Design for Transit: A Background Paper
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Introduction

This paper provides background information on what drives transit demand and how urban areas can be better designed to facilitate transit usage.

Travel Market

Demand

Transit demand is influenced by numerous factors that are not well understood. These generally include income, gender, auto availability, auto operating costs, parking availability and cost, transit service availability, etc. There is a long held notion that population and employment density is a major or even the primary driver of transit demand. While this may be true for extremely large compact cities like New York City, Boston, Singapore and Hong Kong that is not true for cities that are more auto-oriented like Los Angeles and Phoenix. Instead the primary indicators appear to be auto availability, income, and transit availability and service frequency. On Metro's transit system in Los Angeles for example, only 18% of bus riders has access to a car and their annual household median income is $15,000 compared to the Los Angeles County median of $56,000. Meanwhile it is a little higher for subway and light rail with 35% of rail riding having access to a car and an annual household median income of $19,000.[1] So if you are poor and do not have access to a car, you are more likely to use transit than anything else. Including transit availability sounds counter-intuitive but it is similar to the old adage about money – it takes service to generate demand.[2] In general then, transit demand is mostly from those who do not other means of getting around. Also past observation shows that many patrons are self-selective as to where they live and go. People who want or need to use transit will tend to locate near existing service and go to places served by existing service. So over time, higher demand corridors become self-reinforcing.

The primary purpose for taking transit is commuting to and from work. Generally, they represent only 15 – 20 percent of trip making but make up the lion share of trips on transit. In Los Angeles for example, they make work purpose trips comprise up around 52 percent of all transit trips. Percentages are often higher on other large transit systems in the U.S. The dominance of commute trips intuitively makes sense. It is something that most adults do on a regularly scheduled basis with most of which occurring during the peak hours of travel when transit service is most robust while congestion is the heaviest. Taking transit is significantly less prevalent for other trip purposes such as shopping, visiting friends and doing errand since they often involve carrying packages and/or taking trips during off times when transit service levels are much weaker or even non-existent. It is also harder to take transit when trying visit series of destinations along one journey especially if it involves frequent stops and lots of transferring. Work related trips tend to be less complicated since tend to involve just going from home to work and back. If combined with other destinations, they are done either prior or after the main part of the trip is completed based on observation.

Transit Users

Transit users roughly fall into two categories: captive riders[3] and choice riders. Captive riders are those who either do not have access to a car or cannot drive one. Essentially this includes children under 18, disabled people, people who are too frail or have other impairments, do not have a driver's license and of course do not have regular access to a car. Some planners also include people choose not to drive as a life style and tourists into this category.[4] The primary focus of this group is ***access***. This involves being able to easily reach various regions throughout the metropolitan area whenever they want via walking or biking to the nearest transit stop. So their primary concerns are coverage, frequency, span, reliability as well as safety. They are also very sensitive to fare prices. The poorest riders will go to great lengths to save money even if it means taking a much longer trip in order to avoid paying for premium service.

Traditionally transit planners have automatically treated seniors, those 65 or older, as part of the transit captive population. While society still considers anyone 65 and over as seniors, many if not most of them are still very vibrant and both physically and economically able to drive long past age 65. In fact recent studies commissioned by the California Department of Motor Vehicles show that most seniors who were driving before turning 65 will continue to drive until about 85.[5] By then they are too frail to use fixed route transit and have to use para-transit like ACCESS in Los Angeles and taxis to get around.

Then with respect to children 18 or under, many of their needs are met by walking, bicycling and getting rides from parents and carpools. This is especially true for those whose parents typically drive for most or all of their trips. So planners cannot automatically count them as part of the transit captive market.

Choice riders are those who can easily drive but decide to use transit. For this group, their main focus is ***mobility***. This is the ability to get to where to want to go quickly. They are also very sensitive to convenience, comfort, safety and reliability. Travel time must relatively comparable or even better with the car.[6] Therefore, they are very partial to premium transit service such as commuter rail, urban rail and bus rapid transit and freeway express service. If they live within ½ mile of a transit station they will walk. But if not, which is often the case, they will drive to the station. They tend to be very averse to transferring especially using feeder bus service to get to the station. Therefore station parking is very important to them. If they find certain things about the service not to their liking then will go back to driving. Choice riders mainly use transit to get to work.

