PLANNING SUBURBS FOR
PUBLIC TRANSPORTATION

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1. **Introduction**

In late 1980 the *Wall Street Journal* reported that Chrysler was demolishing one of its largest factories, "Dodge Main" in Hamtramck, Michigan. Although the multi-story building was structurally sound and could serve for many years, it was inefficient for modern manufacturing processes. Moving parts from floor to floor by elevator was expensive and difficult to synchronize with the assembly line. General Motors, who will take over the site, plans to build a single-story plant more adaptable to changing production processes.

Similar spatial economies affect urban public transportation. While increased use of public transit is considered essential to achieving a wide range of social and economic goals, in sprawling suburban areas strategies such as subsidizing fares or building expensive subways have had generally disappointing results. More and more it is realized that this land use pattern cannot usually support efficient or effective public transit. Just as the arrangement of machines in a factory affects production economies, so street patterns and the arrangement of houses in a suburb affect the economies of transit operation.

While General Motors has the freedom to re-arrange the layout of its plant to facilitate efficient production, public transit systems must manufacture their "product" in an environment that is not under their control. The "product" a transit system "manufactures" is access between people's front doors and jobs, schools, shopping and other activities.

The most obvious difference between older neighborhoods that support good transit service and new suburbs entirely dependent on the automobile
is lower average densities. With lower densities, fewer trips are generated in a given area, and so transit has a smaller potential market. But planners have been too hasty in concluding that the density needs of good quality, frequent transit service cannot be reconciled with the housing preferences of most Americans. While suburbs as usually laid out cannot support transit, single-family homes can be arranged in many different ways while still preserving the attributes middle class families seek.

Unlike the automobile industry at Hamtramck, we cannot tear down the suburbs and rebuild them to suit transit economies. But every year we build 500,000 to 2 million new homes, and over a decade (it is now almost that long since the first oil embargo) a substantial part of our cities are demolished and rebuilt.

This paper will show how new communities can be designed for and old ones adapted to the spatial requirements of efficient, high quality transit service. First I will examine what exactly the spatial requirements of transit are, and how they can be reconciled with suburban housing types. I will develop a series of hypothetical neighborhoods to demonstrate critical aspects. Then I will look at how the concerns of other actors in the development process conflict or coincide with transit efficiency. Finally I will suggest some rules of thumb for measuring transit efficiency, and policies and negotiating strategies for achieving it. Examples of both new and "retro-fitted" suburbs will be presented.

*Just as houses can be "retro-fitted" for energy efficiency by adding storm windows, insulation, and heat pumps, so neighborhoods can be retrofitted for transit efficiency.
I will demonstrate that it is possible to combine the attributes of suburbia that American families can afford and apparently value, with the minimum spatial requirements of public transportation, in a metropolitan context of employment decentralization, high auto ownership and an extensive freeway system. This efficient, high quality transit service can be competitive with the automobile for most trips by most residents, with fares covering most or all of operating costs.  

2. Urban Densities for Public Transportation

It is widely believed that viability of transit depends greatly on average density. 4 An implication is that unless American families can be persuaded to live closer together, giving up the suburban lifestyle they have chosen, transit will continue to play a minor role in urban transportation. Under these conditions, there is little room for meaningful transit operator input into suburban planning. The density needs of public transit and the spatial characteristics of suburbia do not seem to intersect.

In fact density, measured in persons or households per acre, is a valid measure of neither transit viability or of achievement of the neighborhood environment most Americans seem to value. It is not low density, per se, that causes low transit ridership in the suburbs. Where high quality service is available, even high income adults often choose it over driving. Rather, the problem is that buses must make too many stops, or follow circuitous, time consuming routes if they are to collect reasonably full loads. It is simply impossible to offer frequent service
within walking distance of all homes at a reasonable cost. There are, in a sense, *external diseconomies of scale*.

While density is often used as a measure of potential transit viability, the relationship of land use to the efficient production of transit is in fact more complex. The local and arterial street pattern, the shape of house lots, and the mix and distribution of different uses all affect the viability of transit. The number and distribution of homes within walking distance of a bus stop is a more valid measure of the density needs of transit than the number of units per acre.

