Worcester Light Rail Study

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Introduction

Problem Statement

Although the concept of sustainability first arose over 20 years ago, it has only recently begun to garner the attention of those in positions to do something about it. Though many different definitions of sustainability exist, the most widely accepted one is that sustainability is meeting the needs of the present without compromising the needs of the future. Unfortunately, for the past fifty years or so developers and planners have been compromising their future, which has in turn become *our* present. Automobile dependence and its associated ills of pollution, sprawl, social inequity, and wastefulness of time, resources and space has become the norm in America. In other words, current transportation and growth management policy in both the United States and Worcester specifically is not sustainable. As an increasing number of American cities have in recent years recognized this fact and begun seeking out more efficient and sustainable ways to manage growth and invest in transportation. With so-called "smart growth" strategies coupled with investment in new, efficient mass transit systems they are finally planning not only for today, but for tomorrow. However, it is important to note that most cities investing in these strategies are doing so out of sheer necessity because of their size. Although Worcester is a mid-sized city and not yet suffering from the problems of non-sustainability as acutely as larger cities, it can benefit just as much if not more so from "smart growth" strategies and investment in mass transportation before the problems grow more severe.

Issues of Auto-Dependence

Of the many issues faced by auto-dependent cities, a few are of overarching importance. They range from more abstract issues of quality of lifestyle and social equity to hard economic issues with facts and figures behind them. However, care should be taken to note that all are of supreme importance, despite how some might lack a clear means of quantifying the issue.

Suburban Sprawl and Transportation/Land-Use Policy

Over the course of the past 50 years American land-use policy has seen a concerted shift from more traditional methods of development and land-use which evolved over the course of thousands of years to an entirely new form with little relationship to the past ways of doing things. The result has been what is known today as "sprawl," but in reality extends far beyond the well-known tenants such as disappearing open spaces and increased traffic congestion. Armed with statistics and faced with accommodating the new technology of the automobile, planners of the mid 20th century embarked on a campaign of homogenizing cities through zoning and lowering densities through 'urban renewal' and policies designed to all but force any resident with a choice to move to the burgeoning new suburbs. Through a concerted effort involving Federal organizations, big businesses, local planners and respected academicians the entire shape of American settlement was shifted into a radically new direction.

Today after over 50 years of living and developing by the policies they set in motion America has become a sad wasteland of cheap buildings and wide roads. Suburbs stretch dozens of miles beyond downtown in every direction, strip malls permeate the landscape, open space is more and more difficult to find, utilities and resources are stretched to the breaking point and all the while development continues in the same patterns. Although it is difficult to say whether auto-dependence causes sprawl or sprawl causes auto-dependence at this point, the two are so interrelated that they are certainly two parts of a greater whole. Many of the negative impacts of suburban sprawl can be directly attributed to transportation and land-use policy, although in the past the two have somewhat surprisingly been handled separately. In fact, transportation policy has typically lagged behind land-use policy, attempting furiously to keep up with the new demands placed upon the network as development occurs.

Social Inequity and Lack of Mobility

Who suffers because of auto-dependence in America? In some ways almost everyone does, but those who suffer most acutely are the 80+ million Americans who are too old, too young, or too poor to drive. Since auto-use has become nearly mandatory in most places, those who are unable or unwilling to use an automobile for any reason are excluded from many supposedly 'normal' aspects of daily life. In many cases the dispersion of commerce and services makes it difficult or impossible to live a comfortable day-to-day life. Children are stranded at home, unable to travel far beyond their street or neighbourhood (and when they do so parents must act as chauffeurs). Often unable to find stimulation in their home environment, many teenagers turn to drugs and other destructive behavior. The elderly are unable to meet their daily needs on their own and are often sent to retirement homes to live out their remaining days in an environment that hardly replicates their former lifestyle. The urban poor were marooned in cities as businesses and jobs followed the middle-class to the suburban periphery. Left with few accessible jobs, many simply fall into unemployment and become dependent on the government for their day to day needs.

Waste of Resources

The modern pattern of decentralized development and single-occupant auto use is perhaps one of the most wasteful uses of resources ever seen in the world. In the last few decades America has become increasingly dependent on unstable governments and cartels for its energy needs while taking few actions to curb energy use. Despite the oil shocks of the 1970s, US energy consumption has grown extraordinarily and accounts for a disproportionately large share of world energy use, much of which is used in transportation. Despite advances in fuel-efficiency, the ever-growing number of automobiles on the road is keeping transportation-related energy consumption on the rise.

The increasing numbers of vehicles on the roads is also causing a massive waste of time, a resource not often thought about in conventional terms. The inability of highways and roads to keep up with traffic growth caused by decentralization and population booms has resulted in severe congestion in most auto-dependent cities. This congestion results in large amounts of time devoted to commuting and even to daily errands and leisure trips. Many estimates have been made on the impact of traffic congestion on the economy, most concluding that it causes a sizable dent in the GDP. Furthermore with longer commutes many families find less time to spend together and quality of life suffers.

A further impact of auto-dependence involves the massive waste of physical space to accommodate automobiles. Some estimates put the amount of land devoted to automobiles in American cities at over half of the total land area. In urban areas, because of the large number of automobiles converging, parking is often so scarce that running a parking lot in a prime location for downtown development is more profitable than actually developing the land. This devotion of space to autos also impacts the pedestrians, creating an environment that is unfriendly and sometimes un-navigable by them. Beyond the cities themselves, though, automobile-fueled decentralization and sprawl consume arable land at amazing rates. With further decreases in farmland the US may eventually become dependent on foreign nations for food.

Perhaps one of the most lamentable wastes of auto-dependence is the waste of life that comes from routine driving. With over 40,000 people dying and over 3 million injured every year in automobile accidents, the loss of life is truly staggering. Worse yet, it is also unnecessary, with other transportation-related fatalities and injuries only a tiny fraction of those numbers (and while driving is the dominant form of transportation in America, other modes are still much safer on a per-capita basis). With the personal freedom the automobile brings comes a personal responsibility for safety that is quite often forgotten.

Recent Investments in Transit

An increasing number of American cities have been investing heavily in transit over the last decade. Some have simply expanded older systems that managed to continue running even through the worst times for transit, but more importantly many others have been investing in entirely new systems. In some cases cities have simply said "no" to new highway projects and spent the money on a transit system instead, while in others new systems have been conceived simply due to realizations that automobiles alone cannot handle the numbers of commuters necessary. With twelve entirely new systems since

1990, extensions and expansions of five pre-existing systems, and four entirely new systems in the final design stages or already under construction, it's easy to see that light rail has been a popular choice in most American cities. This trend has been so popular, in fact, that it's difficult to find a very large metro area that has not had at least some form of light rail proposal in the recent past. While the systems range from simple and small to extensive and expansive, they have been met with large riderships and public support in nearly every case. Because of this support, many of the new systems have already had expansion projects or have them currently in the works.

Smart Growth

Perhaps one of the greatest ironies of this modern age is that the solutions to many problems seem to lie in the past. While the policies affecting growth and development in the latter half of the 19th century took shape and began to be implemented very few dissenting voices were heard challenging the vision of the future they had laid out. However after a short while some began to take notice of defects in the new systems and ways of thinking about the future that could not easily be reconciled. Although they went mostly ignored at the time as far as official policy went, their ideas were picked up and expanded upon when the problems they predicted actually took shape. Although the idea of "smart growth" has only recently become popular with municipalities seeking a way out of the problems that sprawl has caused, it has had a close following for some time.

The basic concept of smart growth is not to limit growth (although some communities had tried this approach with limited success), but to mandate that it take place in a more sustainable manner. This is done by seeking to preserve open space, invest in places which already possess infrastructure rather than building new infrastructure to service outlying areas, and to encourage the conservation of resources through better design of communities. There are a variety of ways to pursue these various goals, but in general smart growth development involves mixed-use, higher densities than traditional development, and the permanent preservation of open spaces as part of the development. Smart growth often seeks to combat auto-dependence by integrating workplaces and shops into human-scale neighbourhoods, reducing the necessity for many automobile trips.

A few offshoots of smart growth involving design specifications and aesthetics have also become popular in recent years. Two of the most popular, "New Urbanism" and Transit Oriented Developments (TODs), integrate smart growth concepts into robust urban design guidelines. The New Urbanism takes smart-growth strategies a step further and forges alternatives to current zoning laws for communities that actually mandate smart growth. The codes the new urbanists develop are actually a throwback to the old traditional town and neighbourhood designs of almost every community built prior to the Second World War. Transit Oriented Developments are smart-growth developments built around a transit stop. With a transit stop to offer an alternative to automobile use, TODs can safely achieve higher densities than other developments and mix commercial uses into the neighbourhood fabric around the stop. The two forms of smart-growth implementation are by no means incompatible with one another, and in fact the line is often blurred between these "different" areas of smart growth. Despite the many various flavours of smart growth, all strive to achieve not only a sustainable built environment, but one more pleasant to those who would live in it.

Background

History of Transportation and Growth Policy of the 20th Century

The history of American planning policy in the past century is one of business interests seemingly trumping good sense and in many cases public will. Though General Motors grew to be the largest employer in America, it did so through murky business practices and policy heavily tilted in its favour. From its very inception, the automobile was both a decentralizing force and an opponent of public transportation. Once the process of decentralization had begun it seemed inevitable and was largely supported due to various social and economic factors.

Dismantling of Public Transportation

Because public transportation was a direct competitor to the newly-minted automobile technology, it was in the best interests of General Motors (GM) to squash this competition. Although the trust-busting of the early century was moderately successful and fairly popular with the people, GM managed to slip by the radar soon after. While the motorcar was at first only a novelty, it soon became popular with Americans seeking the freedom to travel without adhering to existing rail routes and schedules. Beginning first in the 1930s and extending into the 1950s, GM, at first alone, and later with other automobile support industries, founded a number a holding companies which bought up streetcar lines in American cities and converted them to buses. These buses were of course manufactured by GM and despite the public outcry as it dismantled streetcar systems, it went on largely unchecked.

The bus service which GM replaced trolley lines with was generally a poor substitute and had the effect of driving people to invest in automobiles. This proved doubly profitable for GM because it had a monopoly on public transportation in many cities and was enlarging its market share for private automobiles. These tactics were so reviled, however, that GM was eventually found guilty of criminal conspiracy in 1949 and investigated for antitrust activities in 1974, but the damage could not be undone by this time. American cities were already committed to the process of decentralization and the automobile was the chief tool.

Hidden Subsidies for Automobile Use and Suburban Loan Programs

Despite the dubious actions taken by General Motors, the automobile did not become the dominant mode of American transportation without help from the government. Through a series of public works projects designed to bring the country out of the depression, the Eisenhower Interstate System was conceived and built. This system was seemingly based upon the assumption that automobiles and trucks were the only viable mode of long-distance transportation and constructed a massive infrastructure system to accommodate them. Although this sunk cost was substantial, the roadways constructed proved to need constant maintenance and expansion, costing taxpayers huge sums of money on a yearly basis. In their quantification of the hidden costs of automobile use, Hart and Spivak estimate the infrastructure cost picked up by the government for each car in use to be roughly $5000 per year. But yet since these costs are paid for by all taxpayers, whether or not they drive, the automobile seems like an attractive option because those $5000 are not factored into the yearly cost of owning and operating an automobile. Although a tax on gasoline was instituted to help cover these costs, it comes nowhere near doing so. In fact, were the gas tax adjusted to cover just the infrastructure-related expenses of driving it would be around $3.50 a gallon. More confounding yet, these expenses are not referred to as a subsidy, but rather as infrastructure improvements and maintenance. Yet money provided for public transportation for the same functions is referred to as a subsidy and public transportation authorities are encouraged to cover as much of the costs as possible from fares. This favourtism in policy and underpricing of automobile usage has resulted in the current 'popularity' of driving. However, the overconsumption of automobiles is just as much if not more so the result of imbalanced market forces upheld by government funding and accounting.

