



Active Traffic Management strategies at expressway merging sections – A driving simulator study from Qatar

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Focus

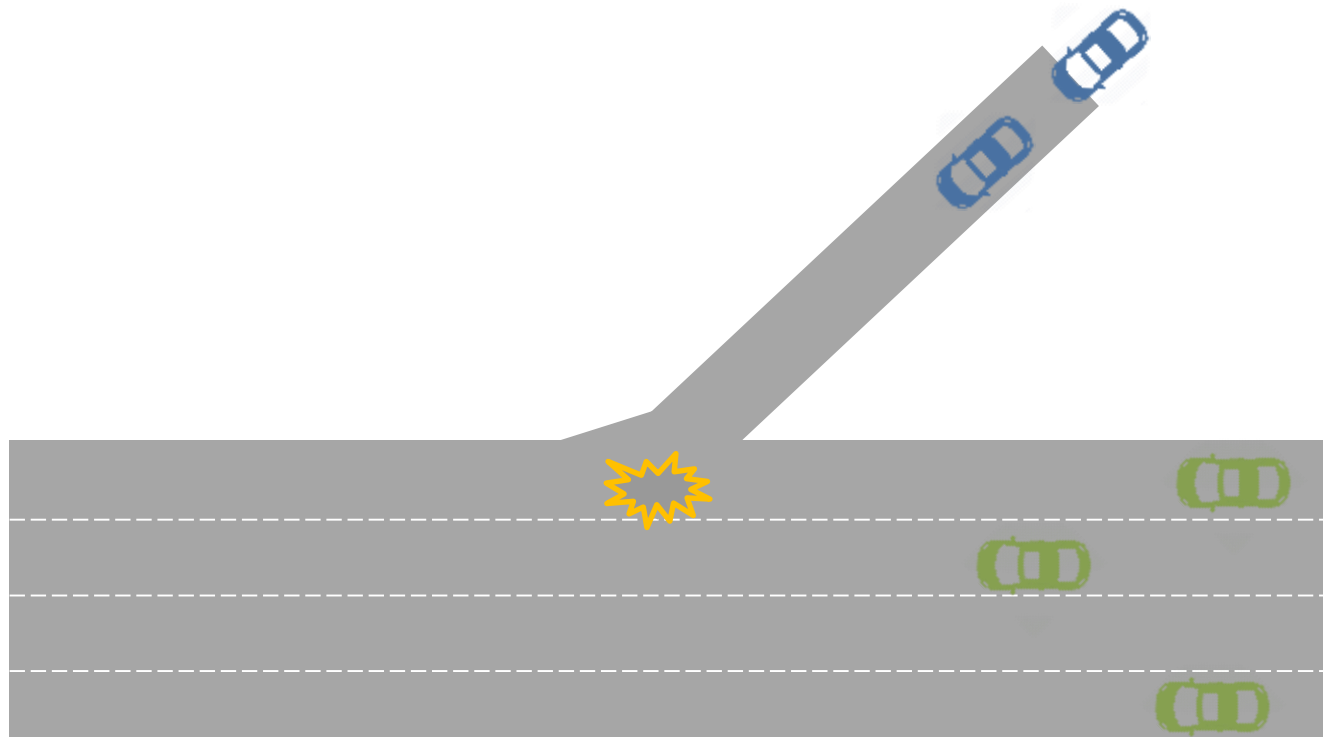
- 1) Merging maneuvers of vehicles from short on-ramps: How does it affect **driving performance and safety of outer lane expressway drivers?**
- 2) Which **traffic management strategies** are effective to improve safety at these expressway merging sections?



Problem definition

Factors influencing driving behaviour at merging sections:

- Geometric configuration of the entrance ramp (~ 150 m)
- Speed differentials between merging and mainline vehicles
- Increased traffic density → conflicts with surrounding vehicles



Problem definition

- Traditional ramp metering does not take into account specific interaction between merging vehicle and outer-lane expressway driver
- Driver's responses to merging vehicle:
 - Harsh deceleration and breaking
 - Abrupt lane change maneuvers
- Increased risks:
 - Traffic conflicts and turbulence
 - Higher likelihood of rear-end and sideswipe crashes
 - Congestion formation and bottlenecks

Traffic Management Solutions

- Passive Traffic Management (PTM)
 - Merge warning signs (available in Qatar)
 - Road marking treatment
- Active Traffic Management (ATM)
 - Variable Message Signs (VMS)
 - e.g. dynamic lane control arrows
 - Variable Speed Limits (VSL)

Research Question:

Are ATM or PTM strategies more effective in preparing expressway drivers to safely respond to merging on-ramp vehicles?

