IMPACTS ON TRAFFIC FLOW AND CAPACITY

CAD 2018 Symposium | Kerry Malone & Isabel Wilmink
How do automated vehicles impact traffic flow?

And what does that depend on?

What do we want to know?
  - Relevant situations
  - Expected impact size over time

Conclusions and recommendations
HOW DO AUTOMATED VEHICLES IMPACT TRAFFIC FLOW?

- Automated vehicles (AVs) behave mostly in the same way as manually driven vehicles, but they do some things differently (longitudinal & lateral behaviour)
- We don’t always know yet when exactly they will behave differently
- (We also don’t always know how conventional vehicles behave, especially laterally)

- A few examples that have been encountered with currently available vehicles:
  - They may need larger headways and gaps (not good for capacity)
  - They can be ‘anti-social’: e.g. not helping to create a gap for a vehicle from the next lane to cut into
  - They may come across as aggressive (braking late) or quite slow to accelerate (in stop-and-go traffic)
- When AVs do unexpected things, drivers may react in unexpected ways too, and this may also impact the traffic flow
WHAT DOES IT DEPEND ON (HOW AUTOMATED VEHICLES AFFECT TRAFFIC FLOW)?

- Or: what do we need to observe, measure, describe, simulate?

- First of all: Characteristics of the driving behaviour of AVs in relation to various
  - Physical and digital infrastructures, including (V2V, V2I) communication
  - Traffic states/conditions (how busy/chaotic?)
  - Traffic laws and regulations
  - Traffic management measures and/or services (road-side or in-car)

- Unknown: do vehicles often come to a standstill in the middle of the road?
  - See the news about the drunk driver who fell asleep in his Tesla (which was on Autopilot) It came to a stop on the Bay Bridge in San Francisco
WHAT DO WE WANT TO KNOW? WHY DO WE WANT TO KNOW THIS?

- Relevant situations to test in, or to simulate
  - Discontinuities, such as lane drops, merging or exiting sections, weaving sections, intersections and roundabouts, toll plazas, places where cars and vulnerable road users meet, …
  - Non-standard geometry

- When and where do drivers use the automated functions (up to level 3, at least)

- Expected impact size over time
  - With increasing penetration rates and levels of automation
  - With increasing mileage
NON-STANDARD GEOMETRY – HOW OFTEN? HOW PROBLEMATIC?

Peak hour lane

Heavy goods vehicle lane (in a weaving section)

Road works

Bad paint job
IMPACTS WE WANT TO GET A GRIP ON
SEE E.G. KEY PERFORMANCE INDICATORS FOR ASSESSING THE IMPACTS OF AUTOMATION IN ROAD TRANSPORTATION

- Vehicle operations / Automated Vehicle (control) operations include acceleration, deceleration, lane keeping, car following, lane changing and merging in adjacent lane.
- KPIs focus on things like:
  - Where AD functions can be used and are used, when transfer of control takes place, how long that takes
  - Speed, acceleration, (strong) deceleration, headways
  - Position in lane, gap acceptance, turning indicators, lane changes, jerk

- With information about changes in vehicle operations, we can explore the impacts on network efficiency
  - Lane, link and intersection capacity and throughput
  - Travel time and travel time reliability
EXAMPLE: SAE L2 PILOT IN THE NETHERLANDS

- Approx. 10 L2 vehicles from different brands (e.g. BMW, Tesla) have been equipped with monitoring devices
  - CAN-bus of the vehicle
  - Cameras installed in the vehicle
  - TNO logger
  - External GPS
  - Mobileye (automotive camera)

- ‘Naturalistic’ (several months of driving per vehicle/driver)

- Challenging: lateral behaviour. We will have camera data but how to analyse the data (within the not-too-large budget that we have)?
# SAE L2 PILOT: RESEARCH QUESTIONS (VEHICLE OPERATIONS / TRAFFIC FLOW)

<table>
<thead>
<tr>
<th>Question</th>
<th>Behaviour to analyse</th>
</tr>
</thead>
<tbody>
<tr>
<td>When and where is the function turned on/off</td>
<td>On what type of roads and under what circumstances do people activate their level 2 function?</td>
</tr>
<tr>
<td>What are the function settings?</td>
<td>System settings such as desired speed and headway settings. Do they depend on the conditions under which one is driving?</td>
</tr>
<tr>
<td>How is the behaviour with automated driving different from manual driving?</td>
<td>Car following with and without automated driving Lane changing, with and without automated driving free driving with and without automated driving</td>
</tr>
<tr>
<td>When will the system be 'overridden'?</td>
<td>Which situations are critical, in which the system is activated but the system cannot cope with the situation? Also: Which situations are not critical, but nevertheless overridden?</td>
</tr>
<tr>
<td>How do other road users react to activated SAE level 2 functions</td>
<td>How do the surrounding vehicles react to the automated vehicle? How does traffic around it react when a driver needs to intervene?</td>
</tr>
</tbody>
</table>
HOW DO AUTOMATED VEHICLES AFFECT TRAFFIC FLOW?

› To figure that out, we must understand:
  › Current driving behaviour (of conventional vehicles)
  › Driving behaviour of automated vehicles (and their AD functions, at L1-5)
  › The interaction between conventional/manually driven vehicles and automated vehicles
**HOW DO AUTOMATED VEHICLES AFFECT TRAFFIC FLOW?**

Where do we expect things to go wrong?

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Potential effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headway</td>
<td>Negative (highly dependent on time-headway settings, river-use and stability)</td>
</tr>
<tr>
<td>Lane changing</td>
<td></td>
</tr>
<tr>
<td>• Fewer</td>
<td>Unclear</td>
</tr>
<tr>
<td>• Different dynamics</td>
<td>• Small positive</td>
</tr>
<tr>
<td></td>
<td>• Possibly small negative</td>
</tr>
<tr>
<td>Vehicle dynamic stochastics</td>
<td>Small positive</td>
</tr>
<tr>
<td>• Greater homogeneity</td>
<td>• Small positive (restricted by low penetration)</td>
</tr>
<tr>
<td>• Shorter reaction time in</td>
<td>• Unknown positive (no evidence)</td>
</tr>
<tr>
<td>emergency situations</td>
<td></td>
</tr>
<tr>
<td>Congestion and propagation</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

Source: Calvert et al., Will automated vehicles negatively impact traffic flow?
ILLUSTRATION OF CHALLENGES (TQ MEMO)

NO SUITABLE GAP

CONFLICT

CUT-IN

DRIVER-ERROR

MANIPULATION
CONCLUSIONS AND RECOMMENDATIONS

» We need to prioritise (where do we start)?
  » Lateral behaviour is the great unknown
  » We want to increase the ODD while continuing to research the challenging situations

» The impact on road capacity is an important question, because it is related to huge investment decisions
  » VKTs can be affected by travel behaviour

» It is also important for user and stakeholder acceptance

» Research questions regarding traffic flow and capacity should be incorporated in the set-up of pilots
THANK YOU

Voor meer inspiratie:
TIME.TNO.NL