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HCM Merge Method Fix Based on User's Input

Dr. Gustavo de Andrade and Dr. Shen Dong

An exception to the HCM6 (Highway Capacity Manual) merge method was causing on-ramp average density to reach unrealistic high values for specific inputs despite the Level of Service (LOS) being correctly calculated, reported a Highway Capacity Software (HCS) user.

The engineering and development teams at the McTrans Center deeply analyzed the cause of this issue. They found that values of the flow rate entering the merge influence area (v_{R12}) lower than the capacity but higher than "maximum desirable" could result in inconsistent density values for uncongested conditions. Note b on **Exhibit 14-10** on the HCM6 (page 14-27) warns the user about this limitation but provides no further guidance.

FFS (mi/h)	Capacity of Upstream or Downstream Freeway Segment[a] — Number of Lanes in One Direction: 2	3	4	>4	Maximum Desirable Flow Rate (v_{R12}) Entering Merge Influence Area[b]	Maximum Desirable Flow Rate (v_{12}) Entering Diverge Influence Area[b]
≥70	4,800	7,200	9,600	2,400/ln	4,600	4,400
65	4,700	7,050	9,400	2,350/ln	4,600	4,400
60	4,600	6,900	9,200	2,300/ln	4,600	4,400
55	4,500	6,750	9,000	2,250/ln	4,600	4,400

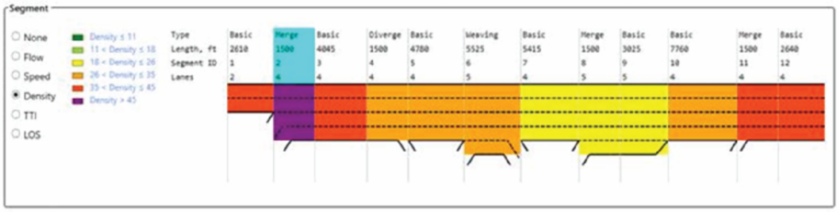
Notes: [a] Demand in excess of these capacities results in LOS F.
[b] Demand in excess of these values alone does not result in LOS F; operations may be worse than predicted by this methodology.

Exhibit 14-10
Capacity of Ramp-Freeway Junctions (pc/h)

The solution proposed by the McTrans team delimits the boundary of V_{R12} to 4,600 pc/h to calculate the average speed on the ramp influence area. The proposed solution produced coherent values for the freeway facilities case study, which matched the user's speed/density field measurement.

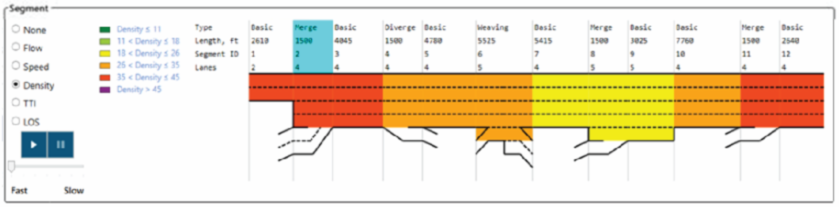
The Highway Capacity and Quality of Service Committee (HCQSC) approved this solution as an errata to be part of the HCM during the TRB's 2021 Mid-Year Meeting by adding a note to **Exhibit 14-13**. We appreciate all the feedback and contributions from HCS users and the HCQSC members and friends for the consideration and thorough discussion.

Original Method



Speed and Density							
Upstream Equilibrium Distance	-	Downstream Equilibrium Distance	-	Prop. Freeway Vehicles in Lane 1&2	0.209	Flow Inner Lanes (v12), pc/h	1678
Flow Outer Lanes (vO), pc/h	2518	Flow Ramp Influence, pc/h	6513	Speed Index (MS)	2.784	Ramp Influence Speed (SR), mi/h	0.0
Outer Lanes Speed, mi/h	63.3	**Average Speed (S), mi/h**	**1.4**	**Ramp Density(DR), pc/mi/ln**	**44.7**	**Level of Service (LOS)**	**E**
Average Density, veh/mi/ln	1535.3	**Average Density, pc/mi/ln**	**1612.7**				

