

SH 392 at I-25 DEIS Interchange Evaluation

August 20, 2007

Introduction

This report describes the existing traffic volumes at this interchange and the adjacent intersections, as well as future traffic conditions with an improved interchange.

Existing Conditions

The interchange of SH 392 (LCR 32) with I-25 (milepost 263) was constructed in 1965. The interchange has a diamond and is similar to several older diamond interchanges (i.e. SH 402, Crossroads) in the corridor. The interchange ramps are one-lane with no dedicated turn lanes at the ramp terminals, but the curb radii at both ramp terminals allow for a right turning vehicle to maneuver around up to two vehicles waiting to turn left onto SH 392/LCR 32. The northbound ramp terminal has signal control while at the southbound ramp terminal a traffic signal controls both ramp terminal and the frontage road intersection.

The interchange area includes the following roadways:

SH 392. SH 392, which runs to the east, is a two-lane roadway with turn lanes at intersections and access points. LCR 32/Carpenter Road runs to the west and is a two-lane roadway with no turn lanes at intersections access points. To the east SH 392 runs from I-25 through the Town of Windsor eventually connecting to US 85 just north of Greeley. West of the interchange, SH 392 becomes LCR 32/Carpenter Road and serves rural areas of Larimer County located between the cities of Loveland and Fort Collins. Land along SH 392 west of the interchange is developing as the Town of Windsor grows west toward I-25. East of the interchange along LCR 32 land is primarily rural and undeveloped.

Westgate Drive. Westgate Drive, located on the east side of the interchange serves commercial uses on either side of SH 392. North of SH 392, Westgate Drive currently dead ends at a cul-de-sac while south of SH 392 it connects to the I-25 frontage road. The intersection of SH 392 and Westgate Drive has traffic signal control.

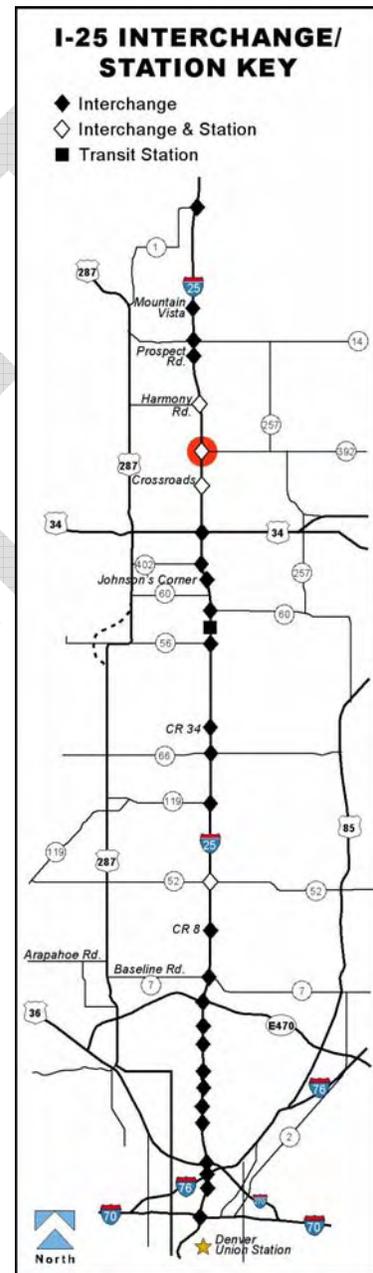


Figure 1. Vicinity Map

SH 392 at I-25 DEIS Interchange Evaluation

Frontage Road. A frontage road is located on west side of the interchange. This frontage road intersects SH 392 in close proximity to the southbound ramp terminal and has signal control. In fact, their proximity to each other causes the ramp terminal and frontage road intersection to essentially operate as one intersection that is controlled by a single traffic controller. This situation results in extra delay and queuing due to long cycle lengths and multiple signal phases needed to safely accommodate all movements at the ramp terminal and the frontage road intersection.

Figure 2 summarizes the traffic counts collected in August 2004 at this interchange. As shown, average daily traffic on SH 392 is around 12,000 vehicles per day (vpd) west of the interchange and 19,000 vpd east of the interchange. Westgate Drive has daily traffic volumes of ranging from 2,400 north of SH 392 to 3,700 south of SH 392. Daily ramp volumes range between 4,000 and 7,000 vehicles per day, with ramp volumes generally higher to and from the north. At the interchange, turn movements to/from the ramps are generally less than 300 vehicles per hour. The westbound to northbound and southbound to eastbound movements exceed 400 vehicles per hour during the AM and PM peak hours, respectively.

Traffic Operations

An operational analysis of the interchange was conducted based on methodology developed in the Highway Capacity Manual (Transportation Research Board, 2000). The result of such analysis is a level of service (LOS) rating. Level of service is a qualitative assessment of the traffic flow based on the average stopped delay per vehicles at controlled intersections (i.e. traffic signal, stop-sign).

Levels of service are described by a letter designation ranging from “A” to “F”, with LOS A representing essentially uninterrupted flow, and LOS F representing a breakdown of traffic flow with excessive congestion and delay. Signalized intersection analyses result in a level of service rating for each movement and for the entire intersection but typically only the level of service for the entire intersection is reported. For unsignalized intersections a level of service rating is determined for each turn movement that must yield to another turn movement but an overall level of service rating is not determined for the entire intersection. The following table shows how average stopped delay at controlled intersections equates to levels of service.

