Driver's deceleration behaviour according to infrastructure

Guillaume SAINT PIERRE
Lara DESIRE

Research scientists
Cerema
France

Introduction

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

SURca
Sécurité des usagers de la route et conduite automatisée

SURCA project

- GOAL: identify the conditions that will allow autonomous vehicles (AVs) to perform as well as drivers in normal driving conditions, and above all, better than them in accident-prone situations

First results from the field

- Detailed US accidents involving AV's (>150 cases)
  - *Mostly rear-end collisions (freq>50%)*
  - *AV's not at fault, mostly braking situations within an intersection at low speeds*
- Biever (2020):
  - *Conflicts may be caused by differences between AVs and human driving behavior.*
  - *Conservative ADS behavior may violate the expectations of other nearby human road users.*

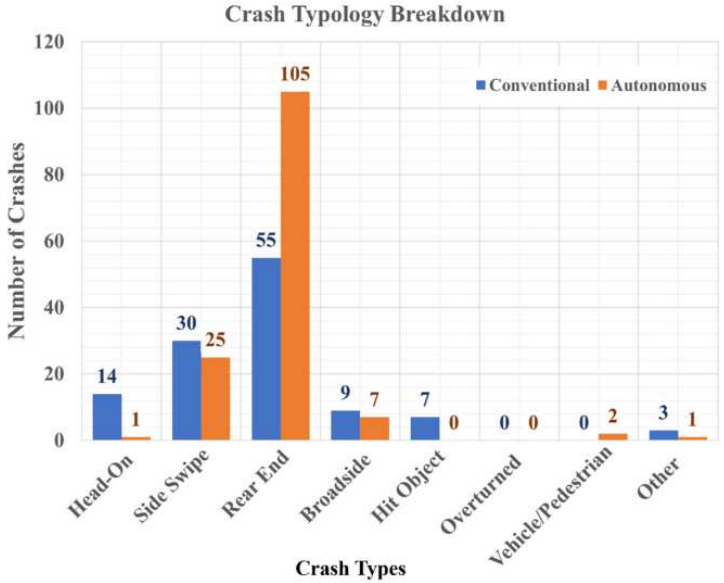


Figure 2. Crash typology distribution.

- Favarò, F. M., Nader, N., Eurich, S. O., Tripp, M., & Varadaraju, N. (2017). Examining accident reports involving autonomous vehicles in California. PLOS ONE, 12(9), e0184952. https://doi.org/10/gbw9sr
- Biever, W., Angell, L., & Seaman, S. (2020). Automated driving system collisions : Early lessons. Human Factors, 62(2), 249-259. https://doi.org/10.1177/0018720819872034
- Wang, S., & Li, Z. (2019). Exploring the mechanism of crashes with automated vehicles using statistical modeling approaches. PLoS ONE, 14(3). https://doi.org/10.1371/journal.pone.0214550
- Petrović, Đ., Mijailović, R., & Pešić, D. (2020). Traffic Accidents with Autonomous Vehicles: Type of Collisions, Manoeuvres and Errors of Conventional Vehicles' Drivers. Transportation Research Procedia, 45, 161-168. https://doi.org/10.1016/j.trpro.2020.03.003
- Sinha, A., Vu, V., Chand, S., Wijayaratna, K., & Dixit, V. (2021). A crash injury model involving autonomous vehicle: Investigating of crash and disengagement reports. Sustainability, 13(14), 7938.

