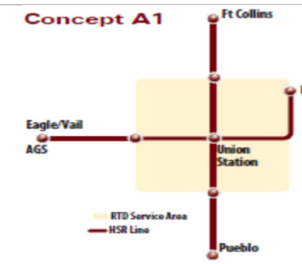
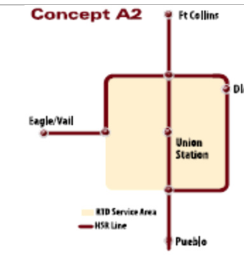
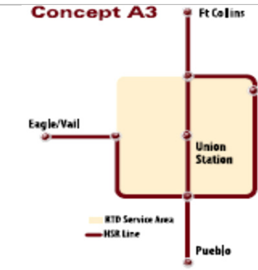
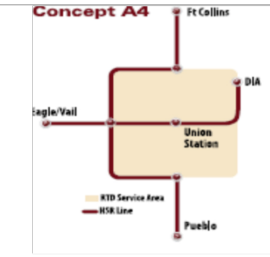
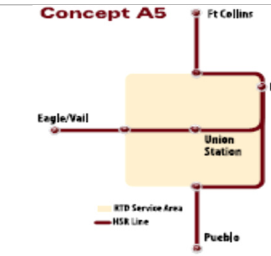
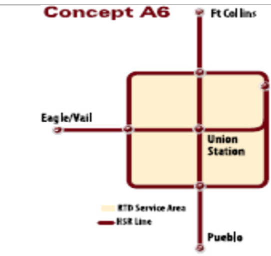
Appendix A:
CDOT Interregional Connectivity Study
Detailed Level 1 Evaluation Matrices
August 2012

ICS – Detailed Level 1 Evaluation Matrix – August 2012
Rollup: Group A-Series Scenarios – Through the Denver Metro Area (Note: Segments Outside of the Denver Metro Area are Evaluated in a Separate Matrix)

		A-1: Direct Routing through Denver	A-2: Beltway Excluding SW Quadrant	A-3: Beltway Excluding NW Quadrant	A-4: Western Beltway	A-5: Eastern Beltway	A-6: Complete Beltway
							
	Description	This alternative travels from the west through Denver along I-70 over I-25 to the Rock Island Branch line to I-70 to DIA. The N-S alignment follows the existing Brush Line and CML from E-470 to Littleton. A new station would be provided in the vicinity of the stock yards. (There are several design options to this scenario including the use of 6th Avenue for the western section and/or the East Rail line for the eastern section.) HSIPR continues on either a railroad or Greenfield alignment outside of the metro area.	This alternative travels from I-70 to a new alignment along the Northwest Corridor to the Northwest Parkway to E-470 and on to DIA. The N-S alignment is the same as for A-1. HSIPR continues on either a railroad or Greenfield alignment outside of the metro area.	This alternative travels from I-70 to C-470 south and east to E-470 and on to DIA. The N-S alignment is the same as for A-1. HSIPR continues on either a railroad or Greenfield alignment outside of the metro area.	This alternative splits north and south from I-70, to the north along a new corridor and to the south via the existing C-470 alignment. The E-W alignment is the same (along with the same design options) as A-1. HSIPR continues on either a railroad or Greenfield alignment outside of the metro area.	This alternative travels N-S from I-25 along the existing E-470 alignment. The E-W alignment is the same (along with the same design options) as A-1. A new station would be provided in the vicinity of the stock yards. HSIPR continues on either a railroad or Greenfield alignment outside of the metro area.	This alternative uses the same E-W and N-S alignments as A-1 and includes a beltway alignment around all four quadrants of the Denver metro area. HSIPR continues on either a railroad or Greenfield alignment outside of the metro area.
Criterion	**Measure**						
Meets P&N	*Number of critical success factors met*	Yes in general. The degree to which the PN is satisfied will be better determined in Levels 2 and 3 screening.	Same as A-1.	Same as A-1.	Same as A-1.	Same as A-1.	Same as A-1.
Transportation & Mobility							
One Seat Ride	*Yes or No: From Mountains, DIA, COS, FC*	Provides the best opportunity for a one seat ride.	No practical one seat ride from the SW.	Same as A-2.	No practical one seat ride to DIA from the north or south.	Generally good opportunities for a one seat ride from major population centers but not as strong as A-1 or A-6.	Provides the best opportunity for a one seat ride.
Travel Time							
Faster than RTD in metro area	*Based on curvature and length*	Yes – HSIPR will stop only once in Denver: at DUS or another central Denver location.	Same as A-1	Same as A-1	Same as A-1	Same as A-1	Same as A-1
Meets FRA Criteria for emerging HSR corridor: (90 to 110 mph)	*Yes, No or maybe*	Yes	Yes	Yes	Yes	Yes	Yes
Population Served		Serves the metro area well - 4 suburban stations, plus a central Denver station.	Does not provide service to the SW quadrant of the Denver metro area.	Does not provide service to the NW quadrant of the Denver metro area.	Does not provide service to the employment centers of the SE quadrant of the Denver metro area.	Does not provide service to the NW or SW quadrants of the Denver metro area.	Serves the metro area the best of the A-series alternatives.
Other Public Benefits							
Potential for environmental impact	*# of people affected*	Anticipate a high level of impact in both the E-W and N-S alignments. Noise, property (ROW), EJ, historic, and recreation/parks impacts can be anticipated. The general lack of ROW results in the need for a high percentage of aerial structure and the resulting visual and noise impacts associated with this approach.	This alternative would require the acquisition of all new ROW for the NW Quadrant. The levels of impact and associated public controversy are unknown. The E-470 alignment is anticipated to result in few environmental impacts. The N-S alignment would result in visual, noise, property (ROW), EJ, historic, and parks/recreation impacts but less than A-1 since the E-W alignment would be on a beltway rather than through the developed metro area.	Avoids the need to acquire new ROW for the NW Quadrant, with few community impacts along the C-470 and E-470 alignment to DUS. The C-470 alignment could result in impacts to the Chatfield State Park and will require careful planning. The N-S alignment would be the same as for A-1 and A-2, with anticipated visual, noise property acquisition, EJ and historic impacts.	Similar to A-2 this alternative would require the acquisition of new ROW for the NW Quadrant alignment. The C-470 alignment is anticipated to result in few environmental impacts. However, similar to A-3 construction near the Chatfield State Park could add challenges. The E-W alignment would have the same noise, property, EJ, historic, and parks/recreation impacts as cited for A-1.	The E-W alignment would have the same noise, property, EJ historic, and parks/recreation impacts as cited for A-1. Few community impacts are anticipated along the E-470 alignment. This alternative avoids the NW Quadrant controversy associated with A-2 and A-4. The alignment also avoids construction issues along C-470 around Chatfield State Park.	Highest environmental impact, combining the impacts of the Denver E-W and N-S alignments along with the beltway impacts in the NW Quadrant and the potential impacts to Chatfield State Park in the C-470 alignment. Also includes more absolute impacts associated with constructing the entire beltway alignment around the Denver metro area.
Safety	*# of at grade crossings*	Minimal at-grade crossings with roadway; and no at-grade crossings of rail.	Same as A-1	Same as A-1	Same as A-1	Same as A-1	Same as A-1

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Rollup: Group A-Series Scenarios – Through the Denver Metro Area (Note: Segments Outside of the Denver Metro Area are Evaluated in a Separate Matrix)

		A-1: Direct Routing through Denver	A-2: Beltway Excluding SW Quadrant	A-3: Beltway Excluding NW Quadrant	A-4: Western Beltway	A-5: Eastern Beltway	A-6: Complete Beltway
Engineering Feasibility							
Probable High Cost	*High cost of construction anticipated*	76 miles – although shorter, comparable or higher in cost to A-2 and A-3 due to a high level of urban construction. Numerous highway structures are affected to accommodate the new construction both N-S and E-W through Denver. High proportion of elevated structure in both the E-W and N-S sections. Would possibly use the proposed I-70 cut and cover tunnel for a portion of the alignment. This would require a 34 foot widening of the tunnel.	119 miles - comparable in cost to A-1 and A-3. Although the amount of new guideway construction is longer, the majority, 79 miles, is outside of the urban area. Two structures on the NW alignment; 6 on the NE (E-470) alignment; 14 on the SE (E-470) alignment. Numerous structures on the N-S alignment through Denver. High proportion of elevated structure in the N-S section along the freight railroad alignment. High proportion of at-grade track along the beltway alignments. No tunneling anticipated.	114 miles - comparable in cost to A-1 and A-2. Again, the majority, 74 miles, of construction is outside the urban area. Six structures on the NE (E-470) alignment; 14 structures on the SE (E-470) alignment and 14 on the SW (C-470) alignment. Numerous structures on the N-S alignment through Denver. High proportion of elevated structure in the N-S section along the freight railroad alignment. High proportion of at-grade track along the beltway alignments. No tunneling anticipated.	93 miles - Second lowest cost alternative - 57 miles of construction is outside of the urban area. Two structures on the NW alignment; and 14 structures on the SW (C-470) alignment. Numerous structures on the E-W alignment through Denver. High proportion of elevated structure on the E-W section along I-70 through Denver. High proportion of at-grade track on the NW Quadrant and C-470 beltway segments. Would possibly use the proposed I-70 cut and cover tunnel for a portion of the alignment. This would require a 34 foot widening of the tunnel.	84 miles - lowest cost alternative due to short length and the fact that 48 miles of the total construction is outside of the urban area. Six structures on the NE (E-470) alignment and 14 structures on the SE (E-470) alignment. Numerous structures on the E-W alignment through Denver. High proportion of elevated structure on the E-W section along I-70 through Denver. High proportion of at-grade track on the E-470 beltway segments. Would possibly use the proposed I-70 cut and cover tunnel for a portion of the alignment. This would require a 34 foot widening of the tunnel.	181 miles - highest cost alternative - most urban construction and highest absolute miles of new construction. Two structures on the NW alignment; 6 on the NE (E-470) alignment; 14 on the SE (E-470) alignment and 14 on the SW (C-470) alignment. Numerous structures on the N-S and E-W alignments through Denver. Same as A-1 for the E-W and N-S sections. Mostly at-grade track around the E-470, C-470 and NW Quadrant beltways
	Availability of ROW	Limited availability of ROW for either the E-W (along I-70) or N-S (Brush Line/CML) alignments through Denver. It is assumed that the N-S alignment would require all new ROW or an elevated structure (straddle bents) over the railroad alignments. The I-70 alignment has limited ROW in some locations.	All new ROW for the NW Quadrant; similar conditions for the N-S alignment as described in A-1. Assumed use of the E-470 ROW for the section to DIA.	ROW is anticipated to be available in the C-470 and E-470 alignments. All new ROW for the N-S alignment is anticipated as stated for A-1.	All new ROW for the NW Quadrant and much new ROW for the E-W (I-70) alignment through Denver. ROW is anticipated to be available in the C-470 alignment.	Probably the lowest ROW cost. ROW is anticipated to be available in the E-470 alignment. ROW on the E-W alignment (I-70) is limited as described under A-1.	Highest ROW acquisition requirement. New ROW for the N-S section through Denver; much new ROW on the I-70 alignment and all new ROW for the NW Quadrant alignment. ROW is anticipated to be available in the E-470 and C-470 alignments.
Freight Conflicts	*Degree or extent*	High in the N-S alignment as there is no capacity on the CML or Joint Line for HSIPR.	Same as A-1	Same as A-1	Can be configured to avoid freight rail	Can be configured to avoid freight rail	Same as A-1
Technology							
	Allows a full spectrum of technologies	Since it is assumed that no RR ROW would be used along the E-W alignment, both compliant and non-compliant technologies would be possible. FRA compliant technology may be required along the N-S alignment paralleling the freight alignment, as it is nearly impossible to completely avoid railroad ROW. This will be unknown until additional engineering is completed. All of the Denver scenarios (A-1 to A-6) could either be combined with a railroad or a Greenfield alignment (which are evaluated in separate matrices). The Greenfield alignments would mitigate this restriction, as they have been configured to avoid freight rail rights of way.	Same as A-1	Same as A-1	The alternative would be configured to allow a full spectrum of technology	The alternative would be configured to allow a full spectrum of technology	Same as A-1
Recommended for Modeling		**Yes - Recommended for modeling as it is short with possible decent travel speeds. (A design option including a stop at DUS would need to be run as a litmus test.)**	**Set aside for now - high environmental controversy is anticipated; longer alignment may reduce travel speed and increase costs.**	**Set aside for now - redundant N-S service will increase cost.**	**Set aside for now - high environmental controversy is anticipated, with no apparent advantage over A-5.**	**Yes - Recommended for modeling - it is likely the lowest cost option of the A-series alternatives.**	**Yes - Recommended for modeling - it provides a test case for the highest amount of ridership**

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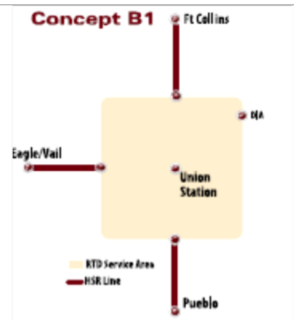
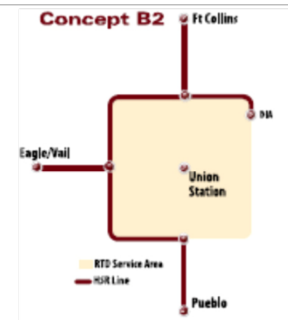
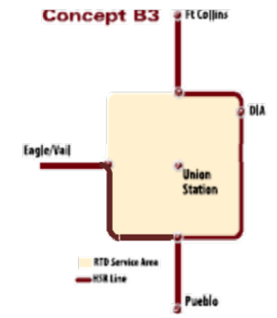
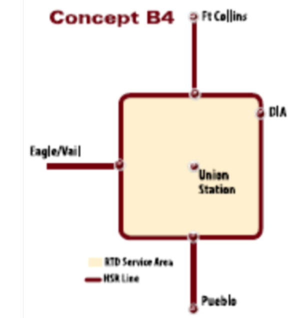
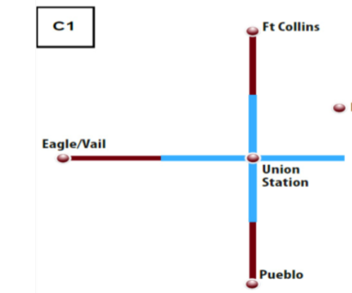
Rollup: Group B-Series Scenarios - HSIPR Around the Denver Metro Area (Note: Alignments Outside the Denver Metro Area are Evaluated in a Separate Matrix)

		B-1: Denver Periphery	B-2: Denver Periphery Excluding the SE Quadrant	B-2A: Denver Periphery Excluding the NW Quadrant	B-3: Denver Periphery Eastern Beltway	B-4: Denver Periphery Complete Beltway	C-1: Shared Track WAY
							
	Description	This alternative constructs no new rail infrastructure in the Denver metro area. Connections to HSIPR outside the Denver metro area are made to either a railroad or Greenfield alignment (Segments N-1, N-2, S-1, S-2).	This alternative connects to the RTD system through the construction of beltway HSIPR alignments along C-470 from I-70 to I-25 and on E-470 from DIA to I-25. A new beltway alignment is constructed from I-70 to I-25 to the northwest. Connections to HSIPR outside the Denver metro area are made to either a railroad or Greenfield alignment (Segments N-1, N-2, S-1, S-2).	This alternative connects to the RTD system through the construction of beltway HSIPR alignments along C-470 south and east from I-70 to I-25 and on E-470 from the south interchange with I-25 to the north interchange with I-25, with a spur to DIA. Connections to HSIPR outside the Denver metro area are made to either a railroad or Greenfield alignment (Segments N-1, N-2, S-1, S-2).	This alternative connects to the RTD system through the construction of beltway HSIPR alignments along E-470 from I-25 to DIA, then south on E-470 to I-25. Connections to HSIPR outside the Denver metro area are made to either a railroad or Greenfield alignment (Segments N-1, N-2, S-1, S-2).	This alternative connects to the RTD system through the construction of beltway HSIPR alignments around the entire Denver metro area using the E-470 and C-470 alignments. A new beltway alignment is constructed from I-70 to I-25 to the northwest. Connections to HSIPR outside the Denver metro area are made to either a railroad or Greenfield alignment (Segments N-1, N-2, S-1, S-2).	This alternative assumes that HSIPR will use an operating window on the existing East Rail and Gold Line Commuter Rail projects and the future North Metro Commuter Rail project. FRA compliant technology would be required. Connections to HSIPR outside the Denver metro area are made to either a railroad or Greenfield alignment (Segments N-1, N-2, S-1, S-2).
Criterion	**Measure**						
Meets P&N	*Number of critical success factors met*	Does not function as a HSIPR.	No access to Central Denver	No access to Central Denver	No access to Central Denver	No access to Central Denver	Limited to one technology
Transportation & Mobility							
One Seat Ride	*Yes or No: From Mountains, DIA, COS, FC*	Does not provide a one-seat ride to either DUS or DIA.	One seat ride to DIA from the west and north. Also, a one seat ride from the south, but the trip is long. No one seat ride to DUS.	One seat ride to DIA from the west and north and south. No one seat ride to DUS.	Provides a one seat ride to DIA from the north and south. No one seat ride to DUS and no one seat ride to DIA from the Mountain Corridor.	Provides a one seat ride to DIA from all directions. No one seat ride to DUS.	Technically could provide a one seat ride assuming an FRA compliant technology. Very difficult to accomplish a one seat ride north and south due to SW and SE (T-REX) Light Rail alignments cannot accept FRA compliant technology.
Travel Time							
Faster than RTD in metro area	*Based on curvature*	No. RTD provides the service within the Denver metro area.	Same as B-1	Same as B-1	Same as B-1	Same as B-1	HSIPR could provide faster service than RTD from periphery to DUS or other central Denver station due to fewer stops and potentially higher speeds.
Faster than auto outside metro area	*Based on curvature*	NA	NA	NA	NA	NA	NA
Meets FRA Criteria for emerging HSIPR corridor: (90 to 110 mph)	*Yes, No or maybe*	Not inside the Denver metro area. Outside the Denver metro area, the criteria will be met.	Same as B-1.	Same as B-1.	Same as B-1.	Same as B-1.	Same as B-1.
Population Served	*# of people served*	Essentially no new service inside the Denver metro area.	Essentially no new service inside the Denver metro area. But new service provided on 75 percent of the periphery of the Denver metro area. However, the high employment areas SE of Denver are not served.	Essentially no new service inside the Denver metro area. But new service provided on 75 percent of the periphery of the Denver metro area. However, the NW Quadrant area is not served.	Essentially no new service inside the Denver metro area. No beltway service on the western portions of the Denver metro area.	Essentially no new service inside the Denver metro area but serves the greatest number of people out of the B/C series alternatives.	Provides persons within the Denver metro area access to the system at DUS.

