Transit-Based Approach to Land Use Design

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The nature of land use patterns that are sensitive to the needs of public transit was examined. Design elements that directly address the success of development activities and transit services are proposed; requirements for successful transit are discussed; and design guidelines for land use, access systems, and transit service types through a range of scales are provided. Transit-sensitive land use design can be developed through the designation of transit corridor districts (TCDs) that would separate transit- and auto-oriented land uses. Such areas would have a mix of land uses, with higher densities located near a transit route. A high-quality access system for pedestrians and bicyclists should be provided to permit easy connections between buildings and transit vehicles. Guidelines are developed for the overall administrative and policy issues, systems planning considerations, and specific designs of individual districts in which transit service is provided. A prototype TCD, based on the guidelines, illustrates how the guidelines can be applied at a specific location.

In the last 50 years, suburban areas have evolved into places having a unique life-style and pattern. Widespread availability of automobiles and the mobility they provide has led to a dispersal of activities and trip making. Employment and commercial activity have grown along with housing and recreation to lead to complicated trip patterns and increasing congestion of local streets and arterials. Activity centers and trip generators are poorly tied to each other and totally depend on the automobile for access. Little, if any, concern has been made for pedestrian or bicycle movement or for the provision of public transit in land use decisions. Most work on the problem of transit in suburban areas to date has concentrated on the development of new methods of operation or administration of public transit services in suburban areas. Demonstration projects have been attempted and new services have been offered with the hope of finding a "magic" transit solution to suburban travel problems. Although these efforts certainly have merit, they tend to ignore the underlying land use planning and design issues that are the root of many of these problems.

Recent efforts to rethink suburban land use provide new directions for suburban planning and design (*1*). Early work by Teska (*2,3*) defined a concept of high-accessibility corridors that would integrate highway, transit, and land use development. Beginning in the early 1980s, proposals for innovative physical design solutions to address suburban problems in high growth areas were initiated. These included development of the Neo-traditional Neighborhood Design concept led by the architectural firm of Duany/Plater-Zyberk (*4*) and the Pedestrian Pocket/transit-oriented development concepts as advanced by Calthorpe and Associates (*5*). Both of these concepts move toward higher density, mixed-use development with an emphasis on pedestrian movement. By the late 1980s, a few developments based on these solutions were under construction. Many of these developments reflect projects done 50 or even 100 years earlier. These precedents included a pedestrian-oriented environment, conservation of the landscape, significant amenities, and higher densities, and often provided mass-transit opportunities as well. Innovative solutions for suburban development have found acceptance by the development community in areas in which suburban problems are most intense. Although it is too early to judge the acceptance of these pioneering projects by market response (the first projects are still under construction), conditions indicate that they may be successful and such solutions may proliferate. At the same time, efforts in the Pacific Northwest by Snohomish County Transportation Authority (SNOTRAN) (*6*) and the Seattle Transit agency (*7*) and in Canada (*8*) have provided a better definition of how public transit can relate to development activities. Collectively these efforts can lead to a model that integrates land use and transit services and a movement away from the auto-dependent suburbs.

This paper provides an outline for a land use planning, design, and development process that is sensitive to the operational and economic requirements of public transit systems. The goal is to develop a transit basis for land use design and to demonstrate how planning decisions could be made to provide a greater variety of modal options for suburban communities. This paper condenses a larger work (*9*) that provides comprehensive guidelines for transit-sensitive suburban land use design.

PRINCIPLES

Elements of Successful Transit

To look at a land use design from a transit perspective requires a clear understanding of what is necessary for transit to successfully compete with the automobile in terms of access, convenience, and comfort. A land use pattern based on transit should incorporate the following principles:

1. *Market orientation.* Transit services should be operated from a market-based, user-oriented point of view. The driving force in decisions regarding the planning, location, design,

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frequency, operation, and maintenance of public transit and associated land uses should be to respond to customer needs. Transit can be successful in attracting a significant number of users from the automobile if it provides a user-oriented service. User-oriented transit operates directly between passengers' origins and destinations without transfer, on a convenient schedule, and at a price that is competitive with the automobile. Transit stops and building entrances should be located to minimize walking and there should be clear pathways that connect activity centers and transit services. Under such conditions, and with the use of appropriate land use patterns, transit will be successful and provide a meaningful alternative to the automobile.

