Reducing Automobile Dependency in Växjö Sweden:
The Application of Smart Growth Planning Principles

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Reducing Automobile dependency through Smart Growth
ABSTRACT

The City of Växjö has committed to reduce CO₂ emissions by working towards being a fossil fuel free city. The greatest challenge to this goal is increasing CO₂ emissions from the transportation sector, creating the need to reduce citizens’ use of private automobile. This thesis research attempts to address the question of how the design of a community development when integrated with transportation demand management strategies (TDMS) based on Smart Growth planning principles (later defined in theoretical perspectives section) can influence citizens to drive less and choose alternate forms of transportation such as public transit, cycling or walking, thereby reducing vehicle miles traveled (VMT) and carbon dioxide (CO₂) emissions. The research results and recommendations for Växjö are an integration of TDMS that focus on prioritizing pedestrianism, cycling, and public transit over automobile usage through five Smart Growth land-use planning principles. By planning for a reduction in automobile dependence and addressing the root cause of the majority of transportation based CO₂ emissions, Jonsboda has the potential to become a model community in its efforts to promote the concept and implementation of sustainable transportation.

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INTRODUCTION

Research Question

The research question simply put is, how can the design of a community development when integrated with transit demand management strategies (TDMS) reduce citizens’ dependence on the private automobile by encouraging them to choose alternate forms of transportation such as public transit, cycling or walking to reduce VMT and CO₂ emissions? The solution to this answer is not one, but a plethora of various Smart Growth design features and associated TDMS that aim to facilitate a greater modal split in mobility choice.

Defining Sustainable Transportation

The concept of sustainable transportation, though debatable, is not particularly controversial. Most people agree that less fossil fuels should be consumed and emissions should be reduced. Why then have we not seen substantial systemic change brought about in this arena? Why does the auto persist as the dominant mode? There is not one particular reason for this, rather a complex web of factors that have ended up preserving the status quo of automobile catered development.

Sustainable transportation, also commonly referred to as sustainable mobility, has received no formal definition, although is commonly an extension of the logic behind the 1987 Brundtland Report definition of sustainable development. This definition suggests “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”¹ The Organization for Economic Cooperation and Development (OECD) in 1994 proposed a commonly practiced definition of sustainable transport as “Transportation that does not endanger public health or ecosystems and meets mobility needs consistent with (a) use of renewable resources at below their rates of regeneration and (b) use of non-renewable resources at or below the rates of development of renewable substitutes”² while the World Business Council for Sustainable Development (WBCSD) in 2001 defined sustainable mobility as “the ability to meet the needs of society to move freely, gain access, communicate, trade, and establish relationships without sacrificing other essential human or ecological values today or in the future.”³ Regardless of the details of various definitions of sustainable transportation or mobility, the wording is often in accordance with the defining organizations’ best interests, whether economic, social or environmental, with the most widely accepted definitions addressing all three aspects equitably.⁴

For the purpose of this paper, the term sustainable mobility or transportation

will be used to describe how transit based transportation and high density, mixed-use land-use planning can contribute to sustainable development by promoting inter-generational economic viability, improved social well being, and environmental stewardship by encouraging a societal shift away from automobile dependence.

The need to address Sustainable Mobility

Personal mobility in our modern society is no longer a luxury in life but a necessity, as travel has become an indispensable aspect of our lives. The mobility of persons and products has become the most significant driver for our current globalized free market economies as transportation efficiencies have aided in overcoming vast distances and time constraints. As a result of this change, the world has experienced considerable economic growth resulting in greater purchasing power parity for the general public. This has further fed the automotive and petroleum industries as an exponential increase in private automotive sales and ever increasing demands increasingly diminishing crude oil reserves. This is evident in that nine out of world’s top ten highest revenue generating companies operate in either the petroleum refining or motor vehicle sectors and wield a significant amount of political clout to ensure this economic trend continues.5

Throughout the 19th and 20th centuries this period of unprecedented growth has been largely due to the exploitation of fossil fuels, which have provided society with a cheap, abundant, and mobile source of energy to drive our economies. Yet this has come at a significant cost to our social and ecological systems.

The most evident of these problems is the current climate change crisis, which was popularized by Al Gore’s documentary ‘An Inconvenient Truth.’ This was a late public response to the recognition of the issue after many years of scientific warning and poor political performance to reduce CO₂ emissions, which is the greatest contributor to the systemic increase of our planet’s average temperatures.

Transportation activities are a significant contributor to global warming with estimates of 18.4% of the global CO₂ emissions coming from the transportation sector, with this share of CO₂ emission output one of the fastest growing of all contributing sectors. As the developing nations gain economic momentum their mobility footprint will increase significantly and ultimately further increase the levels of CO₂ emissions in the atmosphere and increase the necessity to address the issue of sustainable transportation. Within Europe “transport is one of the largest sources of environmental pollution …with a 40% increase in carbon dioxide emissions from transport expected between 1995 and 2010” and these rates are growing. As Europe continues to prosper from economic growth, a significant amount of the wealth generated will be invested by families into new cars, further adding to the output of CO₂ emissions and dependence on the automobile. Car ownership is increasing in Europe which will place continual strain on the already crowded cities of Europe, yet this phenomenon is much more apparent in the developing countries of China, India, and many others as recognized in the following diagram.

Besides current transportation systems having significantly adverse effects on the environment, the social and economic aspects of transportation are highly unsustainable as well. The EU estimates that nearly 100 billion Euros a year are lost due to inefficiency and pollution associated with current transportation systems, and of the 1,219,000 automobile related accidents in 2006, 38,600 caused fatalities and 1,640,000 serious injuries, not to mention the unprecedented poor health effects associated with poor air quality. These impacts from current transport systems are unacceptable and must be addressed to contribute to a more sustainable society. In 2007 the EU’s green paper ‘Towards a new culture for urban mobility’ emphasized the need to improve the ills of transportation systems by moving towards greener cities that provide smarter, safer, and more accessible mobility options in addition to reducing the dependency on the private automobile. This is the challenge. In understanding the need for a change in our current transportation methods and patterns, it is important to look at what the drivers encouraging a change towards a greater diversity of transportation options would look like, and conversely the barriers resisting such a paradigm shift in society.

Drivers for Change

The successes of the various case studies described below are in many ways due to momentous actions taken by brave politicians, insightful planners or public movements to move the urban environment towards the vision of a sustainable city. The Improvement and Development Agency for local Government (2007, May 15) Sustainable Transport: key drivers. (Retrieved Feb. 23, 2009 from http://www.ida-lg.org.uk/)

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recognize that the public demand for more sustainable transportation options are associated with traffic congestion, climate change, poor health and well-being, and diminishing social inclusion.

Traffic congestion has traditionally been recognized as one of the most apparent problems associated with automobile dependent based transportation planning. Cities such as Los Angeles are highlighted as key examples of this. The traditional solution towards traffic congestion has been to improve road capacity with major automotive lobby groups encouraging and motivating political decisions to move in this direction. Cities who are reclaiming road space into public space prioritized for pedestrians, implementing traffic calming mechanisms and placing caps on road capacity are recognizing that it is encouraging people to use alternate forms of transportation and increasing urban quality of life. This can be observed in cities that have refused freeway system intrusions into the city core and in doing so maintained the vitality of their central business district (CBD).

Vancouver Canada is a classic example of how a city’s vitality was preserved by refusal of increasing road capacity and discouraging automobile based commuting. The community-based movement of resistance emerged from the downtown east-sides historic china town residents who wanted to protect their community, which was endangered by the freeway plans. Through legal battles, a young lawyer named Mike Harcourt won the case for the Chinatown residents and put an end to the freeway development plans. Harcourt carried on to become a city council member and later the mayor of Vancouver. He maintained his resistance towards the automobile dependent city and encouraged the transit-oriented development and new-urbanism aspects of Vancouver.

Other ambitious mayors such as Jaime Lerner of Curitiba, and Enrique Peñalosa of Bogota have with radical transportation plans discouraged automobile use and congestion giving priority towards transit, pedestrian and walking modes of transportation. Having the political momentum to implement sustainable transportation initiatives has been one of the greatest success factors in cities that are currently reaping the benefits of transit-based development.

Climate change is recognized as one of the most pressing challenges facing society today and is a point source to a seemingly insurmountable list of environmental, social and environmental problems. Due to the severity of this issue many local governments are working in collaboration with external funding and partners to address change with a growing number of collaborative initiatives such as C40, CityFix, and Civitas, working together to implement change and demonstrating the possibilities of Sustainable Mobility.

Whether through direct accident related deaths and injuries, or indirect obesity and poor health conditions from lack of exercise, automobile dependence has been negatively impacting human health and well being for a long time. It is not surprising that increased physical activity, whether by cycling, walking, or other human powered transportation is beneficial to human health and well being. The promotion of alternate modes of travel will also reduce car accident related deaths and injuries due to a reduction in automobile travel. In addition to the human health and well being benefits associated with reducing automobile dependence through development that promotes various transit opportunities and cycling and walking networks, there is an increase in social interaction and community cohesion.


Copenhagen’s innovative social planning has lead to a tripling of social and recreational activity along major streets due to a strong movement to pedestrianize streets with increases in cafés, street seating, buskers, urban landscaping and markets. These initiatives calmed traffic and brought an increased vitality to the city core making it recognized today as the most cosmopolitan city in Scandinavia. Bogota’s cycleway program closes 110 km of major roadways in the city every Sunday from 7am to 2 pm and encourages over 1.5 million people to get out and get active. Whether cycling, walking, skateboarding, or rollerblading, this promotion of social interaction has been recognized as a one of the leading causes of reducing the murder rate in Bogota (formerly one of the highest in the world) more than 70% in less than ten years.

Social inclusion within society proposes many avenues of discussion. In the context of transportation, social inclusion often refers to the level of access to services that various social classes have. Social inclusion is lowest in cities that have poor access to transit options and thus reduces their opportunities to access services. William Julius Wilson has charted the consequences in his book *When Work Disappears*. His research reveals that there is a negative correlation between the motivation to work and the opportunity to work in most poor urban centers. During and after the shift towards our current global economy there was a massive reduction of middle class jobs, particularly in the manufacturing and heavy industry sectors. As those jobs disappeared, the urban populations that had the lowest incomes lost their ability to earn a decent wage, and to participate in the transportation network, as it was auto-based. Most of the service jobs that were accessible to those with lower levels of education were outsourced to urban fringe industry parks and the suburbs. Without public transit opportunities, the urban population effectively had no work opportunities and fell into the downward spiral of poverty.

The documentary ‘Taken for a Ride’ describes the eradication of the LA streetcars and emergence of the freeway system as a significant impact on social inclusion. The poor bus transit options serving the low-density, non-mixed use regions of LA were a horribly inefficient system that were incredibly slow, infrequent and over-capacitated. This further contributed to a polarization of classes as lower income groups were at a significant disadvantage in terms of access to work opportunities and necessary services. These examples demonstrate the correlation between an efficient transit system and productivity of society and these systems assist in reducing the socioeconomic gap between various income groups.

### Barriers to a Sustainably Mobile Society

The barriers to implementing sustainable transportation systems can largely be broken down into three main areas: social, physical and political/economic. The social barriers deal with the extent that individuals and culture interact with the transportation system through their preferred transportation mode choice. Physical barriers are the actual infrastructure and geography that social actors and land-use planners are interacting with on a consistent basis. Lastly the political/economic barriers encompass the decision-making process through

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15 Tad Fettig (Producer and Executive Director). (2008). *Bogota: Building a Sustainable City* [Documentary Film Series; e2: The Economies of being Environmentally Concious]. USA, PBS.
17 Olson, M.,(Producer) & Klein, J., (Director). (1999). *Taken for a Ride*. [Documentary Film]. USA. New Day Films
influential actors at both the government and business levels.

Much of the social factors revolve around the threat to quality of life. The threats can be perceived or real. Auto travel is associated with high levels of convenience and independence. There is often no need to plan around a set schedule or arrange errands and other tasks while being mindful of predetermined routes. The myriad of styles and brands of autos plays into the desire of many to create an identity for themselves.¹⁸ Much like how fashion expresses a statement without words of one’s perceived social status, the symbolism associated with automobile ownership has been marketed to do the very same. This is of course fueled by the massive amounts of money spent on marketing and advertising automotive products, and the social norm of consumption as a status indicator. A host of other factors play into the popularity of the car, including comfort, access and infrastructure. What ties these together is that a change in transportation habits requires effort, or behavioral changes.¹⁹ Therefore it takes a high degree of motivation to change established life patterns.

Physical development that has taken place throughout the 20th and 21st centuries has ignored sustainability and ecology on the list of priorities. What we have ended up with is a sprawling landscape, with metropolises spread out over vast areas of land requiring mass resources and producing abundant wastes. The metropolitan areas are too large to be served by effective public transportation and instead require, personal, motorized transport. It is not uncommon for commuters to New York City and other areas to drive up to two hours to and from work. The more that people depend on cars, the more they demand living space that is outside of active city life, and the cycle continues.

The developments persist primarily for three reasons. First off, land-use and transportation planning are rarely interconnected. Poor land-use planning that is characteristic of suburban sprawl is responsive to the expansive road networks associated with automobile dependent transportation planning. Secondly, externalities are not accounted for in the costs of development. The true cost of environment is not taken into account as subdivisions and transport networks are constructed. This is a result of direct and indirect factors such as subsidies for petroleum companies and lack of charges for carbon emitters. The third reason is that technology requires large initial investment. New infrastructure is extremely costly, particularly when it is compared with the cost of subsidized gasoline and a personal vehicle.

Political and business actors often have the same goals when it comes to transportation policy, that being, economic growth. A tremendous amount of money flows back and forth between the two interests, ensuring that this link stays strong. Many political figures have enumerated the need for sustainable transportation and enhanced accessibility among their constituency, but projects such as road improvements and motorway additions are often seen as quick and measurable signs of political actions. These figures want to bring home clear improvement, and thus favor a short-term outlook towards transportation issues. Similarly, investors often favor short-term returns on investment. Large-scale infrastructure and paradigm-shifting innovations take a much longer view for implementation, much like that possessed by mayors Lerner, Penalosa and Harcourt.

There is also a severe lack of vertical coordination between policy making and implementing bodies. With smaller agencies looking out for their own interests and working on a smaller scale, there is not always a broad enough view. Further, it leaves them open to the influence of economic actors in the

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marketplace. When nine of the ten biggest companies by revenue in the world are involved in petroleum refining or automotive transport, there is a definite uphill battle for advocates of change. These corporations wield a tremendous amount of influence on political and environmental policies.

By reviewing case studies and observing which transport demand management strategies have been successful, some conclusions can be made on what theoretical urban design features or transport policies contribute towards a more sustainable city. Not only does decreasing the accommodation for automobile usage through transit-oriented developments reduce CO\textsubscript{2} emissions, case studies show a dramatic improvement in quality of life of residents living in urban environments that have been designed to accommodate for people rather than automobiles. Transit oriented development in association with smart growth/pedestrianist urban villages seem to be a dominant trend recognized in cities that are successfully addressing the issue of sustainability. In the transition towards reducing automobile dependence, societal needs and quality of life standards need to be meet. It is therefore in the best interest of city council members to adopt the proposals of city planners and architects that wish to address the issue of sustainability by reducing societal dependency on the automobile and enhancing a higher quality of life. This is not an easy task, as it requires a paradigm shift amongst society members to abandon their dependence on the use of their automobile and reevaluate what a better quality of life may look like.

The described barriers and drivers for change are a collection of complex economic and social inter-relationships which many authors view as determined by path dependence or path creation. Proponents of path dependence view historical events to explain the development of novelty, much like evolutionary change, while proponents of path creation suggest that it is entrepreneurs that explain the emergence of novelty. While entrepreneurs have had some success at introducing new automotive technologies, which can reduce CO\textsubscript{2} emissions and reduce the dependence on oil imports, a more proactive solution is the reduction of automobile use by encouraging a greater modal split in mobility choice.

**Transportation Demand Management as contributor to Sustainable Mobility**

For Växjö to make the transition to a more sustainably mobile city, initiatives that contribute to sustainable transportation should be gradually implemented to ensure successful adoption. Transportation Demand Management (TDM) or Mobility Management is a term used by transportation planners to categorize the multitude of various design and policy initiatives that encourage alternative forms of mobility, such as walking, cycling or public transit and maximize the efficient use of transportation resources. TDMS are an excellent means of facilitating this change within society as they are often a mix of demand and supply based solutions that effectively shape the transportation habits of society. There are many forms of TDMS that municipal planners can propose to contribute to sustainable mobility (SM), although it is the implementation authority of local politicians that effectively decides what TDMS are to be used and the degree to which transportation priorities are encouraged. In this regard

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TDMS must be in the best interest of the community as a whole by benefitting the economic, environmental and social well being of the community.