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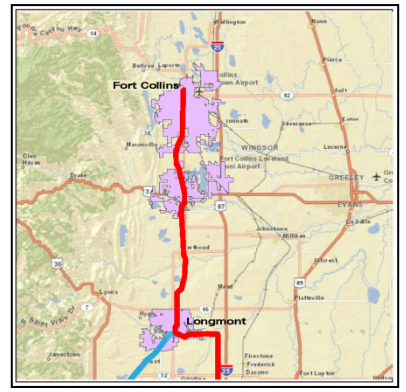
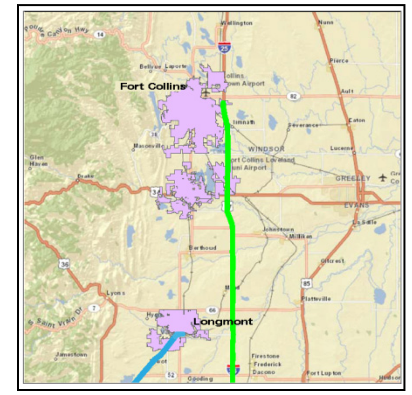
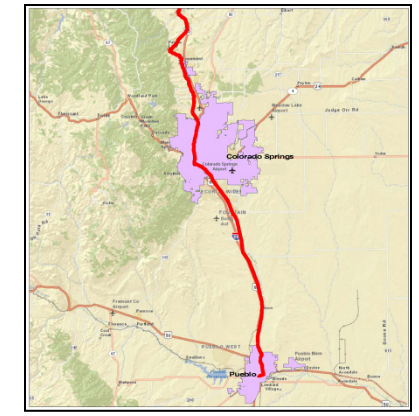
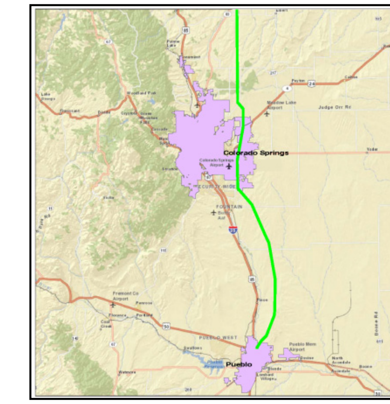
Other Public Benefits							
Potential for environmental impact	*# of people affected*	No new environmental impact inside the Denver metro area.	The NW Quadrant section of the beltway alignment will require all new ROW and the impacts of a Greenfield alignment. The impacts associated with developing HSIPR within the C-470 and E-470 corridors alignments are anticipated to be minor. There could be historic properties affected in Golden and Arvada in the NW Quadrant.	The impacts associated with the C-470 and E-470 alignments are anticipated to be minor. Careful planning will be required around Chatfield State Park along C470.	Similar to B3. Avoids the environmental impacts and controversy associated with new ROW acquisition in the NW Quadrant. The E-470 impacts are considered to be minor. Careful planning will be required around Chatfield State Park along C470.	The NW Quadrant section of the beltway alignment will be highly controversial. The impacts associated with the C-470 and E-470 alignments are anticipated to be minor. Because this alternative involves the most construction, its absolute impact would be greater than the other B-series alternatives. There could be historic properties affected in Golden and Arvada in the NW Quadrant. Careful planning will be required around Chatfield State Park along C470.	Because this alternative shares track with RTD, construction impacts will be minimal except where the Gold Line project needs to be extended to Golden, then south to I-70. Operation impacts of running high speed rail on the existing alignments are anticipated to be similar to the Rotem EMU technology proposed for the Gold Line and East Corridor Commuter Rail systems. However, the number of trains per day would increase.
Safety	*# of at grade crossings*	None anticipated.	None anticipated.	None anticipated.	None anticipated.	None anticipated.	Same number of at-grade crossings as on the existing East Rail and Gold Line projects.
Auto-Rail at grade crossings							
Engineering Feasibility							
Probable High Cost	*High cost of construction anticipated*	This would be the lowest cost as no construction occurs in Denver.	77 miles of new guideway construction resulting in the second highest cost of the B and C series alternatives. Additional track would be constructed outside of the Denver metro area.	59 miles of new guideway construction, thus among the less costly of the B and C series alternatives. Additional track would be constructed outside of the Denver metro area.	48 miles of new guideway construction, thus among the less costly of the B and C series alternatives. Additional track would be constructed outside of the Denver metro area.	105 miles of new guideway construction, thus the highest cost of the B and C series alternatives. Additional track would be constructed outside of the Denver metro area.	12 miles of new guideway construction, thus the second lowest cost of the B and C series alternatives. Additional track would be constructed outside of the Denver metro area.
	Availability of ROW	Essentially no ROW requirements in the Denver metro area.	Not available in the NW Quadrant. Available in the E-470 and C-470 alignments	Available in the E-470 and C-470 alignments.	Available in the E-470 alignment.	Not available in the NW Quadrant. Available in the E-470 and C-470 alignments	ROW requirements for the 12 mile connection to from Gold Line to I-70. About 6 miles of the total is owned by RTD and may be available.
Constructability							
Freight Conflicts	*Degree or extent*	None inside the Denver metro area. Alignments outside the Denver metro area are evaluated in a separate matrix. Both N-1 and S-1 are anticipated to result in freight conflicts, as there is no excess capacity on either the UPRR or BNSF systems.	Same as B-1.	Same as B-1.	Same as B-1.	Same as B-1.	Adds a new track in the RR ROW from Ward Road to Golden, about 6 miles.
Technology							
Limits Choice	*Allows a full spectrum of technologies*	No technologies are eliminated outside of the Denver metro area, but will require connection to and use of existing RTD technologies inside the RTD service area.	Same as B-1.	Same as B-1.	Same as B-1.	Same as B-1.	Limits technologies to FRA compliant on the Gold Line, East Rail and North Metro alignments. Non-FRA compliant technologies may be acceptable on RTD's light rail alignments.
Compatibility	*Need for FRA compliance*	NA	NA	NA	NA	NA	Requires FRA compliant technologies.
Recommended for Modeling		**Set aside - while this is the lowest cost alternative, it is set aside in favor of C-1 which is very similar but has partnership with RTD and operational benefits that are stronger than provided by B-1.**	**Set aside - high environmental controversy and impacts anticipated in NW quadrant. Poor connection to DIA from the south.**	**Yes - Recommended for modeling - this alternative provides good access to DIA from both the north and the south population centers and it avoids the controversial NW Quadrant. It is very similar to A-3 above.**	**Set aside - Poor connection to/from Denver metro area and DIA from the mountains.**	**Set aside - this is the highest mobility option of the B-series alternatives; however, A-6 provides the best test for a maximum mobility scenario.**	**Yes - Recommended for modeling - is one of the lowest cost alternatives and maximizes the use of RTD infrastructure with a one seat ride.**

ICS – Detailed Level 1 Evaluation Matrix – August 2012
Segments Outside Denver Metro Area –North to Fort Collins and South to Pueblo

		North (N)-1: Railroad Alignment (North I-70 EIS)	N-2: Greenfield (FRA Unconstrained)	South (S)-1: Railroad Alignment	S-2: Greenfield (FRA Unconstrained)
					
	Description	From the North Metro end of line station at 162nd Avenue in Thornton, this alignment travels over I-25 northwest following the UPRR ROW, then travels north on the west side of County Road 7(CR 7) to the south side of SH 119, then west to the BNSF alignment through Longmont, Loveland and Fort Collins. It is possible that HSIPR would be able to share track with freight rail in some locations. The alignment would terminate at the MAX Transit Center south of Harmony Road. *(Note that line in graphic above will be shortened to end at Harmony Road.)*	This alignment, recommended by the RMRA study, terminates at the North Metro end- of-line station and proceeds north along I-25 north to Fort Collins, stopping at Harmony Road. *(Note that line in graphic above will be shortened to end at Harmony Road.)*	This alignment follows the BNSF/UP alignment from Santa Fe/C-470 in Littleton to Castle Rock and south to Colorado Springs and Pueblo. This alignment was studied in the RMRA study.	From E-470 this alignment follows I-25 to Castle Rock and then departs the highway alignment near Santa Fe Drive in Castle Rock and travels to the SE and then heads south where it remains approximately 11 miles to the east of I-25; at Manitou Springs the alignment is about 9 miles east of I-25 where it continues through the Black Forest south to the COS Airport. From this point the alignment travels south, generally within 3–4 miles to the east of I-25 until it terminates in Pueblo.
Criterion	**Measure**				
Meets P&N	*Number of critical success factors met*	Weak as it does not meet the speed criteria for HSR	Yes meets the PN.	Weak as it does not meet the speed criteria for HSR	Does not meet the PN critical success factors for public support. Meets the PN for travel speed.
Transportation & Mobility					
One Seat Ride	*Yes or No: From Mountains, DIA, COS, FC*	One seat ride for this segment will depend on the configuration through Denver.	Same as N-1	Same as N-1	Same as N-1
Travel Time					
Faster than RTD in metro area	*Based on curvature*	NA	NA	NA	NA
Faster than auto outside metro area	*Based on curvature*	Unknown at this time, but doubtful due to condition of track and curvature.	Yes	Maximum speed may be 80 mph.	Yes
Meets FRA Criteria for emerging HSR corridor: (90 to 110 mph)	*Yes, No or maybe*	Unknown at this time, but probably not.	Will meet criteria.	Unknown at this time, but probably not.	Will meet criteria.
Population Served	*# of people served*	Closer to population centers than N-2.	About 5 miles farther from the population centers.	Closer to population centers than S-2.	Generally outside of population centers
Other Public Benefits					
Potential for environmental impact	*# of people affected*	Considerably more people along this alignment than N-2. (Would be very difficult to extend tracks north of Harmony Road.) Adjacent to Fairgrounds park in Loveland. Another parcel of what looks like open space just north of Walker Reservoir. Parallels trail system near Prairie Village in Longmont. Next to Collyer Park in Longmont. Also Sandstone Community Park in Longmont along SH 119.	Fewer people than along N-1, especially through Longmont, Loveland, Berthoud and Fort Collins. Since this option follows the interstate, it is expected to have comparatively less public controversy. St. Vrain Park is possibly affected by either N-1 or N-2.	Considerably more people along the railroad alignment than the Greenfield alignment, especially through Castle Rock, COS and Pueblo. Potential impacts to Chatfield State Park; Linbach Park in Monument; Dirty Woman Park in Monument; Gossage Youth Sports Center just north of COS; Monument Valley Park in COS; America the Beautiful Park in COS; Fountain Creek Regioutstanding Natural Areal Park; John Metcalf Park in COS; Gateway Park in Pueblo; crosses Fountain Creek entering into Pueblo	Adjacent to Jimmy Camp Creek Park east of COS; crosses Fountain Creek entering into Pueblo.
Safety	*# of at grade crossings*	Will be numerous. Really not suitable for HSR.	All grade separated.	Will be numerous. Really not suitable for HSR.	All grade separated.

ICS – Detailed Level 1 Evaluation Matrix – August 2012
Segments Outside Denver Metro Area –North to Fort Collins and South to Pueblo

		North (N)-1: Railroad Alignment (North I-70 EIS)	N-2: Greenfield (FRA Unconstrained)	South (S)-1: Railroad Alignment	S-2: Greenfield (FRA Unconstrained)
Engineering Feasibility					
Probable High Cost	*High cost of construction anticipated*	41 miles. Relatively inexpensive on a per mile basis.	50.5 miles; however, 5 miles could be cut off south of Harmony Road to mitigate impacts, thus the effective length is about 45 miles. Similarly, this option would include a large percentage of at-grade track and would be relatively inexpensive on a per mile basis.	105 miles. This construction is more complicated than N-1 as there are more miles of urban construction. The alignment also parallels Fountain Creek, perhaps complicating construction.	94 miles. This is anticipated to be more costly than the Greenfield alignment going north, N-2, due to rougher topography resulting in more elevated track and more retained fill. However, little of the alignment involves urban construction.
	Number of highway or rail structures affected	After the flyover of I-25, there are essentially no hwy structures. However, multiple at-grade crossings, some that may require separation along the BNSF alignment.	15 major hwy structures at interchanges as well as other secondary road grade separations.	Will require a flyover of I-25. Numerous local at grade crossings that will need to be separated and bridges over Fountain Creek will be required.	4 major hwy interchanges between E-470 and Castle Rock. Other periodic grade separations for county roads.
	Probable quantity of elevated structure	No more than 10 percent.	No more than 10 percent.	Probably 10 to 15 percent - more stream crossings, ditches etc.	Higher percentage than S-1; perhaps 25 percent due to the rough topography.
	Use of existing infrastructure	There is the potential to share freight track if desired.	None	None. The State Rail Plan indicates that the freight alignment is over capacity in 2035.	None
	% of alignment in tunnel	None	None	Some tunnel may be required through COS, depending on desired travel speed.	Probably none. However, there is the potential for trenches and retained fill.
	Availability of ROW	ROW is limited through Longmont where it appears to be only 45 feet wide. In much of the area it appears to be 100 feet wide. (North of Harmony Road the ROW is more constrained.) Since this corridor is not projected for heavy freight usage in 2035, the purchase of BNSF ROW is possible.	Generally available from CDOT.	SRP shows this alignment over capacity in 2035 resulting in a probable need to acquire additional ROW. That is, it is assumed that RR ROW would not be available based on projections from the State Rail Plan.	ROW in I-25 corridor to Castle Rock; little ROW though Castle Rock and all new ROW to Pueblo.
Freight Conflicts	*Degree or extent*	There is a potential for freight conflicts.	None	There is a high potential for freight conflicts.	None
Capacity on existing freight corridor		State Rail Plan does not show this alignment to be over capacity in 2035, so there may be a potential to share track. (in reality this section of track does not appear to be rated by the SRP)	None	New track would be required for HSR as this alignment is projected by the State Rail Plan to be over capacity in 2035.	None
Technology					
Limits choice	*Technologies eliminated*	Would have to be FRA compliant	None	Would have to be FRA compliant	None
Compatibility	*Need for FTA compliance*	Limited to FRA compliant.	None	Limited to FRA compliant.	None
Recommended for Modeling		Conditional Yes – The BNSF alignment will not qualify as HSIPR unless the entire alignment is grade separated. As currently configured the alignment would only be appropriate for low speed operation, e.g. 20 mph. Operating HSIPR on this alignment would have high community impacts.	**Yes**	**Yes**	Conditional Yes – A Greenfield alignment is needed as a test against the railroad alignment. However, the alignment will need to be modified from what was presented to the public in July 2012.