Landform and Urban Design

Density and Thresholds

Planners traditionally see density as the primary driver for transit demand. But the actual relationship between density and transit is not well understood. In general, research shows that automobile vehicle miles travel decreases while transit and walking increases as areas become denser. [7] Chris Brandford in his analysis shows that there is a significant relationship between residential density and transit commute trips at the metropolitan statistical area level but to what extent is unclear.[8] A while back, Reid Ewing and Robert Cervero conducted a meta-analysis a variety of past studies regarding travel behavior and mode share in urban areas. Their research shows that there is a weak relationship between residential and employment density and overall transit use when analyzed separately.[9] This agrees with research performed for the Los Angeles Area. It shows that there is only a 1.4 percent correlation between gross residential density and bus ridership and 1.3 percent correlation between gross employment density and bus ridership. However if both densities are combined and only developed acreage is used, the correlation jumps to 42 percent and resulting statistical analysis shows it to be statistically very significant.[10]

However, the story for rail appears to be different. Here research indicates that rail ridership is more dependent on employment density than residential.[11] This is probably because rail service draws more choice riders than bus service. Since choice riders have access to car and there a lot more rail stations with commuter parking than bus stops, choice riders are less dependent on living near a transit stop. Los Angeles for instance, surveys indicate 23 percent of riders drove/dropped off to light and heavy rail compared to 10 percent for bus.[12] Meanwhile at least 60 percent drive to commuter rail.[13]

So density does play important role, but residential and employment densities have to be taken together along with only using net or developed acreage especially when looking at bus service. This make since the dominate mode of access and egress for transit is walking. In Los Angeles for example, 83 percent of bus riders and 68 percent of rail riders access transit through walking and is even higher for egress. [14] So in order to have high ridership, transit needs to be able to connect in very close proximity to both large dense concentrations of residents, employment and other destinations. This agrees with the current research.

But coming up with thresholds for different levels of transit service is another matter. A synthesis of the prevailing literature seems to suggest the following[15]:

Table 1 – General Thresholds for Transit Service

Mode	Service	Threshold	
		Residential	Employment
Local Bus	Minimum - 60 min. Intermediate - 30 min. Frequent	3 - 6 du per acre 7 - 8 du per acre 12 - 15 du per acre	4 emp per acre 25 - 30 emp per acre 50 - 75 emp per acre
Light Rail		9 du per acre 23 pop per acre	50 - 75 emp per acre
Heavy Rail		12 du per acre 30 pop per acre	> 75 emp per acre

du – dwelling unit, pop – population, emp – employees

These thresholds are based on using gross acreage. As mentioned above, both residential and employment thresholds should be used together. Unfortunately the literature is not clear as to what is meant by "frequent" service. Presumably it is at least 10 – 15 minutes during the peak periods.

The 2009 Transportation Plan for the City of Ann Arbor indicates the following using combined population and employment[16]:

- 5 – 10 (population + employment) per acre
  This density represents typical low-density suburban development. All transportation trips occur using the automobile, with bicycle and walking used only for recreation. Little to no transit can be supported.

- 10 – 25 (population + employment) per acre
  This represents typical urban neighborhoods comprised of compact single family homes with adjacent commercial districts. Bus service can be supported and other modes of transportation are also used, but single occupancy vehicles are still the dominant type of transportation.

- 25 – 40 (population + employment) per acre
  This represents denser residential areas and commercial districts. While driving is still a dominant mode choice, the shortage and price of parking make transit and other modes of transportation an attractive alternative. Frequent bus service can be provided in these areas

- 40+ (population +employment) per acre
  This represents a densely developed residential or commercial district. Modes of transportation such as bicycle, walking and transit are used more frequently and there is a marked decrease in the number of single occupancy vehicles. Typically higher quality transit (such as BRT or streetcar) can be supported with this development intensity.

These thresholds are based on using data from Urban Development Intensities in the Washington, DC Metropolitan Area by Terry Holzheimer and residential densities suggested in Public Transportation and Land Use Policy by Boris Pushkarev and Jeffrey Zupan published in 1977. The densities appear to be based on gross area.

Finally, research performed by Robert Cervero and Erick Guerra indicates that the combined density of population and employment should be about 30 individuals per gross acre for light rail service and 45 individuals per gross acre for heavy rail service around a ¼ mile of the station. If these conditions are met, then the service would be in the top quarter of effective rail investments in the United States.[17] This is a little different from previous studies. Clearly much more study and research is needed especially for frequent bus service.

