Breaking the Automobile Addiction: A Vision for Transit-Oriented Development in Seattle

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Abstract

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Cities have recognized the need to shift to a more walkable, transit-friendly urban form to reduce reliance on the personal automobile. Since the concept of transit-oriented development (TOD) was coined by Peter Calthorpe in the late 1980s, it has become a buzzword–along with walkability and pedestrian scale–used in virtually all visioning plans, comprehensive plans, and master plans, yet the implementation of these concepts in the United States is poor at best. Conflicting priorities, differing demands, or a disregard for context-specific solutions often result in projects that do not achieve the stated goals. Developments continue to cater to the automobile and little incentive exists to encourage different behavior. This research aims to identify and explore the best examples of how other U.S. cities have successfully integrated TOD into existing communities, and compare these to completed and planned developments in the Seattle metropolitan area.

This thesis compares TOD projects in three other states (California, Colorado, and Oregon) with three projects in Seattle, Washington. The comparison focuses on the degree to which certain physical characteristics typically associated with walkable and transit-oriented developments–density, proximity and diversity of businesses or services, and demand management of automobiles (namely parking)–are

present in Seattle and how those characteristics are prioritized to meet specific needs of the project area. By understanding how to balance the TOD elements with the needs of the neighborhood through a case study exercise, recommendations can be provided to guide future TOD in Seattle and other U.S. cities to achieve a reduction in automobile reliance, and an increase in walking, cycling, and public transportation use.

There is no single recipe for a successful TOD development. The most successful TODs are those that balanced the TOD elements to respond to the needs and existing elements of the neighborhood depending on its characteristics and context. For example, TOD in urban areas should prioritize vehicle demand management strategies while taking advantage of the existing density and destinations. Suburban retail center environments should prioritize building up a stock of dense residential housing but may rely on the adjacent destinations and services that already exist in the area. Working within the existing urban context and applying TOD elements in ways that correspond with the character of the neighborhood offers the best foundation to drive change in the urban environment.

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Introduction

Since the introduction of personal automobiles, the allure of freedom and independence, combined with heavy investment in infrastructure to support them, has led to a dependency that borders on addiction. Today's urban environment is designed around the scale of the automobile, as opposed to that of the pedestrian. Wide streets, vast parking lots, little landscaping, and small sidewalks sprawled over acres of land all play a role in making pedestrian travel unsafe, unenjoyable, or simply unfeasible. With public transit investments only scratching the surface, climate change looming, and traffic levels and urban growth at all-time highs, cities are left with no choice other than to change the formula that has brought them down this road. The car can no longer accommodate the demand placed on it and development cannot continue to be built around complete reliance on a car for all transportation needs. Proof that the auto-centric development patterns are unsustainable continues to mount as the U.S. population continues to grow and become increasingly urbanized. Roadway congestion, pollution, unstable fuel prices, and the growing costs of buying, maintaining, and housing vehicles are reaching a tipping point. Urban sprawl has grown hand in hand with the growth of the automobile industry, while fostering generations of automobile dependency. American cities are overdue for a revisioning of the urban form and transportation networks to respond to the needs of current and future generations. In urban environments, reliable, highly frequent, and efficient public transit must become the backbone of transportation supported by dense, mixed-use development where daily needs are accessible by walking or biking. A change of this scale, while no easy task, is underway. Pioneered by a handful of transit agencies, cities, and developers, transit-oriented development (TOD) projects have been constructed and are proving to be generally successful in lowering automobile dependency and fostering an urban environment where residents have access to excellent public transit, a wide range of destinations, education, employment and entertainment just a few steps away.

This thesis explores TOD from a distinctly American perspective, in which cities are heavily reliant on automobiles and craft their urban form to embrace them. It should be noted that, despite the characterizations made here, the urban environment and its typologies are broad, as are the needs of its inhabitants. Similarly, TOD is characterized here as a narrowly defined typology for the sake of simplicity

and clear differentiation, however, the urban environment is more fluid. TOD is merely a general title for developments which shun the automobile as primary transportation in favor of a typology better suited for walking, biking, and public transportation. A multitude of benefits can be realized through a reprioritization of urban transportation and corresponding transition of the urban form away from the automobile. Despite the issues presented in the following chapters, the personal automobile can and will continue to serve an important transportation role, but is better suited to specific applications. It is not a blanket transportation solution for the current needs of all Americans; thus, it cannot be completely eliminated from the urban environment. The evolving nature of the city means there will be no single solution to address the issues raised below and that success in a specific environment does not necessarily mean it can be applied to all. The overarching goal of this research is to encourage the reader, as a steward of the urban environment, to step back and consider how reprioritizing transportation and development priorities at a large scale can result in a more sustainable and equitable city no matter where they are located.

Problem Statement and Research Question

Reducing automobile dependency in favor of alternative transportation options for Americans is a monumental task that will require decades and heavy investment (urban infrastructure - mass transit, etc.). These changes will not happen quickly, but must be gradually incorporated into all aspects of zoning code, construction, development and real estate with the eventual goal of achieving a complete overhaul of the urban form for every American city and a paradigm shift in behavior for the typical American. Cities must work towards gradually reducing automobile dependency by increasing the allure of alternatives, thereby directly influencing user decision-making towards more positive outcomes, rather than depend on negative reinforcement and penalties. To that end, concepts such as transit-oriented development (TOD), New Urbanism, and the 15-Minute City are not new, but they have become buzzwords in master plans, vision statements, growth policies, and comprehensive plans in recent decades. Their specific goals vary, but the concepts all are united around reducing automobile dependence through solutions such as, increasing density, pedestrian-friendly infrastructure, and mixed-use development. Providing more destinations in proximity to homes with convenient access to alternative mobility can encourage residents to complete more trips by foot, bicycle, bus, or train.

Developments advertised as TOD can be found almost anywhere. Found in all major metropolitan areas, these developments, which are simply built next to a transit station, qualify as transit-adjacent development, or TAD. Limited by ancient zoning codes, community resistance, political pressures, market demands or financial barriers, TAD does not generate the behavioral change that is needed to escape the multitude of crises currently afflicting the nation as a result of car dependence, such as the looming climate change catastrophe. Few cities, developers, or citizens are willing to commit to a completely different built environment. Effective TOD requires commitment, planning, and flexibility at all levels and by all parties involved. It is a massive shift from current lifestyles and the half-hearted piecemeal approach is not impacting behavior at the speed needed to affect real change. A critical balance of elements, including commercial destinations, residential density, careful vehicle demand management, improved pedestrian infrastructure, and robust transit, is a minimum for successful TOD with long-term sustainability. Only a few examples of great TOD exist in the United States. This thesis will explore a selection of those developments to understand the key elements and implementation strategies that contributed to their successes, and compare them to recent projects in the Seattle, Washington metropolitan area to answer the question: How can Seattle implement TOD in existing neighborhoods to achieve maximum reduction in automobile reliance?

Literature Review

Urban Sprawl and its Impact on Travel Behavior

Patterns of land development, transportation, and movement have evolved throughout the centuries of human existence. “Until the Industrial Revolution, there was pretty much only one way for most people on dry land to get around: on foot” (English 2019). Due to that constraint, “most cities from the ancients to the Industrial Revolution did not grow much bigger than a two-mile diameter” (English 2019). It wasn't a question of designing for walkability, it was the standard. Upon the introduction of railroads and trolleys, the first major sources of public transportation, suburban towns sprang up around major cities. Those working in industrial or office buildings in the city could still access employment while having a better quality of life residing away from the city center. Walkability remained important, but with the greater travel distances afforded by the public transportation innovations, city boundaries grew and

the urban fringe became less distinct. Around the turn of the century the introduction and adoption of the automobile profoundly increased the freedom of the individual, allowing houses to be built anywhere with road access. Demands for suburbanization continued to mount as “state governments began to adopt zoning and subdivision reform in the 1920s, and in the 1930s the New Deal brought federal involvement with mortgage insurance, highway planning, and public housing legislation. These reforms set the stage for mass middle-class suburbanization in the postwar period, which was complemented by massive public transportation infrastructure investment in the Interstate Highway System” (National Research Council of the National Academies 2009). The use of the automobile skyrocketed. “By 1930, 23 million cars were on the road, and more than half of American families owned a car” (National Museum of American History 2017). The growth continued well into the 1950s as the Great Depression ended, World War II (WWII) came and went, and the American Dream was formed. The period of growth, wealth, and stability in the 1950s onward cemented the automobile as the primary mode of transportation. Sprawling single-family housing developments, strip malls, and suburban office parks became standard. Public investment in alternative transportation options became nonexistent. Mass transit options dwindled and walkability was no longer a concern to planners and city officials. The wholehearted adoption of the automobile meant there was no turning back.

“As early as the mid-1960s, however, many observers began to see that low-density and separated uses, which encouraged automobile dependence, would cause as many problems as they solved. As the environmental movement was born, critics of mass suburbanization began using the phrase urban sprawl to describe the low-density, dispersed, single-use, automobile-dependent built environment that— in their view—wasted energy, land, and other resources and exacerbated racial divisions” (National Research Council 2000). Sprawl has continued as the standard practice, despite the rather quick realization that the disadvantages would soon prove disastrous. “Peter Calthorpe codified the concept of transit-oriented development (TOD) in the late 1980s and, while others had promoted similar concepts and contributed to the design, TOD became a fixture of modern planning when Calthorpe published ‘The New American Metropolis’ in 1993” (Carlton 2009). TOD was seen as a response to the unchecked sprawl, and embrace of the single-family home and automobile that followed WWII. Carlton’s conclusion, which provided the basis for this research, states, “Across the U.S. there are too many things

impeding TOD development: free and excessive parking, poor pedestrian environments around transit, poor-quality transit service, incorrect mixes of land uses near transit, lack of transit link between housing and jobs, and antiquated zoning codes." (Carlton 2009) These elements remain roadblocks to transit-oriented development, walkability, and density in virtually every U.S. city.

After decades of disinvestment, the infrastructure of alternative transportation modes remains poor. Sidewalks, bus networks, and commuter rail services, for example, are subpar compared to historic counterparts and international peers, all while infrastructure to support the automobile enjoys generous government support and substantial private investment. Despite the issues stemming from complete reliance on the automobile, it remains the primary mode of transportation for the majority of Americans. Surface parking is almost always available, in favor of higher housing densities which could occupy the site instead. Roads are fast and wide to accommodate cars, rather than pedestrians. The alternatives simply cannot provide the same service in this automobile-centric environment. Users have little incentive to change their behavior to reduce automobile reliance. Therefore, the cycle of automotive reliance is perpetuated. The cycle of disinvestment in alternatives and enforcement of an automobile centric urban form must stop in order to encourage the behavior change that is desired.

What is TOD?

Transit-oriented development, typically shortened to TOD, is an urban planning concept which prioritizes development patterns that reduce dependence on the personal automobile. Although there is not one agreed-upon definition, the Transit Oriented Development Institute states, "It's the creation of compact, walkable, pedestrian-oriented, mixed-use communities centered around high-quality train systems" (Transit Oriented Development Institute n.d.). The 15-Minute City concept, closely related to TOD, but focused more on the relationship between the residential and commercial destinations, states that "Everyone living in a city should have access to essential urban services within a 15-minute walk or bike" (15-Minute City Project n.d.). Both of these concepts heavily prioritize walkability and pedestrian connectivity since walking is the most compact, efficient, and readily available transportation mode. Land use is organized to favor access to and from the transit station by a pedestrian as opposed to a car. Smaller scaled streets, no surface parking lots and wide sidewalks are just a few physical elements

typically present in a TOD. Trips that once needed a car can now be done either locally, by walking or biking, or regionally, by using public transportation.

The transit element of TOD is one of the most important considerations in the overall success of the development. For the residents and visitors, the transit must provide service that is convenient, frequent, reliable, and available at all times. In order to commit to car-free building or living, both TOD developers and residents must be confident that the transit alternatives will operate satisfactorily in the future, not just at the current time. For this reason, existing TOD is often limited to rail-based infrastructure since the investment is inflexible once completed and offers the most surety of future utilization. Bus systems, even bus rapid transit (BRT), are typically not as favored given the more flexible nature of the infrastructure, thus less guarantee of future service. In addition, the hours of operation, reliability, and frequency are often below that of high-quality light rail or commuter rail systems. However, bus-based BRT can serve the same function as light rail when implemented well and should not hinder TOD options or implementation in urban areas in need of alternative transportation. Their flexibility and lower investment costs can be beneficial in terms of building up a solid transportation network to serve as a base for BRT. BRT-based TOD merits consideration and further research. For the purposes of this thesis, only rail-based TOD sites were considered.

