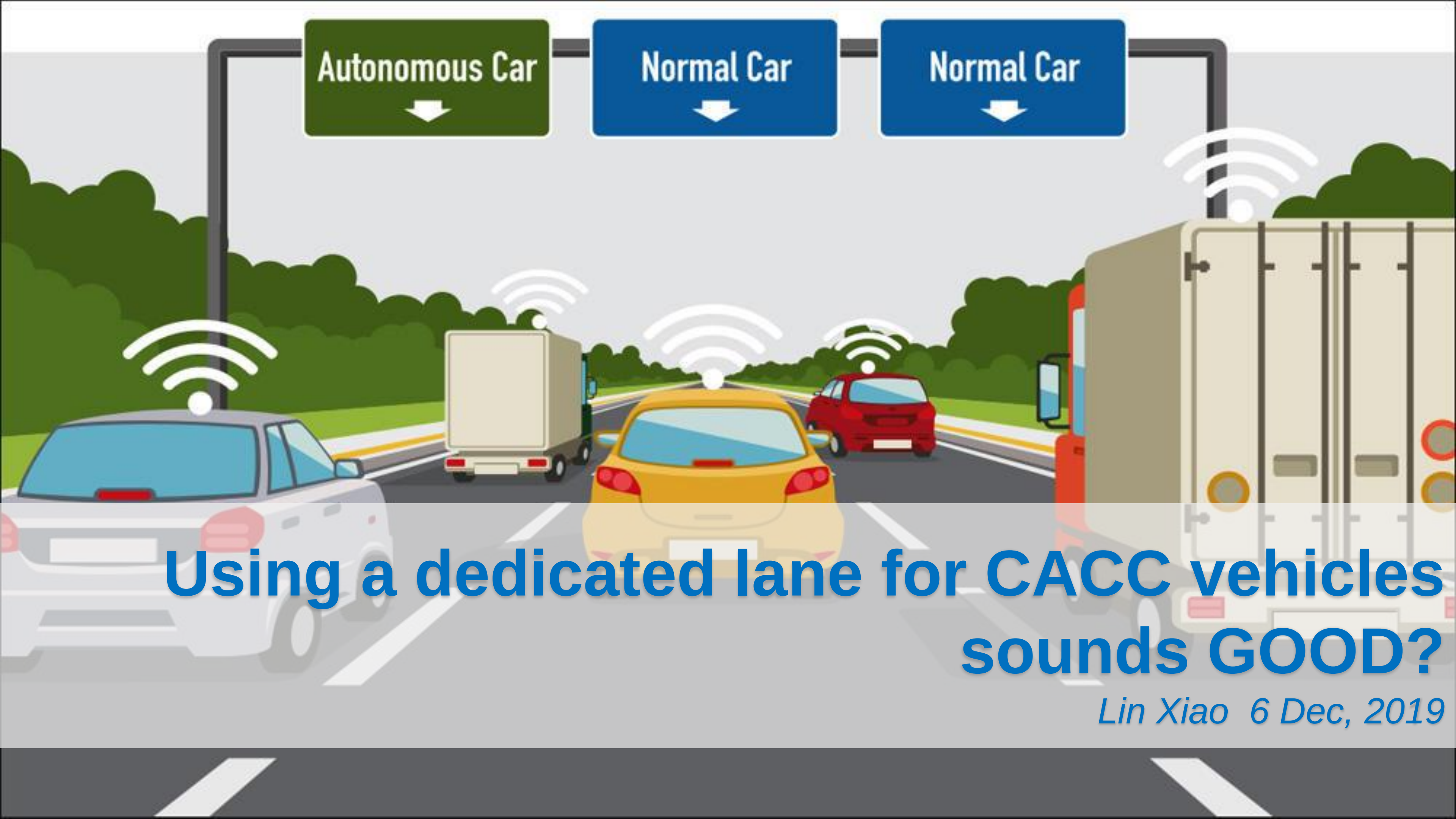


Using a dedicated lane for CACC vehicles sounds GOOD?

