transport along the corridor consisting of four metro stations. TOD could be used as a strategy to retrofit the one and a half kilometre long corridor in order to make it more accessible and attractive to pedestrians and cyclists and to provide a safe pedestrian environment also. The corridor will be seen as a magnet for development.

Along the years, the Republic Avenue was a real headache for the inhabitants of Vila Nova de Gaia, due to the constant works developed along its route. But this situation came to an end, once the most modern public transport was implemented and the citizens of Gaia are now able to enjoy a renewed Avenue.

Running from the Luis I Bridge to the end of the Yellow Line, the Metro stops in four stations as it follows: Jardim do Morro, General Torres, Câmara de Gaia and João de Deus.

The results of the analysis will provide an image of the land use development surrounding existing Metrorail stations and the corridor itself, as well as important informations regarding transportation mode choice, metro functioning an other motion parameters.

- ***Objectives of the case study***

The main objective of this case study is to prove that this Metro corridor has a great potential for further development as a transit-oriented area. The infill of the Yellow Line of Metro acts as a catalyst for intensive development of this spine in the city of Gaia and as an investments attracter.

Concentration of dense mixed-uses at the four stations together with a well-functioning Metro line can increase the attractivity of the area turning it into an active, walkable, liveable part for the city of Gaia.

Public transport and the station area investments could be used to revitalize the corridor if an unified visual image is achieved and public/private spaces are created in order to invite to maximum use and attract a significant number of riders.

Development of accessible places for all modes of transportation including walking, biking, public transport and automobile is needed and pedestrians should be given a primary consideration by creating enjoyable, safe places and a well connected pedestrian network easy to navigate.

- **Location**

The Republic Avenue Corridor develops along 1.5 kilometres of the Republic Avenue in Vila Nova de Gaia, more precisely in the City Platform Area (Plataforma Cidade).

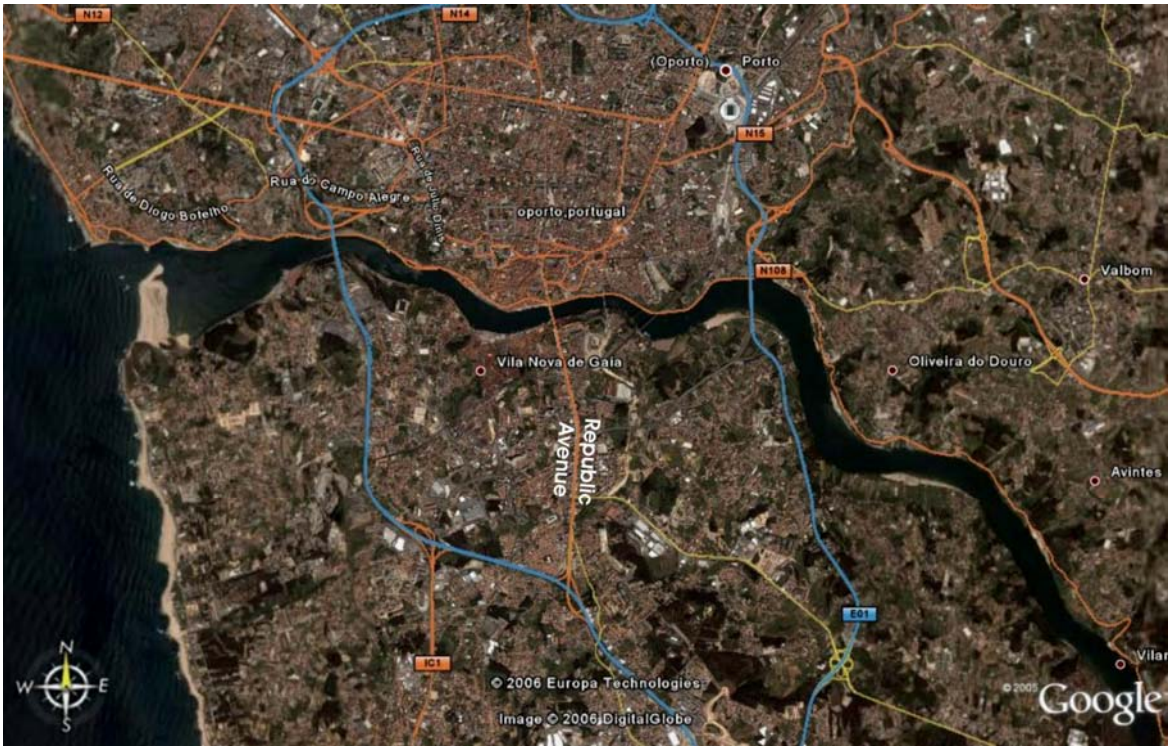


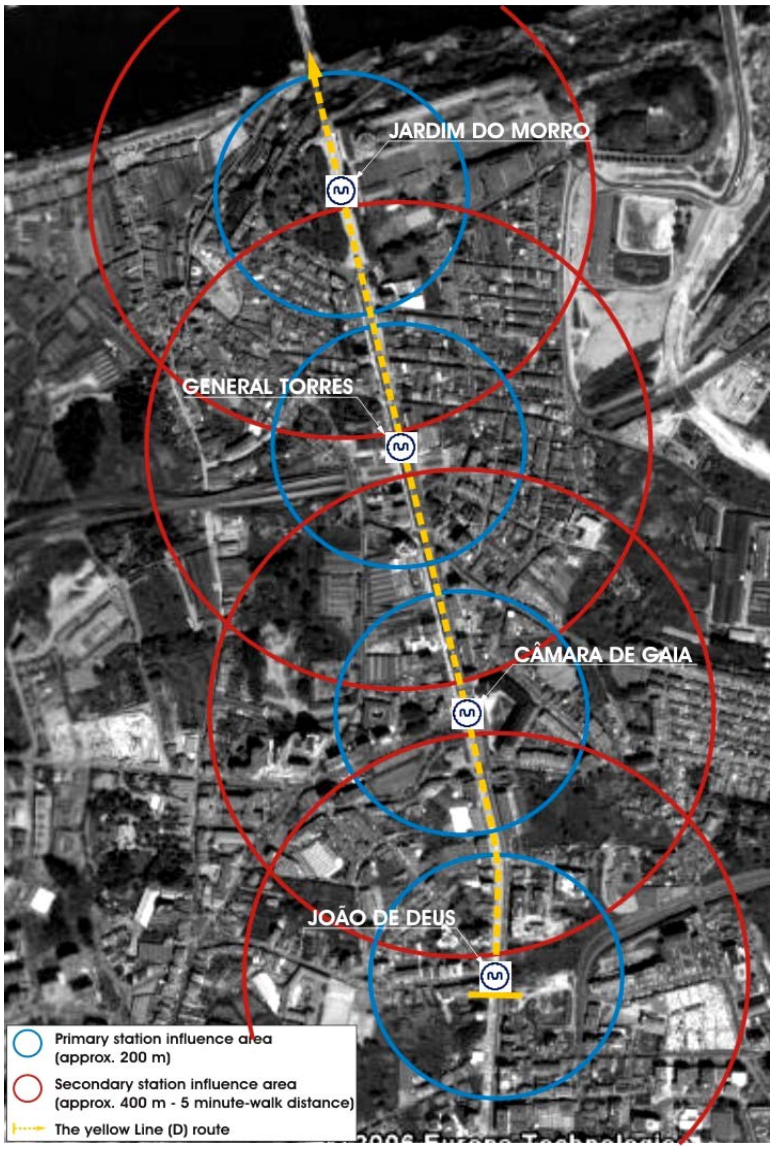
Fig. 19 – Porto and Vila Nova de Gaia – aerial view (Source: http://earth.google.com)

The Avenue starts right at the entrance in the city of Gaia after crossing the Douro River on Luis I Bridge. It is one of the longest avenues in Gaia and also one of the most important since it has excellent highway and arterial access – it is the connection between the city of Porto and the E01 highway.

