APPENDIX T4

I-405 Congestion Relief and Rapid Transit Projects
Corridor Analysis
Mainline Design Speed
I-405 MP 0.00 to MP 30.30

I-405, SR520 to SR522 Stage 1 (Kirkland Stage 1)

Final Package Review – 15%

January 25, 2005

I-405
CONGESTION RELIEF AND RAPID TRANSIT PROJECTS

CORRIDOR ANALYSIS
MAINLINE DESIGN SPEED
I-405 MP 0.00 TO MP 30.30

December 15, 2003

CORRIDOR ANALYSIS

I-405 Congestion Relief and Bus Rapid Transit Projects
Mainline Design Speed
I-405 MP 0.00 TO MP 30.30

Purpose
The intent of this analysis is to document considerations used in selecting the mainline design speed, and to clarify design guidelines for use by the I-405 Design Team in developing the I-405 corridor concept. It is anticipated that a separate document will be developed to specify design requirements for design-build teams working on the I-405 congestion relief and bus rapid transit project(s).

Overview
High traffic volumes are adversely impacting traffic flows and safety on I-405. The purpose of this I-405 Corridor Program is to improve traffic operations and safety by expanding the mainline by two lanes in each direction and to build to full standards where appropriate. The Program is to provide a mix of modal solutions, transportation investments, and demand management to improve movement of people and goods throughout the I-405 corridor and reduce foreseeable traffic congestion.

For this NHS urban mobility interstate project, the Design Matrix calls for full design level. Considering the following justification, the project team purposes to design the project with less than standard mainline design speeds – 60 mph between MP 0.0 and M.P. 14.8 (SR-520) and 65 mph between M.P. 14.8 and M.P. 30.30. These selected design speeds are consistent with the existing geometrics, and are within the design speed limits of 50 mph to 70 mph as specified for urban roadways in Figure 440-4 of the Urban Roadways, Design Manual Supplement, effective July 22, 2003.

Improving the I-405 corridor geometrics to provide a higher design speed is not generally cost effective. Making geometric improvements will have significant impacts to heavily developed urban and environmentally sensitive areas, which surround the corridor.

The selected design speeds of 60 mph (south of SR-520) and 65 mph (north of SR-520) will be incorporated into the I-405 Design Decision Process as a Project Design Criteria, and utilized through the Design Decision Process to help identify the appropriate improvement and supporting documentation required as specific I-405 Corridor Program elements are designed. Although the selected design speeds establish the limiting values of curve radius and minimum sight distance that will be used in design, use of flatter horizontal and vertical curves and greater sight distance will be provided where such improvements can be provided as part of an economical design.

Route Description
Much of the I-405 facility is contained within a fully built out right of way, bordered on either side by heavily developed urban and environmentally sensitive areas. The posted speed is 60 mph in both directions.

Under existing conditions, the design speed for the I-405 corridor is generally 60 miles per hour between Tukwila (the south end of the corridor) and SR-520; and 65 miles per hour between SR-520 and Lynnwood (the north end of the project). The typical I-405 free flow (operating) condition for general-purpose lanes is around 61.5 mph in the "Renton S-curves" area where we have less than 70 mph design speed, typically in the 60 mph design speed range; and around 66 mph in areas north where we have generally greater than 65 mph design geometrics. The typical off peak free flow condition for HOV lanes in areas north is around 70.5 mph. These typical free flow conditions are based on the 85th percentile speed during off peak conditions using 2002 data.

The below Summary - Existing Stopping Sight Distances table summarizes the stopping sight distances for existing I-405 mainline horizontal and vertical alignment geometrics. As indicated in this table, much of I-405, an Urban-Interstate Highway, is currently designed to less than 70-mph design speed specified for an I-1 facility (Design Manual Figure 440-4).