There is another interesting aspect concerning density and transit. Sisinnio Concas and Joseph DeSalvo found that lower densities define a broader activity space which in turn decreases transit demand. But as density increases, the activity spaces contracts as does the need to engage complex trip making. If adequate transit service and access is present, then people will choose transit over driving. This may explain why transit supply is an important factor for transit demand at least for denser corridors. [18]

Urban Structure and Land Use

Perhaps more important than density per se is how the built environment is composed and structured. Places with large concentrations of employment that also have shopping, entertainment, housing, ancillary and other services create a more balanced environment. This allows workers to conveniently take care of other business and engage in non-work activities without needing to go elsewhere. Meanwhile it becomes an attraction for outside residents and tourists. The greater the concentration and mix, the more synergy there is for transit service.
Not all land uses lend themselves to transit use. Some are obvious like agriculture, forestry and mining. But others that are not so obvious are manufacturing, sea ports, suburban styled office parks, and suburban regional shopping malls. Manufacturing tend to be concentrated in lower density areas often away from other destinations and large pockets of populations. These districts also tend to employ a lot shift work which means many of the workers are coming and going outside normal peak travel times when service levels are low. They also tend not to be very walkable since the areas often have long blocks, and unpleasant walking environments. The same also true with sea ports, intermodal rail facilities, salvage yards, recycling facilities and warehouse districts.

Office parks or "campus based developments" tend to be surrounded by parking lots, set back far from the sidewalk and are often located away from centers of population and other destinations. It is common to find them alongside light industrial parks and warehouses. They tend to be in areas with long blocks and not very walkable from the street. Together these attributes are not conducive to transit use since transit works much better when building entrances are placed close to stops with inviting paths with other destinations and complementary uses nearby.

Suburban regional shopping malls and retail outlet centers are not conducive to transit either. While they are major traffic generators and employ large number of lower income people, they are too oriented to the car. This is due to fact that they are typically surrounded by large surface lots and parking structures and contains very large setbacks from the major streets. Carrying large packages and bulky items are hard to do on transit especially during the peak hours. They also tend to be in lower density areas which do not help too. Sometimes this can be rectified if transit service is allowed to go into the center and stop near the main entrance. The drawback is that it forces the buses to deviate from the street and causes delay for the other passengers unless the stop is at end of the line. Because malls are usually on private property, the transit agency does not possess the right to go in and the serve the mall can be asked to leave if desired by the mall. Table 2 in the Appendix contains a list of land uses conducive to transit use.

Street Networks

Another important factor is the street network. The street network that work best for transit are interconnected streets. These are streets that minimize discontinuous segments such as loops, cul-de-sacs and dead ends. They also allow bus lines to penetrate into neighborhoods make it easy for pedestrians to access bus stops, shorten walk distance and disperse auto traffic. Dispersing auto traffic helps make streets safer and minimize running time for buses. Denser the network, the more paths there are for traffic, pedestrians and bicyclists as well as shorter connections to destinations.

The best interconnected street systems are rectangular grids with hierarchical streets or rectangular grids overlaid with some radial streets originating from the urban center like Chicago and Washington D.C.[19] Depending on the development patterns, rectangular grids give transit planners the opportunity to create evenly spaced service with minimal turns and easier to comprehend for both the rider and bus operator. Such a system also makes it easier to create turn around loops and detours. By making the network hierarchical (boulevards, avenues, collectors, residential), allows buses to run on larger streets with appropriate turning radii[20] for curbs while avoiding the use of smaller neighborhood streets which people like. Hierarchical streets can also facilitate the placement of commercial and denser residential development on the larger streets which is good for transit ridership. Rectangular grids are good for serving vast areas of development with multiple major centers. Radial streets are good for providing direct and faster access to very large central business districts.

Another key component to the street system is the block size. Research shows that people will tend to walk more and take transit with smaller blocks. But if they are too short, the extra intersections will begin to slow down travel time too much and become more of a nuisance due to extra stopping at traffic lights and having to pay more attention to cross traffic and pedestrians as you traverse the intersections. Research shows that the ideal lengths should be about 400 – 500 feet.[21] If blocks are longer than 600 – 800 feet, then mid-block crosswalks are recommended. Transit planners will typically place bus stops at every other block or at ¼ mile intervals (1,320 feet) depending on demand and activity density. But too many stops will unnecessarily slow down bus service and displace too much street parking. So the right balance may be 450 foot blocks with stops at every third block.