Her total length is of approximately three kilometres, but the case study only covers half of it – approximately 1500 meters, due to the Metro stations that have been finished and open to public until now (Jardim do Morro – João de Deus).

- **Land – use and Development**

<u>Jardim do Morro – João de Deus Corridor</u>



In Gaia, the first signals of new functional approaches of the territory appear with the tracing of the railroad line Lisbon - Porto and the opening of the Republic Avenue a street with rectilinear tracing playing the role of Southern exit from the city of Porto. It is thus initiated the construction of new infrastructures of rectilinear and geometric tracing imposed by the technological move on, exactly where the topography represented an obstacle - as it is the case of crossing at high elevation over the Douro river.

Fig. 20 – The Jardim do Morro - João de Deus corridor– aerial view (Source: http://earth.google.com)

Crossing at high elevation Luís I bridge and with a transversal profile adapted after the models of *"Boulevards"* the Republic Avenue develops two traffic lanes on each side and lateral sidewalks, while the Metro is implemented on the middle of the street in its own channel.

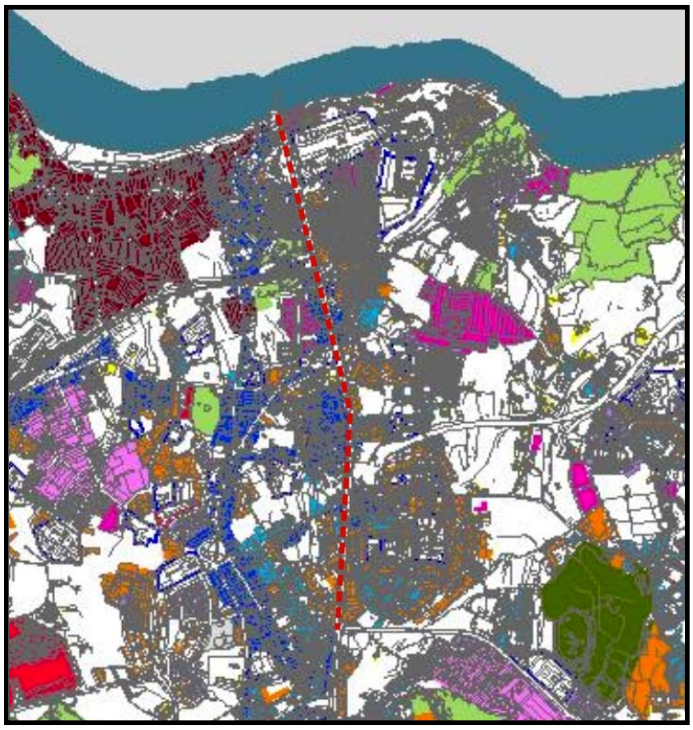
The characteristics of the project stand for the fact that the avenue will turn itself into a much more pleasant place to transit or to shop, emphasizing increase in the quality of life of the citizens.

The boundaries of the corridor area have been easily established at the east by the green physical barrier and at the west by the Candido dos Reis and Sa de Bandeira streets.

The Jardim do Morro - João de Deus corridor contains four metro stations and four corresponding metro station areas: ***Jardim do Morro, General Torres, Câmara de Gaia and João de Deus.***

The corridor develops along the Republic Avenue for 1.5 kilometres and the four station areas encompass approximately 85 ha. The time that the Metro spend to cover the whole corridor is of **3'38"** (information provided by *Metro do Porto*).

The mixture of uses at each station relate to their land use function identified in the Municipal Directory Plan of Vila Nova de Gaia. The predominant land-use function is the residential one, mostly the residential extension of medium density – the traditional quarter (grey colour in **Fig. 21 -** Land morfo-tipology from Gaia PDM**).**



This Morfo-typology corresponds to all the extensions occurred mostly during the first half of the XXth Century, taking advantage of the conditions of increased accessibility due to the proximity of road infrastructures and of transports, as it is the case of the Polish Quarter (along the Republic Avenue).

Fig. 21 – Morfotipology of Territory Occupation from the Municipal Directory Plan of Gaia (Source: PDM Gaia, www.gaiurb.pt)

It's all about street textures of geometrical regular tracing whose initial program was the single family habitation. The configuration of the lots, the narrow fronts and great depth, as well as the continuous front occupation to the main street with the maximum elevation of 2 story-height, illustrate the medium density quarters with an initial residential function.

Fig. 22 – Medium density residential area in the proximity of the Republic Avenue

In time these structures will suffer a makeover into areas of higher urban intensity: increase in the number of stories, parcels aggregation and very often an alteration of the initial residential function usually to commercial or services functions.

The high density residential areas constitute also a form of land occupation (orange colour in **Fig. 21 -** Land morfo-tipology from Gaia PDM). These type of units are randomly located in relation to the existing urban context, implemented with a relative free design and depending essentially on access infrastructures.

The occupation forms – the blocks of flats – are disposed in order to gain autonomy relating to the existing infrastructure – streets or highways. The infrastructure system only guarantees access to habitation without any other land-use designation.

Fig. 23 – High density residential area along the Republic Avenue

There is a noticeable lack of commercial and service facilities and even where they are present, the lack of cohesion and unity develops a poor image for the Avenue. Due to the Metro infill, the development pressure becomes high on all sites of the area.

Overall, this pattern allows mixed-use nodes of activity where citizens can utilize public transit to work, eat, live, play, study, and shop in the same vicinity.

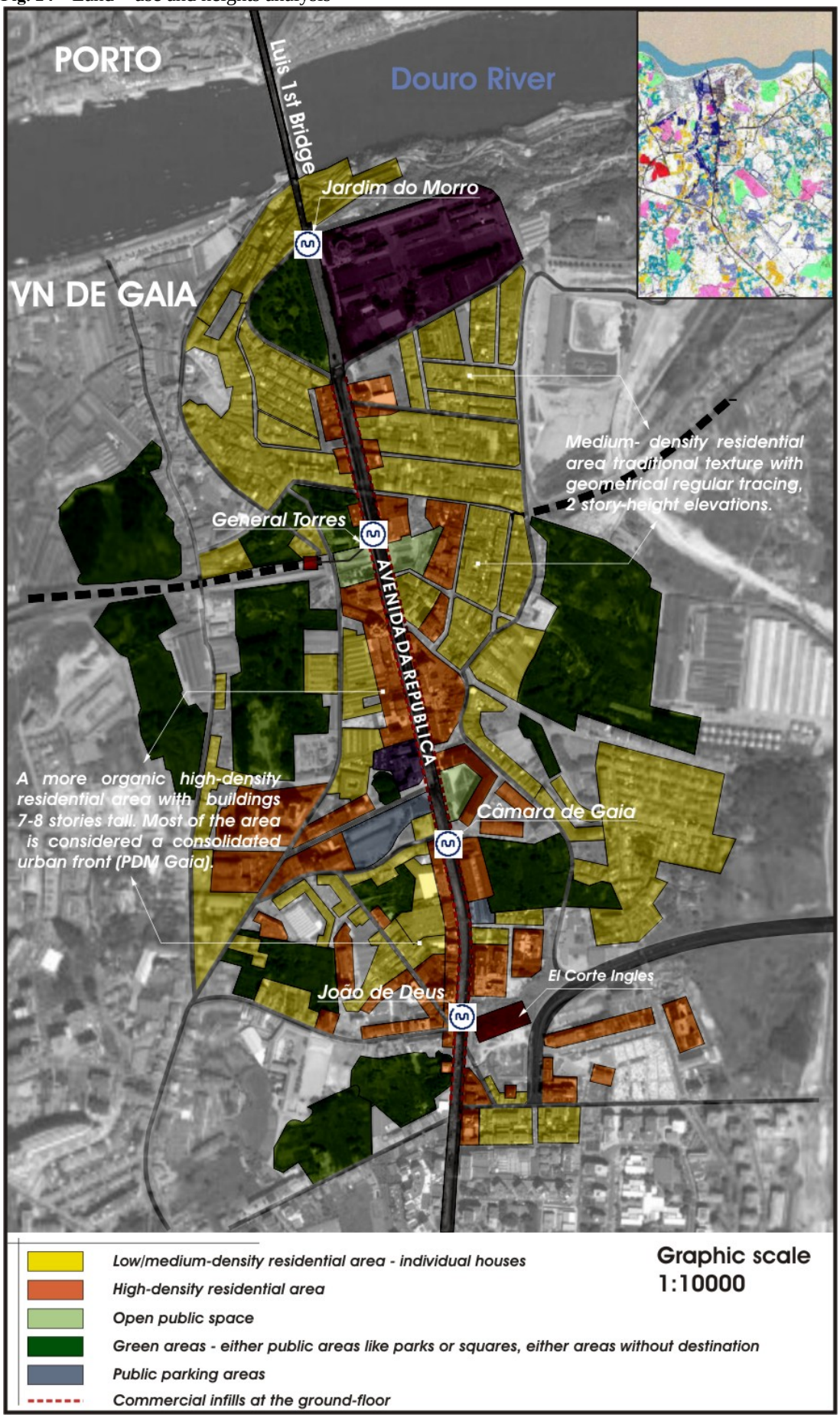
Laura Rodrigues, the President of the Traders Association of Porto mentioned in an interview: *"The metro constitutes for the traders an enormous hope to revitalize the commerce in the centre of the city - at least in its route area of influence - developing the capacity to take the customers from one side to the other. On the other hand, with the competition of great commercial surfaces, the metro with its characteristics of being convenient, fast and with accessible tariffs, comes to stimulate shopping in the centre of the city. For all these reasons, I think that the future of the traditional commerce passes through the metro"*.

