



TRANSIT GUIDELINES IN PROJECT DEVELOPMENT

Mountain Line

Missoula Urban Transportation District

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1 INTRODUCTION

Purpose of the Design Guidelines

The Missoula Urban Transportation District (MUTD) operates the popular Mountain Line public transportation system in the greater Missoula area. Mountain Line includes a fleet of regular route buses and smaller buses to serve as an important mode of transportation for residents. The agency mission statement reads:

“The mission of Missoula Urban Transportation District is to contribute to a safe, seamless, convenient and accessible transportation system for the greater Missoula area which reduces vehicle miles traveled, carbon emissions, air pollution and traffic congestion.”

Public transportation enjoys widespread community support in Missoula. During the Envision Missoula process, fully two-thirds of participants in the workshops favored a vision for the future of the community in which public transportation plays a key role. The dominant vision to emerge through Envision Missoula is known as the Focus Inward scenario.

The Focus Inward scenario seeks to manage travel demand by bringing together activities into one highly concentrated downtown area, encouraging the majority of the Missoula’s transportation investments within a densely developed In-town Mobility District. Focus Inward also supports the concept of a Multi-Modal Corridor from Lolo to downtown Missoula. Mountain Line fully supports the findings of Envision Missoula and the Focus Inward concept, and recognizes the importance of multi-modal development in providing effective transit service and reducing congestion on area roadways.

The ability of Mountain Line to provide an effective and efficient transportation service in the greater Missoula area is determined by a large extent on the development decisions made in the community. Planning decisions are often thought of in terms of residential density, street configuration and geometry, and zoning regulations. However, there are a number of design decision made by developers and jurisdictional officials, such as bus stop layouts, which also facilitate better transit service.

Mountain Line has developed the publication *Transit Guidelines in Project Development* to encourage the coordination of local development and transit services. This manual is intended to provide guidance for the development of physical facilities in the region to assure that they are supportive of transit service.

Through distribution of this manual to jurisdictions and developers in the region, Mountain Line hopes to promote a better understanding of the role of physical development on transit service. We encourage developers to design for transit and pedestrian access concurrent with their overall design process. When facilities such as street intersections, commercial, retail, and residential developments are being planned, the cost of making the investment suitable for transit use is typically not very large. On the other hand, retrofitting a site after construction is usually quite costly. Developers and local officials are strongly encouraged to seek the guidance of Mountain Line staff in making design decisions on development and local infrastructure.

Document Organization

This manual is organized into several sections corresponding with facility decisions. Sections 2 & 3 (Transit Friendly Urban Design and Transit Priority Measures) describe the general relationship between transit service and the built environment, in addition to several concepts and technologies widely used today to improve bus service and reduce travel time.

Section 4 (Streets and Intersections) provides guidance on the design of streets and intersections to facilitate transit utilization and operations. This section contains guidance on curb radii for intersections where transit service operates and other elements of street geometry.

Section 5 (Mountain Line Fleet Characteristics) discusses the physical attributes of Mountain Line equipment including dimensions, turning radii, and curb weight. The purpose of this is to guide local officials, facility developers and owners on the size of Mountain Line equipment to assure that the vehicles can access developments.

Section 6 (Transit Facilities Design) discusses specific designs for transit amenities including bus stops, bus shelters, and bus turnouts.

In general, if local jurisdictions or developers are planning a development which may be in Mountain Line service area, they are requested to consult with Mountain Line staff at 406-543-8386. The following are examples of the types of facilities about which Mountain Line should be contacted early in the planning and design process:

- New housing developments/subdivisions
- Commercial developments
- Road construction, reconstruction and intersection reconfiguration projects
- Street improvements, including driveway entrances on major streets

Coordination of Land Use and Transportation Planning Policies

Currently, Mountain Line participates in the development review process of all jurisdictions in the area by offering suggestions and recommendations that may improve and enhance transit services provided in Mountain Line's service area. The process of siting and installing bus stops and bus shelters may appear to be a simple task; however, this task requires the consideration of many factors, including where and how bus stops are located, if transit service is provided along specific corridors, and proximity to bus stops on the opposite side of the road.

To expedite the development review process, all jurisdictions are encouraged to notify Mountain Line of its planning review calendar, including dates, times and places of meetings for Pre-submittal Conferences, Development Review Teams, Consolidated Planning Board and City Council meetings, in addition to special community outreach and planning activities that may have impact on transit services. The best way is to include Mountain Line on Planning and Public Works Departments mailing lists for new development projects. The mailing address for Mountain Line is 1221 Shakespeare, Missoula, MT 59802, or info@mountainline.com.

Joint Development Opportunities

To promote the coordination of transit facilities with private and/or public sector development, Mountain Line will pursue joint development opportunities with local jurisdictions when appropriate and resources are available. Joint projects can support economic growth and transit use while providing investment opportunities to the development community. Mountain Line encourages joint use for high density residential, office, commercial or industrial development to reduce trip making and alleviate congestion.

Coordination with Construction

Private development construction and local jurisdiction public works activities, such as street improvements, including repaving, street grading or water line installation often impact bus operations and bus stops. Construction impacts to transit service and bus stops can be minimized through conditions placed on private development construction to ensure contractors work with Mountain Line staff. The following are examples of conditions that are effective:

- Mountain Line staff should be contacted at least 15 business days prior to the beginning of construction that will necessitate street closure, rerouting of traffic, or construction in the vicinity of transit service operation and bus stops;
- A representative from Mountain Line should be invited to the project's pre-construction conference meeting.
- Contractor is required to work with Mountain Line to ensure temporary bus stops are established before bus stops are closed during construction;
- Contractor shall make every effort to schedule their work to minimize impacts and the duration of impacts to transit operations and the general public;
- Contractor should work closely with Mountain Line when contemplating the removal of any bus stop signs or the closure or cone off of any bus stops;
- All work must conform to the Americans with Disabilities Act Accessibility Guidelines (ADAAG) requirements, including provisions for temporary access to and from bus stops;
- Contractor will be responsible for costs incurred for loss or damage to bus stop signs, hardware and transit furniture;
- Contractor shall provide Mountain Line with the name and telephone number of the construction manager on site prior to the beginning of construction;
- A minimum four (4) foot wide walkway should be provided to maintain passenger access to and from bus stop during construction, if it is determined that the bus stop will remain open during construction;
- Mountain Line will coordinate with local agencies for providing and posting the appropriate temporary bus stop signage if needed.

