Simulation of the Impact of the Autonomous and Connected Vehicles at a signalized Intersection

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Research Objective

The primary focus of this research is to evaluate if autonomous vehicles (AVs) can decrease the traffic congestion on roads and especially at an urban signalized intersection.

Introduction

- The Governors Highway Safety Association GHSA (2018) reported that more than 90% of automobile crashes are caused by human errors.
- An IIHS (2010) report points out that the high-end crash avoidance features in the AVs can prevent one of every three fatalities and prevent one of five fatal injuries caused by passenger vehicles.
- AVs could reduce the road fatalities by 30,000 each year in the US alone (KPMG 2017).
- AVs use smaller headway (gaps) between other vehicles and constant speeds in traffic stream which can reduce traffic congestion on roadways.
- In addition, an AV has less reaction time which can also reduce delays at the signalized intersections.

Methodology

- Using a real existing traffic count for the morning peak hour at a signalized intersection in Dayton, Ohio.
- Optimizing the intersection signal timing by using Synchro software.
- Using the PTV Vissim microscopic simulation to evaluate the efficiency of the signalized intersection in five different scenarios (Table 1).
- The parameters for the AV that have been used in the simulation are defined by CoEXist and are installed in PTV Vissim software (Table 2).

Table 1 Simulation Scenarios

Scenario	Description
1	100% Conventional Vehicles
2	50% Conventional Vehicles with 50% Autonomous Vehicles **(AV All-knowing CoEXist)**
3	100% Autonomous Vehicles **(AV Cautious CoEXist)**
4	100% Autonomous Vehicles **(AV Normal CoEXist)**
5	100% Autonomous Vehicles **(AV All-knowing CoEXist)**

Table 2 AV (CoEXist) Definitions

Definition under CoExist project		
AV Cautious:	AV Normal:	AV All-knowing:
✓Big gaps ✓Cautious behavior	✓Gaps similar to human drivers but with higher safety	✓Smaller gaps but still safe ✓Cooperative behavior