Method

Driving simulator at QTTSC – Qatar University

- ✓ 135 degrees – horizontal field view
- ✓ Resolution: 5760 x 1080 pixels
- ✓ 60 HZ refresh rate
- ✓ Software: STISIM Drive® 3



- Data collection period: May 2018
- No compensation offered
- Pre-quiz: traffic control signs/ road markings
- Familiarization drive with simulator
- 2 experimental test drives of each 16 km
- Counterbalanced order of scenarios

Experimental test drives

Doha Rural Expressway



Real-world view

Replicated
↔



Driving simulator view

Doha Urban Expressway



Real-world view

Replicated
↔



Driving simulator view

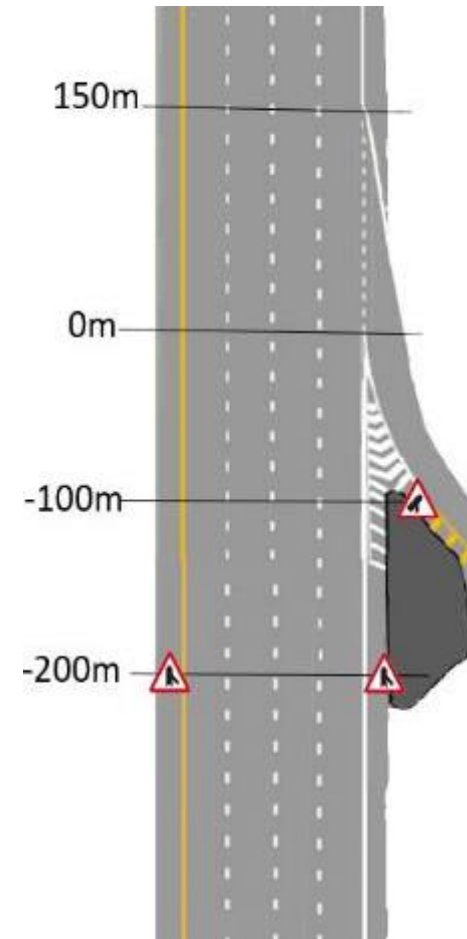
Driving direction 1: urban (80 km/h) to rural (100 km/h) transition

Driving direction 2: rural (100 km/h) to urban (80 km/h) transition

Driving Scenarios: PTM



- Typical road configuration for expressways in Qatar
- Merge warning signs installed at expressway AND on-ramp



