CAP-X NC User Guide

This study provides a modified CAP-X tool as a deliverable for the planning level operational and safety performance evaluation for the seven designs of grade-separated intersection. Therefore, the CAP-X version 3.0, developed by FHWA, is modified by adding the analysis and results tabs for the designs. This section describes in detail how to analyze the operational and safety performance analysis. The other detail analysis process, which are not included in this section, should follow the CAP-X manual.

Steps for Operational Performance Evaluation

Step 1: Volume & Number of Lanes Inputs

The process of volume input follows the FHWA's CAP-X tool user manual[1]. In the [1 – Volume Input] tab, the traffic volumes for turning movements, adjustment factor, heavy vehicle percentage, critical lane volume sum limit, and other parameters can be put into the input table.

For the seven designs of grade-separated intersection, the users can use the respective intersection tab(s) to specify the number of lanes inputs. The three lanes for through movement and a single lane for turning movement are set as default. In the input table, users can adjust the multimodal activity level. But, it does not affect the results of operational and safety analysis for the seven designs of grade-separated intersections. The detail descriptions for the multimodal pedestrian and multimodal bike are included in the FHWA's CAP-X tool user manual.

In the CAP-X NC, for the crash prediction, the input volumes (hourly volume) are converted to AADTs (daily volume) by dividing the hourly volumes by the K-factor (default value = 0.10). The K-factor is the proportion of AADT that occurs during the peak hour. According to the Highway Capacity Manual 6th Edition, the K-factor falls between 0.09 and 0.10 for many rural and urban highways[2]. So, the K-factor of 1.0 was used in this study. The K-Factor can be adjusted in the input volume table, according to the local volume condition.

[1] Jenior, P. et al. (2018). Capacity Analysis for Planning of Junctions (CAP-X) Tool User Manual. FHWA, US Department of Transportation, http://www.cmfclearinghouse.org/collateral/FHWA-SA-18-067%20CAP-X%202018%20Tool%20User%20Guide%20(Final).pdf.

[2] Highway Capacity Manual, Sixth Edition: A Guide for Multimodal Mobility Analysis (2016). Transportation Research Board, Washington, DC.

Traffic Volume Demand						
	Volume (Veh/hr)				Percent (%)	
	U-Turn	Left	Thru	Right	Heavy Vehicles	Volume Growth
Eastbound	0	250	2000	150	0.00%	0.00%
Westbound	0	200	2500	100	0.00%	0.00%
Southbound	0	150	1000	130	0.00%	0.00%
Northbound	0	150	1000	50	0.00%	0.00%
Adjustment Factor	0.80	0.95		0.85		
Suggested	**0.80**	**0.95**		**0.85**		

K-Factor			**Suggested = 0.10**	0.10
Truck to PCE Factor			**Suggested = 2.00**	2.00
Multimodal Activity Level		**Low**	**Multimodal Ped**	**Multimodal Bike**
Critical Lane Volume Sum Limit	2-phase signal	**Suggested = 1800 (Urban), 1650 (Rural)**		**1800**
	3-phase signal	**Suggested = 1750 (Urban), 1600 (Rural)**		**1750**
	4-phase signal	**Suggested = 1700 (Urban), 1550 (Rural)**		**1700**

FIGURE 1 VOLUME INPUT TABLE IN MODIFIED CAP-X

Step 2: Detailed Results

In the [4b – Detailed Results] tab, the users can compare the v/c ratio analysis results of each signalized zone on the major and minor roads for the seven grade-separated intersection designs. FIGURE 2 shows an example of analysis results. The table for the East-West road includes the results for one or more signalized zones on the major (E-W) road. The overall v/c ratios for the designs are determined by the maximum v/c ratio of the multiple signalized zones on major (E-W) road. And the rankings are determined by the overall v/c ratios. For the table for the North-South road, the details are same with the E-W road table.

Grade Separated Intersection Analysis

Results for Grade-Separated Intersections (East-West)

TYPE OF INTERSECTION	Sheet	Zone 1 (North)		Zone 2 (South)		Zone 3 (East)		Zone 4 (West)		Zone 5 (Center)		Zone 6 (Raised)		Overall v/c Ratio	Ranking
		CLV	V/C	CLV	V/C	CLV	V/C	CLV	V/C	CLV	V/C	CLV	V/C		
Direct Left - Downstream	East-West					961	0.57	1163	0.68					0.68	4
Direct Left - Upstream	East-West					1096	0.64	877	0.52					0.64	1
Single Point Left	East-West									1096	0.64			0.64	1
RCUT (U-R)	East-West					1050	0.62	1246	0.73					0.73	6
Contra RCUT	East-West					967	0.57	1179	0.69					0.69	5
RCUT (R-U)	East-West					988	0.58	1121	0.66					0.66	3
Quadrant (SE)	East-West									1277	0.75			0.75	7

Results for Grade-Separated Intersections (North-South)

