HCM 2010 Enhancement:

Turning Movement: Exclusive + Shared Lane Approach Geometry

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## Objective

The approach geometry where the turning movement has an exclusive lane, and is also shared is not currently supported in the HCM 2010 computation.

To overcome this limitation, we apply balancing of lanes and volumes using equivalency factors, so as to re-create similar effect of the original lanes and volumes, in an approach geometry that is HCM 2010 compliant.

## Limitations:

1. Lane utilization are approximately equal:

The algorithm is based on the assumption that the lane utilization for the shared lane and the exclusive lane is approximately equal. If multiple lanes are present, drivers tend to choose the lane that minimizes their service time, which results in relatively equal lane use under most circumstances.

1. Phasing indifference:

The left turning volume in shared lane is independent of the Left turn type. The algorithm works under the assumption that the left turning vehicles would prefer the shared lane as much as the exclusive lane irrespective of the left turn type.

## Volume Balancing Algorithm:

This subsection explains the algorithm designed to help achieve our objective.

When drivers approach an intersection, their primary criterion for lane choice is movement accommodation (i.e., left, thru, or right). If multiple exclusive lanes are available to accommodate their movement, they tend to choose the lane that minimizes their service time (i.e., the time required to reach the stop line, as influenced by the number and type of vehicles between them and the stop line). This criterion tends to result in relatively equal lane use under most circumstances.

The volume balancing algorithm extends the notion of relatively equal lane use to movements with shared and exclusive lanes. If a driver arrives at an approach with multiple lanes to make the desired movement, the driver chooses the least occupied among available lane options.

By computing the average volumes among the lanes with Left / Thru and Right movements, the approximate lane by lane distribution of the each of the movements is computed. This leads to dividing each movement volume into ‘Shared Lane component’ and ‘Exclusive Lane component’.

The shared volume components are used to determine if the shared lane is acting as a de facto of one of it composing movements, i.e. if the shared Left-Thru lane has a much higher presence of Lefts, than thrus, we observe that the shared lane can be analyzed as a de facto Left, and vice versa.

* **Step 1**: Lane by Lane break down of the Movement Volumes:

Distribute the total approach movement into each movement volume, based on the approach geometry.

* **Step 2:** Compare the Volume in Shared Lane in each of the Shared Lanes,

During the shared volume of the turning movement comparison with the Thru movement, a preference factor is used to bias our preference towards the Thru over the Left, and Lefts over the Right movement. Preference Factor is set at ‘0.9’.

* **Step 3:** Balance the volumes:

For a Shared Lane acting as a de facto Left/Right Lane, the total Left/Right Volume is the summation of volumes of each of the exclusive left/right lanes, and the shared volume of the Thru movement adjusted by an equivalency factor. Also, the Thru movement volume in decreased by the shared volume of Thrus added to the Left/Right movement.

Similarly, for a Shared Lane acting as a de facto Thru Lane, the total Thru movement volume is the summation of the volumes of each exclusive Thru lane, and the shared volume of the turning movement(s), adjusted by the equivalency factor. The volume of the turning movement is decreased by the shared volume added to the Thru movement.

The following diagrams illustrate the working of ‘Volume Balancing’ algorithm:

Step 1: Lane by Lane break down of the Movement Volumes:

Step 2: Compare the Volume in Shared Lane in each of the Shared Lanes,

**Shared Lane 1: Shared Lane 2:**

Depending on the greater volume of the two shared components, the Shared Lane acts as:

* Step 3: Balance the volumes:

For a Shared Lane acting as a de facto Left/Right Lane, the total Left/Right Volume is the summation of volumes of each of the exclusive left/right lanes, and the shared volume of the Thru movement adjusted by an equivalency factor. Also, the Thru movement volume in decreased by the shared volume of Thrus added to the Left/Right movement.

Similarly, for a Shared Lane acting as a de facto Thru Lane, the total Thru movement volume is the summation of the volumes of each exclusive Thru lane, and the shared volume of the turning movement(s), adjusted by the equivalency factor. The volume of the turning movement is decreased by the shared volume added to the Thru movement.

The following are the equivalency factors used in the 804 version implementation.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Left Lane | Thru Lane | Right Lane |
| Left vehicle | 1 | 1.4 | 0.9 |
| Thru vehicle | 0.7 | 1 | 0.67 |
| Right vehicle | 1.07 | 1.5 | 1 |

**Implementation:** (May be omitted from the white paper)

Approach geometries with turning movement having an exclusive and shared lane can be classified into six groups. The following table gives their description and possible outcomes:

