Cotton Belt Regional Rail

DRAFT Design Criteria Manual Volume 1

Infrastructure Design Criteria

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1.0 INTRODUCTION

Dallas Area Rapid Transit (DART) is preparing preliminary engineering plans for the Cotton Belt Corridor from DFW Airport to its terminus in Plano. When completed, the regional rail within the Cotton Belt Corridor will provide service to DFW Airport, air passengers and other commuters in the North Central Texas region. In addition, it is proposed to provide connection to the DART Red and Green Lines, as well as the future Orange Line.

The Cotton Belt Corridor is an existing east west freight rail corridor that is proposed to have passenger rail. The DART Cotton Belt project corridor is located mostly on DART right of way and runs from just north of DFW Airport to central Plano. It passes through Collin, Dallas and Tarrant Counties including the cities of Grapevine, Coppell, Carrollton, Addison, Dallas, Richardson and Plano.

This two-volume set document describes the design criteria for use in the development of the Preliminary Engineering (PE) Plans for the regional rail in the Cotton Belt Corridor. Volume 1 focuses on design criteria for basic infrastructure, while Volume 2 provides design guidelines for system elements.

1.1 General Provisions

This design criteria manual is a working document intended to provide guidance and establish design assumptions for the development of the DART Cotton Belt project. It is a living document the DART design team intends to refine during the course of the project as new information and requirements become available to the team. The Design Criteria Manual will greatly depend on the type of technology used to provide service. Type of vehicle used and its specification will alter assumptions made in determining the design criteria. The Design Criteria Manual cannot be established without knowledge of technology to be deployed. It is assumed that the technology will be somewhat similar to DART's current LRT technology. DART's current LRT Design Criteria Manuals (Volumes 1 through 3) shall be referenced and utilized when possible.

1.2 Vehicle Technology

DART has contracted Interfleet to develop vehicle specifications for the Cotton Belt. A separate document is being developed regarding the vehicle specification requirements. This design criteria manual will be further refined based on the development of the vehicle specification requirements.

1.3 Station Design and Maintenance Facility

Stations along the Cotton Belt alignment are anticipated to be at-grade stations. Park and Ride facilities will be provided at selected stations. A maintenance facility will be required for the rail corridor. Additional information for the maintenance facility will be included in this manual once vehicle specifications, operational information, and stakeholder requirements become available. Crew rooms shall be provided for terminal stations. Recommendations on station amenities such as canopies and wind screens will be provided by the design team for DART's approval. Station design for HVAC, electrical, plumbing, fire protection, and elevators shall refer to DART LRT Design Criteria Volume 1; Chapter 19 through 31.

1.4 Other Design Guidelines

Governing criteria of the Counties and Cities that the Cotton Belt project will be crossing through shall be used for the design of the respective segments of the project. A list of municipality design standards is included in Appendix B.

2.0 TRACK ALIGNMENT

2.1 Survey Control

The horizontal control for all alignments shall be based on survey points established under the direction of DART. Coordinates for control points established for the system shall be located on NAD 1983 Texas Coordinate System, North Central Texas (Lambert), as established by the National Geodetic Survey (NGS). The vertical control shall be based on the National Geodetic Vertical Datum of 1988 (NGVD). Refer to Sections 1.2.1 and 1.2.2 in the DART Light Rail Project (LRP) Design Criteria Manual (DCM) for additional information.

2.2 Track Alignment

The design of the track alignment shall abide by the design requirements and recommendations of the current edition of Manual for Railway Engineering published by the American Railway Engineering and Maintenance-of-Way Association (AREMA). The horizontal alignment of the main line shall consist of tangents joined by circular curves with spiral transition curves. The circular curves and superelevation shall be related to the design speed and the acceleration and deceleration characteristics of the design vehicle. The track geometrics shall accommodate the maximum design speed of 80 miles per hour (MPH) for Class IV track. Certain restrictions such as small curve radii, spacing of stations, construction limitations, and the performance ability of the design vehicle require an operating speed less than the maximum. In these instances, the track geometrics shall be designed for the necessary reduced speed.

2.3 Speed Requirements

For the mainline, curvature and superelevation shall be related to the characteristics of the vehicle design, the effects of acceleration, deceleration, and speed command levels of the signal system. For rail yards, the track shall be designed to include operational requirements for each location.

2.4 Track Control

The alignment control shall be the center of the main line track carrying traffic in the direction of line stationing.

2.5 Track Spacing

It is anticipated that a single passenger track will be installed for the entire length of the alignment with segments of double passenger tracks installed as necessary based on operational requirements. The proposed passenger track shall be located 20 feet centers from the existing freight track. For any proposed double passenger tracks, tracks centers shall be 16 feet.

For future double track, sufficient area will be reserved to accommodate future track centers of 16 feet. Exceptions may be made at stations to accommodate wider platform widths.

2.6 Horizontal Alignment

The horizontal alignment of the mainline tracks shall consist of a series of tangents joined together to circular curves by means of spiral transition curves. Superelevation shall be used for passenger comfort and to maximize running speeds where it does not interfere with pavement grades in areas of mixed traffic operation. If perpendicular crossing to existing streets cannot be achieved, street pavement modification will be necessary.

2.6.1 Tangent Track Alignment

The minimum length of tangent track will depend on the vehicle type. Assuming the vehicle size will be similar to LRT, the minimum length of tangent track between curved sections of track shall be:

Desired Minimum	100 feet or 3 times the design speed Considering a maximum speed of 80 mph, three times the design speed would give a desired length of 240' tangents.
Minimum	However, a minimum of 50 feet or the length between truck centers whichever is greater.
Absolute Minimum	Per DART

At station platforms, the track alignment shall be tangent throughout the entire platform, unless otherwise approved by DART.

2.6.2 Curved Alignment

(a) Circular Curves

Degree of curvature shall be defined by the arc definition of curvature as determined by the following formula:

$$D = \frac{5729.578}{R}$$

Where D = degree of curvature
R = radius of curvature (feet)

The **maximum degree of curvature of mainline track** shall be as follows:

At-grade Ballasted	5.00 degrees

The **maximum degree of curvature for yard and service tracks** shall be 10.00 degrees. The minimum length of circular curves shall be 100 feet.

