Bus rapid transit (BRT) and transit-oriented development (TOD): How to transform and adjust the Swedish cities for attractive bus systems like BRT? What demands BRT?

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Licentiate thesis in infrastructure

Bus rapid transit (BRT) and transit-oriented development (TOD): How to transform and adjust the Swedish cities for attractive bus systems like BRT? What demands BRT?

TRITA-TSC-LIC 13-007
ISBN 978-91-87353-16-1

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Abstract

Bus rapid transit (BRT) is an innovative bus system with sophisticated vehicles and inflexible busways integrated in the cities, high capacity and high quality, high speed and frequency, distinctive image and comfort. Many in Sweden believe that it is impossible to introduce BRT, even though the Swedish towns and cities can benefit from the image, speed and frequency that BRT symbolizes. The archipelago-like urbanization, urban sprawl and the uncompetitive journey times of public transportation compared with the private car are identified as main obstacles. New questions emerged: Is it possible to transform and adjust the Swedish towns and cities for BRT? What demands BRT? How is transit-oriented development (TOD) applicable in a Swedish context as a policy to integrate cities and BRT?

In this licentiate thesis I investigate the interrelationship between bus transportation and neighborhoods, between BRT and urban form as well as the possibilities to introduce busways and BRT, to trigger TOD and to transform the Swedish towns and cities for BRT. Much has been written about BRT, but seldom by architects or urban planners and designers. BRT and TOD are seen though urban form and processes of urbanization within a morphological tradition established by Kevin Lynch. BRT is represented by paths and nodes that disperse distinctive attractiveness pattern of desirability cores that shape neighborhoods as districts. TOD is about synchronizing the everyday urban life with public transportation systems. BRT-TOD is defined as a policy to recognize desirability cores spread by the different infrastructures of BRT and promote development of urban form within their attractiveness pattern at urban and regional scale. BRT-TOD is discussed as a concept of BRT metropolis in context of the urbanization of Swedish towns and cities.

TOD is defined morphologically as public transport cities. A public transport city is a city that in its development adapted to specific public transportation systems. TOD is nothing new in Europe or Sweden. To find regularities of the effect of public transportation systems on cities I do a historical overview of the Swedish towns and cities. In the end the position of bus and BRT, public transport cities and TOD and possibilities of future urban transformation of the smaller and larger Swedish cities towards BRT metropolises are discussed in context of today’s “system” of automobility and widespread car society and the emerging knowledge society and its postmodern fringes of urbanization.

Keywords: bus rapid transit (BRT), transit-oriented development (TOD), bus transportation, neighborhood, urban form, urban morphology, urbanization
Acknowledgements

This licentiate thesis is a continuation of the research about bus rapid transit (BRT) in Sweden started by Karl Kottenhoff from *KTH Royal Institute of Technology* and Per Gunnar Anderson from *Trivector*. Their research as well as this project is supported by *Vinnova* and *Trafikverket* under the research framework *Framtidens personresor* (*Future personal journeys*) which aims to contribute to more effective and sustainable public transportation systems. Without *Vinnova* and *Trafikverket* this research would not have been possible.

First I would like to thank my supervisor Karl Kottenhoff for initiating the exciting research framework about buses, BRT and cities, for sharing his knowledge in public transportation and for the perspectives, discussions and comments. I am particularly grateful to my supervisors Haris Koutsopoulos and Lars-Göran Mattsson for their support and suggestions to improve my research and especially for having a critical eye on my research. I would also like to thank the other PhD students, researcher, teachers and staff at the division of Traffic and logistics and department of Transport science for the everyday talks, seminars and company that are always sources of inspiration. I am very grateful to Carl-Johan Engström and Inga-Maj Eriksson from the division of Urban and regional planning at *KTH Royal Institute of Technology* for their comments and constructive suggestions to improve this licentiate thesis.

I would like to express my gratitude to the reference group of the BRT-TOD project: Sven-Allan Bjerkemo, Einar Tufvesson, Torbjörn Einarsson, Hans Hauska, Anders Hagson, Göran Hallén, Sören Bergerland, Bengt Holmberg, Per Gunnar Andersson, Bengt Stålner, Ellen Rube, Maria Håkansson, Anke Xylander, Mari Widegren, Nils Viking, Daniel Firth and Tigran Haas.

In the end I would like to thank my family and friends who inspired me along the way and to say my biggest thanks to my father, mother and sister for all their support and love.

June 2013
Glossary, concepts and definitions

**Bus rapid transit or BRT:** Bus rapid transit (BRT) is a bus system with sophisticated vehicles, high speed and frequency, distinctive image and comfort, inflexibility and high quality that achieves high capacity by canalizing passenger flows in a system of segregated busways, partially or fully separated from other traffic. I use BRT to describe any system of busways. The attribute light is used for partially separated busways and heavy for fully separated busways.

**BRT metropolis (BRT metropol):** BRT metropolis is a vision of a region where the entire public transportation system is operated by buses on different infrastructures. It is realized by through actuating BRT-TOD policies, applying the concept of public transport metropolis by overlaying the four principal public transport cities at urban and regional scale.

**Comprehensive plan (översiktsplan):** It is a strategic document describing development policies and plans enacted by a Swedish municipality that is unbinding by law.

**Desirability core:** It is the most desirable areas in one district, literally the foci of the district. In context of TOD as desirability core it is the area in a neighborhood that becomes observable from the exit from a bus, tram or train.

**Destination (mål):** Destination is where one journey or trip ends.

**Detailed plan (detaljplan):** It is a detailed document describing the urban development of one zone in a municipality. It is enacted by a Swedish municipality and binding by law.

**District:** District is physical territory that corresponds to neighborhood and catchment areas within one public transport node. District is one of the urban elements by Kevin Lynch.

**Floor area ratio (FAR) (exploateringstal):** FAR is the quotient of floor area in all the buildings in one area divided by the plot area. FAR varies depending if the floor area is calculated as net floor area or gross floor area. In Sweden it is common to use net FAR, since the statistics about buildings and real properties include net floor areas and plot areas which are taxed. Net floor area excludes areas under walls, stairs, elevators, corridors and other areas for communication and access if there are many real properties in the building, whereas gross floor area is calculated from the edges of the building. The net floor areas vary between 50% and 90% of the gross floor areas. In urban settings the buildings density or bebyggelsetäthet changes significantly if the streets, squares, parks and other green areas are included in the area.

**Heavy as attribute to busway or railway (-bana):** Heavy means complete or full separation from other traffic that the railways naturally carry. In Swedish context heavy busway translates to bussbana or bus railway, or only railway or bana. In reality there are only few examples of heavy busways and only as sections of bus lines. There are no bus lines that are fully separated from other traffic in their complete length.

**Light as attribute to busway or railway (snabb-):** Light is shortening from light volume of traffic. The light attribute is used for public transportation infrastructures that are partially segregated from other traffic and cannot achieve high volumes or speeds. Light in Swedish context refers to rapid and snabbuss and snabbspårväg translate to rapid bus and light rail transit.

**Light rail transit or LRT (snabbspårväg):** LRT as BRT operates sophisticated trams or short trains on partially or fully segregated railways at ground level, on elevated railways or subways and occasionally on streets (TRB, 1989). LRT is a modern tram. Its rediscovery is motivated due to the inherent advantages of the technology. LRT can run on streets in mixed traffic, in reserved street lanes and freeway medians, in activity centers and in subways (Mills, 1975, pp. 5)
Mixing urban functions (funktionsblandning): Mixing urban functions is a policy of adding new functions and activities in one urban area in order to create more efficient urban environments and cities. It is a postmodern critique of the modern city where the urban areas were conceived through single urban functions.

Modal share (andel): The distribution of the amount of travel of a given individual or group between different modes of travel (Naess, 2005). The modal share depends very much if walking is included and how it included especially in regard to public transportation where walking is part of the journey.

Modern city (den moderna staden): The modern city is a city that was designed for motorized transport. The urban functions are temporally and spatially separated to enable higher efficiency and better quality of life. The industry in the traditional city was mixed with housing, whereas in the modern city the industry was separated and could specialize and increase its productions while keeping the pollution within its zones. It is a city of urban regions.

Multimodality (multimodalitet): Multimodality is a policy and paradigm to mix different transport modes in one infrastructure or different transportation infrastructures between urban areas in one urban region to enable multiple transportation choices.

Neighborhood (grannskap): Neighborhood is qualitative rather than quantitative and the neighborhood usually does not have visible borders. It is something vague and indefinite if we compare it for example to a village or city (Perry, 1929, pp.29-30). The neighborhood here is recognized for its locality that subordinates urban forms and urban communities, sometimes for its urban communities that inhabit different urban forms, or sometimes for its distinctive urban form that extends over different urban communities. Neighborhood fuses urban form, urban community and locality. It is an agglomeration of individuals and social groups that inhabit an agglomeration of buildings in a certain locality in the city.

Neighborhood type (bebyggelsetyp or stadstyp): Neighborhood type occurs when distinctive urban form is inhabited by distinctive social group that creates homogeneous urban community or communities. The attachment of different social groups to distinctive urban forms varies to a point where the neighborhood is “an extension of personality” (Perry, 1929, pp.34). Some distinctive social groups are located in neighborhoods because they have no other options.

Network capital: The network capital comprises of eight elements: 1) array of appropriate documents, visas, money and qualifications to move from one place to another; 2) workmates, friends and family at distance; 3) movement capacity; 4) free access to information at the location and contact points; 5) communication devices; 6) appropriate, safe and secure meeting places; 7) access to transportation and communication technologies; and 8) time and other resources to coordinate the other elements (Urry, 2007). The network capital of a neighborhood in a BRT context increases if there are: 1) public spaces of joint interest, foci in urban regions in the BRT stations or corridors; 2) BRT nodes or corridors are interconnected by transportation and communication technologies to allow continuous movement along and adjustments in schedules; 3) BRT stations or corridors rich with urban activities; 4) that allow social or business contacts; and 5) are coordinated temporally.

Networking places: Networking places is a policy to widely interconnect urban areas into urban network. It is also important to connect places with potential to grow into centers of urban regions. The networked places have to be destinations of regional importance.

Node: Nodes are stops or foci of transportation. They can be stops, intersections or termini. Node is one of the urban elements by Kevin Lynch.

Origin (startpunkt): Origin is where one journey or trip begins.
Path: Paths are physical facilities for different transport modes. Path is one of the urban elements by Kevin Lynch.

Physical accessibility (tillgänglighet): The ease by which a given location can be reached, depending on its proximity, the transportation infrastructures and the network capital of the individuals (Naess, 2005).

Physical mobility (rörlighet): The potential of movement as well as the movement of individual as physical movement in the form of transport (Naess, 2005).

Placemaking: Placemaking is a policy to achieve unique and recognizable neighborhoods that are both livable and support high quality of life. It is ultimately about human scale and citizen perspective in urban planning and design. The argument is that “the city is for humans, not for race of giants playing a new kind of chess” (Jacobs, 1958).

Postmodern city (postmodern stad): The postmodern city is a city in emergence. The modern city in the end of the 20th century lost its popularity and the traditional city that was modernized in the same time became incredibly popular. Postmodern city is a mix of modern and traditional city. It is a multimodal mix of public transportation and private cars.

Private mobility (individuell rörlighet): The share of physical mobility done by private car or automobile.

Public mobility (kollektiv rörlighet): The share of physical mobility done by public buses, trams and trains.

Public transport city (kollektivtrafik stad): Public transport city is a city that grew throughout the history adapting to public transportation infrastructure like heavy or light railways, heavy or light busways, subway lines, bus lines and tramways or public transportation infrastructures on streets, partially or fully segregated or underground.

Public transport metropolis (kollektivtrafik metropol): A public transport metropolis is a city that grew throughout the history adapting to all the public transportation systems on streets, partially or fully segregated or underground.

Regional planning and science (regional planering): Regional planning and science is a research field and profession. It specializes in urban regions, their development and the interactions between urban regions.

Regional scale (regional skala or lokal skala): Regional scale is determined by the ability to use motorized transport modes to travel throughout the urban regions. It is defined by travel time either by private car or by public transportation. The high-speed trains reach speed of over 200km/h. Prototypes of super buses with speeds up to 200km/h also exist.

Social group (social grupp): Social group is an agglomeration of individuals with distinct tastes, preferences, attitudes and lifestyles. Social group is considered in context of Pierre Bourdieu where taste is determining the distinction between groups. In regard to BRT and TOD the distinction of social group is by taste for transport modes and living in neighborhood types. SL, the public authority in Stockholm makes a distinction between car users that never use SL, users that shift between car and SL and everyday SL users (SL, 2011). This is an example of social group by taste for public transportation in context of Pierre Bourdieu. The social groups are usually divided by their position in the economy and labor market and it is very controversial to discuss social groups (Sayer, 2005). The social groups in Sweden until 1970s included: 1) high executives and owners of large businesses and agricultural lands; 2) other executives and owners of businesses and agricultural lands and 3) workers. This division corresponded to higher, middle and worker classes in Marxist sense. The division today includes: 1) workers; 2) executives; 3) owners of businesses; and 4) unemployed as students, homeworkers, pensioners, early retired pensioners, unemployed for long time and other without work and at military service.
Social mobility (social rörlighet): Social mobility is a process of acquiring different forms of capital and turning them into symbolic capital that is recognized in society and improves the social status and position of the individual. Social mobility is for example moving to socially preferred neighborhood type.

Social stereotype (social stereotyp): Social stereotype is a distinctive social group that inhabits distinctive urban form thus creating homogeneous urban community and has preference or struggles in its distinctive neighborhood type.

System of automobility: The “system’ of automobility” includes: 1) manufactured object produced by leading industrial sectors and iconic firms, 2) major item of individual consumption after housing and a status symbol, 3) an extraordinarily powerful complex constituted through interlinkages with other industries, businesses and institutions 4) the predominant global form of mobility that subordinates other mobilities and reorganizes how people live, 5) the dominant culture that sustains major discourses of what constitutes the good life, what is necessary for an appropriate citizenship of mobility, and 6) the single most important cause of environmental degradation and resource depletion (Shiller and Urry, 2002; Urry, 2004; 2006). The “system’ of automobility” characterizes the modernity of the 20th century that is undoubtedly a “century of the car” (Dennis and Urry, 2010, pp. 1). The automobile became a source of freedom and much social life could not be undertaken without its flexibility and perpetual availability. But it also coerces people into an intense flexibility and mobility. It encourages additional journeys to be made, to socialize across significant distances and always be on the move (Urry, 2004; 2006).

Transit-oriented development (TOD): Transit-oriented development (TOD) is a policy to synchronize the public transportation with cities. TOD is defined here in Euroeian or Swedish context as application of the experiences with the historical principal public transport cities as policies in the urban regions. It is essentially about placemaking or designing walkable and unique places at urban scale and networking places at regional scale as enabling regional connectivity from one place. TOD is ultimately about increasing the livability and network capital of neighborhoods and regions.

Traditional city (förindustriell stad): Traditional city is a city that was designed for walking and where all the urban functions are mixed within a walking distance.

Transport (trafik): I use transport to describe the movement of people inclusive the transport modes and transportation infrastructure.

Transport capacity (kapacitet): Transport capacity is defined by the number of passengers in different transportation infrastructures.

Transportation infrastructure (infrastruktur): Transportation infrastructures are physical facilities that link urban areas in urban regions.

Transport mode (färdmedel): Transport mode is any distinctive mean of transportation. For example there is distinction between private and shared car as well as between different buses. In Los Angeles there are local buses, rapid buses, express buses and liners which are conceived as distinctive.

Transportation planning and engineering (trafikplanering): Transportation planning and engineering is a research field and profession. It has specialized view on transportation and its interaction with the city both at urban and regional scale.

Travel time budget (restidsbudget): The travel time budget is the time that we spend traveling during one day. It varies between 1 and 2 hours (Zahavi, 1974).
Travel time ratio (restidskvot): Travel time ratio is a quotient between travel times of different transport modes from one origin to one or many destinations. Travel time ratio between public transportation and private car is a common indicator of competitiveness of public transportation. The ratio 1 means that it takes same time to drive or take the public transportation from one origin to one or many destinations.

Urban activity (urban aktivitet): Urban activities are doings by individuals and groups in order to fulfill or escape the urban functions. The urban activities in the modern cities were temporally and spatially segregated by urban functions for increasing efficiency of work and leisure.

Urban and regional planning (samhällsplanering): Urban and regional planning is a research field and profession. It has synoptic view on the urban regions, their urban structure and urban areas. The urban and regional planning in Sweden is executed on national, regional and municipal level. The planning on municipal level is further divided on strategic or comprehensive (översiktsplanering) and planning in detail (detaljplanering). Samhällsplanering and bebyggelseplanering are basically interchangeably used in Sweden. I use the broader English translation urban and regional planning as translation for the both terms, but there is distinction. Samhällsplanering has broader meaning and it is widely used. Bebyggelseplanering has slightly narrower meaning and tends to exclude the people and the social to emphasize the physical, the buildings or the urban form. The buildings or the urban form or bebyggelse are inseparable parts of Swedish society or samhälle and it is impossible to research or conceptualize urban and regional development and transformation without considering the social. As analogy I also use a broader term urban density to describe both population and building density (befolkningstäthet and bebyggelsetäthet).

Urban area (tätort or område): Urban area is a neighborhood or mosaic on neighborhoods with urban border defined by other urban areas or greenery. It is a physical territory on a regional scale that is linked to the other urban areas in the urban region by transportation infrastructures.

Urban community (samhälle): Urban community is any agglomeration of individuals and social groups that inhabits urban forms and associates to create neighborhoods. The associations vary from friendship to recognition. The urban community is limited in size to one block or street (Gans, 1968).

Urban densification (förtätning): Urban densification is a policy at urban scale that aims to increase the urban activity in one urban area. It revolves around infill of new buildings, inhabitants or work places within defined urban boundaries. It is postmodern critique of the monofunctional modern urban areas entangled in the European compact city concept that is usually combined with mixing of urban functions in Sweden.

Urban density (täthet, befolkningstäthet, bebyggelsetäthet): The urban density (täthet) in Sweden is seen in two fundamentally different ways as population density (befolkningstäthet) or as density of buildings (bebyggelsetäthet). Population density is calculated as number of inhabitants in one area, whereas density of buildings includes either number of buildings in one urban area or floor area ratios (FAR).

Urban element (stadselement): Urban element is any distinctive physical feature at urban and regional scale. In context of BRT the bus infrastructures are represented by paths for bus lines and nodes for bus stops. The neighborhood in regard to BRT and TOD are represented as districts with desirability cores defined by the BRT paths and nodes.
Urban form (bebyggelse): Urban form is any agglomeration of buildings in the city. Urban form implies either design or emergence of form in two or three dimensions at urban scale (modified from Marshal & Gong, 2009).

Urban function (urban funktion): Urban function is determined by urban form and urban activities that are allowed by the urban form. In the modernist conceptualization of the city or the modern city there are four functions: habitation, work, leisure and circulation (Le Corbusier, 1943/1973). Urban function is parallel to land use in geography. The land uses can be regarded as extended set of urban functions.

Urban intensification (förätning): Urban intensification is a policy at urban scale, literally a combination of densification of urban form and mixing of urban functions (Jenks & Gerhard, 2000), which aims to increase the urban activity throughout the day, by improving efficiencies during work and non work hours.

Urbanization (urbanisering): It is a historical process of emergence and transformation of urban form and structure propelled by innovation and revolutions in society and economy, communication and mobility, business and industry.

Urban morphology (stadsmorfologi): Urban morphology is a discipline that studies urban form and its transformation. The scope of the definition varies from researching physical activities and form in two or three dimensional space to a study of processes, knowledge, power and actuation (Friedman, 1987). In its narrower definition within architecture and geography, urban morphology puts emphasis of study of physical form and processes of its emergence and transformation. Greek words μορφος (form) and λόγος (word, speech, discourse, reason).

Urban planning and design (stadsplanering): Urban planning and design is a research field and profession. It specializes at urban scale by looking in detail of the urban areas and specificities of urban form and development.

Urban regions (stadsregioner): Urban region is a physical territory defined by physical mobility and physical accessibility from the city centre. It corresponds to the regional scale or more precisely to the mobility scale. The size of the urban regions varies with the regional scale. It is a variable basically of a mobility scale or scale of physical mobility.

Urban restructuring (urban omstruktuering or regional förandring): Urban restructuring is a policy at regional scale to change the urban structure of urban areas and transportation infrastructures.

Urban scale (urban skala): The urban scale is determined by the ability to walk. It is a scale of a traditional city where everything is within a walking distance of a travel time budget. The travel time budget is the time that we spend traveling during one day and it varies between 1 and 2 hours (Zahavi, 1974).

Urban structure (stadsstruktur or bebyggelsemönster): Urban structure describes the different arrangements of urban areas and transportation infrastructures in urban regions.

Urban transformation (urban förändring): Urban transformation is a policy at urban scale that aims to change the urban form from one to another, or change from one neighborhood type to another. Urban transformation was used to partially transform the traditional city to modern city during the 20th century. Since then it has been very controversial policy in urban and regional planning.
Figures and tables
Figure 1: A typical problem of the bus in the road hierarchies. The first scenario shows the detouring bus line today and the second a BRT alternative with busway and bus stations.....................................................................................2
Figure 2: Analysis of Los Angeles by using urban elements: paths, edges, districts, nodes and landmarks..........................................................................................................................6
Figure 3: Modification of urban elements to represent the morphological interrelationship between neighborhoods and public transportation infrastructures..........................................................................................................................6
Figure 4: Buses on different infrastructures (on streets, partially segregated busways and in tunnels)..................................................................................................................................................12
Figure 5: Trams in Boston on different infrastructures (on street railway, partially segregated railway and in tunnel)..................................................................................................................................................12
Figure 6: BRT initiatives and projects in Swedish towns and cities. ..................14
Figure 7: LRT projects in Sweden simultaneously to the BRT initiatives and projects in Swedish towns and cities. ..................................................................................................................................................15
Figure 8: The rural to urban transect by Andrés Duany ....................................17
Figure 9: The urban and regional scale of TOD in the book “The next American metropolis”..................................................................................................................................................18
Figure 10: The European compact city and TOD experiences .............................21
Figure 11: The American TOD experiences..........................................................22
Figure 12: Interrelationship triangle between public transportation demand and service with its service areas ..................................................................................................................................................28
Figure 13: The effect of urban density on the number of passengers boarding per hectare and per inhabitant and work place in the city of Karlstad. .................................................................29
Figure 14: The effect of function/land use and neighborhood types on the number of passengers boarding per hectare and per inhabitant and work place in the city of Karlstad..................................................................................................................................................35
Figure 15: The effect of bus service factors on the on the number of passengers boarding per hectare and per inhabitant and work place in the city of Karlstad considering the defined neighborhood types..................................................................................................................................................37
Figure 16: The urban forms and diagramed representation of the Swedish urbanization from the traditional city, industrialization, modern city to postmodernism ..................................................................................................................44
Figure 17: A unique integration of the busway and a stereotypical solution .......65
Figure 18: Differences between walking and public transportation in a city of Karlstad and Stockholm. in Stockholm. ..........................................................................................................................72
Figure 19: The historical development of number of annual journeys by public transportation in the Swedish regions ..................................................................................................................................................78
Figure 20: Habitation and mobility system...............................................................80
Table 1: TOD typology in regard to land use mix, minimum housing density, housing type, regional connectivity, transit modes and frequencies..........................19
Table 2: Regression analysis of number of passengers boarding on bus stops in regard to number of inhabitants and work places in the neighborhoods in the city of Karlstad..........................................................................................................................29
Table 3: Number of passengers boarding per inhabitant and work place during the urban densification and mixing in Hammarby sjöstad in Stockholm...........30
Table 4: Predictions for the number of passengers boarding in the main nodes along the Karlstad’s direction using the results from the regression analysis in Table 1........................................................................................................................................32
Table 5: Regression analysis of number of passengers boarding on bus stops in regard to number of inhabitants, work and study places in the neighborhoods in the city of Karlstad..................................................................................................................33
Table 6: Degree of influence on urban and regional planning between USA, UK and Sweden...........................................................................................................52
Table 7: Neighborhood typology in regard to urban form, orientation to transport modes and daily activity .................................................................57
Table 8: Morphological and functional transformations and their scales........58
# Table of contents

Abstract ...................................................................................................................... iii  
Acknowledgements .................................................................................................... v  
Glossary, concepts and definitions ....................................................................... vii  
Figures and tables .................................................................................................... xiii  
Table of contents ..................................................................................................... xv  
1 Introduction ............................................................................................................ 1  
1.1 Problem formulation ....................................................................................... 1  
1.2 Purpose .............................................................................................................. 4  
1.3 Theoretical framework .................................................................................... 4  
1.4 Summary of methods ...................................................................................... 7  
1.5 Organization of the thesis .............................................................................. 8  
2 Summary of results and discussions .................................................................. 10  
2.1 BRT and TOD ............................................................................................... 10  
2.1.1 What is BRT? .......................................................................................... 10  
2.1.2 BRT initiatives and busway projects in Sweden ................................ 12  
2.1.3 What is TOD? ...................................................................................... 15  
2.1.4 New Urbanism and American TOD .................................................. 16  
2.1.5 The European compact city as a counterpart of American TOD ........ 20  
2.1.6 Comparison between examples of the European compact city and American experiences with TOD ................................................................. 21  
2.1.7 Redefining TOD in European context ............................................... 23  
2.2 Which urban density is needed for BRT? .................................................. 25  
2.2.1 The empirical evidence of the interrelationship between urban density and public transportation ............................................................. 25  
2.2.2 Which urban density is needed for BRT if the headway is 10 minutes? ................................................................................................................. 31  
2.2.3 From analyzing urban density to concepts of urban form .............. 34  
2.2.4 BRT enhancements of bus transportation ......................................... 36  
2.3 Urban form, BRT and TOD ........................................................................... 39  
2.3.1 Discourses on urban form .................................................................... 39  
2.3.2 The effect of BRT on urban form and structure .................................. 41  
2.4 BRT and TOD via Swedish urbanization and society, cities and planning ................................................................................................. 43  
2.4.1 Retrospect and trends in Swedish urbanization and society, cities and planning traditions ................................................................. 43  
2.4.2 Policies in today’s Swedish urban and regional planning .............. 52  
2.4.3 Urban densification or transformation through typology of urban forms ................................................................. 56
2.4.4 BRT metropolis through TOD as a policy for networking places, placemaking and urban transformation ............................................................... 58

2.5 What are the obstacles and opportunities to introduce BRT in the Swedish towns and cities ........................................................................................ 60
  2.5.1 What are the obstacles to introduce BRT in the Sweden .............. 60
  2.5.2 BRT as future systems of automated super buses ......................... 61
  2.5.3 Standard bus in today’s “system’ of automobility”, future “omnimobile” in the knowledge society ................................................................. 61
  2.5.4 How to improve the visibility of buses and bus transport in the Swedish urban and regional planning? .............................................................. 63
  2.5.5 A variety of busways, underground, partially or fully segregated as part of a BRT-TOD policy ................................................................. 65

3 Conclusions and recommendations ................................................................ 67
  3.1 Which urban density is needed for BRT? ............................................... 67
    3.1.1 Which urban density is needed for BRT if the headway is 10 minutes? ........................................................................................................... 67
    3.1.2 Beyond urban density ....................................................................... 68
  3.2 BRT, TOD and urban form .................................................................... 69
  3.3 BRT and TOD in the postmodern society ........................................... 70
  3.4 Where and how can be BRT-TOD implemented in Sweden? .............. 71
  3.5 How can TOD help? .............................................................................. 73
    3.5.1 What can Swedish towns and cities learn from American TOD? .. 73
    3.5.2 BRT-TOD as vision of and policies for a BRT metropolis ............ 74
    3.5.3 Networking places as hard TOD policy for increasing regional connectivity ............................................................................................. 75
    3.5.4 Placemaking as a soft TOD policy to involve the communities and entangle BRT in the urban life ................................................................. 75
    3.5.5 Urban transformation as a hard TOD policy to synchronize BRT and neighborhoods ...................................................................................... 75
  3.6 What are the obstacles and opportunities to introduce BRT in the Swedish towns and cities .............................................................................. 76
  3.7 Future research and new research hypothesis ..................................... 77
    3.7.1 The interrelationship between public transportation and urban form ........................................................................................................ 77
    3.7.2 New research hypothesis .................................................................. 79

References ....................................................................................................... 82
1 Introduction

1.1 Problem formulation

Bus rapid transit (BRT) is an innovative bus system with sophisticated vehicles, high speed and frequency, distinctive image and comfort, inflexible busways that target improved integration with cities and lucrative promise of flexible capacity and high quality at lower costs than the railway systems. In contrast to the conventional bus systems which operate predominantly in mixed traffic, on streets or dedicated lanes, BRT achieves high capacity by canalizing passenger flows in a system of segregated busways, partially or fully separated from other traffic. Even though it originates from the late 1930s, BRT achieved world fame after the successes in Curitiba and Bogotá. There is an ongoing global public transportation renaissance in the last two decades with approximately 100 completed BRT systems and a near equal number under development (Wright, 2010). The conclusion from previous Swedish research about BRT was that there is no place for BRT in Sweden even though the Swedish towns and cities can benefit from the image, inflexibility, speed and quality that BRT symbolizes. The *urban form*, the dispersed and fragmented *urban structure* of Swedish towns and cities and low densities were identified as main obstacles (Kottenhoff et al., 2009).

The dispersed and fragmented *urban structure* is a consequence of the Swedish urbanization and modernization in the second half of the 20th century. The modern cities were shaped to accommodate the private car, individual mobility and freedom of movement. The private car in return brought incredible economic growth and innovation, convenience, prosperity and mobile lifestyle in Sweden. It also allowed for design and development of urban areas scattered in the regions. The virtuous circle of new motorways, new suburbs, new industries and new economic growth accelerated the urban decentralization and left vast archipelagos of urban areas interconnected by extensive road hierarchy. The public buses and trains were strangled in a vicious circle. The flexible bus was an alternative to the private car, but the buses performed and perform very poorly on road hierarchies that were optimized for car traffic.

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1 *Urban form* is a translation of the Swedish word *bebyggelse* that means buildings, area with buildings or development as agglomeration of buildings and roughly coincides with *urban form* in English. *Bebyggelse* is however more a dynamic matter, than fixed form.

2 *Urban structure* is a translation of the Swedish word *bebyggelsemönster* which that means pattern of urban areas in English. *Bebyggelsemönster* is a coinage that closely corresponds to *stadsstruktur* in Swedish which translates directly to *urban structure*. 
The bus lines often operated on motorways that bypassed the neighborhoods. The detours to and from the motorways often increased the driving distances and times for buses up to three or four times compared to the cars (Figure 1). The buses also needed to stop when the cars accelerated and the buses lost their competitiveness in the new modern suburbs. The emergence of new urban areas far in the urban regions, the increase of traveled distances and higher car ownership caused decrease of share of bus traffic, less frequent services and higher reliance on the private car.

Figure 1: The bus line 40 in Stockholm passes through one urban island. It is a typical problem of the bus in the road hierarchies. The first scenario shows the detouring bus line today and the second a BRT alternative with busway and bus stations.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euclidean distance</td>
<td>0.8 km</td>
<td>0.7 km</td>
</tr>
<tr>
<td>Network distance</td>
<td>2.1 km</td>
<td>1.0 km</td>
</tr>
<tr>
<td>Directness</td>
<td>280%</td>
<td>140%</td>
</tr>
</tbody>
</table>

Legend
- Bus line and stops
- BRT lines/busways and stops/stations

Many municipal or city councils and public transportation authorities in Sweden believe that is impossible to introduce BRT in such settings. The dispersed urban structure, the road hierarchies and uncompetitive travel times of the public bus compared with the private car, the urban sprawl and low density of the scattered urban areas were identified as major obstacles to introduce BRT in the Swedish towns and cities. A set of new questions emerged in the Swedish BRT debate: Is it possible to transform and adjust the Swedish towns and cities for BRT? What is the relationship between BRT and cities, between BRT or bus transportation, population and urban form? What demands BRT? The knowledge gap between BRT and urban form, effect on BRT on cities, planning
for bus or BRT, was defined though the following questions (Kottenhoff et al., 2009):

1. Which urban density is needed to introduce BRT? Which densities of inhabitants, work places and urban activities are required to support attractive frequency, for example 10 buses per hour?
2. How influence urban form and urban structure the productivity of BRT?
3. What are the effects of BRT on urban form and urban structure? Is BRT a catalyst or driver for urban development? Does BRT produce urban development like corridors or densification along the lines?
4. What are the principal differences in urban and regional planning for bus and BRT?
5. Which groups can benefit from BRT? Are there differences between groups or genders?
6. Where, in which cities or neighborhoods in Sweden, can BRT be introduced and how?

The potential of BRT increases if there is possibility to introduce BRT together with transit-oriented development (TOD) and trigger urban development and transformation of the urban areas. Transit, a shortening from mass transit, is American catchall for public transportation (Cervero, 1998) and TOD is defined as a policy to synchronize urban and regional planning and development with public transportation. The combination of BRT as new attractive bus system with TOD as policy to adapt and transform the Swedish towns and cities to BRT is explored through the questions: What is TOD in Swedish context? What are the Swedish experiences with TOD? How and where in the Swedish towns and cities is possible to apply BRT-TOD? The thesis follows a gradual expansion of the problem:

1. Which urban density is needed for BRT? How to make BRT possible in Swedish towns and cities? The increased supply quality is supposed to attract more passengers.
2. How to utilize softer TOD policies without major changes in the neighborhoods in order to synchronize BRT and the urban life in the Swedish towns and cities?
3. How to apply harder TOD policies of urban redevelopment and transformation in order to adapt and orient the existing neighborhoods to BRT?
1.2 Purpose

The purpose of this licentiate is to contribute with concepts and empirical research about the effect of BRT and bus transportation on cities, their urban form and structure. This is done by mixing urban morphology and transportation systems and by simplifying the complexity and dynamics of the public transportation systems and their operations and the interrelationship with cities as well as by abridging the intricacy of planning processes and uniqueness of neighborhoods and cities. The overall goal in Sweden is to double the use of public transportation and BRT and buses have to play an important role in achieving that goal. To realize the potential of BRT requires BRT and TOD to be used creatively as a public transportation system together with set of policies to support the integration of the system not only in the city, but in the urban life.

The aim of the licentiate thesis is to transcribe BRT with the language of architects and urban designed and to make public transportation systems, bus and BRT visible for architects, urban planners and designers, urban and regional planners. The interrelationship between neighborhoods and public transportation is usually represented only as a point and accessibility radius showing walking distance.

Another aim is also to provide visions and good examples of BRT and TOD that can be used in Swedish towns and cities. The combination of BRT and TOD is conceived through a vision of a “BRT metropolis”. An indirect purpose is to use the BRT metropolis to inspire debates about future cities and public transportation systems in Sweden. BRT on completely separated busways is a piece of the puzzle that enables planning of complete urban and regional public transportation systems with buses.

1.3 Theoretical framework

The theoretical framework conjoins three research traditions or theories. The first tradition explores the interrelationship between transportation and mobility and neighborhoods and cities. The city, its neighborhoods and its urban form are quantified numerically and analyzed as independent variables with different methods. The urban form is described by urban densities, diversities of land uses, distances to public transportation, demographics and they are known as Robert Cervero’s D variables. There are different schools and researchers within this tradition. Much has been done by American scholars, but there are also notable European schools and researchers.
The second theory is from urban morphology. Kevin Lynch conceives the city though *adapted spaces* and *flow system* (Lynch and Rodwin, 1958), *spaces* and *channels, activities and communications* (McLoughlin, 1969). In regard to the physical form of cities, “wayfinding”, flows and breaks in flows he classifies five urban elements: *paths, nodes, districts, edges and landmarks* (Lynch, 1960).

1. *Paths* are the channels along which the observer customarily, occasionally or potentially moves: streets, walkways, bus lines, canals;
2. *Edges* are the linear elements not used or considered as paths by the observer: shores, railroad cuts, edges of development, walls;
3. *Districts* are the sections of the city with two-dimensional extent, where the observer mentally enters *inside of* and which are recognizable as having some common, identifying character;
4. *Nodes* are points, the strategic spots in a city into which an observer can enter and which are the intensive foci to and from which someone travels: break in transportation, a crossing or convergence of paths;
5. *Landmarks* are another type of point reference, but the observer does not enter within them, they are external. A *landmark* is usually a rather simply defined physical object: building, sign, store or mountain.

The urban elements by Lynch (Figure 2) are modified to better illustrate the overlay of public transportation infrastructures and cities. The public transportation infrastructures are represented as *paths* and *nodes* that produce *edges* as barriers. The neighborhoods are conceived as *districts* and *desirability cores*\(^3\) in the *districts*. The *desirability cores* (Figure 3) show the morphological interrelationship between neighborhoods and public transportation. They show the peaks in desirability or attractiveness in one neighborhood as mosaic of *districts*. In regard to TOD, they are the most attractive zones for urban transformation in the neighborhoods.

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\(^3\) The *desirability cores* are inspired by Stephen Marshall’s research on urban patterns (Marshall, 2005; Marshall & Gong, 2008).
Figure 2: Analysis of Los Angeles by using urban elements: paths, edges, districts, nodes and landmarks (Lynch, 1960).

Figure 3: Modification of urban elements to represent the morphological interrelationship between neighborhoods and public transportation infrastructures.

The desirability cores have stretchy borders. They can shrink or extend depending on the design of the urban environments. They start when a person changes transport mode from public transportation to walking and steps out on a public transportation stop and station. The desirability cores are principally nodal. The exit door of a bus, tram or train is an initial vantage point in the isovist shape\(^4\) of

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\(^4\) An isovist is the set of all points visible from a given vantage point in space with respect to the obstacles and voids in the line of sight in one environment. The shape and size of an isovist is liable to change with position of the observer (Benedikt, 1979). The isovist concept
a desirability cores. They can elongate in amoebic space if they continue in attractive walkable urban environment\(^5\).

The third tradition is also from urban morphology and revolves around classifying neighborhoods in typologies by their emergence and historical development and their recognizable character. The neighborhood type corresponds to the district concept of Kevin Lynch in that direction. There is a long tradition in conceptualizing Swedish neighborhood typologies. Sten de Geer was a Swedish geographer that in the early 1920s made distinction and mapped different neighborhood types in Stockholm. The differentiation of urban environments was established by Hans W:son Ahlmann on the end of the 1920s and during the 1930s. Many scholars and researchers use differentiation and typologies. Johan Rådberg in the end of the 1980s and during the 1990s systematized the hundred year old tradition. His neighborhood types (Rådberg, 1988; Rådberg & Friberg, 1996) are conceptual background mapping neighborhoods around public transportation infrastructures. Secondly they are used to discussing ways of typological transformation of neighborhoods in the Swedish towns and cities.

1.4 Summary of methods
The combinations of methods used originate from the three traditions mentioned in the section above and they are completed by a research review and conceptualizations. Andrew Sayer (2010, pp.2) argues that it is important to focus both on theorizing and no how we conceptualize, as well as on empirical research, causation and methods of explanations. Comparisons and descriptive statistics, correlations and regression analyses, general linear models (GLM) are used to explore the interrelationship between public transportation systems and neighborhoods. The characteristics of bus lines and neighborhoods are independent variables whereas the bus performance such as number of passengers boarding in one neighborhood is analyzed as a dependent variable. The neighborhoods are mapped in ArcGIS by the Swedish neighborhood typology conceived by Johan Rådberg with small modifications. The categorical data is analyzed with GLM procedures in SPSS. GLM in SPSS provides regression analysis and analysis of variance for one dependent variable by one or more

\(^5\) Flows and crowds of people trigger subconscious movement of a person in a crowd extend the line of sight and add a sequence of new prospects and isovists. “Go with a flow” is a saying that describes the human “penguin effect”. We are subconsciously drawn to crowds and often imitate or conform to the behavior of the mob.
factors or variables. The factor variables divide the population into groups. It
tests null hypotheses about the effects of other variables on the means of
various groupings of a single dependent variable.

The research review includes theories in urban and regional planning and
transportation planning and engineering that tangle BRT and TOD, public
transports and cities. There is an even broader look at mobility and the
interplay of private and public transport in the cities6. There are several
research fronts: 1) BRT, bus and public transportation; 2) TOD and historical
development of cities oriented to public transportation or other transport
modes; 3) processes of urbanization and the effect of transportation on cities,
the interrelationship between transportation and cities, between public
transportation and urban form; 4) urban morphology and urban transformation
of neighborhoods and cities; and 5) theories, policies and paradigms in
transportation planning and engineering and urban and regional planning. The
exploration of literature is completed by study journeys and case studies of
ongoing or completed BRT or TOD projects and neighborhoods in Sweden,
Denmark, Finland, France, Netherlands, UK, Turkey and USA.

1.5 Organization of the thesis
The thesis is a collage of three chapters and six papers. The introduction
chapter focuses on the problem formulation and methodology. The
methodology is further discusses in two articles that are not included in the
licentiate thesis7. The results of the research are summarized and discussed in
the second chapter. Part of the results and discussion are summaries from the
papers, but much of the discussion and empirical evidence presented in the
chapter derives from the working report of a study in the city of Karlstad. The
third chapter includes conclusions and recommendations. In the conclusions
there are some repetitions from the discussions from the previous chapter. The
repetitions exist to allow a quicker reading of the thesis, by jumping over the
results and discussion chapter.

6 The public transportation is a part of a vicious circle set in motion by the private car. Any
increase in attractiveness of private transportation has rather perceivable impact on the use
of public transportation, whereas improving public transportation has not as strong effect on
private transportation (Brynielsson, 1976; Pushkarev & Zupan, 1977).

7 The first paper “Theoretical framework and limitations of scientific urbanism” is
unpublished and its successor “City information modeling (CIM) and urbanism: blocks,
connections, territories, people and situations” was presented on the Symposium on
simulation for architecture and urban design 2013 in San Diego, USA.
Five papers were presented on conferences and one was both presented and submitted to a journal. Paper 1 was accepted on the *European transport conference 2013* in Frankfurt, Germany. Paper 2 was accepted on the *3rd International conference on urban transportation systems* in Paris, France. Paper 3 was accepted on the *20th International seminar on urban form* in Brisbane, Australia. Paper 4 was co-authored with Mats Johan Lundström and Tigran Haas and presented on *Trafikdage 2012, Annual transport conference at Aalborg university* in Aalborg, Denmark, and on the *12th National light rail conference (Sustaining the metropolis: LRT and streetcars for super cities)*, Salt Lake City, USA. Parts of Paper 2 and Paper 4 were presented as one paper on the conference *BUFTOD 2012 (Building the urban future and transit oriented development)* in Paris, France. Paper 5 was presented on the *3rd International conference on degrowth for ecological sustainability and social equity* and it was submitted to the journal *Urban morphology*. It was accepted and the revisions are ongoing.
2 Summary of results and discussions

2.1 BRT and TOD

2.1.1 What is BRT?

BRT is not restricted to a single definition, bus system or infrastructure. Similarly as Light Rail Transit (LRT), it claims wide infrastructural range from completely segregated busways to bus lanes and operating on streets. Its capacity ranges from 500 passengers per hour and direction in Eugene, Oregon, USA, to 45,000 in Bogotá, Colombia (Hensher & Golob, 2008). It is interpreted differently around the world.

In Europe there is an emphasis on high quality over high capacity and BRT is often exchanged with bus with a high level of service (BHLS). BRT in Swedish context is defined as a road based public transport system that borrows many design and operation principles from railways in order to achieve high levels of service and efficiency (Kottenhoff, n.d.). There are busways in Swedish towns and cities like Halmstad, Gothenburg, Linköping and Lund that are similar to the LRT systems, but there are no BRT lines with completely segregated bus traffic that parallel the design or operations of railways. There are advanced bus lines called trunk lines in the spirit of the BHLS systems around Europe that have

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8 There are many definitions: BRT is a permanently integrated system of facilities, services and amenities that collectively improve the speed, reliability and identity of bus transport (Levinston et al., 2002, pp.2). BRT is a bus based public transport system that delivers fast, comfortable, and cost-effective urban mobility (Wright, 2004). There are also different ways to evaluate if one bus system is BRT. Karl Kottenhoff for example uses the colors of the traffic lights to evaluate different categories as integration with the urban environment, separation from other transport modes and priority in traffic, directness of the line, bus stop spacing and average speed, frequency and reliability of the bus service, identity of the bus line, vehicle design and propulsion, way of boarding and comfort. BRT is achieved if the level of service is green. Yellow level of service might be regarded as BRT. The red level of service cannot be accepted as BRT (Kottenhoff et al. 2009; Kottenhoff, 2010). Another method for evaluating BRT is The BRT standard version 1.0. The systems can get up to 100 points for different aspects like service characteristics, infrastructure and access, integration and information (ITDP, 2012).

9 These differences are often discussed on international conferences and there is a number of the journal Built environment 36(3) that focuses on interpretations and contexts.

10 The motto: “Think rail, operate bus!” (“Tänk spar, kör bus”) was launched in the 1990s by Per Gunnar Andersson and Trivector as advocacy for prioritized and attractive bus systems.

11 The stomlinjer or stombussar translate to trunk lines or quality buses in English. The Swedish trunk lines have distinctive identity in different Swedish towns and cities. They are known as blue buses in Stockholm and trunk buses in Gothenburg and Jonkoping. The trunk lines in
distinctive identity, higher rank in the public transportation system hierarchy and operate predominantly on dedicated lanes or partially segregated busways.

BRT is a complex system of busways and buses, stations and catchment areas, markets and customers, passengers and general public, public authorities and operators, drivers, supervisors, planners and analysts. The dynamics of BRT and buses as transportation system are frozen to fixed infrastructures, busways and stations, or paths and nodes from the urban morphology of Kevin Lynch (Figure 3; Paper 2). The bus infrastructures of BRT are conceived through four principal paths: bus lines on streets or dedicated lanes, light and heavy busways\textsuperscript{12}, or bus tunnels. BRT is defined as any system with busways or with section of busways, regardless if it is light and heavy busway.

BRT is also an adaptive\textsuperscript{13} public transportation system that can operate on different infrastructures (Figure 4). The flexibility to operating on different infrastructures is not a unique property of the bus. There are tram lines like some branches of the Green line in Boston that also operate partly underground, partly on fully segregated railways, partly on partially segregated railways and partly on railways on streets (Figure 5).

Sweden are not regarded as BRT, even though there are no infrastructural differences for example between the partially segregated busway of \textit{trunk line} 16 in Gothenburg or the busways in Curitiba that are considered as BRT.