What do transit-oriented developments look like?

- They are centered around public transportation that is frequent, reliable, and continuous in order to serve the needs of all users, not just peak hour commuters.
- They are dense. Neighborhoods need a high level of residential density to support the necessary number of commercial enterprises to satisfy the daily needs of those residents. Density, usually measured as dwelling units per acre, is based on a number of factors, including how large each unit can be, how many units are stacked together on the same parcel of land, and how large each parcel is. In the case of a TOD, density increases typically come from constructing taller buildings, but can also be achieved through a reduction of personal automobiles, which can remove the need for wide streets, parking areas, and large garages. Space which was traditionally needed to

support the automobiles associated with residents can instead be used for additional dwelling units or other destinations.

- They are walkable. The area must be accessible and comfortable to move about on foot or with compact vehicles such as bikes, wheelchairs, etc., such that residents would choose walking as the preferred mode over the personal automobile. Any needs that cannot be addressed within a reasonable walking radius should then be accessible via a frequent public transit system.
- They are mixed-use. Instead of dividing land uses by type and requiring travel to various parts of the city to satisfy daily needs, the various destinations are located as close as possible to the users. This reduces the personal transportation required on a daily basis and reduces the overall distance traveled. More trips can be completed by walking or biking.

TOD should avoid;

- Personal automobiles. While the car retains an important role in providing transportation options in rural areas, special situations, and for unique trips, their presence in the urban environment should be minimized as much as possible in favor of more efficient forms of transportation better suited to a smaller urban scale.
- Parking. Surface parking lots and parking structures detract from the pedestrian experience and are more effectively utilized as space for housing, businesses, or green space. Constructing parking only encourages greater car use.

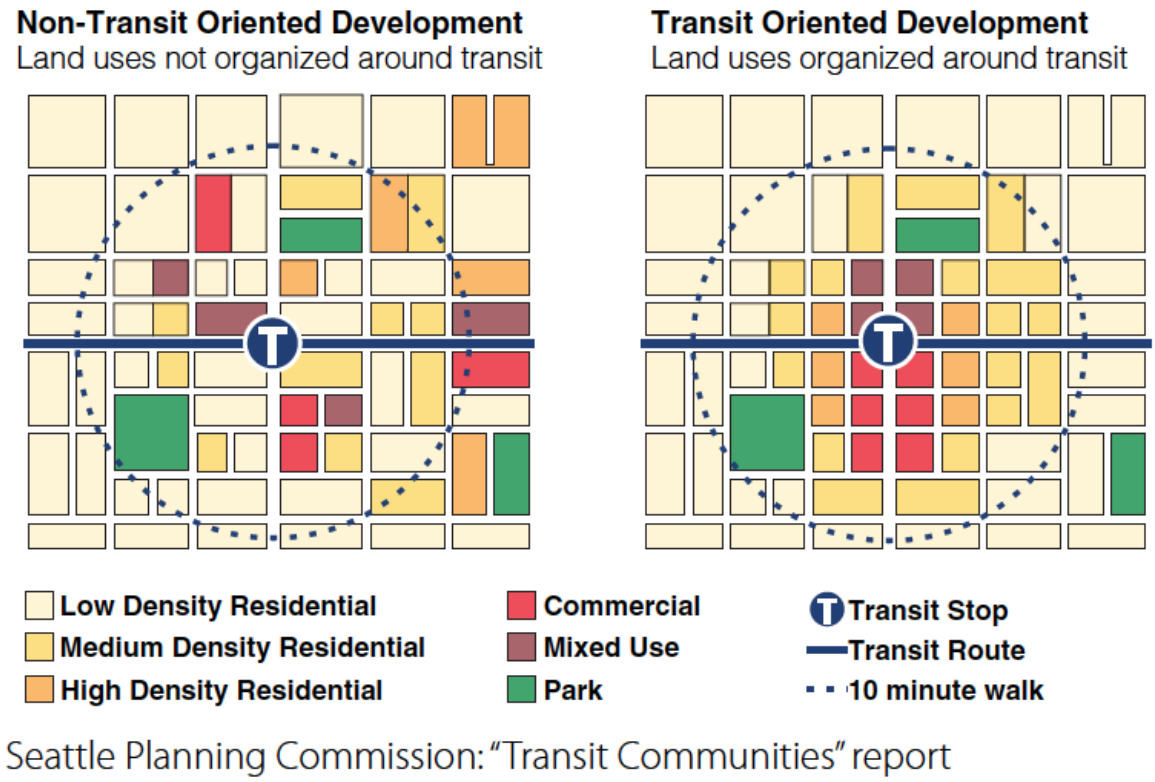

Figure 1: Transit Oriented Development Land Use Schematic, http://courses.washington.edu/hstaa208/items/show/1000

As shown in Figure 1, the land uses on the right are organized around the transit station, instead of a more sporadic layout (depicted on the left) where an automobile would be required. In addition, the parcels closest to the station support the highest density. Density reduces as the distance from the station increases. TOD is a tool, representing a style of development that deprioritizes the personal automobile in favor of walking, cycling, and public transportation. By locating housing, offices, retail, and other services close to transit, TOD can reduce traffic congestion, lower greenhouse gas emissions, improve air quality, benefit residents' health, reduce expenses, and create more livable and sustainable neighborhoods.

Success is typically measured by reductions in VMT, or vehicle miles traveled, per capita. "Vehicle miles traveled (VMT) per capita is calculated as the total annual miles of vehicle travel divided by the total population in a state or in an urbanized area" as defined by the U.S. Department of Transportation (2015). Reductions in VMT represent either reduced total travel or a shift to alternative modes of transportation. It is considered a reliable source of data at a broad scale and research has been

able to directly correlate VMT to the type of urban environment. “VMT levels are lower in communities that are more walkable and compact and in communities that have strong public transportation systems. Increased population density is also associated with lower VMT per capita” (U.S. Department of Transportation 2015). VMT reductions and TOD strategies are very closely related and, therefore, serve as good indicators of success.

Why TOD?

TOD is a response to the decades of ever-larger developments sprawling across the American landscape. The continual outward movement of low-density development and the subsequent reliance on the automobile as the sole source of transportation has brought about congestion and pollution issues due to the number of cars on the roads. The cost of current development patterns is enormous given the extreme inefficiencies of the automobile and its use patterns. Nearly all aspects, from its use to storage and fuel source, leave room for improvement. Most automobiles sit unused at least 95% of the time, taking up a parking spot of around 160 square feet (Schmitt 2016). In addition, when they are used most of the energy used is to move the weight of the car itself, rather than the passenger. When in use, a car only carries an average of 1.6 people, and the majority of trips are distances that are short enough to easily walk or bike for those who are physically able — 28% of car trips are one mile or less (Schmitt 2016). The network required to support the car is one of the largest land uses in a city and requires an outsized investment to build and maintain. It is clear that more effective and efficient forms of transportation exist for urbanized regions. TOD proposes a new model, one that is no longer reliant on the automobile, and which offers a host of other benefits, including increased health, socialization, and transit ridership, as well as reduced costs, environmental burden, and waste.

The benefits of TOD, when considered at a high level, apply to virtually everyone. Lower road usage benefits the remaining users by reducing congestion, municipalities have lower infrastructure maintenance costs, transit providers experience higher ridership, and residents experience the full range of benefits highlighted below. While transit-oriented developments should not limit the types of residents who might occupy them, the nature of their designs make them especially well suited for young adults or students who are generally more likely to occupy small apartment units or studios. Larger dwelling units

are harder to accommodate, though still possible. Large families typically have a wider variety of destinations, including schools, daycares, doctors offices, and athletic events which are more likely to require an automobile to access until a more complete shift to a dense walkable urban form. For this reason, the current TOD projects are often targeted more towards young professionals, retired persons, and students who generally have fewer daily destinations and more typical destinations (grocery store, coffee shop, etc.). TOD may not be ideal for every lifestyle or every stage of life, but the cumulative benefits it offers to the built environment will have a positive impact for all.

Health and Exercise Benefits

While the introduction of the automobile has brought immense freedom and flexibility to users, it is also associated with multiple health risks. From less physical exercise to increased risk of accidents and exposure to pollution, reliance on automobiles is harmful to humans. The typical travel process requires very little physical exertion, since drivers have become accustomed to finding parking options that are located as close as possible to beginning and ending destinations. The American Automobile Association (AAA) reported that, as of 2017, drivers spend an average of 51 minutes driving per day, an increase over the 2015 average of 48 minutes (Gross 2019). While the Coronavirus pandemic and the resulting explosion of work-from-home jobs may have impacted that number, Reuters reported that road users in December of 2021 already surpassed pre-covid levels (Shepardson and Disavino 2022). Time spent driving is one of the many factors preventing Americans from getting enough exercise. “In fact, the majority of Americans (52%) do not meet the Physical Activity Guidelines and the national median of adults who do not engage in any physical activity is 22.6%” (Chriqui et al. 2016). The compact, walkable neighborhoods created by TOD can reduce mental stress by providing more predictable and convenient transportation options, as well as shorter commutes, which can reduce the negative impacts of traffic congestion and long travel times (National Research Council of the National Academies 2009). Even if travel distances are not conducive to walking, users of public transportation were 3.5 times more likely to reach the recommended daily target of 10,000 steps, compared with drivers (Rissel et al. 2012). The increased opportunities for physical activity associated with TOD can have a positive impact on public health by reducing the risks of chronic diseases, such as obesity, heart disease, and diabetes. Moreover,

the denser, mixed-use communities created by TOD often provide greater access to healthy food options, parks, and other recreational opportunities, which can further support healthy lifestyles. Residents are able to walk or bike from beginning to ending destinations and gain the exercise benefits of doing so while completing their daily tasks.

In addition to long-term health impacts, short-term impacts have significant, often deadly, consequences. In 2021 alone, over 45,000 deaths and 5.4 million injuries were attributed to motor vehicle crashes, according to the National Safety Council (National Safety Council 2021). Of the 45,000 deaths, 9,100 (19.4%) were pedestrians, and another 4,100 (3%) were bicyclists (National Safety Council 2021). Reducing vehicle use, especially in heavily populated urban areas, would likely result in fewer injuries and fatalities. When combined with the health benefits, an increase in life expectancy and overall health is an expected outcome. By creating more equitable and inclusive communities, TOD can reduce health disparities and improve overall health outcomes for all residents.

Social Benefits

TOD can help to address social determinants of health by increasing access to affordable housing, education, and job opportunities, in addition to fostering social connections. The creation of affordable housing near transit hubs can also help to reduce transportation costs for low-income households, which can free up resources for other basic needs, such as healthcare and healthy food. Seattle, for example, requires that “at least 80% of the housing units constructed would need to be affordable to those earning 80% of the area median income for the county in which the property is located” (Sound Transit 2018). By locating affordable housing near transit, the transit can be more readily available to the people in lower income groups that depend on it.

Several social benefits arise from the creation of more walkable, mixed-use communities centered around high-quality public transportation systems. TOD can increase access to employment, education, and services, which can improve social mobility and reduce inequalities. A study by Yi “suggested that although private mobility can play important roles in improving employment levels of the disadvantaged, relative access to jobs by transit has a stronger effect of increasing the employment status than private vehicles” (Yi 2006). The creation of transit hubs can also promote social interaction

and create a sense of community, as people from different backgrounds come together to use public transportation and access destinations. This can help to foster social cohesion, reduce isolation, and create a more vibrant and inclusive community by creating more active and lively streetscapes. Public safety is also improved by promoting walking, cycling, and other forms of active transportation. Increased eyes on the street discourages criminal activity and the creation of public plazas, parks, and other shared spaces help to create a sense of ownership and responsibility among residents.