The Republic Avenue will earn a new face and new conditions to stimulate the experience of the citizens with the new centre of the city.

The following part will describe the existing, zoned, and planned land use and development intensities around the four metro stations.

Fig. 24 gives a more focused approach on the Jardim do Morro - João de Deus corridor regarding the land-uses, their disposal, regarding heights of the buildings. It is a noticeable difference between the geometrical development of the traditional residential quarter with medium density of inhabitation lying on the first half of the corridor and the organic development of the high-density area lying on the second half of the route.

Fig. 24 – Land – use and heights analysis



➢ **1st Division: Jardim do Morro – General Torres**

Fig. 25 – Jardim do Morro – General Torres division of the corridor – requalification planning (Source: Infometro, July 2003, www.metrodoporto.pt)

The first division of the corridor is the area comprised between the stations Jardim do Morro and General Torres. The length of the station is of approximately **450 meters** and the time spent by the metro to cover this distance is of **48"** (information provided by *Metro of Porto*).

One of the main aims of TODs is to create a walkable environment, liveable and attractive for pedestrians. Consequently, the concept of "within walking distances" became a central issue for the study. The accepted standard for determining the primary area of development for a transit-oriented development is the area within four hundred meters from the public transport station, considered as the five minute-walk distance. As seen on the map below (**Fig.26**), this area of influence is marked by the 400 meter-circles and the study is developed within these distances. Therefore the station locations were selected mainly to maximize access for passengers arriving by bus, private car, bicycle or on foot.

The area is characterized by a substantial amount of highly intense residential resource, but of medium density : the Polish Quarter – a single-family traditional quarter, perceived as passenger provider.

A study concerning the distances along certain trajectories has been developed in order to emphasize the characteristics of the sites enclosed in the area. The average distances that pedestrians need to cover is mostly around 300 meters. The Polish Quarter is thus very well served by both of the Metro stations. There are, though some sites along the Candido dos Reis street that might request a longer path, due to the organic development of the streets.

According to the numbers, Metro ridership is high and continuously increasing. Due to the distances analysed and discussed at all the four stations, most of the users might get to the stations on foot or by bus – if they are located outside the five-minute walk area.

Jardim do Morro Station Area is located immediately after the Metro crosses the Luis I Bridge right between the Monastery of Serra do Pilar and the Park.

The station is situated at the same ground level with the sidewalks. Between the upper deck of the Luis I Bridge and the junction with the streets Rodrigues de Freitas and Rocha Leão, a pedestrian area has been designed, paved with granite cubes.

Due to this feature and also to the fact that the immediate area of Jardim do Morro station is occupied by the park and the Monastery, this station area could become a space of leisure and relaxation by excellence. The walk is well lit along the sidewalks, although the streetlights are more catered to metro and vehicle traffic than pedestrians walking on the sidewalks.

Fig. 26 – Jardim do Morro Metro station – with a view to the Monastery of Serra do Pilar

At present, the density in this neighbourhood of Jardim do Morro station area is commanding public transport use, but the number of passengers entering this station is lower than the other stations of the corridor.

General Torres Station Area is the second station area in the corridor.

The amount of the residential density is lower in this part of the corridor. It only covers the eastern side of the Avenue while on the western side the railway tracks under-cross the Republic Avenue and cover most of the area on this side together with green public areas. The public open space is needed to create this critical connection between the residential area and the active street and it develops on both sides of the Republic Avenue.

General Torres railway station is also placed in the vicinity of the Metro station, but the interchange between the two different modes of transportation is not accomplished in the easiest manner.

The difficult, sinuous way from the Metro station to the railway station and also the non-inviting underground passage induced a certain attitude of avoidance between the users: they would rather exit the train in Campanhã or São Bento stations where the access to Metro is faster and more friendly.

In the area there is also located a public parking which is exploited only to low capacity due to the lack of users.

Even though residential uses are most prevalent, from this station forward, retail and services start to locate at the ground floor of the building facing the Avenue, positively influencing the pedestrian activity.

Fig. 27 – The 1st Division of the Republic Avenue corridor: Jardim do Morro – General Torres, aerial view (Source: http://earth.google.com)

- **2nd Division: General Torres – Câmara de Gaia**

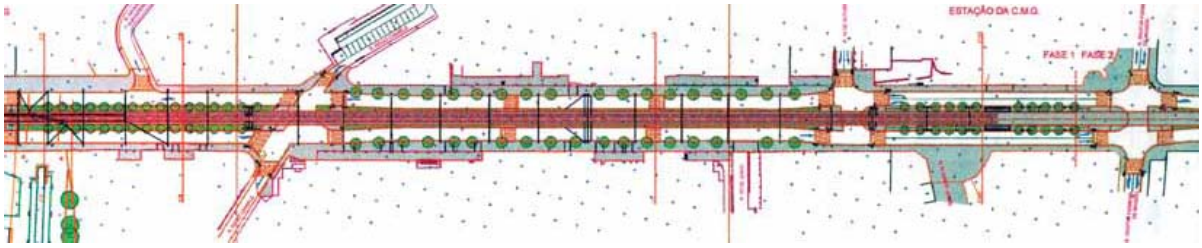


Fig. 28 – General Torres – Câmara de Gaia division of the corridor – requalification planning (Source: Infometro, July 2003, www.metrodoporto.pt)

The second division of the corridor is the area comprised between the stations General Torres and Câmara de Gaia. The length of the station is of approximately **500 meters** and the time spent by the metro to cover this distance is of **1'9"** (information provided by *Metro of Porto*).

The expansion of the residential development is lower in this area, but the medium-density traditional quarter is replaced by the tall high-density collective inhabitations.

From the architectural aesthetics point of view, this part of the corridor benefits both from the existence of the building of VN de Gaia City Hall and from the Barbot House – at General Torres Metro station - which is the finest example of the Arte Nouveau style in Vila Nova de Gaia. The sculptor Alves de Sousa and the masters Baganha and Veloso Salgado were the authors of the project for this valuable house in the beginning of the 20th century.

