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SECTION 2 – BUS TRANSIT FACILITY DESIGN

2.1.0 GENERAL

This section provides the minimum design standards to be used in the design of RTD bus transit facilities. Facilities shall be designed in consideration of the safety of bus passengers and the general public, system reliability, passenger comfort and ease of maintenance. Construction and operation should cause minimum disruption to traffic, local businesses and communities. Bus transit facility design should be economical with respect to construction, maintenance and operations.

2.2.0 BUS RAPID TRANSIT FACILITIES

2.2.1 General

The concept of Bus Rapid Transit (BRT) is currently evolving, and many types of systems are in operation, nationally and internationally. In general, BRT can be defined as a regional or express transit service using rubber-tired vehicles that is designed to reduce travel time, increase reliability and increase the quality of passenger service and ride. The approaches that are used to achieve this include giving priority to transit vehicles, providing a limited number of bus stops, sharing High Occupancy Vehicle (HOV) or toll lanes, traveling in exclusive right-of-way (ROW) or designated bus lanes, using alternative fare collection systems (eliminating on-board fare collection), providing special vehicles and using Intelligent Transportation Systems (ITS).

2.2.2 BRT Facility Design General Concepts

BRT facilities shall be designed to accommodate RTD's current vehicle fleet, unless otherwise directed by RTD. Currently, RTD operates city, intracity, and articulated buses (see Section 2.5) that may be used for BRT service. Bus facilities shall be integrated into the surrounding roadway (local or highway) network, and designs shall be compatible with CDOT or local roadway design standards, as applicable. BRT facilities shall be designed to accommodate quick loading and unloading of passengers, and shall be designed to provide safe pedestrian access between the BRT stations and adjacent park-n-Ride (pnR). Pedestrian access routes between station platforms and pnR should provide the shortest walking distance possible. The walking distance from station platforms to the most distant parking stall should be within a desired range of 1000 feet with a maximum of 1500 feet (or prior approval by RTD).

BRT facilities shall be designed to accommodate support vehicles, such as tow trucks, street supervisor vans and maintenance vehicles.

The BRT system consists of roadway improvements, including priority lanes, acceleration and deceleration lanes and station platforms. Station platforms

will be designed to be located either in a highway median (median stations), at the edge of roadways on bus-only ramps (slip ramp stations), on highway entrance or exit ramps (bus pullout stations) or located at the edge of non-highway roadways (BRT Superstops).

As determined by specific corridor studies, if BRT lanes in highway ROW are constructed along the exterior ROW limit, stations shall be located at exclusive BRT slip ramps along the BRT corridor.

2.2.3 BRT Median Station Design

Median stations shall be used where buses travel within a designated BRT or HOV lane located to the left of the main roadway general purpose travel lanes. A median station shall be located where a pnR is placed adjacent to the highway ROW and shall be connected to the pnR and associated transit plaza areas with pedestrian access facilities. Median stations typically will not be used unless all stations within the corridor are located within the median and are integrated with the design of highway improvements.

Bus Access

BRT vehicles will access median stations from the left traffic lane on multi-lane roads. Acceleration and deceleration lanes for the BRT station shall be designed in accordance with American Association of State Highway and Transportation Officials (AASHTO) design standards. Bus lanes adjacent to station platforms will be 12 feet wide and shall be designed to accommodate the through movement of buses. A 12 feet wide bypass lane shall be constructed to the left of and adjacent to the through lane.

Lanes in opposing directions at stations shall be separated by a barrier system that prevents the movement of pedestrians between platforms at grade. The barrier shall include an emergency access point for movement between platforms.

Lanes accessing BRT stations from the highway will be visually differentiated from the highway lanes by using signage and pavement markings to prevent unauthorized vehicles from entering the station area.

Pedestrian Access

Pedestrian access from pnR plaza areas to median stations shall be via grade-separated walkways connecting the station to platform areas located outside highway ROW (See Section 2.6 of this Manual).

Station Platforms

Median station platform lengths shall accommodate the RTD vehicle fleet. They shall be sized to include the maximum number of vehicles that will simultaneously access them, which shall be determined by the RTD

approved service and operations plan. The Design Engineer shall confirm the required platform length with RTD during the concept design phase.