Proposed Solution



Speed and Density							1678
Upstream Equilibrium Distance	-	Downstream Equilibrium Distance	-	Prop. Freeway Vehicles in Lane 1&2	0.209	Flow Inner Lanes (v12), pc/h	52.9
Flow Outer Lanes (vO), pc/h	2518	Flow Ramp Influence, pc/h	6513	Speed Index (MS)	0.544	Ramp Influence Speed (SR), mi/h	E
Outer Lanes Speed, mi/h	63.3	**Average Speed (S), mi/h**	**55.4**	**Ramp Density(DR), pc/mi/ln**	**44.7**	**Level of Service (LOS)**	
Average Density, veh/mi/ln	38.8	**Average Density, pc/mi/ln**	**40.8**				

TIPS & HINTS

Queue Length Percentile in HCS Streets

The default percentile of the queue length distribution used to calculate the Back of Queue (Q) length output in HCS Streets is the 50th percentile of the queue length distribution.

It is possible to change this default based on user preferences or agency requirements under the Detailed Input Data section of the user interface.

Percentile values of 50, 85, 90, and 95 can be used. Changes in this input will reflect on the calculations and labels on the formatted report.

Movement Group Results	EB			WB		
Approach Movement	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16
Adjusted Flow Rate (v), veh/h	200	1000	10	194	968	10
Adjusted Saturation Flow Rate (s), veh/h/ln	1543	1123	1353	1543	674	1353
Queue Service Time (g_s), s	12.7	15.7	0.4	12.4	21.6	0.4
Cycle Queue Clearance Time (g_c), s	12.7	15.7	0.4	12.4	21.6	0.4
Green Ratio (g/C)	0.15	0.51	0.51	0.15	0.51	0.51
Capacity (c), veh/h	231	1721	691	227	1713	688
Volume-to-Capacity Ratio (X)	0.867	0.581	0.014	0.854	0.565	0.014
Back of Queue (Q), ft/ln (50 th percentile)	124.1	76.4	2.8	130.7	86.6	5.1
Back of Queue (Q), veh/ln (50 th percentile)	5.0	3.1	0.1	5.2	3.5	0.2
Queue Storage Ratio (RQ) (50 th percentile)	0.62	0.00	0.01	0.65	0.00	0.03
Uniform Delay (d_1), s/veh	41.6	10.3	12.1	46.0	20.2	15.4

DETAILED INPUT DATA – General	
Number of Calculation Iterations	15
Critical Merge Gap, s	3.70
Stored Vehicle Lane Length, ft	25.0
Length of Detected Vehicle, ft	17.0
Stored Heavy Vehicle Length, ft	45.000
Queue Length Percentile	50
Acceleration Rate, ft/s2	3.50

STAFF SPOTLIGHT

Ming Li

Web DevOps Team Lead

I joined McTrans two years ago after going through a detailed selection process for developers involving rounds of phone and technical interviews.

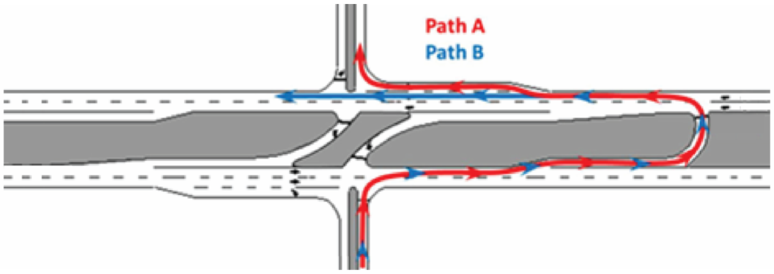
In the past year, I worked on developing a new online store for McTrans to replace the previously existing version of the store. This work was conducted while maintaining the old system fully functional to service our current and new customers. Meanwhile, I worked in collaboration with the University of Florida IT on cloud deployment efforts. At the end of this work cycle, we were able to complete the store implementation tasks and knowledge transfer to other developers in our team, who are now enabled to maintain and upgrade the system as needed.