Beyond the infrastructure costs, another major factor which fueled American decentralization was the post-World War II loan programs, which highly favoured suburban home-building over inner-city renovation. These programs such as the FHA and VA mortgages tended to flatly refuse money for construction of anything but a new home in a suburban area. Private lenders followed suit, refusing to lend money for improvements on cities in a process which became known as 'red-lining.' This policy encouraged decay within the cities and encouraged growth outward, providing a strong force for decentralization, made possible by the affordability of the automobile for these longer-distance trips.

Single-Use Zoning

In the post-World War II years the concept of zoning found a new popularity as a method of strictly segregating uses in cities and towns. Although zoning had been in around in some form for a while, mixed-use buildings with residences over ground-level shops were common before this time. With the new zoning laws, however, mixing uses was strictly forbidden. Many traditional forms of construction and living were completely thrown out as outdated and made illegal by the new zoning laws. A residential neighbourhood had to be just that: residential. No businesses of any kind were allowed in most zoning standards, and vice versa. This forced segregation of uses led to the necessity of using an automobile for daily needs such as going shopping or to work. Because the automobile was now critical to daily life, these zoning laws also mandated amounts of parking that commercial buildings must have to be constructed, resulting in the advent of the modern-day strip-mall.

The Non-sustainability of Auto-dependence

Inequity and Lack of Mobility

Perhaps one of the greatest ills of making the private automobile the only viable transportation option in many communities is the impact this has on those who are unable to drive. This group encompasses quite a few people, including those who are too young to drive, those who are too old to safely drive, and those who are simply too poor to own an automobile. Because life cannot simply stop when one is unable to drive, all of these groups must find alternatives for getting around. Children mostly rely on their parents for transportation, which perhaps makes taking initial steps towards independence more difficult for them later on. Indeed, for many suburban youths receiving a driver's license is a rite of passage into adulthood and a new sense of freedom. These youths also happen to be the absolute worst drivers on the road, owing partly to their inexperience but also to their youthful exuberance as they try to fully explore their newfound freedom. The elderly who are no longer physically capable of safely operating an automobile are perhaps even harder hit than the children, who will not be stranded forever. Without a means of adequate transportation to take care of daily business, the elderly either become entirely dependent on their children and/or a hired helper, or are forced to move into retirement homes and communities where many grow resentful of being treated like children. However, their inability to get around in the existing transportation framework makes them exactly as helpless as the children who live in these conditions.

Although some overlap with the two aforementioned groups exists, the poor are another group which spans all age groups and is impacted deeply by the current automobile-dominated transportation paradigm. Because owning and operating an automobile is an expensive task, especially when the costs of registration, insurance and maintenance are taken into account, those at the lower end of the income scale are unable to afford this extra burden on their cost of living. They are often left with the options of either walking to work or taking under-funded public transportation in the communities where it is provided (often out of legal necessity and not a desire to aid mobility). Even more unfortunate, many businesses have relocated outside the inner-city areas where most of the poor are concentrated to the suburban fringe, to be closer to white-collar employees and residents with money to spend. These suburbs typically lack public transportation, or often gear their transportation towards taking residents into the central city without thought given to a reverse commute. This leaves the poor without good access to a growing number of jobs, making their situation even more desperate.

The American transportation paradigm which holds the personal automobile as the chief method of transportation is inherently discriminatory against any group unable to own or operate a vehicle. Highways are typically repaved yearly at great expense, while public transportation sees continual budget cuts and pressure to pay for itself with fare revenue. The inequity which arises from a publicly funded infrastructure system available only to those with the ability to purchase and operate an automobile deserves far more attention than it receives in the government today. Public transportation systems require a user only to pay the fare, not to own the vehicle or operate it, and are thus a much more equitable solution to transportation problems. Additionally, public transportation empowers the young and elderly to be more independent, which makes both groups less of a financial burden on their families and society as a whole.

Wastes of Resources

Traffic Congestion

The adage that "time is money" certain holds true of time spent stuck in traffic: the total estimated costs of traffic congestion are estimated at somewhere between 2 and 3 percent of the GDP in most industrial nations [4]. Congestion chokes off not only commerce but the daily lives of those forced to sit in the sea of immobile autos that it produces. Longer commute times eat into the personal time of commuters, making them less willing to commute anywhere with severe traffic problems. This in turn makes the area less competitive as it has a tougher time attracting potential skilled workers (and later by extension the businesses which require them). Traffic is largely a product of the popularity (or at least the forced ubiquity) of driving in American cities. This popularity can be destructive to urban areas as congestion chokes off access and businesses look elsewhere (typically outward from the urban core) for cheaper and more easily accessible space.

The grand planners of the mid-century believed that decentralization would yield a uniform population density across the land that was much more pleasant to live and work in. And so office and industrial parks far from anything other than an arterial road were conceived and built, low-density housing developments gobbled up the countryside, and an elaborate network of roads was built to link them up. However, this network relied on a hierarchal system of roads that funneled nearly every trip from one use (like housing) to another use (like shopping or work) to use the same arterial roads. At first the result was as expected, but as time went on and the number of users grew the various trips found themselves at odds with one another, caught in traffic no matter which direction they were headed. Limited-access highways were soon no better, mostly built for modest predictions of traffic volumes which were met and exceeded long before their builders expected. The solution of the time was simply to widen or build more roads. Traffic jams today are a testament to the inability of road builders to keep up with demand.

According to a recent article in the *Telegram & Gazette*, average commute times in Massachusetts increased 19% between 1990 and 2000[15]. Although the average times in Worcester were a full minute lower than the state average, they were still nearly half an hour each direction. However, with an expected population growth of 100,000 people in the region over the next 25 years, should the automobile remain the dominant form of travel, traffic problems would surely worsen. In the Worcester metro area only 4.3% of the workforce uses public transportation.

Energy Consumption and the Peak Oil Problem

A subject which has lately been getting more and more attention outside of the scientific and economic communities from which it spawned is that of "peak oil." The "peak oil" problem dictates that in the very near future the global production of oil will peak out and then decline. In fact, many signs point to the possibility that global oil production has *already* peaked—all non-OPEC oil fields have already peaked in production, as have the 37 largest fields in the world [12]. The repercussions of this will be immense and almost unthinkable for most, but yet the problem remains largely ignored by politicians, planners, and others in positions capable of doing anything about it.

The basics of peak oil are rooted in geology and economic theory, quite accessible to all. Oil is a fossil fuel produced from the decay of organic matter from millions of years ago that has been subjected to extreme geological forces which converted it into a syrupy fuel. Because of its nature and all the circumstances that went into producing it, oil is a finite resource. Only so much oil exists on the earth at any point in time; exactly how much is anybody's guess. Now enters the economic theory. Since the supply of oil is finite, its price must obey the basic supply/demand methodology. In modern times the production of oil (in this case 'production' does not mean the amount actually created, but rather the amount extracted from the finite supply within the earth) has increased dramatically to keep pace with the demand due to energy consumption. In recent times, however, many scientists and economists have grown concerned that the supply will soon not be able to keep up with the demand. Close scrutiny of production curves have led them to believe that the peak production levels of global oil will soon be reached, if they have not already been. In a global market where demand for oil continues to increase, the production shortfall would create dramatic price jumps. Even some of the world's leading oil producers have expressed concern over the lack of excess production capacity to meet the future demand projections.

Many have dismissed the "peak oil" problem as an elaborate doomsday hoax, despite the long list of reputable scientists and economists who have expressed concern and the reports by oil producers themselves on the matter. In the following graph from the ExxonMobil's 2004 energy report, it can be clearly seen that even those involved in the market for profit-making purposes recognize the issue at hand.

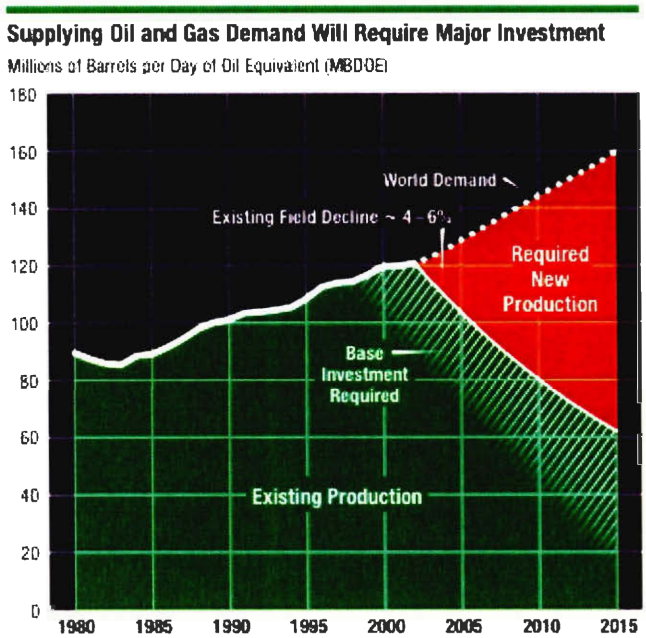

Figure 1: Oil Demand vs. Production Estimates [6]

This particular graph even indicates that the peak may have already been reached, since Exxon is already experiencing a 4-6% yearly decline in production. Other world producers are experiencing similar declines or nearly flat production. With oil prices topping $50/barrel and gas prices already uncomfortably high for many, it is difficult to deny that the peak oil crisis is a paranoid delusion.

While the "peak oil" problem will undoubtedly have far-reaching consequences, one of the most hard-felt issues will be the rising gasoline prices (as they are directly dependent on the price of oil) for the typical American commuter. Since the automobile is the primary method of transportation in America, increased fuel costs will raise the cost of living without any equivalent increase in income, which could be disastrous for the economy. In fact, there may very well be a *decrease* in income thanks to lowered efficiency and increased costs of materials due to similar oil-related problems, the likes of which are already appearing today. Should the production shortfall of oil approach even the more modest predictions, gasoline prices will likely soar to levels that make driving more of a financial burden than many will be able to bear. Some experts cling fast to beliefs that technological solutions will salvage widespread automobile use in the future by restructuring the way they operate or store energy. Two of the most popular 'solutions' cited are the hydrogen fuel cell and so-called 'hybrid' vehicles.

Hybrid vehicles, while a promising development, will never be a complete solution to the energy crisis. The basic concept is that a standard internal combustion engine operates at a fixed rate for maximal-efficiency to power batteries which in turn run an electric motor which provides the motive power. While they do greatly increase efficiency on a miles per gallon basis, they do nothing to remedy the inherent inefficiency of individual auto use. Additionally, they still burn gasoline, and therefore even if an aggressive campaign to force automakers into producing only hybrid vehicles were undertaken, automobile ownership and thereby gasoline use would still be ever-increasing with the population (albeit at a somewhat slower rate, but it is still only a temporary solution at best). The best-case scenario for hybrid vehicles is simply to prolong the 'grace period' before a transportation-related economic collapse (neglecting other related problems that may be *more* severe).

Hydrogen fuel cells and the accompanying 'hydrogen economy' are not so much a new source of energy as a new carrier of it. Electricity cannot be easily transmitted to automobiles and batteries capable of powering a car are expensive and cumbersome, so at this point the internal combustion engine is the most efficient and affordable means of producing motive power on a stand-alone basis. While gasoline is a far better storage medium, it cannot be easily produced in the manner which hydrogen can—it takes millions of years and powerful geological forces to produce, where hydrogen can be produced easily in a factory with any energy input. While a hydrogen economy does solve the problem of energy transmission to personal autos, it ignores the problem of the initial energy source. The hydrogen must still be produced from another source, and at this time oil, natural gas, and coal make up approximately 80% of energy sources[6] (all are non-renewable). No significant investment is being made at this time to convert the back-end energy production to renewable and sustainable energy sources such as wind and solar power, so conversion of the medium of transmission will do little to solve the basic problem of peaking oil supplies. Additionally, even though the energy is produced centrally, it takes several steps for the finished hydrogen to be produced for distribution, resulting in a 75% energy loss from production to final product (that is, only 25% of the original energy makes it into a form that fuel cells can use) [1]. In a future where energy costs have increased dramatically this will simply not do. A hydrogen economy does nothing to circumvent this wastefulness, but simply converts the energy carrier from gasoline to less-efficient (but cleaner-burning) hydrogen.

