Transit Usage and Urban Form:
Lessons for Transit Reliant Neighborhoods

By

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Submitted to the Department of Architecture
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Abstract

Cities are all about people and places. Travel occurs because people want to get to places – places of work, places of residence, places of shopping and so on. Hence, it is people and places that are more important, not transportation. Ideally, we want to minimize travel so we can spend more time socializing, at desired destinations, rather than on transit. However, the paradigm of city design seems to have shifted over the years – from people and places to automobiles. The cumulative effects of planning for efficient movement of the car and enhanced automobility have revealed themselves in the form of urban sprawl, energy depletion, air and noise pollution, climate change, road fatalities, and segregation of people by class and race.

For the sake of social equity and sustainability, it is thus important to increase reliance on transit services. However, merely infusing transit services into an auto-based environment is not likely to reap many rewards or radically change behavior. The fact that availability of subsidized transit services (in almost all regions of the US) has not lured the middle class out of their cars indicates a loophole in the present understanding of its usability.

Many argue that one can only lessen the use of car by demand-management strategies, such as constraints on parking, increase in automobile and gasoline prices, and guaranteed rides home for car-poolers. Does this imply that in the absence of punitive pricing on automobile usage, the transit services are doomed to fail? This Thesis argues that transit ridership depends more on the way transit service relates to its location – and if we want to enhance transit usage, the 'transit service'-'urban form' nexus matters. Based on this premise, the thesis explores how urban form influences transit usage and how development should be directed in order to increase reliance on mass transit.

Thesis Advisor: Julian Beinart
Title: Professor of Architecture

"…….Imagine something like modern Venice, a Venice without water, a Venice of the beginning of 21st century. Imagine a city which provides an accessibility and permeability similar to the ones provided for by the car in traditional cities – but without all the negative ecological effects of private automobile, without all its socially discriminating repercussions. My-City leaves the car-dominated age behind. It uses latest technology, and latest design. It is unique – but since its success is not based on a unique geographical situation it needn't be, other cities can adopt what creative and courageous My-City has come up with".

Dietrich Garbrecht

Tolley, R. S. (Ed.), *Reclaiming the City: Planning for Walkers and Cyclists in Urban Transportation,* Belhaven Press, 1990.

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Julian Beinart, my advisor, for demonstrating through his teaching the significance of theory in urban development, inspiring me to pursue the relationship between urban form and transportation. Without his support, there would have been no true philosophy behind this thesis. Antonio Di Mambro, an insightful practitioner and a sensitive designer, for providing pragmatism in my design inquiry. Roy Strickland, for his constructive criticism and his valued support. John de Monchaux for facilitating the opportunity to work at Wallace Floyd Design Group, where I acquired most of the data used in this research.

Work of this scope would not have been possible without the support of various individuals and agencies. I owe gratitude to several friends and colleagues whose related interests helped me immensely in accessing data and constructive information - Skip Smallridge of Wallace Floyd Design Group for providing contact information, and Michael Grey for sharing MASSGIS data. Peter McDonald of the Boston Redevelopment Authority for clarifying data processing and Iram Farooq from the City of Cambridge for exposing me to the wider development issues of East Cambridge. Joshua Switzky, a colleague and a team member at MIT, for his suggestions and exchanging his valuable experience in GIS software.

My close friends and family for their unwavering support.

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Chapter 1: Case for Mass Transit

1.1 Introduction

At no time in history have finite resources, natural landscapes, and the social and economic well-being of our cities, perhaps been more greatly threatened than they are today. Part of the reason inescapably lies in our growing dependence on the private automobile. The car culture has been blamed for a long list of local and global problems – faceless sprawl,[1] premature deaths from accidents,[2] air pollution,[3] the uprooting of inner-city neighborhoods, social isolation and class segregation,[4] depletion of fossil fuels, climate change, noise pollution, and exploitation of third world economies.[5]

Many claim that the growing reliance on car travel is largely a product of rising prosperity and free choice. One might add, however, that government policies and inaction, such as subsidies for large-lot living and under-priced car travel, have considerably promoted this auto-dependent lifestyle. It is argued that motor-vehicle use provides enormous social benefits and probably exceeds the social cost.[6] This is undoubtedly true for some, but for those who cannot afford cars and those who choose not to own one, the social costs of an auto-oriented world could very well exceed its purported benefits. This is an area where disparities are likely to abound. Moreover, it is unclear whether auto-dependence will be sustainable in the long run, and whether it may even be wise to allow it to continue in the long run. "Sustainable" here implies the stewardship of natural and human resources so that the health and quality of living in our cities and countrysides, does not drastically deteriorate from one generation to another. By continuing along the trend of increasing automobile dependence, we are taking risks, the negative effects of which will be borne by future generations.

We might one day be able to re-engineer the car to emit non-toxic emissions and run on renewable energy, introduce smart technologies so that motorists can overcome traffic congestion, and make cars affordable for all. However, there is no technology that can relieve the social injustices inherent in sprawl, energy depletion, air and noise pollution, road fatalities, or the immobility imposed on those too young, old, or disabled to drive, and the hours spent chauffeuring kids around, and so on.

[1] A serious threat posed by rapid motorization is the loss of arable land. Cars and freeways are notorious land consumers, pushing the envelope of urban development outward and in the process threatening productive farmland, natural habitats, wetlands, and open space. Not only does a typical fast moving four-seat sedan take up the amount of road space occupied by forty-passenger bus, but each car requires up to 25 square meters (including aisles and driveways) to park in an urban setting (Cervero, Robert, *Transit Villages in the 21st Century*, New York: Island Press, 1995).

[2] The WHO places the number of people dying in motor vehicle accidents worldwide at near 1 million annually. (WHO. *The World Health report: Bridging the Gaps*, Geneva: WHO, 1995).

[3] In the United States, about two-thirds of carbon monoxide emis sions come from tailpipes of cars and trucks. At extreme levels, smog can impair visibility, damage crops, dirty buildings, and, most troubling, threaten human health. Smog has been linked to asthma attacks, eye irritations, and upper and lower respiratory problems (Cervero, Robert, *Transit Metropolis a Global Inquiry,* Washington: McGraw-Hill, 1998).

[4] Among the most troubling concerns about a car-dependent society are the social injustices that result from physically and socially isolating significant segments of society. Those who are poor, disabled, young, or old to own or drive a car are effectively shut out of many of society's offerings. For the elderly and physically disabled, isolation can mean loneliness, depression, and inattention to health-care needs. For many working moms, isolation all too often means thousands of extra hours spent escorting kids and family member to and from out-of-the-way places. And for far too many of inner-city poor, isolation means an inability to reach or even find out about job opportunities, what has been called the "spatial mismatch" problem.

[5] As countries modernize and industrialize, increased consumerism and motorization sharply increase the demand for energy. Finite supplies of fossil fuels, however, pose serious threats to sustained economic growth and even world peace. Because of the heavy reliance of major world powers on imported oil, especially from the Middle East, major interruptions in supplies can not only throw the global economy into a tailspin but, as experiences have shown, can also spark political tensions and military confrontations (Cervero, Robert, *Transit Metropolis a Global Inquiry* (Washington: McGraw-Hill, 1998).

[6] Murphy and M. DeLucchi, A Review of the Literature on the Social cost of Motor Vehicle Use in the United States, *Journal of Transportation and Statistics*, Vol. 1, 1998, pp. 16-42.

All of this does not suggest that we abandon automobiles. After all, the automobile has been a 'vehicle,' both figuratively and literally, a means to an end. However, it is imperative now than ever before to realize the need for alternative modes of transport that ensures the safe and efficient movement of people, in a sustainable and environment-friendly way, and in honor to neighborhoods and places.

1.2 Transit – An Essential Public Service and a Distressed Industry

Promoting transit[7] is one of the solutions for reversing the present course of auto-dependency. Reliance on transit services can contain traffic congestion, reduce pollution, conserve energy, and promote social equity. Fully loaded buses and trains emit less pollutant per passenger than do automobiles with one or two occupants. The American Public Transit Association (APTA) claims that on a per-passenger-kilometer basis (using national average for vehicle occupancy), for a typical work trip, riding mass transit instead of driving reduces emissions substantially[8] and also decreases per capita fuel consumption. The physical damage to the environment would be far less if busways and railways were favored over six-lane freeways. Moreover, mass transit, when planned with regional growth, can decrease the mobility gap[9] imposed by private automobiles, and provide people with increased choices in the places they live and work, and their modes of travel.

However, merely infusing transit services into an auto-based environment is not likely to reap many benefits or alter behavior radically. Across the world, mass transit is struggling to compete with the private automobile. In the US, only 1.8 percent of all trips in 1995 were by transit, down from 2.4 percent in 1977 and 2.2 percent in 1983.[10] Despite the tens of billions of dollars invested in new rail systems and the underwriting of more than 75 percent of operating expenses, ridership figures for transit's bread-and-butter market – the work trip – remain flat.[11] The fact that availability of subsidized transit services (in almost all regions of the US) has not lured the middle class out of their cars raises serious questions – "why do people opt not to use mass transit," and "how can we increase transit ridership?"

Many argue that reliance on transit can only be attained by decreasing the use of cars through demand-management strategies, such as constraints on parking, increase in automobile and gasoline cost, and so on.[12] So far, only a few places (Singapore and Norway) have been able to enforce cursory forms of road pricing. In case of the US, road pricing remains a dream in the minds of many.[13] Even if we were to actually implement pricing for automobile use, critics argue

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[7]The term "transit" is used to describe the collective forms of passenger-carrying transportation services that are available to public at large, whether publicly or privately deployed – ranging from vans serving multiple origins and destinations over non-fixed routes to heavy rail trains operating point to point over fixed routes.

[8] American Public Transit Association, *op. Cit.*

[9] In large cities (in the US) with poor public transit connections, low-income households spend as much as a quarter of their earnings on transportation, and those living on the fringe often spend more than three to four hours a day getting to and from work.

[10] Urban Mobility corporation, The 1995 Nationwide Personal Transportation survey, *Innovation Briefs*, vol. 8, no. 7, p. 1, 1997; A. Pisarski, *Travel Behavior Issues in the 90's,* Washington, DC: Federal Highway Administration. US Department of Transportation, 1992.

[11] Cervero, Robert, *Transit Metropolis a Global Inquiry,* Washington: McGraw-Hill, 1998.

[12] Economists often argue that proper pricing – such as congestion fees, carbon taxes, and parking surcharges – would eliminate the need for heavy-handed controls over car use and public interventions into private land markets. With substantially higher motoring fees, people would, in time, move closer to jobs and transit stops to economize on travel. Employers would, locate as close as possible to labor pools to lower their workers' travel expenses (and thus their salaries as well). Retailers would be warmly welcomed into residential neighborhoods by those wanting to reduce the cost of driving to shops. In the United States, few politicians are willing to champion the cause of congestion pricing in fear of reprisal from their constituents.

[13] "This vision is now so strongly entrenched that it has become almost political suicide for elected officials to challenge any of these elements. The very fact that residents of democratic US continue to elect politicians who perpetuate past practice of road building and auto-oriented development suggest that "pricing" automobile and gasoline consumption is almost impossible" (Downs, A, *New Visions of Metropolitan America*, Washington DC: The Brooking Institution and Lincoln Institute of Land Policy, 1994).

that 'pricing to drive' (in this auto-centric society) is an elitist policy, pushing the poor off roads so that the wealthy can move about unencumbered.

Others argue that despite considerable acceleration of capital support for mass transit in the US[14] over the past decade, current government funding in this sector is still less when compared to the economic incentives provided for driving.[15] Only by increasing the funding for transit services will we be able to improve the quality of station design and, upgrade and expand the level of transit services in order to make this industry more attractive for people to use.

Another argument pertaining to the unpopularity of mass transit today is the pattern of regional development. Spread-out development has proven to be especially troubling for mass transit. With trip origins and destinations spread all over the map, mass transit is often no match for the private automobile and its flexible, door-to-door, no-transfer features (Figure 1.1a). Only by clustering developments at nodes along the mass transit corridors, like pearls on a necklace, can the growth pattern be made efficient for transit usage from a mobility standpoint (Figure 1.1b).

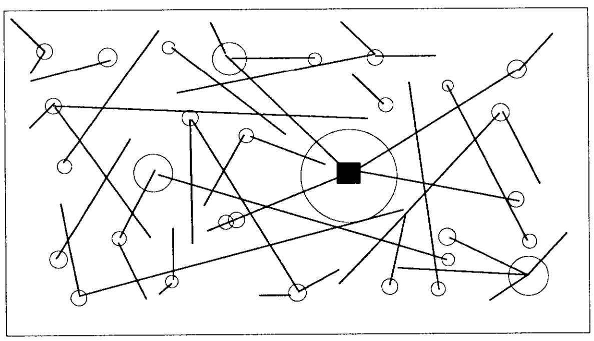

Figure 1.1a: Random pattern of mobility

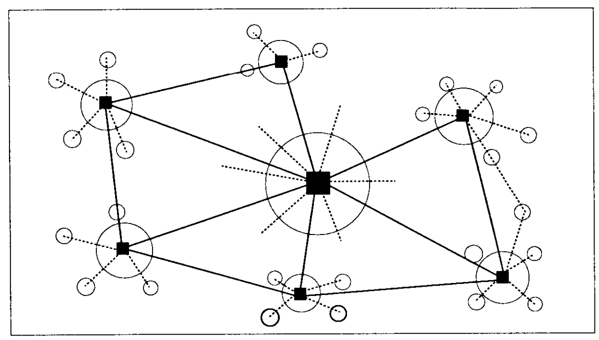

Figure 1.1b: Clustered development patterns

The fact that we, especially in the US, except in few places, have not been able to implement the preceding arguments successfully, despite their validity, raises concern from the practical standpoint. Hence the question: in the absence of true market-based pricing for automobile usage, the lack of public funding, and the inability to tame pro-transit regional growth, are transit services destined to fail?

1.3 Transit Service – Urban Form Nexus

This thesis postulates that it is important to recognize that the challenge of building successful transit reliant growth at the regional scale goes well beyond demand management strategies, increasing capital funding for mass transit, and physical planning, to forming nodes of development. In particular, considerable attention has to be given to the design of neighborhoods and communities themselves. Neighborhood level urban design is the local prerogative; its impacts on travel are felt regionally. When people decide where to live and how to travel, they generally make rational personal choices, weighing the pros and cons of available alternatives, and doing what is best for them. If traffic is the result of "derived demand" – derived directly from how urban activities are organized on land – then transit usage should depend on urban form.

[14] Most money, however, has gone toward modernization of aging equipment as opposed to system upgradation. America's older subway and commuter rail services, such as those in New York, Philadelphia, and Boston, have been substantially upgraded through modernization and rehabilitation of tracks, tunnels, and signaling systems (Cervero, Robert, *Transit Metropolis a Global Inquiry, Washington*: McGraw-Hill, 1998).

[15] The incentives to drive go well beyond cheap gasoline and free parking. Total subsidies to US motorists have been placed at between \$300 billion and more than \$2400 billion annually. American motorists pay only 60 percent of the costs of road construction, maintenance, administration, and law enforcement through taxes and user charges – resulting in an annual subsidy to motorists of some \$350 billion in 1993 currency (Cervero, Robert, *Transit Metropolis a Global Inquiry, Washington*: McGraw-Hill, 1998).

Residential densities, site designs, the degree of mix in land use, and the location of housing with reference to destination centers, together set the stage for travel behavior, and affect the volume and length of trips and the choice of travel modes and routes. In other words, if we want to increase transit usage, then urban form matters.
Here, the term "urban form" is used broadly, intending to convey more than the mere pattern of regional development. It refers to the local built environment at the neighborhood scale, its size and density, the degree to which land uses are segregated or combined, the design of streets and other public spaces, tenant mixes, and the employment-housing balance. "Transit usage" implies the percentile of population of a given area using mass transit as its major mode of travel.

1.4 Methodology

Given the premise of the thesis that transit usage closely depends on the "fit" between transit services and urban form, it becomes important to question whether the design of urban form actually influences transit ridership. If it does, what are the typical features of urban form that encourage higher transit usage? In other words, how should the developments be directed so that more people are attracted to use mass transit?

Based on these sets of inquiry, the thesis is organized in three chapters. Chapter 2 comprises a study of the physical characteristics of neighborhoods around selective transit stops based on their degrees of usage. The intention of this investigation is to explore the correlation between typical features of urban form prevalent in the neighborhoods and higher transit ridership. If a strong correlation does exist, it reveals how transit usage is dependent on urban form.

In light of these findings, Chapter 3 explores how developments should be orchestrated to attract a higher percentage of transit users. Through the process of design inquiry, this segment investigates a framework for a "transit reliant neighborhood." This term does not imply a "car-less" environment, but rather a built environment where people prize the mobility conferred by mass transit and the freedom of movement without having to necessarily travel by private automobiles.

Finally, Chapter 4 briefly summarizes the conclusions drawn from this study in the form of development motives on which transit reliant neighborhoods should be intrinsically based.

1.5 Scope and Limitations

This thesis does not try to establish a new paradigm for neighborhood design. Nor does it advocate for restricting people's mobility only to transit services. Rather, it seeks to develop an alternative design where mobility choices provide greater flexibility to the people to make decisions regarding their place of work and residence without having to rely on private automobiles. Since it is not possible to translate all the variables of a built environment into 'numbers', this study is a qualitative evaluation of the urban form that is best suited for a successful mass transit system. This success is measured in terms of people's degree of reliance on transit services as their primary mode of travel, which in turn, dictates the success of the transit service itself.

The main premise of this thesis is that transit reliant neighborhoods are a prerequisite for increasing transit ridership that, in turn, benefits society, both economically and environmentally. The case studies carried out are in the Boston Metropolitan Area. Conclusions drawn from these cases have been used to make some broad-based generalizations regarding the ideal development of transit reliant neighborhoods within the region. However, it must be borne in mind that ultimately, for the success of any transit service, the context (topography, climate etc) plays a vital role, and the solution for Greater Boston may not be applicable to another city. The idea here is not to provide a quick-fix solution or formula to successful mass transit services, but rather to discuss the various ingredients of the design process that affect transit reliance at the neighborhood level. The negative implications of transit reliant developments, such as the likelihood of gentrification and its impact on the poorer sections of society, have not been discussed in detail. This is not to imply that these issues are unimportant. Given the time frame of this study, it was not possible to analyze these issues at length.

Chapter 2: Visting Subway Neighborhoods

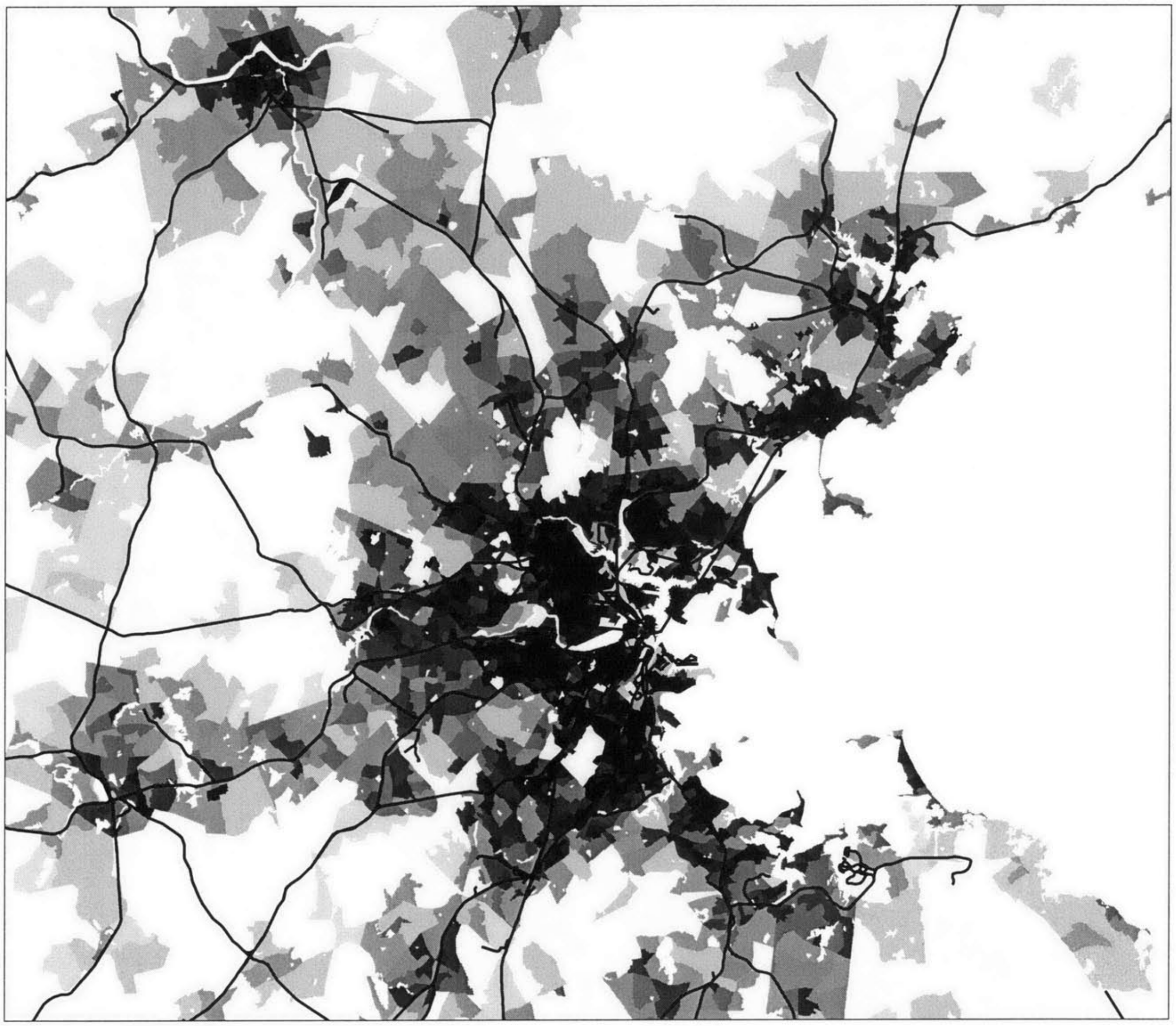

Figure 2.1: Population density along transit lines in the Boston Metropolitan Area, 1990

This section will examine the physical characteristics of selected neighborhoods with transit services. The primary objective of this study is to reinforce the premise that 'urban form' matters in leveraging greater transit usage. The second objective is to understand physical attributes of neighborhood design that are transit supportive.