Platforms shall be designed to load passengers headed in one direction only. At-grade crossings between platforms (across the bus lanes) shall be prevented with a traffic barricade, fencing or other suitable barrier. Station design shall include provisions for an emergency at-grade crossing between platforms.

Station platforms shall be concrete, and shall have a tactile warning strip (TWS) along the edge of the bus-loading area. TWS (detectable warnings) shall be in accordance with the ADAAG.

Platforms shall have minimum and maximum cross-slopes of 1% and 2% respectively, and a maximum longitudinal slope of 2%. Stations shall be accessible to disabled individuals in accordance with ADA and ADAAG requirements. Station platform width shall be determined by the requirements of NFPA 130 and the dimensional requirements for elevators and stairs.

Median station platforms shall be accessed from transit plaza areas at the edge of the adjacent highway ROW. BRT station and transit plaza amenities shall include benches, shelters, trash receptacles, lighting and security. Stations may also include facilities for Intelligent Transportation Systems (ITS) communications. Transit plaza areas shall include the rapid fare collection technology in use by RTD (TVM, RFID, SmartCard, etc.). Plaza areas may include kiss-n-ride facilities for passenger drop-off.

2.2.4 Slip Ramp Station Design

Slip ramp and bus pull-out stations are typically located on limited access roadways, and are placed where a pnR is located adjacent to the highway. The ramps are constructed in pairs and may be located at interchange on or off-ramps or can be located along highways between interchanges. Slip ramps and bus pull-outs will be used where BRT priority lanes are located along the exterior of the highway general purpose lanes.

Bus Access

Slip ramp and bus pull-out station locations shall be coordinated with the location of the adjacent pnR or kiss-n-Ride that serves the station. Where stations are located between interchanges, acceleration and deceleration lanes shall be constructed in accordance with AASHTO standards. Where slip ramps are located on interchange ramps, the interchange ramps should be evaluated for the need to modify existing acceleration or deceleration lane length per AASHTO or other appropriate standards.

Slip ramp design shall include a bus stop area and bus bypass lane. The bypass lane shall be visually different from the highway lanes, if shared with general purpose or other non-transit traffic. Visual contrast shall be achieved with signage and pavement markings to prevent unauthorized vehicles from entering the station area. Wherever possible, a raised island shall be used to separate the bus stop and bypass lanes from highway through lanes for the protection of transit patrons.

Bus pull-outs located on interchange ramps shall be constructed with a minimum taper of 7:1 pulling into the station platform area and a minimum taper of 4:1 pulling out of the station platform area. The pullout area shall be separated from the main ramp lanes by a raised median.

Pedestrian Access

Slip ramp station platforms shall have a pedestrian access between the station platforms. The pedestrian access shall be physically separated from traffic with a grade-separated structure (see Section 2.6). Existing overpasses or underpasses with pedestrian facilities may be used for access between station platforms, if approved by RTD and the owner of the facility.

Station Platforms

Slip ramp station platforms shall be 110 feet long, which will accommodate two 45 foot buses. If articulated buses are planned for the station, then the platform length shall be 150 feet. Longer platforms may be required depending on the number of buses expected to access the facility at the same time, as determined by RTD. The Design Engineer shall verify the platform length requirements with RTD prior to design. Platforms shall be constructed of concrete and shall have minimum and maximum cross-slopes of 1% and 2% respectively, and a maximum longitudinal slope of 2%. Stations shall be accessible to disabled individuals in accordance with ADA and ADAAG requirements. Station platform width shall be determined by the requirements of NFPA 130 and the dimensional requirements for elevators and stairs.

Station platforms shall be accessed from transit plaza areas at adjacent pnr's. BRT station and transit plaza amenities shall include benches, shelters, trash receptacles, lighting and security. Stations may also include facilities for ITS communications. Transit plaza areas shall include the rapid fare collection technology in use by RTD (TVM, RFID, SmartCard, etc.). Plaza areas may include adjacent kiss-n-ride facilities for passenger drop-off.

2.2.5 BRT Superstop

BRT Superstops are BRT stations that are located on the roadway system of the local jurisdiction, typically on arterial streets. Superstops may also serve the local or limited bus system in addition to the BRT service. Superstops shall be designed to accommodate all vehicles that will use the facility.