On the western side of the Avenue, the traditional quarter is taken place by wider parcels, less rectangular texture and less street connectivity. From certain locations in the area the access to Metro stations is difficult due to the poor street connectivity and the physical green barrier – the distance to be covered is around 700-800 meters, which is more than 10 minute-walk distance.

Câmara de Gaia Station Area (Gaia City Hall)

This area is characterized primarily by the existence of the City Hall building which gives the area a high level of centrality. The residential area encompasses mostly high-density buildings of 7-8 story-height. The public open space received a great importance right across the Avenue, on the eastern side in front of the City Hall being surrounded by collective condominiums.

Fig. 29 – 2nd Division of the Republic Avenue corridor: General Torres – Câmara de Gaia, aerial view (Source: http://earth.google.com)

a.

b.

Fig. 30 – a. Public open space and Barbot House at General Torres station ; b. The building of Gaia City Hall.

- **3rd Division: Câmara de Gaia – João de Deus**

The second division of the corridor is the area comprised between the stations Câmara de Gaia and João de Deus. The length of the station is of approximately **400 meters** and the time spent by the metro to cover this distance is of **51"** (information provided by *Metro of Porto*).

João de Deus Station Area

The most important feature in this area is by excellence the *El Corte Inglés* store situated in the vicinity of João de Deus station, an investment of 215 million euros that promises to revolutionize the neighbourhood of the Republic Avenue.

El Corte Inglés opened to public in Vila Nova de Gaia on May, 19. The investment made in Portugal by the Spanish chain promised to stimulate the economic activity in the Metropolitan Area of Porto starting with the supply of 1900 jobs. Also, in accordance with the market studies carried through by the company, the mall will expand its area of influence on a vast market that arrives all the way to the councils of S. João de Madeira, Amarante and Póvoa de Varzim, in a total of 368.000 families.

The building, that alternates rock with glass, dominates the Republic Avenue and is served by the Joao de Deus metro station.

The building has 12.000 square meters of ground-used area and 42.000 square meters of sale area. It encloses 13 levels of which seven above the ground level and six underground being equipped with a wide parking area with a total number of one thousand parking spaces. The building will be surrounded by a pedestrian corridor and a large public space turned towards the Republic Avenue will be opened.

Fig. 31 – El Corte Inglês – perspective (Source: www.jpn.icicom.up.pt)

According to Pedro Gil de Vasconcelos, concerning the accessibility of the area, "everything is almost ready, at least enough for the store to start functioning". The El Corte Inglés will be served by the IC23 (known also as the VCI), whose node with the Republic Avenue has been redefined in order to allow straight access to the parking facility of the building.

The metro, as one of the leading factors that weighed in the choice of the location, arrived at the station João de Deus in December of the last year. The station has been equipped with a tunnel with rolling stairs in order to have straight access to the supermarket.

Meanwhile, the extension of the Yellow Line until Laborim and the construction of the interface are still to be defined.

The opening of the large Spanish store might generate two different moments in the redevelopment of the Republic Avenue. Regarding the Metro and the number of passengers, the opening of El Corte Inglés is like a breath of fresh air for its beneficial functioning since only the number of employees are close to 2000.

As for the surrounding area and the ground-floor retail environment on the Republic Avenue, for the small traders, the huge commercial neighbour represents a real danger and risk to being thrown out of the business.

The residential area consists mainly of high buildings, up to 10 story-height. Most of the area, along the Avenue is considered by the Municipal Directory Plan of Gaia, as consolidated urban fronts. This process of extension and occupation along the links of high centrality and urban density is very common for this types of development. It’s about dealing with multi-functional central axis enhanced by the dynamic constant urban makeover: turning the uses into tertiary and typology substitution from single-family to collective inhabitation.

Fig. 32 – 3rd Division of the Republic Avenue corridor: Câmara de Gaia – João de Deus aerial view (Source: http://earth.google.com)

Fig. 33 – El Corte Inglés at João de Deus Metro Station Area and the residential blocks of flats in the background

- **Transportation**

Requalification of Republic Avenue

As it's known, Gaia does not have a proper developed civic centre, because everything is very dispersed; with the Yellow Line of Metro and the urban planning that its infill causes, the whole area benefit of a major makeover.

During many years, the Republic Avenue was the main access to the city of Porto, crossing the Luis I Bridge.

Today, The Republic Avenue represents a very pressured "spine" for the city, like a structural transportation avenue as all the other streets of the area discharge themselves into this one. The necessity to reorganize the avenue for the passage of the light metro led to the opportunity of rethinking and replanning it from one front to the other.

Between the upper deck of the Luis I Bridge and the junction with the streets Rodrigues de Freitas and Rocha Leão, including also the Jardim do Morro metro station, a pedestrian area has been designed, paved with granite cubes. This decision embraced the idea of giving priority to pedestrians.

Between this junction and the Street of Concelho, the automobiles transit develops on two ways for each direction. Meanwhile, due to the increased usage of Light Rail and the deviation of transit for the highway with access to the Infant Bridge will become hopefully less crowded.

The pedestrians could also be considered winners here, since the width of the sidewalks are to be increased.

Close association of Light-Rail system with land-use integration is the most significant factor for determining its success.

The opening of El Corte Inglés will change entirely the perception of the traffic on Avenue. The mega store will be served by the IC23 (known also as the VCI), whose node with the Republic Avenue has been redefined in order to allow straight access to the parking facility of the building. The closing of the IC23 ring will also be finalized in November 2006, when the tunnel under Soares dos Reis Garden will also open.

Mobility and Evidence of Ridership in Vila Nova de Gaia

The communities, as well as the environmentalists and the urban planners are delighted with the insertion of light rail. Light rail is perceived as an efficient and environmental friendly facility and its success along the corridors can be endorsed to its modern, often futuristic vehicles, perception of reliability, quietness, ease of access, climatic controls and environmentally friendly nature.

Opponents of light rail often claim that buses represent a cheaper alternative to travel. But, at a closer look, this claims melt in almost every case examined. The financial argument of cost advantage comes to support this statement. It is a major fact that, light rail perform a lower cost per passenger than the bus does. It is also important to mention the flexibility of the Andante cards that allow the passengers to change trains or to interchange between light rail and buses of STCP.

Buses, trapped in the increasingly gridlocked streets and freeway traffic, have a hard time keeping their passengers since the Metro is faster and more reliable.

Therefore focusing on the significant developments realized along the Republic Avenue, the question that arises is: *Does the pattern of development show that light rail is an attraction?*

When the community and the authorities consider spending a serious amount of money on a new form of public transport it is important to determine the best appropriate alignment to maximise the potential demand.

As discussed above along with the analysis of the corridor and its neighbourhoods, a detailed evaluation of resident, employment, commercial and residential activities within approximately 400 metres each side of the proposed light rail alignment and associated feeder bus services is needed. Locations for the Metro stations along the Jardim do Morro - João de Deus corridor were selected to maximize access for passengers arriving by bus, private car, bicycle or on foot.

Many light rail researches show that light rail, in combination with attractive land-use developments draw indeed more riders. Close association of light rail with land use integration it is the most significant factor in determining the success of the system. Even the best technically designed and operational system will fail if land uses cannot facilitate an adequate market that would provide enough users to conveniently function.

Stores and goods are classified as either convenience or specialty. Consumers choose handy locations that minimize travel. Even for specialty shopping, consumers generally prefer locations that are as close as possible. This kind of behaviour is a result of the market competition with benefits for the prices, quality, variety, and service that may be spread throughout the metro area.