The study focuses on the Boston Metropolitan Area because its development pattern has to a great extent occurred hand in hand with the MBTA[1] services (Figure 2.1). In other words, transit services in the region have served as an alternate mode of transport between the extremes of a strong central business district and other suburban centers. Therefore, the study assumes that people living around transit stops will rely largely on transit service as their means of transport as long as it serves the travel destinations.

[1] Massachusetts Bay Transportation Authority – or "the T", as we call it – is America's oldest and one of the biggest public transit system: It provides services to 78 member cities in Massachusetts (Fig.1), which has coverage of 1,038 square miles and 2,608,638 people. To carry out its mission MBTA maintains 155 bus routes, 3 rapid transit lines, 5 streetcar (Central Subway/Green Line) routes, 4 trackless trolley lines, 13 commuter rail routes and 5 commuter boat routes.

This assumption, however, might be less appropriate in the case of the many suburban developments that are located away from the Regional Center. Due to the polycentric growth pattern of the region, there is a greater possibility that the travel destinations in such areas might be more localized, dispersed and random, preventing people from utilizing the main transit service aimed at bringing people towards the regional center.

Bearing this in mind, the case-study sites have been selected from within the Central Boston Area (Figure 2.2). Here, the prospect of travel towards the Center from the adjoining neighborhoods is greater (for those people whose travel destination is the center and not the many work locations outside the center) as they are well integrated with the rapid transit services. This limited study within Central Boston Area will only review the neighborhoods that are served by the MBTA Rapid Transit Lines, better known as the Subway.

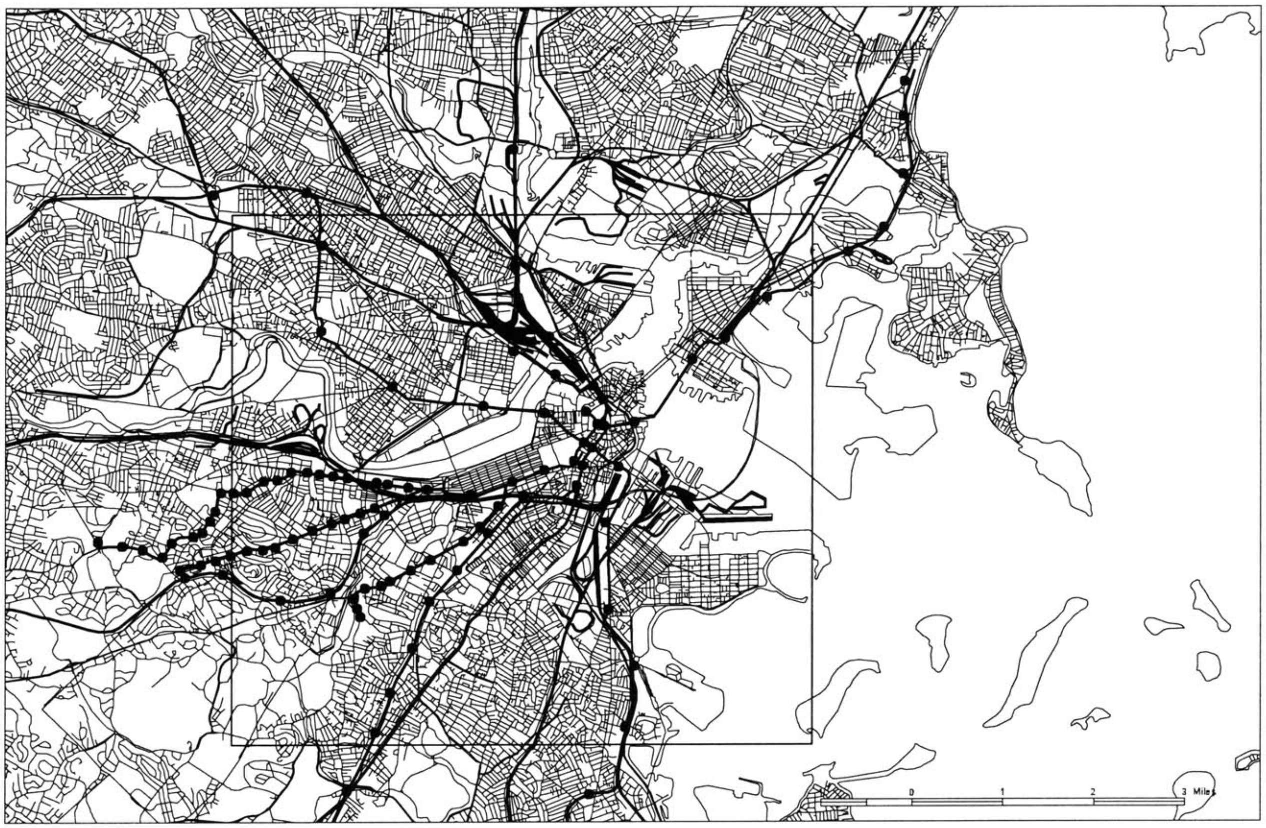

Figure 2.2: Central Boston Area

People using subways may also rely on feeder transit services such as buses to access the subway stops. Therefore, gauging ridership of subway across neighborhoods could be polemical if the study inadvertently combines disparate levels of feeder services. For clarity, the area of analysis for each neighborhood has been limited to *quarter of a mile* (a five-minute walk, referred to as walking distance[2]) radius around subway stops. Such neighborhoods in this study are termed as *subway neighborhoods*. This will allow the research to be independent of feeder transit services, which, in theory, bring people from various locations beyond walking distance to subway stops. Additionally, by focussing on a quarter mile radius and excluding feeder transit from the ridership figures, the study safely assumes that the population living within subway neighborhoods

[2] According to the 1990 National Personal Transportation Survey, the average person walks about 1,500 feet or quarter mile to a transit stop. The number of people willing to walk longer distances to those distances drops off significantly when distances exceed 1,500 feet, and that is probably when others means of transports like cycle, car and bus gain more importance.

will most likely walk (due to the short distance) to reach the subway stop. Based on this assumption, this study analyzes how the urban form of subway neighborhoods impacts commuters who walk to use transit services.
In order to understand the relation between transit ridership and urban form, the study will select various subway neighborhoods with contrasting levels of transit usage. Looking across the MBTA subway corridors (Red, Blue, Orange and Green Lines), the 1990 U.S. Census data reveals that the percentage of people using transit[3] (for home-based work) in various subway neighborhoods differs arbitrarily (Figure2. 3). However, there are other factors, beside the urban form that affect the commuter's decision to use transit.

Conventional wisdom holds household income as a significant factor that guides people's decisions to use transit services or private transport to work. Similarly, availability of jobs within the neighborhoods reduces the need for using transit services by allowing people to walk/bike to work. The level of transit service (speed and frequency of service, areas accessed by the line, etc.) by itself influences the decision of people using it. Therefore, to compare the urban forms of subway neighborhoods with differing levels of transit usage, the study must select neighborhoods with a similar level of transit service, proportion of people walking/biking to jobs, and median household income.

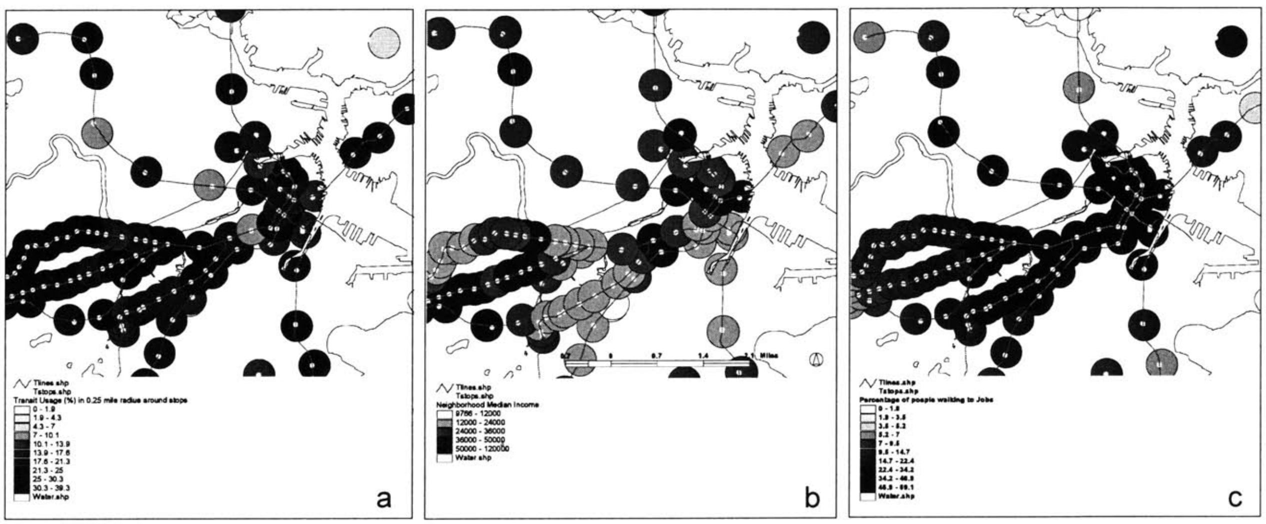

Figure 2.3: a. Percentage of transit usage; b. Median Income; and c. Percentage of people walking to jobs within quarter mile radius

In order to control the level of transit service, only subway neighborhoods along the same line are considered. The study of the Orange Line revealed no subway neighborhoods within Central Boston Area with the attributes mentioned above. (For details, refer to Appendix A.) Therefore, the following neighborhoodson the Red, Blue and Green Lines have been selected for a comparison of their respective urban forms (Figure 2.4a,b):

Subway Line	**Subway Neighborhood**	**Subway Use (%)**
Red	Davis Square	32.6
	Alewife	16.4
Blue	Maverick	39.3
	Airport	28.9
Green	Hynes	26.5
	Science Park	13.2

[3] Home-based work trips is taken in account for reflecting transit usage because maximum number of trips in average per week is made for commuting from home to work and vice versa. The figure for transit usage is represented in percentage because the number of people living in different neighborhoods varies. The percentage of transit usage is the even proportion of people using rapid transit services (not buses) for home based-work out of total population in each ¼ mile radius cluster. This data (Percentage of Transit Usage) is projected from data retrieved from US Census 1990 through Geographic Information System.

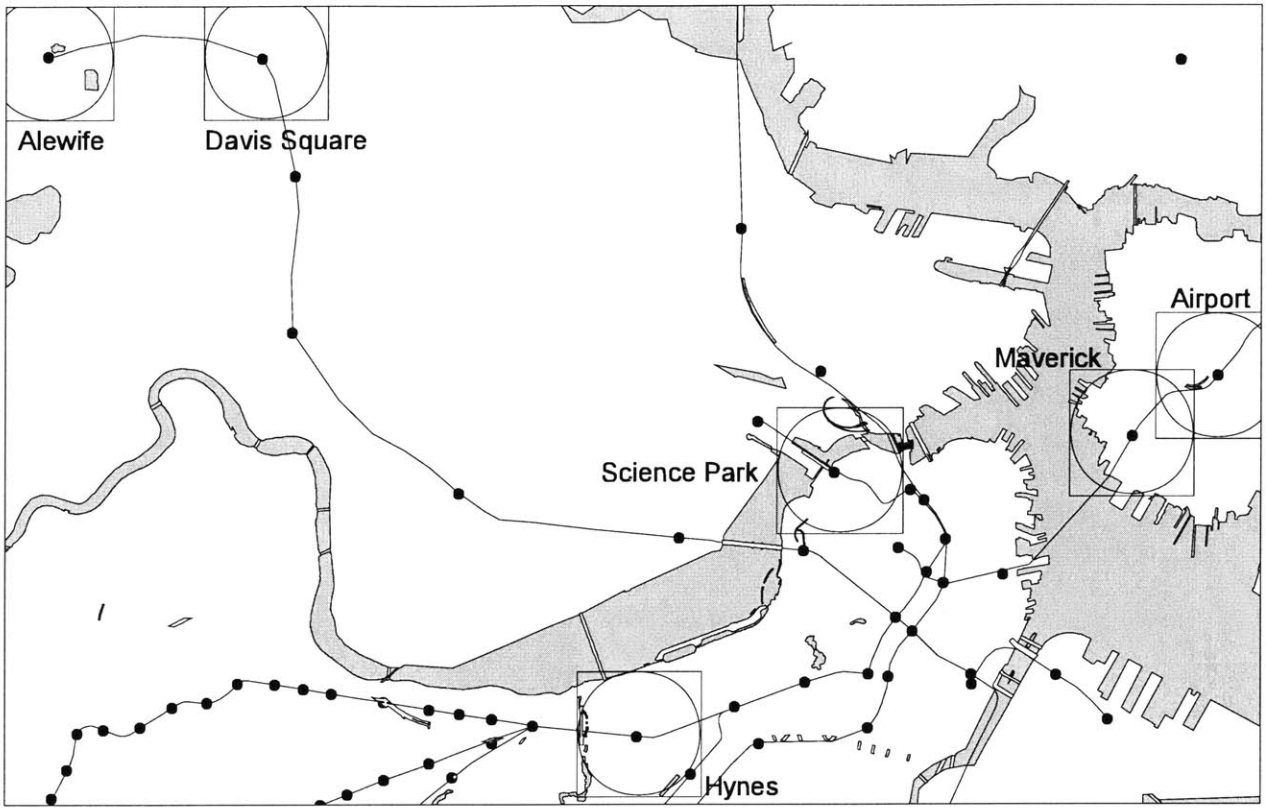

Figure 2.4a: Location of Case Study Sites in Central Boston Area

Having selected two subway neighborhoods with contrasting transit usage (under each Line), the following section takes a closer look at their urban forms in order to identify their distinguishing characteristics. The area of this study is limited to the 'walking distance' around the stations (0.25 square mile). Based on the assumption that people living in these areas are most likely to walk to reach the subway, pedestrian comfort is taken as the primary criterion to evaluate the urban form of each of these neighborhoods. In order to avoid repetitions while comparing the various attributes of urban form, the neighborhoods, although under different subway lines, are grouped according to their relative transit usage. The first group comprises Davis Square, Hynes and Maverick, while the second includes Alewife, Science Park and Airport.

Figure 2.4b: Location of subway stops in neighbourhoods

2.1 Street Pattern

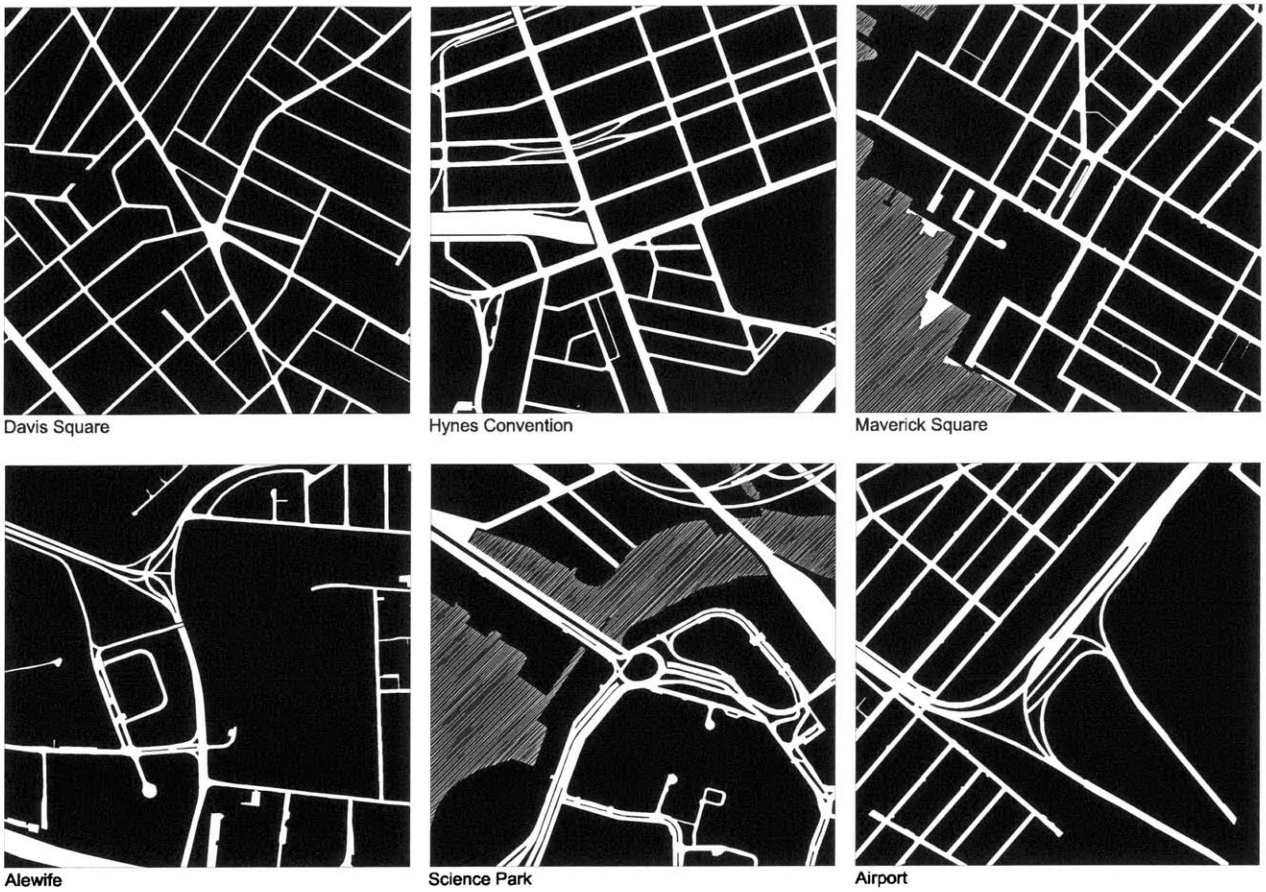

Figure 2.5: Street patterns of subway neighbourhoods

The pattern of streets in a neighborhood is a vital component of its urban form. Besides dictating the size of the neighborhood blocks, it also defines the circulation for the various modes of transport. The streets around Davis Square, Hynes and Maverick are organized in a relatively formal manner. These neighborhoods with higher transit usage offer a strong precedent for a regularized grid pattern for street layouts. In the case of Davis Square and Maverick, most of the feeder streets intersect the primary streets, which then prominently converge towards the subway station. A high level of interconnectivity of different streets allows commuters to choose a more direct route to the station and other destinations. This combination of street systems creates diverse and flexible route options for pedestrians.

In contrast, Alewife and Science Park have a highly irregular street pattern. Except for small areas around Airport station, a coarse-grained network of streets in these neighborhoods impedes pedestrian movement. The unconnected street system with cul-de-sacs and dead ends restricts through traffic, while also forcing commuters to walk long distances to reach a nearby transit stop. A circuitous street pattern with few routing options discourages commuters to walk/bike to the subway station, especially during bad weather - often forcing them to travel by car.

