LANE CHANGE RATES AT FREEWAY WEAVING SITES: TRENDS IN HCM6 AND FROM NGSIM TRAJECTORIES(#19-05033)

Ishtiak Ahmed, Dezhong Xu, Nagui Rouphail, Alan Karr

INTRODUCTION

This study explores the sensitivity of HCM6 weaving method LOS to weaving length and analyzes the trend of lane change rates (per vehicle) with density. HCM6 predicted lane change rates are compared to NGSIM data from the US-101 site in California. In addition, several lane change characteristics at the NGSIM site were analyzed to identify the extent, direction, and motivation of discretionary lane changes in weaving areas.

HCM6 Weaving Method and Segment Length

The HCM6 model for estimating non-weaving vehicle speed is not sensitive to the segment length. Consequently, overall speed, density, and LOS which are derived from it show little sensitivity to length

An example problem: *Simple ramp weave with Demand=6,480 pc/hr, FFS=60 mph, number of lanes, N=6, interchange density=2 per mi., and weaving ratio, VR=0.39.*

Weave Length (ft)	Total Lane Changes	Weaving speed (mph)	Non-weaving speed (mph)	Overall Speed (mph)	Density (pc/mi/ln)	LOS
500	3,008	38.3	36.6	37.24	29.00	D
750	3,312	41.0	36.6	38.20	28.27	D
1,000	3,625	42.7	36.6	38.76	27.86	C
1,250	3,908	43.9	36.6	39.14	27.59	C
1,500	4,172	44.9	36.6	39.44	27.38	C
1,750	4,424	45.6	36.6	39.65	27.24	C
2,000	4,666	46.2	36.6	39.83	27.12	C

- By quadrupling length from 500 to 2,000 ft., density decreased by only 1.82 pc/mi/lane (or ~6.3%).
- Non-weaving vehicles should also benefit from extending the length by spacing the lane changes over a longer distance

Lane Change Rate vs. Density: HCM6 vs. NGSIM

HCM6 Method: In HCM6, lane change rates for weaving vehicles (LCV_W) are predicted to decrease with overall density The trend is reversed for non-weaving vehicles (LCV_{NW}).

NGSIM US-101 data: *Duration = 45 min.; VR= 0.1; Space Mean Speed (SMS) = 21~30 mph; density ~ 50pc/mi/lane.*

Comparison: All parameters are kept the same as in the NGSIM data. Analysis with a higher VR (=0.40) is also shown.