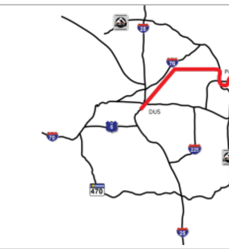
ICS – Detailed Level 1 Evaluation Matrix – August, 2012
Segments within the Denver Metro Area
C-70/I-70 to DUS Segments

		West (W)-1: US 6/Gold Line/DUS	W-2: I-70/I-76/DUS	W-3: I-70/New Stockyard Station	W-4: US 6/DUS
					
	Description	From I-70/C-470 this alignment follows US 6 to Golden, then turns east on the Gold Line near the Coors Brewery, follows the BNSF alignment to Ward Road where is meets up with the Gold Line alignment which it parallels to DUS.	From I-70/C-470 this alignment follows I-70 east to I-76 to Pecos Street, then turns south at Utah Junction and parallels the Gold Line alignment to DUS.	From I-70/C-470 this alignment follows I-70 east typically on aerial structure to I-25, where it flies over the highway to the south side of 48th Avenue. From here it travels east and flies over the CML and North Metro CRT, then parallels the Rock Island Line to a new Denver station adjacent to the North Metro Stockyard Station.	From I-70/C-470 this alignment follows US 6 generally on aerial structure to and over I-25 to the CML alignment. From this point HSR is on structure over the freight rail alignment to the LRT terminal station (800 feet west of DUS) at DUS. The users of HSR would connect to DUS via the new bus system being provided for LRT travelers.
Criterion	**Measure**				
Meets P&N	*Number of critical success factors met*	High impacts and slow travel time result in weak fulfillment of the PN. Will probably fail the community support element of the PN.	Slower travel times than the I-70 or the US 6 alignments. Slightly fewer impacts to neighborhoods than the other three options. Will probably fail the community support element of the PN.	This segment allows a one seat ride to DIA. However, it will probably fail the community support element of the PN. It is probably the second highest cost alignment.	This segment allows for a one seat ride to DIA. However, it will probably fail the community support element of the PN. Possibly the highest per mile cost alignment.
Transportation & Mobility					
One Seat Ride	*Yes or No: From Mountains, DIA, COS, FC*	Functionally impractical – would require a reverse move up the Brush line to 96th and DIA.	Functionally impractical – would require a reverse move up the Brush line to 96th and DIA.	Allows a one seat ride due to the new Stockyard Station.	Allows a one seat ride to DIA through DUS. Assumes a new station near the LRT terminal station at DUS.
Travel Time					
Faster than RTD in metro area	*Based on curvature*	Predicted as the slowest segment overall. Since there will be no stops, the portion from Ward Road to DUS will be faster than RTD.	Second slowest segment.	Fastest travel time because it bypasses DUS, thus eliminating the reverse move at DUS.	Predicted to be comparable to W-3.
Faster than auto outside metro area	*Based on curvature*	NA	NA	NA	N/A
Meets FRA Criteria for emerging HSR corridor: (90 to 110 mph)	*Yes, No or maybe*	Not within the segment, but outside Denver these criteria would be met.	Same as W-1	Same as W-1	Same as W-1
Population Served	*# of people served*	All of the segments except W-3 service the same stations, resulting in comparable populations served.	Same as W-1.	The new Stockyard Station will open up the north metro area to HSR transit services. The comparative impact of this on ridership is unknown until modeling studies are completed in Level 2 screening.	Same as W-1.
Other Public Benefits					
Potential for environmental impact	*# of people affected.*	Dense populations through Arvada. Would require a row of parcels from Ward Road to I-76. Would be very destructive to Olde Town Arvada.	Avoids the dense populations east of Wadsworth. There are construction challenges from Denver West to Wadsworth Blvd. Avoids the visual impacts of the straddle bents down the middle of I-70 from Lowell Blvd. to Pecos Street, as required for the I-70 alignment.	Dense populations from Wadsworth to Pecos. The anticipated straddle bent support of the HSR through this area would result in high visual and noise impacts. Trades off some visual and community impacts for natural environmental impacts.	Densely populated from Kipling east, and especially close neighborhood proximity from Sheridan to I-25. From C-470 to Simms transit would be on both sides of the highway (RTD LRT on one side, CDOT HSR on the other) resulting in especially tight construction and a reduction in CDOT's flexibility to widen US 6 in the future.
	Potential Section 106 - Historic Districts	Yes - all though Arvada	Largely avoids Section 106 impacts.	Probable Section 106 impacts east of Wadsworth to Pecos. Noise and visual will be the greatest concern. Possible Section 106 impacts around the Stockyards station should this design option be selected.	Probable Section 106 impacts east of Kipling to Pecos. Property acquisition, noise and visual impacts will be the greatest concern.
	Potential 4(f)	McIlvory Park. Cuernavaca Park.	Avoids most of the I-70 parks impacts, with the tradeoff being impacts to the Clear Creek corridor, much of which includes wetlands.	Golden Heights Park; Applewood Park; Willis Case Golf Course and Berkeley Lake.	Golden Heights Park; Lakewood Country Club; Barnum Park
	Impacts to low income/minority communities	Some impacts to EJ communities dispersed along the Gold Line corridor.	EJ community in the vicinity of Tennyson Street (just west) and near Federal Blvd.	EJ impacts are probable from Wadsworth to Pecos street and around the new Stockyards station.	EJ impacts are probable from Kipling to Pecos street.
Other impacts	*Other impacts*	Noise and visual impacts through Wheat Ridge and Arvada. Cemetery just west of Ward Road. Water resources impacts to Jim Baker and Lake Sangraco.	In general the I-76 segment is not highly populated - possibly the fewest noise and visual impacts. However, construction could be expected to affect the Clear Creek riparian area.	Particularly high visual impacts from straddle bents east of Wadsworth to Pecos Street. Noise impacts from Wadsworth east to Pecos Street. Visual changes associated with the new Stockyard Station.	Comparable to the other segments, anticipate high visual and noise impacts along the entire populated portions of the corridor. Will have high visual impacts from straddle bents between Sheridan & Federal and continuing on a viaduct through Barnum Park and along the CML. Viaduct will impact the Millennium Bridge near DUS.

ICS – Detailed Level 1 Evaluation Matrix – August, 2012
Segments within the Denver Metro Area
C-70/I-70 to DUS Segments

		West (W)-1: US 6/Gold Line/DUS	W-2: I-70/I-76/DUS	W-3: I-70/New Stockyard Station	W-4: US 6/DUS
Safety	*# of at grade crossings*				
Engineering Feasibility					
Probable High Cost	*High cost of construction anticipated alignment*	Longest segment at 21.5 miles is likely to translate into high cost.	Second longest segment at 18.5 miles	Third longest segment at 16.5 miles.	This is the shortest segment at 13.3, but given the difficult construction conditions will be among the higher cost segments.
	Number of highway or rail structures affected and/or elevated structure	Will require the relocation of Ridge Road and much of downtown Arvada.	Would complicate future widening of both I-70 and I-76.	Would complicate the future widening of I-70 especially east of Wadsworth, should this be desired by CDOT.	Would effectively prohibit future widening of US 6.
	Probable quantity of elevated structure	About 20 percent grade separated. Less elevated structure than either the I-70 or US 6 options.	Eliminates the need for straddle bents on I-70 east of Wadsworth Blvd. Less elevated structure than the I-70 or US 6 options.	Second highest predicted quantity of elevated structure.	Anticipated to have the highest percentage of elevated structure. May be the most expensive alignment on a cost per mile basis.
	Availability of ROW	New ROW would likely need to be acquired for the entire alignment. From Golden to Ward Road in Arvada, some ROW could be purchased from RTD. From Utah Junction to DUS, new ROW would need to be purchased from the freight railroad companies.	Some areas of CDOT ROW along I-70 may be sufficient for aerial structure to Wadsworth Blvd. ROW is available along I-76. There is no railroad ROW available from Utah Junction to DUS.	Some areas of CDOT ROW along I-70 may be sufficient for aerial structure to Wadsworth Blvd. Limited ROW on I-70 from Wadsworth Blvd. to I-25. All new ROW would be required from I-25 to the new Stockyards station. All new ROW would be required for the new Stockyards Station.	ROW is generally very limited along US-6. Anticipate the need to acquire the first row of parcels along much of the corridor from Sheridan to I-25; all new ROW would be required along the CML unless the HSR were carried overhead on straddle bents.
Freight Conflicts	*Degree or extent*	Freight conflicts are expected to be severe from Utah Junction to DUS, a distance of 3.5 miles.	Same as the Gold line alignment.	Minimal impacts on the freight railroads.	Assumes little impact since the alignment would acquire new ROW or be carried over the CML.
	Capacity on existing freight corridor	There is no capacity on the UP/BNSF trackage. High impact on freight operations from Utah Junction to DUS	There is no capacity on the UP/BNSF trackage. High impact on freight operations from Utah Junction to DUS	No impact on freight operations.	There is no capacity on the CML. If the HSR is on a parallel but independent ROW, there will be no impact.
Technology					
Limits choice	*Technologies eliminated*	Requires FRA compliant technology on both the Gold Line alignment and from Utah Junction to DUS.	Would require FRA compliant vehicles from Utah Junction to DUS.	Would allow all technologies.	May require FRA compliant technology.
Recommended for Modeling		Conditional Yes	**Suggest to Set Aside**	**Yes**	**Yes**
		This alternative is retained for operation with Scenario C-1 only and should be set aside as a stand-alone option. It should be set aside for all other scenarios.	**This alignment is longer that the i-70 and US 6 alignment with nearly impossible access through Utah Junction to DUS. It conversely has the least impacts to communities.**		

ICS - Detailed Level 1 Evaluation Matrix – August 2012
Segments within the Denver Metro Area – Central Denver to DIA Segments

		East (E)-1: DUS on CML to I-70 to East Corridor at Colorado Blvd to DIA	E-2: DUS on CML to I-70 to Pena Blvd to DIA	E-3: New Stockyard Station to I-70 to Pena to DIA	E-4: DUS on CML to Brush Line to 96th Ave to DIA
					
	Description	From DUS this alignment follows the CML to I-70 near Brighton Blvd, then merges with the I-70 east to Colorado Blvd; it then travels south to RTD's East Corridor alignment, and east to Pena Blvd. to DIA.	From DUS this alignment follows the CML north to I-70 near Brighton Blvd. and remains on the I-70 alignment to Pena Blvd. to DIA.	This alternative bypasses DUS. From a new Stockyard Station this alignment is essentially the same as E-2, as it remains on the I-70 alignment to Pena Blvd. to DIA.	From DUS this alignment follows the CML/Brush lines northeast to 96th Avenue; it then travels east along 96th over E-470 and then south to DIA.
Criterion	**Measure**	-	-	-	
Meets P&N	*Number of critical success factors met*	Will probably fail the community support element of the PN because of ROW impacts on both I-70 and along the East Corridor alignment.	Will probably fail the community support element of the PN because of ROW impacts on I-70.	Similar issues to E-2.	Can be configured to meet the PN. However, this will require new property acquisition along the entire segment which may be controversial.
Transportation & Mobility					
One Seat Ride	*Yes or No: From Mountains, DIA, COS, FC*	Allows a one seat ride to DIA assuming a new station near the LRT station along the CML at DUS.	Allows a one seat ride to DIA assuming a new station near the LRT station along the CML at DUS.	Allows a one seat ride assuming a new station at the Stockyards.	Allows a one seat ride to DIA assuming a new station near the LRT station along the CML at DUS.
Travel Time					
Faster than RTD in metro area	*Based on curvature*	Yes because there would be no stops.	Same as E-1	Same as E-1	Same as E-1
Faster than auto outside metro area	*Based on curvature*	NA	NA	NA	NA
Meets FRA Criteria for emerging HSR corridor: (90 to 110 mph)	*Yes, No or maybe*	Not within the segment, but outside Denver these criteria would be met.	Same as E-1	Same as E-1	Same as E-1
Population Served	*# of people served*	Serves DUS, which is accessible to a major population center. Serves DIA.	Same as E-1	The number of people served has yet to be determined. The north metro area is among the fastest growing, so the capture area for ridership could be strong.	Same as E-1
Other Public Benefits					
Potential for environmental impact	*# of people affected.*	At I-70 environmental issues are anticipated. The use of the proposed I-70 trench will cause community concerns. Placement of the HSR over the trench will also be resisted in all probability. To the east of Colorado Blvd., population density is low along corridor; however impacts to industrial properties from ROW acquisition would occur. CCD, Aurora and RTD are currently sponsoring a new grade separation at Peoria Street. The structure will be about 800 feet long and 33 high. The new HSR will need to fly over or be aligned around this new bridge. Impact of construction will likely affect low income and minority populations. Probable supplemental EIS required along I-70.	Same I-70 trench issues as discussed for E-1. East of Colorado Blvd, population density is low along corridor; however impacts to industrial properties from ROW acquisition would occur. Avoids potential conflicts with the new grade separation project at Peoria Street. Probable supplemental EIS required along I-70.	Similar issues to E-2.	Population density is low along the segment. Would require new ROW for length of the segment involving industrial properties. The alignment will need to be configured to avoid impacts to Rocky Mountain Arsenal.
	Potential Section 106 - Historic Districts - GIS	Possible Section 106 Impacts along RR corridor	Possible Section 106 Impacts along I-70 corridor	Similar to E-2.	Section 106 Impacts along RR corridor
	Potential 4(f)	Globeville Landing Park - noise, Park Hill Golf Course; Star K Ranch Park	Globeville Landing Park - noise, Park Hill Golf Course; Star K Ranch Park	Similar to E-2.	Globeville Landing Park; Fairfax Park; Joe Reilly Park; Derby Park; ROW acquisition w/in Rocky Mountain Arsenal; Buckley Ranch Open Space
	Impacts to low income/minority communities	This alignment would require widening of the I-70 Highway trench which could impact EJ populations. A supplemental EIS will likely be required.	Similar issues to E-1 with respect to I-70.	Similar issues to E-1 with respect to I-70.	EJ Neighborhoods could be impacted along the Brush alignment
Safety	*# of at grade crossings*	Segment would be mostly elevated.	None anticipated.	Same as E-2.	None anticipated.

ICS - Detailed Level 1 Evaluation Matrix – August 2012
Segments within the Denver Metro Area – Central Denver to DIA Segments

		East (E)-1: DUS on CML to I-70 to East Corridor at Colorado Blvd to DIA	E-2: DUS on CML to I-70 to Pena Blvd to DIA	E-3: New Stockyard Station to I-70 to Pena to DIA	E-4: DUS on CML to Brush Line to 96th Ave to DIA
Engineering Feasibility					
Probable High Cost	*High cost of construction is anticipated*	Will be a mostly elevated section. Tunnel widening at I-70. Requires coordination with the I-70 project from I-25 to Colorado Blvd (the trench section)	Will be a mostly elevated section. Tunnel widening at I-70. High amount of aerial structure along I-70 to Pena Blvd.	Same as E-2 regarding I-70 Construction of a new Stockyard Station will be costly.	Will need aerial structure all along the CML to 96th Avenue. Also a large flyover at E-470.
	Availability of ROW	All new ROW would be required along the CML and along the East Corridor CRT until Pena Blvd.	All new ROW would be required along the CML. Possibly some ROW requirements along I-70.	Same as E-2.	All new ROW would be required the full length of the segment.
Freight Conflicts	*Degree or extent*	Would require tracks through the BNSF yard near Globeville Rd. Future yard capacity will be further constrained because of the project.	Would require tracks through the BNSF yard near Globeville Rd. Future yard capacity will be further constrained because of the project.	No conflicts with freight rail operations.	Would require tracks through the BNSF yard near Globeville Rd. Future yard capacity will be further constrained because of the project.
	Capacity on existing freight corridor	There is no capacity on the CML for HSR.	There is no capacity on the CML for HSR.	NA	There is no capacity on the CML for HSR.
Technology					
Limits choice	*Allows a full spectrum of technologies*	May require FRA compliant technologies to operate adjacent to the CML.	Same as E-1.	Does not operate in the freight corridor, thus no restrictions to technologies.	May require FRA compliant technologies to operate adjacent to the CML.
Recommended for Modeling		**Set aside – E-2 (I-70) would provide similar ridership without as much private property acquisition for ROW.**	**Yes**	**Yes**	**Set aside – There is no capacity on the CML/Brush lines, so assume that E-2 and E-3 would be preferred.**

Level 1 Evaluation Matrix ICS Project CDOT – August 2012
Segments within the Denver Metro Area – Beltway Segments

		Beltway (B)-1: NW Quadrant	B-2: SW Quadrant	B-3: SE Quadrant	B-4: NE Quadrant
					
	Description	From C-470/I-70 this alignment follows US-6 to CO-93, Greenfield (anticipated NW Quadrant Highway alignment), and the Northwest Parkway, then to I-25 north.	From C-470/I-70, this alignment follows C-470 travelling southwest to I-25 south.	From I-25 south this alignment follows E-470 north to DIA.	From I-25 north this alignment follows E-470 south to DIA.
Criterion	**Measure**				
Meets P&N	*Number of critical success factors met*	Yes in general – however the anticipated impacts associated with the NW Quadrant may fail the public acceptance critical success factor.	Yes in general.	Yes in general.	Yes in general.
Transportation & Mobility					
One Seat Ride	*Yes or No: From Mountains, DIA, COS, FC*	Yes but needs to be combined w/ other segments.	Same as B-1.	Same as B-1.	Same as B-1.
Travel Time					
Faster than RTD in metro area	*Based on curvature*	NA	NA	NA	NA
Faster than auto outside metro area	*Based on curvature*	Would be comparable to the speed on the highway beltway study completed by CDOT (2008). Could be higher with modifications.	Would be comparable to the speed on the highway. Could be faster than the highway with some alignment modifications which would require moving off of the hwy alignment in some locations.	Same as B-2.	Same as B-2.
Meets FRA Criteria for emerging HSR corridor: (90 to 110 mph)	*Yes, No or maybe*	Portions of the alignment could theoretically obtain 90+ mph.	Same as B-1.	Same as B-1	Same as B-1
Population Served	*# of people served*	Would provide a link between the Golden area and the north metro area.	Would provide a link between the Golden area and the south metro area.	Would provide a link between the south metro area and DIA.	Would provide a link between DIA and the north metro area.
Other Public Benefits					
Potential for environmental impact	*# of people affected*	Low density population and urban development. High controversy with public. Follows alignment of highway corridor previously stopped by public controversy.	Much lower density along the beltway alignments than any of the alignment going though Denver. ROW should be available within the hwy footprint.	Same as B-2.	Same as B-2.
	Potential Section 106 - Historic Districts - GIS	Anticipated to be negligible.	Same as the NWQ.	Same as the NWQ.	Same as the NWQ.
	Potential 4(f)	Tin Cup Hogback Park; Fossil Trace Golf Course; Prospect Park; Windy Saddle Park; New Loveland Mine Park; White Ash Mine Park; North Table Mountain Park; Rocky Flats National Wildlife Refuge; Colorado Hills Open Space; Glacier Park; Carolyn Holmberg Preserve at Rock Creek Farm and Ruth Roberts Park	Parkland acquisition is not anticipated since the HSR would be located in hwy ROW. However, careful planning will be required to avoid impacts to Chatfield State park which is adjacent to the C-470 ROW.	Parkland acquisition is not anticipated since the HSR would be located in hwy ROW.	Same as B-3.
	Impacts to low income/minority communities - GIS	None are apparent.	Wolhurst community may qualify for EJ; it is located near the Santa Fe/C-470 interchange.	None are apparent.	Same as B-3.
Safety	*# of at grade crossings*	None.	None.	None.	None.
Engineering Feasibility					
Probable High Cost	*High cost of construction anticipated*	31 miles. Among the lowest per mile cost segments anticipated. However, all new ROW would need to be acquired adding $5 to $10 million per mile.	26 miles. Among the lowest per mile cost segments anticipated. However, 14 hwy structures will need to be grade separated.	28 miles. Among the lowest per mile cost segments anticipated. However, 14 hwy structures will need to be grade separated.	20 miles. Among the lowest per mile cost segments anticipated. Six hwy structures will need to be grade separated.
	Number of highway or rail structures effected and/or elevated structure	2 hwy structures	14 hwy structures	14 hwy structures	6 hwy structures
	Probable quantity of elevated structure	Anticipated to be low.	Anticipated to be low.	Anticipated to be low.	Anticipated to be low.
	Availability of ROW	All new ROW would be required.	Probably high use of public ROW.	Same as B-2.	Same as B-2.
Freight Conflicts	*Degree or extent*	None	None	None	None
	Capacity on existing freight corridor	N/A	N/A	N/A	N/A
Technology					
	Allows a full spectrum of technologies	All technologies would be allowed.	Same as B-1.	Same as B-1.	Same as B-1.
Recommended for Modeling		**Set aside - This corridor has previously been met with public opposition for transportation projects.**	**Yes**	**Yes**	**Yes**

