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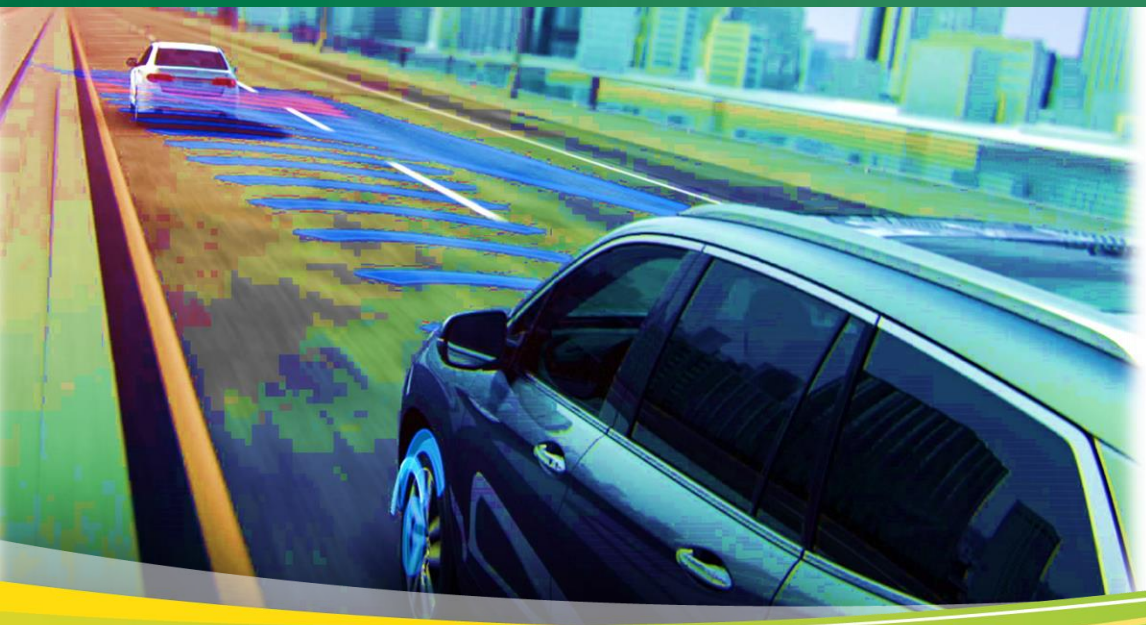
SAFETY, MOBILITY, AND ENVIRONMENTAL IMPACTS OF FORWARD COLLISION WARNING ALGORITHMS ON A ROADWAY NETWORK



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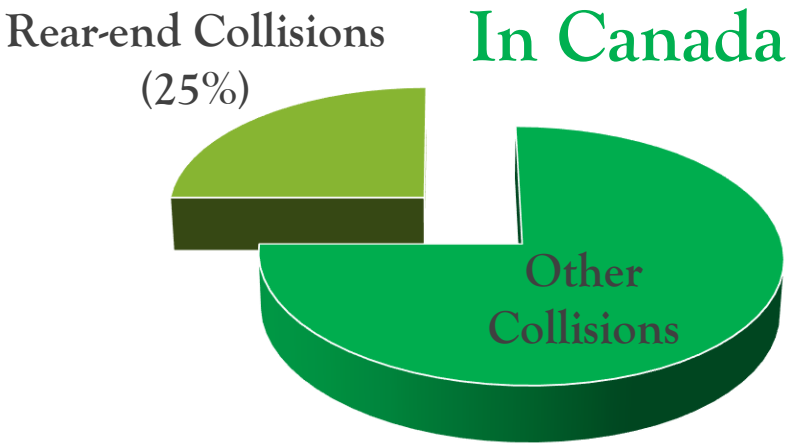
INTRODUCTION

BACKGROUND

- Rear-end collisions are one of the most frequent types of collisions occurring on North American roads [1,2]

- Forward Collision Warning (FCW) algorithms were introduced as an active countermeasure to avoid these collisions



INTRODUCTION

BACKGROUND

- Several studies were conducted to compare the efficiency of various FCW algorithms on a microscopic/individual level [4,5]

- Since the implementation of FCW technologies is expected to occur in a gradual manner over multiple years, the impact of these technologies is worth investigation on a network level

