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Thesis Title:

Assessing Urban Rail Transit Ridership and System Sustainability in Los Angeles and Rotterdam

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Executive Summary

As current trends show urbanization of metropolitan areas increasing, so too, does the amount of automobiles congesting the urban fabric of cities around the world. This has been created as society sprawls toward the periphery for cheaper land with longer commutes toward the economic center. Local government then, constructs public transit infrastructure in an effort to decrease automobile use around its surrounding region. As infrastructure projects are completed, there still lies a congestion problem within and around the urban region with most governments increasing recurring highway expansion to cater to society. Urban rail transit has shown the ability to provide for the mobility needs of large urban regions with the help of contingent multi-modal policies and measures. Coupled by a societal modal choice selection of the private automobile, this studies main objective is to assess the ways that local governments and transit authorities can implement specific policies and strategic measures toward increasing urban rail transit ridership in Los Angeles and Rotterdam. This international comparison will drive further analysis and information regarding the differences between American and European transit planning practices.

In order to establish a well formulated research structure, the following study has utilized literature documents such as policy referendums and contextual studies from local, regional, and national governments as well as in-depth interviews of government and transit authorities. This triangulation approach of various authorities and levels of such has warranted a case for solid research results and findings.

In order to gain a comparative perspective of such urban rail transit systems in Los Angeles and Rotterdam, a set of criteria are explained. The LA Metro system currently operates 2 heavy rail and 3 light rail lines with average total weekday boardings consisting of 301,501. Rather, Rotterdam's RET system consists of 5 heavy rail and 9 tram lines averaging weekday ridership of 509,600. With an urban population 16% the size of LA, Rotterdam outperforms urban rail transit ridership by 70%. These numbers have been accomplished through indicators (policies and measures) drawn out within this studies conceptual spider models. The major findings that have shown to increase ridership have been granted toward the use of parking standards, transit oriented development, fare pricing, and mobility management. LA has achieved a 16.7% increase in urban rail transit ridership over the past 5 years from 2006-2010, but still has yet to achieve higher levels as in Rotterdam. With varying governmental and transit authority levels, Rotterdam has accomplished a greater coverage and modal choice selection over LA. As LA consists of a single transit agency, future increases toward urban rail transit ridership can be accomplished with great success. Congruently, a sustainability assessment as to each cities rail systems was conducted and has shown that Rotterdam's choice in purchasing electricity from a company that produces 100% renewable energy has provided great benefit for future generations in an effort to achieve their goal of a 50% reduction in emissions by 2025. Congruently, LA is also attempting to tackle climate change through expensive internal measures that have concluded costly in nature with little change toward a climate difference.

Overall, for Rotterdam to achieve further increases in urban rail transit ridership, policies and measures along with minimal infrastructure can be the solution as current rail infrastructure supply are apparent and working well. As with the case of LA, the need to couple increased rail infrastructure supply with policies and measures that lead toward a multi-modal split for system integration are critical in the coming years. In the end, policies and measures are never going to be enough, but rather warrant the need for a systematic connection with infrastructure implementation and placement to reach a more sustainable public transport system in the future.

Acknowledgements

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Another big thanks goes out to all of the staff and government officials interviewed in Los Angeles and Rotterdam. The information collected and gained was invaluable toward my research and personal knowledge. I have learned a tremendous amount in urban rail transit and how government procedures are a complex and difficult issue to deal with.

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Foreword

Increasing public transit ridership, and even more so for urban rail systems, is becoming a priority for cities all over the world today. Urban rail transit ridership not only provides a funding mechanism to amplify the supply of such transit, but also creates an inherent social stigma that travels throughout society. Currently, the city of Los Angeles, CA degrades itself with heavy car use and a public policy toward that of the private automobile. Likewise, the city of Rotterdam, the Netherlands is inching closer to auto dependency with increased and stagnant congestion levels. This earth that we live in cannot sustain the current loads of emission levels and conditions that are brought upon it. As such, the basis for increasing ridership is a means to alleviate congestion, increase environmental health conditions, create mobility mechanisms for disadvantaged citizens and enable social equity among such diverse cities, while the list goes on. Ridership is often seen as a scapegoat for public authorities to implement such projects based on political wants and desires; namely economic growth. With diverse government authorities deficient to provide funds for projects, increasing transit ridership through policies and measures has proven heavily effective in numerous cities around the world. Congruently, various studies have proven that increasing transit capacity (infrastructure supply or frequency) are at the apex of ridership increases. As revealed throughout this study, various transit agencies have shown great success toward increasing rail transit ridership in numerous methods such as service improvements, marketing campaigns, mobility management, innovation and technology and housing density standards, among others. The overall design of this study is to gain an understanding as to the methods and approaches for increasing urban rail transit ridership and system sustainability through effective policies and strategic measures.

Abbreviations

BRT –Bus Rapid Transit

CBD –Central Business District

DRIFT –Dutch Research Institute For Transitions

dS+V –Urban Planning Department of Rotterdam

GHG –Greenhouse Gas

HRT –Heavy Rail Transit (Subway/Underground Service)

LA –Los Angeles

LRT –Light Rail Transit

METRO –Los Angeles County Metropolitan Transport Authority (aka. MTA or LACMTA)

MSA –Metropolitan Statistical Area

NL –Netherlands

PROV -Platform Reizigersbelangen Openbaar Vervoer (Platform for the Interest of Travellers)

RET –Rotterdamse Elektrische Tram (Rotterdam Public Transport Company)

SRR –Stadsregio Rotterdam (Rotterdam Metropolitan Planning Agency)

TDM –Transit Demand Management

TDR –Transfer of Development Rights

TOD –Transit Oriented Development

US/USA –United States of America

Keywords:

Transport, Urban, Rail, Ridership, Policy, Rotterdam, Los Angeles

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Chapter 1: Introduction

> "We are often not aware of the ideological blinders that we wear because of our presence in a particular culture at a particular time and the particular training and experiences we have had."
>
> -Kramer (Policy Analysis as Ideology 1975)

1.1 Background

Public transportation is, and should be at the 'heart' of any city today. For decades, people around the world have enjoyed public transportation's ability to offer affordable, timely, and succinct transportation to various destinations around its urban region. Without it, some cities such as New York, Tokyo, Beijing, and Amsterdam could not function. A common misconception of public transit is the increased amount of time it takes to arrive to a specific destination contrary to the personal automobile. Done right, public transit has the ability to be faster and timelier. Public transit has an inherent capability to transport more passengers in a shorter amount of time due to the travel demand of the system. This in turn can alleviate many traffic induced problems (environmental impacts, congestion, photochemical smog, etc). The problem that most cities run into today is the ability to increase their public transit ridership levels. Focusing on a large segment of the public transit market, urban rail symbolizes the heart of any major public transport system. While buses, and even bicycles, can become the 'veins' of the system due to more flexibility, it are the rail systems that transport the bulk and heavy use of its patrons. Public transportation is known in the United States by some to be a inferior way of travelling. Rather, in Europe or Asia, you might see executives and corporate managers riding the train or light rail to work everyday of the week. If you look back at any great city today, you can see how it has been formed by the involvement and implementation of its transportation network. In Europe, you will most often find a public transit connection automatically, while in the United States, there would be new access roads leading toward the new development.

This research will be conducted to assess how effective policy implementation and strategic measure execution can increase public transportation ridership in the greater Los Angeles, California area through the model of Rotterdam, the Netherlands. This study contains multiple elements: first, the current running performance of rail systems in LA and Rotterdam, second, how effective policies and strategic measures affect ridership levels, and third, the assessment of multiple sustainability criteria of the system. The reason for a comparative study between LA and Rotterdam is to link European and American transportation planning practices and what they have in common and in difference. Since the United States, especially on the West Coast, is lacking in public transportation infrastructure and ridership, this study will bring to light some laconic insights that will enable others to see what an international contextual assessment can do to help cities attain sustainable rail transportation. If the answer to these hypotheses can be found, it will open up an alternative future for what many call the freeway capital of the world. Public transportation is for all people, not just the lower income, disabled, and elderly. At the least of these, this study will give policy makers and public officials a reason to think twice about what types of transportation infrastructure to implement and how urban rail transportation can bring a healthier living standard to their city and to the people that it affects.

1.2 Problem Statement

The Los Angeles Metropolitan Statistical Area is currently the largest metro area in California and second largest in the United States, only behind New York City. With a conurbation of nearly 13 million inhabitants (United States Census Bureau 2010), LA only transports approximately 301,000 public rail transit riders a day. (Metro 2011b) Due to the continued growth and urbanization rate of the region, it is imperative that LA find a link that can bridge the gaps between automobile usage and public transit ridership. As the days, months, and years pass, serious implications are affecting this world that we live in due to traffic congestion and automobile use. Congestion does not only include pollution as a negative externality, but wasted money, gas, time, and maybe most important and immeasurable, family moments. Below is a graphical representation of the LA region with the number of freeways and the hours per week a given freeway section is congested. Also located below, is a matching schematic of the current urban rail system.

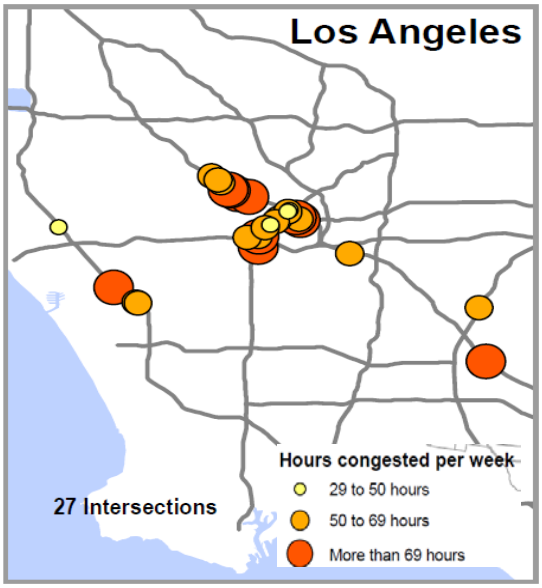

Figure 1: LA's Most Congested Freeways
(Rodrigue & Field 2006)

Figure 2: LA's Rail Infrastructure
(Metro 2011c)

As you can see above, the location of automobile congestion matches closely the location where the public urban rail system operates. This was the identifying factor and ultimate reason for why this study is being conducted. Overwhelmed by many cities today, traffic congestion and public transit projects are capturing the headline of national and regional political battles. Los Angeles, California currently boasts one of the worst traffic congestion and public transit problems in the United States today. (Rodrigue & Field 2006) On the contrary, Rotterdam, the Netherlands has immersed itself into a public transit oriented culture. Transportation infrastructure, and more importantly in the urban sector, has the ability to change society in ways that can create robust economic advantages, strengthened social networks, and enable cleaner environmental conditions. Transportation as a whole alters economies, cities, health, air quality, and growth. This is by no means an exhaustive list. It cannot be without these factors that change the way transportation functions in and around urban cores. Shown below is a current schematic of Rotterdam's metro and tram lines to give a perspective on accessibility of rail transportation in the Netherlands.

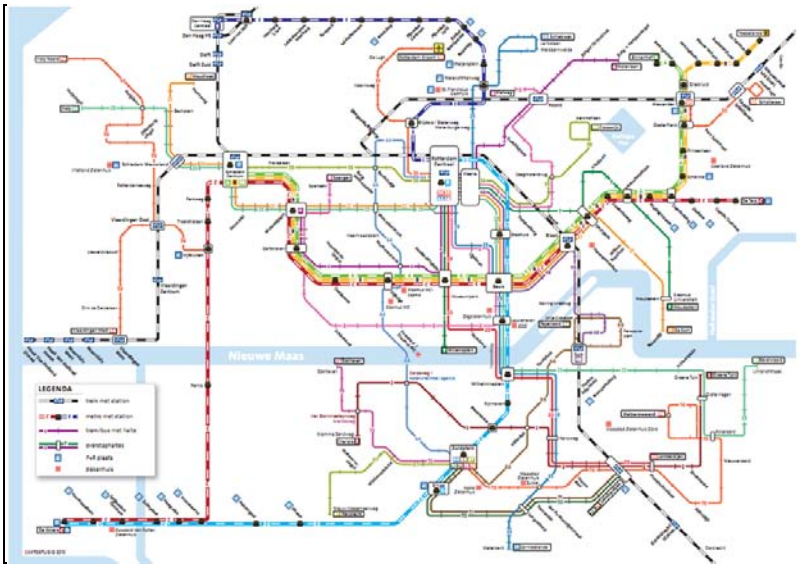

Figure 3 Rotterdam Metro, Train, and Tram Map
(RET 2011a)

What is the correlation of Rotterdam's extensive rail network with a regional population of 2.1 million inhabitants and LA's devolved rail network with a population of nearly 13 million?

As the focal point of this thesis, we look toward the current struggles of Los Angeles and the successful implementation of Rotterdam in how urban rail transportation systems can either provide quality, accessible, and affordable public transportation, or stand idle by while drivers sit alone in their automobiles during the morning and evening rush hours.

Rail transportation modes have evolved over the years to envelop complex systems of light rail, commuter rail, heavy rail, and more recently, high-speed rail. Rail transportation has been both prevalent and the main transportation mode in both the Netherlands and United States during the 20th century. It was not until the mid-1900s that car ownership became a driving force to stop the service of rail transportation in LA. People were willing to increase versatility and independence while sacrificing increased automobile costs. Because of car ownership, rail service had ceased and did not appear again in LA until the early 1990's due to community and environmental action, among others (Richmond 2005). You might ask why the drive for rail transportation after 30 long years? Well, the simple answer is; congestion. Automobile dependency is negatively affecting cities all over the world today. As LA has proved to be one of the worst, but best examples of this, my study will focus on some possible ways to alleviate the current traffic congestion problem through increasing public transit ridership levels on urban rail transportation systems. Rather, the influence and affluence of Rotterdam's rail infrastructure system and policy structure will create a natural link to bridge the gap between cities that have a proper policy structure and those that do not. This will be mentioned further.

What was the start of this problem? During the post Second World War era, the American government decided to act in such a way as to provide automobile transportation infrastructure and enable equitable access to all who could afford it. It provided just that; a limited transportation resource to those who could afford an automobile. This then became part of the 'American Dream,' to drive across the county on an expanse of open freeways. The evolution of the American highway system, which stemmed from the Federal-Aid Highway Act of 1956 (Weingroff 2010), has created an environmentally degrading project that needs to be controlled. At that time in history, it was the greatest infrastructure project,

costing $25 billion (1956 figures), which the American government had ever undertaken. Today, the American Recovery and Reinvestment Act of 2009 has made available only $19.3 billion dollars for public transportation projects, while giving more highway creation and improvements $27.5 billion. (United States Department of Transportation, Federal Highway Administration 2010) With this case in point, cities need to start looking into finding ways to increase sustainable transportation options and public transit ridership on current systems and not look toward the continual increasing of highway lanes.

Therefore, we will take a comparative approach on how the city of Rotterdam, the Netherlands has tackled policy and implementation measures to increase the ridership levels of urban rail systems. The city of Rotterdam has adopted a vibrant urban rail transportation system that currently transports over 500,000 people daily in the metropolitan region. With a conurbation of nearly quadruple this amount, rail transportation carries roughly 30% of its population. (RET 2011) How did Rotterdam achieve such a high ridership rate?

During the Second World War, the city of Rotterdam experienced something that no other city in the Netherlands had; a German blitzkrieg of bombing which levelled most of its infrastructure. Since then, Rotterdam has been known as the 'city without a heart'. This allowed for the planning of a completely new cityscape and the transformation of the city as a whole. The lacking city structure made available a 'blank canvas' for transportation and city planners to create the new Rotterdam. Planners have had the opportunity to implement various policies and measures to shape Rotterdam into what it has become today. Rotterdam is no longer the 'city without a heart,' but rather a pulsating city of ethnic and cultural diversity.

As urbanization increases every day, the need for effective urban transportation is of utmost importance to maintain both passengers and freight. Today, transportation planners are trying to achieve a hybrid matrix of modal choices to enhance the current shift from car dependency toward a more sustainable and environmentally friendly public transportation system. Is there a way to create a brighter transportation future for Los Angeles and how can it be achieved in the near future?

Over the years, it has been societies that have molded their cities into autocratic car metropolises. Europeans are now facing the same unfortunate dilemma as North America is. Americans are driving to be more independent, but at the same time, car dependent. This cycle is degrading the Los Angeles basin due to increasing smog and pollution levels. The time has come to find the solution toward these problems and how to best use the knowledge that we already have and will develop. This study will assess how specific policies and strategic measures toward Rotterdam's and LA's urban rail systems can increase public transit ridership. Please join me as we find the answers toward this great search.

1.3 Research Objective

The main objective of this research is to assess what specific governmental policies and strategic measures have led to increased urban rail transit ridership and what system sustainability performance characteristics can be found in the cities of Los Angeles and Rotterdam through various contextual cases and empirical studies.

1.4 Provisional Research Questions

In order to facilitate the finding of answers toward the aforementioned objective, a set of questions has been constructed to guide this study in a logical approach. The first question underlines the current situation located in both areas of study, while the subsequent questions

try to understand the measures and policies that affect ridership levels and how system sustainability create a net benefit for a given transit agency and local government. They are:

- What is the current performance of the public urban rail transit systems in Rotterdam and Los Angeles?
- What specific policies and measures affect ridership levels in Rotterdam and Los Angeles?
- How can sustainability performance be assessed between the rail systems of Los Angeles and Rotterdam and what are the results of this comparison?

1.5 Significance of the Study

As with any academic research, there should be reasons why increasing public transit ridership is so critical to the future of transportation? This study will show the empirical findings of how sustainable institutional policies and measures can increase, or likely decrease, urban rail transportation ridership. Today, more than ever, urbanization is rising to record highs with over half of the world's population living in urban regions. As we can see in many developing and transitional countries, this is starting to weigh in on the governments ability to provide the increased population with equal access to public transportation. Rather, as this study focuses on developed countries and their differences of public transportation, it provides an understanding as to what governments have done and can do to help citizens move from point A to point B with the best degree of equitability. The European public transportation structure is vastly ahead of America in many ways. This study will explore Rotterdam's rail transportation structure and policy compared with LA's and what can be done to increase the ridership given the current infrastructure. Since the Dutch have one of the most elaborate and exclusive rail transportation systems in the world, it will present this study with an elemental benefit for LA's ridership problem.

1.6 Scope and Limitations of the Study

Geographically, the scope of the study will include an assessed comparison of the metropolitan statistical areas of Los Angeles, CA, USA and Rotterdam, the Netherlands. Furthermore, other cities will be added into the study for an international context for varied answers to questions that arise. Due to the complex issues of the topic and time restraints of the masters program, the following thesis will only cover issues directly related to effective policies and strategic measures towards increasing urban rail transportation ridership and transit system sustainability. As transportation issues and projects affect a variety of stakeholders, the mode choice of this study will lean directly on urban rail (light rail, heavy rail, and tram), contrary to bus use (bus rapid transit, regional bus, etc) services that are trying to mimic rail transportation routes. The technical, social, economic, and spatial factors of sustainable mobility will be mentioned, but not in great detail as this veers from the study. Heavy limitations toward this study were encountered through non-transparency of information regarding RET. Due to the political changing of duties and sensitivity of information, a full assessment of RET could not be completed with regard toward ridership numbers. Secondly, the Dutch language barrier prompted the use of translator software that limited the inherent subject understanding of the material documented or presented. Finally, due to the multiple organizational holdings of information in the Rotterdam region, proper data sets were skewed and information was varied between such agencies which created the need to establish quality judgment of information collected.

1.7 Research Structure

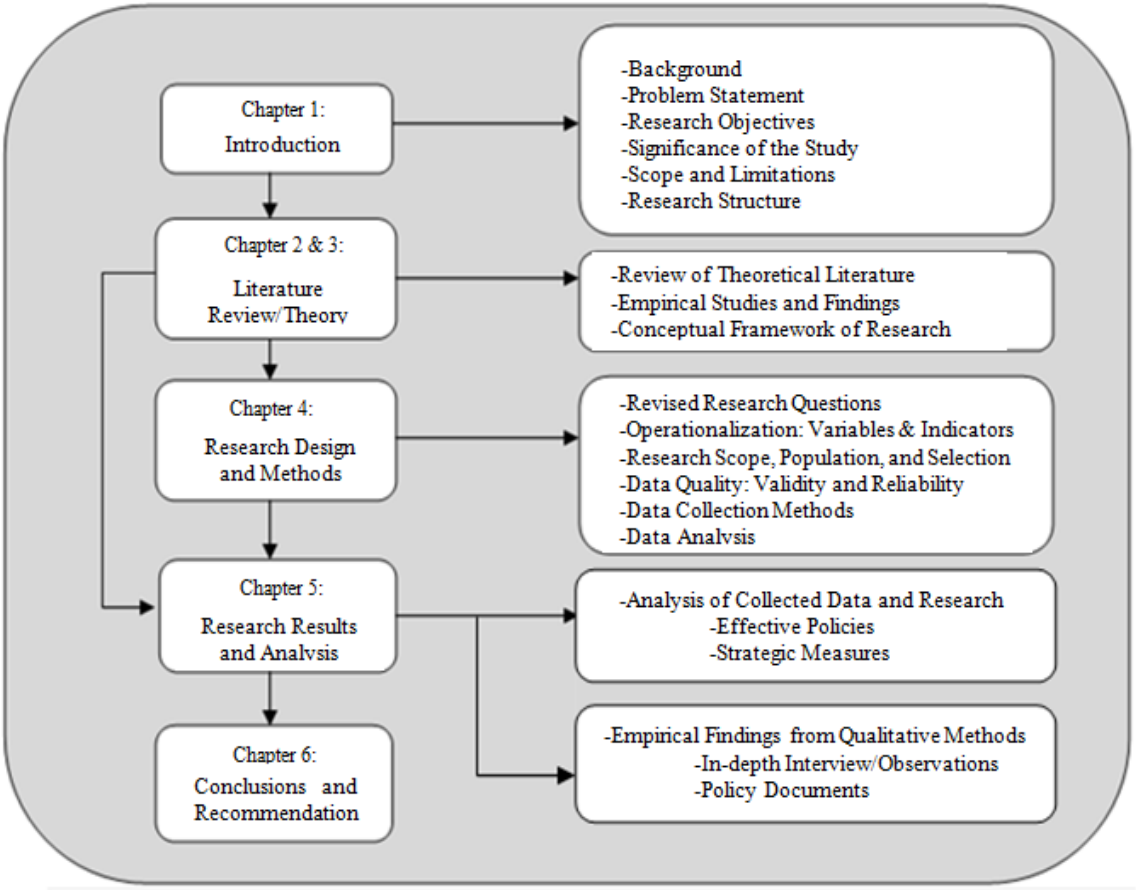

Figure 4: Research Structure
(Source: Author)

Chapter 2: Literature Review on Public Transit, Sustainable Transportation, and Sustainability Transitions

2.1 Introduction

As increased auto dependency has created a latent demand for public transportation use, the need for increased transit ridership is of critical concern. Cities all over the world are faced with the heavy capital costs of public infrastructure and are looking for answers how to either pay for such service provisions, or find a better alternative option. Governments around the world understand that policies and measures are needed, but at what level and to what extent. While more automobile owners are commuting to work every year, this review of academic literature will delve into the policies and measures toward increasing urban rail transit ridership as a means of decreasing highway congestion, creating less strain on the environment, and enabling a funding mechanism for cities to allocate toward increasing urban public transportation infrastructure. Urban rail systems, coupled with regional public transportation, have the ability to provide for societies needs in the future. In order to accomplish this task, multiple levels of sustainable transition management approaches are needed and will guide planning decisions for the future.