The numbers used for the case study, kindly provided by the *Metro of Porto* prove the public tendency to be drawn by the Metro system. The opening of El Corte Inglés has represented a significant increase both for the number of work trips – the 2000 new employees - and for the number of non-work trips – visitors – all trips materialized in a high-level percent by the usage of light rail.

There is an important aspect that need to be argued though. After evaluating and comparing the number of validations for all the four stations of the corridor, it's been ascertained that the only station which recorded real evidence of ridership increase was João de Deus. On the opening day, May 19, the number of passenger validations doubled compared to any other working day before the aperture and continued to remain on a high level in the following months. (**Fig. 34**)

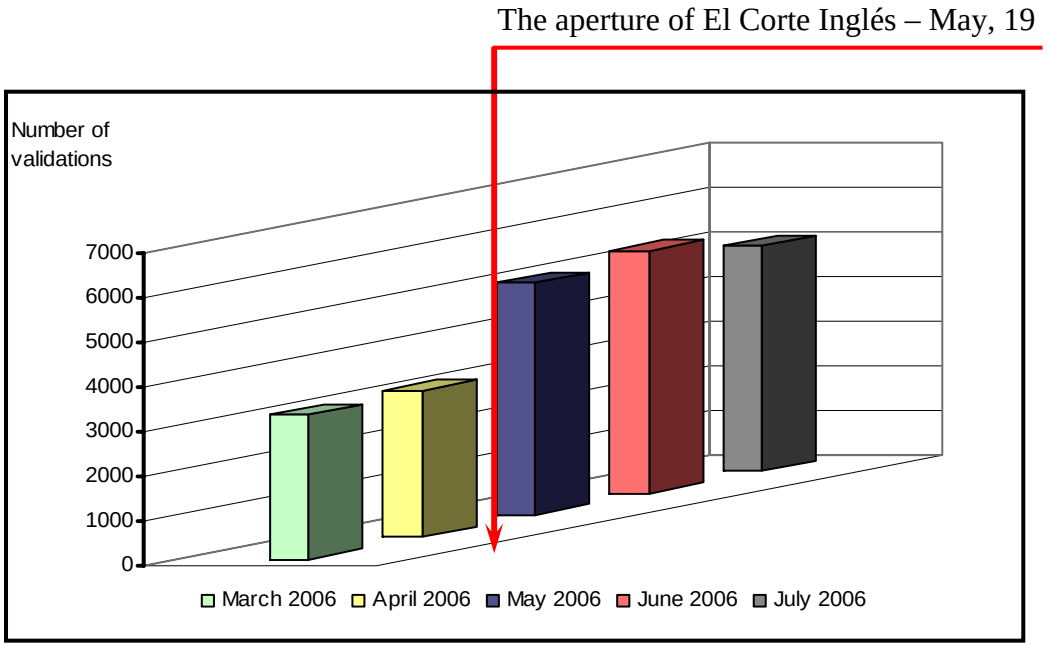


Fig. 34 – Number of Validations at João de Deus Metro Station from March to July 2006, (Source: Metro do Porto, 2006)

What is still considered a concern is the low number of validations that persisted in the other stations even after the opening of El Corte Ingles. The figures in the chart below show the differences between the four stations of the corridor regarding the number of users.

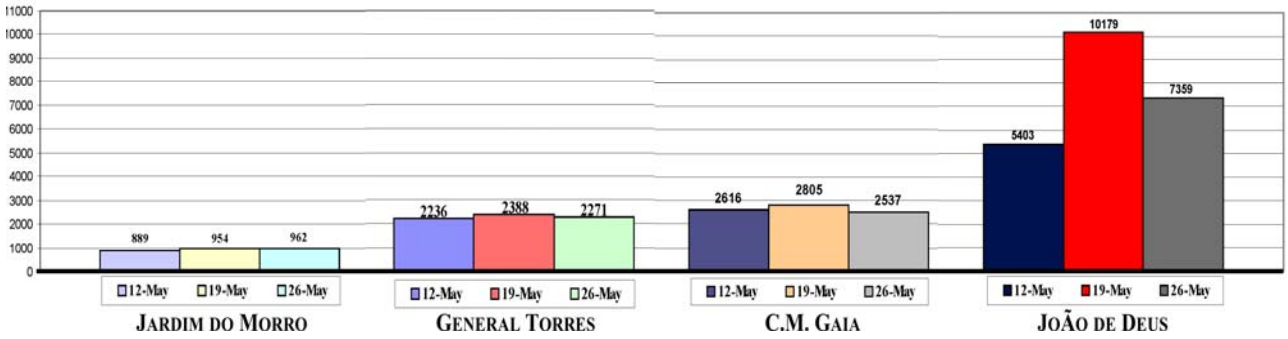


Fig. 35 – Comparison of validations between the four stations before and after the opening of El Corte Ingles (Source of figures: Metro do Porto, SA, 2006)

Hence, the majority of visitors come from the City of Porto, while the residents of Vila Nova de Gaia reach El Corte Ingles in other manner – buses or their own automobiles. The attractiveness of the stations and of the corridor itself still seems to lack significant elements.: affordability, aesthetics, cohesiveness of the retail environment and coordination of station area plans with the surrounding areas.

Mr Francisco Oliveira from the Commercial and Industrial Association of Vila Nova de Gaia, declared that the arrival of the El Corte Inglés "is going to affect enough the commerce, but in a positive way". "I think that the emergence of El Corte Inglés was the best thing that could happen to the establishments located around the shopping centre and in the rest of the City of Gaia", declared Mr Oliveira to the DN, giving as example the fact that many investors would decide to buy spaces in the proximity, "being perceived as a pole of attraction". Confident in this process, Mr Francisco Oliveira stated that "there will be more than a million of euros per month circulating in the City of Gaia, in the barber's shop, in the grocery store. ..".

Public transport dependency within the Yellow Line corridor nearly doubled at Joao de Deus station since the opening of El Corte Inglés on May, 19. The following table is truly eloquent in exposing the increased ridership for João de Deus station and in picturing the situation before and after the opening of El Corte Inglés. This comes to support the initial statement that Light Rail investment, together with well designed station areas can be used as catalysts for redevelopment.

Table 17 – Number of validations at the four stations of the corridor from March to July on selected working days and on selected week-ends (Source of figures: Metro do Porto SA, 2006)

				JARDIM DO MORRO		GENERAL TORRES		C.M. GAIA		JOÃO DE DEUS	
			Total Validations / Day (all the metro lines)	Number of validations	% of the Total Validations / Day	Number of validations	% of the Total Validations / Day	Number of validations	% of the Total Validations / Day	Number of validations	% of the Total Validations / Day
	Saturday	25-Mar-06	**54274**	386	1%	745	1%	1151	2%	1744	3%
MARCH	Sunday	26-Mar-06	**40041**	252	1%	489	1%	688	2%	1159	3%
	Friday	31-Mar-06	**128351**	885	1%	2108	2%	2741	2%	4584	4%
	Friday	28-Apr-06	**132195**	935	1%	2312	2%	3328	3%	4251	3%
APRIL	Saturday	29-Apr-06	**67547**	603	1%	907	1%	1597	2%	2351	3%
	Sunday	30-Apr-06	**77342**	602	1%	1123	1%	1708	2%	2194	3%
	Friday	12-May-06	**138538**	889	1%	2236	2%	2616	2%	5403	4%
	Saturday	13-May-06	**75346**	549	1%	955	1%	1259	2%	3194	4%
	Sunday	14-May-06	**49652**	437	1%	611	1%	749	2%	1603	3%
	Friday	19-May-06	**149984**	954	1%	2388	2%	2805	2%	**10179**	**7%**
MAY	Saturday	20-May-06	**75934**	541	1%	1034	1%	1280	2%	**6925**	**9%**
	Sunday	21-May-06	**41570**	286	1%	472	1%	693	2%	**2535**	**6%**
	Friday	26-May-06	**142120**	962	1%	2271	2%	2537	2%	**7359**	**5%**
	Saturday	27-May-06	**81855**	530	1%	1018	1%	1170	1%	**5841**	**7%**
	Sunday	28-May-06	**55064**	350	1%	652	1%	724	1%	**1983**	**4%**
	Saturday	24-Jun-06	**110930**	2094	2%	1333	1%	1127	1%	3705	3%
JUNE	Sunday	25-Jun-06	**45590**	368	1%	461	1%	683	2%	2028	4%
	Friday	30-Jun-06	**134158**	752	1%	2246	2%	2502	2%	6457	5%
	Saturday	22-Jul-06	**66232**	412	1%	831	1%	953	1%	3960	6%
JULY	Sunday	23-Jul-06	**46780**	376	1%	486	1%	588	1%	1584	3%
	Wednesday	26-Jul-06	**120605**	671	1%	1824	2%	2036	2%	5803	5%