Walkability and Sidewalks

A good walking environment is important too since it encourages walking and facilitates access to transit. This is particularly important to transit riders their primary mode of access and egress in walking as noted earlier. In addition to interconnected streets and with appropriate block sizes, import features includes wider sidewalks, good lighting, landscaping, narrow streets in local neighborhoods, a feeling of safety and interesting sights like architecturally interesting buildings. Of course everything should American Disabilities Act (ADA) compliant and sidewalks should be kept in good repair.

Placement of street furniture such as telephone poles, signs, benches, news racks and so forth should be done with care to avoid impeding pedestrian paths. Caution must be used to selecting landscaping that will not lift or breakup sidewalks over time but are also easy and cost effective to maintain. Monterey-Salinas Transit recommends a minimum sidewalk width of 10 feet where there is bus service. ADA requirements specify an unobstructed path of 5 feet between the curb edge and bus bench and 8 feet for a bus shelter to facility wheelchair boarding. An unobstructed path of 5 feet allows for two wheel chairs to pass one another comfortably while 8 feet is needed for two pairs of people.

Street parking, bicycle lanes, landscaping and street furniture are good buffers between motor vehicles and pedestrians on major streets. If possible, pedestrians should be allowed to cross at all four corners of a signalized intersection. Signalized midblock crossings should be considered for blocks longer than 600 feet where there is high pedestrian activity. When possible, bus stops in one direction should be paired with one in the opposite direction at signalized crosswalks. Bus shelters should be placed at higher demand stops. Ones with decent lighting, security features, seating and protection from the elements are a plus. Good signage and way finding are also desirable.

Pedestrian tunnels and overcrossings can be useful depending on they are deployed. If done right, they can provide safe and convenient means to access a stop or station from a major building, plaza, or parking lot without having to cross the street, a railroad or through a freeway undercrossing. They are particularly useful when trying to divert large amounts of pedestrian crossing from heavily traveled streets. But if they are placed in isolated locations, they could it end serving as improvised homes for the homeless and become places where criminals can hide to attack and rob people especially if there is inadequate lighting and security. So care must be taken designing and implementing these treatments.

Some planners and architects advocate the use of curb extensions/bus bulbs. Generally these treatments ***are not*** recommended for heavily traveled streets with transit service. If located at transit stop, they create more room for waiting passengers and stop amenities while preventing the need for the bus exit and entering traffic. But on the downside, they cause buses to block traffic including other buses behind them. This is particularly a problem when there is only one through lane in each direction. When placed at the corner curb, they contract the crosswalk length which increases pedestrian safety. But they also shorten the curb turning radius making it much harder or even impossible for larger vehicles including transit buses to make right turns. Moreover, curb extensions prevents the use of right turn lanes, makes it difficult for vehicles parked behind them to merge into traffic and tends to unnecessarily slow down traffic which is bad for transit running time. Due to these issues, these should be avoided.

Transit Access and Egress Distances

Research shows that people will typically walk up to ¼ mile or five minutes to reach a bus stop and ½ mile or 10 minutes for a rail station from home.[22] But once they arrive at their destination, it is typically ¼ mile from either the stop or rail station.[23] In fact, survey data for Los Angeles indicate around 97 percent of bus riders and 87 percent of rail riders egress by walking.[24] Riders accessing and egressing bus rapid transit stations probably behave in the same manner as they do rail. Since walking is dominate mode of access and egress, it is therefore extremely important to place stops, stations and development as much as possible within a ½ mile for residential and ¼ of commercial buildings to achieve high ridership. Walking is also the easiest mode to accommodate and the most efficient from economic and environmental viewpoint.

If riders bicycle to transit then research show that they are willing to travel between 1 – 2 miles to get to stop or station.[25] The Federal Transit Administration believes its three miles.[26] Nationwide research indicates that people typically will drive up to 5 miles to reach a park and ride.[27] But distances could be longer for terminal stations and more distant commuter rail stations based on observation in the Los Angeles Region. Information on carpools and drop-offs are not available. Being able to park and ride is particularly important to choice riders who want to access premium transit service living beyond ½ mile of a station or an express bus stop. In fact they are more likely to drive to the station than anything else. So the incorporation of park and rides in the planning and design of premium service is very important especially if we want to get choice riders living beyond ½ mile of station or express stop out of their cars. Many of the more successful park and rides tend to be towards the ends of the line and in more suburban areas.