2.2 Theories and Concepts of the Study

The main subject matter of this chapter will focus on how sustainability and transitional management affects planning decisions and choices in relation to urban rail systems. Not without a proper understanding of [public] transportation history and sustainable development can we move forward to understand transportation policy and measure selection. Part of the proponent and argument of this research stems from Jonathan Richmond's (2005) book, *Transport of Delight: The Mythical Conception of Rail Transit in Los Angeles.* The knowledge behind the book curtails from the analysis of Los Angeles' light rail blue line and the ability for it to be better served by bus service and other modes. Many valid points are brought to this research about public transportation and most specifically regarding rail transport, but the need to uncover a way to transition society toward public transport is of greater concern. This ideology brings forward the concerns for such topics of urban rail transit ridership and subsequent factors that need addressing. These factors can be materialized through a process known as transition management, which guides a set of changes for society and government through a regime shift.

Subsequent research and literature studies will be complementary and forward looking towards the topic of rail transportation due to the necessity for change. To understand the amount of complexity public transit ridership has, varied issues influence the factors that attribute to the change in public transit ridership and will be described below to link these factors. In order to comprehend the gamut of information and forces that truly affect urban rail transit ridership, numerous levels of compound research topics are needed to tackle such an assessment. Furthermore, this study will bring about theories regarding sustainability transitions, sustainable transportation improvements, and future developments in urban rail transit and its associated ridership. A final concept of transit system sustainability will come forward to bring to light an overall need for future development. Not until a blended matrix of factors is brought together can a change for sustainable transit become reality.

2.3 Definition and Understanding of (Public) Transportation

Commonly defined, transport is the movement of people and goods from one place to another. Evolving from human walking to high-speed rail, transportation (supply component), both modes and infrastructure, has changed the way that society (demand component) reacts

to movement. This innovation in technology creates patterns of flows that shape the way society moves from point A to B. As a result, the overuse from people and the combination of mode and infrastructure create congestion. Geerlings creates a basic model to describe how transport interacts with and affects specific trends as a basis for transport flows.

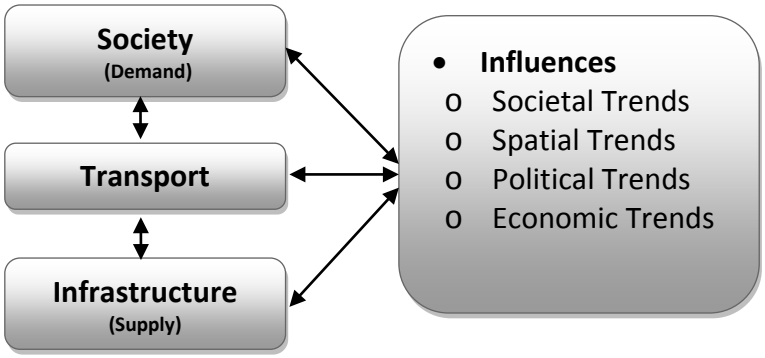

Figure 5: Transport Influence Model
(Source: Geerlings Lecture 2011)

- **Demand** for transportation stems from the size of the city's population and the market environment that affect the extent and volume of stakeholders. People's choice of transit mode is a critical concern in such arenas.
- **Transport** can include various modal choices to achieve the desired demand on the system. It is the system as a whole that moves freight and people through air, land, and sea.
- **Infrastructure** includes all transport networks (roads, railways, canals, airways, etc) and terminal nodes (seaports, railway stations, airports, etc).

"Public Transportation (also called transit**,** public transit**,** or mass transit) is transportation by a conveyance that provides regular and continuing general or special transportation to the public, but not including school buses, charter or sightseeing service." (APTA 2011) Worldwide, public transportation use is increasing due to numerous causes such as an economic downturn, rapid urbanization, and the personal perception of public transportation. Moreover, public urban rail transit, as a segment of the larger market, will be discussed in detail.

2.4 Definition of Public Passenger Rail Systems

Due to varied systems worldwide, this study will be referring to light (LRT) and heavy (subway) rail systems located in urban locations. Commuter rail (CRT) is a secondary proponent toward urban rail systems, but will not be covered in-depth. As such, the definition of each is as follows: "*Light Rail* is a mode of transit service (also called streetcar**,** tramway, or trolley) operating passenger rail cars singly (or in short, usually two-car or three-car, trains) on fixed rails in right-of-way that is often separated from other traffic for part or much of the way. *Commuter Rail* is a mode of transit service (also called metropolitan rail**,** regional rail**,** or suburban rail) characterized by an electric or diesel propelled railway for urban passenger train service consisting of local short distance travel operating between a central city and adjacent suburbs. *Heavy Rail* is a mode of transit service (also called metro**,** subway**,** rapid transit**,** or rapid rail) operating on an electric railway with the capacity for a heavy volume of traffic." (APTA 2011) Public passenger rail systems, as such, are the heart of a cities transportation system.

2.5 Sustainable Development

Today, there is an ever increasing emphasis on the environmental impacts of all public projects and decisions. Through the enhanced knowledge that humans have learned about reactionary changes as well as the degradation we continually see toward planet earth, sustainability continues to become of utmost importance. Sustainability can be described through the common definition of the Brundtland Reports of 1987 as "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (APTA 2011) Through this definition, Professor Mohan Munasinghe has created one of the most well know and adapted sustainable development icons; the "Sustainable Development Triangle," as shown in figure 6.

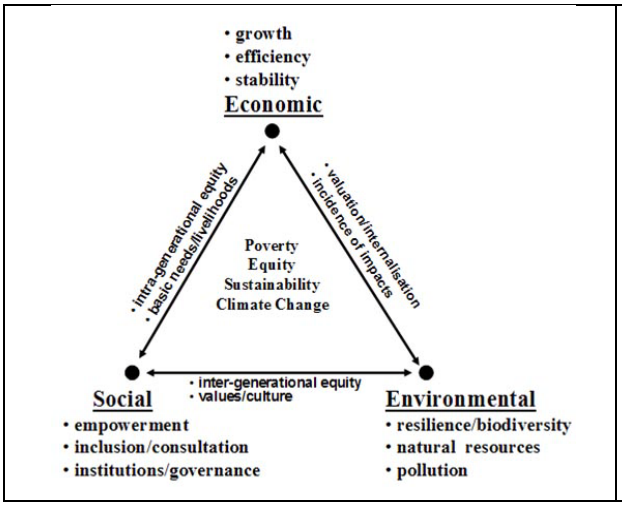

Figure 6: Sustainability Triangle
(Munasinghe 1992)

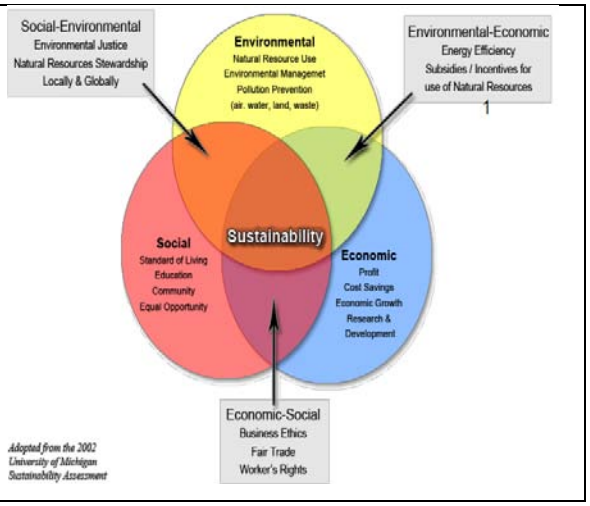

Figure 7: Sustainability Assessment Triangle
(Vanderbilt University 2011)

It has created the building block for what sustainability is and how transport should be modeled in order to serve not only what the people's and government's want, but also what the earth can sustain in the future. A subsequent model shown in figure 7 from Vanderbilt University has been created to depict what society can do to accomplish these tasks (conceptual factors). Sustainable developments core theory is based on the knowledge of the need to increase the wellbeing of society while at the same time decreasing the resource requirements to do so. The concern can be formulated from the degradation of the environment through impacts of the production and consumption of needs of the people. Ultimately, the sustainable development approach is the only approach that humans can take for generations to come. Without it, the earth will be depleted of all its natural resources with synthetic materials being the only form of substance left. According to Rotmans (2011), these choices involve a system of boundaries in: time (25-50 years), space (micro, meso and macro levels), and domain (social, economic, and environment). The only problem is the amount of time that society has left to implement these practices into reality.

2.6 Sustainable Transportation and its Complexity

Sustainability continually plays a vital role in the implementation of rail transport. As countries look toward the future for sustainable transportation, electrified rail systems have provided a mode that does and will continue to use renewable energy. Studies have show that rail is inherently more efficient than road transport, and coupled with renewable energy, it can provide a lasting source of mobility for future generations while at the same time decreasing

emission levels. Creating a connection between sustainability and public transportation can be seen through a concept called transition management. Further discourse will be described in the following section. Long term technological development can only play a limited role in decreasing the ecological footprint that humans are leaving on this planet. A behavioral change is warranted for any substantial improvement in environmental quality. (Pollard 2001) As has been noted in the US, "transportation and land use laws and policies have played a primary role in creating this dependence on motor vehicles; they have spurred scattered suburban development and promoted driving. At the same time these laws and policies have made other transportation options –such as public transit, bicycling, and walking –less practical, desirable, and safe. As a result, driving is often a necessity, rather than a choice." (Pollard 2001) There are however, difficulties within the implementation of policies toward sustainable transit. As society increases, the demand on government follows. Societal driven (market-based) policy structure is a very much one sided approach which decrease the ability for conflicting, but needed changes to occur. Ultimately, a balance between society and government to create and invest in sustainable transportation will prove to be the proper alignment. With this noted governments need to start taking a conceded approach toward policies and measures that increase ridership through sustainable advances in transportation, with the help of society's participation.

2.7 Sustainability Transitions – A Guide toward Change

2.7.1 Fundamental Elements

Before any transformation in any proportion can occur, the necessity to gap the change between livability and sustainability is of utmost importance. Sustainable transitions have occurred over the last decade as the "green movement" has become more pronounced in both the political and private enterprise sectors. Such examples include, but are not limited to energy supply, transport mobility, health care, and water allocation. Continual persistence toward these system failures is a result of unsustainability. Incremental approaches are no longer enough to fix the situation that this earth and the people that inhabit it are in.(Rotmans 2011) Rather, it will take a multi-dimensional approach and a drastic change in order to take any great steps forward. Transitions are rare processes that do not always lead to sustainability. This process is more long term minded with short term goals to accomplish a matrix of achievements throughout the development.

2.7.2 Transition Change

Being established, transitional change toward transportation and policy is needed. Rotmans defines transitions as a "fundamental change of structure, culture, and practices in a societal (sub) system." (2011) Below is a clearer definition of what he implies as the three fundamental changes:

- **Structure**: physical infrastructure, economic infrastructure (market, consumption, production), and institutions (rules, regulations, collective actors)
- **Culture:** the collective set of values, norms, perspectives (shared orientation), and paradigms (defining problems and solutions)
- **Practices:** routines, behavior, ways of handling, and implementation at the individual level

Transitional change occurs when these paradigms are broken down and built back up through a sustainable, methodological approach. As noted, this is not a quick process and takes tremendous time and effort in which alterations occur at the micro, meso, and macro levels. Negatively, these transitions do fail at times due to dominant players against change. This can

be seen most notably through automobile usage and the need for public transit infrastructure. The shortcoming is often induced through political will to cater to the greater majority of modal users: automobile owners. In figure 8, you will see how change occurs and what the natural outcomes are present in a given situation. As noted, there are multiple outcomes from a single development. It is how society accepts, government monitors, and private enterprises act that permit a sustainable approach to reach the level of stabilization and sustainability. Also worth noting; without a decentralized system, the competition between private enterprises will create stagnation among competition. This diagram is not meant to be representative of socialistic government organizations, as competition is held in the government's power, but a more capitalistic approach.

Shown below in figure 9, one can see that the backlash and system breakdown paths create unsustainable path dependencies called, "urban erosion." Transitions are then created to change the solutions, structures, and actors into a manageable application. This subsequent process can then take years to implement due to the varied stakeholders concerned. This level of urban erosion is currently what society and scientists are concerned with. According to the Dutch Research Institute for Transitions (DRIFT), as government continually engages in the vital functions of transitional change, it becomes harder to implement alterations to public transport due to the increasingly dominant role of network influences, societal complexity and uncertainty.

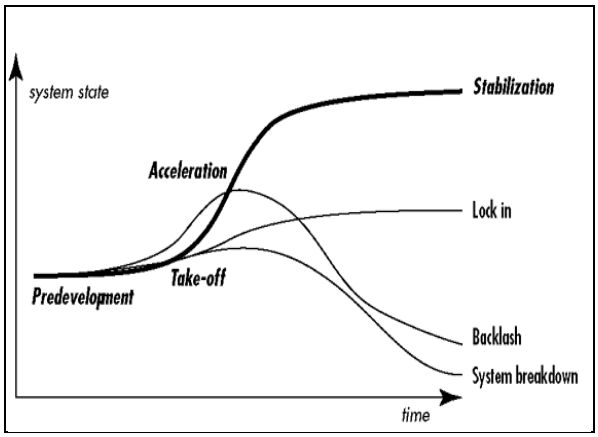

Figure 8: Transition Path Dependencies

(Rotmans 2011)

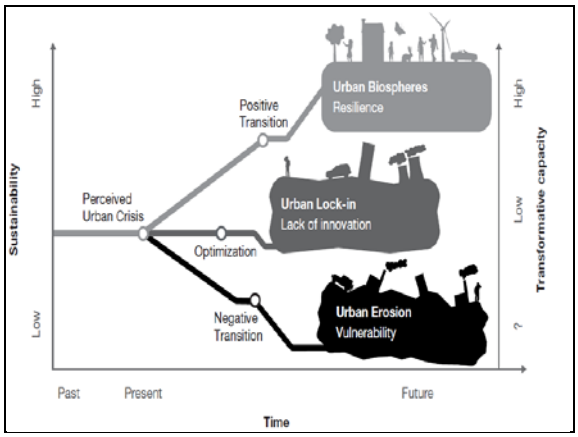

Figure 9: Transformative Capacity of Transitions

(Loorbach & Avelino 2011)

Furthermore, the allocation of transition management entangles multiple levels of planning as shown in table 1 below. First, a short term operational plan needs to become visible for society to accept it. This level then stimulates the need for an overall tactical approach involving an institution or regime. Most notably, as public transportation becomes heavily used, the need for more routes and links to surrounding communities are mandated. Public transportation becomes the topic of society in which they demand a higher level of service. Finally, after a decade of planning and political transition, an overall strategic approach to change culture is warranted. This process can be seen in many European countries with their adaptation toward public transportation usage.

Transition Management Types and Their Focus (Loorbach 2007)

Transition Management Types	Focus	Problem Scope	Time Scale	Level of Activities
Strategic	Culture	Abstract/societal system	Long term (30 years)	System
Tactical	Structures	Institutions/regime	Mid term (5–15 years)	Subsystem
Operational	Practices	Concrete/project	Short term (0–5 years)	Concrete

Table 1: Transition Management Types and Their Focus

(Loorbach 2007)

Likewise, Geerlings (1997) notes that during the operational stage, "network steering and network policy" creates target related influences. He states that, "steering is aimed at realizing these objectives by influencing the behavior of the actors in such a way that it conforms to the aim." As policy objectives are narrowed toward an aim (ie. decreased automobiles in the CBD), they create characteristics that lead the different policy actors decisions. In short, policy creates a way for government to alter and change the way that society acts in the short term. As such, a short term policy can be carried through to maturity if the policy is effective in its aim. Subsequently, it can be amended or terminated to alter its influence on society. Geerlings also points out that this network approach leads to institutionalizing and rules of interaction. Future policy is guided by the rules set out by government, whether positive or negative. Consequently, a collective interest from various stakeholders (government, society, business, etc) needs to be recognized, or policy will fail.

Ultimately, the networks formed between a cities (sub) system can lead to innovations and niches that are linked to solve the problem of unsustainability. In figure 10, niches and innovations are placed into the linked network and 'locations of need.' This blueprint will guide the following section on transition patterns.

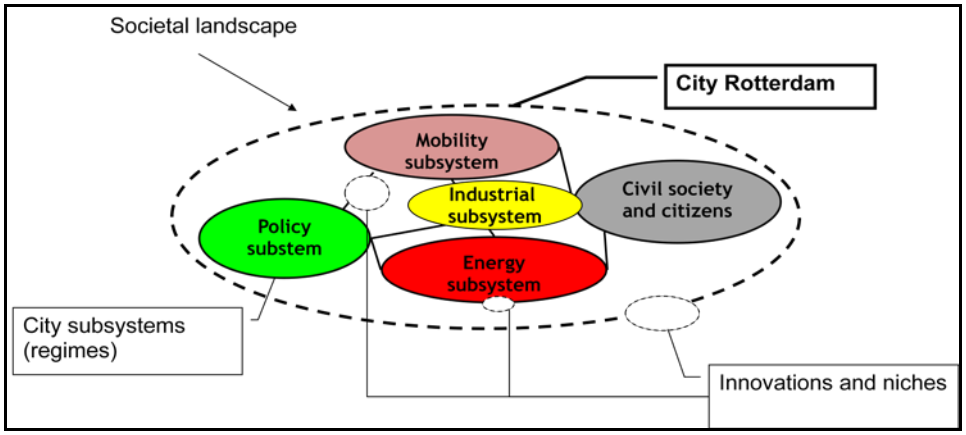

Figure 10: Multi-Phase Transition Concept

(Loorbach & Avelino 2011)

2.7.3 Transition Patters

Transition patterns occur when specific niches emerge and form clusters. When these niche clusters are empowered through outside forces (ie. government, private companies, society), they start to compose a new niche regime. The final stages occur when this new niche regime gains enough power and momentum to overtake the old incumbent regime. (Rotmans 2011)

Below is an analysis of the parts of the overall transition pattern and what factors influence each subset.

- **Regime**: dominant structure, culture and practices with power at systems level
- **Niche:** upcoming, diverging structure, culture and practices at lower scale level
- **Pattern:** built up of mechanisms and a manifestation of such a pattern is a pathway.

This pattern can be applied to many different elements of society today. Particularly, the French Thalys high speed rail line from Paris to Amsterdam is an example of niche patterns at work. The original niche that was created was one of an idea to provide elegant and sheik modes of travel through France, yet connect with strong networks throughout Europe. The second phase of this example is carried forward through the endorsement of the government, the development of the private sector, and the acceptance of society. Today, the Thalys has created a mode of transport that is preferred over certain segments within the airline industry and gives an advantage over taking normal passenger rail cars. This niche regime can also be seen as the State of California in the United States is in the process of creating a high speed rail link from San Diego to Sacramento and San Francisco.

The final key to transition patterns is the ability of the new niche regime to obtain power. This cannot be met without conflict of the old regime through natural and diverse defense mechanisms including: institutional, governance, technological, economic, and social resistance. Although this often proves difficult and tedious, new niche regimes can break through the existing order and structure together with ‘change inclined’ actors. (Rotmans 2011)

Transition = Regime Shift = Shift in Power

With sustainable transitions in place, governments, society, and private enterprises can now move forward to a better working environment. Sustainable transportation and the increase in public transit ridership are paramount in every city today.