INTRODUCTION

OBJECTIVES

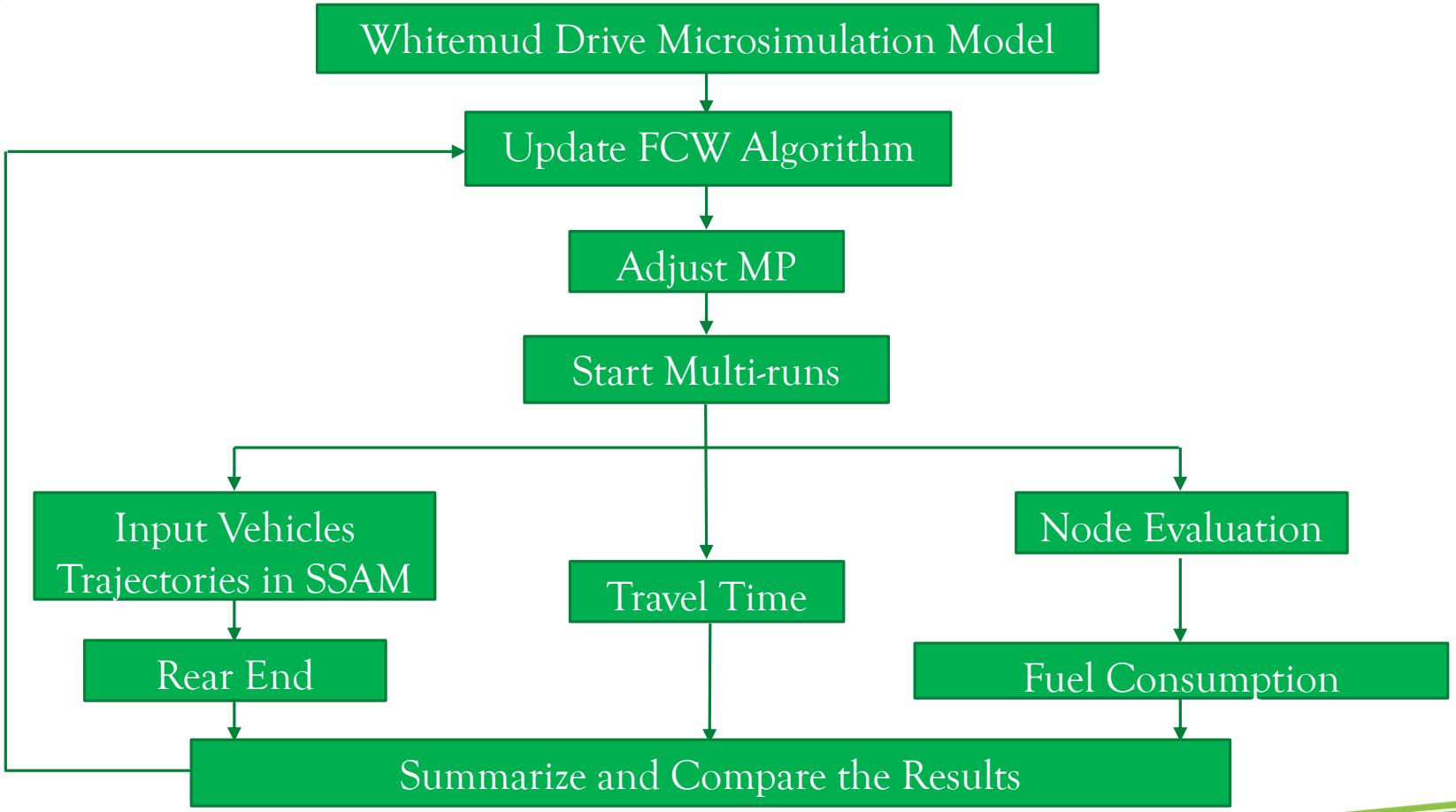
- Assess and compare different FCW algorithms from a safety, mobility, and environmental perspectives under varying market penetration rates (i.e., 25%, 50%, 75%, and 100%)