(b) Track Superelevation

Mainline tracks are designed with superelevations that permit desired design speeds to be achieved without resorting to excessively small degrees of curvature. The design speed criteria stated below are based on a maximum lateral passenger acceleration of 0.1 g.

$$E_t = E_a + E_u = 0.0007\ V^2\ D_c = \frac{4V^2}{R}$$

Where:

E_t = Total superelevation required to balance the centrifugal force at a given speed (in inches)
E_a = Actual track superelevation to be constructed (in inches)
E_u = Unbalanced superelevation the difference between E_t and E_a (in inches).
V = Design Speed (in miles per hour)
R = Radius of Curve (in feet)
D_c = Degree of Curve

The amount of E_u shall vary gradually as follows:

$$E_u = \frac{1.33\ V^2}{R} + 0.67$$

$$E_a = 2E_u - 2$$

Total track superelevation (E_t) shall not exceed 6 inches (5 inches on tracks shared with freight) with a desired 4 inch maximum.

A minimum of 1/2 inch of superelevation should be used on all mainline curves.

Unbalanced superelevation (E_u) shall not exceed 3 inches (1.5 inches on tracks shared with freight) with a desired 1.5 inch maximum. Actual superelevation should be attained and removed linearly throughout the full length of the spiral transition curve by raising the outside rail while maintaining the inside rail at the rail profile grade. Superelevation will not extend in tangent track without DART approval.

Superelevation Runoff

The change in superelevation should be in uniform increments and the rate of change per 31 feet of track should not be more than 3/8 inch. (FRA Class 4 track)

Yard tracks shall not be super elevated.

Shared Freight and Regional Rail

Condition	**Ea**	**Eu**
*Desirable Maximum	2 inches	2 inches
Absolute Maximum	3 inches	2 inches

Regional Rail Only

Condition	**Ea**	**Eu**
*Desirable Maximum	3 inches	2 inches
Absolute Maximum	4 inches	2 inches

(*Not to be exceeded without prior DART approval)

(c) Spiral Transitions

Spiral transition curves shall be used in order to develop the superelevation of the track and limit lateral acceleration, during the horizontal transition of the design vehicle, as it enters the curve. The desirable minimum length of spiral is 60 feet.

The minimum spiral length shall be the greatest length obtained from the following formulas:

$L_s = 62\ E_a$ and/or
$L_s = 1.22E_uV$ (Could be $L=1.63E_UV$ post vehicle selection)

Where:

L_s = length of spiral (feet)
E_a = actual superelevation (inch)
E_u = unbalanced superelevation (inch)
V = design speed (mph)

(d) Compound Circular Curves

Compound curves shall be connected by a spiral transition curve.

The minimum spiral length shall be the greatest length obtained from the following formulas:

$L_s = V\ (E_{a2} - E_{a1})$
$L_s = V\ (E_{u2} - E_{u1})$
$L_s = 30\ (E_{a2} - E_{a1})$ for speeds ≤ 30 mph
$L_s = 50\ (E_{a2} - E_{a1})$ for speeds > 30 mph and ≤ 50 mph
$L_s = 60\ (E_{a2} - E_{a1})$ for speeds > 50 mph

Where L_s = length of spiral (feet)
V = design speed through circular curve (mph)
E_{a1} = Actual superelevation of first curve (inch)
E_{a2} = Actual superelevation of second curve (inch)
E_{u1} = Unbalanced superelevation of first curve (inch)
E_{u2} = Unbalanced superelevation of second curve (inch)

(e) Reverse Curves

It may be necessary to include reverse curves into the track alignment when space is limited. When reverse curves are used, a minimum tangent length of 100 feet is desirable, where feasible tangent as specified in Section 2.6.1 shall be provided.

2.7 Vertical Alignment

The vertical alignment shall contain constant grade tangents connected by a parabolic curve having a constant rate of change.

2.7.1 Vertical Tangents

The minimum length of constant profile grade between vertical curves shall be:

Desirable Minimum	3 times the design speed
Absolute Minimum	100 feet

2.7.2 Vertical Grades

If the desirable maximum grades cannot be met, grades can be raised up to absolute maximums. Absolute grade should not be exceeded without prior DART approval.

Profile grades limitations are as follows:

Maximum Desirable	3.0 %
Absolute Maximum	3.6 %
Minimum	0 %
Desirable Minimum	0.2 %

Mainline Tracks on Curves

Mainline track slope shall have a desirable maximum of 2.0% where freight operations are present and 3.0% otherwise. The absolute maximum is 3.6%.

Station Area

Desirable grades through station. Grades through stations should not exceed 1.0%.

Special Trackwork

Grades on special trackwork shall have a desirable grade of 0.2% and an absolute maximum of 2.0%.

Yard and Secondary Tracks

Grades on special trackwork shall have a desirable grade of 0% and an absolute maximum of 1.0%.

2.7.3 Vertical Curves

All changes in constant grade profile shall be connected with a vertical curve.

Minimum Length of Vertical Curve

The minimum length of vertical curve shall be obtained from the following equation.

$$L = \frac{2.15 * D * V^2}{A}$$

Where:
L = Length of vertical curve (ft)
D = Algebraic difference in grades (%)
V = Design velocity (mph)
A = Vertical acceleration (0.6 ft/s/s for regional rail)

*If the Desirable Minimum can not be met, prior DART approval will be needed in order to lower curve length to any value smaller than the Desirable Minimum down to, and including, the Absolute Minimum length.

2.8 Clearances

Per design vehicle specifications. Additionally, refer to Design Criteria Summary in the Appendix and Section 1.9 DART Light Rail Project (LRP) Design Criteria Manual (DCM) for additional information.