	High Transit Use			Low Transit Use		
	Davis Square	Hyne	Maverick	Alewife	Science Park	Airport
No. of intersections in 0.25 sqaure mile	78	68	55	19	17	31

2.2 Roads network and Parking

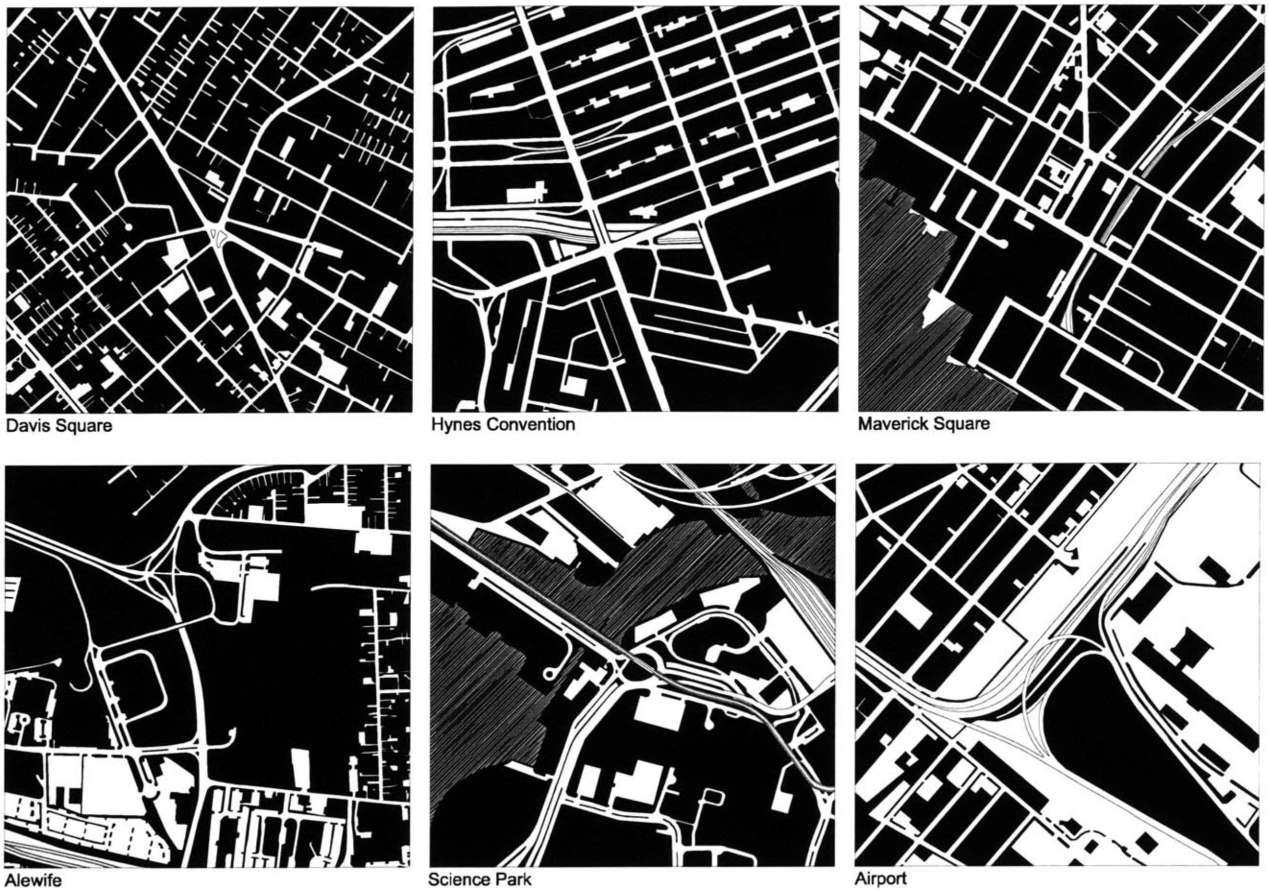

Figure 2.6: Vehicular spaces in subway neighbourhoods

Automobiles have become an important mode of transport, and to safeguard their smooth circulation, considerable amount of space within neighborhoods is delineated for roads and parking. This is often done at the cost of pedestrians. This highlights the need for a sensitive vehicular network that safeguards the interests of pedestrians. The grid pattern of roads in Davis Square, Hynes and Maverick provides auto drivers with numerous routing options. This has had the effect of dispersing and reducing the volume of cars on any one street in the network at any given time. The regular intersections also serve to calm traffic speed, rendering the pedestrian environment safer and more attractive. The parking facilities in these neighborhoods are relatively few. Apart from a few parking garages, most of the parking requirement is absorbed either by curbside or rear-lot parking. While curbside parking protects pedestrians from road traffic, rear lot parking hides these inactive spaces from them.

Alewife, Science Park and Airport, on the other hand, have efficient networks of vehicular traffic. The subway stations are best accessed via car even when the transit stop is within walking distance. High-capacity roads oriented to carry large volumes of automobiles act as barriers to walking. Furthermore, with cul-de-sacs and dead end streets minimizing the need for traffic intersections, the result has been an increase in traffic speed. Although the Airport neighborhood has some degree of regularity in its road pattern, no feeder streets reach the subway station. Large front-lot parking and enormous parking garages surround the station areas. Such large expanses of open space along the streets, covered with asphalt and unusable green strips, make walking less desirable.

2.3 Pedestrian system

Figure 2.7: Open Space Network in subway neighbourhoods

A good pedestrian environment is necessary to instill a sense of safety and comfort within a neighborhood. Pedestrian systems in Davis Square, Hynes and Maverick comprise of narrow streets, and wide sidewalks integrated with parks or plazas to provide a convivial pedestrian environment. In Davis Square and Maverick, the air-rights of subway lines have been developed into an elaborate park network that provides pedestrian access to the respective transit stops and other popular destinations. This kind of pedestrian system gains prominence especially for disabled, elders and children who feel safer to walk in an environment with minimal vehicular conflicts. Similarly, open plazas in front of subway stops, defined by shop-fronts, cafes and other activities, serve as gathering and resting spaces for many commuters. The neighborhood around the Hynes station emphasizes a different pedestrian system. Wide sidewalks, defined by a private garden (as in Beacon street and Commomwealth Avenue) and shop-fronts (as in Newbury Street and Massachusetts Avenue) provide attractive spaces for pedestrian movement.

In contrast, the neighborhoods around Alewife, Science Park and Maverick stations reflect an insensitive response to the pedestrian environment. Sidewalks are defined by narrow foot trails running along wide blocks of parking lots. Short-cuts to the subway station for transit users require crossing through large expanses of open fields, wide roads and macadamized parking lots. During winter, the snow is rarely cleared, making it even more difficult for pedestrians to access the station. The unlit sidewalks along inactive spaces creates an unsafe environment for pedestrians, particularly at night, often discouraging people from using the subway.

2.4 Neighborhood Blocks

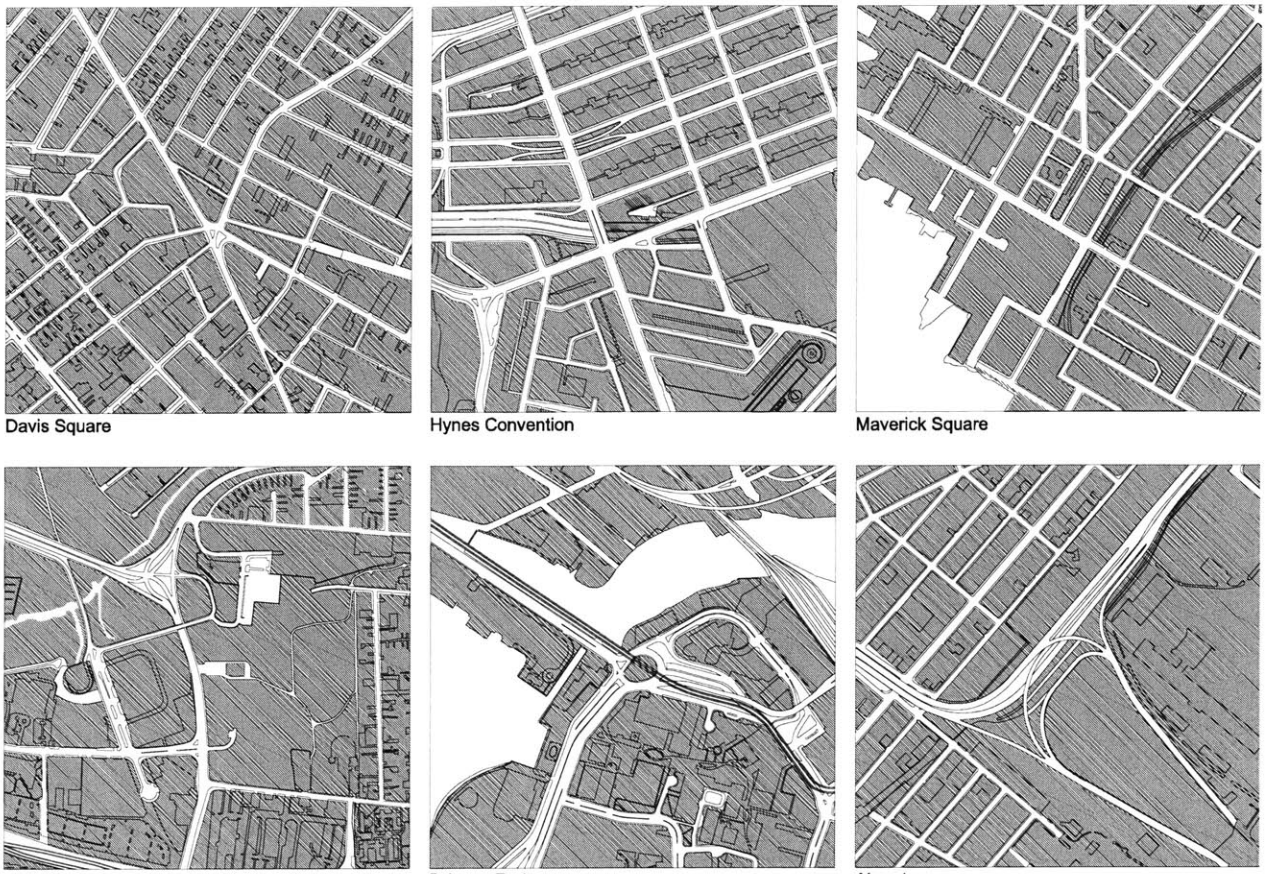

Figure 2.8: Block Pattern in subway neighbourhoods

Technically, blocks separate private property from public. In other words, blocks help define the public realm – their count, size and set backs dictate the pedestrian milieu in a neighborhood. The building blocks around Davis Square, Hynes and Maverick station, due to their street pattern, are of regular shape and size. Barring few exceptions, the average length of the blocks in these neighborhoods does not exceed 600 feet. Most neighborhood blocks are surrounded by streets that allow individual developments an immediate access to public spaces (sidewalks and parks). In case of bigger blocks (such as Prudential Center), mid-block public easements are provided to ease crossing for pedestrians. Adequate setbacks, relative to the height of the blocks, allow sufficient penetration of daylight into the streets.

Neighborhoods block around Alewife and Science Park station are predominantly large, exceeding 600 feet in length. Sometimes, pedestrians are impelled to walk more than quarter mile (walking distance) around a block to reach subway station. There are few provisions for mid-block crossings, and when they do exist, they run through large fields and parking lots.

	High Transit Use			Low Transit Use		
	Davis Square	Hynes	Maverick	Alewife	Science Park	Airport
No. of blocks in 0.25 sqaure mile	58	50	47	20	19	29
Averg. block size	698X152	636X295	629X226	948X684	853X797	723X648

2.5 Parcelization of Blocks

Figure 2.9: Parcelization of blocks in subway neighbourhoods

The number of parcels constituting a block strongly influences the pedestrian environment. Blocks around Davis Square, Hynes and Maverick stations are parceled into numerous lots, with most of the lots representing multiple-ownership. As a result, frequent walkways and gardens leading in and out of individual developments help to animate pedestrian activities throughout the neighborhoods. Dispersed activities provide commuters a safe environment to walk.

In contrast, blocks around Alewife and Science Park station in general, are minimally divided. The large lots often represent single-ownership and occupancy. As a result, limited number of front doors open directly into the streets. The developments spanning over the large parcels frequently leave large portions of vacant land as green space and parking lots. This constrains pedestrian circulation into a limited area, leaving wide stretches of sidewalks empty even during the day. Inactive streets not only increase the psychological distance of walking but also render it unsafe.

	High Transit Use			Low Transit Use		
	Davis Square	Hynes	Maverick	Alewife	Science Park	Airport
No. of lots in 0.25 sqaure mile	692	766	1004	223	53	668
No. Of Front Doors facing Public Spaces	702	778	1021	227	65	672

2.6 Built Pattern

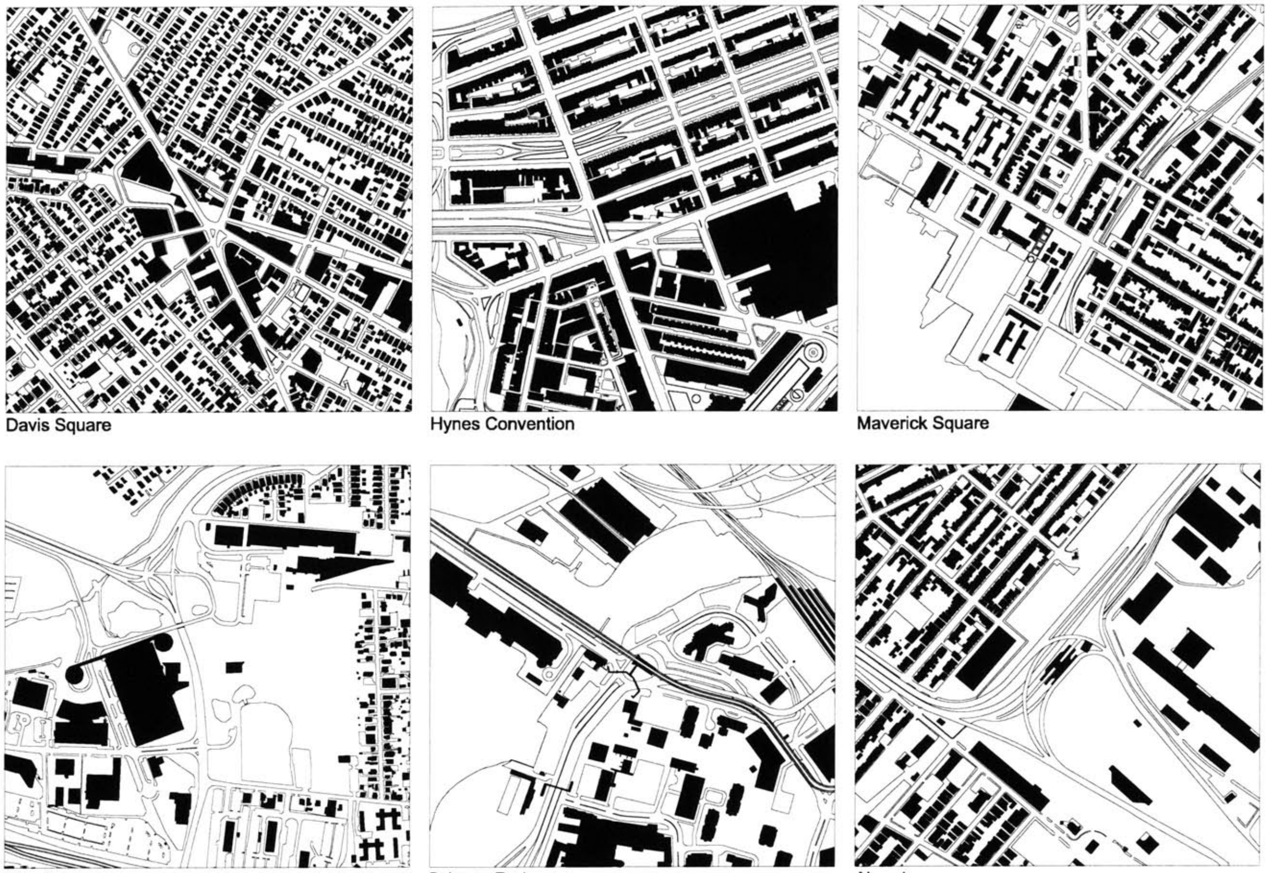

Figure 2.10: Built Pattern in subway neighbourhoods

The findings from the comparative study of the six subway neighborhoods reveal strong contrasts in development attitudes. Neighborhoods around Davis Square and Hynes station reflect relatively dense built forms. The intensity of development, especially around Davis Square, increases with land value, that in turn increases as one gets closer to the subway station. Narrow parceled blocks have generally guided buildings to stretch consistently along the street front to maximize ventilation. The large number of front doors and windows opening out to the street generate active public spaces. Most of the developments, although different in intensity, are built-to-line with minimal setback from the street. Proximate built-edges with frequent openings produce safer pedestrian environment for commuters where there is a strong visual and physical link between built and unbuilt spaces.

In contrast, neighborhoods around Alewife, Science Park and Airport stations are sparsely built, even around the station area. Large parcel sizes and low built-intensity have resulted in a scattered and isolated development pattern. Lack of the built-to-line requirement has pushed developments, which often retain a huge setback to avoid noise from busy vehicular roads, away from the street resulting in a large physical breach between sidewalks and building openings. Distant and fragmented built-edges with few openings have not only rendered pedestrian environment around subways stations dull, but also unpleasant because of large parking lots or unused open spaces.

	High Transit Use			Low Transit Use		
	Davis Square	Hynes	Maverick	Alewife	Science Park	Airport
Built Intensity	34%	38%	35%	14%	17%	20%
(ground coverage)			(area of water has been excluded)			

2.7 Land-Use

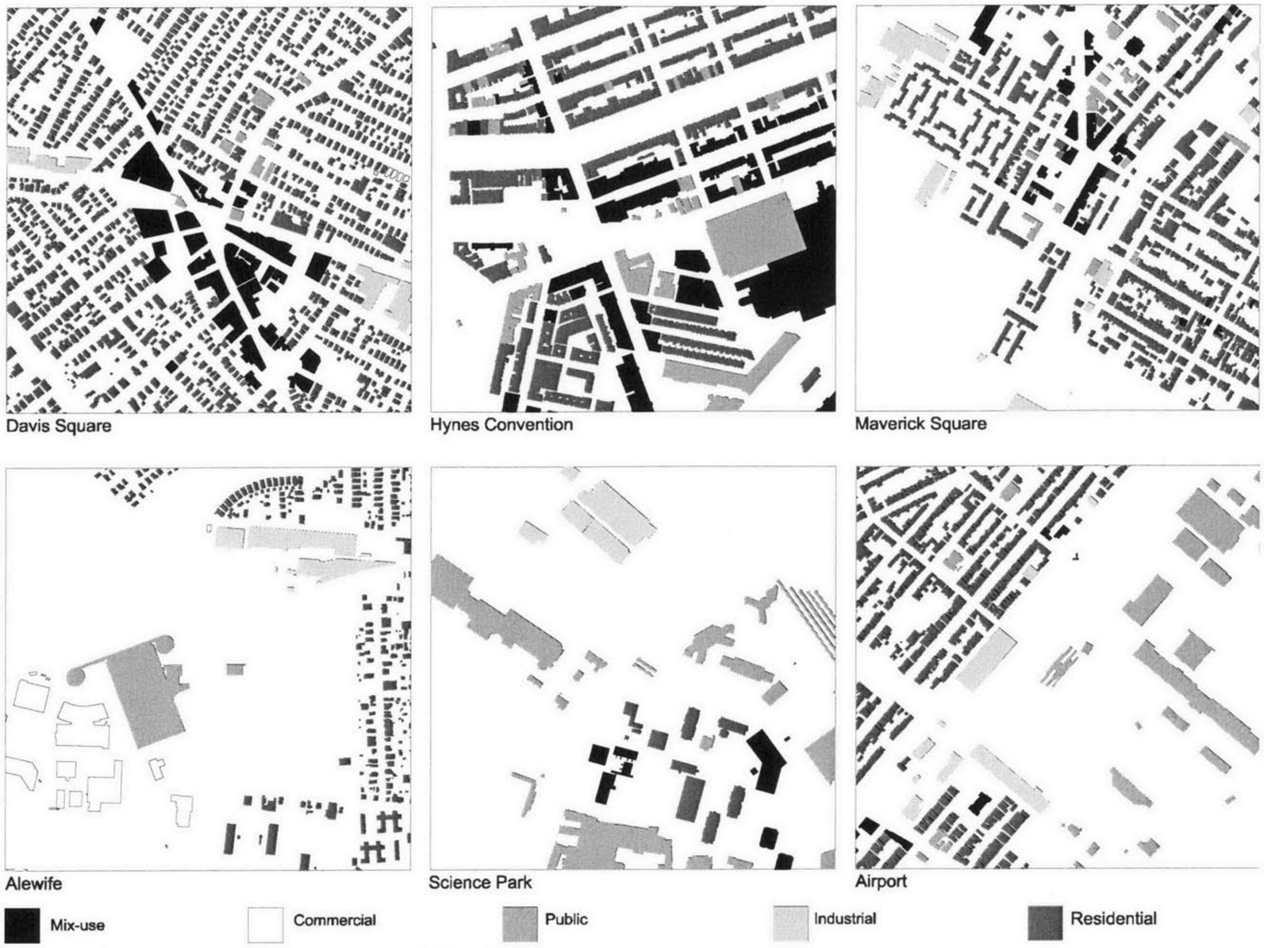

Figure 2.11: Land-Use Pattern in subway neighbourhoods

The land-use characteristics of each set of subway neighborhoods studied display radically different patterns. Neighborhoods around Davis Square, Hynes and Maverick stations inherit the traditional mixed-use type of development, with commercial activities around the station, located in the midst of multi-family residential developments. A fine-grain mix of uses – grocers, shops, restaurants, day care centers, offices and cinemas — spread around the station are well-integrated with recreational spaces. A conveniently located variety of uses facilitates commuters to link other jobs on foot before and after riding the subway. The diversity in land-use also retains activities for longer durations, making the station area safe for transit-riders during after-hours. Moreover, the mixed-use development pattern has reduced the relative parking requirements by allowing users to share parking spaces at different times of the day.

In contrast, neighborhoods around Alewife, Science Park and Airport stations have single-use developments clustered into separate zones. A few developments around Airport station comprise of some degree of mixed-use. However, the manner in which these developments relate to the subway stations makes it impossible for commuters to combine their trips on foot. The mixed-use developments around Science Park station are focused inwards, and cater exclusively to users of the building. Wide roads, garages or parking lots surround the immediate areas around all these stations. Delineation of large areas for vehicular use, besides creating a hostile walking environment, has obstructed pedestrian access to the subway station and also pushed other developments away. As a result of the isolated land-use, the activities fade after the office hours.