Chapter 3: Scenarios and Factors Impacting Rail Transit Ridership

3.1 Introduction

Numerous empirical studies have divided public transit ridership's phenomena into two categories: internal and external factors (also known as direct or indirect strategies). (Taylor & Haas 2002) (Taylor & Fink working paper) (Brown & Neog 2007) These external factors constitute variables such as population change, economic conditions, urban density, and automobile ownership levels, all factors in which public transit personnel have no control over. Rather, internal factors however include variables such as fare prices, transit times, parking rates, and service policies, those in which transit personnel or local government have control and power over. (Brown & Neog 2007) How can individual factors and conditions, either external or internal, affect ridership as a whole? Together, government policy (regulation) and private operation need to function together to create a hybrid transportation system that works. This can be partially explained through the 'Spider Model,' a model designed to analyze the most important factors influencing the future of transportation. As seen in figure 12, the closer the factor is to the center axis, the more associated with non-intervention (market based) methods and practices (ie. liberal attitudes or private services). Rather, the further away from the center axis, the more associated with direct intervention from government (regulatory based) measures (ie. Land-use planning, regulation and/or fiscal measures). (Nijkamp, Rienstra & Vleugel 1998)

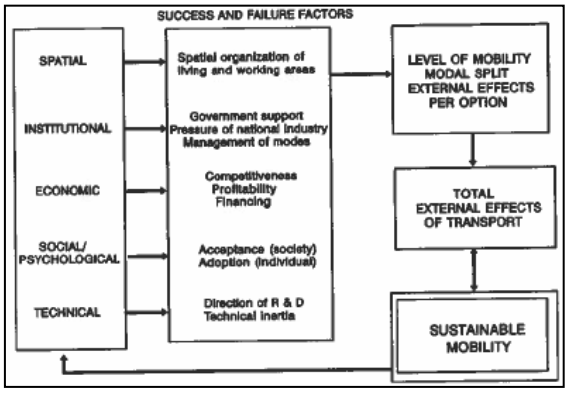

Figure 11: Spider Model Success and Failure Factors
(Nijkamp, Rienstra & Vleugel 1998)

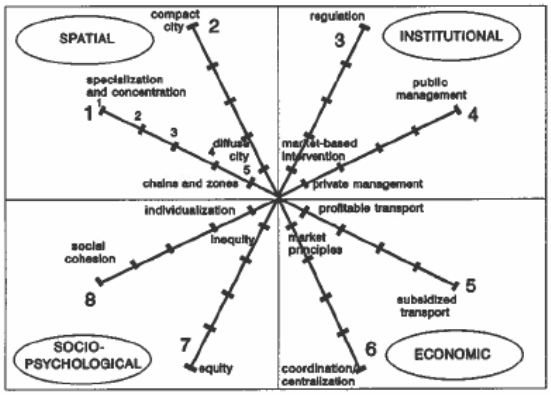

Figure 12: Basic Spider Model Layout
(Nijkamp, Rienstra & Vleugel 1998)

Nijkamp, Rienstra & Vleugel (1998) delve deeper into what scenario's are expected and desired for all sectors over the next 20 years (30 years when the book what written) toward the year 2030. These spider models then show the correlation as to which policies are achievable in a given time and what choices transportation experts perceive society to follow. Figure 14 and 15 then give the expected and desired scenarios from the Dutch transportation experts. These scenarios are heavily drastic due to the perceptions from an expert's point of view and what society is expected to choose in future outcomes.

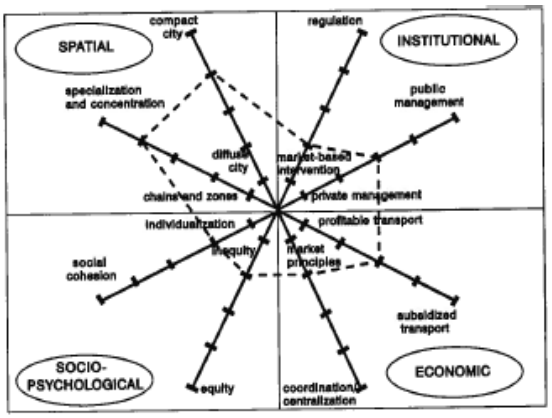

Figure 13: The Spider Model: Expected Scenario
(Nijkamp, Reinstra & Vleugel 1998)

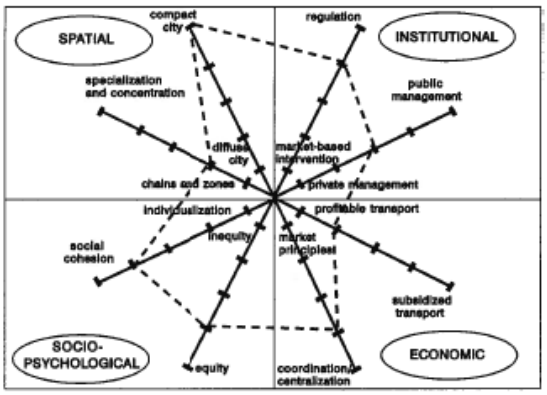

Figure 14: The Spider Model: Desired Scenario
(Nijkamp, Reinstra & Vleugel 1998)

As you can see in figure 14, the devolution of transportation sectors will continue to increase into the future while being based toward a market oriented trend. Management of the system will however be a cooperative effort between the public and private sectors with government allocating and constructing the infrastructure while the private market will be heavily involved with the overall operation and price setting. This scenario will create an urban erosion path dependency that will lead to governments need for subsidization of the system with unprofitability as a whole within the urban context. Rather, in figure 15, a more stringent regulatory approach is taken to construct a stronger stand toward policy initiatives and create societal acceptance of change. Management is still held between the public and private sectors so as to equally involve parties engaged in such activities. A more EU policy standard should be created with less involvement at the national level. This gives the subsidiarity principle (that is, decisions should be made at the lowest level possible, where possible) more leverage to cater to the needs of a local region or city, given they comply with EU policy regulations. With a subsidiarity principle in place, governments can then enact local policies to help foster collective transportation initiatives (ie. rail transportation ridership increases, community cycling programs).

Congruently, Taylor and Fink (working paper) have narrowed down the main factors that affect public transit ridership levels, and "taken as a whole, variables which directly or indirectly measure automobile access and utility (including auto ownership and parking availability) explain more of the variation in transit ridership than any other family of factors." If looking at figure 12, this covers the institutional and social-psychological sectors. Taylor and Fink's research continue to delve into the leading factors attributed for continued use of public transit. Society's main concern is that of service quality over service supply (transit nodes, locations) and the pricing of fares. Contrary to many beliefs, people are willing to pay higher fare rates if the service quality of such transportation is of higher value to the person.

Additionally, Taylor and Haas (2002) argue that increasing both service frequency and transit stop density (also known as *Transit Oriented Development)* in combination with road pricing increases transit ridership more than any other merger of policies. The need for multiple, both internal and external, factors constitute a complex system within a government's policy agenda. This realization can be problematic if government and private enterprise cannot collaborate together through efficient and effective measures.

3.2 The Downfall of Urban Rail Transit Ridership –A Short Guide of Understanding

In Robert Cervero's book, *Unlocking Suburban Gridlock* (1986), he apportions the reasons for decreased public ridership to the link between jobs and housing locations. This problem can be seen in today's transportation system 25 years later and most notably in Los Angeles. Increased automobile usage is just an adverse reaction of such. He argues that "the numerous institutional voids and bureaucratic snags that stymie efforts to respond creatively to emerging transportation problems are all too familiar to most employers, developers, and planners." This produces yet another example why institutional framework capacities are critical toward developing a more sustainable approach en route to public transit infrastructure and increased ridership levels. Here provided, there are two basic principles of fixing the problem; the 'do-nothing alternative,' in which society will decide when the costs, whether internal or external, outweigh the benefits or the 'intervention alternative' where government induces a systematic change in traffic mobility (ie. increase parking rates, decrease speed limits, etc). Cervero continues that the general public cannot choose the 'do nothing' and 'public intervention' scenario at the same time. Congestion itself can create a strong enough opponent for society to change their ways if it reaches a level of true inconvenience and intolerance. Until then, should government intervene or let society correct itself? A main deterrent toward the 'do nothing' alternative is the heavy degradation toward the planet. If emission levels remain like they are for the next 30-40 years, the time that it took for automobile use to gain popularity and the supposed time that it will take to devolve, will there be a healthy and livable city available for society to occupy? Government intervention then is the only alternative, with the help of private enterprises, to create a way for society to desire the use of public transportation.

The job and housing correlation of transit ridership and infrastructure encompasses a major segment of this topic. Likewise, Edwards and Smith (2008) have attributed some public transport problems with the correlation between suburb and suburb connections, (contrary to suburb and CBD), volume of single occupancy automobile dependent drivers, car parks located in urban locales (which devalue property), difficulty of coordinating government actors in policy formation and implementation, and the transfer between modes of transport can create problems. Over the past few decades, public transport ridership has declined so much that rail companies have had to abandon rail lines and decrease maintenance levels due to financial constraints in the loss of riders. This devolving schedule of proper maintenance is just a downward spiraling effect that will eventually lead to either costly repairs or an entirely new system, neither of which option most cities can afford.

Taylor and Fink (working paper) describe public transit as an "inferior good" toward that of the private automobile. Continuing, they state "such that the demand for transit service is largely determined by the supply of private vehicle access." As urban and peri-urban highway expansion has grown in countries all over the world, private vehicle access is gaining priority. Costing more than public rail infrastructure to implement and construct, highway expansion is undercutting the demise of cities all over the world. This is not to say that the private automobile is a bad thing, but rather the overuse is what creates the melting point in discourse and debate. In metropolitan cities such as New York, Amsterdam, Tokyo, and San Francisco, the amount of private vehicle access is limited and public transit use is high. In short, the main problem leading toward public transits downfall is the provision of highway infrastructure and the degradation of public rail systems in the urban locale. On the contrary, this downfall in public transit ridership has been making a comeback over the past few years. The next section will show the subsequent increase over the past decade.

3.3 The Promising Revival of Urban Rail Transit Ridership (Contextual Examples)

Rail transit ridership in the United States has made a dramatic increase over the last 50 years. Compared to the highest levels of public transit ridership in 1958 of 9.8 billion unlinked transit trips, the 2008 count set a record high of 10.5 billion. Even more so, the increase over the last decade has grown 35% from 1995 levels as seen in figure 16. Of the total amount, rail transit accounts for roughly 54% of the public transit share, with buses accounting for nearly 34%. (Dickens and Neff 2010) These numbers alone are a proponent to heuristic research, looking further as to the promotion of additional public transit infrastructure toward increasing public transit ridership.

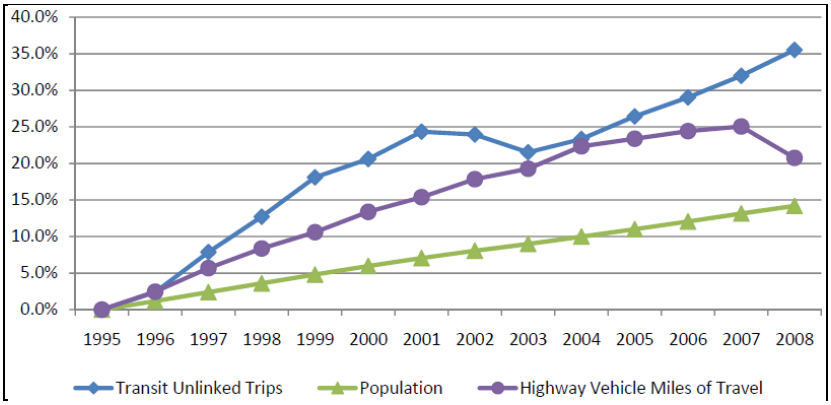

Figure 15: National Growth in Public Transit Use (USA)
(Dickens & Neff 2010)

Given the current state of the worldwide economy, society is looking to cut personal spending. As such, one of the largest personal expenses is that of transportation. Individuals pay insurance, registration, gasoline, automobile payments, repairs, etc. on a monthly and yearly basis. Public transportation is now an affordable alternative and one in which society had not seen before due to the use and low cost of the private automobile. Cities need to continue great service provision, availability, and timely service to continue ridership levels; but how can they increase even more?

Given the differences in culture and government policy, most of the international world has attained public transit numbers far greater than that of the USA. To gain an understanding as to how levels have been achieved and the steps and measures that it has taken, contextual examples are of critical importance. The following section will cover locations that have increased ridership levels higher than that of the average city including Zurich, Switzerland, San Diego, California, and Melbourne, Australia.

Zurich, Switzerland

Most notably, Zurich, Switzerland has been listed as one of the highest cities with per capita public transit ridership in the world. This can be attributed to its fast, efficient, and frequent transit system. Nash and Sylvia (2001) explain the start of this transition with government wanting to spend 1.2 billion Swiss francs for a new underground transit system which would replace its older surface system. Rather, the greater majority of people rejected this measure and voted in favor of only spending 200 million francs over 10 years for the implementation of new transit priority measures toward their current surface transit system. Franc for franc, transit priority measures in Zurich outperformed any other method of increasing public transit ridership. In this study, Nash and Sylvia contribute that over a 10 year period from 1989 to 1999, Zurich had increased its ridership 152% from 159,300 daily S-bahn boardings to

242,300. The main proponent of this success is the structure of the system as a whole. Typically, cities have a three tiered model for transportation; local (generally busses and trams), intermediate (generally a grade separated heavy rail system), and long distance (generally a commuter/suburban rail system). Zurich however, only has local and long distance modes. This gives the city more funding to be put into one system (local level) with increased transportation nodes, thus increasing service frequency and availability. Secondly, transit marketing (often neglected by transit authorities) and ticket pricing proved heavily productive in increasing patrons to ride the rail transit system. Using the train cars themselves as icons of the city, Zurich adapted a marketing strategy around them. Set apart from other ticket pricing models, Zurich implemented monthly, weekly, and 24 hour passes which incentivized users to ride the S-bahn. These 'special passes' proved so effective that they out numbered the total level of automobile ownership in greater Zurich. Overall, multiple measures and policies enables Zurich to become a leader in rail transit ridership.

San Diego, CA, USA

Located just south of Los Angeles, CA, San Diego has become one of the fastest growing urban rail transit cities in the US. Heralded by Kain and Liu (1999), San Diego has created one of the most successful light rail (trolley) transit lines in America since the end of WWII. As San Diego continues into the future to create more extensions, its successful ridership levels have been realized in various ways. The main support of the San Diego Trolley was facilitated through federal and state level subsidies that in turn decreased fare prices and increased service locations. However, San Diego did not pursue the operational subsidy that many cities had done during the same time. This created a need for San Diego's Metropolitan Transit System (MTS) to find ways to keep the system profitable. In 1992, the City of San Diego adopted a Transit Oriented Development guideline and policy that was crucial in supplementing transit density requirements and design standards for locations near transit stops. In an on-board survey done by the San Diego Association of Governments (SANDAG) in 1991, 80% of the trolley patrons either lived or worked within a 10 minute walk of a transit station. Non-CBD and residential connections are critical for a successful rail system to work. Overall, the support of the federal government through subsidies to decrease real fare rates enabled increased ridership for the San Diego Trolley. Congruently, the State of California's Transportation Development Act (TDA) also propelled further subsidies that gave priority for sustainable and mass transit modes.

Melbourne, Australia

Separated as an entire continent, Australia, and specifically the province of New South Wales is rapidly growing. As urban centers continually struggle to maintain the transits market share of transportation due to the decentralization of housing, cities are trying to procure a way for public transport patrons to turn its clock backward during the time of high ridership rates. Melbourne, Australia has encountered, just like many cities around the world today, an auto-oriented, suburban living standard which has degraded its urban core. The Melbourne and Metropolitan Tramway Board have made concerted efforts to enforce low automobile use in the urban core with density standards coupled with increased suburban rail service to commuting cities. This led to an overall decrease in automobile use in the urban core with nearly one third of commuters traveling by automobile and two thirds by public transit. (Cervero 1998) Cervero continues to note that the city of Melbourne created pedestrian zones (those that did not allow automobiles) and restrictions on parking supply. This stemmed from the effort to return the CBD to the people and create green spaces to increase economic and leisure activities. Overall, the conceptual mix of urban design and landscaping was an alternative to achieve the ridership rates needed to sustain continued and increased public rail

transportation. Not only does rail transport achieve the intended goals, so to does the gentrification of retail development which pays back to the city for choice positioning.

With the successes of many different cities implementing various strategies and measures toward the increase of public rail transit, along with infrastructure, there must be a common ground as to what successful transit systems are. Brown and Thompson (2009) "find that successful transit systems are those that: 1) articulate a clear, multi-destination vision for regional transit; 2) rely on rail transit as the system's backbone; 3) recognize the importance of the non-CBD travel market; 4) encourage the use of transfers to reach a wider array of destinations; 5) recognize that rail transit alone is not enough to guarantee success; and 6) recognize the importance of serving regional destinations." This brings the concept back to Taylor and Haas (2002) in the uses of both direct and indirect strategies to increase the levels of successful ridership. The coordination between government's policies and transit authority's operations is the base for establishing an equitable and sustainable transit system.

3.4 Governments Role in Transport Ridership and Policy (Institutional Implications)

As governments continue to regulate the transportation markets, time passes and conditions change. Alterations toward the system need to be addressed on a continual and incremental basis. Rail transportation, to be more specific, is constantly in operational limbo with the demand that society puts on the system, while governments try to keep in step via infrastructure supply, or lack thereof. Due to heavy costs and stress on the financial budget of a region, cities cannot afford to invest in billion dollar infrastructure projects as demand changes. This is where government policy plays a critical role in alleviating such stress on the system. How can governments then, alter the demand side of public transportation so as not to invest in recurring infrastructure supply? The answer lies within the authority and power of government to enact policies and measures that lead to changes in societal choices. With the choices that society makes, they also understand what they forego in making that choice. Governments then, enact policies that entice society to make a decision (partake in riding public transportation), at the expense of subsidizing the cost to do so. Governments hand in neglecting the centralization of a city creates and has proven to be one of the leading causes of the decline in public urban transportation ridership. (Brown & Thompson 2009) Not only does government have a hand in centralization planning, but the regulatory decision toward densification and building permits (ie. Transit Oriented Development and Density Rights). Whichever way public transportation is construed, government will continue to have a hand in it. Social equity and fairness to all members of society need to be accounted for. Government's regulatory powers provide a way to grant concessions and privatization toward public transit's operations that allow for private companies to tender (compete for service) for a specific segment of a given service. Government does this for many reasons, which will be described in the research findings of this study.

According to van den Berg, et al. (2008) transportation policy in cities increasingly includes 'Taylor-made solutions' for specific clusters located in the urban area. Due to the complex issues involved in every city the next section will cover some of the past approaches implemented in an effort to increase rail transit ridership without amplifying the need for increased supply side measures.

3.5 Governmental Policy Approaches toward Increasing Rail Transit Ridership

Carefully construed together, policies and measures have the inherent ability to effectively and equitable alleviate congestion and provide for a sustainable mobility system through increased ridership levels. As such, this next section provides some best practices and congruent examples that have been used over the past decade toward increasing ridership levels. A structured level of policies and measures will be shown through three main categories: auto related, people related, and infrastructure related. As described earlier, all factors can be listed as either internal (those in which government or transit operators have control) or external (those in which they do not). Below are the survey results listing those factors attributed toward increased ridership growth.

Internal	Fare Changes and Innovations	Fare decrease or freeze Universal fare coverage programs Introduction of new payment options
	Marketing and Information Programs	Advertising Niche marketing/marketing segmentation Survey research Customer satisfaction feedback mechanisms
	Service Improvements	Expansion of routes (geographic/temporal) Introduction of new/specialized service Route restructuring
	Amenities/Service Quality	Development of transit centers Development of park-and-ride facilities Increasing frequency/reliability of service Cleanliness of vehicles New equipment/rolling stock Bus stop improvements (signage, shelters, benches)
	Partnerships	Community outreach/education Planning and strategies Intra-agency collaboration
External	Population Growth	More immigration Rising transit dependency (aging populations, etc)
	Strong Economy and Employment Growth	Increased tourism More demand for travel
	Changing Metropolitan Form	Suburbanization Residential and employment relocation
	Changes to Transportation System	Increased congestion Parking shortage and increasing costs Rising gas prices Construction projects and time delays

Table 2: Internal and External Factors Contributing to Ridership Growth

(Taylor & Haas 2002)

Not without mentioning in Annex 1, the International Association of Public Transport (IAPT) has named 16 “Best Practice Approaches” toward public transportation and the effects specific measures and policies have toward its regard.

<u>Car Related</u>

“Strategies to increase parking costs, or the probability drivers will have to pay, are found to be more effective in increasing transit mode share than increasing the level of transit service in terms of frequency and accessibility.” (Taylor & Fink working paper) Auto related policies and measures can prove to be the greatest differential change in transit ridership, but it can also be the hardest to implement as people do not want to give up their automobile (in)dependence. As mentioned previously, limiting automobile access and utility has proven

to be a leading source of increasing ridership levels. The following are subsequent policies and measures that have proved to work with regards toward less congestion and increased ridership: road (congestion) pricing, traffic calming measures, carbon tax, increased fuel tax, speed reductions, and vehicle use restrictions. The bottom line: people love the appearance and social status of owning and operating a personal automobile, regardless of its implications.

Society Related

Possibly the hardest to enact, society related policies and measures can provide the greatest impact. According to the Federation of Canadian Municipalities (FCM), Transit Demand Management (TDM) combines varied tactics such as incentives, disincentives, education, promotion, and outreach to affect how people travel. In a study done among commuters traveling to the city of Amsterdam, the Netherlands, figure 18 shows the reasons why people choose public transportation over the automobile.