3.0 TRACKWORK

3.1 Track Gauge

Track gauge shall be a standard gauge of 4 feet 8-1/2 inches (56-1/2 inches overall). The gauge is the distance between the inner sides of the headrails measured 5/8 inches below the top of rails. Subtle adjustments to this gage can be made in two special conditions:

- First, the gage can be increased by up to (3/8") in curves of 8 degrees and over in order to assist wheels and truck assemblies to negotiate the curves.
- Second, track gage can be reduced to 56-1/4 inches on tangent track with operating speed above 55 MPH. This "tight" gage helps to eliminate truck hunting at higher speeds.

Gage in special trackwork shall conform to the design of the special trackwork. AREMA standard drawings, dimensions, and details should be used wherever possible for special trackwork. The design of special trackwork shall consider the relationships between the back of flange, face of worn wheel, and worn flange limits when establishing design gage.

On shared use track, track gage wider than 56-3/4" will allow truck hunting oscillation amplitudes for freight cars to increase to unacceptable levels at speeds above 55 MPH.

Track gage deterioration is generally due to deterioration of wood ties, gage face wear of rail, crushing of insulators (on concrete ties), or missing or inadequate fasteners. Track maintenance personnel must be trained to observe for these conditions before gage standards are exceeded.

3.2 Cross Ties

NEW MAINLINE TRACKS FOR REGIONAL PASSENGER RAIL SHALL USE CONCRETE CROSS TIES.

3.3 Switch Ties

Timber or concrete switch ties shall be of various lengths conforming to the specific requirements of the turnouts used. Anti-splitting devices shall be used on all wood ties.

3.4 Rail

Rail for all mainline track shall have a base dimension of 6 inches. Typically the rail will be a 136 RE section, control-cooled carbon steel rail manufactured in accordance with current AREMA specifications.

3.5 Emergency Guard Rail

Emergency Guard Rail is used as a safety device. In the event of a derailment the guard rail is designed to catch the inside of the wheel and guide the CR along the track until it stops. Emergency guard rails shall be installed adjacent to the inside running rail of all tracks on bridges and fills with a vertical drop of more than 3 feet. Guard rail will extend over the length of the structure plus 50 feet in both directions. Emergency guard rails will not be installed within the limits of special trackwork.

Emergency guardrail shall be designed so as to retain the wheels of a derailed vehicle moving at maximum speed. The striking face of the emergency rail shall be uniformly located approximately 1 foot from the gauge line of the running rail. Guardrail shall be fastened to every second tie in ballasted track.

3.6 Rail Seat and Fastenings

Reserved for rail seat and fastenings.

3.7 Rail Welds

Reserved for rail welds.

3.8 Rail Joints

Reserved for rail joints.

3.9 Rail/Switch Heaters

Reserved for rail/switch heaters.

3.10 Special Trackwork

Reserved for special trackwork.

3.11 Grade Crossings

Reserved for grade crossings.

3.12 Track Bumping Posts

Track bumping posts shall be designed to clear the coupler and engage the cars' anti-climber. They shall be installed at the ends of all stub-end yard and mainline tracks.

3.13 Rail Expansion Joints

Reserved for expansion joints.

4.0 TRACKWAY

4.1 Subgrade

The project will consist of new track, ballast and subgrade. Subgrade shall be lime treated, or as recommended by the project geotechnical engineer. Geotextile fabric shall be allowed for subgrade improvements.

4.2 Subballast

Subballast is the transition zone between the subgrade and the ballast. The subballast acts as a barrier filter separating the ballast section from the subgrade material. This material plays an integral role in the track structure. The quality of the subballast has a direct relationship to the overall performance of the track structure. This layer acts as a drainage medium for the track bed.

Prolonged water exposure can be harmful to the subgrade. Once the subgrade begins to break down the track geometry cannot be maintained.

A 12-inch layer of sub-ballast shall be installed on top of the subgrade. The sub-ballast shall conform to AREMA specifications. Subballast should extend the full width of the subgrade plus a minimum 12 inches past the toe of the ballast.

4.3 Ballast

Consistent with DART LRT Specification, No. 4 (1-1/2 inches to 3/4 inches) ballast conforming to AREMA specifications shall be used on all main tracks except for those in streets and yards, where No. 5 (1 inch to 3/8 inch) ballast will be used. All ballast is to be thoroughly washed prior to placement.

A minimum depth of 12 inches of ballast shall be used between the bottom of ties and top of the subballast. The ballast shoulder shall extend 12 inches beyond the ends of the ties parallel to the plane formed by the top of the rails. Ballast shoulder shall then slope downward to the subgrade at a 2:1 slope. The final top of ballast elevation shall be at the top of tie, when compacted.

4.4 Slopes

Proposed embankment of track structure will be designed to have a 3:1 side slope. The ballast structure of the track will have a side slope of 2:1.

4.5 Undertrack Structures

Reserved for undertrack structures.

4.6 Maintenance Access Point

Access points for maintenance personnel and equipment shall be provided when practical.

5.0 STREETS AND PARKING

Refer to Chapter 4 of DART Light Rail Project (LRP) Design Criteria Manual (DCM).

6.0 DRAINAGE

Refer to Chapter 7 of DART LRP DCM.

7.0 TRAFFIC CONTROL

Refer to Chapter 5 of DART LRP DCM.

8.0 TRANSIT LOADS

8.1 Dead Load

Reserved for dead loads. For Freight and Mixed (both freight and passenger) tracks, Cooper E80 design load shall apply. For passenger only track, the design dead load shall be based on DART regional rail design vehicle. For the development of the 5% design, Cooper E40 was used to design passenger only tracks and structures.

8.2 Live Load

Reserved for live loads (to be based on DART regional rail design vehicle).

8.3 Impacts

Reserved for impact (be based on DART regional rail design vehicle).

9.0 STATION DESIGN

Refer to Chapters 19, 20, 21, 22 and 24 of DART LRP DCM. Station platform design shall be based on DART regional rail design vehicle standards.