Bus Shelters and Developer Responsibilities

- Bus shelters are covered, semi-enclosed waiting areas with seating. Shelters offer protection from inclement weather conditions, provide for passenger comfort, and establish a transit presence within an area. Bus benches are a convenience amenity provided for passenger comfort.
- Ideally, a shelter should be provided at every bus stop location. However, ridership at many stops is too low to justify shelters given budgetary limitations, so stop amenities must be prioritized using the bus stop assignments detailed previously. When a development is constructed near an existing or proposed bus stop location, the developer should be responsible for providing bus stop amenities and accompanying infrastructure to meet Americans with Disability Act (ADA) standards. ADA regulations can be viewed at www.access-board.gov.
- Developers are encouraged to place shelters that conform to Mountain Line criteria for passenger recognition and ease of maintenance. Shelters should be sized based on the appropriate number of passengers that will use the amenity (to be determined through discussions with Mountain Line), and provide for bus schedule information enclosed in a map case.
- Upon successful purchase and installation by the developer of a shelter that meets Mountain Line criteria, Mountain Line will take ownership and ongoing maintenance of the shelter, except in the case of custom style shelters. Developers may propose a custom style shelter to the Mountain Line Board of Directors that is intended to fit into the landscape and complement the architectural style of their project or streetscape.
- Custom style shelters must be engineered appropriately for strength and durability, provide for shelter and seating of an appropriate number of passengers from the elements (to be determined through discussions with Mountain Line). Custom style shelters must prominently display the Mountain Line logo and provide for bus schedule information enclosed in a standard map case. Additionally, the custom bus shelter will remain the ownership and maintenance responsibility of the developer. Graffiti is to be removed within 24 hours. Importantly, custom shelters and their installation must meet all applicable Americans with Disability Act (ADA) requirements.
- Developers are strongly encouraged to consult with Mountain Line if a custom shelter is to be constructed and installed. Developers should be aware that the installation of a customized bus shelter does not constitute an implied promise to serve or continue to provide transit service to that stop.

Development of Bus Turnouts, Passenger Waiting Areas and Shelters in New Facilities

The design of bus stop waiting areas and provision of amenities that enhance security and comfort plays a significant role in a person's decision to use transit. Passenger amenities are installed at bus stops to improve passenger comfort and the relative attractiveness of transit as a transportation option.

Mountain Line encourages local jurisdictions to condition development projects for the installation of bus shelters, waiting areas, and street improvements. Local jurisdictions are encouraged to coordinate with Mountain Line in determining what passenger amenities and other improvements are appropriate and where they should be installed.

2 TRANSIT FRIENDLY URBAN DESIGN

Transit-Oriented Design

The story of Missoula's urban form is the story of its transportation choices. There is little doubt that its railroads, highways, and public transit (street cars) have shaped the region's settlement patterns. They have also promoted or impacted its livability and guided its sustainability.

Envision Missoula provided a public process for residents to express their desires for how Missoula would be shaped into the future. Missoulians overwhelmingly favored a sustainable and unique community that would manage travel demand by bringing activities together into a highly concentrated urban core area. This "Focus Inward" strategy results in a much higher density of mixed-use development through redevelopment, and designates an In-town Mobility District that focuses on multi-modal transportation options and balance, such as pedestrian, bicycle, and public transportation travel, to minimize roadway congestion. Conversely, the Focus Inward strategy limits roadway expansion projects and the costly geographic scope of development offered by current trends.

Envision Missoula and the subsequent Downtown Master Plan embrace what is referred to as Transit-Oriented Development. The Mountain Line Board of Directors fully supports Transit-Oriented Development ("TOD"). Typically, TOD follows these principles:

- *Mixed Uses.* Land uses are mixed and may include a combination of residential, commercial, retail and entertainment activities.
- *Compact Development.* Residential development occurs at medium to high densities. Parking is often limited.
- *Location within walking distance of transit.* Boundaries of the TOD area extend approximately 1/4-mile from transit service, a distance that can be covered in about five minutes on foot.
- *Neighborhood Focal Points.* Open spaces or plazas near transit stations function as community gathering spots.
- *Pedestrian Orientation.* Streets and open spaces are friendly to pedestrians.

TOD projects can be designed with layouts and site features that enhance transit accessibility and convenience, resulting in diminished reliance on private automobiles for routine trips. For example, developers should endeavor to place commercial, office, institutional, apartment, and other high-intensity uses along existing and proposed transit corridors/centers, or within 1/4 mile of them. This strategy will increase density patterns and evolve into a positive planning policy that many local governments and

transit advocates support. For the elderly and mobility-impaired, distance is particularly important when selecting their mode of transportation, and where they live.

Transit-friendly streets “balance” street uses with respect to having any single mode of transportation dominate. In many cases, this means altering a street to make transit use more efficient and convenient. When these alterations are properly executed, a kind of equilibrium is achieved among transit, cars, bicycles, and pedestrians. Transit-friendly streets accomplish the following four goals:

- Establish a clear priority for transit vehicle operations with convenient, accessible transit stops;
- Reduce conflicts between cars and other vehicles, including reduction of vehicle speeds;
- Create a strong pedestrian orientation where practical, including adequate circulation space, ease in crossing streets, and appropriate amenities, all of which contribute to comfort and convenience;
- Finally, the greatest appeal of Envision Missoula’s Focus Inward strategy is clearly its financial feasibility. By concentrating development in the urban core, the scenario enables Missoula to forego the costly expansion program of the current development trends, reaping economies of scale, taking advantage of increased density on a smaller footprint to lower infrastructure costs and decreasing congestion.