Lane Change Rates v. Density for Ramp Weave Segment with L= 698' & N=6
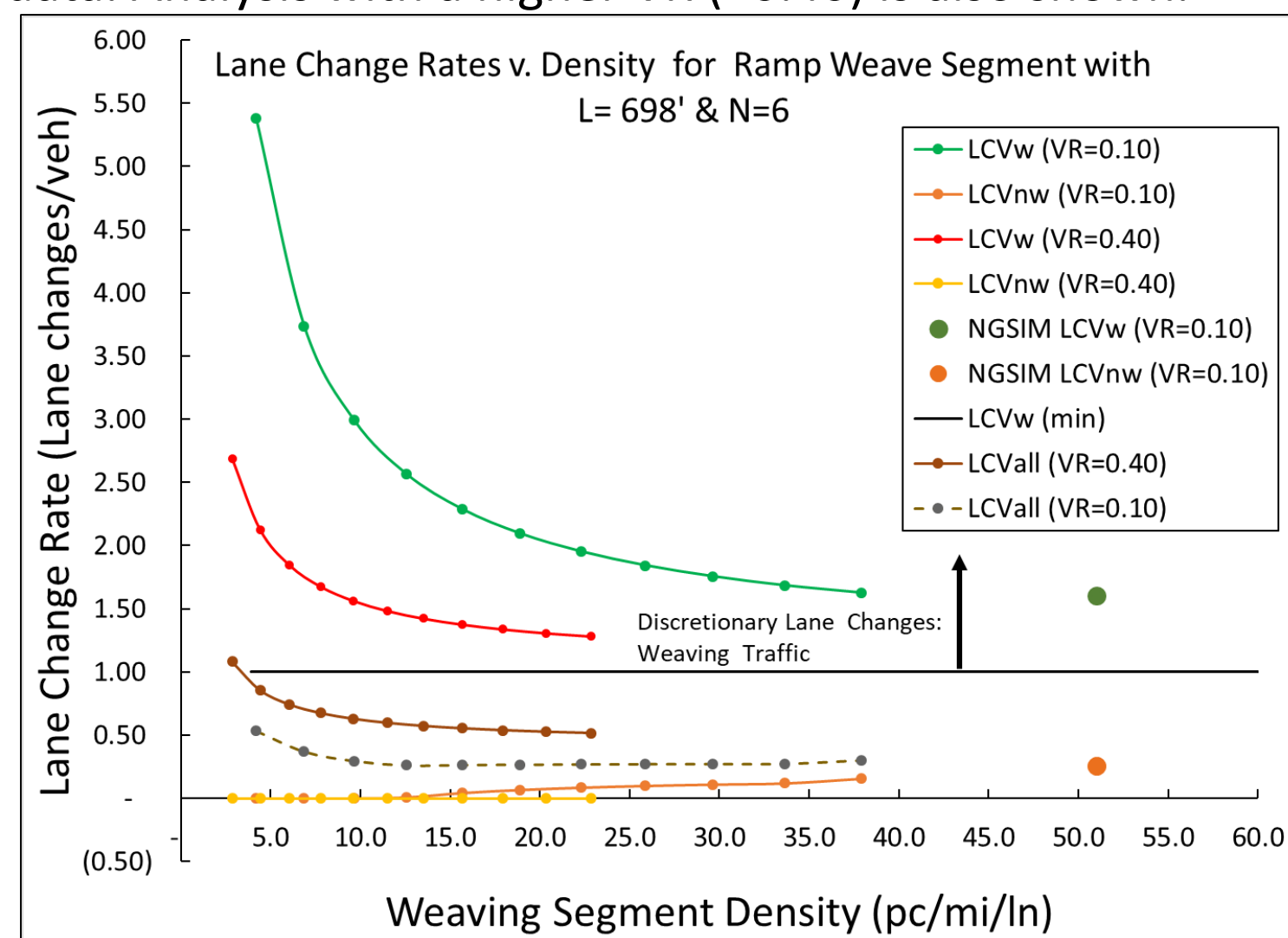
- LCV_W of the NGSIM data follows the trend generated by the HCM6 weaving model.
- One may claim the same for LCV_{NW}, but its counterintuitive trend – more lane changes at higher density ---predicted in HCM6 model makes the claim less plausible.

Location of Weaving Lane Changes

- Spatial distribution of lane changes is an important criterion for designing the length of the auxiliary lane.
- Distance from the gore of the entry ramp is estimated for all lane changes between the auxiliary and the rightmost freeway lane at the NGSIM site.