10.0 ESTIMATE OF CAPITAL COST

The purpose of this section and its related appendix is to outline the basis for preparing capital cost estimate for the Cotton Belt Project. The Estimate of Capital Cost for DART Cotton Belt Regional Rail will conform to current DART methodology which is consistence with current Federal Transportation Administration Standard Cost Categories guidance. The capital cost estimates will allow DART and its partners to evaluate the cost-effectiveness and financial feasibility of the proposed alternatives. Estimates of Capital Costs include the one-time expenditures to design and build the guideway. This includes right-of-way acquisition, rail trackwork, vehicles, structures, maintenance facilities, and signal, communication, and electrical systems. The values used in the Estimates are based on current regional transportation projects and market experience.

The Estimates of Capital Cost are developed at three steps during the planning process:

1. Conceptual
2. Preliminary Engineering (5% and 10% design)
3. Final design

While Step 2, Preliminary Engineering, is the primary focus of the current DART Cotton Belt project, understanding of all three steps with details of cost breakdowns and contingency assumptions is necessary to develop consistent and reliable cost estimates for current and future design phases of the Cotton Belt Regional Rail project.

10.1 Conceptual

At the conceptual stage, the cost estimates are based on the Alternative Analysis (AA) and assumptions about the project scope, each alternative, environmental screening, and design standards. While the cost estimates include allowances for non-quantified known line items and contingencies that are intended to recognize the level of engineering available at this early stage, future project decisions regarding project scope may cause the cost estimates to increase or decrease. At this stage of analysis, the capital cost estimates are developed on a per unit basis and intended to be used primarily for making relative comparisons among the alternatives and represent a rough order of magnitude.

10.2 Preliminary Engineering

At the Preliminary Engineering stage, the cost estimates are developed at the completion of the 5% design level and the 10% design level which reflect a number of assumptions. These project assumptions correspond with the current level of alternative definition, engineering, and environmental screening. Refinements of unit costs are established for defined components of the project in place of order of magnitude unit cost. At this stage estimates are organized in accordance with the FTA SCC. Order of magnitude implementation schedules will be developed to aid in cash flow and applying inflation rates and financing cost to the project as defined in the appropriate FTA SCC work sheet. Contingency on both the 5% and 10% design levels are applied on an allocated basis at the line item level and on an unallocated basis at the subtotal of direct cost in accordance with FTASCC and FTA's Transit Cooperative Research Program "TCRP Report 138" titled "Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects".

10.3 Final Design

At the Final Design stage, the cost estimate reflects the final scope of the project in detail line items or in the form of bid items that are organized and summarized by the FTA SCC for each contract and project grouping. Each estimate line item will reflect a defined unit quantity derived from the Final Design construction bid documents with unit pricing that reflects cost being experienced in the current local market place. Contingency will be on an unallocated basis as reflected in the FTA SCC work sheets and defined in FTA's Transit Cooperative Research Program "TCRP Report 138" titled "Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects". Summary implementation schedules will be developed to aid in cash flow and applying inflation rates and financing cost to the project as defined in the appropriate FTA SCC work sheet.

10.4 FTA Standard Cost Categories (SCC)

FTA implemented the SCC to establish a consistent format for the reporting, estimating, and managing of capital costs for New Starts projects. Submission of capital costs to FTA in the SCC format is required at the following points:

- Request to enter Preliminary Engineering
- Request to enter Final Design
- Request for Full Funding Grant Agreement (FFGA)
- Submission for Annual New Starts evaluation
- FFGA amendments
- During construction at regular intervals
- At revenue operations
- Annually until the later of the submission of the Before & After Study or at project close-out and resolution of claims.

The FTA SCC definitions can be found in Appendix C.

10.5 Add-on Factors and Contingencies

A brief description of the contingencies and add-on factors is as follows:

- **Design Contingency** – A design contingency is added to the civil cost in the estimate to cover possible changes in unit costs that may occur as selected projects progress through the various stages of design development. Generally, this percentage is reduced as the project progresses through the conceptual, preliminary and final stages of design; therefore, less reserve is needed with more design. At the system-level stage, where little or no design has been done, a relatively high percentage of design contingency is included. Values for this contingency begin at 30-35% at the System Plan level and are adjusted based on the potential complexity of the project and the need for substantial guideway structures or special conditions.

- **Construction Contingency –** A 10 percent contingency is added to the construction cost estimate to cover the expense of unforeseen costs incurred by contractors during construction.

- **Add-On Allowance (Professional Services) –** The following is a comparison mapping of the FTA SCC for soft cost to the Standard DART add-on allowance for soft cost. The values used for FTA SCC are from FTA's Transit Cooperative Research Program "TCRP Report 138" titled "Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects" for as built values. These add-on values are well in line with as built cost both based on total and grouping for any level of estimate that is prepared during the life of the program. In the estimating process the detail estimate will develop the values based on the DART breakdown.

80.01 Preliminary Engineering	2.70%	Planning	1.00%	1.00%
80.02 Final Design	9.70%	Civil Design	6.40%	10.20%
		Systems Design	2.40%	
		CADD	1.40%	
80.03 Project Management for Design and Construction	8.80%	Systems Integration	1.50%	8.10%
		Support Services	2.00%	
		Project Controls	3.40%	
		Design Support During Construction	1.20%	
80.04 Construction Administration and Management	6.30%	Construction Management (Civil)	5.00%	7.00%
		Construction Management (Systems)	2.00%	
80.05 Professional Liability and other Non-Construction Insurance	1.60%	OCIP	3.50%	3.50%
80.07 Surveys, Testing, Investigation, Inspection	2.20%	Design Survey	0.40%	2.20%
		Vehicle Support and Inspection	1.80%	
TOTAL per FTA SCC	**31.30%**	**DART Standard add-on TOTAL**	**32.00%**	**32.00%**

Being consistent with FTA's standards, DART's add-on factors and contingencies have been used effectively and reliably for capital cost estimates of the LRT projects in recent years. With the exception of the traction power distribution system for LRT technology, key elements for the Cotton Belt Regional Rail will be largely similar to those used for the LRT. The add-on factors and contingencies typically used for the LRT system will be used for the Cotton Belt Regional Rail PE design.