Fundamental Site Planning Principles

Mountain Line has an extensive network of bus routes and public transportation services. The map on the following page shows the current route network. The area where bus service operates is characterized by either relatively high residential or employment density. The flexibility of bus service is such that routes and services can be extended. However, it is the policy of Mountain Line to focus resources where they are most effective.

In the areas where Mountain Line operates, some fundamental site planning principles are recommended:

- Walking distances for the transit user in urban areas should not exceed one-quarter mile to a transit stop. Transit is very ineffective in areas where passengers must walk a long distance to and from a bus stop.
- Direct walkways or sidewalks that link residences to transit stops should be provided within residential developments.
- Roadways should be designed to permit transit service to appropriate locations within the development. At least one through street should be incorporated into a development’s site design to provide access to transit stops.
- Park and Ride facilities should be provided at appropriate transit points to concentrate transit users from low density residential areas. These facilities should be provided in conjunction with off-street open space parking.

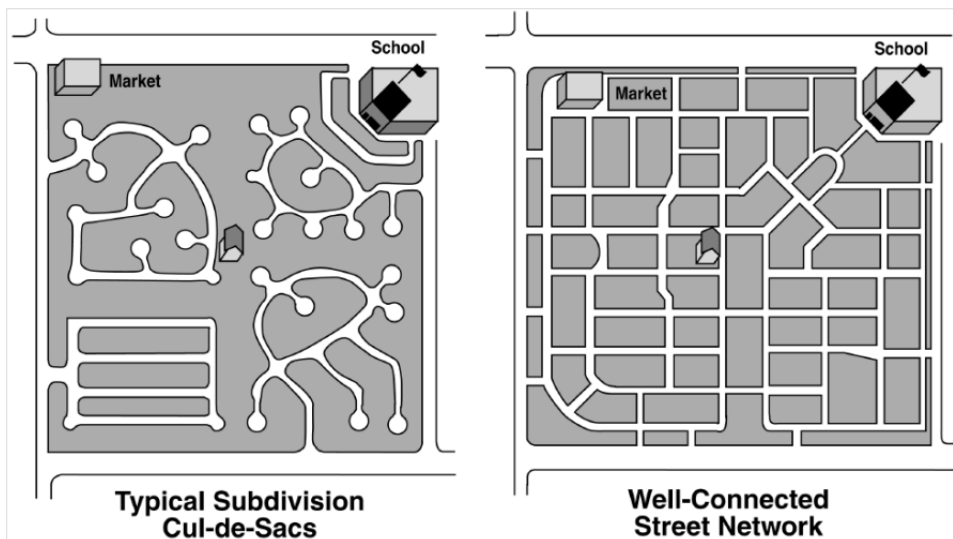
- Retail establishments should be clustered to reduce the number of curb cuts and bus stops and to decrease shopper walking distances.
- Buildings should have a setback no greater than 150 feet from the curb to provide employees with more effective and convenient access to public transit.
- Pedestrian walkways (sidewalks) should be constructed along the perimeter of all developments. Where there are commercial buildings, the walkways should connect to the lobby, located at the front of the building, to the bus stop area.
- Parking spaces should be assigned for vanpool and carpool vehicles. These parking spaces should be given priority designation and located adjacent to the primary building entrance from the parking lot.
- Mixed use developments, where residences are not far from neighborhood commercial activity, reduce the demand for travel of all forms in a region. In addition to the more obvious energy and environmental benefits of such an arrangement of land, recent studies have shown that it is a healthier environment because residents frequently substitute walking for motorized trips of all types.

Other more specific guidance on transit facilities and amenities is provided in later sections of this document.

Street Networks

Transit-friendly designs recognize that a transit customer is a pedestrian first. The segment between the bus stop and the point of origin or ultimate destination is an integral part of the transit journey. Cul-de-sacs and other dead-end streets are common in subdivisions built in America the last half of the 20th Century. Unlike the grid pattern of traditional urban streets, cul-de-sacs limit the ways in and out of neighborhoods and require taking long and circuitous routes to reach close destinations. Figure 2-1 compares two areas of equal size, the first with a cul-de-sac layout and the second with streets arranged in a grid pattern.