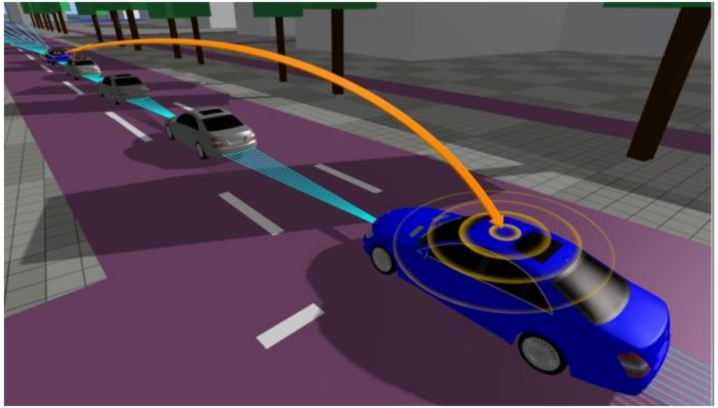
Lin Xiao 6 Dec, 2019

Current Driver assistance systems

Adaptive Cruise Control
(ACC)

Large following gap for safety concerns

Cooperative Adaptive Cruise Control
(CACC)



Enabled small following gap due to V2V communication

Challenges

Insignificant benefits

Insufficient CACC vehicles

Ad-hoc platooning

A CACC dedicated lane !

Advantages:

- Geometrically cluster the CACC vehicles;
- Maximum the use of CACC;
- Less interrupt into the platoon.

Research Gap

Conclusions from existing studies:

- A CACC lane can largely increase the roadway capacity;
- A CACC lane can reduce the congestion or prevent congestion;

However, these studies neglect

- The lane changes heading toward and leaving CACC lane;
- Driver-system interaction between manual driving and automated driving;
- Reduced road capacity for conventional vehicles;
- Low lane utilization at low CACC MPR;