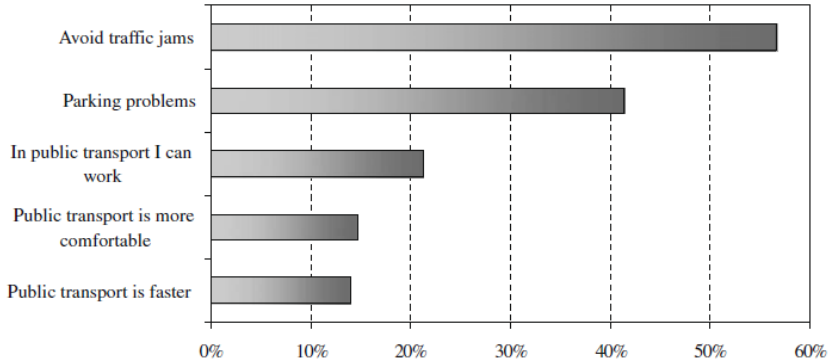

Figure 16: Main reasons for public transport use in lieu of car (with ownership)
(Van Excel & Rietveld 2008)

With TDM policies in place, governments can decrease parking (perceived problem) to alter the mode choice of commuters. The positive, perceived benefits through TDM measures, which include cost and time savings, health and fitness, or more choice selection, have proven effective in many places around the world. Public rail transportation ridership has shown to increase over the past few years due to the previously mentioned measures.

Infrastructure Related

Many cities today have enacted the “low hanging fruit” policies and measures that do not require substantial change in infrastructure. There are, however, policies and measures that can increase public rail transit ridership through the altering of built infrastructure. Such policy examples are the ‘transfer of development rights (TDR),’ which allows land owners to sell their ‘air rights’ to another land owner to build at a higher density, and ‘transit oriented development (TOD).’ TDR’s allow for an increase in density around certain areas the city deems suitable for higher development. This toleration for densification leads to a better connection toward public transit use, thus increasing public transit ridership as seen in such cities as San Diego, Amsterdam, Rotterdam and New York. Secondly, TOD, in conjunction with TDR’s, creates high density living around public transportation stations (usually rail stations). Though there are more infrastructure related policies and measures that have proved effective in European and Asian cities, they are becoming a growing trend in America as automobile related problems arise and people understand the benefits of TOD.

Ultimately, governmental “carrot and stick” approaches are needed to move people out of their automobiles and onto public transportation. Congruently, a sustainable transition management approach is needed for positive changes into the future. This change will involve many stakeholders including government, society, and private enterprise. Only when all of these cooperate together, can a city have ridership numbers great enough to support a sustainable transit system.

3.6 Conceptual Framework

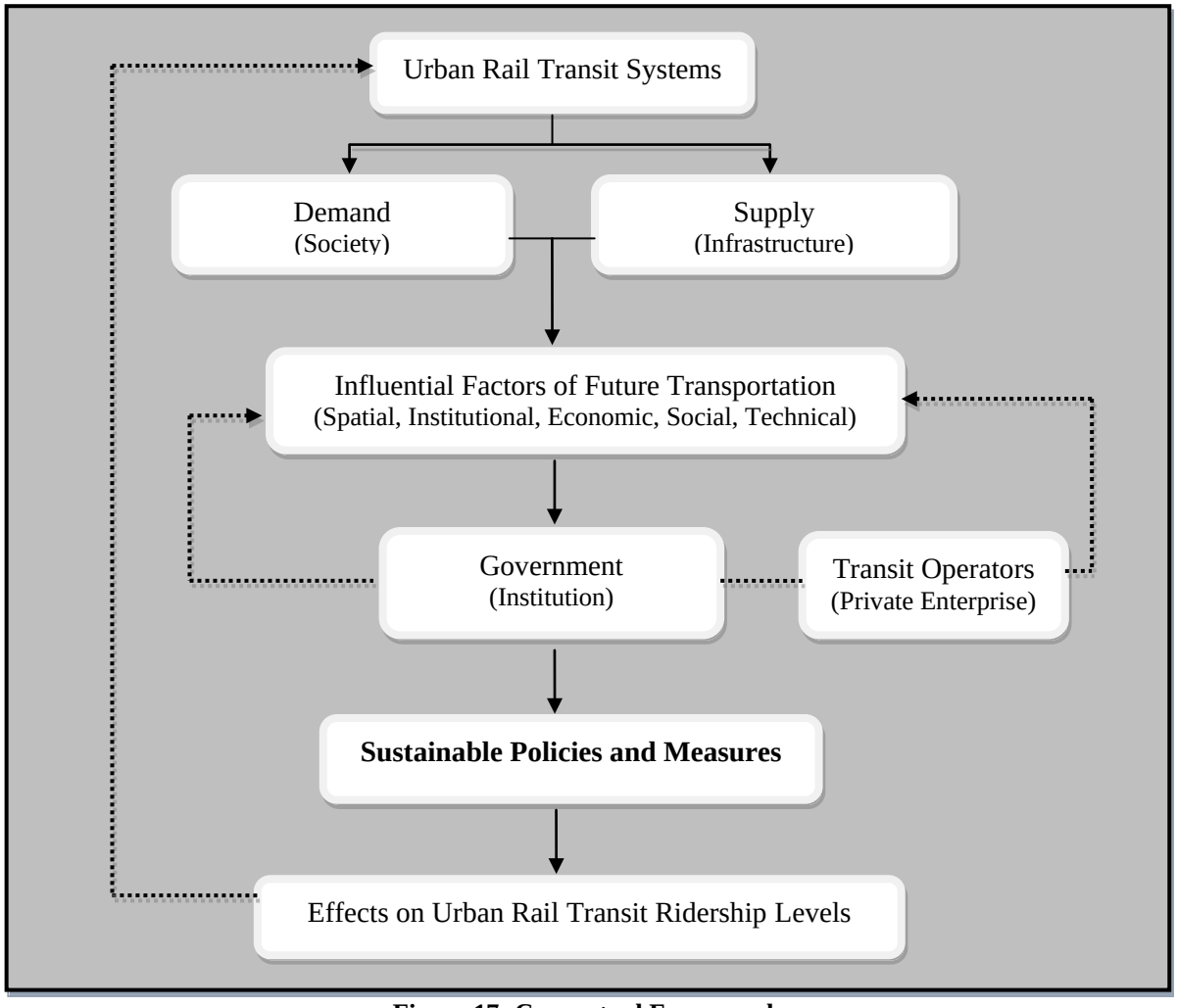

Figure 17: Conceptual Framework
(Source: Author)

As this conceptual framework has taken shape, the need for further understanding and knowledge about sustainable policies and measures is of critical importance. The subsequent research will be an in-depth assessment to find answers to such theory. As multiple stakeholders are needed to affect society in modal choice selection, addressing sustainable policies and measures toward increasing urban rail transit ridership is a vital step in achieving such transit goals.

Chapter 4: Research Design and Methods

This research assessment combines two rudiments toward that of rail transit ridership: effects of governmental policies and measures and sustainable systems creation. The focus will be guided on sustainable, institutional impacts in the metropolitan regions of Los Angeles, California and Rotterdam, the Netherlands. As such, a blend of both exploratory and causal research designs will be needed to find the root of the problem. Due to the fact that institutional policies affect social welfare, the need for causality and exploring are fundamental in this study. Exploratory research seeks to find the story behind certain activity and to investigate social phenomena without explicit explanations. (Schutt 2006) All policies affect society in different ways. The figure below gives an overview of the 'research circle' which presents the correlation between deductive research (that is, specific expectations being deduced from a theoretical premise and tested through collected and analyzed data), and the transition into inductive research through empirical findings.

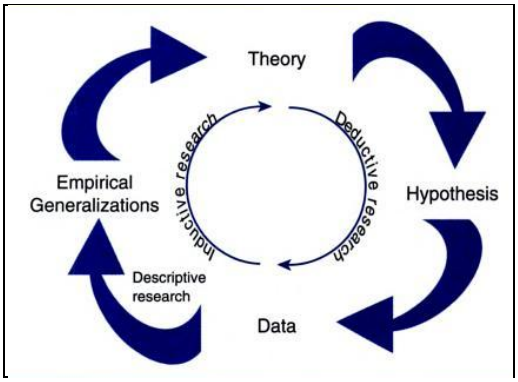

Figure 18: Research Circle
(Schutt 2006)

The main qualitative research methods of this study were in-depth interviews, formal observations, and research of current empirical literature toward specific cases on the effects of rail transit ridership. This framework will guide the forthcoming research into formulated conclusions that will attempt to answer the following research questions.

4.1 Revised Research Questions

The main focus of this research is to understand the effects and correlations governmental policies and measures have toward rail transit ridership and subsequent system sustainability.

Main Research Question: To what extent can governmental policies and measures selection increase urban rail transit ridership and create a sustainable transit system?

Hypothesis: As governmental policies and measures play an integral role in affecting and formulating societal choice selection in urban rail transit use, there is a need to increase sustainable transportation policy and measure selection in Los Angeles to create a livable metropolis which is shown as deficient in the current environmental and social situation.

The following research sub-questions are as follows:

What is the current performance of the public urban rail transit systems in Rotterdam and Los Angeles?

To gain an understanding for future and desirable results, the need for baseline measurements is created for a proper scenario to be executed. Policy and measure guidelines are influenced by baseline information toward a future outlook.

What specific policies and measures affect ridership levels in Rotterdam and Los Angeles?

As past experiences often provide the best information, the need to understand the correlation effects between past and current policies and measures with the effects on ridership levels demonstrates critical if future solutions are to be found.

How can sustainability performance be assessed between the rail systems of Los Angeles and Rotterdam and what are the results of this comparison?

As transportation projects are undertaken in the near future, sustainability of such is paramount to ensure that upcoming generations have public rail transportation available to them. The need to guarantee social, environmental, and economical relationships is vital to the future of society.

4.2 Operationalization: Variables and Indicators

Question	Variable	Indicator	Data Source
What is the current running performance and facilitation of the public urban rail transit systems in Rotterdam and Los Angeles?	Overall system performance and usage	• Mode Choice • Ridership Levels • Types of Riders • Location of Riders • Owners and Operators • Rail service quality	-Local Government Documents and Reports -On-site observation -NGO Reports/Studies
What and how have specific policies and measures affected ridership levels in Rotterdam and Los Angeles?	Policies and measures that affect ridership levels	• Rail time variances • Level of satisfaction • Demand shift • Cost analysis • Mode Choice • Ridership Levels	-Local Government Documents and Reports -NGO Reports/Studies -In-depth Interviews
What sustainability comparison criteria can be assessed between the rail systems of Rotterdam and Los Angeles?	Sustainability criteria of rail systems	• Energy use mode • Emission Levels • Duration of system • Cost effectiveness • Envr. impact reports	-Local Government Documents and Reports -Case Studies -Empirical Studies

Table 3: Operationalization of Variables
(Source: Author)

4.3 Research Scope, Population, and Selection

The scope of the research was focused on the metropolitan cities of Los Angeles and Rotterdam. As such, LA has a population of 3,792,621 residents and covers 1,301,970 km^2. Rather, Rotterdam has a population of 593,050 residents and covers 319km^2. Although research will be narrowed toward the specific cities of Los Angeles and Rotterdam, rail service covers a vast amount of land. As such, the future outlook on policy and measure changes will be for the greater regions of both metropolitan cities. Densities of such regions are drastically varied and may prove to be a large proponent of reasons for lacking of rail transit ridership. As such, LA's population density is 2,913/km^2, while Rotterdam ranks in

with having 2,903/km^2. (StatLine CBS 2011) The sheer population numbers create a close match with density of Rotterdam's urban framework.
The main focus of this research will be toward Los Angeles, as shown through increased urban sprawl (indicated by low density rates, commuter travel times, etc) and automobile use. Secondly, the comparative city of Rotterdam has many similar characteristics (large port, proximity to int'l airport, infrastructure, commerce, etc) to compare. Figures 19 – 22 show the correlation between the two. Notice the similarity in connection with the ports.

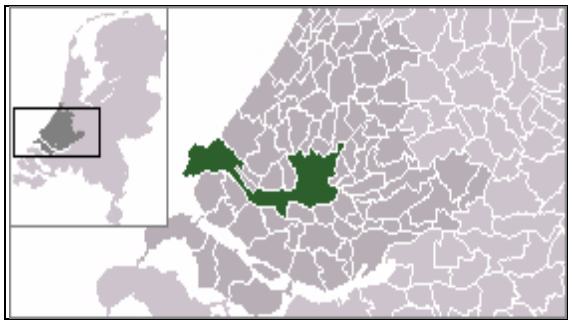

Figure 19: Rotterdam Municipality

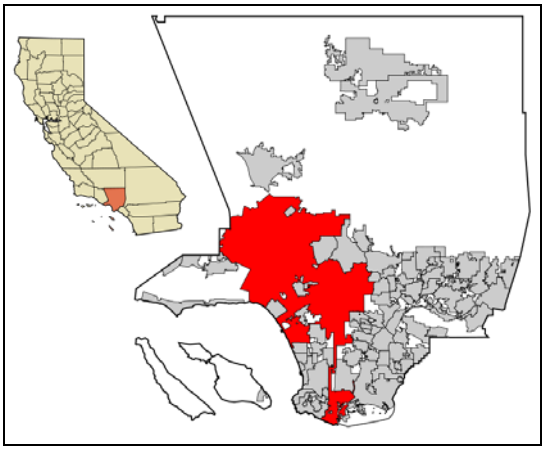

Figure 21: Incorporated Region of LA

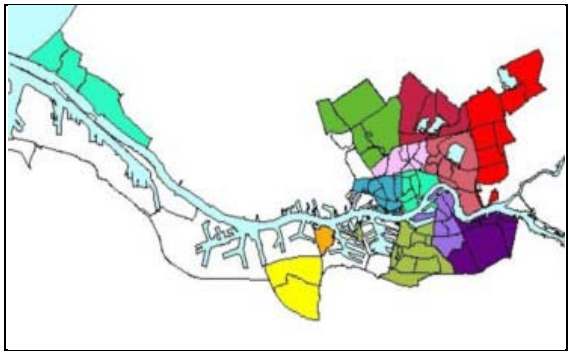

Figure 20: Rotterdam Sub-Regions

Figure 22: Incorporated Cities of LA

4.4 Data Quality

In order to ensure the quality of research and create similar results in various locations, validity and reliability are a critical part of the research structure and process.

4.4.1 Validity

Validity gives the strength of conclusion and proposition results. Due to this fact; validity was obtained through a triangulation approach that accounts for bias by including multiple sources of empirical research results that were qualitatively constructed through in-depth interviews, observations on research locations and secondary data literature studies.

4.4.2 Reliability

Reliability is described as the consistency of research measurements. To enhance the reliability of this study, data collection was administered to various levels of government, non-government organizations, and transit authorities. Through various measurements, including similar questioning during interviews and key observations, consistency between variables creates reliability.

4.5 Data Collection Methods

In order for credibility and quality of research, a varied data range is necessary to capture the true picture of the problem in order to facilitate future changes. In doing so, field work and literature studies are the components toward this study. Collection of data was securely obtained through interview contacts from necessary public agencies through the US and Netherlands.

4.5.1 Field Work (Primary)

Field work was conducted in Los Angeles from June 19 – June 26 and Rotterdam from August 3- August 10 to collect primary data including in-depth interviews and observations.

4.5.1.1 In-depth Interviews

In addition to formal, in-depth interviews, informal interviews with rail transit patrons were conducted to gain an understanding as to the perceived societal response in policy change and measure implementation.

	Organization Type	Organization	Responsibilities
1	Transit Authority	METRO -LA	Deputy Executive Officer - Service Development & Performance Analysis
2	Transit Authority	METRO -LA	Executive Officer – Transportation Development & Implementation
3	NGO	Transit Coalition -LA	CEO and Consultant to Local Government Transit Planning
4	NGO	Southern California Transit Advocates-LA	Executive Secretary and Policy Representative
5	Local Government	Planning Department-LA	Transportation/Urban Planner and Project Manager
6	Transit Authority	RET -Rotterdam	Coordinator of Innovation and Development
7	NGO	PROV -Rotterdam	Active Board Member of Organization
8	Regional Government	StadsRegio-Rotterdam	Senior Policy Advisor for Public Transport
9	Regional Government	StadsRegio Rotterdam	Policy Advisor for Public Transport
10	Local Government	dS+V-Rotterdam	Senior Transportation/Urban Planner

Table 4: In-Depth Interviews

4.5.1.2 Observations

Observations in both participative and non-participative nature were adopted for this research. Non-participative observations were conducted to understand the use of measures and policies implemented toward the rail transit system and to gain an understanding of the current use by patrons. Photos, notes, and descriptions were made to compare locations and facilities of rail transit stations, transfers, and multiple infrastructure changes. Participative observations were conducted to view patrons onboard rail modes to gain an understanding of use.
Observational data collected was not for systematic use, but rather for background information and guidance to the overall study.

4.5.2 Literature Studies (Secondary)

Relevant and critical literature studies were gathered by local government agencies, non-government organizations, and third parties involved within the topic in Los Angeles and Rotterdam to gain a detailed analysis of varied stakeholder points of view and findings. This list is by no means exhaustive, but rather guides an understanding as to the area of study.

No.	Secondary Data	Data Source
1	Policy Report	Maximizing Mobility in Los Angeles: First and Last Mile Strategies (SCAG)
2	Policy Report	LA Metro Long Range Transportation Plan and Technical Document (2009)
3	Empirical Study	The Influence of Service Planning Decision on Rail Transit Success or Failure (Brown and Thompson 2009)
4	Empirical Study	Elements Needed to Create High Ridership Transit Systems (TCRP Report 111)
5	Policy Report	Beleidsvoorstel openbaar vervoerplan (April 2011) Policy Proposal Plan of PT
6	Policy Report	Kadernota Openbaar Vervoer - stadsregio Rotterdam (July 2011)
7	Policy Report	Regionale uitvoeringsagenda Verkeer en Vervoer 2011 – 2014 (July 2011)
8	Policy Report	Ontwikkeling openbaar vervoer 2000 – 2009 (June 2011)

Table 5: In-Depth Literature Studies

4.6 Data Analysis

The data gathered from the initial research questions will provide an understanding of where the researcher will need to collect further information and what are the weak points of the transit and policy systems are. To a large extent, information will be gained through reports and policy documents to understand the direction of the comparative governments and/or transit agencies. Further analysis through in-depth interviews and observations will confirm and/or deny the research findings and locate the efforts of government to increase public transit ridership and its related factors. Primary research conducted through in-depth interviews will guide the necessary findings for quality and accurate secondary data. All information was gained through interviewees and subsequent contacts from such.
Another element of this research will analyze to what extent the urban rail systems are sustainable. With regard toward sustainability, there are multiple criteria that need to be set forth which often times is not fulfilled for many reasons (ie. lack of resources or political will). As such, “policy targets are more relevant for making indicators ‘bite’ than sustainability targets, because policy targets are presumably backed by a political system and administration, whereas sustainability targets may only be backed by some members of academia or environmental NGOs.” (Gudmundsson 2003) Further analysis toward sustainability criteria will be described in the research findings. This will be fulfilled through the in-depth interviews and tertiary data collection.

As described, there will be two stages to this research framework:

1. The need to gain understanding toward the current system and the, what and how of policy and measure initiatives. The need to analyze what the government has already attempted will create insight to the societal acceptance of such institutional alterations.
2. Secondly, through literature studies, analysis of city layouts, and interviews, conclusions will be created to guide the local government on sustainable policies and measures to increase urban rail transit ridership and system sustainability.

4.7 Time Scheduling

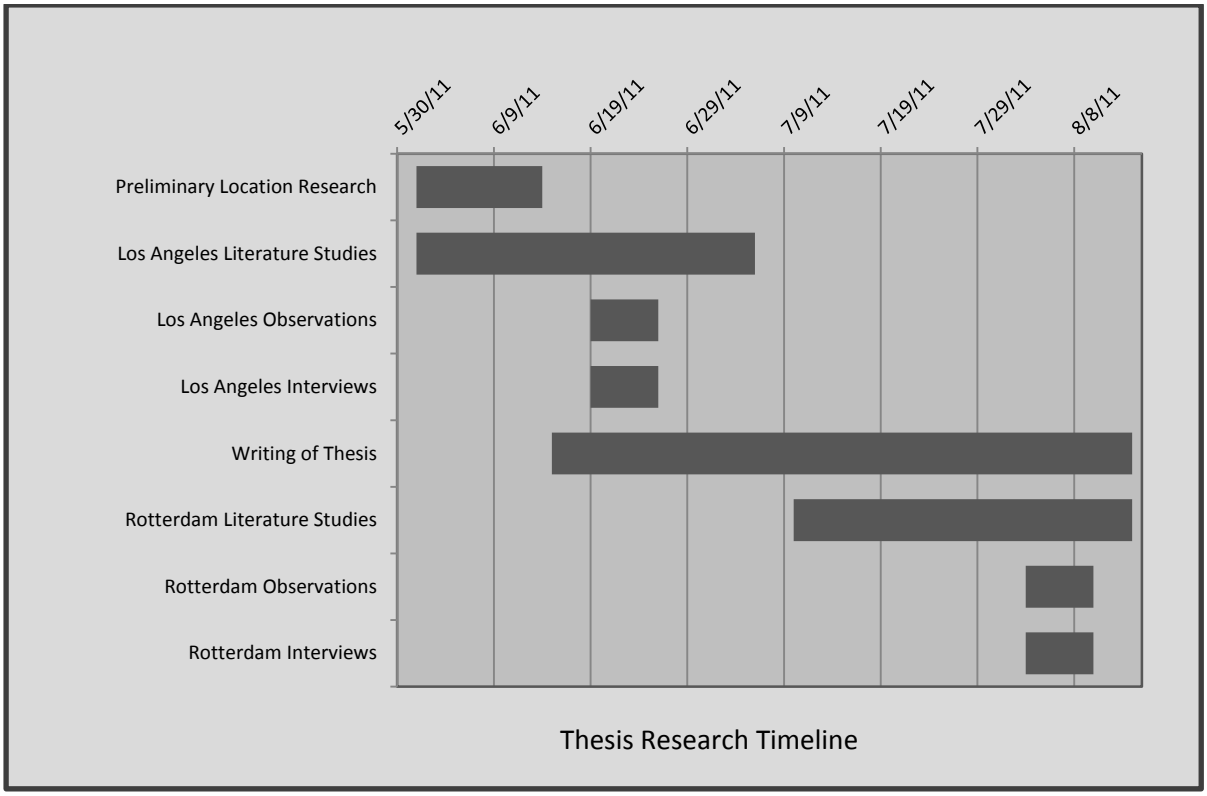

Figure 23: Thesis Research Timeline

Chapter 5: Research Results and Assessment

5.1 Introduction

This chapter will convey the results of research and assessment regarding the author's empirical studies of LA and Rotterdam. Section 5.2 will bring to light the current state of affairs and operation of the urban rail systems in LA and Rotterdam toward differences in system size and type. Section 5.3 moves toward a comparative study understanding priority measures and policy implementation which opens up missing gaps in local government and transit authorities systems through contextual examples found during field work. As such, a guided approach toward changes will come forward through an evaluative spider model. Section 5.4 will bring forward a sustainable assessment of both transit systems to guide future development and alternations as a whole concluded by a secondary evaluative spider model. Lastly, section 5.5 will bring to light concluding remarks warranting an overview affecting ridership and sustainability toward urban rail systems.