Given that the only solutions currently being pushed seem to fall short of actually solving the problem, America's current state of auto-dependence is hardly sustainable. A major shift in transportation trends towards more efficient means than the single-occupant auto is likely to be the only truly effective solution. Rail-transit is actually over four times as efficient per passenger per kilometer traveled than single-occupant autos (and this ratio increases as transit draws more riders [12]. Should automobiles be converted to the less-efficient storage medium of hydrogen, the ratio would increase four-fold. This operational advantage comes both from the transmission efficiency of electricity as well as from the economy of scale provided by transporting many passengers together, rather than on an individual basis. The advantage of economies of scale can even be seen in buses used for public transportation: while they use internal combustion engines like automobiles, they are still 1.4 times as energy efficient at current (relatively low) American ridership levels [12]. As ridership increases, just as with rail, the advantage also increases. Clearly if society wishes to move towards cutting its energy use, single-occupant auto use cannot be the dominant form of transportation.

Waste of Space

One of the most often overlooked costs of large-scale automobile use is the cost of the space needed to accommodate the millions of automobiles on the roads today. When a closer look is paid at this aspect of automobile use, the space necessary to park and drive a single car is staggering. Currently the best example of this kind of analysis is available from Hart and Spivak in *The Elephant in the Bedroom* [8]. In this analysis they determine that each car in daily usage requires at least eight parking spaces totaling 2000 square feet of space (roughly 1/20th of an acre). In an urban environment this space would likely cost roughly $1000 per year in their conservative estimate, yet free parking in most cities is very common. A quick look at private lot prices in cities where parking is scarce can give one a good idea of just how valuable this space is. In another simplified calculation with rather conservative numbers used Hart and Spivak conclude that automobiles on highways and arterials require at least another 2000 square feet of space to operate because of headways required at higher speeds for safety.

With these numbers taken into account, the amount of space required to accommodate the huge numbers of automobiles flowing into and out of cities on a daily basis is enormous. Worse yet, with roads and highways considered a public good, no tax is paid on the land to the local municipalities through which they pass. The same goes for public parking on streets, and although fees are sometimes collected through meters, the revenue from these does not usually make up for the tax revenue which would come from a private use of the land. The overall effect of this is to remove valuable land from city tax rolls with no new source of income to make up for it. Even when tolls are collected on roads, the funds go towards fixing the road itself up and not towards offsetting the lost income in the towns through which it passes. In urban areas with high costs for municipal services, including police and fire protection, these highways do not pay for the land they occupy and ferry commuters to and from their homes in suburban towns where they pay taxes—starving the city of much needed income on two fronts. Indeed, if much of the space used to accommodate vehicles were used for high-density housing, these commuters could live much closer to their jobs and the city would actually receive tax revenue from those who use its services on a daily basis.

Another unfortunate trend that automobile usage has promoted is the overdevelopment of rural hinterlands surrounding cities. This has resulted in a massive loss of arable farmland once used to feed the residents of the cities as it has been paved over and turned into subdivisions of single-family homes and strip malls. Worse yet, contemporary design standards and zoning regulations ensured that these new developments would be entirely dependent on automobiles for daily life, often at the expense of pedestrian safety and comfort. A report from the USDA estimated the loss of prime farmland in the United States at roughly 645,000 acres per year in the period between 1992 and 1997 [8]. Worse yet, they noted the rate at which prime farmland is being developed to be accelerating. The rate at which land-consumption for development is increasing (approximately 1.5%) far outpaces the population growth rate, which lies slightly under 1%. This is a direct result of the population decentralization which automobile use facilitates.

Many outlying communities have even tried to slow development by requiring larger lots in their zoning codes, however this has had the perverse effect of increasing the rate of land-consumption for development as developers are simply developing at the larger lot sizes without being discouraged by the zoning. This also tends to promote homogenous high-income neighbourhoods because a large plot of land tends to only be profitable with a large luxury home on it. High-income residents tend to have certain demands for their convenience which soon results in pressure for a commercial development the town, or possibly a neighbouring town, may not have wanted. This commercial development consumes yet more land with its massive parking lots and low-density design.

A final consideration involved in the spatial impacts of automobile use is its negative impact on pedestrian safety and comfort. Many design manuals for roads vastly overstate the space needs of automobiles, citing worst case scenarios involving extra-long fire trucks and total evacuation procedures. Typically the wider a road is, the less inviting it is to pedestrians. These manuals have also strongly recommended against the placement of trees as buffers between the road and sidewalk, citing safety concerns for drivers. What these manuals fail to mention is the safety concerns to pedestrians who are unshielded from speeding automobiles. Intersection geometries are another area where road planners tend to place the pedestrian last, often throwing in a crosswalk or two only as an afterthought. Often corners are given very wide radii so that cars may turn while traveling at higher speeds than may well be safe when pedestrians are present. This has the additional effect of making the distance a pedestrian must cross that much greater, and when signals often provide barely enough time to run across an intersection, pedestrians feel extremely unwelcome. In areas with more pedestrian-conscious planning departments, many intersections are actually redesigned to *minimize* the distance pedestrians must cross, which has the dual effect of acting as a traffic-calming device to slow down vehicular traffic which can no longer speed around corners. These configurations have proved to be much safer for both pedestrians and drivers where they have been implemented, and make the roadway more inviting for those on foot. They also make clear that roads and streets are not meant to be the sole domain of automobiles.

Environmental Impacts

The automobile is perhaps the largest source of pollution in America today. Although steps have been taken in recent years, largely through the efforts of the environmental lobby, to clean up automotive emissions, it has by no means diminished the overall impact of the automobile on the environment. While these emissions standards have reduced the amount of pollutants individual automobiles produce, the overall number of vehicles has increased at such a rate that the overall level of pollutants expelled into the atmosphere via tailpipe emissions has remained mostly unchanged.

With a growing body of research suggesting a link between these emissions and global warming, it can hardly be considered a victory for environmentalists. But emissions alone do not even account for much of the environmental damage which automobiles wreak on cities and the countryside. Rubber from tires and the material of brake-pads (until very recently the known carcinogen asbestos was used) continually break down into dust and are deposited on roads, in surrounding soil and are even inhaled by people and animals. Automobiles continually leak small amounts of oil, gasoline, brake fluid, antifreeze and a number of other harmful chemicals into the surrounding environment.

The fuels used for automobiles must be distributed and stored in various underground tanks at gas stations. These tanks are often situated above ground water supplies used for drinking due to poor planning and a lack of understanding of ground water systems, yet are invariably leaky. Underground gas tanks must be dug up and refurbished every few years, but even this cannot stop their slow leak of hazardous materials into the ground.

The ground water supplies are not only affected by leaky gas tanks, but also by the immense amount of pavement required to ferry automobiles between their destinations. While rainwater normally percolates back into the soil and replenishes the ground water supplies, when impermeable surfaces block this process the water is turned into runoff. This runoff causes urban flooding during severe storms and can lead to massive erosion at the outlets of runoff systems. Worse still, many of the hazardous chemicals spilled by automobiles as they travel are washed away by this runoff and pollute the streams, rivers and oceans which drainage systems empty into.

Because automobiles are largely considered a disposable good in today's market, the lifespan of each vehicle is only seven to ten years. The construction of vehicles means that the reuse of their materials is difficult and expensive, and much of it is completely worthless for reuse. This is a huge waste of physical resources, and many of the parts of automobiles which cannot be reused are simply thrown away or abandoned.

In addition to the more tangible environmental impacts of automobile use, there are the ecological and sociological impacts. Many highways and rural roads pass directly through migratory paths of wildlife, often resulting in a large number of the animals being killed by automobiles and disrupting the migratory patterns. The noise created by automobiles affects not only wildlife in rural areas, but human life in urban areas. Areas near highways are often extremely unpleasant and uninviting for pedestrians because of this noise. In urban environments noise from automobiles engines, tires, horns and stereo systems can lead to a cacophony that disturbs normal life.

Because of their ubiquity in American life, the negative impacts of automobiles are impossible to avoid. Even large amounts federal forest land currently protected may soon become open to road-building with pending legislation. While these impacts may be unavoidable, reducing automobile dependence can at least reduce the scope and level.

Past, Present and Future Solutions

Although the issues related to automobile dependence in America are hardly new, until recent years many of the offered solutions have only addressed the symptoms. An overzealous approach that favoured only the automobile has been the norm for many years, and in many parts of the country still is. Despite a growing body of evidence that the status quo of solutions do not solve the problems, state departments of transportation have continued to push aggressive programs that differ very little from practices of the past.

Increasing Road Capacity

Because only the symptom was recognized in the past, the solution to traffic congestion seemed to be an obvious one to transportation planners: build more roads. Even as newly constructed roads and highways reached their capacities many years before expected, planners laid out more roads and plans to widen existing roads, often at the expense of historic city infrastructure. Buildings were razed, sidewalks were shrunk and even eliminated, and a flurry of road construction took place. In fact, it's still taking place today. Despite the inability of road-building to keep up with demand, few in highway planning departments even questioned the outlook for success of this strategy until recently. While a growing number of transportation planners are acknowledging the need for multiple modes of transportation, it is far from a consensus. Although innovative uses of technology such as so-called "Intelligent Transportation Systems" (ITS) have been devised and implemented, their success is limited at best.

The main reason why expanding capacity has failed to appease the growing demand of automobiles is a phenomenon known as 'induced traffic.' Although seemingly counter-intuitive at first, results have shown that adding capacity to roads results in *more traffic*. A number of speculations have been made on why this happens, the most likely of which is that the increased capacity encourages more development along and use of the road, but the data collected on capacity expansion projects nationwide shows that the phenomenon is quite real. One fitting analogy is that "trying to cure traffic congestion by adding more capacity is like trying to cure obesity by loosening your belt." Indeed, the limiting factor in how much and how far people will drive seems to be the amount of traffic with which they must contend. This leads to the conclusion that adding capacity to roadways is not an adequate solution to congestion problems. But adding capacity still and never has done anything to address the greater set of problems with automobile dependence and has only made the current situation worse.

Investment in Public Transportation

Since road building cannot provide enough capacity for the multitude of trips which need to be made, many cities which abandoned it in the past have turned back to public transportation to address the problem. Many American cities almost wholly did away with their public transportation systems to make way for increased road capacity for automobiles. The lack of success from that approach has led many of them to construct entirely new systems, often at great expense. Cities such as Boston and New York, which maintained their transportation systems to some extent over this time, have actively engaged in new expansion projects (although a lack of adequate funding has held up many of these projects). Public transportation is often advertised as a way to avoid the hassles and stress of a long commute in traffic, and this much is certainly true. However, the advantages of public transportation go far beyond the simple issues of stress and convenience.

Public transportation is inherently a more efficient use of space for transportation. Because the vast majority of automobiles are used to carry only a single occupant, and at most four (or possibly eight to ten for larger vans), a rail vehicle capable of carrying over 100 people will carry more people in the same or sometimes even less space. Because trains need only a single operator who is thoroughly trained, the riders are also substantially safer since each of them is not personally responsible for a two-ton machine. Additionally public transit is subject to strict safety regulations which automobile drivers typically are not.

However, because of the expense of operating public transportation, it is typically only thought to be appropriate for either high-density corridors or long-distance trips through lower-density corridors. The former tends to take the form of subways, light rail or busses, while the latter is usually a commuter rail with park and ride facilities to accumulate riders along the route. Many cities and states have begun to mix these two ideas to generate lines which serve both low and high density areas along long routes. Surprisingly this has proved to be quite effective, such as with New Jersey Transit's new River Line. The favourite choice of new transit projects has without a doubt been light rail, with almost every new transit line opened in the past 20 years being some variant of this technology.

While public transportation has the ability to serve built-up areas and revitalize redevelopment districts, it can do little to alleviate the automobile dependence of low-density suburbs. The best solution offered to many of these communities is simply a park and ride facility for some sort of commuter line. It cannot replace the automobile where no main corridor(s) and set of focal point exists, as is the case in much of modern suburbia.