Table 1. Equivalent Level of Service to Average Stopped Delay and Density

Level of Service	Average Delay at Signalized Intersections in (sec./veh.)	Average Delay at Stop-Controlled intersections in (sec./veh.)
A	0 to <=10	0 to <=10
B	> 10 to <= 20	> 10 to <= 15
C	> 20 to <= 35	> 15 to <= 25
D	> 35 to <= 55	> 25 to <= 35
E	> 55 to <= 80	> 35 to <= 50
F	> 80	> 50

SH 392 at I-25 DEIS Interchange Evaluation

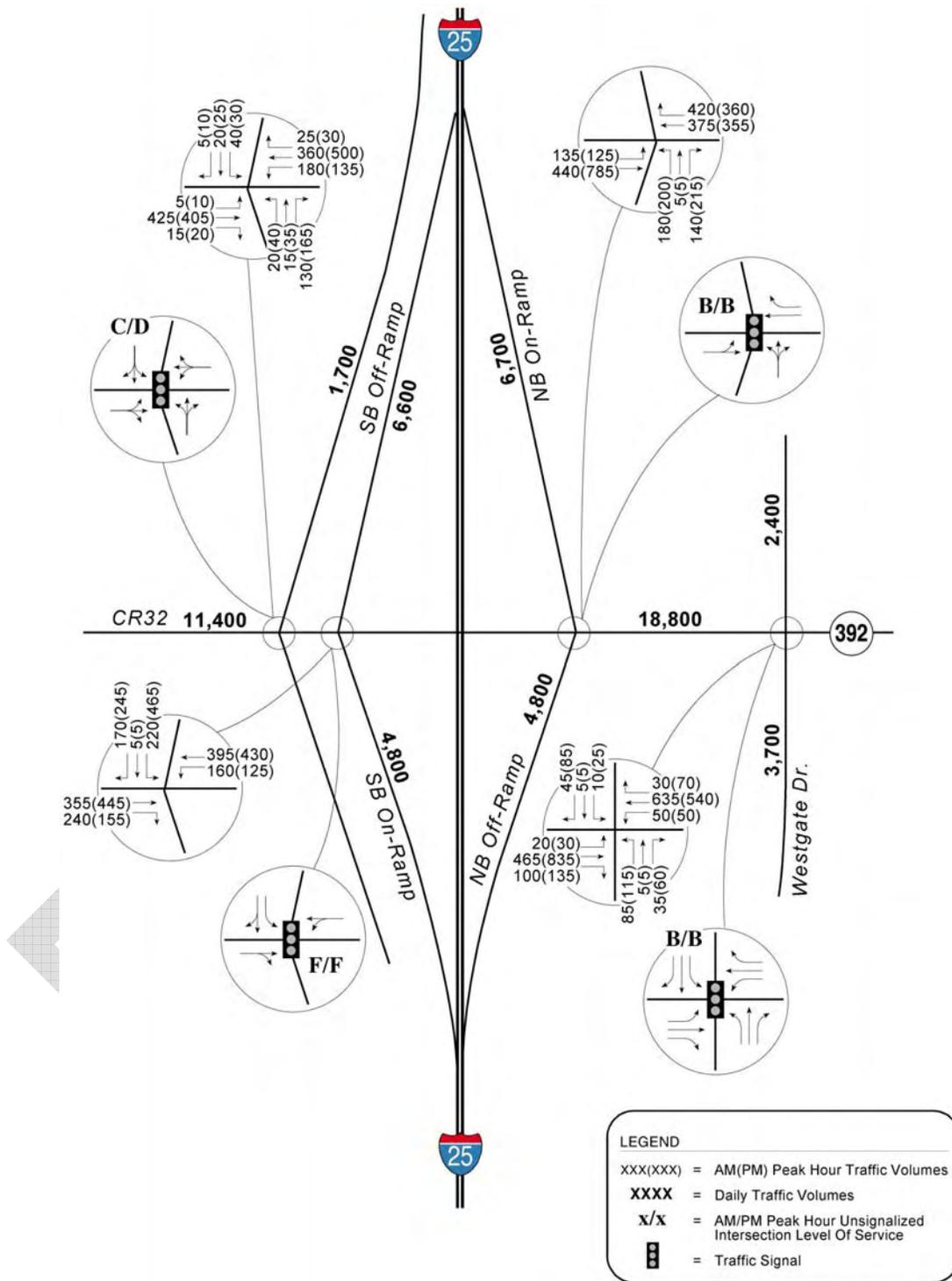


Figure 2. Existing Conditions

SH 392 at I-25 DEIS Interchange Evaluation

Page 4 of 18

Figure 2 also illustrates existing peak period levels of service at the ramp terminals and at adjacent intersections. Field observations reveal that at the southbound ramp terminal westbound drivers can maneuver around one vehicle attempting to turn left from SH 392 to the southbound on-ramp. Accounting for this is an operational analysis with coding a short left-turn pocket results in levels of service not consistent with local perceptions of operations at this interchange. On the other hand, without a left-turn pocket the operational analysis of the southbound ramp terminal gives level of service results more indicative of perceived existing conditions. The levels of service shown in the attached existing conditions graphic and the information presented in Table 1 are all based on analyses without the left-turn pocket at the southbound ramp terminal.