2.8 Zoning Ordinances

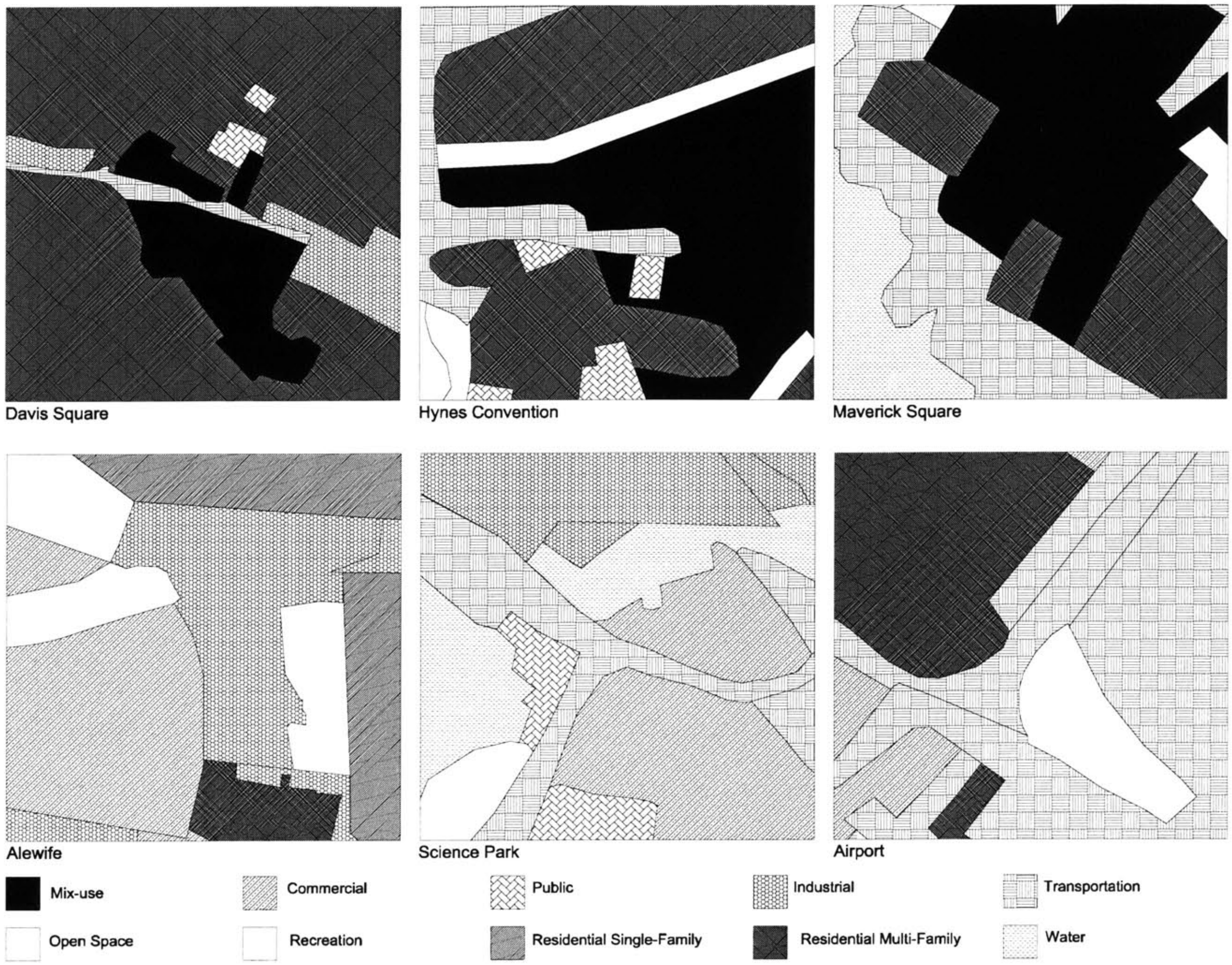

Figure 2.12: Prevailing Zoning By-Laws in subway neighbourhoods

In order to better understand the distinction in landuse patterns in the different neighborhoods, this section analyzes the zoning bylaws around the station areas. Zoning in the neighborhoods around Davis Square, Hynes and Maverick stations are characterized by mixed land-use, with businesses and residential areas integrated in smaller parcels (these areas are represented in black). Most of the purely residential areas allow multi-family housing (code: R0). Minimal land area around the stations is allocated for 'industrial' or 'transportation' uses, and these areas are well separated (by change in levels) to allow the pedestrian access to the stations.

The zoning bylaws around Alewife and Science Park do not encourage mixed-use. This has led to isolated and single-use buildings in larger parcels, mostly catering to the industrial (Code: UI) and commercial (Code: UC) use. In particular, large expanses of land around the stations (Science Park and Airport) dedicated to either open space (code: UO, that includes parks, cemeteries, public and institutional green space, and also vacant undeveloped land) or transportation facilities (code: TF includes spaces for Airports, docks, divided highways, freight storage and railroads) discourages pedestrian activity.

2.9 Design of Pedestrian Realm

Davis Square

Hynes

Maverick Square

Alewife

Science Park

Airport

Figure 2.13: Pedestrian environment around station in subway neighbourhoods

The broader issues that shape the pedestrian realm have been discussed earlier. However, the design and detailing of the pedestrian environment itself becomes important to assure commuters with enhanced levels of safety, comfort and attractiveness. The design of the pedestrian realm in neighborhoods around Davis Square, Hynes and Maverick station reflects a certain degree of sensitivity. The provision of wide sidewalk and narrower roads with long stretches of curbside parking (with minimal curb cuts) has secured the streets for many pedestrian activities besides driving and walking. Many sidewalks are tree-lined, often punctuated with outdoor cafes and street furniture. During the evenings, sidewalks are well lit with street lamps or by infiltration of lights from windows of shops and restaurants. Most of these stations open to a plaza (except for Hynes) that allows a comfortable pedestrian flow because of carefully designed pedestrian crossings with traffic signals.

However, the station areas around Alewife, Science Park and Airport are detailed in a manner that is less sympathetic to the necessities of pedestrians. The subway stations have to be accessed either through overhead bridges (in the case of Science Park) or by crossing wide stretches of open fields or parking lots (in the case of Alewife and Airport respectively). Moreover, single-use buildings with large setbacks deprive walkways of activities. Poorly maintained sidewalks, lack of street furniture and inadequate lighting force commuters to walk in a hostile environment. Therefore, these subway stations are best accessed by automobiles. This dilutes the very purpose of transit usage which tries to minimize the use of automobiles (at least within walking distance around transit station).

2.10 Lessons from Six Subway Neighborhoods

Conventional wisdom has contended that transit usage depends on household income. In other words, as income rises, so does the family's ability to own multiple cars. However, a critical question to ask here is whether this, in fact, influences people's decisions to use transit. The six case studies here (refer to Appendix A for details) reveal that the correlation between transit use and income is low. This implies that rising median income does not necessarily decrease reliance on transit. For instance, although Davis Square and Alewife (on the Red Line) have similar annual median incomes ($34,000 - $35,000), the subway usage of the former is double compared to the latter (33% in Davis Square and 16% in Alewife). Similarly, in the case of Hynes and Science Park (on the Green Line) with slightly lower median incomes ($28,265 - $28,640), subway usage varies likewise (27% in Hynes and 13% in Science Park). It should be noted that the percentage of people walking to jobs is similar in the two groups of neighborhoods compared above, and that the figure does not include people using alternative transit services (apart from subways). This debunks the myth that transit services are only meant for the poor, and suggests that there might be something qualitatively different about places themselves that encourages or discourages people to use transit services.

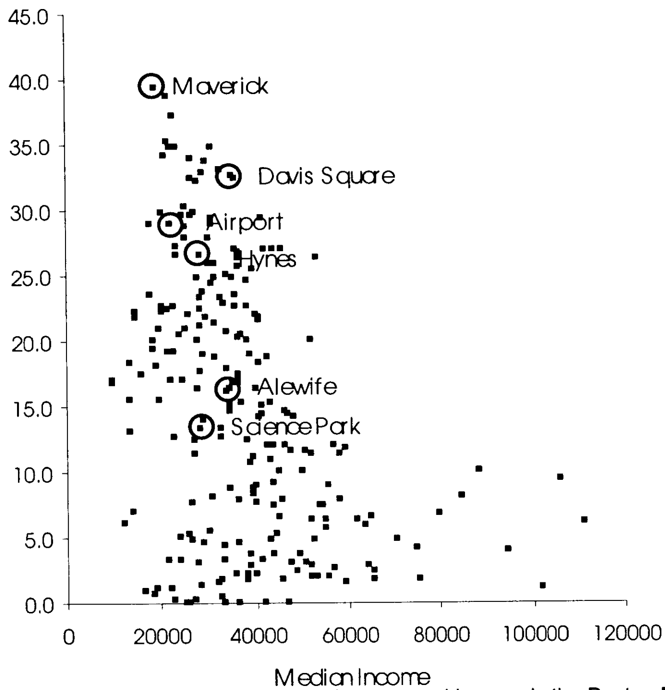

Figure 2.14: Relationship between transit usage and income in the Boston Metropolitan Area, 1990

There are fundamental tradeoffs in mobility associated with high transit use and low transit use neighborhoods. Although located on different subway lines, neighborhoods around Davis Square, Hynes Convention and Maverick stations show a strong similarity in development. They are dense, with mixed land uses that restrict (to a certain extent) the ability of families to live in single family dwellings and drive to their destinations. Also, due to the sensitive design of the street pattern and the organization of other open spaces, they provide pedestrians with the utmost freedom to travel to various destinations(including transit stations) conveniently and through attractive spaces.

Lower transit use neighborhoods such as Alewife, Science Park and Airport, on the other hand, tend to maximize mobility for those who can afford to own cars. Large parcelled, isolated development patterns, along with the absence of shops and housing near transit stations, and

design practices that favor parking stalls over attractive pedestrian paths, give most commuters little choice but to drive. This might be one of the reasons why we in the US, have not been able to lure the middle class out of their cars.
Transit services can only gain popularity when they are able to provide people with better incentives than driving does. Transit ridership is thus not going to increase if we continue to treat neighborhoods in a way that automobile drivers are prized and pedestrians penalized, or where transit stations serve as automobile repositories for residents who drive in and park their cars to take the subway to work. There is no reason why a station or station area development cannot be designed to facilitate pedestrian movement, of people living and working in the immediate vicinity, for whom the station could arguably be more valuable.

This study proves that traffic is a "derived demand" – it derives directly from how urban activities are organized on land. In other words, it is somewhat independent of household income. Residential densities, site designs, the degree of mix in land use, and the location of housing with reference to destination centers, together set the stage for travel behavior, affecting the volume and length of trips as well as travel modes and routes. The notion of this study reflects that travel behavior can be altered through a responsive physical design. Thus if we want to increase transit ridership, then the physical design of neighborhoods matters. It also highlights the fact that transit is more than concrete and steel – it is about people who use it and about the designs of places they travel in order to get to the transit stop.

In this respect, transit should never be planned in isolation, but rather be coordinated with physical developments to promote pedestrian activities that attract people from varying income groups. The study reflects that successful transit reliant developments are broadly dependent on: Density, Diversity, and Design.

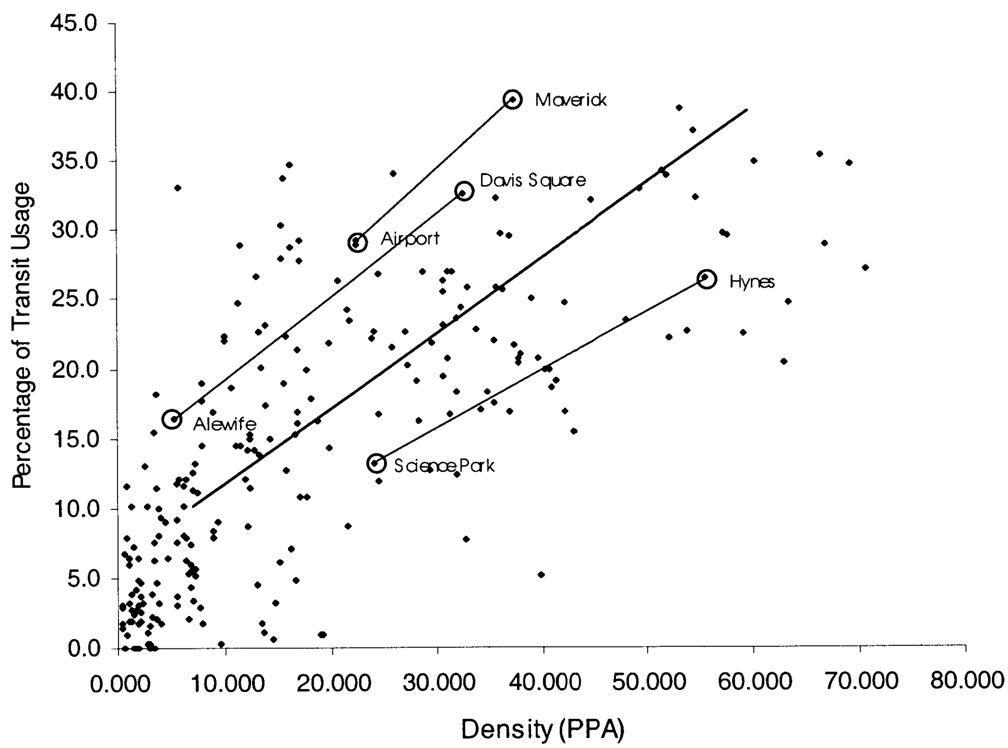

Figure 2.15: Relationship between transit usage and density in the Boston Metropolitan Area, 1990

Density: Most of the lower transit use neighborhoods (such as Alewife) in the US are developed below a gross FAR of 2.0. Such densities are intrinsically dysfunctional from a transportation standpoint. They are generally too low to support viable mass transit services, yet high enough to cause traffic congestion. Population density proportionately offers three primary benefits. It decreases operating cost per rider, increases frequency of transit services and helps promote commercial mixed-use development by creating greater demand. An interesting and clear observation from these case studies is the fact that as population density increases, transit usage also increases.[4] For instance, consider Davis Square and Alewife, two neighborhoods with similar median incomes. The transit usage in Davis Square with a density of 32.47 ppa is more than double that in Alewife which has a density of 5.31 ppa. Similarly, Maverick, with a higher density than Airport commands a higher transit usage, and Hynes with a density (56 ppa) nearly double that of Science Park (24 ppa) has a transit usage also nearly double that of the latter. Lest this appears to be a coincidental or anomalous observation, a similar analytical study was carried out in the Boston Metropolitan Area's transit neighborhoods. The graph below indicates that indeed a strong positive correlation (0.75) exists between population density and transit usage.

Diversity: In terms of inducing people to ride transit or walk, mixed land use is important in four ways:

a) Conveniently sited retail, day care facilities (as in case of Davis Square and Maverick Station area) allow commuters to combine work and other chores in a single trip. A fine-grained mix of housing, shops, offices, and civic places allow transit users to easily cover multiple destinations on foot, reducing the need to use the automobile.
b) Sensitively divided and distributed land uses facilitate an even balance of transit use throughout the day, thereby reducing the peak effect in transit services as well as peak traffic on road.
c) Mixed land use promotes pedestrian activities for a longer period of the day, making streets active and safe for transit users.
d) Mixed land use promotes resource efficiency. An example is the concept of shared parking that can substantially shrink investment and land area for parking.

The idea behind mixed-use development is to create communities where daily activities are integrated rather than segregated. Mixed-use, it should be noted, is not the same as multi-use. Indeed, some developments in Alewife and Science Park feature multiple-use. Mixed-use places compatible activities side-by-side so that they mutually benefit from one another, such as creating a pleasant pedestrian milieu, curtailing travel distances and linking trips, sharing parking and thus promoting transit usage.

Design: As discussed earlier, density and land use diversity are two major components of transit reliant neighborhoods. However, consumer purchasing behavior indicates that, almost universally, people are reluctant to live in high-density environments. It is not density *per se* that people dislike, but rather what accompanies density – the spatial mismatch[5] (at least in the US), expensive housing, congestion, noise, graffiti, street crime and so on. The challenge of transit reliant neighborhoods thus lies in creating dense yet attractive and safe places, through community rebuilding and largely through high-quality design, matched by more public amenities, mixed-income housing and enhanced access to job opportunities.

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4 The term density here is used to define the population per acre that is permanently residing in the neighborhood. Transients are not included in the figures indicated. In practice, the density should include both permanent and transient population.

5 *Spatial Mismatch* is the terms used to explain the conflict between location of housing versus the location of employment opportunities.

Chapter 3: Exploring Transit Reliant Development

After having studied how urban form influences transit ridership, this chapter speculates in depth about of how future development or redevelopment should be directed so that more people can be attracted to use transit as their primary mode of transportation.

3.1 Site Location and Surroundings

For the purpose of theoretical exploration, the neighborhood around Lechmere Station has been selected. The site is located on the northern part of East Cambridge. It is presently a terminus of the Green Line subway line that connects it to the Central Business District and other important destinations of Boston (Figure 3.1).

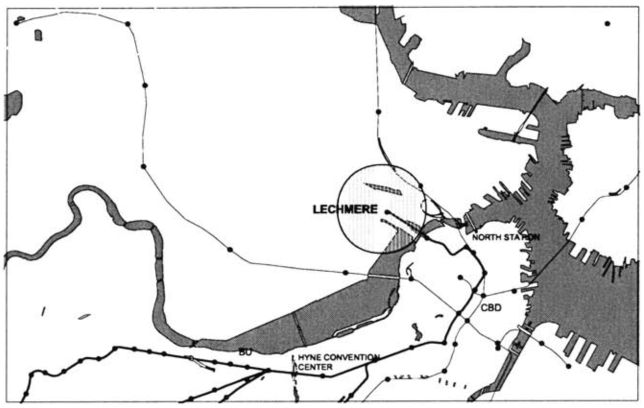


Figure 3.1: Location of Lechmere in Central Boston Area

Figure 3.2: Present Figure Ground of Lechmere

3.2 Lechmere Today

The study is focused on the area defined by a commuter line track on the north, Charles River Basin on the east, 5th Street on the west and Charles Street on the south. Monsignor O' Brien Highway, a major traffic bypass, runs east west, physically dividing the site into two parts. The southern part of the site contains most of the developments. Some of the established uses in this area are commercial developments around Lechmere Canal with the Cambridge Courthouse complex in the center. Most of the commercial developments lie on 1st Street, while light industry and office developments exist along Charles Street (Figure 3.2).

The northern part of the site, in contrast, is devoid of any major developments. A reason for this is the at-grade traffic bypass and the above-grade transit line, which restricts its accessibility. As a result, developments in East Cambridge halt at O' Brien highway. Except for a recent high-density residential development (Museum Tower) and an office building towards Charles River Basin, most of northern Lechmere consists of a vast expanse of unused land, parking surfaces or temporary industrial sheds. However, infrastructure upgrading plans proposed by various state and city agencies are expected to enhance the accessibility of northern Lechmere.

3.3 Infrastructure Improvement Plans

One of the major investments in the area is a proposal for a new transit station for the inter-city circumferential transit line, better known as the "Urban Ring." The Urban Ring will connect all the existing MBTA radial transit and commuter lines at key employment centers (Figure 3.3). MBTA also plans to extend the Green Line subway corridor from Lechmere onwards which will further increase the site's accessibility to and from other areas within the Boston Metropolitan Area. Furthermore, the plan for realignment of the Green Line, by shifting the station from its existing location to a site directly across O' Brien Highway, will open new development possibilities in northern Lechmere (Figure 3.4). To further increase the accessibility of Lechmere, this study proposes a commuter line station in the northern perimeter of the site.

Another infrastructure improvement investment in northern Lechmere is the proposal by the Metropolitan District Commission for the New Charles River Basin. This project will complete the metropolitan park system by reshaping the river and its banks in the 'lost half mile' between the existing Charles River esplanades and Boston's Harbor Park (figure 3.5). Currently under-used edges of East Cambridge (especially along the east edge of Lechmere) and Boston will be integrated into a recreational green belt. The central theme of these new public spaces is the industrial and shipping history of East Cambridge. Public programming will include school programs, adult classes, tours, art works, special events as well as large-scale celebrations. This effort is expected to attract diverse users, increase park security, and raise awareness of both the natural and man-made environment.

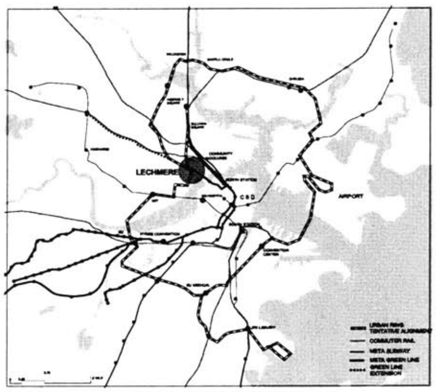


Figure 3.3: Urban Ring Alignment

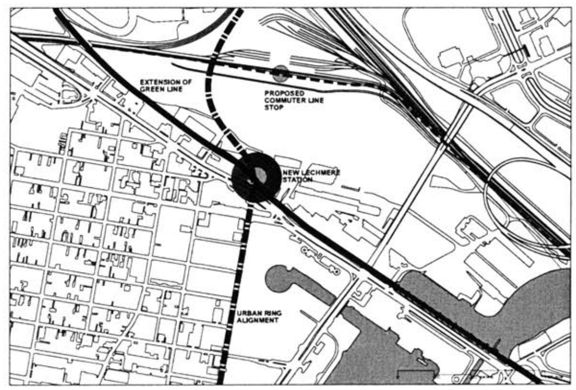


Figure 3.4: Green Line realignment and extension


Figure 3.5: MDC proposal for Charles River Basin

3.4 Development Issues

Given all the proposed investments to improve infrastructure, the availability of buildable land, its connection to the CBD and major institutions[1] via transit service, and its waterfront, Lechmere holds an enormous potential for future developments and densification. However, the willingness of East Cambridge communities to only allow development projects with minimal traffic implications has raised concerns regarding how the high market demand will be met. This highlights that both community and market needs can be simultaneously addressed only through transit reliant development – where developers are encouraged to build in free market conditions provided they control traffic impact by encouraging development to rely on transit as their primary source of mobility. Therefore, the objective of this design inquiry is to postulate a development direction for the city that attracts the majority to use transit as their primary commuting mode.