A few assumptions about the economies of transit service are necessary here. The relative attractiveness of transit as an alternative to the car is believed to depend on: the length in time and the discomfort of the *walk* to and *wait* at the bus stop, and the *ride* on the vehicle or vehicles; the clustering or scattering of destinations such as employment, schools, and *shopping* (near transit stops or isolated in desolate suburban parks); and relative *costs* of different modes (fares versus tolls, parking charges, wear and tear, gasoline). The first three factors have fairly specific critical dimensions within which conventional transit is a viable alternative to the car. Although fares, incomes, and distance and location of employment have real impacts, in most suburbs the most important constraint is simple lack of effective service. (For a more complete model of the production of public transit competitive with the automobile, see Appendix I.)

Many behavioral studies have shown that walking and waiting time is perceived as very onerous. Very few people will walk more than one
quarter mile from their front door to a bus stop, and even less if they are carrying parcels or infants. If transit is to attract passenger making suburb-to-suburb trips between dispersed locations, frequencies must be sufficient so that convenient transfers can be made. Generally speaking waiting times of more than ten minutes are very onerous. The ride time on a bus can be competitive with the automobile provided it does not make detours off direct main roads, or an excessive number of stops. Consequently, the number of houses within one quarter mile of a potential bus stop location along a direct road is critically related to the frequency of service that can be supported.

While the production economies of transit depend on many factors, experience in many cities suggests minimum ridership required if reasonable fares are to cover a reasonable portion of costs. In general, vehicles must be full in at least one direction during two peak hours morning and evening. With peaking rates typically encountered, midday and late evening service at one third the peak frequency will be viable as well.

It is simple to calculate that to fill one 50-seat bus every ten minutes during two hours, about 600 passengers must live in the catchment area of a route. If at most fifteen stops can be made without a serious time penalty compared to the car, then 40 riders must board at each stop. Depending somewhat on household sizes, incomes, location of employment and schools, in cities with a reasonable metropolitan transit network residential areas within one-quarter mile of a bus stop usually generate between 0.2 and 0.4 peak period transit riders per household (see Figure
This suggests a minimum of 100 to 200 homes must be located within one-quarter mile of each of fifteen bus stops along a continuous and direct road to support frequent, economical transit service.\[9\]

For purposes of analysis of hypothetical neighborhood-plans, we will take 160 units within one-quarter mile of a bus stop as the critical minimum density to support good transit service. Using simple geometry I will explore how this density requirement can be reconciled with American suburban housing and neighborhood design norms.

3. Hypothetical Suburban Plans

With post-war suburbanization the dream of a detached house on its own plot has come true for many families. But at typical densities of less than four units per acre, without careful planning of walking routes there are rarely more than 50 or 75 homes within one-quarter mile of a potential bus stop. First we must understand precisely what qualities are essential to a suburban style lot.

A recent builder's survey found that most new homebuyers expect a lot of one-half acre or larger.\[10\] Fortunately lot area is only one dimension of consumer preferences, and tradeoffs can be made with other attributes. House lots have a frontage and a depth, and the usefulness of area depends on more than simply the product of the two.

Lot area is a rather crude measure of housing quality. Most people, including in fact most city planners, are not even sure how big an acre

*Throughout this paper densities will be "gross", in other words housing lots per acrea including land for streets as well as lots.
Figure 1  Transit Ridership as a Function of Walking Distance

Transit Boardings Per Household Per Day (residential trip end only)

100 200 300 400 500 600 700 800m (0.5 mile) 1/8 1/4 3/8 1/2 mile

WALKING DISTANCE

--- Trip Rates in Kitchener-Waterloo, Ontario. 20

--- Trip Rates in three suburbs, Metro. Toronto. Line shows range and mean walking distance. 21

--- Maximum walking distances observed in Washington, D.C. 600m is for "high income", 750m is for "low income". 22

--- Hypothesized linear function.
More important for home-buyers than total area is the arrangement of the house on the lot, and the areas left over for front and rear gardens.

With skillful planning, most of the important attributes of suburban neighborhoods, such as detached houses, garages with basketball hoops, front lawns to weed and mow on Saturday, and rear yards big enough for a swimming pool or vegetable garden, can be achieved at up to eight units per acre. This is two to eight times the density usually found in U.S. suburbs.