\textsuperscript{12} Heavy means complete or full separation of the busways, whereas the light attribute is for busways that are partially segregated from other traffic. The light and heavy attributes indirectly define the transport capacity of the bus infrastructures because they influence the speed and frequency of bus traffic. The light busways can achieve higher capacities by higher speeds than bus lines in traffic or on dedicated bus lanes, because they are disturbed by other traffic only on intersections. But the light busways cannot have high frequencies. They have limited headways in order not to block the circulation of traffic at intersections. The heavy attributes can have highest capacities both by high speeds and frequencies, because they are not interrupted by other traffic. As closed transportation systems they are affected by dwelling times, congestion on stations or possibility to utilize the tracks if it is a mix of single and double track busway or railway. In reality there are only few examples of heavy busways whereas the railways naturally carry the heavy attribute. The heavy railways and heavy busways have similar effect on the cities.

\textsuperscript{13} The railway systems tend towards full or complete separation from traffic and that is seldom case with the busways, with exemption of Bogotá or Istanbul. There are proposed bus systems that imitate the railways like O-bahn by Mercedes-Benz in the 1980s, but their application has been very limited so far. The O-bahn system had a test busway in Kassel, Germany and application in Adelaide, Australia.
2.1.2 **BRT initiatives and busway projects in Sweden**

There are initiatives, advocacies for prioritization of the bus lines and advancement of the bus infrastructure and BRT lines and busways in many Swedish towns and cities. New BRT lines are proposed in Karlstad and Stockholm and there are a completed busways in Gothenburg, Linköping and Lund (Figure 6). In cities like Linköping, Malmö or Uppsala there are proposals for tramways or light rail transit (LRT), while Stockholm and Norrköping had built new LRT lines or extended the existing lines (Figure 7).
Figure 6: BRT initiatives and projects in Swedish towns and cities.
Figure 7: LRT projects in Sweden simultaneously to the BRT initiatives and projects in Swedish towns and cities.

2.1.3 What is TOD?

Transit-oriented development (TOD) is a set of policies to synchronize the urban life, cities and their urban activities with public transportation systems, infrastructures and operations. TOD is a process at different scales, from architecture and urban design to regional planning, involving different stakeholders like public transportation agencies and other public authorities at different levels of government, investors and developers to community groups. It is also a product, neighborhood or metropolis; urban area or region oriented to transit systems. TOD\textsuperscript{14} is viewed and defined differently by other researchers, developers and transit agencies throughout USA, but the visions often include

\begin{footnote}
Over 100 TOD projects exist and they are found overwhelmingly in and around railway stations. Roughly 6\% of the American TODs are located around bus stations (TRB, 2004)
\end{footnote}
compact, mixed use development near *transit* facilities and high-quality walking environments (TRB, 2004).

The policies to synchronize urban activities with public transportation are nothing new, but American TOD is novel in its context of dominating “car culture” in the USA\(^\text{15}\), implementations and variety of urban designs around stations. The catchy coinage was introduced by Peter Calthorpe in the beginning of the 1990s in the “Transit-oriented development design guidelines” for San Diego and the TOD guidelines were later compiled in the book “The next American metropolis”. TOD is defined as a design or development of moderate and high density mixed-use urban areas at strategic points along the regional *transit* system (Calthorpe, 1993, pp.44), with a fundamental purpose to create a land use pattern which will ultimately support *transit* (Calthorpe et al., 1992, pp.4).

As integral part of *New Urbanism*, TOD targets the decayed and vastly asphalted downtowns, sprawled modern suburbs and edge cities in the USA that are poorly accessible by walking or public transportation. It prioritizes walking and design of attractive, walkable and livable cityscapes in a modern society and motorized metropolitan culture that demands undisturbed circulation, decongestion and vast urban spaces for parking and road infrastructures (Calthorpe, 1993). TOD is here understood as a *policy* or a *set of policies* to synchronize urban and regional planning and development with public transportation systems. It is discussed in its American context, as an integral part of *New Urbanism*. It is also seen from European perspective via the advocacy for the compact city and as product of the historical Swedish urbanization.

### 2.1.4 *New Urbanism* and American TOD

The *New Urbanists* advocate for revival of historical architectural styles and *urban forms* though mastery of urban design. The concept of *new traditional development* (NTD) is a solution for the future American metropolis. The neighborhood is an essential element of NTD and it is strongly inspired by the “neighborhood unit” of Clarence Perry (1929) and the *traditional “city of urban quarters”* by Leon Krier (1984). The neighborhood and its urban design, the human scale and walkability, placemaking and attractive public spaces are in highlight in the debates. A neighborhood is limited to an area approximating a

\(^{15}\) The automobile has been the great vehicle of the American civilization in the 20th century, so versatile and so pervasive an expression, an expression of and an instrument for speed around and across the continent and up the social scale (Rae, 1965, pp.vii; Flink, 1975)
5 to 10 minute walk from its centre to its boundaries, ensuring that all urban activities are within convenient walking distance of residents.\textsuperscript{16}

Another core concept in \textit{New Urbanism} is the “transect” by Andrés Duany, which provides a framework for making distinction and identifying the context of development of American neighborhoods. The urban density is the principal differentiation method. The urban typology includes a palette of rural and urban zones from most dense \textit{urban cores} to least dense \textit{rural preserves} and \textit{special districts} that cannot be defined by population density (Figure 8). The distinction exists to choose between different urban design guidelines, regulations and policies by urban type that are catalogued in “Smart codes”.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{transect.png}
\caption{The rural to urban transect by Andrés Duany (from www.dpz.com)}
\end{figure}

Peter Calthorpe with TOD expands the neo-traditional scope to the regional scale. The TOD guidelines describe sets of design rules how to accomplish a \textit{transit metropolis} both\textsuperscript{17} at urban and regional scale (Figure 9). TOD at urban

\textsuperscript{16} There is a variety of housing types and land uses, a mix of shops and services capable of satisfying many of the daily needs of the residents within the boundaries of the neighborhoods (Bohl, 2000). The streets are designed for pedestrian use as scrollable Main Streets (Calthorpe, 1993), with generous sidewalks, street trees and parking on street to provide a buffer from street traffic and make walking a safer and more appealing option. The neighborhood centre provides a focal point for shopping, dining, services and transit (Bohl, 2000).

\textsuperscript{17} Calthorpe fuses the human scale of walking on a scrollable Main Street surrounded by and diversity of buildings, uses and users of the traditional American town with a mobility scale of \textit{transit}. The TOD guidelines are very much influenced and inspired by San Francisco and BART (Bay Area rapid transit), its regional public transport system. They transcribe the urban image and quality of the lively attractive neighborhoods in San Francisco at urban scale and the strong difference between the urban public transportation in the downtown and BART (Bay Area rapid transit) at regional scale.
scale revolves around images of attractive and livable cityscapes spread over an interconnected street pattern that enables walking, prospects and easier orientation (Calthorpe, 1993). At regional scale or mobility scale there is advocacy for urban networks and regional cities (Calthorpe & Fulton, 2001; Calthorpe, 2002). American TOD in the interpretation of Peter Calthorpe deliberates complementing placemaking around public transportation stops and networking places in one urban region. “TOD is about is regional planning, city revitalization, suburban renewal and walkable neighborhoods combined” (Calthorpe, 2004, pp.xi)

Figure 9: The urban and regional scale of TOD in the book “The next American metropolis” (Calthorpe, 1993)

Hank Dittmar and Shelley Poticha (2004) merged the concept of transect into comprehensive TOD guidelines. The TOD typology considers differentiation between neighborhoods in context of American urbanization and hierarchy of urban areas and their need for regional connectivity by different public transportation systems (Table 1). In a Swedish context the TOD typology is applicable too, but within more detailed understanding and categorization of

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18 Placemaking is defined by the mottos and goals: places for people, enrich the existing, make connections, work with the landscape, mix uses and forms, manage the investment and design for change (Dittmar and Poticha, 2004, pp.30-2)

19 It includes: 1) urban downtown is the historical urban core or the central business district of the city; 2) urban neighborhood is any historic neighborhood that is attached to the urban downtown; 3) suburban town center is newly established urban core and job centre in the suburbs; 4) suburban neighborhood is suburban community with access to either suburban town center or urban downtown; 5) neighborhood transit zone is a transit stop with limited neighborhood retail or office space in largely residential area; and 6) commuter town is a community served by commuter service to the urban downtown (Dittmar and Poticha, 2004, pp.34-6)
the TOD types in regard to the Swedish urbanization and neighborhood typologies (Paper 5)

Table 1: TOD typology in regard to land use mix, minimum housing density, housing type, regional connectivity, transit modes and frequencies (Dittmar and Poticha, 2004, pp.38)

<table>
<thead>
<tr>
<th>TOD type</th>
<th>Land use mix</th>
<th>Minimum housing density</th>
<th>Housing types</th>
<th>Regional connectivity</th>
<th>Transit modes</th>
<th>Frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban downtown</td>
<td>Primary office centre</td>
<td>&gt;60 units/acre</td>
<td>Multifamily Loft</td>
<td>Hub of radial system</td>
<td>All modes &lt;10 minutes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Urban entertainment</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retail</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban neighborhood</td>
<td>Residential</td>
<td>&gt;20 units/acre</td>
<td>Multifamily Loft</td>
<td>Medium access to downtown</td>
<td>Light rail</td>
<td>10 minutes peak</td>
</tr>
<tr>
<td></td>
<td>Class B commercial</td>
<td></td>
<td>Townhome Single family</td>
<td>Subregional circulation</td>
<td>Streetcar</td>
<td>20 minutes offpeak</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rapid bus</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Local bus</td>
<td></td>
</tr>
<tr>
<td>Suburban center</td>
<td>Primary office centre</td>
<td>&gt;50 units/acre</td>
<td>Multifamily Loft</td>
<td>High access to downtown</td>
<td>Rail</td>
<td>10 minutes peak</td>
</tr>
<tr>
<td></td>
<td>Urban entertainment</td>
<td></td>
<td>Townhome Single family</td>
<td>Subregional hub</td>
<td>Streetcar</td>
<td>10-15 minutes peak</td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td></td>
<td></td>
<td></td>
<td>Rapid bus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retail</td>
<td></td>
<td></td>
<td></td>
<td>Local bus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Paratransit</td>
<td></td>
</tr>
<tr>
<td>Suburban neighborhood</td>
<td>Residential</td>
<td>&gt;12 units/acre</td>
<td>Multifamily Loft</td>
<td>Medium access to suburban center</td>
<td>Light rail</td>
<td>20 minutes peak</td>
</tr>
<tr>
<td></td>
<td>Neighborhood retail</td>
<td></td>
<td>Townhome Single family</td>
<td>Access to downtown</td>
<td>Streetcar</td>
<td>30 minutes offpeak</td>
</tr>
<tr>
<td></td>
<td>Local office</td>
<td></td>
<td></td>
<td></td>
<td>Rapid bus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Local bus</td>
<td></td>
</tr>
<tr>
<td>Neighborhood transit zone</td>
<td>Residential</td>
<td>&gt;7 units/acre</td>
<td>Townhome Single family</td>
<td>Low</td>
<td>Local bus</td>
<td>25-30 Demand responsive</td>
</tr>
<tr>
<td>Commuter town center</td>
<td>Retail center</td>
<td>&gt;12 units/acre</td>
<td>Multifamily Townhome</td>
<td>Low access to downtown</td>
<td>Local bus</td>
<td>Demand responsive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single family</td>
<td></td>
<td>Paratransit</td>
<td></td>
</tr>
</tbody>
</table>

The conclusion from the advocacy and research in the USA is that TOD can realize its full potential only if it is seen as a new paradigm for development, rather than a series of marginal developments. TOD should operate within constrains of the market and realistic expectations of behavior and lifestyles patterns. The market and lifestyles change as result of policy choices and social
and cultural trends (Dittmar et al., 2004, pp.9). TOD is not simply an assembly of buildings around transit nodes. It is also about communities. TOD is partly about building social capital strengthening the bond between people and the communities in which they live, work, socialize and recreate (TRB, 2004).

2.1.5 The European compact city as a counterpart of American TOD
TOD and the European compact city share similar principles that emerged in the same time. The advocacy in Europe comes from the European commission (EC). There are two principal models in the sustainable cities debate: the compact and green city. Much emphasis in the discussions so far has been done on the compact city. The fashionable buzzwords in European urban and regional planning since the 1990s are “multimodality” and “urbanity”, “intensification” and “mixing”, “compact city”, “polycentricity” and “urban networks”. The compact city emphasizes intensity by urban regeneration, densification and effective public transportation systems. The urban expansion is halted to protect the surrounding environment thus creating a strong contrast between the city and the nature. The green city is based on environmental design and development of contained communities that will integrate with the natural rhythms (EC, 1998, pp.6-7). The compact city is identified as solution for urban challenges such as derelict land, sprawl and quality of the urban environment (EC, 1990, pp.4). The argument is, like in TOD and New Urbanism, that urban density and diversity are more likely to result into people living close to work places and services that are required for the everyday life (EC, 1990, pp.40). The ambition is also to make the private car an option in cities rather than a necessity (EC, 1990, pp.30) by creating integrated, multimodal transportation systems which fully exploit the potential of public transportation (EC, 1997, pp.11-2).

BRT and LRT are preferred as new public transportation systems in the compact city as partially separated busways or railways on multimodal streets in compact neighborhoods. The partially segregated busways or railways in Europe are regarded as urbanity-empowering and more attractive since they do not cause barrier effects as the fully separated railways or busways. The BRT or LRT lines in the projects are often designed as medians, light busways or light railways, on multimodal boulevards and act as public transportation axes in the new sustainable neighborhoods. The boulevards usually include bike lanes, sidewalks along attractive façades with storefronts and ribbons of greenery and landscaping.
2.1.6 *Comparison between examples of the European compact city and American experiences with TOD*

Today we see a wide replication of the same compact city model in Northern and Western Europe. The neighborhoods along the BRT and LRT lines in Gothenburg and Stockholm are not very different than the neighborhoods along the BRT or LRT lines in Copenhagen, Helsinki, Paris, Eindhoven, Amsterdam or Cambridge (Figure 10).

*Figure 10: The European compact city and TOD experiences (photographs 1-2 from up and left to right and down are from Helsinki, 3-5 are from Amsterdam, 6-7 from Eindhoven, 8-9 from Cambridge, 10 from Douai and 11-12 from Paris)*
It is predominantly executed in the brownfields of the historical, today abandoned industrial urban fringe, but there are also many new suburbs developed by the same model on greenfields. There are many finished and ongoing busway projects and BRT is often in the centre of the compact city neighborhoods. Many of these neighborhoods are similar and the compact city model is becoming a European stereotype.

Figure 11: The American TOD experiences (photographs 1-7 from up and left to right and down are from San Diego, 8-9 are from Portland and 10-12 from Los Angeles)

The differences between American cities give much broader scope of TOD projects and designs (Figure 11). American TOD experiences are much more varied than its European compact city counterparts. For example the TOD in Portland is similar in urban structure as the European compact city
neighborhoods, but the architecture and heights of building are much more
different. Every LRT stop is clearly defined by a tower which is embedded in
the structure of the neighborhoods. In Los Angeles, TOD is very broadly
interpreted from very dense urban environments along the Red Line, a subway
line, to simply accentuations by landmark buildings along the Gold Line, a LRT
system. San Diego is the city that was first in USA to adopt TOD guidelines
and the TODs along the San Diego trolleys are very varied.

American TOD is characterized by high-quality architecture and urban design.
That emphasis triggered a critique about gentrification and high attractiveness
of the TODs in contrast to the poor status of public transportation in the USA.
The tension between place and node is mentioned often (Dittmar & Poticha,
2004, pp.32; Belzer et al., 2004, pp.45-6). Sometimes the TOD projects around
LRT or BRT stations like the station Rio Vista in San Diego are designed as
very attractive and luxurious public spaces with plazas, fountains and lavish
landscaping that mask the station and make the public transportation as node
peripheral to the neighborhood as place. In American context they attract
richer social classes that rarely use public transportation, but they like to live in
urban settings with deluxe cityscapes.

2.1.7 Redefining TOD in European context
The public transportation has different context in Europe and in USA, with
exceptions in cities as New York and New Jersey, Boston, Washington DC,
San Francisco and Chicago, that kept and continuously developed its public
transportation systems. In Europe public transportation is deeply entangled in
towns and cities to a level that it is exchanged to urban transportation20. Public
transportation urbanizes villages and landscapes. The buses, trams and trains
often play sentimental and inspiring roles in the European everyday urban life.
It is impossible to imagine London without its red double-decker buses or its
Underground, Paris without its Metropolitan entrances by Hector Guimard, or
Stockholm without its Tunnelbana.

The effect of public transportation on cities is morphologically21 visible by
looking at distinctive urban areas that were developed in periods when different

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20 Public transport or urban transport is commonly used in Europe for transit, public transit or
urban transit. Other European authors like Stephen Marshal have used public transport-oriented
urban design to describe TOD (Marshal, 2001).

21 The emergence of urban form is a product of historical urban processes, economical
development and struggles in society. The urban forms are very rigid to changes and often
stand as artifacts of the age when they were developed and renewed.
public transportation technologies dominated. In this licentiate thesis I define TODs as public transport cities. A public transport city is a historical artifact of urban development towards public transportation infrastructures and a fuzzy model for future cities represented by paths, nodes and stretchable desirability cores (Figure 3). There are four principal public transport cities: 1) the elongated and interwoven city of buses and trams on streets; 2) the city of pearls unfolded by heavy railways and busways; 3) the networked city above the underground; and 4) the compact city along the light railways and light busways that are morphologically distinctive and have unique pattern of desirability cores (Paper 2). TOD in the European redefinition is a set of policies to envision, design and actuate public transport cities at urban and regional scale. TOD is not a matter of replicating historical cityscapes, but a way to understand the structuring effect of public transportation infrastructures in urban areas and regions.

I define public transport metropolis as a city that grew throughout the history adapting to the four principal public transportation systems on streets, partially or fully segregated or underground continuously throughout the history. There are many European like Stockholm, Paris, London, Berlin, Copenhagen or Helsinki that are public transport metropolises. There is a long history and tradition of integration of public transportation in Sweden and some old models as sets of rules to achieve public transport metropolises worked fine (Paper 4). The application of different public transportation systems and their integration with the city allows for multiple travel choices for speedy and slow, warp or sightseeing journey by public transportation. This is a model for a bus metropolis.

TOD also is recognized as an old concept in the evolution of the American towns and cities from development-oriented transit and auto-oriented transit to transit-oriented development. The streetcar suburbs in the 19th century and beginning of the 20th were developed by single owner who developed the streetcar lines and the residential communities or by entrepreneur who worked hand by hand with a developer. The emergence of the automobile triggered wide auto-oriented transit where the buses became the primary mode of transit in most urban regions together with public transportation systems like BART in San Francisco that were explicitly designed to work and compete with the automobile. The suburban stations were surrounded by parking places, rather than with buildings and the systems were only a way to the downtown. From the 1980s the suburban railway systems were used to enhance value of adjusted land (Dittmar et al., 2004, pp.5-9). This has spawned a new term for characterizing land development near transit, transit-adjacent development (TAD). Hank Dittmar remarks: “Most often the TODs have conventional single use development patterns, with conventional parking requirements, so that the development is actually transit adjacent rather than transit oriented” (TRB, 2004).

The desirability cores follow the flows and dispersal of pedestrians and extend in attractive urban environments as amoebas. The desirability cores stretch out and change if the urban environments become more attractive to meet or hang out, walk or cycle.
or BRT metropolis\textsuperscript{24} too, since BRT claims wide infrastructural coverage as buses on streets, buses in tunnels, buses on light and heavy busways.

2.2 Which urban density is needed for BRT?

2.2.1 The empirical evidence of the interrelationship between urban density and public transportation

The question: “Which urban density is needed for different public transportation systems?” emerged in the USA when the share of public transportation began rapidly to diminish. The urban density was targeted as a crucial variable that explained more than half of the share of the public transportation in the American cities (Pushkarev and Zupan, 1977). Boris Pushkarev and Jeffrey Zupan inspired many scholars with their research approach of identifying and analyzing factors that influence public transportation. Within the tradition there is a distinction between urban form factors and non urban form factors or socioeconomics\textsuperscript{25} (Frank and Pivo, 1994). There are analyses of aggregated or disaggregated data, of traveling patterns and flows in neighborhoods or periods and individual travel behavior. The strength of the effect is described either by demand function or elasticity\textsuperscript{26}. At aggregated level the dependent variables often include annual or daily passenger kilometers, vehicle kilometers, number of passengers and passenger revenue (Balcombe et al., 2004).

\textsuperscript{24} Robert Cervero discusses four types of transit metropolises: adaptive cities, cities with adaptive transit, hybrid cities which are adaptive cities with adaptive transit and cities with strong cores where the urban activity in the urban cores dominates the urban region. Stockholm and Copenhagen are examples of adaptive cities, Karlsruhe is an example of a city with adaptive transit, Bogotá is an adaptive city with adaptive transit and Zurich is a city with strong urban core (Cervero, 1998). In context of BRT, the BRT metropolis is adaptive city with adaptive transit. BRT revolves around busways that are inflexible and demand adaptation by urban transformation towards the bus stations.

\textsuperscript{25} The argument that petrol use is dependent on urban density (Newman and Kenworthy, 1989), an urban form variable, was contested with a diagram showing the petrol price relative to income, an economic factor (Wegener & Fürst, 1999). Similar results are seen on the diagrams for annual journeys per capita in Sweden by public transportation for number of inhabitants per kilometers, an urban form variable, and costs for public transportation per capita, an economic variable (Figure 19).

\textsuperscript{26} Elasticity is a measure that expresses the percentage change of one dependent variable as response to one percent change of an independent variable.
The American school\textsuperscript{27} follows the traditions established by Boris Pushkarev and Jeffrey Zupan, but the empirical evidence diversified and the strength of urban density as crucial factor became under question. Originally, the demand for public transportation increased with increase of population and commercial density and depended on its service and price, but even more on the availability and price of the competitive mode, the motorcar. The price is in money, time, discomfort and disamenity (Pushkarev and Zupan, 1977). Robert Cervero continued to research the interrelationship though multiple variables and clustered the many variables of the built environment in four factors: density, size, design and entropy of floor uses (Cervero, 1989). These factors later became known as the \textit{D variables of the built environment}. Originally there were 3D variable: Density, Design and Diversity (Cervero and Kockelman, 1996), which increased to 4D as Density, Design Diversity and Deterrent to Driving (TRB, 2006) and in the end expanded to 3+2+2D, Density, Design and Diversity plus proximity as Distance to the public transportation and Destination accessibility plus Demand and Demographics (Cervero and Ewing, 2010).

In the Swedish school\textsuperscript{28} there is emphasis on travel time ratios and competitiveness with the private car. Travel time by public transportation compared to the travel time by private car, reliability, traffic safety, regularity, capacity, comfort and fares were listed as important factors that influence public transportation. The travel time by public transportation includes weighted walking and waiting time, transfer and egress times (Holmberg, 1972, pp.18-32). In a later study Holmberg (1975) examined the public transportation systems as in interplay of costs and benefits. The factors were systematized in a frame that include fares, public transportation demand and travelled distances, change in public transportation demand due to daily and yearly variations, public transportation standard as walking distances to the public transport stops, frequencies, headways and hours of service, the average speed and distances between the public transportation stops, motorcar ownership, city size and distance to the city centre, residential, commercial and industrial

\textsuperscript{27} There are hundreds of reports and studies within the American school. Transportation research board (TRB) compiles its publications about public transportation through the Transit cooperative research program (TCRP). Transit capacity and quality of service manual (TCQSM) is the main handbook of the school. It was firstly published in 1999 and reached its third edition in 2010.

\textsuperscript{28} There are many manuals and handbooks in the Swedish school published by \textit{Stockholm public transport} (Storstockholms lokaltrafik or SL), the public transport authority in Stockholm region, \textit{Swedish national board of housing, building and planning} (Boverket), \textit{Swedish transport administration} (Trafikverket), \textit{Swedish rail administration} (Banverket) and \textit{Swedish road administration} (Vägverket).
densities, urban form, transportation network, its traffic situation and congestions, climate and topology. The consequent research crystallized the factors within two categories: internal, concerning the public transportation systems and external. Travel time is most important internal factor, followed by availability, accessibility, coverage, reliability, safety, fares, comfort and information. The external factors that influence the public transport are population density, localization of the population, income, level of development of the public transport and motorcar network, motorcar ownership, parking fees, congestions, distance from the city centre (Persson 2008, pp.9-16).

The empirical evidence about the effect of urban form or built environment on traveling is very diverse. A meta-analysis of more than 200 studies shows the weighted average elasticity with the greatest absolute magnitude is 0.39 for urban design as intersection density and the other elasticities are much smaller. The elasticity for urban density as population density is 0.07, whereas the employment density is 0.01. Still, the combined effect of several built environmental or urban from variables on travel is considered to be quite large (Ewing & Cervero, 2010). There are cases where the people use public transportation more or make more journeys by public transportation in low density areas and sometimes use public transportation less in high density areas.

The link between urban form and public transportation is described through an interrelationship triangle that includes neighborhood or service area

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29 The public transportation and urban form are often analyzed through the D variables of the built environment of Robert Cervero. The trip frequency, number and length of journeys, share of public transportation, share of walking, VMT or VKT are usual dependent variables in the analyses. The empirical research shows that trip frequency is primarily a function of socioeconomic characteristics of travelers and secondarily a function of the built environment or the urban form; trip length is primarily a function of the built environment and secondarily of socioeconomic characteristics; and mode choice depends on both, although probably more on socioeconomic. Vehicle miles or kilometers traveled (VMT or VKT) and vehicle hours of travel (VHT) also depend on both (Ewing & Cervero, 2010).

30 The weighted average elasticities were calculated when three conditions were met: 1) a sample of at least three studies was available; 2) for these particular studies, dependent and independent variables were comparably defined; and 3) for these particular studies, disaggregate travel data were used to estimate models (Ewing & Cervero, 2010).

31 The interrelationship triangle was a theoretical framework to analyze the effect of bus service and neighborhood factors on the number of passengers boarding in the city of Karlstad (Stojanovski, 2011). The neighborhoods generate travel demand that affects the public transportation service. When the travel demand for public transportation increases or decreases in the neighborhoods, it influences the public transportation service. Any
characteristics, public transportation service characteristics and public transportation demand or performance measure (Figure 12).

Figure 12: Interrelationship triangle between public transportation demand and service with its service areas (TRB, 2006, pp.18).

The research done in the city of Karlstad shows that numbers of inhabitants and work places as independent variable in the regression analysis significantly explains roughly one third of the number of passengers boarding as dependent variable. More inhabitants and work places mean more passengers boarding on the bus stops (Figure 13).

adjustment of the quality of service potentially causes a change in the travel demand. Increasing the quality of service sometimes triggers urban redevelopment or transformations or new development in the neighborhoods within the service area. People can move out or in, buildings can change function or land use, for example from housing to retail, industry or office, shops can cluster, the neighborhoods decay or develop.

32 There are two types of variables: quantities, amounts or scores such as passengers boarding or journeys by public transportation and rates showing relations in the interrelationship triangle as number of passengers boarding per inhabitant and work place, per hectare, per bus passing, kilometer of bus service or bus hour of service in the neighborhood. It is important to make distinction between them.
Figure 13: The effect of urban density on the number of passengers boarding per hectare and per inhabitant and work place in the city of Karlstad.

Table 2: Regression analysis of number of passengers boarding on bus stops in regard to number of inhabitants and work places in the neighborhoods in the city of Karlstad

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhabitants and work places</td>
<td>0.140</td>
<td>0.028</td>
<td>5.077</td>
</tr>
<tr>
<td>Constant</td>
<td>14.906</td>
<td>43.258</td>
<td>0.345</td>
</tr>
</tbody>
</table>

Summary statistics:

F (Sig.) = 24.398 (0.000)
R Square = 0.315
Number of neighborhoods = 55

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhabitants</td>
<td>0.131</td>
<td>0.034</td>
<td>3.816</td>
</tr>
<tr>
<td>Work places</td>
<td>0.167</td>
<td>0.050</td>
<td>3.338</td>
</tr>
<tr>
<td>Constant</td>
<td>16.885</td>
<td>45.750</td>
<td>0.369</td>
</tr>
</tbody>
</table>

Summary statistics:

F (Sig.) = 12.243 (0.000)
R Square = 0.320
Number of neighborhoods = 55

The data is from Karlstadsbuss and SCB.

An analysis in Hammarby Sjöstad, a neighborhood in Stockholm, shows similar results as in Karlstad study. Hammarby sjöstad gradually developed in the 2000s along orbital LRT line, the Tvärbanan. Hammarby Sjöstad is a redevelopment of an old industrial zone. There are three areas: Mårtensdal
Luma and Sickla Udde and four LRT stations centrally located in the areas. Luma is an area with two stations: Luma and Sickla Kaj.

Hammarby Sjöstad is urban redevelopment project and an experiment with application of policies of urban densification and mixing of urban functions. New residences were developed in the predominantly working area to achieve a functional balance. From 2003 to 2010 the number of inhabitant and work places increased in the three areas of Hammarby Sjöstad (Table 3).

Table 3: Number of passengers boarding per inhabitant and work place during the urban densification and mixing in Hammarby sjöstad in Stockholm

<table>
<thead>
<tr>
<th></th>
<th>Mårtensdal (number of inhabitants increased by roughly 4000)</th>
<th>Luma (number of inhabitants increased by roughly 6000 with 1000 new work places)</th>
<th>Sickla Udde (number of inhabitants increased by roughly 3500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>0.45</td>
<td>1.02</td>
<td>0.34</td>
</tr>
<tr>
<td>2004</td>
<td>0.52</td>
<td>0.80</td>
<td>0.31</td>
</tr>
<tr>
<td>2005</td>
<td>0.55</td>
<td>0.72</td>
<td>0.34</td>
</tr>
<tr>
<td>2006</td>
<td>0.60</td>
<td>0.70</td>
<td>0.36</td>
</tr>
<tr>
<td>2007</td>
<td>0.53</td>
<td>0.70</td>
<td>0.42</td>
</tr>
<tr>
<td>2008</td>
<td>0.49</td>
<td>0.69</td>
<td>0.40</td>
</tr>
<tr>
<td>2009</td>
<td>0.30</td>
<td>0.65</td>
<td>0.34</td>
</tr>
<tr>
<td>2010</td>
<td>0.35</td>
<td>0.70</td>
<td>0.41</td>
</tr>
</tbody>
</table>

The data is from http://www.statistikomstockholm.se/, SL and Sweco.

The urban redevelopment caused increase in passengers boarding on the Tvärbana, but the number of passengers boarding per inhabitant and work place shows randomness, either stayed the same or decreased for example in Luma\(^\text{33}\).

\(^{33}\) There were roughly 1,700 work places and 400 inhabitants in Luma in 2003 that generated more than 2,000 boardings on the Tvärbana or more than 1 per inhabitant and work places. In the same time there were almost 3,000 work places and 400 inhabitants in Mårtensdal that generated 1,500 boardings on the Tvärbana or less than 0.5 per inhabitant and work places. The number of passengers boarding in Luma increased by 4,000 by 2010, but as a consequence of 6,000 new residents and 1,000 new work places. The number of passengers boarding in Mårtensdal increased by roughly 500, even though there were almost 4,000 new residents and the number of work places only slightly increased. In Sickla udde, which is predominantly a residential area with few work places, the number of passengers boarding followed the increase in new residents with regular pattern. The number moved within a small interval of 0.3-0.4 passengers boarding per inhabitant and work place.
The analyses in Stockholm and Karlstad include only passengers boarding on the primary bus network in Karlstad and Tvärbanan, the LRT line in Stockholm. The boardings on the other special, direct or feeder lines is not analyzed. BRT is conceived as a trunk system that operates in parallel to other secondary or tertiary public transportation systems. These analyses are made to coincide with the fraction of passengers, a market share within the total share of public transportation that might use BRT. BRT is conceived as a primary bus network in a BRT metropolis where the public transportation systems are only with buses.

2.2.2 Which urban density is needed for BRT if the headway is 10 minutes?

BRT in the USA and Canada is typically most successful when the urban population exceeds 750,000 and the employment in the central business district (CBD) is at a minimum between 50,000 and 75,000 (TRB, 2003). But in reality there are exceptions in cities like Eugene, Oregon, USA, with 150,000 inhabitants that introduced a BRT line. The BRT line in Eugene achieves 1.5 million boardings per year which correspond to roughly 5,000 boardings per weekday. The 5,000 boardings per day in Eugene can be considered as a minimum service for BRT. It translates to a bus service with headway of 8 to 10 minutes during peak periods and 12 to 15 minutes off peak. Similar headways and capacity as number of boardings are applicable as minimum BRT service in the Swedish towns and cities.

In the discussions about BRT in Karlstad, the regression model (Table 2) can be used to forecast the number of passengers boarding along the new BRT line in regard to urban density. If we stipulate a minimum BRT service and a minimum capacity of 5,000 boardings per day as in Eugene and service headway of 8 to 10 minutes during peak periods the BRT line requires roughly 36,000 inhabitants and work places.

An analysis of the main nodes along the new BRT line in Karlstad shows that there are roughly 28,000 inhabitants and work places. The prediction is that the existing inhabitants and work places would generate around 4,000 passengers boarding in the main nodes (Table 4), but there is a need for additional 8,000 inhabitants and work places along the BRT line.

34 The results of the regression model show that there are roughly 0.14 per inhabitant and work place or 0.13 boardings per inhabitant and roughly 0.17 per work place.
Table 4: Predictions for the number of passengers boarding in the main nodes along the Karlstad’s direction using the results from the regression analysis in Table 1

<table>
<thead>
<tr>
<th></th>
<th>Estimated passengers boarding</th>
<th>Population and work places</th>
<th>Estimated passengers boarding</th>
<th>Population</th>
<th>Work places</th>
<th>Estimated passengers boarding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ikea</td>
<td>900</td>
<td>200</td>
<td>100</td>
<td>200</td>
<td>700</td>
<td>100</td>
</tr>
<tr>
<td>Hospital (Sjukhuset)</td>
<td>4,200</td>
<td>0</td>
<td>600</td>
<td>0</td>
<td>4,200</td>
<td>700</td>
</tr>
<tr>
<td>The urban core of Karlstad</td>
<td>8,800</td>
<td>1,400</td>
<td>1,200</td>
<td>1,400</td>
<td>7,400</td>
<td>1,400</td>
</tr>
<tr>
<td>University of Karlstad (Karlstadsunivesitetet)</td>
<td>2,400</td>
<td>300</td>
<td>900</td>
<td>1,500</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Kronoparken</td>
<td>3,500</td>
<td>3,100</td>
<td>500</td>
<td>4,000</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Rud</td>
<td>3,400</td>
<td>3,100</td>
<td>500</td>
<td>3,100</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Sundsta</td>
<td>4,600</td>
<td>4,000</td>
<td>600</td>
<td>4,000</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Sum</td>
<td>27,800</td>
<td>12,700</td>
<td>3,900</td>
<td>15,000</td>
<td>4,200</td>
<td></td>
</tr>
</tbody>
</table>

Regression analysis as a prediction method for data with variations and residuals must be considered with caution. The interrelationship between number of passengers boarding and number of inhabitants and work places is not linear, but the values are scattered. There are variations and residuals. Most of the numbers vary from 0 to 0.2 passengers boarding per inhabitant and work place for different neighborhoods and that makes the forecast very unreliable (Figure 13). A pessimistic standpoint can halve the 4,200 passengers boarding, whereas an optimistic might double the figure.

The regression analysis uses historical data to predict the future. Today many smaller Swedish towns and cities have low share of public transportation. The low share today is not necessary predictor for the future and it dramatically increases the requirement for inhabitants and work places along the BRT lines. If 5,000 boardings per day is a minimum capacity to introduce a BRT line, the future developments would target higher densities\(^{35}\). In practice the trunk bus lines in Sweden and Scandinavia\(^{36}\) have much higher capacity than the BRT line in Eugene. It is difficult to expect that the regression model will produce reliable projections on a sample from only one year. The changes in Hammarby

\(^{35}\) If the new BRT line for example in Karlstad is aiming for 20,000 boardings per weekday sometime in the future the forecast by using the historical regression model with low share of public transportation would be roughly 150,000 inhabitants and work places.

\(^{36}\) The trunk bus 16 in Gothenburg and Jokeri Line in Helsinki generate around 25,000 passengers per day with 3-5 minutes frequency (Hiddebaut et al, 2010).
Sjöstad over an 8 year period are random for number of passengers per inhabitant and work places.

Another variable that was significant in the Karlstad study was the number of study places and that shows a direction for more detailed analysis. Number of study places is statistically stronger than the number of inhabitants and work places. A multivariate analysis including inhabitants, work places and study places doubles the explanatory coefficients (Table 5).

Table 5: Regression analysis of number of passengers boarding on bus stops in regard to number of inhabitants, work and study places in the neighborhoods in the city of Karlstad

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study places</td>
<td>0.092</td>
<td>0.014</td>
<td>6.741</td>
<td>0.000</td>
</tr>
<tr>
<td>Population</td>
<td>0.130</td>
<td>0.025</td>
<td>5.169</td>
<td>0.000</td>
</tr>
<tr>
<td>Work places</td>
<td>0.083</td>
<td>0.039</td>
<td>2.131</td>
<td>0.038</td>
</tr>
<tr>
<td>Constant</td>
<td>20.237</td>
<td>33.598</td>
<td>0.602</td>
<td>0.550</td>
</tr>
</tbody>
</table>

Summary statistics:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>F (Sig.) = 30.284</td>
<td>0.000</td>
</tr>
<tr>
<td>R Square = 0.640</td>
<td></td>
</tr>
<tr>
<td>Number of neighborhoods</td>
<td>55</td>
</tr>
</tbody>
</table>

There are more than 12,000 study places in University of Karlstad (Karlstadsunivesitetet) and the high school in Sundsta that are responsible for the additional boardings. The study places take boardings from the work places and that influences the future demand and projections. The 15,000 work places would generate 1,200 boardings, instead of firstly estimated 2,500 if we consider the results. Additional work places along the BRT line might not produce the expected results from the model including only inhabitants and working places. There is a “student bias” in the first model.

The significance of the students or study places as specific social group inspired a new perspective on the analysis. There are social groups and work place within the sample that are loyal to public transportation. This is an argument for looking not only at urban density, but also in the character of neighborhoods and social groups that inhabit them or work there. There should be awareness about that when working with urban densities. That is why neighborhood type as a concept of urban form and self-selection are used.

37 The neighborhood type is an important variable in the choice of residential location (Rådberg, 2000). The predisposition for choosing residential location is called self-selection. If someone has preference to use public transportation the choice would be to move to a neighborhood with an easy walk to a public transportation station or stop. The neighborhood type can be used to map social group that are loyal to public transportation.
The empirical evidence especially in the American school (Cervero & Duncan, 2002; Cervero, 2007; Concas, 2010) shows that self-selection is an important factor in determining mode choices in neighborhoods and preferences towards public transportation. Many residents that live in TOD neighborhoods have a tendency to use public transportation, whether to avoid the stress of commuting, for reasons of personal taste or to make more productive use of time spent getting to work (TRB, 2004).

2.2.3 From analyzing urban density to concepts of urban form

Urban density is a significant and fundamental variable to introduce BRT and it is applicable as predictor, but with there is a need for more details and refinement. There is a need for more details and refinement. It is important to consider other factors from the bus service and neighborhoods that enclose the interrelationship triangle. The number of passengers boarding can be analyzed in respect to urban functions or land uses or by neighborhood types that capture differences in urban function and urban form. It is a gradual process of making distinction from urban density to urban function and from urban function to neighborhood types. With neighborhood types it is easier to distinct between different urban areas dominated by same urban function, but the higher detail increases the number of categories and decreases the sample size of neighborhoods in one city. The use of urban function helps to

The students are a social group that can be mapped through student campuses and complexes as neighborhood types.

38 More than 50% of the residents in the TOD neighborhoods in San Francisco and around 20% in San Diego and Los Angeles replied that the access to public transportation was a reason why they moved in a TOD neighborhood. The most important reasons with 50% or over were type or quality of housing, cost of housing and quality of neighborhood (Lund, 2006), which are characteristics of a neighborhood type. The knowledge base in urban morphology about typologies can be very handy to understand self-selection. The access to public transportation and distinctive urban form that results in distinctive quality of housing, cost of housing and quality of neighborhood are embedded characteristics and are easily captured by conceptualizing neighborhood typologies. For example, the new TOD neighborhoods along the BRT and LRT corridors in Stockholm and Gothenburg for example are typologically same and the people that move there make certain self-selection as taste to live in that distinctive neighborhood type. Hammarby Sjöstad is populated by a distinctive social class. There is an influx of middle class families in their thirties with small children. That self-selection produces a social stereotype. The two work areas of Hammarby Sjöstad, Mårtensdal and Luma are inhabited by this distinctive social class which dominates in Sickla Udde. Mårtensdal generated similar number of passengers as in Sickla Udde and it stayed roughly in the interval 0.3-0.4, whereas it decreased by from 1 to 0.7 passengers boarding per inhabitant and work place in Luma. One interpretation can be similar tastes and preferences of the new inhabitants that belong to distinctive social class.
emphasize the higher use of public transportation in some specific functions or land use, but the values of many residential neighborhoods are still scattered (Figure 14).

Figure 14: The effect of function/land use and neighborhood types on the number of passengers boarding per hectare and per inhabitant and work place in the city of Karlstad.

Different urban functions especially retail and professional services and community services as education and healthcare generate more passengers than residential.
Locating urban functions or neighborhood types that generate more passengers decreases the amount of inhabitants and work places along the BRT lines. Some urban functions as community services\(^{39}\) generate up to ten times more boardings per inhabitant and work place than urban areas with predominantly residential functions. Bringing residents, work places and urban activities closer to public transportation is a matter of selecting urban functions and neighborhood types that are both attractive and oriented to public transportation stops and stations.

2.2.4 **BRT enhancements of bus transportation**

One of the arguments is that the high levels of bus service as high speed or frequency, directness and competitive travel time ratios with the private car increases the number of passengers boarding. The study in Karlstad shows that there are double as much passengers boarding in the neighborhoods where the bus lines have with highest A level of service as speeds or frequencies. There were no other regularities. Some bus lines with very low level of service like D generated more passengers than other with B or C level of service regardless of the worse characteristics of bus service (Stojanovski, 2011).

The scatter plots, if ignoring the neighborhood types as superimposed factor, show that there are trends with large variations that support the hypothesis that the BRT enhancements of bus transportation like high speed or frequency increase the number of passengers boarding per inhabitant and work place (Figure 15). It is probable to expect bonuses with introduction of speedier and more frequent bus service. The transposition of neighborhood types confronts these results, since it is difficult to separate the BRT enhancements, high frequency or speed, from the student campuses, universities and high schools. The neighborhoods that have green BRT levels of service (Kottenhoff et al., 2009) and are not dominated by students or education are scattered without trend within an interval between 0-0.3 passengers boarding per inhabitant and work place.

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\(^{39}\) The differences between urban areas with community services can be further described by additional neighborhood types. The community services for example also include healthcare and various administrative services that generate different demand.
Figure 15: The effect of bus service factors on the number of passengers boarding per hectare and per inhabitant and work place in the city of Karlstad considering the defined neighborhood types.
Instead of trendlines, there are fields or intervals for distribution of the variables by neighborhood types and that makes sense for example for bus frequency. Neighborhood type explains urban density as variable and the bus service is organized in regard to the urban density. It is not surprise to have frequency of 1-2 buses per hour and 2-3 buses per rush hours, in the low density neighborhood types with villas, detached houses or row houses. The frequency of bus service on the peripheral neighborhoods through regularities in urban density and adjustment of bus operation to these densities produces indirectly a field or interval in the scatter plots.

2.3 Urban form, BRT and TOD

2.3.1 Discourses on urban form

The use of typological methodology is one discourse on urban form within a narrower definition of urban morphology. Urban morphology revolves around urban form and the processes of formation and transformation of urban areas. It is a multidiscipline between architecture and urban design, geography and history, economics and politics. In its narrower definition within architecture and geography, urban morphology puts emphasis on studying physical form and processes of its emergence and transformation. This definition historically dominated urban and regional planning, architecture and geography and there

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40 The empirical research done in Sweden by Johan Rådberg in Västerås (Rådberg, 1997) and South Stockholm (Rådberg, 2000) in the 1980s and 1990s and the research in Karlstad (Paper 4) showed that the Swedish neighborhood typology explains urban density and diversity. The result in Karlstad shows that the people who live in these neighborhood types with specific character have similar income that varies 1000 Swedish crowns, even though the income in Sweden does not very dramatically. The hypothesis that the combined effect of several built environmental variables on travel is considered to be quite large (Ewing & Cervero, 2010) is testable by using neighborhood typology that joins these variables. It is important to further research the interrelationship between urban density and urban form of unique or typological neighborhoods and bus infrastructures. The tradition of neighborhood planning in Sweden further more strengthens this view and links it to development and transformation of neighborhoods.

41 There is a plethora of definitions in urban theory (Harvey, 2009). Urban theory and practice vary from sensing to actuation (Ratti, 2011), from theoretical conceptualization, researching physical activities and form in two or three dimensional space and studying social, economical and political processes, knowledge, power and action (Friedman, 1987) to a praxis of negotiations, drawing and execution of social policies and physical plans. The practices and theories revolve around complementing urban definitions or standpoints: 1) the city as an artwork of political struggle; 2) the city is a mosaic; 3) the city is agglomerations of flows; 4) the city is localization and aggregate of individuals; and 5) the city as mental image and feeling (Stojanovski, 2013).
are many traditions, methods and representations within\textsuperscript{42}. The representations of an urban mosaic of physical spaces and structure of cities vary from symbolical fuzzy diagrams to accurate drawings, maps and miniature: for example as a pattern of streets, plots and buildings that are shaped by the society and its economy (Conzen & Conzen, 2004). In another conceptualization the urban space is defined by a pattern of buildings, streets and squares (Krier, 1979, Krier, 1984; Krier et al., 2009). In Space syntax there are specific viewpoints in the urban space, from which the city is observed, that turn into axial spaces and shape convex spaces and isovists. The axial spaces are represented by centroids in a graph diagrams and axial lines on maps (Hillier et al., 1984).

The theoretical standing point of this licentiate is the work and concepts of the American urban planner Kevin Lynch\textsuperscript{43}, but the categorization is inspired by the typological traditions of British and Swedish architects and geographers. Kevin Lynch and Lloyd Rodwin looked at the cities as adapted spaces and flow system (Lynch and Rodwin, 1958) or urban systems\textsuperscript{44} of spaces and channels of flows. The activities occur and recur in adapted spaces that are linked by communications within channels (McLoughlin, 1969). Within the framework of urban space and flow, Lynch defined five urban elements that are cognitively recognizable: paths, nodes, districts, edges and landmarks (1.3; Figure 2). He conceived the city as mosaic of orientation points in adapted spaces, flows and breaks in urban flows. The urban elements are ranked experientially and subjectively by observers or by looking at the flows of people. The mental maps are symbolic and show relative relationships between and within the urban elements. In contrast in

\textsuperscript{42} The British or “Conzenian school” originates from the work of geographer Michael R.P.G Conzen. Even though theoretically the urban form is framed as a process, a temporal change of streets, plots and buildings (Conzen and Conzen, 2004), the scholars primarily focus on the two-dimensional extend and representation of urban areas through historical changes in planning practice and architectural styles. In contrast to the British school, the Italian school has strong architectural background inherited from the work of the Italian architect Saverio Muratori and his followers. The Italian cities changed architecturally throughout the history and the “Muratorian school” focuses on three-dimensional transformation, design, representation and interpretation of the architectural detail of the urban form (Caniggia & Maffei, 2001).