RURAL & URBAN

Driving Scenarios: PTM

1

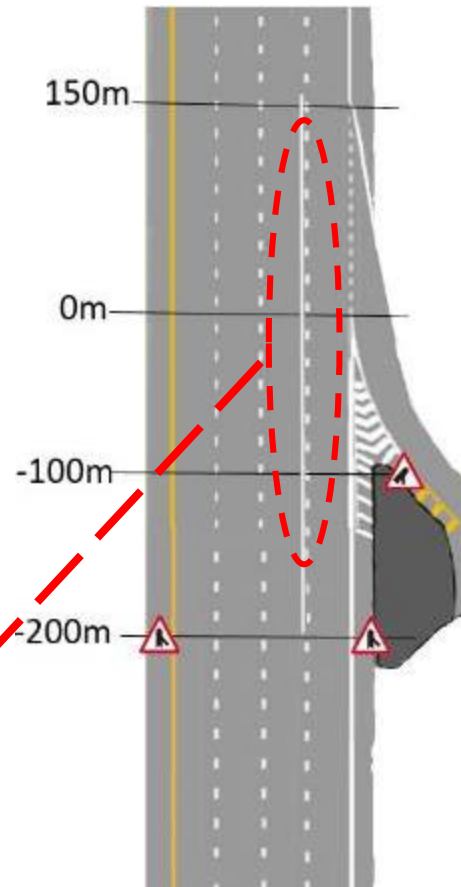
Control Scenario

2

Road marking

left
lane

right
lane



RURAL & URBAN

Driving Scenarios: ATM

1

Merge control
VMS

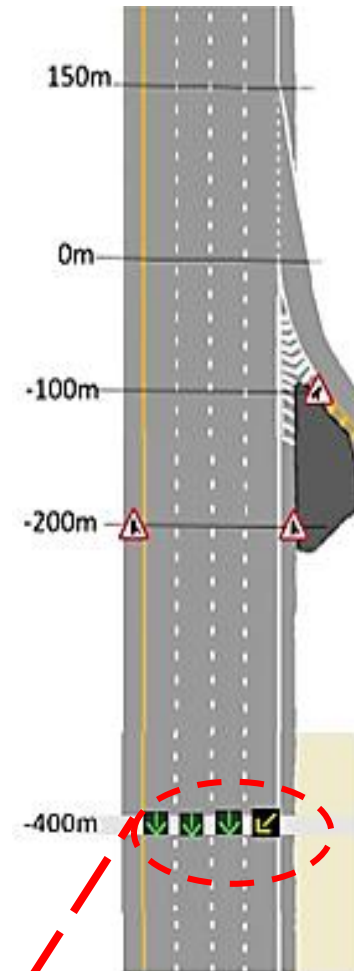
URBAN

2

Combined VSL 80

3

Separated VSL 80



Driving Scenarios: ATM

1

Merge control
VMS

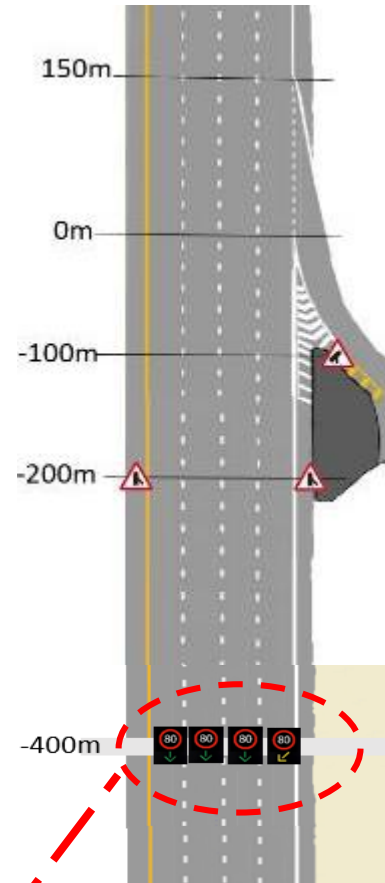
2

Combined VSL 80

3

Separated VSL 80