Superstops shall be designed to differentiate the station from stops that serve only local routes by using urban design elements such as special shelter design and special paving to differentiate them from local bus stops. Superstop platforms shall be accessible in accordance with ADAAG or other more restrictive local standards. Transit plaza areas shall include the rapid fare collection technology in use by RTD (TVM, RFID, SmartCard, etc.). Superstops shall be a minimum of 70 feet long for accommodation of one bus at a time, or as designated by RTD service planners. Platforms shall be located so that buses can maneuver through a 7:1 taper into the bus stop and a 4:1 taper out of the bus stop. If Superstops are located in an area with on-street parking, they may be designed as bus bulbs. Where the Superstop is located adjacent to an asphalt pavement street, a concrete bus pad shall be placed adjacent to the sidewalk (see RTD Standard Drawings).

Superstops shall be located at the far side of street intersections, where possible. Near side stops may be used where bus movements will not conflict with auto traffic right turning movements. "Queue-jumping" (priority bus movement) signals may be used in conjunction with near side stops to provide priority movement for buses traveling in general traffic lanes. Signals shall be designed in coordination with the local traffic authority.

A bus bulb, also known as a nub, curb extension or bus bulge, is a section of sidewalk that extends from the curb of a parking lane to the edge of a through lane. In regard to traffic operations, bus bulbs operate similarly to curbside bus stops. Buses stop in the traffic lane instead of weaving into a parking-lane curbside stop. A major advantage of using bus bulbs is the creation of additional plaza space at bus stops. This space allows for the inclusion of bus patron amenities such as shelters and benches where the inclusion of such amenities would otherwise be limited by lack of space. The motivation for installing bus bulbs is to reduce sidewalk congestion, and to eliminate bus access weaving maneuvers into a parking-lane curbside stop (also called a bus bay stop). Bus bulbs are suitable for sites with high patron volumes, crowded city sidewalks and curbside parking.

2.3.0 BUS STOPS

Bus stops shall be located as directed by RTD. Bus stops shall be located either at the far or near side of intersections, with the preference being the far side and, if possible, should be placed in locations where street grades are less than 4%. The location of a bus stop at a parking lane curbside stop (also called a pull out or bus bay stop) should provide room for a bus to maneuver through a 7:1 access taper into the bus stop and a 4:1 egress taper out of the bus stop. If the bus stop is located adjacent to a street with asphalt pavement, a concrete bus pad shall be placed adjacent to the gutter pan. See RTD Standard Drawings for a typical bus pad.

When bus stops are located along detached sidewalks, a concrete boarding area shall be installed between the back of curb and front of sidewalk. When bus stops are located along attached sidewalks, and attached sidewalks are less than 8 feet wide, a concrete boarding area shall be added behind the sidewalk so that a minimum 8 feet wide area is provided. Concrete boarding areas shall be a minimum of 30 feet in length. See RTD Standard Drawings for additional information.

The cross slope of all boarding areas shall be 2%.

Generally, shelters shall be provided at bus stops where ridership exceeds 40 passengers per day, and as determined by RTD's shelter installation criteria evaluation process. The criteria includes span of service, scheduling, physical space, safety and others as specified.

Where there are known to be bicycle pass-up problems (i.e. full bus bike rack), bike parking shall be provided so that customers may safely lock and store their bike. See Section 4 for shelter facility design criteria.

2.4.0 TRANSFER STATIONS

2.4.1 General

Transfer stations shall be designed for the safe and efficient movement of vehicles and pedestrians. Transfer station access shall be designed to provide rapid, safe and efficient movement of vehicles between the transfer station and local traffic.

2.4.2 Design Characteristics

Transfer station facilities shall be separated from the main travel lanes of adjacent roadways. Walkways and plaza areas shall be provided for pedestrian movement between bus bays.

Transfer station grades shall be designed in accordance with the provisions of Section 3.7.2 of this Manual. Bus bays shall be constructed with sawtooth geometry (see RTD Standard Drawings), unless alternative configurations are approved by RTD. Bus travel and bypass lanes shall have a minimum width of 12 feet.