Appendix A

Appendix A
Cotton Belt Regional Rail Design Criteria Summary Matrix

	MAIN LINE TRACK			SIDING TRACK			STATIONS (on tangent 110'+59'+400' platform+50'+85')			Maintenance Facility/Yard			Freight		
	Desired Value	**Range**	**Notes**	**Desired Value**	**Range**	**Notes**	**Desired Value**	**Range**	**Notes**	**Desired Value**	**Range**	**Notes**	**Desired Value**	**Range**	**Notes**
Horizontal Alignments															
Design Speed (V)	59 mph (Class 3 track = 60 mph)	operation-80 mph = Class 4 track	designed for class 4 (80mph) but operate at class 3 tolerances	40 mph	30-40 mph	AREMA Ch. 5, Sec. 3.1, Eqs. 2 & 3	40 mph designed for thru traffic	10-40 mph for stop condition	AREMA Eq. V2=(Ea+Eu)/(0.0007*(5729.578/R)) , #10 TO	10 mph	10-20 mph		40 mph	- - -	per Class 4 track
Unbalanced superelevation (Eu)	2.0"	0" to 2"	2" is the maximum allowable unbalanced superelevation	2" Max	0" to 2"		0"	0"	Stations are all on tangents	0"	- - -	Long leads into the yard my have warrants for superelevations	3"	Min 3" if E is greater than 0"	
Actual superelevation (Ea)	2.0"	0" to 2"	Minimum 0.5" is desired for curves to prevent settling in the opposite direction to prevent reverse superelevations	3" max	0" to 3"	Minimum 0.5" is desired for curves to prevent settling in the opposite direction to prevent reverse superelevations	0"	0"	Not Desired to have any superelevation present at the station.	0"	- - -	Long leads into the yard my have warrants for superelevations	0"	0" to 3"	
Total superelevation (E)	1.5" to 3" (4" for Commuter only) Maximum	Max 4"	No superelevation above 1.5" on freight tracks	0" to 4"	Max 5"	based on design	0"	0"	Not Desired to have any superelevation present at the station.	0"	- - -	Long leads into the yard my have warrants for superelevations	3-4"	Max 6"	
Maximum horizontal curvature (Rc)	9° 30'	0° 30' to 9°30'		11° 30'	0° 30' to 12°		0°	0°		12°	10° to 12°		10°	- - -	
Minimum Curve Radius	500'	- - -	If Radius is smaller than 500' must have restraining rail	500'	85' to 500'	If Radius is smaller than 500' must have restraining rail	- - -	- - -		500'	85' to 500'	If Radius is smaller than 500' must have restraining rail	- - -	- - -	
Max Curve Radius from Turnout	Same as TO radius	- - -	use No. 20 where practical	Same as TO radius	- - -	per client request	Same as TO radius	- - -	per client request	- - -	- - -		Same as TO radius	- - -	
Minimum Curve Length	L = 3V	100'	62 ft is the very minimum	L = 3V	100'	62 ft is the very minimum	n/a	n/a	Stations should not be placed in a curve.	- - -	- - -		- - -	- - -	
Minimum length of spiral (Ls)	62' or 100'	62 ft; or greater always using the optimal spiral length.	per Vehicle Specs (See formulas) {Ls=1.63(Eu)V, Ls=62Ea, Ls=100 Feet}	62' or 100'	62 ft; or greater always using the optimal spiral length.	per Vehicle Specs (See formulas) {Ls=1.63(Eu)V, Ls=62Ea, Ls=100 Feet}	Stations on Tangent.	Stations on Tangent.	Stations should have no spirals or curves within 75 ft of the platform edge.	- - -	- - -		50'	50ft; 30ft; 0ft. Length pref in this order.	per AREMA
Minimum Tangent Length	# trucks/CVxL truck= 3x80= 240'	Larger of: Lmin. = 100' OR 3V= 3x 80 mph= 240'	(L abs.min.=62' = length longest car per AREMA) & Light Rail Track Design Handbook.	#trucks/CVxL truck= 3x80= 240'	Larger of: Lmin. = 100' OR 3V= 3x80mph= 240'	L abs.min.= 62' = length longest car per AREMA	50'	Greater than 50' (50' min for reverse curves)	per Light Rail Track Design Handbook	50'	- - -		100'	- - -	
Track Centers	17'-0"	15'-6" to 30'	between ML & future	17'-0"	15'-6" to 30'	between ML & future	15'-6"	15'-6"	per platform width= 62'	13'-6"	- - -	per access aisles, etc	15'	13'-6" to 25'	
Turnouts	No. 20	No. 14 to 20	Place on tangent	No. 20	No. 14 to 20	Place on tangent	No. 20	No. 5 thru 20	No. 10 used at Denton	No. 8	- - -		No. 20	No. 5 thru 20	Place on tangent
Edge of platform to track CL *	5'-4"	none		5'-6"	none		5'-6"	none	5'-3"+3"sacrificial pad	- - -	- - -		- - -	- - -	
Length of platform	- - -	- - -		- - -	- - -		L= 400'	- - -		- - -	- - -		- - -	- - -	
Min Distance of platform to C/L of track	- - -	- - -		- - -	- - -		4'-8"	4'-8"	See current design vehicle	- - -	- - -		- - -	- - -	
Horizontal clearance to structures (c-c)	general 8'-6" **	8.5' to 17'		17' **	8.5' to 17'		8-6" to Freight	8-6" to Freight	8-6" to Freight	- - -	8.5' to 30'	per access aisles, etc	10'	8.5' to 15'	
Horiz. clearance to permanent obstructions	10'-8" *	- - -		10'-8" *	- - -		10'-8"	- - -		- - -	8.5' to 30'	per access aisles, etc	10'-8"	- - -	
Vertical Alignments															
Length of vertical curve (crest or sag) [**]	200' (L = 2.15DV^{2}K/A)	100' abs. min.	train speed dependent	200' (L = 2.15DV^{2}K/A)	100' abs. min.	train speed dependent	- - -	- - -		- - -	- - -		- - -	- - -	
Absolute maximum grade	3.6%	3.6%		1.0%	2%		0.50%	1.0% max.		0.20%	- - -		2%	- - -	
Desired maximum grade	3.00%	3.6%		3.00%	3.6%		0%	- - -		0%	- - -		1%	- - -	
Desired minimum grade	0.00%	3.6%		0.00%	3.6%		- - -	- - -		- - -	- - -		- - -	- - -	
Minimum Tangent Length	L = 3V	100' min.	85' Absolute Minimum	L = 3V	100' min.	min. per AREMA	100'	- - -		50'	- - -		- - -	- - -	per freight/AREMA
Vertical Clearance to Structures *	22'	22' to 23'		23'	22.5' to 23'		23'	22.5' to 23'		19.5'	- - -		23'	22.5' to 23'	
Vertical Clearance to Crossing Tracks	22'	22' to 23'		25'	23' min		N/A	- - -		N/A	- - -		N/A	- - -	
Cross Sections															
Rail ***	136#	- - -	CWR	136#	- - -	CWR	136#	- - -	CWR	136#	- - -	jointed, used OK	136#	136#	CWR
Ties (concrete)	concrete	- - -	8.75"x11"x8.5'	concrete	- - -	8.75"x11"x8.5'	concrete	- - -	7"x9"x8.5' (wood)	concrete	concrete	7"x9"x8.5'	concrete	concrete/steel	7"x9"x8.5' (wood)
Tie Spacing (19.5" wood)	24" for regional rail	20" Dc>= 5^30'		30"	20" Dc>= 5^30'		24"	20" Dc>= 5^30'		24"	- - -		24"	20" Dc>= 5^30'	
Ballast	12"		crushed rock	12"	- - -	crushed rock	12"	- - -	crushed rock	12"	- - -	Ballast in Maintenance facility should be at least 12" to allow for better installation of all the switches.	12"	- - -	crushed rock
Subballast	10"	8" to 12"	Class 4 track	10"	8" to 12"	Class 4 track	10"	8" to 12"	Class 4 track	8"	6" to 8"		10"	8" to 12"	Class 4 track
Subgrade width	12'			12'	- - -		12'	- - -		12'			12'	- - -	
Plate Design	double shoulder with spring clips and 1:40 cant			double shoulder with spring clips and 1:40 cant			double shoulder with spring clips and 1:40 cant			double shoulder with cut spikes			double shoulder with spring clips and 1:40 cant		

