Victorian connected and automated vehicle trials

Phase One—Partially automated vehicles

April 2018
On-road findings

Electronic signs

- Electronic speed signs were challenging for some vehicles
- Signs on tunnel walls were rarely read correctly
- Flashing signs were read more reliably than other electronic signs
- Some specific sign types, locations and positioning were harder to read than others

Static signs

Some static speed limit signs on adjacent exit ramps were read by vehicles travelling on the main motorway

Roadworks

- Yellow lines were generally read well
- White lines near yellow lines disrupted lane keeping

Other objects

Stopped/merging vehicles were not always detected
Sound Tube

CityLink’s Sound Tube disrupted lane keeping and a vehicle’s ability to determine speed limits.

Toll point

Lane keeping was disengaged by gaps in line markings under toll points.

Line markings

Lane keeping was sometimes disengaged when line markings changed.

Exit ramp

- Some vehicles followed solid line markings up exit ramps leading vehicles off the motorway.
- Stationary vehicles at the end of exit ramps were not always detected.
Phase One trials focused on levels 1 and 2 automation

**Level 0**
No automation
Driver-assist functions such as safety warnings but not automated driving
HANDS ON
EYES ON

**Level 1**
Driver assistance
Driver-assist system controls speed or steering only
HANDS ON
EYES ON

**Level 2**
Partial automation
Integrated driver-assist system controls speed and steering
HANDS TEMP OFF*
EYES TEMP OFF*

*Technically possible although legality depends on jurisdiction.
Community research

Attitudes to partial automation
Barriers to adoption and acceptance

Conclusion

Next steps

Glossary
Executive summary

Cars that can steer themselves, recognise speed limits and manage their speed are already driving on Australia’s roads. However, much of our 50,000 kilometres of motorways was built decades ago and may not provide the best conditions for these new vehicles let alone be ready for the highly automated vehicles that are to come.

Transurban’s trial of partially automated vehicles, the kinds already on our roads today, set out to understand the infrastructure changes that we may need to make now and over the next few years.

Launched in 2016, the trial is a partnership with the Victorian Government, VicRoads and the Royal Automobile Club of Victoria (RACV), with vehicles supplied by Audi, BMW, Mazda, Mercedes, Tesla and Volvo. This phase was the first of three planned phases. The second and third phases of the Victorian connected and automated vehicle (CAV) trial will explore higher-level automation features and connected vehicle communications. This phase recorded more than 6,500 observations from 12 vehicles on the Monash, CityLink and Tullamarine motorways in Melbourne.

The trial identified a number of challenges for vehicle manufacturers, infrastructure providers and regulators to consider and overcome in order to safely operate CAVs on the roads.

Some of the trial findings were unique to the Monash, CityLink and Tullamarine motorways and warrant further investigation. Detailed findings are discussed in the findings and recommendations section.

Some of the findings within this report will likely be addressed by new technology superseding the tested automation features. We will adopt the recommendations where practical changes to design, operation and maintenance can have real impact now. Where the findings were inconclusive, we will work with vehicle manufacturers to investigate further.

Alongside our on-road vehicle trials, we are also researching community attitudes towards automated vehicles. The first part of this research looked at their attitudes towards partial automation and showed there are still a number of barriers to the community’s acceptance and adoption of automated driving.

With the technology moving so fast, it’s important to monitor the type of vehicle features on the road as they evolve and are taken up by the community. The trial highlighted the importance of ensuring drivers are aware of how to use driver-assisted features safely. As automated vehicles become more commonplace, industry and government will need to build community understanding of the safe use of automated technology.

Key stats

- 4 trials
- 4,900 kms travelled
- 22 days over 4 months
- 6 vehicle manufacturers
- 46 trial sessions
- 12 vehicles tested
- 118+ hours on the road
- 6,500 observations
## Phase One: Findings and recommendations

### Motorway

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Preparing Australian roads for automated vehicles

Technology and massive population growth are transforming urban mobility. A new transport system that is more integrated, connected and automated is emerging. Many of the benefits of this new system will stem from the arrival of automated vehicles. These vehicles have the potential to improve road safety and efficiency, as well as deliver other social and network benefits.