Transfer station facilities shall be designed to accommodate support vehicles, such as tow trucks, street supervisor vans and maintenance vehicles. A driver relief station (DRS) including water and sanitary sewer service, bicycle parking and pedestrian amenities (i.e., shelters, benches, lighting, trash receptacles, information holders and map case) shall be provided at all transfer stations.

2.5.0 BUS DESIGN CHARACTERISTICS

2.5.1 General

Buses in use by RTD are categorized as city, intercity and articulated buses. Some smaller, special transit buses are in use on local routes. Bus transit facilities shall be designed for the largest bus that could use the facility.

2.5.2 Design Characteristics

Table 2A presents the characteristics of the vehicle fleet currently in use by RTD. Figure 2A shows the measurement characteristics. The geometry of all bus facilities should be checked against these characteristics so that vehicles may maneuver through facilities without causing damage to either the vehicles or facilities. All of the vehicles listed below operate on city streets with a 6 inch high curb with the exception of the mall shuttle vehicles, which typically are operated on streets with a 4 inch high curb. All buses, except Mall Shuttles and paratransit vehicles, are equipped with bike racks to transport a limited number of bicycles during the patrons commute.

Because RTD continually acquires and retires portions of its bus fleet, the Design Engineer shall confirm existing or anticipated bus characteristics for use at the time of site construction.