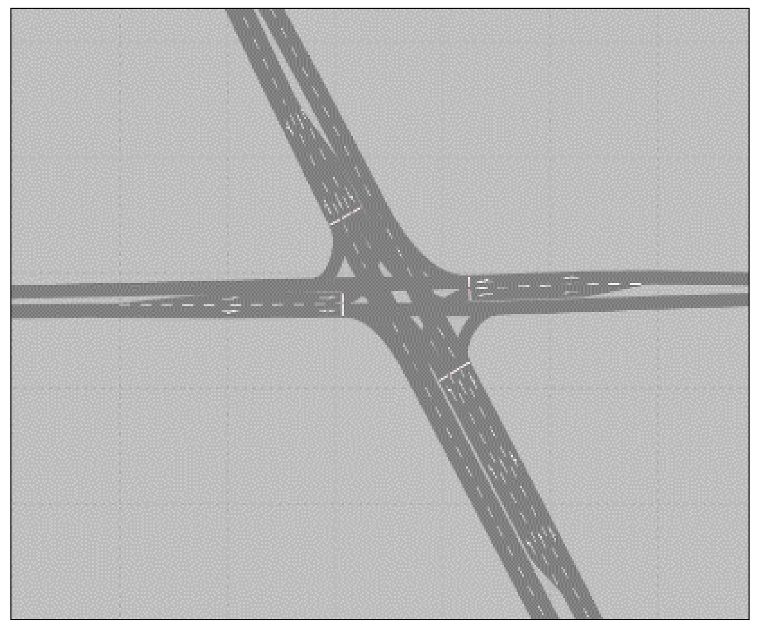

Fig.3 Simulation network model in Vissim

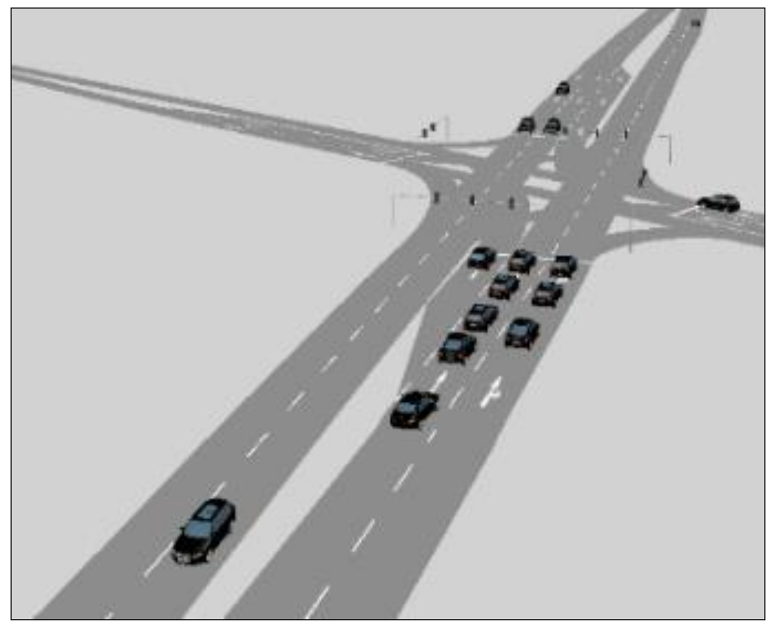

Fig.4 Simulation for scenario 1 in Vissim

Results

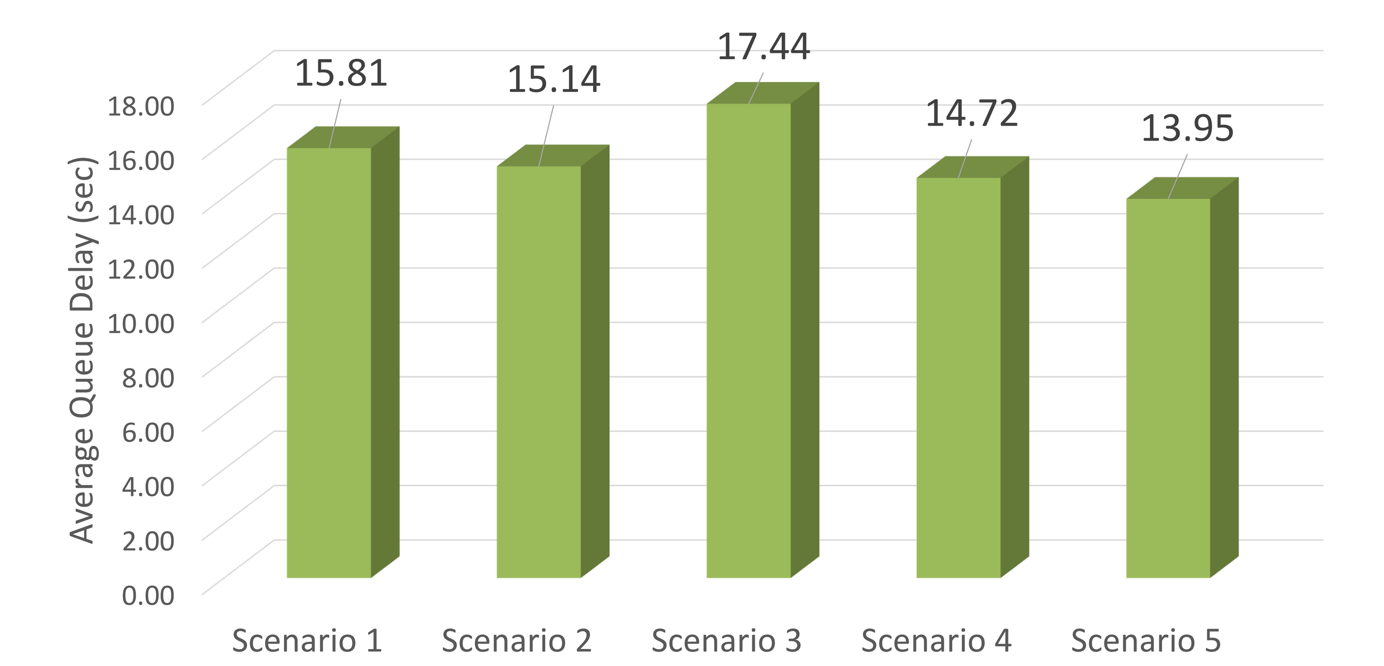

Fig. 5 Average Queue Delay at the Intersection

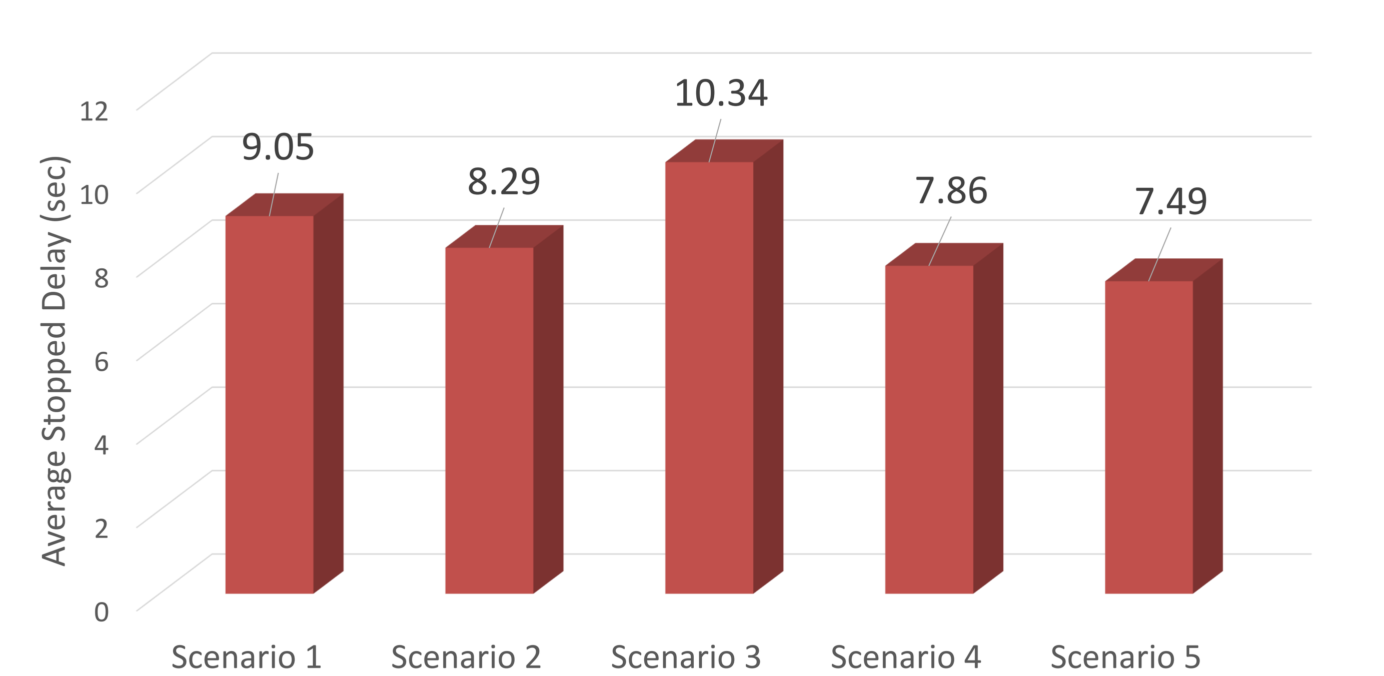

Fig. 6 Average Stopped Delay at the Intersection

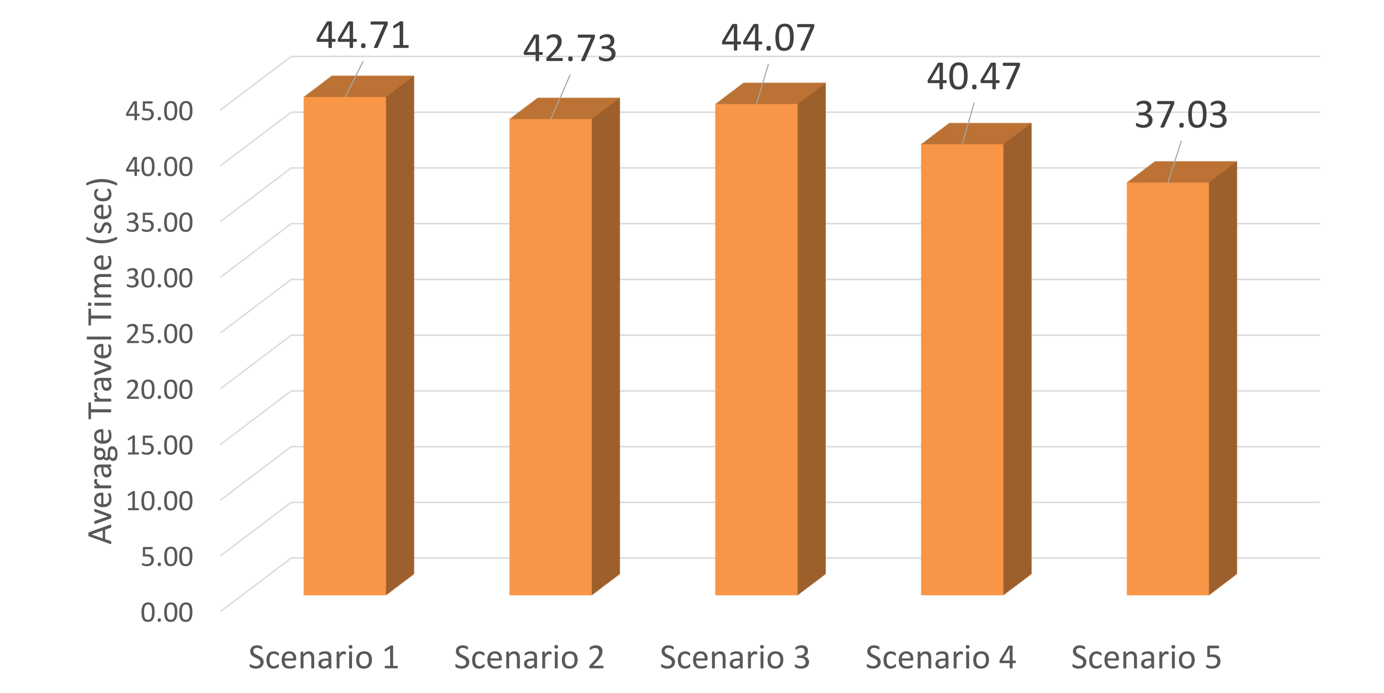