2. *Land use pattern with concentrated trip ends.* Transit requires an adequate market size to be successful. There needs to be a concentration of trip ends along the transit service. Those activities that most relate to transit should be located as closely as possible to transit stops. Furthermore, they should be concentrated to create a number of high-volume destinations to support a high level of transit service.

3. *Quality access system.* Access to public transit by pedestrians, bicyclists, and automobile users should be convenient, safe, and direct. All transit trips begin as pedestrian trips and end as pedestrian trips. Pathways should be provided that minimize walking distances to points of activity, provide an interesting bicycling and walking experience, provide attractive waiting environments, and incorporate land uses and services that support pedestrians and bicyclists.

4. *Transit-oriented streets.* Street systems should be laid out to facilitate efficient transit operations. Streets that have transit service should be free of sharp curves or steep grades, and through routing should be provided. Transit service should directly connect activity centers; there should be no need for shuttle services that connect activity centers to primary transit lines. Geometric design criteria for transit routing should provide for high-speed movement, adequate stopping areas, safe pedestrian crossings, and proper visibility. Automobile traffic should be restricted if necessary, to ensure that transit vehicles do not experience delays because of highway congestion.

Conceptual Design

A major goal of this project was to develop a conceptual framework for the design of transit-sensitive suburban areas. This effort was based on our reviews of the literature and an analysis of exemplary designs as outlined in *The New Suburb* report (*1*). Though none of the designs we examined incorporates all the elements of a transit-sensitive suburb, taken together they provide a variety of concepts and features that could be the basis for such projects. The integration of transit and land use planning should provide the features and services necessary to create a genuine and workable community. The suburban community must be planned to be an attractive and viable place to live and work as well as capable of confronting issues related to the provision of transit. The land use plan should have at its core a mix of uses and a pedestrian orientation. In addition, the location of streets and parking should support transit services. Part of the land use plan is the preservation of land in natural and agricultural areas that will also reinforce the milieu of the developments.

The project must function as a community. The design should provide features, amenities, design, and services that will make the community an attractive place to live in. Market considerations also include the provision of many types of housing to attract a diverse market, as well as a market that will use transit more frequently. Transit services should be market oriented (i.e., the needs of users should be the driving force in its design and operation).

Based on these factors, a conceptual design was developed that separates transit- and auto-oriented land uses and calls for the creation of transit corridor districts (TCDs) where public transit, walking, and bicycles are to play a major role in providing mobility. Transit corridor districts would serve as prime locations of transit-oriented land uses and as a means of creating an environment in which mobility is provided by non-automotive means (Figure 1). Transit corridor districts would be segments of existing arterial streets but ideally would be separated from arterial highway corridors by a distance of at least 1/4 to 1/2 mi. These corridors would be protected through zoning actions and by the careful placement of periodic closures to nontransit traffic—to avoid excessive automobile usage (Figure 2). Technological flexibility should be provided in the design of transit corridor districts. Corridors for transit would likely be serviced by buses at early stages of development, but they should be designed to be easily upgraded to light rail transit or other technological options in the future. The critical feature is that there is a concentrated land use pattern and pedestrian/bicycle access system that supports and is served by transit.

Separation of transit service from conventional auto-oriented arterials is attractive since conventional arterials in the suburbs are seldom suited to transit service (Figure 3). Suburban arterials are typically lined with strip commercial developments that are normally set far back from the roadway and have few, if any, pedestrian facilities that can connect them to transit. Land uses along suburban arterials are also often