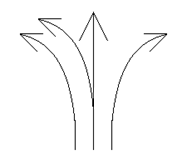
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| # | Description | Original | Possible Approach Geometry | | |
| 1 | At least 1 Left Ex  1 Thru Shared L +R  At least 1 Right Ex |  |  |  |  |
| 2 | At least 1 Left Ex  1 Thru Shared L +R  No Right Ex Lanes |  |  |  |  |
| 3 | No Left Ex Lanes  1 Thru Shared L +R  At least 1 Right Ex |  |  |  |  |
| 4 | At least 1 Left Ex  At least 2 Thru Shared L +R  At least 1 Right Ex |  |  |  | \* |
| 5 | At least 1 Left Ex  At least 1 Thru Shared L  Right: N/A |  |  |  |  |
| 6 | Left: N/A  Thru: At least 1 Thru Shared R  Right: At least 1 Ex |  |  |  |  |

*Note: \* “Possible Approach Geometry” may not be an exhaustive list of all possible geometries.*

### Illustrated Example:

Consider the above illustrated approach geometry with one exclusive left and right turning lanes, and one thru lane share with both left and right.

Let the original volumes be represented as VL, VT and VR respectively.



Let the Left volume in shared lane be denoted by VLS, and volume in exclusive lane be VLEx.

Hence, **VL = VLS + VLEx**

Similarly, Let volume in shared lane be denoted by VRS, and volume in exclusive lane be VRex.

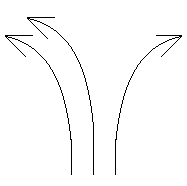
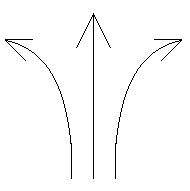
Hence, **VR = VRS + VRex**

Since there is only one Thru lane, all of the Thru volume **VT** is in the shared lane.

Comparing the volume in shared lane by left, thru and Right movements; we can classify the shared lane into a de-facto left, de-facto Thru, or de-facto Right.

|  |  |  |
| --- | --- | --- |
| Shared Lane Classification | Conditions | |
| De-facto Left | VLS is much\* greater than VT | VLS is much\* greater than VRS |
| De-facto Thru | VT is much\* greater than VLS | VT is much\* greater than VRS |
| De-facto Right | VRS is much\* greater than VLS | VRS is much\* greater than VT |

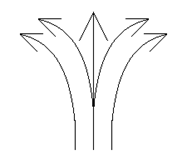
Note: \* Comparing the shared volumes is influenced by a “Preference factor”.

 OR 

De facto Left De facto Thru

## Results:

The following are the some of the results from the following approach geometry:



|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Approach Type | Original Volumes | | |  | Balanced Volumes | | | Shared Lane acting as: |
| L | T | R | L | T | R |
| 1 | Single Left, Single Right | 500 | 50 | 50 | 536 | 0 | 50 | de facto Left |
| 2 | Single Left, Single Right | 500 | 100 | 100 | 571 | 0 | 100 | de facto Left |
| 3 | Single Left, Single Right | 500 | 115 | 50 | 582 | 0 | 50 | de facto Left |
| 4 | Single Left, Single Right | 15 | 1 | 1 | 15 | 1 | 1 | de facto Left |
| 5 | Single Left, Single Right | 50 | 500 | 50 | 50 | 500 | 50 | de facto Thru |
| 6 | Single Left, Single Right | 100 | 500 | 100 | 109 | 543 | 109 | de facto Thru |
| 7 | Single Left, Single Right | 120 | 200 | 120 | 130 | 217 | 130 | de facto Thru |
| 8 | Single Left, Single Right | 120 | 50 | 120 | 105 | 113 | 105 | de facto Thru |
| 9 | Single Left, Single Right | 50 | 50 | 500 | 50 | 0 | 533 | de facto Right |
| 10 | Single Left, Single Right | 100 | 100 | 500 | 109 | 0 | 616 | de facto Right |
| 11 | Double Right, Single Left. | 50 | 50 | 300 | 54 | 0 | 362 | de facto Right |
| 12 | Single Left, Single Right | 1 | 1 | 15 | 1 | 0 | 17 | de facto Right |

Note: Volume in the format of L-T-R

## ~~Conclusion:~~

~~Concerns:~~

~~May be lane use factor is not used correctly?~~

~~Traffic in Shared lane?~~

~~Lane Group Flow?~~

~~If one of the lanes being considered is a shared lane, then service time is influenced by the distribution of turning vehicles in the shared lane. Turning vehicles tend to have a longer service time because of the turn maneuver.~~

Assumption: ~~The volume distribution in each of the lanes is based on the intent to make the volumes in each lane approximately equal, which in turn leads to almost equal queue lengths.~~

~~Once the shared lane is defined as the above, the volumes are adjusted with equilibrium factors.~~

~~distribute the total turning movement volume into two, i.e. volume in each exclusive lane, and volume in the shared lane. Similarly, we~~

~~Based on the turning movement volume in shared lane component, and comparing it with the volume in shared lane of the other movement present in the shared lane, the shared lane can be observed to be acting as a ‘de facto turning’ or ‘de facto Thru’ lane. In each case, the volume component of the other~~

~~If there exists a turning movement (Left turning or Right turning) that is shared with a Thru movement, with an exclusive lane,~~