Forward Collision Warning Algorithms Comparison

Study Area

Forward Collision Warning Algorithms Comparison

Framework



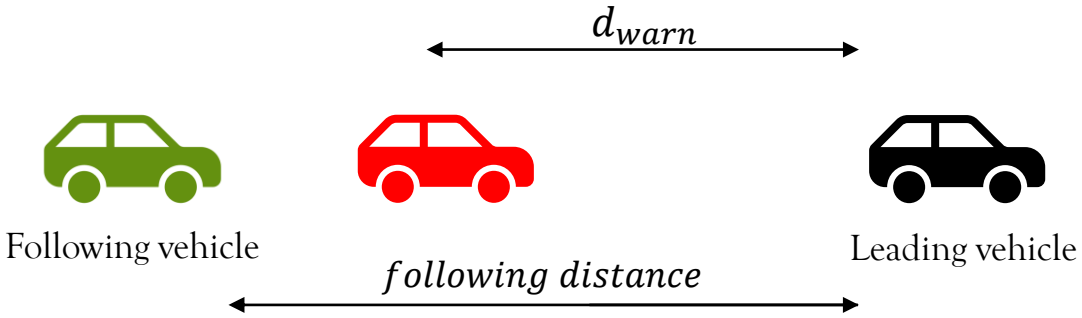
Forward Collision Warning Algorithms Comparison
Whitemud Driver Microsimulation Model

- A previously calibrated VISSIM model representing Whitemud Drive evening peak hours was used[7,8]
- External driver models were coded to make the cars that have an FCW decelerate when needed
- The cars will decelerate based on the braking distance which differs from an algorithm to another

Forward Collision Warning algorithms comparison

FCW Algorithms

- Six of the most commonly cited FCW algorithms[8-13] were modeled in VISSIM and the results of the MOEs were compared on a network basis



Forward Collision Warning Algorithms Comparison
Modeling Assumptions

- The FCW car is equipped with sensing technology which is in a perfect condition and the braking distance with sufficient accuracy

- The model assumes the maneuver is followed perfectly regardless of any variations (i.e., mechanical components, warning system interface or drivers' braking application)

Forward Collision Warning Algorithms Comparison
Modeling Assumptions

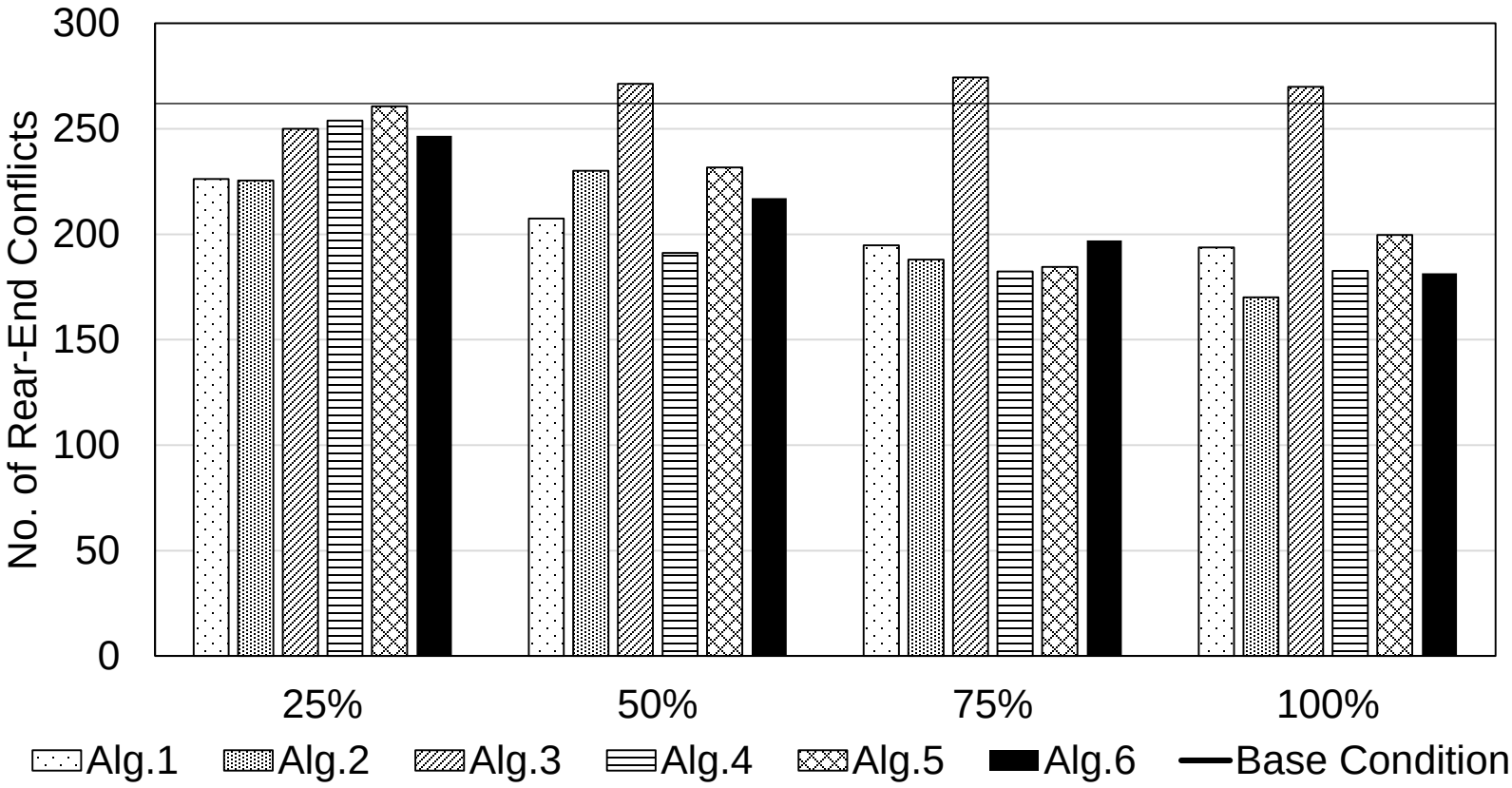
- Each algorithm was modeled based on its own assumptions with respect to driver and system delays.