Lot frontage rather than area effectively determines the number of houses that can be arranged within one-quarter mile of a bus stop. With a stop every block on a rectangular street grid, arranging 160 houses within one-quarter mile requires average lot frontages of 33 feet or less (see Figure 2A). The lot depths, and therefore the total areas, have practically no effect on the competitiveness of transit, since buses and cars must use the same through street. The lots can, in fact, be very deep and the lot areas therefore very large.

Of course 33 feet is a bit narrow for a detached house. A lot width of 40 feet is required for a fully detached center hall plan house with a single side garage. For most purposes a long narrow rear yard is less useful than a somewhat shallower, wider yard, even with less absolute area. A 50 by 120 foot lot is quite adequate for a four bedroom house. With a 30 foot front lawn setback and a 50 by 65 foot rear garden there is plenty of grass to mow on Saturday, and even room for a swimming pool.
FIGURE 2A: HYPOTHETICAL DESIGN -- BUS STOP SERVING ONE STREET

1/4 mile/400m

Bus Stops

Bus Route

33 ft/10m frontage

40 houses per side
160 houses total per stop

FIGURE 2B: HYPOTHETICAL DESIGN -- BUS STOP SERVING TWO STREETS

50 feet/15m frontage

Bus Route

Bus Stops

40m, 125ft

24 houses per side
196 houses total per stop

FIGURE 2C: HYPOTHETICAL DESIGN -- BUS STOP SERVING THREE STREETS

9 large lots
7 medium lots
8 lots appts

3 large lots
9 large lots
10 appts
24 medium lots

Bus Stop

Large lots: 65ft/20m frontage; Medium Lots 50ft/15m frontage; 280 total
Returning to the hypothetical plans, if we constrain the depths of at least half the lots to 120 feet, with 50 foot average frontages we can put 192 houses on two parallel streets within one-quarter mile of a bus stop. At five units per acre this is still very low density, but quite sufficient to support good transit service. (see Figure 2B)

Figures 3A and 3B show the walking distance distributions for these two hypothetical neighborhoods. Note that although 192 homes are within one-quarter mile in the two street example, less than 45% are within one-eighth mile. We would like as many homes to be within one-eighth mile as possible, since even a short walk is a deterrent to transit use. To improve the distribution, we can vary the lot sizes, with narrower frontages closer to the bus stop and larger homes further away.

Land uses that do not generate or attract much traffic, such as primary schools, playgrounds, and local parks should be located farthest from the transit line, near the centers of the grid squares. They are then protected from the noise and dangers of automobile traffic, and do not decrease transit efficiency by occupying valuable space next to the bus stop.

If the bus route is a fairly busy street, as it likely will be if it is a continuous and direct road, traffic control will be desirable so pedestrians can get to and from the appropriate stop. Outside downtown areas traffic signals are rarely spaced closer than 600 feet. Cost aside (over $20,000 per set) it is difficult to time a series of closely spaced lights for efficient traffic flows. Yet if pedestrians must wait two or three minutes for a break in traffic to scurry across the road, the
FIGURE 3A: WALKING PROFILE FOR ONE STREET

Walking distance distribution for 160 house lots, with frontages of 10m/33ft, depths unconstrained, closely packed on one street.

FIGURE 3B: WALKING PROFILE FOR TWO STREETS

Walking distance distribution for 192 house lots, with frontages of 15m/50ft, half with depths unconstrained, closely packed on two streets.

FIGURE 3C: WALKING PROFILE FOR THREE STREETS

Walking distance distribution for 280 homes (84 lots 65ft/20m frontages, 124 lots 50ft/15m frontages, 72 apartments) arranged on three streets around one bus stop.
the effect on transit competitiveness may be the same as a longer wait or a slower bus trip.

If we want a traffic signal at the bus stop, it should coincide with a cross street (not mid-block as in Figure 2B) and be at least 600 feet from an adjacent signal. We must now constrain the depths of at least two-thirds of the lots, and have a bus stop every three blocks (see Figure 2C).