Smart Growth and Land Use

Because modern suburban decentralization is unable to be adequately served by public transportation, but also creates traffic congestion which chokes daily life and presents a living environment unsuitable to those without automobiles, a change must be necessary in the way suburbs are constructed. Current sprawl development patterns not only consume open land at an amazing rate, but force uses so far from one another that the automobile is the only viable means of transportation between them. Although some might say that low density is the suburban ideal, it is clearly not sustainable in its current form. However, smart growth initiatives have shown that a more traditional method of constructing suburban towns can actually be quite successful without compromising the advantages of lower-density living. Although smart growth takes many forms and has many styles of implementation, all seek to ensure the basic principle of sustainability is the chief consideration of the development.

Transit Oriented Developments (TODs) are one of the most popular and most tenable forms of smart growth planning. Basing new neighbourhoods around a transit stop and town center allows residents to walk to transit as well as shops and restaurants for their daily needs. A car in such developments is entirely optional, yet the development itself is not necessarily high-density. This middle ground between high and low density living has proven quite popular where it has been implemented, some say even fostering a sense of community not present in typical suburban subdivisions.

A more thoughtful approach to planning techniques in suburban towns is a good way to help reduce automobile dependence and encourage use of public transportation. It can lead not only to more sustainable cities, but more sustainable suburbs as well. This approach alleviates cities of the crushing burden of dealing with millions of automobiles every day and allows them to concentrate on more important issues of quality of life.

Recent Transit Projects in America

A number of American cities have recently 'rediscovered' public transit and all its advantages, spurring a frenzy of construction from coast to coast. Although many of these cities share some similarities to Worcester, a few stand out as very appropriate for comparison to the city's situation.

Tacoma, Washington: TacomaLink

Figure 2: TacomaLink Map [14]

The city of Tacoma, Washington is very similar to Worcester in size and lies in relatively close proximity to the city of Seattle. Although Tacoma is closer to Seattle than Worcester is to Boston, it is a distinct and separate city in much the way Worcester is, with a small population of commuters. In August 2003 Sound Transit opened the 1.8 mile long TacomaLink light rail line, connecting its downtown with a stadium and convention center at a cost of $80-million. Although it has only five stations, the line has proved quite popular and exceeded its predicted 2010 ridership soon after opening. Portions of the line are single-tracked and much of it is street-running, but the line operates fairly often and does not suffer much in the way of delays, possibly owing to its short length. Sound Transit plans to someday extend the TacomaLink to become part of a light rail system currently being constructed in Seattle. The TacomaLink provides a good example of how a city the size and density of Worcester can have a successful light rail system without having the traditional population densities though necessary to support that kind of transit service.

Minneapolis, Minnesota

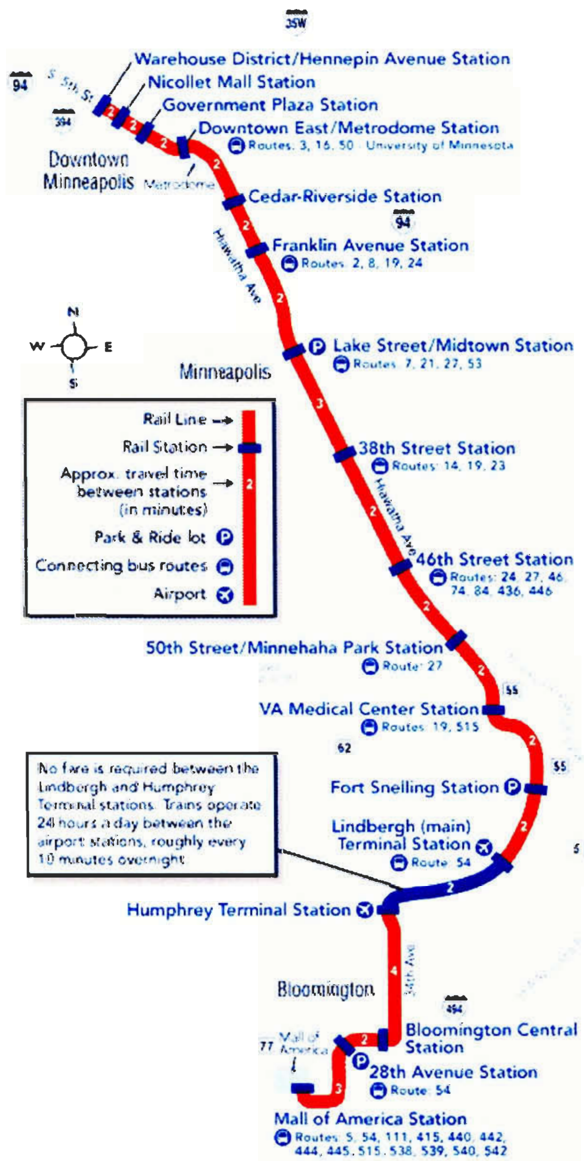

Figure 3: Minneapolis Hiawatha LRT Map [11]

Opened in late 2004 at a cost of $715-million, the Hiawatha Light Rail Transit line currently is the newest transit line in the country. It is also a good example of ways to link suburban centers with downtown effectively. The line's southern terminus, the famous Mall of America, is every bit as much a draw as downtown Minneapolis is on the other end. The line has seen ridership numbers surpass its predicted numbers since it opened in full, and it has become very popular with residents of the city. A recent poll by MetroTransit, the line's operator, found that 39% of the light rail ridership is actually new to transit, having switched over from driving to work. That represents a huge success at encouraging a modal shift in one of America's most auto-dependent regions.

A good portion of the line's success likely comes from its terminus at a popular destination outside of downtown and its airport service. There are multiple park and ride facilities towards the southern, more suburban end of the line, with stations nearer to downtown served mostly by re-routed feeder bus service. The line travels mostly in exclusive right of way, with only the downtown portion running along the street (although cars are not allowed on the railbed). Because of its mostly-exclusive ROW the line runs at speeds upwards of 50mph at times, rivaling the highway speeds achievable when there is no traffic. With the steadily growing traffic in the area, the light rail line becomes even more attractive.

Minneapolis provides a good lesson on how to effectively implement a light rail system. Its utilization of park and ride facilities in the less dense suburban areas combined with its linkage of three important destinations (downtown, the airport and the mall) make it very popular with local residents. It has been so successful that planners are now working on preliminary plans for a second branch of light rail to serve nearby St. Paul, the state capitol.

Light-rail Transit

Light rail transit (LRT) is a modern spin on an old concept. With its roots in the streetcars that shaped American cities, LRT is a modernized version which is seeing a renaissance in recent years. Although streetcar systems largely disappeared from American cities for the last fifty years, current inabilities to deal with traffic effectively have spurred a renewed interest in the transit mode. Recent years have seen the opening of new systems and expansions of existing ones all across America. The reasons for cities choosing light rail over either bus or heavy rail involve its place as a kind of 'middle-ground' between the two. To understand the advantages of light rail from other modes, it is important to understand the differences in technologies.

LRT is neither a bus nor a heavy-rail metro train, but draws on elements from both. It differs from heavy rail mostly in that it does not require a completely-exclusive right-of-way (ROW) to operate in. With traditional heavy-rail metro systems the exclusive ROW is often responsible for the greatest share of the construction costs because either tunnels or elevated structures must be constructed to separate the rail ROW from other traffic. LRT is far more flexible in its ROW requirements and, while it can operate in exclusive ROWs (which is preferable if possible, but *not mandatory*), operates with grade crossings and even in mixed-traffic with automobiles when necessary. This dramatically reduces construction costs, however often results in strife with auto-lobby groups due to the conflict which arises over whether space will be used for automobiles or trains. In fact, if too much of the ROW is in mixed-traffic, LRT suffers from similar problems as bus lines: they become mired in the traffic they are trying to alleviate. However, unlike busses, LRT vehicles have a much higher carrying capacity for passengers and typically utilize electricity for traction (although there are exceptions to this with diesel-powered light rail vehicles), resulting in no direct emissions and less local pollution when commuters switch from automobile to LRT.

Of its similarities to heavy rail, the most beneficial is the ability to carry large volumes of passengers with low operating costs. Typical LRT vehicles are much longer than traditional busses, often in two sections with an articulated joint between, can be operated in trains of two or more, and require only one operator. Although LRT will never be able to carry the same volumes as traditional heavy-rail metro systems, many cities have chosen to install LRT with provisions that may allow it to be converted in the future to an exclusive ROW heavy-rail metro system should the need arise, while others (notably: Portland, OR, San Diego, CA, and Dallas, TX) have made moves towards exclusively LRT systems. For communities of intermediate densities, too low to justify heavy-rail construction costs, but too high to be adequately served by a bus-only system, LRT fits into a rather large gap. However, given its flexibility and multitude of design specifications which can be tweaked, LRT can be adjusted to fit the needs of most any intermediate-density community.

Possibly the greatest advantage of LRT over bus service, next to its carrying-capacity, is the improved speeds that come with partially-exclusive ROWs. Although there is some debate currently over whether LRT really provides better service than busses with similar ROW conditions (called "bus rapid transit," or BRT), an inherent defect in the scheme is that dedicated bus lanes are often difficult to enforce and when uninforced lead to the same congestion problems that typical bus service suffers from. When a semi-exclusive ROW is maintained, however, average operating speeds increase dramatically over service in mixed-traffic.

Perhaps one of the biggest dangers of choosing LRT service over bus service is its fixed-route nature. While bus service can be easily re-routed should demand necessitate a change in service, LRT is limited to where the tracks where placed. This, however, can be one of its greatest assets should it be placed in a corridor which can sustain its use. Many find its fixed-route nature to be comforting and easy to understand, especially when compared to bus routes which often dog-leg and lack the clarity of rail routes. One can see the tracks and know exactly where the train will be going. Also, newer LRT stations typically are more elaborate than bus stops, which can be no more than a sign on the sidewalk. This typically also involves greater comfort in waiting. An important note, however, regarding LRT and bus services is that they are not incompatible. Indeed, LRT alone would do a poor job as a transit system: it must rely not only on walking traffic and park-and-ride facilities, but also on feeder bus service.

Because LRT is quite flexible in its application, the routing of systems is often through a patchwork of ROWs available in a city. Routes can be placed (in descending preference) in exclusive ROWs, along the center median of a wide road, in a preferential on-street alignment, or even in mixed traffic. Although exclusive ROWs are the most desirable, they are also typically the most expensive. A trend in recent LRT projects has been the utilization of abandoned or underused freight rail ROWs running through cities. This has a few major drawbacks, the foremost of which is that typically neither adequate concentration of residence nor destinations are near freight rail ROWs (Worcester is an important exception to this). Another drawback is that LRT does not interface well with freight operations, requiring that the LRT either operate on entirely separate track from the freight or have very strictly enforced use schedules to ensure the two modes do not interfere with one another (this approach is used in San Diego and Salt Lake City). Should these difficulties be easily overcome, however, abandoned and disused freight rail ROW is one of the most promising ways to provide efficient service to cities seeking to build an LRT system.

LRT networks can be constructed in a variety of ways, mostly depending on the needs of the city they are servicing. The most common configuration in recent American projects has been that of lines serving a central business district (CBD). They have often accompanied attempts to revitalize city centers suffering from decline due to competition from outlying areas and the decentralization that accompanies modern sprawl development patterns. Although some doubt that LRT itself has been the catalyst for historic CBD revival, few can refute that LRT has helped the process significantly. Other configurations possible for LRT are that of an entire network of LRT, LRT as a feeder to heavy rail service, LRT as a 'pre-metro' to be later converted to heavy rail, and LRT lines to 'new centers' (an acknowledgement of the decentralization most American cities are experiencing). Whatever the configuration or combination thereof that is appropriate for a city, LRT has just the right flexible nature to accommodate it.