TYPE OF INTERSECTION	Sheet	Zone 1 (North)		Zone 2 (South)		Zone 3 (East)		Zone 4 (West)		Zone 5 (Center)		Zone 6 (Raised)		Overall v/c Ratio	Ranking
		CLV	V/C	CLV	V/C	CLV	V/C	CLV	V/C	CLV	V/C	CLV	V/C		
Direct Left - Downstream	North-South	541	0.32	541	0.32									0.32	3
Direct Left - Upstream	North-South	491	0.29	491	0.29									0.29	1
Single Point Left	North-South									491	0.29			0.29	1
RCUT (U-R)	North-South	614	0.36	588	0.35									0.36	5
Contra RCUT	North-South	564	0.33	538	0.32									0.33	4
RCUT (R-U)	North-South	677	0.40	713	0.42									0.42	6
Quadrant (SE)	North-South									996	0.59			0.59	7

FIGURE 2 THE RESULTS MATRIX IN THE MODIFIED CAP-X

Step 3: Recommended Combinations of Designs

In the [4a – Summary Results] tab, the users can find the matrix of 'Recommended combinations of designs for grade-separated intersection'. The matrix provides the recommended combinations of East-West and North-South road designs. Each recommended design ranked first for each road for a given traffic volume. For the RCUT (R-U) and QUA (SE), the matrix provides the combination of same designs for both roads (e.g. RCUT (R-U) & RCUT (R-U)), since they can be combined only with themselves.

Grade Separated Intersection Analysis

Dynamic Results Summary

Recommended Combinations of Designs for Grade-Separated Intersection

E-W	Direct Left - Upstream	Direct Left - Upstream	
N-S	Direct Left - Upstream	Single Point Left	
E-W	Single Point Left	Single Point Left	
N-S	Direct Left - Upstream	Single Point Left	
E-W			
N-S			

FIGURE 3 AN EXAMPLE OF RECOMMENDED COMBINATIONS OF DESIGNS

Steps for Safety Performance Evaluation

Step 1: Volume Input

The volume input is same with that of operational performance evaluation. The only difference is that the crash predicted is conducted by the traffic volume, instead of equivalent passenger car volume, which is adjusted by the turning movement volume adjustment factors. Also, the input volumes are converted from the hourly volume to the daily volume by using K-factor (default value of 0.1).

Step 2: Summary Results for Safety Performance

For the safety performance comparison, the [6 – Safety Analysis Results] tab is added to the modified CAP-X. On the left side in the tab, the summary tables compares the safety performance. Like the operational performance results table, the two tables provides the sum of predicted CP crashes (unit: crashes/year) on the East-West and North-South roads. So, the users can compare the sum of CP crashes and rankings between the seven designs.

Results for Grade-Separated Intersections (East-West)						
TYPE OF INTERSECTION	Sheet	CP Crashes (crashes/year)			Sum of CP Crashes	Ranking
		Crossing	Merging	Diverging		
Direct Left - Downstream	E-W	0.998	0.496	0.473	**1.966**	7
Direct Left - Upstream	E-W	0.934	0.496	0.467	**1.897**	6
Single Point Left	E-W	0.934	0.496	0.458	**1.888**	5
RCUT (U-R)	E-W	0.000	0.873	0.502	**1.376**	3
Contra RCUT	E-W	0.000	0.858	0.494	**1.352**	1
RCUT (R-U)	E-W	0.000	0.873	0.502	**1.375**	2
Quadrant (SE)	E-W	1.006	0.483	0.275	**1.764**	4

Results for Grade-Separated Intersections (North-South)						
TYPE OF INTERSECTION	Sheet	CP Crashes (crashes/year)			Sum of CP Crashes	Ranking
		Crossing	Merging	Diverging		
Direct Left - Downstream	N-S	0.564	0.306	0.264	**1.133**	6
Direct Left - Upstream	N-S	0.512	0.306	0.259	**1.077**	5
Single Point Left	N-S	0.512	0.306	0.251	**1.069**	4
RCUT (U-R)	N-S	0.000	0.501	0.280	**0.781**	2
Contra RCUT	N-S	0.000	0.488	0.274	**0.762**	1
RCUT (R-U)	N-S	0.000	0.560	0.324	**0.883**	3
Quadrant (SE)	N-S	0.688	0.297	0.171	**1.156**	7

FIGURE 4 AN EXAMPLE OF SUMMARY RESULTS FOR SAFETY PERFORMANCE EVALUATION

Step 3: Detailed Results for Safety Performance

On the right side in the [6 – Safety Analysis Results] tab, the safety analysis tables provide the detail results of predicted crashes (Unit: crashes/year) for the designs. They provides the CP crashes predicted for each CP, the NCP crashes predicted for an intersection, and the total crashes for an intersection.