Hypothesis

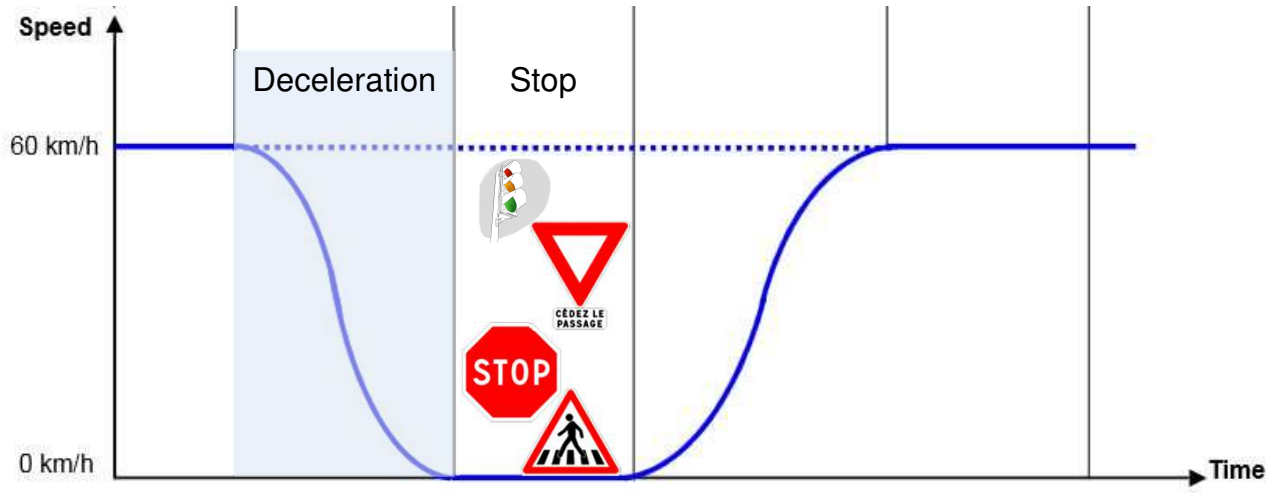
The stopping manoeuvres carried out by light-vehicle drivers produce different deceleration profiles depending on the reason for stopping (priority scheme or road design)

Variable of interest: Reason for stopping

- Priority scheme (traffic light, stop sign, give-way);
- Road design (roundabout, pedestrian crossing, bus stop)

Covariate

- Speed limit (30, 50, 70, 90)



Material

Driving data sets (deceleration)

- Data gathered from 5 previous naturalistic driving studies
- Driving data collected from OBD and GPS
- Drivers were asked to drive several times the same route
- Experiments were designed to observe different behaviors:
  - *General driving style*
  - *Ecodriving style*
  - *Intersection management*

Map data

- Posted speed limit from public map (OSM)
- Infrastructure: on-site data collection (GPS positions of infra candidates)

Methods

Deceleration profiles extraction process

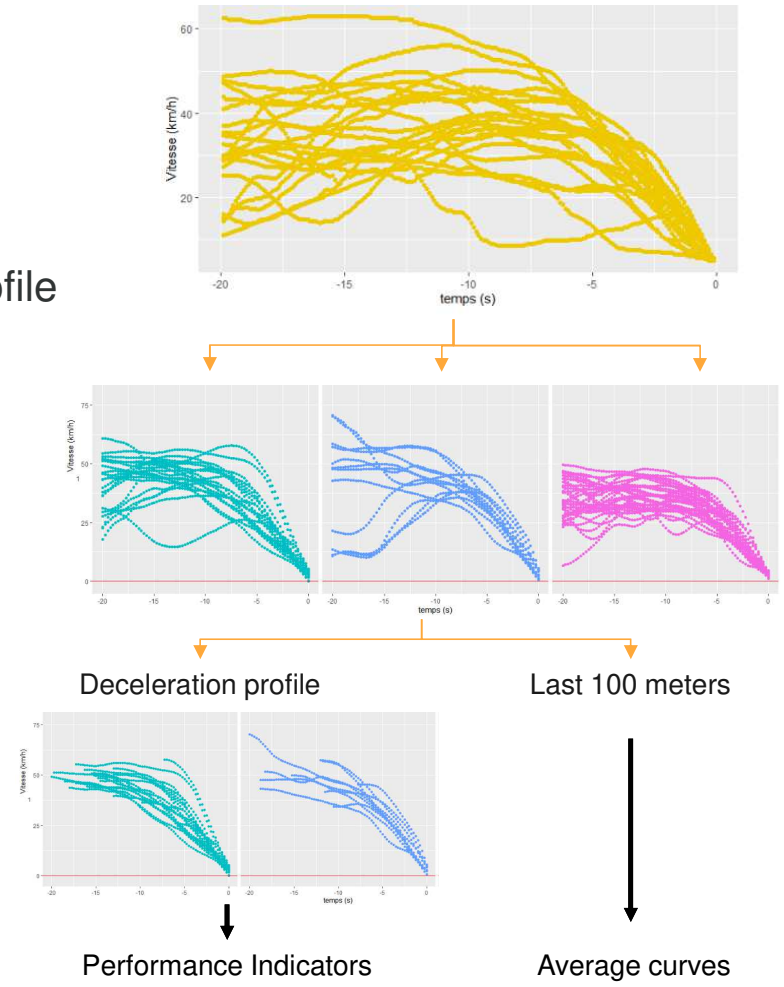
- Detect stops (Speed<5km/h during at least 3 secs)
- Extract the last 20 secs
- Identify the first instant of deceleration & extract the resulting profile
- Do some cleaning