Figure 2-1 Comparison of Street Networks

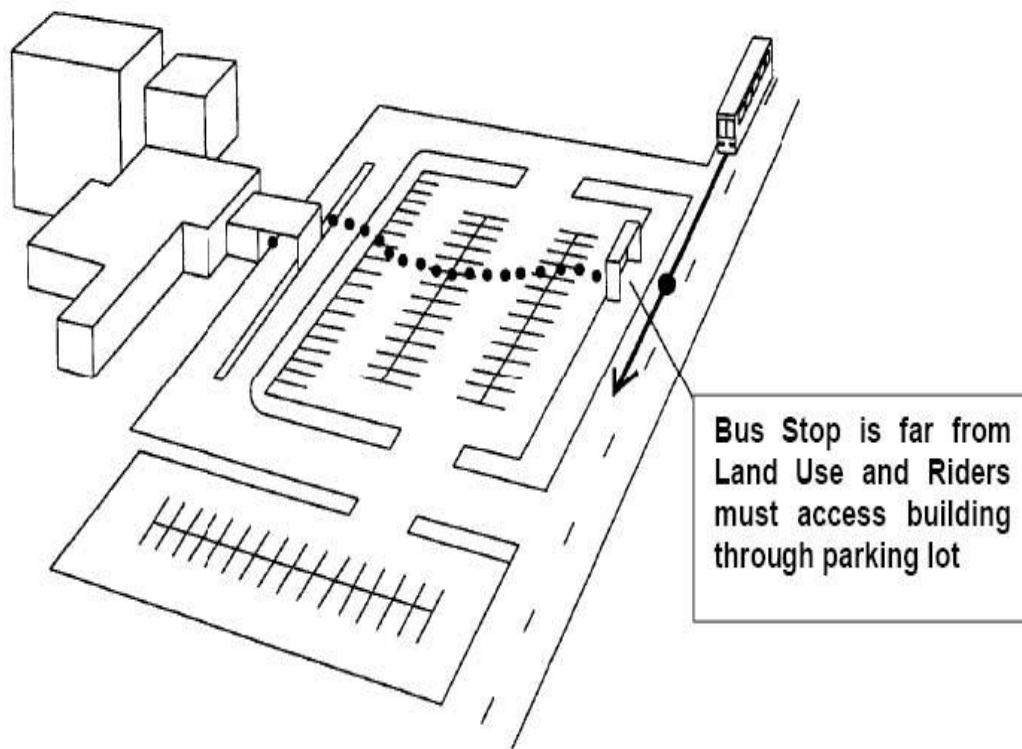


Source: TGM Guidebook, *Neighborhood Street Design Guidelines*

Facility Site Plans

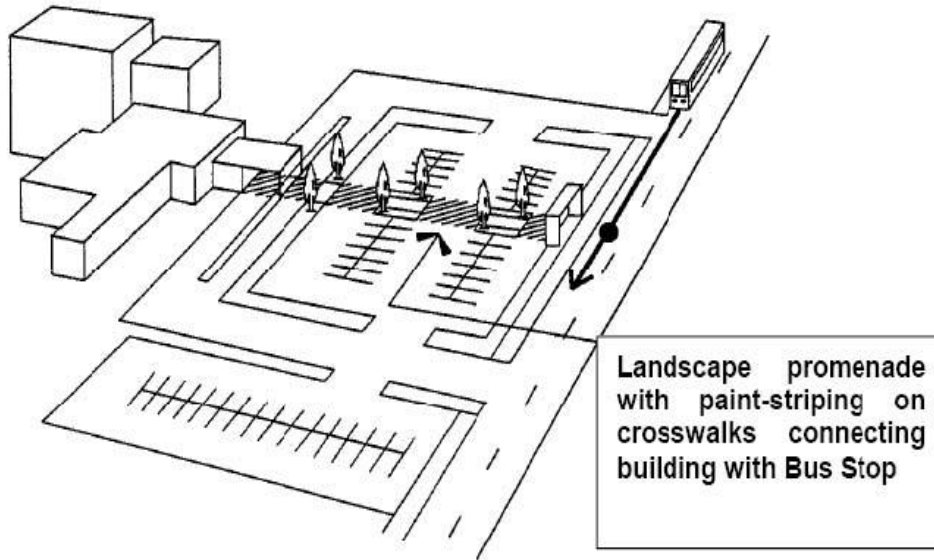
The same general principles in building transit-friendly subdivisions apply to major commercial and institutional facilities. The link between the building entrance and bus stop is a critical part of the transit journey. While it is possible for Mountain Line to deviate routes into major facilities, Mountain Line refrains from doing so because it lengthens the trip of passengers who are not bound to the facility and also due to safety concerns with vehicular conflicts within these facilities. Further, meandering in and out of parking lots of major facilities dramatically reduces travel speed and makes the transit service a less attractive product relative to driving. The figures below also illustrate examples of good and poor practice in facility layout. The site layout in Figure 2-2 requires transit passengers to travel through a parking lot without a clearly identified pedestrian path. Figure 2-3 illustrates an improved example with a clearly defined path from the bus stop to the building. An even better example appears in Figure 2-4, in which the building is not deeply set back from the street.

Figure 2-2 Poor Example of Facility Site Plan



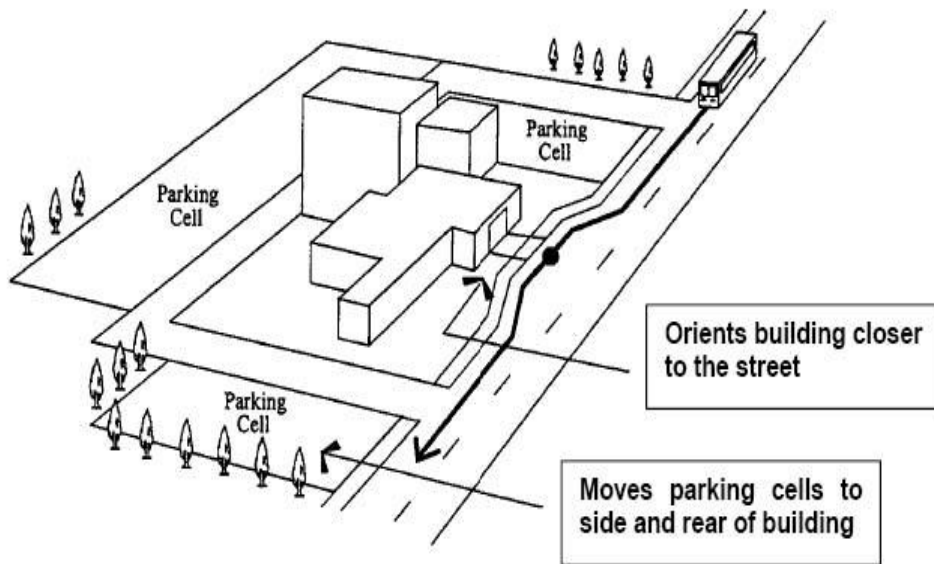
Source: Transit Cooperative Research Program, Report 19

Figure 2-3 Improved Example of Facility Site Plan



Source: Transit Cooperative Research Program, Report 19

Figure 2-4 Ideal Example of Facility Site Plan



Source: Transit Cooperative Research Program, Report 19

3 TRANSIT PRIORITY MEASURES

There are several concepts and technologies widely used today to improve bus service and reduce travel time. Collectively these measures are part of what makes a Bus Rapid Transit (BRT) system. Transit priority measures seek to improve bus service by reducing travel time. The components of travel time include getting to and from bus stops, time waiting for the bus to arrive, and the time spent traveling on the bus. Additional time is required if a transfer is necessary. Transit priority measures primarily seek to reduce in-vehicle travel time by giving buses priority over other types of vehicles on streets, excluding emergency medical and law enforcement vehicles. These measures can include reserved bus lanes and priority treatment for buses at traffic signals. The planning and implementation of bus priority measures works best in urban areas with a high concentration of bus services, high levels of traffic congestion, and good community support for transit service. To be successful, transit priority measures must be coordinated with the local jurisdictions responsible for traffic control and roadway planning and operations.