Evaluations based on **Microscopic Simulations**

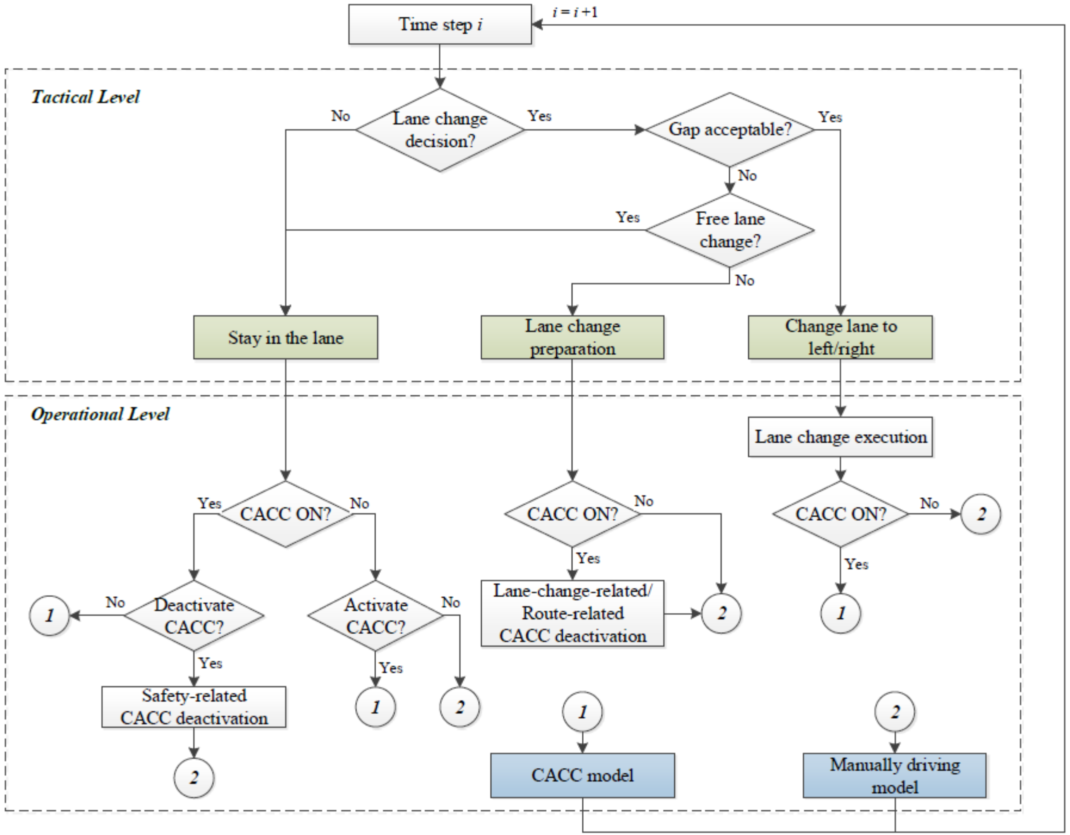


Fig. 1 Framework for the integrated lane change and car-following model.

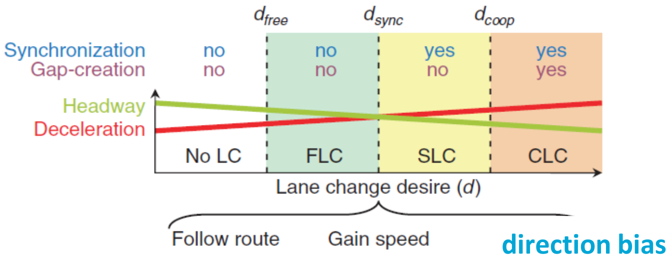
Model highlights

*Lane change model**

- An additional lane change incentive to go to the dedicated lane for qualified vehicles.
- The lane change model is calibrated in a real traffic corridor where an HOV lane is activated.

*Car-following model***

- Multi-regimes car-following behaviour;
- Authority transitions;
- Empirical car-following response.



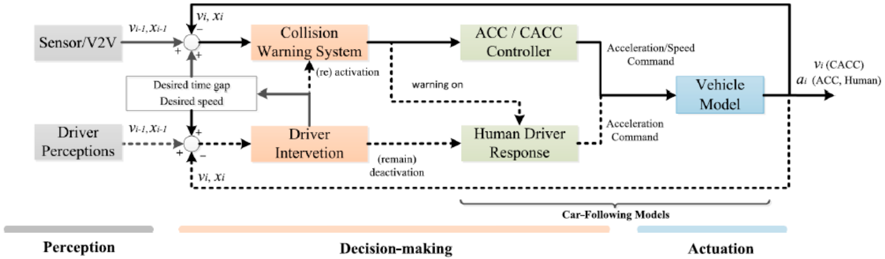


Fig. 1. Conceptual longitudinal model for CACC vehicles in simulations.

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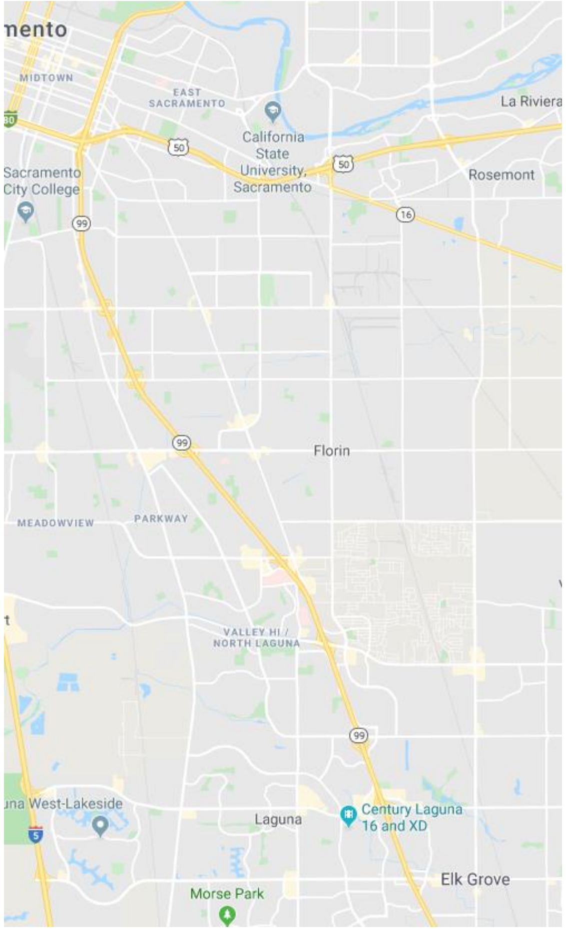
Simulation network