4.3. LESSONS LEARNED FROM THE CASE STUDY

There are exceptional issues that need to be addressed in order to develop and maintain an attractive and an economically successful light rail corridor and a transit-oriented area. The character and the intensity of the relationship born between the main elements of the projects - the Metro and the surrounding areas -, the process generating them and the recommended conditions conducive to the tools that can be used to encourage their integrated corroboration.

The development initiative has to be concerned with the urban design guidelines as well as with the transportation system well-functioning. The implementation has to receive favourable signs from the involved stakeholders. Planners and professionals in the Metropolitan Area of Porto must understand the importance of building a united front to coordinate activities across jurisdictional boundaries.

Development around public transport stations continues to unfold in a largely ad hoc fashion and the lessons to be learned from their implementations are essential for further case studies.

Light rail investments may become catalysts of redevelopment for the areas where they are to be implemented. The Metro insertion in the Metropolitan Area of Porto is not seen as just another transportation alternative for the city, but it is perceived as a provider of the necessary tools to reshape and redevelop different areas. As for Vila Nova de Gaia, developing the Republic Avenue might provide the city with a civic centre that never possessed. Once a low commercial and services corridor, the Republic Avenue might become one of the most populated and dense commercial and services centre with high positive effects on land value and tax revenues.

The mixture of uses promotes and encourages a balanced public transport system. Mixed – use developments at and around public transport stations co-working with the newly organized residential areas will lead to an increased exploitation of public transport trying to balance the trips to and from the locations inside the studied area – avoiding the arrivals and departures from the same place and at the same time.

Density, Diversity and Design support public transport use. If the further development of the project will focus on dense, mixed-use infill then, no doubt the increased choices for residents and visitors of the Republic Avenue area will be a real benefit. This kind of development produces fewer vehicle trips and more public transport ridership.

Urban design guidelines are an integral part of the development project, therefore good urban design and attractive pedestrian environment is necessary. Considering the analysis conducted in the area and the experience with other urban areas, retail becomes one of the most difficult parts in reaching a coherent urban environment. In the present the correlation between different shop-windows along the Republic Avenue as well as the quality of materials or colours are issues that impetuous need future improvements.

A lot of thought should be given to which kind of shop must go where, how they relate to other shops, to the street and to the light-rail station. Pedestrians that will pass before the shops during the day or the night are to be taken into consideration.

All these constraints turn the mission of creating a successful mix of uses into a difficult one. The emergence of El Corte Inglés on the Republic Avenue brought the competition with the surrounding business community – retail, services and offices. Detail is important for Transit-Oriented Development. Therefore, small developers are important for the projected areas.

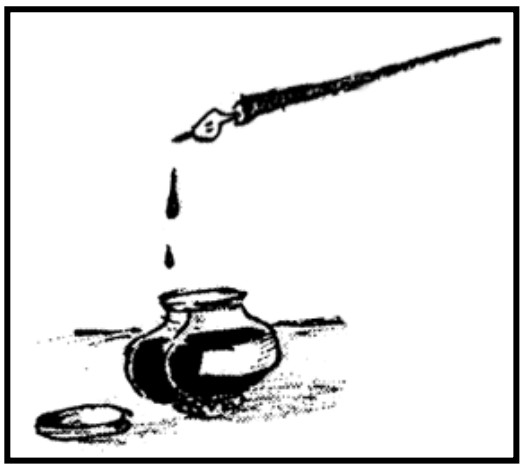
A Transit-Oriented Development in Vila Nova de Gaia takes time to develop. This kind of development must be carefully integrated into their surrounding areas. If it does not provide an interesting and walkable environment as well as good pedestrian and bicycle connections, to the neighbouring areas, it could become an isolated island or a simple corridor in the city of Gaia. Its importance for the city and for the rest of the public transport system could thus be diminished, decreasing ridership leading to a lack of attraction for tenants, shoppers or visitors.

05

CONCLUSIONS AND RECOMMENDATIONS

Today, transportation systems became indispensable to any location. People yearn for convenient, cost-effective means of access to the places they live, work, and shop. Unfortunately, the automobile is still, by far, the most frequently used transportation mode, but public transportation services fight to provide extensive mobility and access, based on land-use patterns that ensure sufficient ridership to make the service cost-effective.

Mixing insights and findings from the previous chapters, this final chapter incorporates the final, concluding key issues of Transit-Oriented Development, based on studies and argumentations concerning the configuration and parameters for this kind of developments.



5.1 GENERAL RESEARCH FINDINGS

Mixing insights and findings from the previous chapters, this final chapter incorporates the final, concluding key issues of Transit-Oriented Development, based on studies and argumentations concerning the configuration and parameters for this kind of developments.

Today, transportation systems became indispensable to any location. People yearn for convenient, cost-effective means of access to the places they live, work, and shop.

Unfortunately, the automobile is still, by far, the most frequently used transportation mode, but public transportation services fight to provide extensive mobility and access, based on land-use patterns that ensure sufficient ridership to make the service cost-effective.

Public transport can influence urban form, and the design of the urban environment can encourage public transport use and reduce dependence on the automobile. This relation of land-use characteristics to public transport system is considered the key gearing for Transit-Oriented Development.

TOD has gained and continuously gains a steady and important position in the urban environment, in the continuous and rapid growth of the metropolitan areas. It is perceived as a tool of promoting smart growth.

TOD is widely defined as compact, mixed-use development near transit facilities with high-quality walking environments, not necessarily at the expense of automobile access (Cervero, 2004).

This kind of development owns the power of easing a broad spectrum of urban situations, such as traffic congestion and sprawl, pollution, long and endlessly commutes, lack of housing, retail and services choice. It can enhance quality of life for the community and bring benefits for the developers.

But the performed research has shown that a fair amount is known about the inputs of TOD and less is known about the outputs and the final results on ridership or traffic conditions. Therefore, case-studies continue to be relied upon in order to develop knowledge and understand Transit-Oriented Development (TCRP, 2002).

5.2 ISSUES OF AGREEMENT AND DISAGREEMENT

Among the most significant issues that Transit-Oriented Developments rely upon, emphasis is given to the following:

- **TOD's Definition and Its Stated Goals**

Given the number of stakeholders involved, the stated goals of Transit-Oriented Developments tend to vary, differently prioritised depending on the achievements that every involved stakeholder aims. They bring different goals to the table, pursue strategies that work at cross-purposes to each other, and finally, they lack unifying policy objectives (Beltzer and Autler, 2002).

Nevertheless, the stakeholders have adopted fairly similar definitions. There is a common ground for TOD to reach a complex functional integration of public transport system and the surrounding developments, as well as the synergy among all the implemented uses. The definitions are spinning around smart growth principles, calling for mixed-use developments and high-quality walking environments that support public transport ridership. Most of them support the idea that intensification of land-use will positively impact on public transport ridership. Even so, the mixture of uses turned into an issue of dispute.