- Over 50% of all weaving lane changes were completed within the first 110 ft, only **16% of the weave short length**
- Very early lane changes by Freeway to Ramp vehicles is attributed to the higher achievable speed in the auxiliary lane proper, compared to the speed on right lane freeway
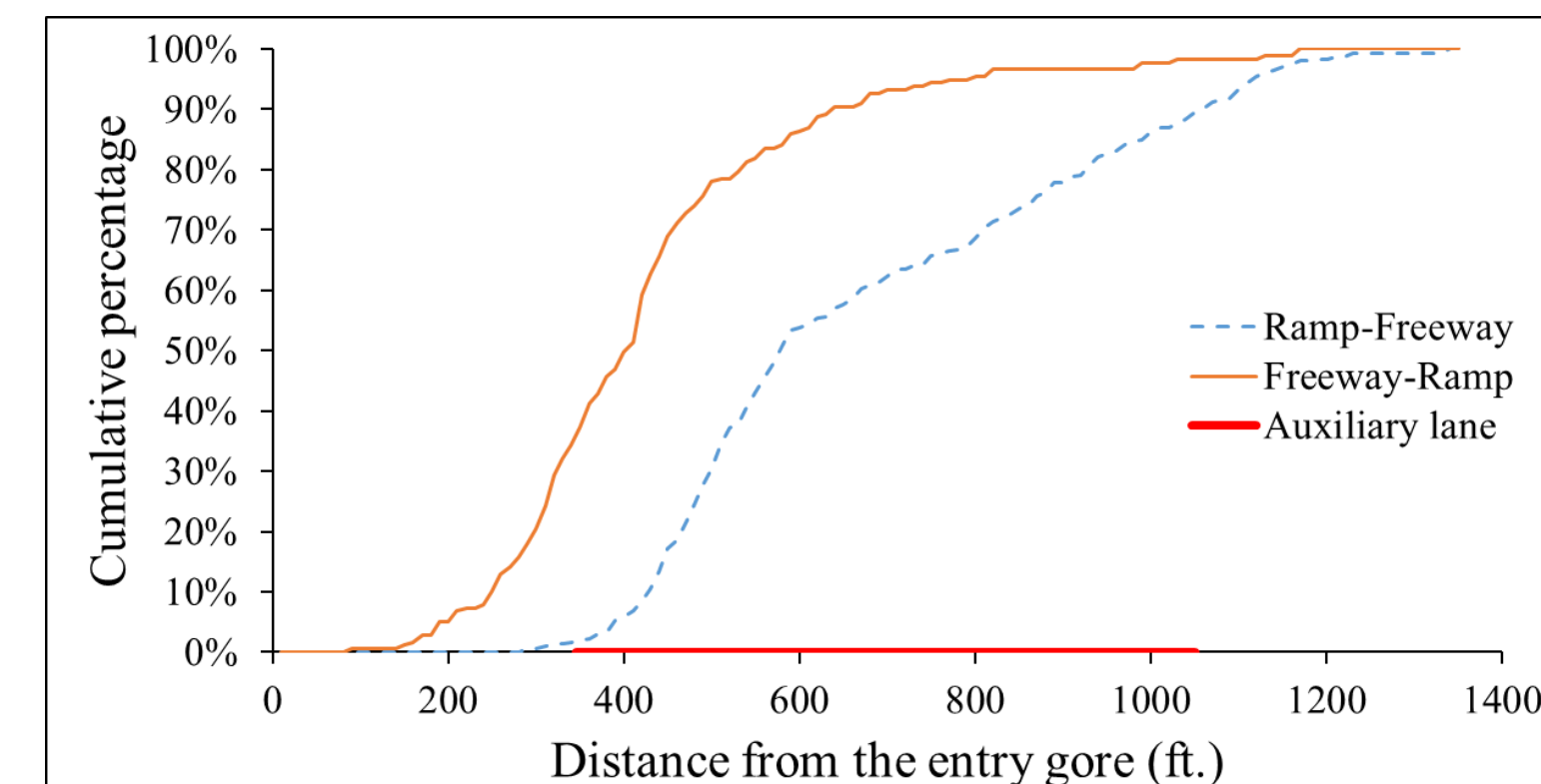

Discretionary Lane Changes by Lane OD

- This metric reveals how often and between which lanes discretionary lane changes were made at the NGSIM site.
- The highest % where for vehicles **moving further to the right** (e.g., from lanes 1→3, 2→4, 3→4 and 4→5) on the freeway mainline, with lane 6 being the auxiliary lane
- The average weaving vehicle had a **0.60** discretionary lane change rate, compared to **0.28** for a non-weaving vehicle.

% vehicles executing discretionary lane changes by start and end lanes in weave	To 1	2	3	4	5	Aux. Lane
1 (Far Left)	1.5%	7.0%	33.5%	0.0%	0.0%	0.0%
2	6.0%	1.0%	13.5%	20.0%	0.0%	0.0%
3	0.0%	1.0%	3.0%	28.5%	0.0%	0.0%
4	0.0%	4.5%	10.5%	3.5%	36.5%	0.0%
5	0.0%	0.0%	8.0%	11.5%	3.0%	2.0%
Aux. Lane	0.0%	5.5%	4.0%	9.5%	7.0%	0.0%