- Transit priority measures should effectively:
- Alleviate existing bus service deficiencies,
- Achieve attractive and reliable bus service,
- Serve demonstrated existing demands for transit,
- Provide reserve capacity for future growth in bus trips, and
- Attract auto drivers to transit.

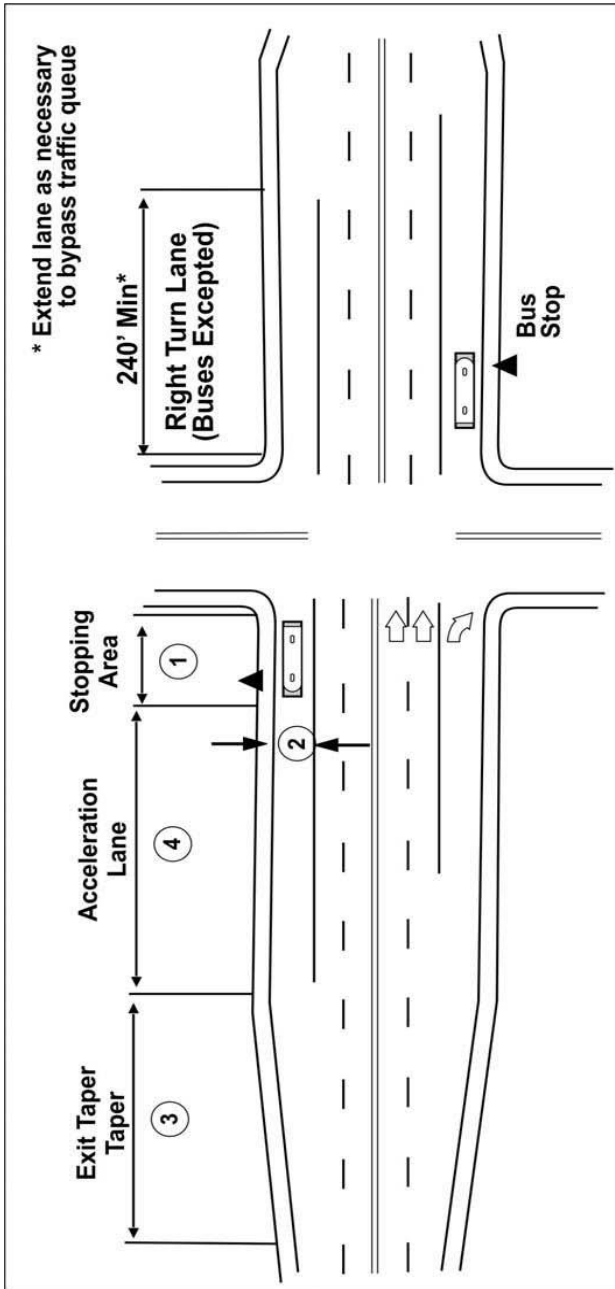
The following sections describe some of the transit priority measures that local jurisdictions should be planning for and implementing in the future.

Queue Jumps

Queue jumps provide a priority treatment for buses along arterial streets by allowing buses to bypass traffic queued at congested intersections. Queue jumps evolved from the need to solve problems not answered by bus turnouts. In the past, traffic engineers constructed bus turnouts to move buses out of the traffic stream while they are stopped for passengers. Unfortunately, bus turnouts introduce significant travel time penalties to bus patrons because buses are delayed while attempting to reenter the traffic stream. Queue jumps are able to provide the double benefit of removing stopped buses from the traffic stream to benefit the general traffic and getting buses through congested intersections so as to benefit bus operations.

Queue jumps consist of a nearside right turn lane and farside bus stop and/or acceleration lane. Buses are allowed to use the right turn lane to bypass traffic congestion and proceed through the intersection, as shown in Figure 3-1. Additional enhancements to queue jumps could include an exclusive bus only lane upstream from the traffic signal, an extension of the right turn lane to bypass traffic queued at the intersection, or an advanced green indication allowing the bus to pass through the intersection before general traffic does.

Figure 3-1 Queue Jump Design - Right Turn Only Lane



Source: Transit Cooperative Research Program, Report 19

Traffic Signal Priority

Traffic signal priority measures are designed to eliminate delays in bus service due to excessive waits at intersections signals. There are two general types of systems. In the first, depending on the program algorithm, a bus approaching a downstream traffic signal extends the green light or advances the cycle to green, either through transponders or other electronic communications means, to proceed through the intersection. The bus operator determines when signal priority is needed to maintain the bus schedule. In the second, a bus system equipped with an automatic vehicle location system and advanced radio communications gives signal priority control to the operations center, where typically a computerized system determines bus adherence to schedule and automatically triggers traffic signals when needed. Mountain Line encourages local and state agencies to invest in community intelligent transportation systems.

Bus Rapid Transit

Conventional urban bus operations often are characterized by sluggish vehicles inching their way through congested streets, delayed not only by other vehicles and traffic signals, but also by frequent and time-consuming stops to pickup and discharge passengers. Buses travel on average at only around 60 percent of the speeds of automobiles using the same streets due to the cumulative effects of traffic congestion, traffic signals, and passenger boarding.