\textsuperscript{43} I write that there is an established tradition of urban elements by Kevin Lynch, but it is a tradition that is not widespread. The drawing of mental maps with urban elements is a long process that requires observations and data about urban flows, circulation of people, meeting and gatherings places and ways of orientation.

\textsuperscript{44} Another interpretation of within the systems paradigm inspired by Kevin Lynch and Lloyd Rodwin includes seeing the city as mosaic of spaces for people and urban activities, spaces for vehicles and communications and shared spaces (Boverket, 1991).
Space syntax the emphasis is on the line of sight of the observer and perceived physical space within the prospect of viewpoints. The structure of space is investigated by geometrical and topological analysis often using graph theory. These approaches can be mixed and hybridized.

Urban form implies either design or emergence of form in two or three dimensions at a variety of scales (Marshal and Yong, 2009, pp.22). The design and emergence of urban form is a continuous political process where economical and social interests clash. The physical form of cities and urban flows are shaped by continuously defined and redefines social structures and mental maps, economical and political processes. The urban mosaic is ultimately a physical product, an artwork of this struggle that is produced and reproduced in historical conditions (Lefebvre, 1996). It is rigid product both with physical and social inertia to changes. To make difference between the scales I make distinction between urban form and urban structure. Urban form is design or emergence of any agglomeration of buildings at urban scale. The urban scale is determined by walking and includes an urban area with one or several neighborhoods. Urban form defines agglomerating three dimensional urban spaces that are represented structurally as two dimensional urban elements (Figure 3). Urban structure describes the different arrangements of urban areas and transportation infrastructures in the urban regions.

2.3.2 The effect of BRT on urban form and structure

BRT is conceived as an adaptive public transportation system. The different bus infrastructures and busways influence the development of the cities in a historical process. The busways came very late and had very limited application in the urbanization of European towns and cities. Many large European cities have developed high capacity railway systems and much of the effort with bus system is about advancement of the systems and assigning bus lanes by taking out spaces for parking and by turning car into bus lanes. The diversity of bus

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45 Urban form translates to bebyggelse, while urban structure to bebyggelsestruktur in Swedish.
46 There was a slow start towards separation of bus traffic. Until the 1950s even though there were proposals for BRT, there were no visualizations of busways. The expressways for buses were not separated from the expressways for the cars. The bus lanes were firstly introduced in the 1950s in Nashville, Tennessee. The busways replaced the abandoned railways in Europe. One of the oldest busway is in Halmstad, Sweden from the mid 1960s, but it was not completely separated. The car traffic on the “busway” is too low to disturb the bus operations. In the 1960s came the first urban design along the busways in Runcorn, England, and the new town was completed in the 1970s. The busway in Runcorn and the new British town did not become a successful project and prototype for future British or European cities.
infrastructures that BRT utilizes is translated in variety of *urban form* or *structure* that BRT unfolds. We can discuss effect of public transportation infrastructure as *public transport cities* equally for bus infrastructures. There is no specific *urban form* or *structure* for BRT on partially segregated busways that cannot emerge for LRT partially segregated railways. The buses and trams on street have the same effect on the urban environments (Paper 4).

The effect of BRT on *urban form* and *structure* is captured by the concept or *public transport cities*. The BRT systems with heavy busways or bus lines with very long distance between stations act as heavy railways and they unfold a nucleated urban structure as *pearls on a string*. The range of a BRT line can extend to 60km. The partially segregated busways like in Gothenburg spread out urban corridors similarly as the bus lines on streets. The difference is that the partially segregated busways cause a permeable barrier effect, but that influences the circulation in the urban corridor. The sidewalk on the edges and the crossings are more attractive. These consistencies at urban scale are illustrated though the concept of *desirability cores* (Paper 2) and at regional scale exist as *urban corridors or nuclei* (Paper 3).

The partially segregated BRT or LRT are entangled in the urban and regional planning processes and negotiations as part of a new compact city advocacy for developing sustainable neighborhoods and cities. The argument is that BRT and LRT contribute to sustainable mobility and development and the debates often revolve around the question: BRT or LRT? BRT is often regarded as a more affordable system that can easily be replaced by LRT in the future. The busway in Gothenburg is in the centre of the urban redevelopment of the industrial fringe on the north and the busway continues also in the neighborhoods that are currently under development. In Stockholm there is a new LRT line and there is ongoing urban redevelopment of the abandoned industrial fringe on the south of the city similar as in Gothenburg. In Norrköping the extension of the tramways was also followed and coordinated with urban development (Paper 4). In Linköping the busways was built in coordination with extension of the university, but it is today in large sections shared with car traffic. The busway section in Lund is a unique example. It runs

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47 In Stockholm the line 676 is a system of bus stops on the motorway that terminates in the small town Norrtälje on the north. The length of the bus line is 67km and the buses drive with average speed of 60km/h. They arrive in Norrtälje in roughly 1h and 5 minutes. The line 676 is potential BRT line if the areas around the bus stops on the motorways are developed as urban nuclei by TOD policies.
between existing buildings and a part of a building was demolished to allow a smoother turn for the buses.

LRT and BRT are declared as drivers of urban development and vehicles of sustainable mobility, but they are part of the development model of the compact city and trends of redevelopment of the abandoned industrial zones caused by postmodern deindustrialization in many Northern and Western European cities. There are similar trends in the USA, where the urban development is often adjacent instead of oriented to BRT or LRT\textsuperscript{48}. It is impossible to separate the effect of BRT on urban form and structure from the today’s trend to develop compact cities and sustainable neighborhoods. The compact city is European BRT-TOD concept.

2.4 BRT and TOD via Swedish urbanization and society, cities and planning

2.4.1 Retrospect and trends in Swedish urbanization and society, cities and planning traditions

The integration of BRT in Swedish towns and cities has to be seen through a complex of urbanization and society, cities and planning. The towns and cities in Northern and Western Europe expanded outward in distinctive fringe belts characterized by different periods of urbanization (Whitehand, 1967; Whitehand & Morton, 2003). In Swedish context there are four distinctive periods of societal changes that triggered waves of urbanizations as fringes. They are referred more generally as traditional, industrial, modern and postmodern cities. These eras are characterized as pre-industrial, industrial, welfare and knowledge society by Carl-Johan Engström and Göran Cars (2008) or pre-industrial, industrialization, industrial and post-industrial by the three industrial revolutions (Luke, 1990). The Swedish societies do not follow each other, but there are modernizations, returns to traditions and mixing in different parts. It is dynamic process of development, decay and refurbishment, where the traditional and modern, old and new are in perpetual struggle. In each period the society was equipped with more advanced communication, information and transportation, manufacturing and building technologies that shaped cities, lifestyles and mobilities (Figure 16).

\textsuperscript{48} Hank Dittmar remarks: “Most often the TODs have conventional single use development patterns, with conventional parking requirements, so that the development is actually transit adjacent rather than transit oriented” (TRB, 2004)
There are models within the model with the emergence of new urban cores in the modern age. Each new modern urban core resets its position in the model. The historical urbanization is visible in the city of Karlstad (Figure 13; Paper 6).
The Swedish urbanization was shaped by a long tradition of urban and regional planning. Even the traditional cities developed according to urban regulations and laws, growing densely on small hills, rivers and waterfronts as wooden cities or trästäder. The increasing densities in the wooden cities caused disastrous fires in the 17th century. The risk of fires demanded better regulation, division of the city by wider streets and new stone buildings as in the traditional urban core of Stockholm. The Swedish stone cities or stenstäder with rectangular street network emerged as visionary plan that shaped the traditional urban cores of many Swedish town and cities. The traditional Swedish society was predominantly rural. It revolved around communities and agriculture, sustenance and perseverance. The city was a business and trade hub inhabited by merchants, bankers and nobility in a region of villages, mines and industries. The flows on boats and ships on natural waterways shaped the urban life and economy in the traditional Swedish towns and cities.

The Swedish industrial society started from the middle of the 19th century. The speedy urbanization and transportation revolutions, the omnibuses and railways, shaped the industrial Swedish towns and cities. The business and economy was propelled by Swedish capitalists. The capital accumulated in cities shaped two very different fringes or cityscapes of the industrial city that began to stratify and suburbanize on the end of the 19th century. Two different ways of urbanization emerged that reflect the praxis of Swedish planning. The

49 Johan Rådberg (1988) refers to the traditional city as pre-industrial (förindustriell stad).
50 Magnus Eriksson’s “Stadslag” or “City’s legislation” already in the 14th century regulated the size of buildings and neighborly conflicts in cities.
51 For solutions the Swedish looked at Italian, French and Dutch cities and experiences. The urban plans in the 17th century depicted ideal cities with rectangular grid of streets and blocks like the plan for Gothenburg or exceptionally the star-shaped city with radial streets like the plan for Hamina, now in Finland, that was inspired by Palmanova in Italy. The street in the traditional Swedish towns and cities was designed for walking and small volumes of traffic of carts and carriages. The main streets were 10-12m wide like Stora ngatan in Stockholm or Västra hamngatan in Gothenburg, whereas the side streets were narrower, but slightly larger than in the earlier wooden or stone cities.
52 The urban blocks along Stora ngatan in Gamlastan in Stockholm are example of 17th century stone city as well as the urban cores of Gothenburg and Norrkoping.
53 New industrial cities as Norrkoping and a fringe of factories and industrial zones in Stockholm emerged already in the 17th century when Dutch capital entered Swedish iron mining and industry. But the industrial society started much later and in context of accumulation of capital by Swedish industrialists, bankers and entrepreneurs.
54 Sweden was divided in 1868 on städer or cities, köpingar or market towns and landskommuner or rural municipalities. The Swedish cities were obliged to draw urban plans and set urban regulation by the “Building act” or “Byggnadstadsaga” from 1874, whereas the development in rural municipalities was not regulated by urban plans. The urban planning and design of the

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industrial core regularized, became incredibly dense and interconnected by a network of wide boulevards and streets, omnibus lines and tramways, whereas new neighborhoods with villas and garden cities or villastäder and trädgårdstäder emerged in the Swedish landscapes, very much influenced by the American and English railway suburbs. The traditional urban core was surrounded and intersected by a fringe or residences, universities, schools, factories, warehouses and ports. The manufacturing, research and invention took place in a filthy, polluted and congested industrial core. The second cityscape depicted villas in nature. The richer moved to new garden suburbs which were connected to its industrial core by roads or railways, private coaches or public trains.

The industrial city was unpredictable and explosive and troubled by class conflict in Marxist sense, between capitalists and proletarians. The solution in Sweden was the welfare state, driven by capitalism, but highly taxed and controlled by politicians from the left that formed national government in 1932 and dominated the politics of the mid 20th century. The left politicians got a power and capital to invest in social welfare and expand the influence of bureaucracy into the “public sphere” (Habermas, 1989). The Swedish public sector established a “system of automobility” in the spirit of Fordism. The private car propelled the Swedish modern society. It became a privilege of the working class and a driver for innovation, industrial development and growth. The new taxes from the industry were invested by the public sector in new suburbs with high standard of living and that triggered a demand for new cars. The working class in the modern society emerged as wealthy suburbanites copying the lifestyle of the industrial rich.

industrial urban cores was largely influenced by the renovation of Paris by Baron Haussmann in the mid 19th century. The industrial urban cores are characterized by patterns of enclosed urban blocks regulated by standardized building heights and widths of boulevards and streets. The main streets and boulevards were 18-30m wide, for example Odengatan and Karlavägen in Stockholm, compared to 10-12m wide Stora nygatan in Stockholm or Västra hamngatan in Gothenburg. Johan Rådberg (1988) drawing inspiration from Françoise Choay (1967) conceived these two urbanization trends as separate paradigms or doctrines: regulation or regularism and garden cities or trädgårdsstäder. Another interpretation of the two urbanization patterns is urban adjustment to two public transportation technologies that dominated and coexisted in that time: buses and trains.

55 Volvo and Saab became icons of the Swedish modern society. The stereotypical Swedish dream of prosperity in the modern age includes a house in nature with a Volvo or Saab on the driveway. This modern dream was shaken, but did not vanished, by the rise of global environmental concerns in the 1970s and sustainable development in 1980s. Ads about new houses in nature are regularly displayed for example in the Stockholm Tunnelbanan.

56 The alienated wealthy suburbanite rushing to work became a stereotype of a modern human. Henry Ford had a dream to put the world on wheels by making cheap cars available
The vision of the Swedish modern city was propelled and executed by proponents of modernism in architecture that entered the public sphere in the 1930s and 1940s. Sven Markelius (1945; 1956) argued for “concentrated decentralization” in the Stockholm region along radial railways and development of hierarchy of suburbs as satellites (C of the ABC) and planets (A and B of the ABC) linked to the modernized industrial urban core. Vällingby, a suburb of Stockholm was a prototype of the Swedish ABC city in the 1950s. Vällingby city was one of the new urban cores of the modern fringe. Sweden in the same time experienced strong industrial growth that was caused and relied on rapid motorization. It became the most motorized European state in the 1950s. The congestion on streets and rising death tolls increased dare concerns. The Swedish looked at UK and USA to solve the motor city problem by leaving the city” (Flink, 1975, pp.39).

57 The book “Culture of cities” by Lewis Mumford was translated into Swedish in 1942 and became one of the inspirations for the Swedish concept neighborhood principles or grannskapsprincipen (Nyström & Lundström, 2006). Mumford drew experiences from the “Regional plan of New York and its environs” from 1929, the “neighborhood unit” by Clarence Perry, Patrick Geddes and British town and country planning. Swedish modernism was also highly influenced by CIAM (Congrès International d’Architecture Moderne), where famous Swedish architects like Uno Åhrén and Sven Markelius took active parts, and by the neighborhood planning from UK and USA. The neighborhood became a scale of design and development: “it size is determined by the convenient walking distance for children between the farthest house and the school or playground. Its pattern is determined by the need of isolating house and school from the noise of traffic and its danger: so main traffic arteries of any sort must never run through a neighborhood: they must exist at its boundaries, separated for both safety and amenity by a broad parkway” (Mumford, 1938, pp.472). Arsta in Stockholm was the first Swedish suburb conceived and developed by the neighborhood principle. Arsta centrum or the community center in Arsta was designed by the architect Uno Åhrén in 1943 and completed in the 1950s.

58 In the Swedish ABC city, A stands for arbete or work, B for bostad or residence and C for centrum or centre. The plan for Vällingby, a suburb of Stockholm, envisioned by Sven Markelius was conceived as the first ABC city. It was completed in 1950 and “Vällingby centrum” opened in 1954. Vällingby was a pearl of the neighborhood planning and a modernist interpretation of the railway suburbs from the 19th century. The ABC city became known as modern city or funktionalistisk stad. Rådberg (1988) described this paradigm or doctrine as functionalism or funktionalism in Swedish. The ABC suburbs turned Stockholm into a transit metropolis (Cervero, 1998) and one of the most successful regional models for TOD. Despite the high motorization in the Stockholm region of 400 cars per 1000 inhabitants the share of public transport is almost 70% during rush hours. It is a public transport metropolis model that can be executed only by buses as BRT metropolis.

59 Henry Ford had a dream to put the world on wheels by making cheap cars available to millions and faced with the congestion problem in cities he once nicely phrased the
problem (Lundin, 2008). “Traffic in towns” was an influential British report from 1963 that offered vision. It served as background to develop the SCAFT principles\(^{60}\) in Sweden. The ABC city revised by SCAFT was standardized, industrialized and replicated in almost all Swedish towns and cities at grand scale. One million dwellings were built or refurbished in Sweden during Miljonprogrammet or The Million Program in 1965-75, roughly less than quarter of all the dwellings today\(^{61}\). Many ABC cities emerged in the modern fringe around the smaller towns and cities for example as Karlstad (Figure 13; Figure 17). In the modern hierarchy of motorways and detouring roads the ABC cities were segregated from the industrial urban cores and not accessible by walking and the public buses were not competitive to the private car. The industrial urban cores were depopulated, decongested and modernized into business and office hubs\(^{62}\). In the small towns and cities the A satellites of the C planets to the industrial urban cores were scaled down to neighborhoods with detached houses. The modern Swedish towns and cities on the end of the 20\(^{\text{th}}\) century sprawled into wide suburbia, a modern fringe of scattered neighborhoods with detached houses in nature, bypassing motorways, edge cities, segregated industrial zones, shopping malls and office parks and modernized central business districts (Figure 16).

motorist’s paradigm for urban reform: “We shall solve the city problem by leaving the city” (Flink, 1975, pp.39).

\(^{60}\) SCAFT 1968 was an urban planning handbook that revolved around separation of car traffic from the neighborhoods and separation of the car traffic by different speeds according to the neighborhood principles. The urban sphere included pedestrians and neighborhoods, whereas the cars dominated in the transport sphere in the SCAFT principles. SCAFT 1968 and “Traffic in towns” did not consider public transportation. Additional book called “Bussen i stadsplanen” or “The bus in the urban plan” was published in 1969 which illustrated bus routes in the SCAFT neighborhoods.

\(^{61}\) The ABC cities and modern suburbs in Sweden are regarded as least attractive in comparison to neighborhoods from the other periods (Rådberg, 1997). If we compare ABC cities in Stockholm, there are differences in attractiveness. The ABC city prototypes in Välingby and Farsta and ABC cities that continued to develop throughout the 1990s and 2000s are more attractive than the cities that did not developed and slowly deprived during these decades, for example as Tensta or Rinkeby. The main reason is that the modern ABC cities were conceived as functionally competed finished projects that do not need adjustments or changes.

\(^{62}\) The modernization of Nedre Norrmalm in Stockholm is one example. The works lasted more than a decade and part of the industrial urban core of Stockholm was bulldozed. Karlstad experienced similar project of modernization of the urban core.
The postmodernism emerged as critique of modernization, standardization, human scale and control and it is multifaceted. Environmentalism, anarchism, collectivism and conservation stand in contrast to the modern pursuit of individuality, standards and norms, profits and consumption. The Swedish society is in a period of transition to postmodernity. Since the 1990s, the “system’ of automobility” is contributed with new global systems of communications. The cities are “extraordinary agglomerations of flows” today, not only of people on the move, but as other forms of mobility like flows of information, capital, values, norms, habits and lifestyles (Ash and Thrift, 2002, pp.42). In the postmodern city the middle class splits in subcultures: suburbanites, urbanites and suburban urbanites. The tendency is to break the modern suburbanite stereotype, but not completely apart from it. The emerging knowledge society is a mix of individual and global, innovation and retro, standard and uniqueness, consumption and environmentalism, private car and public transportation, public car and private transit.

The postmodern city of Western and Northern Europe has several fringes or development zones. The first fringe is the abandoned zones of factories, warehouses and ports of the industrial city. The second development zone is within the new urban networks. The science edge cities are embryos of the

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63 The modernity spans its roots and inspiration to the ages of enlightenment and exploration and today it extends on global scale. It revolves around rationality and universality, science, time and standards. To become modern one nation must accept to “become bureaucratized, industrialized, rationalized, urbanized and so forth”. The modernization mystifies forces of metrocentricity: ethnocentrism, chronocentrism or technocentrism, or “world culture”, future awareness and control based on scientific and technological knowledge (Luke, 1990). The era of modernity crystallized a complex of industries and institutions of the state that unlike anything before “lives in the future, rather than the past” (Giddens & Pierson, 1998, pp.94).

64 The application of a systematic ABC model and the SCAFT principles of speed, separation and mobility that characterized the Swedish modern “car society” were under a continuous postmodern critique about the human scale in a system of motorized humans, inhuman transport infrastructures and fragmented unattractive modern cityscapes (Hultgren, 1974; Söderlind, 1998; Hagson, 2004; Lundin, 2008).

65 It is difficult to separate modernism from the postmodern. In its embryo it is a critique on only certain aspects of modernity grounded on an eclectic reconnection with the historic heritage rather than progressive thinking at least in architecture and urban planning and design. The postmodern exists as a mix of neo-modernism and neo-traditionalism. There is a perpetual struggle between the modern and postmodern, progressive and traditional, large and small, standard and unique.

66 Its urban realm is worldwide, endless and interweaved with digital technology. It is brought into existence by massive globally extended sets of systems and infrastructures (Graham, 2004).
emerging knowledge society that are interconnected with the central business districts and sky cities or “aeropolises” (Urry, 2007) that are developing next to the airports. The third fringe is not anymore in the urban regions and includes zones of fields, factories, warehouses and ports far away that manufacture, transport, store and distribute goods for global consumption (Figure 17).

Today urban and regional planning is widely regarded as “art and science” (LeGates et al, 2009, pp.767), but Henri Lefebvre demystifies that by arguing that urban and regional planning is “nothing more than ‘ideology’ that claims to be either ‘art’ or ‘technology’ or ‘science’ depending on the context” (Lefebvre, 2003, pp.159). Much work in urban and regional planning has been done to escape the ideological element of power. The postmodern age triggered a paradigm shift towards planning processes, knowledge and power67. Urban and regional planning in its postmodern paradigm68 revolves around communicative and informative practices and enablement and acknowledging many kinds of information and finding consensus69 between technical and scientifically validated analyses, the experiences of the experts and stories told by the general public (Innes, 1998). The role of the Swedish urban and regional planner has changed. It evolved from author of plans to manager of planning processes and communicator (Cars and Engström, 1997; Cars, 2001).

Many methods, policies and approaches today are mixed and hybridized: negotiations, systems analyses, drawing plans. The Swedish economy and urbanization is propelled by large businesses supported by the public sector, local or the national government, politicians and bureaucrats. The urban and regional planning depends much on the traditions in the municipality and

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67 “Plan- och bygglag (1987:10)” or “Planning and building act 1987” replaced the “Building act” or “Byggnadslag” from 1947 and put a stronger priority on process and communication with the general public. The “Planning and building act 1987” introduced public participation or samråd as part of a planning process.

68 Postmodernism developed firstly in architecture as critique to the uniformity and repetitiveness in modernism and international style in architecture. “Complexity and contradiction in architecture” by Robert Venturi is the first book of postmodern critique, while Jean-François Lyotard introduced the term postmodern in the end of 1970s.

69 The negotiations for consensus do not always result into participatory planning and giving the right to the city to the general public. Harvey (2009, pp. 310) sees the urban and regional planning today as partly reflecting the prevailing ideology of the ruling groups and institutions in society and as partly fashioned by the dynamics of market forces and capitalism.
regions in Sweden. It varies between Sweden and other region and within Sweden\textsuperscript{70} (Table 6).

Table 6: Degree of influence on urban and regional planning between USA, UK and Sweden (modified and adapted from Williams, 1971).

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>UK</th>
<th>Sweden</th>
<th>Region of Skåne</th>
<th>Region of Gothenburg</th>
<th>Region of Stockholm</th>
</tr>
</thead>
<tbody>
<tr>
<td>National government</td>
<td>Moderate</td>
<td>Very powerful</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
</tr>
<tr>
<td>Regional government</td>
<td>Weak</td>
<td>Weak</td>
<td>Weak</td>
<td>Weak</td>
<td>Weak</td>
<td>Strong</td>
</tr>
<tr>
<td>Municipal government</td>
<td>Weak</td>
<td>Strong</td>
<td>Very powerful</td>
<td>Very powerful</td>
<td>Very powerful</td>
<td>Very powerful</td>
</tr>
<tr>
<td>Community groups</td>
<td>Very powerful</td>
<td>Strong</td>
<td>Very powerful</td>
<td>Very powerful</td>
<td>Very powerful</td>
<td>Very powerful</td>
</tr>
<tr>
<td>Construction companies</td>
<td>Strong</td>
<td>Strong</td>
<td>Very powerful</td>
<td>Strong</td>
<td>Very powerful</td>
<td>Strong</td>
</tr>
<tr>
<td>Car manufacturers</td>
<td>Strong</td>
<td>Strong</td>
<td>Very powerful</td>
<td>Strong</td>
<td>Very powerful</td>
<td>Strong</td>
</tr>
<tr>
<td>Oil companies</td>
<td>Strong</td>
<td>Weak</td>
<td>Weak</td>
<td>Weak</td>
<td>Weak</td>
<td>Weak</td>
</tr>
<tr>
<td>Banking companies</td>
<td>Very powerful</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Very powerful</td>
</tr>
<tr>
<td>IT companies</td>
<td>Very powerful</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Very powerful</td>
</tr>
</tbody>
</table>

2.4.2 Policies in today’s Swedish urban and regional planning

The Swedish urban and regional planning is shaped by postmodern policies and visions like the advocacy for the compact city\textsuperscript{71} that are popular and widespread

\textsuperscript{70} The local governments in some regions like the region of Skåne closely cooperate to coordinate the urban and regional development. Stockholm’s county has a long tradition for regional planning and influential regional planning authority. The urbanization depends also on degrees of influence of other factions, like the power of local businesses and industries to affect the decisions in the Swedish municipalities. Region of Stockholm specializes in construction, banking and information technology (IT), Skåne in construction, IT and agriculture, whereas region of Gothenburg in car industry and IT. Stockholm is a polycentric city with clearly defined urban core as banking centre of Sweden and Scandinavia and satellite cities as a result of the regional variations and political struggles. Skåne is polycentric agglomeration of small and medium sized cities and towns with strong urban borders interconnected by railways, whereas Gothenburg has fuzzy urban borders and sprawled widely along a network of motorways. The differences in urbanization between the three large Swedish cities and their regions and their tastes towards specific transport modes were suggested and inspired by Anders Hagson.
in many Swedish municipalities from the end of the 1990s. Hammarby Sjöstad was a prototype of compact city neighborhood and many “Sjöstads” are currently under development in other towns and cities too. In Swedish context the compact city is a concept at urban scale actuated through policies of urban densification and mixing of urban functions. These policies in UK are known as urban intensification. The intensification is seen as changes in form and activity (Jenks & Gerhard, 2000) and defined as increased use of the buildings, changes of urban function which leads to increase in urban activity, increases in the number of people living in, working in or traveling through an urban area (Williams et al., 1996).

The densification emerged as policy in Sweden the 1980s. Hammarbyhöjden in Stockholm is a suburb that experienced increase of urban density by adding buildings that were designed specially no to destroy the character of the neighborhood. It was regarded as a success by the inhabitants. The densification was discussed and accepted in the comprehensive plan for Stockholm 1999. It adopted the compact city motto “Build the city inward!” or “Bygg staden inåt!” The knowledge about urban density of the prominent Swedish scholars from different traditions of looking at urban form was compiled in the report

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71 The compact city concept is a vision at urban and regional scale and it inspired very much by the Dutch experiences with centralized decentralization which also exists traditionally as urbanization trend for example in Stockholm or Skane regions. At regional scale the compact city vision is as polycentric development of urban cores in one region, urban boundaries, densification and mixing with Randstad in Netherlands as a prototype. At urban scale it revolves around development within urban boundaries and delimiting urban extension out of the development zones.

72 “How dense should we build?” is a question that dominates in Swedish urban and regional planning in least a hundred years (Rådberg, 1988, pp.5). The discussions throughout the century were focused on issues like quality of life and at looking for optimal densities to avoid overcrowding. The debate and policy changed from optimal urban density to densification and more dense urban areas. The definition of urban, city or stad in Swedish was exchanged with dense or tät and density täthet in the 1970s and densification or förätning since is synonymous to urbanizing or urbanization. The urban density in Sweden is seen as density of buildings or the urban form (bebyggelsetäthet) or as population density (befolkningstäthet). In Sweden the number of working places or employees is also considered as daily population (dagbefolkningen).

73 The “dense and mixed city” or “tät och blandad stad” since the end of the 1990s is the most popular vision and goal in the comprehensive plans in all the large cities and many small towns and citie.

74 The densification potential is considered though four aspects: need, freedom, pressure and empty space. The processes were conceived though four scenarios of densification: 1) complete when new buildings are added in regard to the existing neighborhood type; 3) rise when the heights of buildings are increased by 50%; 3) refurbish when new buildings with
“Denser Stockholm” or “Tätare Stockholm” (SLL, 2009). The tendency with densification until recently was to preserve the urban structure of the neighborhood types in Stockholm region and complete the modern centralized decentralization vision described as Swedish experience with TOD (Paper 4). The densification actuated through infill development of new buildings around the Tunnelbana or Pendeltåg stations that will not disturb the character of the existing neighborhoods. Hammarby Sjöstad was an exception from this policy, an experiment and part of the postmodern fridge of the abandoned industrial fringe (Figure 16) along the Tvärbana, the LRT orbiting the city.

The mixing of urban functions in Sweden refers to integration of different urban functions in order to achieve diversity of multiple urban activities and services within one urban area. Mixing urban functions comes from architecture and originates from conceptualization of the modern city and it is deeply rooted in modernism of architecture and urban design. Le Corbusier in the 1920s conceived and envisioned a city of tomorrow functionally separated by work, repose and sleep (Le Corbusier, 1929/1987). Peter Calthorpe in a same direction suggests percentages for different mixtures in the TOD guidelines. He argues for functional mixtures of public spaces and commercial and residential zones (Calthorpe, 1993). There is no recipe for perfect mix of urban functions or land uses. The concept of limiting urban diversity to one urban area contrasts the exploration aspect of the modern human. Urban diversity is achieved by physical mobility and not only by variety, but excess of urban functions, activities and areas. The urban areas have to continuously transform to satisfy the curiosity and search for novel and original experiences of the increased heights by 50% are added; and 4) transform when 10-20% of the buildings are bulldozed and new buildings with increased heights by 50% are added (SLL, 2009).

Urban function is synonymous to land use in geography and economics. The original sociological definition of urban diversity by Louis Wirth emphasizes heterogeneity of individuals in the city together with density and number, or size of the city (Wirth, 1938). Diversity can be measured mathematically by various indices: entropy, dissimilarity and interaction. Ludwig Boltzmann developed an expression for the probability of finding a given distribution of the particles in a considered system in the late 1800’s. The entropy index often called “Shannon index” and its maximum is achieved when all subpopulations are equally present. The dissimilarity index is used to measure segregation. It is interpreted as a percentage of a group that would have to change residences to achieve an even distribution. The interaction index is known as “Simpson index”. This index describes the probability that two members of the population at random will be of different subpopulations (White, 1986). For example the $D$ variable in Robert Cervero’s 3Ds for urban diversity shows the entropy of different land uses.

The concept of excess is human and biological in context of modernity is discussed by Jürgen Habermas review of Georges Bataille (1987)
modern eye. The real need of diverse urban life is possible by physical networking with other urban areas. In modern society this is achieved by private car and individual mobility. The new trend is to make multimodal connections. In TOD-BRT context networking places it is a goal for designing BRT metropolis. But urban diversity and networking places must be understood broadly in a context of network capital and postmodern society where there are possibilities for virtual mobility and telecommuting.

The concept of urban density is criticized from two standpoints in urban and regional planning, as concept and as policy of densification. Urban density is ambiguous and vague concept, especially at urban scale, and often causes difficulties since the population or the buildings are often unevenly distributed in one urban area (Rådberg, 1988; Westford, 2004; Batty, 2009). It can change significantly if streets, squares, parks and other green areas are included or not included. It lacks precision in respect to urban form (Berghauser Pont & Haupt, 2007) and it must be supplemented with other coefficients (Åhrén, 1928, Rådberg, 1988). Urban densification is a policy that is widely criticized especially by British and American scholars. The critique is based on a research of 12 urban areas in UK that were intensified in the 1980s, in a same period when the densification project of Hammarbyhöjden happened in Stockholm. The results in UK showed that intensification do not always contribute to improvements. The conditions after intensification worsened in 7 of the 12 cases in UK (Jenks & Gerhard, 2000). Other argument is that the attachment to the car is too strong and that causes congestions. The costs of congestion by urban density decrease the benefits (Melia et al., 2011). The last line of critique is that people love to live in houses in suburbs (Gordon & Richardson, 2000). Many European scholars and researches disagree and their empirical research shows that people travel shorter distances in more dense areas and the car use is lower (Susilo & Stead, 2009; Naess, 1995: 2006).

The urban densification over an 8 year period in Hammarby Sjöstad shows that there is an increase as number of passengers boarding, but also that there are variations in each of the three areas. More residents generate mor passengers,

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78 The mixing of urban areas is by default wrong. If we look at one urban area in Sweden with a small shopping centre with H&M, Ica, Coop and Thai restaurant. It is a mixed area only for individuals that like Thai food and shopping in Ica, Coop and H&M.

79 The effects of implementing the strategic goals of the compact city are often problematic. There are cases where cities have benefited from intensification, especially where new development has upgraded an area. However, there are also cities, or parts of cities which are perceived as over-developed or overcrowded by their residents, where valuable open space has been lost and traffic is congested (Williams et al., 1996, pp. 93).
but the number of passengers boarding per inhabitant and work place changed differently. It Luma and varied only slightly in the other two areas (Table 3).

2.4.3 **Urban densification or transformation through typology of urban forms**

The urban density and diversity are crucial for high frequencies of public transportation. Urban density cannot stand alone as a policy of densification, especially in unattractive areas. Intensifying urban areas with attractive character lowers the risk of failure as it was case in Hammarbyhöjden in Stockholm\(^80\). Infill of new buildings in unattractive neighborhoods increases the risk of worsening. The new fashion in the urban and regional planning in Stockholm is to consider the typological unattractiveness and to solve it by urban transformation as change of urban form and character of the unattractive neighborhoods (Svensson, 2012).

Including the character of urban areas is important for densification. The neighborhood type is characterized by recognizable character and subsequently exists as social stereotype. The general public is familiar with social stereotypes. The traditional Swedish typology (Paper 5; Table 7) that can be revised and modified to better describe the interrelationship between urban form and public transportation by targeting historical integration of public transportation, daily urban activities, and in the end social groups which prefer and are loyal to public transportation. Besides urban density and urban form as neighborhood type, it is important to consider the process of integration of transport modes in different neighborhoods typologically and historically and their position in the Swedish urbanization\(^81\).

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\(^80\) Hammarbyhöjden is an early modern suburb with recognizable character. It is very attractive to a hipster subculture of young people in Stockholm that look for apartment in similar areas in the south of the city. This social group had acquired a taste for retro and the early modern suburbs are best examples of retro modern architecture.

\(^81\) This argument is supported by looking at the results from the urban core of the city of Karlstad which is dense and developed during the industrialization as city for walking. During the modernization it became a business hub of the urban region and it was not developed for public transportation, but for private car and commute from within the urban region. University of Karlstad on the other hand was strategically placed far from the urban core to walk, but within an optimal direct bus journey to the urban core of 10-15 minutes. The newer neighborhoods with apartment blocks in the area were also part of this development. The number of passengers generated is better explained by self-selection and number of students that inhabit these urban areas. They have a student character and everydayness that are loyal to public transportation. The new hypothesis is that historical development and integration of transport modes in neighborhoods plays important role if we consider the generation of passengers by number of inhabitants and work places.
Table 7: Neighborhood typology in regard to urban form, orientation to transport modes and daily activity. The categorization is partial and inspired by urban fringes in the British school of urban morphology (Whitehand, 2001). In Karlstad there are neighborhoods from different periods of urban expansion located in rings around the historical urban core (Figure 15).

<table>
<thead>
<tr>
<th>Neighborhood type</th>
<th>Building type</th>
<th>Transport mode</th>
<th>Daily activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban by Trästad</td>
<td>Detached buildings</td>
<td>Private transport</td>
<td>Non work hours</td>
</tr>
<tr>
<td>Kringbyggestaden</td>
<td>Quadrangles</td>
<td>Walking</td>
<td>Perpetual</td>
</tr>
<tr>
<td>smästadskvarter</td>
<td>Enclosed blocks</td>
<td>Walking</td>
<td>Perpetual</td>
</tr>
<tr>
<td>Kringbygged (sten)</td>
<td>Enclosed blocks</td>
<td>Walking</td>
<td>Perpetual</td>
</tr>
<tr>
<td>Kringbygged (sten)</td>
<td>Enclosed blocks</td>
<td>Walking</td>
<td>Perpetual</td>
</tr>
<tr>
<td>Kringbygged (sten)</td>
<td>Enclosed blocks</td>
<td>Public transport</td>
<td>Perpetual</td>
</tr>
<tr>
<td>Trädgårdsstad</td>
<td>Detached buildings</td>
<td>Public transport</td>
<td>Perpetual</td>
</tr>
<tr>
<td>Villastad</td>
<td>Detached buildings</td>
<td>Public transport</td>
<td>Non work hours</td>
</tr>
<tr>
<td>Tidigare lamellhus- eller punkthusområde</td>
<td>Detached buildings</td>
<td>Public transport</td>
<td>Non work hours</td>
</tr>
<tr>
<td>Funktionalistisk stad</td>
<td>Mix</td>
<td>Private transport</td>
<td>Perpetual</td>
</tr>
<tr>
<td>Centrum</td>
<td>Complexes</td>
<td>Private transport</td>
<td>Work hours</td>
</tr>
<tr>
<td>Kontorkomplex</td>
<td>Complexes</td>
<td>Private transport</td>
<td>Work hours</td>
</tr>
<tr>
<td>Industriområde</td>
<td>Complexes</td>
<td>Private transport</td>
<td>Work hours</td>
</tr>
<tr>
<td>Handelsområde</td>
<td>Complexes</td>
<td>Private transport</td>
<td>Work hours</td>
</tr>
<tr>
<td>Institutionsområde</td>
<td>Complexes</td>
<td>Private transport</td>
<td>Work hours</td>
</tr>
<tr>
<td>Idrotts-, kultur- eller rekreasionsområde</td>
<td>Complexes</td>
<td>Private transport</td>
<td>Events</td>
</tr>
<tr>
<td>Bostadskomplex</td>
<td>Complexes</td>
<td>Private transport</td>
<td>Non work hours</td>
</tr>
<tr>
<td>Radhus- eller kedjhusområde</td>
<td>Buildings in rows</td>
<td>Private transport</td>
<td>Non work hours</td>
</tr>
<tr>
<td>Småhusområde</td>
<td>Detached buildings</td>
<td>Private transport</td>
<td>Non work hours</td>
</tr>
<tr>
<td>Fritidshusområde</td>
<td>Detached buildings</td>
<td>Private transport</td>
<td>Non work hours</td>
</tr>
<tr>
<td>Senare lamellhus- eller punkthusområde</td>
<td>Detached buildings</td>
<td>Private transport</td>
<td>Non work hours</td>
</tr>
<tr>
<td>Kvasi-smästadskvarter (sten)</td>
<td>Quasi enclosed blocks</td>
<td>Multimodal</td>
<td>Perpetual</td>
</tr>
<tr>
<td>Kvasi-storstadskvarter (sten)</td>
<td>Quasi enclosed blocks</td>
<td>Multimodal</td>
<td>Perpetual</td>
</tr>
<tr>
<td>Nyare lamellhus- eller punkthusområde</td>
<td>Detached buildings</td>
<td>Multimodal</td>
<td>Non work hours</td>
</tr>
</tbody>
</table>

Urban transformation is a recurrent process of change at urban scale from one urban form to another. The urban transformation is morphologically defined as change from one neighborhood type to another. The urban transformation actions or processes are morphologically typological operators defined as “process typologies” or “typological processes” (Kropf, 2001). Urban transformation from one neighborhood type to another is simultaneously predictive to changes in urban density. I made a table to describe the different
scale of urban development and transformation through morphological and functional actions. The development or transformation actions and their scales are displayed on figure 8 where X designates usual and (X) possible actions. Similar table with transformation from one urban form or neighbourhood type to another can be made too (Table 8). In Sweden the neighbourhood was and still is the common or dominant scale of development and the usual actions include new development and redevelopments like *demolish the old and develop new, infill or adjust new development and occasionally superpose new over the old*. The pattern of *new developments* and continuously extending outward is ongoing even today on the modern periphery of Stockholm despite the compact city policies.

*Table 8: Morphological and functional transformations and their scales*

<table>
<thead>
<tr>
<th>Morphological actions</th>
<th>Building/real property</th>
<th>Block</th>
<th>District/neighbourhood</th>
<th>City</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preserve (do not develop)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>(X)</td>
</tr>
<tr>
<td>Renovate (keep the old)</td>
<td>X</td>
<td>(X)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renovate (change the old without transformation)</td>
<td>X</td>
<td>(X)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformation (change into new form)</td>
<td>X</td>
<td>(X)</td>
<td>X</td>
<td>(X)</td>
</tr>
<tr>
<td>Redevelopment (infill or adjust new development)</td>
<td>(X)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Redevelopment (vertically extend)</td>
<td>X</td>
<td>X</td>
<td>(X)</td>
<td>(X)</td>
</tr>
<tr>
<td>Redevelopment (superpose new over the old)</td>
<td>(X)</td>
<td>(X)</td>
<td>(X)</td>
<td>(X)</td>
</tr>
<tr>
<td>Redevelopment (demolish the old and develop new)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>New development</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Functional changes</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Preserve (do not develop)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Change function</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>(X)</td>
</tr>
<tr>
<td>Add new functions</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### 2.4.4 BRT metropolis through TOD as a policy for networking places, placemaking and urban transformation

The integration of BRT and cities demands a broader view in the economy and society and historical urbanization. Sweden is entering a *knowledge society* with high environmental profile and it is a global centre of the communication and information technology (IT) industry and inventions. To better understand the TOD policies of networking places and placemaking it is crucial to

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82 The IT industry is a major developer of creative cities in Sweden like Science City in Kista, Stockholm or Science Park in Lindholmen, Gothenburg. These creative cities demand *urban networks*. 

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understand and apply the concept of network capital. The network capital of a neighborhood in a BRT metropolis increases if there are: 1) public spaces of joint interest, foci in urban regions in the BRT stations or corridors; 2) BRT nodes or corridors are interconnected by transportation and communication technologies to allow continuous movement along and adjustments in schedules; 3) BRT stations or corridors rich with urban activities; 4) that allow social or business contacts; and 5) are coordinated temporally (rephrased from Urry, 2007).

The process of introduction of busways and BRT in the Swedish municipalities and regions is major undertaking that includes initiatives, negotiations and productions of comprehensive plans and detail plans. There is not much space for BRT in the Swedish towns and cities today if we consider the developer perspective (Paper 6). The success depends much on the entrepreneurship and negotiation ability of the public transportation authorities and the local government to attract developers that support BRT-TOD.

The “four step model” recommended by Trafikverket is applicable in the analyses of the neighborhoods, their attractively and potential for development and transformation: 84

1. Brainstorm: Which transport mode is dominant in the neighborhood? Can BRT help to improve the situation? What are the other options?
2. Adjust: Can BRT use the existing infrastructure? Is it possible to add new urban activities without making changes in the neighborhoods? How would they contribute in integrating BRT in the neighborhoods?
3. Modification: Is it possible to change the existing streets or roads in order to introduce busways in the existing neighborhoods? Is it possible to infill new development or bus infrastructures that will contribute to better integrating BRT in the neighborhoods?
4. Build new: Where to build new busways and neighborhoods? How to integrate the new neighborhoods in the city?

Networking places, placemaking and urban transformation are three TOD policies that can help introduce BRT in the Swedish towns and cities. They are

83 The network capital is sociological concept by John Urry (2007) that is analogous to discussions about the emerging Swedish knowledge society of urban networks (Cars & Engström, 2008).

84 The idea to apply the “four step model” by Trafikverket in urban and regional planning processes was inspired by Amy Rader Olsson. She argued that the “four step model” is equally applicable in urban and regional planning.
policies towards the BRT metropolis. These policies must overlay. It should start with strategic visions of urban networks in regions and end with details. Each neighborhood and each BRT line in the BRT metropolis must be analyzed in detail following expansion from urban density and urban function to urban form and neighborhood type. These policies can be summarized as:

1. Envisioning and drawing few BRT lines as BRT metropolis with busways that networks urban nuclei or corridors with regional importance. In Swedish context probably the surrounding municipalities should develop joint public transportation strategy in their comprehensive plans. BRT metropolis links to other cities, high speed railway stations and airports.
2. Focusing on each BRT line specifically and the neighborhoods along that should achieve temporal completeness. This interrelationship should be discussed and visible in the comprehensive plans. Working with placemaking at urban scale and mapping the neighborhoods as districts long busways and bus stations as paths and nodes that unfold desirability cores. The desirability patterns have to be considered before the detailed plan is enacted. The placemaking includes softer TOD policies of citizen initiatives and events to intensify the BRT nuclei or corridors.
3. Targeting unattractive neighborhoods along the BRT network and negotiating hard TOD policy as transformation of the districts and desirability cores in desirable neighborhoods.
4. Adding complementary public transportation services that are slow and fed the primary network. This should include bus corridors on streets.

2.5 What are the obstacles and opportunities to introduce BRT in the Swedish towns and cities

2.5.1 What are the obstacles to introduce BRT in the Sweden

In Sweden new BRT lines were proposed in Karlstad, Stockholm and Malmo and there are a completed busway sections in Gothenburg and Lund. The actors and proponents behind the BRT initiatives are public transportation authorities, the Swedish bus and coach federation (Svenska bussbranschens riksförbund) and Trivector, a Swedish company from the city of Lund that advocates more sustainable mobility. But, many BRT initiatives and negotiations in Sweden fail or are very slow. The problems that hinder or slow down the BRT initiatives are the buses and busways. The introduction and integration of busways in the European urban cores is also very problematic. For example the negotiations about a new BRT in Stockholm stopped because there were difficulties to introduce busways. The initiative for a new BRT line in Karlstad is going very
slow and one of the reasons is that there is no bus, a sophisticated vehicle to inspire and hasten the debate.

2.5.2 **BRT as future systems of automated super buses**

BRT is recognized as a future public transportation system with sophisticated super buses, but the “super buses” in reality are often the plain old buses that operate on busways that are not attractive especially if they are completely segregated from other traffic. BRT lacks visions about sophisticated future bus in the knowledge society. The postmodern age revolves around automation of repetitive jobs, communications and knowledge. The bus driver is a concept that does not fit in the postmodern future. The role in the system is too boring and uncreative for a postmodern human. Instead there is a need for another role from the industrial: a bus conductor as a communicator with a wide knowledge not only of the bus system, but also with the stations, neighborhoods and urban activities along the stations. The postmodern humans do not need a driver, but someone to communicate with. The future bus debates must consider the automation aspect\(^\text{85}\) and emergence of future roles in the bus system\(^\text{86}\).