With two-thirds of the lot depths constrained to 120 feet, with lot frontages of 50 feet we can put 280 houses within one-quarter mile of a bus stop serving three parallel streets. With several similarly transit-efficient neighborhoods, arranged along a more or less continuous and direct route, bus service every five minutes in the peak, and every 15 minutes in the off-peak can almost certainly be supported with reasonable fares.

But we can do even better. In recent years rising costs have forced developers and homeowners to shift from single family detached homes to a mix of cluster townhouses, and garden apartments. This is potentially of great benefit to transit. If we build a neighborhood with 25% attached houses or garden apartments, 50% regular lots at 50 by 120 feet, and 25% large lots at 65 by 120 feet, we can pack just as many units in one quarter mile, but with the larger units further away and the smaller units close in we can have over 150 within one-eighth mile of the bus stop. This will certainly support very good transit service. (see Figures 3C, 4)
**FIGURE 4: IDEAL HYPOTHETICAL SUBURB**

Legend

① Playground Site
③ School Site
⑨ "Reverse Frontage" Street Pattern
④ Bus Stop
② Bus Route
⑥ Houses where shown
⑦ Garden Apartments

---

**FIGURE 5: MAJOR ROAD GRID SPACINGS**

1 mile
1600 m

Standard One-Mile Grid With Secondary Roads

Primary Roads
Secondary Roads

Suitable for buses

Areas Beyond 400 metres of bus routes
The aggregate mix of housing types and lot sizes in this "ideal hypothetical transit efficient suburb" corresponds with the average mix that is being built in America today. Unfortunately very few developments are laid out with transit efficiency as even a minor consideration. Street patterns, lot shapes, density mixes and distributions are usually far less efficient. Rarely are even 100 homes within one-quarter mile walk of a bus stop in a modern suburb.

Transit authorities can and should participate in planning suburban developments. In the past they have not, partly because they lacked political clout, but also because they did not have a clear understanding of the interests of other actors in the development process, or urban design alternatives to suggest that improve transit economies without destroying the essence of the suburb. As long as transit operators asked only for higher densities they are 'frozen out' of new suburbs. With growing awareness of the need for energy efficient transportation, the political environment may be ripe for more transit operator input in the suburban planning process.

Compared with energy-efficient building construction for heating and air conditioning, transit serviceability is not seriously considered. New so-called energy conserving communities focus on solar heating, but completely ignore reducing automobile use by making transit more viable. Transit is usually only considered to the extent that planners say it will be provided, but street plans and density distributions are not designed for transit operation.
While good public transit does not need particularly high densities, if the minimum requirements are not met it simply will not be viable, or will require large subsidies to support even poor service. With some foresight and planning, the densities and spatial configurations that will support transit can be assured. The benefits to the community in increased mobility, reduced pollution and congestion, and energy conservation more than justify the required effort.

However, there are other valid and sometimes conflicting design considerations, such as the traffic engineering standards already discussed. The seemingly random pattern of suburban sprawl satisfies at least some of the interests of the variety of actors already involved in the development process. How their concerns conflict or coincide with the ideal transit plan, and how solutions can be achieved, is the subject of the next section of this paper.

4. Neighborhood Design Issues

4.1 Major Street System

Multi-lane arterial roads are usually built on a one to one and one-half mile grid spacing throughout suburban areas. These typically follow the old farm section lines, which were spaced to create optimally sized homesteads. While they fortuitously meet the needs of private motor vehicle traffic quite well, unless reasonably direct secondary routes continuous through the grid squares exist, most of the developed areas will always be more than one-quarter mile from a transit line (see Figure 5). For effective service parallel routes must be spaced no more
than one-half mile apart, so that no home is more than one-quarter mile from a bus route.

Often no suitable road exists. Buses cannot operate efficiently on winding residential streets, nor can they compete with automobiles on faster arterial roads. Residents may object to bus service operating on formerly quiet streets. Ideally, roads for transit routes should be continuous for at least two and preferably five or six miles, so that frequent buses can pass through a large enough exclusive catchment area to collect full loads, before following other roads to a downtown, regional center or transfer station.