While the timeline to full automation is hotly debated, the transition phase could last up to 20 years. It is important for road operators to understand the benefits and limitations of automated vehicles, including the impacts on infrastructure operation and maintenance.

Vehicles with partial automation features are already driving on Australian roads, and the emergence of more advanced vehicles is imminent. How quickly Australia can prepare its systems, regulations, infrastructure and communities for the arrival of CAVs will underpin their successful introduction.

Shifting the driving task from humans to vehicles is incredibly complex and touches all aspects of the transport industry. Existing rules for vehicle manufacture, insurance, road operations, and driving all need to be revised. This process will likely involve significant legislative change, and the development of new regulations and guidelines that ensure public safety and foster innovation.

Recent work by national bodies such as the National Transport Commission (NTC) has been critical to progressing these considerations. The NTC is currently working on a phased reform agenda to support the introduction of vehicles with automated driving systems (ADS) can be introduced from 2020.

The Victorian Parliament has passed legislation enabling trials of higher-level automation on Victorian roads, based on nationally approved guidelines.

Physically preparing Australia’s roads for CAVs is also essential. In a recent assessment of 20 countries’ preparedness for automated vehicles, Australia ranked 14th. We received the maximum score for the quality of our mobile networks but only average ratings for the quality of our roads, availability of 4G and the number of electric charging stations.

Infrastructure upgrades generally require long lead times and come at significant cost. As a country we urgently need to understand if we have to retrofit Australia’s almost eight million square kilometres of local and arterial roads and motorways with CAV-ready technology and infrastructure.

1 KPMG 2018, Autonomous Vehicles Readiness Index
Phase One comprised two complementary programs: a series of on-road trials and a community research program.

During Phase One, on-road trials focused on identifying the:

• issues CAVs encountered while driving on the Monash, CityLink and Tullamarine motorways
• infrastructure changes we could and should make now and over the medium term.

Our four-month on-road trials involved 12 current model vehicles with partial automation features, sourced from six vehicle manufacturers. The broad range of vehicles helped us identify common themes—which, in turn, will help inform our future road upgrades and operations.

The trials were not about comparing vehicle models or features—vehicle manufacturers conduct their own tests before launching vehicles onto the market. While testing vehicles by manufacturers is commercially sensitive and generally not shared publicly, our research spans many vehicle types. We believe this makes the findings useful to both road operators and governments.

Our findings are available via our website: cavs.transurban.com

During Phase One, we also explored Australian’s views about automated driving, and identified potential barriers to the adoption of CAVs in Australia. This understanding could help shape public education programs.

What we trialled

Phase One trialled current-model Audi, BMW, Mazda, Mercedes, Tesla and Volvo vehicles with partial automation features. While partially automated vehicles are already on the road, we expect the number to increase significantly over the next few years.

What is partial automation?

Technology installed in partially automated vehicles generally helps vehicles:

• steer themselves and stay in their lane (known as latitudinal control)
• manage their speed relative to other vehicles on the road (known as longitudinal control)
• recognise the speed limit.

Vehicle manufacturers highlight that current partial automation features are intended for driver-assistance only. They are not designed to automatically handle every scenario that may arise on the road.

Our trial looked at how vehicles with those features interacted with the motorway environment, including: speed signs, toll points, line markings, motorway artwork and architecture, entry and exit ramps, objects on the road, merging vehicles, different light and weather conditions, peak-hour congestion, and road works.

Partial automation features

Look out for these technologies as you make your way through the report.

- Lane Keep Assist (LKA)
  Reads lane lines and proactively intervenes with vehicle steering to ensure the vehicle stays in its lane.

- Adaptive Cruise Control (ACC)
  Building on standard cruise control functions, ACC sets a maximum speed, but may adjust speed based on distance to the vehicle in front.

- Traffic Sign Recognition (TSR)
  Camera technology detects and reads speed signs and displays them in the vehicle.

- Minimal Risk Condition (MRC)
  This refers to the way the vehicle reacts if, after multiple warnings, the driver does not take back control of the vehicle.