In addition to the intersection level of service shown graphically, Table 2 provides additional information for key movements at intersections and give further insight into existing operations at this interchange. Key movements are those movements that could have an impact on adjacent intersections or an impact to I-25. For example, east-west movements along SH 392 can queue into adjacent intersections and impede traffic flow at those locations, while vehicles on the ramps could queue back onto the interstate. North-south movements at the west frontage road and at the Westgate Drive intersections have not been included in the table because they would not impede traffic flow on SH 392.

The level of service and queuing results in Table 2 shows the main issue at the SH 392 interchange is the signal controlling the southbound ramp terminal and the west frontage road intersection; operational analyses show LOS E and F conditions for the westbound and southbound movements, while queuing analyses show the westbound queues extending through the northbound ramp terminal and southbound queues exceeding the ramp length and backing up onto I-25. At the northbound ramp terminal, queuing analyses show the westbound through movement extending through the Westgate Drive intersection and the westbound right-turn movement exceeding the available storage length, despite good level of service results estimated by Synchro. It is likely that these queuing issues observed at the northbound ramp terminal are being influenced by westbound queues at the southbound ramp terminal.

Table 2. Existing Level of Service and Queue Lengths for Key Movements

Intersection / Movement	Level of Service		Estimated 95 th Percentile Queue ¹		Intersection Spacing and Storage Length Provisions
	AM	PM	AM	PM	
West Frontage Road Intersection					
WB Approach	A	A	120'	120'	Distance to Adjacent Intersection – 80'
Southbound Ramp Terminal					
WB Approach	F	F	680'	690'	Distance to Adjacent Intersection – 520'
EB Approach	A	A	90'	90'	Distance to Adjacent Intersection – 80'
SB Left	E	F	490'	1540'	Ramp Length – 1,250'
SB Thru/Right	D	D	160'	160'	Storage – 100'
Northbound Ramp Terminal					
WB Thru	A	A	740'	690'	Distance to Adjacent Intersection – 520'
WB Right	A	A	460'	350'	Storage Length – 200'
EB Approach	A	B	360'	590'	Distance to Adjacent Intersection – 520'
NB Approach	D	D	460'	570'	Ramp Length – 900'
Westgate Drive Intersection					
EB Left	E	E	70'	90'	Storage Length – 170'
EB Thru	A	A	170'	350'	Distance to Adjacent Intersection – 520'
EB Right	A	A	80'	90'	Storage Length – 170'
¹ The queue lengths given in this table primarily come from SimTraffic with some engineering judgment.					

2030 Conditions

2030 traffic projections were developed for the three alternatives being considered:

- 1) No-Action Alternative
- 2) Package A: GPL + CR + CB 85
- 3) Package B: TEL + BRT

These three packages are illustrated in Figures 3 through 5. In developing peak hour turning movements at the ramp terminals and the nearest adjacent intersections, model results were calibrated against existing traffic counts to derive an adjusted model forecast. These adjusted forecasts along with existing turning movement data were used in the NCHRP 255 balancing procedure to develop 2030 peak hour turning movement forecasts. These forecasts were further adjusted, as necessary, to balance between intersections and for reasonableness.

LEGEND

- ★ Major Structure Rehab by 2030
- Minor Structure Rehab by 2030
- Replace / Rehab Pavement by 2030
- Minor Safety Modifications by 2030
- FasTracks Rail Line

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Figure 3. No Action Alternative

LEGEND

	1 New General Purpose Lane (GPL) in Each Direction
	1 New General Purpose Lane (GPL) + Auxiliary Lane in Each Direction
	Commuter Rail (CR)
	Commuter Bus (CB) Service on US 85
	Feeder Bus Service
	Interchange Upgrades
	Number of Lanes
	Commuter Bus Station / Stop
	Commuter Rail Station
	FasTracks Rail Line
	FasTracks / RTD Transit Station
	Potential Commuter Rail Operational & Maintenance Facility
	Potential Commuter Bus Operational & Maintenance Facility

Congestion Management Measures include:

- Enhanced carpool lot parking capacity and amenities
- Courtesy patrol (incident management) from SH 14 to SH 7
- Variable messaging signs at all transit stations
- Automated Vehicle Locaters on all transit vehicles - "next bus" technology
- Links to local bike and pedestrian systems at station areas
- Support for development of Transportation Management Organization (TMO)

NOTE:

- Select sections of I-25 would require auxiliary lanes and / or an additional through lane in addition to this 6-lane cross section.
- Where widening is needed between SH 66 and SH 7, the median would be used.
- Commuter Rail Service without a Longmont to North Metro connection will also be evaluated.