5.2 Current Performance and Facilitation Analysis

5.2.1 Urban Rail Transit Demographics

Stemming from quite an array in demographic variances, LA and Rotterdam both have a similar characteristic: modality problems. To understand more clearly the subset of this research, a comparative overview of the cities' urban rail transit systems includes such factors as public mode choice of riders, ridership profiles, service quality, and frequency of the system.

5.2.1.1 Comparison

The current urban rail system of the Los Angeles County Metropolitan Transportation Authority, here within, Metro consists of 3 light rail lines covering 57 stations, totalling 99.28km of track and 2 heavy rail lines covering 16 stations, totalling 28km of track. Average weekday heavy rail boardings in May of 2011 consisted of 144,244 with weekends averaging 85,076 and average weekday light rail boardings in May of 2011 consisted of 157,257 with weekends averaging 91,817. The system includes a total of 104 heavy rail and 146 light rail cars. (Metro 2011b) The present rail system is currently in the process of heavy infrastructure expansion which will drastically change ridership statistics in the future. Further explanation will be drawn out in subsequent sections.

Likewise, the current rail system of the Rotterdamse Elektrische Tram, here within, RET consists of 9 tram lines covering 301 stations totaling 93.4km of track and 5 heavy rail (metro) lines covering 49 stations totaling 78.3km of track. Within the 5 metro lines is a special commuter line, entitled the Randstad Rail, covering service between Rotterdam and Den Haag, a commuter town directly linked to Rotterdam. Average weekday tram boardings in June of 2011 consisted of 210,950 and average weekday metro boardings in June of 2011 consisted of 298,650. A total of 123 trams and 184 heavy rail cars create the system. (RET 2011d) Current construction, expansion, and merger/acquisition of national rail lines are underway and will heavily change ridership statistics in the future. Congruently, major service changes and government requirements forced on RET in 2012-2013 will alter ridership through internal factors dramatically.

5.2.2 Public Mode Choice of Riders

5.2.2.1 Comparison

Given the small amount of ridership on the urban rail system as mentioned in section 5.2.1, bus ridership accounts for 1,187,869 patrons a day. (Metro 2011b) This modal split concludes that the bus system creates the main backbone of LA's public transit system. Public mode choice is an inherent selection from both discretionary riders (those who own an automobile) and non-discretionary riders. With 20.2% of riders traveling via urban rail, the transfer from bus ridership is critical toward decreasing emissions and sprawl. Bus ridership only caters to an increase in sprawl and decreases the chances of TOD projects around rail transit stations. Historically, LA planning practices have mostly benefited roadway vehicle access, rather than urban rail, bicycling, or walking.

On the contrary, daily ridership in the Rotterdam metropolitan area consists of nearly 600,000 patrons a day. Of such numbers, roughly 200,000 patrons travel via tram, 300,000 via heavy rail, and 100,000 via bus. (RET 2011d) This modal split suggests that rail transport is truly the backbone of Rotterdam's public transit system. A continued in-depth study toward increasing such numbers will be carried as RET continues to ascertain a sustainable public transit system. The modal split and pertinent infrastructure of such is critical toward Rotterdam's urban framework.

5.2.3 Ridership Profile

5.2.3.1 Comparison

Due to the multi-ethnic variance among LA's population, riders come from a large mix of backgrounds. As such, the following is a percentage of rider ethnicities among patrons on Metro's system conducted on the 2009 customer satisfaction survey: 58% Latino, 19% Black, 9% White, 9% Asian, 1% American Indian, and 4% other. As such, 69% of those surveyed make a household income of less than or equal to $26,000USD. The gender breakdown of patrons is 49% male and 51% female. The majority age gap from 23-49 accounts for 52% with 50-64 at 18%, 18-22 at 22%, and 65+ at 5%. (Metro 2011b)

Currently, RET does not publically publish information regarding rider demographics. This lack of transparency has led to a deficient comparison of data between the two cities. Alternatively, the Kennisplatform Verkeer en Vervoer (KpVV or Knowledge Platform of Traffic and Transport), a national, independent organization dedicated to mobility, has produced multiple reports listing transit statistics. As such, KpVV's OV-Klantenbarometer (Public Transport Service Rating) has rated the tram with a 7.1 and heavy rail with a 7.2 out of 10 for overall satisfaction of each public transit mode. (In the Dutch system, 9 and 10 are rarely given) Furthermore, additional demographics of the survey concluded that Rotterdam region patrons between the ages of 18-27 account for 48% of the ridership with those between 41-64 at 23%, 18 and under at 14%, 28-40 at 10%, and over 65 at 4%. The gender breakdown of patrons accounts men at 42% and women at 58%. (KpVV 2011)

5.2.4 Service Quality and Frequency of System

5.2.4.1 Comparison

Service quality of the system is currently at levels that society concludes to be positive. In a ridership survey conducted in 2009 by Metro, 85% of participating patrons stated that they are satisfied with the current rail service provisions. Within this survey, 79% of patrons stated that Metro has produced service better than they had received the year prior. Congruently, 76% said that the rail system is generally on-time (wait of 5 minutes or less from posted

time). Over 70% of the interviewed patrons participated in rail transit 5 or more days a week. Concurrently, the LRT system begins service operation at 05:00 and HRT at 04:31 with workdays starting at 08:00 and finishes daily service at 01:41 and 01:11 with average workdays stopping at 17:00. With operation starting at 04:31, the HRT system averages a wait time of 5-10 minutes and the LRT system with 6-12 minutes. Times depend on if there are multi-modal transit stations and peak hours. (Metro 2011d)

The StadsRegio's OV-Klantenbarometer has rated the overall satisfaction of the Rotterdam area with 7.6 out of 10, while the national average was rated a 7.2 out of 10. This report demonstrates the stature of quality and level of satisfaction patrons conferred to KpVV for the overall system. Roughly 48% of patrons travel 5 or more days per week. Moving toward operational frequency, tram service begins at 04:42 and heavy rail at 05:32 with workdays starting at 09:00 and finishes daily service at 00:32 and 00:58 with average workdays finishing at 17:00. Average wait times of the tram system are all equally set at 15 minutes, while heavy rail varies between 10-15 minute intervals. (RET 2011b)

5.2.5 Synthesis of Comparison

The demographic and modality differences in LA and Rotterdam are great, but were chosen to bring to light a variance in European and American rail transit policies and measures. The main noticeable differences between the systems are the leading source of ridership patrons, the mode composition of the system, and the majority ridership age category. Coupled by governmental policy to cater to road systems, LA has created an enormous bus system to follow suit. Rather, Rotterdam has transformed its city with an integrated tram and heavy rail network. Congruently, the types of rail systems that LA and Rotterdam have are quiet different as show in the table below. Finally, with a national policy toward student subsidized (free) transport, Rotterdam's ridership majority lies within the ages of 18-27 with LA following its majority at 23-49 years of age. This demonstrates LA's majority rail travelers are commuting to work locations, contrary to educational institutions. The table below is a comparative synthesis between the two systems to gain a better understanding at how they weigh against each other.

	Los Angeles	Rotterdam
Public Transit Mode Choice	Daily Ridership in May: Heavy Rail: 144,244 Light Rail: 157,257 Bus: 1,187,869 Backbone: Bus	Daily Ridership June: Tram: 210,950 Heavy Rail: 298,560 Bus: ~100,000 Backbone: Rail
Rider Profile and Satisfaction	Majority Age: 23-49 @ 52% 50-64 @ 18% and 18-22 @ 22% Gender: 49% Male/ 51% Female Satisfaction: 85 out of 100%	Majority Age: 18-27 @ 44% 41-64 @ 23% and 28-40 @ 22% Gender: 42% Male/ 58% Female Satisfaction: 7.1/10 Tram and 7.2/10 Heavy Rail
Service Quality and Frequency	Service Quality: 85/100 Patron Use: 70% @ 5+ days/wk Light Rail Hours: 05:00-01:41 Heavy Rail Hours: 04:31-01:11 Light Rail Wait: 6-12 minutes Heavy Rail Wait: 5-11 minutes	Service Quality: 7.6/10 Patron Use: 49% @ 5+ days/wk Tram Hours: 04:42-00:32 Heavy Rail Hours: 05:32-00:58 Tram Wait: 15 minutes Heavy Rail Wait: 10-15 minutes

Table 6: Comparative Synthesis of LA and Rotterdam's Rail Systems

5.3 Policy and Measure Assessment toward Increasing Urban Rail Transit Ridership

5.3.1 Introduction

In order to recognize what factors have the most influence toward increasing urban rail transit ridership, the following contextual assessment was created to list such items gained from literature studies, governmental reports and in-depth interviews as per section 3.5. Likewise, according to Taylor and Haas (2002) and Brown and Neog (2007), internal factors are those that can be controlled by institutional arrangements. Regulation of such factors are held in the power of government, often times granted toward transit authorities with strict guidelines and monitored regularly. The main contributing internal factors for this study are mode choice, fare structure, operational efficiency and security, electronic fare cards, transit oriented development, parking standards, marketing levels and mobility management. The outcome of said analysis will generate varied segments where governments are rated through a conceptual spider model. Each topic will be described in-depth and analyzed toward the cities of LA and Rotterdam. With an understanding as to how policies and measures work and how they operate, further recommendations toward a workable solution on such topics can be found. These solutions hope to create a more equitable and smooth system in the future.

5.3.2 Demand Shift in Mode Choice

5.3.2.1 Comparison

Currently, the underground Metro HRT system offers duplicate service with that of the BRT and regular bus services. In doing so, Metro has decreased the amount of leverage the HRT system has. The end result brings forth an amount of decreased ridership toward that of the urban rail system. A mismatch between these two modes of transit concludes the need for better bus-rail interface planning. Transit authorities stated that this occurrence will be combated in the future through cancellation of concurrent bus services that currently run in parallel with that of the rail service. The bus services alone on these parallel lines carry 24,000 people a day, while the HRT purple line averages only 11% carrying capacity. Society pushback is a major hurdle in eliminating bus service due to the fact that the rail system does not extend as far as the current bus routes do. As such, mode choice has been favorable toward that of the bus for this very reason. Brown and Thompson (2009) equally convey an opposite point that successful transit systems are those that rely on rail transit as the backbone of the system. They continue that in order to serve the whole of society, non-CBD markets are a necessity for rail to survive. Furthermore, frequency and stop locations for rail are further apart than the one block intervals that bus routes offer. Coupled by multiple levels of bus service on the surface, rail cannot match the frequency and location with that of the current bus service. In order to change the mentality of patrons, Metro is creating a LRT connection, called the “Regional Connector,” which will link the mismatch of urban rail transit lines together for a unity of the system. Their goal is to increase ridership through fluidity of service and operation. Brown and Thompson continue once more to state that “the use of transfers makes it possible for transit systems to serve a wider array of origins and destinations in dispersed metropolitan areas than can be served by one-seat-ride, point-to-point service. Transfers help extend the geographic reach of the transit system.”

Secondly, mode choice is based on destination and arrival locations with adequate infrastructure provisions present. The Southern California Association of Governments (SCAG) has labelled a report in December of 2010 entitled, “Maximizing Mobility in Los Angles, First and Last Mile Strategies.” (Nelson & Nygaard Consulting Associates 2009) Its aim is to better connect service locations with riders from start to finish, whatever the reason

for travel. These concerns include CBD to suburb and suburb to suburb connections, an increase in service locations, alternatives toward multiple modes of access to service locations, short trip alternatives, and increased bicycle routes. As Metro continues to increase the frequency and service locations of urban rail; mode choice of patrons will hopefully continue to follow in step through a more advanced and established system. A Metro interviewee stated that service frequency and capacity is right where they want it to be and have not had any complaints from patrons toward such. "Choice riders," as described by this report, need an incentive to partake in public transit use in order to switch over. Only until service frequency, locations, access, and availability of such service can be present will mode choice change in the future?

The RET's rail concession in 2011 was granted €40,794,951 in national subsidy. This does not account for sales, marketing, social security, management, or maintenance. (Information gained through an internal RET source). As of April 2011, RET is owned by the municipality of Rotterdam. Due to this fact, RET requires subsidy from a regional government called StadsRegio, who ultimately receives subsidy from the national level. As political desires have shifted and economic stress has taken its toll, the RET will be drastically cutting bus service in 2012 to levels that are of minimum need. As per an RET interview, the total cuts will account for at least a decrease in 15% of service, but only will affect 2% of patron ridership (forecasted). As such, multiple measures are being taken to induce the amount of ridership from bus service toward the urban rail system for the future as to increase the carrying capacity of current rail operations. The need to ensure a proper leverage of the urban rail systems is of critical importance due to the fact that a large amount of subsidy is coming from the national government, or tax payers. A heavy push toward mobility management has become a central position with the StadsRegio Rotterdam's (SRR) policy entitled Kadernota Openbaar Vervoer (Framework Document on Public Transport). (StadsRegio Rotterdam 2011b) One of the Kadernota's main aims is to increase nodal parking infrastructure toward inducing the use of public transit via park and ride/walk locations. This policy will try to induce riders to travel via car to the peri-urban parking infrastructure and then participate in riding the metro and tram systems in an effort to slow the overall traffic flow, especially automobile use. Similarly, bicycle use and priorities of such modes of transport are elemental toward helping create accessibility of the urban rail transit system. As urban rail transit nodes are located to accommodate an average walking distance of 500-600 meters, bicycles provide an alternative to walking this segment of travel. As such, parking infrastructure of said bicycles is needed.

Coupled by the Rotterdam Climate Initiative (Rotterdam Climate Initiative 2011), the city of Rotterdam aims to reduce 40% of CO_2 emissions by 2025. This drastic aim is trying to be accomplished through a blended mix by means with 30% bicycle use, 40% public transit, and 10% pedestrian movement. (Gemeente Rotterdam 2009) To achieve a total increase in the overall system, various modes and methods of transit are needed. SRR, the municipality of Rotterdam, and RET understand this and are currently taking drastic measures for future needs. A transition from auto dependency toward public transit, or at the least, a hybrid modal mix will grant a better future for mobility and sustainability of Rotterdam.

5.3.3 Fare Structure (Cost Implications)

5.3.3.1 Comparison

The current fare structure for Metro's urban rail system has been created through a single, one-way fare with transfer costs among varied modes of transport. The current rate for a

normal, non-discounted fare is $1.50 one way with a $0.35 municipal transfer fee. Currently, the system is set up in such a way that users have to tap their fare card every time they enter and exit a mode of transit. For example, if a patron needs to take two different lines to arrive at their destination, but the same mode, they will need to tap a total of 4 times throughout the duration of their trip costing them $3.00. This leads to more confusion and error from the user, as noted from an interviewee. With a ridership level lower toward certain lines in the system, this one-way pricing model creates a way to naturally cross-subsidize the system.

Congruently, the fare box recovery ratio for Metros urban rail system currently accounts for 29% of expenses. This is an increase of 4% from the past five years which yielded 25%. According to a report produced by the Washington State Department of Transportation, (Lindquist, Wendt & Holbrooks 2009) the national median farebox recovery ratio was 35%. National and state subsidies take a large part in helping move Metro's system. In order to combat the disparity between Metro's and the national average, Metro will be increasing fare prices from the fiscal year 2011 to 2015 in order to achieve a 33% farebox recovery ratio. (Metro 2009b) Cost implications will be discussed into further detail under the section Sustainability Analysis-Associated Costs.

As Metro has created a more front-loaded fare pricing policy and model, urban rail users are dealing with difficulty and problems with excessive TAP card swiping and having to think about possible missed swipes due to transfers. Current and on-going mitigation tactics are being developed at the current moment. Only time will tell how successful the TAP system will be and to what extent the users are satisfied with the system. With over 70% of riders using the TAP card, the overall use is unanimous for the future. Only continued design and integration of transit systems capabilities will prove to be successful for the future of the card.

The current fare structure for the RET is quite complex. With multiple sources of payment, RET provides a way for all users to participate in traveling via urban rail. The policy choice of RET and SRR to move toward an all electronic form of ticketing has changed the way that the fare structure is set up. Currently, RET charges a base trip fee of €0.79, which is nationally set for all carriers, and €0.12 per kilometer traveled (SRR price rate). (StadsRegio Rotterdam 2011d) If the trip duration takes more than 35 minutes, the patron will be charged another €0.79 base fee. There is no cost for patrons to transfer, unless the trip is over 35 minutes, then the €0.79 fee is charged again, which includes transfers. The fees charged in SRR are constructed in cooperation with RET and PROV, a NGO in Rotterdam representing the travelers of public transport. This policy to create a distance based form of payment captures the true costs of travel for all patrons. A negative aspect would be from those who travel further away. This method of payment encourages society to live near work locations and closer to public transit. As noted from an RET interviewee, the farebox recovery for the tram is 50% and heavy rail is 75%. (Percentages do not take into account infrastructure and maintenance)

The national government has also created an incentive fare policy for students within the hogeschool, college, and university levels to participate in either free weekday or weekend public transit as long as they are enrolled into an accredited institution. This policy is congruent with the fact that society cannot obtain a drivers license until the age of 18.

Contrary to the front-loaded system that Metro has implemented in LA, the RET OV-chipkaart integration into multiple modes of transit create ease of use on the travelers end. Unfortunately, this back-loaded approach creates a tremendous effort to coordinate the financial calculations needed for multiple mode types and transfers. Further analysis will be drawn out in the section under *electronic fare cards*.

5.3.4 Operational Efficiency and Security of the System

5.3.4.1 Comparison

Operational inefficiencies have led to a cut in roughly 11% of total urban rail services for Metro. These cuts have been accomplished through a Blue Ribbon Committee which analyze poor performing line segments and decrease frequency or cut service completely in order to close the gap between budget surplus and shortfall. The concern of service cuts is a major topic. Currently, Metro does not have a committee dedicated toward increasing ridership through programs and incentives, but rather only one to cut poor performing line segments. “Service trimming” only decreases the chances for patrons to participate in riding the urban rail. In congruence, numerous reports have been filed by the elderly and handicapped toward Metro regarding poor and inadequate servicing of handicap accessible and escalator/elevator equipment located at rail stations. An interview from a Metro employee concluded that young adults and children have been vandalizing such equipment needing the servicing attention by maintenance workers to reset and fix machines. Additionally, urination and trash around stations as well has proved to show a negative image and scene for a decrease in ridership. The amount in loss of ridership toward the rail system is unknown, but an increase in bus patron ridership, which is usually longer in duration to reach a given destination, has precluded such theory. This service rather provides an alternative clean and easily accessible mode for those who cannot travel by urban rail due to poorly performing facilities.

A natural segway of such a topic brings to worry the security of the system. In correlation with vandalism, peddling (selling of products illegally) is a major concern with the LA Sheriffs Department, the contracted security force on Metro vehicles. Currently, Metro is working with the LA Sheriffs Department to increase forces on lines that are prone to have peddlers. At present, this activity is being held to the blue line due to the fact that it runs through the poorest communities in LA County. While this does not deter it from being the most used line in the system, it creates an atmosphere that allows it to happen. There is no saying that it cannot transfer to another line in the future. Metro and the Sheriffs department are actively looking for ways to mitigate such activity. As such, mitigation measures toward peddling have been added to the contractual stipulations and agreements of the Sheriffs Department in the coming years.

In order to expedite the tram and heavy rail system, RET and SRR is working through an electronic travel system called the *Dynamic Reis Informatie System (DRIS)*. This system will allow passengers to see up-to-date information on where the vehicle is, how long a wait they have, and at what time a patron will be arriving at their destination location. A total of 800 new digital panels have been installed already with more in future expansions. Policy regulations also mandate that 80% of all newly built residential developments, commercial buildings, and offices are to be located near public transit stations or stops. With this implemented, greater access to all society will only increase participation of public transit. (StadsRegio Rotterdam 2011b)

Furthermore, the Kadernota has focused the mentality of planning toward improving the quality of the traveler over growth of the system. SRR believes that a more baseline rail system, coupled by excellent service will serve the region of Rotterdam better and increase the ridership in the future. One of the 4 objectives in their vision is to enhance the facilities around urban rail transit stops. Such operational enhancements include increased bicycle facilities, timetable punctuality, speed of transport, and ease of use of transit stops (kiosks, maps, etc). Park and Ride locations near the periphery of the urban core are heavily being

marketed for use of daily commuters. Further explanation will be talked about in the section entitled, Urban Parking Requirements.