TDMS can act as a significant contributor to sustainable mobility (SM) as it addresses the root cause of transport’s impact on economic, ecological and social systems. As discussed previously, transportation is a significant contributor to the CO$_2$ emissions that cause global warming, although this is primarily due to the significant increase in use of the private automobile in the last 60 years. Social and economic systems were negatively impacted by this accommodation for the automobile. Economic stresses grew due to continual infrastructural improvements and unprecedented health related issues. TDMS can mitigate this dependence on personal automobile mobility by encouraging the use of alternative forms of transportation. This can be accomplished through emphasizing the movement of people and goods, rather than motor vehicles, and prioritizing more efficient and affordable modes of travel such walking, cycling, ridesharing and public transit. Ultimately, reducing the impacts on social, economic and environmental systems.

For the purpose of this research paper, TDMS are reviewed and applied that promote the efficient and compact use of land resources and focus on the reduction of CO$_2$ emissions through five Smart Growth planning principles prioritizing transit oriented development (TOD), density, mixed-use development, the promotion of alternate forms of transportation through walking and cycle friendly design, and abundant green space. These guiding principles place a high focus on the improvement and accessibility of the urban fabric through the promotion of public transit, walking and cycling as primary means of mobility. To further encourage these alternate forms of mobility, compact and mixed-use development that is supported by safe, aesthetic and convenient pedestrian and cycling paths is required. By building dense compact developments, more room is available for green spaces, providing recreational, agricultural and natural reserves for the public to enhance greater social cohesion and enhanced quality of life. By promoting these development goals and integrating land-use planning and transportation planning it is understood that societal transportation habits can change, resulting in less use of the private automobile for daily mobility activities. Mobility prioritizing walking, cycling, or public transit can significantly reduce vehicle miles traveled (VMT) and vehicle trips (VT) resulting in a reduction of CO$_2$ emissions from the transport activities in Jonsboda. For the purpose of this paper, TDMS discussed in relation to Jonsboda will describe all design or policy suggestions that encourage alternate forms of transportation and support the Smart Growth planning principles.
METHODOLOGY

Research Procedure

To determine that design suggestions would contribute to a reduction of fossil fuel generated emissions and a higher quality of life in Jonsboda, extensive research of sustainable transportation planning and community design was needed to validate the proposal suggestions. In addition to literature reviews and case studies, various transportation engineers and urban planners with extensive experience within this area of study were consulted to gain reassurance that the methods and proposals were consistent with their experience. The research and consultations consistently converged on the reoccurring themes of Neo-Traditionalism, New-urbanism and Smart Growth approaches towards community and neighborhood design to avoid a suburban bedroom community. A common thread found between these three planning and design approaches was that high-density and mixed-use development concentrated at major public transit nodes was critical to reducing dependence on automobile usage and thereby reducing CO₂ emissions and improving quality of life. Smart Growth was found to be the most advantageous for these purposes as outlined in the theoretical perspectives.

Research was based on the following sources of data:

- Review of peer-reviewed journal articles sourced from a plethora of academic journal databases such as: ScienceDirect, J-Stor, Academic Search Elite, and others in addition to well researched books on the subject by accredited authors highly familiar with transportation planning and urban design.

- Review of case studies and best practices highlighted by various institutions and organizations such as: C40 cities climate leadership group, Victoria Transport Policy Institute (VTPI), Institute of Transportation Engineers (ITE), New Urbanism Congress, EuroCities, Planetizen, European Platform on Mobility Management (EPOMM), CIVITAS, CItyFix and many others.

- Review of documentary films associated with the negative aspects of transportation planning and poor urban design such as: ‘Taken for a Ride’, New Urban Cowboy: Towards a New Pedestrianism, and The End of Suburbia: Oil Depletion and Collapse of the American Dream.

- Discussions with various transportation engineers and urban planners familiar with the study area of Växjö such as: Erland Ullstad (previous head planner of Växjö and Planning Professor), Sven-Allan Bjerkamo (transportation engineer and urban planner), and Kristina Thorvaldsson (current Växjö strategic head planner).

By designing Jonsboda to be a transit-orientated development of a mixed-use and high-density nature consistent with the Smart Growth planning principles, this approach could provide an example of how development can reduce dependence on automobile use and improve local residents’ quality of life. By following similar research procedures, it can be assumed that one would find similar outcomes for design and planning approaches, which suggest that Smart Growth is the most practical and comprehensive approach to reducing VMT and VT in growing development areas. By confirming what the macro, theoretical design strategy should be, the second aspect of research and work was to assess the micro aspects of development through various conceptual design recommendations for Jonsboda.
Design Procedure

To guide the conceptual design proposals, five Smart Growth planning principles were used as guiding principles to ensure that the design elements would encourage a greater modal split in mobility habits. To accompany the design recommendations, sustainable transportation indicators (STIs) and associated policy recommendations were recommended. Växjö could also utilize these elements to further guide the development’s intent of reduced VMT, VT, and high quality of life and monitor annual progress. The STIs and policies were adopted from the various sources of data found during theoretical research as highlighted in the research procedure above.

To guide the physical development of Jonsboda, what services the community needed to provide to create a self-contained living environment for 4-5 thousand inhabitants needed to be assessed. With the intent of reducing automobile dependence, it is a high priority to provide local employment opportunities and other necessary services to the residents of Jonsboda, thereby reducing the need to travel to other areas of Växjö. To assess these metrics a series of assumptions were devised based on the best available knowledge from Växjö and consultation with strategic head planner Kristina Thorvaldsson. Once these metrics were established, design could begin for what the physical layout of Jonsboda would look like in three phases of development. To guide the design approach, a number of influencing agents were considered with ultimately the five Smart Growth planning principles as top priority. Design patterns and influences from Neo-Traditionalist and New-Urbanist planners such as Ebenezer Howard, Peter Calthorpe, Raymond Unwin, Leon Krier, John Nolan, Henry Wright, Lewis Mumford, Andreas Duany and many others were considered by reviewing their development designs and theories. To guide the proximal relationships and specifications of design features, SmartCode, an open source integrated land development ordinance, and LEED ND specifications were considered in addition to consultations with Sven-Allan Bjerkemo. Accompanying the computer and library based research, numerous field trips were conducted to other cities to document various land-use and transportation initiatives that were consistent with Smart Growth. The cities visited were, Copenhagen, Malmo, Gothenburg, Stockholm, Helsinki, Barcelona, Amsterdam and Berlin. This opportunity was highly valuable to gain a feeling of the transit-based culture and better determine the potential that Jonsboda could have.

The tools utilized to design the physical layout of Jonsboda were an integration of rudimentary Geographical Positioning System (GPS) surveying and Geographic Information Systems (GIS) analysis with the Adobe creative suite 2 (CS2) to add further elements of aesthetic appeal to the final product. By surveying the area via a Garmin 60CSx GPS at an average accuracy of 3 meters we were able to choose appropriate boundaries for various land-use designations and road infrastructure networks. GIS analysis with both Manifold and ArcMap made it possible to create buffers that established proximal distance relationship between various land use types and various transportation services, such as the distance from car-free residential dwellings to the BRT transit stops. The GIS program was also used as a medium to create the land-use and transport map, road typologies, and provide a base for diagrams demonstrating the design proposals. The various GIS layers that were utilized for analysis of the region were either compiled from tracks recorded by GPS based surveying which were converted from point data to vector based line data, or drafted with Manifold using geo-referenced locations for all designs. Shapefiles (.shp) acquired from Växjö GIS specialist Karl Magnusson were utilized as the basemap and starting point.
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The benefit of using Manifold GIS as the drafting medium is that all layers are geo-referenced so proposed transportation footprint and land-use zones can be exported as .shp files. Växjö can then integrate them into their own ArcGIS catalogue of data, and very easily integrate the proposed designs into their Master Plan and future spatial layout designs if so desired.

Continual consultation with thesis supervisors and contacts in Växjö guided the drafting process and lead to the final design map illustrating the transportation footprint of the area, associated road types and land-use designations which are portrayed in the results section of this paper.

Ultimately, the design intentions were to demonstrate to Växjö what a transit orientated Smart Growth community could potentially look like and how it could be linked to the CBD. By providing visual representations and descriptions of the design elements, along with STIs to monitor and evaluate the development, this research can be highly valuable to the 2010 Master Plan and easily incorporated. A high level of theoretical research, which indicated Smart Growth would be the most ideal land-use management approach as the city develops Jonsboda, drove this conceptual design proposal and supports it’s legitimacy as being an effective means to increase the modal split in mobility choice through the design based TDMS. Given Växjö’s serious aspirations for reducing transport related CO₂ emissions, it seems likely these designs will be considered.

THEORETICAL PERSPECTIVES

Historical progression of Transportation Planning and Urban Land Use

Transportation priorities are often recognized as one of the greatest forces shaping the urban environment in parallel with economic priorities and social or cultural priorities. Through historical transportation planning successes and failures it has become evident that the impact of transportation policies, and how they have encouraged or discouraged the use of the private automobile, have been one of the greatest factors in creating dismal or healthy urban environments.\(^{23}\)

The earliest known cities of Mesopotamia designed roughly 7,000 years before present were originally characterized by dense, mixed-use development with narrow streets organically formed to the natural landscape, allowing for pedestrian access to an abundance of services. These traditional Walking Cities improved with time to accommodate larger populations and growing service requirements and are suggested to have reached a peak of urban function and societal well being roughly 2000 years before present.\(^{24}\) By rarely exceeding a diameter of 5 km and with all services within the city core accessible by foot in less than 10 minutes time, the high density Walking City accommodated for pedestrians and a high quality of life.

High qualities of life could be attained with abundant services that were easily

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accessed, and highly aesthetic urban form promoting mixed-use development and abundant public and civic space.\textsuperscript{25} The Walking City was the dominant design up until the mid nineteenth century until the pressures of population and industrial expansion required greater mobility of citizens, and lead to the use of horse-drawn, steam-powered, then electric trams and streetcars to access the less dense and expansive Transit City.\textsuperscript{26}

The Transit City flourished economically while providing socially equitable mobility at a low environmental cost. They often expanded as far as 30 km in diameter with a CBD serviced by arterial transportation corridors and medium density, mixed-use transit-oriented developments concentrated near transportation nodes. The Transit City maintained many of the aesthetic appeals that the City Beautiful Movement in the US and Europe had promoted, and maintained an element of social cohesion found in the traditional Walking City.

By concentrating development at the nodes of transportation hubs, growth was limited and controlled as transportation planning and land-use planning maintained a symbiotic relationship. Due to the significant amount of economic growth and prosperity from the increased mobility and urban expansion, transportation received significant praise and was envisioned as the future driver for shaping the urban environment by influential architects and modernists such as Le Corbusier who stated in 1935:

\textbf{“The cities will become part of the country: I shall live thirty miles from my office in one direction; my secretary will live thirty miles away from it too, in another direction, under another pine tree. We shall both own cars. We shall use up tires, wear out road surfaces and gears, consume oil and gasoline.”}\textsuperscript{27}

The current Automobile Dependant City that we are familiar with gained significant momentum in the mid 20\textsuperscript{th} century particularly in North America and Australia as political pressures from transportation lobbyists in conjunction with the modernist movement coerced the decisions of politicians to move towards buses and automobiles as the primary means of transportation.

The transportation lobbyists replaced train, tram and rail transit services with what was perceived to be a more flexible and expansive bus transit system.\textsuperscript{28} The most notorious example of this was the replacement of the streetcar transit lines with inefficient buses in 44 states of the US. A consortium of petroleum and automobile corporations (General Motors, Firestone Tires, Mack Trucks, and Standard Oil) formed National City Lines; a bus transit company which bought out the urban streetcar transit systems and replaced them with inefficient bus lines. The outcome was the birth of the freeway systems as the consortium’s lobbying and pressuring of political decisions dramatically reshaped the urban-land form, resulting in a greater dependence on the private automobile for mobility. Los Angeles was a prime case study of how one the world’s most efficient and expansive electric streetcar systems (the Pacific- Electric trolleys) were replaced by one of the worst public transit systems. The result today is the vast network of freeways and traffic congestion Los Angeles is renowned for.


With the increasing ownership of private automobiles and bus lines, the Automobile Dependant City allowed the urban environment to spread vast distances as low-density and single-use zoning became the dominant characteristics. The expansive development instigated by the automobile and bus lines encouraged the development of suburbs on average 50 km from the CBD creating large economic, social and environmental pressures. The expansion and infill of the arterial transit corridors increased the ecological footprint of cities, reduced social equity in mobility options and significantly drained municipal monetary resources and has acted as the catalyst of much urban decay and social segregation.

The Automobile Dependant City we are familiar with is no longer a feasible option as the years of cheap abundant oil come to an end, and climate change and reducing C02 emissions becomes a more pressing issue to address. In addition, with growing urban populations, the environmental, social and economic strains placed on society from an urban design that accommodates the private automobile are unsustainable. The following table demonstrates some of the more prominent, over-arching negative attributes of automobile dependent travel as noted by authors Newman and Kenworthy.

<table>
<thead>
<tr>
<th>Economic</th>
<th>Social</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic congestion</td>
<td>Inequality of impacts</td>
<td>Air pollution</td>
</tr>
<tr>
<td>Mobility barriers</td>
<td>Mobility exclusion</td>
<td>Water pollution</td>
</tr>
<tr>
<td>Accident damages</td>
<td>Human health impacts</td>
<td>Hydrological impacts</td>
</tr>
<tr>
<td>Infrastructure costs</td>
<td>Community interaction</td>
<td>Land-use impacts</td>
</tr>
<tr>
<td>Consumer costs</td>
<td>Community livability</td>
<td>Habitat loss</td>
</tr>
<tr>
<td>Depletion of non-renewable resources</td>
<td>Aesthetic quality</td>
<td>Depletion of non-renewable resources</td>
</tr>
</tbody>
</table>

The ills created by automobile dependence in urban environments have created a long list of interconnected social, environmental and economic problems. These demonstrate the significant impact that transportation planning and land-use has on all aspects of a city’s well being. This has lead planners, engineers and architects to begin envisioning, planning and designing for sustainable cities, which are often characterized by the movement towards New-Urbanism or Smart Growth development of urban villages focusing on dense, mixed-use transit-oriented development.

In order to effectively address the transition towards a more sustainable city, a series of priorities must be re-established to reduce the level of dependence on the automobile. Transportation priorities in the post-automobile dependent city need to focus on the provision of not additional roads and parking but less, opening opportunities for more green space with integrated cycling, walking and pedestrian prioritized space adding greater social cohesion and livability to the city. Land-use planning priorities need to move from low-density, highly distributed, single-use developments to high-density, centralized, mixed-use developments.
use developments at major transit service nodes. This reduces the need for automobile travel, increases accessibility, and drastically increases the efficiency of land-use as it becomes tightly integrated with transportation planning.

**Planning Theory and Progress towards urban design reform**

Transportation planning and land-use can be generally broken down into the 4 models discussed above (Traditional Walking or Pedestrian City, Transit City, Automobile Dependant City, and the Neo-traditional or Sustainable City). In the evolution of urban planning much of the thought that went into design was based on either the expressions of Rationalism or Empiricism, which were the dominant influence up until the 19th century as they appeased the wishes of an elitist class of royalty and the aristocracy. As cities grew with the advent of the industrial revolution, they became dismal places to live as pollution and poor health conditions grew. This called for policy in many cities to improve the living conditions of the working class and the birth of Pragmatism, the planning movement that recognized the practical application of urban form. In addition to the new planning and design ideologies of the Pragmatists, policy in larger cities began to have a large effect on urban land reform. In London, the Act of 1875 set specific guidelines regarding the design of streets and buildings in addition to provision of sanitary facilities to improve the working class quality of life and urban planning. Theories regarding higher quality of life for not just the elitist classes of society but for all grew.

The emergence of planning theories that arose at the turn of the 19th century and throughout the 20th century could be categorized into either Modernist or Neo-traditionalist. Simply put the Modernists wanted to abandon the medium to high density and mixed use development associated with traditional planning recalling the urban decay characterized by poverty, disease, crime, and ugliness which initiated the Pragmatist planning movement by promoting low-density urban sprawl. The Neo-traditionalists recognized the benefits of high density and mixed use, recalling the high quality of life in pedestrian cities prior to industrialization of the urban core.

In France, Pragmatist planners such as Baron Haussmann were given the task of reengineering the streets so that in addition to ensuring a higher quality of life for the working class as in London, wide streets would prevent angry mobs from building barricades between the walls of narrow streets. This lead to the very wide Haussmann Boulevards, which followed a highly neat and organized geometric form. Though the Haussmann Boulevards served function, they lacked aesthetic appeal. Julien Gaudet and Camille Sitte recognized the Haussmann boulevard’s as “too grandiose, too formal and too monumental” and pleaded for irregularity and an importance of aesthetic urban design. Camillo recognized that for a city to truly have an aesthetic form it must take an organic irregular form opposing the geometric planning of Haussman, and that it must contain an abundance of large open green spaces that could function as healthy forests. Gaudet recognized the largest challenge in achieving aesthetic reform was in planning for traffic. He recognized that the absence of a high traffic roadway could greatly facilitate the growth of the ‘picturesque’ and saw transport engineering as based entirely on utility, insisting that roads must be aesthetic and appealing.