Context enrichment

- For each deceleration profile:
  - Get the posted speed limit
  - Get the reasons to stop candidates
  - Select the most likely following a selection rule

PI's

- Deceleration distance
- Deceleration duration
- Maximum deceleration
- Average deceleration
- Initial speed
- Std speed



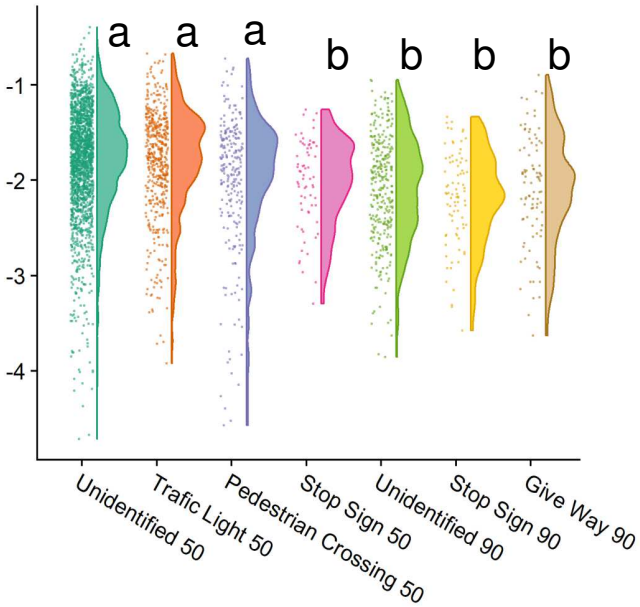
Results

Deceleration profiles distribution

Speed Limit					
Reason to stop	30 km/h	50 km/h	70 km/h	90 km/h	Total
Bus Stop	3	40	0	0	43
Give Way	1	1	7	**91**	100
Traffic Light	80	**505**	12	0	597
NA	139	**1875**	177	**312**	2503
Pedestrian Crossing	10	**235**	17	1	263
Roundabout	0	16	0	0	16
Stop Sign	3	**66**	0	**83**	152
Total	236	2738	213	487	3674

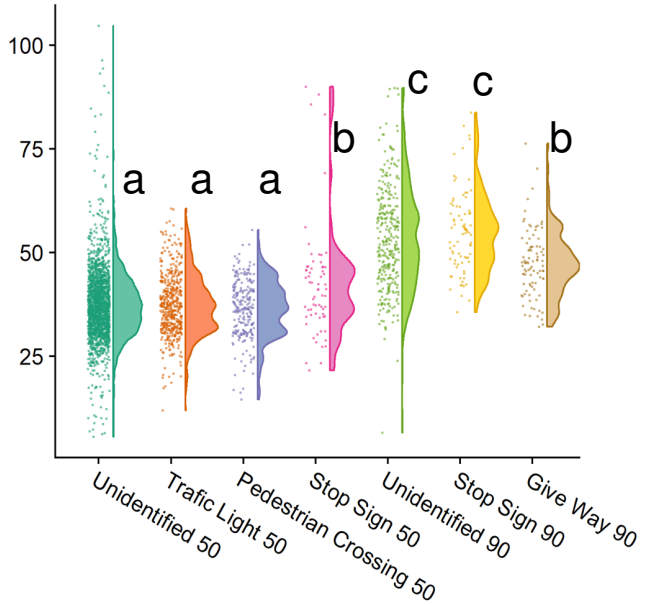
Performance indicators according to infrastructure

Max deceleration (ms^{-2})



F(6 ; 1438) = 31,64 ; p < 0,001

Initial speed (km/h)