The previous store systems, including the old online store, served McTrans for the past 30 years. Making the best use of the latest technology, the redesigned store was launched in August 2021 and has been available to the transportation industry ever since. It was a real thrill to accomplish this goal and to be part of that change.

Analyzing the performance of RCUT Intersections

Dr. Fabio Sasahara

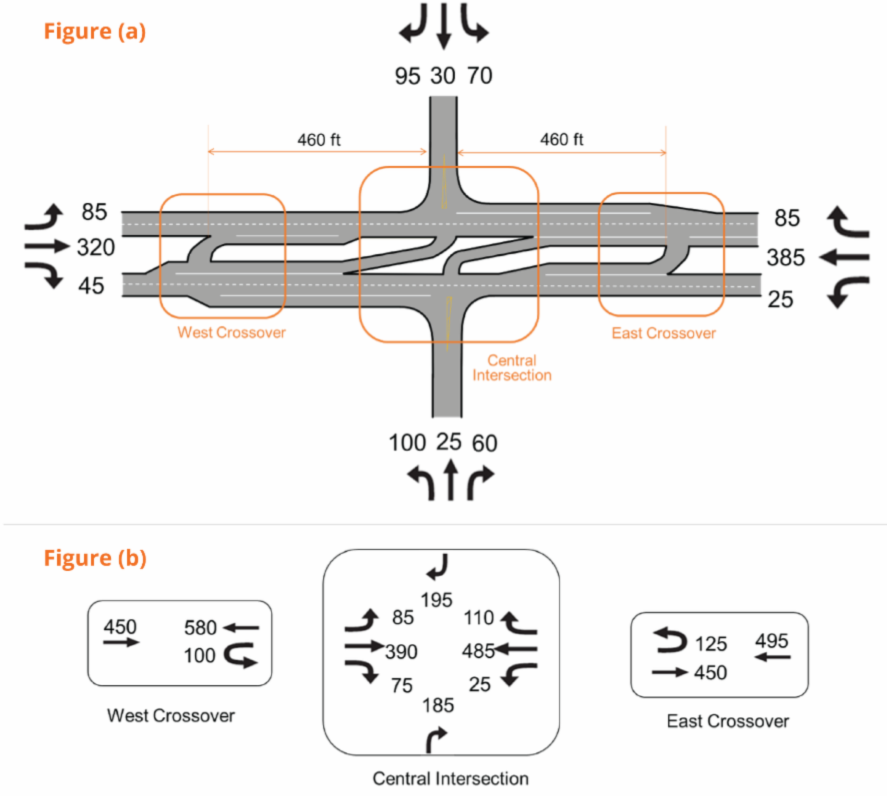
The Restricted Crossing U-Turn, or “Superstreet,” is a type of Alternative Intersection covered by the HCM methods. It works by prohibiting left-turn and through movements from the minor street. Therefore, drivers who want to perform these movements are required to perform a right-turn at the central intersection, followed by a U-turn in the adjacent crossover so they can proceed to their desired destination.



Diverted movements from the Northbound minor street approach (Source: Georgia Department of Transportation)

RCUT intersections can have both unsignalized or signalized operations, and both can be handled by HCS. This article will illustrate the application of the HCM methods to analyze a stop-controlled RCUT, which is handled by the Two-Way Stop Controlled (TWSC) module in HCS.

For this example, the major street is in the East-West direction; therefore, movements in the Northbound and Southbound approaches in the central intersection are diverted to an adjacent crossover. The next figure (a) illustrates the intersection geometry and its traffic demands. The first step in the analysis is to convert the actual demand in the RCUT to specific demands to the central intersection and crossovers, as shown in (b):



*Sample RCUT geometry with **(a)** turning movement demands and **(b)** specific demands for the central intersection and crossovers*

The first step in the analysis is to convert the original demand in the RCUT to specific movements at the central intersection and crossovers, as shown in the following figure:

The NB approach can be used to illustrate this process: the actual demand shown in the previous figure is 100 veh/h (Left) + 25 veh/h (Through) + 60 veh/h (Right). The total demand of 185 veh/h is then assigned to the right-turn movement, which is the only permitted movement in the NB approach. Next, the total diverted demand in the NB approach (100veh/h for left and 25 veh/h for through) is assigned to the U-turn maneuver in the East Crossover. This process is then repeated for all movements in the intersection.