- The weather condition is clear and stable and has no effect on the drivers' and/or vehicles' performance.

Forward Collision Warning Algorithms Comparison
Measures of Effectiveness

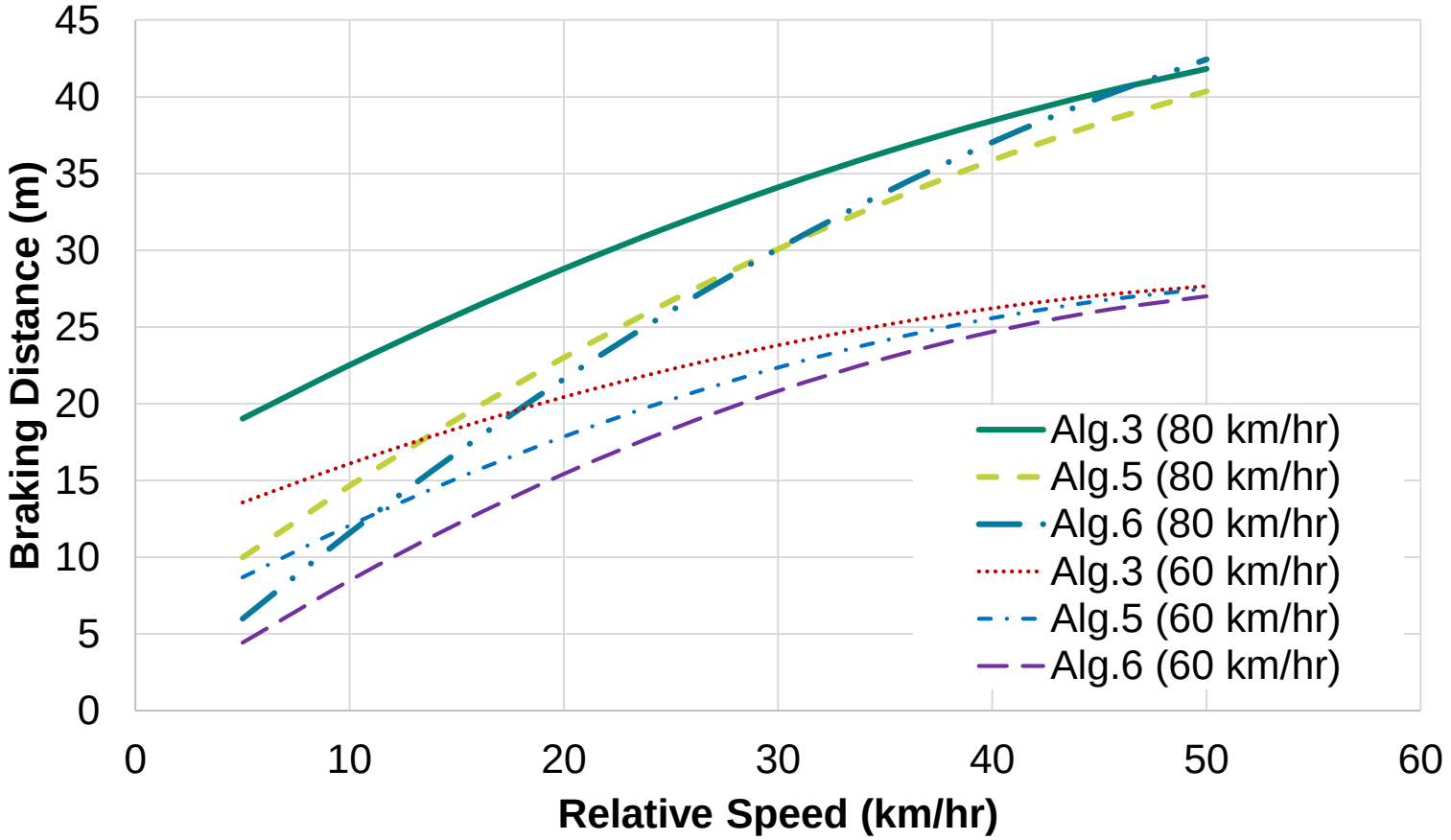
- **Safety measure:** rear-end conflicts
- **Mobility measure:** travel time
- **Environmental measure:** fuel consumption