When a new suburb is laid out it is easy to include a continuous secondary road for bus service. Usually this involves linking together a string of local streets. Occasionally this will require slightly more land for roads and perhaps an additional bridge over a stream. While perhaps costing slightly more to build than the most expedient "sprawl" plan, the expenditure will be recovered many times over in reduced transit costs and decreased auto dependence. Often the developer can be required to pay for the necessary improvements as a condition of project approval.

There are other benefits of a continuous and direct road network. Refuse collection, snow plowing, street cleaning and police patrolling are all easier and less expensive if vehicles do not have to continually turn around and backtrack out of dead ends. Fire brigades can respond more quickly in a wider area, and fewer stations may be required as a result. (With the annual costs of maintaining a fire station often
exceeding $500,000, the savings can be considerable). Most city departments may be only dimly aware of the costs street patterns can impose on their operations since the bulk of research has been directed towards the relation between average density and costs, ignoring the effects of configuration. Once they are enlightened of the possibilities of change they can be effective allies.

Continuous secondary roads may attract traffic through neighborhoods that is noisy and hazardous for children. If this is a problem, simple traffic control measures can be applied. Four-way stops signs at every bus stop, if enforced, will slow and discourage traffic without adding delays to busses (which must stop anyway). This will usually be sufficient to deter most short-cutting traffic.

In Calgary, Alberta, a more drastic technique has been used. Bus-only "gates", similar to cattle grates used on ranches, have been adopted. Parallel bars across the pavement trap auto tires but are spaced to let fire trucks and buses through.

4.2 Local Street Pattern

The hypothetical transit-oriented suburb developed above assumed grid street plan. While such plans were once common, they are now generally out of fashion. In unplanned sprawl, fragmented land ownership and haphazard development timing often result in no consistent street layout. In "planned" developments, non-grid street plans are used to adapt to the topography (reducing sewer costs), to discourage or eliminate fast through traffic, and to avoid monotonous straight rows of houses. (Occasionally the "drunk planner" hypothesis is advanced as well.)
Non-grid plans usually result in unnecessarily long walking distances along circuitous routes. Walk distance distributions are often very poor. However, it is possible to achieve a reasonable level of transit efficiency while still satisfying the motives that led to abandonment of grid plans. Although the shortest route between two points is still usually a straight line, a slightly curved route may not be much longer as long as it is reasonably direct (see Figure 6). Indeed, on hilly terrain topography-following streets may make walking easier if they reduce climbing.

Carefully placed pedestrian walkways can greatly reduce walking distances in cul-de-sac developments (see Figure 7). However, there may be problems with maintenance (cleaning and snow removal), lighting, and security. They may adversely affect the privacy of adjacent homes. Where traffic signals are provided to help pedestrians cross at the bus stop it is more likely to be obeyed if it corresponds with a cross street serving automobile traffic as well. Except for retro-fitting existing developments, pedestrian walkways are less desirable than a continuous and direct street system. (A demonstration of the benefits of a retro-fitted walkway is presented in Appendix 4.)

If the bus route is on a very busy street, with four or six lanes of traffic, the traffic engineers may prefer to have local streets combine within the neighborhood so that fewer emerge onto the arterial road. This may be somewhat safer since cars will make left turns into and out of side streets only at controlled intersections. However, it will also reduce the transit efficiency of the neighborhood, since the
FIGURE 6: CURVED STREETS

15m/50ft frontages

Walk Distance Distribution:
Curved versus Grid

- - - curved streets
- - - grid streets

FIGURE 7: CUL DE SACS

Houses per 50m
Walk

Indirect Walk Routes
97 within 400 m, 120 beyond.
195 within 400 m, 22 beyond.

Walk Distance Distribution:
Effect of Walkways

--- With Walkways
--- Without Walkways
collector road occupies land near the bus stop that could otherwise be used for housing. This collector road occupies a prime location in the walk-distance distribution. We may or may not wish to comply with this "reverse frontage" system (Figure 4 presents both alternatives).

When planning development on either side of an arterial road and bus route, it is important to ensure that cross streets line up. This avoids the need to duplicate stops and traffic signals, and reduces the need for pedestrians to walk along the arterial to the stop.