F(6 ; 1438) = 96,61 ; p < 0,001

Max deceleration

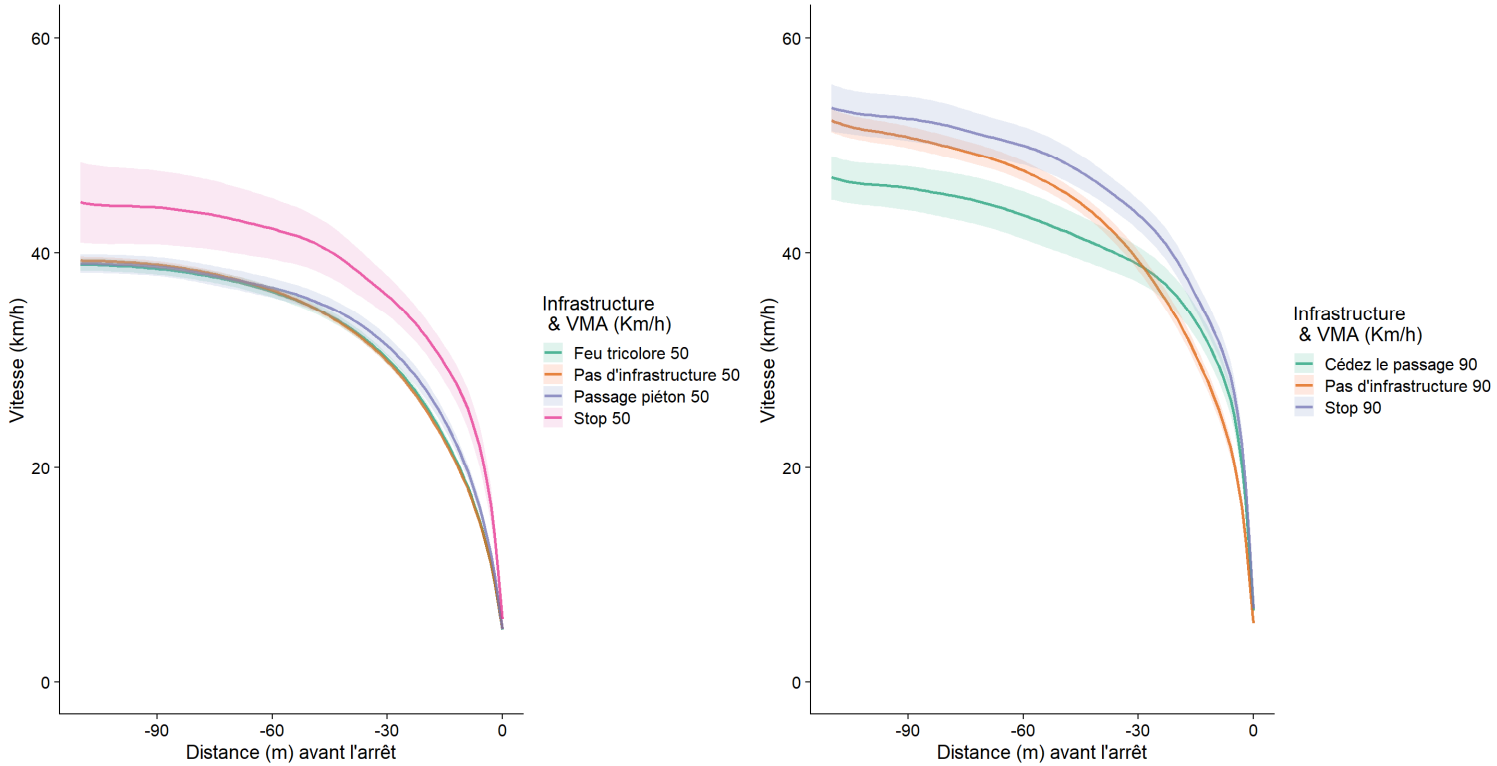
- Stop : 50 km/h = 90 km/h (Wang et al. (2005))
- 50 km/ h : Stop > Traffic light = Pedestrian crossing
- 90 km/h : Stop = Give way

Initial speed

- Stop : 50 km/h < 90 km/h (Wang et al. (2005))
- 50 km/h : Stop > Traffic light= Pedestrian crossing
- 90 km/h : Stop > Give way

- Wang, S., & Li, Z. (2019). Exploring the mechanism of crashes with automated vehicles using statistical modeling approaches. PLoS ONE, 14(3). https://doi.org/10.1371/journal.pone.0214550

Results: Average curves



stop signs are associated with higher approach speeds, followed by a late but harder deceleration phase, for the both available speed limits

Conclusion

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

SURca
Sécurité des usagers de la route et conduite automatisée

Human driver's deceleration differs according to the reason to stop

Is it the case for AV's ?

Recommendations:

- AV's should mimic the human deceleration behaviour according to the reason to stop
- AV's should be better identified
- Human drivers should be familiarized with AV's behaviour specificities

A complete list of recommendations will soon be available from the Surca project.


Smart and
Sustainable
Mobility
for all.
its
EUROPEAN
CONGRESS
TOULOUSE
30 May - 1 June 2022

Thank you!