Level 1 Evaluation Matrix ICS Project CDOT – July 25, 2012
Segments within the Denver Metro Area – North-South Segments Through Denver

		NS-1: CML	NS-2: CML/Joint Line
			
	Description	From 96th Avenue this segment travels south on the CML to DUS. It is assumed that the HSR would not share track with the freight rail system due to capacity constraints.	From DUS this segment travels south on the CML and Joint Line to C-470 in Littleton. It is assumed that the HSR would not share track with the freight rail system due to capacity constraints.
Criterion	**Measure**		
Meets P&N	*Number of critical success factors met*	In general, but would not meet the criteria for minimal community impacts.	Same as NS-1.
One Seat Ride	*Yes or No: From Mountains, DIA, COS, FC*	Yes but needs to be combined w/ other segments.	Same as NS1.
Travel Time			
Faster than RTD in metro area	*Based on curvature*	Yes as it would not stop.	Same as NS-1.
Faster than auto outside metro area	*Based on curvature*	NA	NA
Meets FRA Criteria for emerging HSR corridor: (90 to 110 mph)	*Yes, No or maybe*	Probably not, due to curvature.	Same as NS-1.
Population Served	*# of people served*	Serves the northern portions of the Denver metro area to central Denver.	Serves from central Denver to the southern portion of the Denver metro area.
Potential for environmental impact	*# of people affected*	It is assumed that a new ROW would be obtained for this segment. From 96th Avenue south to Quebec Parkway the segment is bounded by the Rocky Mountain Arsenal and un-populated. South of Quebec Parkway to Vasquez Blvd (2.6 miles) the segment is bounded by what are likely to be low income housing. South of Vasquez the land use is industrial to near 23RD Street. The acquisition of industrial property would be the dominant impact. From that point to DUS the construction of HSR would have impacts to loft neighborhoods and commercial activities. There is a high probability of property impacts.	It is assumed that a new ROW would be obtained for this segment. Since the corridor is characterized by industrial land use from DUS to Littleton, the impacts would be related to the acquisition of private property. Nonetheless, visual impacts would persist along the entire corridor and be visible from I-25 and then US 85 to Littleton. Once the HSR enters Littleton greater community impacts are probable, especially in the downtown area. The existing rail trench that carries the freight railroads and RTD's SW LRT could not accommodate the HSR and an elevated system would need to be constructed to parallel the trench. Construction of the elevated section would have a high impact on the downtown area. Operational impacts such as noise would also affect the downtown Littleton area. The HSR would also impact residential areas from West Ridge Road to just south of Mineral Avenue (1.9 miles). Both construction and operational impacts are anticipated.
	Potential Section 106 - Historic Districts - GIS	There is a high potential for Section 106 impacts.	Same as the NWQ.
	Potential 4(f)	The HSR may affect the Globeville Landing Park.	NS-2 would pass close enough to potentially affect the following parks: Overland Park Municipal Golf Course, Cushing Park, Slaughterhouse Gulch Park, Littleton Cemetery and Lower Ridgewood Park.
	Impacts to low income/minority communities - GIS	Impacts to low income and minority populations are probable between Quebec Parkway and Vasquez Blvd.	Impacts to low income and minority populations are highly possible but unknown at this time.
Safety	*# of at grade crossings*	It is anticipated that the system would be elevated, thus no at grade crossings.	Same as NS-1.
Probable High Cost	*High cost of construction anticipated*	Anticipate very high costs for aerial structure and new ROW.	Same conditions as with NS-1. Construction through City of Littleton is anticipated to be especially difficult.
	Availability of ROW	All new ROW would need to be acquired and no freight railroad ROW is available.	Same as NS-1.
Freight Conflicts	*Degree or extent*	Potential for high conflicts with freight operations.	Same as NS-1.
Capacity on existing freight corridor		The existing CML has no additional capacity – thus, there is no capacity on the CML for any potential for a shared track operation.	Same as NS-1
Technology			
Limits choice	*Allows a full spectrum of technologies*	All technologies would be allowed so long as no ROW or track were shared with the freight railroads.	Same as NS-1.
Recommended for Modeling		Conditional Yes - This is the northern half of the only North-South alignment through the Denver metro area that could be considered. However, the curvature, heavy freight traffic with no available capacity, and lack of available ROW make this segment a poor candidate for HSIPR.	Conditional Yes - This is the southern half of the only North-South alignment through the Denver metro area that could be considered. However, the curvature, heavy freight traffic with no available capacity, and lack of available ROW make this segment a poor candidate for HSIPR.

Appendix B:

Capital Cost Methodology for CDOT Interregional Connectivity Study

August 2012

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1.0 Introduction

This Capital Cost Methodology was developed by the CH2M HILL Team and will be used as a guide for preparing capital cost estimates for the Colorado Department of Transportation (CDOT) Interregional Connectivity Study (ICS). This methodology will be used throughout all phases of the project. The Capital Cost Methodology is a working document and will be updated as necessary.

2.0 Project Background

In 2010, a High Speed Rail Feasibility Study (Feasibility Study)[1] was prepared for the Rocky Mountain Rail Authority (RMRA) to assess the feasibility of providing intercity rail service in the Interstate 25 (I-25) and Interstate 70 (I-70) corridors. The Study identified a variety of possible alignments—including highway, Greenfield, and existing railroad right-of-way alignments—in each of the corridors and considered the following train technologies:

- Conventional steel wheel on steel rail, Federal Railroad Administration (FRA) compliant diesel locomotive or diesel multiple unit (DMU) equipment suitable for use on track shared with freight trains, operating at speeds up to 79 mph
- Steel wheel on steel rail (steel wheel/steel rail), FRA compliant diesel locomotive equipment suitable for use on existing rail corridors, operating at speeds up to 110 mph
- Steel wheel on steel rail, FRA compliant equipment, electrified locomotive or EMU equipment, suitable for use on dedicated track at speeds up to 150-220 mph
- High-speed magnetic levitation (LSM) technology operating at speeds up to 250-300 mph
- Urban magnetic levitation (LIM) technology operating at speeds up to 125 mph

An engineering assessment of infrastructure was conducted to identify improvements within existing, abandoned, and out-of-use service rail lines to support 79/110-mph service scenarios and to prepare estimates for Greenfield alignments for the 220 mph (steel wheel/steel rail), 300 mph (LSM), and 125 mph (LIM) scenarios.

The engineering assessment was conducted at a feasibility level of detail and accuracy. **Table 1** highlights the levels of accuracy associated with typical phases of project development and engineering design.

TABLE 1
Engineering Design Levels

Development Phases	Approximate Engineering Design Level	Approximate Level of Accuracy
Feasibility Study	0%	+/- 30% or worse
Project Definition/Advanced Planning	1-2%	+/- 25%
Conceptual Engineering	10%	+/- 20%
Preliminary Engineering	30%	+/- 15%
Pre-Final Engineering	65%	+/- 15%
Final Design/Construction Documents	100%	+/- 100% or better

Since the RMRA Feasibility Study was the first step in the project development process, the level of accuracy expected was +/- 30%.

During the engineering assessment process, alignments were examined in the field, general concepts were developed, and assumptions made regarding the capacity and operational improvements needed to accommodate future passenger operations. Using data collected during the engineering assessment, quantity estimates were developed for each RMRA alignment for the following:

[1] Rocky Mountain Rail Authority High-Speed Rail Feasibility Study. Transportation Economics & Management Systems, Inc. March 2010.

- Guideway and track elements;
- Structures;
- Systems;
- Crossings;
- Stations;
- Maintenance facilities;
- Right-of-way and land;
- Vehicles; and
- Professional services & contingencies

Quantities and unit prices were multiplied to yield the capital cost estimates that were reported in the RMRA Feasibility Study, subject to appropriate contingencies.

The process used to estimate capital costs for ICS alignments is similar to the process used to estimate capital costs for RMRA alignments; ICS alignments surviving the Level 1 conceptual screening will be divided into segments, an engineering assessment on the segments will be conducted to determine quantities, and quantities will be multiplied by associated unit costs to determine capital costs. The cost estimating methodology is further described in Section 3.

3.0 Cost Estimating Methodology Approach

The CH2M HILL team will perform Level 1, 2, and 3 screenings to examine the reasonable range of alternatives and vehicle technologies within the I-25 corridor. The purpose of the screening process is to identify only those alignments and technologies that are capable of meeting critical evaluation criteria for the corridor including travel time, environmental compliance, safety standards, constructability, and ridership expectations. Capital cost estimates for the ICS project will be completed for Level 1, Level 2, and Level 3 Screenings. The sections below describe the level of engineering design and accuracy that will be utilized in each screening level.

3.1.1 Level 1

In Level 1 (Fatal Flaw) conceptual screening, capital costs will be measured qualitatively. The cost comparison between alternatives will be evaluated using a ranking of 1 for least costly and 5 for most costly. Capital costs are not expected to be a dominant discriminator in Level 1.

3.1.2 Level 2

In Level 2 screening, a process similar to that used in the RMRA Feasibility Study will be applied to the ICS corridors to estimate capital costs:

- Conduct field inspections of the alignments surviving Level 1 conceptual screening
- Divide these alignments into segments
- Identify the improvements needed based on alignment and vehicle technology
- Determine quantities for the ten Federal Railroad Administration (FRA) Standard Cost Categories (SCC), developed as part of its High-Speed Intercity Passenger Rail Program (HSIPR):
  - 10 Track Structures and Track
  - 20 Stations, Terminals, Intermodal
  - 30 Support Facilities: Yards, Shops, Administrative Buildings
  - 40 Sitework, Right of Way, Land, Existing Improvements
  - 50 Communications & Signaling
  - 60 Electric Traction
  - 70 Vehicles
  - 80 Professional Services
  - 90 Unallocated Contingency
  - 100 Finance Charges
- Multiply quantities by unit costs, which are discussed in section 4.0, to calculate total capital cost for each alignment

Level 2 cost estimates will be presented in a spreadsheet format and a summary will be incorporated into the Level 2 Detailed Screening Matrix.

3.1.3 Level 3

Unit prices for Level 3 screening will be the same as used in Level 2 screening. Quantities will be refined based on additional engineering analyses conducted in the most challenging sections of reasonable alignment(s).

Level 3 cost estimates will be presented in a spreadsheet format and a summary will be incorporated into the Level 3 Detailed Screening Matrix.

4.0 Unit Costs

Capital cost estimates for ICS will build off the capital unit cost estimates that were completed for the Midwest Regional Rail Initiative (MWRRI), the California High-Speed Rail Association (CHSRA), the RMRA Feasibility Study, the SANDAG Maglev Study Phase 1 – Final Report, and Federal Transit Administration's (FTA) Urban Maglev Technology Development Program Colorado Maglev Project Final Report. Furthermore, the RMRA Study determined the unit costs for the structures by using established bridge construction costs from the 2009 Annual Program Review Units Rates for Capital Projects of the FasTracks Regional Transportation District.

Unit costs for the ICS are developed for steel wheel/steel rail on existing rail alignments and Greenfield alignments and magnetic levitation on Greenfield alignments, and will be presented within FRA SCC categories. Unit cost sub-categories will be added when costs are being estimated to account for variations in the type, length, and use of items in a particular cost category (i.e. track center width, embankment size, turnout size). Because station costs can vary widely based on train technology type and site-specific conditions, station unit costs will be developed in coordination with the Colorado Department of Transportation (CDOT) and local governments. The FRA SCC format will be used to present all levels of capital cost estimates.

4.1 Steel Wheel/Steel Rail – Existing, Abandoned, and Out-of-Use Rail Lines

4.1.1 Unit Cost Validation

Should it be applicable, unit costs for steel wheel/steel rail technology on existing, abandoned, and out-of-use rail lines are developed using unit costs produced as part of the Midwest Regional Rail Initiative Phase 7 contract (MWRRI) in 2010[2]. For MWRRI Phase 7, a base set of unit costs was developed for the design and construction of infrastructure capable of supporting high speed passenger rail service operating at speeds up to 110 mph. These unit costs were vetted by peer panels, freight railroads, and contractor and were found to be reasonable for developing capital costs. The MWRRI unit costs were used to estimate the capital costs of the corridors within the MWRRI by multiplying the quantities and unit prices to yield the capital cost estimates.

4.1.2 Unit Cost Application to ICS

For this methodology, MWRRI unit costs were escalated to account for inflation from March 2010 to July 2012. The *Engineering News-Record's* (ENR) Construction Cost Index (CCI) was used to adjust the MWRRI costs. The CCI is a general purpose index used to track the cost of 200 hours of local (union) common labor including fringe benefits, the local cost of 1.128 tons of Portland cement, and the national average price of 25 cwt of fabricated structural steel. From March 2010 to July 2012, the CCI increased by a factor of 1.075[3].

The unit cost adjustment value considering inflation for steel wheel/steel rail technology from March 2010 to July 2012 is computed as follows:

ICS Unit Cost (2012) = MWRRI Unit Cost (2010) x 1.075.

Attachment 1 depicts the unit costs for steel wheel/steel rail on existing, abandoned, and out-of-service rail lines.

[2] Midwest Regional Rail Initiative Phase 7 Capital Cost Estimates Report. Quandel Consultants, LLC. April 2011.

[3] Engineering News-Record, Cost Index History Tables, enr.construction.com/economics/historical_indices/

4.2 Steel Wheel/Steel Rail – Greenfield Alignments

The task of identifying appropriate unit costs for steel wheel on steel rail technology on Greenfield alignments is made more difficult by the lack of existing High-Speed Rail—Express service in the United States (Amtrak's Acela Express service operates at a top speed of 150 mph over two short track sections in Rhode Island and Massachusetts). Construction costs are not available for this type of service

A current study of High-Speed Rail—Express service for the Chicago-St. Louis/Indianapolis corridor included an examination of unit costs from both international sources and the CHSRA[4]. The examination found that the CHSRA unit costs are current, are well-developed and documented, and have been confirmed by a thorough peer review process. The CHSRA capital unit costs also were developed in large part using methods based on U.S. material and labor costs. CHSRA unit costs provide a consistent data source, as compared to using unit costs from several different high-speed rail projects from Europe, Asia and the U.S. — each of which may have developed unit costs using different methodologies.

Unit costs for steel wheel/steel rail technology on Greenfield alignments therefore are developed using unit costs produced as part of the CHSRA Draft 2012 Business Plan for High-Speed Rail—Express service in that state.

The CHSRA developed unit cost prices using two methods:

- Historic bid prices
- Analysis of production rates, labor and equipment rates, and material costs for each construction activity.

The CHSRA used historic bid prices to develop costs for common construction elements. The CHSRA's methodology allowed the bid price data to come from local, regional, statewide, and national sources. The methodology also allowed use of data from international high-speed rail projects with unique elements. The methodology required that the historic bid prices be documented, verified for appropriateness, and adjusted as necessary for escalation (inflation) and location factors.

The CHSRA used a unit price analysis method to develop costs for complex construction elements such as viaducts, retained earth systems, and tunnels. Unit prices were developed based on current local construction and market conditions and required the following steps:

- Analyze the proposed construction conditions
- Estimate production rates
- Compile a list of materials
- Obtain materials prices using local available sources
- Determine labor and equipment rates
- Calculate direct unit price using the above factors
- Add allowances for contractor overhead and profit to arrive at a final unit price
  - Markup allowance on labor: 20%
  - Markup allowance on equipment: 20%
  - Markup allowance on material: 7%
  - Markup allowance on subcontract or composite unit cost: 7%
  - Markup allowance for profit: 8%

The CHSRA used the following sources to obtain data for the unit price analysis method:

- Labor Rates: Federal Davis-Bacon Wage Determination and/or California Department of Industrial Relations Prevailing Wage Determinations.
- Equipment Rates: RS Means and/or Corp. of Engineers Construction Equipment Ownership and Operating Expense Schedule, Region VII.
- Material Prices: Material and supply prices for locally available material obtained from local supplier quotes (if possible) or secondary sources of material cost data including RS Means, Engineering News-Report (ENR) or other published resources.