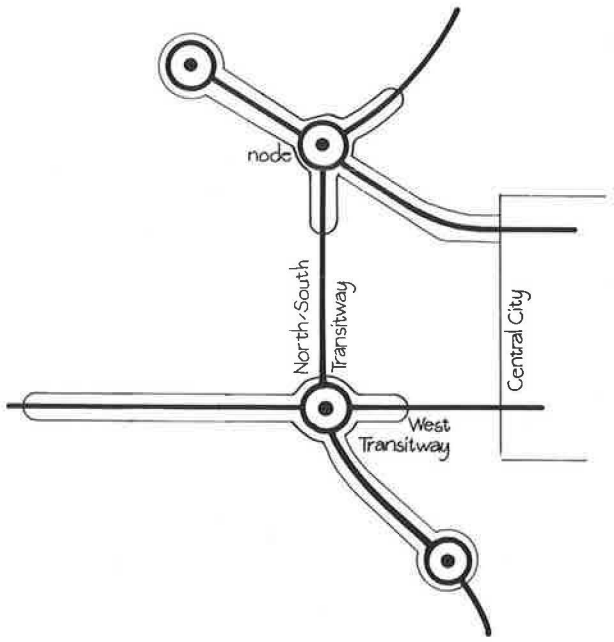

FIGURE 1 General location of transit corridor districts.

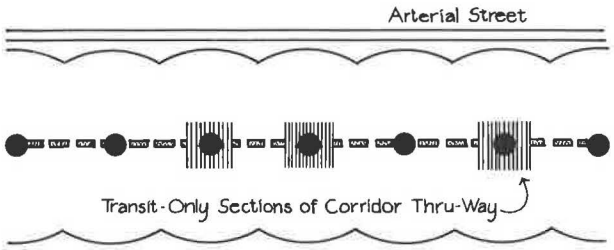

FIGURE 2 Control of through auto traffic.

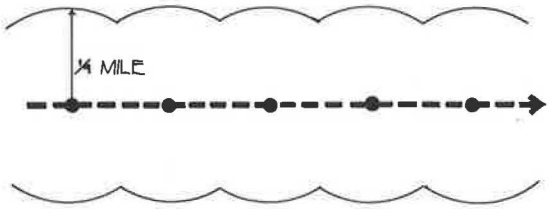

FIGURE 3 Separation of auto- and transit-oriented land uses. Auto-oriented land uses are kept near arterial to maintain pedestrian movement at the transit corridor.

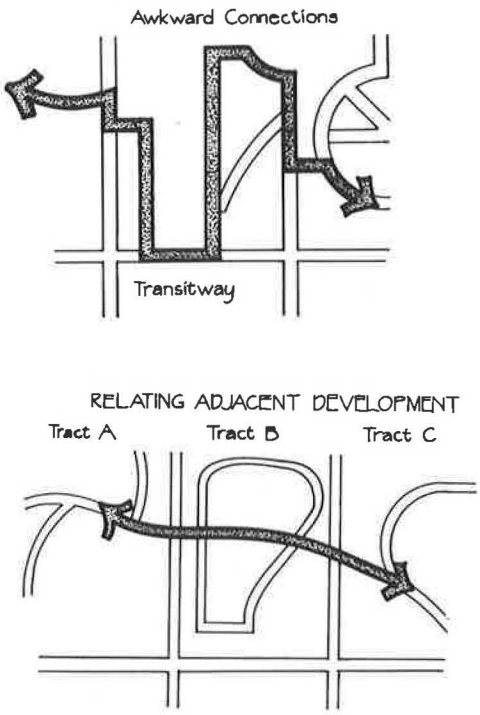

FIGURE 4 Provision of direct routing between parcels.

inappropriate for transit use. Auto-oriented uses such as lumber yards, garden centers, drive-in banks, auto dealers, fast food drive-through restaurants, and funeral homes, which predominate along suburban arterials, are intermixed with land uses that relate to transit. On the other hand, those land uses that relate strongly to transit, such as housing, office buildings, educational facilities, retail buildings, and factories are often separated from the arterials that have the transit service. Thus the separation of transit corridors from highway/arterial routes and the location of land uses appropriate to each of these modes can create a more efficient and convenient overall system (Figure 4).

Part of the transit corridor district zoning would designate locations for activity centers where stops would be located. These centers, which would allow a variety of uses and high levels of activity, would be the focus of individual neighborhoods, as developed by various organizations. This type of zoning creates an attractive community as well as a feasible public transit system.