NOTES:
Maximum operating speed of 65 mph, with 35 mph at siding are:[**] L=(DxV^2xK)/A (see AREMA p. 5-3-15 & Figure 5-3-4)
CWR: Continuous Welded Rail
***Centerline of track was designed by arc definition by radius rounded to the nearest 10'.

[**] L=(DxV^2xK)/A (see AREMA p. 5-3-15 & Figure 5-3-4)

REFERENCES: AREMA. Manual of Railway Engineering. 2004.

Appendix B

Appendix B
Cotton Belt Rail Corridor Municipality Design Standards

Municipality	Design Standards	Effective Date	URS Network Location
DFW Airport	Design Criteria Manual (16 Divisions)	April 1, 2005	S:\City_Of\DFW Airport\Design Standards
	FAA Drainage Design Manual	September 29, 2006	S:\City_Of\DFW Airport\Design Standards\FAA Drainage Design Manual.pdf
City of Coppell	City of Coppell Floodplain Map	August 28, 2007	S:\City_Of\Coppell\FEMA\FEMA_440_4_stat2.pdf
	Floodplain Ordinance	June 26, 2001	S:\City_Of\Coppell\Floodplain Ordinance 2001-952.pdf
	Standard Construction Details	August 22, 2006	S:\City_Of\Coppell\Standard Construction Details
	Preliminary Dallas County FIRM Panels	N\A	S:\City_Of\Coppell\FEMA
City of Dallas	Standard Construction Details	September 1, 2002	S:\City_Of\Dallas\Scanned 251-D.pdf
	Drainage Design Manual	May 1, 1993	S:\City_Of\Dallas\Drainage\CityofDallas Drainage Manual_1993.pdf
	Pipeline Design Manual	February 1, 2010	S:\DWU_Standards\DWU Standard Drawings\DWU Design Standards - 2010
	Paving Design	June 1, 1998	S:\City_Of\Dallas\Paving Design\CityofDallasPavementDesignManual_1998.pdf
	Water Master Plan	July 1, 2007	S:\City_Of\Dallas\Water Master Plan - 2007
	Wastewater Master Plan	October 22, 2007	S:\City_Of\Dallas\Wastewater Master Plan - 2007
	Pavement Cut and Repair Manual	October 1, 2003	S:\City_Of\Dallas\PavementCutandRepairManual_2003.pdf
	Parking Driveways Handbook	June 1, 2004	S:\City_Of\Dallas\Parking_Driveways_Handbook.pdf
	Traffic Signal Design Guidelines	March 10, 2008	S:\City_Of\Dallas\Traffic Signal Design Guidelines
	Water & Wastewater Key Maps	March 26, 2010	S:\DWU_Standards\DWU Water & Wastewater Key Maps\2010-03-26 Maps
	DWU Standard Drawings	January 1, 2010	S:\DWU_Standards\DWU Standard Drawings\DWU Design Standards - 2010
City of Carrollton	2005 Aerials	January 1, 2005	S:\City_Of\Carrollton\2005 Aerials
	Carrollton General Design Standards	January 1, 2009	S:\City_Of\Carrollton\Carrollton General Design Standards.pdf
	Stormwater and Flood Protection Ordinance	December 1, 2000	S:\City_Of\Carrollton\Carrollton Stormwater and Flood Protection Ordinance.pdf
	Water & Sewer Design		Now Section 12 of General Design Standards (See above)
	Standard Construction Details (in pdf and zip)	January 1, 2007	S:\City_Of\Carrollton\1996 Wastewater Collection System.pdf
Town of Addison	Wastewater Collection System	July 1, 1996	S:\City_Of\Addison\1996 Wastewater Collection System.pdf
	Drainage Criteria Manual	March 1, 1990	S:\City_Of\Addison\Addison Drainage Criteria Manual.pdf
	Transportation Plan	June 1, 1998	S:\City_Of\Addison\TransportationPlan.pdf
	Water Master Plan	August 1, 2007	S:\City_Of\Addison\Water Master Plan.pdf
	Water System Requirements		S:\City_Of\Addison\Water System Requirements.pdf
City of Richardson	Standard Construction Details	February 1, 2005	S:\City_Of\Richardson\stdconstrdetlsComplete.pdf
	Current Land Use	December 1, 2007	S:\City_Of\Richardson\Current Land Use.pdf
City of Plano	Addendum to NCTCOG Specifications	January 1, 1997	S:\City_Of\Plano\PublicWorksStdConstruction.pdf
	Storm Draiange Manual	August 1, 1993	S:\City_Of\Plano\storm_drainage_manual.pdf
	Thoroughfare Standards	February 15, 2009	S:\City_Of\Plano\Thoroughfare_Stds.pdf
	Water & Sewer Design Manual	January 1, 1997	S:\City_Of\Plano\WaterSewerDesignManual.pdf