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In America the artistic planning ideologies of Camillo and Gaudet inspired the City Beautiful movement that emerged from the 1893 World’s Columbian Exposition in Chicago. The City Beautiful movement in the US was spearheaded by Daniel Burnham’s architectural experience and Fredrick Law Olmstead’s spatial planning experience. They focused on improving the beautification and monumental grandeur not as a means of improving aesthetic form but as a social control device with the intent of improving civic and moral responsibility amongst society. While the neo-traditionalist planning ideologies of the City Beautiful movement focused on improving the quality of life within the city, Modernist planners sought to reduce the pressures of population growth by promoting sprawl.\(^\text{37}\)


In the UK Ebenezer Howard’s Garden City movement was held as a potential solution to the overcrowded inner city. Howard’s utopian Garden City Plan was composed of concentric spatially orientated and self-sufficient planned towns, which were limited to a population of 32,000 people on a 6000 acre Greenfield plot surrounded by agricultural greenbelts. Each Garden City would serve as a satellite city denoting 5000 acres of land to green space and agriculture and 1,000 acres dedicated to residential and commercial activities. The satellite cities would be connected by railway and road to other garden cities with a central city core supporting larger populations at the core.\(^\text{39}\) At the core of each garden city would be a city park where public buildings would sit, concentric avenues would contain commercial and residential buildings, and industrial zoning would rest at the edge of the city core. Howard’s Garden Cities were indeed a means to alleviate the pressures of urban growth from the city core, but they also were insight into regional town planning.

Howard’s Garden City influenced a group of planners including Lewis Mumford, Clarence Stein, Henry Wright, and Catherine Bauer who were informally recognized as the Decentrists and endorsed Howard’s ideas of decentralizing the population. Most commonly recognized from this movement was Stein’s


neighborhood unit, which emphasized what the Decentrists recognized as the best elements of a community. Crucial to the concept of the neighborhood unit was that all ‘day-to-day’ activities such as shops, schools, playgrounds, parks, community halls and various other services should be within walking distance. They suggested the ideal community size they suggested should be around 5000 people; large enough to provide the various services, yet small enough to retain a feeling of community. In regards to roads, the Decentrists viewed streets as a form of blight on the health of a city with the suggestion that houses be turned away from the street and face onto gardens and walkways.

In France, Le Corbusier was influenced by Howard’s Garden City although he felt that instead of having a city with abundant gardens he would place the city in a garden, with high densities achieved through vertical growth, reserving space for agriculture and green space. Le Corbusier’s transportation layout differed from Howard’s in that he preferred the more authoritarian rectangular grids, with wide highways elevated to maximize mobility feeding a central transportation hub with numerous transportation modes. Corbusier once stated: “the street is no longer a track for cattle, but a machine for traffic, an apparatus for its circulation.”

In practice, these theories have not been as successful as they were planned out to be. One argument for why this was is that despite all the talk of creating a place and high standard of living for the working man, these plans were uniform, top-down, and even authoritarian. Despite the tremendous amount of vision and high-minded philosophy that these planning forms were based on, there was little grounding in actual data or research. Due to this grounding in thought, many critics of Le Corbusier or Howard would argue that prefabricated city planning is too idealistic and utopian. However, the tremendous vision allowed the theories to gain much traction at the beginning of the 20th century, and many cities began to evolve with these elements, demonstrating their influential theories on planning. New York City echoed Le Corbusier’s Radiant City with the Cartesian transportation grid and the height and density of Manhattan skyscrapers, and Los Angeles adopted the fundamental ideas of Howard’s satellite city model.

Author and urbanist Jane Jacobs shocked planners and designers with her critique on the urban environment in the book *The Death and Life of Great American Cities*. She stated simply “Think of a city and what comes to mind? Its streets. If the city’s dull, the city looks dull.” Jacobs continued to emphasize the need for attractive and safe streets and plazas, which could be attained with a certain level of density and mixed-use such as Greenwich Village, which she regards as a prime example of urban planning. Her main recommendations were to disregard zoning and promote mixed-use, create smaller blocks with higher connectivity, and maintain an ideal density of 100 dwellings per acre to increase social cohesion and safety. Many other influential urbanists, designers and planners during the latter half of the 20th century such as Christopher Alexander, Nicholas Taylor, March and Trace, Peter Cowan, Oscar Newman and Alice Coleman made great contributions to urban design that showed a greater improvement in quality of life for its users. The common thread amongst these planners was the revival of traditionalist planning ideologies and the movement from the Modernist planning ideologies popular at the beginning of the 20th century.

New-Urbanism

In response to the economic, social and environmental degradation resultant of the planning and design for automobile dependent cities by the modernist movement, many planners, urbanists, and architects saw the need for recreating the urban form. Much like how the industrialized cities required urban reform, the automobile dependent cities of today require this reform through neo-traditional design. Sometimes referred to as post-modernism or new-urbanism, the associated design theories strive to redevelop urban space into denser and more mixed-use livable environments that prioritize green space and promote healthier lifestyles by facilitating walking and cycling. In regards to transport behavior, new-urbanist ideals suggest that while it is preferable if people use alternate modes of transportation such as public transit, walking, or cycling, it is best if trip generation can be completely eradicated through self-contained mixed-use planning. This notion of reducing the need for mobility by integrating transportation and land-use planning is supported by increasing the accessibility of services in mixed-use, high-density urban villages and improving the communities health through improved social interaction.

New-urbanism, arose as an urban design movement in the early 1980’s with the intent of reforming many aspects of American real-estate development and urban planning, which promoted automobile dependence and urban sprawl. New-urbanism shares many similarities with traditional European town planning, and the transit-based cities of the U.S. Both emphasized centralized public transit options, mixed-use zoning and medium to high-density urban developments spatially oriented towards transit nodes. Drawing its conceptual design roots from early 20th century architects and planners such as Patrick Geddes, Ebenezer Howard, Raymond Urwin, Leon Krier, and German town planning of the 1920’s, new-urbanism boasts a commitment to: “The poetics of small town life, the virtues of sustainable communities, and the appeal of environments that emphasize the pedestrian over the automobile.” The common design elements found throughout these various approaches to design are the very elements recognized in the case studies highlighted in this paper. The Charter of the New Urbanism advocates for public policy and development practices to honor the following principles: “neighborhoods should be diverse in use and population; communities should be designed for the pedestrian and transit as well as the car; cities and towns should be shaped by physically defined and universally accessible public spaces and community institutions; urban places should be framed by architecture and landscape design that celebrate local history, climate, ecology, and building practice.” By adhering to design principles that encourage high density and mixed use developments, new-urbanists foresaw greater neighborhood social cohesion with the understanding that urban design and form were a significant part of the solution towards social and political problems.

New-urbanism is often regarded as a planning movement that adopts the best aspects of previous planning theories, yet the success of new-urbanism can only be measured against its achievements, which have received much criticism. Alex Kreiger summarizes the critiques of new-urbanist developments thusly.


48 Alex Kreiger, 1991. Since (and before) seaside. In: Towns and Town-
Reducing Automobile dependency through Smart Growth

- Densities too low to support much mixed-use development or public transit
- Continual dependence on the use of the private automobile
- Lack of varied demographic enclaves (economically and socially)
- More greenfield subdivisions, resulting in sprawl, albeit they are innovative ones
- Increased reliance on private management of communities
- Form-follows-function determinism reflecting modernism ideologies
- Manufactured landscapes portraying artificial sense of community

A prime example of these critiques against the new-urbanists are developments such as Seaside, Laguna West, Kentlands or Celebration in the US. Critics suggest the communities felt artificial and that they do not mitigate the dependence on the private automobile enough. Edward Robbins adds further criticism towards new-urbanism by highlighting the lack of density needed to support commercial activities and various social services within the communities. Due to this lack of mixed-use, residents tend to drive outside the community to obtain the required ‘day to day’ commercial and social services in addition to daily employment activities.

In an attempt to improve the issue of facilitating less dependence on the private automobile, a branch of new-urbanism called new-pedestrianism has gained more recognition as a sustainable approach towards community design. New-pedestrianism adopts most of the critical design elements from new-urbanism (concerning: diverse building types, growth boundaries, walkability, environmental consideration, connectivity, sustainability, traffic calming, aesthetics, diversity, alternative transport, and livability), although it also places a significant emphasis on the reduction of automobile traffic and a strong prioritization on pedestrian and cyclist networks. Michael E. Arth argues that through urban design, pedestrian villages can drastically improve the health and wellbeing of a community and add significant value to invested developers, residents, businesses and municipalities.

Smart Growth

New-pedestrianism is a relatively small movement, which primarily deals with aesthetic design features as a means to implement a behavioral change in commuter mode choice. A more prominent theory relating to efficient land-use and transportation planning that contributes to the notion of sustainable development has been termed Smart Growth. Architects Peter Calthorpe and Andres Duany (currently members of the Charter for new-urbanism) began to popularize the idea of ‘urban villages’ in the early 1970’s after reviewing the transit based development models recognized in European cities such as Berlin, Stockholm and many others, which placed high density developments at nodes along public transit routes. This regional transportation model termed transit oriented development (TOD) has been adopted in many forward thinking cities which have wanted to contain urban sprawl, relieve pressure on existing highway systems and encourage polycentricism through a diversity of mixed-use and self contained community developments. With significant influence from Howard’s Garden City regional development pattern, TOD that connects compact, mixed-use developments is often recognized as the most efficient way to achieve sustainable urban design.
means of integrating transportation planning and urban land use. A research paper published by the Urban Land Institute entitled *Growing Cooler: Evidence on Urban Development and Climate Change* argues that compact developments connected by an effective public transit network such as bus rapid transit (BRT), light rail, or heavy rail, is the most effective way to address reducing private automobile use as the primary means of transportation.51

Smart growth is very similar to New-Urbanism in that it attempts to rectify the problems associated with sprawling development, although the difference is that where New-Urbanism places its focus on architecture and design, Smart Growth is more focused on policy and specific macro design elements which can be regarded as Smart Growth land-use planning principles. New-urbanism can be recognized as the private sector’s solution to reducing sprawl, while Smart Growth can be seen as the public sector’s approach to mitigating sprawl and automobile dependence.

Smart Growth has no formal definition and is a concept that is malleable to address the efficient use of transportation resources and integrated land-use planning. The CSA define Smart Growth as

"Development in or near cities intended to lessen or reverse suburban sprawl, decrease the use of automobiles, and shorten daily travel. Smart Growth occurs in or near existing transportation centers, such as subway stations. It clusters together residential, shopping, and work areas and encourages walking and public transportation."52

Various municipalities and regional authorities define Smart Growth as a series of principles from which more responsible development can evolve from. Smart Growth BC recognizes the following Smart Growth principles:53

1. Mix land uses. Each neighborhood has a mixture of homes, retail, business, and recreational opportunities.

2. Build well-designed compact neighborhoods. Residents can choose to live, work, shop and play in close proximity. People can easily access daily activities, transit is viable, and local businesses are supported.

3. Provide a variety of transportation choices. Neighborhoods are attractive and have safe infrastructure for walking, cycling and transit, in addition to driving.

4. Create diverse housing opportunities. People in different family types, life stages and income levels can afford a home in the neighborhood of their choice.

5. Encourage growth in existing communities. Investments in infrastructure (such as roads and schools) are used efficiently, and developments do not take up new land.

6. Preserve open spaces, natural beauty, and environmentally sensitive areas. Development respects natural landscape features and has higher aesthetic, environmental, and financial value.

7. Protect and enhance agricultural lands. A secure and productive land base, such as BC’s Agricultural Land Reserve, provides food security, employment, and habitat, and is maintained as an urban containment boundary.

8. Utilize smarter, and cheaper infrastructure and green buildings. Green buildings and other systems can save both money and the

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Reducing Automobile dependency through Smart Growth


The Smart Growth planning principles for the purposes of this paper are simplified to the following:

1. Transit-oriented development
2. High-density neighborhoods
3. Mixed-use development catering to various social and economic classes of society
4. Pedestrian and cyclist friendly design
5. Abundant and safe public, green and recreational spaces

The Smart Growth planning principles chosen for basing design recommendations and TDMS on are a simplified collection of the common elements of various Smart Growth planning principles from a collection of Smart Growth organizations. When implemented concurrently these can have significant effects in increasing transportation modal splits and reducing use of the private automobile.

When discussing transit-orientated development (TOD) Smart Growth highly stresses the need for a transit network to be in place prior to the development commencing so that initial residents can gain value from these services, and high-density development near transit nodes can be justified and priced accordingly. Transit use must be encouraged by TDMS and affordable pricing mechanisms (such as traffic calming, fuller cost accounting, or limitations on access). These strategies will reduce the convenience of using the private automobile and reflect the fuller cost accounting decreasing private automobile use and increasing in public transit use through various subsidies supplied by parking fees, toll roads, or higher insurance premiums. When designing the physical layout for a new development, transit stops should be central to the development, and within walking distance (less than 5 minutes) to a multitude of high density, mixed-use buildings providing the various services required by the community. The type of transit system is of course highly dependent on the scale of the community it serves. At a regional scale, trains are most appropriate, although at an inter-urban scale a metro, tram, or bus-rapid transit might be more appropriate depending on the ridership demand and finances available. Patrick Siegman defines truly transit-orientated development with promised social and economic benefits as containing the following elements:

- The transit-oriented development lies within a five-minute walk of the transit stop, or about a quarter-mile from stop to edge. For major stations offering access to frequent high-speed service this catchment area may be extended to the measure of a 10-minute walk.
- A balanced mix of uses generates 24-hour ridership. There are places to work, to live, to learn, to relax and to shop for daily needs.
- A place-based zoning code generates buildings that shape and define memorable streets, squares, and plazas, while allowing uses to change easily over time.

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Reducing Automobile dependency through Smart Growth

• The average block perimeter is limited to no more than 1,350 feet. This generates a fine-grained network of streets, dispersing traffic and allowing for the creation of quiet and intimate thoroughfares.

• Minimum parking requirements are abolished.

• Maximum parking requirements are instituted: For every 1,000 workers, no more than 500 spaces and as few as 10 spaces are provided.

• Parking costs are “unbundled,” and full market rates are charged for all parking spaces. The exception may be validated parking for shoppers.

• Major stops provide BikeStations, offering free attended bicycle parking, repairs, and rentals. At minor stops, secure and fully enclosed bicycle parking is provided.

• Transit service is fast, frequent, reliable, and comfortable, with headway of 15 minutes or less.

• Roadway space is allocated and traffic signals timed primarily for the convenience of walkers and cyclists.

• Automobile level-of-service standards are met through congestion pricing measures, or disregarded entirely.

Regarding neighborhood design, Smart Growth places a strong emphasis on the promotion of high-density development, which in turn preserves abundant green space and provides urban containment boundaries. Edward Robbins suggests that a community of 5,000 to 10,000 persons can sufficiently supply basic services, yet the population is not a large enough to provide employment opportunities for all of the community residents resulting in a proportion of residents commuting elsewhere for work. Jane Jacobs suggests that densities as high as 100 persons per acre is enough to facilitate mixed-use and multi-diverse communities such as found in Greenwich village, in New York City. In the book *Visualizing Density*, authors Julie Campoli and Alex S. MacLean demonstrate visual representations of various levels of density by the number of dwellings per acre, suggesting a multitude of mixed-use services are supported at densities greater than 35 persons per acre. High-density neighborhoods have two purposes, which directly influence a reduction of VMT and promote accessibility. Firstly, as density increases, the distances between services decrease, resulting in less need to drive short distances and greater convenience within a smaller geographic space. Secondly, with higher densities, higher populations can be supported and contribute to a greater community demand resulting in a higher diversity of services provided.

Mixed-use development is another key feature of Smart Growth, which provides the various commercial, social, institutional or industrial services required for a community and results in a reduction of commuters in need of accessing day-to-day services. Mixed-use zoning and high-density are highly dependent on each other as mixed-use provides the various retail, office, commercial or residential space that can be utilized to provide the necessary services for the population. Zone based planning, which fragments the various land-use types of residential, commercial, office, or retail space decreases the accessibility and often increases the distance of day to day services. Land-use forecasting models such as the Lowry, Penn-Jersey or Kain models can be useful in establishing which various


sectors can be supported depending on the population density of a region. The Lowry model defines the retail or non-basic sector as the local employment opportunities consistent with local demands such as retail, food and services and the basic sector as local employment opportunities meeting non-local demand.\(^5\)

It is essential for Smart Growth development to maintain at least what Lowry refers to as the retail or non-basic sector which are the services supporting local needs.

Pedestrian and cyclist friendly design is critical to Smart Growth ideals that aim to prioritize walking and cycling as the residents’ first choice in mobility. To facilitate this, vast networks of well-maintained and safe cycling paths and pedestrian ways must be incorporated into design plans. Often termed as ‘complete streets’ mobility networks should cater to not only cars but also to transit, cyclists, and pedestrians. In the Smart Growth mobility hierarchy, walking should be the first choice, cycling second choice, transit third choice, car-sharing or car-pooling fourth and the private automobile as a last resort.\(^6\)

To encourage these prioritized modes of mobility, density is encouraged to minimize trip distance and mixed-use zoning encouraged to support a high level of accessibility of services. Most important is that there are an abundance of cycling paths and walking paths providing much greater connectivity than the road networks supplied for automobiles so that cycling or walking becomes the most efficient and time-effective means of getting around town. Pedestrian only or car-free zones are an effective way to encourage cycling or walking within the city as it provides a safe and comfortable environment to access urban services.