These designated transit corridor districts will capture much of the metropolitan growth for some time. Areas between districts will either be preserved as agricultural and natural areas or will contain low-density uses. The use of only a portion of the land surrounding the central city for development encourages preservation of the environmental quality of open and rural spaces.

GUIDELINES

Our basic approach was to define a development pattern that follows corridors and occurs as linear extensions of urbanized areas. Transit routes will operate most effectively in a linear pattern with very few turns. These overlapping demands of market forces and transit service needs provide a natural situation for the development of organized transit corridors.

Three major guideline categories were developed: (a) administration and policy guidelines; (b) systems planning guidelines; and (c) guidelines related to the design of the transit corridor districts. The systems planning and district planning guidelines each have three parts: land use, access to transit, and transit operations guidelines. Policy guidelines relate to how things are implemented, who has input into the process, and how services and areas are managed. Systems planning refers to the overall location of transit corridor districts, access to public transit, and general rules for the operation of transit services. District level relates to the way in which land uses are arranged within a transit corridor district, how access is provided, and how transit services are accommodated.

Space does not permit a discussion of all of these guidelines. However, certain key guidelines were developed to help explain the concepts. In addition, a prototype design was developed to help illustrate the concepts involved.

Separate Transit-Oriented and Auto-Oriented Land Uses

A key element in the design of transit-sensitive suburban land uses is to spatially separate activities that are highly related to the automobile from those that are related to public transit. Certain activities are distinctly auto-dependent—it is difficult to perform them using transit. These are activities that require transporting large objects, that require multiple stops, or that take place in evenings or on weekends. Examples include purchases at a lumberyard, collecting a group of children and taking them to a soccer practice, or going out for dinner and

a movie. Activities conducive to the use of public transit include those that occur with some regularity and with a direct origin-destination pattern.

To maximize the potential for the use of public transit and to alleviate suburban traffic problems, there should be a separation of land uses based on their associated traffic modes. Ideally, parallel corridors would be developed, one primarily for the automobile and its associated land uses, and one for transit and its related land uses. Land uses oriented to the automobile—car dealers, large-package retail shopping, low-density housing, motels, car-oriented food franchises, large-plot outdoor recreation, etc.—should be located along highway corridors. Land uses oriented to transit—high-density residential developments, office buildings, schools, facilities for the elderly, and some retail—should be located along a transit corridor. Within the corridor, a mixture of building types and the proximity of building types would also encourage pedestrian access. Concentrated locations of educational facilities, office buildings, shopping, and housing would reduce the amount of transportation required—whether by auto or public transit (*1,6*).

Encourage Transit-Sensitive Land Use Design by Designating TCDs

The local zoning ordinance is the primary tool used to implement land use policy. Unfortunately transit issues are seldom addressed in contemporary zoning ordinances. The local zoning ordinance should be updated to include the consideration of transit throughout all relevant sections. The inclusion of transit will provide a regulatory basis for the enforcement of a transit-based land use pattern. Detailed transit regulations should be incorporated into the zoning code for transit corridor districts as an overlay zoning area.

Additions to the existing zoning ordinance will improve a municipality's efforts to encourage transit and to concentrate development in areas with a potential for high transit use. A TCD would permit much greater regulation of transit-related concerns in primary service areas while allowing the conventional zoning code to govern development in other areas.

The review process for proposed projects in a TCD would be much like the review process for planned unit developments. The TCD would expand on the concept of a transit overlay zone, used in the Portland, Oreg., area that focuses on the mixture and density of developments near light rail stations (*6,7*). Transit districts of 10 to 11 acres in size were created at light rail stations for high-density residential and office development. Another example of a zoning district would be the many historic districts created to preserve the history of older downtowns. Transit corridor districts could be areas along existing arterial streets or could be future sites of new roadways/corridors.

Predesignate a Future System of Transit Corridors

A transit-sensitive solution to land use in the suburbs must be part of an overall metropolitan or regional transportation plan. A transportation corridor must be linked to heavily concentrated locations, such as the central business district or existing major employment areas and suburban activity centers.