Appendix C

FTA Standard Cost Categories Definitions

Standard Cost Categories for Capital Projects **D E F I N I T I O N S** (Rev.13, June 1, 2010)		**NOTE:** The SCC cost breakdown is based on a traditional Design Bid Build model. If your project is Design Build, to the best of your ability, separate construction costs from design, administration, testing, etc. Put all construction costs in 10 through 50. Put design, administration, testing, etc. in *80 Professional Services*.
10 GUIDEWAY & TRACK ELEMENTS (route miles)		Include guideway and track costs for all transit modes (Heavy rail, light rail, commuter rail, BRT, rapid bus, bus, monorail, cable car, etc.) The unit of measure is route miles of guideway, regardless of width. As associated with the guideway, include costs for rough grading, excavation, and concrete base for guideway where applicable. Include all construction materials and labor regardless of whom is performing the work. In your written description of the scope and in supporting graphic diagrams, indicate whether busway or rail track is single, double, triple, relocated, etc. Put guideway and track elements associated with yards in *30 Support Facilities* below.
10.01	Guideway: At-grade exclusive right-of-way	
10.02	Guideway: At-grade semi-exclusive (allows cross-traffic)	
10.03	Guideway: At-grade in mixed traffic	
10.04	Guideway: Aerial structure	Include foundation excavation; guideway structures including caissons, columns, bridges, viaducts, cross-overs, fly-overs.
10.05	Guideway: Built-up fill	Include construction of earthen berms.
10.06	Guideway: Underground cut & cover	Include excavation, retaining walls, backfill, underground guideway structure and finishes.
10.07	Guideway: Underground tunnel	Include tunneling by means of a tunnel boring machine, drill blasting, mining, and immersed tube tunneling; tunnel structure and finishes.
10.08	Guideway: Retained cut or fill	Include excavation, retaining walls, backfill, underground guideway structure and finishes.
10.09	Track: Direct fixation	Include rails, connectors.
10.10	Track: Embedded	Include rails, ties; ballast where applicable
10.11	Track: Ballasted	Include rails, ties and ballast.
10.12	Track: Special (switches, turnouts)	Include transitional curves.
10.13	Track: Vibration and noise dampening	Include upcharge for vib/noise dampening to any track condition above.
20 STATIONS, STOPS, TERMINALS, INTERMODAL (number)		As associated with stations, include costs for rough grading, excavation, station structures, enclosures, finishes, equipment; mechanical and electrical components including HVAC, ventilation shafts and equipment, station power, lighting, public address/customer information system, safety systems such as fire detection and prevention, security surveillance, access control, life safety systems, etc. Include all construction materials and labor regardless of whom is performing the

		work.
		Put guideway and track associated with stations in *10 Guideway & Track Elements* above.
20.01	At-grade station, stop, shelter, mall, terminal, platform	
20.02	Aerial station, stop, shelter, mall, terminal, platform	Include station structures including caissons, columns, platforms, superstructures, etc.
20.03	Underground station, stop, shelter, mall, terminal, platform	Include retaining walls, backfill, structure.
20.04	Other stations, landings, terminals: Intermodal, ferry, trolley, etc.	
20.05	Joint development	Per FTA's Joint Development Guidance, "Joint development is any income-producing activity with a transit nexus related to a real estate asset in which FTA has an interest. . .Joint development projects are commercial, residential, industrial, or mixed-use developments that are induced by or enhance the effectiveness of transit projects. . ."
20.06	Automobile parking multi-story structure	Include retaining walls, backfill, structure
20.07	Elevators, escalators	
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS		As associated with support facilities, include costs for rough grading, excavation, support structures, enclosures, finishes, equipment; mechanical and electrical components including HVAC, ventilation shafts and equipment, facility power, lighting, public address system, safety systems such as fire detection and prevention, security surveillance, access control, life safety systems, etc. Include fueling stations. Include all construction materials and labor regardless of whom is performing the work.
		Where a support facility shares the structure with a station, its cost may be included with station cost. Identify this with a note.
		Except for guideway and track associated with a yard, include all guideway and track costs associated with support facilities in *10 Guideway & Track Elements* above.
30.01	Administration Building: Office, sales, storage, revenue counting	
30.02	Light Maintenance Facility	Include service, inspection, and storage facilities and equipment.
30.03	Heavy Maintenance Facility	Include heavy maintenance and overhaul facilities and equipment.
30.04	Storage or Maintenance of Way Building	
30.05	Yard and Yard Track	Include yard construction, guideway and track associated with yard.
40 SITEWORK & SPECIAL CONDITIONS		Include all construction materials and labor regardless of whom is performing the work.
40.01	Demolition, Clearing, Earthwork	Include project-wide clearing, demolition and fine grading.
40.02	Site Utilities, Utility Relocation	Include all site utilities - storm, sewer, water, gas, electric.