Finally, Smart Growth needs to emphasize a large proportion of green space, public space and recreational space. By developing dense residential and commercial developments, ample space can be reserved for such open spaces, which can drastically improve quality of life and social connectivity amongst users. Ebenezer Howard and Le Corbusier agreed that there should be ample space dedicated to parks facilitating public space and recreational activities. Jane Jacobs recognized the liveliness of city streets as a means to evaluate a city and critiques how the city has planned for automobiles in the past and not people. It is crucial that the community has a high level of ‘livability’ with many people ‘out and about’ and not contained inside all the time. By providing ample green space accessible by walking or cycling paths and integrating a plethora of recreational activities such as golf courses, sport fields, playgrounds, skateboard parks, ping pong tables, mini golf, public gardens, exercise equipment, etcetera, people can connect on a casual level, increase trust and build a greater sense of community. What if the public spaces in a community were as comfortable as your living room or backyard? By improving the livability of a city through great public space, people are much more inclined to walk, cycle and get outside, while a greater abundance of green space can be reserved for maintaining the health of local ecosystems.

Whether discussing New-Urbanism, walkable communities, New-Pedestrianism or Smart-Growth theories, these concepts are very similar and reflect the Neo-Traditionalist planning theories that developed throughout the 20th century. As societies have learned from the flaws associated with Modernist sprawl and automobile dependent planning, the majority of planners and architects are recognizing the Neo-Traditionalist theories of New-Urbanism and Smart Growth as a means to address sustainability, and in particular, to reducing societal dependence on the private automobile.

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60 Smart Growth BC Transportation Policy, (2005). Vancouver, B.C.
SUSTAINABLE TRANSPORTATION IN PRACTICE

The Sustainable City

As the world’s population continues to grow and our resources continue to diminish, humankind is at a turning point where something needs to change. On May 30th, 2007, humanity reached a seminal turning point as more than half of the world’s population began living in urban areas, and more than 80% of Europeans live in cities. In the last century, as the world’s population migrated towards urban centers in search for economic opportunity and better qualities of life, cities had to adapt to accommodate for growth. The planning and design of space has had an increasingly dramatic impact on culture and society’s way of life and thus its relationship to sustainability. A common observation is that the traditionalist European cities are much more sustainable than many modernist American cities due to their higher densities, greater proportion of mixed-use developments, higher transit ridership, cycling and walking. The cities of the 21st century have the potential of becoming the laboratories for sustainable development as concerns grow regarding the abundant provision of modern day amenities to a growing population.

There is no definition of what a sustainable city is, although most academics would agree that at the core of sustainability is the concern for the long-term improvement of the social, environmental, and economic aspects of the city. A practical approach to, or perspective on a sustainable city is to design and manage the city to function as a closed system, much like an ecosystem with the complex interactions between the physical and biological components being symbiotic and inclusive to the system. Newman and Kenworthy provide a comparison of a young developing city and a more mature sustainable city sharing similar attributes to that of the primary and mature ecologic successional stages of a forest. They demonstrate that a mature sustainable city should, like a mature forest, be energy efficient, recycle materials, provide a high level of economic diversity, yield a dense structural diversity, support diverse communities and organizations, provide strong environmental protection, be adaptable to change, and maintain a high level of system stability. Simply put, as cities grow, they should become more complex and diverse, resulting in improved efficiencies. These complexities and efficiencies will only occur when there is competition for space, thus emphasizing the necessity for a dense urban environment.

The concept of the city as an ecosystem suggests that a city needs to minimize, or at best eradicate its inputs of energy and materials and outputs of waste so that it functions more like a closed system that is self sufficient in providing the modern amenities required by its citizens. This concept of the city as a system is often recognized as the extended metabolism model of human settlements, and draws parallels to the physical and biological processes of converting resources into useful products similar to the human body’s metabolic process. By adhering to the laws of thermodynamics, where material passing through a biological system produces waste dependent on the input resources and energy, the city should become more complex and diverse.

cities can apply this concept to attempt to minimize waste by reducing various inputs. By reducing inputs of energy or resources, cities can effectively reduce waste outputs of various forms of environmental pollution and contribute to a more sustainable urban environment as the city moves towards becoming a more autonomous and self-sufficient system. Many utopian planning theories such as Ebenezer Howard’s garden city or Clarence Stein’s neighborhood unit have emphasized the need for self-sufficiency, yet little examples of these self-contained urban dwellings have been effectively implemented. In regards to transportation systems, those that cater to the use of the private automobile as the primary means of mobility are dependant on vast amounts of non-renewable resources for the production of the automobiles, materials for infrastructure, and consumption of fossil fuels with an abundance of waste outputs, most notably, C02 emissions.

Cities around the world are jumping on the sustainability bandwagon. The most common motivations for doing so are often to improve economic efficiency and the local environment, and create a greater sense of livability within the city. A common approach for cities to address the issue of sustainability is by devising feasible and measurable sustainability indicators. From these they can devise sustainability action plans to address how to improve the various areas they have defined. A common thread in various collections of sustainability indicators is that they commonly aim to address the following environmental and social issues of:

- Energy and Air Quality
- Water, Materials and Waste
- Land-Use, Green Spaces and Biodiversity
- Transportation
- Livability, Human amenities and Health

With each indicator having more specific sub-indicators, the list can grow to be very extensive. The intention of addressing sustainability in cities is to ultimately improve the long-term economic, social and environmental impacts on the urban environment. By doing so, most sustainable indicators for cities address in one way or another the environmental and social aspects with the dual intent of also improving economic systems.

For a city, addressing the issue of sustainable transportation is one of the best ways that it can mitigate environmental, economic and social harm, and is becoming a main priority for forward-looking cities. Due to the significant amount of resource inputs required for transportation infrastructure, automotive manufacturing, and expansive sprawling developments, the extended metabolism model would suggest that by reducing these inputs, society can reduce it’s associated outputs, particularly CO2 emissions. In addition to the environmental stresses from the required resource inputs and inevitable waste outputs from automobile dependent transportation planning, land-use is also drastically re-shaped and adversely affected. Land-use planning plays a key role in the promotion of a more sustainable city as it shapes the patterns of personal mobility choice, social cohesion, human health and safety, the proportion of available green space and overall efficiency of the city. Therefore it is crucial that the sustainable city is not catering to the use of the private automobile. By implementing effective TDMS and Smart Growth based land-use planning principles, the integration of transportation and land-use planning can have considerable impacts on communities’ well being.
Sustainable Transportation Indicators (STIs)

Transportation is always highlighted as one of the key subject areas within Sustainable City Indicators due to the immense impact it has on shaping the city. It often has adverse effects on environmental, social and economic systems when catering to the automobile dependent infrastructure and development, as discussed in the theoretical perspectives section. As used by planners, Indicators are a very effective tool. They allow progress towards a particular goal to be measured and evaluated in addition to adding greater accuracy to trend tracking, comparing regions and activities, and evaluating policies and planning options. Due to these benefits, STIs are a critical component of any comprehensive transportation plan.

Traditional transportation indicators have been primarily focused on increasing mobility and accommodating the use of the automobile. These traditional indicators have been conventionally concerned with:

- Amount of transportation infrastructure: More was assumed to be better to accommodate automobile use.

- Average traffic speeds: increased traffic speeds were assumed to be better to increase mobility.

- Parking convenience and price: increased parking and lower parking prices was assumed to be better.

These indicators are the product of an unsustainable transportation system due to the accommodation of the automobile and are almost in direct opposition of STIs that are beginning to be adopted by forward thinking cities around the world.

Since there is no set standard of STIs, cities are responsible for devising their own, which can influence the effectiveness of their transportation plans. The Sustainable Transportation Indicators Subcommittee of the Transportation Research Board (STISTRB) research program for developing sustainable transportation indicators have outlined the various levels of analysis that can be ascertained from STIs. They also set forward a set of recommended STIs which they see as the most effective potential indicators for a city to adopt under the categories of travel activity, air pollution emissions, noise pollution, traffic risk, economic productivity, overall accessibility, land-use impacts, equity, and transport policy and planning. The STISTRB illustrates how indicators can be used to reflect not just the progress towards sustainable mobility but also to address the quality of planning through gaining insight on the various travel patterns and associated impacts on the social, environmental and economic aspects of a community. Through this insight gained from high quality metrics, effective modeling and forecasting can aid in understanding future trends and add significant support to transport demand management strategy proposals.

In addition to this by-product of STIs, another advantage is increasing the transparency of the city’s transportation plan to allow comparisons between jurisdictions and promote effective initiatives.

<table>
<thead>
<tr>
<th>Level of Analysis</th>
<th>Examples of Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Trends ↓</td>
<td>Changes in population, income, economic activity, political pressures,</td>
</tr>
<tr>
<td>Decision-Making Process ↓</td>
<td>Planning process, pricing policies, stakeholder involvement,</td>
</tr>
<tr>
<td>Policies ↓</td>
<td>Facility design and operations, transport services, prices, user information, etc.</td>
</tr>
<tr>
<td>Response ↓</td>
<td>Travel activity, (VMT, model choice, ride sharing), pollution, emissions, crashes, land development patterns, etc.</td>
</tr>
<tr>
<td>Cumulative Impacts ↓</td>
<td>Changes in ambient pollution, traffic risk levels, overall accessibility, transportation costs, etc.</td>
</tr>
<tr>
<td>Human and Environmental Effects ↓</td>
<td>Changes in pollution exposure, health, traffic injuries and fatalities, ecological productivity, etc.</td>
</tr>
<tr>
<td>Economic Impacts ↓</td>
<td>Property damages, medical expenses, productivity losses, mitigation and compensation costs</td>
</tr>
<tr>
<td>Performance Evaluation ↓</td>
<td>Ability to achieve specified targets.</td>
</tr>
</tbody>
</table>

Prior to choosing STIs, a city should adopt sustainability principles on which they can base their decisions regarding transportation issues in need of change, and move towards a more sustainable and livable urban environment. There are more than enough sustainability principles that have been designed to assist in directing organizations and institutions on the road towards sustainability; a common approach being to equitably address and promote the three pillars of sustainability (economic, social and environmental). From these principles, indicators should evolve, from which Sustainability Action Plans can be developed which should, if successfully implemented, be reflected by the various metrics of the indicators. For example, if a city wishes to decrease it’s carbon emissions, their sustainability principles could generally state that the city wants to mitigate climate change, an indicator to evaluate this process may suggest reducing VMT, and an action or policy might be to add a fuel tax, which would ideally discourage driving as much as possible.

A common obstacle is that each indicator cannot be addressed by a single program but needs a myriad of solutions that are often associated with politically controversial policy reform, possibly causing public protest or high cost urban land-use restructure. The challenge for policy makers is in creating a paradigm shift in the public’s transportation mode choice so that less drive and more walk, cycle, or utilize transit. How does a city make public transit ridership attractive? How do politicians gain the courage to implement change where the benefits are not recognized within their term of office? By reviewing case studies and best case practices, patterns begin to emerge showing which policy reforms and urban design strategies consistently improve the livability of cities and contribute significantly to sustainability.

**BEST CASE PRACTICES**

Although a simple concept, addressing sustainability within the urban environment requires immense political will and a significant paradigm shift amongst society members and all relevant stakeholders. Currently cities around the world are beginning to become familiar with what it means to be a
Sustainable City and are designing appropriate indicators to facilitate change. Still, only a handful of cities are making serious change happen. The challenge in implementing actions required to stimulate change is overcoming the barriers that obstruct society’s moving towards less automobile dependent cities. The cities throughout the world that are recognized as the most sustainable share a similar quality in that they have urban design and policy strategies which have restricted the convenient use of the private automobile and have prioritized urban space for people, not cars. They have efficient and diverse transit options, vast cycling and walking networks and abundant public space promoting the social connectivity and overall health of society.

When discussing sustainable transportation and questioning what it takes for people to choose alternate forms of transportation, people often look towards what is being done in Europe. Copenhagen and Amsterdam are often showcased for having more than 35% of their population commuting by bicycle despite cold and wet winters. Stockholm and Berlin have contained urban sprawl and managed growth through effective transit-oriented development. Barcelona is often regarded as a prime case study for its pedestrian friendly streets and squares. Many other European cities also demonstrate compact, mixed-use city centers serviced by an assortment of transit options. In addition to European cities, many other cities around the world are also applying the various Smart Growth elements to manage growth and promote sustainability.

The following are a handful of forward looking cities across the globe that are making significant efforts to address the issue of sustainability by reforming their transportation systems through design features and innovative policies: Curitiba Brazil, Zurich Switzerland, Copenhagen Denmark, Bogota Columbia, Singapore, Portland USA, Vancouver Canada, Stockholm Sweden, Sydney Australia, and London England. Each of these cities have seen significant reductions in automobile use as the primary means of mobility and have experienced benefits to the quality of life within society. The table provided below highlights how each city has improved traffic calming to favor pedestrian and cyclist safety and accessibility, instigated policies placing economic penalties on automobile use, promoted alternate transportation modes to reduce automobile usage, and integrated transportation planning and land-use through effective urban design to reduce the need for automobile transportation.

<table>
<thead>
<tr>
<th>Traffic Calming/limiting mobility</th>
<th>Policies reducing automobile use</th>
<th>Encouragement of Alternate Modes</th>
<th>Integration of Transport Planning and Urban Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrianized central city core</td>
<td>Heavily subsidized single zone bus fares</td>
<td>Arterial transport network prioritizing express bus transit</td>
<td>Arterial Transit network integrated with high-density, mix use development</td>
</tr>
<tr>
<td>Traffic arteries reduced to tree lined pedestrian boulevards</td>
<td>Social programs integrated with transit system</td>
<td>Vast network of cycling paths and pedestrian boulevards</td>
<td>Transit Oriented Development (TOD) with compact development located near transit nodes</td>
</tr>
<tr>
<td>Trinary road system reserving slower roads for private automobile</td>
<td>Automobile licensing scheme restricting usage on certain days</td>
<td>Unique loading tubes increasing efficiency of bus system flow rates</td>
<td>Land use planning oriented towards discouraging car usage and encouraging public transit</td>
</tr>
<tr>
<td>Numerous pedestrian prioritized cross walks</td>
<td>Limited parking space</td>
<td>Policies discouraging automotive use</td>
<td>Policies discouraging automotive use</td>
</tr>
<tr>
<td>Traffic Calming/limiting mobility</td>
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<tr>
<td>Zurich</td>
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<tr>
<td>Traffic obstructions to slow traffic with extensive 30km/hour zones</td>
<td>Enforcement of car restraint</td>
<td>Coordinated transit marketing campaigns encouraging public transit ridership and excellent transit maps</td>
<td>Containment of urban sprawl</td>
</tr>
<tr>
<td>Reclamation of roadways into light rail traffic lanes</td>
<td>No congestion pricing</td>
<td>High-density growth near transit nodes</td>
<td>High parking fees</td>
</tr>
<tr>
<td>Traffic calming design features such as speed bumps and prioritized pedestrian crosses</td>
<td>High parking fees</td>
<td>New-urbanist villages proximal to rail nodes</td>
<td>Extensive light and heavy rail services and vast network of pedestrian and cycling networks</td>
</tr>
<tr>
<td></td>
<td>European fuel tax and vehicle registration costs</td>
<td>Mix use development</td>
<td>Cap on parking and road capacity</td>
</tr>
<tr>
<td>Copenhagen</td>
<td>Annual 3% reduction of parking for 15 years</td>
<td>Extensive cycle lanes with priority to cyclists and city bike program</td>
<td>Transit oriented urban form based on ‘five finger’ transit plan</td>
</tr>
<tr>
<td>Traffic management reducing speed limits</td>
<td>Five finger plan reducing automobile convenience and flow</td>
<td>Cap on road capacity with a 3% annual reduction of parking space for 15 years</td>
<td>Highly pedestrianized city core with public space revitalized</td>
</tr>
<tr>
<td>Rejection of 1970’s mass freeway system</td>
<td>High parking fees</td>
<td>High density mixed use development along transit networks</td>
<td>High density, mixed-use development plans focused near transit nodes</td>
</tr>
<tr>
<td>Traffic calming design elements</td>
<td>European fuel tax and vehicle registration costs</td>
<td>Strong cycle culture</td>
<td><strong>Traffic calming design elements</strong></td>
</tr>
<tr>
<td>Reduced road capacity</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Bogota</td>
<td>Reclaiming road space and reducing traffic lanes</td>
<td>‘Pico y Placa’ automobile licensing scheme restricting usage on certain days</td>
<td>Priority to bus with designated lanes</td>
</tr>
<tr>
<td>Traffic calming design elements</td>
<td>Traffic calming design elements</td>
<td>Reclamation of road-side parking spaces to wider sidewalks and cycling paths.</td>
<td>Priority to improve pedestrian and cycle pathways before private automobile roadways</td>
</tr>
<tr>
<td>Limitations on new road development in an already low road capacity city</td>
<td>Poor road infrastructure reducing traffic speeds</td>
<td><strong>Policies reducing automobile use</strong></td>
<td>Utilized land-use planning to develop high-density mixed-use regions proximal to transit arteries</td>
</tr>
<tr>
<td></td>
<td>Area licensing scheme restricting automobile use in designated areas</td>
<td>Area licensing scheme restricting automobile use in designated areas</td>
<td>Reclaimed and promoted public space as public asset.</td>
</tr>
<tr>
<td>Singapore</td>
<td>Visitor parking restrictions reducing accessibility</td>
<td>Priority to bus with designated lanes</td>
<td>High density mixed-use development plans focused near transit nodes</td>
</tr>
<tr>
<td>Traffic calming design elements</td>
<td>Heavy investment in mass rapid transit</td>
<td>Extensive cycling paths</td>
<td>New-urbanist villages proximal to rail nodes</td>
</tr>
<tr>
<td>Limitations on new road development in an already low road capacity city</td>
<td>Bus prioritizing roadways</td>
<td>Very high vehicle taxes and parking fees</td>
<td>High density mixed-use development plans focused near transit nodes</td>
</tr>
<tr>
<td></td>
<td>Area licensing scheme restricting automobile use in designated areas</td>
<td>Bidding system for rights to purchase car</td>
<td>High density mixed-use development plans focused near transit nodes</td>
</tr>
<tr>
<td>Traffic Calming/limiting mobility</td>
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</tr>
<tr>
<td><strong>Portland</strong></td>
<td>Cap on parking availability in CBD</td>
<td>Limitations on parking in CBD</td>
<td>Growth management strategy limiting urban sprawl</td>
</tr>
<tr>
<td>Traffic calming design features</td>
<td>High parking fees</td>
<td>Reclamation of freeways favoring transit-oriented development and park space</td>
<td>Transit oriented development at light rail nodes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Revitalization of residential development in CBD</td>
<td>Revitalization of residential development in CBD</td>
</tr>
<tr>
<td><strong>Vancouver</strong></td>
<td>Dense street grid reduces traffic speeds</td>
<td>Pedestrianized city center</td>
<td>European fuel tax and vehicle registration costs</td>
</tr>
<tr>
<td></td>
<td>Gasoline surtax in Vancouver region for BC Transit</td>
<td>Extensive 30 km/hour zones</td>
<td>Tolls on new roads</td>
</tr>
<tr>
<td></td>
<td>No highway servicing CBD</td>
<td>Strict enforcement of traffic laws</td>
<td>High parking fees</td>
</tr>
<tr>
<td></td>
<td>High parking fees</td>
<td>Pedestrianized city center</td>
<td>European fuel tax and vehicle registration costs</td>
</tr>
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<td>Tolls on new roads</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extensive 30 km/hour zones</td>
<td>High parking fees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small, one way streets</td>
<td>Transit subsidies and travel card program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Abundant green space</td>
<td>Excellent network of cycling paths and pedestrian streets</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Highly efficient and convenient tram, train, metro and bus systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Long-lasting culture of cycling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>New developments developed around extensions of rail and tram lines</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High-density mixed use city centre with multiple neighborhood identities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>New metro line stops built prior to metro line to promote TOD</td>
</tr>
</tbody>
</table>