Current situations

- 20 km
- Multiple on/off ramps
- An HOV lane
- Recurrent congestion

Experiment setup

- CACC MPRs 10 – 50%
- Convert the HOV lane to CACC lane



Traffic Congestion pattern

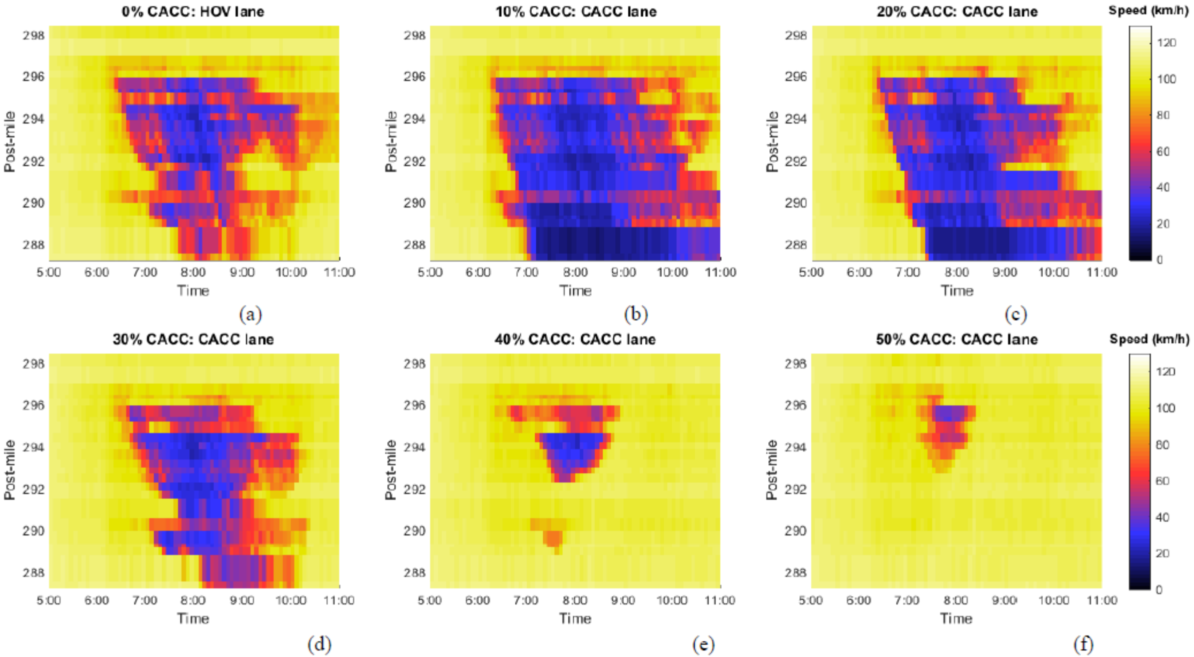


Fig. 4 Traffic congestion pattern with increasing CACC MPRs in a CACC dedicated lane scenario.

(1) The dedicated lane shares less demand and more traffic is in the general purpose lanes;
(2) CACC vehicles entering the leaving CACC lane reduce the lane speed of CACC lane.