Figure 4. Package A

LEGEND

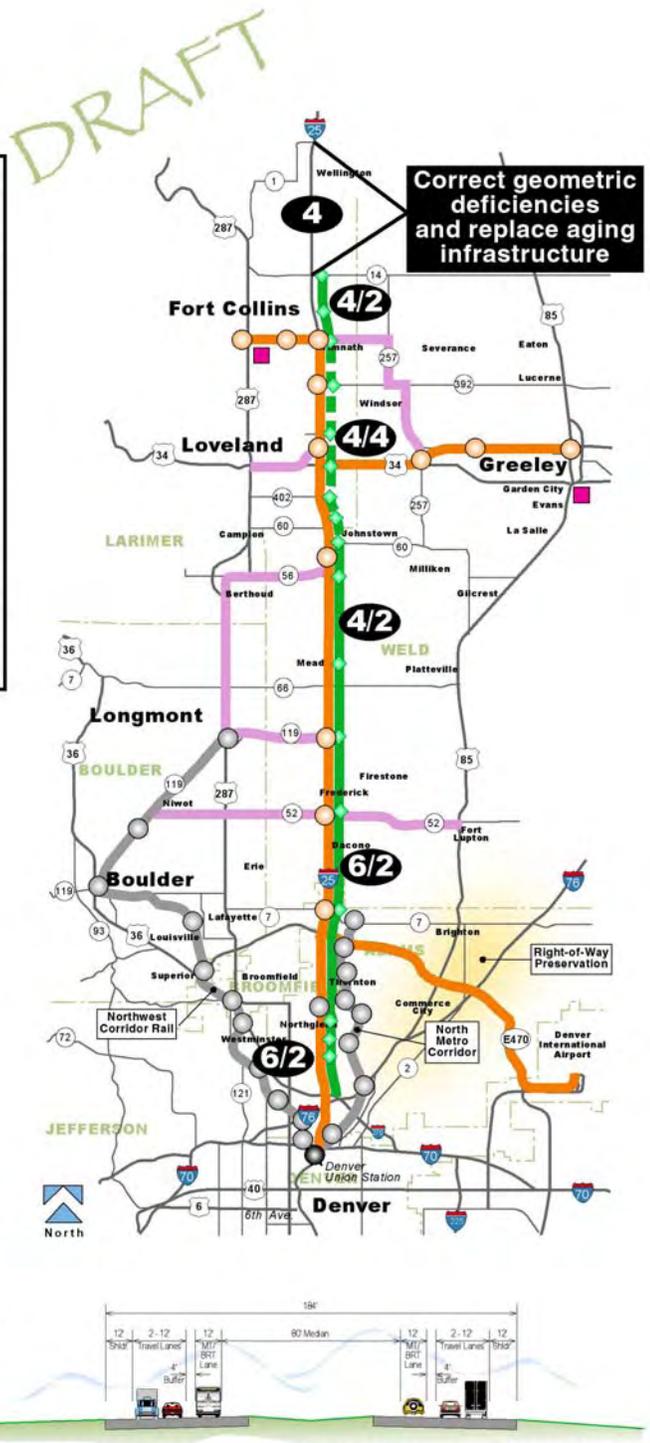
- 1 Buffer-Separated Tolloed Express Lane (TEL) in Each Direction
- 2 Barrier-Separated Tolloed Express Lanes (TEL) in Each Direction
- Bus Rapid Transit (BRT) Route (Uses TELs on I-25)
- Feeder Bus Service
- Interchange Upgrades
- X Number of Lanes: General Purpose/Tolloed Express Lanes
- Bus Rapid Transit Station
- FasTracks Rail Line
- FasTracks / RTD Transit Station
- Potential Commuter Bus Operational & Maintenance Facility

Congestion Management Measures include:

- Enhanced carpool lot parking capacity and amenities
- Courtesy patrol (incident management) from SH 14 to SH 7
- Variable messaging signs at all transit stations
- Automated Vehicle Locaters on all transit vehicles - "next bus" technology
- Links to local bike and pedestrian systems at station areas
- Support for development of Transportation Management Organization (TMO)

NOTE:

- A wider barrier and express lanes cross section is included between SH 60 and Harmony Road.
- BRT stations located within an expanded median area.
- Where widening is needed between SH 66 and SH 7, the median would be used.



NOT TO SCALE

TYPICAL I-25 CROSS SECTION - BUFFERED SEPARATED TOLLOED EXPRESS LANES

Figure 5. Package B

2030 No Action Traffic Volumes

Figure 6 depicts 2030 daily and peak hour No Action traffic projections for the SH 392 interchange and adjacent intersections. As shown, daily volume projections on SH 392 range from 43,900 vpd east of the interchange to 34,800 vpd west of the interchange, and ramp volumes range from 8,200 to 13,800 vehicles per day. These volumes show the same patterns as existing counts; the highest traffic flows are to and from the east on SH 392 and to and from the north on the ramps.

2030 Package A Traffic Volumes

Figure 7 depicts 2030 daily and peak hour Package A traffic projections for the SH 392 interchange and adjacent intersections. The volumes in the figure are generally similar to volumes in the No Action Alternative, but are slightly higher due to additional capacity on I-25. Daily volume projections on SH 392 range from 49,000 vpd east of the interchange to 34,800 vpd west of the interchange, and ramp volumes range from 10,700 to 15,600 vehicles per day.