Reducing Automobile dependency through Smart Growth
Although this collection of TDMS are associated with larger cities, the reoccurring theme of compact mixed-use development at transit nodes that promotes accessibility and reduces VMT and VT, is the most crucial aspect of land-use planning in any size community that wishes to minimize automobile dependency and integrate more sustainable mobility options for residents. In addition to the policies noted that discourage automobile use through economic penalties and promote alternate forms of transportation, there are many ways for policy and design to alter the mobility patterns of a community towards preference for public transit if the service is reliable, safe and affordable. Cycling and/or walking can also be improved if the services and residential dwellings are in close proximity to one another and there are the appropriate cycle paths and pedestrian prioritized streets. The following table describes various land use factors that can affect travel behavior and population health.

<table>
<thead>
<tr>
<th>Traffic Calming/limiting mobility</th>
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<th>Integration of Transport Planning and Urban Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>London</td>
<td>Congestion pricing in CBD</td>
<td>Roads giving higher priority for pedestrian, cycling, and transit</td>
<td>Reclaiming roads into public space with 'streets for people' initiative</td>
</tr>
<tr>
<td>Congestion pricing reducing traffic congestion</td>
<td>10 billion GBP investment into promoting transit systems</td>
<td>Highly effective metro, trams, rail and bus services.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor</th>
<th>Definition</th>
<th>Travel Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>People or jobs per unit of land area (acre or hectare).</td>
<td>Increased density tends to reduce per capita vehicle travel. Each 10% increase in urban densities typically reduces per capita VMT by 1-3%.</td>
</tr>
<tr>
<td>Mix</td>
<td>Degree that related land uses (housing, commercial, institutional) are located close together.</td>
<td>Increased land use mix tends to reduce per capita vehicle travel, and increase use of alternative modes, particularly walking for errands. Neighborhoods with good land use mix typically have 5-15% lower vehicle-miles.</td>
</tr>
<tr>
<td>Regional Accessibility</td>
<td>Location of development relative to regional urban center.</td>
<td>Improved accessibility reduces per capita vehicle mileage. Residents of more central neighborhoods typically drive 10-30% fewer vehicle-miles than urban fringe residents.</td>
</tr>
<tr>
<td>Centeredness</td>
<td>Portion of commercial, employment, and other activities in major activity centers.</td>
<td>Centeredness increases use of alternative commute modes. Typically 30-60% of commuters to major commercial centers use alternative modes, compared with 5-15% of commuters at dispersed locations.</td>
</tr>
<tr>
<td>Network Connectivity</td>
<td>Degree that walkways and roads are connected to allow direct travel between destinations.</td>
<td>Improved roadway connectivity can reduce vehicle mileage, and improved walkway connectivity tends to increase walking and cycling.</td>
</tr>
</tbody>
</table>
Whether improving traffic calming, instigating economic penalties on automobile use, promoting alternate transportation modes or integrating transportation planning and land-use, none of these initiatives can stand alone in reducing automobile use. The most important aspect to consider is that a collection of initiatives is required to make a significant and effective reduction in automobile dependency. By using the five Smart Growth planning principles as a platform for policy and design strategies, communities or cities can formulate specific actions which can be monitored through indicators to reduce VMT and VT contributing to a more sustainable city, less dependent on fossil fuels.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Definition</th>
<th>Travel Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway design and management</td>
<td>Scale, design and management of streets.</td>
<td>More multi-modal streets increase use of alternative modes. Traffic calming reduces vehicle travel and increases walking and cycling.</td>
</tr>
<tr>
<td>Walking and Cycling conditions</td>
<td>Quantity, quality and security of sidewalks, crosswalks, paths, and bike lanes.</td>
<td>Improved walking and cycling conditions tends to increase nonmotorized travel and reduce automobile travel. Residents of more walkable communities typically walk 2-4 times as much and drive 5-15% less than if they lived in more automobile-dependent communities.</td>
</tr>
<tr>
<td>Transit quality and accessibility</td>
<td>Quality of transit service and degree to which destinations are transit accessible.</td>
<td>Improved service increases transit ridership and reduces automobile trips. Residents of transit oriented neighborhoods tend to own 10-30% fewer vehicles, drive 10-30% fewer miles, and use alternative modes 2-10 times more frequently than residents of automobile-oriented communities.</td>
</tr>
<tr>
<td>Parking supply and management</td>
<td>Number of parking spaces per building unit or acre, and how parking is managed.</td>
<td>Reduced parking supply, increased parking pricing and implementation of other parking management strategies can significantly reduce vehicle ownership and mileage. Cost-recovery pricing (charging users directly for parking facilities) typically reduces automobile trips by 10-30%.</td>
</tr>
<tr>
<td>Site design</td>
<td>The layout and design of buildings and parking facilities.</td>
<td>More multi-modal site design can reduce automobile trips, particularly if implemented with improved transit services.</td>
</tr>
<tr>
<td>Mobility Management</td>
<td>Policies and programs that encourage more efficient travel patterns.</td>
<td>Mobility management can significantly reduce vehicle travel for affected trips. Vehicle travel reductions of 10-30% are common.</td>
</tr>
</tbody>
</table>
EMPIRICAL ANALYSIS

Fossil Fuel Free Växjö

Växjö has been a leader in recent times regarding municipal sustainability policy. It has demonstrated that it understands what is at stake ecologically for each policy decision that a town its size makes. Cities have been leading the way in green policy in recent times. Organizations such as the C40, a part of the Clinton Climate Initiative have been pushing the issues of green planning and technology, taking the responsibility to reduce carbon and other pollutants and reduce consumption overall. City governments have been able to respond more flexibly to the needs of the current climate in contrast to national governments which face a much bigger task to build up political will. Växjö is at the forefront of this movement in Europe in many ways. It has been dubbed “the greenest city in Europe” by some, and is using its position to lead the way with a number of positive initiatives. Efforts began in earnest in 1993 to increase ecological responsibility on a broad scale. The Agenda 21 document from the 1992 Rio conference served as a catalyst to begin the process. In the seventeen years since then, the city’s actions have demonstrated that they have an understanding of the importance of ecologically sound policies from both an environmental and business point of view. Växjö set out ambitious goals for itself, and started to analyze what steps it would need to take to achieve their goals.

A central theme in Växjö’s planning was its bold declaration in 1996 that it intended to become a fossil fuel free city. It has made consistent, significant progress towards this goal throughout the years following. The city implemented an environmental management system called ecoBUDGET across all departments, pushing ecological concerns to the forefront and changing perspectives from within, first. The ecoBUDGET system has numerous indicators for emissions, waste and efficiency, and has helped the town to make significant gains in environmental responsibility. The indicators cover a broad range of factors in the city, from “Protected land area in relation to total land area,” to “amount of printing/copying paper per employee.” The system conflates ecological and monetary “costs” which traditionally are often kept separate. This goes along with a new line of thinking that calls for the inclusion of such “externalities” in the bottom lines of businesses’ and municipalities’ accounting. The indicators are intended to keep track of a wide swath of the environmental situation in the city, in particular, to track progress towards goals and follow-up with any action that might be needed. They are grouped into three main areas: Budget indicators, Environmental asset indicators and Efficiency indicators. The ‘Budget indicators’ are tightly controlled elements that are tied to current goals of the municipality. ‘Environmental’ indicators are coupled with proposed goals, and are kept track of to make sure that the municipality is heading in the right direction. The ‘Environmental’ indicators are not associated with any particular goals, but looked at to inform whether policies are being effective. Requiring the city departments and citizens to be aware that the role the environment plays in their daily lives and business infuses an ethos of ecological responsibility into many of the actors affecting the city. This ethos has been in existence at the top for some time, and is responsible for many of the policies that have been
Reducing Automobile dependency through Smart Growth

implemented since 1993.

Many cities have drawn on the policies of Växjö, looking at ways that they can implement similar initiatives themselves. Accolades have come from many areas, including awards from the European Union. Particularly encouraging for other towns is the way that Växjö has decoupled its economic growth from much of its climate impact. GRP per capita has increased by 50% between 1993 and 2006, while CO₂ emissions have decreased by 30%.

They have shown clearly that ecological responsibility is not a threat to growth, and can promote growth if new technologies and innovations are implemented correctly.

As part of Växjö’s drive to address environmental and sustainability issues, they have set very aggressive goals for themselves. The goal that has been most publicized and central to much of their policy decisions is their targeted reduction of CO₂ emissions. Växjö has stated that it would like to reduce carbon emissions by at least 50% per inhabitant by 2010, and by at least 70% by 2025, as compared to 1993 output levels. The city has made tremendous progress toward their goals, identifying sources of CO₂ and adopting ways to mitigate or eliminate emissions. The analysis showed that district heating and transportation were the sectors responsible for the most emissions. Steps were taken to eliminate district heating emissions and towards other, smaller, low-hanging fruit. By 2005, a 24% decrease has been achieved. Most of this was due to the renovation in provision of district heating. Despite enormous strides, it has been clear that the city will fall short of its initial goal. Emissions are still growing in the transportation sector despite hard work and critical analysis.

Initiatives have also been created to help residents and businesses reduce carbon emissions by not using the energy in the first place. Individual energy monitors have been placed in student housing, helping them see better the exact amount of resources they use. Real-time energy monitors are also used in single-family homes so that individuals can more effectively track and reduce their energy usage. Retrofitting is encouraged in housing as well, and there is a partnership between the researchers at Växjö University and planners to bring efficient wooden houses to the market that utilize passive technologies.

District heating underwent a complete transformation in Växjö, which has been the central component to the progress that has been made so far. Starting in 1980, existing power plants were converted to run on biomass instead of oil. In the 1990’s a 100 mega-watt plant, burning woodchips, was constructed along with smaller plants in the outlying areas. Subsidies were given to households who needed to convert to bio-mass as well. These

68 Växjö Kommun, The Greenest City in Europe, 2008, Växjö

69 Växjö Kommun, Environmental Program, 2006, Växjö

68 Växjö Kommun, The Greenest City in Europe, 2008, Växjö

69 Växjö Kommun, Environmental Program, 2006, Växjö
changes, along with small-scale solar projects have been responsible for much of a substantial reduction in carbon emissions.

Significant efforts have been made to address transportation related emissions, as this sector remains the greatest source. Växjö has worked to disseminate information on more ecologically responsible transport, such as combining trips, cutting out short, unnecessary trips, and using bicycles as much as possible. They have also made a push for increased usage of bio-fuels by those who are dependent on vehicles. Ethanol is provided at filling stations, and long-term, the municipality would like to be involved in the production of bio-DME as a replacement for diesel. Some public transport has been switched to bio-gas as well, further reducing emissions. Because of the complexity of transportation systems, they present some of the largest challenges, and this is where the city is focusing much of its energy currently.

They have put a lot of time and resources into this issue, investing in consulting for a traffic model, and scenario building that will help them further transform the current transit environment so that it will have fewer emissions. On both a physical and social level, they have worked at this issue. They have built up and connected more cycle tracks to encourage
greater ridership in place of auto dependency. They have also implemented an educational program aimed at encouraging students to walk or cycle to school rather than be driven by their parents. Unfortunately, the research and efforts that they have made have revealed that the city faces almost insurmountable odds to achieve the dramatic reductions in transportation related emissions that they seek. Three scenarios were built that would enable Växjö to hit their targets, each requiring huge shifts in transportation patterns that will be very difficult to implement in established development areas. The three scenarios are:

1. Shifting 30% of automobile trips to bicycle, and 30% of trips to transit (bus)
2. Increasing bus ridership by 50%
3. Maximizing efficiency of current transit system, requiring substantial infrastructural retrofitting and redevelopment, including high-speed lines and reduction of automotive lanes

Achieving the kind of behavior modification required this large a shift in mode split on this time scale is unprecedented, and it appears that given the rate of growth for Växjö, even more dramatic policy shifts may be needed to attain their targeted reductions. The current approaches have begun to run into their limits, and have not always been well enough integrated. This has caused gains to be achieved in a somewhat splintered fashion and isolated from the sort of systemic change that will be needed in the long run.

Adding further complexity to the situation is the fact that as a result of their forward-looking planners, politicians and policy, Växjö is experiencing remarkable growth. As they develop new areas to the south of the city center such as Vikaholm, Telestad and Jonsboda, they want to ensure that the areas will contribute to the reduction of emissions and high quality of life. They will do this, firstly, by incorporating much of the initiatives that they have worked so hard to already pioneer. However, these areas also provide a proverbial “blank slate” where space itself can be ordered to guide the transportation sector to make even more significant reductions.

It is becoming more and more clear that transportation emissions need serious attention to help Växjö achieve its targets. There is a significant opportunity to facilitate the public’s choice for sustainable transportation options, and provide an example of how Smart Growth can make this possible. Jonsboda is the first development area in Växjö that is considering how sustainable transportation can assist their goals from the very beginning, and it will be able to utilize a set of transportation solutions that combine to provide convenient, efficient and ecologically responsible mobility for the citizens.

RESULTS

Making the case for Smart Growth Development in Jonsboda

What is clear from the theoretical perspectives section of this paper is that transportation planning cannot stand on its own. In order for a transit plan to be effective, it must be integrated with land-use planning that is compact and mixed-use. Thus this physical plan for Jonsboda is an integration of Smart Growth planning principles, emphasizing multi-modal transportation planning, integrated with land-use planning. The goal is for these components to form a symbiotic partnership. The transportation system should be integrated within all areas of the development, and contribute to the economic, social and ecological aspects of sustainability. The efficiency of land-use should be utilized in a way that serves as the underpinnings for the transportation system, and enables residents to make more sustainable transportation choices such as public transport, car sharing, walking and cycling.

The five Smart Growth planning principles chosen are key components in the design of a community with the intent of reducing VMT and encouraging the use of alternate forms of travel, such as public transit, cycling, and walking. The conceptual design of Jonsboda was influenced by the urban form and transportation infrastructure of cities recognized as leaders in sustainable transportation, and by the urban planning and design theories that attempt to promote a higher quality of life for citizens. The neo-traditionalist planning and design theory of Smart Growth emphasizes what are recognized as the most critical elements in community design that contribute to sustainable mobility, and are characterized by the five planning principles that follow:

1. Transit oriented development
2. Compact and dense neighborhoods
3. Pedestrian and cyclist friendly design
4. Mixed-use development catering to various social and economic classes of society
5. Abundant and safe public, green and recreational spaces.