CACC lane characteristics

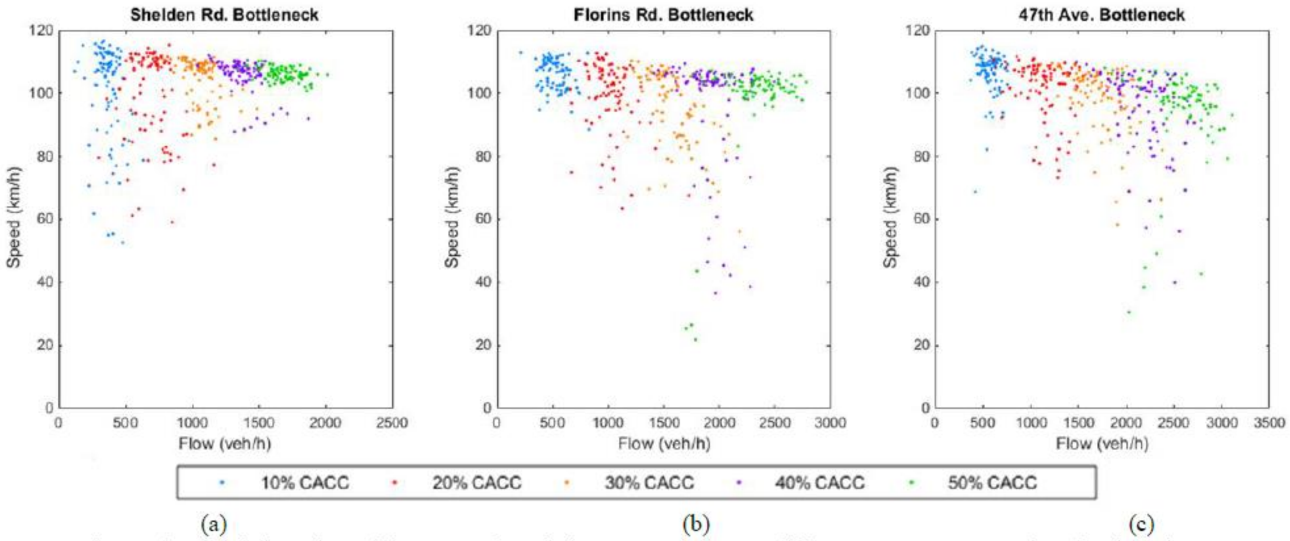