TOD can provide a more equitable transportation environment when compared to an automotive-centric approach. Currently, subsets of the population who cannot drive, including children, teens, and elderly individuals, are very limited in their abilities to access critical daily needs without assistance. According to the Federal Highway Administration (FHWA), in 2022, only 69.7% of our population holds a driver's license, leaving over 30% with limited or no access to the most common form of transportation (FHWA 2022). Shifting investment away from auto-oriented projects and focusing on public transportation and walkability provides better access to daily needs for all members of the population. TOD can also encourage the use of public transportation by women, seniors, and other vulnerable populations, who may feel safer and more comfortable traveling in groups or in well-lit areas. Walking infrastructure and public transportation, with the proper implementation, can better support the entire population.

Environmental Benefits

Transportation is one of the largest contributors to greenhouse gas emissions in the U.S. "According to the Environmental Protection Agency, Greenhouse gas (GHG) emissions from transportation account for about 27% of total U.S. greenhouse gas emissions, making it the largest contributor of U.S. GHG emissions. Between 1990 and 2020, GHG emissions in the transportation sector increased more in absolute terms than any other sector" (US EPA 2015). The climate change crisis can be directly attributed to these emissions in the long term and in the short term are detrimental to human health. The Union of Concerned Scientists found that "Poor air quality increases respiratory ailments like asthma and bronchitis, heightens the risk of life-threatening conditions like cancer, and burdens our health care system with substantial medical costs. Particulate matter is single-handedly responsible for up to

30,000 premature deaths each year" (Union of Concerned Scientists 2014). It is clear from the research that the personal automobile has played a large role in the climate crisis and declining health and life expectancy experienced by current generations.

Waste produced as a function of automobile use constitutes another massive environmental impact of the personal car. As many as 280 million tires (FHWA n.d.), 425 million oil filters (State of California n.d.), and over 380 million gallons of fluids (CNET n.d.) are discarded every year in addition to the roughly 10 million vehicles (CNET n.d.) that are retired and must be disposed of. While a considerable percentage is recycled, as much as 75%, the impact in terms of energy use in production, recycling, and transportation is very impactful on the environment. Despite reduced emissions from adoption of new technologies, including electric vehicles and alternative fuels, reductions are minor as vehicle use increases with the growing population. The importance of reducing reliance on the personal automobile has never been greater.

Economic Benefits

Vehicle owners don't often consider the total costs generated by vehicle ownership, which can quickly become a sizable portion of family expenditures, and can include everything from the direct costs of insurance, fuel, maintenance, registration, and parking, all the way down to the money indirectly spent on real estate for garage space and driveway construction, and tax dollars paid to maintain and build roadway infrastructure. The average American spends $9,282 to purchase, insure, fuel, and maintain their automobile on a yearly basis (AAA n.d.). With the average American income just shy of $70,000 per year, automobile ownership expenses are approximately 13% of gross income (U.S. Census Bureau 2021). While that may not sound atypical, the indirect costs associated with automobiles should be considered, as they also constitute portions of income and property taxes paid by residents.

Roadway infrastructure spending is poorly understood due to poor transparency and a disconnect between use and fees charged. Money for infrastructure projects is sourced from a wide range of funds, grants, accounts, and trusts. Dutzik, Weissman, and Baxandall (2015) stated that U.S. households spent an estimated $597 annually in general tax revenue, which was dedicated to road construction and repair, and $199-$675 in annual tax subsidies for driving, which included sales tax exemptions offered by many

states for fuel purchases and federal income tax exclusions commuter parking benefits. “An estimated $216 per year in government expenditures [were] made necessary by vehicle crashes, not counting additional, uncompensated damages to victims and property” (Dutzik, Weissman, and Baxandall 2015). These additional costs are not typically considered by vehicle users and demonstrate just how entrenched the car is in the American government and culture. Parking is a significant source of additional construction costs to properties that inflate the costs of the products to the consumers. From the cost of construction for a garage, driveway, and land on a single-family residence, to elaborate underground or aboveground robotic parking systems, the additional costs to build parking are present in all aspects of the built environment. The typical parking garage structure costs approximately $25,700 per space provided to construct and takes up land that could be used for any number of more economically productive purposes (McConnell and Smith n.d.). Through greater efficiency in transportation, TOD benefits the local economy in a number of ways, including the reduced cost to provide roads, utilities, and infrastructure, greater property values contributing to the tax base, and greater sales of local businesses due to increased foot traffic.

Constructing more housing near transit has been shown to increase transit ridership and lower vehicle use (Su et al. 2022). This in turn not only helps struggling public transportation operations in the U.S., but also can lower household transportation expenditures by as much as $1,232 per year for the average Californian family, according to Dong et al. (2021). While many public transportation agencies struggle to return ridership to pre-pandemic levels, with many workers now working remotely, a greater focus should be placed on building a new ridership base through residential development.

Considering these benefits, along with others that may not be mentioned here, it's hard to understand how our development patterns have strayed. Although TOD cannot solve all problems afflicting urban areas, it stands to greatly contribute to a better livelihood for residents and provide a more sustainable way of living. The automobile’s promises of freedom and independence come at a price. It’s time to take action and rethink the status quo.

Elements of Success

Although transit-oriented development elements are often shown and defined in the most traditional sense–a pedestrian scale street with landscaping, mixed-use structures of about 5 stories, little or no parking, and ample pedestrian space–that does not apply to all situations. TOD strategies can apply to a broader range of the built environment to begin to introduce or continue efforts towards pedestrianization, walkability, public transportation density, etc. into an auto-centric built environment. Urban areas which already support walkability with robust infrastructure should prioritize other elements such as the complete removal of parking to more fully comply with TOD ideals, while undeveloped or lightly developed suburban locations must be built from the ground up, introducing mixed-use development patterns, while reducing vehicle use and infrastructure. Su et al. (2022) stated, “TOD is conceived as a unified framework formed by three structural factors (e.g., transit, land use, and their functional linkage).” Transit serves as a base, which must be present in order to provide a transportation alternative to the automobile. Land use must be designed to support the transit element. This may include a high-density residential development to reach a critical mass of residents to support the function of the transit system and local businesses. Introducing commercial areas to bring residents’ daily needs closer reduces transportation congestion overall, and proper allocation of parking and driving spaces prioritize pedestrians and walkability. Lastly, the linkage serves a bit as a catch-all term for the potentially hundreds of other elements that impact the use, decision making, and, ultimately, the success of the TOD; otherwise broadly defined as the urban environment within which everything is constructed and experienced. While transit and land use both represent a physical, quantitative element, the functional linkage encompasses a wide range of other elements which must be adapted to each environment and are the most flexible.

Black et al. provided more detail on elements considered under the functional linkage category of Su et al. These elements include accessibility, amenity, axis, affordability, and ancestry (2016). Accessibility and amenity are directed towards the ability to reach the proposed destination using pedestrian or bicycle modes and the commercial services, entertainment or businesses available at the destination. Axis speaks to the public transportation available between origin and destination. Affordability applies to both the pricing of the residential and commercial spaces, as well as the building design and

functional elements that can be removed to lower costs, such as parking. Ancestry captures the existing elements of a particular site, a topic specifically explored by this thesis. TOD sites can be anything from greenfield development to existing suburban single family, old commercial or industrial districts, and even city centers which already feature TOD elements, such as a dense and walkable urban form. It also includes the non-physical elements, such as cultural aspects, activity levels and community character, which are heavily based on the physical nature of the urban form, as well as the residents and inhabitants of the neighborhoods. These speak not only to the physical built environment, such as accessibility, but also elements such as affordability and ancestry, which are more policy or community-driven.

Elements	Objectives	Issues
Accessibility	- To improve walking and cycle access to the Transitway and in centres - To promote the use of the Transitway and other bus services - To maximise pedestrian and vehicular cross-flows along the Transitway	- Restricted access to bus stops through current subdivision pattern - Bus stops are visually inaccessible from the main street - Barrier effect caused by fences and the Transitway having limited cross-over - Safety factor with deserted areas forming access ways
Amenity	- To improve the quality of the public domain in centres and neighbourhoods - To enhance and vitalise town centres and the Transitway - To incorporate a mix of well integrated services in towncentres - To develop public areas that accommodate for environmental conditions	- Quality of public realm - Quality of built environment - Lack of variety - Lack of shade and shelter
Axis	- To improve connections between the T-way and local bus services - To strengthen the relationship between cultural precincts, open space and centres - To provide parking opportunities for Transitway bus stops in activity centres	- Poor connection between the Transitway and other bus services - No major connection of community with cultural facilities - No relationship between amenities and civic space - No provision for car parking at major Transitway bus stops
Affordability	- To increase mix housing types and housing affordability to devise sharing water and energy between buildings and innovation ideas e.g., prefabricated building systems, innovative unit design solutions, and shared living environments (intelligent building design) - To encourage shared bicycle and car facilities to encourage developers to	- A smart city centre ensures that there is a wide range of dwelling types and sizes within its precinct - Discourages the exclusion of families, people on lower incomes, and people who might otherwise be marginalised

	incorporate principles of a smart city and green infrastructure in new developments	- The consequences of diminished affordability are loss of social and cultural diversity
Ancestry	- To encourage increased activity in centres - To promote an outdoor experience in town centres - To respond to the cultural character of communities - To improve the safety and security of the public domain	- Lack of opportunities for informal social cohesion Shopping malls can restrict outdoor activity - Multi-cultural composition of locality not reflected in design of centres - No strong relationship between land uses Need for improved safety and surveillance

These five elements are a mix of qualitative components which bring about a difficulty in studying and comparing TOD in different geographical areas and with differing economic, political, and social conditions, but are no less important for consideration in TOD.

Langlois et al. stated that “the most studied built environment characteristics have been density, land use, pedestrian-oriented design, and accessibility to multiple services” (2015). Cervero and Kockelman et al. found that “compact mixed-use, pedestrian friendly designs can ‘degenerate’ vehicle trips, reduce VMT per capita, and encourage non-motorized travel” but only if the elements “co-exist to a certain degree” (Cervero and Kockelman 1997). The interplay and importance of including all elements demonstrate how TOD depends on careful planning and implementation. In many ways it should be considered an *all or nothing* situation where a deficit in just one element hinders the overall success. This study is modeled on the work and relies on the basic elements identified by Langlois et al., and Cervero and Kockelman.

These elements also factor into the rural-to-urban transect (Figure 2) created by Alexander Von Humbolt and popularized by Andrés Duany, known for his work with New Urbanism (Pape 2015). The transect depicts the range of urban form from rural to urban over six distinct built form typologies. Starting with the natural zone, representing open spaces, wilderness and forests where no human inhabitation, moving to rural, sub-urban, general urban, urban center and finally urban core, the largest structures, and highest densities and intensities of use. Many versions also include a special district category, which is applied to land uses such as shopping malls, sports stadiums, hospitals, or other special use areas. The characterizations may not apply to all environments, and the differentiations in reality are very slight, often

unclear. However, the transect remains useful to classify and differentiate between the varied typologies of the urban environment.

Figure 2: Urban-to-rural transect, https://www.canr.msu.edu/news/understanding_the_urban_transect

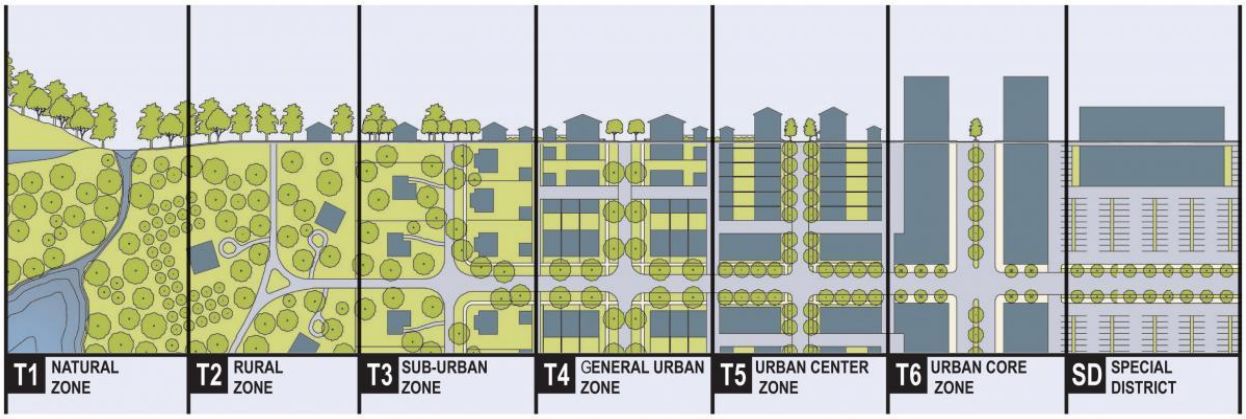

Figure 3: Urban-to-rural transect including the special district category, https://www.cnu.org/publicsquare/2017/04/13/great-idea-rural-urban-transect

Residential Density

TOD relies on a higher density than the typical American suburban, single-family residential style of development. Higher densities were directly attributable to greater transit use and increased pedestrian activity as well as reduced vehicle trips (Cervero and Kockelman 1997, Langlois et al. 2015). The concept of economies of scale, or the cost advantages that enterprises obtain due to the scales of their operations, apply to urban development just as much as the manufacturing sector. Patterns of grouping together can be traced back to the earliest humans, as it proved beneficial in terms of hunting, security, and caretaking. The same concept applies today. Living closer to places of employment, destinations, and family/friends results in less need for travel. Density is needed to provide a large user base for public transportation systems and retail enterprises found in TODs.