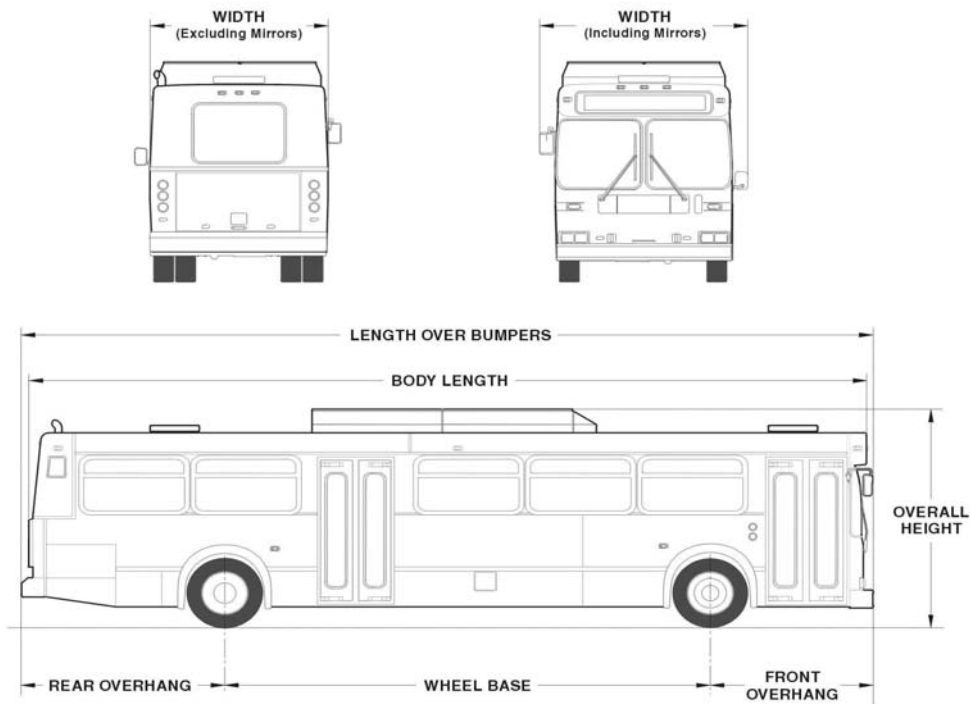
TABLE 2A BUS DESIGN CHARACTERISTICS

Bus Type*	Transit Bus- 29-ft.	Transit Bus 31-ft. 4-in.	Low Floor 30-ft.	Low Floor 40-ft.	Inner City	Inter City	Articulated	Mall Shuttle
Bus Features								
Max. Body Width (in.) **	96	102	102	102	102	102	102	102
Body Length (ft.)	29	31.33	30	41	40 - 45	45	60	45
Wheelbase (in.)								
Axle 1-2	139	170	163	279	139-318	275	264	276
Axle 2-3	N/A	N/A			N/A-52	54	233	N/A
Max. Outer Wheel Turning Radius (ft.)	30	31	29	44	47	47	44	46
Max. Height (in.)	120	120	120	122	140	140	138	136
Ground Clearance (in.)			10.2	11.8	10	10	10	
Axle Clearance (in.)			6	8.5	5.5	5.5	6	
Curb Weight (lb.) ***	22,800	26,220	23,100	28,200	28,600	40,000	44,000	25,000
Approach Angle			> 8.6°	> 9°	> 8.5°	> 8.5°	> 9°	
Departure Angle			> 8.2°	> 9°	> 9°	> 9°	> 9°	
Seating Capacity	24	29	26	36	43-47	55	63	18

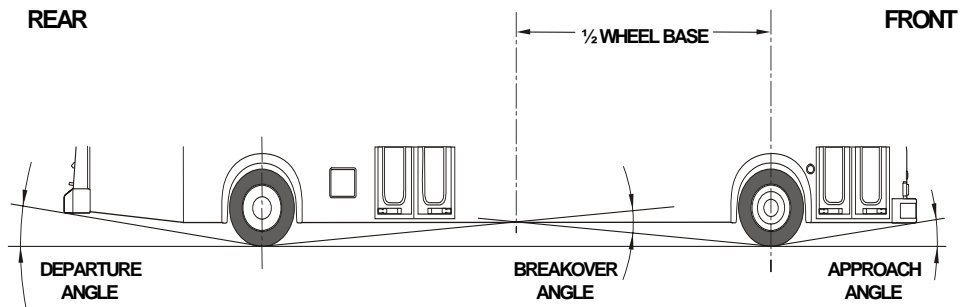
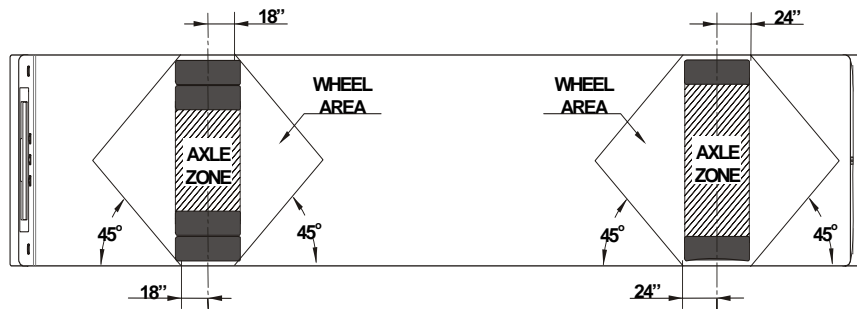
* The Design Engineer shall confirm bus overhang (front and rear) and include bicycle rack deployment length for all designs.

** Maximum Width - This width does not include rear view mirrors, bumpers, signal lights or rub rail. Add 18" to each side of the bus for rear view mirrors.

*** Maximum Curb Weight - Curb Weight is the weight of vehicle, including maximum fuel, oil and coolant; and all equipment required for operation and required by this Design Criteria, but without passengers or operator. For gross load, calculate one hundred fifty pounds for every designed passenger seating position, for the operator and for each 1.5 square feet of free floor space. Gross Vehicle Weight equals curb weight plus gross load. See vehicle specifications for the weight distribution by axle.



TRANSIT COACH EXTERIOR DIMENSIONS



TRANSIT BUS MINIMUM ROAD CLEARANCE

FIGURE 2A BUS CHARACTERISTICS

2.6.0 GRADE-SEPARATED PEDESTRIAN ACCESS

Grade separated pedestrian accesses will be constructed wherever pedestrian traffic traveling between elements of the transit system must be protected from vehicular traffic. In general, bridges are preferable to tunnel access because of security concerns. All accesses shall be designed in accordance with the most current version of ADAAG, or other local, more restrictive accessibility standards. Ramps, stairs and elevators shall be included in order to satisfy ADA requirements, emergency egress requirements and to provide convenient and efficient mobility between transit system elements. Elevators shall be capable of accommodating bicycles and emergency medical equipment (gurneys). Pedestrian bridges shall include enclosed walkways in order to protect the users from the weather. Grade separated accesses shall include provisions for periodic cleaning, maintenance and inspection of structural members. Grade separated access shall be designed with consideration of economical construction and maintenance. Design guidelines for grade-separated pedestrian access facilities are provided in Section 6 of this Manual.