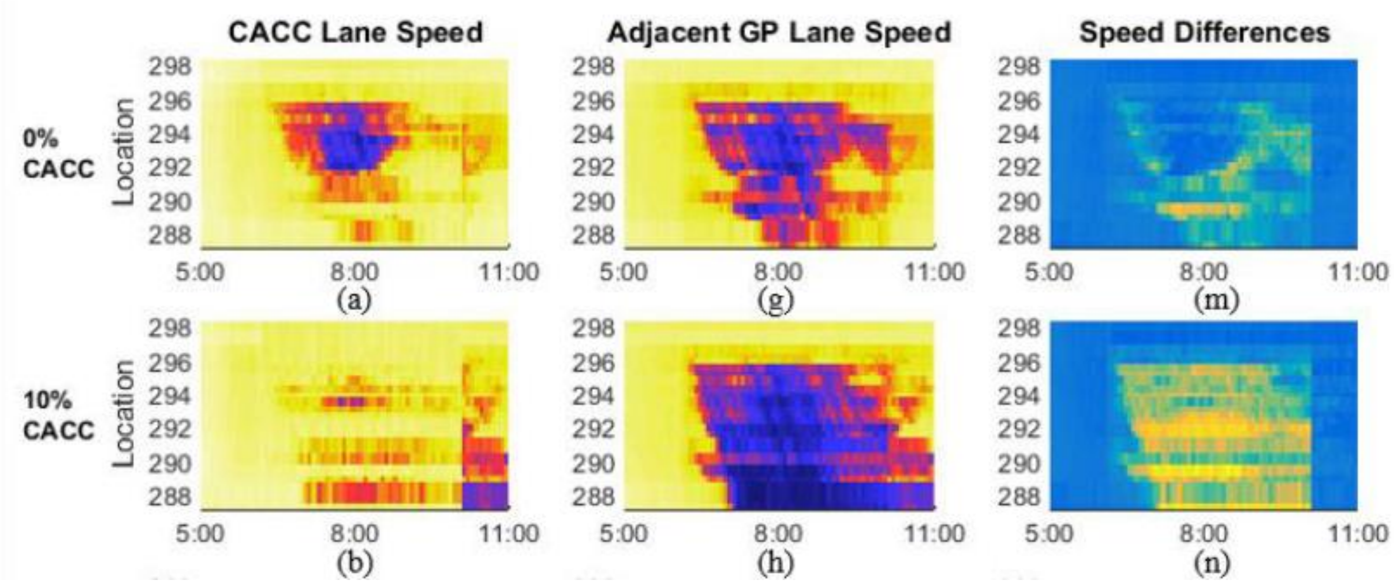
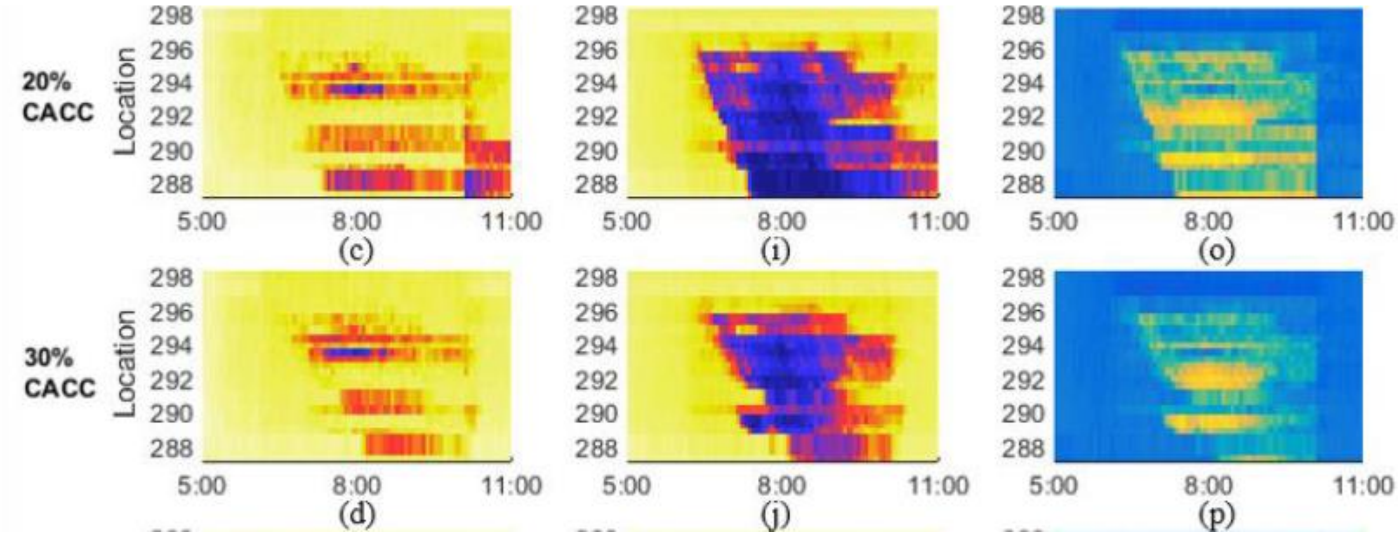