Next, the RCUT can be modeled with HCS using the following steps:

1. Create a TWSC file for the Central Intersection

a. "General" page: check the "RCUT Alternative Intersection" box and select the intersection type "RCUT with Stop Signs"

b. “Traffic" page: provide converted demands for the central intersection

c. “RCUT" page: provide actual demands for the intersection and required geometry inputs, such as storage lengths and distance from the main intersection to crossovers (460 ft)

2. Create one TWSC file for each crossover

a. “General” page: check the “MUT/RCUT Crossover Intersection” box

b. “Traffic”: provide converted demands for the crossover

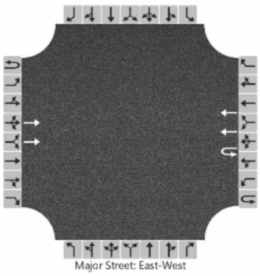
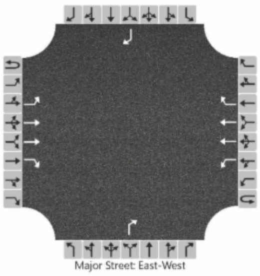
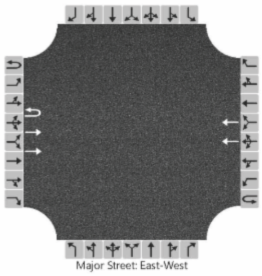
c. Save and close the file

3. Go back to the Central Intersection file and under the “RCUT” page, import the TWSC files for each crossover

After all required inputs are provided, the performance measures for every O-D pair (Experienced Travel Time, per HCM Chapter 23) will be provided in the HCS Report as shown:

HCS7 Alternative Intersections Results Summary

Demand	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
Intersection One Demand (*v*), veh/h			450		100		580									
Intersection Two Demand (*v*), veh/h	0	85	390	75	0	25	485	110				185				195
Intersection Three Demand (*v*), veh/h	125		450				495									

(1) West Crossover	(2) Main Intersection	(3) East Crossover
		

Queue-to-Storage Ratio	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
Intersection One (R_Q)					0.03											
Intersection Two (R_Q)		0.02				0.00						0.06				0.07
Intersection Three (R_Q)	0.04															

Alternative Intesection Results

O-D	O-D Movements	Flow Rate (veh/h)	Control Delay (s/veh)	EDTT (s/veh)	ETT (s/veh)	v/c>1?	R_Q>1?	LOS
EBL	EBL(2)	92	9.3	--	9.3	No	No	A
EBT	EBT(2)	348	0.0	--	0.0	--	--	A
EBR	EBR(2)	49	0.0	--	0.0	--	--	A
WBL	WBL(2)	27	8.5	--	8.5	No	No	A
WBT	WBT(2)	418	0.0	--	0.0	--	--	A
WBR	WBR(2)	92	0.0	--	0.0	--	--	A
NBL	NBR(2) + EBU(3) + WBT(2)	109	21.4	10.4	31.8	No	No	C
NBT	NBR(2) + EBU(3) + WBR(2)	27	21.4	10.4	31.8	No	No	C
NBR	NBR(2)	65	11.1	--	11.1	No	No	B
SBL	SBR(2) + WBU(1) + EBT(2)	76	21.7	10.4	32.1	No	No	C
SBT	SBR(2) + WBU(1) + EBR(2)	33	21.7	10.4	32.1	No	No	C
SBR	SBR(2)	103	11.9	--	11.9	No	No	B

HCS report for RCUT intersection

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