Transit in Worcester

A Brief History of Urban Transportation in Worcester

Like much of New England at the turn of the 19th century, Worcester was a quiet agrarian town. While there was some limited manufacturing taking place at mills built upon its brooks, most goods were imported from Europe. But when the Embargo Act of 1807 was passed in an attempt to force Great Britain and France (at the time in the midst of the Napoleonic Wars) to recognize the importance of trade with America, this system was no longer tenable. With the importation of foreign goods mostly cut off, American towns and cities were forced to begin producing their own. In Worcester this resulted in a rapid boom in mill construction (at this point water-power was the only viable option for manufacturing) and the development of multiple transportation links to distribute goods from the newly booming manufacturing center. First the Blackstone Canal (opened in 1828) and later the railroads (the first of which was the Boston & Worcester and opened in 1835) established Worcester as a major hub of trade in central Massachusetts. However, until the advent and widespread adaptation of steam power in the mid-19th century most manufacturing operations in Worcester were still relatively small (although much more plentiful than they had been at the turn of the century).

When steam power became readily available in America and began to see use in manufacturing and transportation, Worcester's industrialization picked up even more speed. With its industrialization naturally came a population boom. The establishment of various civic amenities in the mid-century and its official chartering as a city in 1848 reflected its rapidly changing character. With urbanization well underway, Worcester soon experienced the growing pains that were all-too-common at the time.

Before the technology to build skyscrapers came about there was a definite saturation point for city districts when literally no more people could physically live there. The only solution was, of course, to build outward. Space, at the time, was not hard to come by, but often cumbersome to travel through. In moving from one part of the city to another the only option readily available was one's own two feet (horses and especially carriages were more expensive than most workers could afford at the time). As the distance from one's home to work became greater, so did their commute time. At first this was not much of an issue, but as space near workplaces began to disappear it soon became apparent that alternatives were needed.

In 1861 Worcester's first urban railroad, The Worcester Horse Railroad Company, was incorporated [13]. Tracks were laid down major streets through town and horse-drawn omnibus service was opened in 1863. This venture, however, soon failed and its properties were sold at auction in 1867. Its new owner revived service in 1869 and was the only such service in town until 1886 when a second line was founded. Within a year the new company, the Citizens Street Railway, absorbed the original lines and became the Worcester Consolidated Street Railway. In 1893 electric trolleys replaced the horse-drawn cars which had provided service until that point, providing faster, cleaner, and more reliable service. Within five years the system's capacity had been doubled thanks largely to the new technology, but owing also to expansion of the system to all parts of the city. By the end of the century the need for urban transit was obvious and many other street railways were chartered, most leading from Worcester to the surrounding towns (all were eventually acquired by Worcester Consolidated). The establishment of these lines marked an important step in Worcester's development where it transitioned from a city to a region. Development in the outlying areas followed the clustered 'streetcar-suburb' pattern of the day, with dense development near the streetcar corridors and very little further out from the lines.

In the early 20th century various other suburban lines were built and summarily acquired by the Worcester Consolidated. Of the various lines constructed in Worcester, only the Boston & Worcester never became a part of the Worcester Consolidated Street Railway. At its peak Worcester Consolidated carried over 72 million passengers per year and consisted of over 300 miles of track (impressive by today's standards, where annual ridership for the WRTA is less than 5 million) [3]. The streetcar's days were numbered, however, thanks to the developing automobile technology.

As automobiles became affordable to the average worker, cities began another major paradigm shift in America. Public transportation was seen as an absolute necessity thanks to the development patterns that followed streetcar lines, and so these lines were heavily regulated by government agencies. These agencies made it nearly impossible for the Worcester Consolidated to keep its fare high enough to cover operating costs because of inflation, aging equipment and facilities, and loss of ridership to the automobile. Worse yet, new mechanized alternatives such as the private jitney and the bus sprang up and began leeching away riders and their valuable fare monies just when the company needed it most. It responded the only way it could: by cutting service back to levels it could afford. In 1924 the first stretches of the Worcester Consolidated's lines were abandoned and replaced by bus service. The abandonment continued and by 1931 its streetcar lines operated mostly within the city limits, with buses serving the outlying communities. The company went into receivership and was reorganized in 1932, but its decline would continue until 1945 when trolley service was completely abandoned and replaced by buses.

With increasing volumes of auto traffic and greater dispersion of the population fueled by the mobility the automobile provided, Worcester soon began to head down the path of most every American city of the time. Roads were widened, buildings torn down to make way for parking and expressways constructed. I-290 was plunged through the heart of the city, eviscerating its core, and became a formidable barrier to pedestrian traffic, essentially cutting off portions of town. When a large part of downtown was razed to make way for the Worcester Galleria, the city had changed beyond recognition from its early days.

Today much of the city is almost inaccessible by foot, and only around 1% of all long-distance trips in the city are made on public transit (with ridership consisting mostly of the disadvantaged who simply cannot afford to own or are unable to operate a car). The city suffers from chronic traffic congestion and has low utilization of downtown buildings as residents and businesses are lured to surrounding towns or outlying areas because of sprawl-development trends.

Auto-Dependence in Worcester

While Worcester may seem to be less auto-dependent than many American cities, it is certainly more so than comparable New England cities. Although Boston and its neighbouring cities are a good deal larger than Worcester, they have embraced progressive policies on transit, parking and development which have made them much less reliant on the automobile. This has in some ways been in response to necessity, as ageing infrastructure has proved inadequate to support the massive influx of automobiles into the area, however Worcester's capacity is also nearing its limits, but without many of the same progressive policies. Though Worcester is not likely to ever grow to the same size as the Boston metropolitan area, it is expected to see a continued growth in population that may force higher-density living to be considered. Higher density, however, means more cars unless steps are taken to provide alternative transportation infrastructure.

Another instructive example is that of Providence, Rhode Island, 40 miles to the southeast of Worcester. Worcester and Providence are very similar in size and distance to Boston, however Providence has recently begun to flourish while Worcester has continued to stagnate. While much of this can be attributed to careful planning and a successful downtown revitalization effort, other aspects deserve examination. Providence, with a slightly higher population, is a much more compact city. While the overall density of living arrangements is much the same, consisting mainly of triple-decker homes, Providence has very little in the way of wasted space in the central city. Downtown Worcester, by contrast, is full of parking lots. One important lesson from the revitalization of Providence comes from its relaxation of parking requirements for downtown developments, which has encouraged many residents in and around downtown to simply walk or bike to work. In fact, Providence has a very strong bicycle-enthusiast community. Another advantage Providence seems to boast is that much of its retail space is not dispersed to the far reaches of town as in Worcester, but concentrated in a few districts in and near its downtown. While the success of Providence's downtown mall and the failure of Worcester's provide for an interesting albeit confounding comparison, it is important to note that Providence's mall did not involve the razing of any of its downtown and did not cut off access from an entire portion of town the way Worcester's did.

Beyond comparisons to other New England cities, Worcester can take a lesson from statistics on its own population regarding automobile ownership. While an average taken of Worcester and eighteen of its surrounding towns has an average of 1.11 cars per qualified driver (see Appendix B: Automobile Ratio Methodology for methodology and sources), the city itself has an average of only 0.27 cars per qualified driver. This begs the question: if the residents of Worcester don't have cars, how are they getting around? While official planning analysis says only a small minority of Worcester's population rides public transit, this leaves the question of how the rest of these people get around. Because Worcester is a largely middle-class city, many families can afford only one car, which must be shared by every member of the family. This undoubtedly results in some inconvenience to all members of the family. Younger people in the city often must share rides with friends or simply walk or bike around town, and many college students simply live within close proximity to their schools so they may walk to them. Although much attention is given to traffic congestion and parking concerns in the city, many of the drivers being accommodated are not even residents of the city and pay no property tax for its upkeep and services. Worcester may do well to place the interest of its own residents ahead of those of out-of-towners, and in the process may encourage some of the commuters to move back into the city.

Selecting a Transit Corridor

The two most important factors in choosing a transit corridor are proximity and space. A transit corridor must be in close proximity to both important destinations and to riders who will use it. Beyond this, it must also have adequate space to run in an exclusive right of way as much as possible to ensure speedy and uninterrupted trips. In older cities such as Worcester many destinations and residences already lie in close proximity to older established corridors from their pre-automobile development. However, in the years since the automobile became the dominant form of transportation new development has emerged which lie outside the well-established old transit corridors. Additionally many of these older corridors are too narrow for the space requirements of modern transit solutions because in their original formation only one mode of transportation utilized them. This presents a challenging design problem where new transit corridors must be fit into existing infrastructure and development while providing a modern level of service. Because Worcester is so densely built-up in many areas, it becomes critical to identify rights of way which may be re-used as a modern transit corridor.

Destinations and Points of Interest

The first step in creating a new transit corridor should be to identify current developments and land-uses which create a large draw for potential riders. These can be classified on a basic level as commerce/employment centers, cultural facilities and educational complexes. Worcester has a large number of land uses falling into each of these categories and because of its age many of them are located in mixed-use neighbourhoods and districts. Several of the most important of these areas have been identified here to provide a general idea of Worcester's physical structure to aid in the selection of a transit corridor.

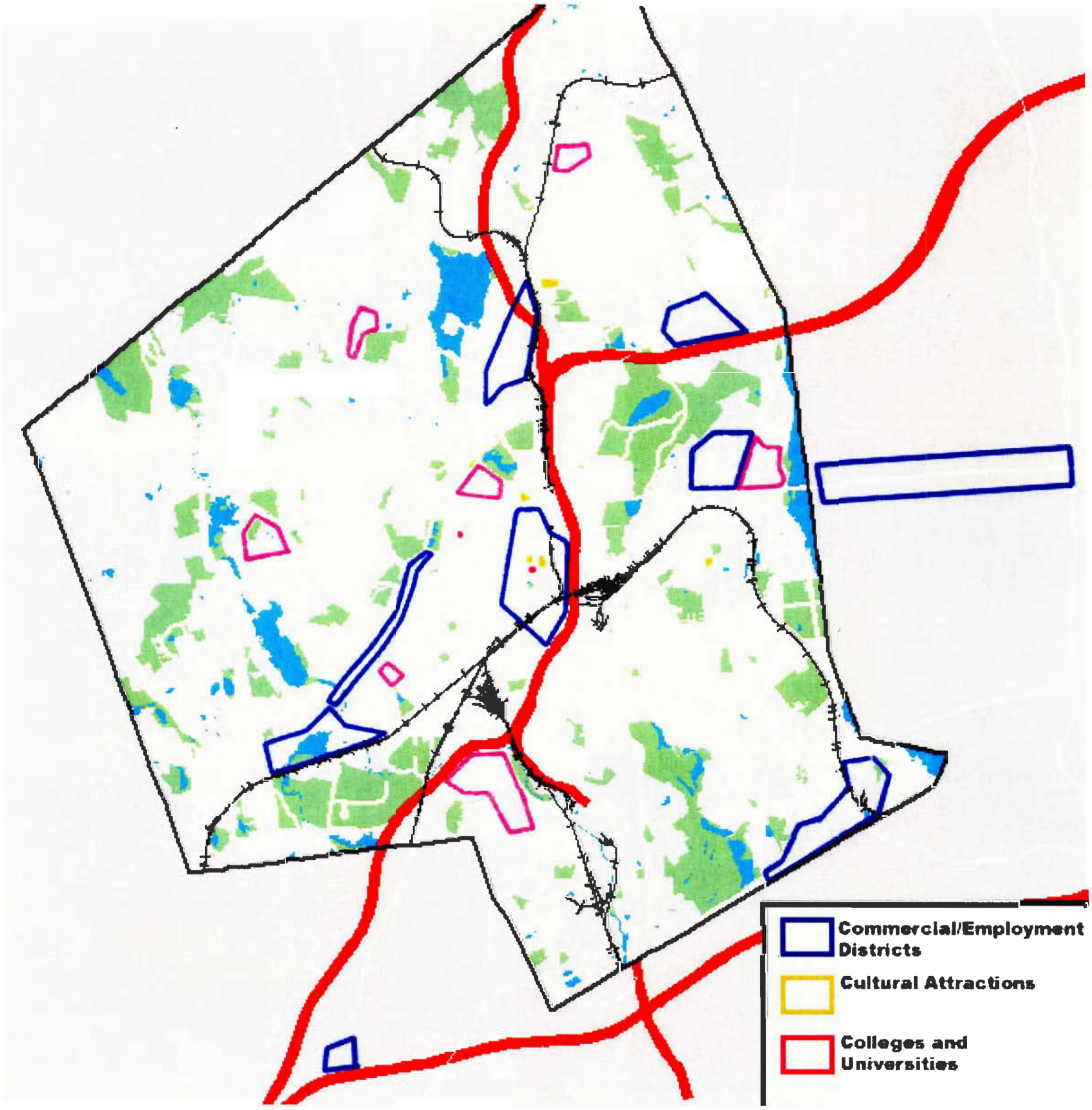

Figure 4: Attractions and Destinations in Worcester

Perhaps the most important of these districts is Worcester's Central Business District (CBD), more commonly known as its downtown. This area has seen its share of decline thanks to automobile-fueled sprawl, but is still quite healthy despite the many missteps which have been taken in past planning. It is currently the target of multiple redevelopment efforts, including the City Square redevelopment of its failed downtown mall, a new hotel and courthouse, and a redesign of a major intersection of routes by Union Station, its intercity transit hub. The city has sought to reinvigorate the downtown district through these projects and the positive impact transit could have on these efforts should not be ignored.