SUMMARY
EXISTING STOPPING SIGHT DISTANCES

Number of Existing Curves Meeting Sight Distance with respect to Design Speed		**Vertical 6-In Object**	**Horizontal**
70 mph (existing) Design Speed	South of SR520 North of SR520 Total	55 (71%) 65 (87%) 120 (79%)	36 (45%) 25 (48%) 61 (46%)
65 mph (existing) Design Speed	South of SR520 North of SR520 Total	64 (83%) 70 (93%) 134 (88%)	40 (50%) 31 (60%) 71 (54%)
60 mph (existing) Design Speed	South of SR520 North of SR520 Total	71 (92%) 73 (97%) 144 (95%)	51 (64%) 38 (73%) 89 (67%)
Total	South of SR520 North of SR520 Total	77 75 152	80 52 132

The above table summarizes the number of I-405 corridor mainline curves that meet sight distance requirements for 70 mph, 65 mph, and 60 mph design speeds, respectively. Using this summary, a design speed of 60 mph is selected for the I-405 mainline south of SR-520, and a design speed of 65 mph is selected for the I-405 mainline north of SR-520. Over 90 per cent of the existing vertical curves and 60 per cent of the existing horizontal curves meet this 60/65 mph design.

South of SR-520, over 90% of the vertical curves provide stopping sight distance for the selected design speed of 60 mph. The remaining vertical curves, that are less than 60 mph sight distance, are discussed in the following section entitled "Existing Design Issues". Less than two-thirds (2/3) of the existing horizontal curves provide horizontal sight distance for the selected design speed. Horizontal curves with less than the proposed sight distance will be reviewed using the I-405 Design Decision Process to identify the appropriate improvement and supporting documentation needed at each of the locations.

North of SR-520, 93% of the vertical curves meet the sight distance criteria for the selected design speed of 65 mph. Only 60% of the existing horizontal curves have sight distance at the 65 mph design speed. Horizontal curves with less than 65 mph sight distance will be reviewed using the I-405 Design Decision Process to identify the appropriate improvement and supporting documentation needed at each of the locations.

Existing Design Issues:

Vertical Sight Distance – South of SR 520

With a 60 mph design speed there are seven (7) existing vertical curves that have less than adequate stopping sight distance, based on WSDOT Design Manual Figure 650-3:

- ARM 1.22 (east of the SR-181 Interchange) Northbound and Southbound – Existing stopping sight distance is for a design speed of 59 mph. The crest curve is not proposed for reconstruction. It is located on an existing 765 linear-foot bridge structure over several railroad tracks, and would require replacement of the existing structure and reconstruction of the approaches to improve the stopping sight distance. If the AASHTO stopping sight distance criteria with a 24-inch object height is used, the stopping sight distance for this curve exceeds that required for a 70 mph design speed.
- ARM 2.32 (overcrossing structure at SR-167 Interchange) Northbound and Southbound – Existing stopping sight distance is adequate for a design speed of 59 mph. The crest curve is not proposed for reconstruction. It is located on an existing 188 linear-foot bridge structure over SR-167, and would require replacement of the existing structure and reconstruction of the approaches to improve the stopping sight distance. If the AASHTO stopping sight distance criteria with a 24-inch object height is used, the stopping sight distance for this curve exceeds that required for a 70 mph design speed.
- ARM 4.51 (north of the Sunset Interchange) Northbound and two Southbound – Existing stopping sight distance is for a design speed of 42 mph northbound, and 50

mph and 45 mph southbound. These curves are proposed for reconstruction and will provide, as a minimum, stopping sight distance for a 60 mph design speed.