Low cost investments in infrastructure, equipment, operational improvements and technology can provide the foundation for Bus Rapid Transit systems that substantially upgrade bus system performance. Conceived as an integrated, well-defined system, Bus Rapid Transit would provide for significantly faster operating speeds, greater service reliability, and increased convenience, matching the quality of rail transit when implemented in appropriate settings. Improved bus service would give priority treatment to buses on urban roadways and would be expected to include some or all of the following features:

- **Bus lanes:** a lane on an urban arterial or city street is reserved for the exclusive or near-exclusive use of buses.
- **Bus streets and busways:** A bus street or transit mall can be created in an urban center by dedicating all lanes of a city street to the exclusive use of transit buses.
- **Bus signal preference and preemption:** Preferential treatment of buses at intersections can involve the extension of green time or actuation of the green light at signalized intersections upon detection of an approaching bus. Intersection priority can be particularly helpful when implemented in conjunction with bus lanes or streets, because general-purpose traffic does not intervene between buses and traffic signals.
- **Traffic management improvements:** Low-cost infrastructure elements that can increase the speed reliability of bus service include bus boarding islands, and curb realignments.

- Automated Vehicle Locating (AVL) Systems to track transit vehicles against their designated route schedules. AVL can be integrated with a local jurisdiction's central traffic control center and used to dynamically adjust signal timing to maintain route schedules.

Traveler/Customer Information

Upon arrival to a bus stop or transit center, passenger orientation and wayfinding is a critical element of the convenience of using the transit system. Minimum information that should be displayed on bus stop signs includes route number, route name, transit agency symbol, and variable information such as operating times. Sign visibility and proper lighting of signs at night is also very important. In addition to basic signs, schedules and maps provide valuable information, particularly to new users. Specific guidance information to provide at bus stops includes:

- Hours of services and routes
- Schedules/headways and waiting times
- Locations of terminals, transfer points, and stops with routes served
- Maps showing transit system and local area

In addition to basic signs, route maps and schedules, Mountain Line recently deployed on-board wifi, real-time arrival information. Real-time displays are typically only installed at transit centers or bus stops with shelters that have a high number of boards and/or a high rate of transfers.

4 STREETS AND INTERSECTIONS

The design of streets and intersections greatly affects the provision of transit services. Generally, bus stops are located at intersections for safety reasons, and proper design is necessary to assure safety of transit passengers, pedestrians, and motorists and to operate the intersection efficiently.

Intersection Radii

The minimum interior radius of a 40 foot coach is 28 feet and the minimum outer radius is 50 feet. These templates may be used in the design of facilities to identify required pavement width and possible vehicle encroachment. Additional allowance should be made under special circumstances such as:

- Bus speeds greater than 10 miles per hour
- Reverse turns
- Sight distance limitations
- Bike racks on front of bus (which add four feet to the length of the bus)
- Changes in pavement grade
- Restrictions to bus overhang

The corner radius at street intersections is a common transit related design problem. Some intersections are difficult to negotiate with a bus. Several advantages of a properly designed corner curb radius are:

- Less bus/auto conflict at heavily used intersections
- Higher bus operating speeds and reduced travel time
- Improved bus rider comfort

The design of intersection radii should consider the following elements:

- Bus turning radius
- On street parking
- Right of way/building restrictions
- Allowable bus encroachment into other traffic lanes traveling in the same direction
- Placement of power poles or other utilities

Mountain Line's larger buses for fixed route services have bike racks mounted on the front of each bus, and have the capacity to carry three bicycles. Because of the bicycle rack, the turning radius of Mountain Line's larger buses increases an additional four feet.

If the facility being designed is intended to be used exclusively by transit vehicles, a bus would be an appropriate choice for a design vehicle. If, however, the facility is to be used by general traffic, the selection of either a single unit truck or a tractor-semitrailer may be more appropriate. In the latter case, a design based on the operating characteristics of

a truck should be checked to ensure that a bus would also be satisfactorily accommodated.

The width of the roadways involved enters into the design because as the width increases, the length of the radius required to accommodate the turning vehicle decreases. For example, if the width of both roadways is 12 feet, a single curve with a radius of approximately 50 feet is required in order to accommodate a 90° turn by a bus with no encroachment outside the 12 foot lanes. If the width of both roadways is increased to 16 feet, the radius required in order to accommodate the bus with no encroachment outside the 16 foot lanes decreases to 40 feet.

The final element of corner radii design is the amount of lane encroachment which can be tolerated. This tends to be a subjective decision made by the designer based on an evaluation of the speed and volume of the vehicles involved and the functional classification of the roadways. In general, there should be no encroachment. However, in low speed, low volume situations, some encroachment into adjacent lanes may be acceptable.

One additional item should also be evaluated. At intersections, as the size of the corner radius increases, the walking distance across the intersection increases. Designers should be aware of this pedestrian factor and be prepared to accommodate the pedestrians if the length of one particular crossing increases to the point where it may create operational problems.

When designing a new facility, the designer should select the design vehicle, the roadway widths, and determine the amount of encroachment which can be tolerated. If an existing intersection or driveway is to be evaluated for transit operations, a layout showing existing lane widths and corner radii should be prepared. The layout should then be checked with the appropriate turning radius template and the resulting encroachment, if any, determined. This can then be compared to the amount of encroachment that can be tolerated and potential remedial efforts such as increases in lane width or corner radii evaluated.

The simple curve is the most simple corner radius which will be encountered in typical urban designs. A simple curve uses a uniform radius connecting the points of tangency of the intersecting streets. However, in some special situations such as a skewed intersection or when it is desirable to allow turns at speeds greater than 10 miles per hour, the designer should consider using a compound curve. Compound curves are a combination of simple curves with different radii joined together. Compound curves have an advantage over simple curves because they more closely fit the natural turning paths of design vehicles. Design procedures using compound curves and the channelization which frequently accompanies them can be found in local agency street design standards or the Association of American State Highway Transportation Officials (AASHTO) "Green Book".

Parking and Loading Zones

In built-up commercial areas, there should be sufficient space for on-street truck loading and unloading. If there is no provision for deliveries, truck drivers will inevitably park at bus stops or double-park, neither of which is beneficial for transit service or efficient traffic flow.

Crest and Sag

The distance between the front and rear axle of a bus poses limitations on bus operations. A sharp rise and fall on a hill may result in a bus “bottoming out” at the crest of a hill—a bus’ front and rear overhang beyond the respective axles. A similar conditions known as sag occurs where a road surface depression is so severe that it can leave a bus suspended or “hung up.”