3.5 Site Focus

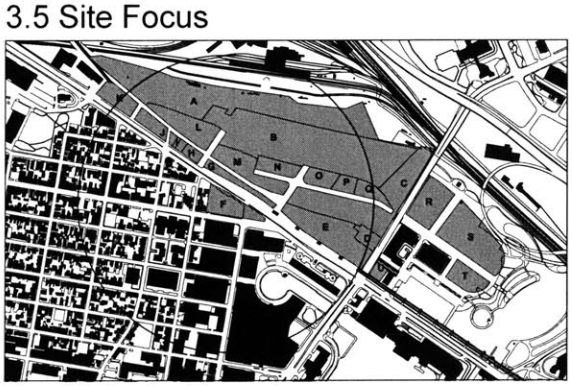


Figure 3.6: Developable parcels

As most of the land area on southern Lechmere is already developed, the study focuses on the northern part. Except for a few existing developments (Museum Towers and an office building), this part of the site offers approximately 62 acres of developable land, with the majority of parcels under single ownership (figure 3.6).

[1] Massachusetts Institute of Technology, Harvard University, Tufts University and Museum of Science.

3.6 Development Agendas

The proposition of increasing transit usage will only be satisfied if we can lessen the dependency on private automobiles. A proactive way of doing so is to create an urban environment that is more attractive for walking, cycling and riding transit rather than driving an automobile. Transit users frequently change their mode of transport during a single trip. Typically, they begin their trips by walking from their homes to the nearest transit stop, and then walking to their destination at the end of their transit trip. As a result, the success of transit-reliance in neighborhoods will depend strongly on the quality of their pedestrian environment. Hence, the agendas for Lechmere development are aimed at safeguarding the needs of pedestrians-based transit riders.

In order to minimize vehicular reliance, the proposal allocates only 20 percent of developable land[2] area for vehicular circulation (including roads and surface parking). The idea here is not to eliminate vehicular use but instead discourage it by curtailing the free and swift movement of automobiles, and provide commuters with attractive options to walk or bicycle. Therefore, 30 percent of the 62 acres is dedicated to all kinds of public spaces, both covered and open, accessible by pedestrians at all times. This area includes (publicly or privately managed) street sidewalks, public squares, winter gardens, parks, and waterfront promenades. The remaining 50 percent of gross land area (buildable area) is allocated for joint and private development.

Function	Percent	Area(sq.ft.)	Area(acre)
Vehicular (Surface)	0.20	538568.12	12.36
Open Space (Pedestrian)	0.30	807852.19	18.55
Buildable Ground Area	0.50	1346420.30	30.91
		2692840.64	**61.82**

Agenda A: High Intensity Development

Considering the fact that the proposed transit infrastructure upgrading in Lechmere entails heavy investments, its viability depends on the number of people using the service which, in turn, is generated from the density of development allowed. Therefore, development density is a critical element of the cityscape that determines and affects transit usage. In order to maximize market demand and support infrastructure investments, northern Lechmere is proposed to be developed at a net FAR of 5.2 (of buildable area) and a gross FAR of 2.5 (of total land area) which will generate a total buildable floor area of approximately 7.0 million sq. ft. The larger population per unit area proportionately offers two benefits for transit riders:

a) It decreases operating cost per riders; and
b) It increases frequency of transit service.

Agenda B: Mixed Use Environment

The idea behind mixed-use development is to create communities where daily activities are integrated rather than segregated. In terms of inducing people to ride transit or walk, mixed land use is important in four ways:

a) Conveniently sited retail, and day care facilities allow transit riders to link their work and other chores in a single trip. A fine-grained mix of housing, shops, offices, and civic places allows transit users to easily cover multiple destinations on foot, reducing the need to use, or even own automobiles.
b) Sensitively divided and distributed built spaces for offices, shops and residences facilitate an even balance of use throughout the day, thereby reducing the peak effect in transit services as well as peak traffic on roads.

[2] Typically, US urban areas dedicate 35 percent of land for vehicular traffic. (Cervero, Robert, *Transit Metropolis a Global Inquiry,* Washington: McGraw-Hill, 1998).

c) Mixed land use also retains activities for a longer period of the day, making streets active and safe for transit users.
d) Finally, mixed land use promotes resource efficiency. An example of this is the concept of shared parking[3] that can substantially shrink investment on parking and release space for other useful developments.

As a result, the total developable area has been broadly distributed to accommodate three types of land uses – Residential, Commercial and Institutional. The connection of Lechmere with the CBD and other job centers via transit service indicates that Lechmere could address part of the city's housing demand. Therefore, 60 percent of the development is allocated for housing – developed at a net FAR of 5.0 and a gross residential density of 144 ppa. This area for residential development, approximating 4.4 million sq. ft., will provide approximately 4,500 units (at 1,000 -1,200 sq. ft. per unit) of various types for the resident-population, totaling 8,000 people (at 2-3 people per unit) from varying incomes and age groups.

Likewise, to address the growing demand for commercial spaces and to lessen dependence on private automobiles by allowing live-work opportunities, 30 percent of the buildable area will be dedicated for commercial use at an FAR of 6.0. A total of 2.6 million sq. ft. of commercial space will be developed to include office spaces, hotels, light industries, restaurant cafes, destination and incidental retail spaces, cinemas and health clubs that will attract a minimum transient population of 15,600.[4] The remaining 10 percent of buildable area developed at net FAR of 4.0 will furnish 0.6 million sq. ft for public buildings such as the MBTA subway, commuter line and water taxi stations, museums, libraries and schools.

Use	Percent	Area (sq.ft.)	Area (acre)
Residential	0.60	807852.18	18.55
Commercial	0.30	403926.09	9.27
Public	0.10	134642.03	3.09

(Total Buildable area = 1346420.30sq.ft. = 30.91 acres)

Use	Total Area (sq.ft.)	Area (acre)
Residential (FAR 5)	4039260.9	92.75
Commercial (FAR 6)	2423556.5	55.62
Public (FAR 4)	538568.1	12.36
	7001385.5	**162.73**

Net FAR = 7001385.5 / 1346420.30 = **5.2**

3.7 Development Pattern

The development pattern of Lechmere is directed by five objectives. These are:

A. **To develop the main Lechmere station as the "center" of the overall development:** In order to draw more users, the Lechmere station needs to be more than just an entry to the subways. Popular activities such as cinemas, public libraries, day-care centers, convenient stores, grocers, restaurants and shops, if coordinated with the station development, will make the environment attractive and convenient to ride transit by allowing commuters to consolidate other trips with their journey to the station (Figure 3.7).
B. **To distribute activities by locating major public uses at pivotal addresses:** Even dispersal of activities is important in transit-reliant neighborhoods in order to create an attractive and safe environment for pedestrians. The northern bank of the Charles River Basin

[3] When offices and theaters are side by side, for example, parking spaces used by offices workers from 8:00 A.M. to 5:00 P.M., Mondays through Fridays, can be used by movie-goers during evenings and on weekends.
[4] Transit Population indicates the number of people visiting the development as workers and visitors who are not residents of the development. The figure calculated is based on an assumption of 6 people per 1000 sq. ft.

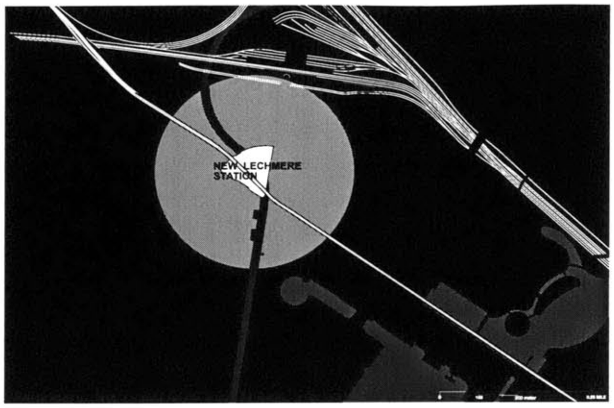


Figure 3.7: Lechemere Station as a centre of development

Figure 3.8: Dispersal of activities

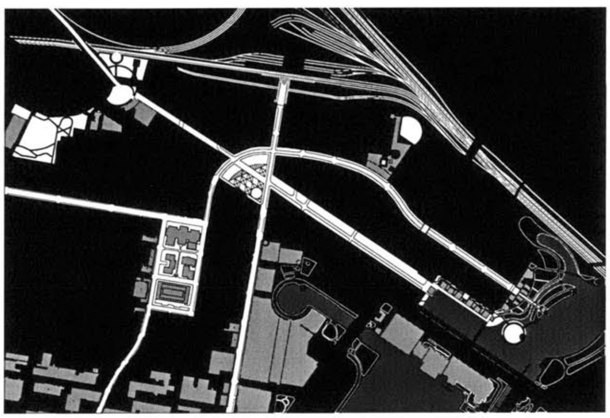


Figure 3.9: Connecting the station with high-use areas

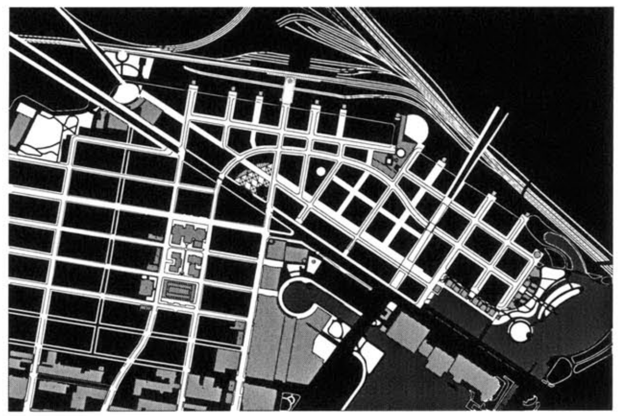


Figure 3.10: Developing feeder street systems

(east of the site) will be developed as a recreational destination that contains Cambridge Industrial Museum, MBTA water taxi stop, seafood restaurants, parks, performing spaces and public boating facility. Similarly, the north-west corner of the site will have a public sports center and the north east corner will have an elementary school in conjunction with a Community College. The southern part of the site already holds Cambridge Court House complex, Cambridge Side Galleria mall and light industries (Figure 3.8).

C. **To develop major streets as public spaces connecting the station with high-use areas:** In order to minimize travel distance and enhance the travel experience, a system of open public easements will be developed to connect the station and high use areas in the shortest and most attractive manner. These open spaces are envisaged as pedestrian *collector streets* that will engage commuters in various activities apart from travel. The existing streets that connect standing high-use areas in the southern part of the site will be enhanced to incorporate pedestrian needs (Figure 3.9).

D. **To develop network of feeder streets:** As all the developments cannot have direct access to collector streets, it is important to develop a second layer of the street system that feeds into them. These feeder streets will provide transit riders immediate and multiple route options to access the collector streets leading to the station. In order to shorten the travel distance and increase the line of visibility, the feeders streets will be generally perpendicular to the collector streets, setting an orthogonal street pattern (Figure 3.10). Interconnected grid street patterns also provide multiple route options to both pedestrians and auto drivers, thereby dispersing traffic and reducing the volume of cars from the collector streets.

E. **To allow market based development:** Just as the built environment shapes transit demand, transit investments should shape the built form of neighborhoods. In theory, transit should provide locational advantages. If transit were to actually become the major source of travel mode, more people would want to live/work nearer to the stop to reduce the cost and time of travel. In response to people's desires for locational advantages (to minimize travel time and distance), and real estate developers' awareness of those desires, the intensity of development will be allowed to increase as it approaches the station. In order to satisfy the varying needs of the concentrated population, a higher degree of mixed use will be encouraged around the station and along the main pedestrian corridor. The trade-off between location and commuting time will help people determine the location of their houses and workplaces (Figure 3.11).

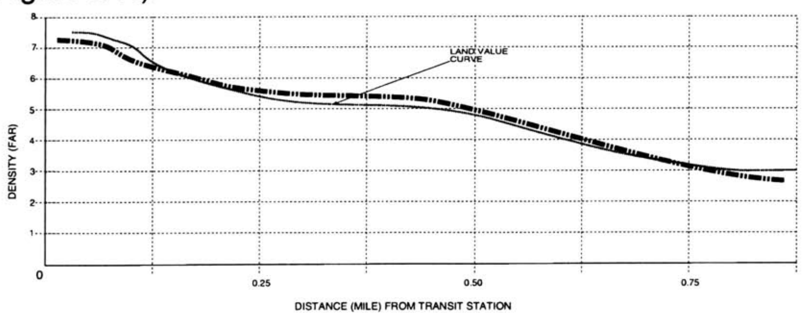


Figure 3.11: Intensity of development in relation to the location of the station

3.8 Design of Neighborhood Blocks

The organization of streets defines building blocks, the arrangement and design of blocks determines the quality of streets and open spaces. In order to achieve an attractive pedestrian milieu, the design of neighborhood blocks will be directed to attain a coherent agglomeration of individual developments. In an effort to support walking as a realistic travel alternative, the block design addresses issues of pedestrian convenience and safety, and attractiveness.

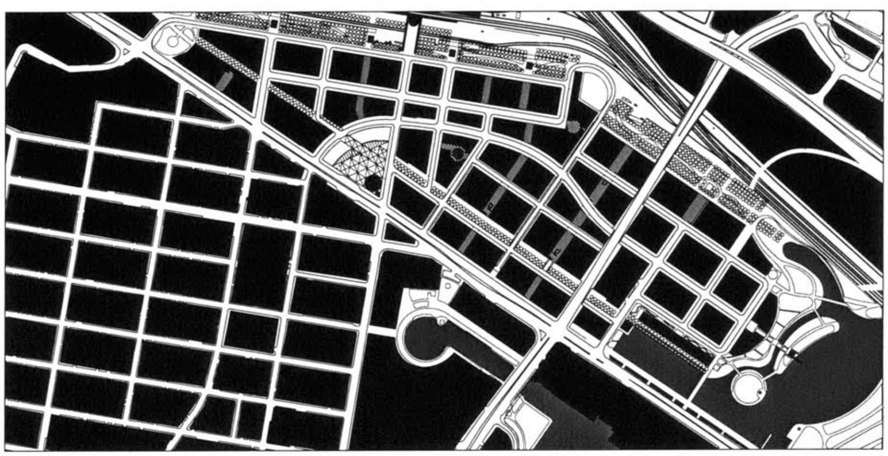


Figure 3.12a: Resulting structure of blocks

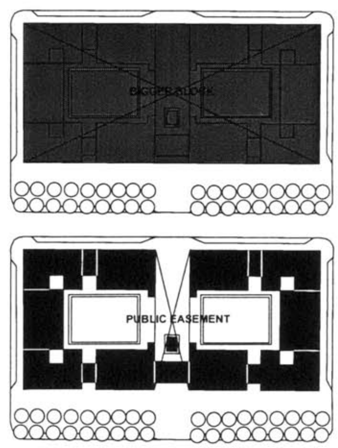


Figure 3.12b: Public easment through longer blocks

Size: In order to allow multiple route options and maintain convenient walking distances, the dimension of blocks, in general, does not exceed 600 feet. In the case of longer blocks, public easements are provided to comfort pedestrian circulation through private developments that link them with the main streets connected to the station (Figure 3.12b).

Setback: The interface between blocks and public spaces is important to strengthen the relation of pedestrians with the private developments. In order to discourage inactive open spaces, a "built-to" line mandates the individual buildings to build upto the required setback (Figure 3.13). Exceptions include spaces that accommodate public activities, street-side cafés and open-displays.

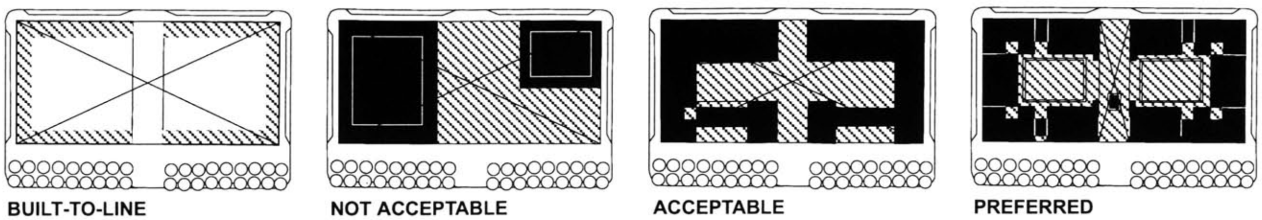


Figure 3.13: Built-to-line requirements

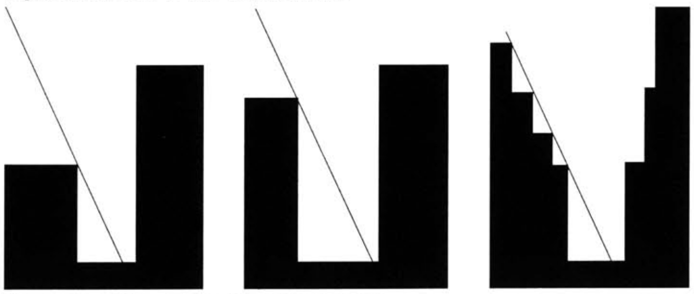


Figure 3.14: Regulation of building heights

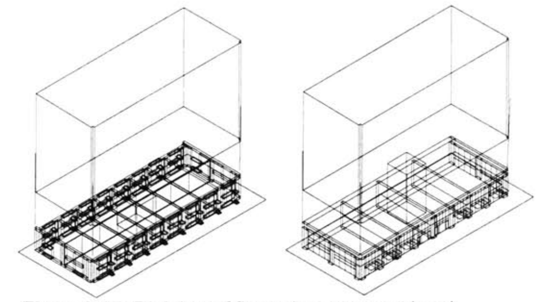


Figure 3.15: Division of floor plate at street level

Orientation: All blocks with commercial uses orient the front doors and display windows of high-level activity towards open public spaces. This is to leverage a visual and economic link between the businesses and the pedestrians. An exception is the elevated Gilmore bridge, where low use areas such as parking garages and service yards are to be located away from pedestrian areas. In residential areas, porches, terraces, verandahs and main entrances should face the street. The idea underlying such an orientation is to provide public spaces with added activity and safety, that sustains pedestrian movement for longer periods of the day.

Height: Transit usage during extreme climate decreases due to the exposure of pedestrians to harsh weather conditions (such as wind-chill or intense sunlight). The height of the block and the width of the adjacent open spaces dictate the penetration of sunlight and speed of wind at the street level. Therefore, the building height is determined in accordance with the width of the open space it faces. Where a neighborhood block needs to satisfy a high FAR, it is stepped-up away from the public space (Figure 3.14).

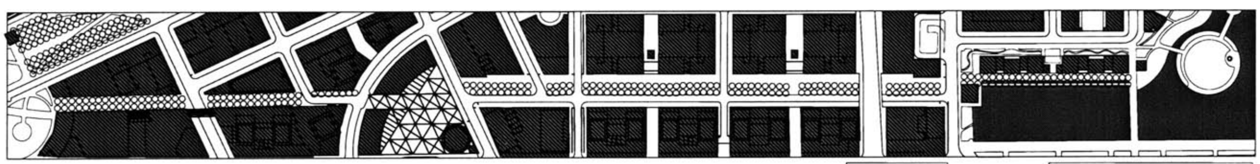

Figure 3.16: General plan for building footprint

Division: The number of lot divisions constituting a block largely determines pedestrian activity in the street. The division of large blocks into smaller individual lots might not be a lucrative proposition for developers in high-density environments. Instead, it would be more profitable to carry out a comprehensive development on the upper levels, and only divide the ground floor. Hence, the blocks will maximize the ownership count at the street level. In residential areas, the units facing the street will be designed in a manner so as to maximize the number of front entries and openings. Similarly, in mixed-use areas, various commercial uses at grade will be divided to incorporate optimum number of tenants (Figure 3.15). Facades facing pedestrian walkways will avoid any form of blank walls.

3.9 Design of Collector Streets

The design of collector streets is based on the premise that they will be a part of the greater street system within the neighborhood. This is to allow transit riders to reach various destinations (including the station) in the most direct, convenient and attractive way. More people are likely to take transit when their routes to and from transit stops are safer. A number of factors – such as the number of people in public spaces, the type of activities, the number of front doors opening to pedestrian streets, and the line of visibility – dictate the safety of our physical environment. Three streets have been identified to serve this purpose:

a. Lechmere Boulevard:



Lechmere Boulevard is a public space that runs east west through the neighborhood leading people directly from the station to the waterfront via high-density developments. While the northern blocks are mixed-use developments (retail, offices and housing) spanning over the Green Line tracks, the southern block is primarily housing. The high-density development will continue commercial activities (at the street level) originating from the station towards the waterfront. In order to encourage a wide range of pedestrian-based activities (both community and commercial), this street will be the widest (109 feet R.O.W.) in the neighborhood. Two parallel rows of trees planted along wide sidewalks (60 feet) will shelter community spaces with street furniture, vending machines, bicycle stands and telephone booths. Outdoor restaurant seating, open-air markets, and vendors will be encouraged to occupy parts of sidewalk (Figure 3.17). The infusion of commercial use will sustain activities in this street for longer durations making it safe for transit riders to use after dark.