RURAL



Driving Scenarios: ATM

1

Merge control
VMS

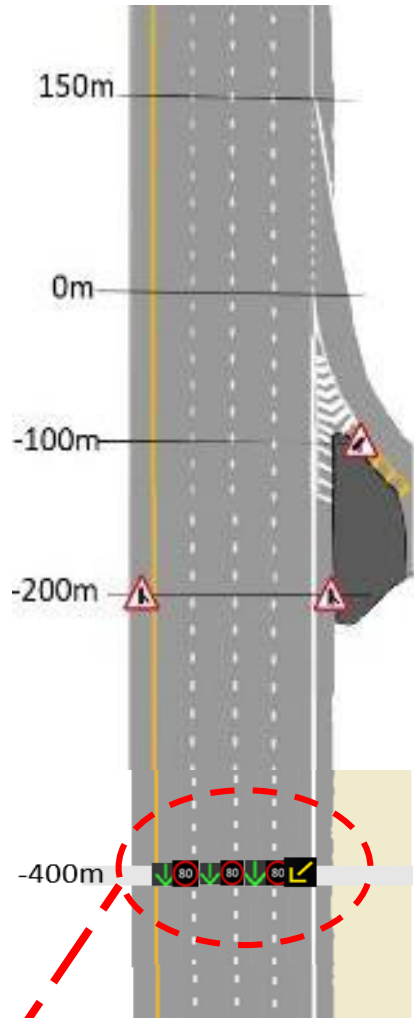
2

Combined VSL 80

3

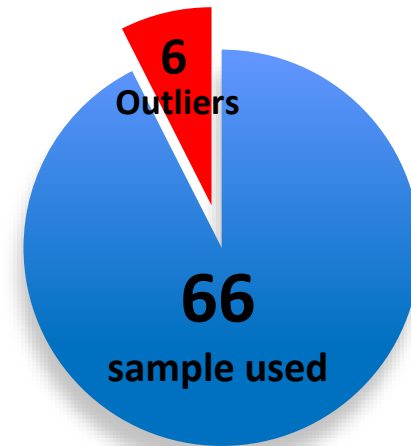
Separated VSL 80

RURAL

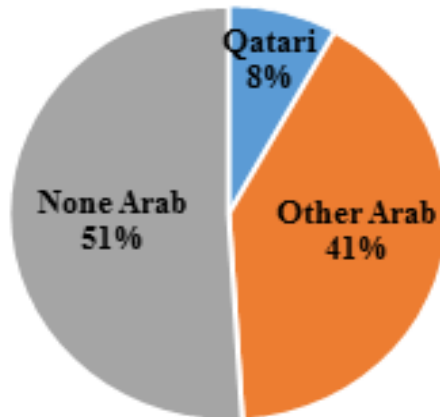


Sample characteristics

- Subjects participated
 - ✓ Total: 72 (with Qatari driving license)
 - ✓ Male: 43 / Female: 29
 - ✓ 29 different nationalities
 - ✓ Mean age: 28.9 years