2.5.3 **Standard bus in today’s “system’ of automobility”, future “omnimobile” in the knowledge society**

Very few politicians, bureaucrats or urban and regional planners can escape from the poor status and public image of the bus. The image of “metal can of human sardines” brings uneasiness to many. It is difficult to justify and investment and defend it in front of the general public with the sophistication of the buses today. Information, extra space and comfort are highly valued in the emerging postmodern European towns and cities today. The buses must

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\(^{85}\) The “Transit expressway” by Westinghouse from the 1960s for example had automated redesigned buses on guideways that look like mini-metros. The automation of the bus never realized even though the “Transit expressway” had a miniaturized realization as “Private rapid transit” in Morgantown, USA and automated mini-metro systems. The new mini-metro line in Copenhagen for example is a variant of the “Transit expressway” technology. The automation was redefined in the “O-bahn” concept by Mercedes-Benz from the 1980s by introducing standard buses on a guideway track. The drivers took control over the wheel when they are on streets or stations, while the guide wheels control the direction of the bus on the busways.

\(^{86}\) During the industrialization the bus emerged as a system of bus driver and conductor because the low wages allowed that. The welfare state in Northern and Western Europe guaranteed universal high salaries in the modern society. The modern driver took the role of the conductor to cut the costs of operation. The envisioned future buses and busways in the modern age went further in deleting the driver from the bus system.
decongest\textsuperscript{87} and their interiors must be redesigned to fit these trends. The image of crowded bus keeps the low status of the bus and evokes strong memories. If we compare the car with the bus, the car costs finite resources and it is a cause for environmental degradation and climate change, but also plays three major roles in the modern society: 1) a machine of speed\textsuperscript{88}; 2) an instrument for socializing and driver of social life\textsuperscript{89}; and 3) a driver of the economy and welfare.\textsuperscript{90} (Urry, 2004) Where is the bus in this story? Which role of the car can it take?

Much can be learned about the bus from the history. The bus industry emerged in the 1920s and competed and flirted both with the railway and car industry until the 1960s when the demand for buses dropped. Since then the bus industry exists as part of a bruck industry\textsuperscript{91}. The “bruck” is a term for a hybrid of bus and truck\textsuperscript{92} crafted in the journal “Bus transportation”. An important factor in the revival of bus is to stop the competition and make peace with the car industry to which the bruck industry is entangled. Sooner or later the world

\textsuperscript{87} The industrial urban cores decongested and modernized during the 20\textsuperscript{th} century, but the industrial buses did not. The crowded bus exists as social place in its minimal austerity and claustrophobia. It is a metal can of human sardines in collective crunch. The crowded bus is probably the densest public space, a parallel and reflection of the 19\textsuperscript{th} century industrializing city. It is incredibly urban symbol of conjoint tolerance and fury, a true barrel of powder. If the car is a “metal cage of modernity” (Urry, 2004), the bus is modernity’s “boxed mob” that is about to explode.

\textsuperscript{88} An image that inspires invention, adventure and progress set by Karl Benz. It captivates and thrills. The speed record for example is perpetual challenge for inventors and entrepreneurs.

\textsuperscript{89} It has a social use, as John Urry argues firstly discovered by Bertha Benz when she visited her parents at a long distance. Bertha Ben was the advocate of the car not as machine for speed, but as instrument for socializing.

\textsuperscript{90} Henry Ford saw the car as driver of the economy and welfare. It mobilizes workforce and resources. It produces value. It contributes to common wealth and prosperity. It networks businesses and shapes cities.

\textsuperscript{91} Not much attention has been done on the design and sophistication of the buses. The main reason is the non profitability of the public transportation in the modern society that revolves around time and temporal convergence of spaces. The buses throughout the 20\textsuperscript{th} century were procured by public transportation authorities and companies that wanted to minimize costs for public transportation. The cheaper or “thriftier” the buses were it was more probable to win on the tenders. The lack of demand and developments of bus in a direction to decrease operation costs and improve the efficiency of the engines had damaging effect on the bus industry that literally survived as a branch of the truck industry. The buses today are replicas of “Model 40” that was also designed by Twin Coach in the 1927 that basically unchanged until today.

\textsuperscript{92} An example of “bruck” is sadly, the innovative “Super Twin”, the first articulated bus designed by Twin Coach in 1938 that found its place as truck for the USA postal service in the 1950s. Another example is through different designs of trucks hauling passenger cars.
will motorize until the market for cars saturates. The public transportation remains as new infrastructures to be constructed and industry to be developed. Many Swedish urban regions lack dedicated public networks and infrastructures. The buses operate on car infrastructures. Everyone wins if there are different infrastructures with high quality in cities. It is important even for the car industry to early see the prospect of public transportation in future development. The future development of sophisticated buses depends very much on the motor industry and changes in the “system’ of automobility”.

The omnibus evolved from a carriage with seats facing each other and it was literally a mobile comfortable lounge with lavish interior, chosen company along a route, both attractive prospect and veil on the city and the street life. It evolved in the first class saloons in the trains and car limousines. It carries the original image of the bus. The bus industry has to design a super bus and revive the omnibus as “omnimobile”, a mobile social space for the wired world: flexible luxurious mobile lounge for everyone and instantaneously available.

2.5.4 How to improve the visibility of buses and bus transportation in the Swedish urban and regional planning?

The buses are adaptive and the bus networks can easily change. It is very difficult to draw a plan with permanent bus lines that will fit the reality. The general perception among urban and regional planners even today is that there is no need to plan for the bus or draw plans with bus networks. A large

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93 I was on a conference in Salt Lake City in 2012 where Lane Beattie, the president of Salt Lake Chamber of Commerce talked about prospects of business and transport. He said that the business went worse when they invested only in car or only in public transport. The business went best if there are both investments in the private car and public transport. The TRAX system in Salt Lake City opened in 1999 and today there are 3 lines over 30 miles of light railways and the rail connection to the airport is nearly completed. Utah Transit Authority and their charming manager Michael Allegra managed to network contractors and businessmen from Salt Lake

94 The buses induced two sociabilities in the history. The omnibuses, the social carriage and the motor bus, the collective horseless carriage, shaped two very different social spaces: the former was a lavish social carriage and the latter a modified thrifty automobile (Paper 1). The social image today is fixed only on the standard bus.

95 To find creative bus design I browsed the journal “Bus transportation” from its optimistic beginnings in the 1920s until the 1950s when it ended. There are bus bodies and interiors like one-and-a-half decker buses and modified truck designs that can be used in the future design of buses. For example it is possible to design double-and-a-half decker bus for BRT, where the double decks can serve low platforms on streets, whereas the half deck can be used for high platforms on BRT station (Paper 1).

96 The bus was more an excuse for urban planners and designers not to plan public transportation. The flexible bus like the car could reach anywhere. Usually the bus stops are
obstacle in promoting BRT is the flexibility of the bus and the perception that there is no need to plan for bus. The problems is that the accessibility in strategic or comprehensive plans is simply considered by circles around public transportation stops and in the plans it is always easy to pin a bus stop along a road and declare accessibility by public transportation. The bus networks are often invisible on the comprehensive plans and detail plans and not coordinated with\textsuperscript{97}. There is a need to show not only the bus or BRT lines on comprehensive and detailed plans, but also show the zones that are most attractive for development around stations development along the four principal bus infrastructures: 1) on street; 2) on partially segregated busways; 3) on fully segregated or elevated busway; or 4) underground. BRT and buses must be conceived as part of BRT-TOD policy, where even the buses on streets produce urban corridor effect.

The modified urban elements by Kevin Lynch\textsuperscript{98} are method to improve the visibility of public transportation systems and their representation in comprehensive and detail plans. The modification is conceived in a way to make visible and overlay even the very flexible bus lines and put them aside the urban areas and land uses, plots, buildings and streets in the comprehensive and detail plans. This visibility helps to see the urban flows, urban forms and their interaction on maps. The illustrations of desirability cores, paths and nodes (Paper 2) is helpful to analyze public transportation infrastructures in relationship to the neighborhoods and to highlight zones for urban transformation and development where the TOD policies are applicable at urban scale.\textsuperscript{99}

\footnotesize{pinned to the plans afterwards. The bus even as BRT is neglected and patronized. It is a constant in the compact city model that is used repeatedly by scaling in different smaller and larger European towns and cities. The partially segregated busways are often justified as temporary stage for the future LRT.\textsuperscript{97} The BRT line in Karlstad is one exception, but the BRT line is not presented as TOD strategy for development. Even more there are development zones that are located out of the BRT line.\textsuperscript{98} Kevin Lynch’s morphology is nothing new in Sweden. It is used for example in the comprehensive plan (översiktsplan) for Malmo and it is easily applicable.\textsuperscript{99} The report “Denser Stockholm” uses a similar method of identifying neighborhoods as nodes (SLL, 2009). The distinction between nodes is not made because the neighborhoods were around typical completely separated railway stations and infrastructures. But the report does not go in details of the desirability cores neither do the TOD guidelines by Peter Calthorpe. The desirability cores are conceived to show the difference of attractiveness between the principal public transportation infrastructures in the neighborhoods.}

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2.5.5 **A variety of busways, underground, partially or fully segregated as part of a BRT-TOD policy**

The introduction and integration of busways in the European urban cores is also very problematic and the compact city solutions envision multimodal boulevards with partially segregated medians. The busways can run on different streets and there is a possibility to have combine single or double track. The busway in Eugene, Oregon, USA is a great example of integration of such busway in a median of a boulevard. The busway is literally invisible and the concrete pavement and grass between as decoration in an elongated park. The single and double track solution does not allow high frequencies and it is a solution for lighter volumes of bus traffic (Figure 17).

![Figure 17: A unique integration of the busway mixing a single and double track with a careful choice of materials and design in a median of a boulevard in Eugene, Oregon, USA and a stereotypical solution of a bus track in Douai, France.](image)

Only sophisticated vehicle and future infrastructures can have priority in a European town or city. BRT today comes up on the agenda as a part of the compact city model which is preferred and actuated by developers. There is a need to completely change the ways how BRT is communicated. The BRT
advocacy must entangle TOD into BRT-TOD with focus on automated vehicles, super buses in the future operating on busways that tend to be completely segregated.
3 Conclusions and recommendations

3.1 Which urban density is needed for BRT?

3.1.1 Which urban density is needed for BRT if the headway is 10 minutes?

Urban density is needed for many reasons. The public transport is efficient if there are many inhabitants that have same travel demand at the same time (Kottenhoff, n.d.). This means that there should be many people at one origin that want to go to same destination or many people that circulate within an urban network of destination in one region. Since it is impossible to link the entire region with many public transportation connections it is important to have concentration of urban activities or high urban density around the public transportation stations and stops.

Outgoing from the figure of 5,000 boardings per day on the BRT line in Eugene, Oregon, USA we can calculate the urban density needed for the newly proposed BRT line in Karlstad by using the regression model (Table 2) from the study. The projections for 5,000 boardings per day are 36,000 inhabitants and work places within the urban corridor.

These results must be taken with caution especially the number of working places is prone to changes. The results are based on research only in the city of Karlstad and the sample size is small. Much more research in other city must be done for better conclusions. There is also no clear linear trend in the data. Regression analysis as a prediction method for data with variations and residuals must be considered with caution. The regression model is also fixed and does not consider future changes. The research in Hammarby Sjöstad (Table 3) shows that the generation of passengers per number of inhabitants and work places changed in time in Luma and varied in the other two areas. The fixed model also dramatically increases the demand for inhabitants and work places for a typical BRT line: 20,000 boardings per day would need 144,000 or almost 300,000 inhabitants and work places in a pessimistic scenario. This is impossible to achieve by densification policies.

100 The mean and median for the walking distances to a bus stop from all the buildings in the studied 55 neighborhoods was 200 and 190 meters Euclidean and 300 and 250 meters Network distance, whereas the mean and median for maximum Euclidean distance were 500 and 500 meters and 790 and 630 meters for Network distance.
3.1.2 *Beyond urban density*

The significance of the students or study places as specific social group inspired a new perspective on the analysis. There are social groups and workplace within the sample that are loyal to public transportation. This is an argument for looking not only at urban density, but also in the character of neighborhoods and social groups that inhabit them or work there. There should be awareness about that when working with urban densities. There are also urban functions and land uses that are friendly to public transportation like certain retail and professional services or community services or neighborhood types like modern institutions as universities and high schools. A combination of BRT properties of bus service and selected urban function or neighborhood type can reach 0.6-1 passenger boarding per inhabitant and workplace. That would hypothetically make possible to generate 20,000-28,000 boarding from the 28,000 inhabitants and workplace along the

That is why neighborhood type as a concept of urban form and *self-selection* are used. The empirical evidence shows that *self-selection* is an important factor in determining mode choices in neighborhoods and preferences towards public transportation. If someone has preference to use public transportation the choice would be to move to a neighborhood with an easy walk to a public transportation station or stop. It is a matter of careful placemaking and networking places, or developing or transforming places for social groups and workplace that are loyal to public transportation.

These analyses include a system of variables in interrelationship triangle of bus service factors, bus performance as aggregated number of passengers boarding on the bus stops in the neighborhoods and neighborhood characteristics as urban density or function or type. The mechanisms, risks and empirical knowledge of the urban system and interrelationship between public transportation infrastructure and urban form ought to be communicable and results to be presented simply and critically taking every aspect. There is much uncertainty in using both urban density and typology of urban forms, because of the randomness and scattered pattern of variables. There are fields of variables instead of trendlines. It is important to simplify and illustrate information about the empirical interrelationship and results between bus infrastructures and traffic flows, urban form and development or transformation. The elements in the urban system have to be made in a way that all the discussants are able to understand their meaning in the system and results. The trends are not linear, but in a form of fields and intervals, minimums and maximums.
Neighborhood type was used to exchange urban density on scatter plots that consider the relationship between factors from the bus service and number of passengers boarding. That makes visible more than two factors on two axes (Figure 15). The neighborhood types are composite categories that intertwine urban density, arrangement of buildings, street layouts, architectural styles, urban functions or land uses. That makes possible to characterize the residuals. Without considering the neighborhood types the BRT properties of the bus transportation as higher speeds, lower travel time rations in respect to the private car or higher frequencies show that there is a trend of more passengers generated. Again the values are scattered and there are residuals that make the trendline upward. Characterizing these residuals as areas inhabited by students questions the trendline upward. It is impossible to separate if the reason for the peak is the BRT service, the students or even the optimal distance from the urban core. These neighborhoods are around the University of Karlstad and within a radius of roughly 5km. It is a 10-15 minute by bus or more than 1 hour walk through urban islands, green wedges and under a major motorway.

3.2 BRT, TOD and urban form

BRT is adaptive public transportation systems and there is no specific urban form or structure for BRT. We can discuss effect of public transportation infrastructure as public transport cities equally for bus infrastructures. The buses and trams on street have the same effect and unfold similar urban environments (Figure 15; Figure 16). BRT can shape urban corridors or urban nuclei, depending on which infrastructures the buses run: 1) on street; 2) on partially segregated busways; 3) on fully segregated or elevated busway; or 4) underground. These consistencies at urban scale are illustrated though the concept of desirability cores of public transport cities (Paper 2) and at regional scale as new postmodern fringe that exists either as urban corridors or nuclei (Paper 3). The bus infrastructure in the public transport cities vary in an interval of speeds and frequency that defined their urban reach as theoretical radius (Paper 2).

The experiences with partially separated busways and railways in Sweden show that BRT triggers development by structuring urban corridor (Paper 4), but BRT can unfold a string of urban nuclei. One rare example is the planned development along the new busway in Cambridge. The busway has unfolded both urban corridors and new urban nuclei surrounded by agricultural land. The effects of BRT, neither of LRT, cannot be separated from the urban development. BRT is part of a compact city model that includes distinctive urban
form and is replicated in Europe as trend of Swedish urbanization as postmodern fringes.

**3.3 BRT and TOD in the postmodern society**

BRT is a public transportation system that has to find its place in the Swedish postmodern society, within the new trends of urbanization and business and industry. The high network capital and global connections are very attractive for postmodern urban development. The large Swedish cities are advantaged with functioning urban networks and higher network capital recognized globally. The existing urban network in Stockholm attracts urban growth and development. The speedy regional railway and bus connections tend to annex and subordinate the surrounding smaller towns and cities. That makes the smaller towns and cities disadvantaged to the large. There is a trend of stagnation or very low population growth.

The new postmodern business and industry ideology is Post-Fordism and the functioning of many IT industries and online businesses is not directly dependent of many modern technologies like the car\(^1\). The public transportation and the IT industries are naturally completing themselves\(^2\). Driving disconnects from the global networks of information flows. Sweden is one of the leading countries in IT industry and online business, where many cannot lose an hour or two per day on driving. The question is how much BRT facilitate for the needs of the postmodern human. John Urry argues that the “public mobility” pattern of the 19\(^{th}\) century will not be re-established in the future. That pattern is irreversibly lost because of the character of the “system’ of automobility” that “produced and necessitated individual mobility based upon instantaneous time, fragmentation and coerced flexibility”. The post-car system “will substantially involve individualized movement that automobility presupposes” (Urry, 2007, pp.285).

The automated public transportation systems, the hybrids between public and private transportation and self-driving cars are postmodern solutions for

\(^1\) In its embryo the IT industry is flirting with the “system of automobility”. Google needs people that click or touch and look at the computer or smart phone screen. This is a reason to develop a driveless car. Driving deters potential customers from being online. The interest to drive and own a driving license decreases in Sweden. The percentage of driving licences in the age group from 18 to 30 years in Sweden decreased between 50% and 10% from 1984 to 2008. Similar trend is visible in the USA, but not in all Northern and Western European countries. In Finland and the Netherlands the trend is opposite (Sivak and Schoettle, 2011).

\(^2\) The trains of in the Stockholm’s Tunnelbana, the subway system, are full with passengers overwhelmingly fixed on their smart phones.
mobility that are under development. The super bus as automated machine is also an alternative and the advocacy for BRT has to be towards completely segregated busways for self-driving super buses, which can achieve higher frequencies with smaller vehicles and eliminate the cost for drivers\textsuperscript{103}. BRT has to be conceived as complete advancement of the bus transportation to inspire creative response from the Swedish knowledge society.

3.4 Where and how can be BRT-TOD implemented in Sweden?

BRT is applicable equally in the smaller towns and cities and larger cities in Sweden as structuring public transportation system. BRT can unfold urban corridors as system of partially segregated busways or open urban nuclei with intensive urban activities in the region as direct buses or buses on completely segregated busways. In the postmodern society there is a trend of deindustrialization of the industrial urban fringe. The business moves to the new global manufacturing fringe far away, but in Sweden there is also a trend to develop new industrial zones in the modern fringe within the urban regions, especially near airports or within the emerging urban networks. BRT is already entangled in the advocacy for compact city and new urban networks of the redevelopment of the abandoned industrial fringe. But BRT can also establish urban networks of nuclei or corridors in the regions that have no high frequency connections. The challenge is not only to connect and bring alive a system of buses and busways, but also to open new creative cores of the Swedish knowledge society.

An application of BRT in the smaller towns in cities is in establishment of urban corridors. Walking between the modern Swedish archipelagos of neighborhoods is equally a problem as taking public transportation in many Swedish towns and cities. TOD is a solution for walkable cityscapes and attractive public transportation journeys. The low share of public transportation is as big problem as the low share of walking in the smaller towns and cities (Figure 18). Heavily dependent on private cars and individual mobility and with specialized and scattered urban islands and modernized urban cores into business hubs and central business districts, the smaller towns and cities have to adopt urban corridor development. Using TOD and negotiating urban development and transformation with introduction of

\textsuperscript{103} When the automobile emerged as horseless carriage and mixed with the horse-drawn coach, segregation was one of the solutions to separate the slower from faster traffic. In direction of driver-less buses, the segregation is essential to enclose the system, automate the driving and control the traffic.
busways is much more attractive and challenging for the urban planners and designers than just discussing BRT.

Figure 18: Differences between walking and public transportation in a city of Karlstad and Stockholm. Stockholm is a public transport metropolis, but much attention has been done on enabling walking environments and slow public transport modes for shorter journeys too. The widespread use of monthly public transportation tickets, SL cards, allows quick decision to jump on and off buses in Stockholm. The smaller towns and cities also need to enact a walking strategy and develop some promenades or urban corridors. BRT-TOD on partially segregated busways is a transport mode that can enable that.

Another argument for discussing BRT-TOD is difficult to separate BRT from the urban development. But, for successful implementation of BRT, BRT has to find a place in the urban and regional planning and development processes and negotiations as BRT-TOD, as strategy for urban development oriented for
empowering walking and public transportation in the everyday life in the Swedish towns and cities. The success depends much on the context of the municipality and region and the entrepreneurship and negotiation ability of the public transportation authorities and the local government to attract developers. The BRT and LRT initiatives in the Swedish towns and cities were more successful if they were negotiated with developers and coordinated with urban development, especially when they were advertised as new sustainable neighborhoods. However the urban development in the smaller towns and cities like Norrköping or Linköping is much slower than the large cities like Gothenburg or Stockholm where the compact city neighborhoods are developed as long urban corridors along the light busways and light railways. In Norrköping and Linköping there is urban development and growth only around some stations.

3.5 How can TOD help?

3.5.1 What can Swedish towns and cities learn from American TOD?
The BRT and LRT lines are entangled in the compact city model preferred by many developers and there is not much variety about how the bus or tram stations are integrated with the surrounding buildings. The bus and tram stops or stations are uniform and they are sometimes surrounded by well designed, but often empty public spaces with not much urban activity around. TOD is a supportive policy in urban and regional planning that can help in better integration of BRT, the busways and bus stations or stops in the cities.

There are many compact city projects, but there are too few debates and too little reflections on the replication of the compact city model and no debate about Swedish TOD. From perspective of urban planning and design much can be learned from the American experiences with TOD and applied. The American TODs, stops and station are conceived and designed differently both contextually and architecturally. Very important contribution of American TOD is in the originality of architectural and urban design solutions around stations or along urban corridors, for example in San Diego or at least rising awareness about the need. That is not case in many European cities where the stations and the neighborhoods around are very uniform and similar. Similar approach can be used to promote BRT-TOD in other Swedish towns and cities as unique designs and attractive developments, instead of replicating typical compact city neighborhoods. There are parallels in Sweden too, as the interiors of the Tunnelbana stations, the subway in Stockholm, where each station was designed by different artist.
3.5.2  **BRT-TOD as vision of and policies for a BRT metropolis**

There is a need to completely change the ways how BRT is communicated and presented and American TOD can help to: 1) evoke more positive reactions to BRT as part of BRT-TOD; 2) increase focus on urban design and morphological, as architectural and infrastructural, integration transfer by using the TOD experiences in USA; 3) inspire discussion about placemaking and networking places that would eventually result in visions of BRT metropolises and contribute to more through more creative urban designs than the stereotypical compact city model today.

**BRT metropolis** is a set of principles at urban and regional scale that derives from the experiences with the principal public transport cities in Europe. The implementation of BRT in Swedish towns and cities includes several key steps (modified and expanded from TRB, 2003):

1. Integrating BRT with the city at regional scale by designing urban networks of busways, urban nuclei and corridors considering the competitiveness with the private car, existing urban activities and temporalities by their regional and urban importance and possible future urban development and transformation at urban scale. This TOD policy allows regional connectivity and is referred to as networking places;
2. Introducing BRT and busways through the existing cities by looking at possibilities to allow undisturbed bus traffic;
3. Integrating the city at urban scale by applying softer TOD policies as placemaking that orient the neighborhoods towards BRT and increase number of passengers without major development projects;
4. Bus operations that include improvement of frequencies, operating hours and speeds, reliability, comfort and flow of information; and
5. Integrating the city at urban scale by applying hard TOD policies as urban transformation and adjusting the neighborhoods to the bus infrastructures. The neighborhoods have to be conceived as adaptive to future changes in bus operations.

The research, conclusions and recommendations are limited only on the TOD policies. The assumption is that BRT is a high quality bus service with sophisticated buses that are comfortable and have identity in the city. The recommendations in urban and regional planning have to be considered critically since the contexts are different from municipality to municipality or region to region in Sweden.
3.5.3 **Networking places as hard TOD policy for increasing regional connectivity**

Many smaller cities can apply *public transport metropolis* thinking and develop their own rules for *BRT metropolises* with light or heavy busways. BRT achieves higher frequencies with lower capacities, whereas the trains have lower frequencies with higher capacities. Higher frequencies with lower capacities fit much better the decentralized or decentralizing cities in Sweden or Europe.

The TOD policy for networking places revolves around *regional connectivity* and connecting places in the urban regions that are important for many. The regional and urban connections add *network capital* and allow communication to the nodes on the *urban networks*. In BRT context it means connections by busways and urban corridors and nuclei. It is not only important to make *urban networks* interconnected in the urban regions, but it is also important to increase the need to travel to and between BRT corridors and nuclei.

3.5.4 **Placemaking as a soft TOD policy to involve the communities and entangle BRT in the urban life**

Placemaking offers solution for livable cityscapes and it is about involving communities in urban and regional planning processes. It is about the human scale and citizen perspective. Placemaking has worked as successful TOD policy for example in Portland (Paper 4). By living, planning and designing together the community enjoys their neighborhoods. The BRT nuclei or corridors should be places where the communities will produce urban activities and slowly integrate the buses and BRT in the urban life. In the context of *network capital* and *knowledge society* the BRT nuclei or corridors are places where the people want to travel and be. The distinctive place is a reason to travel. The creative place is a reason to travel. The place of learning is a reason to travel. The *network capital* revolves equally around connectivity as well as the reason to travel and visit places. Often there is no need to completely transform or redevelop the neighborhoods to improve their livability and urban activities.

3.5.5 **Urban transformation as a hard TOD policy to synchronize BRT and neighborhoods**

The Swedish urbanization followed a pattern of new developments and continuously extending outward (Paper 2) and there was no need for urban transformation. The new trend that emerged with the compact city revolves around development inward and transformation and redevelopments before new developments. The modern suburbs of the second half of the 20th century are regarded as very unattractive (Rådberg, 1997; 2000; Rådberg & Johannson,
it is important to transform them in more attractive types with policies for BRT-TOD.

The research shows that if we look at the neighborhood scale, the development potential along the new BRT line in Karlstad is rather limited (Paper 6). It is similar in other smaller towns and cities that are already developed and rigid to development. There is very low probability that there will be large scale renewal of the existing neighborhoods. In the developer eye there is too much complexity and uncertainty to take that risk.

It is difficult to develop typologies of urban transformation and pursue a grand scale. Urban transformation is needed at smaller scale and that opens possibility for smaller companies and businesses to specialize in urban renewal and transformation. The smaller Swedish towns and cities are vast market and as the modern suburbs become older, the demand for renewal will supersede the demand for new development. When urban development happens at small scale without adapting to existing cityscapes and mental images the neighborhoods usually escapes urban typologies. These atypical places in cities are especially respected and cherished. An example is the concept of bokaler as bostäder+lokaler (residences and shops) in Malmö. Another luxurious development at small scale as plot by plot is Borneo in Amsterdam.

3.6 What are the obstacles and opportunities to introduce BRT in the Swedish towns and cities

Many BRT initiatives and negotiations in Sweden fail or are very slow. The problems that hinder or slow down the BRT initiatives are the buses and busways. BRT is recognized as a future public transportation system with sophisticated super buses, but the “super buses” in reality are often the plain old buses that operate on busways that are not attractive especially if they are completely segregated from other traffic. The introduction and integration of busways in the European urban cores is also very problematic.

BRT lacks visions about sophisticated future bus in the knowledge society. The future bus debates must consider the automation aspect and emergence of future roles in the bus system. The standard bus in today’s “system’ of automobility” does not fit a postmodern future of knowledge society. Very few politicians, bureaucrats or urban and regional planners can escape from the poor status and public image of the bus. The image of “metal can of human sardines” brings uneasiness to many. The bus industry has to design a super bus and revive the omnibus as “omnimobile”, a mobile social space for the
wired world: flexible luxurious mobile lounge for everyone and instantaneously available.

Another hindrance is the flexibility of the bus. The buses are adaptive and the bus networks can easily change. It is very difficult to draw a plan with permanent bus lines that will fit the reality. The general perception among urban and regional planners even today is that there is no need to plan for the bus or draw plans with bus networks. The planning of bus lines comes later and it is always flexible. The modified urban elements by Kevin Lynch are a method to improve the visibility of public transportation systems and their representation in comprehensive and detail plans. The modification is conceived in a way to make visible and overlay even the very flexible bus lines and put them aside the urban areas and land uses, plots, buildings and streets in the comprehensive and detail plans. This visibility helps to see the urban flows, urban forms and their interaction on maps. The illustrations of desirability cores, paths and nodes (Paper 2) is helpful to analyze public transportation infrastructures in relationship to the neighborhoods and to highlight zones for urban transformation and development where the TOD policies are applicable at urban scale.

The introduction and integration of busways in the European urban cores is also very problematic and the compact city solutions envision multimodal boulevards with partially segregated medians. There is a need of visions with variety of busways, underground, partially or fully segregated as part of a vision for BRT-TOD. The busways can run on different streets and there is a possibility to have combine single or double track. Only sophisticated vehicle and future infrastructures can have priority in a European town or city. BRT today comes up on the agenda as a part of the compact city model which is preferred and actuated by developers. There is a need to completely change the ways how BRT is communicated. The BRT advocacy must entangle TOD into BRT-TOD with focus on automated vehicles, super buses in the future operating on busways that tend to be completely segregated.

3.7 Future research and new research hypothesis

3.7.1 The interrelationship between public transportation and urban form

It is important to further research the interrelationship between urban density and urban form of typological neighborhoods and bus infrastructures in other cities and compare them. The Swedish database of neighborhoods has to be larger. The sample of neighborhoods has to be higher to better understand
regularities and randomness. The tradition of neighborhood planning in Sweden further more strengthens this view and links it to development and transformation of neighborhoods.

Figure 19: The historical development of number of annual journeys by public transportation in the Swedish regions in regard to costs by inhabitant and urban density as number of inhabitants per kilometer. The arrow shows the yearly trend from 2003 to 2011.
It is important to put this research in process perspective of historical and future urbanization and development through a new hypothesis. It is important to increase the detail from urban density to urban form, but keep urban density as indicator and crucial variable. The differences between cities and regions have to be considered as traditions of urban and regional planning and urbanization, as well as through quantitative comparisons of statistical data. The statistics show that the densities and costs for public transportation vary in different regions. This can be a starting quantitative point to compare the network capital and urbanization tendencies in the different regions.

3.7.2 New research hypothesis

The neighborhoods are complex social and physical phenomena. They are agglomerations of individuals and buildings, but they are also complex individuals themselves with particular name, character and history (Reclus, 1905). Its physical character is socially judged and reconsidered. It is compared with other neighborhoods and its reputation varies when other neighborhoods emerge or are renewed, when new transportation technologies emerge, when architectural styles change. Some neighborhoods are outdated, while others regain popularity. The physical character of neighborhoods links them to different transport modes too. Some neighborhoods emerged or renewed in periods of flâneurs, coaches and carts, some in the motor ages of public buses, trams and trains and private cars. John Urry argues in his book *Mobilities* that different mobilities produce distinctive sociabilities.\(^\text{104}\)

The new research hypothesis about the interrelationship between public transportation and urban form is that urban form and social mobility have indirect, but profound effect on physical mobility and transportation by producing neighborhood types and social stereotypes. An urban form inhabited by a certain social group produces neighborhood type, which transforms social group in stereotype. Social stereotype is ultimately a group of individuals with similar lifestyles and socioeconomics that ends in typical neighborhood. Within cities there is social mobility that revolves around economic, social and cultural capital and people develop tastes and preferences, earn or lose money and

\(^{104}\) The people not only develop taste towards neighborhood types, but also towards transport modes. SL, the public authority in Stockholm makes a distinction between bilister or car users that never use public transport or SL (35%), växlarer or users that shift between car and public transport or SL (26%) and vardagsresenärer or everyday SL users (39%). The customer segment of everyday public transport or SL users is further divided on hänvisade or persons that do not have other transport option (16%) and loyal public transport or SL users (12%) that own car, but prefer SL (SL, 2011). Another study clustered persistent car users, (33%) frequent car users (45%), constrained public transport users (11%) and consistent green travellers (9%) (Prillwitz och Barr, 2011).
adopt, change or shape lifestyles and cultures. This social mobility creates and recreates patterns of neighborhood types and social stereotypes. Social group is considered within the conceptualization by Pierre Bourdieu (1979/1984; 1994/1997; 2005/2012) where taste is determining the distinction between groups. Social group is an agglomeration of individuals with distinct tastes, preferences, attitudes and lifestyles.

![Figure 20: Habitation and mobility system. The illustration shows the emergence of neighborhood type through social mobility. As one social group inhabits one urban form it turns into social stereotype and neighborhood type. The habitation and mobility system is a social mechanism that is conceived as research agenda.](image)

The interrelationship between physical mobility and socioeconomics of the different neighborhood types can unravel the indirect effect of urban form to physical mobility. The research targets the relations in the mobility and habitation system considering the prospects for future transformation of Swedish neighborhoods in the background. What is the interrelationship between physical mobility and socioeconomics in the different neighborhood types? Are there regularities between neighborhood type and lifestyles, travel behavior and physical mobility? Do people who live in stereotypical neighborhoods tend to adopt similar lifestyles? Do they also change lifestyles for example if they move to neighborhoods that are oriented to public or private transportation?

More research in other cities must be done according to the mobility and habitation system in order to grasp how typological are the neighborhood and bus infrastructures and how these typologies influence physical mobility. Second line of future research can be the attitudes and preferences for different neighborhood types and bus and streets infrastructures, and preferences for “typological processes” of urban transformation. There are some embryos in
that direction. There is a web survey where the people to rank or choose between different neighborhood types like between neighborhoods with detached houses or neighborhood with towers and typological processes of urban transformation for example from one neighborhood type to another.
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86


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The revival of buses as bus rapid transit (BRT) in urban and regional planning: retrospect and prospects

Abstract
We are in the midst of an emergence of a new multimodality paradigm in urban and regional planning. Within the new paradigm towards sustainable development there is priority on more environmental friendly and more energy effective transportation systems like public transportation, cycling and walking. European commission (EC) advocates for balance between transportation modes and more sustainable mobility. In the emerging planning paradigm there is much advocacy for Bus Rapid Transit (BRT) and its integration in cities through the compact city model. Many argue that BRT triggered a public transportation renaissance in the last decade. In contrast to the conventional bus systems that operate predominantly on streets, in mixed traffic or on dedicated lanes, bus rapid transit (BRT) achieves high capacity by channelling passenger flows in a system of segregated busways, partially or fully separated from other traffic.

The motorbus with the emergence of the car was a preferred and widespread alternative to the 19th century tramways and railways. But in the same time the bus was profoundly patronized. It was more an excuse for urban planners and designers not to plan public transportation than a mobility solution. The flexible bus like the car could reach anywhere. What is the perception and position of bus and BRT today? Did BRT made a change in urban and regional planning? What is happening on the historical, today abandoned industrial urban fringe of the cities in Northern Europe? How is BRT included? How BRT can help? Today we see a wide replication of the compact city urban model in the abandoned industrial zones in Europe and BRT is in the heart of many compact city neighborhoods. The urban model includes partially separated or light busways integrated in multimodal streets alongside sidewalks, bicycle and car lanes. BRT is conceived as a future public transport system, a sophisticated high speed system integrated in cities. BRT as more sustainable transportation mode is a driver for urban new development.

There are many finished and ongoing busway projects in Europe. But there are too few debates and too little reflections on the replication of the compact city model. The partially separated busways integrated with cities do not allow high
speeds. Thus they cannot compete with the private car on regional scale because they are slower (20-25 km/h) than the typical regional public transport systems. The aspect of a speedy public transportation journey in the multimodality is lacking. Secondly, the sophisticated vehicles are often the plain old buses that run on busways. They are as austere and uncomfortable as the other buses in every city. There are some new concept buses, but they are still prototypes. The emergence of the stereotypical compact city neighborhoods and utilizing BRT as a constant in the model opens new questions: Should we replicate more compact city neighborhoods? How creatively BRT is used and how creatively can it be used?

Keywords: bus, Bus Rapid Transit (BRT), urban and regional planning, multimodality, compact city, public transportation
1 Introduction

Bus Rapid Transit (BRT) is an innovative bus system with sophisticated vehicles, high speed and frequency, distinctive image, quality, comfort and infrastructural inflexibility that adds permanent value and targets full integration with cities. BRT comes with a lucrative promise of high capacity and quality of service at lower costs than railway solutions with similar performance. Transmilenio, the BRT in Bogotá, inspired a worldwide public transportation renaissance (Wright, 2010) in the last decade. The thunderous implementation and its service performance of 45000 passengers per direction and hour redefined the position of bus transportation and placed the completely segregated busways of BRT in Bogotá side by side with high capacity railway systems.

The completely segregated busways completed the palette of bus transportation infrastructures and BRT opened possibilities to envision complete urban and regional public transportation systems with buses in small and medium-sized towns and cities or to add new supplementary to the existing railway networks in the large cities. BRT subsequently triggered a debate about application of buses and bus transportation and set a standard of attractive bus service (Kottenhoff et al., 2009; ITDP, 2012). As a result of the BRT debate and advocacy the bus systems in many cities are advanced with more highly prioritized bus lanes or new busways to achieve the BRT standard.

The perception among urban and regional planners was that there is no need to plan for buses. The bus started with a poor status in urban and regional planning in the 20th century. It was more an excuse for urban planners and designers not to plan public transportation than a mobility solution. The flexible bus operated on streets and roads and could reach anywhere. The planners could draw bus lines over roads and streets and pin bus stops everywhere. These bus lines and stops were very adaptive. BRT on the other hand demands careful planning of busways and integration of cities to justify the investment for high frequency and capacity. There are many experiments, initiatives and negotiations in many towns and cities, small and large, and many new busways and BRT systems are developed or under development. Did BRT really made a change in the perception and position of buses in urban and regional planning? What is the position of bus and BRT?

BRT and Light Rail Transit (LRT) in Europe are entangled in a postmodern model of development of sustainable suburbs and the new sustainable
neighborhoods in Northern and Western Europe are strikingly similar. With the BRT initiatives and projects we see an introduction of new, reintroduction or extension of LRT systems in many, especially European and North American towns and cities. BRT and LRT lines acts as axes for development and positioned as medians in a wide multimodal boulevard partially segregated from the other traffic by landscaping ribbons. The boulevards include also bike and car lanes and curb parking. This model is slowly becoming a stereotype, not only as urban form, but also as a fringe in the postmodern European urbanization. The developers that use the model carefully target the derelict brownfields of the abandoned industrial urban fringe or greenfields near the industrial urban cores. In contrast BRT in the industrializing world exists as a high capacity system which parallels the congestion of the omnibuses and electric trams in the 19th century industrial society in Northern and Western Europe. The emergence of the stereotypical compact city neighborhoods and utilization of BRT as constant in a model for development opens new questions: Should we replicate more compact city neighborhoods with BRT as an axis? What is happening on the historical, today abandoned industrial urban fringe of the cities in Northern and Western Europe? How is BRT included? How BRT can help? How creatively BRT is used and how creatively can it be used?

2 The history of bus and its position in the modernization of Northern and Western Europe

2.1 The omnibus in the entrepreneurial, vibrant and polluted industrial city

The omnibus evolved from a carriage with seats facing each other. It had deluxe interior, assumed chosen company along a route with attractive prospect and veil on the crowded city and its street life. Blaise Pascal in 1662 started a passenger service on the streets of Paris with vehicles on routes and available to the general public called carrosses à cinq sols, the coaches for five sols. The only difference from a bus service today that is was terribly expensive. There were not many that could afford the costly and luxurious original bus. The average daily wage of a worker was eight sols and the fare of five sols corresponded to roughly 250 crowns, 25€ or 25£ in Sweden, EU or UK today.

The original bus ceased after several years only to reappear in the beginning of the 19th century. Stanislas Baudry was an entrepreneur who owned hot baths in Nantes. In 1823 he started a passenger service called voiture des bains de Richebourg.
or car of the Richebourg’s baths from the center of Nantes to his baths with a coach carrying 6 passengers. The station was in the front of the shop of a hatter named Omnes, who adopted the slogan “Omnes omnibus” (“Omnes for all” from the Latin word omnis meaning for all). The people used to say: “To the omnibus!” and they adopted the name omnibus for the vehicle. The omnibus service became much more popular than the baths and Baudry’s focus shifted towards transportation. He redesigned the vehicle for more passengers and opened the first line in Nantes in 1826 with two omnibuses with a capacity of 16 passengers each. Two years after, in 1828, Baudry with several associates established l'Entreprise générale des omnibus (EGO). EGO obtained a permit to establish 12 omnibus routes in Paris (Dunbar, 1967, pp. 10-11) and to operate transporter à bas prix or transports at low price. The omnibuses were exported from Paris to London within a year. George Shillibeer was a coachbuilder who was commissioned to improve the design of coaches in Paris in the 1820s. He started an omnibus service in London in 1829 with new vehicles carrying 22 passengers (Miller, 1941, pp. 16-9). The omnibuses were a great success in Paris and London and spread quickly throughout Europe. They reached Copenhagen and Stockholm in the 1830s, within a less than a decade.

The omnibus on rails appeared in New York in 1832 and was exported in Europe by Alphonse Loubat. Loubat invented and patented the U-shaped rails in 1852 that suited the European cobblestone streets and laid an experimental tramway in Paris which opened in 1855. The grooved rails became widespread in the European cityscapes where the horse-drawn buses and trams competed fiercely for the streets until the trams and trains were electrified. The electric trams outcompeted and completely replaced the horse-drawn omnibuses by the beginning of the 20th century. The 20th century started as a heyday of trams in Europe as only remaining successors of the industrial omnibuses.

The omnibus was perfectly suited for the business conditions in the industrial city. The startup investment for omnibus service was low, the market was not regulated and the competition was fierce in the 19th century. Stanislas Baudry and George Shillibeer themselves bankrupted within few years. The vehicles were handmade in workshops by customized orders of individuals, entrepreneurs and small businesses. The low wages for drivers and conductors, the high population density of the industrial city and the congestion on streets guaranteed profits.
2.2 The motorbus in the modern society and its “‘system’ of automobility”

The European industrialization was propelled by horse and ox power, coal, steam and electricity, but also by ingenuity, entrepreneurship, handicraft and skilled workers. Karl Benz and Gottlieb Daimler invented the motorcar, as a horseless carriage powered by petroleum motor in 1880s, but manufactured cars, trucks and buses in workshops in the spirit of the industrial society that revolved around mechanization and mastery of handwork. The industrialization was an overture for the modern society that started with an industrial revolution and fossil oil economy. The assembly line designed by Henry Ford for the T-model revolutionized not only manufacturing of automobiles and changed the perspective on industrial processes, but also on the society as a whole. The assembly line was introduced in Europe by André-Gustave Citroën in 1919 and in the 1920s Le Corbusier in his book “The city of to-morrow” envisioned a progressive modern architecture and cities of tomorrow that are manufactured with uniformity in detail like a Citroën. The writings of Le Corbusier were recognized internationally in the 1930s and his work had profound effect on architecture and urban planning and design in Europe in the mid 20th century.

The specialization and standardization of the industrial processes resulted in increased production and efficiency, low costs per product, allowed for high wages for industrial workers and demanded less both unskilled and highly skilled labor. The number of workers in the industry generally decreased with continuous optimization and automation of the processes throughout the 20th century causing a crisis in 19th century capitalism. The high industrial output and diminishing numbers of highly paid workers in the industry quickly stockpiled profits in corporations and agglomerates of companies that networked and grew rapidly. The unequal accumulation of capital decreased the number of consumers and saturated the market. The increased involvement of the government in the economy mitigated the low consumption crisis with high national budgets, bureaucratization and pursuit of social equality by redistribution of capital and decreasing working hours. The modern society of Northern and Western Europe fused the speedy growth and efficiency of Fordism with the public spending of Keynesianism. The national state rose in prominence and created a dominating middle class of rational, motorized and urbanized individuals with increased hunger to produce and consume services for enriched living. To become modern one nation must accept to “become bureaucratized, industrialized, rationalized, urbanized and so forth” (Luke, 1990, pp. 224). The high taxes gave the politicians and bureaucrats the power
and capital to increase the size of the public sector, to standardize the urban life, introduce minimal wages and provide social welfare and ultimately to modernize the cities. The house and car were anchored as drivers for economic growth and innovation and major items of consumption. The public sector invested in new suburbs with high standard of living, whereas private businesses developed the suburbs, advanced the industry and offered a multitude of products and services.

The private car demanded suburbs, driving and living at a distance. Henry Ford once nicely phrased the motorist paradigm for urban reform: “We shall solve the city problem by leaving the city” (Flink, 1975, pp.39). The Fordism demanded a new complex of modern industries and mobile lifestyles in contrast to the concentration and propinquity of the industrial city. The high output of new way of industrial production in the motor industry triggered rapid motorization in a virtuous circle of new motorways, prefabrication and assembly of new suburbs, increased motorization and new demand for cars, new industries and new economic growth. The private car demanded new roads and motorways that opened new land for development in the regions.

The car had much different context and meaning than in today in the beginning of the 20th century. I twisted the “‘system’ of automobility” by John Urry to illustrate the narrative of the car in modern society. The automobile existed as:

1. a manufactured object produced by leading industrial sectors and iconic firms;
2. a major item of individual consumption after housing and a status symbol;
3. a complex constituted through interlinkages with other industries, businesses and institutions that generates innovation, economic growth and prosperity and social welfare; and
4. the dominant culture that sustains major discourses of what constitutes the good life, what is necessary for an appropriate citizenship of mobility. The car today seen more critical both through its advantages mentioned abouve and disadvantages as:
   3. an extraordinarily powerful complex of transnational corporations and national institutions;
   4. a predominant global form of mobility that subordinates other mobilities and reorganizes how people live; and
   6. the single most important cause of environmental degradation and resource depletion (Shiller and Urry, 2002; Urry, 2004).

The Fordism and motorization brought incredible progress, prosperity and comfortable lifestyles in Northern and Western Europe. The private car and individual mobility opened new business opportunities, practices and inventions that seasonally delivered new and exciting products and services. The GDP of Sweden for example increased four times exactly as the total mobility of its inhabitants in the second half of the 20th century. The increase in
mobility is followed by an increase in GDP (Figure 1). Similar trend exist in UK too (Glaister et al., 1998, pp.7).

![Graph showing population, GDP/capita, mobility by private car, and mobility by public bus and rail growth over years from 1950 to 2000.]