Vertical Sight Distance – North of SR 520

There are five (5) vertical curves north of SR-520 (M.P. 18.8 to M.P. 30.3) that have less than adequate stopping sight distance for a 65 mph design speed:

- ARM 19.9 (north of the NE 116th Street Interchange) Northbound Only – Existing stopping sight distance is adequate for design speed of 59 mph. This crest curve is not proposed for reconstruction. It is located on an existing bridge structure over railroad tracks, and would require replacement of the existing structure and reconstruction of the approaches to improve the stopping sight distance. If the AASHTO stopping sight distance criteria with a 24-inch object height is used, the stopping sight distance for this curve exceeds that required for a 70 mph design speed.
- ARM 23.14 (SR-522 Bothell Interchange) Northbound and Southbound - Existing stopping sight distance, based on headlight sight distance for a sag curve, is for design speeds of 52 mph northbound and 61 mph southbound. Since these curves are located within an illuminated interchange, driver's visibility will exceed that required for the selected 65 mph design speed, as the light beam distance will not limit it.
- ARM 23.64 (SR-522 Bothell Interchange) Northbound Only - Existing stopping sight distance is for a design speed of 63 mph. This crest curve is not proposed for reconstruction. It is within the SR-522 Interchange, and would require modifications throughout the interchange to improve the stopping sight distance beyond that which is currently exists. If the AASHTO stopping sight distance criteria with a 24-inch object height is used, the stopping sight distance for this curve exceeds that required for a 70 mph design speed.
- ARM 24.4 (NE 195th St. Beardsley Interchange) Southbound Only - Existing stopping sight distance, based on headlight sight distance for a sag curve, is for a design speeds of 63 mph. Since this curve is located within an illuminated interchange, driver's visibility will exceed that required for the selected 65 mph design speed, as the light beam distance will not limit it.

Horizontal Sight Distance

There are 29 existing horizontal curves south of SR-520 and 21 existing horizontal curves north of SR-520 that currently have a stopping sight distance less than 60 mph and 65 mph, respectively. Each of these will be reviewed using the I-405 Design Decision Process to identify the appropriate improvement and supporting documentation needed at each of the locations.

Ramp Design Speed

For the I-405 Program, the project team proposes to design ramps to meet or exceed the ramp design speed for the 60/65 mph mainline design speed, and as required for operational needs. Ramp connections to the freeway will meet or exceed the upper range value from Design Manual Figure 940-1. Ramps will meet Design Manual Figures 940-8 and 940-10 acceleration and deceleration requirements. Ramps not meeting the

minimum ramp design speed for the 60/65 mph mainline design speed will be reviewed using the I-405 Design Decision Process to identify the appropriate improvement and supporting documentation needed at each of the locations. A decision process will be developed to address when a ramp design will need to exceed the minimum ramp design speed.

Superelevation

The project team proposes to design the project with superelevation rate and corresponding radius for mainline and ramps, based on Design Manual Figure 640-11a, Superelevation Rate (10% Max). Areas not meeting the 60/65-design speed will be reviewed using the I-405 Design Decision Process to identify the appropriate improvement and supporting documentation needed at each of the locations.

Comparison

Options considered include the following:

1. Design mainline to full Interstate design level – Urban-Interstate highway I-1 facility with a 70 mph design speed

2. Design mainline with a 60/65 mph design speed, to match the existing I-405 mainline design speed.

The use of a full design level with a 70 mph design speed would require significant revisions to mainline vertical and horizontal geometrics which would in turn increase impacts to adjacent urban development and environmentally sensitive areas, additional right of way including acquisition of numerous businesses and homes, and utility impacts.

Accidents

The accident history from January 1, 1999 to December 31, 2001, indicated 7,264 reported accidents resulting in 4,358 injuries and 14 fatalities over the length of the I-405 corridor:

Rear end type collisions	63.3% of the reported accidents
Side swipe type accidents	11.6% of the reported accidents
	74.9% of the reported accidents

Based on 75% of the reported accidents being rear-end and sideswipe related accidents, which are accident types more related towards congestion, the congestion is construed to be the main safety issue, rather than the less than standard speeds and geometrics. This is further supported by no I-405 mainline areas being currently listed as High Accident Locations (HAL).

See attached accident list for additional accident information.