Results
Rear-end Conflicts

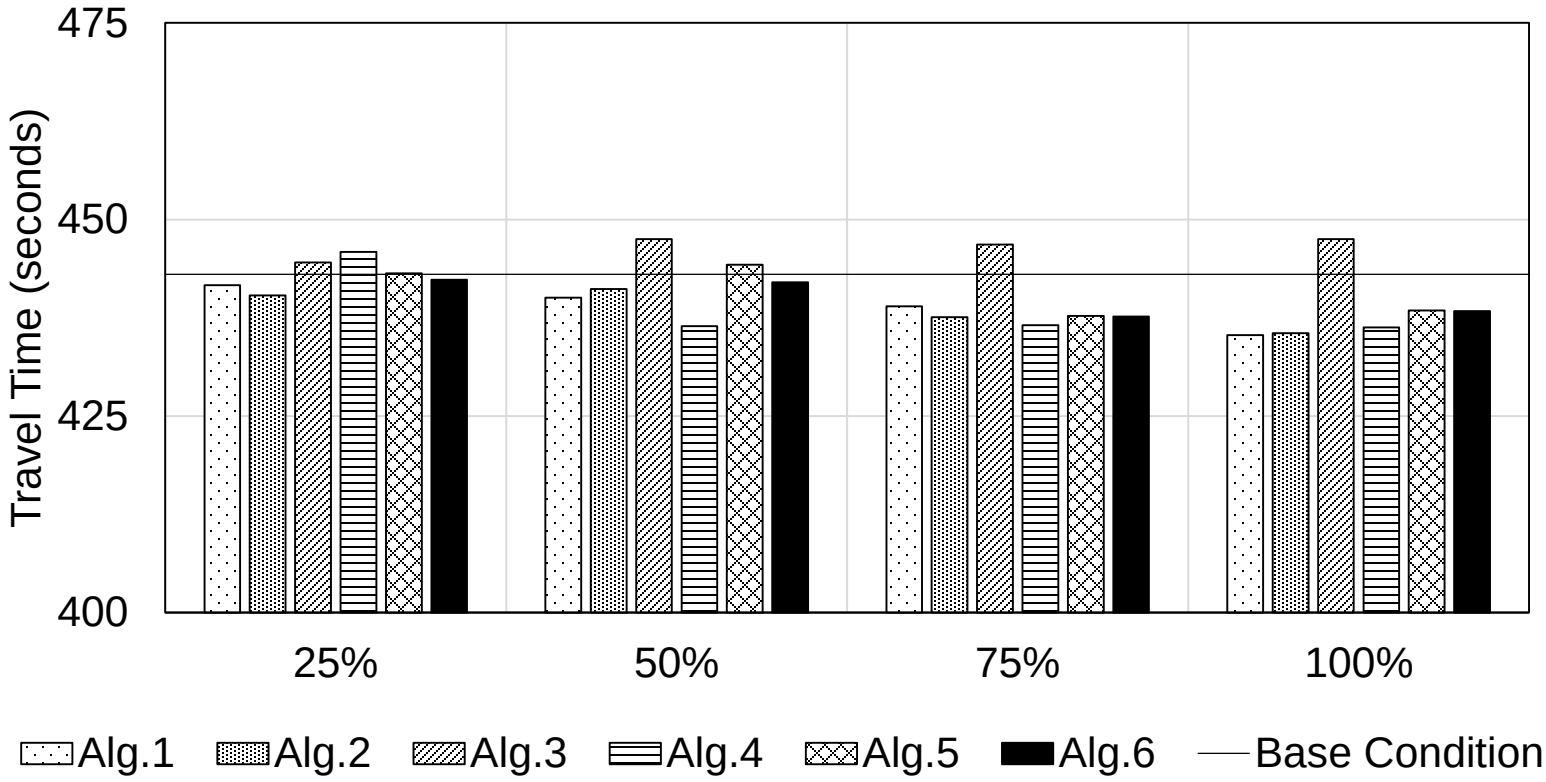


Results

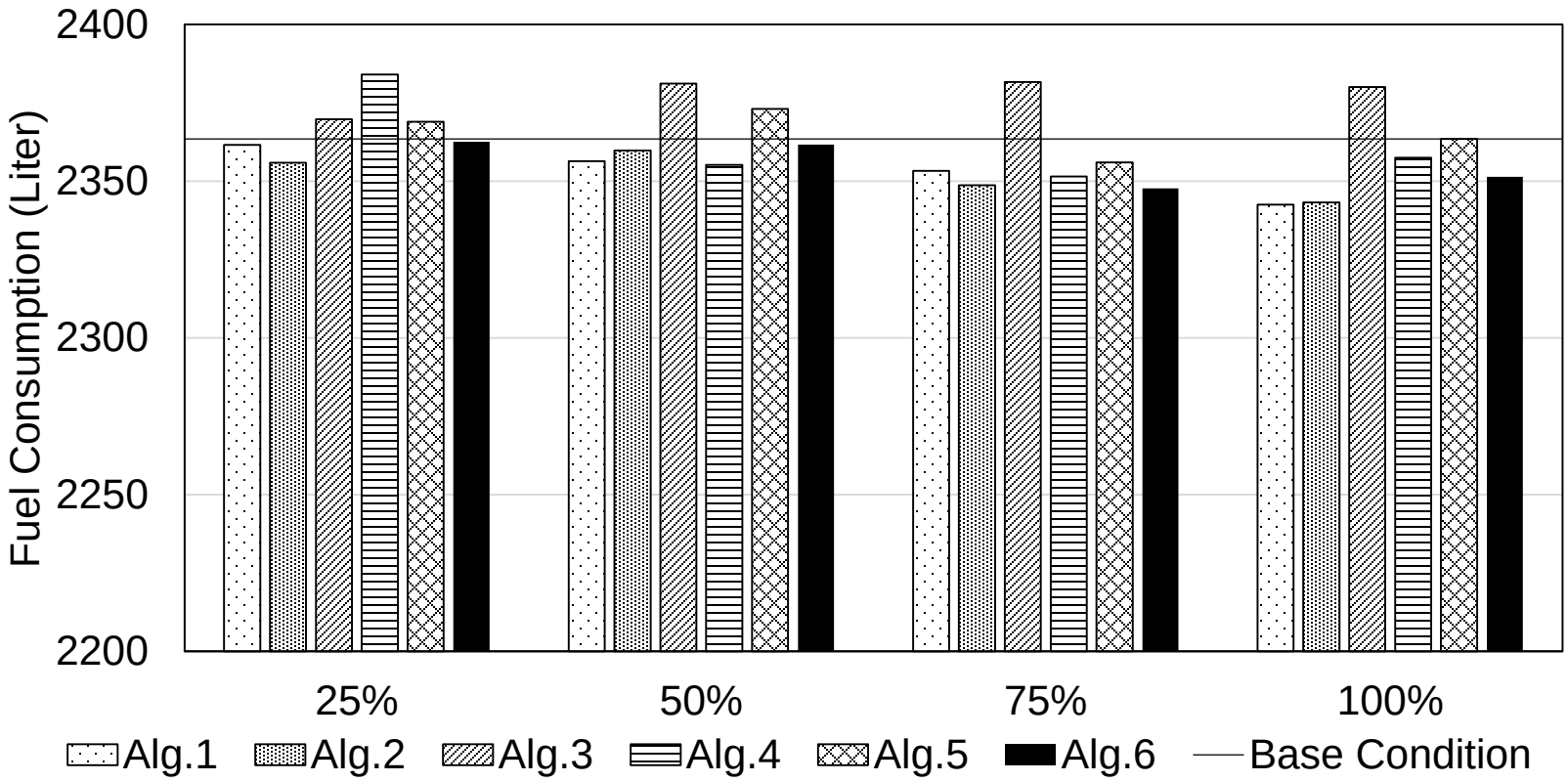
Rear-end Conflicts



Results
Travel Times



Results
Fuel Consumption



Conclusions

- Systematic improvements (i.e., on the network level) caused by the FCW systems will generally overlap with the situational improvements (i.e., on a driver level)

- More tangible improvements were noticed with higher penetration rates

Conclusions

- Generally, safety benefits on the network level for most of the FCW algorithms did not have a substantial effect on mobility and environment

- The FCW systems, which did not provide a network-level safety benefit, were more likely to have negative impacts on mobility and environment

Conclusions

- The more conservative algorithms (e.g., Alg.3) in terms of braking distance (i.e., longer distance) had inconsistent results on a network level for all measures

- Alg.2, which is a perceptual FCW algorithm, gave the best results in terms of safety benefits

Limitations and Future Research

- The modeled FCW algorithms assumed perfect drivers' compliance and sensing capabilities