In order to further enhance the experience of pedestrians, the vehicular circulation will be pushed to the north of the street, allowing wide sidewalks to receive winter sun through receding building

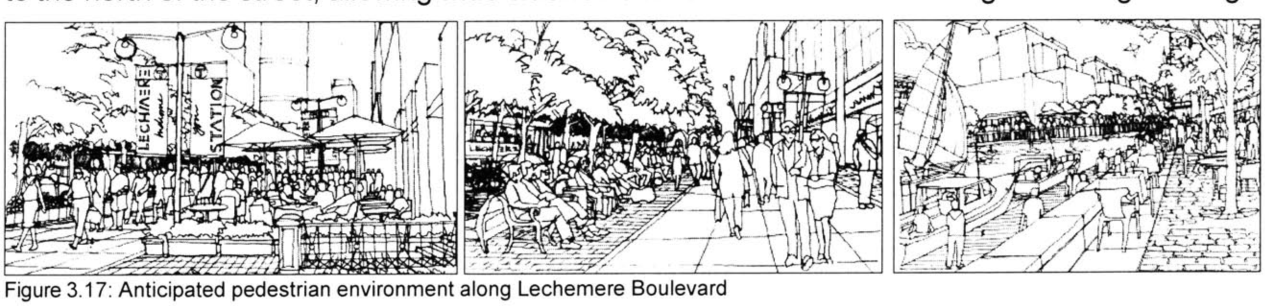


Figure 3.17: Anticipated pedestrian environment along Lechemere Boulevard

setbacks of the northern blocks (Figure 3.18). The vehicular traffic will be restricted to two lanes, with curb parking on both sides. Pedestrians will have to cross only four traffic intersections to get to the station from the waterfront (a distance of approximately 1,715 ft.). Access to parking garages will not be allowed from the street except in cases where a development does not have a secondary access road.

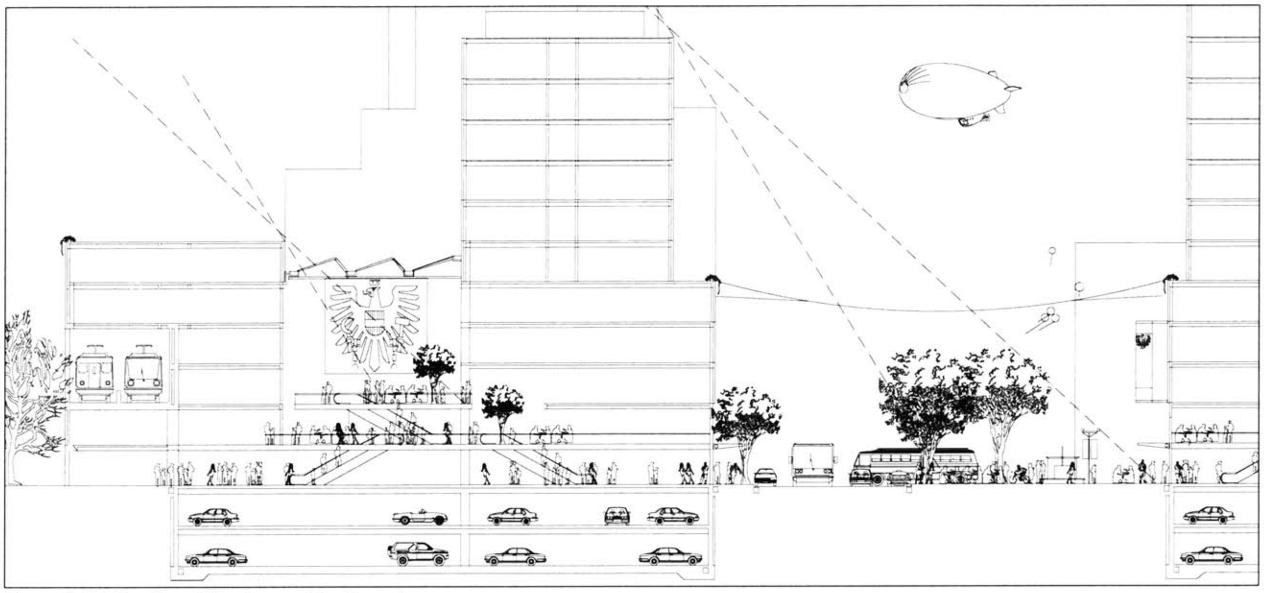


Figure 3.18: Section of Lechmere Boulevard

b. East Street

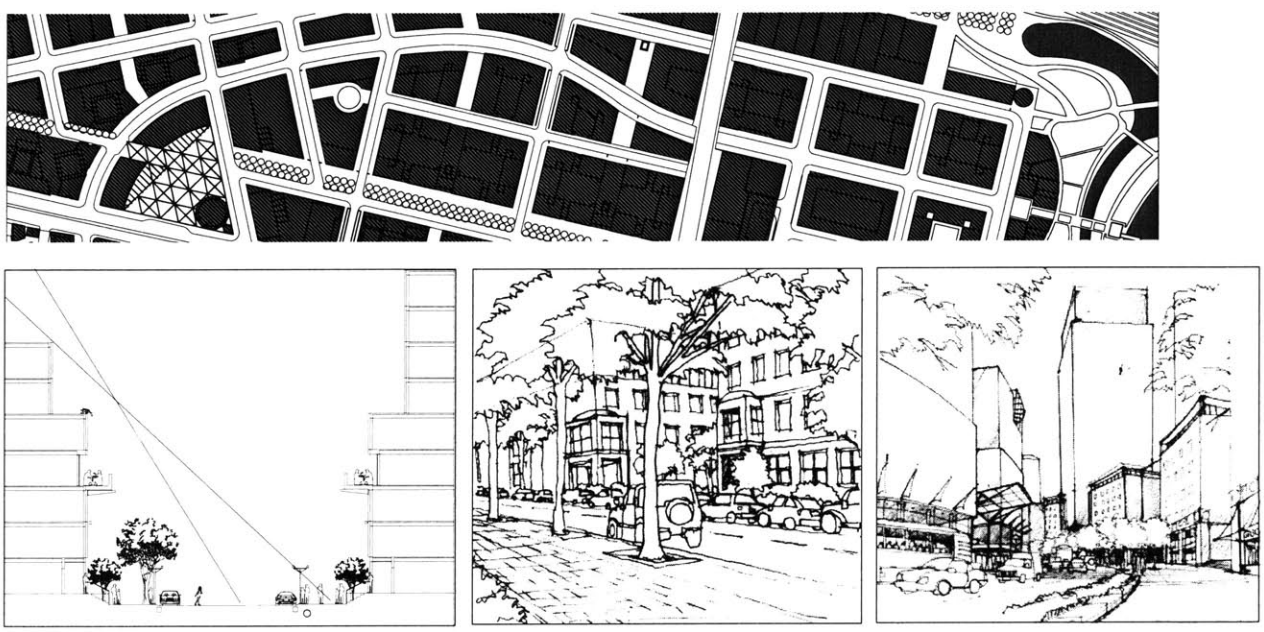
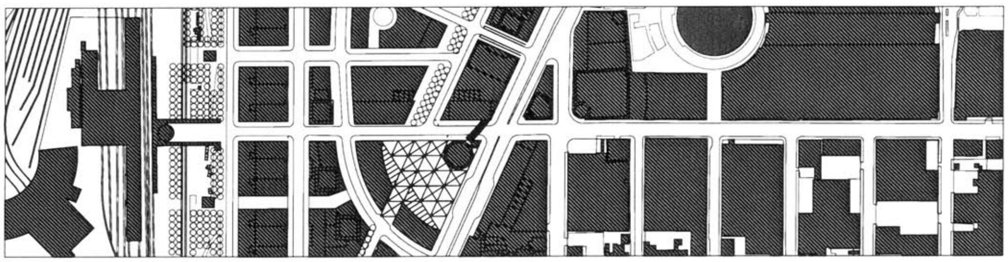


Figure 3.19: Section and views of East Street

A major stretch of East Street runs along residential developments, linking them with the station and Charles River Basin. With the exception of small convenience stores and daycare centers (to allow commuters to link different jobs on their way to and from transit stops), East Street will be developed predominantly as a residential street. All at-grade units will orient their living room windows, porches and front gardens towards the street. This provision will animate the street with activities of residents sitting in porches, people entering and exiting through front doors, and children playing in front gardens. During non-active hours, well-lit porches and living rooms will serve as additional street lighting, increasing visibility at night and pedestrian safety.

In order to reduce the noise impact of automobiles, the street circulation is limited to two lanes of traffic(Figure 3.19). The narrow road flanked by curbside parking (38 feet in total) will decrease automobile speed and serve as protection for pedestrian activities on the sidewalk. The remaining 17 feet width, allocated for sidewalks on either side of the road, dedicates 6 feet for easy pedestrian flow, leaving 9 feet for street furniture and entry to the units through private gardens.

c. 1st Street



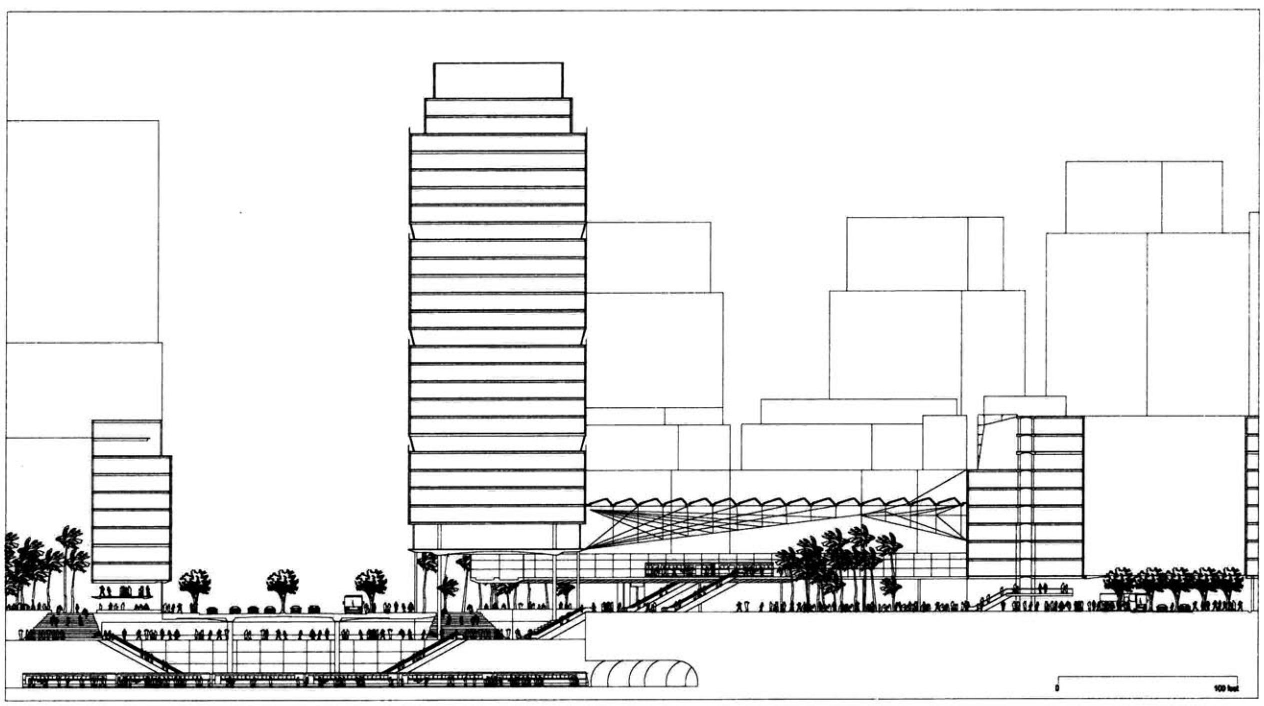


Figure 3.20: Section through sub-level pedestrian concourse (1st Street and O'Brian Highway) leading to Lechmere Station

1st Street, that presently ends at O' Brien Highway, will be extended north to connect both the Lechmere and the Commuter Line stations, providing a direct access for transit riders from the southern part of Lechmere. This street is envisaged as a major commercial-cum-entertainment corridor that links the stations with a series of office developments, a shopping mall, ethnic restaurants, and a multiplex theater. In order to facilitate an easy and safe pedestrian flow, a well-designed at-grade pedestrian crossing is introduced at the O' Brien Highway intersection, supplemented by a below grade pedestrian concourse leading to the Urban Ring Station (Figure 3.20).

3.9 The Lechmere Station Design

The Lechmere station is proposed as an intermodal transit center that comprises of three transit services:

1. Elevated Green Line that runs along 0' Brien Highway;
2. Below-grade Urban Ring Line that approaches the station under 1st Street, crossing it at an angle of approximately 45 degrees. The Urban Ring station will be an interface with the Green Line station, allowing easy transfer between the two lines. It will also serve as a sub-level pedestrian crossing across O'Brien Highway; and
3. Inter-city MBTA buses (numbers 69, 80 and 88) that service other areas in Cambridge and Somerville.

Due to the high investments of three inter-city transit services, the station development should have the greatest concentration of built density, the highest land value, and the most diverse use. This would provide a means of recapturing the value added by public transit investments, allowing land price windfalls to be channeled into financing supporting community facilities and services. Therefore, the Lechmere station is seen as a Joint Development initiative where MBTA will sell or transfer its rights to develop a mixed-use hotel-cum-office complex that will facilitate an easy and attractive transit access to various users (Figure 3.21).

The development of the station is conceived as a grand community space defined by the union of all the collector streets (Figure 3. 22). Here, 'grand' does not pertain to the magnitude of the structure, but rather to the degree to which the space is connected with the surrounding uses. For this community space to evolve as the neighborhood hub, the station will share the space with private developments that incorporate physical and visual links to various facilities such as

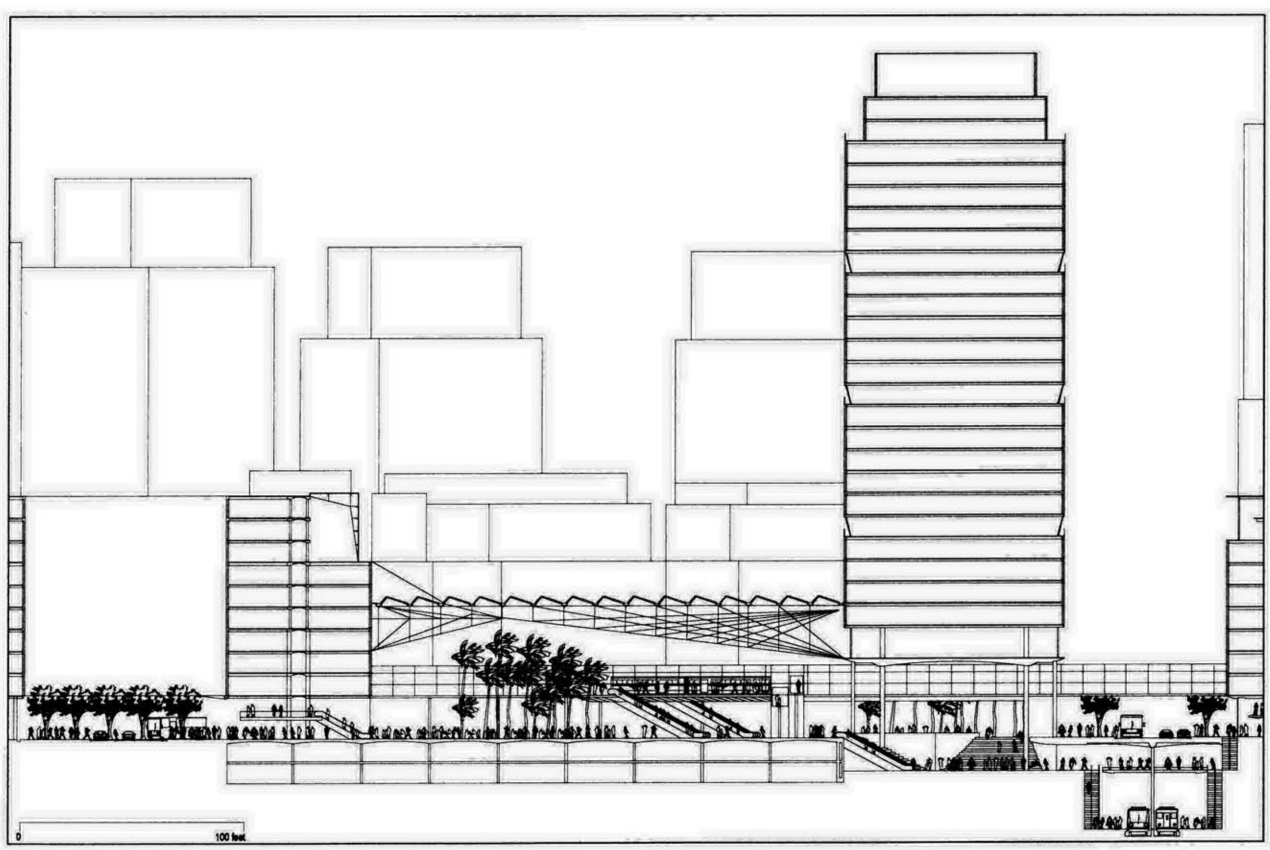


Figure 3.21: Section through Lechmere Station Joint Development

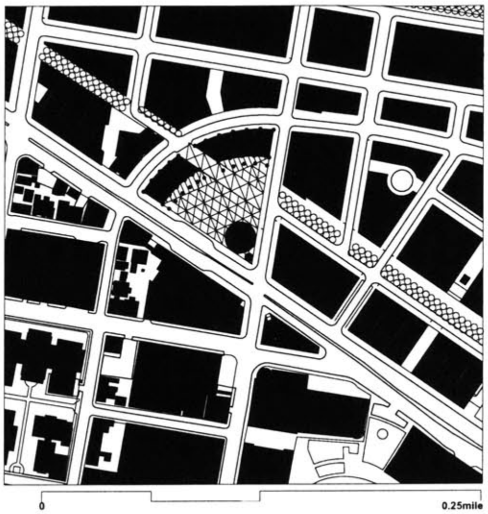


Figure 3.22: Contextual plan of the station

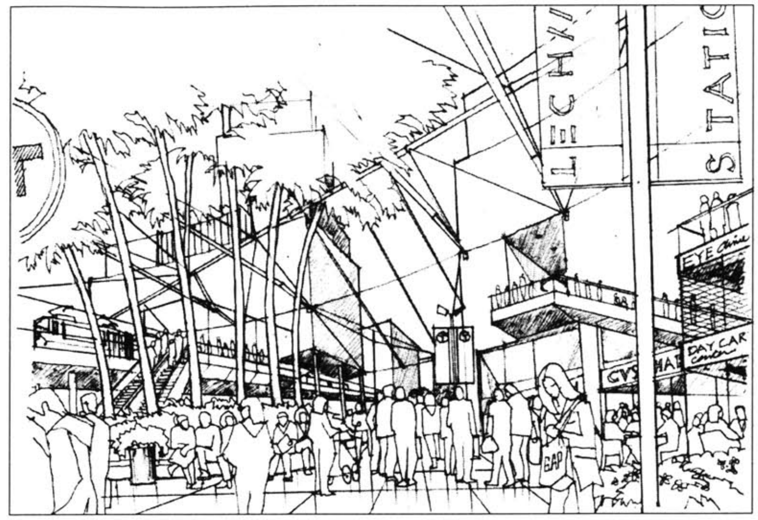


Figure 3.23: Lechmere Station as a neighbourhood hub

supermarkets, 24-hour convenient stores, shops, cafes, restaurants, car rentals, banks, post offices, dry cleaners, health clubs and day care centers. In order to sustain perennial use, the space will be covered to create an attractive microclimate by introducing winter garden with waiting areas, restaurant spill outs, and spaces for florists, newspaper stands and musical performances (Figure3. 23). This space will be managed and maintained jointly by MBTA and private developers. By introducing transit-related uses and other community services within the overall joint development, commuters will be able to engage in various activities before or after riding transit, do their shopping on the way home, and consolidating child-care trips with journeys to the transit station.

Under the parameters outlined to guide Lechmere as a free-market based development reliant on transit services, its urban form seeks to define a strong public realm through the integration of a variety of uses structured around high density pedestrian corridors (Figure 3. 24).