2030 Package B Volumes

Figure 8 depicts 2030 daily and peak hour Package B traffic projections for the SH 392 interchange and adjacent intersections. The volumes in the figure show the same general patterns as the No Action Alternative and Package A. Compared to Package A, south ramp volumes are lower and north ramp volumes are higher in Package B. Daily volume projections on SH 392 range from 36,000 vpd west of the interchange to 46,100 vpd east of the interchange, and ramp volumes range from 8,800 to 16,500 vehicles per day.

2030 No Action Traffic Operations

Interchange Configuration

The No Action interchange configuration includes minor modifications to the northbound off-ramp. These modifications include shifting its intersection with SH 392 approximately 100 feet to the west and widening of the ramp to provide exclusive left and right-turn lanes. The operational analysis of No Action assumed widening of the southbound off-ramp, even though it is not a planned No Action improvement, in order to provide exclusive left and right-turn lanes and additional storage to minimize the potential for queues extending into the I-25 main lanes.

Interchange Operations

Figure 6 shows the projected levels of service at the frontage road intersections and ramp terminals on SH 392 under the No Action Alternative. As the figure indicates, all intersections along SH 392 would operate at LOS F in both peak periods. Table 3 shows the projected levels of service and queuing for key movements at the interchange and further underscores that the existing interchange would be significantly over capacity with the projected traffic volumes. As shown, even with the off-ramp widening the turn movements from the ramps would still operate at LOS F and ramp queues would still extend into the I-25 main lanes.