Thirdly, the drastic 2012 decrease of €7.5-8.0 million in national subsidy toward RET means a possible cut in personal security checkers on every public transit vehicle. (StadsRegio interviewee information) Currently, RET fare checkers (employees) are located on every tram and metro to help assist customers with information, but to also decrease the occurrence of violence, vandalism, and free riders. Upon further investigation with an interviewee from PROV, they feel that this would be allowable, only to the extent that checks are done often and random. Currently however, if a patron is caught without a ticket, they only have to pay a higher priced €2.50, 2 hour electronic paper ticket for bus, tram, and metro. There is no punishment or fine for not having a ticket. Overall, policy regulations need to become stricter with regard toward free riders and create a mentality of ethical payment procedures, however hard.

5.3.5 Electronic Fare Cards

5.3.5.1 Comparison

Metro introduced their version of the electronic fare card called the "TAP" (Transit Access Pass) Card in 2007. It is a plastic card that can be uploaded at any transit kiosk and linked directly to your bank account for additional credit. Two versions of the card can be purchased, regular or reduced fare. Reduced fare cards are eligible to seniors, disabled, Medicare, college/vocational, or K-12 students. This card has identity features on it so no other rider may use such a card for discounts. The card costs $2.00 plus whatever fare product is uploaded. The TAP card's internal controls are handled through an authorized agent of Metro called, the TAP Service Center. All financial implications and products are dealt with through this company. As with any system, there are problems that need to be worked out. Current struggles include integrating the card into multiple modes of service and monitoring free riders on the system. Likewise, the payment for services rendered is collected with tap cards only at stations. As noted, the integration of the TAP system with multiple modes of transport is critical toward the success of the card. A Metro interviewee stated that they currently have troubles with patrons not "tapping" out or in when they depart or arrive on the urban rail system. The problem is created due to some LRT stations being at-grade. Patrons then can jump turnstiles, but at their own safety as they land on the tracks to avoid payment. (The other side is gated for security and to avoid free riders). Overall, Metro needs to incentivize potential riders through a proper electronic fare card system, whether for one time use tourists or everyday, regular riders. In a Metro survey conducted in 2009, 70% of patrons prefer using the TAP card over paper and token based payment methods. This data reveals that people want to use the card and prefer it, but a higher percentage could be achieved in the future. (Metro 2011b)

RET introduced the "OV-chipkaart", an electronic, plastic fare payment card, in 2005. Since January 2009, the card was the only form of payment on the heavy rail system and since February 2010, it became the only form of payment throughout the entire city of Rotterdam. There are currently two types of cards, anonymous and personal. Both types of cards cost €7.50, plus any fare product uploaded. Personal cards can carry special discounts (abonnements), while the anonymous card can only card monthly subscriptions, day passes, and credit. Likewise, persons 65 years and old can rider free on the RET system with a personalized OV-chipkaart after 09:00. If the elderly are traveling in other areas around Rotterdam, but not on the RET system, or before 09:00, then they are entitled to a 34%

reduction on base fare, but per kilometer traveled. The same is for those ranging from age 4-11. (RET 2011c) When traveling, €4 is deducted from the card and when the rider checks out, the subsequent amount, minus the travel cost, is uploaded back to the card. By doing this, public transport companies are covering themselves with a guaranteed €4 if the patron forgets to check out. This is the maximum fare that a person can get charged for a single route segment. The benefit of having an OV-chipkaart is the ability to travel throughout the entire country with the same card, no matter the provider of service. This is done through internal controls from an outsourced company called Trans Link Systems (TLS). The OV-chipkaart is not without its flaws however. The only current "problems" of the card stated by RET authorities is the need for counting the amount of trips a patron has taken and charging the rate for a one-day pass over continuing to charge passengers if they have traveled enough to pay for the one-day pass. The other problem is the inability of the fare card to count the overall use of travel during a given time frame and stopping the limit at, let's say a monthly pass rate, if a patron has traveled enough to pay for it. Overall, the OV-chipkaart has decreased the amount of staff required due to automatic uploading of credit and self-service kiosks, enabled people to expedite their travel times, and decrease waiting at transit stops, among others.

5.3.6 Transit Oriented Development

5.3.6.1 Comparison

LA's history of recurring suburban sprawl has led to lower densification and longer commute times. As stated further in this study, under the section "Liveability Standards," average commuting times in LA have increased to 29 minutes, one of the nations leading metropolitan regions. The need to combat such development is a continued and current project for Metro. At the present time, Metro has established a preferred maximum walking distance toward metro stop locations, whether for bus or rail at ¼ mile (400 meters). Standards are based around providing access to such parameters. As such, Metro has taken on TOD developments around strategic station locations among the system. This program is called the "Joint Development Program (JDP)." (Metro 2010b) The program encourages smart growth strategies toward increasing densification around transit stops and multiple use tenants such as retail, residential, and commercial opportunities. The JDP projects also provide additional return on the public's investment through revenues collected from tenants located on Metro's land. This process is called "land value capture." Through strategic investments and developments, Metro can reinvest the funds collected to enhance and add to the current urban rail network. So far, 11 projects have been completed, 1 project is under construction, 16 are in negotiations, and 15 are under consideration. (Metro 2010b) Ultimately, Metro's goal is to create a win-win situation toward inducing ridership through partnerships with tenants near transit stops and capturing value for increasing urban rail transit infrastructure.

With a natural history of dense living standards, Rotterdam has surprisingly been spreading apart into the peri-urban regions. Over 4 new cities have heavily increased in population and are the newest commuting towns in the region to add to more automobile use. As such, the Gemeente Rotterdam dS+V (City Planning Department) has made an effort to create a document entitled: Citylounge Bereikt: Een Bereikbare en aantrekkelijke binnenstad (City Lounge Achieved: An Attractive and Accessible Downtown). (Gemeente Rotterdam 2009) Their aim is to create a thriving, clean, and accessible downtown region served by multiple modes of transit, with dedication toward urban rail, supplemented with a bicycle plan. Rotterdam is set up in such a way that a high level of coordination is required for implementation. The StadsRegio does not have any authority to implement TOD projects, but

rather the Gemeente. Currently, the Gemeente is in the planning phase for multiple TOD projects totally 5000 new housing units by 2015. Their plan aims to increase city life and entertainment, and in doing so, increase the urban rail system for society to move around. Not only is the Gemeente and StadRegio planning to increase urban life, but attract those from the peri-urban areas into the center. This tactic will hopefully increase the urban rail transit ridership with numbers to be seen in the near future. According to an interviewee from RET, walking standards toward the heavy rail system are set at 600 meters and tram at 500 meters. The StadsRegio as set a standard that 80% of metropolitan region live within a 400 meter walking distance and 1200 meter cycling distance by 2030. (StadsRegio Rotterdam 2011b) They feel that a healthy way of life can be achieved through proper walking distances and a well serviced urban rail system, coupled by proper bicycle routes. In order for effectiveness of infrastructure, proper policies and measures need to be in place, such as TOD, bicycle lanes, and quality frequency of rail lines.

5.3.7 Urban and Peri-Urban Parking Standards

5.3.7.1 Comparison

Park and ride locations at urban rail transit stops have copious capacity for a boost in car usage when needed. A Metro interviewee noted that when gasoline prices in the LA metro area reached approximately $4.80 a gallon in 2010, there was a 25% spike in urban rail transit ridership with park and ride locations completely full. In total, the LA metropolitan region has 106 park and ride locations totalling 40,113 parking spots. (Metro 2011a) These results warrant the conclusion that society is well acquainted with park and ride locations when deemed necessary. The following is a map of the urban rail transit system and the subsequent park and ride locations at each rail stop. In Figure 24, “B” stands for bicycle parking and “P” for cars. This simple map shows the amount of accessibility for discretionary riders to park at transit stop locations and makes use of the urban rail system for a simpler mode trip.

Figure 24: Urban Rail Park and Ride Lots
(Source: metro.net)

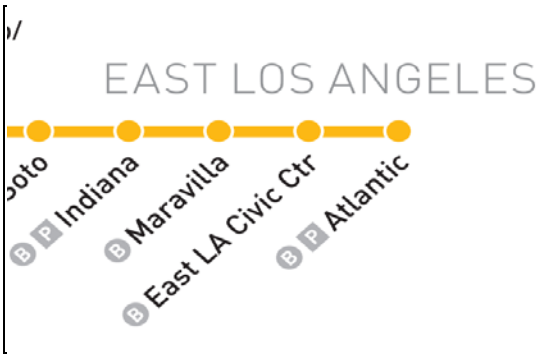

Figure 24: Urban Rail Park and Ride Lots
(Source: metro.net)

With downtown parking rates varying from $0.50 to $2.00USD per 15 minutes, free parking at transit locations will pay for a given rail ticket in less that an hour to park downtown. LA’s parking policies are very strictly enforced and carried out, increasing the amount of revenue that the city takes in and self-regulating the amount of car traffic that follows. Likewise, maximum parking time at curb side locations varies from 1-3 hours, limiting people and workers to keep their vehicles away from the downtown region. This deterrent possibly increases the amount of riders who partake in public transit. As curb side parking is only one segment of the picture, downtown parking structures are located on every corner block and in underground structures. LA’s parking coverage rate (parking area as a percentage of the total land area) is 81%. (MRSC 2009) The city of LA has set parking space standards with 1 per

habitable dwelling of less than 3 rooms, 1.5 spaces for 3 habitable rooms and 2 spaces with a dwelling of more than 3 habitable rooms. (Los Angeles Department of City Planning 2002) This policy is heavily under scrutiny with the problems of automobile use and land coverage in LA.
Prices for garage parking can range anywhere from $8.00 to $20.00 an hour in the downtown region. A large amount of said parking is reserved for tenants and owners of buildings in the downtown area that require a permit to park. These lots are specifically reserved and not open to general public parking.

As parking in Rotterdam is a sensitive subject for society and willingness to change is almost absent, policy makers and planning authorities need to find common ground. A major policy and measure proponent from StadsRegio and Gemeente Rotterdam is to cater to automobile drivers; not in a way that increases car use, but rather deters it through incentives. Shown in figure 25 and 26, Rotterdam's mobility concept creates rings that allow easy access for society to partake in rail transit through integrated urban parking locations. There are two options: a typical park and ride or a park and walk. As such, the closer a vehicle is parked in relation to the urban core, the more the hourly charge is. Situated on the peri-urban ring, park and ride spots are free of charge. With most urban rail round trips costing below €3, public transit provides a better alternative than the personal automobile.

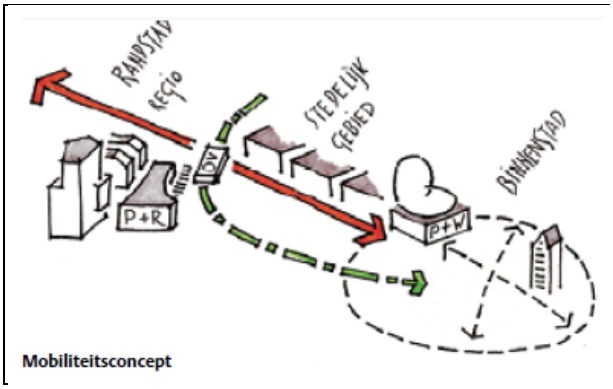

Figure 25: 2009 Mobility Concept of Inner Rotterdam
(Gemeente Rotterdam 2009)

Figure 26: Car Accessibility in the City and Region
(Gemeente Rotterdam 2009)

Current downtown parking garage rates vary from €2-3 per hour, with on-street parking varying from €0.50 per 10 minutes free depending on the day and time. City residents are able to purchase a monthly subscription to park in garages for a fee of €25.10 or an on-street subscription for €5. The Gemeente's policy just cut resident on-street prices in half from the 2010 prices levels. (Gemeente Rotterdam 2011) As parking and vehicle access become a greater concern to society, Rotterdam's ability to counteract with positive methods may be just the way to increase urban rail transit ridership in the future. Shown below in figure 27 are the 2009 levels of occupancy for park and ride locations around the Rotterdam metropolitan area ranging from 98% capacity in Krimpen aan de Ijssel to 47% in Ridderkerk. Maximizing park and ride locations is a critical link for metropolitan regions to decongest its urban core and increase the use of urban rail systems. Figure 28 rather, gives a snap shot as to all of the park and ride locations, both regional and local granting even greater access to a variety of automobile parking. (StadsRegio Rotterdam 2011c)

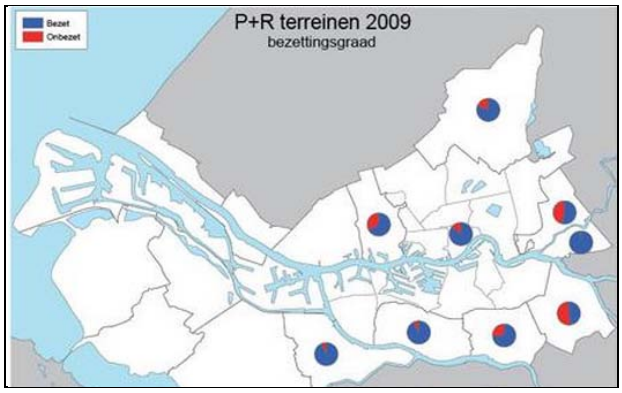

Figure 27: Rotterdam P + R Locations as % Ocuppied
(StadsRegio Rotterdam 2011c)

Figure 28: Rotterdam Regional & Local P + R
(StadsRegio Rotterdam 2011a)

5.3.8 Marketing Levels

5.3.8.1 Comparison

Programs for schools have been created to help students understand and learn about public transit for their future mode of travel. Metro has enabled staff to dedicate time to speaking with children and providing a free round trip to various "field trip" destinations for schools in the local area. What this does is create awareness at a young age that public transit is an affordable and easy way to travel to many popular destinations with ease. This trip is permitted during off-peak hours so that the children will have time to enjoy the entire experience and at less congested times to decrease confusion.

Art work and enhanced lighting schemes around larger transit stops are used to increase positive feelings of safety and cleanliness. In total, Metro invests 0.5% of its total urban rail construction budget for the arts and decoration. Contributing locally and through municipal help, external donations have exceeded $1.5 million since the program started in 1989. (Metro 2009a) Located in Annex 1 and 3, the IAPT's best practices approach toward increasing public transit and TCRP Report 27 has listed art and lighting in transit stations as a way to create a lighter and more vibrant atmosphere. Passengers then have the opportunity to not only look at their magazine, newspaper, or article, but contemporary and historical art pieces as well. Metro offers contemporary art tours through various transit stops along the urban rail system twice a week. This program enables society to see yet another side of public transportation and the benefits of participation.

More recently, Metro has introduced a time schedule called the "15 minutes or less" service to capture the discretionary riders who would otherwise travel by automobile. A Metro interviewee stated that people, who are travelling for the first time by urban rail, are more likely to make the "plunge" if travelling in a group setting. There seems to be a social stigma that is underlying the use of urban rail transit. Metro has not yet tapped into creating a campaign toward stimulating such groups to meet, but it was noted that they will take the idea into consideration. Marketing the system in a different light may be just the thing that will help discretionary riders to travel by urban rail. The current urban rail system already serviced these times; it was yet another way to market the service to patrons and make their choices easier for the future.

With 9 trams lines present within Rotterdam's urban region, people cannot travel throughout the city without waiting for a tram or seeing one. This physical sight alone warrants a natural marketing scheme that helps people realize urban rail systems are present and ready to be

traveled. The presence of trams within an urban region distinctly mark what priorities a city has to its local and regional environment which can only be enhanced by its marketing department.

RET has a long standing relationship with educational institutions teaching younger children about how to travel via urban rail both safely and affordably. With fare incentives for children ranging from ages 4-11, students have a natural benefit to travel by public transit. Likewise, the national government has set the minimum age to obtain a drivers license at 18 years. Marketing of public transit to the contingent age group is nullified and students are granted annual transit passes as described in section 5.3.3. As RET continues to create various marketing schemes, the process of leveraging an already apparent and vast network has enabled a built in advantage for future projects. RET has yet to become publically transparent with a majority of information.

5.3.9 Mobility Management (Transit Demand Management)

5.3.9.1 Comparison

The necessity for bus service to match the timetables with that of urban rail is a major topic within Metro. Disparity of such creates a decrease in ridership and ill-feelings with patrons due to wait time at transit stops. This idea again shows that security of transit stop locations has a large impact on ridership. Ongoing studies are being looked into toward syncing schedules and timetables to better serve patrons in the future and as well decrease waiting times. The Brookings Institute conducted a study in 2010 that stated the average wait time during rush hour for LA's transit system was 6.2 minutes. (Brookings Institute 2011) Of the top 100 transit agencies in the national averaging 10.1 minutes, LA has created a 40% better average.

Another negative aspect of the current rail and payment system, as mentioned by an interviewee, is the need to pay for every trip taken. In order to feed the rail system, an incentive to better integrate the payment structure would encourage riders to travel via urban rail over bus. With the current municipal transfer charge of $0.35 coupled with having to tap multiple times possibly creates more hassle than people want to tolerate. Metro is currently analyzing the different types of trip cost systems including time and distance based. The options could include a one time use (time based) and multiple use (distance based) card. The one time use card can allow flexibility of the system; while at the same time allow an option for visitors to travel without having to purchase a permanent, plastic card. Multiple levels of payment allow for the ability of more patrons to travel, but allow for more work and processing within the information and electronic systems. Disincentives need to be broken down before ridership can increase.

In an effort to increase rail transit ridership, the integrated bicycle plan of 2010 allows for more service locations to place bicycles at transit stops and create more road space and length to travel by bicycle to needed destinations. (LA City Planning Department 2011) This is but one means toward an overall framework approach Metro and the LA Planning Department are taking toward sustainable modal integration.

Modality problem solutions are currently in a heavy developing and implementing state in Rotterdam. With automobile congestion increasing to drastic levels, the Rotterdam urban planning department is creating a new plan mentioned in section 5.3.6. The plan will include decreasing automobile use in the city center from the forecasted year of 2020 by 9%, while increasing public transit use by 4% and bicycle use by 5% respectfully. (Gemeente Rotterdam

2009) This push in modality choice selection creates a more sustainable and equitable modal split that serves a broader function in society.

Changing the mentality of society is a difficult issue, especially if policies and measures infringe on a person's rights. As such, Rotterdam has already executed a program to incentivize people in not owning an automobile. With the national "Green Wheels" program, short term rental cars give society a way to have independent mobility when needed. Since the program started in 1995, the program has been integrated with the national rail system and grants discounts for yearly and monthly ticket holders to rent the car. Decreasing the need to own a car and incentivizing public transit has proven successful in the Netherlands, but automobile congestion continues to increase annually. The transition in modal choice toward urban rail systems over the next 5-10 years will prove critical for Rotterdam to achieve continued ridership numbers.

One final measure and policy, as mentioned during an interview with the Rotterdam city planning department, that has helped in the execution of bicycle riding is traffic signal priority and safety. This measure allows people who ride public transit around the city to be able to access stops and locations faster and timelier. Rotterdam is currently underway conducting traffic studies with efforts to increase traffic signal priority and length of signal for bicyclists. This measure is yet another way to decrease car use and grant priority for public transit access and sustainable modes of transit.

5.3.10 Evaluative Policy/Measure Spider Model

Contrary to the spider model of Nijkamp, et al. in chapter 4, this primary spider model aims to assess how well the cities of Los Angeles and Rotterdam have implemented, or are in the planning stages of creating policies and measures toward increasing urban rail transit ridership. As such, the closer the internal factors are to the center of the model, the worse the city has done in executing or implementing such a given factor. Through the previous assessment, each city has fallen short on some level or category. As local governments and transit agencies continue to provide for society, urban rail can provide the necessary mode of transit they are searching for.