[4] Technical Report: Chicago-Champaign 220 MPH HSR Feasibility Study Capital Unit Costs Comparison. Quandel Consultants, LLC and d'Escoto, Inc. March 2012.

4.2.1 Unit Cost Validation

The CHSRA conducted two peer reviews to assess the accuracy and validity of the cost estimating methodology used to develop the capital cost estimates in the 2012 Business Plan. The two peer reviews included:

- Selected unit cost items peer review by two different teams of consultants
- Contractor bid peer review for the Merced-Fresno and Fresno-Bakersfield sections

The peer review of selected unit cost items involved two CHSRA Regional Consultant teams assessing the composite unit price of several major cost items including viaducts, tunnels, embankments, and retaining walls/ trenches. Each team was provided the cost items design, material, equipment and labor assumptions. The two consultant teams found that the composite unit prices were within a reasonable range. However some adjustments were incorporated into the *2012 Business Plan* cost estimates based on the reviews. More detail on the CHSRA's unit cost peer review process can found in *Technical Memorandum 100.01 Peer Review of CHSTP Unit Prices*[5].

To conduct the contractor bid peer review, the CHSRA project team hired an independent contractor to generate a contractor bid price based on the Draft 15% Design Submittal for the Merced-Fresno and Fresno-Bakersfield corridor sections. No previous CHSRA cost estimates for these two corridor sections were provided to the independent contractor. The independent contractor produced a preliminary bid estimate for the two corridor sections that was within 10% of the CHSRA cost estimate. The CHSRA viewed this result as confirmation of the validity of its cost estimating methodology.

4.2.2 Unit Cost Application to ICS

For this methodology, CHSRA unit costs were escalated to cover inflation from 2010 to July 2012. ENR's CCI was used to adjust the CHSRA costs. An average CCI for January through December 2010 was used to represent the CCI for 2010 since the date that the CHSRA unit costs were published was not given. From 2010 to July 2012, the CCI increased by a factor of 1.060.

Adjustments for regional differences between California and Denver were not made because the CHSRA costs were developed at a planning level. In contract, MWRRI costs were regionally adjusted because the unit costs were based on actual construction costs.

ICS Unit Cost (2012) for Steel Wheel/Steel Rail on Greenfield Alignments = CHSRA Unit Cost (2010) x 1.060.

Because station costs can vary widely based on train technology type and site-specific conditions, station unit costs will be developed in coordination with the Colorado Department of Transportation (CDOT) and local governments. Cross sections taken from the CHSRA Technical Memorandum 1.1.21 *Typical Cross Sections for 15% Design* and Technical Memorandum 2.3.3 *Design Guidelines for High-speed Train Aerial Structures* will be used to estimate the infrastructure improvements needed for steel wheel/steel rail on Greenfield alignments.

Attachment 2 depicts the unit costs for steel wheel/steel rail on Greenfield alignments.

4.3 Magnetic Levitation – Greenfield Alignments

Unit costs for magnetic levitation technology on Greenfield alignments are developed using unit costs produced as part of the RMRA Feasibility Study. RMRA used the following source documents when developing its capital costs for magnetic levitation on Greenfield alignments:

- *Urban Maglev Technology Development Program – Colorado Maglev Project Final Report,* June 2004, Federal Transit Administration
- *SANDAG Maglev Study Phase 1 – Final Report*, March 17, 2006, Prepared by HNTB in association with PBS&J and Project Design Consultants

Capital costs were developed for two types of magnetic levitation technologies as follows:

- High-speed magnetic levitation (LSM) technology, represented by the German TransRapid system with top speeds from 250 to 300 mph. The system will be constructed in new, fully grade separated corridors, and will not share right-of-way with freight railroads.

[5] Technical Memorandum 100.01 Peer Review of CHSTP Unit Prices. California High-Speed Rail Authority. February 2011

- Urban magnetic levitation (LIM) technology, represented by Japanese CHHST, with speeds up to 125 mph. The system will be constructed in new, fully grade separated corridors, and will not share right-of-way with freight railroads.

4.3.1 Unit Cost Validation

As part of the SANDAG Maglev Study process, industry representatives were given an opportunity to review and comment on the study's draft capital unit cost estimates. The study's final capital unit cost estimates were refined based on comments received by the industry representatives.

4.3.2 Unit Cost Application to ICS

For this methodology, RMRA unit costs were escalated to cover inflation from January 2009 to July 2012. The *Engineering News-Record's* Construction Cost Index (CCI) was used to adjust the MWRRI costs. From January 2009 to July 2012, the CCI increased by a factor of 1.029.

4.3.2.1 Right-of-Way Costs

Right-of-way costs are To Be Determined.

4.3.2.2 Guideway and Track Elements

Guideway costs are developed for at-grade, aerial and bridge structures and tunnels. The guideway system is comprised of a concrete and/or steel guideways to support the vehicles, stator packs, power rails, low-speed switches and high-speed switches. The types of guideways used in this estimate are detailed in **Attachment 3**. All civil engineering costs associated with the construction of the guideways are included in the unit costs.

A unit cost of $3,457 per lineal feet is used for at-grade guideways. A unit cost of $6,823 per lineal feet is used for Type A aerial structures. A unit cost of $9,012 per lineal feet is used for the Type B aerial structure. Type B is a straddle-bent aerial structure needed to carry the guideway over public roadways and other obstacles encountered on the alignment. The unit cost for these guideways includes an allowance of 15% for special guideways required for project elements such as crossovers between guideways and tail structures at end stations for storage of train sets in off-peak hours.

A unit cost of $26,507 per lineal feet is used for the bridge structure required to carry the guideway over deep valleys and major rivers.

A unit cost of $34,574 per lineal feet is used for a Type A tunnel section consisting of two tunnels for the guideway. A unit cost of $46,099 per lineal feet is used for a Type B tunnel section consisting of two tunnels and a service/relief tunnel.

4.3.2.3 Systems

Propulsion, Control and Communication (PC&C) systems include: civil structures for substations and cable trenches; propulsion blocks; propulsion equipment for low, medium, and high power; motor windings; wayside equipment; propulsion maintenance equipment; operation control subsystems for communication and data collection, and associated civil structures. A unit cost of $18,900,000 per mile is used to estimate the cost of the very high speed maglev.

Power distribution unit costs were determined by a review of similar costs for the FRA demonstration projects. The unit cost used for this project is $1,429,000 per mile for very high speed systems.

The sum of the PC&C and the power unit costs is approximately $20.3 M per mile for very high speed systems using liner synchronous motor (LSM) technology. The systems cost for the urban maglev is approximately $8.0 M per mile base on information provided by Sandia National Laboratories during the development of the I-70 Mountain Programmatic Environmental Study.

4.3.2.4 Stations

Because station costs can vary widely based on train technology type and site-specific conditions, station unit costs will be developed in coordination with the Colorado Department of Transportation (CDOT) and local governments.

4.3.2.5 Maintenance Facilities

Maintenance Facilities and Yards include the construction and all equipment necessary to properly maintain the fleet of vehicles. Whereas, a history of maintenance facility costs for the full build-out of steel wheel technologies is available, the size of the maintenance facility for magnetic levitation technology, is related to the size of the Maglev fleet needed for this program. The unit cost of $3,169,000 per section of a train set for this study is determined by averaging the cost of the maintenance facilities for Baltimore- Washington and the Pittsburgh projects adjusted to year 2012 dollars. The SANDAG Study reported these unit costs and sourced the costs to the Report to Congress; Costs and Benefits of Magnetic Levitation, FRA, September 2005.

Appendix C depicts the unit costs for magnetic levitation on Greenfield alignments.

5.0 Other Costs

5.1 Contingency

Contingency costs are added as an overall percentage of the total construction cost. Contingencies are an allowance added to the estimate of costs to account for items and conditions that cannot be realistically anticipated. The contingency is expected to be needed as the project develops. The contingency for this level of detail is set at 15% for design contingency and 30% for contingency for unknowns at the planning level and will be reduced as the project advances into more detailed engineering and conceptual uncertainties are investigated and resolved.

As a check on contingency values, the CH2M HILL team will conduct a risk assessment on each estimate using FTA's spreadsheet (OP 40) risk model. this will involve stripping all contingencies (patent and latent) from the estimates and then evaluating each SCC line item for the optimistic case (known as P10 – would occur 1 in 10 times), most-likely (P50) and the pessimistic (P90). Given the amount of design, construction and political risk associated with the ICS alternatives, the team recommends CDOT adopt a P80 level of certainty for budgeting. Under these circumstances, the difference between the P50 estimate and the P80 estimate becomes the contingency. This is often a defensible method of calculating contingency.

5.2 Professional Services and Environmental

The project elements included in the Professional Services category are environmental planning, design engineering, program management, construction management and inspection, engineering services during construction, insurance, and testing and commissioning. For a project of this size, an overall program manager with several section designers is needed to provide conceptual engineering, preliminary engineering, environmental studies, geotechnical engineering, final engineering, and engineering during construction. Field and construction management services and testing and commissioning of various project elements are also required. Professional services and other soft costs required to develop the project have been estimated as a percentage of the estimated construction cost and are included in the overall cost estimates as a separate line item. These costs include, as a percentage of construction cost:

- Environmental Planning 3%
- Design Engineering 10%
- Insurance 2%
- Legal 1.5%
- Program Management 4%
- Construction Management 6%
- Engineering services during construction 1.5%
- Testing and Commissioning 2%
- Noise Mitigation 1%
- Hazardous waste 1%
- Erosion control 0.5%

Attachment 1 – Unit Costs for Steel Wheel/Steel Rail on Existing, Abandoned, and Out-of-Use Rail Rights-of-Way

ICS Unit Costs for Steel Wheel/Steel Rail on Existing, Abandoned, and Out-of-Service Rail Right-of-Way

FRA Standard Cost Categorty	Description	Unit	MWRRI March 2010 Cost (thousands)	July 2012 Cost (thousands)
10 TRACK STRUCTURES & TRACK				
10.01	Track structure: Viaduct			
10.01.01	Single Track on Flyover/Elevated Structure	LF	$ 10.231	$ 10.998
10.01.02	Double Track on Flyover/Elevated Structure	LF	$ 17.904	$ 19.247
10.01.03	Land Bridges	LF	$ 2.963	$ 3.185
10.02	Track structure: Major/Movable bridge			
10.03	Track structure: Undergrade Bridges			
10.03.01	Four Lane Urban Expressway	EA	$ 5,468	$ 5,878
10.03.02	Four Lane Rural Expressway	EA	$ 4,552	$ 4,893
10.03.03	Two Lane Highway	EA	$ 3,454	$ 3,713
10.03.04	Rail	EA	$ 3,454	$ 3,713
10.03.05	Minor river	EA	$ 915.977	$ 985
10.03.06	Major River	EA	$ 9,158	$ 9,844
10.03.07	Double Track High (50') Level Bridge	LF	$ 13.735	$ 14.765
10.03.08	Ballasted Deck Replacement Bridge	LF	$ 3.200	$ 3.440
10.03.09	Rehab for Higher Passenger Speeds (90 - 110 mph)	LF	$ 2.000	$ 2.150
10.03.10	Convert open deck bridge to ballast deck (single track)	LF	$ 5.288	$ 5.685
10.03.11	Convert open deck bridge to ballast deck (double track)	LF	$ 10.575	$ 11.368
10.04	Track structure: Culverts and drainage structures			
10.04.01	Culvert Extension	MI	$ 58.000	$ 62.350
10.06	Track structure: At-grade (grading and subgrade stabilization)			
10.07	Track structure: Tunnel			
10.07.01	Two Bore Long Tunnel	route ft	$ 45.540	$ 48.956
10.07.02	Single Bore Short Tunnel	LF	$ 25.875	$ 27.816
10.08	Track structure: Retaining walls and systems			
10.08.01	HSR Double Track on 15' Retained Earth Fill (Cross Country)	MI	$ 15,972	$ 17,169
10.08.02	Single Track on Approach Embankment w/ Retaining Wall	LF	$ 5.115	$ 5.499
10.08.03	Double Track on Approach Embankment w/ Retaining Wall	LF	$ 9.378	$ 10.081
10.09	Track new construction: Conventional ballasted			
10.09.01	HSR on Existing Roadbed	MI	$ 1,123	$ 1,207
10.09.02	HSR on New Roadbed	MI	$ 1,380	$ 1,484
10.09.03	HSR on New Roadbed @ 30' offset from ex. Track centerline	MI	$ 1,550	$ 1,666
10.09.04	HSR on New Roadbed & New Embankment	MI	$ 1,687	$ 1,814
10.09.05	HSR on New Roadbed & New Embankment (Double Track)	MI	$ 3,024	$ 3,251
10.09.06	Freight Siding (3 mile)	EA	$ 4,288	$ 4,610
10.09.07	Passenger Siding (10 mile)	EA	$ 14,496	$ 15,583
10.10	Track new construction: Non-ballasted			
10.11	Track rehabilitation: Ballast and surfacing			
10.12	Track rehabilitation: Ditching and drainage			
10.13	Track rehabilitation: Component replacement (rail, ties, etc)			
10.13.01	Timber & Surface w/ 33% Tie replacement	MI	$ 251.046	$ 269.874
10.13.02	Timber & Surface w/ 66% Tie Replacement	MI	$ 374.307	$ 402.380
10.13.03	Replace Existing Rail w/ 136#/141# CWR	MI	$ 400.316	$ 430.340
10.13.04	Elevate & Surface Curves	MI	$ 65.589	$ 70.508
10.13.05	Curvature Reduction	MI	$ 444.419	$ 477.750
10.13.06	Elastic Rail Fasteners	MI	$ 92.729	$ 99.683
10.14	Track: Special track work (switches, turnouts, insulated joints)			

ICS Unit Costs for Steel Wheel/Steel Rail on Existing, Abandoned, and Out-of-Service Rail Right-of-Way

FRA Standard Cost Categorty	Description	Unit	MWRRI March 2010 Cost (thousands)	July 2012 Cost (thousands)
10.14.01	#33 High Speed Turnout	EA	$ 695.520	$ 747.684
10.14.02	#24 High Speed Turnout	EA	$ 508.876	$ 547.042
10.14.03	#20 Turnout Timber	EA	$ 183.000	$ 196.725
10.14.04	#15 Turnout - Timber	EA	$ 147.500	$ 158.563
10.14.05	#10 Turnout Timber	EA	$ 105.000	$ 112.875
10.14.06	16'6" Double Switch Point Derail	EA	$ 34.000	$ 36.550
10.14.07	#20 Turnout Concrete	EA	$ 281.578	$ 302.697
10.14.08	#15 Turnout - Concrete	EA	$ 155.000	$ 166.625
10.14.09	#10 Turnout Concrete	EA	$ 133.439	$ 143.447
10.14.10	#33 Crossover	EA	$ 1,285	$ 1,381
10.14.11	#20 Crossover	EA	$ 563.000	$ 605.225
10.15	Track: Major interlockings			
10.16	Track: Switch heaters (with power and control)			
10.17	Track: Vibration and noise dampening			
10.18	Other linear structures including fencing, sound walls			
10.18.01	Highway Barrier Type 6	LF	$ 1.275	$ 1.371
10.18.02	Highway Barrier Type 5	LF	$ 0.196	$ 0.211
10.18.03	Fencing, 4 ft Woven Wire (both sides)	MI	$ 57.673	$ 61.998
10.18.04	Fencing, 6 ft Chain Link (both sides)	MI	$ 173.018	$ 185.994
10.18.05	Fencing, 10 ft Chain Link (both sides)	MI	$ 197.896	$ 212.739
10.18.06	Decorative Fencing (both sides)	MI	$ 445.549	$ 478.966
10.18.07	Drainage Improvements (cross country)	MI	$ 74.635	$ 80.233
20 STATIONS, TERMINALS, INTERMODAL				
20.01	Station buildings: Intercity passenger rail only	EA		TBD
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS				
30.02	Light maintenance facility			
30.02.01	Layover Facility	LS	$ 10,350	$ 11,126
30.03	Heavy Maintenance Facility			
30.03.01	Maintenance Facility (non-electrified track)	EA	$ 82,800	$ 89,010
30.03.02	Maintenance Facility (electrified track)	EA	$ 103,500	$ 111,263
30.04	Storage or maintenance-of-way building/bases			
30.04.01	Maintenance of Way Spur	LS	$ 1,000	$ 1,075
30.05	Yard and Yard Track			
30.05.01	Yard - Category A - Placeholder	LS	$ 10,000	$ 10,750
30.05.02	Yard - Category B - Placeholder	LS	$ 30,700	$ 33,003
30.05.03	Yard - Category C - Placeholder	LS	$ 37,400	$ 40,205
40 SITEWORK, RIGHT OF WAY, LAND, EXISTING IMPROVEMENTS				
40.07	Purchase or lease of real estate			
40.07.01	Land Acquisition Rural	MI		TBD
40.07.02	Land Acquisition Urban	MI		TBD
40.08	Highway/pedestrian overpass/grade separations			
40.08.01	Four Lane Urpan Expressway	EA	$ 4,722	$ 5,076
40.08.02	Four Lane Rural Expressway	EA	$ 4,722	$ 5,076
40.08.03	Two Lane Highway	EA	$ 4,045	$ 4,349
40.08.04	Rail	EA	$ 6,909	$ 7,427
40.08.05	Rail-Rail Flyovers	LS	$ 40,000	$ 43,000
40.08.06	Access to Signal/Switch Location	LS	$ 100.000	$ 107.500
50 COMMUNICATIONS & SIGNALING				