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>GDP/capita (real)</th>
<th>Mobility (pkm/capita)</th>
<th>by private car (pkm/capita)</th>
<th>by public bus and rail (pkm/capita)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>7,046,900</td>
<td>79,569</td>
<td>3,037</td>
<td>993</td>
<td>1,490</td>
</tr>
<tr>
<td>1960</td>
<td>7,498,000</td>
<td>106,891</td>
<td>6,842</td>
<td>4,575</td>
<td>1,654</td>
</tr>
<tr>
<td>1970</td>
<td>8,081,100</td>
<td>159,789</td>
<td>9,281</td>
<td>6,942</td>
<td>1,757</td>
</tr>
<tr>
<td>1980</td>
<td>8,317,900</td>
<td>195,316</td>
<td>10,688</td>
<td>8,103</td>
<td>1,900</td>
</tr>
<tr>
<td>1990</td>
<td>8,590,600</td>
<td>236,342</td>
<td>13,061</td>
<td>9,999</td>
<td>2,072</td>
</tr>
<tr>
<td>2000</td>
<td>8,882,800</td>
<td>282,498</td>
<td>13,611</td>
<td>10,346</td>
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</tr>
<tr>
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<td>9,182,900</td>
<td>334,840</td>
<td>14,233</td>
<td>10,814</td>
<td>2,396</td>
</tr>
</tbody>
</table>

*Figure 1: GDP and mobility growth in Sweden (source: Trafikanalys and SCB)*

The motorbus was a modern version of the industrial omnibuses and trams, but it never achieved the symbolism of the cars or trucks. In the modern society and its “system’ of automobility” the bus was trivially peripheral. Powered by diesel engines, it was a silent, swift, more comfortable, flexible and superior to the noisy and bounded trams and trolleys. While the car and truck were machines of speed and power respectively, that inspired innovation and new records, the bus was standardized to an austere uniformity. In 1927 the Fageol brothers, Louis, Frank and William, established Twin Coach company and designed and manufactured the Model 40. The standard buses today are replicas of the Twin Coach Model 40 from the 1920s.
The public buses in contract to the private car were strangled in a vicious circle of modernization, motorways and suburbs. The buses performed and perform very badly on detouring motorways and road hierarchies and in sprawled suburbs. In the highly motorized modern society they lost the competitiveness with the car.

The emergence of motorbuses as a new technology had bad timing too. The American and European cities where the bus industry started had existing systems of electric railways and trams that were in their heyday in the 1920s and the private car started its ascendancy as vehicle of the modern society. The motorbuses competed both with the trams and railways and with the cars. The buses were only successful when they competed with or replaced the trams on the existing directions, since the cities were designed to utilize the directions of electric railways and trams. With the rapid motorization and suburbanization the demand for buses decreased dramatically. The monthly reports in “Bus transportation” the show that in the 1950s roughly two hundred buses were sold in the USA and the diesel buses by General Motors Company (GMC) dominated the sales. As a consequence the bus industry and transportation in the USA shrank dramatically in the 1950s. Northern and Western Europe experienced a similar trend in the 1970s. The number of buses did not drop in Europe as in the USA due to subsidies, but it stagnated. Today there are 4.5 million cars in Sweden, almost one car per two inhabitants. The number of buses, around 14,000, did not change from the 1960s, while the number of cars doubled (Figure 2).

The demand for buses was too low in the second half of the 20th century and there were too many companies that competed in the 1950s. That was a
hindrance why the production of buses did not advance from the workshops of the industrial society. Over 1 billion cars were produced in the 20th and more than half a billion only in the first decade of the 21st century. For comparison around 300000 buses and coaches are produced every year and around 60000 in Europe. The capacity of passengers in the buses roughly coincides to 10% of the capacity of the produced cars (Figure 3). The global production of buses roughly equals the capacity of two large assembly plants for cars.

Figure 3: Global car and bus production (source: www.oica.net)

In the period of the decline of the bus, the pioneers of bus manufacturing, companies like Twin Coach or Yellow Coach, bankrupted or were bought by companies like GMC of Flexible that also do not exist today. Ford and Mack produced buses only until 1950s and 1960s. The bus companies that survived the bus demise in the 1960s had mixed production of buses and trucks. The largest manufacturers of buses today that are organized in groups as Volvo, Daimler and Volkswagen dominate the markets of trucks too. The bus industry today exists as part of a bruck industry. The “bruck” is a term for a hybrid of bus and truck crafted in the journal “Bus transportation”. An example of a bruck is the Super Twin, the first articulated bus designed by Twin Coach in 1938 that found its place as truck for the USA postal service in the 1950s. Another example is through different designs of trucks hauling passenger cars. “Bus transportation” was the only journal about buses that published articles from 1920s until middle of 1950s. The journal “Bus transportation” started as a part of the “Electric railways journal” in 1922 and merged with “Fleet owner” in 1956 which is a journal of the truck industry.

The bus was an unprofitable business in the modern society. The bus transportation system became more complex and needed planning, control, operation, maintenance and marketing. The welfare model of the modern society guaranteed high wages and the bus system needed many workers and
bureaucracy. The operation costs of the bus transportation system increased rapidly with pressure from labor unions, syndicates and strikes, while the patronage dropped. For example the conductors vanished from buses to decrease costs and the drivers took their roles. The increases of fares and optimization of the costs resulted in fewer passengers and lower bus frequencies. The attitude towards public transportation is different in the modern societies in USA and Europe. The public transportation is regarded as a public service in Europe and the Europeans accepted higher taxes and subsidies for public transportation. The bus and railway systems were often nationalized and bureaucratized to be saved. The pursuit for profitability and optimization between profits and level of service decreased the share of the public transportation in USA to its minimum.

Since the entrepreneurs and businesses abandoned bus transportation in the 20th century, the bus industry had only city governments and public authority officials to negotiate with. The buses were procured on tenders or orders by public transportation authorities and operators that wanted to minimize costs for public transportation. The cheaper the buses were it was more probable to win on the tenders. “Thrifty bus!” was an advertisement in the journal “Bus transportation” for attractive buses from the 1940s and 1950s. The developments of bus technology were also in a direction to decrease operation costs and improve the efficiency of the engines. This was a joined research framework in the bus and truck industry. Very little attention was made on strictly bus issues like comfort. The comfort in a bus today is much worse than on trams or trains (Kottenhoff and Sundström, 2011).

2.3 The bus in the industrial and modern urban and regional planning

The contexts in the industrial and modern society are very different. The holistic urban and regional planning during the industrialization divided on many specialized disciplines that also branched within a narrower scope. Urban and regional planning has very diverse body of knowledge often including prophesying books, pamphlets and manifestos that established schools and doctrines. The knowledge in transportation planning and engineering is compiled in scientific journals and books, as well as technical reports and manuals about systems, technologies, infrastructures, standards and capacities. The position of the bus and BRT is easily followed through the reading the literature.

The urban and regional planning during the industrial society was a discipline of polymaths that equally considered issues as architecture and urban design
and planning as design of streets and traffic planning and engineering. Baron Haussmann, Ildefons Cerdà or later Hermann Josef Stübben in the book “Der Städtebau” had systematic, but holistic view both on buildings and streets, habitation and mobility. The traffic in the traditional and industrial cities revolved around low speeds, walking and carriages and coaches, omnibuses and trams that were on the main streets and boulevards. The cities were too crowded for higher speeds and the trains terminated on the edges of the industrial urban cores. The bus business during the industrialization was done by individual drivers and private entrepreneurs that changed the network of bus routes to fit the demand. The buses and trams were visible during the regulation of the traffic, for example in the Baron Haussmann plan for Paris or in the street sections of cities (Cerdà & Puig, 1867/1999). Not much was written about buses, except descriptions of journeys and paintings with crowded omnibus benches. There are however many books about cities along railways as railway suburbs or new towns and about railway engineering. Ebenezer Howard’s book “City of tomorrow” and the Garden City Movement and Letchworth Garden City in UK are examples of process of designing suburbs and integration of cities and railways. In Sweden Adolf Wilhelm Edelsvärd designed an urban plan of an ideal city with a railway station in its core in 1859 that was executed in the city of Nässjö. There are two American journals “Street railways” and “Electric railways” and many books and manuals about railway engineering from the end of the 19th and beginning of the 20th century. The journal “Bus transportation” was one of the few publications that specialized on buses.

During the modern era there was almost complete focus on car traffic and circulation and individual movement in transportation planning and engineering. The buses were excluded or barely mentioned in the road and highway capacity manuals until the end of 1960s. There is no chapter in the first edition of the American “Highway capacity manual” from 1950, whereas there is only one chapter on the buses or 10 pages in a 400 page second edition of the manual from 1967. There were no chapters about bus planning or bus systems in the influential British report and manual “Traffic in towns” from 1963 or in the similar Swedish manual “SCAFT 1968”. However a small book called “Bussen i stadsplanen” or “The bus in the urban plan” was published in 1969 as complementary document to “SCAFT 1968”. The perception in the 1960s, like in the report “Bilstaden” or “Automobile city” from 1960 was that with high motorization the demand for public transportation will be so low that it will be replaced by demand responsive services and taxis (Lundin, 2008). But from the 1970s and especially 1990s we look at a change from car traffic, road and highway engineering towards transportation engineering and multimodality
when the postmodern critique in urban and regional planning started and strengthened. The revival of public transportation started in the 1970s with discussions and national conferences in USA about LRT, the modern version of the industrial electric tramways and railways on street and in the 1990s with emergence of BRT as advanced system with buses.

3 The bus and BRT in the postmodern critique to modern urban and regional planning

3.1 The postmodern syntagm in urban and regional planning

The postmodernism is a multileveled critique, but also acknowledgement of different aspects of modernity. The postmodernism is eclectic, of discovery and rediscovery, and conflicting. It is a process of mixing the where the traditional and modern, old and new, historic and progressive, the human and machine, natural and artificial, are in perpetual struggle and coexistence. The central element of postmodernity is character of knowledge (Lyotard, 1984), its sources, contexts and ultimately the actuation of multifaceted truths (Friedmann, 1987). While, the modern knowledge revolves around general theories, rationality and universality, time and standards, the postmodernists recognize knowledge as a non unitary and prone to multiple interpretations and irrationality. The postmodern is a reaction to the “monotony” and uniformity of the universal vision of the world by modernity (Harvey, 1989, pp.9). There is a shift from individuality and looking at the individual as rational agent. The modern individual is multilayered and understood as an agent in networks: social, technological, economical, political that creates knowledge and trigger random actions. The postmodern actors are mediators and propose their own theories of actions. They are something between their “authentic selves” and “their social roles”, “actors on a stage never alone in acting”, “constantly engaged by others in group formation and destruction, providing controversial accounts for their actions and actions for other” (Latour, 2005, pp. 46-7).

There are four distinctive periods of in respect to development of the economy and industry that coexist in the postmodern. In a context of Northern and Western Europe these eras exist as traditional, industrial, welfare and knowledge society (Cars & Engström, 2008) or pre-industrial, industrialization, industrial and post-industrial society in regard to the three industrial revolutions (Luke, 1990). The societies do not follow each other, but there are modernizations, returns to traditions and mixing in different parts. They are in syntagmatic, multilayered postmodern mix. Within these eras the character of
work and production, need of access and transportation technology influenced the society and urban structure and vice versa (Table 1).

<table>
<thead>
<tr>
<th>Epoch</th>
<th>Economy and industry</th>
<th>Work character</th>
<th>Need of access</th>
<th>Communication and transportation technology</th>
<th>Urban structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional society</td>
<td>Labor division</td>
<td>Work by demand and wages by product or harvest</td>
<td>Spatial proximity</td>
<td>Narratives and stories, private carts and carriages</td>
<td>City and villages</td>
</tr>
<tr>
<td>Industrial society</td>
<td>Mechanization of labor</td>
<td>Wages by hour and maximum work hours</td>
<td>Spatial proximity</td>
<td>Newspapers and telegraph, public omnibuses, trams and trains</td>
<td>City and region</td>
</tr>
<tr>
<td>Welfare society</td>
<td>Specialization of processes and automation</td>
<td>Wages by month with limited 40 work hours per week</td>
<td>Temporal proximity</td>
<td>Television, radio and telephone, private cars and public buses and trains</td>
<td>Urban region</td>
</tr>
<tr>
<td>Knowledge society</td>
<td>Specialization of services</td>
<td>Flexible work hours and wages by product</td>
<td>Proximity to a network</td>
<td>World wide web, private and public cars and jets and high speed buses and trains</td>
<td>Urban network with global reach</td>
</tr>
</tbody>
</table>

Table 1: Epoch of the Swedish society in respect to development of the economy and industry (expanded from Cars & Engström, 2008)

3.2 The historical urbanization in Northern and Western Europe

The towns and cities in Northern and Western Europe expanded outward in distinctive fringe belts characterized by different periods of urbanization (Whitehand, 1967). Each fringe belt is a front of urban expansion that was shaped by the four societies (Table 1). I use traditional, industrial, modern and postmodern to fuse the aspects of society, technology and industry into trends of urbanizations and re-urbanizations in the postmodern age.

The traditional society was predominantly rural. The people worked in fields and their wages dependent on harvests or exchange of products. It revolved around communities and agriculture, sustenance and perseverance. The city was a trade hub in a region of villages. The city had a core with clearly defined boundary and its periphery was rural.

The traditional society was contested by the mercantilism, capitalism and free entrepreneurship of the industrialization. The life in the industrial cities revolved around mastery of handwork, wages, work hours and schedules. The labor force was highly skilled and handcrafted products in workshops from
dusk till dawn with help of rudimentary machines. The industrial city stratified in two very different cityscapes, a core and periphery. The industrial urban centre was filthy, polluted and congested. It was surrounded and intersected by a fringe or factories, warehouses and ports where all the manufacturing took place. Its periphery was in the countryside and included garden suburbs with houses in the nature. With mechanization of the agriculture and new transportation technologies the villages were abandoned and left to suburbanization.

In the modern society the business created industrial processes as machines with mechanical or human parts. The work day had less work hours. With automation of industry and the labor moved in the service sector that offered education, healthcare, recreation and entertainment before and after work. The residents motorized and flocked to the suburbs and the dense historical urban cores were modernized, decongested, commercialized or turned into tourist attractions. The business and industry also moved in the new modern suburban fringe to escape from the congestion and traffic jams. The cities became urban regions sprawled in the countryside and developed as belts of fragmented urban areas, cores and fringes interconnected by motorways.

The postmodern city of Western and Northern Europe has several fringes or development zones. The first fringe is the zones of factories, warehouses and ports of the industrial city that are abandoned due to globalization of capitalism. The second front of development is in the urban regions that fulfils the program of the modern society. The historical urban cores, edge cities and business hubs in the suburbs are networked with “aeropolises” or sky cities that are developing around the airports. These creative cities of the knowledge society establish networks in the urban regions for global flows of information, knowledge, business and tourism. The third fringe is not anymore in the cities and includes complexes of fields, factories, warehouses and ports, which manufacture, transport, store and distribute food and goods for global consumption as a consequence of transnational capitalism.

3.3 The vision of the postmodern European city
The future knowledge society and its postmodern cities are now in their embryos. The humanity is amazed by virtual worlds and instantaneous connections around the globe, new speed records on rail and supersonic speeds in air. Since the 1990s, the “system’ of automobility” is contributed with new global systems of communications. The cities are “extraordinary agglomerations of flows” today, not only of people on the move, but as other
forms of mobility like flows of information, capital, values, norms and lifestyles (Ash & Thrift, 2002, pp.42).

The postmodern sustainable European city is advocated through policies for urban networks. The vision includes compact cities which are hubs for multimodal flows in the urban networks. The compact city is a postmodern critique of suburbanization and metropolitanization of the modern era and it is traced through documents, papers, reports and responses on sustainable cities and mobility published by the European Commission (EC) since 1990. It emphasizes intensity by concentration of urban flows, densification of urban form and mixing of urban functions, urban regeneration of brownfields, conservation of greenfields and effective public transportation systems. The name of the concept originates from the book “The compact city” that offered a vision of a highly technological city with temporarily and spatially organized urban activities (Dantzig & Saaty, 1973). The argument is that urban density and diversity of urban functions are more likely to result into people living close to work places and services that are required for the everyday life (EC, 1990, pp. 40). The ambition is also to make the private car an option in cities rather than a necessity (EC, 1990, pp. 30) by creating integrated, multimodal transportation systems which fully exploit the potential of public transportation (EC, 1997, pp. 11-2).

The compact city synergizes high-tech architecture and neo-modernism with an neo-traditional advocacy. A new historicism emerged in European architecture and urban design. Architects like Aldo Rossi, Paolo Portoghesi, Leon and Rob Krier advocated return to historical roots and European traditional “cities with quartiers” (Krier, 1984) since the 1960s. The compact city similarly favors architectural heritage, by respecting rather than imitating the old (EC, 1990, pp.30). It depicts the traditional European city, but draws its inspiration from high-tech architecture and new technologies. Reichstag dome by Norman Foster or Louvre Pyramid by Ieoh Ming Pei are examples of this postmodern fusion of traditional and modern.

3.4 Entanglement of BRT and LRT in the postmodern European city

The introduction of BRT and LRT is a consequence of an emergence of a new paradigm of urban and regional planning that revolves about sustainable cities. The advocacy in the USA comes as transit-oriented development (TOD) and New Urbanism, whereas in Europe the integration of public transportation and cities is promoted by the EC and its documents about urban environment and transport. The postmodern fusion dominates architecture and urban planning.
and design from the 1990s. BRT and LRT are preferred as new public transport systems as partially separated busways or railways on multimodal streets in neo-traditional compact neighborhoods. The partially segregated busways or railways in Europe are regarded as urbanity-empowering and more attractive since they do not cause barrier effects as the fully separated railways or busways.

The BRT or LRT lines in the projects are often designed as medians, partially segregated busways or railways, on multimodal boulevards and act as public transportation axes in the new sustainable neighborhoods. The boulevards usually include bike lanes, sidewalks along attractive façades with storefronts and ribbons of greenery and landscaping. Today we see a wide replication of the same compact city model in Northern and Western Europe. The neighborhoods along the BRT and LRT lines in Sweden, Denmark, Finland, Netherlands, England and France are too uniform and alike (Figure 4). The development is predominantly executed in the brownfields of the historical, today abandoned industrial urban fringe, but there are also many new suburbs developed by the same model on greenfields.

LRT and BRT are conceived as sophisticated high speed system integrated in cities. The partially segregated busways are not high speed systems. The combination of sophisticated high speed system and urban integration is not working in reality. They neutralize themselves. LRT and BRT are similar systems that use partially segregated busways or railways and cannot compete with the private car because they are slower (20-25km/h) than the typical regional public transport systems. The buses are again mistreated by the urban model by narrowing their application on one solution. The partially segregated busways cannot achieve high speed due to their infrastructure and integration with cities. The complete segregated busways are much harder to integrate in cities, much as the heavy railways, but they are the real high speed systems. There is a need of new concepts for public transportation in urban and regional planning and particularly in urban design and planning that can show ways to achieve high speeds and urban integration.
Figure 4: The European compact city experiments along partially segregated busways or railways (photographs 1-2 from up and left to right and down are from Helsinki, 3-5 are from Amsterdam, 6-7 from Eindhoven, 8-9 from Cambridge, 10 from Douai and 11-12 from Paris, 13-14 from Gothenburg and 15 from Stockholm)
3.5 The multimodality paradigm in transportation planning and engineering and postmodern revival of public transportation

Transport planning and engineering slowly also shifts towards a new paradigm of mixing transport modes. The change is illustrated by renaming of the institutions in the Northern and Western Europe and USA. TRL was originally established in 1933 by the UK Government as the Road Research Laboratory (RRL). It became Transport and Road Research Laboratory (TRRL) in the 1970s and 1980s finally to become Transport Research Laboratory (TRL) in the 1990s. Similarly Transportation Research Board (TRB) in USA was established in 1920 as the National Advisory Board on Highway Research and in 1925 renamed in Highway Research Board. In 1974 the Highway Research Board became the TRB. The Swedish Road Administration and Swedish Railway Administration, Vägverket and Banverket in Swedish, merged into Swedish Transport Administration or Trafikverket.

The multimodality paradigm in transportation planning and engineering started in the 1970s and revolves around a revival of public transportation, buses, BRT and LRT in transportation planning and engineering. It started with LRT in the 1970s and continued with BRT in the 1980s and 1990s. In the last decade there are many manuals and handbooks and much research about bus transportation. There are several interlinked, but slightly traditions in public transportation planning from the 1970s. I refer to them as schools. In the American school there is a focus on optimization of the supply of the service to the demand. The public transportation is as public service entangled with European cities and the supply is decided by heuristics, empirical rules and traditions.

TRB is the pillar of transport research in USA and its publications comprise the American school. The separated manuals for public transport came very late, but there is much research by or related to TRB. The “Transit capacity and quality of service manual” (TCQSM), was published in 1999 and reached its third edition in 2010. It is public transport parallel to “Highway Capacity Manual” which had its fifth edition in 2010. George E. Gray and Lester A. Hoel edited the compilation of papers “Public transportation: planning, operations, and management” in 1979. Vukan Vuchic published “urban public transportation: systems and technology” in 1981 and expanded them in two “Urban transit” books in the 2000s. His books are a hybrid between schools of European and American schools as the title “Urban transit” suggest. The “public transportation” is usually translated as “urban transportation” in Europe.
because they are regarded as constitutive element of cities, whereas “transit” is an American catchall for “public transportation”. The Canadians also make compromise between the American school and European schools, but more aligning to the concept of public service than to the pragmatic. There are three editions of the “Canadian transit handbook” published in 1980, 1985 and 1993. Peter White published the manual “Planning for public transport” in 1976 and there are several editions until today. TRL also published many reports about different public transport systems in the UK and two guides “Demand for public transport” in 1980 and 2004. The books and reports by Peter White and TRL can be regarded as the British school. The difference to the other schools is that there is subtle emphasis on the market and on passengers as customers. The bus was also part of the manual “Stadens trafiknät” from 1976. The public transport manual in Sweden from 1981 was abbreviated PLANK from “Planeringshandbok för kollektivtrafik” or “Planning handbook for public transportation”. The public transports were also included in the guidebooks for transport TRAD 92 and TRAST, but without differentiating planning for bus or BRT. The latest manual for public transport within this Swedish school “Kol-TRAST: planeringshandbok för en attraktiv och effektiv kollektivtrafik” or “Planning handbook for attractive and effective public transportation” was published in the end of 2012 and it includes planning for bus or BRT.

4 The history of BRT and revival of the bus in the postmodern society

4.1 A short history of BRT and busways

BRT made a breakthrough in the Colombian capital Bogotá in year 2000. In two years the mayor Enrique Peñalosa, managed to complete Transmilenio, the BRT in Bogotá. The thunderous speed of implementation, the low costs and high capacity invigorated strong interest and worldwide support. The World Bank now promotes BRT. Approximately 100 BRT systems are operational today and a near equal number is under development (Wright, 2010). Due to its popularity and fame, especially after the success in Bogotá, BRT is widely used for a range of public transportation systems with busways. There are also many definitions. BRT is a permanently integrated system of facilities, services and amenities that collectively improve the speed, reliability and identity of bus transport (Levinston et al., 2002). BRT is a bus-based public transport system that delivers fast, comfortable, and cost-effective urban mobility (Wright, 2004). BRT is also evaluated through levels of services (Kottenhoff et al., 2009) or with points (ITDP, 2012). There are many different contexts and conceptualizations. In South America and Asia BRT is seen as a high capacity
system that parallels rail solutions but at low costs. The Europeans prioritize high quality or *bus with a high level of service* (BHLS) over high capacity. The BRT systems in Curitiba and Brisbane are completely conceptually different. The Europeans and South Americans prefer a hierarchical system of feeder and trunk services, whereas Australians and some new systems in Asia revolve around systems with many bus lines that serve many origins and destinations and operate on and off the busways. An entire number of the journal “Built environment” 36(3) dedicated to this topic.

Historically the coinage “bus rapid transit” or “rapid bus transit” precedes the emergence of busways or even bus lanes. The “rapid” referred to a type of service that is speedier than the local service. The December issue of “Bus transportation” from 1940 describes expressway for buses as differentiation between fares and lengths of bus services. The local buses operated to 7 miles for 10¢, express to 10 miles and 15¢ and limited service extended to 17 miles and 20¢. Los Angeles even today keeps the same distinction with shuffled names (Figure 5). The original hierarchy is complemented by liner buses on the Orange Line which operate predominantly on busway.

![Figure 5: The differentiation of the bus services in Los Angeles.](image-url)
The American concept of hierarchical bus system with express buses and expressways for buses was executed in Curitiba, Brazil in the 1970s. Jaime Lerner became a mayor in 1971. Curitiba was a quickly growing city. In 1974 he developed RIT (Rede Integrada de Transporte or Integrated Transportation Network) as a model of urban corridors along a system of express buses and busways. In this period in USA there is a revival of LRT and interurban railways with a model of development that revolves around urban corridors with major arteries. This model of development is from the industrialization and it is widespread in the industrial European urban cores. There are many public transportation corridors in the European cities like the model of BRT in Curitiba. Almost exclusively these corridors were along tramways. It exists also in the writings about the main street or boulevard sections, for example by Ildefons Cerdà. The same model has been utilized during the American urban expansion along the interurban railways, for example in Los Angeles.

The urban development of Curitiba is conceived by the same model, but the medians of the urban corridors are busways. Curitiba grew exactly as planned along its busways from the 1970s, similarly as Los Angeles from the 1900s, where the difference was only the height of the buildings. The superiority of the bus system in Curitiba was in the size of the buses changed to increase the capacity of the system. Articulated buses were introduced in the 1980s and bi-articulated in the 1990s (Lindau et al., 2010). The interurban trains in Los Angeles were dimensioned for low density and urban sprawl, but the possibility to revive the public transportation corridors and even for higher densities exists even today also in many other American cities that copied the “car-oriented development” of Los Angeles. The busways as partially segregated infrastructures are also characteristics of the compact city model in Europe.

The first experiment with dedicated bus lanes on streets was in Nashville, Tennessee in USA by the reporter of the February issue of “Bus transportation” from 1956. Even though the BRT originates from the possibility to utilize the expressways or motorways for bus transport, and is traced to the American expressways, there are no clear visions about busways until 1950 and 1960s, even though the coinage “bus rapid transit” is continuously used. The busways as completely segregated infrastructures started in Europe in the 1960s. The oldest busway in Sweden is Vallås bussgata in Halmstad, which replaced an old railway in 1966. The busway was not segregated completely from the other traffic and the low volumes of cars allowed for undisturbed bus service. Runcorn, the British New Town near Liverpool, was designed along a busway in the 1960s and probably is the oldest vision of completely segregated bus infrastructures. The busway was
operational in the 1970s. The experiments with busways continued until today. The new Dutch town Almere Stad in the 1980s was also designed with a radial system of busways that fed the railway stations. Tvm or Trans-Val-de-Marne was launched in Paris in the 1990s (Figure 6). In the last decade there are several new busways in France, UK, Netherlands and Sweden. New busway is under construction in Denmark too.

Figure 6: The busways in Runcorn (top two photographs) and Istanbul (bottom two). The busway in Runcorn is completely segregated by greenery, whereas the busway runs as a completely segregated median of a motorway. The contexts of the two completely busways are very different. Runcorn is a small city in highly motorized and industrialized country as UK. The traffic on the busway is low and it looks abandoned. The Metrobus, the BRT of Istanbul is highly occupied, since Turkey is in a process of industrialization, urbanization and modernization. Istanbul is not motorized as the towns and cities in Northern in Western Europe and many walk longer distances to get the bus. The frequency of buses every 30 seconds in Istanbul versus one bus every 10 minutes in Runcorn shows the difference between of transition from traditional to modern society in Turkey and late modern society in UK.
4.2 BRT in the postmodern society and its fringes of urbanization

BRT has a very specific role in the postmodern society and its fringes of urbanization. BRT as a high capacity system is applied in the industrializing cities that are in a transition from traditional to modern society around the world like Turkey (Figure 6) very similar as omnibuses and trams in Northern and Western Europe during the industrialization in the 19th century. The context is however much different, because these countries are simultaneously in a transition towards the postmodern society.

BRT and LRT also find their specialized place as partially segregated busways and railways in the abandoned fringe of the industrial society in the large cities of Northern and Western Europe that are in a transition to postmodern society (Figure 4). BRT and LRT are only successful in Northern and Western Europe if they are part of a project that revolves around redevelopment of brownfields or development on greenfields. There are visions of BRT systems through the historical urban cores, but these BRT initiatives and negotiations fail or are very slow. The problem that hinders implementation of BRT is the difficulty to introduce partially or completely segregated busways especially in the urban cores of the industrial and the cores and periphery of the modern society.

The suburbanization in Western and Northern Europe had a different character than in USA. Los Angeles was a prototype for “car-oriented development”. Many American cities sprawled continuously and along arterial roads and the freeways were superimposed to this continuous stretched cityscape. The European cities suburbanized as archipelagos of urban areas along E-motorways segregated from the urban cores by following manuals like “Traffic in towns” or “SCAFT 1968”. The urban regions are very specialized. The historical urban cores of the smaller towns and cities are business hubs in sprawled suburbia and the road networks are extensive. The road network of Sweden is 600,000 kilometers and there is roughly less than 80 meters road length or 200 to 250 square meters paved road space per person in Sweden without considering parking lots. It is an extensive road infrastructure that is in large extend incompatible with the conceptualization of a busway in a median of a boulevard in a model of compact city neighborhood and placing busways on motorway is not an option because the urban areas are protected by green areas from the motor traffic.
5 Discussions and conclusions

5.1 The strangled bus in the world of the car and its persistent poor social status

John Urry in his books and articles is enlighteningly insightful about the world of the car, its “system” of automobility, past and future mobilities. The private car in the 20th century brought new sociability of mobility, new ways of socializing and freedom of movement, economical growth and prosperity, social welfare and lavish lifestyles through an extraordinary powerful complex of industries, businesses and institutions with a power to transform cities. This modern transformation with worldwide motorization is ongoing on a global scale and there are not really changes in that modernization trend in the postmodern society today.

The bus has a low status in the world of the car and it is often neglected. In his wide investigation of the mobilities John Urry (2007) forgets to mention the bus and its sociabilities. He describes only walking, public trains, private cars, airplanes and being online as mobilities that shape social spaces. The buses experienced two histories: first of a lavish social carriage during and second of a modified thrifty horseless carriage. The histories shaped two very different social spaces. The luxurious mobile lounge evolved in parlor cars and first class saloons and coupés in the public trains and lavish private limousines, while the crowded bus exists as social place in its minimal austerity and claustrophobia. The latter image of the industrial omnibus is persistent. The bus is a “metal can of human sardines” or a “boxed mob” collectively groaning and counting the number of turns to the next stop. The crowded bus is probably the densest public space, a parallel and reflection of the 19th century industrializing city. It is incredibly urban symbol of conjoint tolerance and fury, a true barrel of powder.

Very few politicians, bureaucrats or urban and regional planners can escape from this poor status and public image of the bus, especially as a future public transportation system in the motorized cities in Northern and Western Europe. The image of “metal can of human sardines” brings uneasiness to many. It is difficult to justify and investment and defend it in front of the general public with the sophistication and the poor status of the buses today. The buses must improve their design and decongest to fit the modern and postmodern expectation for public transportation service. It has to be conceived as a process of evolution to a postmodern bus. The industrial urban cores decongested and modernized during the 20th century, but the industrial buses
did not. The image of crowded bus keeps the low status of the bus and evokes strong memories.

The automobile plays three major roles in the world of the car today. It is a *machine of speed*, an image set by Karl Benz. It captivates and thrills. It inspires invention and progress. The speed record for example is perpetual challenge. It has a social use, as John Urry argues firstly revealed by Bertha Benz who used the car to socialize with family and friends at distance. She was the first advocate of the car as an *instrument for socializing* and driver of “social life”. During the modernization the “social life” moved to the suburbs and the postmodernity has this mobile and lavish modern lifestyles as a reference point. Henry Ford saw car as *driver of the economy and welfare*. It mobilizes workforce and resources. It produces value. It contributes to common wealth and prosperity. It *networks businesses* and makes business flourish. The questions that stand in front of the postmodern society and the actors in the industry and business are: Where is the bus in this story? Which major role of the car can it take in the future?

### 5.2 The ending of the car and the future of bus transportation

Many argue that the car is here to stay (Webber, 1992:283). Cars cannot be disinvented. They firstly provide advantages for too many people and secondly, the attachment is too strong. When faced with lack of fuel, the people managed to keep their cars going by anything burnable (Ward, 1991, pp. 11-2). Others argue that the car is ending (Dennis and Urry, 2010). John Urry argues that the “public mobility” pattern of the 19th century will not be re-established in the future. That pattern is irreversibly lost because of the character of the “system of automobility” that “produced and necessitated individual mobility based upon instantaneous time, fragmentation and coerced flexibility”. The post-car system “will substantially involve *individualized movement* that automobility presupposes” (Urry, 2007, pp.285). The automated public transportation systems, the hybrids between public and private transportation and self-driving cars are postmodern solutions for mobility.

Much neglected aspect of the postmodern revival of public transportation is automation of the service. The postmodern age inherited the modernist trend to automate repetitive jobs. The “Transit expressway” by Westinghouse from the 1960s for example had automated redesigned buses on guideways that look like mini-metros. The automation of the bus never realized even though the “Transit expressway” had a miniaturized realization as “Private rapid transit” in Morgantown, USA. Similar system was VAL (Véhicule Automatique Léger or
Automatic Light Vehicle) or mini-metro system in Lille. The new mini-metro line in Copenhagen is also a variant of the “Transit expressway” and VAL technology. In the bus industry there is a contrary trend to conserve the standard bus. The O-Bahn concept by Mercedes-Benz from the 1980s looked at automation only on tracks. It introduced standard buses on a guided track. The drivers took control over the wheel when they are on streets or stations, while the guide wheels control the direction of the bus on the busways. The concept of guided wheels and tracks spread very slowly and it was only recently applied or reintroduced for a busway in Cambridge, England.

Driving in general is under a process of automation by the pressure to be perpetually online. The concept of guided wheels can be replaced by GPS, magnetic or computer vision guiding. Google is funding research on driverless cars and there are successful experiments with driverless cars in traffic. But there are no discussions about driverless buses in traffic, even though the bus driver is a concept that does not fit in the postmodern future of transportation. The role in the system is too boring and uncreative for a postmodern human. The bus conductor had a role of collector of fares in the industrial society, but in the postmodern it need to evolve in a communicator with a wide knowledge not only of the bus system, but also with the stations, neighborhoods and urban activities along the stations. The postmodern humans do not need a driver, but someone to communicate with and exchange information. The super bus as automated machine is also an alternative and the advocacy for BRT can be towards completely segregated busways for self-driving super buses. The driverless buses can achieve higher frequencies with smaller vehicles and eliminating the high costs for modern bus drivers. The progressive debates about future buses must consider the automation aspect and emergence of new roles, specializations, professions and aspects in the bus systems. BRT in that direction can be conceived as a complete advancement of the bus transportation to inspire awe and creative response from the postmodern knowledge society.

Another postmodern direction can be adopting a modernization of the bus industry. The bus industry must find its “T-Model” that can be produced in few major global factories. The “T-Model” of public transportation can be one design of universal bus or be conceived in a context of a business model of the personal computer with one body and compatible standardized parts. The bus industry today has not reached consensus to negotiate this model. The other path of the bus industry, the design of universal bus that can be produced in two global factories has to revive the omnibus as “omnimobile”, a mobile social space for the wired world, flexible luxurious mobile lounge for everyone.
There are projects about new high quality and sophisticated buses. At TU Delft about future “Superbus” that focuses on comfort, individuality and privacy. Superbus is 15 meters long vehicle with 8 doors per side and provides seating for 23 passengers (www.superbusproject.com). Volvo recently launched a new concept bus with flexible interior within the European bus system of the future project (www.ebsf.eu). In contrast, the train manufacturers and the railway industry figured out the need for speedy, but also very comfortable journey. The success of the high speed railways (HSR) in Northern and Western Europe and especially in Sweden is partially in the comfort and partially in high speed. The second aspect of the success is the integration with European cities. The train stations are in the centers of cities and linked to other urban public transportation networks. The real urban revival of buses as BRT depends not only on the high speed, but ultimately on comfort and integration. The integration is not only between bus infrastructures and cities, but also between the bus, car and road building industries, public transportation authorities and city governments, development companies and other businesses which can benefit from proximity to public transportation networks.

The postmodernity is prone to multiple interpretations of a same phenomena and the knowledge as a non unitary, but multilayered. The public transportation in the knowledge society has to be interpreted and reinterpreted, conceptualized and re-conceptualized until it finds its postmodern meanings, contexts and applications. Much of the fantasy and science fiction images had been abandoned in recent years by the bus industry. If we look at the history of transport modes there was much hybridization between modes. The omnibus started on streets and ended on rails. The coach started on dust and gravel and the car is today on asphalt. The trains evolved from wooden, iron, steel rails to magnetic levitation. The far or close future might bring magnetic levitated roads, boots, buses and cars that will hover over the planet leaving it to the plants and animals. The bus industry needs a bit of fantasy and futurism to better fit the progressive stream of postmodernity. The bus inspired creativity and fantasy in the mid 20th century and since then it has been very little done. The future bus designs by Mack from the 1930s or the Golden Dolphin by Viberti from the 1950s are bus designs that inspire fantasy and different perspective on the bus.

5.3 Ceasing the hostilities between the private car and public bus

The attitude towards the automobile in transportation planning and engineering and urban and regional planning changed a lot from the 1970s with the oil crisis and rising environmentalism, but in a modern fashion of specialization
multimodality was understood as competition between the private and public transportation (Nash, 1976). The public transportation is a part of a vicious circle a zero-sum game set in motion by the private transportation. Any increase in attractiveness of private transport has rather perceivable impact on the use of public transportation and causes consecutive decreases in numbers of journeys, whereas improving the attractiveness of the public transportation has, but not as strong effect on private transportation (Brynnelsson, 1976, pp. 1.1; Pushkarev and Zupan, 1977, pp. 21).

The private car and private transportation are not adversaries because they are part of the same motor industry. In the modern society the automobile was an anchor for the industry. The low share of public transportation is equally a result of fewer buses and trains produced (Figure 3). The car industry is very protective to its market share in urban traffic. Forcing a competition between private car and public bus is futile. The motor industry produces both engines for cars, trucks and buses and it is the only actor that can make a balance in the transportation capacity of the produced cars and buses.

Progressively thinking the world has limited capacity for cars. Sooner or later the world will motorize until the market for cars saturates and stabilizes. The public transportation remains as new infrastructures to be constructed and industry to be developed. Many urban regions in Northern and Western Europe lack dedicated urban public transportation networks and infrastructures. The buses today for example operate on car infrastructures. Everyone wins if there are different infrastructures with high quality in cities. It is important even for the car industry to early see the prospect of public transportation in future development. The future development of sophisticated buses depends very much on the motor industry and changes in the “system” of automobility”. I was on a conference in Salt Lake City in 2012 where Lane Beattie, the president of Salt Lake Chamber of Commerce talked about prospects of business and transportation. Beattie’s argument was that the business was worse when they invested only in cars and motorways or only in public transportation. The business turned best if there were both investments in the private car and public transportation. The TRAX system in Salt Lake City opened in 1999 and today there are 3 lines LRT system and the rail connection to the airport is nearly completed to allow for future multimodality.
5.4 Revising the multimodality definition in urban planning and design and transportation planning and engineering

The bus was and is continuously neglected in urban and regional planning. The general perception that there is no need to plan for the bus has not changed. LRT and BRT as public transportation system on multimodal streets are entangled as a constant in a model for development in the postmodern fringe in the towns and cities in Northern and Western Europe as well as in Northern America. There is a need to revise the multimodality definition and deeper understand the morphological interrelationship between public transportation systems and urban environments as urban flow versus form, mobility versus habitation and sociability. There is a need to diversify the model and the stereotypical neighborhoods and plan for bus transportation with infrastructures that parallel motorways. Brisbane is a good example of a city that envisioned a creative bus system including various bus infrastructures that adapt to the sharp difference between the skyscrapers of the Australian “city” and extensive suburbs with houses and suburban town centers. The busways operate in a network of tunnels in the “city” and disperse in the suburbs.

Françoise Choay (1997) argues that planning and design includes rules and models. The rules are procedures for conceiving and generating space and models are prototypes, a model space or a model of space. The models prevail in the practice of modern and postmodern urban and regional planning and they result in stereotypes. It is easier, cheaper and safer to copy or modify a model than really to set rules. Rules lead to additional surprises, lack of control over the wholeness and incoherencies. It takes time to change. The public transportation systems, their integration with the urban environments can be understood as rules too. There is a need to conceptualize and re-conceptualize the public transportation systems through paradigm and viewpoints different disciplines and through a prism of paradigms and parallel urbanizations and fringes. There are more creative solutions if knowledge from different disciplines and combination of rules are applied, than if one rule or one model is applied.

I made a simplified conceptualization (Table 2) of public transportation by their urban morphology and effect on cities. The categories are unorthodox and open for further discussion. There is principal public transportation: 1) on streets (buses and trams); 2) completely separated, either elevated or on the ground (heavy railways or heavy busways); 3) underground (subways); contributed by a hybrid of the three: 4) public transports partially separated on ground (light railways or light
busways). Every public transport infrastructure spreads different attractiveness pattern in the city and they can be considered as element for placemaking and urban design. The categories show the anchor designated by X and ranges designated by (X) of the various infrastructures and their position as public transport technologies shaping cities. I abducted the common capacity distinction in transports (light versus heavy), where heavy means always complete or full separation regardless if it is a bus or rail system, whereas light attribute is for systems that anchor on partially separated, or are partially on street or partially fully separated.

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<tr>
<th></th>
<th>On streets in traffic</th>
<th>Dedicated lane on streets</th>
<th>Partially separated on ground</th>
<th>Fully separated on ground or elevated</th>
<th>In tunnel or underground</th>
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<tr>
<td>Bus line</td>
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<td>Light busway</td>
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<td>Heavy busway</td>
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<td>Tramway</td>
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<td>Light railway</td>
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<td>Heavy railway</td>
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<td>Subway</td>
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*Table 2: Simplified public transportation systems and infrastructures (designed with Karl Kottenhoff)*

I compared and shown different ratios in travel time speeds between different bus and car infrastructures (Table 3) to simplify the competition between private car and public bus. The hierarchy of roads is described from European perspective as motorways, wider, normal and smaller streets. The motorways are segregated and have speed limit of 100km/h. The wider streets have 4 lanes and more (speed limit 30-70km/h), the normal streets between 2 and 4 lanes (speed limit 30-50km/h), whereas the smaller streets have 2 narrow lanes (speed limit 30-40km/h). Travel speed ratio is only a theoretical measurement showing the quotient of the private car and public transport speed. In practice the travel time is calculated as perceived journey time. For public transport it also includes walking, waiting, in vehicle, transfer and egress time which are weighted by coefficients to calculate the differences in perception of the journey time. The perception of waiting time is usually double than the time in vehicle and the perceived journey time can increase dramatically with all the penalties for walking, transfers and waiting. The car networks are basically motorways and streets with various speed limits and bus lines with different infrastructures. We can see the bus lines as combinations of various streets and busways. The table shows how much a motorway can make a difference in the
competitiveness of the car without taking in consideration waiting, walking and transfers. Being 10 minutes in a car on a motorway would mean from 17 to 33 minutes on a heavy busway. It is important to understand bus transports and BRT through these simple, but elementary infrastructural rules. In the end it is important to look at the bus and analyze each bus line separately.

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<th>Car speeds</th>
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<td></td>
<td>Motorway</td>
<td>Wider streets</td>
<td>Normal streets</td>
<td>Smaller streets</td>
</tr>
<tr>
<td></td>
<td>70-100</td>
<td>30-70</td>
<td>30-50</td>
<td>20-40</td>
</tr>
<tr>
<td>Motorway</td>
<td>50-70</td>
<td>1-2</td>
<td>0.42-1.4</td>
<td>0.42-1</td>
</tr>
<tr>
<td>Wider streets</td>
<td>10-30</td>
<td>2.33-10</td>
<td>1-7</td>
<td>1-5</td>
</tr>
<tr>
<td>Normal streets</td>
<td>10-20</td>
<td>3.5-10</td>
<td>1.5-7</td>
<td>1.5-5</td>
</tr>
<tr>
<td>Smaller streets</td>
<td>10-15</td>
<td>4.6-10</td>
<td>2-7</td>
<td>2-5</td>
</tr>
<tr>
<td>Light busway</td>
<td>20-30</td>
<td>2.33-5</td>
<td>1-3.5</td>
<td>1-2.5</td>
</tr>
<tr>
<td>Heavy busway</td>
<td>30-40</td>
<td>1.75-3.33</td>
<td>0.75-2.33</td>
<td>0.75-1.66</td>
</tr>
</tbody>
</table>

Table 3: Span of speeds (km/h) and car/bus travel speed ratios on different infrastructures

BRT is defined as any system with busways or with section of busways, regardless if it is partially or completely segregated busway. Even though the busways give the character of BRT as a system that parallels railways (Kottenhoff, 2009), BRT is inherently a system of flexible buses that can operate beyond the busways, on streets or in mixed traffic. The discussion about BRT in urban and regional planning must include a variety of bus infrastructure. BRT needs to be conceptualized and re-conceptualized in different context of creative introduction of different bus infrastructures, urbanizations and modernizations and transformation of urban fringes, societies and cities. The modern temporal competition of the private car and public transportation is a grand modern narrative. It can be complemented with smaller postmodern narratives as driving during the weekend instead of commuting by car every day. There is a need of both a cultural and change in urban form towards transforming the existing modern cities towards and designing new postmodern cities that are friendlier to public transportation. Multimodality does not mean only access to public transportation, but also a network capital of speedy and slow public transportation connections, links with important destinations and being destination in the urban and global networks. The “network capital” is a sociological concept by John Urry that comprises of eight elements: 1) array of appropriate documents, visas, money and qualifications to move from one place to another; 2) workmates, friends and family at distance; 3) movement capacity; 4) free access to information at the location and contact points; 5) communication devices; 6) appropriate, safe and
secure meeting places; 7) access to transport and communication technologies; and 8) time and other resources to coordinate the other elements (Urry, 2007, pp. 197). There is a need of multilayered view on public transportation, multimodality and competition with the car.

Élisée Reclus (1905, pp. 85) described the cities as agglomeration of neighborhoods, each with its own unique life and form. Analogically the city is also an agglomeration of transport channels and flows where every bus line is unique and part of a larger network. It is either speedy or slower. It goes somewhere special, or just circles around. It connects to other lines or it is a main axis of mobility. There is a need of a new and multilayered view on urban form and flow, habitation and mobility that will join these two definitions and decrease the gap in specialization towards urban form in urban planning and design and urban flow in and transportation planning and engineering. There is a need understand the mechanisms and irregularities in urban environments and transportation systems through rules and narratives.