Fig. 5 The speed-flow plots of the CACC lane during 6:00-7:30 AM at different CACC MPRs at three bottlenecks.

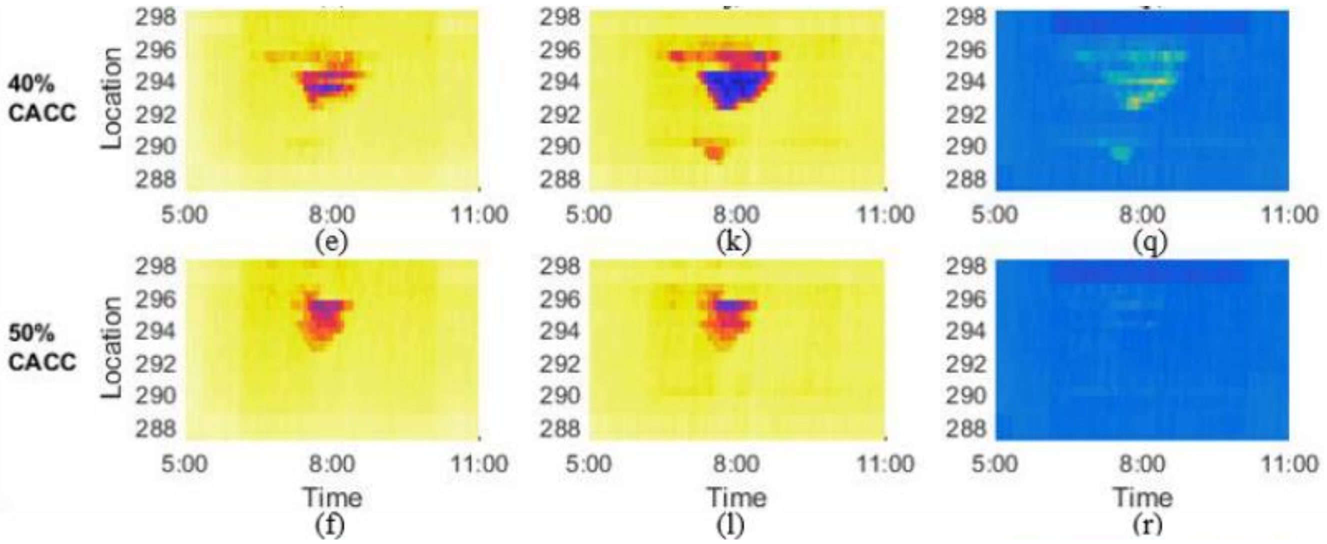
Traffic safety - friction effects



Friction effects



Friction effects



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Travel time reliability

TABLE 3
TRAVEL TIME AND DELAY ANALYSIS OF ALL TRAFFIC IN EACH CACC MPR

	CACC					
	0%	10%	20%	30%	40%	50%
Total TT (h)	10961	15546	14337	10997	7586	7065
mean TTD (s/veh)	255	536	446	324	86	79
std TTD (s/veh)	381	861	723	555	110	89

Note: TT is travel time; TTD is travel time delay and std is the standard deviation.

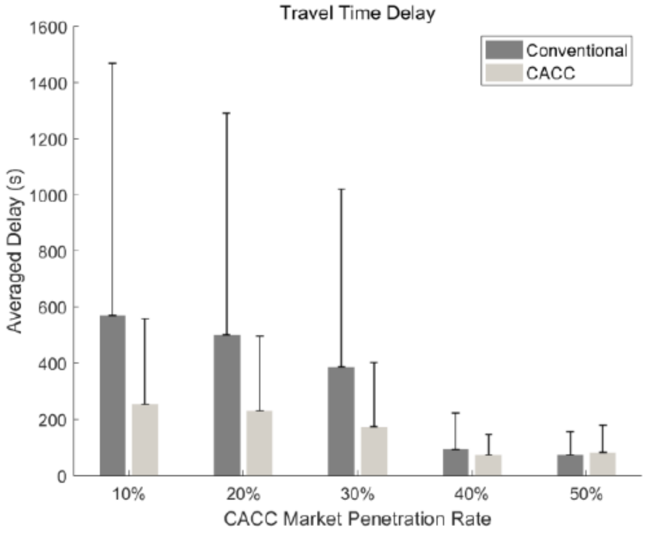

Fig. 7 Mean and standard deviation of the travel time delay of conventional and CACC vehicles at each CACC MPRs.

CACC system operations

TABLE 4
CACC OPERATIONAL CHARACTERISTICS

	CACC MPRs				
	10%	20%	30%	40%	50%
Time Usage per CACC vehicle					
CACC System	23.94%	31.12%	38.1%	43.83%	48.45%
Gap-regulating Mode Ratio	57.39%	56.39%	52.47%	48.03%	45.55%
Number of Deactivations per CACC vehicle					
Total	5.86	6.06	4.66	3.32	3.43
Lane-change related	2.25	2.35	2.05	1.65	1.71
Safety-related	2.97	3.05	1.93	1.01	1.06
Route-related	0.64	0.66	0.68	0.67	0.66

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Conclusions

At low CACC MPRs < 40%

- *Traffic is more congested;*
- *The CACC lane is underutilized;*
- *Safety concerns arise with larger lane speed difference;*
- *More travel time delay for road users;*
- *More lane changes and deactivations;*

Positive influences:

- *More reliable travel time for CACC vehicles;*
- *Increased usage of CACC system;*

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We could wait..