Destinations

Destinations are the places that we visit for goods, services, or entertainment on any given day. This includes everything from grocery stores and restaurants to barber shops and nail salons to schools and employment. Locating destinations closer to the end user is beneficial in reducing travel time, increasing modal choice options, and increasing health and accessibility (National Research Council of the National Academies 2009, Cervero and Kockelman 1997). Frequently visited destinations should be within walking distance for simple and convenient access, the main priority of the 15-Minute City concept which is often associated with TOD.

Vehicle Demand Management

Land use must correlate with the goals of TOD, which includes facilitating higher densities of middle housing types, mixed-use development, walkability, etc. In order to achieve this and encourage behaviors, careful management of personal automobiles must be included. Parking is expensive to build and takes up valuable space which could be used for more economically or culturally productive purposes. Personal automobiles will not be eliminated based on current trends, so balancing vehicle access with other TOD elements is critical. While a multitude of vehicle demand strategies exist and may prove to be effective, both Langlois et al. and Cervero and Kockelman found parking availability to be

leading factors in determining mode choice and overall TOD success (Langlois et al. 2015, Cervero and Kockelman 1997). For example, the availability of free parking at a workplace results in users who are more likely to drive than use a more sustainable mode of transportation (Langlois et al. 2015). Parking is then offered as an amenity to building inhabitants, thus perpetuating the cycle of automobile reliance. In addition, “homeowners in walkable communities with a mix of uses and good transit access own 43 percent fewer cars than those who live in suburban communities" (Reconnecting America n.d.). Building additional parking is simply adding cost and inefficiency.

Methods

This research is an attempt to develop better strategies for implementing TOD into existing neighborhoods in ways that achieve the greatest reduction in automobile use. The study will assess three TOD developments that are considered to be “best practice” examples in the industry to date. The projects were identified through publications and research, including the Transit Oriented Development Best Practices Handbook developed by the City of Calgary Land Use Planning and Policy Office, Transit-Oriented Development (TOD) Success Stories report from the New Haven-Hartford-Springfield Rail Program, the Metropolitan Council Transit Oriented Development Guide, and the Transit Oriented Development Institute. Each development highlights how the major principles of TOD can be implemented in a cohesive design that has become a thriving community. The case studies will then be compared to TOD developments in the Seattle, Washington metropolitan area. Based on the comparison, the framework can be applied to improve future TOD developments in Seattle. Specific questions considered in the research are:

- What are the key elements that contribute to TOD success which can be accurately measured and compared?
- What locations are considered “best practices” and why?
- How were the key TOD elements balanced to respond to the neighborhood characteristics where each development was constructed?

The first question was addressed in the literature review. The key factors of density, destinations, and vehicle demand management are well understood and easily defined quantitative data types which

have served as a basis for other adjacent research. The locations addressed by the second question were identified by the researcher after review of numerous data sources, combined with a desire to capture a range of project types, sizes and environments in which TOD projects are completed. The specific locations are not critical to the soundness of the research, as any TOD development can be analyzed to garner the same conclusions and identify the positive and negative aspects of the project.

This research is primarily working to address the third question. To garner a better understanding, each development will be analyzed using the specific components which are considered the hallmark elements for TOD. These are qualitative data types that will allow for relatively simple comparisons between the developments to determine how closely each complies with an ideal walkable and transit-oriented development.

1. **Density:** Measures the units per acre as determined using the master plan, as-built plans, permit data, or census data as available. Using units per acre is more agnostic towards the specific type of housing provided and family status of inhabitants versus a population count. A greater number of units per acre represents a higher density and is considered better for the purposes of this study. The data is publicly available and generally accessible online or through communication to a city staff member.
2. **Destinations:** Measures the diversity of businesses, services, stores, etc. utilizing the Walk Score website. The Walk Score is designed to associate a score of how many stores and services are within a reasonable distance of a property. A high score is 100 representing the best availability of destinations within a walking radius of the requested address while a score of 0 means no destinations exist within a walking radius. The specific distances, multipliers, and methods to determine Walk Score is available on Walk Score's Website.
3. **Vehicle Demand Management:** For the purposes of this thesis, it is a measure of parking provided within the development as determined using the master plan, as-built plans, permits, or city data as available. The data is generally accessible online or through communication with a city staff member. No parking provided is considered the best, while increasing numbers of parking spaces per acre is considered less beneficial to advancing the TOD goals of the development.

The three case study developments in other states will be compared to TOD in Seattle where the same data–density, destinations, and parking–can be measured and compared. Through the comparison, the differences in the elements and neighborhood types will reveal how various elements were balanced to create successful TODs and determine if the same balance was applied to Seattle projects. The Seattle study locations were chosen to represent three unique development environments and stages;

1. **Capitol Hill Station** represents a completed development within an existing urban environment featuring generally high density, mixed-use developments.
2. **Beacon Hill Station** is also complete, but a suburban residential area at a much lower residential density and with little to no commercial activity.
3. **Northgate Station** is still in the planning stages and is a suburban auto-oriented commercial shopping area.

Based on the comparisons, we will determine how successful Seattle has been in implementing these TOD elements and provide recommendations for improvement on future projects. Since each TOD development is entering an existing developed area, it is important that it be responsive to the neighborhood as well as advance TOD goals. The most successful TOD developments balance the needs of the neighborhood with its own TOD-specific goals. Recommendations for recognizing those needs based on the neighborhood characteristics and responses for implementation of TOD will be made and can be applied to future transit-oriented developments in the Seattle metropolitan area.

Studies

The chosen case study locations are ORENCO Station in the Portland, Oregon metro area, Englewood CityCenter Station near Denver, Colorado, and Fruitvale Station in Oakland, California. They represent not only some of the best recognized TOD projects in the United States, but also a varied mix of built environments, existing conditions, and sizes.

Orenco Station

Orenco Station is a new community in the town of Hillsboro, a suburb of Portland, Oregon. An area that had formerly been the town of Orenco, a company town of the Oregon Nursery Company, was rebuilt following some of the old town development patterns, but was largely focused on creating a dense, walkable, and unique community (Mehaffy 2001). The area, totaling a little over 200 acres, now hosts 428 single-family units, 716 townhomes and live/work units, 203 condos, 503 apartments along with 218,000 square feet of retail and 30,000 square feet of office space (Gardner).

The property was developed in 1999 after the Westside MAX light rail project was projected to include a station adjacent to the site (Fader 1999). The desire for higher density was partly due to the desire to add additional housing around the new light rail, but also to pay homage to the historic streetcar town of Orenco. The master developer, PacTrust, worked to build a unique product unlike any other development despite there being “no real precedents even for attached product in that suburban market, let alone the kinds of radical densities and other features proposed” (Mehaffy 2003). To achieve this, “the team sat down with City of Hillsboro planners, and together wrote a radically new zoning ordinance for the site. The partnership allowed the development to work around some of the typical TOD limitations found in zoning and planning codes.

Figure 4: Map of Orenco Station Development, https://www.researchgate.net/figure/Mixing-of-land-uses-at-Orenco-Station_fig4_242626592

Figures 5 & 6: Live/work units (left) Single-family housing (right), https://www.terrain.org/unsprawl/10/

Orenco Station continues to thrive as a successful suburban neighborhood of Portland. The development has won awards, including “Best New Burb” by Sunset magazine in 2005. Other awards include the Oregon Governor's Livability Award in 1998, the Best Master Planned Community in America

Award by the National Association of Home Builders in 1998, the Ahwahnee Award in 1999, and Transit Communities Livable Design Award awarded by AIA/ULI/FTA/STPP in 1999 (“Orenco Station (TriMet)” 2023). “Orenco Station was among the fastest-growing neighborhoods in the Portland metropolitan area, according to newly released Census data. The population grew more than 43% between 2010 and 2016” (Hale 2017). The density of Orenco Station is much higher than the typical suburb. The original density goal was 45 residents per acre but legal challenges forced the total down to about 34.5 residents per acre (“Orenco Station (TriMet)” 2023). This is still well above a typical suburban density, which is around 3.1 people per acre. It is even well beyond the 12.5 people per acre found in urban areas according to Bloomberg (Florida 2019). In addition, ‘‘a ‘sociology study’ (Podobnik, 2002) has shown very high levels of resident satisfaction with the community, very high ‘social cohesion,’ and relatively high transit and alternate mode transportation habits (a 22% modal split versus about 6% regionally). Many of those automobile trips are also captured within the community, reducing overall travel” (Mehaffy n.d.).

Orenco is unique since the development property itself is large and was essentially unoccupied although some low density single family development existed nearby. The biggest challenge faced was not community pushback, but spending the time and taking advantage of political support to re-envision the zoning code to build a new TOD from scratch. Here, the critical need was to support the inclusion of destinations in a rural area which was solely residential while constructing more residential dwelling units to provide a user base for the station and transit system, transforming the property from a rural zone (T2) development on the urban-to-rural transect to a general urban zone (T4) with an urban center zone (T5) adjacent to the station. Significant time and effort was taken early on to rewrite the zoning code to a TOD-friendly version suitable for the development’s vision, versus an urban redevelopment project where a developer would have to work within an existing automotive-oriented street system or lack of commercial activity. Zoning rules were modified specifically for the project to achieve TOD development. “A number of significant innovations were used, including ‘skinny’ (20-foot) streets, close maximum street setbacks (19 feet), side yard easements (which allowed for high privacy windows in one home while the adjacent home has full use of the side yard), ‘granny flat’ accessory dwellings, live/work units, and alley-loaded garages” (Mehaffy 2001). However, once the revised zoning was accepted, the less developed nature of the property allowed maximum freedom and flexibility in the physical construction

and design process to minimize street space, include greater walking and biking infrastructure, and orient the entire neighborhood to the transit station.

Figure 7: Plaza space adjacent to multifamily housing at Orenco Station, https://www.hillsboro-oregon.gov/our-city/departments/economic-development/development-areas/orenco

A residential density of about 10 dwelling units per acre is typical of a more suburban TOD development which includes single-family properties along with more dense residential dwelling types. The Walk Score of 79 is very respectable for the lower density and more residential-leaning character of Orenco, representing the high priority placed on providing destinations in the development. Most errands can still be done on foot; while a car is not a necessity, the portion of large format big box retail on the west end of the site is a remnant of some effort to cater to the low density suburban surroundings. While total parking is not known, one report estimates that the town center portion of the development, the higher density, mixed-use portion was built with about 13.6 parking spaces per acre (Fader 1999). This is much lower than comparable properties and shows how walkability and transit use were considered to be primary transportation modes for Orenco residents. The estimated average, however, is higher as the remainder of the development contains big box retail and some single-family homes with a higher

assumed parking space per acre ratio. Future iterations of the ORENCO development can focus on lowering parking as the success of the transit system and providing walking infrastructure in combination with thoughtful inclusion of destinations has been a proven success.