Implementations of these features vary across vehicles, for example in the range of speeds at which they function. Some of the trial vehicles allowed these features to be used in combination.
Victorian CAV trials
Phase One

How we ran the trials

Phase One included four trials which increased in complexity. These trials were run between August and November 2017 (refer to Figure 1).

Professional drivers from the state-of-the-art Australian Automotive Research Centre (AARC) testing facility drove the test vehicles, with observers from Transurban as passengers.

Trial vehicles completed circuits of the Monash, CityLink and Tullamarine motorways while drivers and observers recorded how the vehicle's automated features responded to road infrastructure.

Observations were corroborated by video footage from four cameras installed on the vehicle's front, rear and interior.

We collected more than 6,500 observations via this structured approach. Analysis of these observations helped us identify themes and issues warranting further investigation. We provided reports to participating vehicle manufacturers documenting the particular vehicles' responses – giving vehicle manufacturers the opportunity to assess their vehicles' recognition and reaction performance.

However as an infrastructure owner and operator, our focus was on identifying any issues common to multiple vehicles—as common issues were more likely to warrant future changes to motorway infrastructure.

While we present quantitative information, it is indicative only, and not statistically significant.

Technology is constantly changing and, after these trials concluded, some vehicle models may have been modified and may now behave differently. Conditions on the trial's motorways have also changed. Road works in progress during the trial are now complete.

Safety first

Each trial included safety and vehicle technology briefings followed by a driver familiarisation day at the AARC's closed track facility with the vehicle manufacturers. This gave drivers the opportunity to become familiar with activating and deactivating the automated features of each vehicle prior to testing in live-traffic situations.

The exclusive use of a closed test track also provided a safe, controlled environment in which the vehicles could be put into a Minimal Risk Condition.

This allowed us to gain a rare insight into how the vehicles would behave if a driver was to fall asleep or become medically incapacitated while driving using automation features.

Except for the MRC test, trial drivers had their hand on the steering wheel. They remained in control of the vehicle at all times.

Figure 1: Phase One timeline
Findings and recommendations

This section outlines key findings across lines, exit ramps, speed signs, motorway art and other objects and vehicles on the road which informed a number of recommendations. Some of the findings presented here relate to motorways in general. Some findings are toll-road focused, and some are specific (or even unique) to individual motorways.

Lines: the stronger, the better

Yellow line markings aren’t that confusing

- Yellow lines were reasonably well read
- Line contrast had a greater effect than colour, for example a solid white line amidst yellow lines disrupted lane keeping

In Victoria, yellow lines are used over the standard white lines to temporarily shift traffic lanes and create room for road works. This means there can be two sets of line markings on the road, which can be confusing for drivers to navigate.

We expected the vehicles would find the yellow lines difficult too, and while lane keeping within yellow lines was less reliable than in white lines, the difference was not as significant as anticipated (refer to Figure 2).

Roadworks related to the CityLink Tulla Widening Project and Monash Freeway Upgrade meant that sections of the trial route were marked with yellow lines. Vehicles navigated roadwork areas quite well, especially in instances where white lines had been blocked out at the transition to or from yellow lines.

While the lane keeping sometimes disengaged within the yellow lines, this was likely due to the number of changes to line markings in a roadworks environment, rather than the colour of the lines. Vehicles tended to follow the ‘best’ line based on contrast (for example, solid rather than dashed, wider, brighter, freshly painted, or continuous).

Recommendation
- Where yellow lines are used, block out ‘competing’ lines, especially at transitions
- Avoid leaving strongly contrasting white lines alongside yellow lines during roadworks
- Revisit guidelines for line markings in roadworks, to provide clarity for contractors

![Figure 2: Proportion of lane keeping observations within roadworks with yellow line markings, relative to the proportion of distance travelled within yellow lines](image-url)
Gaps in line markings under toll points are confusing

- Gaps in line marking under toll points disengaged lane keeping

Short gaps in the line markings under the tolling gantries on CityLink are a legacy of an earlier toll operating system, however, advances in technology means the gaps are no longer necessary.

As expected, these gaps in line markings created challenges for vehicles, with lane keeping systems sometimes disengaging as lines disappeared under gantries.

