DRIVER BEHAVIOR IN MIXED CONVENTIONAL-CONNECTED VEHICLE TRAFFIC AT THE FREEWAY MERGE

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INTRODUCTION

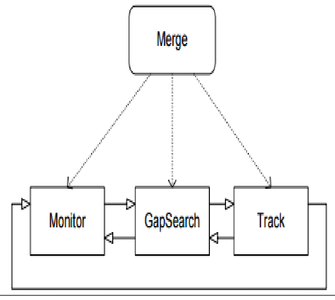
Wireless communication through automated and connected vehicles is an evolving technology, with the goal of improving driving conditions, reducing time spent in traffic and curtailing the crash occurrences.

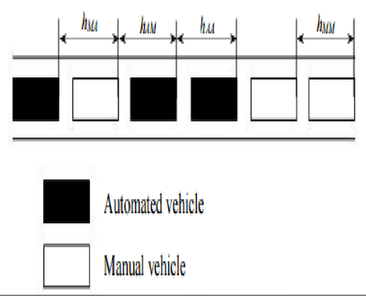
The primary motive of this investigation was to employ a driving simulator to analyze how this technology helps in maintaining traffic safety for the aging population.

BACKGROUND

The following studies were performed to evaluate the influence of a mixed traffic of conventional and connected/autonomous vehicles traveling on a mainline freeway on the driver of a manually-driven (conventional) car merging onto the freeway:

- Review and formulation of the distribution of vehicle inter-arrival times of the vehicles on the mixed traffic of conventional and connected/autonomous vehicles traveling on the mainline freeway.
- Observing and recording the merging driver's behavior in terms of the acceptance of gaps between vehicles on the mixed traffic of conventional and connected/autonomous vehicles traveling on the mainline freeway. The gap acceptance was observed both based on perception of the driver and the actual selection when driving in the simulator.
- Statistical analyses of the gaps and related factors including the demographics of the drivers.
- Review of the impacts of the merging driver's actions on the mainline traffic vehicles in terms of acceleration, deceleration, and crashes.





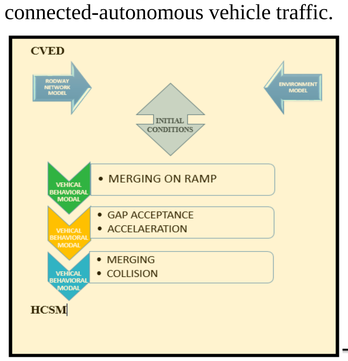
METHODOLOGY

This research aims to coalesce the concepts of mixed traffic conditions and the driving simulator. The mixed traffic conditions at a freeway merge ramp can be designed and the driver behaviors can be observed with the application of a driving simulator. An experiment using the driving simulator is conducted which showed the judgment of the drivers merging onto the ramp. Three scenarios were designed, which showed the behavior of drivers in mixed traffic conditions. Monte Carlo simulation was used to generate headways between the traffic.

$$t = \ln(1-\theta) - \ln(1-R)/(\gamma+\tau) \ldots (1)$$

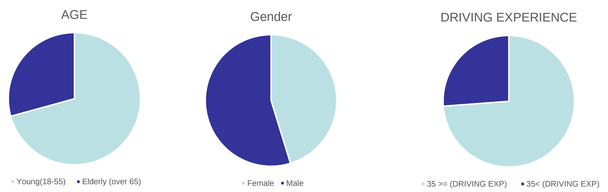
Equation (1) displays the generation of headway between vehicles on mainline.

't' denotes the headway, 'θ' denotes the penetration rate, 'R' denotes the random number, 'γ' denotes the exponential decay constant and 'τ' denotes the constant headway between the connected-autonomous vehicle traffic.



DATA COLLECTION

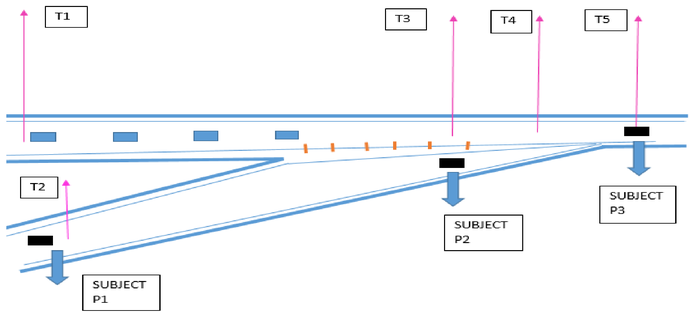
There were 42 drivers who participated in the study .



There were three scenarios:

First scenario gathered the gaps accepted by the drivers based on perception in a static condition for 0%, 50%, 75% penetration of mixed traffic condition.