Even if Transit-Oriented Development has been a frequent topic of discussion among developers and planners during the last years, many of them still shy away from TOD. As in every project that involves mixed land-use, there is a noticeable higher degree of risk involved, than simply building single-use zoning out of the metropolitan areas.

As a result, many of past implemented TOD projects have often favored immediate financial reimbursement and have failed in delivering long-term motivations for success.

There is also a high risk reflected by the tension between place an node. The discussion raised by this challenge makes clear, the multitude of actors and goals to be found in any TOD project. This turns the integration of node and place into an extremely difficult issue. Some actors see their interests as closely connected to the role of a station area as a node while others are more concerned about the quality of the place.

Properly addressed, these tensions do not necessarily have to engender conflict or suboptimal outcomes.

- **Misconceptions and Impediments**

Planners are now looking toward the future, eager to apply the lessons learned in the past and to improve the established standards and processes, in order to turn Transit-Oriented areas into fully functional areas. Some factors and some common misconceptions stood as impediments to TOD.

The idea that *it's all about proximity* of uses without full cooperation and integration between them, led to the failure of some TOD projects. Simply building a mixed-use environment near a Metro station does not ensure the project's success. Instead, the uses must be tightly mingled with the station, with logical pedestrian traffic flow, ample public spaces and thoughtful scale.

Good planning and design can go a long way toward achieving this goals by creating the messy vitality of a traditional main street, truly building a community hub, and strengthening the symbiotic interaction of uses with each other and with the transit stop.

Public transport alone is not a sufficient achievement to have a significant impact on the city development patterns, on car dependency, on real estate markets and on transportation behaviour. The careful mixture of demographics, facilities, housing, their locations as well as the market demand must be well placed and mingled, in order to fully capitalize on the benefits of public transport presence. So, *it's not all about public transport*.

One size fits all is also a nature of approach that does not ensure the success of the process. If a TOD project works in one location that does not mean that it could successfully work elsewhere. Problems might occur when communities go through the long process of implementing light rail transit if this process is focused around transportation and engineering alone. Creating exciting and memorable places geared to market-based success and pedestrian interest are what ultimately lead to great ridership.

TODs always base on synergy of uses and on public transport. But achieving this synergy is not an easy thing to do. As a result, TOD almost always involves more complexity, uncertainty, and higher costs than other forms of development. The transportation system, station access routes - buses, taxis, cars, bicycles and pedestrians infrastructure – as well as the surrounding development need to interface with each other, but the necessary process to link all these parts together into a single well functioning system place remains extremely complex.

- **Benefits of TOD**

If successful, Transit-Oriented Developments will generate the development of the area where implemented, speeding up the transition of places suffering from slow commercial advancement, contributing to the design of a more sustainable urban form. TOD supports public transport usage and also induces walk and bicycle trips to and from public transport station as well as to and from the uses surrounding the station.

The research findings support the idea that any increase in land-use will have positive impacts on public transport ridership. Research conducted in this field showed that people living near public transport stations tend to use public transport facilities to six times more often than their counterparts who live further away from them. Development of mixed-uses and improvement of pedestrian environment could raise these market shares even more. But auto dependency also functions within high rates making the projects vulnerable to traffic congestion problems. TOD users are more likely to use public transport if the time benefit is increased compared to travelling via highways using the personal automobile, if there is a pedestrian friendly activity.

Many other positive impacts could be witnessed if the implementation of TOD occurs successfully:

- Opportunities for new tax base could be achieved.
- Employment and retail would be added, as well as more residents.
- Housing would be available and would give residents a broader spectrum of choices.
- There would be more connectivity throughout the corridor, applying to all modes of travel, including walking, bicycling, automobile, and public transport.
- TOD is time-saving and increased accessibility.

Theory says that these benefits positively influence land value and market rents.

The major increase in developing new light-rail corridors over the last decades has fostered today's interest in Transit-Oriented Developments. The ever changing retail market is characterized today by considerably more diversity and opportunity than ever before. The consumers' array of choices for household needs, leisure-time pursuits, and other personal activities is larger now. Light rail implementation is favourable and encouraging for this residential needs.

Public transport and mainly light rail provide increased accessibility if the service is reliable, with high frequency and covers a large area. These characteristics, together with the design elements at and around the station that determine its integration into the neighbourhood, significantly influencing the residential values.

This study drew lessons from the body of materials encountered and from the contemporary practice across Europe or United States. Since lessons cannot be easily adopted from one location to another, some “bits and pieces” are likely to be relevant in most of the cases.

Transit-Oriented Development is a two way street regarding the impacts and benefits of its final urban form. This synergy developed between land-use and transportation provides the area with a range of benefits. Reliable and quality public transport confer value premium to residential and commercial properties, stimulating also the intensity of development at and around station areas while high-density mixed-use land provide users for light rail generating bidirectional flows and discouraging the use of cars. Even under these conditions the two elements are not self sufficient for generating growth without strong market forces and supportive policies.

- **Final Considerations**

Over the past two decades, a large number of communities have embraced the idea of light rail and the associated development of Transit-Oriented areas, as part of refreshing strategies for the cities. This way, Light Rail has become a tool for moving people and building new communities.

Capturing the opportunities and benefits of TOD has important implications for the planning, design, and implementation of Light Rail systems. TOD is perceived and defined in various manners, but common issues remain significant: compact and mixed-use development with high quality walking environments at and around public transport facilities. This kind of synergic development aims to enhance ridership.

Implementing TOD should always start with a vision for the long-term development and further proceeds with station-area planning and the appropriate zoning. One of the learned lessons during the implementation process was that spatial proximity is not enough without assuring that the walk between an infill project and a station portal is safe and very attractive –gathering together convenient shops and service retailers.

Many obstruction stand in the way of TOD: higher costs, risks in the mixture of uses, difficulties in lining up funding, investors, and contractors. Vertical mixing is particularly problematic, most of developers would rather use horizontal mixing instead (Cervero, 2004).

In the end, the potential benefits of TOD are social, environmental and financial. It could be an valuable tool in fighting and stopping sprawl, in reducing traffic congestion and in expanding housing choices. But the most direct and significant benefit is the increased ridership and its associated revenues.

To extend the theoretical insights, case studies are needed. They provide valuable information that give further lessons to planners.

Last years played an important role for the progress of understanding and handling Transit-Oriented Development, if it works and how it works, what are the weak elements and what are the necessary prerequisites necessary to efficiently control land-uses around stations.

REFERENCES

Books and papers

1. Arrington, G.B. *Light Rail and the American City.* Portland, Oregon: 9th National Light Rail Transit Conference, 2003

2. ARUP and N. Nygaard. *Intermodal and Terminal Access Study - Terminal Good Practice Design Guidelines.* ARUP, November 2001

3. Belzer, D. and G. Autler. *Transit Oriented Development: Moving from Rhetoric to Reality.* Washington, D.C.: The Brookings Institution Center on Urban and Metropolitan Policy, 2002.

4. Bermudez, A. and al. *Avenue 26: Re-connecting a Community.* Los Angeles: University of California, Spring 2003

5. Calthorpe, P. *The Next American Metropolis: Ecology, Community and the American Dream.* Princeton: Princeton Architectural Press, 1994.

6. Center For Transit-Oriented Development. *Hidden in Plain Sight – Capturing the Demand for Housing near Transit.* Reconnecting America and the Center for Transit-Oriented Development, September 2004

7. Cervero, R. and J. Landis. *The Transportation – Land Use Connection Still Matters.* Research at the University of California Transportation Center, Access No. 7, Fall 1995

8. Cervero, R. *Meeting Mobility Challenges in an Increasingly Mobile World: An American Perspective.* Paper prepared for Conference on Cities on the Move, Paris, June 2001

9. Cervero, R., C. Ferrell and S. Murphy. *Transit-Oriented Development and Joint Development in the United States: A Literature Review*. TCRP Research Results Digest Number 52, National Research Council: Washington, D.C. 2002.