Englewood CityCenter

Englewood is a suburban community located about six miles south of Denver, Colorado, in proximity to I-25, the primary north-south interstate in the region, and State Highway 85 (Santa Fe Drive). Made up of primarily single-family residences, Englewood serves as a home to many white-collar workers, as the downtown core of Denver is a short drive away. Back in the late 1960s, Englewood was also the home to the major mall in the region. “When it opened in 1968, Cinderella City, with more than 1.3 million square feet of space, was the largest mall west of the Mississippi” (Transportation Research Board 2004). It didn’t take long for the mall to decline and the city started looking for alternatives in the 1990s. Around the same time the local transit agency, Regional Transportation District (RTD), finalized plans for a light rail extension adjacent to the property. This opportunity changed the proposal from a big box retail center to one of the earliest redevelopment projects of this nature and what became “the first transit-oriented development (‘TOD’) project in the Front Range region” (City of Englewood n.d.). “The city brought in TOD planner Peter Calthorpe to develop a master plan, which was adopted by the city council in 1998” (Transportation Research Board 2004). Constructed in 2000, the development is made up of 438 multifamily dwelling units, 300,000 square feet of retail, and 150,000 square feet of office space (Metropolitan Council 2018). In addition, a new Civic Center was constructed in the shell of an old department store and 910 parking spaces were constructed as a park-and-ride for light rail users (Metropolitan Council 2018).

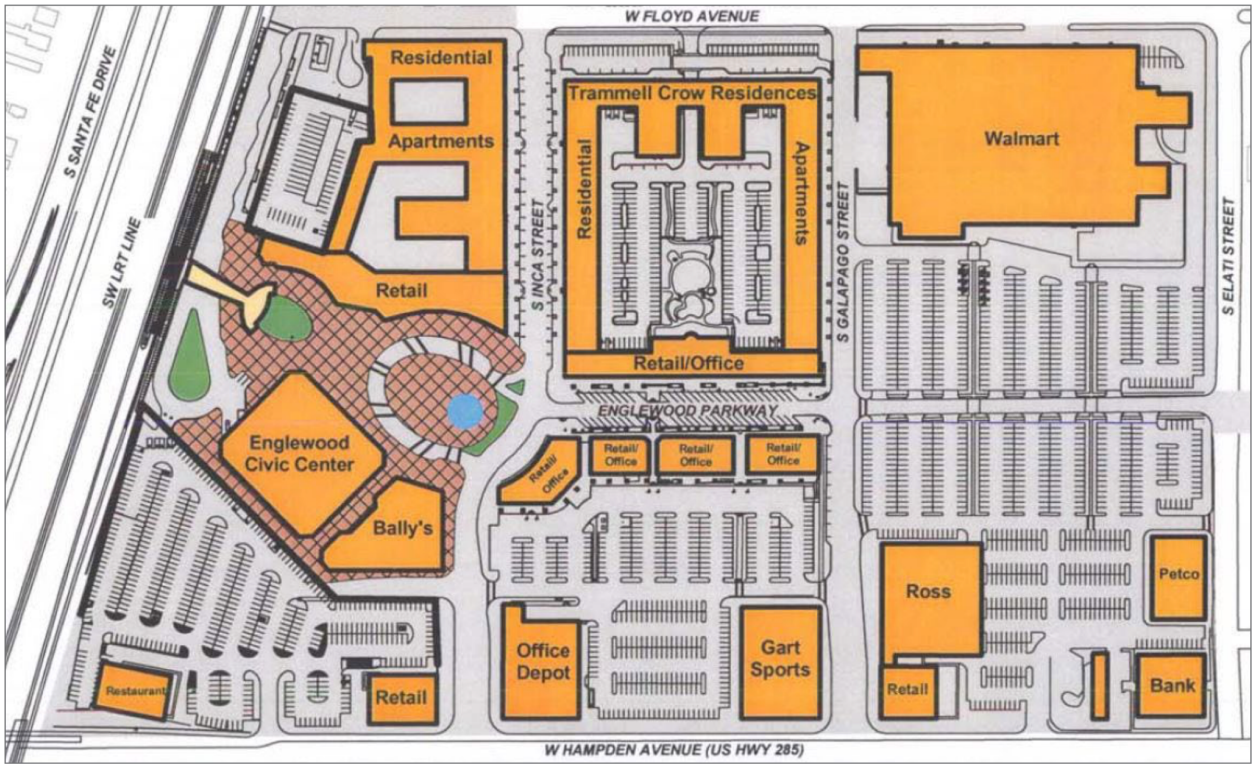

Figure 8: Englewood CityCenter Site Plan, https://metrocouncil.org/Communities/Planning/TOD/Files/Case-Study-Englewood-Colorado.aspx

The development focused more on the residential and institutional activity nearest to the light rail station and less on the pedestrian-oriented uses further away. The inclusion of some auto-oriented stores were necessary to balance tax revenue with the desire for housing. For Englewood, this is especially important as the site is one of the primary income-generating properties from sales tax. The need for balance resulting in a higher level of parking then is optimal for TOD. “The ratio of 4.9 parking spaces per 1,000 square feet of retail floor space, while below the optimal level for automobile-oriented retail, is still high for a transit-oriented site according to Cervero et al. (2002). However, long term plans are still in place to convert the entire site to TOD in the near future. “The City accommodated new lower-density retail, but they took actions to ensure that site plans would not preclude future TOD,” which included maintaining rights to repurchase properties if they were ever put up for sale or offered ground leases instead of selling (Metropolitan Council 2018). While an ideal development would have constructed less parking and included less automotive-oriented development patterns, it was a good starting point, and additional steps are already underway. In 2018, the city hired a redevelopment manager to implement

long-term redevelopment plans, which include more housing, high-density retail, pedestrian-friendly connections, and infill development (Metropolitan Council 2018). In 2018, citing “the evolution of retail trends away from so-called ‘big-box’ retail centers” the master developer foreclosed on the portion of property which was subject to the ground lease and the redevelopment process has been accelerated (Arnold 2018). Although slowed by the COVID-19 Pandemic, much work has taken place. “The community formed the Englewood Downtown Development Authority, authorized up to $70 million in tax increment financing for this and other downtown projects, rezoned the area for higher density and worked with SKB/Tryba to lay out initial development plans at one of the largest redevelopment sites along the Regional Transportation District’s D Line” (Englewood Engaged 2022).

Figure 9: Englewood CityCenter looking towards the station, https://parkbench.com/englewood-co

Englewood CityCenter is a good example of a suburban redevelopment style of TOD where the development is subject to greater physical and political constraints due to the previous land use and surrounding properties compared to a greenfield development. Whereas Orenco station was very low density residential, falling in the rural zone (T2) category, the CityCenter redevelopment is a special district which had greater physical constraints in its construction, including some of the street layout, lack of existing greenspace, and parking demands from the transit agency. The proposal for the second round of redevelopment lists very similar challenges as those faced in the first phase including, inefficient land use, current Park-n-Ride parking burden and extensive infrastructure investments required (“CityCenter Redevelopment Planning Process with SKB” 2020). It is also a good example of balancing the transition

to full TOD while supporting traditional development in the short term. Slowly introducing density, walkability, and mixed-use zoning may be the key to getting broad political support for similar projects. Careful planning for the future and maintaining property ownership gives the city control, which allows the current round of redevelopment to further reduce vehicle reliance and enhance the TOD elements present in the area.

Adding residential density was a primary goal of the project, as the site was solely commercial prior to redevelopment. Overall residential housing density remains low at just shy of 8 dwelling units per acre, but a significant portion of the site has remained big box retail while the TOD remains focused on a smaller area. The continued planning efforts for the site envision greater residential development in the future which will increase overall density. Its function as a retail center means a Walk Score of 85 is not unexpected (“800 Englewood Parkway, Englewood CO - Walk Score” n.d.). Multiple options for dining, entertainment, and errands exist and the infrastructure is able to support residential and commercial growth. The most improvement is needed in vehicle demand management. In total, 2,735 parking spaces were built, 910 of which were for the RTD park-and-ride. An average of nearly 50 parking spaces per acre is uncharacteristic of TOD developments where transit and walkability are the primary focus. The trade-off of maintaining some big box retail and parking means that most visitors will choose to drive. Ideally, more parking will be removed in future phases of redevelopment.

Fruitvale Village

Fruitvale is a neighborhood of Oakland, California, located south of downtown Oakland and north of Oakland International Airport and Oakland Arena. The area is a fairly dense single-family residential community with a little over 4,000 residents, many of which are of Mexican or Latin American heritage (“Fruitvale Neighborhood of Oakland, CA” n.d.) The heart of the neighborhood is Fruitvale Station, served by the Bay Area Rapid Transit (BART) blue, green, and orange lines, which connect the east side of the bay to San Francisco. In addition, International Boulevard is located two blocks from the station; it serves as the main commercial area and has a strong transit presence thanks to the Tempo Bus Rapid Transit Line, which opened in late 2020 (TransitCenter 2020).

Figure 10: Fruitvale Village Site Plan, https://casestudies.uli.org/wp-content/uploads/2015/12/C035004.pdf

Figure 11: Fruitvale Station and the entrance to Fruitvale Village, https://critical-sustainabilities.ucsc.edu/fruitvale-transit/

Fruitvale is just one of the many TOD developments in the bay area. The Bay Area Rapid Transit agency has been extremely successful in implementing various levels of TOD at a number of stations. Over 4,000 housing units and 865,000 square feet of commercial space have been constructed at 16 stations, with more on the horizon (Bay Area Rapid Transit n.d.). Recent projects have increased the affordable housing ratio up to nearly 100% of residential units to reduce displacement and increase the stock of affordable housing options for residents.

Status	Station	Total Units	Affordable Units	% Affordable	Office (SF)	Retail (SF)
Completed	Castro Valley (1993)	96	96	100%		
	Fruitvale Phase I (2004)	47	10	21%	27,000	37,000
	Fruitvale Phase IIA (2019)	94	92	98%		
	Pleasant Hill Blocks A & B (2008)	422	84	20%		35,590
	Pleasant Hill Block C (2020)	200	0	0%		
	Hayward (1998)	170	0	0%		
	Ashby (2011)	0	0	0%	80,000	
	Richmond Phase I (2004)	132	66	50%		9,000
	MacArthur Phase I (2016)	90	90	100%		
	MacArthur Phase II (2019)	385	0	0%		39,100
	MacArthur Phase III (2020)	402	56	14%		
	San Leandro Ph I (2017)	115	115	100%	5,000	1,000
	San Leandro Ph II (2019)	85	85	100%		
	West Dublin (2013)	309	0	0%		
	East Dublin (2008)	240	0	0%		
	South Hayward (2017)	354	152	43%		
	Coliseum (2019)	110	55	50%		
	West Pleasanton (2019)	0	0	0%	410,000	
TOTAL COMPLETED		**3,251**	**901**	**28%**	**522,000**	**121,690**
Construction	Walnut Creek (began 2017)	596	0	0%		
	Millbrae (began 2019)	400	100	20%	150,000	45,000
TOTAL UNDER CONSTRUCTION		**996**	**100**	**10%**	**150,000**	**45,000**
In Planning	Fruitvale Phase IIB	181	181	100%		
	Balboa Park	131	131	100%		11,400
	West Oakland	762	240	31%	300,000	52,625
	Lake Merritt*	557	233	42%	500,000	25,000
	West Dublin (Program TBD)					
	Pleasant Hill Block D*				290,000	
	North Concord*	360	90	25%	800,000	
	El Cerrito Plaza (Program TBD)					
TOTAL IN PLANNING		**1,991**	**875**	**44%**	**1,890,000**	**89,025**
GRAND TOTAL		**6,238**	**1,876**	**30%**	**2,562,000**	**255,715**

*Estimated development program

Figure 12: BART TOD Project Status as of 03/2021, https://www.bart.gov/about/business/tod

Figure 13: Fruitvale Village Plaza, https://pgadesign.com/projects/fruitvale-transit-village/

The Fruitvale Village project area consisted of a group of surface parking lots that served commuters using the Fruitvale BART station. The project “grew out of community resistance to BART’s plan to build a parking garage between the BART station and the Latino neighborhood’s commercial center, which the community worried would hasten the decline of the already distressed neighborhood” (Reconnecting America n.d.). Through multiple phases, the parking has been reduced or consolidated and 141 residential units–102 of which are affordable housing–along with 27,000 square feet of office space and 37,000 square feet of commercial space have been constructed on the property (Bay Area Rapid Transit 2021). Phase IIB is currently underway and will create an additional 181 affordable housing units to the property. A specific effort was made to include community destinations for the residents already living in the adjacent neighborhoods, including “a seniors’ center, a Head Start child development center, a City of Oakland public library, and a health clinic that provides linguistically and culturally appropriate care to patients regardless of their ability to pay” (Scully 2005). A total of 150 parking spaces were constructed in a grade-covered parking lot to serve the first two phases of village development, and

a parking garage was constructed to serve BART commuters (Scully 2005). This parking arrangement creates a much more enjoyable environment for residents and commuters alike as the station is directly adjacent to a pleasant pedestrian plaza and retail shops.