- Varying levels of service and weather conditions were not taken in consideration while modeling the FCW algorithms
- The assessment of integrating the FCW systems with other Connected Vehicle applications should be investigated

REFERENCES

1. National Safety Council, "National Safety Council Injury Facts," 2015.
2. Transport Canada, "National Collision Database Online," 2017.
3. P. Seiler, B. Song, and J. Hedrick, "Development of a collision avoidance system," *Automot. Eng.*, vol. Vol. 106, pp. 24–28, 1998.
4. L. Yang, J. H. Yang, E. Feron, and V. Kulkarni, "Development of a Performance-Based Approach for a Rear-End Collision Warning and Avoidance System for Automobiles," pp. 316–321, 2003.
5. K. Lee and H. Peng, "Evaluation of automotive forward collision warning and collision avoidance algorithms," *Veh. Syst. Dyn.*, vol. 43, no. 10, pp. 735–751, 2005.
6. M. Hadiuzzaman, "Variable Speed Limit Control to Mitigate Freeway Congestion," University of Alberta, Canada, 2014.
7. X. Wang, M. Hadiuzzaman, and T. Z. Qiu, "Analyzing Sensitivity of Freeway Capacity at a Complex Weaving Segment," in 2012 CSCE Conference, 2012, pp. 1–11.