An important element in making the concept feasible is to predesignate corridors for transit service and for the location of transit-oriented land uses. It is vital to establish the basic transit corridor district locations before most development activity. The most effective corridors will be initiated in undeveloped areas. Early location and designation of the corridors is essential to making subsequent land use decisions with a commitment to future transportation services. Early establishment of TCDs also reflects a commitment from the government to future developers that a full-service transit line will operate in a specific area, which helps to eliminate fear and speculation about the future of the corridor. Demand for land along the corridor should stabilize once the zoning is established. This will enable communities to separate auto-oriented land uses from transit-oriented land uses and to locate them according to the appropriate means of transportation.

The creation of transit-sensitive districts ideally can be accomplished by a physical separation of transit services from primary auto-oriented arterials. Transit services should be at least 1/4 mi away from the parallel arterial and should provide opportunities, through zoning, for development of land uses, population sizes, and densities that relate to transit. The success of the corridor relies on the ability to integrate a pattern of land uses that is compatible with transit, as well as with the internal design of each site.

Provide Adequate Population Size and Density to Support Transit Use

The density of trip ends at a transit stop is critical in determining if public transit has sufficient demand to justify its service. Both land use densities and the total population in the service area of a stop are important. Suburban areas have many areas with higher densities that could relate to transit, but they are physically separated and difficult to connect. TCDs provide a way to organize such areas that can be served by transit. Average residential densities of at least seven dwelling units per acre within the service area of a route are considered the minimum level to justify the use of local bus routes with 30-min headways, whereas densities of 15 dwelling units per acre are needed for 10-min headways (*7,10*). These values, however, can vary significantly based on assumptions about capture rates of transit, service frequency, average fares, subsidy rates, hours of operation, speeds, and average hourly costs. The critical factors that lead to density requirements are the capture rate, the cost recovery ratio, and the service ratio of transit (*9*).

The required density of residential or employment land use depends on assumptions about the portion of trips that use transit and trip rates per household. An important tradeoff occurs between these factors. Whereas a high density is required if there is a low capture rate by transit, a lower density is needed if the capture rate is higher. The density requirements drop off rapidly if transit successfully captures market share. On the other hand, a high capture rate is likely the result if there are low fares and high levels of service. These in turn increase the need for higher densities.

Density requirements also vary directly with service frequency and farebox recovery rates. If high levels of service are provided, there will be a need for higher densities. Analysis of these factors indicates that the required residential and employment densities for transit are complex and strongly dependent on policy (i.e., subsidy rates and fares), as well as operational factors (i.e., hours of service, headways, and hourly cost of operation). It is important that these factors be explicitly considered in land use design to ensure an adequate market for transit services.

Encourage Technological and Infrastructure Flexibility

A transit corridor must be able to accommodate various transit modes. It is expected that the transit corridor would initially be used by buses and perhaps even minibuses; however, the corridor should be designed to provide options for other technologies. As the market size increases, more capital-intensive modes, such as light rail, become feasible. Thus alignment and placement of underground utilities should permit an upgrading to light rail transit in the future if warranted. Geometric design of transitway components of the corridor should be based on the needs of a rail system rather than a bus system including more stringent standards for gradient and curvature. The corridor could be used by a mixture of road-based vehicles and services such as a conventional buses, vehicles for the disabled, express services, shuttles, subscription buses, taxis, and van pools.

Control Through Automobile Traffic

The provision of a convenient transit service requires a speed and level of service competitive with those of automobile travel. If transit vehicles operate along a congested street, travel times by transit will be increased and the street will be dominated by auto traffic. Because TCDs are areas of concentrated development that generate significant numbers of trips, it is important to control through automobile traffic to prevent excessive congestion. One way would be to provide periodic sections in the transit right-of-way where only transit vehicles would be permitted. These breaks would occur approximately at every mile and would likely be located at high-activity stops. The remainder of the corridor would operate with mixed traffic, with the roadway serving as a local or collector street.