Beyond downtown several other employment centers exist in town, thanks both to its industrial heritage as well as modern sprawl development. These include the Park Avenue commercial strip, the Shrewsbury Street commercial and industrial corridor, the Worcester Biotechnology Park, the Lincoln Street commercial strip, the Gold Star Boulevard commercial strip, the Webster Square industrial/commercial area, the Route 20 commercial/industrial strip and just outside of Worcester the Shrewsbury Route 9 commercial strip. While other employment centers exist in and around Worcester, these are some of the most important and frequently visited for their services as well. Worcester also has two malls in close proximity to the city: the Greendale Mall in the northern part of town and the Auburn mall in Auburn just south of Worcester.

Worcester's cultural destinations are important draws for both residents of the city as well as tourists from outside the city. While some of these, such as Mechanics Hall and the DCU Center lie within Worcester's CBD, other are scattered elsewhere around town. The Worcester Art Museum and Tuckerman Hall are both located directly north of the CBD, but are far enough from Union Station that they can be a significant walk for those coming into town by train or bus. The Higgins Armory museum is located across a set of railroad tracks from the Greendale Mall, but is inaccessible from it because of the barrier these tracks create. The Worcester Ecotarium is rather distant from downtown in the eastern portion of the city and the American Antiquarian Society is located across Park Avenue from WPI.

One of Worcester's biggest strengths comes from its many colleges and universities about town. With 9 institutions located within the city limits, Worcester has a large college student population during the academic year. Many of these students come to town and do not bring cars, whether due to parking regulations or inability to afford one while pursuing their education. This makes colleges and universities prime targets for transit corridors because they are far more likely to utilize them than the general population. Worcester's colleges and universities are (in alphabetical order): Assumption College, Becker College, Clark University, College of the Holy Cross, Massachusetts College of Pharmacy and Health Sciences, Quinsigamond Community College, UMASS Medical School, Worcester State College, and the Worcester Polytechnic Institute. Although most of these schools serve only a few thousand students each, they still play an important role in Worcester's daily life and economic vitality.

Identification of Potential Corridors

Beyond the destinations a corridor must serve, it must also have adequate space to provide good service. In a built-up city like Worcester the best option for establishing a new transit corridor is to re-use existing rights of way to piece together a corridor which serves as many destinations as possible while simultaneously having as little of an impact on existing infrastructure as possible. This means that where road infrastructure is to be reused it must be on sufficiently wide roads to maintain vehicular circulation whenever possible in separate ROWs and to keep shared usage of lanes between private and public transportation to a minimum. Additionally if rail ROWs are to be utilized care should be taken to ensure that basic linkages of freight ROW are maintained where possible and a complete conversion of ROW to transit is only undertaken when the ROW is abandoned or extremely underutilized. With these caveats in mind, wide roads and abandoned/underutilized rail infrastructure throughout the city were identified and marked in Figure 5 below.

Figure 5: Possible ROWs Available for Reuse

Many of Worcester's densest areas are served by a relatively dense network of somewhat narrow streets (by modern design standards). While this does well to preserve its urban character, it makes finding room for a transit corridor somewhat difficult. Many of the areas in the city where streets have been widened and wide streets constructed from scratch have only tenuous linkages or are well outside the densest parts of town. Worcester Center Boulevard, Shrewsbury Street and Chandler Street are notable exceptions to this and the latter two provide important east-west links through the city. Park Avenue is an important north-south link through the city, but bypasses downtown to its west. Gold Star Boulevard has an extremely wide ROW but is a one-way road extremely unfriendly to pedestrian activity. Route 9, while a major east-west thoroughfare in the state, shrinks to an extremely narrow ROW shortly after its intersection with Shrewsbury Street and does not widen again until it reaches Park Avenue. With existing conditions it is not likely possible to piece together either an east-west or a north-south transit corridor from wide road ROWs alone without forcing a transit line to operate in mixed-traffic, thus hurting its service quality. It becomes important then to look to another source of ROWs, namely those of freight rail.

Perhaps the most promising prospects for re-use of freight rail ROW exist in the northern portions of town. Tracks coming out of a tunnel just north of Lincoln Square owned by the Providence and Worcester Railroad lead northward closely following I-290 much of the way (in fact the interstate was constructed on what used to be rail yards for these tracks). Along this ROW space exists for three and sometimes four or more sets of tracks, yet only one set of tracks is actively used along this stretch. The unutilized ROW could easily be converted for use as a transit corridor if the railroad would agree to sell the space for such a purpose. Beyond a junction just north of the Greendale Mall, a ROW exists for two sets of tracks which closely parallels West Boylston Street until a crossing at West Mountain Street. These tracks were formerly owned by the Springfield Terminal Railroad (which no longer exists) and are now owned by the Guilford Rail System, which makes infrequent use of one track of the ROW. This line continues northward through Clinton and eventually joins up with a more frequently used line in Ayer by the new town of Devens. Because of its relatively low usage this line (or at least the part of it running through Worcester) would be a prime candidate for acquisition and reuse for a transit corridor.

In the southern portions of town several branches of rail ROW exist which are in varying levels of use. Leading southwest from downtown are a set of tracks owned by CSX, which are in moderate to heavy usage by CSX for freight and Amtrak for intercity passenger service. Despite the amount of usage these tracks see, two sets of tracks are in active use, with a third set decaying and unused. The ROW for this third set of tracks extends down to where Cambridge Street passes over the tracks, and beyond this point the ROW narrows to only be wide enough for two sets of track at some points. At Southbridge Street tracks owned by the Providence and Worcester Railroad split off and head in two directions, with the Port of Worcester intermodal terminal between the two as they split. While the actual split from the main CSX lines is a rather complicated overpass structure, there is perhaps an opportunity to reconfigure this interchange to make room for a transit corridor without disturbing freight traffic. While the eastern of these branches is used for freight loading and unloading operations and may not prove suitable for reuse, the western branch mostly just passes by this facility (with connecting track to its south. Additionally this western branch has ROW for three sets of track, only one or two of which seem to be in active use. This track extends southward largely mirroring the path of Southbridge Street into Auburn. Along this portion of its ROW there is only one active track.

Corridor Alternatives

With some idea of both the existing ROWs open for reuse and the important destinations within the city, several possible candidates for transit corridors can be identified. The process involved in selecting these candidates involves linking together ROWs which pass close by as many identified destinations as possible while still forming a coherent and easily identifiable corridor. A few clear axes through town emerge: two with a north-south orientation and one with an east-west orientation.

Alternative 1: Tatnuck Square to Shrewsbury via Downtown

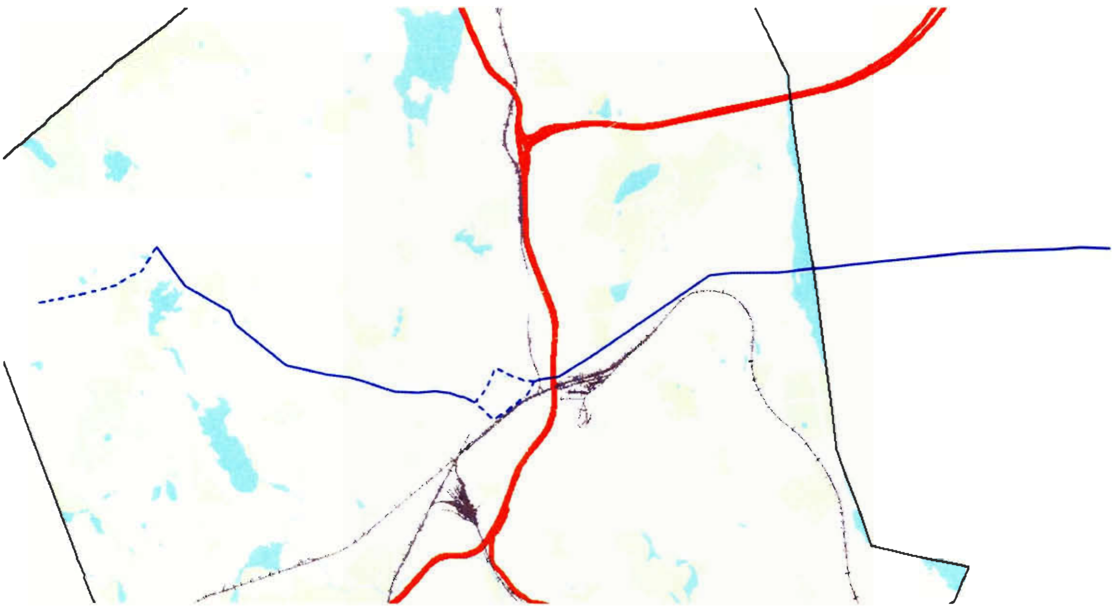

Figure 6: Transit Corridor Alternative 1

This corridor forms an east-west axis from Tatnuck Square on the far west end of town to the Shrewsbury commercial strip on Route 9. Because no rail ROWs exist along this route it would be entirely dependent on converting portions of wide road ROWs into a transit-only corridor, but would involve several areas where it would operate in mixed traffic.

Starting in the west the corridor would either begin at Tatnuck Square (the intersections of Chandler, Mill and Pleasant Streets) or at the Worcester Regional Airport should commercial use be restored. It also offers the possibility of a later extension to the airport if is reopened after the line goes into service. From Tatnuck Square the corridor continues east along Chandler Street, passing through several residential neighbourhoods and by several commercial shops as well as Worcester State College before reaching Park Avenue. This portion of the corridor would be street-running in mixed traffic, which is undesirable. Additionally this route is also designated as State Route 122 so state regulations may play into any rail-based transit implemented to run in mixed traffic along this route.

Beyond Park Avenue, Chandler Street becomes two lanes in each direction, providing adequate space for an exclusive ROW in the center while preserving traffic lanes on either side. This configuration persists from Park Avenue to Kelly Square, providing no further obstacles along this stretch of ROW. However, the linkage between the western and eastern portions of the corridor through downtown is slightly more difficult with the street geometries in this area. The corridor could alternatively turn onto Main Street and run north for a few blocks until turning onto Front Street and running through the new City Square development to Washington Square or run east to Frances McGrath Boulevard and travel north along it to reach Washington Square. With the latter option it should be noted that Chandler Street goes under Francis McGrath Boulevard with no intersection and a corridor would have to involve the construction of a new link between the two.

At Washington Square the corridor would provide an important link to Union Station, the city's intercity transit hub as well as possibly act as a catalyst to the planned redevelopment of that area. The corridor would then continue under I-290 and up Shrewsbury Street, which has an extremely wide ROW and could easily provide exclusive ROW in a median. Shrewsbury Street is also a large draw for night life because of its many restaurants and bars, and so it would benefit greatly from transit service to downtown and beyond.