4.3 Lot Frontages

The hypothetical examples demonstrated the relationship of lot frontage to transit efficiency. Fortunately wide frontages are inefficient for most other services as well as transit. The length of water mains, sewers, streets, sidewalks and curbs that must be built relate directly to frontage. Many operating costs, including snow removal, street lighting and cleaning, and tree planting and pruning, may be effectively halved (per house) if lot frontages are halved.16 Police, fire, and refuse collection costs depend at least partly on the lengths of streets. With lot frontages halved, the same police cruisers can patrol the same number of houses twice as frequently, or half as many can patrol with the same frequency. These fairly obvious relationships are rarely considered when suburbs are built.

Until recently, most municipal service costs were financed entirely from local tax revenues and federal and state subsidies.17 Developers did not pay the costs, and so they had no reason to consider them. Large lot frontages were commonly built, at great and still unestimated expense
to the rest of the community. Now, more and more communities require developers to pay at least the capital costs of services, so narrower frontages are again becoming common. As taxpayers revolt against higher and higher levies paying for only mediocre services, more efficient narrower frontages offer a partial long run solution.

4.4 Mix and Distribution of Densities

In the hypothetical ideal suburb, medium and low density units are combined in the same neighborhood. Medium density units (cluster townhouses and garden apartments) are placed closer to the transit line to improve the walk-distance distribution. Usually developers are eager to build higher densities, since packing more units on a given piece of land will increase their profits. A mix of units can also attract a more heterogeneous population, something most American suburbs are sadly lacking. Preventing this efficient mix are zoning policies intended to produce the low density homogeneous suburb most Americans seem to want to live in.

While individual families may want to live in segregated homogeneous neighborhoods, planners have a social responsibility to encourage mixing and integration, or at least not to intentionally discourage it.* Single density zoning of large areas has contributed to segregation by income and family type.

With a mix of densities in a neighborhood, there is likely to be a mix of family types, if not also racial and income groups, representing

* This would be exclusionary zoning, usually held illegal by the courts.
the diversity of American society. Schools will not be subject to the
same extremes of baby boom and bust, if the neighborhood has a mix of
families at different phases of the life cycle. Older adults will be
able to move from large houses once their children have grown and left,
and live in smaller houses or apartments without leaving the neighbor-
hood where they may have strong social ties. A neighborhood with a
mix of ages and housing types is also perhaps less susceptible to cyclical
blight and decay.\textsuperscript{18}

Higher housing densities along major roads can support shops and
services within walking distance of all homes, reducing the need for
automobile use for local trips. Availability of pedestrian-oriented
shops may also make the walk to the bus stop less onerous, since errands
can be combined with other trips.

Zoning is presently the most important barrier to an efficient mix
and distribution of densities and uses. Zoning is supposed to prevent
mixing of incompatible uses, not to prevent mixing of complementary activi-
ties. While zoning can be a useful and effective city planning tool,
carelessly applied it prevents a transit-efficient mix in at least three
distinct ways.

First, suburban areas are usually zoned at densities that are too
low: lower than homebuyers really want or can afford. Neighborhoods
are zoned with the objective of achieving a consistent character. Yet
as discussed in the hypothetical studies, lot frontage, not area, deter-
mines the neighborhood character.\textsuperscript{19} What happens behind is mostly of
private, not public concern. The common practice is to zone for minimum
lot areas. Setting minimum lot frontages can assure the same consistency of street face while allowing higher overall densities.

Secondly, zoning prevents transit-efficient development when the areas zoned at each density are too large. While it may be desirable to have a neighborhood consistent for two or three blocks, there is no need for several square miles to be all built at the same density. A fine grained mix of higher and lower densities will support transit, as well as local shopping and service within walking distance, while still ensuring that most houses will be next to other houses and will not be overshadowed by towering apartments or steel mills. While there may be more "boundary conditions," with careful planning and design these need not pose serious problems.

Placing higher density townhouses and apartments along major roads makes sense from a physical design standpoint as well. The lots immediately adjacent to a major road are not very suitable for families with small children, because of traffic hazards and noise. These problems are not nearly so serious for apartments housing mostly adults. Not only are adults less susceptible to traffic hazards, but also apartments can be designed to mitigate the effects of street noise. Such buildings can, in fact, be effective noise buffers sheltering the lower density and more noise-sensitive neighborhood behind.