Similar to Orenco station, the primary challenges were the existing zoning limitations around density and parking. Although the area already featured a mix of residences and commercial destinations, the projects would not have been successful had it not been for partnerships with the city to modify the existing zoning requirements to accommodate the TOD project. “Highly supportive of the project, the city created a new overlay zone so that a high-density, mixed-use development would be legal in the area. The code for this zone (S15) allows for higher [housing] densities around transit facilities, gives density bonuses, and lowers parking requirements. However, the project’s schedule was delayed by the rezoning, as the FDC [Fruitvale Development Corporation] had to wait until the new code was passed into law before construction on the village could begin” (Scully 2005). As is often the case, traditional zoning does not allow transit-oriented development; while developers can take advantage of supportive political environments, the increased time and money spent to gain approval lessens the appeal of the project.

This project is a good example of an urban infill TOD since the existing site falls into the general urban zone (T4) or urban center zone (T5) range of the rural to urban transect. Unlike Orenco Station and, to an extent, Englewood CityCenter, the development in Fruitvale was very limited physically. The street and station layouts were fixed and the adjacent neighborhood was already built up. However, the existing development provided some opportunities. Since a significant residential and commercial presence already existed in the area, the initial project phases were able to focus on vehicle demand management and community destinations to attract the existing community members to the site using alternative modes of transportation. The project did not have to build up a network of commercial and residential uses from scratch.

The first phase of Fruitvale did not highly prioritize residential density. With only 47 housing units in the four-acre site, the overall density was not much different than the relatively compact single-family development surrounding it (Scully 2005). As future phases in the 19-acre parcel are completed, there will be an average of about 16 dwelling units per acre, more representative of dense urban development. However, the destinations, including shops, restaurants, and medical services, were the primary

consideration, which is reflected in the Walk Score of 95, making it “the third most walkable neighborhood in Oakland” (“Fruitvale Station Neighborhood in Oakland - Walk Score” n.d.). Off-street parking remains important for this site, given its function as a park-and-ride for commuters of the BART system; however, careful planning resulted in the parking spaces being farther away from the station and relatively hidden, to clearly prioritize the walkability and pedestrian activity of the site. As the nearby bus rapid transit system grows in ridership, the pedestrian activity is expected to increase.

Transit Oriented Development in Seattle

Seattle shared a similar growth and development pattern as other American cities in the 20th century, including the use of streetcars, trolleys, and even boats for transportation to and from the outlying towns. An excerpt from the 2010 Seattle Planning Commission Report titled, *Seattle Transit Communities, Integrating Neighborhoods with Transit*, states “Transit communities are not new. Many of Seattle’s favorite neighborhoods were originally developed around the old streetcar network” (Seattle Planning Commission 2010). This section will focus on the contemporary efforts to reintroduce TOD into the urban fabric of Seattle.

The first automobile was driven through downtown Seattle in 1900 by Ralph S. Hopkins (Caldbick 2018). Interest only grew from there. “By 1907 there were about 300 automobiles in Seattle, and that year Polk's listed 16 car dealers, with 10 scattered around town in no obvious pattern but six concentrated in the Pike/Pine neighborhood, and four of those on the same block on Broadway” (Caldbick 2018). Most development was limited to what is now considered downtown Seattle, Capitol Hill, and the International District since the transportation possibilities of the automobile were just being discovered. Over time, roads were improved to better accommodate larger and faster automobiles. It didn't take long before growth and sprawl became rampant. Highways were popping up everywhere while old neighborhoods, seen as blighted and irrelevant, were demolished to make room. “Government engineers had drawn up a Bay Freeway over South Lake Union to encircle downtown; a 14-lane version of I-90 that would have trenched the Mount Baker neighborhood rather than pass through tunnels; and most famously the R.H. Thomson Expressway that would have stretched from the Highway 520 bridge past the Washington Park Arboretum and into Central Area (then a predominantly black neighborhood) and Rainier Valley, plus a

spur north to Lake City" which was stopped by a coalition of University of Washington students, Montlake homeowners, the League of Women Voters, and the Black Panther Party (Lindblom 2018). These plans represented the “creation of a transportation system that would have a greater freeway density than Los Angeles […] These possibilities fostered a public outcry that resulted in a public outcry from affected residents which saw the citizens suing the city two years later” (Goldstein-Street 2018). Thankfully, Seattleites recognized the dangers of over reliance on the automobile and how it and the infrastructure negatively impacted communities.

Despite unfavorable views of highway construction, public transportation wasn't any more popular.

> [On] May 19, 1970, King County voters opted to reject four bond issues that would've included […] a regional rail transit system. It was an initiative by the Forward Thrust effort to get light rail in the late 1960s and early 1970s, and it never quite grabbed the voters the way organizers wanted. Though the transit system would have been heavily subsidized by the federal government with 500 miles of bus routes and 49 miles of rail, the package first failed in 1968. If local bonds had passed in 1970, $900 million in local funding would've covered all but 1/4 of the total system's costs ($1.321 billion, at the time) (Millman 2019).

Today, car ownership remains high. “Among the 10 most densely populated big cities, Seattle easily has the most cars per capita — even more than Los Angeles” (Brasuell 2017). The auto-centric nature of Seattle has resulted in extreme levels of congestion and urban sprawl.

Light rail transit was eventually constructed in Seattle and consisted of the Sound Transit Link light rail system running north-south with future extensions planned to the north, east, and west. A multitude of express bus services by Sound Transit and others by King County Metro branded “RapidRide” operate all around Seattle and to outlying cities. Regular bus services, regional commuter rail, and water-based taxi and ferry services are also present in the Seattle area, but are less applicable to TOD. For transit to serve as the backbone for TOD, it must be frequent, reliable, and run 24/7, or very close to it, to accommodate all users.

Extensions of the Link light rail system are currently under construction including the East Link Extension across Lake Washington to Bellevue and the Lynnwood Link Extension north from Northgate to

Lynnwood. Future expansions are planned to connect to West Seattle, Ballard, Redmond, Everett, and Tacoma, likely resulting in close to 50 additional stations. These stations vary from low-density suburban locations to urban villages and downtown cores, such as West Seattle Junction and Bellevue.

In April 2014, Sound Transit updated its Transit-Oriented Development Program Strategic Plan, which followed the original Transit-Oriented Development Policy adopted in December 2012. Sound Transit's policy defines TOD as a "land development pattern that integrates transit and land use by promoting transit ridership while supporting community land use and development visions. TOD typically consists of public and private development projects that create dense, pedestrian-oriented environments with a mix of land uses and activities at and around transit facilities. The design, configuration, and mix of buildings and activities around the transit facility, as well as the location and design of the transit facility, should encourage people to use transit and foster a healthy, livable environment" (Sound Transit 2014). TOD project areas were envisioned to be "compact, walkable, urban centers linked by fast and frequent high capacity transit service, which promote economic and environmental vitality, increase personal mobility and improve public health" (Sound Transit 2014). Since then, a number of projects are currently being planned, constructed, or completed, including Angle Lake, Federal Way, Lynnwood, U-District, Capitol Hill, Kent/Des Moines, Mount Baker, Roosevelt, Beacon Hill, and throughout the Rainier Valley ("Transit-Oriented Development Overview" n.d.). Three of these projects will be evaluated and compared to the case studies above to identify strengths and weaknesses of TOD implementation.

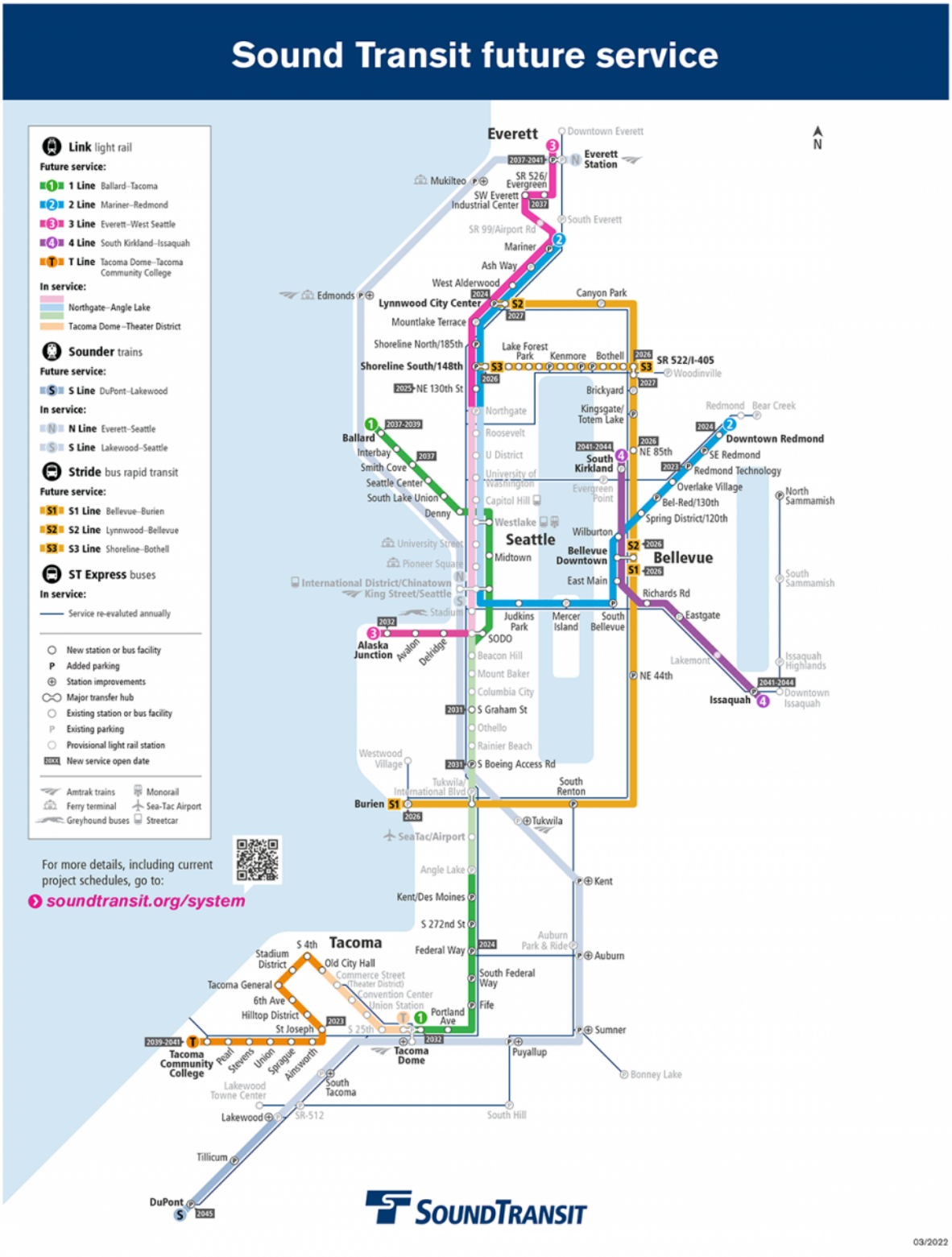

Figure 14: Sound Transit Present and Future Service, https://www.soundtransit.org/get-to-know-us/maps

Capitol Hill Station

Capitol Hill Station is located in the bustling Capitol Hill neighborhood, just northeast of downtown Seattle. It is a few blocks away from the Pike/Pine corridor, previously known as Auto Row, which demonstrates the drastic changes Seattle has experienced in the past century. The area has grown throughout the decades, resembling an urban center zone (T5) on the transect. The light rail line extension from the downtown core was completed in 2016, and plans for a mixed-use TOD development on top of the underground station began to take shape immediately (Fesler 2017). At just 2.17 acres in size, the project area is an urban infill development to enhance the residential and commercial density of the area. The project, split into four sites, provides 428 apartment units–176 of which are affordable housing–39,510 square feet of commercial space, a public plaza space for a farmers market and other activities, as well as 216 below ground parking spaces. At nearly 200 dwelling units per acre, this project is well above the case study examples, which should be expected given the highly urban location of the project. Similarly, a Walk Score of 99 shows just how many destinations are within a short walking distance of residences, many of which were available before the completion of the TOD. The amount of off-street parking provided is very high, at about 100 spaces per acre.