2.7.0 PARK AND RIDE (pnR) DESIGN

Park-n-Rides (pnR) are provided for the use of transit patrons using personal vehicles to reach the transit system. A pnR should provide convenient facilities for access to the transit system and for transit patrons to leave personal vehicles long term.

Park-n-Rides are provided in locations as designated by RTD service planners or where indicated by specific corridor studies. Typical pnR locations are at light rail or commuter rail stations, adjacent to BRT stations and at locations that can be conveniently accessed by multiple local and express routes or by regional bus routes.

A pnR shall typically provide individually marked parking stalls and access drives, passenger pick-up and drop off facilities (kiss-n-Ride, short term parking), bus transfer facilities including bus bays for loading and unloading, a drivers relief station (DRS), shelters, benches, trash receptacles, bicycle parking, lighting, information kiosks, public telephones (pay and emergency) and security features. Facilities shall be paved, landscaped and designed to provide safe and convenient parking and bus transfer facilities for transit patrons. A pnR shall be designed with consideration for efficiency of use, economical site construction and convenient maintenance activities. The site design shall meet the requirements of the local jurisdiction.

2.7.1 Bus Transfer Areas

Bus transfer areas can be internal to the site or may be located at the edge of an adjacent roadway.

Where transfer facilities are located adjacent to the site on the local roadway system, bus pads shall be constructed in accordance with RTD Standard Drawings. The location of bus pads shall be coordinated with the local roadway authority.

Where transfer areas are located on site, integrated with a pnR, bus transfer areas shall be separated wherever possible from parking areas so that bus traffic and private vehicle traffic do not share drive lanes. The bus waiting area shall be constructed with concrete pavement and concrete curb and gutter, and individual bus loading bays shall be designed in accordance with RTD Standard Drawings. The number of bus bays provided in the waiting area shall be as designated by RTD's service development division.

Access to the bus transfer areas shall, wherever possible be located at signalized intersections. Two points of access shall be provided, if possible. All access shall be designed so that buses may enter and exit the transfer facility without reverse movement. Access to the site shall be coordinated with the local roadway authority. Bus access from the local roadway to the site shall be constructed with the use of curb returns or curb cuts, as required by local jurisdictions. The use of curb cuts shall be avoided. Curb return and drive lane minimum radii shall be designed in accordance with Section 3.7.9 of this Manual. Bus facility turning radii shall be designed for the radius of the most restrictive vehicle that could access the facility.

A DRS shall be located within a convenient distance (50 feet or less) from the bus waiting area, unless site constraints require a longer distance, which shall be coordinated with RTD.

Bus transfer area facilities, including site fixtures, pavement, lighting, DRS, utilities, bike facilities, drainage, and urban design and landscaping shall be designed in accordance with the appropriate sections of this Design Criteria and local requirements.

2.7.2 Parking Areas

Parking areas can be constructed as surface lots or as multi-story parking structures. Wherever possible, parking areas shall be constructed as surface lots. If parking demand is high and ROW is unavailable, parking structures shall be considered. For planning purposes, the designer shall assume a ratio of 75 parking spaces per acre for surface lots (see Section 1.1.0).

The pnR shall have access from public roadways from at least two locations. Full movement access must be available from at least one signalized intersection, if possible. Right-in-right-out (RI/RO) and three-quarter movements may be acceptable for additional access points. Drive lanes that mix bus traffic with private vehicle traffic shall be avoided. Site access shall be coordinated with the local roadway authority.

Parking areas shall be constructed of concrete or asphalt and shall include concrete curb and gutter. The type of pavement shall be based on recommendations from a geotechnical study or pavement design and as directed by RTD. See Section 3 of this Manual for site design standards. Parking area facilities, including pavement, lighting, security, drainage and

landscaping shall be designed in accordance with the appropriate section of this Design Criteria and local requirements. See Section 6 of this Manual for parking structure criteria.