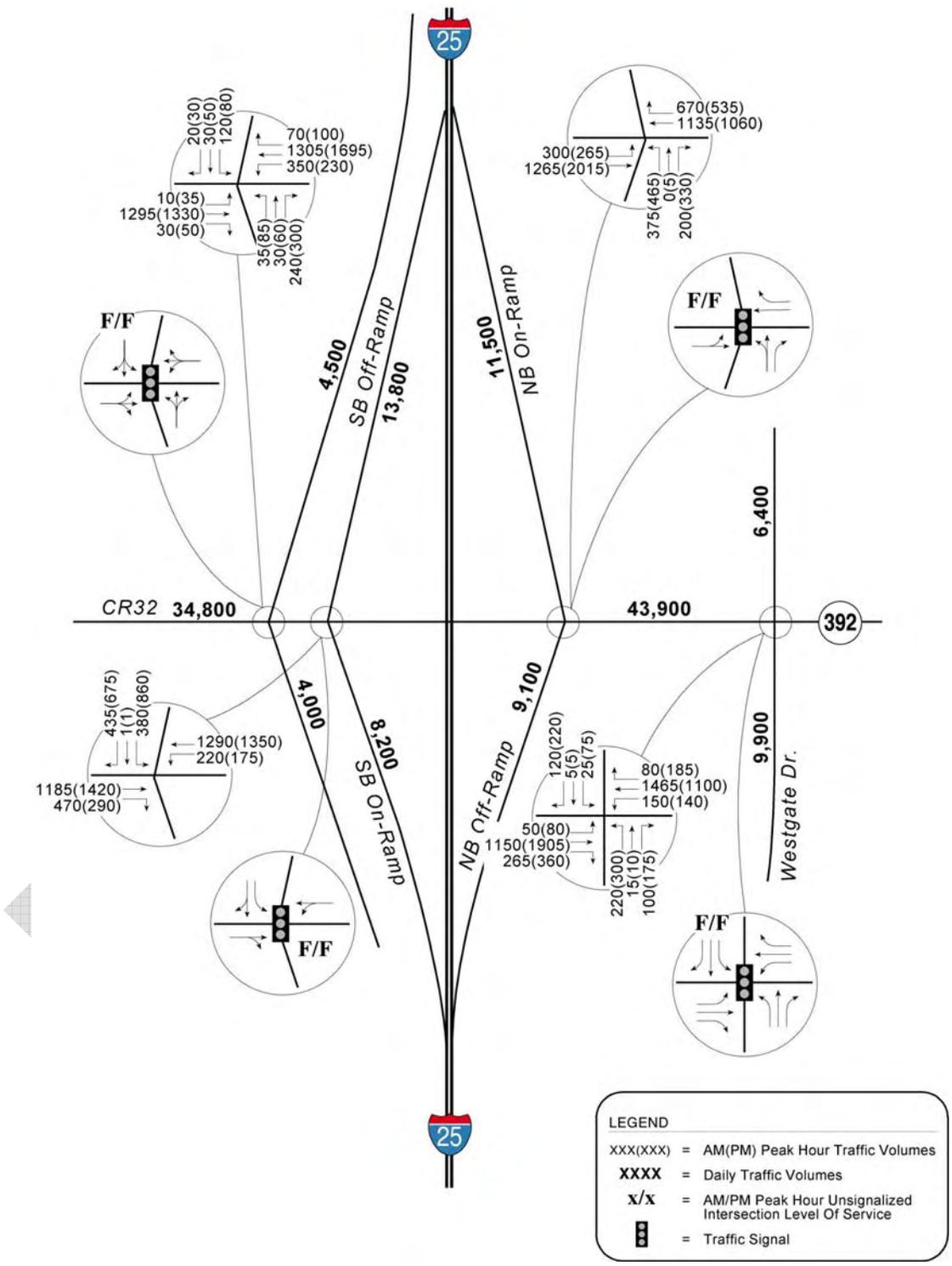


Figure 6. No Action Forecasts and Levels of Service

Table 3. 2030 No Action Level of Service and Queue Lengths for Key Movements

Intersection / Movement	Level of Service		Estimated 95 th Percentile Queue ¹		Intersection Spacing and Storage Length Provisions
	AM	PM	AM	PM	
West Frontage Road Intersection					
WB Approach	F	F	90'	120'	Distance to Adjacent Intersection – 80'
Southbound Ramp Terminal					
WB Approach	F	F	>2,000' ²	>2,000' ²	Distance to Adjacent Intersection – 640'
EB Approach	F	F	>1,000' ²	>1,000' ²	Distance to Adjacent Intersection – 80'
SB Left	F	F	>1,500'	>1,500'	Ramp Length – 1,250'
SB Thru/Right	F	F	>1,500'	>1,500'	Ramp Length – 1,250'
Northbound Ramp Terminal					
WB Thru	B	B	³	³	Distance to Adjacent Intersection – 420'
WB Right	B	B	460'	450'	Storage Length – 200'
EB Approach	F	F	730'	675'	Distance to Adjacent Intersection – 640'
NB Thru/Left	F	F	>1,500'	>1,500'	Ramp Length – 900'
NB Right	D	C	>1,500'	>1,500'	Ramp Length – 900'
Westgate Drive Intersection					
EB Left	E	D	90'	75'	Storage Length – 170'
EB Thru	F	F	480'	640'	Distance to Adjacent Intersection – 420'
EB Right	C	B	150'	190'	Storage Length – 170'
¹ The queue lengths given in this table primarily come from SimTraffic with some engineering judgment.					
² Due to the high traffic volumes on SH 392, queues extend through adjacent intersections.					
³ Queues on this approach are impacted by queues from upstream intersections.					

2030 Package A Traffic Operations

Interchange Configuration

The proposed configuration for the SH 392 interchange in the DEIS evaluation is a tight diamond configuration. The tight diamond configuration has a ramp terminal spacing less than the North I-25 EIS project standard of 660 feet. This configuration is necessary in order to avoid impacts to environmental resources that would result from shifting the west frontage road the standard 660 feet west. As a result the following intersection spacing has been provided at the interchange.

- 600 feet between the west frontage road and the southbound ramp terminal
- 450 feet between ramp terminals
- 600 feet between the northbound ramp terminal to Westgate Drive

Tight diamond interchanges are not uncommon along the I-25 corridor. Existing diamond interchanges in the Denver metro area at 84th Avenue, 104th Avenue and 120th Avenue have similar spacing characteristics as those proposed at SH 392.

Interchange Operations

Figure 7 also shows the levels of service for the ramps and frontage road intersections, along with recommendations for laneage and storage at each location. As shown, all four intersections in the vicinity of the interchange are anticipated to operate at LOS C or better with the forecasted traffic volumes and the enhancements identified.

Table 4 summarizes the levels of service, queue lengths, intersection spacing and designed storage lengths for key movements at the interchange. As shown in the table, specific movement levels of service at this interchange mostly range from LOS A to LOS D. Only the northbound left at the northbound ramp terminal and the westbound left movement at the southbound ramp terminal operate at a substandard level of service (LOS E). Therefore it appears that improvements identified at this interchange provide good operations at both ramp terminals and at the frontage road intersections.

Table 4 also compares SimTraffic estimates of the 95th percentile queue length for key movements to the storage distance available for each. For turning movements, the distance listed is the planned turn lane storage length, while for through movements the length listed is the distance between intersections. The queuing analysis shows that in most cases the estimated 95th percentile queues would be contained within the turn bays or within the space between adjacent intersections. In addition, both the northbound and southbound ramp terminals, the left and right turn queues would be accommodated well within the storage length and would not extend into the I-25 main lanes.