40.03	Haz. mat'l, contam'd soil removal/mitigation, ground water treatments	Include underground storage tanks, fuel tanks, other hazardous materials and treatments, etc.
40.04	Environmental mitigation, e.g. wetlands, historic/archeological, parks	Include other environmental mitigation not listed.
40.05	Site structures including retaining walls, sound walls	
40.06	Pedestrian / bike access and accommodation, landscaping	Include sidewalks, paths, plazas, landscape, site and station furniture, site lighting, signage, public artwork, bike facilities, permanent fencing.
40.07	Automobile, bus, van access ways including roads, parking lots	Include all on-grade paving.
40.08	Temporary Facilities and other indirect costs during construction	As a general rule and to the extent possible, appropriately allocate indirect costs among the construction costs in Categories 10 through 50. Where that is not possible, include in *40.08 Temporary Facilities* costs for mobilization, demobilization, phasing; time and temporary construction associated with weather (heat, rain, freezing, etc.); temporary power and facilities; temporary construction, easements, and barriers for storm water pollution prevention, temporary access and to mitigate construction impacts; project and construction supervision; general conditions, overhead, profit. **NOTE: Include contractor's general liability and other insurance related to construction such as builder's risk in Cats. 10 - 50, not in 80 Professional Services below.**
50 SYSTEMS		Include all construction materials and labor regardless of whom is performing the work.
50.01	Train control and signals	
50.02	Traffic signals and crossing protection	Include signal prioritization at intersections.
50.03	Traction power supply: substations	
50.04	Traction power distribution: catenary and third rail	
50.05	Communications	Include passenger information systems at stations and on vehicles (real time travel information; static maps and schedules). Include equipment to allow communications among vehicles and with central control.
50.06	Fare collection system and equipment	Include fare sales and swipe machines, fare counting equipment.
50.07	Central Control	
Construction Subtotal (10 - 50)		
60 ROW, LAND, EXISTING IMPROVEMENTS		**Include professional services associated with the real estate component of the project. These costs may include agency staff oversight and administration, real estate and relocation consultants, legal counsel, court expenses, insurance, etc.**
60.01	Purchase or lease of real estate	If the value of right-of-way, land, and existing improvements is to be used as local match to the Federal funding of the project, include the total cost on this line item. In backup documentation, separate cost for land from cost for improvements. Identify whether items are leased, purchased or acquired through payment or for free. Include the costs for permanent surface and subsurface easements, trackage rights, etc.
60.02	Relocation of existing households and businesses	In compliance with Uniform Relocation Act.

70 VEHICLES (number)		**Include professional services associated with the vehicle component of the project. These costs may include agency staff oversight and administration, vehicle consultants, design and manufacturing contractors, legal counsel, warranty and insurance costs, etc.**
70.01	Light Rail	Include light rail and streetcar rail using electric, diesel or other power supply.
70.02	Heavy Rail	
70.03	Commuter Rail	Include locomotives (diesel, electric, or other), trailer cars, self-propelled multiple units (EMU electric or DMU diesel, or other power supply)
70.04	Bus	Includes "rubber-tired" buses and trolleys including new, used, historic replica, articulated, using electric, diesel, dual-power, or other power supply.
70.05	Other	Include Vans, Sedan/Station Wagon, Cable Car, People Mover, Monorail, Car/Inclined Railway, Ferry Boat, Transferred Vehicle
70.06	Non-revenue vehicles	
70.07	Spare parts	
80 PROFESSIONAL SERVICES (applies to Cats. 10-50)		Cat. 80 applies to Cats. 10-50. Cat. 80 includes all professional, technical and management services related to the design and construction of fixed infrastructure (Cats. 10 - 50) during the preliminary engineering, final design, and construction phases of the project. This includes environmental work, design, engineering and architectural services; specialty services such as safety or security analyses; value engineering, risk assessment, cost estimating, scheduling, Before and After studies, ridership modeling and analyses, auditing, legal services, administration and management, etc. by agency staff or outside consultants. Include professional liability insurance and other non-construction insurance on 80.05 unless insurance for the agency and its consultants is already included in other lines. Include costs associated with professional services related to real estate and vehicles in Cats. 60 and 70. *(Note that costs for alternatives analysis and NEPA work done before FTA approval to enter preliminary engineering (PE), regardless of funding source, are not included in an FFGA and therefore, should not be included in the Standard Cost Category worksheets. For example, on one and the same grant, costs incurred prior to FTA approval to enter PE should be omitted from these worksheets whereas costs incurred after FTA approval to enter PE should be included.)*
80.01	Preliminary Engineering	
80.02	Final Design	
80.03	Project Management for Design and Construction	
80.04	Construction Administration & Management	
80.05	Professional Liability and other Non-Construction Insurance	
80.06	Legal; Permits; Review Fees by other agencies, cities, etc.	
80.07	Surveys, Testing, Investigation, Inspection	
80.08	Start up	Include start up and training. Include in Cats. 10 - 50 above access and protection work by agency staff or outside contractors.
Subtotal (10 - 80)		
90 UNALLOCATED CONTINGENCY		Includes unallocated contingency, project reserves. Document allocated contingencies for individual line items on the Main

	worksheets.
Subtotal (10 - 90)	
100 FINANCE CHARGES	Include finance charges expected to be paid by the project sponsor/grantee prior to either the completion of the project or the fulfillment of the New Starts funding commitment, whichever occurs later in time. Finance charges incurred after this date should not be included in Total Project Cost. (See FFGA Circular FTA C5200.1A Chapter III for additional information.) Derive finance charges from the New Starts project's financial plan, based on an analysis of the sources and uses of funds. The amount and type of debt financing required and revenues available determine the finance charges. By year, compute finance charges in year-of-expenditure (YOE) dollars. On the Inflation Calculation to YOE worksheet enter the finance charges for the appropriate years.
Total Project Cost (10 - 100)	