A) Origin of 66 participants:



B) Registered active Driving Licenses in Qatar in 2016:

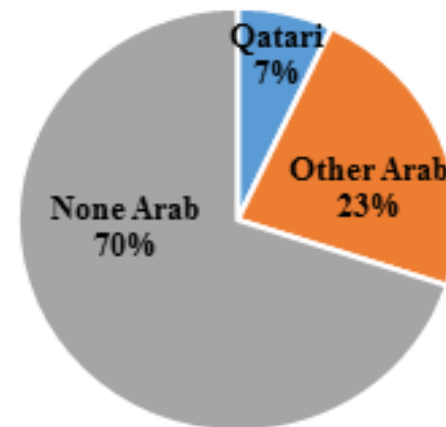
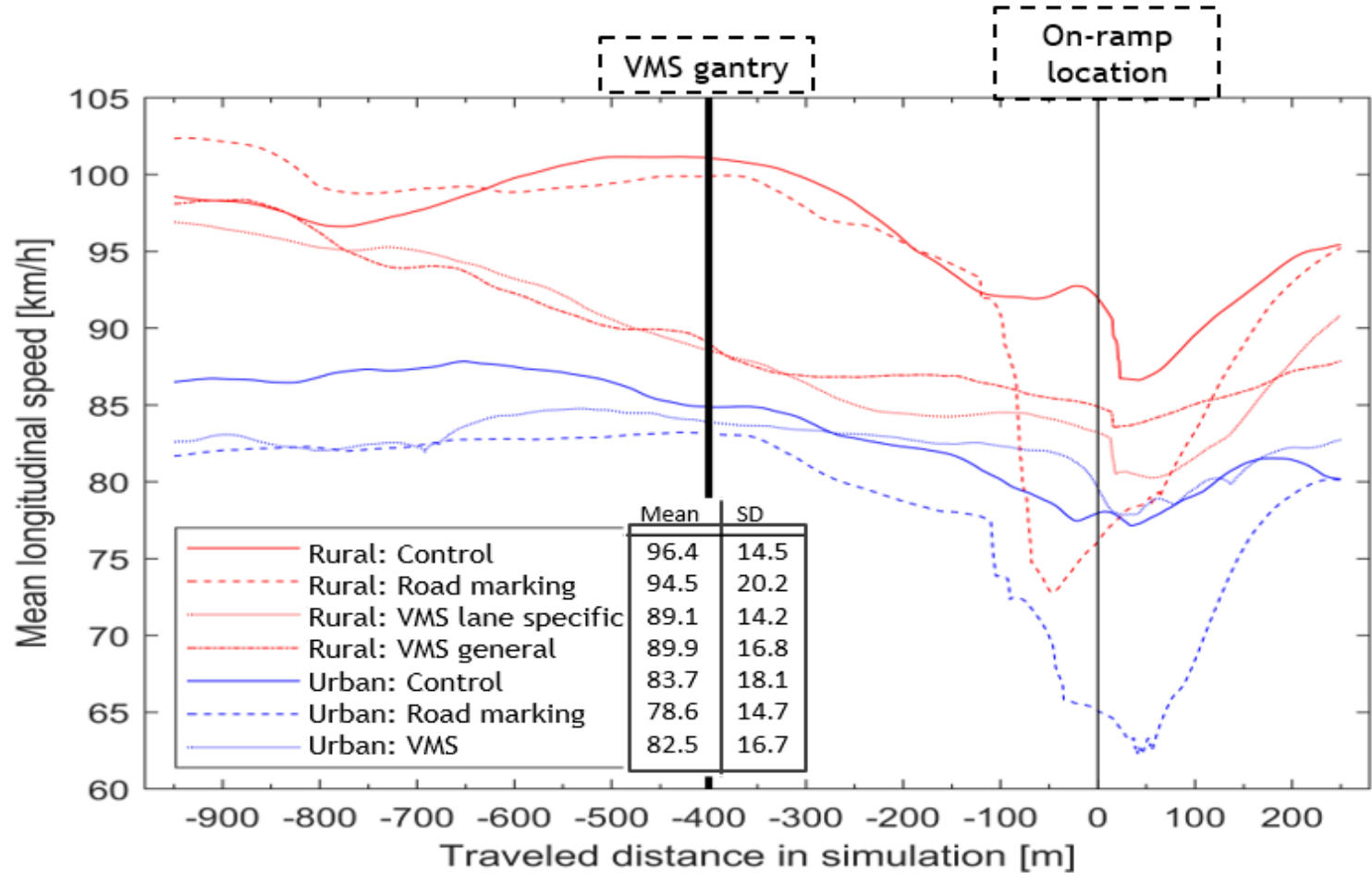
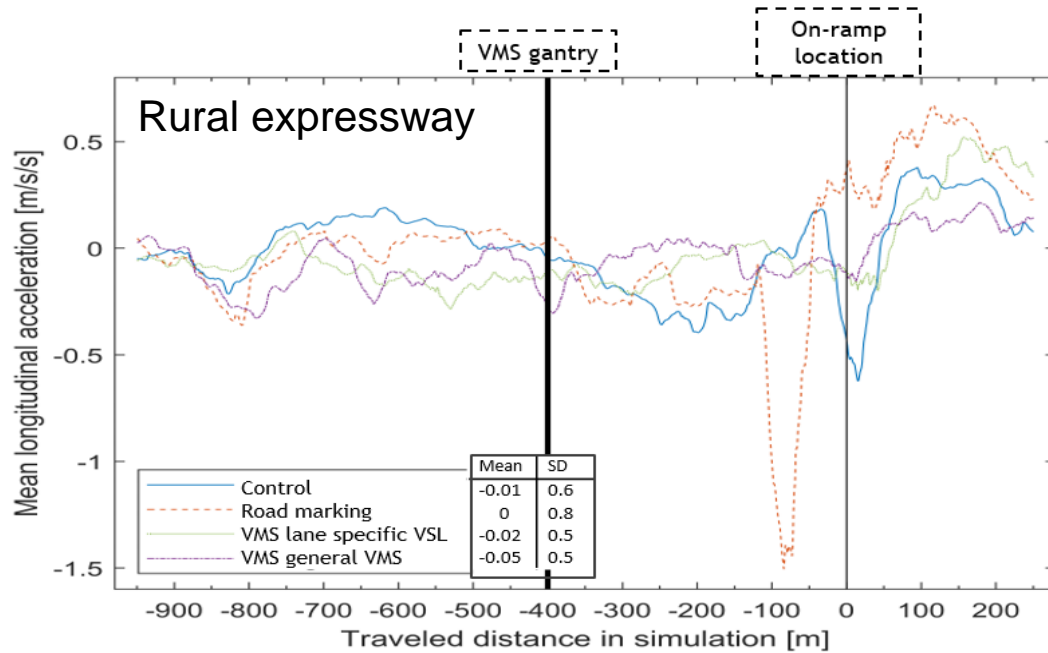