SH 392 at I-25 DEIS Interchange Evaluation

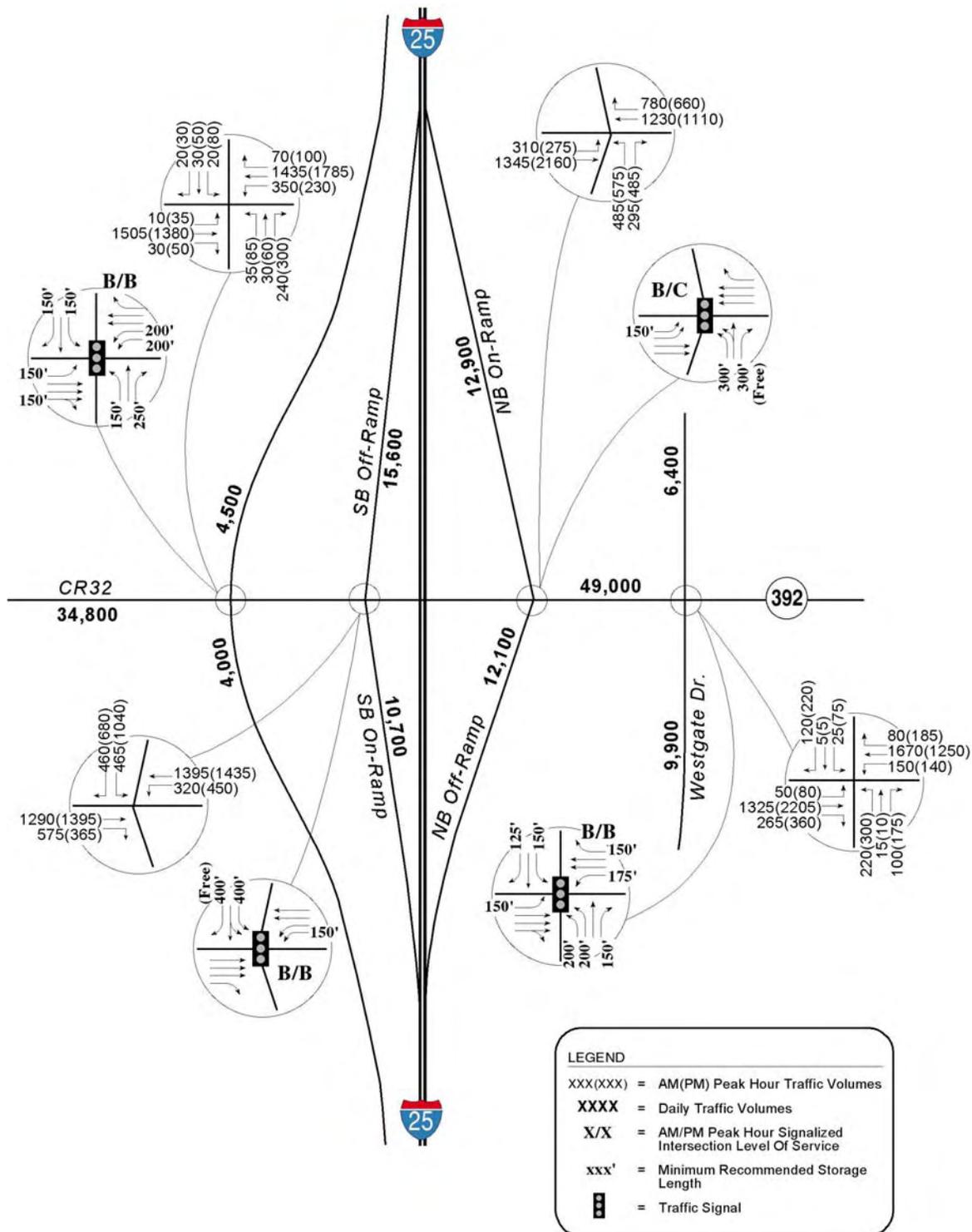


Figure 7. Package A Forecasts and Levels of Service

SH 392 at I-25 DEIS Interchange Evaluation

Page 14 of 18

Table 4. 2030 Package A Level of Service and Queue Lengths for Key Movements

Intersection / Movement	Level of Service		Estimated 95 th Percentile Queue ¹		Intersection Spacing and Storage Length Provisions
	AM	PM	AM	PM	
West Frontage Intersection					
WB Left	C	C	330'	210'	Storage Provided in Design – 400'
WB Thru	A	A	190'	250'	Distance to Adjacent Intersection – 520'
WB Right	A	A	20'	220'	Continuous accel / decel. lane
Southbound Ramp Terminal					
EB Thru	A	B	270'	550'	Distance to Adjacent Intersection – 520'
EB Right	B	A	130'	90'	Storage Provided in Design – 520'
WB Left	D	E	460'	520'	Storage Provided in Design – 800'
WB Thru	A	A	190'	350'	Distance to Adjacent Intersection – 400'
SB Left	D	D	400'	630'	Storage Provided in Design – 800'
SB Right	Free	Free	N/A	N/A	Storage Provided in Design – 400'
Northbound Ramp Terminal					
EB Left	D	B	490'	510'	Storage Provided in Design – 800'
EB Thru	A	B	90'	420'	Distance to Adjacent Intersection – 400'
WB Thru	B	D	180'	320'	Distance to Adjacent Intersection – 500'
WB Right	A	F	270'	290'	Continuous accel / decel. lane
NB Left	D	E	400'	520'	Storage Provided in Design – 600'
NB Right	Free	Free	N/A	N/A	Storage Provided in Design – 300'
Westgate Drive Intersection					
EB Left	B	A	70'	90'	Storage Provided in Design – 150'
EB Thru/Right	A	A	140'	270'	Distance to Adjacent Intersection – 500'

¹ The queue lengths given in this table primarily come from SimTraffic with some engineering judgment. SimTraffic gives a queue length for each lane. For example, with dual left-turn lanes SimTraffic estimates a queue for each lane. In the table, for thru movements the queue length is the longest queue observed in any through lane. For multiple turn lanes (i.e. dual lefts), the queue length is the sum of the queues in each lane. For a single turn lane (i.e. right turn), the queue is just the queue for that lane.

2030 Package B Traffic Operations

Interchange Configuration

The proposed configuration for SH 392 in Package B is the same as in Package A (Figure 7).