The network capital is equally a product of grand modern narrative of speeds, times and convergence of distant spaces, as of small narratives about public transportation and urban life. The symbolic capital of public transportation and neighbourhoods plays role in the network capital. For example there is symbolic distinction, but no physical difference is someone is on the bus 18 in London or on a double-decker in London. But the double-deckers in London have global significance. The symbolic distinction “rests on cognition and recognition”, since the “symbolic capital is a capital with cognitive base” (Bourdieu 1994/1997, pp. 85). The public transportation systems have symbolic value in cultures and societies, but there are no definite success stories by modes. Usually the small narratives make the difference. The subways in Los Angeles are occupied only by tourists on a way to Hollywood boulevard and has no symbolic capital in the automobile society of Los Angeles, whereas Stockholm’s Tunnelbana has profound symbolic value, not only for the Stockholmers, but also wider in Sweden. The list of nicknames illustrates the symbolic value of the Stockholm’s Tunnelbana: Tuben, Tricken, T-banan, Korven, Bullertranan, Banuliten, Vitolökpilen, Blåbulln, Snöret, Kloaksnöret, Vitolökexpressen, Sorken, Kommunalsnurran, Tubleroni, Socialsnöret, Kommuniststrafiken, Förseningshelvetet, Orientexpressen (for the Blue Line), Bunneltanan or Tunn Banan. The busways and double-articulated orange buses in Curitiba also have symbolic capital, which for example more expensive and technologically advanced bus systems like the Silver line in Boston have not achieved.
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environment. 36(3), 307-316.
Public transportation systems for urban planners and designers: the urban morphology of public transportation systems

Abstract
The ambition in European cities is to create an integrated, multimodal transportation system which fully exploits the potential of public transportation. The “compact city” and “multimodality” are new fashionable buzzwords. But many, especially smaller cities in Europe developed rapidly in the years of rapid motorization and decentralization of cities. These cities were designed for the private car and are dominated by individual mobility. The change from a city for a private car to multimodal public transport cities demands major urban transformation.

In this article the public transportation systems are seen through a perspective of a morphological concept in urban planning and design established by Kevin Lynch. The public transportation infrastructures are combinations of paths and nodes that disperse distinctive attractiveness pattern of desirability cores that shapes the neighborhoods. There are many examples of integration public transportation systems shaped the urban form. A “public transport city” is a section of a city that historically adapted to specific public transportation systems. There are four distinctive public transport cities which unfold consistent and unique urban form and mobility patterns. Each public transport city has different urban morphology with weaknesses and strengths important for urban designers, planners and developers especially when there is a need to introduce new public transportation systems in urban areas dominated by private cars.

Keywords: public transportation, urban planning and design, urban morphology, urban form
1 Introduction

The European response to the urban challenge of sustainable development is traced through the documents of the European Commission (EC) on urban environment, sustainable cities and urban transport since the 1990s. Derelict land, urban sprawl and quality of the urban environment were identified as major urban problems (EC, 1990:4) and the compact city and green city emerged as solutions. The compact city emphasizes urban intensity by setting urban boundaries, pursuing urban renewal and densification within these boundaries and connecting urban areas with public transportation systems. The urban expansion is halted to protect the surrounding environments thus creating a strong contrast between the city and the nature. The green city relies on environmental design, innovation and development of communities in order not to disturb the natural rhythms and landscapes (EC, 1998, pp. 6-7). The compact city revolves around urbanity and multimodality, historicity and creativity. It favors architectural heritage, by respecting rather than imitating the old, greater diversity by mixed uses and solving urban problems within existing boundaries of the city (EC, 1990, pp.30). The argument is that urban density and diversity are more likely to result into people living close to work places and services that are required for the everyday life (EC, 1990, pp.40). The ambition is to make the private car an option rather than a necessity (EC, 1990, pp. 30) by creating integrated, multimodal transportation systems which fully exploit the potential of public transportation (EC, 1997, pp. 11-2).

The “compact city” and “multimodality”, “intensification” and “mixing” are new fashionable buzzwords urban and regional planning throughout Europe, but the realities are different. Many, especially smaller towns and cities in Western and Northern Europe developed rapidly in the years of rapid motorization and decentralization of cities. The trend of urban decentralization spread eastward and southward during the second half of the 20th century (Hall, 1997). In the countries of Western and Northern Europe the modernism recipe of inhabiting, working, recreation and circulation advocated by Le Corbusier and CIAM (Congrès International d'Architecture Moderne) was vigilantly executed. The cities were shaped by an ideology of large scale suburban projects, controversial reconstructions and modernizations of the industrial and historical urban cores and major investments in roads and motorways. The Western and Northern European modern city developed as archipelagos of shopping districts, residential neighborhoods and industrial zones segregated by vast green areas for recreation or agriculture. The modern cities were designed for the private car by lavish parking regulations, traffic separation and extensive road hierarchy and today they are dominated by individual mobility.
The public bus emerged as preferred often only alternative to the private car during the modernization of European towns and cities. Buses were conceived as flexible and universally applicable. The buses use the same roads as the automobiles and trucks. They easily overcome obstacles and eventually reach their stops or stations by alternative routes. There is no place on the road network that is inaccessible by bus. The flexibility and universal overuse of buses prove to be devastating for public transportation in the smaller cities where the entire networks were planned with buses.

The general perception even today is that there is no need to plan for the bus. The urban planners and designers usually pin a bus stop and declare public transport accessibility by drawing a 400m radius. The buses are usually forgotten in the planning processes and as results of this negligence there are often lonely bus stops misplaced on motorways. The second more challenging problem is the competitiveness of buses especially in the smaller towns and cities. The smaller towns and cities today are equally fragmented and dispersed in their regions and interconnected by bypassing motorways as the larger cities in Western and Northern Europe. The buses serve long distances and they perform very poorly on the road hierarchies and motorways. They need busy streets and need to stop often. They need to pass though the neighborhoods that are designed with roads that allow traffic separation.

There is a need of changes to make the buses visible in the urban planning and design processes. A neighborhood within a 400m walking radius to a bus line with frequency of one bus per hour is hardly a viable public transportation alternative. Public transportation is often peripheral in urban planning and design. However the position of the private car on the other hand is as strong as always. For example the number of parking places is one of the strongest regulations policies.

2 The urban morphology of public transportation systems

Urban morphology revolves around urban form and the processes of formation and transformation of urban areas. It is a multidiscipline between architecture and urban design, geography and history, economics and politics. The scope of the definition varies from researching physical activities and form in two or three dimensional space to a study of processes, knowledge, power and actuation (Friedman, 1987). In its narrower definition within architecture and geography, urban morphology puts emphasis of study of physical form and
processes of its emergence and transformation. There are many schools, traditions and scholars even in the narrower definition of urban morphology. The British or Conzenian school originates from the work of geographer Michael R.P.G Conzen. The urban form is framed as a process, a temporal change of streets, plots and buildings (Conzen and Conzen, 2004) and the scholars primarily focus on the two-dimensional extend and representation of urban areas through historical changes in architectural styles. In contrast to the British school, the Italian school has strong architectural background inherited from the work of the Italian architect Saverio Muratori. The Italian cities changed architecturally throughout the history and the Muratorian school focuses on three-dimensional transformation, design, representation and interpretation of the architectural detail (Caniggia & Maffei, 2001).

The vantage point within the narrower urban morphology field is the American urban planner Kevin Lynch. With Lloyd Rodwin, he set a morphological tradition to look at the cities as adapted spaces and flow system (Lynch and Rodwin, 1958) or spaces and channels of flows. The activities occur and recur in adapted spaces that are linked by communications within channels (McLoughlin, 1969). Within the framework of urban space and flow, Lynch defined five urban elements that are cognitively recognizable: paths, nodes, districts, edges and landmarks. Paths are the channels along which the observer customarily, occasionally or potentially moves. They may be streets, walkways, public transportation lines, canals, railroads. Edges are the linear elements not used or considered as paths by the observer. They are the boundaries between two phases, linear breaks in continuity: shores, railroad cuts or walls. Districts are the sections of the city, conceived of as having two-dimensional extent, which the observer mentally enters “inside of” and which are recognizable as having some common, identifying character. Nodes are points, the strategic spots in a city into which an observer can enter and which are the intensive foci to and from which he is traveling. They may be primarily junctions, places of a break in transportation. Landmarks are another type of point reference, but in this case the observer does not enter within them, they are external: building, sign, store or tree (Lynch, 1960, pp.4).

The Lynch’s urban elements are conjoint by another district element and the edge element is modified to represent the morphological interrelationship between neighborhoods and public transportation infrastructures (Figure 1). The desirability cores are inspired by Stephen Marshall’s research on urban patterns (Marshall, 2005, Marshall & Gong, 2008). They show the peaks in desirability or attractiveness in one district in regard to the exits from the public transportation station or stop areas that are represented by nodes. The urban
areas around stations are also represented by districts with distinctive urban form. The challenge for urban designers, planners and developers when there is a need to introduce new public transportation systems in urban areas is to integrate the urban form with the desirability cores of the public transportation infrastructure and consider their barrier effects.

![Figure 1: Modification of Kevin Lynch’s urban elements to fit the representation of the morphological interrelationship between neighborhoods and public transportation infrastructures.](image)

The desirability cores have stretchy borders. They can shrink or extend depending on the design of the urban environments. They start when a person changes transport mode from public transportation to walking and steps out on a public transportation stop and station. The desirability cores are principally nodal. The exit door of a bus, tram or train is an initial vantage point in the space of a desirability cores, but they can elongate in amoebic shape if it is continues in attractive and walkable urban environment. For example flows and crowds of people trigger subconscious movement of a person in a crowd, extend the line of sight and add a sequence of new prospects.

### 3 The public transportation and cities

The urban form depends on the transportation infrastructures. The cities adapt, integrate or isolate transportation infrastructures. The unattractive motorways for example bypass the cities, but are very unattractive and the urban areas dispersed along the motorways, but separated by green areas. The bus lines and tramways elongate the cities by highlighting streets as urban corridors. The railways interconnect and disperse urban areas as beads on a string. By their effect on development on cities, there are basically three principal public transportation technologies (Table 1): 1) on streets (buses and trams); 2) completely separated, either elevated or on the ground (buses or trains on heavy railways or heavy busways); 3) underground (buses or trains in subways or tunnels); contributed by a hybrid of the three: 4) partially separated on ground (buses and trams on light
railways or light busways). The designation X shows the anchor whereas (X) ranges of the various public transportation infrastructures as technologies. I abducted the common distinction in transportation (light versus heavy) to define types of infrastructures. Heavy means always complete or full separation regardless if it is a bus or rail system. In reality there are only few examples of heavy busways whereas the railways naturally carry the heavy attribute. The light attribute is for systems are partially separated, or are partially on street or partially fully separated and the light railways and light busways also have same effect on urban form and structure.

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<th></th>
<th>On streets</th>
<th>Dedicated</th>
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<th>Fully separated on ground or elevated</th>
<th>In tunnel or underground</th>
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<td>Light busway (BRT)</td>
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<td>Subway</td>
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Table 1: Principal public transportation infrastructures and technologies

Two technologies concentrate over specialized infrastructures and excel either at urban scale as public transportation on streets or at regional scale as fully separated on ground or elevated public transportation. The underground public transportation excels on both scales but at very high cost. The hybrids, public transportation partially separated on ground also tend to have wide span claiming both domains with tradeoffs of cost, speed and capacity.

Each public transportation technology enables unique pattern of desirability cores beyond the network of paths and nodes. These morphological consistencies and regularities as four principal public transport cities (Figure 2): 1) the elongated and interwoven city; 2) the city of pearls; 3) the networked city; and 4) the compact city. In reality there are no exclusively or distinctively elongated and interwoven cities, cities of pearls, networked cities or compact cities according to the classification above. The cities are rather combinations of public transport cities that overlay and coexist simultaneously as public transport metropolises. The large Western and Northern European cities like London, Paris, Berlin, Copenhagen, Stockholm or Helsinki are example of public transport metropolises that throughout the history integrated continuously new public transportation infrastructures and technologies. Stockholm is one example. Stockholm’s subway and heavy
railways structuralize networked city and city of pears in its region, while the buses elongate and interweave its urban cores into corridors

City of pears by heavy railways and heavy busways

Elongated and interwoven city of bus lines and tramways

Compact city of light railways and light busways

Networked city of subways

Figure 2: The principal public transportation cities with the desirability cores

4 The morphological effect of the public transport cities

According to Kevin Lynch we make mental maps of territories as networks of districts accessible by paths through a sequence of landmarks. He refers to the concept as wayfinding (Lynch, 1960). The public transport cities historically unfolded consistent and unique cityscapes and networks of interwoven or isolated urban nuclei and corridors (Stojanovski et al., 2012). These historical artifacts are summarized, illustrated and discussed at urban and regional scale. The urban scale is determined by walking and sight. The regional scale is defined by mobility and cognition of accessible territories by availability and speed of motorized transport modes.
4.1 The elongated and interwoven city of the bus lines and tramways

The *elongated and interwoven city* of the bus lines and tramways emerged in the 19th century when the buses and trams struggled on the busiest streets forming attractive urban corridors. The buses and trams followed the people and the businesses. The additional bus lines and tramways folded new layers of people and businesses over the existing urban fabrique. The dense 19th century cities became denser and more congested as the public transportation on streets added capacity. The urban areas were fused and interconnected by bus lines or tramways. The desirability along public transportation on the streets is the street itself as elongated desirability core. The bus lines and tramways are fully integrated in the city without barrier effects and shape urban corridors. The distances between stops are often too small to achieve disturbance in attractiveness (Figure 3).

![Diagram showing desirability cores of bus lines and tramways.](image)

*Figure 3: The desirability cores of the bus lines and tramways. The representation with paths, nodes and desirability cores inspired by Kevin Lynch on the right of the common representation of lines, stations or stops and buffers.*

4.2 The railway city of pearls

The railways had profound effect on the urban form from the 19th century. Completely separated from the other traffic the trains are fast transport modes enabling warp transports which temporally glue distant place together and blur the spaces in between. Unlike the closely located bus and tram stops on the streets, the stations are nodes, *pearls on an impenetrable string.* They are placed at
distances that prevented overlapping buffers. This gives total and direct control over the accessibility between two places and enables temporal convergence of distant places. Every station opened a new spatially far, but temporally close urban area and the heavy railways or heavy busways enact monopoly over the direct access. The heavy railways or heavy busways unfold urban nuclei.

Figure 4: The desirability cores of the heavy railways and heavy busways. The type of station and the arrangement of exits from the station define the desirability cores.

The desirability around train stations is nodal and the attractiveness can vary depending if the train stations are on the ground, elevated or are termini (Figure 4). The position of the station exists, the shading and permeability profoundly affects the pattern of desirability cores. They have unique urban attractiveness which often starts where the station ends as a node. The heavy railways or heavy busways are segregated from the city and regardless if they are on the ground or they are elevated they cause severe barrier effects.
4.3 The networked city above the subway
The subways act much like monumental baroque diagonals and boulevards, just invisible to the city above. They interconnect and fuse spaces similarly as the railways. At terrible expense, they preserve the city above, protecting the traditional urban fabric and historical heritage. They rival or outperform any surface transport in the congested urban cores and they do not cause visual impacts as the elevated railway systems. They profoundly affect the vibrancy of urban life above, increasing speed and adding capacity that does not disturb the traffic flows on the ground. The subways have nodal attractiveness and the desirability core that depends on the exits and entrances from the underground. The exits are conjoint in amoebic desirability core and the illustration below is rather schematic. The station itself is part of the desirability core with urbanity and attractiveness that blends with the city above. The lack of barrier effects on the ground and underground produces desirability core as multileveled space (Figure 5).

![Diagram of subway desirability cores](image)

*Figure 5: The desirability cores of the subways. The desirability cores of the exits and entrances that blend with the city fuse in one desirability core as urban nucleus.*

4.4 The compact city along partially separated railways or busways
The light railways or light busways are usually realized as median on boulevards or major streets. As medians they are often partially segregated from the city and that causes some barrier effects. The urban design details define the strength of separation: from accentuation of the busways or railways by curbs to elongated parks and impermeable fences. The compact city advocacy revolves
around BRT and LRT and the tendency is to recreate the traditional European
city. But the urban form is much different than in the traditional urban cores.
The blocks are wider and the segregated sections of the busways and railways
block wide strolling over the boulevards. The attractiveness along the partially
separated light railways or light busways is a compromise between the
elongated core of the bus lines and tramways and the barrier effect of the heavy
railways or heavy busways. There are two elongated cores of highest
attractiveness centered on the sidewalks parallel to the light railway or light
busway (Figure 6).

Figure 6: The desirability cores of the light railway or light busways. Two elongated
desirability cores are within one urban corridor.

4.5 The mobility scale of public transport cities

The motorized transport allows for convergence of space and time and the
urban boundaries today are more a variable of time, than distance. The public
transport cities here are present from motorized and walking perspective, at
urban and regional scale. There are constrains in and temporal invariants in
travel behavior (Marchetti, 1994). The travel time budget is the time that we
spend traveling during one day. The empirical research of travel behavior
shows that it varies between 1 and 2 hours per day (Zahavi, 1974). The
invariant of 1 hour travel time per day is known as Marchetti constant and it is
considered as determinant of the radius of the city (Marchetti, 1994). Here it is
used to theoretically calculate the rounded distances that the public transport cities
can reach. At regional scale, the public transport cities unfold patterns of urban
nodes and corridors within some urban radius (Figure 7).
The urban radiuses of the four principal public transport cities compared to the motor city. The convenience of the private car and the speedy motorways allow daily travel distances up to 80 km in Sweden (Hagson & Mossfeldt 2008).

The public transportation on streets accelerates the urban life and enables elongation and interweaving of the urban flows in cities into attractive urban corridors. The omnibuses, cable cars, horse cars, trams or streetcars, motorbuses or commonly buses, trolleybuses or trolleys, are public transportation on streets. They are all modification of a same technology. If we consider capacity and speed they did not change dramatically with different propulsion systems. Hindered by the traffic on the streets, they are slow transport modes reaching 10-20 km/h average speed, thus delimiting the length of their lines to roughly 10 km. The radius of the elongated and internwoven city is therefore limited to around 10 km. The longer bus lines or tramways are usual, but they are not as attractive in regard to the travel time budgets of Zahavi or Marchetti constant. The lack of speed of the public transportation on streets is completed by a longitudinal attractiveness, urbanity and short walking distances. The buses and trams add vibrancy on streets, give pleasant urban vistas and create mobile public spaces.

The fully separated public transportation orchestrates discontinuity of urban fabric and regional existence as temporal convergence of distant places. The railways spread a pattern of urban nuclei in regions and usually use the shortest distance, by almost direct lines, to travel between them. The trains reach over 500 km/h today. The high speed railways (HSR) operate at average speeds of around 200 km/h. With these speeds, theoretically, the city of pearls can extend over 100 km. The urban radius of the city of pearls is set to 60 km here that roughly corresponds to the lengths of the suburban railway lines in the large European cities, for example Pendeltåg, RER or Overground lines in Stockholm, Paris or London.

The public transportation underground strengthens the poly-nucleated agglomeration of the historical cores of the cities by adding concentration and quick getaways. They act much like monumental baroque diagonals and boulevards, just
invisible to the city above. With speeds of more than 30km/h they can open, connect or establish urban nuclei. If we consider the average speed of subways in European cities the radius of a networked city can reach 20 km, but the theoretical size of a networked city is practically comparable to the city of pearls. The costs of tunneling within a radius of 100 km can be incredibly high.

The partially separated public transportation makes a tradeoff of the barrier effect of the public transport infrastructure and the attractiveness of the urban corridors. LRT and BRT on light railways or busways have an average speed of 20-30 km/h. The speed of the buses and trams on light railways or light busways is higher than public transportation on streets, but it is not possible to achieve high speeds because of the conflicts on intersections. It is also not possible to have high frequencies too, because it can cause stops at intersections.

5 The competitiveness with the private car
There are many urban areas in the Europeans towns and cities that are reliant on the private car. The challenge is to introduce competitive public transportation system that can replace the car. John Urry argues that the “public mobility” pattern of the 19th century will not be re-established in the future simply because the private car “produced and necessitated individual mobility based upon instantaneous time, fragmentation and coerced flexibility”. The post-car system “will substantially involve individualized movement that automobility presupposes” (Urry, 2007, pp.285). The real challenge for urban and regional designers, planners and developers is to create a network of urban areas interconnected by public transportation systems that can compete with the instantaneity and flexibility of the car. It is not a challenge to design public transportation systems, but cities where it is possible to take a slow and quick bus, direct or detouring. The knowledge of public transport cities, their weaknesses and strengths can be important. Each public transport city revolves around distinctive public transportation infrastructure and pattern of paths and nodes that has to be integrated with the city. They public transport cities can be superposed over each other and hybridize in many variations.

The competitiveness of the public transport cities with the motor city, the city of the private car, is considered here simplistically from narrow morphological standpoint by comparing infrastructures and travel speeds and times on different infrastructures. The competitiveness is usually calculated by travel time ratios, which are defined as the quotient of the travel time by private car and public transportation between same origins and destinations in the city. The empirical evidence from Stockholm’s region shows that if the travel time
ratio is 1-1.5, the share of the public transport is 50-70% (SLL, 2001). When the travel time and costs of a between a private car and public transport journey are equal, there are other factors like comfort or attitude that decide, but there are competitive public transportation alternatives. For easier calculation there is a table that shows the ratios in travel time speeds between different infrastructures (Table 2).

<table>
<thead>
<tr>
<th>Car speeds</th>
<th>Motorway</th>
<th>Wider streets</th>
<th>Normal streets</th>
<th>Smaller streets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>70-100</td>
<td>30-70</td>
<td>30-50</td>
<td>20-40</td>
</tr>
<tr>
<td>Motorway</td>
<td>50-70</td>
<td>1-2</td>
<td>0.42-1.4</td>
<td>0.42-1</td>
</tr>
<tr>
<td>Wider streets</td>
<td>10-30</td>
<td>2.33-10</td>
<td>1-7</td>
<td>1-5</td>
</tr>
<tr>
<td>Bus speeds</td>
<td>Normal streets</td>
<td>10-20</td>
<td>3.5-10</td>
<td>1.5-7</td>
</tr>
<tr>
<td>Smaller streets</td>
<td>10-15</td>
<td>4.6-10</td>
<td>2-7</td>
<td>2-5</td>
</tr>
<tr>
<td>Light busway</td>
<td>20-30</td>
<td>2.33-5</td>
<td>1-3.5</td>
<td>1-2.5</td>
</tr>
<tr>
<td>Heavy busway</td>
<td>30-40</td>
<td>1.75-3.33</td>
<td>0.75-2.33</td>
<td>0.75-1.66</td>
</tr>
</tbody>
</table>

Table 2: Span of speeds (km/h) and car/bus travel speed ratios on different infrastructures

The hierarchy of roads is described from European perspective as motorways, wider, normal and smaller streets. The motorways are segregated and have speed limit of 100km/h. The wider streets have 4 lanes and more (speed limit 30-70km/h), the normal streets between 2 and 4 lanes (speed limit 30-50km/h), whereas the smaller streets have 2 narrow lanes (speed limit 30-40km/h). Travel speed ratio is only a theoretical measurement showing the quotient of the private car and public transport speed. In practice the travel time is calculated as perceived that includes walking, waiting, in vehicle, transfer and egress time which are weighted by coefficients. The perception of waiting time is usually double than the time in vehicle and the perceived time can increase dramatically with all the penalties for walking, transfers and waiting. The table shows how much a motorway can make a difference in the competitiveness in one urban region even without taking in consideration penalties for waiting, walking and transfers in public transportation. Being 10 minutes in a car on a motorway would mean from 23 to 50 minutes on a bus or tram on light busway or light railway or between 3 to 33 minutes on a bus or train a heavy busway or heavy railway.

6 Conclusions

There are many ways to represent and conceptualize urban form and public transportation systems. The concepts presented here are simplified from a perspective of transportation planning and engineering. The modified Kevin
Lynch’s morphology is representational. It is made to make visible and overlay even very flexible bus lines and put them aside the urban areas and land uses, plots, buildings and streets in the urban and regional plans. This visibility helps to see the urban flows, urban forms and their interaction on maps. The desirability cores as urban details can be decisive urban catalysts, inducers and drivers for urban development around stops and stations. At urban scale the public transport infrastructure produce edges and cause barrier effects at urban scale (Figure 8). They do not only influence the creation of paths and flows of pedestrians, but also the patterns of districts. This knowledge is of particular interest those that want to plan livable places.

![Diagram of public transport infrastructure](Figure 8: Permeability and barrier effect of different public transportation infrastructures)

It is important to start with a vision of networked metropolis where the urban areas develop as future nuclei and corridors with layers of speedy and slower
public transportation systems. The private car establishes a flexible and convenient system that is deeply rooted beyond the need of movement and transportation in economy, society and culture. It can be used for slow and fast transportation, for short and long distances, to socialize, to dream about. It is available around the clock. A high share of public transportation can happen only if the public transportation systems are equally integrated with cities, everyday life and fantasy and vice versa.

Seeing morphologically it is important to understand the competition on public transportation through simple, but elementary infrastructural rules of nodes, paths and desirability cores at urban scale and possibility to reach urban areas at regional scale. The desirability cores are zones that interlink neighborhoods and public transportation infrastructures and systems and these are the most attractive zones in a future public transport metropolis. In the end there is a need to consider the temporalities as availability and diversity as need of sightseeing and warp via sociabilities, spectacles and daily lives. Much of the advocacy in Europe revolves around multimodality and the compact city, where LRT and BRT are universally applicable solutions. If we look at the European history, the principle of mixing different public transportation systems at urban and regional scale worked fine.

References
Pushing the urban edge: high speed public transports as future shapers of cities

Abstract
The cities throughout the history relied on transports to sustain their urban life. The different transportation technologies and the need for undisturbed flows of goods and people shaped the cities. The omnibuses, steam trains and electric trams revolutionized the transports in the 19th century only to be overtaken by the petroleum driven cars and buses in the 20th century. Many argue that there is an emerging public transportation renaissance in the 21st century. High speed trains and sophisticated super buses are new transportation technologies that have potential to push the urban edges over 100 kilometers from their historical centers.

The major challenge in cities is to introduce new public transportation systems and integrate them with the urban form. In this paper I look at the history of Swedish cities and their adaptation to transportation technologies. The future of public transportation infrastructures and their integration with cities is discussed via permeability and barrier effects, attractiveness cores and desirability, concepts that derive from the urban morphology of Kevin Lynch. There are different transportation infrastructures that historically pushed the urban edges and unfolded consistent patterns of mobilities, urban forms and structures. These regularities reveal possibilities and obstacles important for urban designers, planners and developers.

Keywords: Urban form, urban structure, public transportation, Swedish cities, integration
1 Introduction

Many Swedish towns and cities embraced the private car as a vehicle of modernization in the 20th century. In return it trigged innovation, new ways of industrialization and doing business, incredible economic growth and prosperity. The automobile brought convenient and mobile lifestyles to many. The Swedish modernism produced a consistent pattern of decongested historical urban cores transformed in business hubs or central business districts (CBDs), clone towns and tourist attractions, sprawled suburbs, suburban shopping centers, factory outlets and edge cities on the periphery. The architects, urban planners and designers vigilantly executed the modern city envisioned by Le Corbusier (1929/1987, 1943/1973) and CIAM (Congrès International d'Architecture Moderne). The urban life in the metropolitan archipelagos of many sprawled Swedish towns and cities would malfunction without cars and imports of petroleum. The lavish lifestyle and prosperity in the suburbs is threatened today by an apocalyptic vision of a future with depleted oil wells and junkyards of rusting automobiles.

High-speed rail (HSR), bus rapid transit (BRT) and light rail transit (LRT) in Sweden are discussed as attractive and speedy future public transportation systems that are more efficient and contribute to more sustainable patterns of mobility. The ambition is to make the private car an option in the cities, rather than a necessity (EC, 1990, pp. 30) by creating integrated, multimodal transport systems which fully exploit the potential of public transportation (EC, 1997, pp. 11-2). The model for postmodern metropolis depicts urban networks of sustainable compact cities and neighbourhoods that are interconnected with high-speed public transportation systems into polycentric urban regions. At urban scale there is emphasis on urbanity, intensification and mixing of urban activities. The argument is that urban density and diversity of the traditional or industrial urban forms are more likely to result into people living close to work places and services that are required for the everyday life (EC, 1990, pp. 40).

The emphasis on public transportation in the sustainable cities debate inspired many ongoing and finished proposals and projects for BRT, HSR or LRT in Sweden. There is an emerging public transportation renaissance in the 21st century, but the revival is driven by development interest. It is selective and targets specific cities and zones in cities. The focus on HSR is solely on the large Swedish cities and the smaller towns and cities that surround them. The developers at urban scale have target on specific zones in the Swedish towns and cities: greenfields in proximity to the industrial urban cores or specific
industrial zones around the city centers, a fringe of industrial city that is slowly being abandoned due to the deindustrialization caused by transnational capitalism (Luke, 1990). The postmodern metropolis is actuated as a model for sustainable neighborhood, a modification of historical city with attractive high-tech architecture, along multimodal boulevards with BRT and LRT systems as medians. BRT and LRT on multimodal streets are not high-speed systems. They are not competitive with the private car in the urban regions. The new postmodern metropolis model, like the Swedish modernism in the 20th century, produces a consistent pattern of urban corridors, where the multimodal transportation system is unsustainable.

There are consistencies in the Swedish or even broadly in the urbanization of Northern and Western Europe. The cities historically integrated with transportation systems that were preferred in different ages (Whitehand, 2001). The neighbourhood that developed in the ages dominated by public transportation integrated with the public transportation and it functions there even today. The automobiles and parking lots on the other hand dominate in the modern suburbs that were explicitly designed for the private car and individual mobility.

The artefacts of historical urbanization and integration of transportation systems is very important to understand the effect of transportation on cities and the consistencies in urban form that different public transportation systems leave. This knowledge is valuable to urban planners, designers and developers that faced with a challenge to introduce new public transportation systems and integrate them with existing urban forms. It is also an endeavour that ultimately tangles the traditional concepts of urban form and modern urban flow, where the form is rigid and the flow is dynamic. What can we learn from the history and periods of urbanization to broaden to prospect of introduction of more efficient public transportation system in the Swedish urban regions? Where are BRT, HSR or LRT positioned in the postmodern trends of urbanization? How did the cities integrated with public transportation in the history? What are the principal differences between the public transportation systems? How far the super trains (HSR) and buses (BRT) can extend the urban edges? What will happen to the other smaller cities that are out of the HSR urban networks? What will happen to the other parts of the cities that are not interesting to the developers and where the postmodern metropolis model is inapplicable?
2 Cities as form and flow

2.1 The cities as “extraordinary agglomerations of flows”

The cities are “extraordinary agglomerations of flows” today, not only of people on the move, but as other forms of mobility like flows of information, capital, values, norms and lifestyles (Ash and Thrift, 2002, pp.42). The cities cannot function today without a physical mobility by private cars and jets that propel the regional and global economy.

The physical flows in cities are enabled and hindered by transport infrastructures and systems. The concept of systems of movement was introduced by Robert Mitchell and Chester Rapkin in the book “Urban traffic - A function of land use”. The urban flow was a function of land use that was differentiated by the major activities of establishment based on the land. The term land use refers to buildings or other improvements on land, to the occupants or users of the land, to the major purpose of the occupancy of the land or to the kind of activities on the land (Mitchell and Rapkin, 1954, pp.13). It triggered a tradition of looking at cities as urban systems. Kevin Lynch and Lloyd Rodwin (1958) used the systems theory to conceptualize urban form. The physical form of cities was described through the flow system, excluding the flow itself and distribution if adapted spaces. Within the urban system there are activities that occur and recur in adapted spaces and are linked by communications through channels (McLoughlin, 1969). Land use is defined by urban activity and the interaction with transportation was a feedback cycle between the transportation system and the land use (Wegener, 1994). The concept of feedback loop was introduced in the book “Urban dynamics” (Forrester, 1969).

The movement of physical flow of people in a transportation system is channeled within a network, along the line or it is free within an area. The public transportation systems are linear, but they can achieve network effect by temporal coordination in the transfer points from one line to another line. The private car is predominantly network-based system. There is an instant network effect because within the network every destination is accessible from every origin. Cycling is a hybrid system that shifts between a network and area on streets and squares. Walking is an area system, but Lynch (1960) argues that the movement in cities is through consistent paths, by “wayfinding” and orientation to landmarks. There is a mental map of network of paths within an area. The transportation modes also change perception of reality. Driving triggers an engaged, a “flow” mode of thinking (Csikszentmihalyi, 1990). The
drivers neglect the spatial and the urban environment to focus on the flow, traffic signs, turns and stops. Walking evokes sense of space and orientation in space. Then the quality of the urban environment and what is going around matters. Public transportation is a hybrid system that shifts between “flow” and “sensing space” mode. The groups of people evoke the flow mode. The public transportation also includes walking and it is a mobile space where the “sensing space” mode comes out.

2.2 Representations of form and flow

The representations of physical space and flows of cities vary from algebraic formulas or topology and matrices, to geometric symbolical diagrams and accurate drawings and maps (Marcus, 2011). The representations on paper include two principal viewpoints on cities (Cecchini and Rizzi, 2001): within or inside the city (perspective), or from the top (plan).

The classical representation of the urban form includes patterns of streets, plots and buildings that are shaped by the society and its economy (Conzen & Conzen, 2004). In another conceptualization the urban space is defined by a pattern of buildings, streets and squares (Krier, 1979, Krier, 1984). In Space Syntax there are specific viewpoints in the urban space, from which the city is observed, that turn into axial spaces and shape convex spaces and isovists. The axial spaces are represented by centroids in a graph diagrams and axial lines on maps (Hillier et al., 1984).

The physical flows in cities are represented within the edges of streets from the classical representation of the urban form, by topology of spaces and graphs in Space Syntax and hierarchy of flows in transportation engineering and planning (Marshal, 2005a, pp. 16), but also by sequences of images and serial vision through urban spaces (Cullen, 1961). To represent a serial vision of three dimensional spaces I joined plan and perspective (Figure 1) in one planar representation of space.
Within the framework of urban systems, space and flow, Lynch (1960, pp.47-8) defined five elements: paths, nodes, districts, edges and landmarks. The transportation systems are paths and nodes that produce barrier effect as edges. In context of public transportation there are desirability cores too. They show the peaks in attractiveness in regard to the exits from the public transportation stop or the dispersal and grouping patterns of passengers in public spaces around the exits of the stops in reality. I use paths, nodes, districts and desirability cores in the districts as elements to map the shape of the morphological interrelationship between urban areas and transportation infrastructures (Figure 2).

Figure 2: Modification of the elements by Kevin Lynch urban to describe the morphological overlay of urban areas and transportation infrastructures.

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**Figure 1: Representation of within, top and top-within view (Stortorget, Stockholm).**

Within view (perspective)

Top view (plan)

Top-within view (plan perspective)
3 Public transportation and cities

3.1 The principal public transportation technologies

The public transportation dominated the industrial society. Four principal technologies emerged and shaped the cities during the industrialization in the 19th century: 1) public transportation on streets (buses and trams); 2) completely segregated, either elevated or on the ground (buses or trains on heavy railways or busways, HSR or BRT); 3) underground (buses or trains in tunnels); contributed by a hybrid of the three: 4) partially segregated on ground (buses and trams on light railways or busways, LRT or BRT). The common distinction in transports light versus heavy was abducted from transportation engineering and planning. Heavy means always complete or full segregated from a street regardless if it is a bus or rail system. The traditional meaning of heavy and light in transportation planning and engineering designates volumes of traffic. The segregation allows for heavier volumes of traffic.

Each public transportation technology has consistent effect on the urban form and pattern of desirability cores in urban space. These desirability cores as amoebic nuclei or corridors exist as historical artifacts in many European metropolises. The public transportation on streets accelerated the urban life and enabled elongation and interweaving of the cities. They created urban corridors along the bus lines and tramways. The fully segregated public transportation orchestrates discontinuity of urban fabric and regional existence by temporal convergence of distant urban areas. The railways dispersed and fragmented the city in its region. The public transportation underground strengthened the polycentric agglomeration of the existing cities: the subways fused urban nucleuses in a network similarly as the boulevards in the industrializing European cities, just without disturbing the city above. I refer to these regularities as: 1) the elongated and interwoven city of buses and trams; 2) the city of pearls along heavy railways and busways (HSR and BRT); 3) the networked city of subways; and 4) the compact city along light railways and busways (LRT and BRT). Today in reality there are no exclusively or distinctively elongated and interwoven cities, cities of pearls, networked cities or compact cities according to the classification above. The cities are rather combinations that overlay and coexist simultaneously. The large European cities like London, Paris, Berlin, Copenhagen, Stockholm or Helsinki are examples of public transportation metropolises that continuously integrated new public transportation infrastructures and technologies throughout the history. Stockholm is an example where there is regional hierarchy: the subway and heavy railways structuralize networked city and city of pears in its region, while the buses elongate and interweave the urban core.
3.2 The elongated and interwoven city by public transportation on streets
The omnibuses, cable cars, horse cars, trams or streetcars, motorbuses, trolleybuses or trolleys, are public transportation on streets. They are all modification of a same technology. If we consider speed they did not change dramatically with different propulsion systems. Hindered by the traffic on the streets, they are slow transportation modes reaching an average speed of 10-20 km/h. The length of the lines is limited to roughly 10 kilometers which is the limit of the radius of the elongated and interwoven city of the buses and trams. The public transportation on streets unfolds urban corridors. The lack of speed of the public transportation on streets is completed by lack of barrier effects.

3.3 The city of pearls along fully segregated public transportation
The fully segregated public transportation orchestrates discontinuity of urban fabric and regional existence as temporal convergence of distant places. The railways spread a pattern of urban nuclei in regions and usually use the shortest distance, by almost direct lines, to travel between them. The trains reach over 500 km/h today. HSR operate at average speeds of around 200 km/h. With these speeds, theoretically, the city of pearls can extend over 100 kilometers. The urban radius of the city of pearls is set to 60 kilometers that roughly corresponds to the lengths of the suburban railway lines in the large European cities (Pendeltåg, RER or Overground lines in Stockholm, Paris or London). The heavy railways and busways produce strong barrier effects and the desirability cores depend on the exits from the bus and train stations.

3.4 The city networked city above the public transportation underground
The public transportation underground strengthens the agglomeration of the historical cores by offering quick getaways within or to the suburbs. With speeds of more than 30 km/h they can open, fuse or establish urban nuclei. If we consider the average speed of subways in European cities the radius of a networked city can reach 20 kilometers, but the theoretical size of a networked city is practically comparable to the city of pearls. There no barrier effects and the desirability cores depend on the location and exists from the subway.

3.5 The compact city along partially separated public transportation
The partially separated public transportation makes a tradeoff of the barrier effect of the public transport infrastructure and the attractiveness of the urban corridors.
LRT and BRT achieve an average speed of 20-30 km/h on partially segregated busways or railways. The speed of the buses and trams is higher than on public transportation on streets, but it is not possible to achieve high speeds and high frequencies and have a closed system because of the conflicts at intersections.

4 Representations of public transportation systems

4.1 The urban form and flow perspective

The public transportation technologies are represented as paths, nodes and desirability cores on map by using the modified elements by Kevin Lynch (Figure 3) or conceived as models for urban design (Figure 4). The desirability cores depict continuous space as a serial vision of photographs (Cullen, 1961) or a sequence of top-within perspectives (Figure 1). It is a district within a district phenomenon in sense of the elements by Kevin Lynch inspired by the research on urban patterns of Stephen Marshall (Marshall, 2005b; Marshall & Gong, 2008).

The desirability core starts when a person changes transportation mode to walking and steps out on a public transportation stop. The exit door of a bus, tram or train is a starting vantage point in the space of a walk through the desirability cores. The desirability cores have stretchy borders. They can shrink or extend depending on the design of the urban environments. They can elongate in isovist shape if it is continues in attractive urban environment that does not disturb the serial of urban images. For example flows and crowds of people trigger subconscious “flow” mode of thinking and movement of a person, extend the line of sight and add a sequence of new prospects and overlaying isovists.
An isovist is the set of all points visible from a given vantage point in space with respect to the obstacles and voids in the line of sight in one environment. The shape and size of an isovist is liable to change with position of the observer (Benedikt, 1979). The isovist concept has been further developed within Space Syntax into convex and axial space: space delimited by edges of buildings and possible paths or axial lines between buildings (Hillier et al., 1984). The crowds, invisible exits and entrances in attractive urban environment fuse convex and axial spaces.
4.2 The urban structure perspective

The city revolves around central places and directions. The urban flows concentrate around one or many central points, elongate along directions or interweave on intersections of directions. These regularities are captured by the three classical urban models: concentric rings, sectors and multiple nuclei (Harris and Ullman, 1945; Ehlers, 2011). The importance of transportation is visible in all of them. The urban rings extended by increasing speeds of transports; the cities elongated along transport axes or grew around nuclei at transport foci or breaks of transports. The transportation systems have scaling, agglomeration, elongation or dispersal territorial effects. They can agglomerate
nuclei. They can expand one nucleus by scaling or elongate it in a corridor or ribbon. They can scatter urban nuclei. The principal public transportation technologies historically unfolded consistent urban structures (Figure 5).

Figure 5: Structure of urban areas in one region shaped by different transportation technologies

The effect on the city depends on the hierarchy of the traffic flow and the capacity of the transportation system. The highly prioritized and recognizable traffic flows as motorways or easily identifiable lines in public transportation have effect on the structure of urban areas. Traffic flow and capacity are complex concepts in transportation planning and engineering. I simplified their dynamics by considering a single variable, an average speed that defines maximum distance reached by a public transportation line. The motorized transport allows for convergence of space and time and the urban boundaries blurred. The urban life is more a variable of time, than distance, experienced by mobility before propinquity (Webber, 1964). There are constrains in mobility and temporal invariants in travel behavior (Marchetti, 1994). The travel time budget is the time that we spend traveling during one day and the empirical research of travel behavior shows that it varies between 1 and 2 hours per day (Zahavi, 1974). The invariant of 1 hour travel time per day is known as
Marchetti constant and it is considered as determinant for the historical change of urban boundaries. The distance from the urban centre to its periphery is defined by the speed of transportation (Von Thunnen, 1826/1966; Marchetti, 1994).

![Diagram of urban radiiuses of transportation technologies](image)

**Figure 6: Urban radiiuses of the transportation technologies**

## 5 A retrospect to the Swedish urbanization

### 5.1 Urbanization of fringes extending outward

The towns and cities in Northern and Western Europe expanded outward in distinctive fringe belts characterized by different periods of urbanization (Whitehand, 1967; Whitehand & Morton, 2003). The Swedish urbanization was not exceptional from the pattern. Each fringe was a front of urban development preconditioned by innovations in business and industry, technology and society. In each period the society was equipped with more advanced communication, information and transport, manufacturing and building technologies that shaped cities, lifestyles and mobilities. There are four distinctive periods of societal changes that triggered waves of urbanizations as fringes. They are referred more generally as traditional, industrial, modern and postmodern cities (Figure 7). In a Swedish context these eras are characterized as pre-industrial, industrial, welfare and knowledge society (Engström and Cars, 2008).
Traditional city

Industrial city and its fringes

Modern city and its fringes

The fringes of the postmodern city

Legend

- Plots
- Buildings
- Streets
- Tramway

Core | Redevelopment/new core/new periphery | New cores in the region (creative cities) | Annexed cores/new periphery of small towns and cities | New periphery (global industries)
Figure 7: Diagramatic representation of the Swedish urbanization from the traditional city, industrialization, modern city to postmodern in regard to transportation technologies (expanded from Cars & Egypt, 2008).
The consistencies are visible if neighborhoods from different ages are presented in respect to the distance from the traditional urban cores. The analysis of 55 neighborhoods in the small Swedish city of Karlstad shows that there are not only regularities in respect to distance, but also to urban density as number of inhabitants and work places per hectare (Figure 8). These results are repetition of the research done by Johan Rådberg (1988; 1996; Rådberg & Friberg 1997).

Figure 8: The longitudinal extension of the urban fringes in respect to the network and Euclidean distance from the traditional urban core by using the Swedish typology of neighborhoods.

The Swedish societies do not follow each other, but there are modernizations, returns to traditions and mixing in different parts. It is dynamic process of development, decay and refurbishment. There are models within the model with the emergence of new urban cores in the modern age. Each new modern urban core resets its position in the model (Figure 8).

5.2 Traditional society and its urban cores

The Swedish urbanization has a long tradition of urban planning. Even the traditional cities developed according to urban regulations and laws. They were growing densely on small hills, rivers and waterfronts as wooden cities or trästäder. The increasing densities in the wooden cities caused disastrous fires in the 17th century. The risk of fires demanded better regulation, division of the city by wider streets and new stone buildings as in the traditional urban core of
Stockholm. The Swedish stone cities or *stenstäder* with rectangular street network emerged. The street in the traditional Swedish towns and cities was designed for walking and small volumes of traffic of carts and carriages. The main streets were 10-12 meters wide like Stora nygatan in Stockholm or Västra hamngatan in Gothenburg, whereas the side streets were narrower, but slightly larger than in the earlier wooden or *stone cities*. The traditional Swedish society was predominantly rural. It revolved around communities and agriculture, sustenance and perseverance. The city was a business and trade hub inhabited by merchants, bankers and nobility in a region of villages, mines and industries. The flows on boats and ships on natural waterways shaped the urban life and economy in the traditional Swedish towns and cities. The *traditional* Swedish cities relied on walking, carts and coaches, horses and oxen for transportation until the 19th (Figure 9)

5.3 The fringes of the industrial society

The Swedish industrial society started from the middle of the 19th century. New industrial cities as Norrköping and a fringe of factories and industrial zones in Stockholm emerged already in the 17th century when Dutch capital entered Swedish iron mining and industry. But the industrial society started much later and in context of accumulation of capital by Swedish industrialists, bankers and entrepreneurs. The speedy urbanization and transport revolutions, the omnibuses and railways, shaped the industrial Swedish towns and cities. The business and economy was propelled by Swedish capitalists. The capital accumulated in cities shaped two very different fringes or cityscapes of the industrial city that began to stratify and suburbanize on the end of the 19th century. Two different ways of urbanization emerged that reflect the praxis of Swedish planning. Sweden was divided in 1868 on *städer or cities*, *köpingar* or market towns and *landskommuner* or rural municipalities. The Swedish *cities* were obliged to draw urban plans and set urban regulation by the Building Act from 1874, whereas the development in *rural municipalities* was not regulated by urban plans. The urban planning and design of the industrial urban cores was largely influenced by the renovation of Paris by Baron Haussmann in the mid 19th century. The industrial urban cores are characterized by patterns of enclosed urban blocks regulated by standardized building heights and widths of boulevards and streets. The main streets and boulevards were 18-30 meter wide, like Odengatan and Karlavägen in Stockholm. Johan Rådberg (1988) drawing inspiration from Françoise Choay (1969) conceived these two urbanization trends as separate paradigms or doctrines: *regulation or regularism* and *garden cities* or *trägårdstäder*. Another interpretation of the two urbanization patterns is urban adjustment to two public transportation technologies that dominated and coexisted in that time: buses and trains.
The industrial core regularized, became incredibly dense and interconnected by a network of wide boulevards and streets, omnibus lines and tramways, whereas new neighborhoods with villas and garden cities or villastäder and trägårdstäder emerged in the Swedish landscapes, very much influenced by the American and English railway suburbs. The traditional urban core was surrounded and intersected by a fringe or residences, universities, schools, factories, warehouses and ports. The manufacturing, research and invention took place in a filthy, polluted and congested industrial core. The second cityscape depicted villas in nature. The richer moved to new garden suburbs which were connected to its industrial core by roads or railways, private coaches or public trains.