These five planning principles are in essence the community design principles, which can act as a foundation for reducing dependence on the private automobile. Thus reducing VMT and VT by shortening distances, increasing service availability and accessibility, and prioritizing public transit, cycling and walking.

A traditionally European quality maintains its place as a key element for planning and sustainability from a transportation perspective. Many European settlements built prior to the advent of the car have a unique advantage in that they are compact and mixed-use, encouraging accessibility and reducing necessary trip distance. Many modern cities and recent developments in Europe have recognized the benefits of compact development and maintained the Neo-Traditionalist planning that encourages density and mixed-use. Växjö’s former strategic head planner for 20 years, Erland Ullstad made significant efforts to contain the development of Växjö and encourage dense development. He
maintained a Traditionalist view, having the insight that the Modernist sprawling developments highly dependent on the use of the private automobile were not a good option. 71 With Växjö experiencing a consistently growing population and requiring the need for expansion, the city needs to utilize the surrounding public lands to develop new residential dwellings. Smart Growth planning principles must guide this development to ensure a reduction in VMT between the CBD of Växjö and Jonsboda, and within Jonsboda itself.

Jonsboda’s location is isolated from the CBD due to the geographical barriers of lakes Norra and Södra Bergundasjön. There is a small land bridge on the northern end of Jonsboda, but on the other side of the water is a Natura 2000 nature reserve, Bokhultets which has specific limitations on how much traffic can flow through it due the environmental degradation associated with automobile traffic. The guidelines for Natura 2000 are so strict, it is feasible that they could prevent any development from happening at all in Jonsboda. 72 For example, if a conventional residential community were to be planned for Jonsboda without alternate transportation options, the dramatic increase of traffic and emissions would endanger the habitats that are protected by the Natura 2000 guidelines. This possible threat alone could give the review board reason to halt development plans for Jonsboda or another similar area. This challenge also brings with it tremendous opportunity as it makes a very strong argument for the need of a public transit network to service the area of Jonsboda and relieve the expected increased traffic flows. Currently the most direct route to enter the Växjö CBD from Jonsboda is through the Bokhultets nature reserve. Alternatively, one could travel around the North via highway 23, which is considerably longer.

The Bokhultets reserve begins at the narrow split of land between the North and South Bergundusjön lakes, jutting south and west from the city center. There are two types of Natura 2000 preserves. The first is to protect particular species of flora or fauna, and the second is to protect a particular type of habitat. Bokhultets is the latter type.

The significance of this designation for Jonsboda lies in the administrative approval required from the regional governing body (the board is for all of Kronobergs ‘län,’ or county, in this case). This board has administrative authority to approve or deny not only development and changes within the reserve itself, but any developments that could affect the nature reserve. Significant amounts of traffic or pollution would not be acceptable in a reserve such as this, and thus would cast serious doubt on the probability of an administrative board granting permission for a development on the scale proposed. That is, unless a dramatically different approach is taken for Jonsboda. Design proposals (further detailed in the findings section) call for the closing of this road link to all public traffic, and keeping it open only to human powered and public transit, such as the proposed BRT. This should ensure that there is no significant increase in vehicle traffic or emissions through Bokhultets and keep the impact of the Jonsboda development to a minimum. To support a transit system capable of servicing this development, the land use proposals for organizing around transit hubs and reducing demand for car travel are very important as well. Each of these elements show a proactive approach to preserving the reserve, and should appeal to the administrative body.

Literature reviewed suggests that as city populations grow they should be organized in a nodal fashion. Authors such as J.H. Crawford suggest that future cities could be made of looping patterns of interconnected nodes. In Smart Growth planning, one of the planning principles is transit-oriented

71 Ullstad, E., Personal Interview, March 2, 2009.
72 http://www4.g.lst.se/nat2000/n2000visa.asp?SITECODE=SE0320106
development, which places community developments at the various nodes along a transportation network. When there are multiple centers in a city, residents have access to a greater variety of services close by, and potentially a greater sense of connection to the community, each leading to lower demand for travel and transportation services.

The European Union has prioritized this principle, termed ‘policentricity,’ as a crucial element for economic growth and ecological sustainability. The two main documents dealing with EU policy on territorial cohesion, the Territorial Agenda (TA) and the European Spatial Development Perspective (ESDP), hold policentricity as a core element of their strategies. Commenting on the TA, Andreas Faludi remarks: “Promoting polycentric territorial development with a view to making better use of the available resources in Europe’s regions is also the main plank of the Territorial Agenda.”

He highlights the link that has constantly been made in the political dialogue between European competitiveness and a polycentric urban system. The TA itself highlights policentricity as a crucial objective, and necessary for economic competitiveness. The ESDP tackles the subject much more in-depth, suggesting specific policy initiatives and reasoning. Policentricity is called for as a strategy to create dynamic ‘zones’ that can better interact with the new world economy. The conventional way of developing the periphery, through providing better links to urban centers, is challenged as outdated and economically unbeneficial. It requires mobility of more people, and reduces economic viability of the peripheral areas. Nodal development can stimulate economic activity across a broader area and reduce the demand for resources devoted to travel. EU policy makers also seem to understand the importance of integrating planning on multiple levels as well. Most importantly, land-use planning should be a top priority, realizing that it can promote accessibility and transportation other than the private automobile.

On a smaller scale, these ideas seek to develop a ‘compact’ area that provides a mix of residential, services, employment and recreational space with unique identities and community pride. This kind of development is key to the future sustainability of urban areas. As alluded to in the EU policy, it is extremely important for future economic security to have diverse employment and commercial activity. Not just many centers within a region, but also within expanding urban centers themselves. By providing an integrated space for multiple uses, it removes the dependency of Jonsboda on the Växjö CBD while maintaining a strong connection to, and complimenting the city center for economic and commercial activity and helping stimulate a broader economic base. It also helps achieve the goal of lower carbon emissions through lowering required trips outside of the development. In policy discussions, policentricity is often not talked about at this level. However, it is in fact elements such as those proposed within this paper that allow true nodes to develop, and assist with macro policentricity. Mixed-use development and transit options must be concentrated in small scale developments such as Jonsboda if regions hope to benefit from the advantages of economic diversity associated with the availability of multiple centers.

Territorial Agenda of the European Union, Agreed on the occasion of the informal ministerial meeting on Urban Development and Territorial Cohesion in Leipzig on 24/25 May 2007
European Spatial Development Perspective, Agreed at the Informal Council of Ministers responsible for Spatial Planning in Potsdam, May 1999, p. 20

ESDP (1999) p. 23
Jonsboda should be organized around ‘pedestrian zones.’ Each of these centers will be the main areas for living, working, public transportation and services. The biggest demarcation of these centers from the surrounding areas should be that each zone will be car free. Each of these ‘hubs’ will be circularly oriented with a diameter no more than one kilometer across. Inside the zone will be a looping main thoroughfare, which gives access to transit for the residents, and will be lined with many of the service and commercial activities needed for daily life and employment for the citizens along with residential options. The zones of phase one and two will be located close to the water on Södra Bergundasjön. Both will be open on the eastern side into a large green/recreational space jutting into the center of the zone, creating a c-shaped concentration of mixed-use development.

The green space will lead out to the coastline, which will contain recreational opportunities and amenities for human powered transportation, all situated in an easily accessible greenbelt that will follow the coast south into the second zone providing recreational opportunities and public access to the lake front. The greenbelt will maintain an average width of 150m along the coast, with wider areas around the zones.

Aside from the main BRT thoroughfare, all other streets will be prioritized for pedestrian and cycle traffic. This will allow a more compact arrangement of dwellings, providing tremendous access to services and shops, while still maintaining significant amounts of open space for community activities, recreation, exercise, air circulation and light. Residents will not miss their cars, as they will become truly unnecessary. Of course, some residents may still own cars, so there will be parking facilities located outside of the zone and street parking on the outer ring road.

Bus Rapid Transit Oriented Development

This element is the lynchpin of the entire Jonsboda development. It is not only the lifeblood and circulatory system of the development, but the key to getting approval from the Natura 2000 administrative board. At the heart of the needed approach is a roadway dedicated to low-emission public and human-powered transit and closed to personal automotive traffic. The only way that the board will approve the plan is if it can be assured that negative effects befalling the reserve are kept to a minimum. Auto traffic will therefore need to be eliminated or severely restricted to service vehicles, and possibly some HOV traffic utilizing the proposed car sharing service. In this way, it serves a dual purpose of not only guaranteeing access to the rest of the city with a low environmental impact, but also ensuring the ecological foundation of the development as a whole.

The basic structure of this element is as follows. A roadway will continue from the existing link through the reserve down to the first car-free zone, looping through the zone along the main thoroughfare and around the green space that extends into the center. From there it will continue Southwards into the central zone of phase two. There, it will form a similar loop skirting the green space and providing maximum accessibility to residents and workers. From the north end of Jonsboda the line will travel through to the central station and CBD, from the south it should pass through Vikiholm, Teleborg and the University, then connect with the northern portion. To make the connection in the northern portion, priority will need to be established by either designating existing lanes

for BRT use, or expansion of the roadways. This should be a consideration in the creation of the Södra Länken project connecting highways 23 and 27. To access the CBD and service communities in the Northeastern regions of Växjö the BRT will have an additional line looping through these regions as demonstrated below by the black and white hashed line representing the BRT line. The BRT line should be 12 meters wide, providing two single lanes of traffic bordered by 2-meter wide cycling/walking paths on each side (except through Bokhultets, where it will only be on one side and be 10m wide) which should be illuminated and separated from the roadway by a curb.

The goal of looping through the development is, again, to prioritize accessibility. At maximum, every residence within the car-free zones should be within 300m of the BRT stations, an easily walkable distance. Average walking speed for pedestrians is approximately 76m a minute. Any distance less than 380m would be accessible in a five minute walk. Keeping accessibility within a five minute walk will require four stations in the northern zone and two stations in the southern zone, ensuring service will flow rapidly and efficiently.

Since cycling opportunities will be available along the pedestrian ways as well, it will be very quick and easy to move towards other parts of the city. Each car-free zone should act as a BRT transportation hub, where people can access easy ways to move around the city. The elements should be as integrated as possible with one another encouraging multi-modal trip generation with bike racks on buses, and cycle terminals offering showers, lockers and covered bicycle racks. In addition to the BRT, pedestrian and cycle modes, land-use elements must also be integrated. Access points and stops will be located within the thoroughfares, joined well with services and commercial space, but also with green space, having at least one stop on the edge of the central green space in the zone. Future concerns are addressed through this mode of transit as well. Beginning the service with buses will allow routes and timing to be easily adjusted until the perfect mix is found. Because it will operate on a dedicated roadway, it will be easily expandable and transformable from a biogas bus to electric, to a light rail system. As the development grows, and ridership increases, this conversion would be a logical step in addition to efficiencies such as bus loading tubes. This plan allows maximum flexibility to serve riders’ desires, thus gaining the highest possible ridership.

In initial stages the bus should be powered by bio-fuels, with which Växjö has already had some success. From there they could move to electric busses...
followed by trams/light rail. This will ensure that the system is contributing to the reduction of CO$_2$ emissions. The table below demonstrates the reduction in vehicle travel with respect to transit oriented development, and mixed-use development.

<table>
<thead>
<tr>
<th>Design Feature</th>
<th>Reduced Vehicle Travel</th>
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<tbody>
<tr>
<td>Residential development around transit centers.</td>
<td>10%</td>
</tr>
<tr>
<td>Commercial development around transit centers.</td>
<td>15%</td>
</tr>
<tr>
<td>Residential development along transit corridor.</td>
<td>5%</td>
</tr>
<tr>
<td>Commercial development along transit corridor.</td>
<td>7%</td>
</tr>
<tr>
<td>Residential mixed-use development around transit centers.</td>
<td>15%</td>
</tr>
<tr>
<td>Commercial mixed-use development around transit centers.</td>
<td>20%</td>
</tr>
<tr>
<td>Residential mixed-use development along transit corridors.</td>
<td>7%</td>
</tr>
<tr>
<td>Commercial mixed-use development along transit corridors.</td>
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</tr>
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</tr>
<tr>
<td>Commercial mixed-use development.</td>
<td>7%</td>
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</table>

**Car Sharing**

An additional element in mobility options is the implementation of a car-sharing program. Such programs have been up and running in neighborhoods of larger cities such as Chicago, Amsterdam, Malmö and many others with great success, and can assist greatly with reducing overall trips and vehicle miles traveled. Though the greatest reduction in CO$_2$ emissions will come from facilitating greater mode split towards public transit use, walking and cycling, it is understood that there are some cases where one has to have a car. Certain errands, or trips outside the city simply require access to a car. Car sharing is a very user-friendly way to reduce overall car ownership and use, while still keeping the option available for a large amount of people. It is also a good way to give access to different kinds of vehicles that are less efficient and should be used sparingly such as trucks and sport utility vehicles, while making sure the majority of trips are being made with efficient, low-emissions vehicles.

Research conducted by I-GO, a non-profit car-sharing program in Chicago has shown that such programs can have a tremendous impact on the transportation habits of participants. Some of the findings include the following:79

- Each I-GO car replaces 17 cars on the road
- 25% of I-GO users increased their walking.
- 14.5% of I-GO users increased their biking.
- 17.6% of I-GO users increased their public transit usage.
- 45.9% gave up or postponed purchase of a vehicle or considered selling a vehicle because of joining I-GO.
- Members report driving only 9.6 miles per week, or 500 miles per year, whereas the typical car owner in Chicago drives 10,000 miles per year.
- Of those who did not own a car at the time of orientation, 56% postponed buying a car because of I-GO or gave up a car prior to joining I-GO.

Car sharing programs offer a way to reduce driving for those who feel they have

to maintain access to cars. I-GO is just one example, Zip cars is a similar for-profit company operating in Chicago. Fourteen countries in the EU have car-sharing available to varying levels. In Sweden, programs exist already such as Sunfleet in Malmö, Pilotfish in Göteborg, and Bilpool in 24 cities throughout the country including Växjö. In addition to reducing the VMT, car-sharing reduces the demand for parking space, freeing up more land for as green or recreational space, and improving quality of life.

Density

Any areas not designated as green or recreational space will be zoned with varying degrees of medium and high density. This will be especially important for the central, car-free zones. Within these zones, all buildings should be 2-6 stories in height. The different heights will be distributed throughout the zone, keeping available sunlight and view lines accessible to as many dwellings and businesses as possible.

A particularly good measure of density is Floor Area Ratio (FAR). FAR is determined by multiplying the plot ratio (amount of space taken by the building’s footprint in relation to its lot) multiplied by the number of levels of the building. It is suggested that an area developed according to Smart Growth should have a FAR of at least 1.5.\textsuperscript{80} This is quite a high ratio compared with conventional development. Normally, a 13-story elevator apartment building would be needed to get to 1.8. By building a car-free zone, a tremendous amount of space is freed up that would normally be set aside for automobile infrastructure. A FAR of 1.5 can be achieved by building 4-story buildings on 37.5% of the site area, which would still leave much public and green space.\textsuperscript{81} Todd Litman suggests “Increased density tends to reduce per capita vehicle travel. Each 10% increase in urban densities typically reduces per capita VMT by 1-3%.”\textsuperscript{82}

Density is not the same as congestion or crowding. Many people associate negative connotations with dense urban living.\textsuperscript{83} However, much of the frustration of living in an urban context is resultant from accommodation of the automobile. Cars increase wasted time in traffic, emissions, noise, death and injuries. When cities are built on a human scale it can negate many of the common complaints people have about urban living. Studies have been conducted on the effect that high-density development has on congestion, and found that there is a weak correlation between the two. They have instead found that while urban areas have greater congestion than rural, it is the conventional edge developments that have the highest congestion, and corresponding commute time.\textsuperscript{84}

Variety and non-uniformity will be key to keeping livability and aesthetic interest high. The buildings will also be ordered in an organic fashion, eschewing the more typical grid or cul de sac layouts. There is an opportunity to feature the sustainable wooden construction that has been in development at the university of Växjö. These elements should be combined with design ideas from multiple architects and significant community consultation to create diversity and high community investment. An effort should be made to concentrate the very highest density along the transportation corridors. This is particularly important in larger urban areas with arterials that stretch for many kilometers. Curitiba, in Brazil has provided a strong example of this on a much larger scale.

Due to expected growth of populations and vehicle ownership, increases in

83 Crawford, J.H, \textit{Car-free cities}, International books, 2002p. 228
efficiency will not be enough to stem the growth of carbon emissions. To achieve a sufficient reduction in greenhouse gasses in the transport sector, both VMT and VT must be significantly reduced. Studies have been conducted in four different emphasis areas as to the impact of compact development on VMT and VT. After Meta analysis, they have demonstrated a reduction in VMT by 20-40% over conventional development. This is incredibly exciting as CO₂ emissions are reduced on a one-to-one basis with VMT. That is, if there is a 30% reduction in VMT, there will be a corresponding 30% reduction in CO₂ emissions. When combined with the possibility of the even higher reduction of VMT possible in a completely car-free development, the resultant reduction of CO₂ is potentially striking.