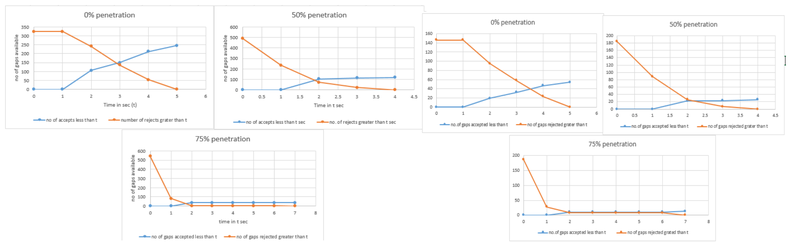
Second and third scenarios consisted of driving the simulator in a 0% and 50% penetration conditions respectively.



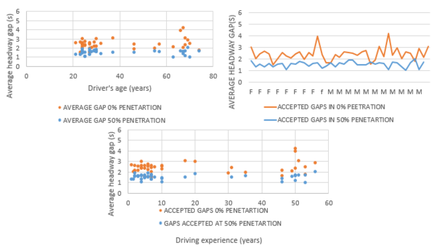
RESULTS

Questions	Breakdown	Response
AGE	YOUNG (18-54 Years) ELDERLY (55-65 Years)	29 12
SEX	MALE FEMALE	23 18
DRIVING EXPERIENCE	≤ 35 years >35 years	31 10
CHOICE OF MERGE MANEUVER	ACCELERATE DECELERATE STOP AND MERGE	23 12 6
RECEIVE MESSAGE (MOIBLE NETWORK, INFRASTRUCTURE)	YES NO	29 12
CHOICE OF LANE AFTER MERGE	SAME CHANGE	21 20
WHEN TO MERGE	START MIDDLE END	10 10 11
TIME SPENT ON RAMP (SEC)	IMMEDIATELY 2-5 5-7 7-10 >10	15 10 9 6 1

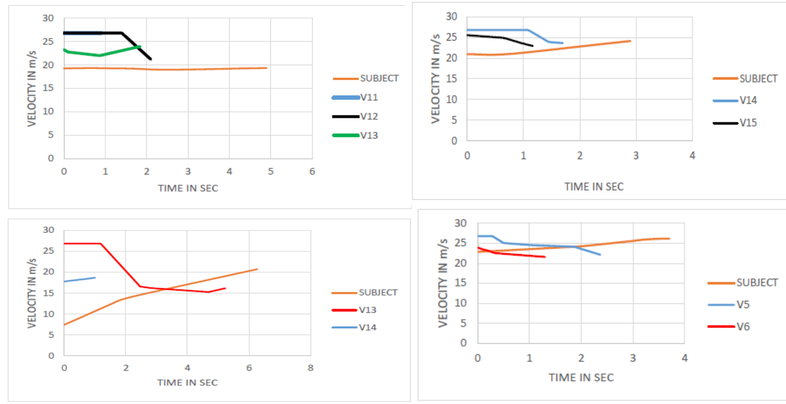
Scenario 1: The critical gap calculations are performed using Raffs method.



- In 0% penetration, the average gap observed for young drivers is 2.9 sec and it was 3.4 for elderly drivers.
- The gap acceptance in 50% penetration for young drivers is 1.8 sec and 2.0 sec for elderly drivers.
- The gap acceptance for 75% penetration rate was 1.6 sec for younger drivers and 1.9 sec for elderly drivers.



0% AND 50% ACCEPTED HEADWAY (GAPS)		
Groups	Average (gaps in sec)	Variance
YOUNG	2.36	1.18
YOUNG	1.53	0.61
OLD	2.72	3.27
OLD	1.55	0.54
FEMALE	2.38	1.89
FEMALE	1.79	0.97
MALE	2.48	1.46
MALE	1.56	0.60



These velocity profiles define how the drivers behaved in 0% and 50% penetration of connected-automated vehicle conditions. The velocity profiles show that when the driver's chose gaps between the automated and connected vehicles, the effect on mainline vehicles was higher, that is, the vehicle had to decelerate much more than when merging between conventional vehicles.

FUTURE STUDY

- The work could be extended by observing gaps acceptance by different categories for each penetration rate.
- The study can be also observed by allowing drivers to merge at any point of the merge ramp and not restricting it to a specific location.
- Study can also be extended for multiple lanes and observe the lane changing patterns for different penetration rates. Future study can also include traffic on the ramp as well and to observe if any queuing or delays would occur if there is conventional traffic on the ramp and various penetration of connected automate traffic on mainline

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