Summary

The project team is recommending the I-405 mainline meet or exceed a design speed of 60/65 mph (above Option 2). Design speed for these conditions will be determined using the data in WSDOT Design Manual Figures 650-2 for design stopping sight distance. Deviations will be submitted for situations that don't meet this criterion.

A design speed of 60/65 mph is selected for the following reasons:

- I-405 Corridor Program is defined by the FEIS and ROD as a widening project, which for the most part utilizes existing pavement and preserves the existing roadway geometrics. Increasing the design speed for the I-405 corridor above 60/65 mph would require reconstruction of a significant portion of the I-405 mainlines—changing this project from a widening project to a reconstruction project.

- A mainline design speed of 60/65 mph is consistent with the existing geometrics. Significant sections of the I-405 mainline are constructed with horizontal and vertical alignments that provide stopping sight distance for design speeds between 60 and 70 mph, as indicated in the attached Summary of Existing I-405 Stopping Sight Distances (Horizontal and Vertical).

- In widening I-405 to accommodate the additional lanes, improvements will be made to I-405 safety and operational elements. Mainline lanes and shoulders will be widened to full interstate standards, auxiliary lanes will be added and in some locations braided to mitigate congested weaves, and ramp geometrics will be reconfigured to standards. Adding these elements will result in an improved I-405 facility, even with the preservation of the existing I-405 horizontal and vertical mainline geometrics.

- The existing design speed / geometrics safely accommodate I-405 mainline traffic as is indicated by the fact that 75% of the reported accidents (rear-end and sideswipe related accidents) that are related more towards congestion than speeds and geometrics; and that no I-405 mainline areas are listed as Hazardous Accident Locations (HAL).

- Maintaining a design speed of 60/65 mph minimizes right of way impacts. Providing stopping sight distance for a 60/65 mph design speed can be accomplished without significantly impacting the heavily developed urban areas, which surround I-405 throughout the corridor. Modifying the mainline geometrics to accommodate the standard Urban Interstate design speed of 70 mph would increase impacts to these adjacent heavily developed urban areas.

- Maintaining a design speed of 60/65 mph minimizes environmental impacts. Providing stopping sight distance for a 60/65 mph design speed can be accomplished without significantly impacting the environmentally sensitive areas, which surround I-405 throughout the corridor. Modifying the mainline

geometrics to accommodate the standard Urban Interstate design speed of 70 mph would increase impacts to these adjacent environmentally sensitive areas.

The above noted design decision for an I-405 mainline design speed of 60 mph south of SR-520 and 65 mph north of SR-520 is noted and approved for use on the I-405 Congestion Relief and Bus Rapid Transit Projects.

WSDOT: _____ 12/15/03
I-405 Chief Engineer – Kim Henry, PE — Date

WSDOT: John Milton 12/23/03
Assistant State Design Engineer - John Milton, PE — Date

FHWA: Jim Leonard 1/12/04
Urban Area Engineer - Jim Leonard, PE — Date

Supporting Documentation:
See attached figures and references:

- WSDOT Design Manual Figure 325-4 Design Matrix 1, Interstate Routes (Mainline)
- WSDOT Design Manual Section 430 Modified Design Level
- WSDOT Design Manual Figure 440-4, Geometric Design Data, Interstate
- WSDOT Design Manual Figure 640-11a, Superelevation Rates (10% max)
- WSDOT Design Manual Figure 940-1, Ramp Design Speed
- WSDOT Design Manual Figure 940-8, Acceleration Lane Length
- WSDOT Design Manual Figure 940-10, Deceleration Lane Length
- WSDOT Design Manual Figure 650-3 Existing Stopping Sight Distance, as modified by the Design Manual Supplement, dated October 9, 2002.
- WSDOT Urban Roadway Design Manual Supplement, Effective date: July 22, 2003
- I-405 Design Decision Flowchart
- Summary of Existing I-405 Stopping Sight Distances (Horizontal and Vertical)
- Accident List