Mixed Use

It will be crucial that at least 60% of the buildings within the car-free zones are designated as mixed use. Combining residential and commercial zones is essential to providing maximum accessibility for residents and workers. Both accessibility of services from residential dwellings, and accessibility of services from each other have shown to have an impact on travel patterns. Specifically, linking more than one errand can cut household travel 15-22%. This, again, attacks CO₂ emissions at the source. Reducing VT and VMT is the only way to make a big enough reduction.

Mixed use office space in Västra Hamnen, Malmö

Dwelling types will also be mixed. There should be equal part rental apartments, owned apartments and condos, with detached, single family housing making up a small portion of the development and located outside of the car-free zones. Housing should be accessible for a wide range of incomes, budgets and family sizes. Oftentimes, eco-villages or new-urban developments can price out lower-income residents, but for these developments to promote sustainability on a large
scale, they cannot be limited only to high-income residents. In consideration of the social aspect of sustainability, the area must have housing options accessible to a wide variety of income groups, age and race. Ideally there would be a small percentage of social housing as well as multi-income mixed residences. This kind of policy can help with much quicker integration and promotion of overall diversity.

Development of this type is virtually assured of strong consumer demand. Which in the current economic landscape is certainly a welcome trait. There is an incredible demand for housing situated in mixed use areas and it is continuing to grow as more people are becoming aware of the need to reduce carbon footprints, and of the advantages of living in a neighborhood with high accessibility. Studies conducted in the United States by real estate analysis firms, National Association of Homebuilders, National Association of Realtors, the Fannie Mae Foundation and other researchers have all found that minimally one third of respondents are interested in Smart Growth (mixed use) communities and neighborhoods. In some studies over 55% of Americans showed preference for higher density and mixed usage if they could lower their commute time. This demand is placing sustained price premiums on residences in such areas and making them very competitive in multiple market segments.

Developments such as these have been highly successful in Europe as well, with examples such as Borneo Sporenburg in Amsterdam and Poundbury in England setting precedent as best case practices. In the Swedish context, both the Västra Hamnen development in Malmö and Hammarby Sjöstad in Stockholm have shown great levels of success thus far, emphasizing again the success of Smart Growth.

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**Walkable and Cycling Friendly Neighborhoods**

It will be extremely important that the car-free hubs maintain a walkable quality beyond simply prioritizing pedestrian traffic. The aforementioned characteristics will go a long way towards making the development walkable. High density and mixed usage will maintain pedestrian accessibility, and make mobility by foot the most convenient option.

Also important is going beyond making walking and cycling simply the most convenient options, and making them truly desirable options. Maintaining high visual interest through good design and the integration of points of interest throughout will be a key to promoting high desirability for human powered transportation.

To assist the mixed-use areas in promoting walking and cycling, particular attention must be paid to the design of the streets of themselves. Designing of streets with the intention of promoting more than simply car travel is often referred to as “complete streets.” The typology of streets in Jonboda is expressed visually below in 7 cross-sections of the street types designed for promoting alternate modes of mobility in Jonboda and described with more detail in the following tables.

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### Jonsboda Street Typology

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
<th>Characteristics</th>
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<tbody>
<tr>
<td>A</td>
<td>Jonsboda Cross Roads</td>
<td>4 meters wide, no parking, priority given to pedestrian and cyclists crossing, speed limit of 30 km/hr, traffic calmed streets</td>
</tr>
<tr>
<td>B</td>
<td>Cycling/walking access paths</td>
<td>2 meters for pedestrians and 2 meters allocated for cyclists offering connections between various roads making walking or cycling more efficient that car use in short trips within Jonboda</td>
</tr>
<tr>
<td>C</td>
<td>Residential complete streets</td>
<td>2 meters of angled parking, 4 meter two lane road complete with traffic calming mechanisms of pedestrian and cyclists crossings, speed limit of 30 km/hr and speed bumps, 2 meter 2 lane cycle path, then 2 meter pedestrian sidewalk</td>
</tr>
<tr>
<td>D</td>
<td>Jonsboda BRT</td>
<td>Within Jonsboda the BRT line will be a truly complete street with 6 meters allocated for the BRT line (initially biogas bus, then electric bus, then electric tram) neighbored on each side by a meter of grass and planted fruit trees, then 2 meter wide uni-directional cycle path, then 2 meter wide pedestrian path. Integrated with the pedestrian path should be benches and small market stands.</td>
</tr>
<tr>
<td>E</td>
<td>Car-free pedestrian streets</td>
<td>Within the car-free zones pedestrian streets between park space or mixed use buildings provide 3 meter wide 2 way cycling paths neighbored by 1.5 meter pedestrian sidewalks on either side. Service vehicles may drive on bike path with valid access pass.</td>
</tr>
<tr>
<td>F</td>
<td>Car-free pedestrian promenade</td>
<td>The pedestrian promenade will be an area for social integration with a 6 meter wide pedestrian zone at its heart with abundant room for proximal cafes outside seating, markets, recreational events, pubic benches and street art. A 1 meter buffer on either side of lawn and fruit trees will be followed by 2 meter wide uni-directional cycle path, then 2 meter wide pedestrian path.</td>
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</table>
Results

The main thoroughfare looping through the development should be at least 16 meters wide within the car-free zones allowing dedicated lanes for public transport, cycling and foot traffic. External from the car-free zones, the BRT line will narrow to 10 meters through Bokhultets compressing the cycling and pedestrian lanes and minimizing impacts on the nature reserve. There will also be green space and areas for cafes and bars to have outside seating in the warmer months. All other streets found throughout the development should prioritize cycling with distinguished cycle lanes, and providing abundant traffic calming features such as pedestrian prioritized crosswalks, road tapering and appropriate speed limits. Streets such as these can create “spaces unto themselves” as J.H. Crawford puts it. Streets that are walkable and have human activity are enjoyable spaces to congregate and move about. With streets this size and the area allocated in the car free zone, blocks could be as small as 24m². Small block size can offer interconnectivity and communal space promoting social cohesion.

<table>
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<tr>
<th>Type</th>
<th>Characteristics</th>
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<tbody>
<tr>
<td>G</td>
<td>Växjö BRT</td>
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The Växjö BRT will be the BRT line everywhere outside of Jonsboda and only 10 meters wide to minimize the transportation footprint through the Natura 2000 park, Bokhultets and existing road infrastructure where BRT will be implemented. A 2 meter wide uni-directional cycle path on either side of the BRT line will be shared with pedestrians, as most walking through the park will more likely take one of the pre-existing nature trails.

From left to right, these pictures above from Barcelona show streets that prioritize pedestrian space. The first from the left demonstrates a truly complete street with 2 lanes of automobile traffic at the edges, then a tram line located where the grass is, then cycle paths, then pedestrian space with integrated cafes, game boards, benches and street art. The middle street excludes automobile...
traffic with outer lanes designated to cycle traffic, yet wide enough for service vehicles and a pedestrianized center with ample room outdoor sitting for proximal cafes and shops, playgrounds for children, and many benches and tables to take advantage of. The third photo on the right is the famous La Ramblas, stretching over 1.5 kilometers from the harbor, this street hosts an abundance of street performers, markets, information booths, and many other sources of entertainment for pedestrians.

Walkability addresses all three areas of sustainability: 1) Social and quality of life, by supporting community interaction with other residents and encouraging healthier mobility choices. 2) Economic, through savings on road infrastructure, auto transportation and energy expenditures, and by also promoting local businesses, strengthening the local economy. 3) Environmental, by significantly reducing the per-capita carbon emissions of residents who seek to swap cars for footpaths and providing more green space.

Though there are some very cold periods when cycling may not be preferable, most of the year it remains a very good option, free of fossil fuels. There is already a strong tradition of cycling here in Sweden, with it being a part of life for many people. It will be very important to build on the tradition and utilize this mode as much as possible if the aggressive emission goals of Växjö are to be met. A small survey conducted among residents of Växjö by students of BTH showed that more than half the respondents were willing to bike at distances greater than 5km and the rest were willing to bike at least 2km for basic trips. With the kinds of amenities recommended, pleasant routes and dedicated pathways, it would be fair to assume those numbers to increase.

Key to increasing usage of cycling will be to include dedicated cycle tracks on all roadways, and ensure that pedestrian areas will be sufficiently wide enough to accommodate both walkers and cyclists. Because Jonsboda, and the car-free zones within it are to be compact, cycles will get riders where they want to go very quickly, making it an attractive option particularly for mobility within Jonsboda itself.

Cycle tracks will also be included throughout the green and recreational spaces. Residents should not be asked to use it only as a carbon mitigation tool, but also be able to enjoy it as a recreational opportunity. Making it easy to increase physical activity can tremendously increase one’s health and quality of life. To make cycling as convenient as possible, there should also be cycle amenities integrated with transit stops and recreational infrastructure. At least one central cycle parking house will be built near a central BRT stop. It should provide indoor storage for bikes and facilities for showering, changing clothes or storing personal effects at the beginning or end of a commute.

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Here and along tracks in other areas there will be places to inflate tires, and perhaps tools or services for light repairs. A bike sharing system such as Vélib in Paris, Bicing in Barcelona or similar programs in Copenhagen and elsewhere could be used to model at a smaller scale to service the residents and workers in Jonsboda. This would also be quite flexible and adaptable, and require relatively low initial investment, or could be provided and cared for by a private company.

Green and Recreational Spaces

A design element that is strongly recommended to tie together each of the other elements and really promote interest and dynamism in the development is that of green space which incorporates recreational opportunities. Much has been written and discussed about the role of green space in urban living environments. Ebenezer Howard, was the first to promote development centered around green space (termed green belts) as a direct antidote to the “ills” of the city.90 His Garden City influenced generations of planners throughout the 20th century with green space continually maintaining an important place in the perspective of planners.

The green space integrated into the Jonsboda design concept aims to promote an increased connection with nature or ‘biophilia’ by prioritizing its accessibility to residents. Green space in Jonsboda should have three classifications, agricultural, recreational, and natural. Agricultural areas will be reserved for community garden plots managed by residents, the recreational areas will be integrated with various sport fields, playgrounds, and gardens, and the natural areas will be reserved to promote the local flora and fauna and protect local biodiversity and habitat. By interspersing small, accessible green spaces and community gardens throughout the development, residents can become active in communal gardening practices, take part in sporting activities, or appreciate the local flora and fauna.

These spaces should be integrated with the residential areas so that residents and workers will not need to go far to enjoy an element of nature and feel a greater sense of attachment to nature. The spaces will also facilitate social cohesion through enhancing community activities such as barbequing, gardening, playing games or sports, and hosting markets and other social events.

While preserving the most attractive natural spaces throughout Jonsboda for use by all, special attention will be given to the area along the lakefront, which

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should include walking and cycling paths, docks, picnic areas, kayaking, canoeing, rowing or sailing clubs, sport fields, and other amenities intermingled throughout the lakefront park. The lakefront greenbelt will be a mixed use park emphasizing recreation yet containing nature reserves in ecologically unique areas and the centrally located golf course will be also be designated as recreational. Many of the smaller and more dispersed green spaces will be partially agricultural and recreational with much of the natural reserve areas preserved in west and south of the development (see landuse map p.55).

There is a key difference between conventional green space planning and what is proposed here however. This plan pushes the concept past the historical model of a ‘garden city,’ to a ‘recreational city.’ Each green and public space will be assessed to see how recreational activities can be integrated into it.

There is a limitless amount of recreational activity that can be provided for unobtrusively and at no, or a very low cost to residents. Each of these activities will draw people out into the communal spaces and areas around the development, increasing community and health of those involved. These activities will be integrated not just into the little spaces throughout the development, and the greenbelt along the lakefront, but also into the transportation hub itself. This will give commuters a chance to meet and engage with others spontaneously and in between segments of the workday. Lunch will still include coffee and cafes, but now can also include Frisbee golf, tennis, bocce ball or other refreshing activity before the afternoon behind a desk.

Integrating open space and recreational opportunities into the community has important social benefits beyond physical and health realms. Jane Jacobs strongly criticizes the efforts of planners to create centralized green spaces in isolation of everyday activity in her book *The Life and Death of American Cities*. Throughout the first half of the book she makes a strong case that instead of providing freedom, they can in fact foster anti-social behavior away from the watchful gaze of people going about their everyday business. By including


Reducing Automobile dependency through Smart Growth
smaller, widely distributed open space throughout the mixed-use areas and recreational opportunities in the larger areas, it will help infuse lively activity and a sense of social responsibility. Overall, it is a simple, easy and inexpensive way to add value to the development, encourage community health and well-being and attract residents.

The photos below demonstrate how simple recreational elements can add value to public parks. Starting from the left this a bocce ball sand pit in Barcelona used by a collection of elderly men, the middle photo is some concrete ping pong tables, also in Barcelona, and on the right is a side street in downtown Amsterdam which has numerous objects for children to play on.

Proposed Phases of Development

All of these elements can be constructed in three phases to minimize budget pressures and let the community build in parallel with the development. The first phase would focus on development for the North East corner of Jonsboda as it is the closest connection to the CBD. This stage should begin to incorporate all of the design elements discussed thus far and begin to attract investors and potential homeowners. The central car-free zone should be constructed with dense, mixed-use buildings and streets. All the internal streets should be closed to cars and be pedestrian and cycle friendly as discussed above. Implementation of a BRT link between the zone and central station should happen prior or concurrent to this stage, along with upgrading of, and elimination of auto traffic on the road link through Bokhultets. Construction and planting of green space along the coastline and in the center of the car-free zone should also be completed. The portion of the greenbelt that extends into zone two should also be underway with recreational elements integrated and cycle and walking paths under construction. Parking zones/structures should be built outside the outer ring of the zone, and permits should be priced at a premium. As a way to keep track of VMT, odometer reporting should be required for parking registration with parking discounted for residents with low bi-annual VMT.
Phase two should develop the South Eastern portion of Jonsboda beginning with a second car-free zone. It will be patterned after the first one using the same features of density and mixed use to order its development. Connectivity will be maintained via an extension of the BRT through Vikiholm and Telestad, connecting to the university and CBD. Green space along the coast and in the center of the car-free zone should be completed.

Phase three involves the entire Western portion of Jonsboda. The main recommendation for this phase is to use a significant portion of the area for a central park and natural land reserves. This park could be in the form of a par-three golf course, with hiking paths, soccer fields, gardens, etc. The rest of the area should be reserved for a large range of services and land-uses, which can provide for local demand and meet the needs of Jonboda residents. Light industrial or utility service zones should be integrated into the area with plans for a biofuel manufacturing site and fire department hall and training grounds required in the upcoming future. Additional space could be made for various services occupying a larger footprint, such as automotive garages, department
stores, or office space, provided that they are serviced by transit and cycle tracks. If city growth necessitates development of more residential areas, there would also be ample space to create a third car-free zone in the North West corner of the development. At this point, the transit system should have worked out any kinks and found optimal service routes and patterns to establish connector services to the BRT. This could be an opportune time to transform it into a light rail, tram system or similar, and also explore expansion of the system.

An element that can be developed between the first and second phases is a promenade along the coastline that begins and the southern tip of the first car-free zone. This would be oriented towards the water and greenbelt, taking advantage of a broad, open walkway. It would be another highly advantageous area for mixed usage, as residences with water views would be highly sought after. Cafes, restaurants and retail would provide attractive surroundings for residents of Jonsboda, and would be steps away from areas for picnics and walks by the water. Weekend markets and social events would draw people from Växjö out to Jonboda for a weekend stroll along the lake front promenade connecting car-free zones 1 and 2.

**Design Approach**

The descriptive aspects of Jonsboda reflecting the TDMS associated with the five Smart Growth planning principles provided above offer a visual image of what the development should look like in components. To demonstrate an integrated spatial visualization of the design features described above much time was spent designing a land-use and transportation map for the city of Växjö. This map incorporates the TDMS and design elements described above, and provides the city planners of Växjö with a visual representation of what Jonsboda could potentially look like. By utilizing Manifold GIS software and data obtained from Växjö the foundations of the conceptual spatial layout for the Jonsboda development site were created with the available data layers including the following shapefiles and an .ecw orthophoto of the area:

- Urban land-use type (describe various attributes of layer)
- Rural land-use type (describe various attributes of layer)
- Contours (elevation at 5 meter intervals)
• Hydrology (including, rivers, wetlands, etc.)
• Roads (including all road types)
• Planned development areas (including proposed development sites)
• Housing (all housing types)
• Park Reserves (all park types or various designations)
• Planned Highway development

The locations of the car-free zones were plotted from these initial layers in respect to the location of the BRT. Placing the larger of the two car-free zones closer to the CBD emphasized that the community was a TOD and minimized the distance between the CBD and majority of Jonsboda residents, encouraging cycling and minimizing transit travel time. Placing compact and mixed use development proximal to the BRT service stops and within the car-free zones, mimicked the design strategies and planning influences of many New-Urbanist and Neo-Traditionalist planners reviewed during theoretical research.