The American Association of State Highway and Transportation Officials (AASHTO) minimum acceptable vertical curve length is calculated by determining the “K-Value.” This is the length of vertical curve divided by the algebraic difference in the grade. The following are the minimum vertical curve K-Values for crest and sag at various speeds:

Figure 4-1 Minimum Vertical Curve

Speed (mph)	Crest (ft)	Sag (ft)
60	160	105
50	85	75
40	55	55
30	28	35

Roadway Surfaces

Roadway pavements need to have sufficient strength to accommodate repetitive bus axle loads of up to 25,000 pounds. Concrete is preferred where buses start, stop, or turn to avoid failure problems that are experienced with asphalt. Concrete aids in the retention of roadway surface shape, drainage capabilities, and skid resistance. Rarely will Mountain Line buses use unpaved roads or parking surfaces.

Clearance Requirements

Buses usually travel in the curbside traffic lane and make frequent stops to pick up and drop off passengers. Therefore, it is important to consider bus clearance requirements:

Overhead obstructions should be a minimum of 12 feet above the street surface.

For future street improvements, obstructions should not be located within a minimum of two (2) feet of the edge of the street to avoid being struck by a bus mirror (this lateral clearance is not only important at ground level, but it is necessary at the top of the bus).

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Missoula Urban Transportation District

A traffic lane used by buses should be wide enough to permit adequate maneuvering space and to avoid sideswipe accidents. Since the maximum bus width including mirrors is 10'-4", the minimum curb lane width (including gutter) should be 11 feet.

When buses pull out of the bus zone to reenter traffic, on occasion the rear of the bus will pivot and extend over the curb line. If above grade obstacles are located too close to the street, buses could sideswipe these fixtures damaging both the fixed object and/or bus. The rear overhang swing should be checked, possibly requiring a lateral clearance greater than (2) feet.

5 FLEET CHARACTERISTICS

Types of Bus Service

Mountain Line operates two types of service; fixed route service and demand response, or curb-to-curb service. The fixed route services consist of regularly scheduled routes using large buses that operate throughout the greater Missoula area. The demand response buses are generally smaller and provide curb-to-curb service for the region's senior and disabled population. Facilities should be sensitive to accessibility issues.

Figure 5-2 illustrates the physical dimensions of 40 foot buses, which are the largest bus that will be operated by Mountain Line in the foreseeable future. Figure 5-3 illustrates the physical dimensions of a demand response bus, which is typical of the vehicles used in curb-to-curb service for seniors and disabled residents.

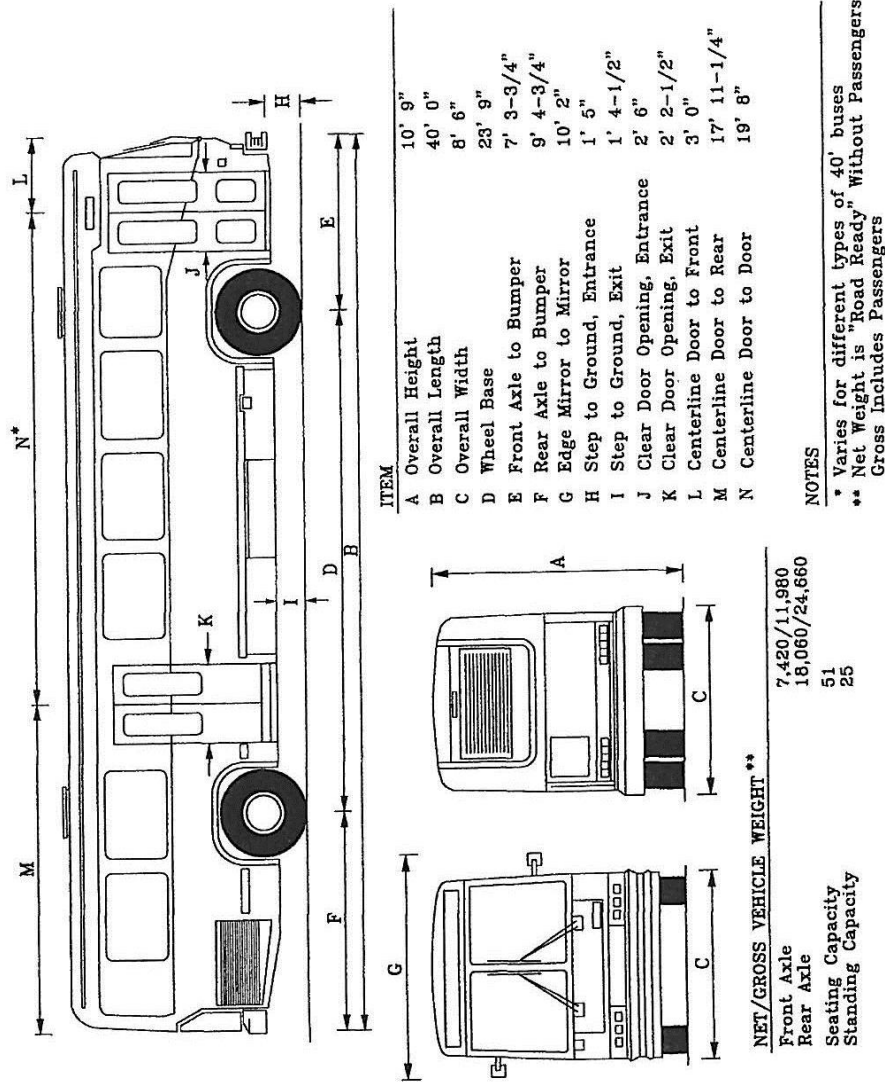
The weight of a loaded bus is summarized in the Figure 5-1 below along with axle weightings with diagrams of both fixed route and paratransit buses shown on the next two pages.