ICS Unit Costs for Steel Wheel/Steel Rail on Existing, Abandoned, and Out-of-Service Rail Right-of-Way

FRA Standard Cost Categorty	Description	Unit	MWRRI March 2010 Cost (thousands)	July 2012 Cost (thousands)
50.01	Wayside signaling equipment			
50.01.01	Install CTC System (Single Track)	MI	$ 206.943	$ 222.464
50.01.02	Install CTC System (Double Track)	MI	$ 339.251	$ 364.695
50.01.03	Install PTC System	MI	$ 176.985	$ 190.259
50.01.04	Electric Lock for Industry Turnout	EA	$ 116.476	$ 125.212
50.01.05	New Control Point (CP) - End of siding turnout, single track	EA	$ 650.000	$ 698.750
50.01.06	New Control Point (CP) - End of siding turnout & crossover, double track	EA	$ 1,296	$ 1,393
50.01.07	New Control Point (CP) - Universal Crossover	EA	$ 1,619	$ 1,740
50.01.08	Signal work to add Turnout to CP	EA	$ 452.335	$ 486.260
50.01.09	Signal work to add Crossover to CP	EA	$ 791.585	$ 850.954
50.01.10	Traffic Signal Preemption	EA	$ 75.000	$ 80.625
50.01.11	Traffic Signal Preemption and Intersection Signalization	EA	$ 300.000	$ 322.500
50.01.13	New Control Point (CP) - End of siding turnout, single track	EA	$ 650.000	$ 698.750
50.02	Signal power access and distribution			
50.03	On-board signaling equipment			
50.03.01	Install CTC System (Single Track)	MI	$ 206.943	$ 222.464
50.03.02	Install CTC System (Double Track)	MI	$ 339.251	$ 364.695
50.03.03	Install PTC System	MI	$ 176.985	$ 190.259
50.03.04	Electric Lock for Industry Turnout	EA	$ 116.476	$ 125.212
50.03.06	New Control Point (CP) - End of siding turnout & crossover, double track	EA	$ 1,296	$ 1,393
50.03.07	New Control Point (CP) - Universal Crossover	EA	$ 1,619	$ 1,740
50.03.08	Signal work to add Turnout to CP	EA	$ 452.335	$ 486.260
50.03.09	Signal work to add Crossover to CP	EA	$ 791.585	$ 850.954
50.03.10	Traffic Signal Preemption	EA	$ 75.000	$ 80.625
50.03.11	Traffic Signal Preemption and Intersection Signalization	EA	$ 300.000	$ 322.500
50.04	Traffic control and dispatching systems			
50.05	Communications			
50.06	Grade crossing protection			
50.06.01	Crossing Closure	EA	$ 93.859	$ 100.899
50.06.02	Four Quadrant Gates	EA	$ 325.681	$ 350.107
50.06.03	Four Quadrant Gates w/ Trapped Vehicle Detector	EA	$ 556.371	$ 598.099
50.06.04	Convert Dual Gates to Quad Gates	EA	$ 169.625	$ 182.347
50.06.05	Conventional Gates single mainline track	EA	$ 187.719	$ 201.798
50.06.06	Conventional Gates double mainline track	EA	$ 231.821	$ 249.208
50.06.07	Convert Flashers Only to Dual Gate	EA	$ 56.542	$ 60.782
50.06.08	Dual Gate with Median Barrier	EA	$ 203.551	$ 218.817
50.06.09	Convert Dual Gate to Extended Arm	EA	$ 16.963	$ 18.235
50.06.10	Precast Panels without Rdway Improvements	EA	$ 90.467	$ 97.252
50.06.11	Precast Panels with Rdway Improvements	EA	$ 169.625	$ 182.347
50.07	Hazard detectors: dragging equipment high water, slide, etc.			
50.08	Station train approach warning system			

Attachment 2 – Unit Costs for Steel Wheel/Steel Rail on Greenfield Alignments

ICS Unit Costs for Steel Wheel/Steel Rail on Greenfield Alignments

FRA Standard Cost Categorty	Description	Unit	CHSRA 2010 Cost (thousands)	July 2012 Cost (thousands)
10 TRACK STRUCTURES & TRACK				
10.01	**Track structure: Viaduct**			
10.01.222	Elevated Structure - 2 Track (20' Avg. Pier Ht)	Route Mile	$44,058	$46,702
10.01.223	Elevated Structure - 2 Track (30' Avg. Pier Ht)	Route Mile	$53,593	$56,808
10.01.224	Elevated Structure - 2 Track (40' Avg. Pier Ht)	Route Mile	$54,558	$57,831
10.01.225	Elevated Structure - 2 Track (50' Avg. Pier Ht)	Route Mile	$55,524	$58,856
10.01.226	Elevated Structure - 2 Track (60' Avg. Pier Ht)	Route Mile	$73,181	$77,572
10.01.227	Elevated Structure - 2 Track (70' Avg. Pier Ht)	Route Mile	$74,790	$79,278
10.01.423	Elevated Structure (LS) - 2 Track (30' Avg. Pier Ht)	Route Mile	$59,134	$62,682
10.01.424	Elevated Structure (LS) - 2 Track (40' Avg. Pier Ht)	Route Mile	$60,207	$63,819
10.01.425	Elevated Structure (LS) - 2 Track (50' Avg. Pier Ht)	Route Mile	$61,280	$64,957
10.01.522	Elevated Structure Straddle over 2 RR - 2 Track (20' Avg. Pier Ht)	Route Mile	$78,905	$83,639
10.01.523	Elevated Structure Straddle over 2 RR - 2 Track (30' Avg. Pier Ht)	Route Mile	$83,600	$88,616
10.01.524	Elevated Structure Straddle over 2 RR - 2 Track (40' Avg. Pier Ht)	Route Mile	$85,010	$90,111
10.01.525	Elevated Structure Straddle over 2 RR - 2 Track (50' Avg. Pier Ht)	Route Mile	$86,459	$91,646
10.01.960	Stream Crossings HST Structure Box Culverts	EA	$20.386	$21.609
10.02	**Track structure: Major/Movable bridge**			
10.02.023	Bridge Structure - 3 span with 2 Track	Route Mile	$68,190	$72,281
10.02.043	Bridge Structure - 3 span with 4 Track	Route Mile	$101,975	$108,094
10.02.043a	Bridge Structure - 2 Track Steel Truss Bridge	Route Mile	$12,078	$12,802
10.05	**Track structure: Cut and Fill (> 4' height/depth)**			
10.05.121	At-Grade Track-bed in Cut - 2 Track (5' Avg. Exc Depth)	Route Mile	$2,577	$2,731
10.05.122	At-Grade Track-bed in Cut - 2 Track (10' Avg. Exc Depth)	Route Mile	$3,949	$4,186
10.05.123	At-Grade Track-bed in Cut - 2 Track (15' Avg. Exc Depth)	Route Mile	$5,594	$5,930
10.05.124	At-Grade Track-bed in Cut - 2 Track (20' Avg. Exc Depth)	Route Mile	$7,517	$7,968
10.05.221	At-Grade Track-bed in Fill - 2 Track (5' Avg. Fill Ht)	Route Mile	$1,839	$1,950
10.05.222	At-Grade Track-bed in Fill - 2 Track (10' Avg. Fill Ht)	Route Mile	$2,563	$2,717
10.05.223	At-Grade Track-bed in Fill - 2 Track (15' Avg. Fill Ht)	Route Mile	$3,486	$3,696
10.05.224	At-Grade Track-bed in Fill - 2 Track (20' Avg. Fill Ht)	Route Mile	$4,586	$4,861
10.06	**Track structure: At-grade (grading and subgrade stabilization)**			
10.06.220	At-Grade Track-bed with Closed Drainage - 2 Track	Route Mile	$2,211	$2,343
10.07	**Track structure: Tunnel**			
10.07.104	TBM Double Track 50ft ID in soft ground	Route Mile	$306,766	$325,172
10.07.105	TBM Double Track 40ft ID in soft ground	Route Mile	$231,420	$245,305
10.07.201	D&B Double Track Tunnel 40ft ID in hard rock (competent)	Route Mile	$150,692	$159,734
10.07.206	D&B Double Track Tunnel 50ft ID in rock (poor)	Route Mile	$495,131	$524,839
10.07.214	Cut & Cover Box - 2 Track / 1 Box (40' Avg. Exc. Depth)	Route Mile	$143,918	$152,553
10.07.224	Cut & Cover Box - 2 Track / 2 Box (40' Avg. Exc. Depth)	Route Mile	$192,674	$204,234
10.07.303	SEM Double Track Tunnel 40ft ID in soft ground (competent)	Route Mile	$274,475	$290,943
10.07.306	SEM Double Track Tunnel 50 ft ID in soft ground (poor)	Route Mile	$457,458	$484,905
10.07.403	RH Double Track Tunnel 40ft ID in soft rock (competent)	Route Mile	$182,983	$193,962
10.07.404	RH Double Track Tunnel 40ft ID in soft rock (poor)	Route Mile	$252,947	$268,124
10.07.406	RH Double Track Tunnel 50ft ID in soft rock (poor)	Route Mile	$409,021	$433,562
10.07.801	Ventilation Shaft	VF	$13.890	$14.723
10.07.802	Mid-line Ventilation Structure	LS	$8,912	$9,446
10.07.803	Tunnel Portal Structure	LS	$8,245	$8,740
10.07.850	Pumping Station	EA	$216.405	$229.389
10.07.902	Mechanical & Electrical Allowance for Underground (Double)	Route Mile	$14,994	$15,894
10.07.920	Ventilation Equipment Allowance	EA	$2,254	$2,389
10.07.950	Allowance for Construction Monitoring	Route Mile	$148.754	$157.679
10.08	**Track structure: Retaining walls and systems**			
10.08.221	Retained Cut, Trench - 2 Track (10' Avg. Exc Depth)	Route Mile	$38,127	$40,414
10.08.222	Retained Cut, Trench - 2 Track (20' Avg. Exc Depth)	Route Mile	$93,174	$98,765
10.08.223	Retained Cut, Trench - 2 Track (30' Avg. Exc Depth)	Route Mile	$166,455	$176,442
10.08.421	Retained Fill, Walls Both Sides - 2 Tracks (10' Avg. Wall Ht)	Route Mile	$9,515	$10,086

ICS Unit Costs for Steel Wheel/Steel Rail on Greenfield Alignments

FRA Standard Cost Categorty	Description	Unit	CHSRA 2010 Cost (thousands)	July 2012 Cost (thousands)
10.08.422	Retained Fill, Walls Both Sides - 2 Tracks (20' Avg. Wall Ht)	Route Mile	$26,415	$28,000
10.08.423	Retained Fill, Walls Both Sides - 2 Tracks (30' Avg. Wall Ht)	Route Mile	$45,930	$48,685
10.09	**Track new construction: Conventional ballasted**			
10.09.120	Ballasted Track - 2 Track	Route Mile	$3,482	$3,691
10.09.122	Ballasted Track (Track Laying Machine) - 2 Track	Route Mile	$2,471	$2,619
10.09.922	Ballasted Track Relocation - 2 Track (Permanent)	Route Mile	$332	$352
10.1	**Track new construction: Non-ballasted**			
10.10.120	Direct Fixation Track - 2 Track	Route Mile	$3,694	$3,916
10.14	**Track: Special track work (switches, turnouts, insulated joints)**			
10.14.110	Direct Fixation Turnout (110 MPH)	EA	$904.444	$958.711
10.14.115	Direct Fixation Turnout (150 MPH)	EA	$1,244	$1,319
10.14.145	Direct Fixation Crossover (150 MPH)	EA	$2,298	$2,436
10.14.199	Ballasted Turnout (25 MPH)	EA	$133.017	$140.998
10.14.205	Ballasted Turnout (80 MPH)	EA	$543.917	$576.552
10.14.210	Ballasted Turnout (110 MPH)	EA	$754.041	$799.283
10.14.215	Ballasted Turnout (150 MPH)	EA	$1,032	$1,094
10.14.300	Ballasted Crossover (60 MPH)	EA	$746	$791
10.14.310	Ballasted Crossover (110 MPH)	EA	$1,399	$1,483
10.14.315	Ballasted Crossover (150 MPH)	EA	$1,914	$2,029
10.14.400	Terminal - Bumping Post	EA	$28.299	$29.997
20 STATIONS, TERMINALS, INTERMODAL				
20.01	Station buildings: Intercity passenger rail only	EA		TBD
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS				
30.03	**Heavy maintenance facility**			
30.03	Heavy Maintenance Facility (HMF)	EA	$227,945	$241,621
30.04	**Storage or maintenance-of-way building/bases**			
30.04.010	Maintenance of Way Facility (MOWF)	EA	$11,938	$12,654
30.05	**Yard and yard track**			
30.05.110	Ballasted Track - Yard Track	Route mile	$1,719	$1,822
30.05.200	Ballasted Turnout, No. 15	EA	$412.031	$436.753
30.05.210	Ballasted Diamond Crossover, No. 15	EA	$585.415	$620.540
40 SITEWORK, RIGHT OF WAY, LAND, EXISTING IMPROVEMENTS				
40.01	**Demolition, clearing, site preparation**			
40.01.010	Demolition Allowance, Bridge	SF	$0.027	$0.029
40.01.110	Demolition Allowance, Asphalt Pavement	SF	$0.057	$0.060
40.01.140	Demolition Allowance, Concrete Curb	LF	$0.013	$0.014
40.01.150	Demolition Allowance, Concrete Sidewalk	SF	$0.042	$0.045
40.01.810	Demolition Allowance, Remove Railroad Track	Route Mile	$172.728	$183.092
40.02	**Site utilities, utility relocation**			
40.02.001	Utility Relocation Allowance, Level 1	Route Mile	$1,121	$1,188
40.02.005	Utility Relocation Allowance, Level 5	Route Mile	$5,022	$5,324
40.05	**Site structures including retaining walls, sound walls**			
40.05.012	Retaining Wall - 1 Wall (12' Avg. Height)	LF	$3.088	$3.273
40.05.020	Retaining Wall - 1 Wall (20' Avg. Height)	LF	$4.020	$4.261
40.05.030	Retaining Wall - 1 Wall (30' Avg. Height)	LF	$5.496	$5.826
40.05.111	Containment (Crash) Wall - 1 Wall (6' Avg. Height Above Rail)	LF	$0.820	$0.869
40.08	**Highway/pedestrian overpass/grade separations**			
40.08.322	Roadway Overcrossing HSR - 2 lane retained fill roadway over 2 tracks	EA	$4,045	$4,288
40.08.324	Roadway Overcrossing HSR - 4 lane retained fill roadway over 2 tracks	EA	$4,722	$5,006
40.08.345a	Roadway Overcrossing HSR - 2 lane retained fill roadway - 8 spans	EA	$16,956	$17,974
40.08.422	Roadway Overcrossing HSR - 2 lane roadway on embankment over 2 tracks	EA	$3,163	$3,353
40.08.422a	Roadway Overcrossing HSR - 2 lane roadway on embankment over 2 tracks	EA	$5,363	$5,685
40.08.424	Roadway Overcrossing HSR - 4 lane roadway on embankment over 2 tracks	EA	$4,349	$4,609

ICS Unit Costs for Steel Wheel/Steel Rail on Greenfield Alignments

FRA Standard Cost Categorty	Description	Unit	CHSRA 2010 Cost (thousands)	July 2012 Cost (thousands)
40.08.424a	Roadway Overcrossing HSR - 4 lane roadway on embankment over 2 tracks	EA	$7,058	$7,481
40.08.432a	Roadway Overcrossing HSR - Interchange	EA	$25,987	$27,546
	Pedestrian Overcrossing	EA	$2,100	$2,226
40.08.530	Permanent Service/Emergency Access Road (20' Wide)	Route Mile	$560.538	$594.170
40.08.540	Access Road Entrance Point	EA	$32.553	$34.506
40.08.994	Wildlife Undercrossing HSR - 3 Ft Box Culvert	EA	$20.000	$21.200
50 COMMUNICATIONS & SIGNALING				
50.01	**Wayside signaling equipment**			
50.01.010	Train Controls (ATC)	Route Mile	$1,150	$1,219
50.01.020	Wayside Protection System	Route Mile	$110.083	$116.688
50.05	**Communications**			
50.05.010	Communications (w/Fiber Optic Backbone)	Route Mile	$195.704	$207.446
60 ELECTRIC TRACTION				
60.02	**Traction power supply: Substations**			
60.02.010	Traction Power, Supply Station Site Work	EA	$786.815	$834.024
60.02.020	Traction Power, Switching Station Site Work	EA	$297.723	$315.586
60.02.030	Traction Power, Paralleling Station Site Work	EA	$258.784	$274.311
60.02.100	Traction Power Supply	Route Mile	$2,472	$2,620
60.02.102	Traction Power Supply - Yard	EA	$12,103	$12,829
60.03	**Traction power distribution: Catenary and third rail**			
60.03.100	Traction Power Distribution	Route Mile	$2,160	$2,289
60.03.200	Traction Power Distribution - Yard	Route Mile	$538.186	$570.477