Fig. 7 Average Vehicle Travel Time at the Intersection

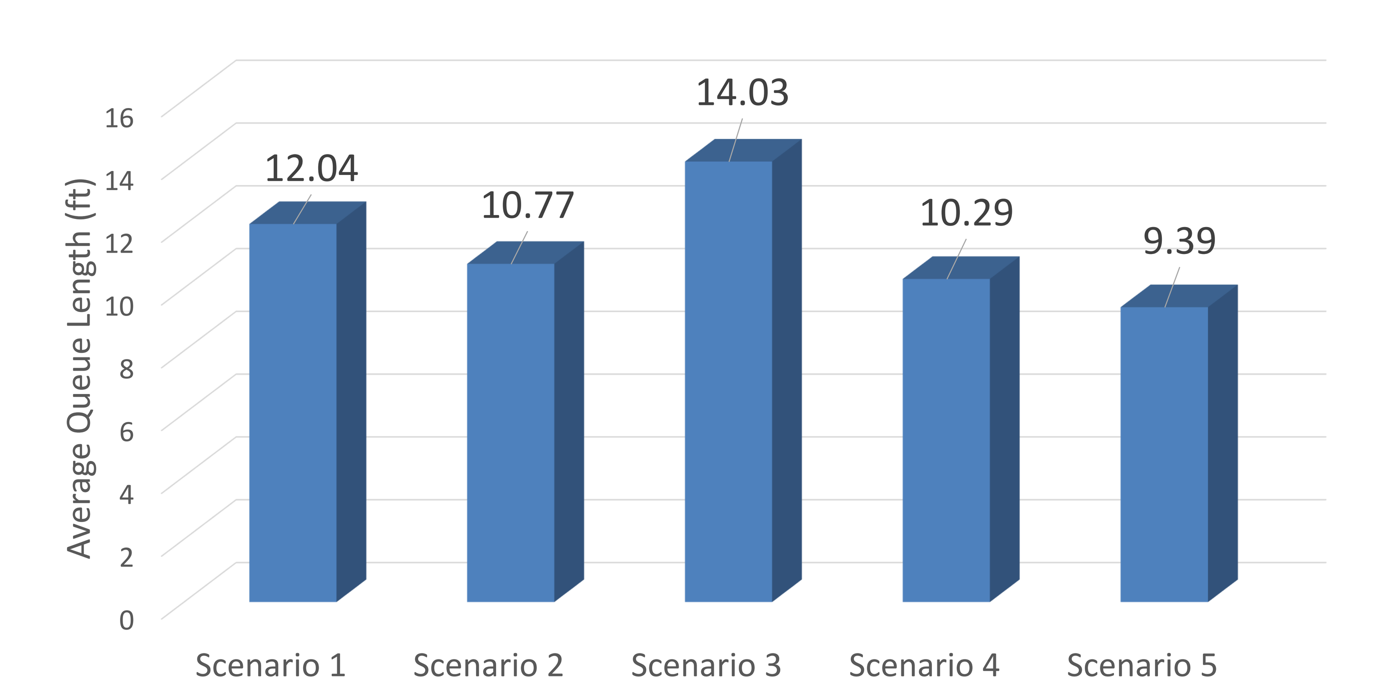

Fig. 8 Average Queue Length at the Intersection

Table 3 Results Summary

Network performance measures of effectiveness (MOEs)	Decreasing or Increasing in MOEs in each scenario				
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Average Queue Delay (sec) [%]	0%	-4%	10%	-7%	-12%
Average Stopped Delay (sec) [%]	0%	-8%	14%	-13%	-17%
Average Vehicle Travel Time (sec) [%]	0%	-4%	-1%	-9%	-17%
Average Queue Length (ft) [%]	0%	-11%	17%	-15%	-22%

Conclusion

- AVs can decrease the queue delay (7% - 12%), the stopped delay (13% - 17%), the vehicle travel time (9% - 17%), also the queue length will dropped by (15% - 22%).
- Therefore, traffic congestion at the signalized intersection will be decreasing as well.