Building Site Design

The placement of buildings, entrances and parking can influence transit ridership too. In general, buildings should be placed at or very close the lot lines[28], parking in back or underground and the primary entrances on the street. This minimizes the distances between then entrances and transit stops while maximizing the interaction of the buildings and greater built environment with the street and pedestrians and eliminating perceived barriers. Small setbacks of 15 feet can be used to highlight significant buildings, be available for outdoor cafes, and to create usable, publically accessible open space.[29] If integrated into the building they can be used to provide shelter for transit patrons at a stop.

Also helpful is orienting the main entrances toward the transit stop and integrating subway stations portals to the buildings adjacent to them. Locating the primary entrances of corner buildings toward the corner of the intersection is a plus. Researchers Stover and Koepke recommend placing transit stops no further than 200 feet from the principal building entrance, 300 feet at the absolute maximum.[30] Where possible, building driveways should be place on side streets on in back alleys. Doing this reduces the need for pedestrians and vehicles to stop for one another and makes being on the street more inviting. Providing clear to direct paths to plazas, squares, pocket parks and special pedestrian alleys also help. Of course primary street entrances should be very visible. [31]

Some planners suggest, placing public uses and high trip generators on the ground floor, minimizing blank walls with windows and art, sizing windows and entrances to pedestrians, adding interesting art and architectural treatments and providing amenities and weather protect to transit riders at stop locations. In summary, everything should be done as much as possible to oriented buildings, entrances and spaces to transit stops/stations while fostering street level activity.[32]

Summary

In auto-oriented cities, the primary drivers of transit demand are low income, lack of access to a car and to some extent the supply of transit service. Density is important too but its relationship to transit use is not well understood. But what is clear that population and employment should be considered together over the net area rather separately over the gross area as it is often done. Furthermore, it is not just the presence of density but how is structured and interfaces with transit. So the key is to high transit use is to connect large dense pockets of residents with large dense employment clusters consisting of office, professional, research, administrative, government, creative based industry and store front retail within walking distance to the line. This strategy works even better when intermixed with shops, services, ancillary uses, restaurants, and entertainment coupled with interconnected streets and paths with lots of four-way intersections and blocks around 450 feet long. An example of good interconnected street is a hierarchical rectangular grid with allows denser housing and commercial activity to be on the primary streets which is good for transit service while having low density housing, schools and other neighborhood uses on the smaller streets.

Also important is placing buildings at or very close to lot line, locating parking in back or underneath buildings, orienting the primary entrances to the street and transit stops, stationing driveway on side streets and alleys, positioning major traffic generators on the ground floor, good lighting and wide sidewalks. Landscaping, lots of ground floor windows, adjacent street parking, way finding and signage, interesting street and architectural features, bus shelters at higher demand stops and scaling the ground floor doors and windows to the pedestrian can make a difference too. Employing all these strategies together creates an inviting and active street environment which ultimately creates synergy for transit use.

Appendix

Table 2: Transit Supportive Land Uses

Office
- Professional/Business
- Administrative
- Customer Service Centers
- Design and Creative Services
- Research and Development
- Government

Medical
- Medical Offices
- Hospitals
- Outpatient Clinics
- Urgent Care
- Laboratories

Education
- Universities
- Community Colleges
- Trade School
- Urban Secondary Schools

Retail/Personal Services
- Shopping Centers - street oriented
- Community/Local - street oriented
- Pre WW II middle size markets
- Ancillary Services
- Restaurants and Bars
- Social Services
- Bazaars and Farmer Markets
- Gyms

Entertainment and Tourism
- Movie and Live Theater
- Concert Halls
- Amusement Parks/Circuses
- Stadiums and Arenas
- Convention Centers
- Meeting Halls
- Hotels
- Museums
- Major Landmarks
- Public Beaches
- Boardwalks and Piers
- Bowling
- Art Galleries
- Public Spaces and Plazas

Table 1 – Transit Supportive Land Uses Continued

Residential

Small Lot Single Family
(<6,000 sq. ft. lots)
Townhouses
Row houses
Multi-Family Housing

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