Capitol Hill Station excels at being a truly mixed-use development. The highest Walk Score of any property compared within this research, and very close to a perfect Walk Score is illustrative of the already vibrant community and the addition of nearly 40,000 square feet of commercial space provided by the project. Even the plaza, which is not considered commercial space, hosts an extremely successful farmers market drawing visitors from all over Seattle. The project is very similar to Fruitvale which also featured a higher than average density before TOD implementation and availability of existing residential density and commercial destinations.

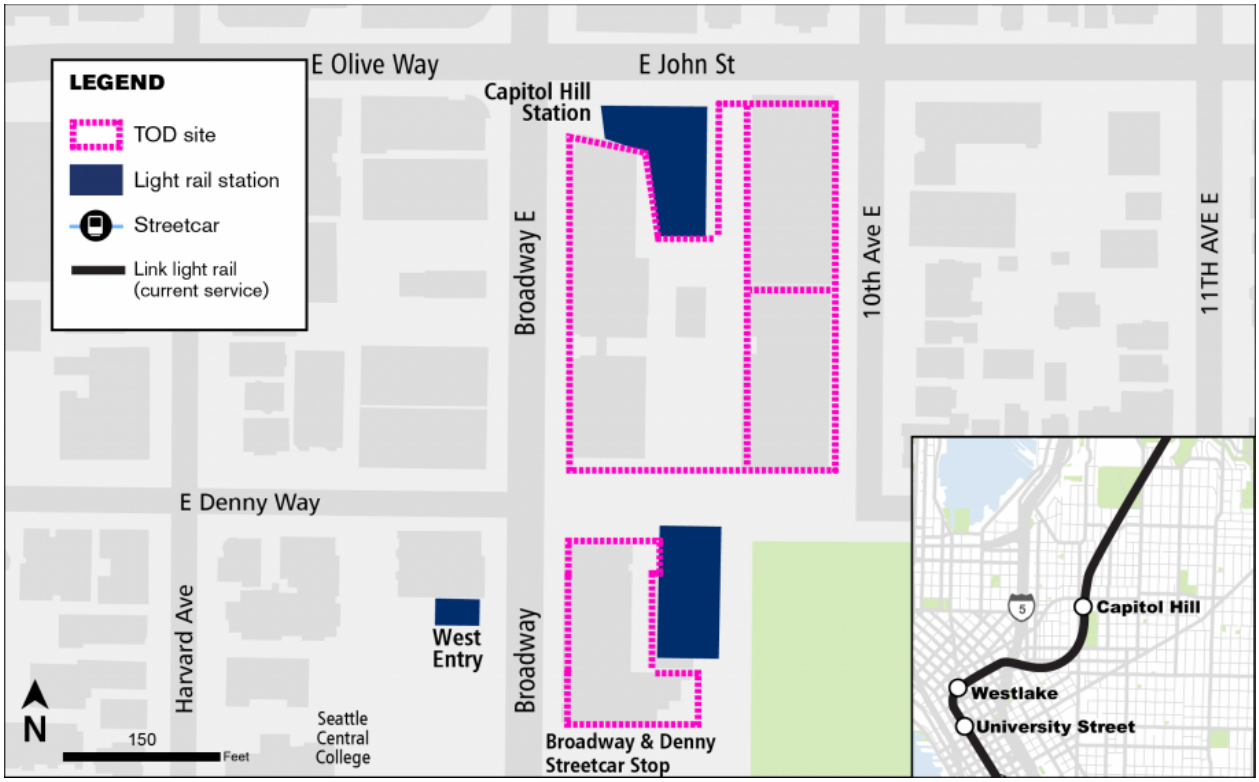

Figure 15: Capitol Hill Station Map, https://www.soundtransit.org/system-expansion/creating-vibrant-stations/transit-oriented-development/capitol-hill-north-site-tod

With 100 parking spaces per acre of structured parking, the parking ratio is significantly higher than in the case studies. Given the destinations and transit, greater effort could have been made to reduce parking as much as possible. The benefits would have included lower construction costs or more usable square footage for residential or commercial space, and residents could have been encouraged to prioritize use of the transit and pedestrian infrastructure in the area.

Figure 16: Capitol Hill Farmers Market in the center plaza of the TOD development, https://hewittseattle.com/project/capitol-hill-tod/

Figure 17: North corner of the TOD project facing Broadway showing the well-integrated light rail entrance, https://hewittseattle.com/project/capitol-hill-tod/

Beacon Hill Station

Beacon Hill Station sits atop one of the more unique geographical features of Seattle. At 350 feet above the Rainier Valley, the neighborhood is geographically constrained, with I-5 immediately west and I-90 to the north (Wilma 2001a). While the underground station had opened as part of the full Central Link service in 2009, the first transit-oriented development project was completed some years later, in 2014 on the property above, known as The Denning, while the remaining property was built out in 2021 as the Colina apartments (“Beacon Hill Station (Sound Transit)” 2023). In total, 185 apartments were constructed, with 20% of the units designated as affordable housing, 57 parking spaces, and over 7,200 square feet of retail space, in addition to a public plaza (“46 Apartments and Shops Leased in TOD above Beacon Hill Station” 2015) (“Beacon Hill TOD | Sound Transit” n.d.). Its surroundings remain primarily single-family residential, although some commercial activity exists along Beacon Ave S, and new multifamily structures are appearing as the light rail continues to draw more inhabitants to the area. The area fits into the sub-urban zone (T3) category of the transect, similar to ORENCO in its low density, residential focused

With only 0.83 acres of total site area, the combined projects have slightly higher density than even the Capitol Hill Station TOD, despite the much lower housing density of the surrounding neighborhood. Just over 220 dwelling units per acre is the highest density rating of any project compared in this thesis. The Walk Score remains respectable at 87 but could be improved with additional space dedicated to commercial destinations for the neighborhood (“2801 Beacon Avenue South, Seattle WA - Walk Score” n.d.). Parking is slightly higher than most of the comparables but notably lower than the Capitol Hill Station, with only 68 off-street parking spaces per acre.

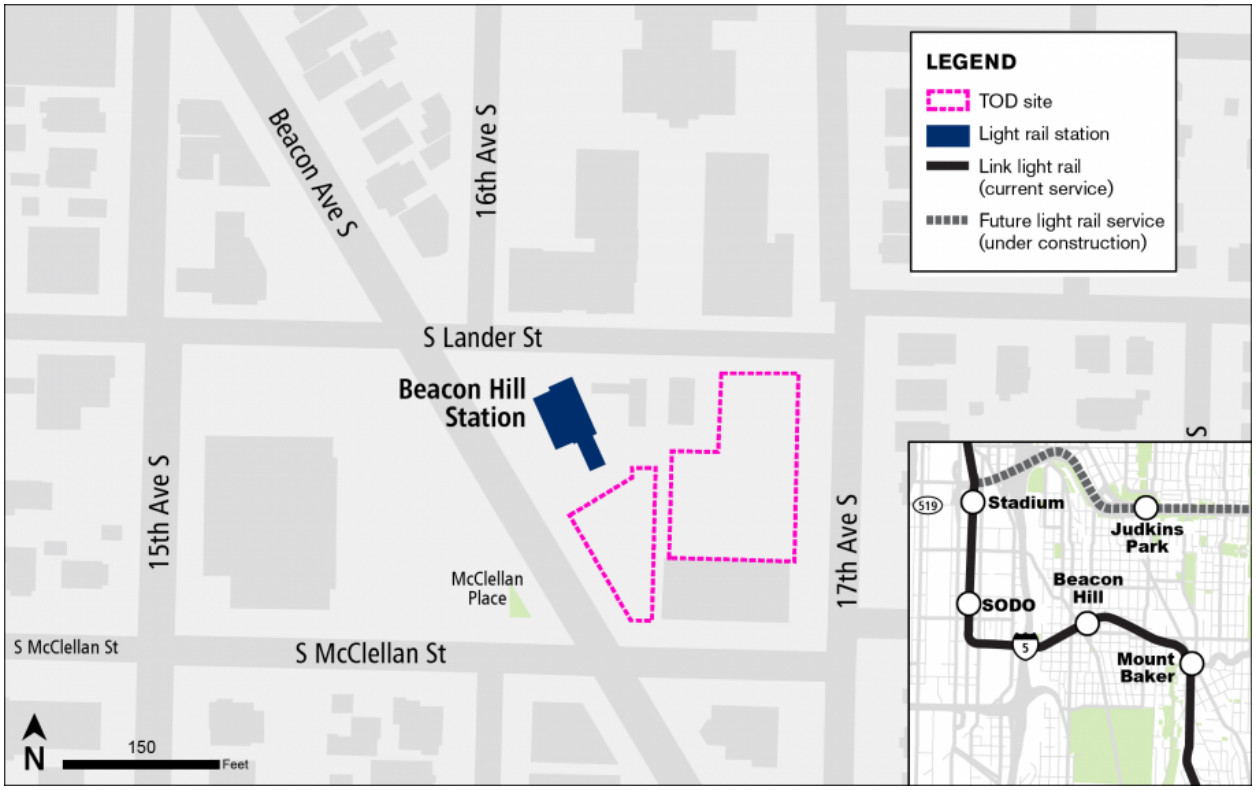

Figure 18: Beacon Hill Station and Colina apartment TOD sites; The Denning is at the corner of 17th Ave S and S McClellan St, https://www.soundtransit.org/system-expansion/creating-vibrant-stations/transit-oriented-development/beacon-hill

This project leads the way in terms of density when compared to both local and national project examples. The upzoning efforts undertaken by the City of Seattle are paying off in neighborhoods such as Beacon Hill by providing housing for more individuals, as well as a huge benefit to Sound Transit by positioning riders who are able to access the station entrance immediately adjacent to their front door.

Given the existing low-density surroundings of the neighborhood and the general lack of commercial and retail space, this project could have been more successful by focusing on dedicating more space to those uses. The Walk Score is better than both Englewood CityCenter and Orenco Station, which shows some progress, but remains geographically limited with most development along the busy arterial of Beacon Ave S. This location is only on par with the Northgate station, which originally contained an old mall and large format retail center with no residential density.

Figure 19: Beacon Hill Light Rail Station with the Colina Apartments just behind, https://www.soundtransit.org/system-expansion/creating-vibrant-stations/transit-oriented-development/beacon-hill

Northgate Station

Northgate Station is the current northern terminus of the Link light rail system, although the Lynnwood extension, which is due to open in 2024, will add another 8.5 miles. The property was initially developed as a crown of Seattle's auto-centric culture. “Opened in 1950, Northgate Mall in Seattle was the first shopping center in America to be called a mall” (Jiang 2019). With initial success and “the opening of Interstate 5 just west of the mall spurred a $10 million, 25-store expansion in 1965, more than doubling the project's size” (Wilma 2001b). But now, after years of struggling to reinvent the mall, developers have decided to transform the property and the land surrounding it into a mixed-use commercial and residential complex and National Hockey League (NHL) training center (Jiang 2019).

The Link light rail station on the west side of the property, adjacent to I-5, opened in 2021 and has initiated a plan to replace sections of the old parking lot into TOD. The special district classification of the Northgate station is very similar to Englewood CityCenter station and shares the slower more iterative approach to development as the retail uses decline over time. The first project is expected to provide 232 affordable apartments and a 7,500 square foot daycare center on a 1.1-acre lot (“151 NE 103RD ST –

Seattle in Progress" n.d.). Zero off-street parking spaces are proposed; instead, residents will be offered a complimentary three-year ORCA pass (One Regional Card for All) for free travel on all public transportation services, and bike parking at a ratio of one space per unit is planned ("151 NE 103RD ST – Seattle in Progress" n.d.).