Figure 5-1 Loaded Bus Weight

Total weight	40,500 pounds
Front axle	14,500 pounds
Rear axle	26,000 pounds

TRANSIT GUIDELINES IN PROJECT DEVELOPMENT
Missoula Urban Transportation District

Figure 5-2 40-Foot Transit Bus Physical Characteristics

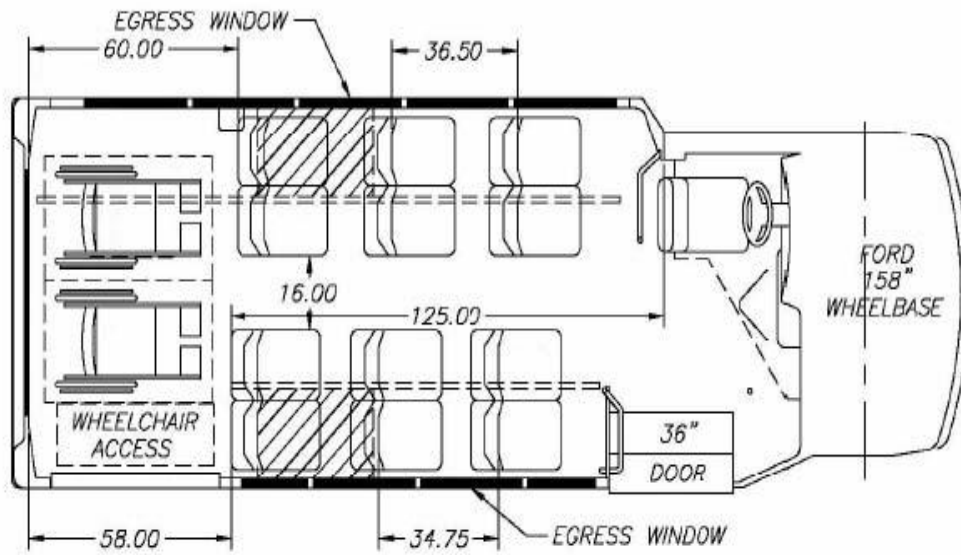


Vehicle Feature	"Paratransit" Maximum Dimensions
Overall Height,	9 Feet, 0 Inches
Overall Length, w/bumpers	23 Ft, 0 In
Overall Vehicle Width	8 Ft, 0 In
Front Axle to Front Bumper	7 Ft, 5 In
Rear Axle to Rear Bumper	10 Ft, 0 In
Edge of Outside Mirror-to-Mirror	10 Ft, 0 In
Step to Ground, Front Entrance	0 Ft, 10 In
Step to Ground, Rear Entrance	Not applicable

Source: Transit Cooperative Research Program, Report 19

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Figure 5-3 Demand Response Bus



Source: Vehicle Manufacturer

Glossary

Accessibility - The extent to which facilities are barrier free and useable by persons with disabilities, including wheelchair users.

Association of American State Highway Transportation Officials (AASHTO)
– A national organization that develops and publishes planning and engineering design guidelines for streets and highways.

Alighting – Exiting a bus.

Americans with Disabilities Act (ADA) – An act passed by the United States Senate in 1990 to provide a clear and comprehensive national mandate for the elimination of discrimination against individuals with disabilities. Provides consistent, enforceable standards addressing discrimination against individuals with disabilities.

Attached sidewalk – A sidewalk which is directly attached to the back of curb.

Boarding – Entering a bus.

Bus bench – A bench that can accommodate three or more persons and is placed at a bus stop for use by waiting passengers.

Bus pad – Concrete pad constructed in the street, adjacent to a bus zone, that can accommodate the weight of a bus.

Bus shelter – A covered passenger waiting area, often semi-enclosed with benches, that provide protection from the elements.

Bus stop – A linear curbside area that is specially designated for bus passenger boarding and alighting. It is identified by a bus stop sign and is accompanied by a red curb zone and/or “No

Parking sign. Bus stops can be located nearside, farside or between intersections (mid-block).

Bus turnout – A bus stop located in a recessed curb area, separated from moving lanes of traffic.

Bus zone – A length of curb designated as a bus stop where parking is prohibited.

Curb lane – A travel, parking, or bike lane adjacent to the curb.

Curb ramps – A ramp constructed to allow persons with disabilities and wheelchairs to travel from a sidewalk to the street level.

Far side bus stop – A bus stop located at the farside of an intersection. At a farside bus stop, buses cross the intersection before stopping to serve passengers.

Fixed route – Transit service provided on a repetitive, fixed-schedule basis along a specific route with vehicles stopping to pick up and deliver passengers to specific locations; each fixed route trip serves the same origins and destinations, unlike demand responsive service.

Large bus – a standard 40-foot long coach.

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Layover – Time built into a schedule between arrivals and departures, used for the recovery of delays and preparation for the return trip.

Mid-block bus stop – A bus stop located between two adjacent intersections.

Mixed-use development – A development which has a variety of land uses placed together in one project area (commercial, residential, industrial). Mixed-use developments are different from activity centers because mixed-use developments are concentrated in relatively compact areas whereas activity centers have separate but complementary uses.

Nearside bus stop – A bus stop located at the approach side of an intersection. At a nearside bus stop, buses stop to serve passengers before crossing the intersection.

Park and Ride - Designated parking areas for automobile drivers who then board transit vehicles from these locations.

Parking lane – A curb lane that is used for on-street parking.

Passenger boarding area – see Boarding area.

Protected crossings – a pedestrian crosswalk controlled with a traffic signal.

Queue jump lane – A short section of preferential lane that allows transit vehicles to bypass an automobile queue or a congested section of roadway. Usually located at approaches to intersections.

Sight distance – The distance between a driver's eye and some object allowing the driver to react to a hazard or decision.

Transfer – A passenger's change from one transit vehicle to another transit vehicle.

Transit center – A bus facility which acts as a hub for transit routes with a region.

Transit amenities – May consist of a transit shelter, bench, trash receptacle or other components provided at a bus stop for the comfort and convenience of waiting passengers.