At the eastern end of Shrewsbury Street the corridor would continue onto Belmont Street (Route 9) where it would pass by both the Massachusetts Biotech Research Park and the UMASS Medical School before continuing across Lake Quinsigamond into Shrewsbury. Here the road provides adequate ROW for an exclusive transit corridor, however Route 9 is a very busy state route and may be subject to state regulations on its use. Should the corridor be unable to run along the existing Route 9 bridge across the lake, a new bridge may have to be constructed alongside it or the bridge may require renovation to handle the exclusive ROW of the corridor. In Shrewsbury the corridor would, with the cooperation and support of the town government, run along Route 9 up to its interchange with Route 140, where a park & ride facility should be constructed. This facility would allow drivers who may have formerly used Route 9 to get into Worcester to make a modal shift and take advantage of the new transit corridor because of the decreased capacity on this portion of Route 9. Additionally this transit corridor would enable the town of Shrewsbury to remake the commercial strip along Route 9 into a more pedestrian friendly area if it wished to do so.

The main advantages of this alternative are its creation of a strong east-west link in the city, where current linkages are rather weak because of barriers such as I-290 and the various railroad overpasses throughout town, and its potential to reduce pollution along part by encouraging a modal shift in Shrewsbury. Beyond this, it would adequately serve downtown as well as the Shrewsbury Street district, while linking the Biotech Park and two institutions of higher learning with downtown and one another. It also provides the potential to link the struggling airport to downtown.

Disadvantages of this alternative come mainly from its utilization of street ROWs, which may prove to be unpopular with drivers and residents. The necessity of running in mixed-traffic is also a large detriment as transit services would be slowed by any private transportation traffic and prone to accidents with unobservant drivers. Its path through the west side of town passes through a largely suburban area, which may not possess adequate population densities to justify an improved transit corridor, even with feeder bus service. Another major issue lies in the cooperation of the local government of Shrewsbury. Should the city decide it does not wish to participate in such an undertaking, the corridor would be truncated on the Worcester side of Lake Quinsigamond where adequate space for a park & ride facility may not be present.

Alternative 2: South Worcester to Summit via Park Ave. and Gold Star Boulevard

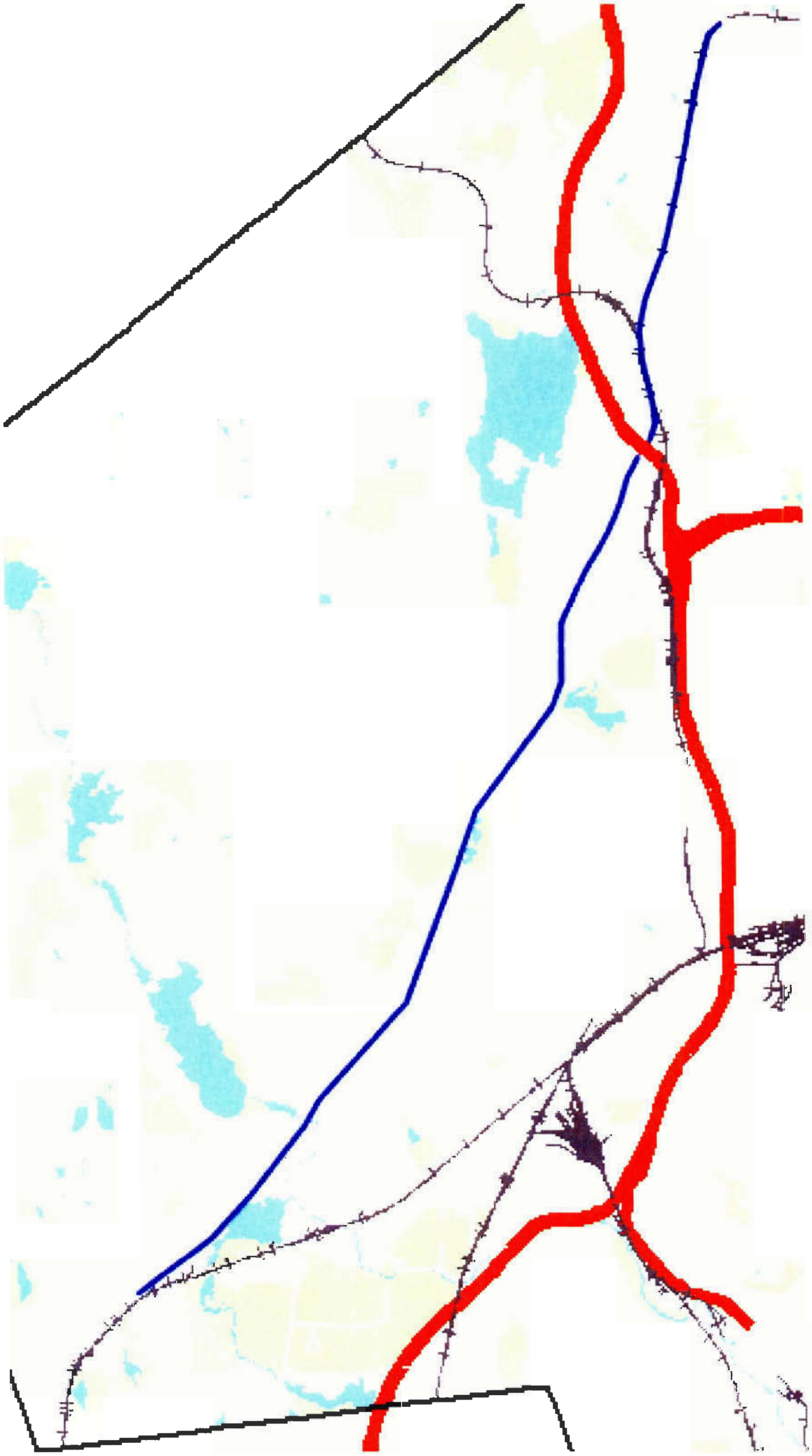

Figure 7: Transit Corridor Alternative 2

This alternative follows a north-south axis through Worcester largely already defined by major roads and State Route 12. It would make use of wide road ROWs and a small portion of acquired rail ROW in the north. From its southern end it would run along part of Stafford Street before following Park Avenue and then Gold Star Boulevard to the Greendale mall where it would shift to the rail ROW and continue to the Summit.

At its southern terminus just southwest of the Webster Square area there exist several large parking lots and parcels of unused land not far from the road where a terminal facility could be constructed. This area along with Webster Square is a large commercial shopping center for south Worcester which is located at the intersection of several important roads and is adjacent to several neighbourhoods as well as a few high-rise housing projects. From the terminus the corridor would travel north along Stafford Street and Park Avenue (which Stafford Street becomes after its intersection with Main Street). Park Avenue is a rather wide thoroughfare with a large concentration of businesses and thus would prove quite conducive to supporting a transit corridor.

Along Park Avenue the corridor would pass within close proximity of both Clark University and WPI, as well as historic Elm Park and Institute Park. Along this ROW Park Avenue is two lanes in each direction with on-street parking, providing plenty of space for a dedicated transit corridor. However, since it is designated as State Route 12 along its entire length, as well as being designed along some part of its length as State Route 122A and State Route 9, it may be subject to state regulations concerning the use of part of its ROW for transit.

At its intersection with Grove Street, Park Avenue ends and becomes Gold Star Boulevard (northbound) and West Boylston Street (southbound). At this point the transit corridor would continue along Gold Star Boulevard, the wider of the two, which is four lanes of one-way northbound traffic. Insertion of a transit corridor along this route may call for a reconfiguration of both Gold Star Boulevard and West Boylston Street to become two-way roads, rather than counter-flow one-ways. The addition of a transit corridor would, however, provide an opportunity to turn Gold Star Boulevard, known as an extremely pedestrian-unfriendly part of town, to be remade into a more lively business district akin to the narrower West Boylston Street. Although some difficulties may arise with the presence of highway on- and off-ramps on both the left and right sides of the road in the vicinity of the Greendale Mall, these are not impossible to overcome with some reconfiguration of the area. At Greendale Mall the transit corridor would cross the mall property on the southern end of its parking lots and begin to follow the abandoned rail ROW in this area. A transit station in this vicinity also could allow for pedestrian travel from the east side of the railroad tracks to the mall, breaking down a formidable barrier in this area. On the east side of the tracks is the Higgins Armory Museum, which would be well-served by transit.

While a short stretch of abandoned tracks in the Providence and Worcester Railroad ROW would need to be utilized to pass under the West Boylston Street overpass, the corridor would soon depart from these as it traveled along the Guilford rail ROW which would be completely acquired and converted. This ROW parallels West Boylston Street closely until the Summit (where West Boylston Street intersects with West and East Mountain Streets) before turning to the east and continuing on. The remaining path of the ROW would not be useful for a transit corridor, which would likely be truncated at the Summit. The possibility for a park & ride facility exists here if adequate space is available to deck over a parcel on the northwest side of the West Boylston Street-West Mountain Street intersection where the rail ROW passes underneath. This park & ride facility could capture traffic traveling into the city from the north along nearby I-190, which has an exit onto West Mountain Street. Along this rail ROW the transit corridor would pass close by Quinsigamond Community College and within close proximity to a number of dense residential neighbourhoods, as well as being moderately close to the Showcase North Cinema, which is a major attractor to this area for residents all over town.

The chief advantage of this alternative is its proximity to many businesses and residences. It follows a strong north-south axis and would provide a good transit linkage between the north and south ends of town. It would also allow for a rethinking of Gold Star Boulevard's configuration that could lead to it being a more pedestrian-friendly road. It would also link the Greendale Mall and to some extent the Showcase North Cinemas to the southern portions of Worcester which currently have extremely poor access to them for residents without cars.

Above all else the main disadvantage of this alternative is the fact that it does not pass through downtown. While it does make important linkages, it completely bypasses downtown by traveling along Park Avenue on the west side of town. If anything this might have the effect of further decentralizing development in Worcester. Beyond this, the corridor is mostly run in street ROWs, meaning it would encounter resistance from drivers who would not want to see lanes and capacity sacrificed to be exclusive to a transit corridor. The reconfiguration of highway ramps to and from Gold Star Boulevard necessary for this option could also prove to be quite costly.