The Walk Score of 87 is the same as that of Beacon Hill, but Northgate's will improve once the project is completed and the proposed daycare center opens ("401 Northeast Northgate Way, Seattle WA - Walk Score" n.d.). This is the only project of those selected to not propose any off-street parking, representing a very strong desire to set an example for future TOD development. The numerous transit options adjacent to the project and nearby destinations will support the needs of the residents well. A density rating of slightly over 200 dwelling units per acre is comparable to both Capitol Hill and Beacon Hill and remains much higher than the national case studies; however, this project parcel acreage does not include streets, which is unlike the Orenco Station and Englewood CityCenter projects. An estimated density calculation using equivalent measuring would likely yield a density rating anywhere from 10-30% lower.

Figure 20: Surrounding Uses plan for the proposed Northgate TOD project, https://www.seattle.gov/dpd/AppDocs/GroupMeetings/DRProposal3037586AgendaID11349.pdf

The absence of off-street parking will be the best feature of this development. Even though large amounts of parking remain adjacent to the site the regulations on time and use limit feasibility for use by residents attempting to retain their car. Not only will the project be cheaper to construct due to the absence of costs for a parking garage or surface lot, which will funnel more money to help house underprivileged residents of Seattle, but the transit passes available to the residents in the adjacent housing units will allow for free travel on the multitude of bus and rail options which are easily accessible within the neighborhood. Downtown Seattle, the University of Washington campus, and SeaTac airport are mere minutes away, which will incentivize the residents to live car-free.

The project falls short of housing density expectations when the greatly increased zoning allowances are taken into consideration. The current zoning (SM-NG-240) allows buildings up to 240 feet, yet the proposed structure is only a third of the allowance at 80 feet (“Bridge Northgate 151 NE 103rd Street” 2022). Constructing additional higher-density residential units would not only support the remaining commercial enterprises in the mall, it would also support the ridership of the adjacent transit services. Efforts should be made to address this in future phases of the TOD development and the ongoing redevelopment planning for the entire Northgate commercial district.

Figure 21: Rendering of the Northgate TOD proposal, https://www.djc.com/news/re/12146022.html

Vision for Seattle TOD

To date, Seattle's transit-oriented development is impressive for a city of its size and existing transportation environment. With additional light rail service on the horizon and an untold number of additional dwelling units in the planning process, it is important to consider the role that transit-oriented developments have in the neighborhoods they are enhancing or building. The unique characteristics of each Seattle neighborhood mean that the approach must be specialized to respond to the varied needs of the area, for both existing and future residents. The elements of housing density, destinations, and vehicle demand management must be balanced. While the City of Seattle and its partners, including Sound Transit and King County Metro, should be commended for their efforts to date, the reality is that more fine-tuning is needed to implement TOD projects that are responsive to the neighborhood and community needs in order to achieve the vision set forth by the TOD plan. Given the assessment of the national studies and review of three key TOD projects in Seattle within this paper, three recommendations can be made based on the classification of a neighborhood.

The first is the ***special district locations*** for those in the special district (SD) classification of the urban to rural transect. These areas are often older malls, disused stadiums or office parks which no longer generate the demand expected of them. Upon the introduction of light rail, the opportunity to introduce TOD elements is presented. Both Englewood CityCenter Station and Northgate Station fit this description of malls in transition. The primary goal for these sites is to build up the residential density level where previously there was little to none. Often, the transition from commercial area to residential is slow, and the intermixing of both presents unique opportunities to build on the existing destinations, along with the freedom to build completely new, very dense communities among the vast expanses of parking lots. Citizen support for density is generally more favorable since there are few who embody the NIMBY (Not In My Backyard) phenomenon and argue in favor of the “preservation of neighborhood character.” As in the examples, the suburban nature may lessen the demand for a full pivot from commercial to mixed-use, but the iterations and phases create a unique product.

1. Focus
    a. Density - build housing density where little to none previously existed
2. Opportunities

   a. Iterations and phasing - acres of parking lot to develop over time without extreme impact to existing residents, businesses, and transportation systems
   b. Flexibility - project sites often allow for the creation of a new urban fabric, including street layout and biking infrastructure to fit the specific needs of a TOD development
   c. Destinations - take advantage of the existing destinations and commercial activity in the area
3. Challenges
   a. Creating a pedestrian-friendly environment in an area designed solely for the automobile - existing structures were likely not built with the pedestrian scale in mind
   b. Balancing economic needs - retain the sales tax base of successful commercial enterprises while transitioning to the mixed-use product

The second are the ***sub-urban locations*** or those falling in the lowest density, rural leaning or light urban zones such as T2 and T3. These differ from suburban retail in that there are typically existing single-family residences as opposed to commercial development, and remain highly auto-centric. Destinations are limited since the housing density is not up to a level to maintain critical mass. Driving is the primary form of transportation to reach the vast majority of destinations. Here, focusing primarily on bringing additional destinations to the neighborhood will have the greatest impact. Orenco Station and Beacon Hill Station both fit this description as they are less urban locations, and did not have the same commercial presence as the suburban retail examples.

1. Focus
   a. Destinations - support additional destinations in the neighborhood to serve the existing residential customer base and accommodate future growth
2. Opportunities
   a. Existing community - neighborhood already has an identity and community feel
   b. Walking infrastructure - generally has existing elements to accommodate walking and biking in a tighter neighborhood grid compared to suburban retail
3. Challenges

   a. Community support - resistance towards additional density and neighborhood change; strong city leadership must advocate for the development
   b. Rigid infrastructure - typically less flexibility to redevelop street and sidewalk layouts due to existing residents and utility networks
   c. Site acquisition - finding properties large enough to develop effectively is more difficult

Finally, the most complete example of effective TOD is ***urban center neighborhoods,*** for the urban locations on the transect, T4 & T5. These can build on the existing mixed-use developments where both residential and commercial densities are high and off-street parking is reduced or eliminated. Capitol Hill–where light rail was introduced as infill–or Fruitvale–which has grown over time as a result of continued growth and development–are excellent examples. These areas tend to have a predominance of multifamily residential neighborhoods and generally have a strong presence of nearby destinations, which earns them the highest Walk Scores. TOD in urban neighborhoods should not construct off-street parking, rather, it should instead focus on accessibility and/or infrastructure improvements to pedestrian-scale transportation. Upon the introduction of the Link light rail in Seattle, residents will have access to frequent, reliable transportation to utilize the existing destinations in the area to fulfill their daily needs.

1. Focus
   a. Vehicle demand management - reduce reliance on the automobile and make a concerted effort to encourage smaller scales of transportation, or transition vehicle use directly to public transportation
2. Opportunities
   a. Community support - likely more open to high-density residential development if multifamily housing is an existing land use
   b. Mixed-use success - already proven demand for destinations from which to build
3. Challenges
   a. Working within a fully developed neighborhood - it is difficult to make adjustments, both from a community character standpoint and when considering the physical limitations of construction in a tighter urban grid

b. Rigid infrastructure - working within the existing infrastructure is extremely difficult and time consuming for large-scale changes

Challenges and Limitations

A few limitations and challenges must be addressed as the nature of development and cultural aspects have a real impact on even the best transit-oriented developments. Success of TOD depends on numerous factors beyond the density, destinations, and parking availability. Those elements are building blocks that serve as a foundation for a transit-oriented neighborhood but must work within the vast array of additional elements that need to be considered when planning and implementing TOD, including. But not limited to affordability, demand, equity, existing conditions, and cultural aspects.

One of the most prominent challenges in research around TOD implementation, especially at a local scale is accurate data on VMT, public transit use, vehicle use and walking or exercise time. Most studies attempting to determine how human decision making and behavior is impacted when adding TOD or moving to a TOD location can only access broad data types such as congestion information for the city, average commute times, transit ridership data, etc., but few are able to gather data that can explicitly exhibit a reduction in vehicle use and an increase in walking or public transit use for an individual if the infrastructure is provided. This challenge may be overcome as anonymous tracking data from cellular devices continues to become common and vehicles become more connected to the cloud, allowing tracking data to be gathered from them as well creating a more detailed picture than traditional methods of use, usage times, and many other important characteristics of peoples' transportation needs.

TODs operate within the same real estate market as other forms of housing and must be competitive. A successful development is based not only on the construction, but also the occupation and participation of the community. There must be demand for both the residential and commercial spaces provided, which depends on a variety of factors that can extend far beyond the scope of the development or even the municipality. Initial successes give some indication that demand for walkable and transit-oriented neighborhoods are more highly in demand than traditional single-family housing types, however, additional challenges with displacement, gentrification, and affordability will need to be

addressed. Flexibility to respond to changing housing markets must also be considered as municipalities work to incorporate TOD.

Institutional limitations through zoning and building code continue to restrict the ability of developers to construct TOD in many communities. Required parking minimums, Euclidean zoning standards, street width requirements and height limits are just a few of the most common hindrances to building dense, mixed-use developments dependent on public transportation and walkability. Cities and municipalities should endeavor to remove these restrictions on TOD projects in a manner that maintains functionality and equity in the urban environment.

The public sector investment priorities rarely align with TOD goals. Decades of heavy investment in automobile infrastructure must be shifted to support better public transportation, including light rail, commuter rail, bus services, and first/last mile connectivity options. Additionally the physical infrastructure including sidewalks, bus stops, stations, and bike infrastructure must be improved in order to be accessible to the entire population and promote their use. Without good options, Americans will continue to rely on the automobile, further entrenching society in its addiction.

Equity is an extremely important consideration when working in any neighborhood. As stated above, TOD has the potential to be a small part of the foundation for more equitable housing and transportation opportunities, however, there is no guarantee. Many members of society have come to depend on automobiles for personal transportation and business. Placing additional limitations without facilitating alternatives will likely increase inequities faced by those already struggling. Specific efforts to address inequities as they arise will be required to implement TOD in ways that work for all members of the community for which they are designed.

Conclusion

For TOD to be a complete success, there must be proven evidence of a modal shift and behavioral change to lower vehicles miles traveled (VMT) per capita. Replacing the automobile with other forms of transportation will not occur overnight, but, with a targeted approach, cities can begin to affect real change. Cities, transit agencies, and municipalities are tasked with providing infrastructure, policy, and funding to support TOD. This includes flexible zoning to build the foundation for higher residential and

commercial densities, support for small local businesses, better walkable environments, and careful consideration of vehicle demand management strategies that equitably challenge users to shift their behaviors. There is no set recipe for TOD, only strategies and elements required for success that leave room for iteration. Policy revision and property redevelopment will demand to be continually updated to meet current needs and identify opportunities to incrementally introduce TOD strategies. Achieving these goals depends heavily on the support of government and planning officials at all levels. Despite previous efforts and proof of successes, the culture of the automobile continues to be entrenched in government. Many changes are needed to zoning codes, building codes, fire codes, engineering standards, vision plans, and comprehensive plans to achieve the change envisioned here. In addition, more information and data around the true impact and use of TOD is important to more fully understand how to more effectively implement TOD developments.

The automobile addiction can and will end in favor of an urban environment that is equitable, accessible, enjoyable, and functional. TOD offers planners a tool to achieve this vision in Seattle and other cities. By locating housing, offices, retail, and other services close to transit, automobile reliance–or VMT per capita–can be reduced in favor of walking, cycling, and public transportation.

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Appendix

Appendix A - Data Summary

National Study Locations				
	Neighborhood Type	Density (Units per Acre)	Destinations (Walk Score)	Parking (Spaces/Acre)
Englewood CityCenter Station	Special District (SD)	8	85	50
ORENCO Station	Sub-urban Zone (T3)	10	79	13.6
Fruitvale Station	Urban Center Zone (T5)	16	95	37.5

Seattle Locations				
	Neighborhood Type	Density (Units per Acre)	Destinations (Walk Score)	Parking (Spaces/Acre)
Northgate Station	Special District (SD)	200	87	0
Beacon Hill Station	Sub-urban Zone (T3)	222	87	68
Capitol Hill Station	Urban Center Zone (T5)	200	99	100