After the car-free zones were established we began to insert the various land-use types to demonstrate the proportional relations between green space and urban land-use. The road typology was devised from a collection of influential design books, consultations with transportation planners and from observations during field trips to Copenhagen, Malmo, Gothenburg, Stockholm, Helsinki, Barcelona, Amsterdam and Berlin. With GIS various buffers were calculated, determining proximal relationships between the land-use elements and transportation corridors. The amount of land that would be allocated to transportation corridors was also determined, demonstrating the proportion of green space that should be reserved for recreational, agricultural and natural designations.

The variety of GIS layers designed can be exported into a wide range of file types and imported into various software applications used by Växjö’s various designers, engineers and GIS analysts. This allows not only a visual representation of Jonsboda as a map but allows for the easy adaptation of various design layers into the Växjö Master Plan 2010. Ultimately having a greater influence on politicians to proceed with a Smart Growth development for Jonsboda.
Sustainable Transportation Indicators (STIs) and Projections

In order to make sure that both design and policy are fulfilling their purpose, a system should be in place by Växjö to monitor and track the sustainability and health of the community in regards to transport and land-use planning. It can also assist in creation and evaluation of goals throughout the process. The STIs that follow provide examples for areas that are worth monitoring. It is not crucial that every one is tracked upon the development of Jonsboda, but they are thought out, concrete suggestions for areas of evaluation that can assist the planners and policy makers.

<table>
<thead>
<tr>
<th>Category</th>
<th>Sub category</th>
<th>Disaggregate</th>
<th>Quantifiable Indicator</th>
<th>Targets</th>
<th>STI #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation Trends</td>
<td>Mode Choice</td>
<td>Auto</td>
<td>Km per vehicle (VKmT)</td>
<td>50% reduction</td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transit</td>
<td>Number of passengers (%)</td>
<td>30% increase</td>
<td>T2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cycle</td>
<td>Number of trips (%)</td>
<td>30% increase</td>
<td>T3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walking</td>
<td>Km walked on average</td>
<td>25% increase</td>
<td>T4</td>
</tr>
</tbody>
</table>

See Appendix A for larger image
<table>
<thead>
<tr>
<th>Transport modes</th>
<th>Accessibility</th>
<th>Social Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto restriction</td>
<td>% of roads closed to cars</td>
<td>30%</td>
</tr>
<tr>
<td>Public transit</td>
<td>Minimum distance of residents from transit stops</td>
<td>300m</td>
</tr>
<tr>
<td>Cycling</td>
<td>% of residents that have access to proximal cycle paths</td>
<td>90%</td>
</tr>
<tr>
<td>Walking</td>
<td>% of roads with pedestrian access</td>
<td>70%/100% within CFZ</td>
</tr>
<tr>
<td>Services</td>
<td>% of residents within 150 m from services</td>
<td>60%</td>
</tr>
<tr>
<td>Land Use</td>
<td>% of residents within 200m from green space</td>
<td>100%</td>
</tr>
<tr>
<td>Recreation</td>
<td>% of land used for transport infrastructure footprint</td>
<td>25%</td>
</tr>
<tr>
<td>Mitigation</td>
<td>% of trips eliminated (VT) compared to other areas</td>
<td>30%</td>
</tr>
<tr>
<td>Equity</td>
<td>Affordable Transit</td>
<td>Cost is low % of household budgets</td>
</tr>
<tr>
<td></td>
<td>Accommodation of special needs and non-drivers</td>
<td>% of residents with special needs able to utilize service</td>
</tr>
<tr>
<td></td>
<td>Accidents</td>
<td>Deaths and injuries</td>
</tr>
<tr>
<td></td>
<td>Physical activity/Calories burned</td>
<td>Km walked</td>
</tr>
<tr>
<td></td>
<td>Amount of green/natural space</td>
<td>% of land that is green space</td>
</tr>
<tr>
<td></td>
<td>Amount of Recreational Space</td>
<td>% of land that can be utilized for recreation or agriculture</td>
</tr>
<tr>
<td></td>
<td>Affordability of Recreation</td>
<td>% of recreational opportunities that are free or very low cost</td>
</tr>
</tbody>
</table>
### Environmental Impacts

<table>
<thead>
<tr>
<th>Environmental stewardship</th>
<th>Land use impacts</th>
<th>Measurable increase in biodiversity</th>
<th>Continual increase</th>
<th>E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource impacts</td>
<td>Minimizing vehicles using fossil fuels transportation</td>
<td>10% decrease annually</td>
<td>E2</td>
<td></td>
</tr>
</tbody>
</table>

#### Energy Consumption

<table>
<thead>
<tr>
<th>Public Trans</th>
<th>% of renewable energies used</th>
<th>100%</th>
<th>E3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Trans</td>
<td>% of renewable energies used</td>
<td>15% increase annually</td>
<td>E4</td>
</tr>
</tbody>
</table>

#### Air Pollution

<table>
<thead>
<tr>
<th>CO$_2$ emissions</th>
<th>decrease of transport carbon output per capita</th>
<th>Reduction of 50% to rest of Växjö</th>
<th>E5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total vehicle emissions</td>
<td>Per capita +/- of conventional exhaust pollutants</td>
<td>Reduction of 50% to rest of Kommun</td>
<td>E6</td>
</tr>
</tbody>
</table>

#### Noise Pollution

| Minimizing noise from transport ROW | % of population exposed to high traffic noise | < 5% | E7 |

### Environmental Impacts

<table>
<thead>
<tr>
<th>Light Pollution</th>
<th>Minimizing light obstructions from transportation</th>
<th>% of ROW with “downlighting” etc</th>
<th>100%</th>
<th>E8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure cost</td>
<td>Minimizing through use of transit</td>
<td>% of budget for roads, parking and traffic service</td>
<td>E9</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fuller Cost accounting</th>
<th>Degree to which prices reflect true cost of transportation (social and environmental)</th>
<th>Report economic cost, including resources used, emissions, accidents and clean up</th>
<th>50% reduction to rest of Kommun</th>
<th>E10</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Net Transit cost</th>
<th>Minimizing subsidy of system by Kommun</th>
<th>Fares – operating cost + revenue stream</th>
<th>E11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commuting cost</td>
<td>Money Cost</td>
<td>Total monthly cost for residents &lt; 15% of household budget</td>
<td>E12</td>
</tr>
<tr>
<td>Opportunity Cost</td>
<td>Total time spent on necessary travel 50% reduction over rest of Kommun</td>
<td>E13</td>
<td></td>
</tr>
</tbody>
</table>
Closely following the STIs is the question, what are reasonable expectations from the very beginning? Will all the corresponding targets be reachable in the initial phases of Jonsboda’s development?

The one environmental area that is certain to show dividends however is vehicle related CO\textsubscript{2} emissions. If all elements of the transportation and land-use plan are implemented in Jonsboda, significant reductions in carbon emissions are expected over a similar area that would instead be developed according to conventional planning methods. As discussed before, a reduction of VMT of 20-40% is a very reasonable expectation for compact developments relative to automotive dependent sprawl. The plan calls for Jonsboda’s main centers to be car-free, replacing even more day-to-day trips with human powered and mass transit. Given these features, it would be more than likely for Växjö to see a 50% or more reduction in VMT. With a one to one ratio for carbon emissions and VMT, this would also mean a 50% reduction in carbon emissions resulting from changes in transportation alone. There would also be further benefit from utilization of green building and efficiency technologies.

It is difficult to determine exact metrics for traffic flows and patterns. Municipal traffic modeling for even small towns can take more than a year and often is only 20% accurate. These projections are not guaranteed either. There was relatively little existing data on specific carbon sources within the Växjö to work with from the beginning but effort was put into making the most solid and dependable case possible.

### Policy Discussion

The results section of this paper has focused mainly on the Smart Growth design elements proposed for Jonsboda, and suggests ways that the built environment can encourage residents to utilize environmentally friendly and convenient transportation options. To successfully promote cycling, walking and public transit as alternate modes of mobility, the city must support the design elements with policy initiatives that can further encourage multi-modal transit. In the same way as all five of the Smart Growth planning principles must be implemented concurrently to ensure an effectively integrated transportation system and land-use plan, policy must be implemented simultaneously with Smart Growth design elements to ensure a paradigm shift in societal habits towards more sustainable modes of transportation.

Växjö has already shown a strong use of policy to lower CO\textsubscript{2} emissions and
increase sustainability throughout the city, demonstrating strong political will to instigate positive change. Initiatives like free parking for alternative fuel vehicles and requirement of GPS use in all taxis have helped Växjö to make great progress with their environmental goals of reducing transport based CO₂ emissions, although for Jonsboda to achieve a significant reduction of VMT and VT additional policies are needed.

Policy initiatives can be broken down into three main areas. First, incentives, like the aforementioned free parking for flex fuel vehicles, can help residents benefit from making green decisions. The second area for policy to address is disincentives, in the form of fuller cost accounting, such as making sure auto users are paying more directly for infrastructure and pollution. This can be done through higher fuel taxes, increase in toll roads, or higher taxes on automobile ownership. The last is general awareness for the public through marketing and educational campaigns. A tremendous example for this is the existing educational program in Växjö that has led to more students walking or cycling instead of being driven to school each day. Recommendations such as high parking prices and odometer reporting can be implemented specifically for Jonsboda where ample transportation alternatives can exist.

There is no shortage of resources to assist municipalities in devising creative policy that will discourage automobile use and promote alternate modes of mobility. Economist, transportation engineer and planner Todd Litman has published a vast compilation of policy resources in relation to TDMS that aims to promote alternate modes of transportation. Litman has categorized policy suggestions that are relevant to all stakeholder groups, with his policy recommendations reflecting the vast diversity of TDM topics, including the five elements of Smart Growth. The table in appendix 1 shows Litman’s priority ranking of TDMS for various stakeholder groups. His rankings suggest that municipalities should lead in the implementation of policy that encourages the five Smart Growth planning principles; something Växjö should be mindful of as it proceeds with Jonsboda.

Policy writing can be difficult, as what is in the best interest of the community is not always in the best interest of the individual or political party in power. Växjö has been very progressive in their policies towards reducing the overall CO₂ emissions for the city, which demonstrates there is the political will to act on goals made. As discussed in the theoretical perspectives section, there is tremendous value in establishing sustainable transportation indicators, which can then be used as guiding principles that designs and policy can address. Due to the complexity of accurately suggesting defined policy solutions, this paper highlights the relevant policy areas and defines targets for the various policies to reach. The STIs suggested are essentially the platform from which policy makers can devise actions to address the necessary targets and monitor the reduction in transport based CO₂.
CONCLUSION

It is not an easy task for municipal planners to balance the relationships between the environment, transportation needs and land-use planning, yet these considerations are at the heart of growth management. To seriously reduce CO\textsubscript{2} emissions in Växjö, it is evident that addressing the transportation sector is of the utmost importance. This paper has attempted to advocate for effective reduction of CO\textsubscript{2} emissions in a growth development such as Jonsboda by integrating multi-modal transportation planning with compact, mixed-use land-use planning and adhering to Smart Growth planning principles. By keeping to these principles and considering the design suggestions provided, it is possible to reduce VMT and VT at the source, by altering mobility mode choice of residents and reducing automobile dependence.

The various design features and policy recommendations suggested by this thesis are a mix of ‘carrot’ and ‘stick’ approaches towards mobility management that use five Smart Growth planning principles as the basis for land-use planning. Critics of these TDMS may view various ‘stick’ policies that reduce automobile accessibility or instill economic penalties discouraging car use as an attack against society’s mobility liberties and a radical approach to reducing automobile dependency. Conversely, ‘carrot’ approaches encouraging the use of alternate forms of mobility such as increasing accessibility proximal to transit nodes, improving the quality and convenience of transit services, or providing vast networks of attractive and safe cycling and walking networks are a much easier political decision to make. Although it is controversial and potentially difficult politically to implement various ‘stick’ policies, it is crucial that policies discouraging automobile use are implemented parallel to those that promote alternate forms of transportation thus encouraging a paradigm shift towards more sustainable modes of mobility.

By using the five Smart Growth land-use planning principles as a platform from which to develop TDMS, Växjö planners can begin to integrate transportation plans and land-use plans with the concept of sustainability (development benefitting social, economic, and environmental aspects of society). But why Smart Growth?

The search for the most appropriate meta theory was influenced initially by the successes witnessed in forward looking cities that were demonstrating reductions in automobile dependency and improvements to the quality of life for inhabitants. The re-emerging themes of high-density, mixed-use and transit-oriented development that promoted accessibility and reduced VMT and VT were recognized as highly desirable critical elements in land-use planning and design. Various initiatives encouraging cycling and walking whether through design, policy or awareness programs in the various case study cities also affirmed the value of integrating green or recreational space and vast networks of cycling and walking paths and car-free zones into the land-use plans.

Planning and Design theory that attempts to promote the five thematic areas of Smart Growth to encourage alternate modes of mobility is not overly innovative but more traditionalist and reflective of transit-town planning. As discussed in the theory section, the evolution of planning theory can be categorized into two distinct schools of thought; the Modernists and the Neo-Traditionalists. The Modernist school of thought has been the dominant planning ideology of the 20\textsuperscript{th} century, and it is evident in the sprawling metropolises of North America, Australia, and more recently Asia and India. These urban developments are

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highly dependent on vast amounts of non-renewable resources and energy supplies which contribute significantly to economic growth, yet come at great environmental and social costs to society. Through the theoretical perspectives section it was determined that the Neo-Traditionalist approaches to planning and design have many more benefits towards sustainable community design than the Modernist approach. When examining the various Neo-Traditionalist approaches we found Smart Growth to be the most pragmatic as it draws on lessons from the past and emphasizes the identifiable development goals of transit oriented development, compact and dense neighborhoods, pedestrian and cyclist friendly design, mixed-use development catering to various social and economic classes of society, and abundant and safe public, green and recreational spaces.

The conceptual design for Jonsboda emphasizes integration of the five Smart Growth planning principles as the top priority of the development with the understanding that all five of these elements must be equitably considered and concurrently implemented in order to alter mobility habits of the citizens of Jonsboda and reduce automobile dependence. The results section, highlighting design and policy recommendations for Jonsboda in respect to the principles, lays out a conceptual blueprint for Växjö planners to consider when revising their Master Plan.

Due to the complexity of the topic, it is evident that there is not a single answer to reducing CO$_2$ emissions created by the transportation sector but a myriad of solutions. Ultimately it is the citizens and their individual mode choice of mobility, which will reduce emissions. This required paradigm shift in societal behavior towards utilizing alternate modes of travel will best reduce automobile dependence, VMT, and CO$_2$ emissions. Therefore it can be concluded with confidence that if transportation and land-use plans are consistent with the five Smart Growth planning principles, and strict TDMS in the form of policy and design features are implemented, rising mobility demands do not need to be coupled with increasing CO$_2$ emissions. Development that is ‘smart’ can greatly improve residents’ quality of life, economic opportunities, and remain in balance with nature, ultimately contributing towards sustainability and acting as a model for other developments to follow.
# Rail Station Proximity Impacts on Property Values

<table>
<thead>
<tr>
<th>City</th>
<th>Factor</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newcastle upon Tyne</td>
<td>House prices</td>
<td>+20%</td>
</tr>
<tr>
<td>Greater Manchester</td>
<td>Not stated</td>
<td>+10%</td>
</tr>
<tr>
<td>Portland</td>
<td>House prices</td>
<td>+10%</td>
</tr>
<tr>
<td>Portland Gresham</td>
<td>Residential rent</td>
<td>&gt;5%</td>
</tr>
<tr>
<td>Strasbourg</td>
<td>Residential rent</td>
<td>+7%</td>
</tr>
<tr>
<td>Strasbourg</td>
<td>Office rent</td>
<td>+10-15%</td>
</tr>
<tr>
<td>Rouen</td>
<td>Rent and houses</td>
<td>+10%</td>
</tr>
<tr>
<td>Hannover</td>
<td>Residential rent</td>
<td>+5%</td>
</tr>
<tr>
<td>Freiburg</td>
<td>Residential rent</td>
<td>+3%</td>
</tr>
<tr>
<td>Freiburg</td>
<td>Office rent</td>
<td>+15-20%</td>
</tr>
<tr>
<td>Montpellier</td>
<td>Property values</td>
<td>Positive, no figure given</td>
</tr>
<tr>
<td>Orléans</td>
<td>Apartment rents</td>
<td>None-initially negative due to noise</td>
</tr>
<tr>
<td>Nantes</td>
<td>Not stated</td>
<td>Small increase</td>
</tr>
<tr>
<td>Nantes</td>
<td>Commercial property</td>
<td>Higher values</td>
</tr>
<tr>
<td>Saarbrücken</td>
<td>Not stated</td>
<td>None-initially negative due to noise</td>
</tr>
<tr>
<td>Bremen</td>
<td>Office rents</td>
<td>+50% in most cases</td>
</tr>
</tbody>
</table>

---

1 Carmen Hass-Klau, Graham Crampton and Rabia Benjari (2004), *Economic Impact of Light Rail: The Results Of 15 Urban Areas In France, Germany, UK and North America*, Environmental & Transport Planning