Third, zoning prevents transit-efficient mixing when the zone boundaries are drawn in the wrong places. For the planner working with large scale maps, major roads, railroads and rivers seem natural places to draw boundaries between neighborhoods. Almost by accident we have
accepted that a well planned neighborhood will have a certain single density, a "high density neighborhood," a "low density neighborhood," etc. The ability to conceive of a hierarchical mix of highs and lows within a grid square defined by railroad tracks and roads has been lost. While it may be technically expedient to zone large tracts defined by major arteries at each required density, a mix of densities within each neighborhood will greatly improve transit efficiency (see Figure 8).

Finally, zoning reduces transit efficiency when it makes no provision for convenience shopping within neighborhoods. Fear of proliferation of dilapidated corner stores, with noisy traffic and smelly garbage may be the reason local stores are only usually permitted at busy intersections, beyond walking distance of most homes. While we may not want to permit stores on streets with single family homes, the ground floors of apartment buildings on major streets can be ideal locations for neighborhood convenience stores. It will be in the owner's best interest to maintain the property to a high standard, to protect the value of the apartment investment. Availability of convenient shopping near the bus stop can greatly improve the relative attractiveness of transit.

4.5 Pedestrian Environment

Besides the length of the walk to the bus stop, the quality of the walking environment has an important effect on the relative attractiveness of transit compared with the automobile. As mentioned above, the presence of convenience shopping on route from the bus stop can make transit more attractive. But if shopping along the arterial road is built in standard suburban fashion, with large parking lots in front of the
FIGURE 8: FINE GRAINED "HEIRARCHICAL" ZONING

Legend
Low Density
(20m/65ft frontages)
Medium Density
(15m/50ft frontages)
Garden Apartments
Industrial
Floodplain (open)
Shopping Center

Typical Zoning Pattern in Suburbia

Proposed Heirarchical Zoning Pattern
stores, the environment will still be hostile to pedestrians, even if actual walking distances are small. To reduce pedestrian boredom, sidewalks to and from the bus stop should pass immediately adjacent to store display windows, rather than through parking lots. If the neighborhood density is sufficiently high, continuous commercial development along the arterial road can be supported. With wide, tree lined sidewalks this is an almost ideal environment for pedestrian access to and from the bus stop. (See Figures 9A and 9B for good and bad examples of street-sidewalk-commercial design.)

5. **Policy Recommendations**

In review, then, to support good transit service, suburban neighborhoods should be designed so that as many "front doors" as possible are located within one-quarter mile of each bus stop. At least 160 homes must be clustered around each stop, with 100 within one-eighth mile. The bus route must be along a continuous and direct road, serving at least two or three thousand homes and ten or fifteen stops. Ideally local convenience shopping should be located at bus stops. Achieving this requires:

- Lot frontages averaging fifty feet or less in a neighborhood;
- Direct local street patterns, following a shortest rectangular grid path to each bus stop from each home;
- Continuous development around each bus stop, with space-greedy low intensity uses such as parks and primary schools located farthest from the bus stops, in the midpoints of the grid;
- A hierarchical mix and distribution of densities within neighborhoods,
Figure 9A Typical Suburban Shopping Area

Note Bus Stops isolated in "sea" of parked cars, with storefronts set back from street and isolated from pedestrian routes.

Figure 9B Transit-Oriented Shopping Area

Note development of stores to sidewalk line, with parking located behind.

LEGEND
Houses on Street
Parking
Retail with Windows
Bus Stop and Route
with the highest densities around bus stops, and lower densities in between;

- Parallel roads suitable for bus use spaced roughly one-half mile apart through all built up areas, continuous for at least two miles without catchment areas overlapping other parallel routes;
- Neighborhood shopping accessible to pedestrians as well as automobiles, located adjacent to bus stops on major roads.

What policies can be adopted that will achieve these requirements without unnecessarily restricting the activities of developers who must actually build the community in response to market forces?

5.1 Half Mile Road Grid

Given the relatively small size of most suburban development tracts, continuous mid-grid streets can only be achieved if planners map these before development occurs. In areas with a one-mile surveyed grid, an additional street in at least one direction can simply be mandated as a precondition of development approval. It may be possible to transfer some of the construction costs onto developers as well, if the road is made up of a string of local streets that would be built anyway. This transfer is justifiable since it is these property owners who will benefit most from convenient transit service.