Figure A+B: Proportion of drivers' origin in this study vs. registered drivers in the State of Qatar (Ministry of Interior, Police Department, 2017)

Results: Mean speeds

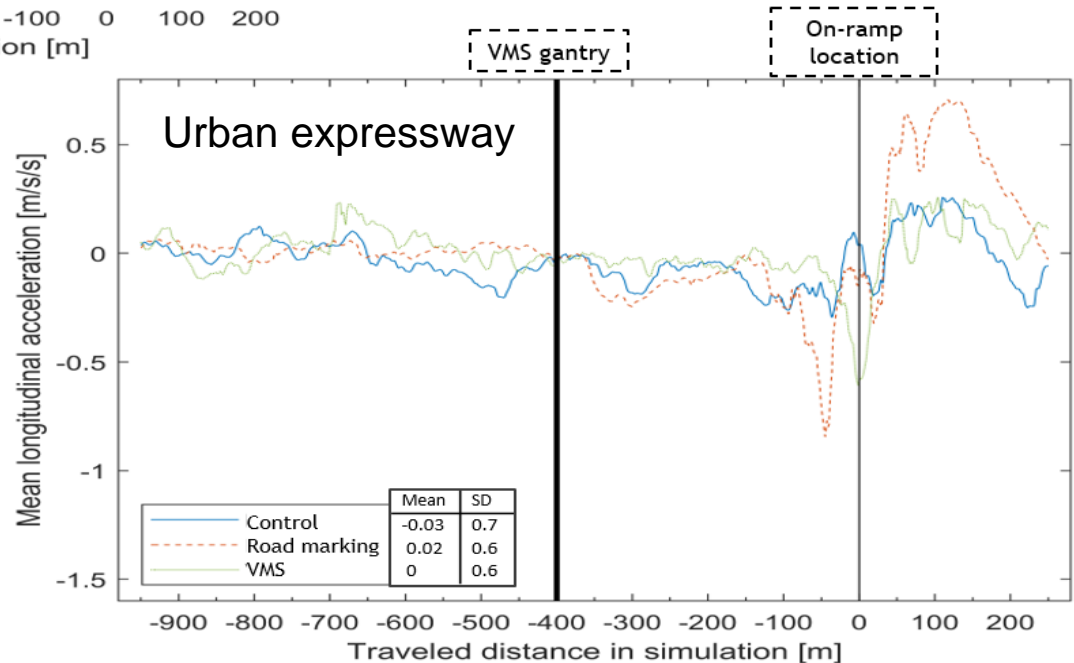


Results: Mean Longitudinal Acc/Dec

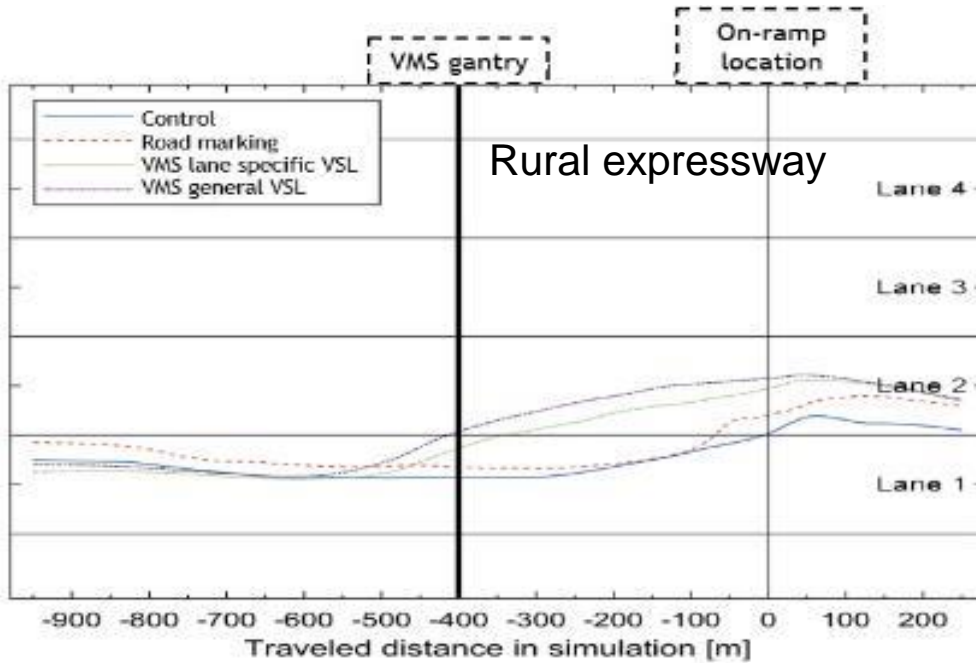


Deceleration peak in the rural expressway control condition

Strong deceleration peak in the road marking condition on both expressways!