Grade Separated Intersections Safety Analysis - Detailed Results Table

*** Note: The total predicted number of crashes (CP + NCP crashes) can be compared in the following table.**

Safety Analysis											
Type of Intersection	Road	CP Type	Move_1	Move_2	CMV_1 (vph)	CMV_2 (vph)	CMV_Maj or (veh/day)	CMV_Min or (veh/day)	CP Crashes (crashes/year)	NCP Crashes (crashes/ye	Total Crashes (crashes/ye
Direct Left - Downstream	E-W	Diverging	EBT+EBL	EBR	2250	150	22500	1500	0.113	20.05	23.15
Direct Left - Downstream	E-W	Merging	EBR	WBL	150	200	2000	1500	0.037		
Direct Left - Downstream	E-W	Crossing	EBT+EBL	WBL	2250	200	22500	2000	0.462		
Direct Left - Downstream	E-W	Diverging	EBT	EBL	2000	250	20000	2500	0.111		
Direct Left - Downstream	E-W	Merging	EBT	NBR+SBL	2000	200	20000	2000	0.188		
Direct Left - Downstream	E-W	Diverging	WBT+WBL	WBR	2700	100	27000	1000	0.123		
Direct Left - Downstream	E-W	Merging	WBR	EBL	100	250	2500	1000	0.042		
Direct Left - Downstream	E-W	Crossing	WBT+WBL	EBL	2700	250	27000	2500	0.536		
Direct Left - Downstream	E-W	Diverging	WBT	WBL	2500	200	25000	2000	0.126		
Direct Left - Downstream	E-W	Merging	WBT	SBR+NBL	2500	280	25000	2800	0.228		
Direct Left - Downstream	N-S	Diverging	NBT+NBL	NBR	1150	50	11500	500	0.063		
Direct Left - Downstream	N-S	Merging	NBR	SBL	50	150	1500	500	0.027		
Direct Left - Downstream	N-S	Crossing	NBT+NBL	SBL	1150	150	11500	1500	0.282		
Direct Left - Downstream	N-S	Diverging	NBT	NBL	1000	150	10000	1500	0.065		
Direct Left - Downstream	N-S	Merging	NBT	WBR+EBL	1000	350	10000	3500	0.124		
Direct Left - Downstream	N-S	Diverging	SBT+SBL	SBR	1150	130	11500	1300	0.070		
Direct Left - Downstream	N-S	Merging	SBR	NBL	130	150	1500	1300	0.030		
Direct Left - Downstream	N-S	Crossing	SBT+SBL	NBL	1150	150	11500	1500	0.282		
Direct Left - Downstream	N-S	Diverging	SBT	SBL	1000	150	10000	1500	0.065		
Direct Left - Downstream	N-S	Merging	SBT	EBR+WBL	1000	350	10000	3500	0.124		
Direct Left - Upstream	E-W	Diverging	EBT+EBR	EBL	2150	250	21500	2500	0.116	20.05	23.02
Direct Left - Upstream	E-W	Diverging	EBT	EBR	2000	150	20000	1500	0.105		
Direct Left - Upstream	E-W	Merging	EBR	WBL	150	200	2000	1500	0.037		
Direct Left - Upstream	E-W	Crossing	EBT	WBL	2000	200	20000	2000	0.426		
Direct Left - Upstream	E-W	Merging	EBT	NBR+SBL	2000	200	20000	2000	0.188		
Direct Left - Upstream	E-W	Diverging	WBT+WBR	WBL	2600	200	26000	2000	0.129		
Direct Left - Upstream	E-W	Diverging	WBT	WBR	2500	100	25000	1000	0.117		
Direct Left - Upstream	E-W	Merging	WBR	EBL	100	250	2500	1000	0.042		
Direct Left - Upstream	E-W	Crossing	WBT	EBL	2500	250	25000	2500	0.509		
Direct Left - Upstream	E-W	Merging	WBT	SBR+NBL	2500	280	25000	2800	0.228		
Direct Left - Upstream	N-S	Diverging	NBT+NBR	NBL	1050	150	10500	1500	0.067		
Direct Left - Upstream	N-S	Diverging	NBT	NBR	1000	50	10000	500	0.058		
Direct Left - Upstream	N-S	Merging	NBR	SBL	50	150	1500	500	0.027		
Direct Left - Upstream	N-S	Crossing	NBT	SBL	1000	150	10000	1500	0.256		
Direct Left - Upstream	N-S	Merging	NBT	WBR+EBL	1000	350	10000	3500	0.124		
Direct Left - Upstream	N-S	Diverging	SBT+SBR	SBL	1130	150	11300	1500	0.071		
Direct Left - Upstream	N-S	Diverging	SBT	SBR	1000	130	10000	1300	0.064		
Direct Left - Upstream	N-S	Merging	SBR	NBL	130	150	1500	1300	0.030		
Direct Left - Upstream	N-S	Crossing	SBT	NBL	1000	150	10000	1500	0.256		
Direct Left - Upstream	N-S	Merging	SBT	EBR+WBL	1000	350	10000	3500	0.124		

FIGURE 5 AN EXAMPLE OF DETAILED RESULTS FOR SAFETY PERFORMANCE EVALUATION