Attachment 3 – Unit Costs for Magnetic Levitation on Greenfield Alignments

ICS Unit Costs for Magnetic Levitation on Greenfield Alignments

FRA Standard Cost Categorty	Description	Unit	RMRA Jan 2009 Cost (thousands)	July 2012 Cost (thousands)
10 TRACK STRUCTURES & TRACK				
10.01	**Track structure: Viaduct**			
10.01.01	Aerial Guideway Type A	LF	$ 6.630	$ 6.823
10.01.02	Aerial Guideway Type B	LF	$ 8.758	$ 9.012
10.02	**Track structure: Major/Movable bridge**			
10.02.01	Bridge	LF	$ 25.760	$ 26.507
10.06	**Track structure: At-grade (grading and subgrade stabilization)**			
10.06.01	At Grade Guideway	LF	$ 3.360	$ 3.457
10.07	**Track structure: Tunnel**			
10.07.01	Tunnel Type A	LF	$ 33.600	$ 34.574
10.07.02	Tunnel Type B	LF	$ 44.800	$ 46.099
20 STATIONS, TERMINALS, INTERMODAL				
20.01	Station buildings: Intercity passenger rail only	EA		TBD
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS				
30.02	Light maintenance facility	Section	$ 3,080	$ 3,169
40 SITEWORK, RIGHT OF WAY, LAND, EXISTING IMPROVEMENTS				
40.07	**Purchase or Lease of Real Estate**			
40.07.01	Land Acquisition Rural	Mile		TBD
40.07.02	Land Acquisition Urban	Mile		TBD
60 ELECTRIC TRACTION				
60.02	**Traction**			
60.02.01	Propulsion, C&C Systems	Route Mile	$ 18,368	$ 18,901
60.02.02	Propulsion, C&C Systems for VHS Maglev	Route Mile	$ 18,368	$ 18,901
60.03	**Traction power distribution: Catenary and third rail**			
60.03.01	Traction Power Distribution	Route Mile	$ 1,389	$ 1,429
60.03.02	Traction Power Distribution for VHS Maglev	Route Mile	$ 1,389	$ 1,429

Appendix C:
CDOT Interregional Connectivity Study
Operating & Maintenance Cost Methodology
August 2012

Prepared by:

Connetics Transportation Group

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1.0 Introduction

This paper describes the methodology used to develop operating and maintenance (O&M) costs for the Colorado Department of Transportation's (CDOT) Interregional Connectivity Study (ICS). This study builds upon the vision set forth in the Colorado Statewide Transportation Plan of providing a multimodal transportation system including High-Speed Intercity Passenger Rail (HSIPR). The objectives of the ICS are to:

- Serve as a planning document and provide preliminary recommendations for High Speed Intercity Passenger Rail (HSIPR) alignments, technologies and station locations in the Denver Metropolitan Region that will maximize ridership for the proposed RTD FasTracks system and future High Speed Rail service.
- Focus on the future high speed rail connections with the RTD FasTracks transit program.
- Determine optimal locations for a north-south (Colorado Front Range Corridor) HSIPR alignment from Fort Collins to Pueblo, and an east-west HSIPR alignment from Denver International Airport to Jefferson County. (I-70 alignment).

The ICS' development of an optimal plan is based on a three-level screening approach to evaluating scenarios:

- Level 1 Fatal Flaw Screening: The goal of this screening is to eliminate infeasible technologies, confirm general alignments outside the Denver metro area, and define several alignments within the Denver metro area. This stage would use qualitative assessments.
- Level 2 Screening: This stage would use the same criteria as for the Level 1 Screening but evaluation would be quantitative rather than qualitative. The goal of this stage would be to select a technology that is feasible for the Front Range portion of the study area, incorporate Advanced Guideway System (AGS) technology recommendations for the Mountain portion of the study area, select an alignment for the north-south corridor outside of the Denver metro area, and define the few best alignments through the Denver metro area.
- Level 3 Screening: The remaining alternatives are further developed to refine costs, reduce impacts, and improve ridership performance. These refinements are expected to affect the quantitative evaluation of the remaining alternatives. The goal of this final screening is to select a Preferred Alternative with defined system characteristics, evaluate performance, develop a funding and financial strategy, develop a phasing strategy, and define a regulatory strategy.

The O&M cost estimation approach becomes more detailed as alternatives move through the three levels of screening:

- For Level 1 screening, O&M costs are considered not to be a defining factor in the fatal flaw analysis. Therefore, no O&M cost analysis is performed for Level 1.
- For Level 2 screening, O&M cost estimation uses a simple unit cost approach that varies according to HSIPR technology. Several potential HSIPR technologies may be involved.
- For Level 3 screening, O&M cost estimates for HSIPR alternatives are developed using a cost allocation approach with several cost drivers, differentiated by technology. By Level 3, it is assumed that the number of HSIPR technologies will have narrowed. At this level, associated bus feeder networks will be defined and bus O&M costs will also be developed. Bus O&M costs will use a unit cost approach.

The following sections describe the proposed approaches used for estimating O&M costs for Level 2 and Level 3 screening. As alternatives advance toward Level 2 and Level 3 screening, more will be known about the distinctions that are important to incorporate in the cost models and will be integrated accordingly. Once the Level 3 O&M cost model is developed, this memorandum will be modified to more specifically document the resulting structure of each model and how each line item is calculated.

2.0 O&M Cost Methodology for Level 2 Screening

The Level 2 screening evaluates scenarios that survive the Level 1 fatal flaw analysis and begins to quantify differences between alternatives. This level of screening is likely to still involve a large number of alternatives and calls for a straightforward method of quantifying O&M costs for comparison purposes.

Toward this end, the resulting unit costs per train mile from the operating cost analysis provided in the Rocky Mountain Rail Authority *High-Speed Rail Feasibility Study Business Plan*, March 2010 (RMRA study) is proposed to be applied to alternatives in Level 2 screening.

The RMRA study used a cost build-up method, adapting the costing framework developed for the Midwest Regional Rail System. Nine specific cost areas were identified. These cost areas are summarized in **Table 1**.

TABLE 1
Operating Cost Categories and Primary Cost Drivers from RMRA High-Speed Rail Feasibility Study

Cost Category	Cost Driver	Technology Distinction
Equipment Maintenance	Train Miles	Yes
Energy and Fuel	Train Miles	Yes
Train and Engine Crews	Train Miles	No
Onboard Service Crews	Train Miles	No
Insurance	Passenger Miles	No
Sales and Marketing	Fixed Cost, Ridership and Revenue	No
Service Administration	Fixed Cost, Train Miles	No
Track and ROW Maintenance	Track Miles	Yes
Station Costs	Number of Stations	No

Source: RMRA *High-Speed Rail Feasibility Study* Business Plan, March 2010.

As noted in **Table 1**, the RMRA O&M cost method included distinctions based on technology differences for several cost areas. Cost information included data provided by suppliers, current operators' histories, testing programs and analysis from other passenger corridor studies.

Associated statistics were developed for each technology option in the RMRA, and applied to the O&M cost model. This led to the calculation of total annual operating costs in 2008 dollars for each system option. The total costs were then divided by the total train miles, in order to express an average cost per train mile. **Table 2** provides the resulting average cost per train mile as calculated in the RMRA study in 2008 dollars.

TABLE 2
Average Cost per Train Mile by Technology

Cost Category	Cost Driver	Technology Distinction
79 mph Rail	$52.16	$54.74
110 mph Rail	$50.07	$52.55
125 mph Maglev	$45.46	$47.71
150 mph Rail	$49.32	$51.76
220 mph Rail	$50.18	$52.66
300 mph Maglev	$38.11	$40.00

Source: RMRA *High-Speed Rail Feasibility Study Business Plan*, March 2010 ($2008);
Connetics Transportation Group (escalation to $2011).

Table 2 also provides these unit costs as escalated to 2011 dollars, based on the Bureau of Labor Statistics' Consumer Price Index – Urban Consumers (CPI-U) for the Denver-Boulder-Greeley region. An escalation factor of 1.049 was determined by comparing the annual CPI-U from 2008 to 2011. Further escalation to 2013 dollars would use factoring compatible with the approach used for capital cost estimates.

Application of an average cost per train mile necessitates the development of rail operating plans to determine annual train miles for each alternative. Development of a rail operating plan requires the following steps:

- Calculate the one-way travel time for each rail line. These will be tailored according to different maximum speeds and potential distinctions in geometry.
- Develop a total cycle time for each rail line.
- Develop a service plan that specifies headways for different periods throughout the day for weekdays, Saturdays and Sundays and the duration (number of hours) of each period.

Definition of these components leads to being able to calculate the number of trains, anticipated daily train-hours, and daily train-miles. Daily statistics are annualized to annual statistics.

To determine the O&M costs for Level 2 screening, the annual train-miles calculated under the HSIPR alternatives will be multiplied by the average cost per train mile in 2011 dollars as presented in **Table 2**, or further escalated to 2013 dollars.

3.0 O&M Cost Methodology for Level 3 Screening

For the final level of screening, a more detailed analysis is proposed for calculating O&M costs. At this point, not only will rail O&M costs will be developed for all HSIPR alternatives, but also bus O&M costs associated with changes to bus service to complement HSIPR service.

For rail and bus modes, separate O&M cost models will be employed. An O&M cost model estimates the annual cost to operate, maintain and administer a transit system for a given set of service indicators. O&M costs are expressed as the annual total of employee earnings and fringe benefits, contract services, materials and supplies, utilities, and other day-to-day expenses incurred in the operation and maintenance of a transit system.

In general, the steps of the O&M cost estimating process are:

1. Develop methodology for estimating O&M costs;
2. Develop appropriate cost model(s) to evaluate alternatives;
3. Calibrate the model for current year operations;
4. Generate operating plans and statistics for each study alternative; and
5. Estimate annual transit operating and maintenance costs for each study alternative.

3.1 HSIPR O&M Cost Model Approach

Because not a great deal of experience exists for high-speed rail operations in the United States, the challenge is to establish a cost model that is based on the soundest data available. The proposed HSIPR O&M cost model draws upon the following sources:

- The RMRA *High-Speed Rail Feasibility Study Business Plan*, March 2010. This study effort developed a cost build-up model based on data provided by suppliers, current operators' histories, testing programs and analysis from other passenger corridor studies.
- The California High Speed Rail Authority's *2012 Business Plan,* April 2012 and California High Speed Rail Program Management Team, *HST Operating and Maintenance Cost for use in EIR/EIS Project Level Analyses*, memorandum to Central Valley Regional Teams, July 11, 2011 (collectively referred to as CHSRA study). A cost allocation model was developed for California's 2009 HSR efforts, at that time using California and national costs and labor requirements as related to conventional rail operations, and drawing on international experience. For the 2012 business plan, costs were benchmarked against European and Japanese HST experience, as well as reports prepared for the Northeast Corridor.
- 2010 National Transit Database (NTD) reports for commuter rail systems such as Caltrain (Peninsula Corridor Joint Powers Board) and Downeaster (Northern New England Passenger Rail Authority).

- Amtrak Acela data as available.

The O&M cost model primarily will be based on the RMRA study, using the other sources to confirm and update the assignment of driving variables to specific costs, and the determination of unit costs in the model as appropriate.

3.1.1 Proposed Key Supply Variables

The following key driving supply variables are used as cost drivers in the RMRA-based O&M model:

- **Annual Revenue Train-Miles:** This variable is defined as the sum of miles that trains travel while in revenue service over a year period. Revenue train-miles include layover and schedule recovery but exclude miles for deadhead, operator training and maintenance testing.
- **Annual Passenger Miles:** The sum of the miles traversed by all the passengers using the service over a year period.
- **Ridership:** The number of annual passengers.
- **Revenue:** Expected income from fares.
- **Track Miles:** The total length of mainline trackage. This calculation excludes staging or storage tracks at the beginning or end of a rail line. This variable is often used as an indicator of track and right-of-way maintenance costs.
- **Stations:** Stations are passenger boarding/alighting facilities with a platform which may include stairs, escalators, elevators, shelters, lighting, ticket machines and signage. Stations may be manned or unmanned.

Other potential supply variables may be investigated, which are commonly used for rail transit O&M cost models:

- **Annual Revenue Train-Hours:** The hours that trains, of any number of passenger cars, travel while in revenue service over the entire fiscal year. Revenue train-hours include layover and schedule recovery but exclude time for deadhead, operator training and maintenance testing.
- **Peak Cars:** The maximum number of passenger service vehicles actually operated simultaneously on an average weekday. The model uses peak cars as a variable when it needs to estimate a line item cost based on overall rail system size.

3.1.2 Proposed Line Item Detail

After selecting the key supply (resource) variables, the next steps in model development are establishing the list of expense items, assigning a resource variable to each expense line item, establishing unit costs and/or productivity ratios, and inflating the model's base year costs to represent year 2013 dollars. **Table 3** provides the basic HSIPR O&M model structure as derived from the RMRA study.

For Phase 3 screening, rail operating plans will be developed with greater specificity to determine operating statistics for each alternative including revenue train-miles, revenue train-hours, and number of required peak vehicles. Engineering drawings will be the basis for determining track miles and number of stations. Ridership forecasts will be prepared which will allow the calculation of ridership, passenger miles, and revenue.

3.1.3 O&M Cost Model Refinement

The O&M cost approach from the RMRA study is selected as the base for the HSIPR cost model, since the RMRA study developed cost distinctions for a variety of HSIPR technologies. Given the potential for Phase 3 alternatives to include more than one HSIPR technology, the RMRA model provides a ready approach to address cost differences.

The more recently completed CHSRA study also provides a cost allocation method which was benchmarked against information from European and Japanese HSR systems. An earlier version of their cost model included train-hours as an additional resource variable (where a later simplified model removed this). The CHSRA study will be used to confirm costs as developed from the RMRA study, and refine the approach as appropriate. Additional sources such as NTD data for conventional rail systems and any available O&M cost data for the Amtrak Acela line will also be reviewed and integrated as appropriate.

Rail operating plans will be developed with greater specificity to determine operating statistics for each alternative including revenue train-miles, revenue train-hours, and number of required peak vehicles. Engineering drawings will be the basis for determining track miles and number of stations. Ridership forecasts will be prepared which will allow the calculation of ridership, passenger miles, and revenue. These sources will supply the quantities for the resource variables identified in the O&M cost model.

TABLE 3
HSIPR O&M Cost Model
Based on RMRA High-Speed Rail Feasibility Study

Expense Line Item	Resource Variable	Resource Unit Cost (2008 $)
Equipment Maintenance	Train Miles	$7.24 - $14.36/train mile depending on technology
Train and Engine Crews	Train Miles	$4.28 - $6.13/train mile depending on technology
Fuel and Energy	Train Miles	$1.80 - $6.10/train mile depending on technology and grade
Onboard Service Crews	Train Miles Goods Revenue	$1.66 - $2.38/train mile 50% of revenues
Insurance Liability	Passenger Miles	$0.013/passenger mile
Sales and Marketing	Fixed Cost Ridership Revenue	$2.7 million fixed $0.66/rider 2.8% of revenues
Service Administration	Fixed Cost Train Miles	$10.3 million fixed $1.53/train mile
Track and ROW Maintenance	Track Miles	$45,000 - $75,000/track mile depending on technology
Station Operations	Stations by type	$600,000/staffed station $75,000/unstaffed station

Source: RMRA *High-Speed Rail Feasibility Study Business Plan*, March 2010.

3.2 Bus O&M Cost Approach

For Phase 3 screening, O&M costs associated with bus service complementing the HSIPR system will be quantified:

- Bus service plans will be developed to define a local transit feeder distribution network.
- Bus operating plans will be developed in sufficient detail to quantify the incremental annual service hours.
- Incremental annual service hours will be multiplied by bus operating expense per revenue vehicle hour, based on similarity of operations to the transit providers in the study area (see **Table 4**).

TABLE 4
Bus Operating Expense per Revenue Vehicle Hour

Transit Provider	Service Area	Bus Operating Expense per Revenue Vehicle Hour	
		2010 NTD	2011 Dollars
Denver RTD	Denver	102.76	106.55
Transfort	Fort Collins	78.71	81.62
Loveland Transit (COLT)	Loveland	76.42	79.24
Greeley Transit Services (GET)	Greeley	59.71	61.91
Mountain Metropolitan Transit (MMT)	Colorado Springs	92.92	96.35
Pueblo Transit System (PT)	Pueblo	86.03	89.21

Source: 2010 National Transit Database; Connetics Transportation Group (escalation to $2011)

Table 4 shows 2010 NTD unit costs escalated to 2011 dollars, based on the Bureau of Labor Statistics' Consumer Price Index – Urban Consumers (CPI-U) for the Denver-Boulder-Greeley region. An escalation factor of 1.037 was determined by comparing the annual CPI-U from 2010 to 2011. For Phase 3 analysis, 2011 NTD may be released which would supplant the provided escalation to 2011. Further escalation to 2013 dollars would use factoring compatible with the approach used for capital cost estimates.

Appendix D:
CDOT Interregional Connectivity Study
Environmental Methodologies Manual
September 2012

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Table

1 Summary of ICS Environmental Methodologies

1.0 Introduction

The Interregional Connectivity Study (ICS) is evaluating alternative scenarios for implementing more than 300 miles of high-speed rail (HSIPR) infrastructure in Colorado. The HSIPR system would serve Colorado's major population areas and tourism destinations, connecting the Front Range north and south from Fort Collins to Pueblo and from the Denver area west to Eagle County Regional Airport. Denver International Airport is a central connection to both the north-south and east-west lines.

This memorandum outlines the environmental methodologies that will guide the ICS analysis of environmental impacts of HSIPR alternative scenarios. The environmental criteria will be integrated with other evaluation criteria for each of three anticipated levels of evaluation. The ICS will describe the potential for impacts of the alternative scenarios to the level of detail appropriate to incorporate environmental factors into decision making and advance a reasonable range of alternatives that could be considered in more detail under a future National Environmental Policy Act (NEPA) process—likely a programmatic or Tier 1 process.