Alternative 3: South Worcester/Auburn Mall to Summit via Railroad ROWs

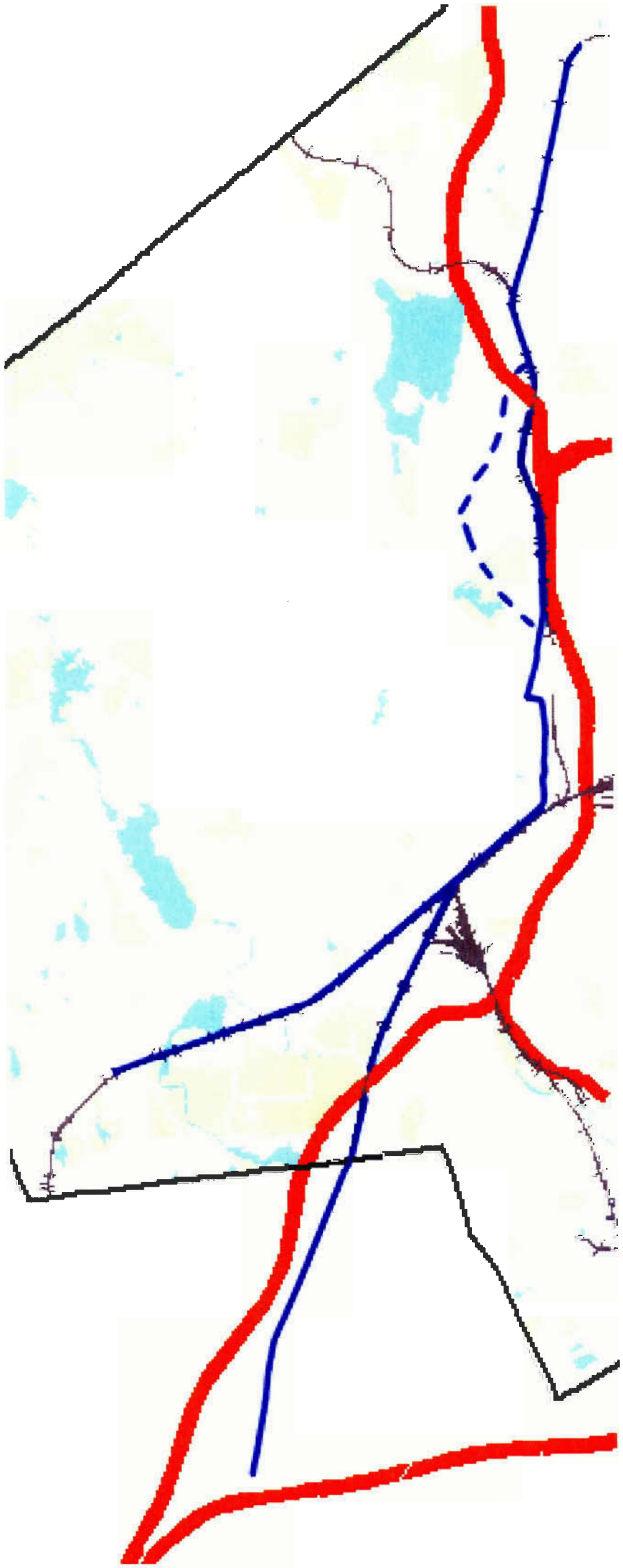

Figure 8: Transit Corridor Alternative 3

This alternative consists of the possibility of two possible branches on the southern portion of the corridor and follows a north-south axis through town like alternative 2. The corridor would largely reuse existing freight rail ROW with a few instances of street ROW reuse. From the Summit to Greendale Mall the corridor would follow an identical path to the corridor proposed in alternative 2, however beyond Greendale Mall it would follow the rail ROW instead of turning onto Gold Star Boulevard. The possibility exists to utilize the same Gold Star Boulevard ROW as alternative 2, turning onto Grove Street to meet back up with the corridor at Lincoln Square, however this would involve mixed-traffic running along Grove Street, which is not wide enough to support a separate transit corridor. Should the rail ROW option be utilized, the corridor would run along beside existing Providence and Worcester Railroad tracks in active service for freight from the Greendale Mall to the Gateway Park brownfields redevelopment site. This ROW has space for at least three sets of tracks, often times even more, while only one set of tracks is regularly used for freight. Adequate space is available for a dedicated transit corridor along this entire stretch without impacting freight operations by the Providence and Worcester Railroad.

At the Gateway Park brownfields site, currently in early stages of redevelopment by Gateway Park LLC, a partnership between WPI and various other organizations, the transit corridor has the potential to aid redevelopment efforts by providing a transit link to downtown and elsewhere. Although early plans are already in place for the use of this land, they could be reconfigured to act as a transit village around a possible transit stop in the vicinity. From Gateway Park the transit corridor could utilize what is currently a one-way underpass tunnel that links Concord Street to Main Street, bypassing Lincoln Square.

Because this tunnel is one-way, it typically sees very light traffic because it is not useful for return trips. The current plans for the Gateway Park redevelopment include closing off this tunnel completely, so utilizing it for a transit corridor would not significantly impact traffic conditions in the area beyond what will already occur.

On the southern end of this tunnel where the corridor emerges onto Main Street, it would take a turn east on School Street where it would travel one block over and turn south onto Worcester Center Boulevard, which is an extremely wide thoroughfare. Part of this road would be converted to a transit corridor, thereby narrowing what is currently a rather pedestrian-unfriendly street downtown. As the transit corridor would travel south along Worcester Center Boulevard it would pass a planned new hotel, the new Worcester County Courthouse (currently under construction) and the DCU Center, which provides a major draw for the area.

At the southern end of the DCU Center the transit corridor would make use of a tunnel which currently carries cars to a parking garage for the Worcester Common Outlets mall, which is scheduled to be demolished soon for redevelopment of the area. This redevelopment plan, known as "City Square" would turn the former mall site into a mixed-use urban village which would be an ideal location for a transit stop serving downtown. The corridor would travel in a newly constructed tunnel, which would have to be integrated into the project designs currently taking shape, and emerge on the southern end of the development onto Frances McGrath Boulevard.

On Frances McGrath Boulevard the corridor would reuse part of the existing ROW, thereby narrowing the street, and climb along the existing roadbed to an overpass over Madison Street. At this overpass the road is nearly level with the elevated railroad tracks of CSX and the Providence and Worcester Railroad, and the corridor could easily make a transition to this elevated structure. Here the rail bed is wide enough for several sets of tracks, although most are currently in active use. However, sufficient space exists between Frances McGrath Boulevard and the elevated rail structure to provide space for a transit corridor to run along at grade with the railroad ROW.

At the rail overpass of Southbridge Street, the tracks owned by the Providence and Worcester Railroad split from those owned by CSX in a complex multi-level set of overpasses, with CSX's rails on top, the Providence and Worcester Railroad's tracks under this, and Southbridge street below this. Although this massive structure is extremely old and complex, the possibility of reconfiguring it to accommodate branching of not only freight lines but also transit corridors exists. One possible branch of the transit corridor would follow CSX's ROW to south Worcester where the corridor would terminate, while another possible branch would follow the Providence and Worcester Railroad's ROW south to the Auburn Mall, where a park & ride facility could be constructed to entice drivers from I-290, I-90, Route 12 and possibly Route 20 to make a modal shift to transit. Both these ROWs are currently underutilized with space for two additional sets of track in most places. Only a small portion of the CSX tracks near the Cambridge Street underpass lack adequate room for only one additional set of tracks.

The south Worcester branch would pass within close proximity to Clark University as well as a redevelopment zone adjacent to the railroad ROW which would benefit from the addition of a transit stop for easy access to downtown and elsewhere. This branch would end near Webster Square in much the same location as the southern terminus for alternative 2.

The Auburn Mall branch provides an endpoint at a large mall, which would provide an important end-of-the-line draw to keep ridership on the southern end of the corridor high. A park and ride facility here would also greatly benefit commuters from the south and west, who could make an easy modal shift here. Along its route to the mall, the corridor would pass close by the College of the Holy Cross as well as Quinsigamond Village, both important fixtures in this portion of town. Several of the industrial businesses along and close by Southbridge Street may also benefit if workers have a convenient transit link in close proximity.

This alternative has many advantages, including its linkage of important cultural, employment and shopping destinations as well as its potential to be a catalyst for redevelopment. It provides some measure of flexibility with the opportunities for multiple branches in the southern portions and adequately serves downtown along its principle north-south axis. Much of the corridor closely parallels Main Street, which is an important business corridor throughout the city. Another large advantage is that it passes within easy walking distance of six of the city's colleges and universities, missing only the UMASS Medical School, Worcester State College and Assumption College. One easily-overlooked advantage of this alternative is its ability to knit together neighbourhoods split by the railroad tracks which run through town. These tracks currently present a formidable barrier, both physical and psychological, between areas on either side of them. Should a transit corridor be integrated into these tracks, it could serve as a unifying force for neighbourhoods on opposing sides.

The disadvantages of this alternative lie mostly in a few complicated bits of construction and reconfiguration which are needed to establish the corridor. Because it pieces together several bits of underutilized ROW, several re-alignments of existing freight rail would have to be made so that the corridor would not interface directly with the ROW and thus risk any sort of collision. One other disadvantage is that the use of the Providence and Worcester Railroad's ROW north of downtown would take the corridor along a slightly undesirable route surrounded mostly by industrial businesses and walled in on one side by I-290 much of the way. Despite this, the ROW still passes within proximity of several dense neighbourhoods, although the links between the ROW and these neighbourhoods are not currently very pedestrian friendly in parts.

Evaluation of Transit Corridor Alternatives

Although all three alternatives deserve serious consideration alternative 3 stands out as a plan which deserves immediate attention. Because of its reutilization of infrastructure slated for demolition in the next few years, as well as its ability to aid in redevelopment projects currently underway it is the most time-sensitive of the three. It also provides the best linkages between important destinations in the city at the least expense of road ROW, and so may see less resistance from drivers in and around the city. Alternative 2 does not adequately serve downtown, which should be a primary factor in current transit planning. Although alternative 1 does serve downtown, it involves the taking of a large amount of road ROW and may not find suitable public support until another corridor has proven itself.

While both alternatives 1 and 3 involve the support of neighbouring towns, alternative 3 involves the least impact to a neighbouring town and would not require a major reconfiguration of a roadway there. The flexibility of alternative 3 in providing two possibilities for a southern branch is also inviting, as it may be constructed in a phased approach with one branch preceding the other. Although the other lines may also be constructed in a phased manner, operation of a partial line may not provide adequate service while the later phases are being constructed. By operating in almost entirely exclusive ROW, alternative 3 would also likely offer the best service, being unencumbered by frequent interference with automobile traffic.

Conclusion

Automobile dependence is an inherently non-sustainable transportation paradigm that is currently the dominant form of American transportation. It has negative social, economic and environmental impacts which are largely overlooked, but should be immediately addressed before their effects wreak havoc with everyday life. Worcester suffers as acutely as many other small American cities, but has taken few steps to remedy the non-sustainability of its transportation infrastructure. The aggressive pursuit of establishing one or more transit corridors through the city can help the city achieve sustainability in the future before many of the negative repercussions of automobile dependence take hold. Worcester should examine the possibility of constructing a light rail line along the suggested corridor to not only enhance its resistance to a possible transportation energy crisis in the near future, but to strengthen its economy in the short-term. Many other American cities have recently begun to see the advantages of light rail transit and constructed transit lines, and Worcester should take notice of their achievements. Light rail has proven to be a popular and affordable alternative to traditional heavy rail systems and provides superior service to buses, which are currently the public transportation norm. The city has the potential to be a pioneer among small and medium cities by pursuing an investment in its future which will prove more than worth the cost, likely in the relatively near future.

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Appendix A: GIS Notes

ESRI's ArcMap was used in the creation of maps of Worcester along with data layers from MassGIS (http://www.mass.gov/mgis). The layers were used to create the base maps, which were then modified in Adobe Photoshop 7.0 (http://www.adobe.com) to create the overlays.

Appendix B: Automobile Ratio Methodology

Data from Boston.com's Community Profile section (http://www.boston.com/realestate/communities/profiles/) was used to compile statistics on automobile registration by city and town as well as population demographics. The data on the site was obtained from the US Census Bureau and the Massachusetts RMV. To obtain the ratios cited, the number of children under 18 was subtracted from the total population to get the number of eligible drivers. While this did leave out those teenage drivers between 16 and 18, it did not exclude the elderly who may not be able to drive. The number of registered vehicles was broken down by category, and so the numbers of heavy trucks, trailers and other were subtracted from the total, while the number of 'luxury' vehicles was added to the total (the site noted that these were left out of that statistic). The ratios were obtained by simply dividing the number of registered vehicles by the number of eligible drivers. Full results for Worcester and the 18 surrounding communities calculated can be found on the next page.

Town/City	# of residents	# over 18	# of registered vehicles	adjusted # of vehicles	R
Auburn	2,380	1784	2,618	2409	1.350336
Berlin	4,386	3338	3,520	3618	1.083883
Boylston	3,353	2383	3,459	3368	1.413345
Clinton	6,353	4399	5,701	5308	1.206638
Grafton	11,691	8819	10,480	9770	1.107835
Holden	7,257	5260	7,312	7013	1.33327
Leicester	8,250	5821	7,810	7374	1.266793
Millbury	15,901	12285	15,357	14497	1.180057
Oxford	4,008	3034	4,253	4087	1.347067
Paxton	13,435	10342	10,744	10738	1.03829
Princeton	14,894	11058	13,523	13123	1.186743
Rutland	15,621	11397	13,555	13588	1.192244
Shrewsbury	10,471	7752	8,888	8567	1.105134
Spencer	12,784	9835	11,494	10819	1.100051
Sterling	13,352	9872	12,178	11404	1.155186
Sutton	31,640	23529	27,188	27698	1.177186
Webster	16,415	12599	11,524	12697	1.007778
West Boylston	7,481	5883	3,213	3479	0.591365
Worcester	172,648	131921	35,801	35004	0.265341