The industrial urban life in Swedish cities relied either on walking or on public transportation and the cities became incredibly dense and overcrowded regardless if they were small or large. The cities with buses and trams grew faster and evolved urban promenades and corridors and developed garden cities along the tramways or bus lines. The garden suburbs in the cities without tramways or bus lines emerged in proximity to the industrial urban cores, usually separated by a green or blue fringe. Stockholm was the only city in Sweden where the garden suburbs were developed at distance and served by railways as new periphery far in nature. The garden suburbs survive until today and they are as attractive as in the 19th century. The urbanization during the industrialization of a constellation of smaller Swedish towns or cities like Karlstad where there was limited development of public transportation is illustrated below (Figure 8) in contrast to the growth of a large Swedish like Stockholm with extensive network of suburban railways and industrial garden suburbs (Figure 10).
Figure 9: The constellation of smaller towns and cities during the industrialization (-1930s)
Figure 10: The urbanization of a Swedish large city during the industrialization (-1930s)
5.4 The modern society of cores and peripheries

The industrialization brought improved sawmills, ironworks and brickworks, and new transport modes: omnibuses from 1830s, steam trains from 1850s, horse trams from 1870s and electric trams and railways from 1890s. The railways allowed quicker transportation and flows of goods and the Swedish cities boomed. The urban population in almost all cities either doubled or increased four times from 1840 to 1880. The population doubled from 1880 to 1900 and one more time from 1900 to 1940 (SCB, 1969). The industrial city was unpredictable and explosive in its density and congestion and troubled by class conflict in Marxist sense, between capitalists and proletarians. The solution in Sweden was the welfare state, driven by capitalism, but highly taxed and controlled by politicians from the left that formed national government in 1932 and dominated the politics of the mid 20th century. The left politicians got a power and capital to invest in social welfare and expand the influence of bureaucracy into the “public sphere” (Habermas, 1989). The Swedish public sector established a “system of automobility” in the spirit of Fordism. The private car propelled the Swedish modern society. It became a privilege of the working class and a driver for innovation, industrial development and growth. The new taxes from the industry were invested by the public sector in new suburbs with high standard of living and that triggered a demand for new cars. The working class in the modern society emerged as wealthy suburbanites copying the lifestyle of the industrial rich.

By the official statistics from SCB the Swedish economy grew four times from 1950 to 1990 while the car traffic increased tenfold. Roughly one million new single family houses were constructed from 1941 to 1990 and almost two million new apartments in multifamily houses from 1946 to 1990. The Swedish population increased by two million inhabitants from 1940 to 1990, while the number of cars increased by four million. The modern suburbs emerged in the 1930s as solution for improved quality of life and alternative to the polluted industrial city. During the 1950s they were industrialized as ABC city. A means arbete (work), B bostad (residence) and C centrum (center). The ABC city consisted of dispersed urban areas specialized for work, residence or leisure. It was a Swedish transcript of the recipe for habitation, work, recreation and circulation recommended by Le Corbusier in the 1920s and CIAM in the 1930s and it was executed by architects like Uno Åhrén and Sven Markelius. The urban cores of the 19th century, which relied on walking or public transportation, were depopulated, partly modernized with new architecture and bypassed or pierced by motorways. New modern ABC suburbs emerged everywhere in Sweden. The suburbs were prefabricated and assembled with incredible speeds. An
extensive network of motorways and roads interconnected the modernized urban cores and the new modern suburbs. The private car allowed for temporal convergence of urban areas into urban regions blurring the image of the traditional and industrial city. The proletarians and petit bourgeoisie of the *industrial society* quickly motorized and flocked in the fashionable modern suburbs.

During the second half of the 20th century the Swedish cities lost its population densities from the *industrial society*, decentralized, sprawled and fragmented. The modernization included removal of the electric trams from the industrial urban cores. By 1970s there were no tram systems left except in Gothenburg and Norrköping. Without trams or suburban railways the smaller cities developed ABC cities along the motorways. They were serviced by buses, but the buses did not perform well on motorways and in the dispersed cities (Figure 11). The car, bus and truck and the subway or Tunnelbana in Stockholm were preferred transportation modes in Sweden. The ABC cities oriented towards the Tunnelbana in Stockholm, in the small cities they were located along the motorways. The expansion of a fictional large Swedish city in the 20th century was illustrated by the artifacts in Stockholm (Figure 12). Stockholm preserved its tradition of suburban railways and regional public transportation network with the Tunnelabana and new suburban railways at higher speeds and capacities. In contrast to Stockholm, Gothenburg invested in trams. The trams in Gothenburg had limited radius of 10km and could not compete with the private cars on motorways in its urban region. Gothenburg sprawled along the motorways since the 1940s.
Figure 11: The urbanization of a constellation of smaller modern towns and cities (1930s-) with future zones for HSR and BRT
Figure 12: The urbanization of a modern Swedish large city (1930s-) with future zones for HSR and BRT
5.5 The global reach of the postmodern society

The modernity spans its roots and inspiration to the ages of enlightenment and exploration and today it extends on global scale. It revolves around rationality and universality, science, time and standards. It mystifies forces of “world culture”, future awareness, cybernetic control and automation based on scientific and technological knowledge (Luke, 1990). The postmodernism emerged as critique of standardization, mechanized scale and control. It is multifaceted: environmentalism, anarchism, collectivism and conservation stand together with the modern pursuit of individuality, standards and norms, profits and consumption. In the postmodern city the tendency is to mix, but do not abandon the modern. It breaks the modern suburbanite stereotype, but not completely apart from it. The dominating middle class splits in subcultures: suburbanites, urbanites and suburban urbanites. It is not about alienated individuals and actions, but about actors and networks (Latour, 2005). The knowledge society is post-Fordist. It revolves around small scale, fantasy and virtual realities, uniqueness, being online, mobile and informed. Invention like Facebook, Twitter, Sportify start small, but become accepted very quickly and had global effect. They network people, shape lifestyles and sociabilities. The interest to drive and own a driving license decreases in many countries. The percentage of driving licenses in the age group from 18 to 30 years in Sweden decreased between 50% and 10% from 1984 to 2008. Similar trend is visible in the USA, but not in all Northern and Western European countries. In Finland and the Netherlands the trend is opposite (Sivak and Schoettle, 2011).

The emerging knowledge society is a mix of individual and global, standard and uniqueness, innovation and retro, consumption and environmentalism. Since the 1990s, the “system’ of automobility” is contributed with new global systems of communications that breaks the cybernetic control of modernity. Its urban realm is worldwide, endless and interweaved with digital technology. It is brought into existence by massive globally extended sets of systems and infrastructures (Graham, 2004). The postmodern consumption is a mix of farmer markets and products “Made in China”. New mobilities emerge as shifting between private car and public transportation, shared cars and private rapid transit, cheap airlines and private jets. The postmodern city of Western and Northern Europe has several fringes or development zones. The first fringe is the abandoned zones of factories, warehouses and ports of the industrial city (Figure 12). The science edge cities are embryos of the emerging knowledge society that are interconnected with the central business districts and sky cities or “aeropolises” (Urry, 2007) that are developing next to the
airports are the second front. The third periphery is not anymore in the urban regions. It includes zones of fields, factories, warehouses and ports far away that manufacture, transport, store and distribute goods for global consumption (Figure 8).

6 The introduction of new high-speed public transportation systems in the postmodern Swedish towns and cities

6.1 HSR projects and initiatives
In Sweden, as almost elsewhere in Northern and Western Europe, there is a postmodern public transportation renaissance. There are many initiatives, ongoing and finished projects for high speed rail (HSR). In European context HSR are primarily applied for connections between larger cities and airports, but also in direction to enlarge the polycentric urban networks. In Stockholm there is already a HSR to the airport and there is a new railway tunnel under construction for more high speed trains on the central station. Adding more frequent HSR service allows commuting at longer distances and in Stockholm there is a regional plan to annex the smaller towns and cities within a radius of 100 kilometers (SLL, 2010). These new high speed connections between Swedish cities are discussed as new urban networks and enlargements of urban regions (Cars & Engström, 2008).

HSR in Europe functions much as the waterways in medieval Europe. HSR connects major cities. The trains bring business, passengers and tourists, but they are isolated from the modern cities and suburbs where the urban life is by zones of offices and hotels. These postmodern HSR urban centers are business and transportation hubs, depopulated nodes and transfer points. The introduction of high-speed public transportation systems must consider repopulation, not only new offices, shopping centers and hotels around the major train stations served by HSR. Without adding population in the nodes and their desirability cores the strengthening of the business and transportation hubs causes urban sprawl at distance that adds extra transfer points. In Netherlands the train stations in Rotterdam and Utrecht are under major redevelopment. They are strengthened as major urban nuclei on the Thalys HSR network. But there is a need for metropolitan HSR network that will serve population centers within the urban regions. Without adding population in the HSR nodes and their desirability cores the strengthening of the business and transportation hubs causes urban sprawl at distance that adds extra transfer points.
The bus analogy is the HSR concept of BRT with super buses and busways interconnecting a constellation of small towns and cities into BRT metropolis, a replica of the European public transportation metropolises with automated super buses running on different bus infrastructures. This concept is not discussed in the smaller towns and cities in Sweden that are business hubs in large urban regions of sprawled modern suburbs dominated by individual mobility. There are regional public transportation authorities in Sweden that have bus service between small cities, but these services are infrequent to achieve a sense of an urban network. The bus stations are also vast gray fields of asphalt that are not very attractive for passengers or businesses and the buses are not sophisticated. The buses have the mobility potential to extend the public transportation up to 60 kilometers similar as the trains today. In Stockholm the line 676 is a system of bus stops on the motorway that terminates in Nörtälje. The distance is 67 kilometers and there are ten stops. The buses drive with average speed of 60 km/h and arrive in Nörtälje in roughly 1 hour. The line 676 is a candidate for BRT metropolis development if the bus stops on the motorways develop as urban nuclei following the urban morphology of paths and nodes that unfold distinctive desirability cores and cause barrier effects.

### 6.2 The renaissance of BRT and LRT

The HSR discussions are complemented with development of new sustainable suburbs along BRT and LRT systems on the fringe of the historical urban cores. In Europe BRT is often understood as quality bus or bus with a high level of service (BHLS). BRT and LRT are entangled in the advocacy for compact city and new urban networks. This advocacy targets the redevelopment of the abandoned industrial fringe and development of new sustainable suburbs on greenfields. BRT and LRT are regarded as urbanity-empowering and more attractive since they do not cause barrier effects as the fully segregated railways or busways. BRT/BHLS and LRT are also forwarded as universal solution for smaller towns and cities or for new orbital suburbs in the large cities. Douai is a small city in France with a busway that connects the train station in the city with two radial directions. Similar proposal is negotiated in Karlstad in Sweden. A new urban ring is under development in Stockholm with LRT as orbital public transportation axis. Similarly in Gothenburg the northern part of the urban ring is actuated along orbital busway. There are new orbital urban corridors or urban fingers extending from the industrial urban cores along the LRT or BRT/BHLS lines in Paris, Amsterdam, Eindhoven, Helsinki and Copenhagen too. The compact city model with LRT or BRT/BHLS is widely replicated by developers.
The problem is that LRT or BRT/BHLS are urban systems, they extend to 15 km and they are viable solutions for orbital and feeder connection in the large cities to a limited distance. It is not only important to design a sustainable urban form, but also to understand and enable sustainable urban flows from the neighborhood. The Tvärbana, LRT system operating on partially segregated railway in Stockholm, is orbital and there is no direct connection to the city center of Stockholm by quick regional public transportation system. The inhabitants of Hammarby Sjöstad need to do an extra transfer to the Tunnelbana, the subway system in Stockholm. That caused an ongoing debate to extend a branch of the Tunnelbana to Hammarby Sjöstad. This station will make Hammarby Sjöstad a node in the major urban flows within the region.

6.3 Introduction of new public transportation infrastructures

The postmodern knowledge society in Sweden is in its embryo, but it demands multimodal transportation connections and urban networks. HSR, BRT and LRT are speedy advancements of the trains, buses and trams, but they have to go beyond its industrial or modern application. John Urry argues that the “public mobility” pattern of the 19th century will not be re-established in the future. That pattern is irreversibly lost because of the character of the “system of automobility” (Urry, 2004) that “produced and necessitated individual mobility based upon instantaneous time, fragmentation and coerced flexibility”. The post-car system “will substantially involve individualized movement that automobility presupposes” (Urry, 2007, pp.285). The private car is very flexible and convenient transportation system. It can be used for slow and fast transportation, for short and long distances. It is available around the clock. The new public transportation systems have to achieve this availability in order to really push the urban edge and produce future urban networks of the postmodern city. The public transportation and wired societies are compatible. In its embryo the IT industry is flirting with the “system of automobility”. Google needs people that click or touch and look at the computer or smart phone screen. This is a reason to develop a driveless car. Driving deters potential customers from being online. No one discusses driveless buses on streets and busways or automated BRT. How would that look like? Where can that fit? How will they affect the cities? Just imagine if most of the people live around public transportation modes where the traffic is automated, coordinated and perpetual. Similar conditions of perpetual public transportation exist for example in the European metropolises. The minimetro in Copenhagen, which is basically automated LRT is one system in that direction. With Google’s “driveless bus” this is possible on a range of infrastructures.
The postmodern visions of automated BRT or LRT are more exciting trigger of discussion about future development and transformation for urban planners and designers than the historical buses and trams. The urban fringes and expansions outward coexist and the processes of adaptation of urban form and transformation must consider all the fringes in Swedish cities, not only the regional and global fringes of transnational capitalism in today’s postmodern society.

7 Conclusions

To achieve sustainability there is a need for a broader view on Swedish towns and cities in respect to their historical urbanization and future integration with public transportation systems and by considering both form and flow aspects. The model for a postmodern city preferred by the developers in Sweden and around Northern and Western Europe is inapplicable in the industrial urban cores and modern suburbs. The future challenge is not to be immobile, but to be sustainable mobile by using more efficient transportation modes like high-speed public transportation systems. The model revolves assumes walking as in the traditional city, but the modern society is motorized. BRT and LRT on multimodal streets are not high-speed systems. They are not competitive with the private car in the urban regions. The model often fails to contribute to more sustainable mobility in the new neighborhoods. The private car is the unsustainable transportation choice that prevails. The prospect of introduction of more efficient transportation technologies must consider public transportation systems though a postmodern mix of traditional urban form and modern urban flows via a prism of fringes of urbanization and regional and global business and transnational capitalism (Luke, 1990) that shapes postmodern urbanities.

HSR, BRT and LRT are speedy advancements of the trains, buses and trams. They can extend the urban edges and open urban nuclei at a distance of 100 kilometers or extend the historical urban cores. But they have to go beyond its industrial or modern application. The postmodern visions of automated BRT or LRT must reach urban planners, designers and developers and contribute to more varied actuations of the compact city. It is important to use methods from urban morphology to design or transform the urban areas for public transportation. The modified elements by Kevin Lynch and introduction of desirability cores, flows of pedestrians in urban space, help to represent the effect public transportation infrastructures on urban areas on a map. The desirability cores are also fuzzy hypothetical models of integration of public transportation
infrastructures in cities. This is useful information to urban planners, designers and developers to understand the potentials and obstacles of different public transportation infrastructures and it is also a framework for discussion with transportation planners and engineers. Other methods like Space Syntax axial lines and convex spaces are also applicable to analyze are represent desirability cores. The desirability cores sequence of convex spaces.

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Light railways and busways as key driver for sustainable urban development: the Swedish experiences with transit-oriented development (TOD)

Todor Stojanovski, Mats Johan Lundström and Tigran Haas

Abstract
Sustainable urbanism and good placemaking revolve around creating and maintaining sustainable and attractive places, by reviving planning and urban design paradigms, by experimenting and innovating. The transports play crucial role in the sustainable urban endeavor and expectations for wide accessibility and networking are very high. The challenge today is to integrate and improve the efficiency and effectiveness of urban and transport systems and the transports have to fulfill the ongoing demands for enhanced efficiency, comfort, safety and speed, as well as the environmental factors in the light of global climate change and energy crisis. One accent has been on public transports and transit-oriented development (TOD), compact cities and urbanity-empowering public transports like light railways or light rail transit (LRT) and bus rapid transit (BRT) with its busways as key drivers for sustainable neighborhoods.

TOD in a Swedish (European) perspective is by no means a new idea. Three cases of newer light railway and busway projects (Stockholm, Gothenburg and Norrkoping) are explored in this paper and they are seen through a historical overview of the TOD experiences in Sweden. We also investigate and draw attention to the values of placemaking and sustainable urbanism via the advantages and disadvantages of the urban and regional public transport systems and TOD principles.

Keywords: transit-oriented development (TOD), Sweden, light railway (LRT), bus rapid transit (BRT), sustainable urbanism, placemaking
1 Introduction

Sustainable urbanism and good placemaking revolve around creating and maintaining sustainable and attractive places, by reviving urban planning and design paradigms, by experimenting and innovating, and by building synergies between the old and the new. The transports play crucial role in the sustainable urban endeavor and the expectations for wide accessibility are very high today. The challenge today is to integrate and improve the efficiency and effectiveness of the urban and transport systems and the transports have to fulfill the ongoing demands for enhanced efficiency, comfort, safety and speed, as well as the environmental factors in the light of global climate change and energy crisis. One solution is transit-oriented development (TOD) or compact cities with urbanity-empowering public transports like light railways or light rail transit (LRT) and bus rapid transit (BRT) as key drivers for sustainable neighborhoods. Transit, a shortening from mass transit, is an American catchall for public transport (1) while TOD is a policy to synchronize urban planning and development with public transports. Peter Calthorpe, who introduced the catchy coinage in the beginning of the 1990s, defines TOD as design or development of moderate and high density mixed-use urban areas at strategic points along the regional public transport system (2).

The European parallel to the American TOD is roughly the compact city. It is advocated by the European Commission (EC) and is central in the European sustainable cities debate since the 1990s. The vibrant and lively compact city and the contained and ecological green city are two sustainable urban concepts. The compact city favors architectural heritage, by respecting rather than imitating the old, greater diversity by mixed uses, particularly housing in inner city areas, and solving urban problems within existing boundaries of the city without extending its periphery (3). The argument is that density and diversity are more likely to result into people living close to work places and services that are required for the everyday life (4). The ambition of the compact city is also to make the private car an option in cities rather than a necessity (3) by creating integrated, intermodal transport systems which fully exploits the potential of public transport (5). There are numerous experiments of compact neighborhoods in the last 20 years throughout Europe with a paramount accent on multimodality and urbanity.

TOD as policy to synchronize urban planning and development with public transports in a Swedish and European perspective is by no means a new idea. There is wide body of knowledge and heuristics about public transport systems, cities and their interplay. We focus in this paper on three cities with newer light
railway and busway projects (Stockholm, Gothenburg and Norrkoping) in a historical overview of TOD experiences in Sweden.

2 The principal public transport cities

The cities throughout the history were shaped by transport technologies and the mobility of their citizens. We made a simplified categorization (Table 1) to describe and cluster the public transports infrastructures as technologies with similar effect on cities.

<table>
<thead>
<tr>
<th>On streets in traffic</th>
<th>Dedicated lane on streets</th>
<th>Partially separated on ground</th>
<th>Fully separated on ground or elevated</th>
<th>In tunnel or underground</th>
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<tr>
<td>Bus line</td>
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<td>Light busway</td>
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<tr>
<td>Heavy busway</td>
<td>(X)</td>
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<td>Tramway</td>
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<td>Subway</td>
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Table 1: The public transport technologies through infrastructures (designed with Karl Kottenhoff)

There are basically three technologies: 1) *public transports on streets* (buses and trams); 2) *completely separated*, either *elevated* or *on the ground* (heavy railways or busways); 3) *underground* (subways); contributed by a hybrid of the three: 4) *public transports partially separated on ground* (light railways or busways). The categories are unorthodox and open for further discussion. *Heavy* means always *full separation* regardless if it is a bus or rail system, whereas *light* attribute describes *partially separated* systems.

The designation X shows the anchor whereas (X) ranges of the various public transport infrastructures and their position as public transport technologies shaping cities. Two technologies tend to concentrate over specialized infrastructures and excel either on urban (public transports *on streets*) or regional scale (fully separated on ground or elevated public transports), whereas the *underground* public transports excel both on urban and regional scale. The hybrids, public transports *partially separated* on ground, also tend to have wide span claiming both domains.

Each technology enables distinctive urban and regional growth pattern and unique placemaking. The public transports *on streets* accelerate the urban life and
enable elongation and interweaving of the cities along the bus lines and tramways. The fully separated public transports orchestrate discontinuity of urban fabric and regional existence as temporal convergence of distant places: the railways disperse and fragment the city in its region. The public transports underground strengthen the polycentric agglomeration of the existing cities by adding speed, capacity and concentration: the subways connect urban nucleuses in a network. Analogically, there are four public transport cities (Figure 1): 1) the elongated and interwoven city of buses and trams; 2) the railway city of pearls; 3) the networked city above the underground; and 4) the compact city along the light railways and busways. The four public transport cities are fuzzy models for TOD, each with its own history and future.

Figure 1: The public transport cities

3 The public transport cities in Sweden

The public transports facilitated accelerated urbanization in Sweden from the 1830s, but with different impacts in Stockholm, Gothenburg and Norrkoping. The three cities developed differently. Stockholm and Gothenburg developed as dominant cores in their regions, whereas Norrkoping shared its region with Linkoping. Stockholm continuously developed a variety of public transports and expanded along the railways and subways which slowly urbanized its region with satellite cities, whereas Gothenburg and Norrkoping concentrated within
the range of the tramways and jealously kept them. The tramways became uncompetitive when the E-motorways interconnected entire Sweden in the 1970s and the urban life lost its attractiveness compared to the prospect of living in a peaceful and scenic landscape. The population dropped in the urban cores and the cities dispersed. Stockholm annexed its satellite cities and developed new, whereas Gothenburg sprawled in its region. While both Stockholm and Gothenburg had strong, Norrkoping had much slower regional growth (Figure 2) and it competed for population with Linkoping. As a consequence Norrkoping had almost no change in urban population in the last 40 years.

Figure 2: The population growth in Stockholm, Gothenburg and Norrkoping and the public transports

The compact city and urban living advocacy from the 1990s inspired urban developments in Stockholm and Gothenburg and their urban populations slowly recuperated. Gothenburg reached its urban population level from the 1970s in the 2000s, while Stockholm started to grow rapidly.
3.1 The buses and trams elongate and interweave the cities
The horse-drawn buses or omnibuses (hästomnibussar) were introduced in the 1830s, whereas horse-drawn trams (hästspårvagnar) rolled from the end of the 1870s. Only Stockholm, Gothenburg and Malmo had horse-drawn tramways. In the 1900s the trams (spårvagnar) were electrified and nine Swedish cities developed tramway networks. Most of the tramways were removed in the 1950-70s and replaced with motorbuses (motorbussar).

The omnibuses, cable cars, horse cars, trams or streetcars, motorbuses or commonly buses, trolleybuses or trolleys, are basically modification of a same public transport technology and if we consider capacity and speed they did not change dramatically. Hindered by the traffic on the streets, they are slow, reaching averagely 10-20 km/h (7-13 miles/h). The bus lines and tramways are optimally 7-8 km (5 miles) long. The longer lines are usual, but they are not attractive within the travel time budgets. Their lack of speed is compensated by a longitudinal attractiveness, urbanity and wide access to the general public by shortening walking distances. They add vibrancy on streets, give pleasant urban vistas and create mobile public spaces. The buses and trams as public transports on street elongated and interweaved a continuous amoebic city. The streets with public transports were and often remained as very attractive directions in the city.

3.1.1 The buses and trams in Stockholm
The omnibuses arrived in Stockholm as inspiration from Paris and Copenhagen in 1835 and reached its peak in the 1870s, when the first trams were introduced. Even though the tramways exchanged bus lines, the central line on Drottningatan, one of the main streets in Stockholm, was continuously operated by omnibuses and motorbuses even in the heyday of the trams in the beginning of the 20th century. The buses carried over 1 million passengers in 1900 (7; 8). On the end of the 19th century the electric railways became much more fashionable than the horse-drawn omnibuses and noisy motorbuses. Stockholm became a stage where several tramway and railway companies competed for turf. There were nine tram and three bus lines in the 1920s and they shaped and interweaved the urban core of Stockholm. Five tramways and one bus line extended outward and elongated the city in a radius 8-10km (5-7 miles). Stockholm grew from 75,000 to 300,000 inhabitants from 1830 to 1900 (6). The inner city, where the buses and trams operated, continued growing until 1940 when it reached its maximum of 470,000 inhabitants (http://www.statistikomstockholm.se/).
The directions of the historical bus lines and tramway are basically the main promenades in Stockholm today. The buses and trams followed the urban activity along the main streets, but in a same time they facilitated the formation of urban promenades with attractive frontages and façades. Drottningatan in Stockholm was an attractive shopping street where buses traversed, whereas the trams accelerated and enriched the urban life on streets like Hornsgatan, Sveavägen, Kungsgatan and Odengatan. The trams were declared obsolete in the 1930s with an emergence of a new generation of motorbuses. In a visionary modernization they were replaced with the trains of the Tunnelbana (the subway system in Stockholm) and motor buses from 1933 to 1967. Today there are trunk lines with blue buses which perpetually traverse the main streets and operate on the historical tramways. The blue buses orbit the urban core of Stockholm and complete the radial network of subway and railway links. There are also feeder lines with red buses which circulate the smaller streets in meandering fashion. The buses today compete with walking or cycling. Their average speed is around 15 km/h or 10 miles/h. The buses give literally acceleration to walking and quick refuge from the cold, better comfort for astonishing urban outlooks and vibrancy on the street.

3.1.2 The trams in Gothenburg and Norrkoping

Gothenburg and Norrkoping are the only two Swedish cities which kept their tramways. But they had very different histories. Gothenburg had accelerated growth and continuously extended its tramways. Norrkoping stagnated and reduced its tramway network.

Gothenburg experienced rapid industrialization in the second half of the 19th century and it spread out of the spiky city wall already in the 1860s. The trams facilitated expansion outward from the end of the 1870s, supported by boats and ferries crossing the river (Göta älv) on the north. In the 1900s there were 6 lines within a radius of 5 km (3 miles) and the city grew compactly along these lines. As in Stockholm, the streets along which the tramways operated created attractive promenades (Västra and Östra Hamngatan or Vasagatan) which connected the main squares and neighborhoods. Gothenburg diligently extended its tramways and neglected fast public transport links. The average speed of the Gothenburg trams is 15-25 km/h (10-17 miles/h) and they extend roughly 10 km (7 miles) in all directions.

Under the pressure of accelerated motorization the city experienced very strong regional growth and rapid urban decline. The dispersed city achieved staggering mobility with people living over 80 km (50 miles) from the city centre today (9), far beyond the reach of the trams.
Norrkoping had a dense urban core already in the 18th century. It was an old industrial center on a river regulated with dams to power factories since the 17th century. The city grew slowly from 10,000 in 1800, 40,000 in 1900, to 80,000 inhabitants in 1960 (6). Norrkoping elongated northeastwardly and southeastwardly along the tramways which opened in the 1900s and developed compactly within a radius of roughly 5 km (3 miles). The tramways concentrate the development along and enriched the urbanity and charm of Drottningatan, the main street in the city.

3.2 The railways introduced the city’s suburbs
In the 19th century the railways were exciting revolutionary technology of speed, schedules and timetables, wagons and compartments, classes and tickets. Unlike the typical bus and tram stops on the streets, the train stations were nodes, pearls on an impenetrable string. They were placed on distances that prevented overlapping buffers, gave total control over the accessibility. The city of pearls was motivated by monopolistic entrepreneurship that targeted twofold gains. The developers bought almost worthless land on the periphery, laid railways and designed suburbs. The buildings were sold or leased, while the fares were bringing continuous and lucrative profits.
Because of their speed, the railways created a hierarchy of access and desirability that linked urban pearls scattered over wide distances. The city of pearls can theoretically extend radial over 100 km (70 miles) creating a string of subordinate nodes, gravitating suburbs and suburban centers.

3.2.1 Edelsvärd’s ideal railway city
The railways inspired many urban planners and architects. Adolf Wilhelm Edelsvärd was an architect who made a model of an ideal city with a railway station in its core in 1859. Edelsvärd’s city (Figure 3) was functionally divided. It had an urban core of public buildings (hatched blocks) with a picturesque boulevard as an axis. The sequence of public spaces started with a square in front of the railway station, parks on both sides, square with church surrounded by court and other public buildings and ends with an amusement park or Tivoli. The industries (W) were located along the railway, while the houses on the wings. Each housing block (hollow blocks) was around 120m (400 feet). There were 12 houses in each block with 30-40% building coverage. In the core of the housing quarter there was a square (V) (10).
3.2.2 The railway suburbs in Stockholm

Stockholm was the only city in Sweden which developed a metropolis structure, and the pattern of urban satellite as pearls on strings was visible already in the 1930s. Its suburbanization started in the 1890s, and the garden suburb was the realistic counterpart to Edelsvärd’s city. The tramway and railway companies who competed for turf in the city also bought land in the countryside and laid suburban railways to profit on increasing land values (11). They developed garden suburbs similarly as in many British and American cities that achieved copious fame as cities of villas (villastäder) in Sweden (Figure 4).

The entrepreneurs quickly understood that railways dramatically increase land values and that the garden suburbs are very attractive. The battle for turf in the city expanded to the countryside around Stockholm and there were two entrepreneurship models in suburbanization. Sometimes the development and railway companies cooperated, whereas sometimes one company laid both railways and developed land. Djursholmsbana (or Roslagsbana today) is a railway which connected Djursholm, one of the first garden suburbs with a terminus then on the north of the city. One company was running the trains and extended the railway network northward, while another company planned and developed suburbs along the railway. Other companies had funds to invest both in the development of railways and land. Knut Agathon Wallenberg was a banker and politician who both financed the Sältsjöbana, suburban railway which terminated in Slussen, and developed a string of suburbs eastward (12). The suburban railways with speeds of 40 km/h (25 miles/h) and over are competitive with the cars even today. The journey to the centre of Stockholm
with the Roslagsbana is 10 minutes and it takes 13 minutes only to drive the same distance.

Figure 4: Collage of photographs from Djursbolm, city of villas on the north of Stockholm, and Roslagsbana, the suburban railway, from the end of the 19th century and today (source for the historical photographs: Stockholms Spårvägsmuseum/Stockholm Transport Museum)

3.2.3 The ABC suburb and city

The ABC suburb and city were functional replication of the railway suburb. ABC city stands for arbete (working), bostad (housing) and centrum (centre) and is much inspired and critical to Le Corbusier’s urbanism and the functional city in CIAM’s “Athens Charter”. The ABC principle was also inspired by the advocacy for polycentric metropolis and neighborhood planning in Lewis Mumford’s book “Culture of Cities” (13). The metropolis structure was described by Mumford (14) and recognized by Sven Markelius, the planning director in the city of Stockholm, who established it as a model for future development. The ABC principle was actualized either as suburb or a satellite city, a cluster of suburbs. The suburb as a pearl has urban sectors that should represent a Stockholm in a miniature, whereas the satellite city literally lays an array of smaller satellites and suburbanizes the suburbs (Figure 5). Sven
Markelius in two articles (15; 16) argued for larger suburbs with at least 50,000 inhabitants with various building typologies to support the housing preferences. The satellite city of pearls was a response to that problem. Markelius planning office produced both the visionary overture “Future Stockholm” or “Framtida Stockholm” and the unbinding Generalplan för Stockholm 1952, which shaped the ABC principle and what are the ABC suburbs in Stockholm today.

The Stockholm metropolis model one of the most successful TODs. Despite the high motorization in the Stockholm region (400 cars per 1000 inhabitants) the share of public transport is very high, especially during rush hours (almost 70%). The centers in the ABC suburbs or cities act as public transport nodes, whereas the diversity and density of the ABC city attracts passengers and balances the public transport demand between the satellites.

Figure 5: Suburb as pearl from the book “Future Stockholm” from 1945 on the left (the numbers represent the floor area ratios of the housing districts) and the satellite city by Sven Markelius on the right from Byggmästaren 1945 (C main centre, L.C local centre, H multifamily housing, R row housing, V villas, I industries)
3.3 Stockholm’s underground network

The subways are the heart of the metropolis hierarchy. They connect feeding railways or extend as railways outward. Terribly expensive, they preserve the city above and protect the traditional urban fabric and historical heritage. They rival or outperform any surface transport in congested urban cores and they do not cause visual impacts as the elevated systems do. Nevertheless, they affect the vibrancy of urban life by networking the places above. They act much like the diagonals of Rome or the baroque European capitals, just invisible to the city above.

The debate about Stockholm’s underground network opened in 1913 in the heyday of the railways, when Knut Agathon Wallenberg, suggested tunnels under the city which will connect the suburban railways which terminated on the urban fringes. The hybrid system of subways and railways adopted the
name “Tunnelbana”. The first tunnel opened in 1933 and the central station in 1957 (17).

Stockholm’s Tunnelbana is the heart and the main arteries of the metropolis hierarchy, while the buses are the capillaries that feed the urban tissue. It also networks the ABC cities and original railway suburbs and generates more than one million passengers each day in a region of two millions extending over. The average speed of the system is 30-40 km/h (20-25 miles/h) and it extends to a radius 15-20 km (10-12 miles) from the central station. The Tunnelbana system is additionally strengthened with branches of a commuter trains (Pendeltåg).

4 Compact cities along light railways and busways as sustainable European cities

The light railways emerged as a compromise between tramways and railways in the 19th century as systems partially on the street and partially fully separated. Many, especially American cities developed along light railways or interurbans in the end of the 19th and the beginning of the 20th century. Los Angeles had the most extensive railway network in the world which in its peak, in the 1920s, had over 1600 km (1000 miles) of interurban railways connected with over 320 km (200 miles) of tramways.

The compact city advocacy in the last 20 years in Europe revived the model of a city with partially separated public transportation services (light railways and busways) which enable the urbanity. Stockholm and Gothenburg have started experiments with sustainable neighborhoods having light railways and busways as structuring urban elements, whereas Norrkoping extended its tramways as partially separated in order to renew, diversify and intensify the neighborhoods along.

4.1 Hammarby Sjöstad and the Tvärbana in Stockholm

Hammarby Sjöstad (Waterfront City) evolved as a sustainable city model in the 1990s. It is a redevelopment of an abandoned industrial zone located south from the inner city district Södermalm. The neighborhood winds along an ideally sized light railway corridor and it replicates the façades and urban form of Södermalm. The northern waterfront developed a pattern of quasi enclosed urban blocks in the early 1990s to maximize the lake views, which mirrored on the southern waterfront.

The green esplanade of the Tvärbana, the orbital light railway, is the backbone of the neighborhood. This 37 meter wide urban corridor collects pedestrians,
bikers, trams, buses and cars in clearly defined linear stripes. The median tramway is partially separated from car traffic and fenced by longitudinal park. The bicycle lane is placed between the car lane and a strip of on street parking. The sidewalks are the last stripe having direct contact with the commercial frontage of the buildings. The politicians wanted a true urban feel (stadsmässighet in Swedish) along the esplanade, as in the inner city.

The city planning office pursued a policy of less private cars and higher share of public transport and had heavy restrictions on parking places. These measures were subverted by the development companies who had problems selling the apartments. Some apartments were sold in a package with a new car and soon there was a problem with parking.

Figure 7: Urban development along the Tvärbanan

Secondly the neighborhood also attracted younger affluent families with high demand for mobility and wide accessibility and the slower light railways and the
extra transfer seemed like a worse alternative than the car. The neighborhood was not directly connected to the subway or railway lines, but the people needed to make transfer through an old grayish industrial area on the west which felt like leaving the city and returning back. To solve this problem the newest debates are about extending the Tunnelbana towards Hammarby Sjöstad and further more to Nacka.

Figure 8: Cityscapes from Hammarby Sjöstad and its main esplanade

The *Tvärbanabana* opened the industrial fringe of Stockholm for development. There is ongoing extension of the *Tvärbanabana* northwards towards Solna (see Figure 7) which already inspired infill projects and redevelopments in Sundbyberg and Ulvsunda, besides Hammarby Sjöstad (Figure 9).
4.2 Norrkoping’s tramway extension in Hageby

Norrköping is one of only two Swedish cities, with Gothenburg, that have kept its tram system over the years. There are two tram and four urban bus lines in the city and the trams handle almost half of all the passengers that use the urban public transport. The city opened a 4km (more than 2 miles) extension of the tramway to the southern suburbs of Ljura, Hageby and Navestad in 2011. The extension should make these suburbs more attractive and sustainable and inspire new urban infill projects. The tram extension connects Ljura, a housing area from the 1950s, Hageby Centrum, a 1960s shopping centre and terminates in Navestad, a housing area from the 1960s. Navestad has two housing complexes called Golden Ring and Silver Ring that were upgraded in the 1990s. To diversify Navestad, there are plans for more retail, housing and public spaces. The tramway extension will have 10 stops laid on grass, which reduces noise. The simultaneous development along the tramway extension was the renovation of Hageby Centrum. New developments are expected in the following years.
Figure 10: Urban development along Norrköping’s tramway extension

Figure 11: Photographs of the newly developed Hageby centre (Mirum Galeria from 2012), a newly developed building and a new area assigned for development in the fall 2012
4.3 Gothenburg’s busway in Norra Älvstranden

Gothenburg and its region have been the industrial centre and largest port in Sweden since the mid-1900s when Götaverken, Lindholmen and Eriksberg, three of the world’s biggest shipyards opened on the north shore of Götälv (the wide river that separated the city from the industrial zone). The manufacturing power further strengthened when Volvo formed on the end of the 1920s. But since the 1970s, Gothenburg suffered from deindustrialization that heavily hit the northern industrial waterfront. The industrial area gradually emptied and the city assigned the northern waterfront (Norra Älvstranden), between the Götälv Bridge in the East and Älvsborgs Bridge in the west, for development. Large portions of the land are owned by the city and the renewal started in the 1990s with quite heterogeneous and fragmented developments. Eriksberg, an early development, much like the northern waterfront opposite of Hammarby Sjöstad, displays a pattern of quasi enclosed urban blocks opening prospects on Götälv, still closing up towards the streets to achieve an urban feeling. The more recent developments show less urban attitude, using more building typologies associated with the modernist era, but still focusing on maximizing water views.

Göteborg kept and carefully developed its tramway system in the city limits from 1879, but there was no agreement of a tram extension along the waterfront. Instead, the city and the public transport authority decided for a system of busways adopting the motto “think railways, run buses”, which also influenced the emergence of blue buses in Stockholm. The busways in Gothenburg however on some parts have been developed on a grand manner and served by double articulated buses. Lindholmsallén (Lindholm’s Esplanade) is extremely wide (almost 90 meters or 300 feet), including separate bus lanes in the middle, a wide longitudinal park with double tree lines, double car lanes, another green stripe, single tree line, two-way bicycle lane and a separate sidewalk. The urban development is slow, but ongoing. It is located mainly on the waterfront. The dense development around public transport nodes is yet to come in this part of the Norra Älvstranden. The esplanade today feels very open and empty.
Figure 12: Urban development along Gothenburg's busway in Norra Älvstranden

Figure 13: Photographs of the busway and the developments along the busway
The waterfront is also served by Älvsnabben (River Quick). It is a popular ferry line within the public transport system, connecting five stops on the northern and two on the southern (city centre). Two departures per hour in rush-hours is not very much, but it is about to increase in the near future. The Älvsnabbare (River Quicker) shuttle is, as its name suggests, a quicker shuttle line connecting Lindholmen on the north shore to Rosenlund on the southern shore – each sixth minutes in rush-hours. Since spring 2011, travelling with Älvsnabbare is free of charge. Similar ferry line free of charge exists in Hammarby Sjöstad, which was introduced instead of a bridge between the southern and northern waterfront.

5 Light railways and busways as key drivers for sustainable urban development

5.1 Light railways and busways as drivers for urban development

The rapid urbanization was essential to integration of the public transports in the cities in the 19th and early 20th century. Cervero argued that public transport redistributes rather than produces growth (18) and the public transport cities were both product and driver for urban concentration around public transports. The urbanization and population growth are prerequisites for urban and regional development, whereas the public transport stops and lines are one of many urban attractors.

Even though Stockholm, Gothenburg and Norrkoping had different urbanization and growth patterns there are new developments, infill developments or redevelopments, along the new light railways or busways in the three cities. The busways in Gothenburg as partially separated public transport systems equally added value and triggered developments along as the light railways in Stockholm and Norrkoping.

5.2 Compact city and TOD

Urban planning includes rules and models. The rules are procedures for conceiving and generating space and models are prototypes, a model space or a model of space (19). When we talk compact neighborhoods or TODs, seems that the models prevail. We see a wide replication of a similar urban model of sustainable neighborhood not only in Gothenburg and Stockholm, but in cities in Germany, Holland, France and Great Britain. It is a model of a dense and diverse neighborhood along an intermodal boulevard as main axis. The
question is do we have to think in models and replicate them when sustainability escapes blueprints?

5.2.1 Urbanity and multimodality advocacy

Every age imprinted itself on the cities. The public transports dominated the 19th century and the beginning of the 20th and the private car the 20th century. Each age reflected on the planning paradigms, urban models or regulations. Mixing as urbanity or multimodality of public and private transports prevails in the sustainable cities debates today.

The urbanity is widely highlighted and pursued today both by the compact city and TOD models. The urban advocacy works in Sweden where we can see recuperation and population growth in the larger cities like Stockholm and Gothenburg. It however evades the smaller cities which have stagnating urban population, but yet experience population growth in their regions. Without urban growth it is difficult to integrate the public transport systems into the cities. There is a need for a louder advocacy for urban living and public transports especially in the smaller cities, which are sprawled as the larger ones, but almost completely dependent on the private car.

The multimodality is also loudly advocated, especially among planners and the light public transports seem to dominate that stage. The light infrastructures of BRT and LRT are disadvantaged compared to the fully separated systems. They are too slow (20-25 km/h or 13-15 miles/h) to compete with the private car on regional scale. To enable competitive light public transports like BRT and LRT in the regions there must be incredibly strong policies restricting car access and urban containment. There is ongoing project about the Tunnelbana in Stockholm at KTH, Royal Institute of Technology, and the preliminary results from the traffic models and simulations show that if the tramways or light railway remained instead of the Tunnelbana, the number of daily passengers would decrease between 50% (within inner city), 70% (to the inner city) and 75% (through the city from north to south). The results are from the lectures and seminars held by Maria Börjesson and Daniel Jonsson.

The motorization rate is not as strong a factor as the competitiveness of public transport systems. In Stockholm’s region there 398 cars per 1000 people and it is slightly lower than in Västra Götaland’s region with 457, but the public transport share is more than double. There are in average 357 annual journeys in Stockholm’s region compared to 144 in Västra Götaland.
5.3 Placemaking and networking places

There are two important scales, of walking distances which define place and neighborhood and of motorized mobility which enables our city life. If the hierarchical combination of public transports which establishes a metropolis is one solution for competitive public mobility, placemaking is one solution for livable cityscapes.

Placemaking is about communities and processes, not about completed models. It is about the human scale, citizen perspective or view inside of cities in urbanism. Jan Gehl’s “in between buildings” describes lucidly the prospect within. It started as a loud critique of modernism, the architect’s perspective from the top and its city grandiose in the end of the 1950s. William Whyte and Jane Jacobs wrote *The exploding metropolis* or *The death and life of great American cities* and the view inside was entangled in Gordon Cullen’s *Concise townscape* and Kevin Lynch’s *wayfinding* and *imageability*. The argument was that “the city is for humans, not for a race of giants playing a new kind of chess” (20) and places, districts or neighborhoods must be developed within neighborhoods and to human scale. The development of Pearl District in Portland, one of the most famous and successful American TODs, is an example of placemaking through action plans, proactive planning and community involvement, instead of finished or defined models. By living, planning and designing together the community enjoys its urbanity and diversity today. In this ongoing urban process the neighborhood and public transport entangled together and the Portland Streetcar became a driver for urban development. Namely in 10 years there were $3.5 billion invested along the line.

Without placemaking and gradual integration of the public transports in the city, urbanity evades TOD and the tramways and light railways do not guarantee vibrancy and livability. In South Waterfront, a new development in Portland, we see exciting, but finished new architecture, great integration of urban design and public transport, but without real feeling of a place that exists in the Pearl District. Secondly and very important, Portland Streetcars are urban public transport system and cannot compete regionally with the cars. That is why the share of public transport in the Pearl District is low. The Portland Streetcars are only a Downtown alternative and the people have regional existence. It is not only important to make places, but also to network these places in the region with competitive public transports.
6 Conclusions

We show in this paper that there is a long history and tradition of integration of public transport in urban and regional planning and some old models and operators worked fine. The two operators are basically placemaking and networking places, or pursuing livable and sustainable places in continuous process of change and adaptation while superimposing metropolitan systems that interconnect these places into regional hierarchy. Citizens today have regional existence which sometimes extends over 80km (50 miles) and the public transports must reach and serve these urban edges. Stockholm is an example of where the public transports make this regional hierarchy with variety of technologies and modes. It is not always necessary to have one choice, one model and one system, which can be replicated. In practice the partially separated public transport systems like light railways or busways thrive on the wide infrastructural coverage and are advocated universal solutions. But, how efficient are these systems if they are be compared with innovative combinations of old or new public transport systems that excel in urbanity and mobility, on urban or regional perspective?
The synchronization of these universal public transports and cities is possible and implies two approaches which are not exclusive. The first is basically the compact city which revolves around policies of containment and preservation of the urban fringes as green wedges or agricultural land. In the smaller cities the LRT and BRT systems can act as mobility systems if the regional accessibility is somehow restricted. It is a very challenging endeavor, since many European and American cities developed extensive road hierarchies along the E-motorways or the Interstate Highway System which enables excellent car access almost anywhere in their regions. The second solution is to enact a public mobility hierarchy even in the smaller cities, a metropolitan system with wide regional accessibility brought by attractive and speedy public transport infrastructures like heavy railways or busways and urban mobility by slower, not less attractive bus lines and tramways or light railways or busways. It is again a challenge to superpose an expensive public network over the extensive road hierarchies.