Use Corridor for Primary Pedestrian, Bicycle, and Transit Movement

The corridor should be designed to accommodate pedestrian and bicycle movement as well as transit vehicles. Separate pathways should be provided parallel to the transit routes. These pathways should be on both sides of the roadway and should accommodate two-way movement. In addition, direct pathways should be provided to lead pedestrians safely and directly to the transit stops. High-quality pedestrian/bicycle facilities are essential for bringing users to and from the transit system, to interconnect areas, and to improve the overall quality of the environment in the corridor.

The designation and location of transit stops are key decisions in the planning process for a transit corridor district. Because pedestrian use of transit falls off rapidly when offices or residences are located more than 1/4 mi from a stop, to provide good quality pedestrian access, stops should be spaced no more than 1/4 mi apart. This distance provides a maximum walking distance of 1/8 mi for trips beginning or ending on the corridor itself and a band width 1/2 mi wide for concentrated land use related to transit. The overall pattern is a series of overlapping concentric circles that define the zone of transit-oriented land uses. These areas (*stadtwurst* or sausage city) may be separated by areas of open space where stops are omitted. In areas of concentrated demand, stops could be located more closely together, as close as 1/8 mi to improve accessibility.

Reduce Noise and Air Pollution Levels of Transit Vehicles

Transit vehicles, especially buses, have a poor image in suburban areas (*11*). Local residents will often protest the location of bus routes in their neighborhoods because of the noise and air pollution produced by the vehicles. To prevent negative reactions to transit services, present noise levels of buses (in the range of 80 to 85 dbA while pulling out from a stop) would need to be significantly reduced. Similarly, vehicle emissions of pollutants and visible exhaust need to be reduced. Transit service in the corridor district must be of a high quality to both attract patrons and not be a nuisance in the community. Efforts to design cleaner, quieter, and higher-quality vehicles are critical to the development of the overall concept.

Provide Mixed Land Uses

Traditional suburban zoning can be characterized by a separation of land uses, such as residential, commercial, educational, and recreational land uses, requiring the use of the car and many separate trips. By locating various land uses in close proximity, two benefits can be achieved. First, the total number and length of vehicle trips within the area could be reduced. It would not be necessary to travel to numerous locations because most destinations would be within a few minutes' walking distance of each other.

The second advantage of mixed-use activities and land use is the improved feasibility of transit service. Transit operates best when there are simple origins and destinations and when users can meet their needs by walking to the destination of the trip. Generally, suburban residents do not use transit because they need to make trips to multiple locations during the day. If these activities and destinations can be concentrated, the auto's advantage over transit will be greatly reduced (*5,6*).

Land uses should be arranged to maximize the potential for walking and bicycle trips as well as for use of transit. A mixture of activities, including housing, employment, shopping, public facilities, and schools is desirable around each

transit stop. Densities would be highest near the stop and then remain fairly high within the 1/4-mi walking distance of transit.

Relate Design and Connections of Adjacent Developments Across "Seams"

The incremental planning and development of suburban subdivisions and parcels result in an unrelated functional and visual environment between tracts (*6*). These mismatched "seams" can be avoided in a master planned district. During site planning, each land development parcel should be required to include access points to neighboring tracts. The coordination of these seams and connections should be strictly regulated by the district. Considerable flexibility can be allowed within parcels as long as proper connections are maintained to the adjacent parcels.

Minimize Distances Between Building Entrances and Transit Stops; Provide Logical Connections Between Buildings and Transit

Nearly all trips begin in a building and end in a building. To maximize the potential for transit, building entrances and transit stops should be located in close proximity to each other. Moreover, there should be a clear, direct path between the building and transit stop locations. Although it may seem obvious, this point is seldom taken into consideration in conventional suburban development. Transit stops usually are located on arterials, and it is necessary to walk considerable distances through parking lots and across grassy areas to get to a building. Pedestrian walking distances should be measured along the actual paths, not just straight line distances.

There are various ways to provide good access to buildings, especially in the site design phase of development. For example, buildings and their entrances could be directly located next to transit stops, which could mean locating parking or open space behind or beside a building rather than in front of it. In addition, buildings themselves could be set perpendicular to the transit corridor rather than parallel to it.