Lane Change Frequency and Resulting Speed

- To investigate the motivation for changing lanes, non-weaving vehicles are grouped by their lane change frequency.
- In most cases, more frequent lane changes yielded a higher space mean speed.
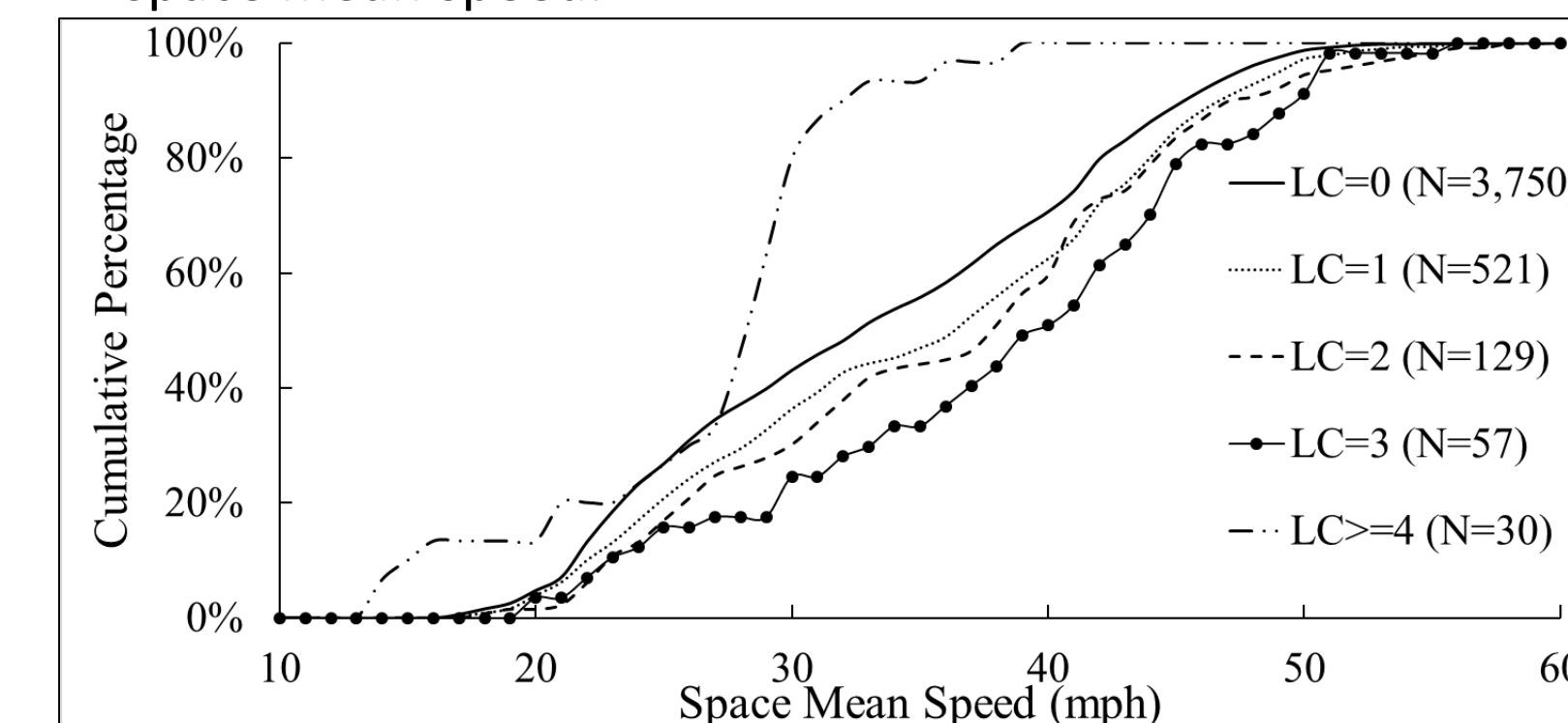
CONCLUSIONS

- The minimal sensitivity of HCM6 weaving method to the segment length and the unexpected trend in non-weaving lane change rate against segment density underscore the need for improving the HCM6 weave method
- NGSIM data revealed the expected trend of lane change rate in a congested condition. Moreover, the trend of lane change origination between freeway and ramp vehicles revealed here is unique due to the large speed imbalance in favor of the auxiliary lane.
- Discretionary lane changes for non-weaving vehicles actually yielded higher speeds/ lower travel times for those drivers. Their effect on neighboring vehicles is unclear and should be evaluated in future research.

ACKNOWLEDGMENTS