8. R. Kiefer, D. LeBlanc, M. Palmer, J. Salinger, R. Deering, and M. Shulman, "Development and Validation of Functional Definitions and Evaluation Procedures For Collision Warning/Avoidance Systems," no. August, p. 75, 1999.
9. Y. Fujita, K. Akuzawa, and M. Sato, "Radar brake system," JSAE Rev., vol. 16(2), pp. 95–101, 1995.
10. A. Doi, T. Butsuen, T. Niibe, T. Takagi, Y. Yamamoto, and H. Seni, "Development of a rear-end collision avoidance system with automatic brake control," JSAE Rev., vol. 15, no. 4, pp. 335–340, 1994.
11. S. J. Brunson, E. M. Kyle, N. C. Phamdo, and G. R. Preziotti, "Alert Algorithm Development Program NHTSA Rear-End Collision Alert Algorithm," no. September, 2002.
12. P. Seiler, B. Song, and J. Hedrick, "Development of a collision avoidance system," Automot. Eng., vol. Vol. 106, pp. 24–28, 1998.
13. A. L. Burgett, A. Carter, R. J. Miller, and W. G. Najm, "A collison warnig alorithm for rear-end collision," Natl. Highw. Traffic Saf. Adm. Washington, DC, pp. 566–587, 1998.

Images:

https://automobiles.honda.com/images/2016/pilot/features-safety/forward-collision-warning.jpg
https://transformingedmonton.ca/get-there-faster-slow-down/

QUESTIONS?

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