PROTOTYPE DESIGN

To test our guidelines and concepts, a prototype design of a transit-based land use pattern was developed for a suburban area. The site chosen is 1/2 mi wide by 2 mi long and is located west of Milwaukee in the township of Menomonee Falls. The area is rural in character with little development. However, urban development activity is occurring south, north, and east of the site, and it is likely that it will see a transition from rural to suburban land use in the near future. The site lies between two suburban centers that have had substantial suburban development during the past 20 years. To the east is an industrial district and the city of Milwaukee, and to the west are other rapidly growing areas. The site chosen is parallel to a major east-west arterial that connects to the U.S. Highway 45 belt freeway 2.5 mi east. The comparable arterials located to the south have been sites of substantial commercial strip development.

The site consists of gently rolling hills with no significant slopes to impede development. Current use is agricultural with a few scattered residences. A large wetland is located in the northwest corner of the site. There are some wooded areas in the site, primarily in the form of mature fence rows with some larger wooded tracts in the south-central and west portions of the site. Land ownership is primarily in large parcels up to 80 acres in size.

The selection of this site was based on its potential for future suburban development activity. In addition, it appeared to be a potential location of transit services that could connect into the Milwaukee central area and provide an east-west crosstown service into the city of Milwaukee. Because the site is relatively undeveloped and has relatively few owners, there are opportunities to provide concentrations of demand that could create a significant market for transit services.

Transit Service

It was assumed that there would be two transit routes that would intersect in the district. An east-west line that parallels Silver Spring Drive and a north-south route that connects the suburban centers of Menomonee Falls and Brookfield Square. Our primary emphasis is on the east-west line, which could be extended westward an additional 2 mi before it would encounter existing development and have to be rerouted along Silver Spring Drive. The intersection of the two routes presented an opportunity to create a town center for shopping and office activity built around the transit services. Since no substantial shopping districts existed nearby the town center appeared to be a logical use that would work well with the transit service.

Transit stops were located approximately every 1/4 mi along the corridors with a closer spacing in the town center. Generally stops were located 1/8 mi in from crossing arterials to provide for reduced walking distances to transit. Some modifications of stop locations were made to take advantage of site conditions.

Design

The prototype design (Figure 5) was developed by a team of architectural faculty and students following the guidelines developed for this project. Four districts were identified as a basis for design. These areas—the Woods, the Farms, the Central District, and the Estates Area—were identified based on existing land use or the impact of the transit system on design or both. These themes helped to develop a basis for design, they also help to illustrate how various approaches can be blended within a transit corridor district and to examine how the guidelines would be used by various designers working on five sites with varying topography and other natural features such as woods, lakes, and wetlands.

In general, the design includes a band of high-density housing and office facilities located along the east-west transit route and a lower density development at the fringes. A business district/civic center is located at the point of intersection of the two transit routes toward the east end of the site.

Smaller neighborhood business areas are located at other transit stops to the west. The plan would contain approxi-

FIGURE 5 Prototype design.

mately 3,000 housing units and approximately 1.4 million ft² of commercial/office space. Substantial retail areas also would be included which would result in a net residential density of approximately 6.5 units per acre for residential areas only. Densities in individual areas may vary considerably ranging up to seven to ten residential units per acre near the center and eastern edge of the site. Commercial densities are highest in the central district and lower elsewhere. Actual densities could vary, however, depending on how individual lots and multifamily units were used.

CONCLUSIONS

This paper has outlined an approach to arranging land uses to be more responsive to the needs of public transit. The purpose is to demonstrate how planning decisions could be made to provide a greater variety of modal choices and more efficient use of transportation. Transit-sensitive land use design can be developed through the designation of transit corridor districts, which would separate transit and auto-oriented land uses. Such areas would have a mix of land uses with higher densities located near the transit route. A high-quality access system for pedestrians and bicyclists should be provided to permit easy connection between buildings and transit vehicles. Auto access should be controlled, if necessary, to prevent excessive automobile traffic within a transit corridor district. Finally, such areas should be designed to permit flexibility in land use patterns and transportation technology.

This paper has included a summary of guidelines that could be used to develop such areas and has provided an illustration of how such an area could be designed in an actual situation. Such an approach appears to be promising and may have the potential for more efficient land use and transportation patterns in the future.

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