Potential Impacts of Connected Autonomous Vehicles on Mobility and Conflicts in a Work Zone: A Microsimulation Based Approach.

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Research Objective

This study attempts to understand the impacts of connected autonomous vehicles (CAVs) on traffic mobility and conflicts in a work zone using the VISSIM simulation software.

Motivation

The motivation of the research comes primarily from the consideration of deployment and full utilization of CAVs in the real traffic world, especially in work zones which typically require altered road geometry such as lane closures and reduced speed areas. With variation in market penetration rates (MPRs) of CAVs, the prospects for success are evaluated in two ways: (1) the potential benefits of CAVs in improving travel time resulting from work zone impacts; and (2) safety benefits of CAVs through reduction in number of conflicts.

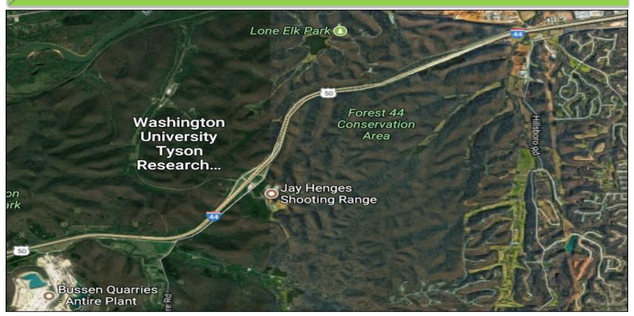
Introduction

1. Work zones have been confirmed as major cause of congestion bottlenecks on roadways (*1*) and are unavoidable in the highway system.
2. Over the past one and half decade, work zones have accounted for 9,900 fatalities in the United States (2).
3. Current studies are looking for means to develop ways that CAVs can reduce congestion and conflicts.
4. It is anticipated that CAVs will make efficient use of the existing roadways through shorter gaps between vehicles, and a coordinated platoon in the case of a higher market penetration rate.

Methods

The experimental set up involved creating a base model in VISSIM consisting of conventional vehicles representing field traffic conditions. The field data was extracted from a previous study (3) on a work zone in Missouri. The model was calibrated and validated to match field conditions. 10% to 90% CAVs are utilized for the evaluation scenario. The assumptions for the driving behaviors of CAVs are based on estimated values selected from previous works on CAVs and adjustment of the parameters available in VISSIM. CAVs' potentials for work zone conflicts reduction are evaluated using the Surrogate Safety Assessment Module (SSAM).

Work Zone Site Location

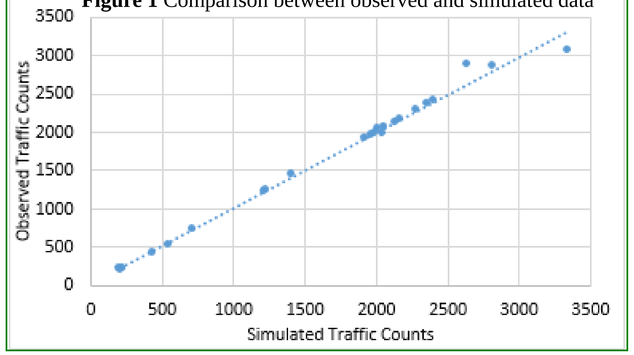


Description of study site:
The work zone is located on I-44 between Antire Rd and Lewis Rd, Missouri. There were no alternative routes. A long-term work zone with one lane out of three lanes closed in both directions. Only the east bound traffic considered for the study.
Study data Extracted from (3)

Model Calibration and Validation

Geoffrey E. Havers (GEH) to test for the percent error with respect to the means of the observed and calibrated traffic counts.

Figure 1 Comparison between observed and simulated data



$$GEH = \sqrt{2 * \frac{(V_{obs} - V_{sim})^2}{V_{obs} + V_{sim}}}$$

The results obtained from the GEH formula was desirable and less than five which showed that the model was acceptable fit.

Modeling CAVs in VISSIM

The simulation of CAVs driver behaviors within VISSIM was based on the assumptions from a previous study(4). The VISSIM Wiedemann 99 driver parameters were adjusted to implement the presence of CAVs in the model.