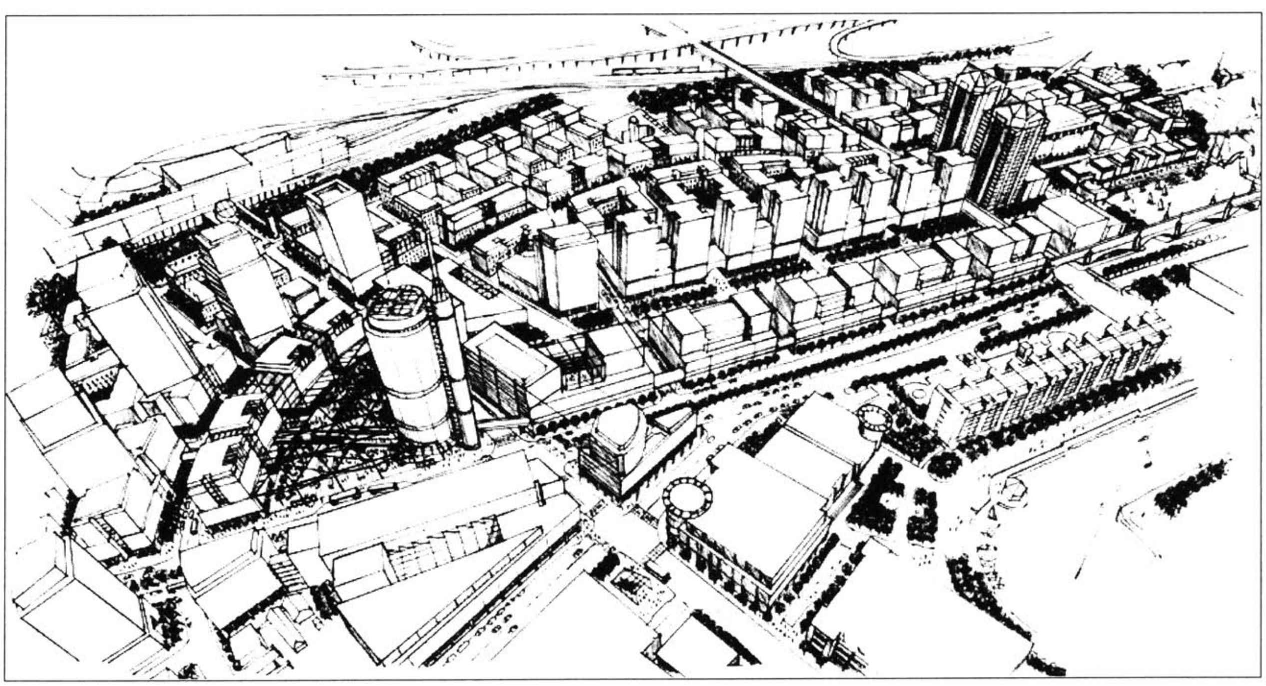


Figure 3.24: Schematic view of overall development

3.11 Design of Pedestrian Streetscape

Based on the philosophy that a transit ride does not begin when the user boards the vehicle, but rather at the moment (s)he sets out for the transit station, the design of the environment that commuters are exposed to becomes a critical factor in determining their dependency on transit services. Designing for automobility decreases the reliance of people on transit services. Moreover, if automobiles are used to reach transit stops, there are few environmental benefits of transit usage.[5] Therefore, advocating for better walking conditions and advocating for higher transit reliance are two sides of the same coin.

Given the fact that automobiles are here to stay, balancing pedestrian and vehicular traffic gains importance for supporting transit ridership. However, mitigating conflicts between pedestrians and automobiles does not necessarily imply a total prohibition of vehicular traffic or a segregation of their respective rights-of-way to avoid conflicts.

In Lechmere, automobiles, instead of being excluded, will be tolerated and controlled to ensure a safer passage for pedestrians. In order to enhance the pedestrian realm, and increase its compatibility with autos, the following measures and traffic-calming[6] initiatives will be applied in the design of the pedestrian streetscape:

Pedestrian Pavements: The required widths are established on the basis of the street type and the amount of anticipated pedestrian and bicycle traffic. The paving design will provide a sense of continuity in the fabric of old and new buildings to indicate building entries, street crossings, and spaces for special events (Figure 3. 25). All pedestrian paving will be separated from carriage-ways by granite curbing raised 4 inches from vehicular level.

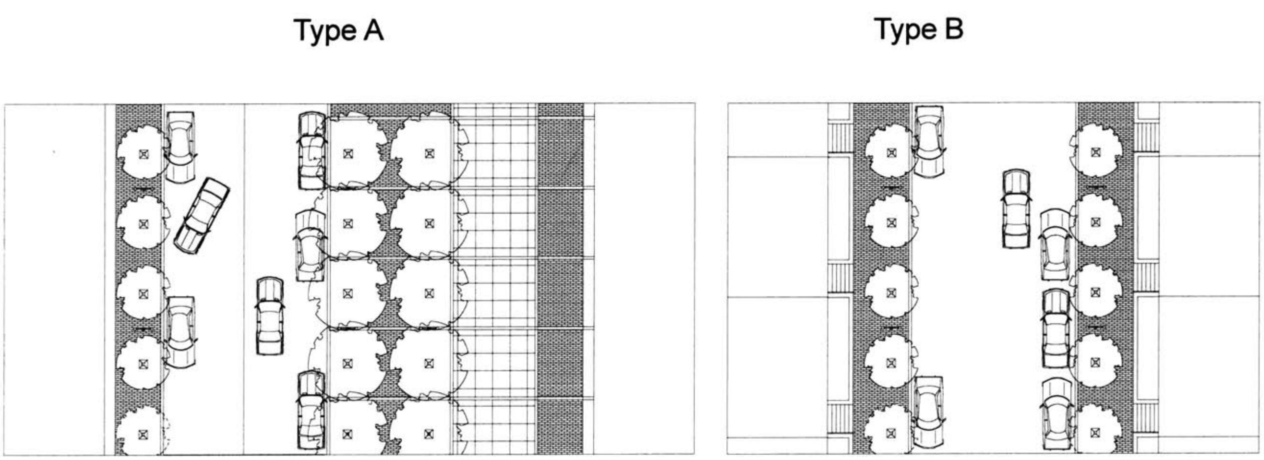


Figure 3.25: Paving details

Street Lighting: Street lighting will serve to provide both an aesthetic quality and suitable light levels for safety and security of pedestrians. Lighting fixtures will be used to emphasize street intersections, street seating and bicycle stands. In recognition of potential blockage of some light on pavements by tree plantings, street lighting will be augmented by "spill light" from buildings.

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[5] Rates of tailpipe emissions and energy consumption are disproportionately high for short access trips (due to the cold start phenomenon).

[6] Traffic calming implies slowing down driving speeds, improving traffic safety, lessening car dominance in the streetscape, increasing spaces for other street uses, controlling noise and exhaust, and increasing mobility of pedestrians and bicyclists.

Pedestrian Crossings: The design of pedestrian crossings involves narrowing of traffic lanes, widening of sidewalks at street intersections and raising them to the level of the sidewalk (Figure 3.26). This provision allows pedestrians to freely cross streets on a leveled surface, while cars will have to climb and descend a slight slope. This design, besides slowing the traffic, will also eliminate the possibility of clogging from storm water and snow that often occurs in conventional crossings.

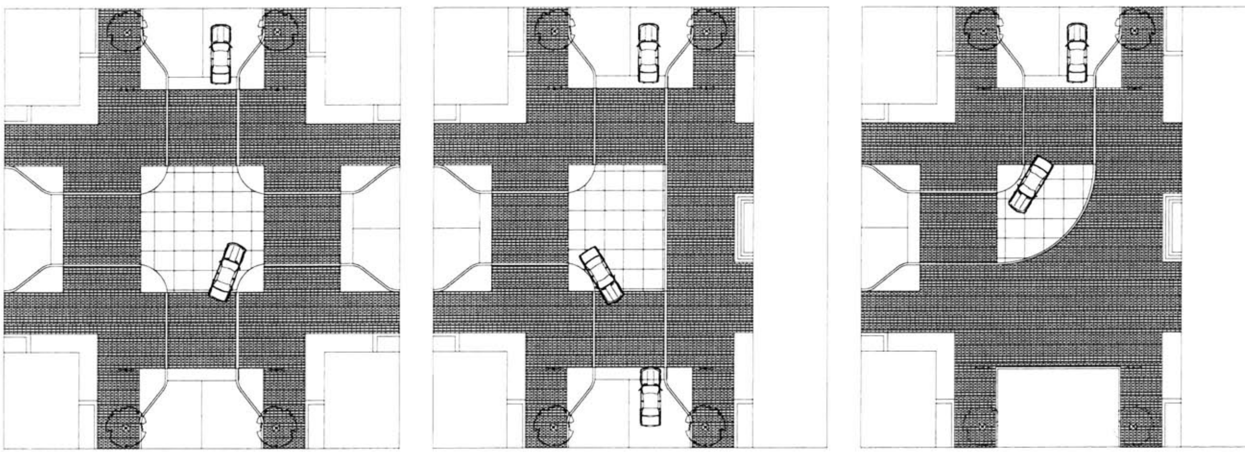

Figure 3.26: Pedestrian crossing details

Parking Standards: Plentiful free parking located adjacent to streets detracts from pedestrian activities and makes it convenient for auto owners to use their cars instead of transit. Therefore, parking provisions are rationed in this development. It places a ceiling on parking – tight maximums, but no minimums. A development will be allowed a maximum parking provision depending on its use and location relative to the transit station.

Use	**1//8 mile Zone**	**1/8-1/4mile Zone**	**1/4mile onwards**
Residential	0.7cars/unit	0.7cars/unit	1car/unit
Commercial	0.5cars/1000 sq. ft.	0.7cars/1000 sq. ft.	1car/100 sq. ft.

In the case of mixed-use developments, the parking standard is applied according to the distribution of uses. Curbside parking will absorb 20 percent of the total parking requirement. Besides reducing the building cost of parking lots and garages,[7] on-street parking also serves as a buffer/protection for pedestrians from auto traffic. Developers will be encouraged to build less parking spaces by using various incentives such as creating a *fee-in-lieu-of-parking*[8] option, 'tax cuts' and 'floor area bonuses'. Any parking spaces designated on/above grade will be counted into the FAR.

Structure Parking: Parking structures, although visually less unpleasant than vast strip-parking lots, are often large and lacking in pedestrian activity. Therefore, they are discouraged in this development. However, recognizing the need for parking, they are allowed to be built in a few critical locations. For instance, a few parking garages will be allowed on the sides of the Gilmore Bridge in order to utilize the 'unusable' space under it (where the clear height is less than 15 feet). However, the garages facing collector streets will have a preponderance of retail activity. Parking

[7] Typical costs: On- street parking cost - $2000 to $3000 per car space; On site open parking $3500/car space; Garage parking $12000 to 16000/car space. The figures do not account for the cost of land.

[8] Businesses contribute cash in lieu of providing parking. The fee is a set dollar amount multiplied by the number of parking spaces that would normally have been required for a given use.

structures located on minor open spaces will have pedestrian amenities at the corners or other important points. The blank facades of these structures will be covered by vegetation and well lit for pedestrian safety (Figure 3.27).

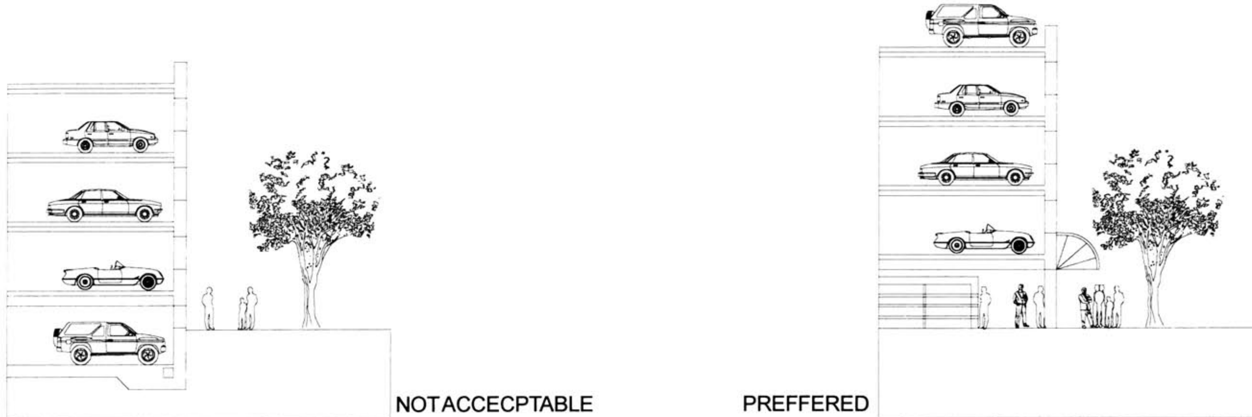

Figure 3.27: Design of parking garages

3.12 Design of Paratransit system

If pedestrian convenience were to be a true measure for the development of Lechmere, then the furthest distance a perswilling to walk to and from the transit stop might best define its boundary. On an average, a quarter of a mile (a five-minute walk) is a comfortable distance that people are willing to walk.[9] Hence, a quarter-mile radius from the Lechmere station becomes the area that its transit services can serve. Since the size of the Lechmere development is much bigger than a quarter-mile-radius area, the integration of paratransit services[10] with MBTA transit lines gains importance (Figure 3.28). This facility will attract people to use transit even during late hours and during harsh weather conditions.

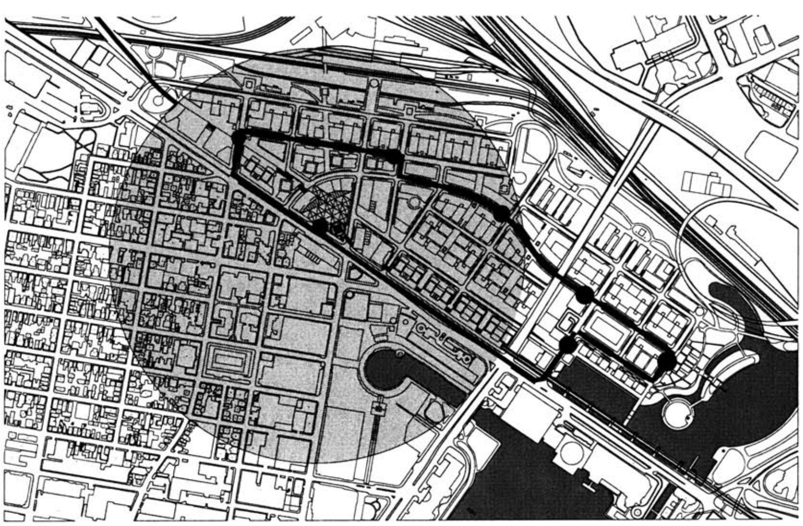

Figure 3.28: Paratransit

[9] According to the 1990 National Personal Transportation Survey, the average person walks about 1,500 feet or quarter mile to a transit stop. The number of people willing to walk longer distances drops off significantly when distances exceed 1,500 feet, and that is probably when others means of transport like cycle, car and bus begin to gain more importance.

[10] Paratransit represents the spectrum of vans, jitneys, shuttle, and minibuses owned and operated by private companies and individuals. They are smaller public carriers which is comparatively more flexible connecting multiple destinations, sometimes door-to-door service at a price below taxi.

Chapter 4: Conclusion

Through the study of and a design exercise in transit reliant neighborhoods, this thesis redefines "transit," not as a physical public-carrier, but as a well-integrated system of modes that together allow a free and flexible movement of people of all ages, physical abilities and incomes. A "well-integrated system of modes" implies a balanced use of different transportation modes according to their social costs (both economic and environmental), flexibility and autonomy: walking is prioritized over cycling, cycling over public transit, and transit over private cars. Such integration can only be achieved through a design of places that respects the mobility of pedestrians, referred to here as transit reliant neighborhoods.

The freedom with which a person can walk about and look around is a useful guide, not only for transit reliant neighborhoods but also for any civilized urban area. The Lechmere development highlights some of the issues that shape such places. The proposed development pattern in Lechmere is not very different from many high-density neighborhoods. However, what distinguishes it from the others is the tight hand-in-glove fit between transit services and the settlement pattern: its cityscape is physically and functionally oriented to transit. It is this harmony between transit services and urban form that will make Lechmere a place with high transit ridership.

While good quality urban designs are unquestionably essential for creating places of this calibre, they are clearly not sufficient in and of themselves. The challenges of designing a mass transit system in thinly spread development, with origins and destinations distributed evenly throughout the landscape, is a difficult proposition. Such settings produce randomly patterned trips, akin to Brownian motion (refer to Figure1.1a), seemingly going from anywhere to everywhere. With the ongoing decentralization of jobs and retail users to the suburbs, more and more commuters want to move tangentially, and are being forced onto transit (in the case of those who use it at all) that was never designed or oriented to serve these movements. As a result, what exists is a few islands of transit reliant neighborhoods in a sea of freeway-oriented low-density suburbs. This will do little to change fundamental travel behavior.

A key for making a neighborhood transit reliant is to ensure consistency in development at the regional level. While arguing that the design of the built environment can shape transit usage, the thesis likewise embraces economic determinism, based on the idea that if the true social costs of building at low densities were passed onto dwellers and developers, the marketplace itself would give rise to a built form that respects transit usage. It is certain that initiatives pertaining only to physical form are not cure-alls for increasing transit ridership. When combined with other demand-management strategies, they can exert a far greater and more enduring influence.

The underlying assumption of the design exercise – that the function of transit services is to supply the capacity to carry the population to where developers choose or are encouraged to build – raises a few concerns. Barring zoning restrictions and other restraints, the competition for locational advantages will drive up land values. In this respect, a transit oriented development might prevail into a place where lower-income residents, for whom transit is arguably more important, will get much less housing for their money. However, this issue of gentrification could be partially addressed through incentives for developers, such as tax cuts, to build mixed-income housing with subsidized units. This is where other financial incentives could also play an important role. Financial institutions could grant "efficient location" mortgages for home purchases to those living near transit nodes.[1] If living near rail nodes lowers transportation costs (mainly because the family need own only one car and developers will have to provide less parking spaces), then these savings might be subtracted from the principal, interest, taxes, and insurance expenses while qualifying applicants for home loans. This way, reduced transportation outlays will free up more money for housing consumption.

This type of development will most likely occur when and where there is the motivation and the means to break out of traditional, entrenched practices. This, of course, is no small feat in the public realm. Steadily eroding shares of transit in metropolitan travel are a telltale sign and, fresh, new approaches are needed to accommodate people from wider sections of the society. This thesis contends that places that appropriately adapt to changing times, varying demands, finding harmony between transit services and urban landscapes, are the places where transit stands the best chance of competing with the car through the next millennium.

To summerize some of the work of this thesis, the following principles define the parameters for transit reliant neighborhoods:

Principle 1: Urban Transportation Planning is a social, psychological, ecological, economical, architectural and engineering venture.

Principal 2: The prosperity of a city does not depend on private traffic, but rather on its internal accessibility which is based on the degree of mobility of its populace. The requirements of children, the elderly and disabled, and the poor need to be carefully considered.

Principle 3: Transportation and urban form, both local and regional, must be coordinated. While mixed land use must be achieved to reduce journey distances, high density should be encouraged to support public transportation.

Principle 4: Transportation modes should be encouraged according to the general affordability level and also their environmental implications. The order of preference should be (i) walking, (ii) cycling, (iii) public transit, and (iv) private car traffic, with the last being the least preferred.

Principle 5: Urban streets and open spaces are public easements that accommodate various walks of urban life as well as the various modes of transport. They are a mode by themselves, that facilitate walking, the most autonomous, self-determined and flexible movement of people.

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[1] J. Holtsclaw, *Residential Patterns and Transit, Auto Dependence, and Costs* (San Francisco: Natural Resources Defense Council, 1994).