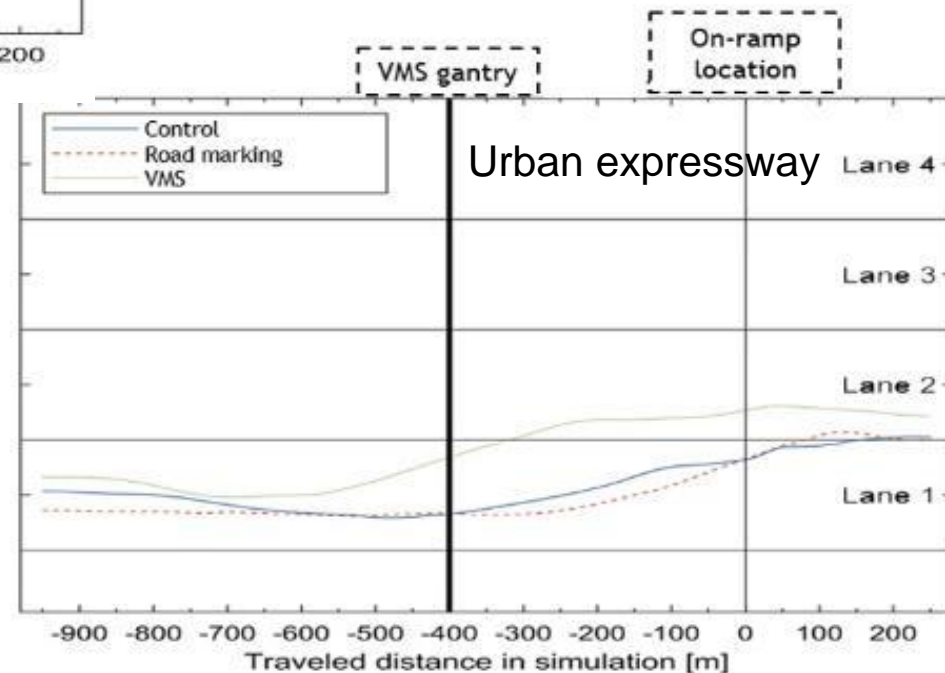


Results: Mean Lateral Position

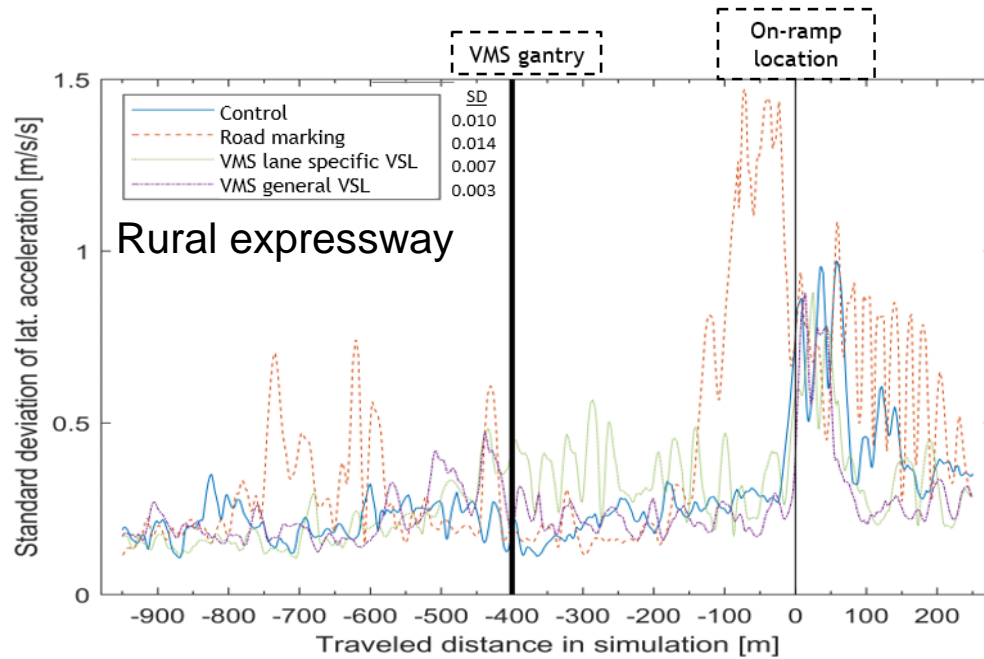


Early lane change initiation for VMS conditions on both expressways

Abrupt lane change in road marking condition on rural expressway!

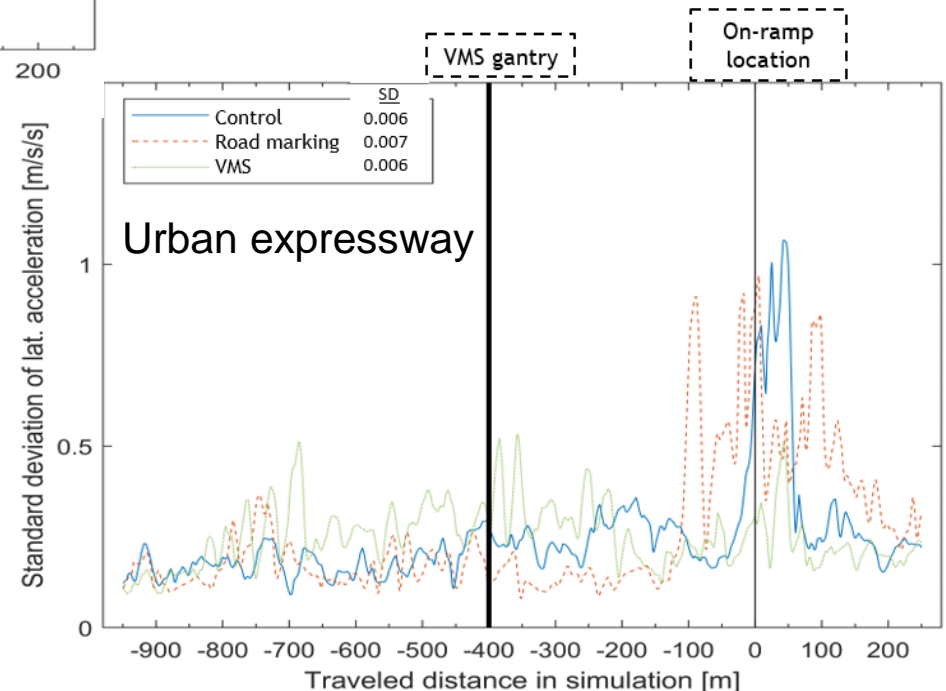


Results: SD Lateral Acc/Dec



Peak variations in lateral acceleration for **road marking** condition on rural expressway