Interchange Operations

Figure 8 also shows the levels of service for the ramps and frontage road intersections, along with recommendations for laneage and storage at each location. As shown, all four intersections in the vicinity of the interchange are anticipated to operate at LOS C or better with the forecasted traffic volumes and the enhancements identified.

Table 6 summarizes the levels of service, queue lengths, intersection spacing and designed storage lengths for key movements at the interchange. As shown in the table, specific movement levels of service at this interchange mostly range from LOS A to LOS D. Only the northbound left turn movement at the northbound ramp terminal operates at a substandard level of service (LOS E), but the queues for that movement are contained within the turn bays and do not impact other movements at the interchange. In general, it appears that improvements identified at this interchange provide good operations for key movements at the ramp terminals and at the frontage road intersections.

Table 6 also compares SimTraffic estimates of the 95th percentile queue length for key movements to the storage distance available for each. For turning movements, the distance listed is the planned turn lane storage length, while for through movements the length listed is the distance between intersections. The queuing analysis shows that in most cases the estimated 95th percentile queues would be contained within the turn bays or within the space between adjacent intersections. In addition, both the northbound and southbound ramp terminals, the left and right turn queues would be accommodated well within the storage length and would not extend into the I-25 main lanes.

Package B at the SH 392 interchange includes a 143 space park-n-ride station for the BRT line on I-25. This station is proposed in the southeast corner of the interchange and would have access to the frontage road. Figure 8 shows projected turn movements, levels of service and recommended lane improvements at the park-n-ride access. As shown, the majority of park-n-ride traffic would be oriented to and from SH 392 and turns from the access would operate at LOS B or better during the peak hours.

Table 6. 2030 Package B Level of Service and Queue Lengths for Key Movements

Intersection / Movement	Level of Service		Estimated 95 th Percentile Queue ¹		Intersection Spacing and Storage Length Provisions
	AM	PM	AM	PM	
West Frontage Intersection					
WB Left	C	C	330'	220'	Storage Provided in Design – 400'
WB Thru	A	A	120'	320'	Distance to Adjacent Intersection – 520'
WB Right	A	A	20'	30'	Continuous accel / decel. lane
Southbound Ramp Terminal					
EB Thru	A	C	250'	490'	Distance to Adjacent Intersection – 520'
EB Right	B	A	100'	80'	Storage Provided in Design – 520'
WB Left	D	C	400'	510'	Storage Provided in Design – 800'
WB Thru	A	B	170'	230'	Distance to Adjacent Intersection – 400'
SB Left	D	D	380'	610'	Storage Provided in Design – 800'
SB Right	Free	Free	N/A	N/A	Storage Provided in Design – 400'
Northbound Ramp Terminal					
EB Left	D	D	490'	570'	Storage Provided in Design – 800'
EB Thru	A	A	110'	120'	Distance to Adjacent Intersection – 400'
WB Thru	B	C	160'	220'	Distance to Adjacent Intersection – 500'
WB Right	B	C	310'	280'	Continuous accel / decel. lane
NB Left	D	E	360'	520'	Storage Provided in Design – 600'
NB Right	Free	Free	N/A	N/A	Storage Provided in Design – 300'
Westgate Drive Intersection					
EB Left	B	A	60'	110'	Storage Provided in Design – 150'
EB Thru/Right	A	A	150'	350'	Distance to Adjacent Intersection – 500'

¹ The queue lengths given in this table primarily come from SimTraffic with some engineering judgment. SimTraffic gives a queue length for each lane. For example, with dual left-turn lanes SimTraffic estimates a queue for each lane. In the table, for thru movements the queue length is the longest queue observed in any through lane. For multiple turn lanes (i.e. dual lefts), the queue length is the sum of the queues in each lane. For a single turn lane (i.e. right turn), the queue is just the queue for that lane.

Alternatives Evaluation Comparison

Traffic Operational Analysis

Table 7 compares the levels of service and delay at the SH 392 interchange for the three packages. As the table indicates, without improvements at this location, all four intersections would operate at LOS F during both peak periods, but with the improvements identified above, all would operate at LOS C or better during both peaks. The levels of service and delays at each intersection are virtually the same for in Packages A and B, so it would appear that either package would result in adequate operations at this interchange.

SH 392 at I-25 DEIS Interchange Evaluation

Table 7. Intersection Level of Service and Delay

Intersection	No Action ¹		Package A		Package B	
	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
Southbound Ramps	LOS F (>80 sec.)	LOS F (>80 sec.)	LOS B (13 sec.)	LOS B (19 sec.)	LOS B (12 sec.)	LOS C (22 sec.)
Northbound Ramps	LOS F (>80 sec.)	LOS F (>80 sec.)	LOS B (13 sec.)	LOS C (34 sec.)	LOS B (15 sec.)	LOS C (21 sec.)
West Frontage Road	LOS F (>80 sec.)	LOS F (>80 sec.)	LOS B (18 sec.)	LOS B (18 sec.)	LOS B (19 sec.)	LOS B (18 sec.)
Westgate Drive	LOS F (>80 sec.)	LOS F (>80 sec.)	LOS B (12 sec.)	LOS B (14 sec.)	LOS B (12 sec.)	LOS B (14 sec.)

LOS X – Level of service

- Average delay in seconds per vehicle

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