2.0 Environmental Assessment Methodologies

The ICS will develop and evaluate alternative scenarios, building off of the alternatives configured by the Rocky Mountain Rail Authority High Speed Rail Feasibility Study completed in 2010. The environmental impact analysis provides a basis to evaluate, compare, and screen alternative scenarios for implementing HSIPR in Colorado. The purpose of environmental impact analysis at this stage in corridor development is not to meet NEPA analysis standards but to document how environmental criteria were used in making decisions.

The ICS is looking at two basic alignment options for implementing HSIPR along the Front Range:

1. Those following existing transportation corridors
2. Those following "Greenfield" alignments that do not constrain the curvature requirements of HSIPR

The ICS will also evaluate alignments through and around the Denver metro area; the Advanced Guideway System (AGS) alignments west of Denver will be evaluated by the AGS Feasibility Study. The ICS has three levels of evaluation, integrating environmental factors into each. The ICS will consider the following environmental and social factors defined in the ICS Master Scope of Work (SOW):

- Air quality
- Noise
- Energy and congestion
- Land use and development effects, including TOD potential
- Fuel Cost Savings
- Initial and Permanent Employment Changes
- Safety benefits
- Reliability
- Consumer Surplus – a user benefit similar to the estimated time and cost savings often cited in evaluating highway projects
- Other environmental measures as discussed below

A high-level environmental review of each short-listed alternative should be conducted to determine sensitive community or natural resources that may be potentially affected. These may include but are not limited to historic resources, regulated materials, wetlands and parks or recreation resources. A calculation of "acres disturbed" has also been added to help assess the absolute impact of the construction of any considered alternative.

2.1 Level 1 Initial Evaluation

Environmental analysis in Level 1 Evaluation centers on the potential for "show-stopper" natural or social resource impacts that would seriously damage public support, be prohibitively expensive to mitigate, or for other institutional reasons would prevent an alternative scenario from being implemented. Focus will be on comparing the alignments inside and outside the Denver metropolitan area. Impacts are differentiated by whether the alignments follow existing transportation corridors or new alignments and whether the alignments pass through or circumvent developed communities. The evaluation will be qualitative and will not include consideration of ridership or cost estimates, which will be prepared during Level 2 Evaluation. Impacts will be aggregated (that is, summarized as a whole rather than detailed resource by resource) and scored on a scale (1 to 3).

2.2 Level 2 Conceptual Evaluation

Level 2 Evaluation will include more detail on alignment footprints, ridership, and cost estimates. Engineering will be advanced to support evaluation of the physical characteristics of the remaining alignments, including identifying basic right-of-way needs, focusing on the widths and capacities of existing transportation corridors. The ICS will define resources that may be highly sensitive to impact based on input from resource agencies, community organizations, and the public. Alternative scenarios will be refined and evaluated using quantitative measures to compare performance and advance those that have the potential to offer statewide social, environmental, and economic benefits that are greater than the capital and operating costs of its implementation. The evaluation and measuring of environmental impacts during Level 2 Evaluation is supported by existing mapping and environmental data (available through recent NEPA studies) and newly developed travel demand modeling data.

It is anticipated that environmental factors will be most discriminating in Level 2 Evaluation. While, environmental factors will be considered in Level 1 and Level 3 Evaluations, political and policy matters, cost-effectiveness and financial issues will likely be greater drivers.

2.3 Level 3 Detailed Evaluation

The purpose of Level 3 Evaluation is to optimize the technology, alignment, ridership, revenues, funding, phasing, and overall implementation recommendations, and to communicate the advantages and disadvantages of the alternatives in a manner that is readily apparent to stakeholders and can be supported. During Level 3 Evaluation, the ICS will refine the alternative scenarios remaining from the Level 2 Evaluation to reduce costs, reduce impacts, and improve ridership performance. Alternative scenarios will be evaluated based on engineering refinements, which could change the footprints or operating assumptions from Level 2 Evaluation. At this level, field investigation through windshield surveys may supplement mapping and modeling data to refine impact analyses.

2.4 Environmental Resources Evaluated in Level 2 and 3 Evaluations

2.4.1 Acres Disturbed

The calculation of acres disturbed is necessary to obtain the high level consequences of constructing a major civil project. This measure is calculated based on the assumed cross sections required for guideway construction for each technology times the length of the alignment. Added to this total will be the acreage requirements for HSIPR stations, maintenance and storage facilities. Acres disturbed will be calculated for urban areas and for natural/vacant areas to determine the relative impacts on the human and biological environments, respectively. Further refinements of this measure will be provided during Level 3 Evaluation if it is determined to provide a discriminator among the final alternative scenarios.

2.4.2 Air Quality

The study area includes areas of attainment, nonattainment, and maintenance for National Ambient Air Quality Standards. Particulate matter, ozone, and carbon monoxide are or historically have been pollutants of public health and visibility concern in larger metropolitan areas in the study area. Additionally, emission of greenhouse gases has become an issue of increasing concern state- and nationwide. HSIPR has a potential to effect statewide, regional, and localized air quality by shifting vehicle miles traveled (and emissions) from passenger cars and airplanes to rail. Depending on the rail technology selected, rail-related emissions could be directly related to train operations, such as diesel-powered locomotives, or indirectly related to increased electricity use and emissions from stationary sources. Construction of HSIPR could also generate additional air emissions.

For the ICS, potential long-term impacts to air quality will be measured based on the reduction of vehicle miles traveled (VMT) by classification of vehicle. Lower VMT associated with the implementation of transit, generally results in lower air pollutant emissions as measured by tons of pollutants (CO, NOx, VOC, PM10) removed annually using emission factors provided by EPA. Estimates of VMT will be generated by travel demand modeling and will be measured in Levels 2 and 3 Evaluations. The ICS will also estimate construction emissions at Level 2 and 3 Evaluations based on the ground disturbance, duration, and intensity of construction activities among alternatives.

2.4.3 Noise

Noise emissions can be a significant concern for HSIPR traveling through residential and outdoor recreation areas. Train noise can also be a concern for wildlife and cause changes in wildlife patterns. The ICS will describe potential noise impacts by measuring the distance of sensitive activities to the HSIPR alignments—alignments closer to sensitive areas have a greater potential for impacts. Noise modeling will not be performed.

2.4.4 Energy and Congestion

Energy is used during the construction and operation of transportation facilities. The ICS will focus on operational energy consumption—that is, the fuel and electricity used to power the vehicles using the transportation facility.

Energy use during operations of any alternative is related to the gasoline and diesel consumption of automobiles, trucks, and buses, as well as to the propulsion energy generated for powering HSIPR and other transit. To compare across technologies, energy usage will be converted to British Thermal Units (BTUs), the common unit of energy measurement. The ICS will follow the methodology used in the RTD Gold Line Environmental Impact Statement regarding energy consumption rates per mile of travel use by vehicle type.

To evaluate energy usage of HSIPR and the potential shift in energy usage, Level 2 and 3 Evaluations will compare travel demand and VMT traveled on roadways and transit energy use (fuel and electricity) with and without the HSIPR. Reductions in congestion will be measured to the extent possible through the travel demand model.

2.4.5 Land use and development effects, including TOD potential

The study area includes a variety of land uses, including developed residential and commercial areas, community facilities, recreational areas, farmland, industrial development, and open spaces. In most cases, the HSIPR alignments follow existing transportation corridors (rail and highway) but some alternatives will require new alignments with large amounts of private property acquisition.

To determine potential land use impacts, the ICS team will review available aerial photography, mapping, and GIS-based land use mapping to generally characterize existing land uses and rights-of-way. Land use compatibility will be summarized in the evaluation matrices from existing land use plans and input from the PLT representing the communities along the corridors. Land use impacts for Level 2 and 3 Evaluations will detail the number of potential conflicts that each alternative may pose, with special focus in Level 3 Evaluation on those conflicts that are difficult to mitigate.

Since station locations will be general, TOD potential will be qualitatively assessed. The assessment will be focused on the level of support received by the affected municipality, the extent to which a HSIPR station would contribute to a planned TOD (if any exist), and the potential to which projected development would sustain a future TOD. The potential environmental impacts of any future TOD development will not be assessed.

2.4.6 Initial and Permanent Employment Change

Implementing HSIPR has the potential to create a sizeable number of jobs, both short-term during construction and longer-term in the operation of the system. Job creation has a positive short- and long-term effect on Colorado's economy and can be viewed as a quantifiable benefit of HSIPR that could vary among alternatives based on the lengths of alignments, technologies selected, number of stations, and other factors. At Level 2 and 3 Evaluations, the ICS will estimate the total number of construction jobs created for each alternative. Employment estimates derive from the total capital expenses (labor percentage) divided by the average annual construction salary, plus a multiplier for indirect employment based on studies conducted by RTD.

At Level 2 Evaluation operating employment will be calculated as a percentage of total operating cost. At the Level 3 Evaluation operating employment will be based on an anticipated organizational structure developed for the OPEX estimates required for the final alternative scenarios.

2.4.7 Safety Benefits

The introduction of HSIPR could have both positive and negative effects on public safety.

HSIPR could result in safety benefits from reducing highway-related crashes as travelers move from highway to rail options. The increase in safety would generally be related to a reduction in highway VMT, particularly in locations where congestion-related crashes are prominent. The ICS will characterize safety impacts in Level 2 and 3 Evaluations when the travel demand modeling outputs are available. The ICS will not conduct a detailed safety assessment of crash reduction potential but rather will focus at a higher level on the mode shift opportunities (reduction in VMT) and introduction of new at-grade crossings.

Potential safety impacts associated with the number of at grade crossings will also be evaluated for each alternative scenario.

2.4.8 Reliability

All of the conventional HSIPR systems will provide a high degree of reliability. These systems have proven to be generally unaffected by weather and incidents, especially when compared to the automobile. Assuming similar operating plans and spare ratios, proven technologies will likely be considered more reliable than new technologies. The uncertainties associated with unproven technologies will need to be addressed in the Level 2 and 3 Evaluation matrices.

2.4.8 Historic Resources

Historic properties are protected by both Section 106 of the National Historic Preservation Act of 1966 and Section 4(f) of the Department of Transportation Act of 1966. Section 4(f) in particular limits the authority of federal transportation projects to acquire historic properties to construct transportation projects if alternatives that avoid historic properties are available. For this reason, historic properties are often a constraint to developing transportation projects. To identify historic properties throughout the alignments and station areas is not practical, as determination of properties listed on or eligible for the National Register of Historic Places (NRHP) requires substantial records and field research. However, because historic properties can significantly affect the planning of transportation facilities, the ICS will identify known historic properties listed on the NRHP (through National Park Service and Colorado Office of Archaeology and Historic Preservation listings) and areas of older development (greater than 40 years old that have a higher potential to be historic) through land use plans, County Assessor records, aerial photography, and limited field observation.

For Level 1 Evaluation, impacts to historic properties will be considered at a high level based on land uses. Level 2 Evaluation will map NRHP-listed properties and districts and review and incorporate information from land use plans and Assessor records. Level 3 Evaluation will involve field review of sensitive areas as needed.

2.4.10 Parks and Recreation Areas

Like historic properties, parks and recreation areas are protected by Section 4(f) of the Department of Transportation Act of 1966 and require special consideration to avoid their use in developing new transportation projects. Parks and recreation facilities are often important and valued community resources. The ICS team will identify park and recreation facilities through aerial photography and GIS mapping of land uses. For all levels of evaluation, potential impacts to parks and recreation resources will be identified. Levels 2 and 3 Evaluations will identify numbers of affected properties, while Level 1 Evaluation will identify the potential magnitude of effects on a broad level. Level 3 Evaluation will incorporate field review as needed to validate and assess potential impacts.

2.4.12 Wetlands and Water Resources

Section 404 of the Clean Water Act protects wetlands and other waters of the U.S. from damage (generally filling and dredging) during development projects. Wetlands and waters of the U.S. are part of the larger biological community and support riparian areas, water quality, and aquatic and other biological resources. Transportation agencies avoid direct impacts to wetlands and waters of the U.S. wherever possible and minimize impacts to the extent practicable during transportation construction projects.

The ICS will consider potential impacts to wetlands and water resources by comparing alignments and station locations to the National Wetland Inventory (NWI) mapping available from the USFWS as well delineated wetland areas that have been mapped through previous NEPA processes, if this is found to be applicable. During Levels 2 and 3 Evaluations, NWI data and aerial mapping will be overlaid with alignments, and areas of impact will be quantified using GIS. In other areas, the acres of riparian area affected will be calculated based on an anticipated construction footprint compared to the length of the crossing. In Level 3 Evaluation, field review may be conducted to validate the impact areas and assess the quality of the areas affected.

2.4.8 Benefit/Cost Ratio

The project Purpose and Need states that any selected HSIPR alternative scenario will need to "offer statewide social, environmental and economic benefits that are greater than the capital and operating costs of its implementation." Two B/C studies will be prepared:

- Calculation of the Operating Ratio
- Calculation of Project Benefit/Cost Ratio (B/C Studies)

Operating Ratio – As required to determine FRA feasibility, the OR will be calculated by dividing the sum of all revenues by the estimate of OPEX.

B/C Studies – Public support will require an undisputed B/C Ratio methodology, one that is endorsed by both the FRA and the PLT. Consequently, prior to the work being completed, the Team will present its approach to the B/C studies to the FRA and PLT for concurrence.

It is anticipated that the introduction of HSIPR will divert trips away from the highway system and, to a lesser extent, the aviation system, as well as reduce accidents and the discharge of pollutants to the atmosphere, all of which are expected to generate substantial benefits to the residents of Colorado. As referenced above a B/C greater than 1.0 is a condition for acceptance of the Colorado HSIPR program.

It is envisioned that the B/C studies will be predicated on quantitative measures of benefit that can be monetized for a direct comparison to the present worth of the annualized capital and O&M costs of the system.

Benefits are expected to include the following:

1. Passenger revenue
2. Reductions in VMT
3. Reductions in highway delay
4. Reductions in accidents
5. Reductions in atmospheric pollution
6. Reductions in aviation delay (if any)
7. Reductions in highway investment requirements
8. Reductions in aviation investment requirements
9. Increases in property tax revenue around HSIPR stations (tax increment basis)
10. Increases in personal income from the construction and operation of the HSIPR system

Costs are expected to include the following:

1. All operating and maintenance costs (OPEX)
2. All capital costs, including right of way and soft costs (CAPEX)

It is anticipated that the operating life assumed for the B/C studies will be 50 years; that long term interest for bonding will be assumed at 5 percent; and that inflation will average 3.5 percent per year, resulting in an "effective interest rate" of 1.5 percent. A sensitivity analysis will be provided to identify the risks associated with changes in the baseline conditions.

2.2 Summary of Environmental Methodologies

Table 1 summarizes the environmental resources that will be considered by the ICS, along with the data sources and analysis methods for the three proposed levels of evaluation.

Table 1: Summary of ICS Environmental Methodologies

Topic	Data Sources	Level 1	Level 2	Level 3
Acres disturbed	Typical cross-sections, engineering alignment drawings and footprints of stations and support facilities	N/A	Acres of urban land required Acres of natural or undisturbed land required	Acres of urban land required Acres of natural or undisturbed land required
Air Quality	Travel demand model outputs	N/A	VMT and emission calculations measured in tons of criteria pollutants removed per year	VMT and emission calculations measured in tons of criteria pollutants removed per year
Noise	GIS mapping; aerial photography; land use mapping	N/A	Linear miles of alignments near sensitive receptors	# of residences or population within 500 feet of an alignment
Land Use and Right-of-Way	Local Land Use Plans and mapping; Interviews with Planners; highway and railroad ROW mapping	Qualitative potential for affect	# of communities with land use conflicts; acres of ROW required	# of land use conflicts that cannot be mitigated; acres of ROW required; # and type of developed properties acquired
Energy and congestion	Travel Demand Modeling Output	N/A	VMT and energy usage calculations; estimates of energy usage	VMT and energy usage calculations; estimates of energy usage
Initial and Permanent Employment Change	Capital and operational cost estimates	N/A	# of construction and operational jobs created & number of indirect employment generated	# of construction and operational jobs created & number of indirect employment generated
Reliability	Historic performance data; manufacturers	N/A	Performance record of the technology being considered.	Performance record of the technology being considered.
Safety Benefits	Engineering data; Travel Demand Modeling Output; CDOT safety statistics	Qualitative potential for affect - # of at grade crossings only	# of new at-grade crossings; VMT reduction translated into a reduction of accidents and fatalities	# of new at-grade crossings; VMT reduction translated into a reduction of accidents and fatalities
Historic Properties	NRHP listing, county assessor records, field review (Level 3 only)	Qualitative potential for affect	# of NRHP listed properties potentially affected; linear miles of alignment adjacent to developments older than 40 years	# of NRHP listed properties potentially affected; linear miles of alignment adjacent to developments older than 40 years
Parks and Recreation Facilities	Aerial photography, Google Earth, GIS	Qualitative potential for affect	# of properties affected	# of properties affected
Wetlands	NWI mapping where available; GIS, Google Earth	N/A	# of stream crossings and linear miles of streams adjacent to alignments	Acreage of potential impacts based on the construction footprint over each crossings
Benefits and Cost Evaluation • **Operating Ratio** • **B/C ratio**	FRA protocols, Travel demand model, OPEX/CAPEX estimates, previous studies and input from the PLT	N/A	Methodology reconciled with FRA and PLT Operating Ratio calculated	Operating Ratio revised B/C of selected Scenario