APPENDIX A : Data of Neighborhoods within 1/4 Mile Radius Of Train Stops

SUBWAY STATIONS	ID	%AUTO USE	TOT % OF TRANSIT USE	% USE OF TRAIN	% WALKING	NEIGHBORHOODS DENSITY (PPS)	MEDIAN INCOME ($)
	5	90.9	0.0	0.0	4.3	1.540	25858
	10	90.7	4.3	0.0	0.8	0.539	36561
	11	84.0	3.2	0.0	7.8	2.972	25178
	12	91.2	2.1	0.4	2.5	2.930	33082
	13	99.0	0.0	0.0	0.0	1.662	47071
	15	94.8	1.7	1.7	0.8	0.387	45499
	16	89.3	5.5	0.3	4.5	9.585	23149
	17	69.7	16.3	7.0	10.9	16.222	14054
	18	85.8	5.4	5.3	8.3	6.640	26093
	19	93.7	2.0	1.8	3.7	4.096	38346
	20	88.1	9.1	7.9	0.9	0.898	58420
	21	88.0	7.6	7.3	0.8	1.386	54256
	22	94.4	5.3	2.1	0.0	3.584	38347
	23	89.3	6.6	2.1	2.2	6.620	36107
	24	86.6	6.5	6.5	1.1	1.008	65231
	25	88.8	5.4	4.3	5.7	6.724	33424
	26	84.0	10.2	10.1	1.7	1.249	45140
	27	81.1	11.6	11.6	1.1	0.906	47373
	28	89.3	4.6	3.8	1.7	3.164	49730
	29	95.6	2.7	2.2	0.8	3.095	40155
	30	77.2	4.8	3.7	16.1	2.174	44173
	31	85.3	9.2	9.0	2.0	4.406	40078
	32	85.8	7.6	7.6	2.9	3.336	40044
	33	81.1	14.7	12.0	2.4	5.819	43894
	34	99.9	0.1	0.0	0.0	0.614	46948
	35	76.9	16.2	13.2	5.4	7.176	32792
	36	88.8	4.0	3.7	3.3	5.589	39101
	37	85.2	9.3	7.5	4.0	5.572	44066
	38	89.7	6.9	6.4	1.1	1.964	61738
	39	84.7	7.7	6.2	2.6	3.327	52246
	40	83.5	6.5	3.2	6.2	3.884	41464

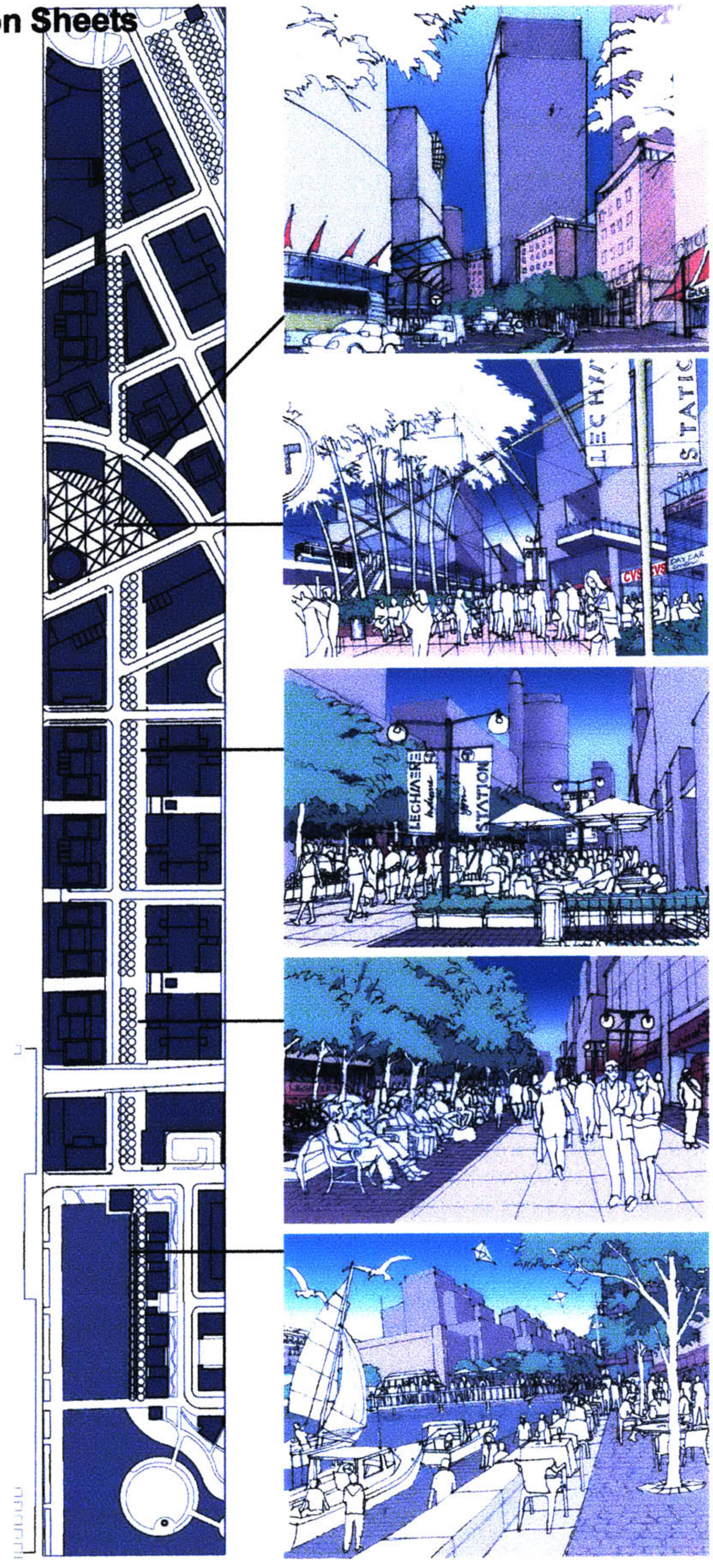
41	87.7	4.8	0.0	0.0	1.996	42273
42	86.0	11.6	7.9	1.4	6.319	36543
43	89.9	4.8	4.8	1.7	1.980	52866
44	82.2	10.4	10.1	3.1	6.091	50337
45	76.2	19.4	12.5	2.0	6.963	38109
46	82.2	10.7	2.4	4.3	1.575	49009
47	82.9	10.4	2.0	2.1	1.255	53401
49	63.6	27.4	24.8	8.7	11.173	31376
50	62.5	26.4	20.1	8.9	13.314	27731
51	73.2	17.1	11.4	5.0	12.363	27175
53	90.2	1.5	1.5	1.3	0.495	59515
55	80.1	12.4	12.0	3.0	6.437	56814
56	79.4	12.4	11.8	3.1	5.529	59554
57	84.7	5.3	3.3	9.2	7.100	24353
58	80.0	15.7	12.0	0.8	11.945	42436
59	79.5	9.0	7.4	5.9	6.788	53602
60	58.5	38.3	12.7	0.6	29.335	22965
61	84.7	12.1	11.5	0.9	6.224	50785
62	75.8	19.1	14.1	3.1	12.796	48224
63	85.4	6.0	5.2	6.2	7.238	44266
64	74.6	19.8	14.3	2.5	19.709	46784
65	65.7	29.5	16.8	3.1	16.732	35402
66	85.5	7.4	6.3	3.4	6.437	55144
67	77.3	11.6	11.2	6.5	7.085	51763
68	46.2	46.1	34.7	6.9	16.151	30963
69	73.2	10.5	10.0	9.5	3.831	88242
70	60.7	28.6	12.3	8.1	31.800	27143
71	79.6	10.8	9.4	2.6	4.051	106680
72	23.8	37.5	16.7	36.5	31.235	9842
73	89.6	7.6	1.0	0.8	0.849	101800
74	79.9	10.2	5.7	4.1	7.295	54806
75	79.0	12.2	1.7	2.9	7.912	65631
76	16.7	29.2	22.1	50.5	52.208	20511
77	29.9	28.4	21.7	35.9	37.347	41030
78	75.3	14.8	7.9	4.1	8.996	45995
79	22.8	15.7	13.0	39.5	2.554	13341

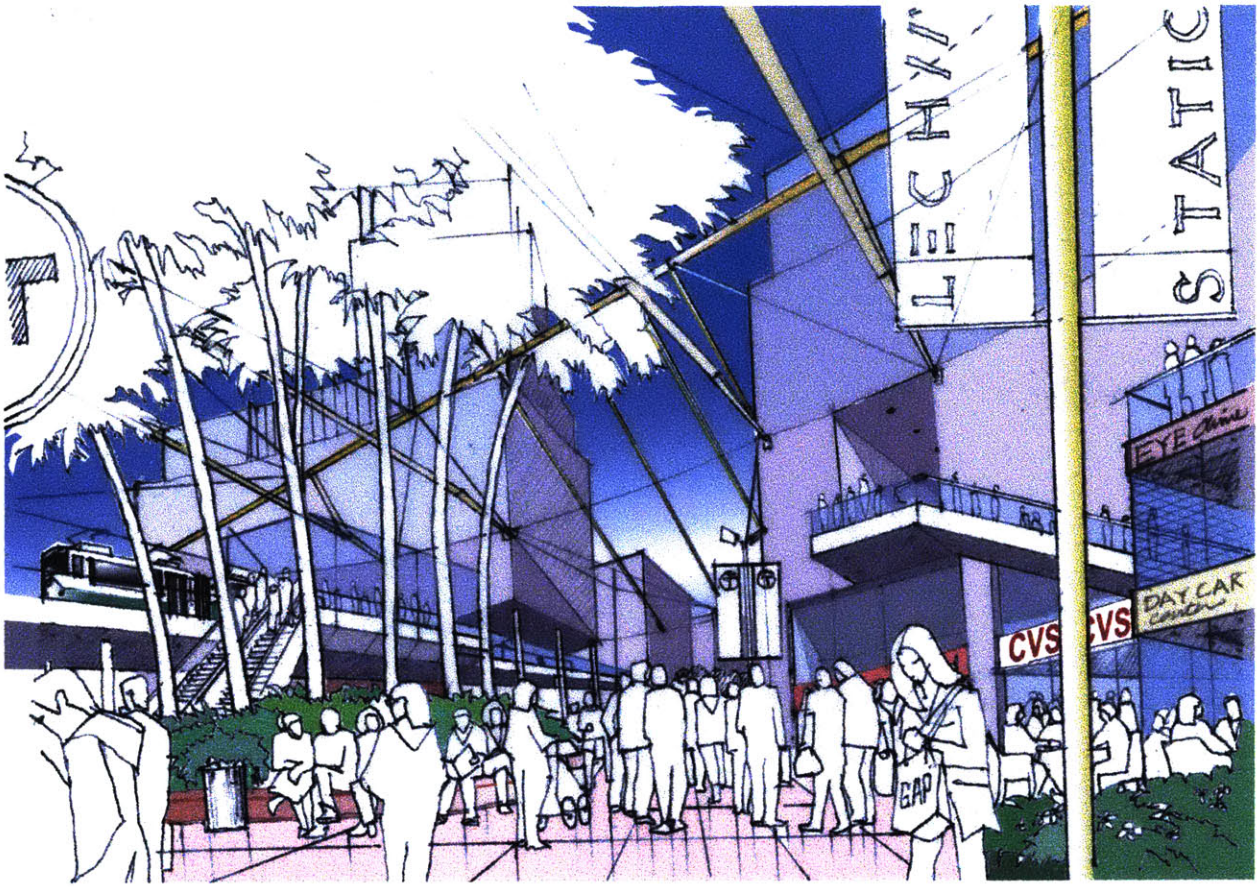
80	51.0	4.7	2.9	41.7	7.534	39051
81	22.5	27.9	21.3	46.9	16.700	31347
82	75.8	11.2	3.2	11.1	14.653	21683
83	75.2	10.1	6.0	3.4	1.164	111356
162	45.5	43.6	29.3	6.7	22.179	41658
163	52.1	33.3	26.3	7.5	20.482	53361
164	27.4	39.7	20.0	29.2	40.362	18831
165	42.2	48.9	32.3	6.3	35.594	35734
166	23.4	37.2	17.0	37.2	34.115	9766
167	49.3	39.6	27.0	6.8	30.950	41989
168	49.8	36.9	27.0	7.5	28.628	43959
169	19.8	34.6	18.3	41.1	34.756	13468
170	44.1	48.8	32.9	5.8	49.473	28835
171	48.3	36.0	27.0	9.5	28.666	45469
172	48.4	34.4	25.5	11.4	30.487	39892
173	55.5	37.1	25.9	5.4	32.790	30610
174	49.0	33.6	24.5	11.2	32.353	38231
175	48.1	34.3	25.7	11.8	36.333	36771
176	55.9	32.3	16.1	9.5	16.815	33713
177	46.1	47.2	29.5	5.2	57.756	26492
178	19.1	37.7	28.9	40.3	66.858	17886
179	58.3	30.5	15.3	8.3	12.277	43171
180	47.4	33.0	24.8	15.2	42.241	35127
181	43.5	47.9	29.8	7.0	57.253	27302
182	40.2	49.4	32.3	8.4	54.774	26864
183	38.5	28.1	23.4	26.7	21.582	35749
184	29.3	36.1	24.8	30.7	63.489	27636
185	50.3	29.1	19.9	17.1	40.766	38323
186	25.0	36.4	27.2	35.6	70.742	23416
187	51.9	26.4	18.3	16.7	31.746	40649
188	38.5	25.4	18.1	31.2	3.590	19244
189	35.5	52.8	37.1	10.1	54.620	22939
190	50.0	25.8	21.5	16.5	25.572	40752
191	20.7	35.7	29.7	39.9	35.992	20438
192	41.3	30.1	26.8	21.1	24.471	36633

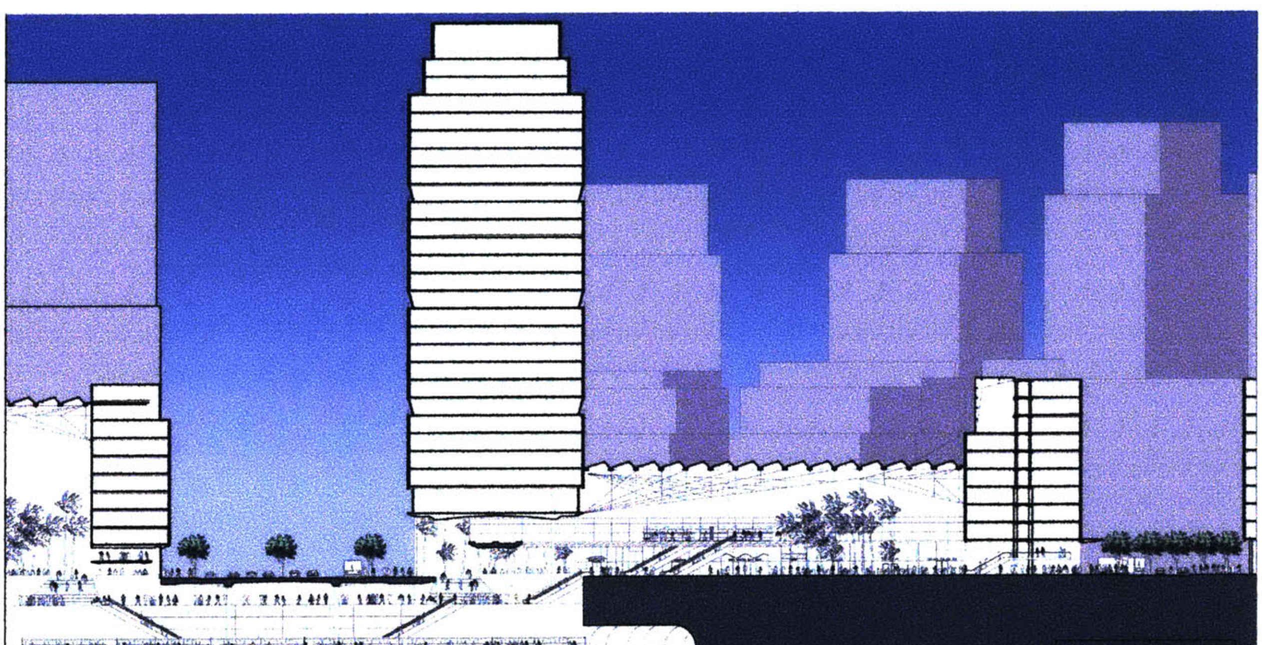
	193	35.4	52.5	38.8	10.3	53.198	21871
	194	23.7	34.4	29.5	37.6	36.856	24570
	195	31.7	32.5	25.0	31.5	39.136	33857
	196	30.0	28.6	22.0	35.6	35.474	40366
Hynes Convention Center	**197**	**27.7**	**34.3**	**26.5**	**34.2**	**55.670**	**28265**
	198	36.8	50.4	35.3	11.1	66.327	21344
	199	37.4	49.9	34.2	10.9	51.609	20879
	200	36.0	50.4	34.7	11.9	69.194	22567
	201	16.9	30.2	22.5	48.6	59.240	21392
	202	12.3	27.7	22.6	55.9	53.962	20167
	203	9.4	27.9	23.4	60.0	48.068	17894
	204	31.4	22.0	17.5	40.1	35.460	16279
	205	10.8	25.6	20.8	60.2	37.826	19798
	206	34.7	50.2	34.8	13.8	60.201	23373
	207	25.7	23.9	18.6	43.7	41.046	42498
	208	37.7	47.8	33.9	13.0	51.999	26413
	209	39.3	21.6	16.2	32.2	18.769	40235
	210	50.2	24.2	16.7	19.7	24.379	36295
	211	48.0	30.7	20.7	17.9	31.022	34143
	212	39.3	44.6	32.1	14.4	44.672	27696
	213	44.1	37.2	25.8	16.3	35.639	31821
	214	27.5	13.4	8.6	52.7	21.377	34451
	215	23.1	18.3	15.5	37.0	3.468	13427
	216	25.5	27.7	22.1	39.3	23.758	15077
	217	24.6	26.9	21.8	41.5	19.672	14692
	218	18.9	28.1	22.7	42.8	13.128	22711
	219	18.8	22.3	17.9	52.1	18.108	33859
	220	17.3	23.1	17.4	51.0	13.824	36577
	221	15.2	24.1	18.9	52.8	15.511	38913
	222	32.8	13.5	11.9	50.2	24.487	46166
	223	19.7	23.1	20.4	52.4	62.924	36916
	224	16.2	24.3	20.3	54.4	27.202	36462
	225	16.4	11.8	8.1	65.6	3.773	31200
	226	21.0	26.5	21.0	48.4	37.955	28195
	227	38.4	33.4	20.8	24.9	39.776	25580
	228	21.7	29.6	23.2	46.1	30.621	28622

Science Park	**229**	**37.2**	**20.8**	**13.2**	**39.3**	**24.077**	**28640**
Maverick	**230**	**40.9**	**45.3**	**39.3**	**11.4**	**37.429**	**19220**
Lechmere	**231**	**49.9**	**27.1**	**18.6**	**21.2**	**10.525**	**31836**
Airport	**232**	**49.4**	**37.9**	**28.9**	**12.1**	**22.284**	**22503**
	233	47.7	28.3	16.9	22.2	8.857	36198
	234	12.5	14.8	7.7	69.1	32.746	26642
	235	54.4	37.5	22.0	4.5	9.920	26230
	236	56.3	36.8	22.3	6.6	10.052	28694
	237	56.7	39.2	33.7	3.1	15.400	29769
	238	46.1	34.3	27.0	15.9	31.500	36008
	239	56.9	37.7	33.1	3.1	5.707	32617
Alewife	**240**	**63.2**	**26.8**	**16.4**	**6.7**	**5.312**	**34815**
Davis Square	**241**	**48.8**	**39.2**	**32.6**	**8.3**	**32.472**	**35246**
	242	63.8	29.7	26.6	4.2	12.898	23686
	243	80.6	16.1	11.1	1.7	7.426	39733
	244	54.0	38.0	34.1	4.1	25.920	20885
	245	55.8	38.0	28.9	3.4	11.510	30993
	246	57.7	31.4	27.8	7.7	17.056	25603
	247	65.5	27.5	23.2	5.5	13.863	33081

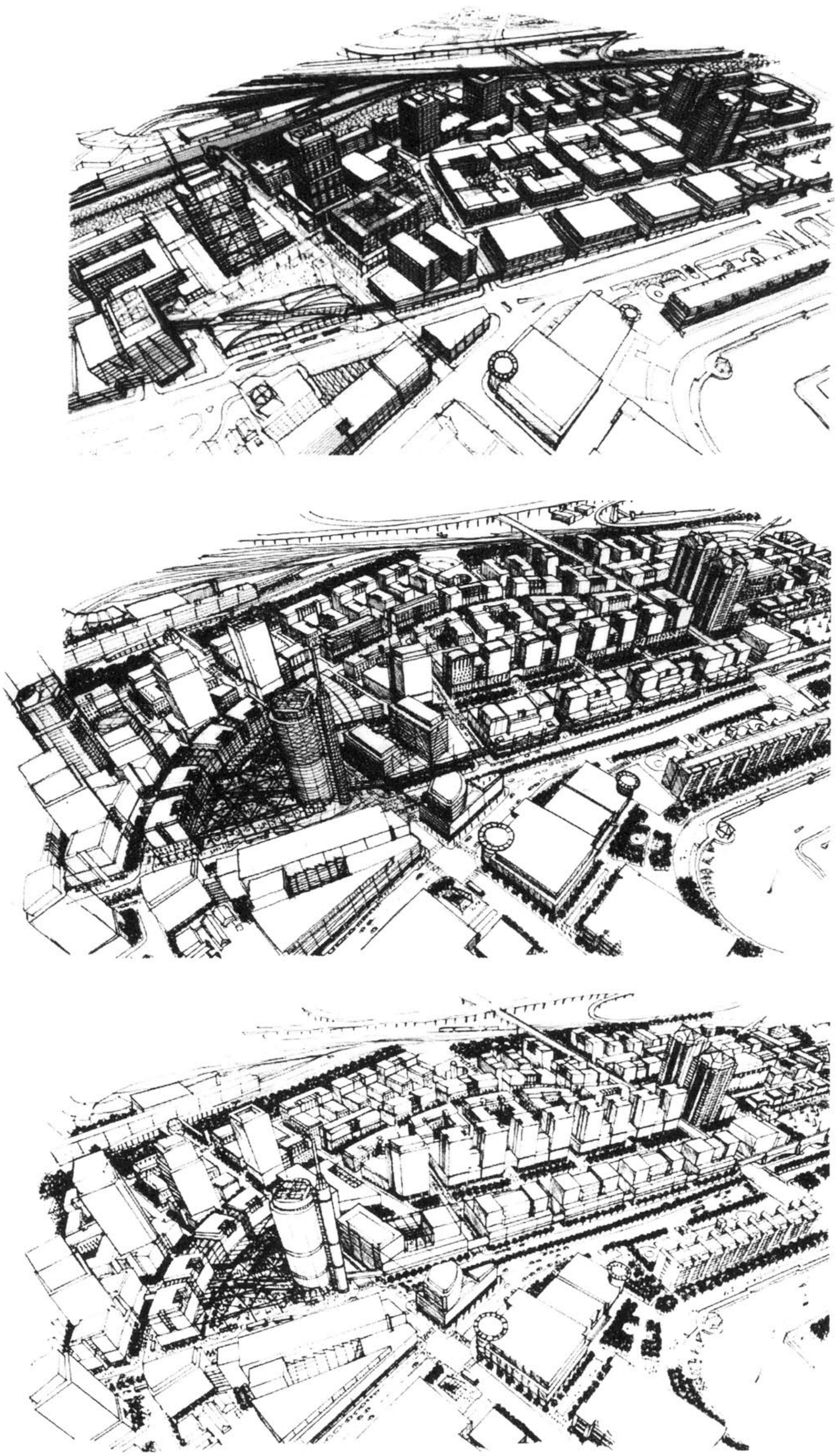
APPENDIX B : Presentation Sheets







Lechmere Station Design



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List of Illustrations

Chapter 1: Case for Mass Transit

Chapter 2: Visitng Subway Neighbourhoods

Chapter 3: Exploring Transit Reliant Development

Note: Figures, unless otherwise mentioned are the property of the author.