Travel Time Results

Figure 2 Trend in Work Zone Hourly Travel Time with Different CAV Penetrations

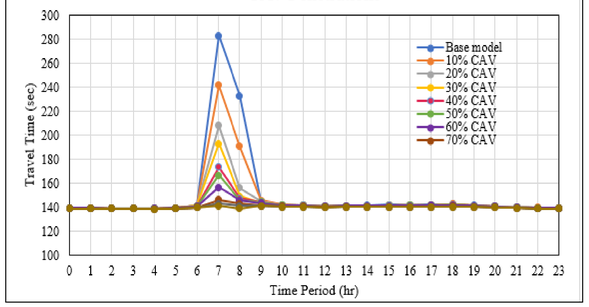
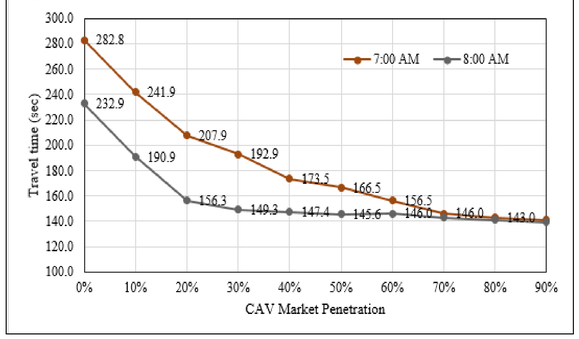
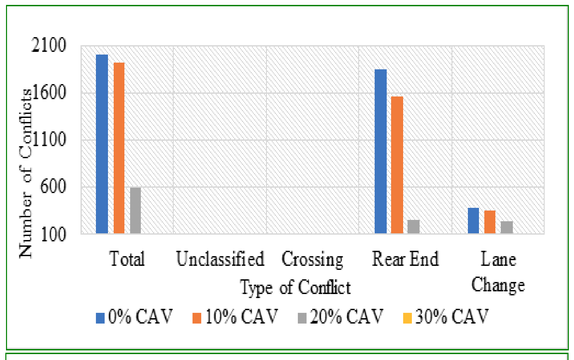


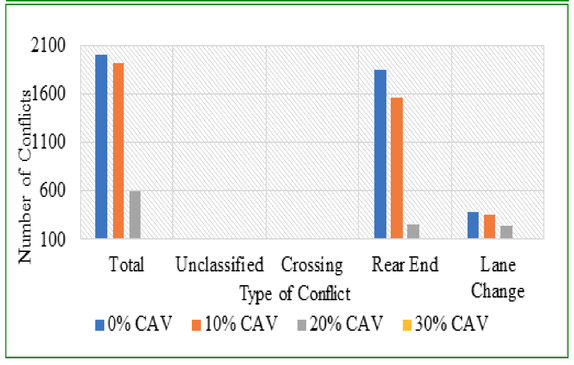
Figure 3 Trend in Travel Time for Peak Period in Work Zone



SSAM Output

Figure 4 Percent difference in conflicts between base scenario and CAVs Market Penetration





Findings

1. Based on the representation of CAVs used in this study, the result showed a positive effect of AV on traffic performance. Drivers will experience significant decrease in travel time when CAVs account for a 10% to 90% the traffic.
2. Travel time improvement was considered for the peak periods where demand was high. Figure 3 shows that there was a constant improvement of travel time till 70% CAV market penetration.
3. The analysis of the results showed that there is effective improvement of traffic congestion when the market penetrations of CAVs increase.
4. From 70% to 90% penetrations, the CAVs did not further cause a reduction in travel time.
5. At the different market penetrations of CAVs, the values for conflicts were lower as the market penetration of CAV increased.
6. At 10% MPR, there was a 43% decrease in the total number of conflicts, while at 20% MPR, the decrease in total conflicts was about 70%.
7. There is an indication that the CAVs are safer than the conventional vehicles when the traffic demand is high, especially as the percentage of the CAVs increases. Between 20% and 30% CAVs, the reduction in greater than between other subsequent consecutive penetrations.

Future Research Agenda

1. Incorporate connections such as V2I and V2V for both autonomous and conventional vehicles.
2. Consider using field data from different construction work zones in Florida State.
3. Analyze more complex networks and a diversity of work zone configurations.
4. Expand the scope of the network,

References

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