10. Cervero, R., S. Murphy, C. Ferrell et al. *Transit-Oriented Development in the United States: Experiences, Challenges and Prospects.* Washington: Transportation Research Board. 2004

11. Cervero, R. and P. Bosselmann. *An Evaluation of the Market Potential for Transit-Oriented Development Using Visual Simulation Technique.* Berkeley, CA: National Transit Access Center; Institute of Urban and Regional Development, September 1994

12. Cervero, R. *The Planned City: Coping with Decentralization – an American Perspective.* Paper prepared for presentation at the Workshop on the Planned City – International Conference on *Cities on the Threshold of the 21st Century.* Utrecht, The Netherlands, April 1998

13. Compin, N.S. *The Four Dimensions of Rail Transit Performance: How Administration, Finance, Demographics and Politics affect Outcomes.* Dissertation, Doctor of Philosophy in Urban and Regional Planning. University of California Irvine, 1999

14. Crane, R. *The Impacts of Urban Form on Travel.* Lincoln Institute of Land Policy, 1999

15. Dittmar, H. and G. Ohland. *The New Transit Town. Best practices in Transit-Oriented Development.* Washington, D.C.: Island Press, 2004

16. Dow, A. *Metro Transit-Oriented Development Program. Improving Accountability Through Enhanced Measures of Service Efforts and Accomplishments.* Portland, March 2001

17. Edwards, H.R. and C.G. Phillips. *Delineating and Integrated, Multifaceted Light Rail Corridor for Northeast Baltimore City*. Portland, Oregon: 9th National Light Rail Transit Conference, 2003

18. European Conference of Ministers of Transport. *Implementing Sustainable Urban Travel Policies – Final Report.* France, 2002

19. Gilbert, D. and S. Ginn. *Transit Oriented Sustainable Development.* Queensland Department of Public Works for: The National Taskforce on Promoting Best Practice in Transport and Land-Use Planning, August 2001

20. Ginn, S. An Overview of Light Rail Technology and its Potential within an Australian Environment. Western Australian Planning Commission, August 1998

21. Giuliano, G. *The Weakening Transportation – Land Use Connection.*, Research at the University of California Transportation Center, Access No. 6, Spring 1995

22. Gordon, P. and H. Richardson. *Transportation and Land Use.* Forthcoming in: Holcombe, R and Staley, S. *Smarter Growth: Market-Based Strategies for Land Use Planning in the 21st Century.* Westport, Connecticut: Greenwood Press, 2001

23. Graham, S. and S. Marvin. Splintering Urbanism – networked infrastructures, technological mobilities and the urban condition. New York: Routledge, 2001

24. Hague, C. *Transit Oriented Development: Transnational and National Actions within Europe.* International Planning Symposium on Incentives, Regulations and Plans – The Role of States and Nation States in Smart Growth Planning. The Netherlands: National Center for Smart Growth Research and Education, University of Maryland, Habiforum Foundation

25. Hendricks, S.J. *Impacts of Transit Oriented Development on Public Transportation Ridership. Final Report.* University of South Florida: Center for Urban Transportation Research, August 2005

26. Kockelman, K.M. *Travel Behaviour as a Function of Accessibility, Land Use Mixing and Land Use Balance.* Thesis of Master in City Planning, Berkeley: University of California. 1996

27. Lund, H., R. Cervero, and R. Willson. *Travel Characteristics of Transit-Oriented Development in California*. Caltrans Transportation Grant “Statewide Planning Studies”. 2004

28. The Maryland-National Capital Park and Planning Commission. *New Carrollton Transit-Oriented Development Strategy Planning Study*. Washington Metropolitan Area Transit Authority, November 2004

29. Metro do Porto S.A. *Relatório e Contas 200*5.

30. National Cooperative Highway Research Program. Research Results Digest No. 294, *Transit-Oriented Development: Developing a Strategy to Measure Success*. February 2005

31. Nelson, D., J. Niles and A. Hibshoosh. *A New Planning Template for Transit-Oriented Development.* San Jose: Mineta Transportation Institute, 2001

32. Nelson, D. and J. Niles. *Enhancing Understanding of Non-Work Trip Making – Data Needs for the Determination of TOD Benefits.* Washington D.C.: Transportation Research Board, 1999

33. O'Sullivan, S. and J. Morrall. *Walking Distances to and from Light-Rail Transit Stations*. Transportation Research Record No. 1538, Pedestrian and Bicycle Research. Washington D.C.: Transportation Research Board, 1996

34. Porter, D. et al. *Transit Focused Development* Transit Cooperative Research Program, Transportation Research Board, Washington, D.C. : National Research Council, 1996

35. Porto Sempre – Revista da Câmara Municipal do Porto, no.6, Outubro 2004

36. Purvis, C.L. *Incorporating the Effects of Smart Growth and Transit Oriented Development in San Francisco Bay Area Travel Demand Models: Current and Future Strategies.* California: Planning Section – Metropolitan Transportation Commission, November 2003

37. Renee, J. and J. Wells. *State of Literature: Transit-Oriented Development*. Voorhees Transportation Policy Institute, December 2002

38. Renee J.L , J.S. Wells et al. *Transit-Oriented Development: Developing a Strategy to Measure Success*. Research Results Digest 294, February 2005

39. RICS. *Transit Development Area – guide to good practice.* Coventry, UK: Royal Institution of Chartered Surveyors. 2000

40. South East False Creek Development Plan , July 2005

41. Transit Cooperative Research Program. Report 16 – *Transit and Urban Form, Volume 1,Part I: "Transit, Urban Form, and the Built Environment: A Summary of Knowledge"; Part II: "Commuter and Light Rail Transit Corridors: The Land Use Connection"*, Transportation Research Board, Portland, OR: Parsons Brinckerhoff Quade & Douglas, INC.

42. Transit Cooperative Research Program. Report 95*: Land Use and Site Design – Traveler Response to Transportation System Changes.* Washington, D.C.: Transportation Research Board, 2003

43. Van Acker, V. and F. Witlox. *Exploring the Relationships Between Land-Use Systems and Travel Behaviour Concepts: Some First Findings.* Solstice : An Electronic Journal of Geography and Mathematics, 2005

44. White, S.M. and McDaniel, J.B. *The Zoning and Real Estate Implications of Transit-Oriented Development.* TCRP Research Results Digest Number 12, National Research Council: Washington, D.C. 1999.

Internet sites

1. APOR – Agência para a Modernização do Porto: www.apor.pt
2. Jornal de Notícias: http://jn.sapo.pt
3. Gaia City Hall: www.cm-gaia.pt
4. Metro do Porto, S.A.: www.metrodoporto.pt
5. Porto City Hall: www.cm-porto.pt
6. Sociedade de Transportes Colectivos do Porto (STCP): http://www.stcp.pt
7. TRANSDEV - Desenvolvemos Mobilidade: www.transdev.pt
8. Transportes Intermodais do Porto (TIP): http://www.linhandante.com
9. Arlington County Department of Community Planning, Housing and Development, Planning Division, Master Planning Team - http://www.co.arlington.va.us/cphd/planning
10. Institute for Sustainability and Technology Policy, Murdoch University, Australia: http://www.sustainability.murdoch.edu.au
11. Google Earth: http://earth.google.com

PPT Presentations

1. Bernstein, S. *Moving Toward TOD – An Emerging View of a Performance-Based System.* Congress for New Urbanism, June 2004
2. Poticha, S. *Building Community with Transit.* Center for TOD – Reconnecting America, 2003
3. Leach, D.M. *Rosslyn – Ballston Corridor, Arlington – 30 Years of TOD – Community Outcomes and Performance Measurement.* June 2003