5.2 Direct Local Street Patterns

These can be achieved by the planning of subdivisions. This requires at least 20 acres under single developer control, or municipal intervention to map streets before development. If less direct municipal intervention is desired, to give developers more freedom, an incentive zoning
system might be set up. The transit operator would first plan future bus routes and stop locations throughout the area to be developed. Zoning would be then based on walking distances to the bus stops, with the highest (and for the developer, the most profitable) densities permitted closest to the bus stop. Developers would be able to build more units on their land, effectively up-zoning it and increasing their potential profits, if they devised more direct street systems. Where land ownership is fragmented, there would be a strong incentive for developers to negotiate easements through properties leading to the bus stop. This "walk-distance zoning" would be a simple but effective method of encouraging both efficient street patterns and clustering of densities.

5.3 Lot Frontages

Simply requiring developers to pay the capital costs of installing municipal services will usually result in substantially smaller frontages. This is justifiable on grounds of economic efficiency even without considering public transit benefits. Taxes for municipal service operations based on lot frontage can also be theoretically justified, although more studies would be necessary to determine what proportions of costs relate to frontage. Linking some portion, (perhaps 28%), of local property taxes to frontage might prove a strong incentive to infill existing low density neighborhoods.

5.4 Hierarchical Mix and Distribution of Densities

Achieving this only requires more sophisticated, careful zoning. Either hierarchical zoning can be designed with conventional fixed boundaries, or "walk-distance" zoning can be used.
5.5 Continuous Development Around Bus Stop

Cities cannot force land owners to build anything. But by limiting the supply of land zoned for higher densities to sites around bus stops, either with conventional or "walk-distance" zoning, municipal governments can make certain that all the market demand will be focused at the desired locations.

5.6 Neighborhood Shopping

Here also only more careful, fine grained zoning may be required. If permitted, many bus stops along major roads could support a small convenience store. With design controls well within the proven capabilities of any competent city planner, such stores need not become a blight or nuisance in the neighborhood.

If the commercial development is located along the arterial road, as discussed above, it will create the most attractive environment for pedestrians and transit riders if store windows are located immediately adjacent to the sidewalk. In some cities, setback and parking regulations prevent precisely this arrangement. Also, developers may prefer to put parking in front as a lure to driving customers. Planners can amend setback and parking regulations to permit sidewalk-fronting development. Parking can be located in the rear, accessible either off side streets or by driveways. Bonus or incentive zoning can be used to encourage developers to arrange shop windows and store entrances all along the sidewalk front.
6. **Conclusions**

The density requirements of public transportation and the suburban housing preferences of Americans can be reconciled. Suburbs can be built that will support effective and efficient public transit, without sacrificing the attributes of low density housing that consumers value. While more active city planning is required, compared with existing widespread large-lot zoning the policies proposed here would probably amount to a net decontrol of the development industry. Without the policy changes proposed in this paper, suburbs will continue to be built so that they cannot support viable public transit and dependence on the automobile will continue. But with the changes proposed in this paper, transit will be economically viable in new areas, and suburban life will be richer and more satisfying as a consequence.
References


3. Much of the supporting evidence for statements in this article comes from the operation of the Toronto Transit Commission, which operates a successful transit system through most Toronto suburbs, with an average fare of about 50c covering more than 70% of operating costs.


5. This list is based on behavioural travel demand modelling research. See, for example, Moshe Ben Akiva and T. Atherton: "Transferability and Updating of Dissaggregate Travel Demand Models" in Transportation Research Record 610, Washington 1976.

6. ibid.

7. Based on discussions with staff at the Toronto Transit Commission and Professor N. Wilson, Dept. of Civil Engineering, Massachusetts Institute of Technology.
8. ibid. From 7 AM to 9 AM there are twelve ten minute periods. Twelve 50-seat buses have 600 seats total.

9. The arithmetic is straightforward: \( 600 / 15 \times (1/0.2) = 200 \)


17. RAND, op. cit.