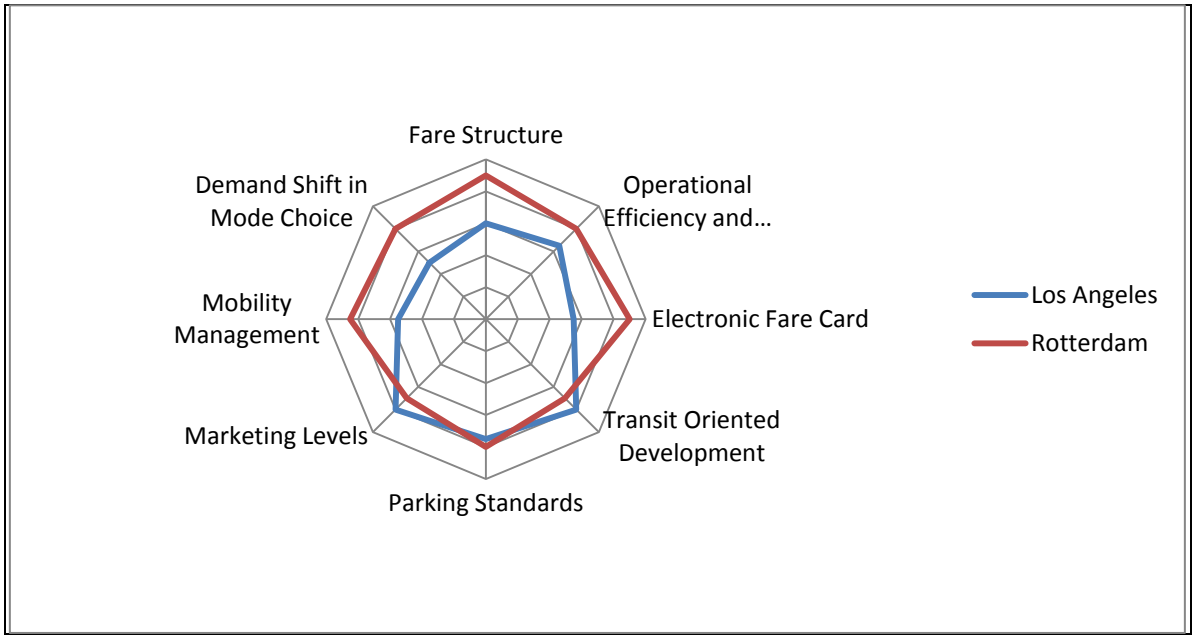

Figure 29: Conceptual Urban Rail Transit Policy/Measure Spider Model
(Source: Author)

In order to accurately quantify a rating for each category, the summation of information for each section warranted the concluding results. As pricing is both a marketing and profit strategy for transit agencies, Rotterdam has created a better overall flow of pricing through its fare collection system rating it a 4.5 and with LA choosing a burdened system that creates patron confusion, a score of 3 was given. Operational efficiency and security are major concerns of any transit authority, but Rotterdam has created a way for security/fare checkers on-board to exert an added level of safety as well as effective transit times giving it a 4. LA on the other hand continues to have struggles with its contracted security forces and coupled by rail service that runs longer at decreased capacity granting a 3.25. Due to LA's lack of integration between transit modes and pricing schemes and Rotterdam's exemplary integration, the electronic fare card ranked LA with a 2.75 and Rotterdam with a 4.5. Out ranking Rotterdam for the first time, LA has created and executed multiple TOD developments that have shown increases in ridership at project stations giving LA a 4. Rotterdam on the other hand already integrates TOD with everyday planning practices, but hasn't produced large increases in transit ridership, but rather overall ridership increases ranking it with a 3.5 for future improvement to densify around nodal rail locations. As increased parking standards play a large role in Rotterdam's new city plan toward alleviating congestion the ranking warrants a 4 with LA falling just behind with stringent and heavily enforced parking rates, but a large amount of structural parking inhibiting the urban core rating LA with a 3.75. The marketing factor for both cities is quite different with LA contributing quite a value in construction capital costs to art and marketing giving LA a 4 and Rotterdam with subsidized transit passes to younger age groups and the tram system presence alone granting a 3.5. Coupled by a high percentage of multi-modal options and priority toward public transit, Rotterdam ranks in with a 4.25, while LA has not provided an adequate amount of bicycle priority and public transit strength to rank it low at 2.75. Finally, as Rotterdam has created an exemplary demand model for multiple mode choice granted a 4, LA has limited its access public transit modes to a far lesser degree ranking it with a 2.5. The bottom line is created by encompassing quality measures and the right policies to achieve such levels of transit ridership.

5.4 System Sustainability Assessment

5.4.1 Introduction

Sustainability toward urban rail transit and its overall framework of planning is of critical importance for future generations to partake in an equitable and efficient system. For this reason, a multi-criteria assessment of each agency will be analyzed through six different topics that cover environmental, financial, and social sustainability. The need to cover various categories of sustainability is due to the fact that multiple actors and conditions play a vital role in establishing and monitoring transit systems. This assessment creates a brief, but solid background in an effort to uncover methods toward sustainability transition as mentioned in section 2.7. The following analysis will encompass such criteria as energy type and source, associated costs, ecological footprint, integration of public authorities, quality of public urban rail accessibility, and congestion mitigation. This analysis not only focuses on urban rail systems, but overall transit system changes as a whole.

5.4.2 Energy Type and Source (System Wide)

5.4.2.1 Comparison

Metro's stance toward sustainable energy sources cannot be better exemplified than through its ownership of 1.8 megawatts worth of solar panels on Metro property. This amount ranks Metro as one of the largest solar power installations within the transit industry. (metro.net) Congruently, Metro's heavy rail system runs on a 750v third-rail with the LRT vehicles running on a 750v catenary overhead system. Consuming 182 million Kilowatt hours in 2010, Metro's urban rail system cost $22.4 million to move rail cars throughout the system. Power is purchased from 3 sources with different levels of price. The majority of power is generated from the Los Angeles Department of Water and Power (LADWP) at 65% with Southern California Edison producing 31% with the remaining contingent toward Pasadena Water and Power. (Metro 2010) LADWP only produces 20% of its power from renewable sources, but aims to increase this number in the future to 33% by 2020. (LADWP 2011)

RET's heavy rail system is currently run on a combined 750v third-rail and catenary overhead system with the tram system composed of a 600v catenary overhead system. With a large amount of electricity usage, RET's choice selection of power company can make a large difference in environmental conditions. As such, the current electric energy provider for RET since 2008, Green Choice, provides a 100% green energy supply to the transit system. According to the Green Choice website, commercial electric energy production is produced through the following sources with a percentage of total output: wind (24.0%), solar (0.3%), hydro (39.9%) and biomass production (35.8%). (Green Choice 2011) The inherent choice of RET to choose such an environmentally sustainable power company will allow future generations to enjoy urban rail transit in Rotterdam.

5.4.3 Associated Costs (Capital and Operations)

5.4.3.1 Comparison

Through various types of sustainable energy sources, Metro has taken a stand in increasing the implementation of such infrastructure; creating a net cost savings of $400,000 annually in electricity costs. (Metro 2009b) As Metro pushes forward in a creative way to cut costs, they are critically assessing how to construct measures and implement policies that help decrease the emission impact on the environment. Table 7 give examples toward how Metro is assessing which measures and policies would not only have the best environmental impact, but create a net cost savings for the future.

The outcome of this study shows the least costly or cost savings strategies with the largest degree of greenhouse gas decrease to be ridesharing programs, transit oriented development, vanpools, and on-board rail car energy storage capabilities. These are but a few measures and policies that can save Metro funds for alternate uses with an overall net benefit at low cost. As Metro looks into the future, further high cost projects such as expansion of the rail system and wayside energy storage substations will be needed to increase the amount of GHG reduction in order to meet standards according to state and national policy.

Summary of Greenhouse Gas Reduction Cost Effectiveness and Maximum Annual Emission Reduction			
	Cost Savings/ Cost Neutral	**Moderate Cost ($300 - $900 per ton)**	**High Cost (> $1,000 per ton)**
Large GHG Benefit (> 10,000 MtCO2e/year)	• Ridesharing/Transit Programs for Employers • Transit Oriented Development • Vanpool Subsidy • On-board Railcar Energy Storage		• Expand Rail and BRT Systems • Wayside Energy Storage Substation
Moderate GHG Benefit (1,000-10,000 MtCO2e/year)	• 45-foot Composite Buses • Facility Lighting Efficiency	• Metro Employee Transit Subsidy	• Bicycle Paths along Transit Corridors • Gasoline-Electric Hybrid Buses
Small GHG Benefit (< 1,000 MtCO2e/year)	• Red Line Tunnel Lighting Retrofit • Hybrid Non-Revenue Cars • Recycled Water for Bus Washing • Low Water Sanitary Fixtures	• Solar Panels • Bike-to-Transit Commuter Incentives	• Hybrid Non-Revenue Light Trucks

Table 7: Metro GHG Reduction Cost Effectiveness and Maximum Annual Emission Reduction
(ICF International 2010)

In order to understand how rail operations can increase ridership, funding of such a mode is paramount. According to the 2009 Long Range Transportation Plan-Technical Document (Metro 2009b), multiple sources of revenue collection include sales tax Propositions A and C with a special measure passed by public voters entitled *Measure R*. All three methods incur a half cent sales tax increase for multiple durations of time ranging from indefinite to 30 years. Rail development and operations receive 35% funding from Proposition A, with 5% rail/bus security and 40% rail/bus capital infrastructure split from Proposition C, and 5% rail operations, 2% rail capital improvement, and 35% bus/rail infrastructure split with Measure R. The remaining funds are mainly allocated toward highways, roadways, and bus operations. These cost implications grant favor toward road access and priority over rail operations and its subsequent right of entry. Alternatively, six capital rail projects are currently underway and/or in construction for extension of the overall system. The total amount of capital funds for these rail projects amounts to $7.75 billion. As these rail lines open within the next 5-7 years, subsequent rail cars will need to be purchased totaling 33 at $3.8 million each.

Overall, the operating and capital funds are providing a quality system now and toward the future, but Metro will need to implement initiatives toward increasing self-supporting revenue mechanisms and a way to increase ridership to achieve their targeted 33% farebox recovery ratio.

Due to service cuts in bus operations in the coming years, more emphasis by the Stadsregio and RET will be toward the urban rail systems (heavy rail and tram). As the national government cannot sustain such a high amount of subsidy given to the regional government of Rotterdam, RET has been forced to decrease its bus operations saving the transit agency around €5.26 million for the upcoming year in 2012. (15% decrease from previous year) With a total yearly budget from the StadsRegio of €268 million dedicated toward public transit and another €102 million for traffic and transit related projects, the current capacity to provide quality transport is a paramount concern for the government of Rotterdam and its society. (StadsRegio Rotterdam 2011c)

5.4.4 Ecological Footprint

5.4.4.1 Comparison

With the adoption of U.S. Senate Bill 375, which aims to decrease greenhouse gas (GHG) emissions from transit related sources and the California Assembly Bill 32, which was a precursor to the previous bill regarding global warming solutions, Metro has taken a position toward improving and increasing its public transit infrastructure and policies to couple together and provide a sustainable transit system that will provide the needs for its society throughout future generations. As such, Metro has implemented the following policies already: Metro Environmental Policy, Metro Energy and Sustainability Policy, Metro Construction and Demolition Debris Recovery and Reuse Policy, Metro Environmental Liabilities Reduction and Reporting Policy, and Metro Water Use and Conservation Policy. Likewise, Metro as a whole has reduced its building use in electricity by 33% and water by 50%. (Metro 2009b) Annually, Metro spends $20 million dollars alone to electrify its rail system. (Metro 2007) Their aim is to purchase electricity at the most affordable rates to save tax payer funds. This is an outdated system and needs to be replaced with a solution toward buying energy from a renewable energy company. Energy production is a costly endeavor, which should be left to specific companies, rather than transit authorities. Purchasing energy from a sustainable source is a way for Metro to achieve a higher ecological footprint. In contrast, Metro creates an overall net reduction in GHG emissions, such as CO_2, by 862,000 Mt per year. (This amount takes into consideration the emissions produced by Metro's facilities, vehicles, etc.) In a specific case of 8 locations within LA County, the policy of Metro to lease land to developers to construct TOD projects has created a reduction in CO_2 emissions by 14,600 Mt in 2010. One other noticeable measure that has worked very well is the transit pass programs for students and employers. The outcome of such a program has actually produced revenue of $3 per Mt of CO_2 reduced. Like this project, there are many cases that have been implemented by Metro that have led to an overall reduction in CO_2. (ICF International 2010) Through continued efforts, Metro is well on their way to creating a sustainable public transit agency for the future.

RET will be heavily decreasing bus service operations in the coming years. Consequentially, the emission levels from bus operations will drastically decrease the ecological footprint of the RET. With a push toward the urban rail systems, electrically powered heavy rail and tram cars will be a way to continue a sustainable source of public transit into the future. As noted in section 5.4.2, RET's choice is purchasing electricity from a company that produces completely renewable energy, warrants great rewards toward an overall decreased ecological footprint. Coupled by the Rotterdam Climate Initiative and the UITP Sustainable Development Charter, the goals set for Rotterdam are advantageous with a 50% reduction of CO_2 emissions (as per 1990 levels) and 100% climate change resilient by 2025. In order to achieve such a high stake level of achievement, RET has already managed a 80% coverage rate of their public transit kilometers traveled by electrification coupled by a completely renewable source of electricity provided by Green Choice as mentioned in section 5.4.2. Special urban rail driver courses, called EcoDrive, are mandatory for rail operator employees. This program teaches operators to brake and speed up in certain locations throughout the system that offers the maximum energy benefit and greatest savings to the operator. The final step that grants knowledge for future change is found through a learning cooperative agreement between 5 partners in Europe including GMPTE (UK), moBiel (Germany), RATP (France), RET (NL), and STIB (Belgium). Together they have formed "Ticket to Kyoto," a learning project that aims to reduce CO_2 emissions in public transport. Of such, EcoDrive was

birthed from moBiel's innovation and idea. Together, cooperative organizations can help reduce the ecological footprint of transit agencies around the world. (T2K 2011)

5.4.5 Integration of Public Authorities

5.4.5.1 Comparison

In order to create sustainable policies and measures toward increasing urban rail transit ridership, a connection with organizations and government need to be in place. Metro has made it a priority to link effective policies with strategic measures to efficiently and equitably increase urban rail transit ridership. Without this connection, governments will have failed to capture the necessary link needed to gain the ridership numbers projected. A Metro interviewee stated that these policies are created to maximize the public's investment in their public transit infrastructure. Sustainable practices are at the root of transportation development and implementation. Routine meetings with Metro and the surrounding cities planning offices create a well established connection for future development toward increased ridership numbers. This connection can be scene through the placement of the integrated bicycle network. Spanning every city in LA County, this mobility management approach toward planning creates a natural linkage with Metro to increase ridership for the future. Alternatively, too many projects that involve local studies are granted to local and international consulting groups. This creates a natural disparity between what the knowledge of the local transit authority and project that is being proposed. As policy planning evolves through the transit planning stages, the integration among and within authorities is lost through outsourcing during the knowledge stage. Throughout the entire process, Metro's "one-stop shop" organization has provided for efficiency is operations and overheard. Overall, the integration of Metro, the surrounding city planning departments, and the neighboring communities is well established, but the disparity of local knowledge and outsourcing of studies takes away from key requirements to provide what society truly needs. With Metro taking a stance as a "one-stop shop" transit authority and operator, the knowledge of ground level planning is of utmost importance.

After years of challenging struggles, the RET is now a separate transit operator that is owned by the municipality of Rotterdam. Before 2011, RET was owned by SRR, with a concession to operate the public transport. The current situation of separation has moved RET into more of an operator organization, than a regional transit authority. As such, SRR is taking the initiative to place requirements on RET to provide a base standard of service and operation. As the split has been recent, the technical operations of the transit is still in the hands of RET, but SRR is in negotiations to take over such capacity. SRR believes that RET should be solely an operator and be regulated by standards set by the national government, not set their own standards. In the coming 2 years, the integration of SRR and Stadsgewest Haaglanden (Den Haag Regional Authority) will change integration of public authorities and how financial and operational standards are set and met. This connection will create more succinct and leaner transit systems that will hopefully provide for the area of the zuidvluegel (southern half of the Randstad planning area) better in the future. Likewise, multiple planning agencies (transit, spatial, social, etc) cooperate on a daily and weekly basis to provide information on what would be best for the area of Rotterdam. Overall, heavy emphasis on cooperative planning is set as a backbone in the Netherlands, and much more so in Rotterdam as a testing ground for new innovations such as the OV-chipkaart.

5.4.6 Quality of Public Transit Accessibility

5.4.6.1 Comparison

Through information gained during an in-depth interview, Metro has taken the stance that if every rider is seen as a pedestrian, then how can public transit be made available to them? Metro has shown their main motive to be people oriented over profit and planet. This approach has brought a new meaning toward how urban rail transit is created and how it can be used to increase the livability and sustainability standard of such a region. On the other hand, the average commuting time in the LA region is 29 minutes, while the lowest city consists of roughly 15 minutes. (U.S. Census Bureau 2011) This large gap will need to be filled in the coming years. Recently, suburban sprawl has reached a standstill in LA due to many factors including foreclosures, economic status resulting in people wanting to travel closer to work destinations, and fuel prices.

With an influx of public transit moving toward privatization, these companies are looking to capture discretionary riders via transit nodes. Commercial activity is then being conducted near transit stops, which share location with residential living. (Bertolini 2007) Metros increased JDP projects will continue to aide in the sustainability and livability of the expanding urban rail system. Likewise, the City of LA's planning department has made dramatic steps in increasing bicycle lanes, increasing dual use parking locations for rail patrons near transit stops, and granting incentives for public transit patrons to purchase folding bicycles to arrive and depart at transit locations. Multiple policies and measures are being taken into consideration, with implementation coming in subsequent years ahead. (Nelson and Nygaard Consulting Associates 2009) The idea of inducing society to participate in rail transit is not new, but another push has the planning department conducting studies toward casual carpooling, taxis, car-sharing, hourly car rentals, folding bikes, and a bike sharing program. Incentivizing society to participate in urban rail transit does not only involve financial incentives, but also providing alternative methods to arrive and depart destination locations such as a job, shopping center, or childcare facility.

The natural densification of Rotterdam and inherent planning techniques of the Dutch are shown in how well its urban rail system is integrated within the city. This planning motive justifies the claim for enabling the planet and people motive. To describe better through application, the Rotterdam planning department has set maximum walking distances to public transit as per section 5.3.6. RET aims to grant quality access to its spheres of influence. These 3 spheres are given extensive detail under the new Kadernota 2011 document allowing minimum desired standards. As such, the 3 spheres are the core network, enabling network, and custom transport. With 80% of society living within the core network the maximum walking distance has been set at 800m, cycling at 2400m, and a minimum public transit mode stopping at least 4 times per hour with a strict schedule. The enabling network accounts for 30% (overlap of core network) of the influential area with walking standards set at 400m, 1200m cycling, and public transit on strict schedules. The enabling network guarantees a stop within 200m of all colleges, universities, hospitals, and municipality offices, where there is no stop otherwise. The final level of service is the custom transport network which accounts for 10% of the area and receives service as is or through paratransit services. There is no direct link to public transit services in these locations. Furthermore, the StadsRegio has made it mandatory on the core network to have the DRIS system (section 5.3.4), adequate bicycle parking and shelter, and complete handicap access at all stops. The enabling network requires adequate shelter and half of all stops to be handicap accessible. Overall, with a coverage rate

of 90%, RET has created a solid backbone of service and accessibility for the patrons it serves. (StadsRegio Rotterdam 2011b)

5.4.7 Congestion Mitigation

5.4.7.1 Comparison

As with any metropolitan area, congestion plays a large role in how a city operates. Two inherent negative externalities of congestion are hours and fuel wasted. Shown below in table 8, a 2010 study of the largest metropolitan areas in the US, LA's public transit system has yielded the fourth highest time savings by hours of delay with 33 million and indicates that the region has saved a total of 13.7 million gallons of gas and $773 million in congestion costs. As the current LRT system not only expands to create access to more of society, the induction of more passengers per trip and constant flow throughout the day will only increase this amount.

Hours of Delay Rank	Urban Area	Savings from Public Transportation Use		
		Hours of Delay Saved	Gallons of Fuel Saved	Congestion Cost Savings
1	New York-Newark NY-NJ-CT	368,062,189	267,205,900	8,810,307,584
2	Chicago IL-IN	92,506,568	82,323,700	2,351,660,815
3	Washington DC-VA-MD	34,119,772	24,150,500	766,572,738
4	Los Angeles-Long Beach-Santa Ana CA	33,187,437	13,766,600	773,174,258
5	Boston MA-NH-RI	32,885,168	23,597,800	745,480,195

Table 8: Public Transit Traffic Congestion Savings
(Schrank, Lomax & Turner 2010)

As the leading transit and congestion management agency in Los Angeles, Metro has implemented the congestion management program in 2010. (Metro 2010a) This program not only covers highways and roadways, but a variety of multi-modal transit. Finding ways to decrease congestion, Metro has conducted transit network corridor studies that have identified LRT on the Artesia, Santa Ana, and San Fernando Freeway corridors to have increased passenger throughput 150%, 135%, and 97% from 1992 levels. Congruently, from 1992-2009 a 44% increase in system wide throughput has been attributed to the urban rail system as referenced from the programs indicators. Without the ability to expand freeway and roadway systems any further, urban rail systems are becoming a forced mode of transit for certain patrons. As congestion continues to get worse, urban rail systems continue to provide accessibility and prove that trip times are faster and timelier that automobile trips.

Rotterdam has been hit with a heavy increase in automobile congestion over the past few years. The need to mitigate such disturbances has been given heavy priority for SRR with the help of RET and the municipality of Rotterdam. In order to combat the heavy flows of traffic into and around the city, Rotterdam is pushing and incentivizing travelers to park in the peri-urban park and ride locations. Through use of the urban rail system, automobile users have multiple tiers of parking standards to choose from. As shown in section 5.3.7, park and ride locations have proven to alleviate a large amount of traffic from roadways onto urban rail systems. The StadsRegio's Kadernota 2011 (Framework Document on Public Transport) supports the efforts of increasing park and ride locations in order to alleviate congestion around the urban center. Their aim to provide succinct public transit to these nodes will hopefully guide automobile driving patterns for the future.

5.4.8 Evaluative Sustainability Spider Model

A secondary spider model has been created to critically assess whether or not the current government or transit authority is setting standards toward urban rail transit that are sustainable for future generations. A set of indicators are needed to completely analyze the whole situation and as such, the following model will assess factors that take into account the environmental, financial, and social implications of a public transit agency or operator. As noted in section 2.6 and 2.7, sustainability efforts are an endeavor between governments and society, affected by the operational outcomes of transit authorities.