Homogenous lateral acceleration for **control** & **VMS** conditions



Conclusion: Urban Expressway

- No significant different longitudinal driving behaviors among ATM and PTM
- Earlier lane change maneuver when ATM is implemented → unnecessary road capacity reduction?
- Costly ATM have no additional safety benefits as compared to low cost PTM for urban expressway merge sections with a speed limit of 80 km/h

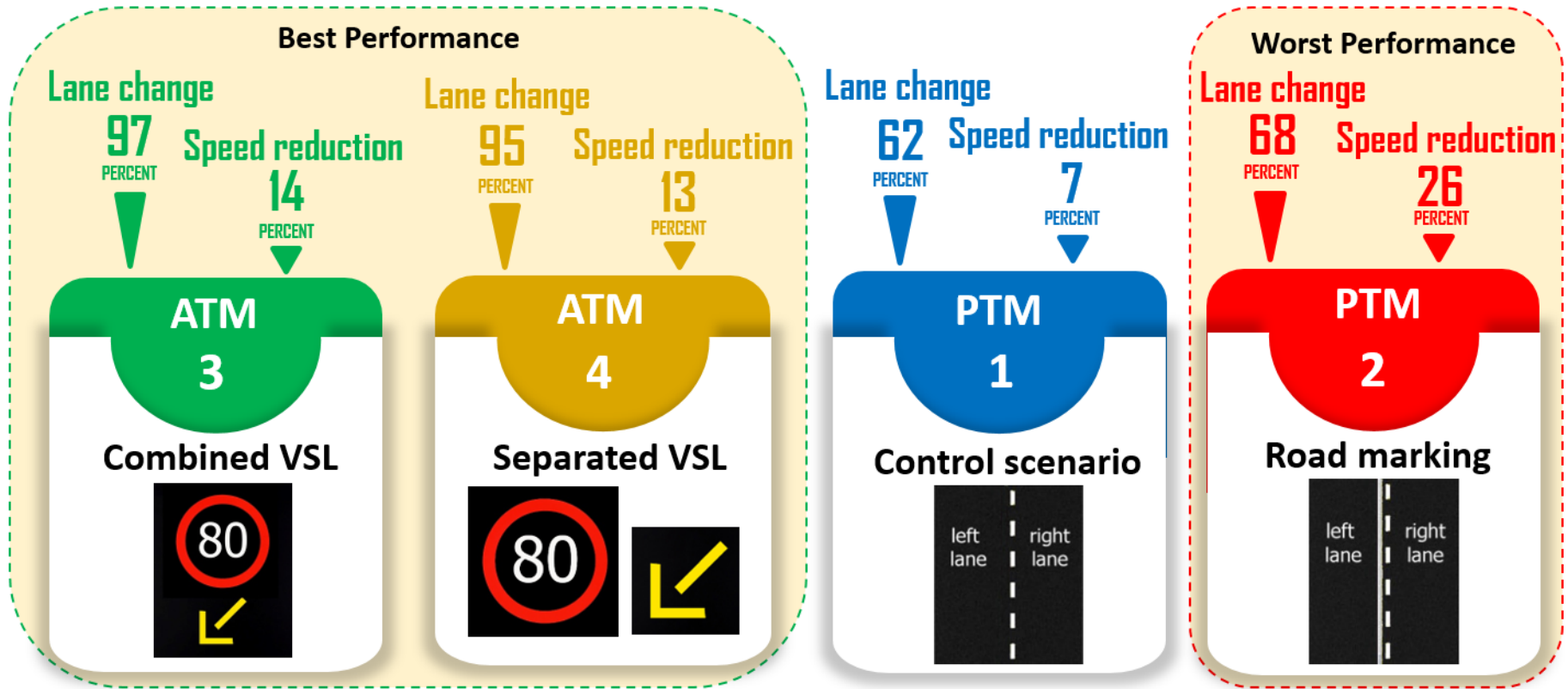
Conclusion: Rural expressway

- Significant safety effects due to ATM:
 - Number of safe lane changes increased by 35% as compared to PTM
 - Abrupt lane changes of through lane drivers were eliminated
 - Gradual and smooth mean speed reduction was achieved
- ATM prepared drivers to safely respond to merging vehicles, which increased traffic safety at merge sections of rural expressways (100 km/h)

Recommendation rural expressway:

Active Traffic Management (ATM)

Passive Traffic Management (PTM)



- ATM strategies with VSL 80 km/h are recommended!
- Road marking treatment is not recommended for rural expressways (100 km/h)

Thank you for your attention!

This research was made possible by the NPRP award [NPRP 9-360-2-150] from the Qatar National Research Fund (a member of The Qatar Foundation).