In the end for gradual and continuous placemaking there is a need to consider the disadvantages and desirability of the different public transport infrastructure on the urban scale. The effect of the different public transports and infrastructures on cities is often forgotten. Various public transport infrastructures have different attractiveness and permeability around stations and along lines. There are desirability cores which are important urban catalysts, inducers and drivers for urban development.

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Applying the Swedish urban typology in the city of Karlstad: neighborhood conceptualizations for urban development and transformation in the 21st century

Abstract

Many Swedish as many European cities experienced a similar history of urbanization, architectural styles and planning paradigms. Most of the Swedish neighborhoods originate or were modified in the 20th century and many of them, often copyrighted by architects and planners, have been preserved as they were designed. The fundamental urban challenge in this century is to find ways of urban redevelopment, transformation and adaptation of these neighborhoods to futures of social and environmental changes.

The type in urban morphology is the encompassing category that fuses form with time and space and there is a long tradition and established schools in Europe which document the consistencies between urban form, history and society. In this article I analyze the neighborhoods in the city of Karlstad via the previously defined Swedish urban typology. The results show high explanation coefficients and low deviations. The typological neighborhoods have similar urban densities, either as population or work places per hectare or as floor area ratios (FAR) and some neighborhood types even deviate little in income. This allows discussions about urban densities, redevelopment and transformation without really talking about coefficients or numbers.

The results awake a palette of debates. How stereotypical are the urban neighborhoods today and how and should we make them more unique? Are there other alternatives for the 21st century than the urban typologies from the past? Is conceptualizing neighborhoods through typologies enough for urban transformation?

Keywords: urban morphology, typological method, urban transformation, urban form, Karlstad, Sweden
1 The urbanization and urban transformation challenge in Sweden

The Swedish urbanization followed a pattern of new developments which left the cities with morphology of continuously extending outward. The rapid urbanization started in the 19th century. Before that not many people lived in cities. In 1800 there were 92 cities defined by charter and just less than 10% of the Swedish population of 2 million was urban. Stockholm had 75,000, Gothenburg (Göteborg) 13,000, while Karlskrona and Norrkøping (Norrköping) had 10,000 inhabitants each. Only 6 cities including Stockholm had more than 5,000 and 15 over 2500 inhabitants.

The public transports and the industrialization facilitated faster urban expansion from the 1830s and almost doubled the urban radius to roughly 5km. Firstly horse-drawn buses and later horse trams were introduced in three cities in Sweden, Stockholm, Gothenburg and Malmo (Malmö). The public transports thrived in the dense cities and concentrated urban population. Stockholm, for example, grew around its medieval core Gamlastan and had a population density of almost 100 inhabitants per hectare. The urban population increased 5 times in the 19th century to more than 1 million people in 1900 (20% of the Swedish population). Stockholm grew five times to 300000, Gothenburg tenfold to 130000 inhabitants, while Malmo 20 times to 60000 (SCB, 1967).

The electrification of the public transports in the beginning of the 20th century extended the urban radius up to 10 km, while the flexible motor buses and electric railways enabled a new pattern of urbanization. They opened nodes for urban development in the countryside, urbanized existing villages and annexed other urban cores along in fragmented urban agglomerations. The urban population in 1930 doubled to 2 million (30%) and doubled again to almost 4 million in 1960 (more than 50% urban population).

The heyday of the public transports was shadowed by the spread of the private car in the middle of the 20th century and again by a new change in urbanization. The flexible car opened the entire countryside for urban development, while the functionalism and the traffic system, the private car and traffic safety dominated the Swedish planning from the 1940s. The need of undisturbed traffic flows demanded thoroughfares and decentralization. The urban cores of the 19th century, which relied on walking or public transports, were
depopulated, renovated or modernized with new architecture and bypassed by the E-motorways. The new functional city developed as archipelagos of monofunctional areas on the endless urban fringe along the E-motorways. The motto “Form follows function” and the functional recipe of inhabiting, working, recreation and circulation by Le Corbusier and Congrès International d'Architecture Moderne (CIAM) were vigilantly executed. The definition of urban changed in 1971 from cities by charter (städer) to municipalities (kommuner) and densely populated areas (tätorter). It revised the urban population in 1960 from 4 million in cities (SCB, 1969) to 5.5 million in densely populated districts (SCB, 2012). The urban population was 8 million in 2010 (more than 80%).

The modernization of the urban cores, improved living standards and the shift from public to private mobility caused a fluctuation in population densities and decentralization throughout the 20th century. The inner city of Stockholm reached 450,000 inhabitants in 1940, during the heyday of the public transports to halve in 1980 and recuperate to over 320,000 in 2012. Stockholm’s outer city developed rapidly from 10000 inhabitants in 1900, 130,000 in 1940, 420,000 in 1980 and 540,000 in 2012 (SCB/SWECO, 2012).

Until recently there was no need to radically transform or discuss urban transformation of the Swedish cities. The cities grew outward and most of the new developments happened in the second half of the 20th century. Roughly 70% of the buildings in Sweden were built after 1946 (Björk et al., 2003; 2009). Many of these neighborhoods, often copyrighted by architects and planners, were preserved as finished. But these 20th century neighborhoods are getting older and outdated. The planning then embraced the private car and cities transformed to enable undisturbed private mobility. The cars are crucial for functioning urban agglomerations of older and outdated neighborhoods. The problem is bigger in the small Swedish cities. They act as hubs in vibrant wide urban agglomerations which overlay.

The fundamental challenge in this century is to find ways and concepts to lessen the car dependence and one solution is to transform the urban agglomerations into cities adaptable to pending futures of social and environmental changes and disturbances in mobility and transports. Today there is a shift in planning paradigms towards compactness and multimodality which prioritizes other transport modes than the private car and development inward before growth outward.
1.1 The scales of urban development and transformation

The cities in Sweden developed and transformed partially. The neighborhood is the large, the urban block medium, whereas the plot is the small scale of urban development and transformation. The development or transformation actions and their scales are displayed on Table 1. X designates usual, whereas (X) possible actions.

<table>
<thead>
<tr>
<th>Actions</th>
<th>Small scale (plots)</th>
<th>Medium scale (urban blocks)</th>
<th>Large scale (neighborhoods)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preserve (do not develop)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Renovate (keep the old)</td>
<td>X</td>
<td>(X)</td>
<td></td>
</tr>
<tr>
<td>Renovate (change the old without transformation)</td>
<td>X</td>
<td>(X)</td>
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</tr>
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<td>Transformation (change the old in new form)</td>
<td>X</td>
<td>(X)</td>
<td>X</td>
</tr>
<tr>
<td>Redevelopment (infill or adjust new development)</td>
<td>(X)</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Redevelopment (horizontally extend the old)</td>
<td>X</td>
<td>X</td>
<td>(X)</td>
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<tr>
<td>Redevelopment (vertically extend the old)</td>
<td>X</td>
<td>X</td>
<td>(X)</td>
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<tr>
<td>Redevelopment (superpose new over the old)</td>
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<td>(X)</td>
<td>(X)</td>
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<tr>
<td>Redevelopment (demolish the old and develop new)</td>
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<tr>
<td>New development</td>
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Table 1: Urban development and transformation actions and scales

In Sweden the neighborhood was and still is the dominant scale of development and the usual actions included new development and redevelopments (demolish the old and develop new, infill or adjust new development and occasionally superpose new over the old). The planning paradigm today changes towards development inward and actions like renovations, transformation and redevelopments before new developments. The neighborhood scale allows only transformation and redevelopments (infill or adjust new development or demolish the old and develop new, and occasionally superpose new over the old or vertically extend the old). The urban development and transformation actions are morphologically typological operators where on a large scale urban transformation implies change from one neighborhood or urban type to another. The neighborhoods are both environments where these actions take place and their products and they exist as urban typologies.

2 Swedish urban typologies

Many Swedish as many European cities, somewhere earlier, somewhere later, experienced a similar history of urbanization, architectural styles and planning paradigms. Transmissions and convergences of European urban images
happened continuously throughout the history, but stronger from the middle of the 19th century. For example, Paris with its lavish cityscapes inspired urban reflections throughout Europe in the end of the 19th. The international style in the second half of the 20th century was the culmination when the urban reflections became literally replications appearing instantly in many European cities. These consistencies can be followed by urban typologies. An urban or neighborhood type fuses urban form with time and space, with history and society, with ages, styles and paradigms.

There is a long tradition and many established schools of urban morphology in Europe which have understood and explained cities either through urban elements or typologies. The morphologies or urban typologies in Sweden were method firstly used by geographers and later by architects and urban planners. The geographers surveyed and mapped similarities between neighborhoods and described their characteristics. The city was defined geographically as “agglomeration with clear inner differentiation” (Ahlmann at al., 1934:7) and the Geographical Institute at Stockholm’s University under Hans Ahlmann, made extensive and detailed geographic studies of Stockholm’s morphology from 1929. They linked urban geography and morphology with history, economy and sociology and drew inspiration from French, German, British and American schools of geography and sociology.

The urban form and its relation to living standards, to the Sun as insolation and shadows, to the Nature as access to green areas dominated the architectural and urban debates from the 1920s. Uno Åhrén (1928) inspired by Walter Gropius developed guidelines for urban form as geometric rules and urban coefficients. By these morphological rules the architects designed new neighborhoods and they are still widely used.

Sven Markelius, the head of the Planning Office in Stockholm, used urban typologies both to investigate housing preferences and to design urban developments. The questionnaires included urban typologies like villas and other single family houses, multifamily buildings with 3 and 4 stories and multifamily buildings with more than 5 stories, while the design for a future city (see Figure 1 below) had clear urban typology (C main centre, LC local centre, H multifamily housing area, R row housing area, V villas and single house area, I industry area) which diversifies the functional recipe (habitation, work and recreation).
Figure 1: The satellite city by Sven Markelius from Byggmästaren 1945 on the left and the twelve urban typologies from the Plan for Stockholm from 1999

The Planning Office in Stockholm used urban typologies together with functional zoning from the 1940s. In the Plan for Stockholm from 1999 there are twelve urban types which reflect the historical development of Stockholm, from before the industrialization until today. For example Gamla stan is preindustrial urban core, stenstad and äldre förstad are industrial urban cores, villastad and trädgårdsstad are garden suburbs from 1890 onwards, while tunnelbanestad is the Swedish ABC city which developed from 1950-1990 (see Figure 1 above).

Johan Rådberg in the 1980s made very deep and comprehensive insight in Swedish urban morphology. He developed detailed and chronological Swedish urban typology (Rådberg 1988, pp. 435-40; 1995) drawing from Conzenian and Muratorian schools (Rådberg, 1995, pp. 6). Rådberg divided the urban typology historically by four epochs, each characterized by specific planning paradigm. In his consecutive studies, for example in the morphological study of the city of Vasteras (Västerås), Rådberg and Johannson (1998) explored the relationship between urban typology and quality as housing preferences.
A planning method with a matrix of neighborhood types was developed by Arken Architects and Ekologigruppen Ekoplan, together with Jerker Söderlind and Håkan Jerenius. Another urban typology of residential areas was developed in detail and encyclopedically illustrated in two books of the “Så byggdes” trilogy (Björk et al, 2003; 2009).

3 Karlstad’s urban typology study

Karlstad is a city with around 60000 inhabitants. It is the capital and largest city in Värmland, a county in Sweden on a border with Norway. As many smaller cities in Sweden developed slowly in the first half and rapidly in the second half of the 20th century, in the years of rapid motorization. The city expanded neighborhood by neighborhood, firstly around the historical urban core and later linearly along the E-18 motorway and its road hierarchy. The city today is like an archipelago of residential and working bubbles stemming out of the exits of E-18. The gradual extension of the city resulted in consistent pattern of neighborhoods around the urban core or on the both sides of E-18. Many neighborhoods within deformed concentric circles or rings reflect clearly the planning trends and fashions of the 20th century as well as the paradigm
changes. The 85 neighborhoods which are categorized as typical in this study more than cover 70% of the city.

Figure 3: Map of the neighborhoods in Karlstad by neighborhood typology

The continuous extension of Karlstad is clear on the map (Figure 3). The urban core of the city was shaped by enclosed urban blocks of the stone city (kringbyggd (sluten) småstadskvarter (stenstad)). The second period of expansion was with villa cities (villastäder) and earlier modernist blocks and towers (tidigare lamellhus- eller punkthushusområde) and the third with functional modernist cities (funktionaliska städer), later modernist blocks and towers (senare lamellhus- eller punkthushusområde) and a variety of monofunctional areas scattered along E-18.

3.1 Method and data

I used a standard method in morphological studies. I made a survey of the neighborhoods and their characteristics according a neighborhood typology (see Appendix 1) which draws inspiration from the Swedish urban typologies
mentioned before. Later I joined the statistics and made a database where I used general linear models in SPSS to analyze the interrelationship between neighborhood type as nominal and the various statistics as numeric variables. The data from the city of Karlstad dated from the end of 2009. The GIS maps were from Lantmäterier’s (National Land Survey of Sweden) Digital Library and municipality of Karlstad. Two statistical packages AMPAK and FASTPAK by NYKO4 areas and the GIS map of the NYKO4 areas were supplied by the municipality of Karlstad and Statistiska centralbyrån (SCB, Statistics Sweden). NYKO4 is one of the six layers of administrative divisions within one municipality. AMPAK shows statistics about the labor market whereas FASTPAK about buildings, real properties and floor areas per NYKO4 area. The NYKO4 administrative borders did not always corresponded to the neighborhoods and I adjusted their areas in ArcGIS to fit their typologies. Sometimes I joined two or more NYKO4 area to make one neighborhood. Table 2 shows the statistics about sizes and urban densities of the neighborhoods.

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</table>

*Table 2: Descriptive statistics for the neighborhoods*

### 3.2 Results

The results of the general linear model (GLM) for neighborhood type showed high explanation coefficients for population or population and work place densities ($R^2 \approx 0.80$) and slightly lower for work place densities and floor area ratios or FAR ($R^2 \approx 0.70$). The significant parameters in the GLM for population or population densities were the residential areas, where in the GLM for the work place densities were the working areas, whereas the mixed areas were significant for in the both GLMs. The parameters and explanation coefficients for the GLMs were included in Appendix 2. The descriptive statistics for the common neighborhood types which had higher samples showed low deviations, especially for population or population and work places. It means that typological neighborhoods like neighborhoods with urban villas around the city have similar urban densities and we can basically within some range predict how many people will live and work. The chart (Figure 4) also shows the clear specialization of neighborhoods, some were predominantly with residences and other with work areas.
Figure 4: Neighborhood types and urban densities

Figure 5: Neighborhood types by urban density and FAR
The chart (Figure 5) illustrates that the residential neighborhoods (with square and circle symbols) are almost linearly distributed in the chart that displays the relationship between urban density (population and work places per hectare) and FAR. The charts above (Figure 4 and 5) also show that similar neighborhoods make clouds by urban densities or FARs.

3.3 Discussion and conclusions of the typological study

Even though the sample of neighborhoods from the city of Karlstad is rather small (n=85) and there is a variety of neighborhood types we can see a statistical significance between neighborhood type and urban densities. Basically in some interval it is possible to discuss about typological, recognizable or characteristic neighborhoods, while keeping the urban densities and other urban coefficients in the background. The results have similar findings as an earlier morphological study of the city of Vasteras (Rådberg and Johansson, 1998). The repetition of the results for another city can be evidence both of correct typology, but also of repetitive urban development in the cities. Yet, much more studies in other Swedish cities need to be done for a more complete picture.

Secondly we can compare the morphological differences between the various neighborhood types and recommend actions for transformation or redevelopment of one type to another. The prospect to use typologies, categorize and discuss urban phenomena, while running processes of systematization, explanation, quantifying and modeling in the background is a promising one in my opinion.

4 Urban transformation discussion

The results from the Karlstad study and the consistency with the previous Vasteras study awake a palette of debates. How stereotypical are the urban neighborhoods today and how and should we make them more unique? Are there other alternatives for the 21st century than the urban typologies from the past? Is conceptualizing neighborhoods through typologies enough for urban transformation?

4.1 Neighborhood and urban transformation typologies, repetitiveness and stereotypes

The neighborhood typologies can be very useful for urban development and transformation. They can be mapped and discussed as categories, while
analyzed and modeled as numbers in the background. The advantage with neighborhood types is that they are easily identified and recognized by non professionals and the general public. They can be experiences and illustrated and there is usually a public opinion about the urban quality of the neighborhood types which can be easily followed by preference surveys. We can not only develop neighborhood typologies, but also typological transformations from one neighborhood type to another. The disadvantage of the typologies is lack of innovativeness and individuality. It is difficult to discuss the unique or non typical which sometimes can be a driver for novel or progressive urban development. The typologies are predominantly historic and retrograde and what is not included is usually not considered. The retrograde disposition and nostalgic attachment to traditional neighborhood types can result in repetitiveness and stereotypes.

The people are imitative and docile argues Marcus Vitruvius Pollio in ‘The ten books on architecture’. They copy each other and learn from each other. The first buildings were imitations of the nests of swallows and their methods of building and the same copying exist today worldwide. Many Swedish and European cities today are terribly stereotypical. It started with the Parisian transmission of urban images and continued with Le Corbusian visions and modern surgery and replications in the European cities. The modernization dramatically increased the quality of life and very few cities escaped the process. The traditional urban and rural life, historical villages and cities disappeared, while certain rural and urban cores were embalmed as islands, monuments or attractions in the functionally divided urban archipelagos. The 19th and 20th century architects, planners, bureaucrats and politicians envisioned and executed networks of inflexible urban infrastructures for many centuries to come. The planning today is more an inertia to fill in the pockets along the renovated railways and E-motorways. The neighborhood typologies are ideal conceptualization to fill the gaps around the existing infrastructures. But do we still need to fulfil some outdated visions or we need to live our own, while leaving place for the future generations to accomplish their own. It is difficult to think out of the planning systems, but why not try?

4.2 Neighborhood versus mobility perspective
The last, but not least question is: Are the neighborhood types and their understanding enough for urban development and transformation? The answer is certainly not. The neighborhood typologies cover only one aspect of the urban life, the human prospect, the walkable, the near. The urban morphology revolves around two urban theories. The first sees the city as “a mosaic of little worlds that touch” (Park, 1925, pp.40) and the second defines urbanity by size,
density and heterogeneity (Wirth, 1933). The schools of urban morphology have neglected the fluidity of urban life.

The urban life today is mobile and cities are “extraordinary agglomerations of flows” (Amin and Thrift, 2002:42). Life is literally described by a sequence of inhabited places, movable or fixed. The mobility perspective has other scales of urban development and transformation and it is as crucial as the neighborhood perspective. From the mobility perspective the neighborhood is the small scale, the region medium, while the globe the large scale.

The urban fixity of the morphologies and the dynamics of flows, the neighborhood and mobility perspective are brilliantly conceptualized by Brian McLoughlin’s maps for activities and spaces and communications and channels (McLoughlin, 1969). A full awareness and understanding of the morphological and mobility scales is needed for successful urban transformation. One neighborhood has important morphological details and in a same time it is unit in layers of mobility.

References


Appendix 1: Neighborhood typology

In this study I made summary of the four urban typologies mentioned above and I expanded the list with postmodern neighborhoods which occurred after 1980s. I also added distinction by transport paradigm or policy (walking, public transports, private transports, intermodal), since the neighborhoods after 1960 were lavishly equipped with vast parking areas and garages. The complexes which are literally buildings and parking garages are neighborhoods oriented towards the private car.

The neighborhood typology is divided by five paradigms. The vernacular neighborhoods cannot be really pinned to an age or to planning paradigm. These neighborhoods include haphazardly grown and agglomerated villages and unplanned urban cores.

- **By (1-2 storeys, ~10%, far 0.10)** (translated: village)
- **Urban by (1-2 storeys, ~10%, far 0.10)** (translated: urban village)
- **Trästad (1-3 storeys, 25-50%, far 0.25-1.50)** (translated: wooden city neighborhoods)
- **Ursprunglig stadskärna (1-8 storeys, 50-90%, far 0.5-5)** (translated: embryonic, irregular or unplanned city core)
- **Kvadrangelhusområde? (1-3 storeys, ~75%, far 0.70-2)** (translated: area with quadrangles)

The classical and neoclassical neighborhoods include planned city cores by various regulations that emerged from the antiquity and consecutively until today in its eclectic neo-classicism or neo-traditionalism.

- **Kringbyggd (sluten) småstadskvarter (1-4 storeys, 50-90%, far 1-3)** (translated: neighborhood with enclosed urban blocks in small city)
- **Kringbyggd (sluten) storstadkvarter (5-8 storeys, 50-90%, far 2-5)** (translated: neighborhood with enclosed urban blocks in large city)
- **Kringbyggd (sluten) storstadsstorgårdskvarter (4-8 storeys, 50-90%, far 2-5)** (translated: neighborhood with enclosed urban blocks and large courtyards in large city)
- **Kringbyggd (sluten) kvarter med skyskrapor (18-110 storeys, 50-90%, far 10-44)** (translated: city of skyscrapers in urban blocks that does not exist in Sweden, but it is the final evolution today of the classical city of urban blocks)
The garden city emerged in the end of the 19th century as critique of the overcrowded, unhealthy, polluted and dangerous industrial city that kept its classical and neoclassical form with staggering densities and poor conditions of life.

- Trädgårdsstad (1-3 storeys, 10-50%, far 0.10-0.50) (garden city neighborhood with mix of functions)
- Villastad (1-3 storeys, 10-50%, far 0.10-0.50) (translated: area with detached houses in regular, rectangular internal street network without cul-de-sacs)

The modernist neighborhoods emerged in the 1920s and mainstreamed in the 1940s. Heavily criticized from the 1960s it is a paradigm with strong roots even today. Therefore we can categorize the similar neighborhoods as earlier (before 1940s), later (1940-1980s) and newer (1990s-today) which enter in the postmodern categories. The modernist neighborhoods are also differentiated by the transport paradigms and revolutions. The ascendancy of the private car was grasped by the late modernism which found expression through various building and parking complexes which emerged from the 1940s. The modernist neighborhoods before the emergence of the private car were always adjusted to public transport with minimal parking spaces, but spacious green areas. The modernist neighborhoods in the end can be conceived as a whole, functional entity or modernist city or as functional parts.

- Funktionalistisk stad (over 4 storeys, 10-30%, far 1-10) (modernist city with mix of typologies)
- Tidigare lamellhus- eller punkthusområde (to 5 storeys, 10-30%, far 0.40-1.20) (earlier modernist blocks and towers)
- Senare lamellhus- eller punkthusområde (over 4 storeys, 10-30%, far 1-10) (later modernist residential areas)
- Bostadskomplex (over 2 storeys, 10-70%, far 0.2-10) (modernist residential complexes)
- Småhusområde (1-2 storeys, 10-25%, far 0.10-0.25) (translated: area with detached houses with hierarchical street network often with many cul-de-sacs reaching each house or cluster of houses)
- Radhus- eller kedjehusområde (1-2 storeys, ~25%, far 0.25-0.50) (translated: row houses area)
- Centrum (1-30 storeys, 10-50%, far 0.10-10) (modernist centres)
- Industriområde (1-30 storeys, 10-30%, far 0.10-10) (industrial parks, areas or complexes)
- Handelområde (1-2 storeys, 10-30%, far 0.10-0.20) (retail parks, areas or complexes)
- Kontorkomplex (over 2 storeys, 10-70%, far 0.2-10) (modernist office complexes)
- Idrottspark, kultur- eller rekreationsområde (1-3 storeys, ~10%, far 0.10-0.25) (sport, recreational or leisure parks, areas or complexes), squares and parks included
- Institutionområde (1-10 storeys, ~10%, far 0.10-1) (institutional and other community services parks, areas or complexes)
- Fritidshusområde (1-2 storeys, ~10%, far 0.10) (translated: area with houses for recreation)

The postmodernism is deeply eclectic selectively choosing pieces or returning completely to some of the preceding paradigms. Large part of the planning is deeply neo-modernist today still enriching the extensive database of urban diagrams and patterns. There is one striking hybrid that reaches into the classical and liberated the enclosed urban blocks with arrangements as quasi-urban blocks. The postmodernism also includes a new paradigm in transports. The private car and the parking are de-prioritized in favour of multimodal transport solutions. There is a hierarchy of walking, cycling, public transports, with the private car on the bottom of the pyramid.

- Kvasi-småstadskvarter (to 4 storeys, 30-50%, far 0.90-3) (translated: small city neighborhoods in quasi-urban blocks)
- Kvasi-storstadskvarter (over 4 storeys, 30-50%, far 1.20-4) (translated: big city neighborhoods in quasi-urban blocks)
- Nyare lamellhus- eller punkthusområde (to 4 storeys, 10-30%, far 0.40-1.20) (newer neo-modernist residential areas)
Appendix 2: Descriptive statistics, parameter estimates and explanation coefficients of the GLMs

<table>
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<th>Type</th>
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<th>Mean</th>
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Figure 6: Descriptive statistics
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R Squared = 0,692 (Adjusted R Squared = 0,631)
R Squared = 0,870 (Adjusted R Squared = 0,844)
R Squared = 0,867 (Adjusted R Squared = 0,840)

Figure 7: Parameter estimates and explanation coefficients of the GLMs (continues)
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R Squared = 0,865 (Adjusted R Squared = 0,839)
R Squared = 0,992 (Adjusted R Squared = 0,990)

Figure 8: Parameter estimates and explanation coefficients of the GLMs (continuation)
Is there a place for Bus Rapid Transit (BRT) in the Swedish towns and cities? - Applying Multi-Criteria Evaluation (MCE) to evaluate the potential for urban development and transformation along the newly proposed BRT line in Karlstad, Sweden

Abstract
Karlstad as many smaller towns and cities in Sweden developed rapidly in the 20th century, in years of rapid motorization and decentralization. As a consequence it sprawled into archipelago of urban areas along motorway E18. Karlstad was designed for the private car and today it dominated by individual mobility. The change from a city for a private car to multimodal public transport cities demands major urban transformation and adaptation efforts and Karlstadsbuss, the public transportation authority in the city of Karlstad, proposed a new BRT line named Karstadssträk or Karlstad’s Corridor to improve the bus transportation and achieve better integration with the city. In this project I explore the possibility for urban development and transformation along the newly proposed BRT line in the city of Karlstad by using multi-criteria evaluation (MCE) that consider analysis not only the physical constrains, but also the preferences of the different actors in the urban development. The questions are: What is the development potential of the neighborhoods along the new BRT line? How and which neighborhoods can develop stimulated by the introduction of BRT?

If we look at the neighborhood scale and on urban development through neighborhood typologies and typological processes, the development potential along the new BRT line in Karlstad is rather limited. But the urban development can happen on small scale. The small scale can be very important in smaller cities where there is a new urban attractor like BRT. If the city of Karlstad wants to have successful implementation of the newly proposed BRT line it is maybe important to rethink urban integration as urban transformation of the city small scale. One solution involves “BRT free development zones” where small businesses and residents, architects and builders from the city can coordinate and develop their own visions of the future city.

Keywords: Bus Rapid Transit (BRT), Multi-Criteria Evaluation (MCE), urban form, urban transformation, urban development
1 Introduction

Karlstad is a city with around 60000 inhabitants. It is the capital and largest city in Värmland, a county in Sweden on a border with Norway, a vibrant business hub of its region with over 40000 work places. Over 32% of the workers commute from other and 17% commute to other municipalities achieving staggering mobilities. Karlstad as many smaller cities in Sweden developed rapidly in the 20th century, in years of rapid motorization and decentralization. It was designed for the private car and today it dominated by individual mobility (Figure 1).

Figure 1: The differences in public mobility in Karlstad and Stockholm as well as in Stockholm and Värmland region. The chart on the left shows the change in annual number of journeys by public transportation from 2003 to 2011 (Source: www.trafa.se), whereas the charts on the left show the share of public transportation for different lengths of journeys for year 2005 (Trivector, 2005a; 2005b).
A person in the city of Karlstad travelled 49 km per day in 2004 or 29% more than the Swedish average by the official statistics, whereas a person in the countryside travelled 62 km per day or 62% more than the average of 38 km per day (Trivector, 2005a, pp. 42-7).

Karlstadsbuss, the public transport authority in Karlstad, in recent years has been recognized in Sweden for their successful advertisements and marketing campaigns, reorganization of the bus network, reimagining of the orange buses and introduction of the “boat buses” which traverse the delta of Klarälven that cuts through the city. The buses are organized in fewer lines, in easily comprehensive map that looks like a subway map. When Färjestad BK, the local hockey team, plays the bus network completely changes and hockey buses come out to bring Karlstadsborna, the inhabitants of Karlstad, to and from the Färjestad Arena. Their guerrilla marketing increased the use of public transport by 50% from 2005 to 2010 and the satisfaction of the customers is among the highest in Sweden. In 2009 as part of their effort to double the share of public transportation the manager of Karlstadsbuss, Sören Bergerland, and Robert Sahlberg, who is responsible for marketing started to promote an experiment with future bus transportation system. Together with Karl Kottenhoff, we took part in the discussions as academic representatives from KTH Royal institute of technology. The meetings in Karlstad resulted in a Bus Rapid Transit (BRT) vision named Karstadsstråk or Karlstad’s Corridor (Figure 2) It is newly proposed BRT line which connects the most important nodes in Karlstad. The idea was that BRT revolves around inflexible busways that add permanent value and it triggers urban development around the stations. This is known as Transit-Directed Development (TOD) in the USA and defined as design or development of moderate and high density mixed-use walkable urban areas, or pedestrian pockets, at strategic points along the regional public transport system (Calthorpe, 1993, pp. 41-45). In this project I explore the possibility for urban development and triggering TOD along the newly proposed BRT line in the city of Karlstad. What is the development potential of the neighborhoods along the new BRT line? How and which neighborhoods can develop stimulated by the introduction of BRT?
2 Method

2.1 Urban development and transformation as “planning and development system”

It is very hard, almost impossible, to predict precisely and in detail how a neighborhood or city will develop, even if they are carefully planned and controlled. The neighborhoods are entangling complex and changes happen randomly. Joel Garreau in the book “Edge City” writes: “No matter what you plan, the result will always be a surprise”. There are social and physical aspects of the neighborhoods that can influence urban development and transformation. Gans (1968, pp. 5-11) in his essay “The potential environment and the effective environment” describes the clash and difference between human and natural factors that affect the urban environments. I transcribe his title in potential and effect for urban development and transformation. The potential for urban development is determined by the physical characteristics or consistencies in politics and social life, whereas the effect is determined by social and political conditions in the neighborhoods, the city or the country. I
analyze the potential for urban development and transformation through physical parameters of the urban form and their frictions, but also as process of actors in a system of planning and development.

The urban development and transformation is driven by profits, societal endeavors and utopias, urges for monumentality and extravagance, but also by the need to solve everyday problem, by the mundane and ordinary. There is a clash of interests, public or private, individual or collective, veiled or transparent. There are tendencies neatly expressed through Lefebvre’s prism of tendencies in planning. The “scientific planning” tendency neglects the so-called human factor and focuses on cities and neighborhoods as systems. The “people of good will”, architects, artists and writers, want to build neighborhoods and cities to the human scale or to its measure, even though the human scale has grown beyond their grasp. The “developers” do it without hiding for the profits (Lefebvre, 2000, pp. 83-85).

There are many definitions of the city. The urban morphologists look at the city as a mosaic of areas or spaces. Every city has “unique individuality, own life and physiognomy” and it is a “complex individual” of different urban quarters or neighborhoods (Reclus, 1905, pp. 385) or “a mosaic of little worlds that touch, but do not interpenetrate” (Park, 1925, pp. 40). But others look at the city as artwork of political struggle. The cities are artworks accomplished by clearly defined people and groups in historical conditions (Lefebvre, 1996, pp. 101), products of political struggle, or struggle of the control over the right of the city (Soja, 1989, pp. 49). The city is stage where different individuals, social groups or classes and their interests struggle for the right to develop the city today. In a same time it is an artifact, a monument of political clashes in the past. The conflict is not only between the actors today, but also with the fossilized successful endeavors from the past and the future expectations too. Lefebvre (1996, pp. 83-85) writes about tendencies in urbanism instead of actors, whereas Hall (1980) extracts bureaucrats, politicians and the community as a “concert of actors” that shapes the city.

I illustrated a development and planning system that revolves around urban form and describes the sphere of play and domain (extended with dashed lines) of the different actors (Figure 3).
The development and planning system starts with the city as problems, interests and urban forms and ends in the city as urban forms. The negotiations are the core of the system. There are negotiations firstly between ideas, goals and visions versus legislation which results in urban plans. Secondly there are negotiations between the administration and the developers as control over the urban development. The system is inspired partially by Henri Lefebvre, John Turner, Carlo Ratti and Peter Hall, and partially by the wish to connect urban morphology with urban planning, development and transformation. David Harvey argues that urban planning and development is partly reflecting the prevailing ideology of the ruling groups and institutions in society and partly is fashioned by capitalism and the dynamics of market forces. Urbanization has always been a class phenomenon where the control typically lies in a few hands and increasingly, we see the right to the city falling into the hands of private or quasi-private interests (Harvey, 2009, pp. 310-29). But if we look historically the power can lay in the hands of the bureaucrats too. Robert Moses managed to serve under many mayors and worked with many developers and still pursued his own agenda of urban renewal and transformation of New York.
2.2 Development and transformation of the urban form in the neighborhoods through urban morphology and Swedish typologies of neighborhoods

Urban morphology revolves around urban form and the processes of formation and transformation of urban areas. It is a multidiscipline between architecture and urban design, geography and history, economics and politics. In its narrower definition within architecture and geography, urban morphology puts emphasis on studying physical form and processes of its emergence and transformation. This definition historically dominated urban and regional planning, architecture and geography and there are many traditions, methods and representations within. The British or Conzenian school originates from the work of geographer Michael R.P.G Conzen. Even though theoretically the urban form is framed as a process, a temporal change of streets, plots and buildings (Conzen and Conzen, 2004), the scholars primarily focus on the two-dimensional extend and representation of urban areas through historical changes in planning practice and architectural styles. In contrast to the British school, the Italian school has strong architectural background inherited from the work of the Italian architect Saverio Muratori and his followers. The Italian cities changed architecturally throughout the history and the Muratorian school focuses on three-dimensional transformation, design, representation and interpretation of the architectural detail of the urban form (Caniggia & Maffei, 2001). The representations of an urban mosaic of physical spaces and structure of cities vary from symbolical fuzzy diagrams to accurate drawings and maps: for example as a pattern of streets, plots and buildings that are shaped by the society and its economy (Conzen & Conzen, 2004). In another conceptualization the urban space is defined by a pattern of buildings, streets and squares (Krier, 1979, Krier, 1984).

Urban development and transformation is a process of emergence of urban form or change from one urban form to another. The urban transformation actions or processes are morphologically typological operators defined as “process typologies” or “typological processes” (Kropf, 2001). Urban transformation from one neighborhood type to another is simultaneously predictive to changes in urban density (Rådberg, 1997; 2000; Stojanovski, 2012).
In Sweden the neighborhood was and still is the common or dominant scale of development. Many Swedish as many other Northern and Western European cities, somewhere earlier, somewhere later, experienced a similar history of urbanization, architectural styles and planning paradigms. Transmissions and convergences of European urban images happened continuously throughout the history, but stronger from the middle of the 19th century. For example, Paris with its lavish cityscapes inspired urban reflections throughout Europe in the end of the 19th. The international style in the second half of the 20th century was the culmination when the urban reflections became literally replications appearing instantly in many European cities. These consistencies can be followed by typologies. In Sweden there is a long tradition of making typologies of neighborhoods. A neighborhood type fuses urban form with time and space, with history and society, with ages, styles and paradigms. The latter of Swedish neighborhoods and cities, from wooden to stone and brick and concrete and steel prefabricated city, from traditional, industrial, modern to postmodern is described by many authors. The morphologies or urban typologies in Sweden were method firstly used by geographers and later by architects and urban planners. The city was defined geographically as “agglomeration with clearly differentiated areas” (Ahlmann at al., 1934:7) and the Geographical Institute at Stockholm’s University under Hans Ahlmann, made extensive and detailed geographic studies of Stockholm’s morphology from 1929. They linked urban geography and morphology with history, economy and sociology and drew inspiration from French, German, British and American schools of geography and sociology.

Johan Rådberg made the deepest and most comprehensive insight in Swedish urban morphology throughout the 1980s and 1990s. He developed detailed and chronological Swedish neighborhood types (Rådberg 1988, pp. 435-40; 1996) drawing both from the Conzenian and Muratorian schools in urban morphology (Rådberg, 1995, pp.6). In his consecutive studies he explored the relationship between urban types, attractiveness, quality and housing preferences in the city of Västerås (Rådberg and Johannson, 1998) and south Stockholm (Rådberg, 2000). Arken Architects and Ekologigruppen Ekoplan, together with Jerker Söderlind and Håkan Jersenius, inspired by Rådberg’s research developed an operational urban morphology as a planning method called STEP in the 2000s with a matrix of neighborhood types. Another Swedish typology was illustrated in two books of the “Så byggdes” or “That is how it was built” trilogy (Björk et al, 2003; 2009). The trilogy looks in detail at urban form, architectural styles and materials from 1880 until today. The first book described the development of multifamily housing and the second building single family houses and villas.
2.3 Data

The GIS maps were downloaded from Lantmäteriet’s (National Land Survey of Sweden) digital library. The data is from 2009 and it includes polygon maps of buildings, real properties and land uses. I used two statistical packages (AMPAK and FASTPAK) from Statistiska centralbyrån (SCB, Statistics Sweden). AMPAK is a package about the labor market, work places and commuting, whereas FASTPAK includes statistics about buildings and real properties. I also received a GIS layer from the NYKO4 areas done by SCB, but there were large differences between the NYKO4 areas layer and the layer of real properties of Lantmäteriet and it was impossible to use it. Instead I merged the real properties in NYKO4 according a table that was sent to me by Karlstad’s municipality.

2.4 Analysis

Different factors and constrains are explored with a use of multi-criteria evaluation (MCE) and map algebra in geographic information systems (GIS). MCE in GIS is a powerful analysis tool to when “multiple and conflicting criteria, interests and objectives are concerned” (Carver, 1991). The factors are captured by MCE. The factors or criteria interact therefore they are weighted according the assumed or systematized strength of effect. I consider land use, neighborhood type and impedance (which corresponds to the willingness of friction of the people to develop certain neighbourhood types), open spaces and FAR in the urban blocks (which is conceived as factor posed by the administrators), existing buildings, as well as distance from the new BRT stations as factor.

In the end I use a “developer cut” agreeing with David Harvey that the right to the city is into the hands of private interests and developers. The developers in Sweden prefer large projects and prefer to build on empty land and sizable plots. It is a multiplier and focal model in map algebra. Developers tend to find empty field, a large empty piece of land, and build new. They prefer to be left alone with the bureaucrats in the urban development and tranformation phase of the planning and development system.

I used both ArcGIS and Idrisi. I used Idrisi to do the MCE and to make the “developer cut” and I used ArchGIS’s tool “block” for focal analysis and look for large areas with high development potential. The background layers for the MCE were prepared by my experience and judgment, where 0 means no desire for development, while 255 means top desirability (Table 1).
Table 1: Assumed desirability values of the factors land use, distance to stations, building coverage and neighborhood type

The FAR is considered as regulatory factor set by administrators or planners. I made three weightings of the FAR factor depicting three visions that will be discusses in the scenarios (Table 2).

Table 2: Assumed desirability values of the factors FAR

The weighting of the factors in Idrisi showed acceptable consistency ratio of 0.06. The weights of the different factors are shown blow (Table 3).

Table 3: Results of MCE weighting in Idrisi with and without neighborhood impedances
2.5 Scenarios
There are nine scenarios which are multiplication of three basic scenarios which revolve around FAR. The visions of the administrators or planners are usually described by FAR. There are three administrative visions or goals, a city of villas with FAR of 0.25, small city with FAR=1.5 and big city with FAR=4. Each vision is refined through neighborhood impedances showing what happens in the neighborhoods that are preferred and give friction to development. In the end the developers make the cut, looking for large pieces of empty land for development. They completely ignore small plots or any neighborhoods.

3 Results
The maps below show the areas with high desirability for development in regard to the design of the new BRT line. The greener the area is it is more desirable. The first collage shows the desirability in detail and the second blocks of minimum desirability. The horizontal axis shows the different FARs, where the vertical shows the refinement by urban form and actors.

The analysis display different desirability patterns through the refinements. The neighborhood impedances lower the desirability and the potential for development and the focal tool block really cuts off the areas undesirable for developers. The areas on the west of the line are currently discussed for development in the city of Karlstad. Another interesting result of the analysis is high desirability of the empty areas on the fringes of the neighborhoods. The develop cut shows tendency for urban sprawl and it is what it usually happens in reality.
Figure 4: Detailed desirability maps of the urban development potential

**Legend**
- 0: 126 - 150
- 1 - 25: 151 - 175
- 26 - 50: 176 - 200
- 51 - 75: 201 - 225
- 76 - 100: 226 - 250
- 101 - 125: 251 - 255

**No impedances**

**Neighbourhoods impedances**

**Developer cut**
Figure 5: Desirability maps of the urban development potential as 100m x 100m blocks
4 Discussion

The analysis of the potential for urban development and transformation needs to be further developed, but it is promising method. It needs improved and more specialized data. It needs better conceptualization of the desirability of the geography, the forests, lakes and landscapes. The analysis can be even simplified by using fewer factors. My recent analysis of neighborhood types in Karlstad (Stojanovski, 2012) and Rådberg’s previous research in Västerås and south Stockholm showed consistencies between neighborhood type, FAR and building coverage. FAR and building coverage can be excluded and replaced with other economical factors. The profitability of development was not well captured by the FAR factor. There was no difference in desirability when the MCE was pursuing small or large Swedish city. In reality there is big difference in transformation from single house neighborhoods to small Swedish city is on edge of profitability. The development from 1-2 stories to 3-4 stories is at least half as less profitable than developing to 4-6 stories. Additional aspect that would be interesting to include is the market values of the apartments and houses in the areas, since they play are the one that play essential role in the development. The analysis can be even more simplified.

A very important technical aspect of MCE or any other GIS analysis is the data quality. I had access to both data from SCB and Lantmäteriet. When I compared the data for example for total areas of real properties or NYKO4 areas there were errors. The mean error between the SCB and Lantmäteriet datasets was 21% where around 50% of the areas were in an interval of ±5%. That is the reason why I did not made direct join between the datasets, but I used one as background for the MCE and I used the data from SCB to estimate and assume. For example I estimated the total floor area and FAR by the population and number of work places in the SCB dataset.

The approximations, weighting and estimations are also an issue. The analysis is largely heuristic, done by my judgment, but the results of the MCE are as expected. The zones with high development potential in the developer cut even coincide with the development zones planned in the municipality of Karlstad.

The margins of error for this analysis are ±20%. But the purpose is not predict where the development will occur, but to discuss what will happen around the new BRT line if there are different development tendencies.
4.1 The powerful developer cut
The analysis shows that if the there is a developer tendency the BRT line will trigger limited development around two stations before the last on the both sides of the line. It seems that is more likely that the main focus of the developers will be the areas far from the new BRT line. In reality that is what is going on in Karlstad. There are no discussions about transformation, but about building new neighborhoods along the BRT line. David Harvey argues that the development of the city is in the hands of private interests and developers and he is right. They have freedom to move their investment in Orebro or other smaller city which offers them large empty plot.

4.2 Linking urban morphology, neighborhoods and urban transformation
The cities in Sweden developed and transformed partially and the neighborhood is usually the dominant scale in urban development. The knowledge neighborhood types can be very useful for urban development and transformation and MCE and GIS are excellent tools for analyses. The neighborhood types can be mapped, analyzed and discussed. The advantage with neighborhood types is that they are easily identified and recognized by the general public. They can be experiences and illustrated and there is usually a public opinion about the urban quality of the neighborhood types which can be easily followed by preference surveys. We can not only develop neighborhood typologies, but also typological transformations from one neighborhood type to another.

There are different scales of development and transformation. The development or transformation actions and their scales are displayed on Table 4 where X designates usual and (X) possible actions. Similar table with transformation from one urban form or neighborhood type to another can be made too. In Sweden the neighborhood was and still is the common or dominant scale of development and the usual actions include new development and redevelopments like demolish the old and develop new, infill or adjust new development and occasionally superpose new over the old. The pattern of new developments and continuously extending outward is ongoing even today on the modern periphery of Stockholm despite the compact city policies.
Table 4: Morphological and functional transformations and their scales

Similar table with transformation from one urban form or neighborhood type to another can be designed too. But there are disadvantages in replicating transformations or forms. The typologies have systematic retrograde disposition and nostalgic attachment to traditional neighborhood types can result in repetitiveness and stereotypes. Many Swedish and European cities today are terribly stereotypical. It started with the Parisian transmission of urban images in the 19th century and Haussmann’s regulation and renewal of medieval Paris and continued with Le Corbusian visions and modern surgery of the urban cores and wide replications of same neighborhood types on the urban fringes of the European cities. Urban development can happen on any scale and when it happens on small scale it usually escapes urban typologies. These atypical places in cities are especially respected and cherished.

5 Conclusions and recommendations

5.1 MCE as tool to analyze urban development and transformation

Overall the MCE showed to be a valuable tool in assessing the potential for transformation and development. With certain modification of the analysis and including market values and possible profits it will be more complete. Another technical recommendation is a suggestion for improving the data quality and decreasing the error between the various datasets by SCB and Lantmäteriet for the NYKO area. It will be also very useful to include building heights as well as
the number of stories for the buildings. It will make the calculation and analysis much easier.

5.2 Urban transformation, “BRT free development zones” and the smaller scale of urban development

If we look at the neighborhood scale, the development potential along the new BRT line in Karlstad is rather limited. There is very low probability that there will be large scale renewal of the neighborhoods. In the developer eye there is too much complexity and uncertainty to take that risk. The urban development can be seen systematically through neighborhood typologies and “typological processes”, but there is also the small scale with its uniqueness of the detail. The unique and small scale urban development produces special situational values. Every city has “unique individuality, own life and physiognomy” and it is a “complex individual” of different urban quarters or neighborhoods (Reclus, 1905, pp. 385). Each neighborhood is complex individual too of blocks and real properties. The urban development and transformation can happen on small scale and that is very important for smaller cities. The developers always think large and sometimes there are small solutions. It is especially important when there is an attractor for urban development like future public transport system that can link large part of a small city. If the city of Karlstad wants to have successful implementation of the newly proposed BRT line it is important to consider small scale transformation of the city. It should involve “BRT free development zones” where small businesses and architects and builders from the city can develop their own visions of the future city. Similar successful low scale development is for example Borneo in Amsterdam (FIGURE 6). Same system of unique urban design or transformation plot by plot can be applied everywhere around the station of the BRT line.

Figure 6: Plot by plot urban development in Borneo in Amsterdam
References