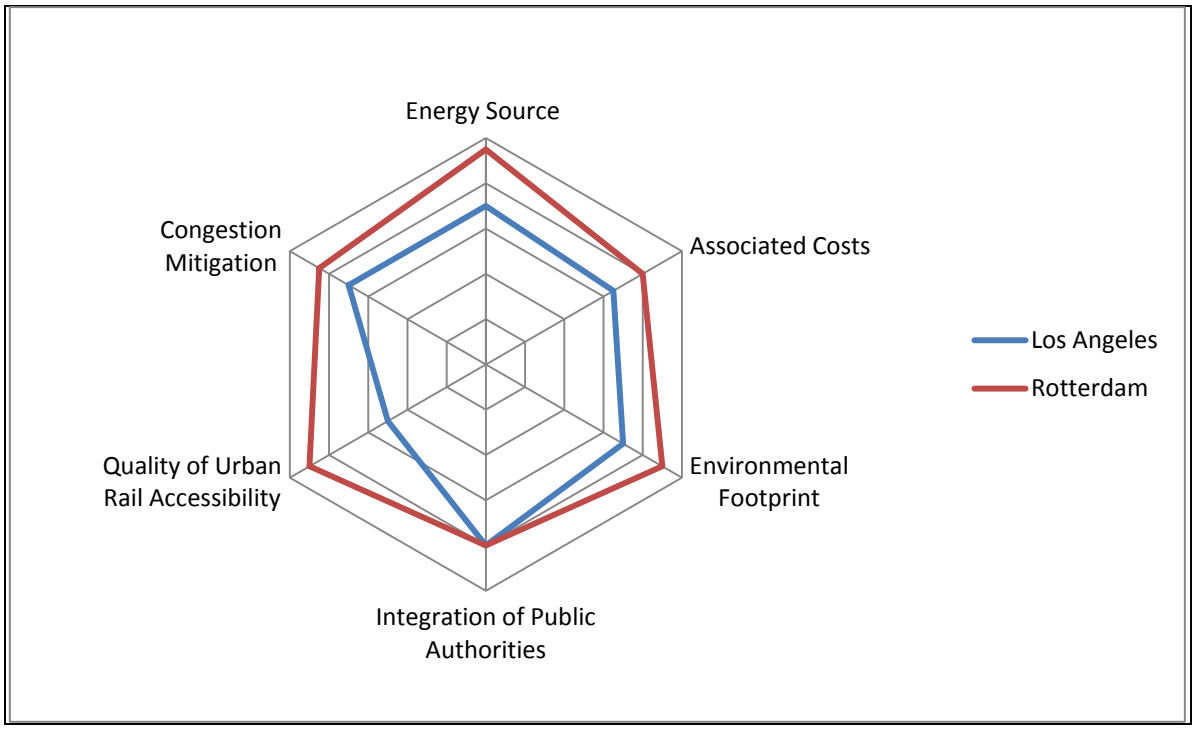

Figure 30: Conceptual Urban Rail Transit Sustainability Assessment Spider Model
(Source: Author)

The largest contributing factor for Rotterdam's energy source ranking is concluded from its choice to purchase electricity from an all renewable energy producing company scoring a 4.5, with LA drastically behind for the main reason that they are trying to tackle electricity production on their own, which creates high costs for the authority in total ranking LA at 2.5. Cost wise, Rotterdam has allocated more funds toward public transit and urban rail systems and increasing services of such granting a rating of 4 with LA saving money from its solar power installation which doesn't come close to its overall electricity budget ranking it with a 3.25. As emissions play a vital role in wanting urban rails systems to succeed, Rotterdam's choice of where they purchase electricity coupled by a difficult to achieve climate initiative grants a ranking of 4.5 with LA choosing to take lower electricity costs, but at a higher emission level degrades its ranking to a 3.5. The integration and structure of both of organizations is quite opposite, but warrants a high mark of 4 due to the fact that Rotterdam is integrated over multiple agencies that works very effectively and efficiently, while LA has encompassed all agencies under one organization to execute timely programs and projects. Moving on, the heavily devolved network of urban rail infrastructure coupled by the sprawl of the city has marked LA with 2.5, while Rotterdam has given access to over 80% of its metropolitan region with urban rail marking it with a 4.5. Finally, being the freeway capital of the world with one of the highest commuting times in the US, LA deserves a 3.5, while Rotterdam's congestion increases; the city has created a program to mitigate it attaining 4.25.

5.5 Overview of Factors Affecting Ridership and System Sustainability

Ridership plays a critical role in assessing public transit for society. As shown throughout this study, multiple measures or policies have different effects both in ridership and frequency, but as well quality and accessibility. The subsequent graphs show the historical annual ridership frequencies of LA and Rotterdam from 2006-2010. Due to a current regime shift among RET and StadsRegio, information transparency was heavily apparent. This change did not allow for an in-depth view of internal information that LA had produced. The majority of Los Angeles' ridership increases has been through urban rail expansion, but congruently through proper policies that coincide with such expansion such as TOD projects, parking standards, system security, fare pricing, and mobility management factors. After review of LA's system and operations, Los Angeles can value most from employer incentive programs for employee public transit passes, increased marketing of park and ride locations, and shift mode operations from bus to rail. Rather, after an assessment of Rotterdam, the most valued policies and measures toward increasing ridership are toward the future of automobile parking in strategic locations around the periphery of the city, continued increase of multi-modal access to urban rail stations/stops, and continued integration of its OV-chipkaart as demonstrated on the policy and measure spider model. Creating standards that limit the flow of automobile traffic into urban areas create a place to live, work, and play. The future lies within cities and its ability to provide and care for its people. It's up to politicians, planners, and societies to create, employ, and accept such choices for a better future.

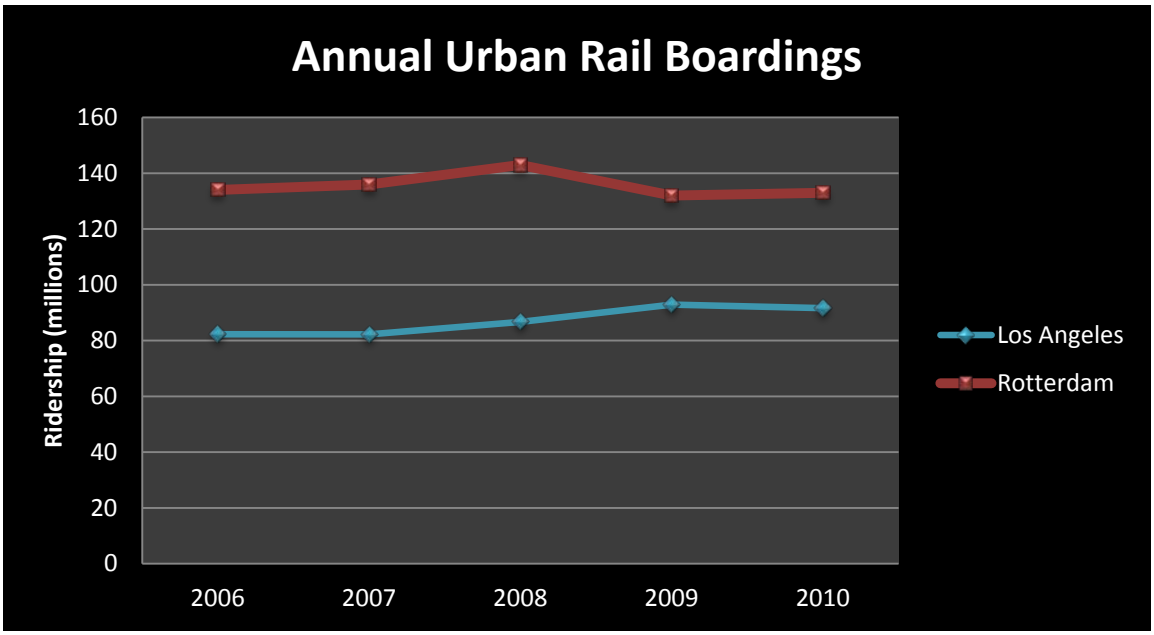

Figure 31: Los Angeles and Rotterdam Annual Urban Rail Boardings 2006-2010

Chapter 6: Conclusions and Future Research

6.1 Conclusion

The empirical study of this thesis assessed the methods and abilities governments and transit authorities can place into operation in order to increase urban rail transit ridership and enhance system sustainability. In order to critically analyze and gain insights for a significant assessment, an international comparison was conducted. As such, the city of Rotterdam has brought about an alternative approach toward urban rail systems planning over the American method with regard towards policy and measure choice selection. Rotterdam has shown that multiple governmental and transit agencies can work well to accomplish a quality urban rail system while Los Angeles has created a ubiquitous organization that provides for all things transit. Due to the dynamic structure of public transit, multiple actors, interests, and layers all have an affect on how policies and measures are implemented and created. This constant struggle creates a gap in the technology and methodology that governments and transit authorities can ultimately implement. Congruently, with the RET in a transitional state from owner to operator, data collection and transparency outside the organization is slim to none. The use of specific data seems to be a sensitive issue while assessing multiple levels of the organization. To mention last, the correlation between the assessed policy and measure and system sustainability spider models has no cordial relationship, but were used to gain insight into a deeper and overall understanding of the current operational system.

Moving forward, the largest factors toward increasing transit ridership are toward changing the behavior of society and implementing an infrastructure system that can handle the subsequent demand. Since both of these tasks are monumental and costly in nature, incremental steps toward transformation are accomplished through policies and measures. To bring to light the way sustainable transitions are met is mentioned in section 2.7.2. Loorbach (2007) concludes that policies and measures are short term strategies that are aimed to achieve an overall long term framework of change for society. This transitional formation can be seen below again as to what levels governments and transit authorities can best accomplish such tasks toward increasing urban rail transit ridership and system sustainability. Transition is paramount for society to partake in urban rail transit and for government to provide such.

Transition Management Types and Their Focus (Loorbach 2007)

Transition Management Types	Focus	Problem Scope	Time Scale	Level of Activities
Strategic	Culture	Abstract/societal system	Long term (30 years)	System
Tactical	Structures	Institutions/regime	Mid term (5–15 years)	Subsystem
Operational	Practices	Concrete/project	Short term (0–5 years)	Concrete

Table 1: Transition Management Types and Their Focus
(Loorbach 2007)

In order to gain an answer of rejection or acceptance, the original hypothesis is stated as mentioned in section 4.1:

As governmental policies and measures play an integral role in affecting and formulating societal choice selection in urban rail transit use, there is a need to increase sustainable transportation policy and measure selection in Los Angeles to create a livable metropolis, which is shown as deficient in the current environmental and social situation.

To answer this, the subsequent study has given the types and functions of Los Angeles' policies and measures which have been drawn out from various empirical literature studies and analyzed. As such, LA has shown to have a great magnitude of policies and measures in place including a new bicycle plan that lays out a better future for increased mobility within the urban core, transit oriented development projects that have increased urban rail transit use around station nodes, and marketing levels that stimulate the awareness toward society that travelling via urban rail is most often cheaper and more timely than a personal automobile. As stated during in-depth interviews, various ordinances and policies are outdated and does not capture the full value of infrastructure expansion toward increasing urban rail transit. LA and Rotterdam have both struggled in certain instances however that warranted a confirmation of this studies hypothesis.

As with any empirical research, data validity and reliability are critical in order to achieve a solid research framework. Multiple levels of in-depth interviews through various authorities have made this research vertically solid while being coupled by an international comparison for horizontal strength. The research findings have been critically reviewed by the author and are the opinions of such analysis. There may be further interpretations of the data, but the following are solely those of the author.

To gain an overview of the research findings, a summary of individual research questions have been laid out in order to answer to the overarching main research question.

Main Research Question: At what level and to what extent can governmental policies and measures increase urban rail transit ridership?

What is the current performance of the public urban rail transit systems in Rotterdam and Los Angeles?

Based on this study, LA has placed the backbone of their transit system with the highway prone bus. As bus service consistently finds itself being reduced and then increased due to rider demand, urban rail provides a more consistent means of transit ridership. Conversely, Rotterdam has developed an immense urban rail network within its region that caters to 80% of its constituents. Moving toward the demographic selection of each transit system, the majority of transit users in LA are higher in age than Rotterdam due to select policies from the Dutch national government to subsidize younger travels. Alternatively, more patrons in LA travel via public transit during a given week than Rotterdam, while the mode choice of bus necessitates greater resources over urban rail. Various policies toward a multi-modal transit system within an urban region have granted a greater amount of options in Rotterdam over LA. Ultimately, the running performance and facilitation of urban rail transit systems is directly linked toward policies and measures set by national, regional, and local government carried out through local and regional transit authorities.

What specific policies and measures affect ridership levels in Rotterdam and Los Angeles?

Increased urban rail transit frequency and nodal locations coupled by proper modal policies can create a more succinct and faster public mobility system than automobile use within a metropolitan region as noted by Rotterdam. This study has found that LA has increased its urban rail transit ridership 11% over the past 5 years with Rotterdam achieving -1%. The policies and measures that have achieved the greatest influence in transit ridership are fare pricing, transit oriented development, parking standards, and mobility management. As LA faces many challenges to implement infrastructure supply for bicycle lanes, TOD projects, and recurring mobility enhancements, Metro's ability to set fare prices toward levels of equity and further integrate the TAP card are critical. Rotterdam has shown that policy directly related toward a truly mixed modal use has enhanced not only the urban landscape, but

increased an urban rail ridership count 1.6 times that of LA. The achievement can be granted toward a variety of planning choices, but governments and transit authority need to take initiative for the better of society rather than accept the choices of such. This has been shown by excellent accomplishments of RET, StadsRegio, the municipality of Rotterdam, and the Dutch national government. In order for any policies or measures to accomplish their given task, governments need accountability. As seen through this study, Metro's ability to control the entire tasks of operation, planning, and policy possibly hinder the capabilities to perform as well as it should. Congruently, as RET is becoming devolved from StadsRegio into more operator based, a proper set of guidelines as to the powers of operation and decision making is needed. This can be seen through the highly varied annual ridership numbers from 2006-2010. Overall, specific policies and measures toward increasing urban rail transit are critical to achieve the future mobility goals of governments and transit agencies for the coming years.

What sustainability comparison criteria can be assessed between the rail systems of Rotterdam and Los Angeles?

This study indicates that the most determining factor from the sustainability assessment of Rotterdam points toward the purchasing of 100% renewable energy for the use toward its urban rail system. If renewable electricity is used, transit can continue in operation for generations to come. Such secondary factors of Rotterdam's assessment conclude that the accessibility of urban rail stations creates a win-win situation for both society and environment. With urban rail transit stations/stops located around 80% of its urban population, society does not need to travel by personal automobile which decreases harmful emissions. Moving toward LA, the spider models worst rankings among the assessment noted congestion management, urban rail accessibility, and energy type and source. LA has the obligation of its people and planet to provide a rail system that can be emission free. Such lessons from Rotterdam can be noted. Secondly, congestion in LA can be decreased if and only if policies incentivize the user of the automobile as noted in Rotterdam's park and ride locations. The final step in creating a sustainable transit system is the expansion of the urban rail which is shown as being heavy worked on and in progress. This expansion has shown the largest increase in ridership over any other policy or measure and can be the way toward a more sustainable Los Angeles in the future. As infrastructure supply is not always the answer, this study has drawn out such policies and measures that can resourcefully compliment such sustainable infrastructure choice selection. The need to create a baseline measurement of urban rail transit accessibility is crucial for future ridership increases. LA's viewpoint should start to direct itself toward planet over people first in order to achieve a more healthy region to live in, with profit following in step through further expansion of the system.

6.3 Further Research Topics to Consider

As with any research, there are topics that can be described into more detail and given more analysis. The following are topics into which in-depth studies can be completed to gain a more insightful approach toward ridership increases.

1. Investigation toward the ethicise of corporate America granting cross subsidies for its employees to travel via public transit.
2. Effects of park and ride locations toward increasing ridership or decreasing automobile users in an effort to increase public transit patrons.
3. Effectiveness of TOD projects located in urban and peri-urban locales with regard toward urban rail transit.
4. How can marketing of urban rail systems increase ridership and to what extent?

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Annex List

Annex 1: The International Association of Public Transport Best Practices Approach: 16 Points

Best Practice 1:	**Public transport adds value to developing new areas**. High quality public transport increases the value of real estate. New transport infrastructure can be jointly financed with developers who benefit from these rising land values.
Best Practice 2	**Light rail regenerates city centers.** Many cities have successfully combined public transport projects with a policy of revival of its city centre. In the last 20 years, 14 cities in the USA and Canada have introduced new light rail systems: Baltimore, Buffalo, Calgary, Dallas, Denver, Edmonton, Los Angeles, New Jersey, Portland, Sacramento, Saint Louis, Salt Lake City, San Diego, San Jose.
Best Practice 3	**Pedestrians, cyclists, buses and trams make a good combination for inner city centers.** Even in narrow streets where cars are banned, pedestrians, cyclists, deliveries, buses and trams can co-exist.
Best Practice 4	**Attractive rail and bus services to out of town shopping and leisure centers.**
Best Practice 5	**Fast reliable links from city centers to airports**. In some cities public transport caries as much as 40% of all airport passengers.
Best Practice 6	**Co-ordination of all modes.** The market share of public transport rose by 10% in four years in Vienna, the capital of Austria. This is due to: a common ticket for all modes in the metropolitan area; well planned interchange stations making changes from one mode to another easy; expansion of metro and suburban rail; modern light rail system in city streets; new tramline to a new housing area; personalized marketing in new residential areas.
Best Practice 7	**Technology to better inform passengers.** Good passenger information is a deciding factor to increase the competitiveness of public transport. GöteBorg, Sweden, has a network wide real time passenger information system. The information centre monitors the position of over 450 buses and trams vehicles on their routes allowing real time information of the next service to be given at more than 140 stops. Information is accessible via the internet and mobile telephone.
Best Practice 8	**Easy access to all modes by 'e-ticket'.** Contactless smartcards have been introduced in many cities, including Hong Transport Problems Facing World Cities 5 Kong (Octopus Card) and London (Oyster card). In Hong Kong the smart card is used by 85% of passengers, and reduces access time to platforms and vehicles.
Best Practice 9	**Quality bus corridor transports 40% to 200% more passengers at peak times**. Dublin has invested in 12 Quality Bus Corridors. These include: priority right of way and dedicated road space for buses; a bus every one to three minutes during peak periods; real time information; shelters at every stop. Bus journey times have been reduced by 30% to 50%, and a survey in 2004 found that average bus journey times in the morning peak were less than the average car journey times in 9 of the 12 bus corridors. The number of cars entering Dublin's inner city was reduced by 21.4% from November 1997 to November 2004, and the number of bus passengers increased by 49% during the same period.
Best Practice 10	**High capacity bus networks can successfully transport large quantities of people.** Emerging and developing countries need to invest in urban transport

	systems that are sustainable and can respond to their growing needs for mobility.
Best Practice 11	**Light rail can also satisfy heavy demand**. Tramways on dedicated rights of way provide an economic and effective solution for emerging countries.
Best Practice 12	**The renaissance of trams**. 20 years ago, only 3 cities in France still had trams. Totally new systems have been successfully introduced in Nantes, Grenoble, Strasbourg, Paris, Rouen, Montpellier, Lyon and Orleans. These have been made possible by the implementation of a 'transport levy', a tax paid by employers and used for investment in and the operation of public transport.
Best Practice 13	**Tram-train, a new concept using both light and heavy rail lines**. Urban trams and regional railway trains can be run on the same railway lines, linking the city with outer regions.
Best Practice 14	**Metro can rapidly move a large number of passengers.** In large cities the metro is unrivalled in its capacity to rapidly move large numbers of people: 20,000 passengers an hour in each direction is the average, rising to over 80,000 on some networks. Madrid built 56km of metro in five years.
Best Practice 15	**Art brings light underground**. Citizens look to their metro as a reference of public transport quality, and including art improves its positive image. The Lisbon metro is considered to be a contemporary art gallery, and other cities are doing the same.
Best Practice 16	**Wealth and public transport go together.** Public transport becomes the preferred choice for everyone if it is quick and comfortable and if parking capacity is limited.

Annex 2: Summary of mode choice impacts of public policies

Transportation Investment Policy • Infrastructure spending directly affects the relative attractiveness of each mode • Transit operating assistance can help maintain, improve or expand services • Research and development funding provides innovations in the provision of transportation services
Transportation Pricing Policy • Taxes and tolls make automobile use more expensive • Local policies dictate taxi fares, and indirectly, service levels • Local parking pricing and availability are very important components of the cost of driving
Environmental Policy • Federal/state emissions standards increase new car prices • Local air quality mandates require programs to reduce single-occupant vehicle use • Local policies influence development patterns and transportation pricing
Energy Policy • Minimum average fuel economy standards increase new car prices and decrease operating costs • Alternative fuel vehicle and research and development provisions of Energy Policy Act are unlikely to affect choices made by consumers/households
Tax Policy • Income taxes affect economic activity and disposable income, thereby influencing the affordability of various travel choices • Preferential parking cost deductions promote automobile commuting over transit • Sales taxes affect automobile costs and may support public transit • Mortgage interest deductions influence housing location choice • Property taxes may support local roadway infrastructure
Land Use Policy • Provisions of zoning laws (lot size, use) affect the viability of public transit • Design reviews and other restrictions can require definitive plans for addressing transportation issues in new developments

SOURCE: *TCRP Report 27: Building Transit Ridership: An Exploration of Transit's Market Share and the Public Policies That Influence It* (1997), p. 33

Annex 3: Potential Transit Strategies List for Building Ridership

Category	Type	Strategies
Service improvements	General	Increased route structure Increased frequency Service cutbacks Dynamic scheduling Increased speed Improved security Improved comfort Increased capacity
	Suburb to suburb	High-occupancy vehicle lanes/facilities Transportation demand management programs Suburban activity centers
	Suburb to central city	Feeder services Fare integration Service coordination (timed transfers) Unitickets Station parking provisions
	Within central city	Core services
Information to customers	Real-time information services	Location Schedules
	Low technology	Tailored schedules Bus stop information
	Medium technology	Computerized information systems Kiosks
Marketing and promotion		Fare incentives Education New resident promotion Image advertising Cooperative promotions
Public policy changes		User-side subsidies Parking pricing/regulation Income taxes Fuel/carbon taxes Dedicated operating support Land use policy Local area bus services
Road pricing		Various

SOURCE: *TCRP Report 27: Building Transit Ridership: An Exploration of Transit's Market Share and the Public Policies That Influence It* (1997), p. 8