Vehicles reacted to the change differently, with some simply carrying-on and waiting for lines to reappear and others shifting side-to-side hunting for lines to follow.

There was also a difference in the time (typically it was 0 to 10 seconds) until vehicles would re-engage their lane keeping after lines reappeared.

**Recommendation**

- Paint lines beneath toll points

Disruptions to line markings are problematic

- Changes in line markings (solid-dotted, expansion joints, dual lines, gap due to lane add) sometimes disengaged lane keeping

In general, the lane keeping features, worked well where there were good quality line markings on the road. Although sometimes lane keeping disengaged for no apparent reason, most of the time clear factors triggered it.

The main causes for disengagements occurred due to: changes in line types (for example, solid lines changing to dotted lines), exit ramps, expansion joints, drains, dual lines, marks on the road, chevron markings at exit ramps and other roadside objects, such as roadwork bollards (refer to Figure 3).

**Figure 3:** Type and frequency of trigger causing lane keep assist system disengagement, excluding toll gantries (Trials 3 & 4—2,210km)

Lines can also be disrupted when a lane is added after merging traffic enters the freeway. When this occurs, the lane widens and the middle line does not appear until it is the full width of two lanes. In this instance, lane keeping sometimes disengaged.

When lanes had a sharp curve, vehicles would not necessarily slow down as a driver would. This was unsettling for drivers, in some cases leading them to deactivate auto steering around sharp bends.

**Recommendation**

- Evaluate impact of painting line markings over objects including expansion joints and drains
- Investigate options for line marking treatments where lines change (solid to dashed) or disappear (lane added)
Marks on road — road repairs

Chevrons

Expansion joints

Dashed to solid line markings

Lane add

Dual lines

April 2018
Pay attention next exit

Exit ramp line markings lead the way

- Vehicles favour solid lines, and would sometimes follow a solid line up an exit ramp, rather than continuing along the main motorway.

At exit ramps, the solid line at the edge of the far left lane veers off the motorway as it follows the exit ramp, while a dotted line continues across the exit ramp lane marking the main motorway, which is consistent with current guidelines. Because lane keeping systems sometimes favour solid lines over dotted lines we found that vehicles in the left lane using lane keeping would follow the solid line marking and be led up the exit ramp rather than continuing along the motorway. If not anticipated, this behaviour could lead drivers to take the wrong exit or make last-minute swerves back on to the motorway.

Recommendation

- Where available, suggest drivers choose middle lanes when using lane keeping technology, if their vehicle is susceptible to these issues.

Stopped vehicles become camouflaged

- Sometimes vehicles did not detect vehicles stopped at the end of a ramp and did not slow down. This observation was not unique to exit ramps, but more frequent with particular ramp alignments.

The end of motorway exit ramps typically intersect with other roads, causing vehicles to pause at give way signs or traffic lights.

In some cases, vehicles using adaptive cruise control (ACC) along an exit ramp did not seem aware of stopped vehicles at the end of the ramp and did not slow down as they approached those vehicles. At certain exit ramps such as at Toorak Road, Hawthorn East, this occurred frequently, across several different trial vehicles.

At times in other locations on the motorways vehicles using ACC did not seem to detect and slow down for a stationary vehicle ahead (for example, when driving in congestion or approaching stopped vehicles around a tight corner).

ACC systems rely on moving vehicles to identify and modify speed. If trial vehicles approached stationary vehicles without driver intervention, it is presumed that autonomous emergency braking (AEB) would have activated. However, the braking would have been severe and may have caused a collision.

The alignment and geometry of certain ramps may have made it difficult for CAVs to detect the movement of another vehicle along the ramp, though further investigation is required.

Recommendation

- Advise drivers of the technology’s limitations through industry-wide awareness campaigns.
- Explore further with vehicle manufacturers and raise with ANCAP.
- Consider adding warning signs further up ramp (for example, to advise vehicles to ‘prepare to stop’).
- Await high-precision maps, so vehicles can recognise ramps.
- Explore longer-term options to alert vehicles on selected ramps and on other locations where queues may build up out of sight, through available connected vehicle communications.

Female, 36-40, VIC, CAV advocate

“My previous model car had ACC but would ignore and would not react if approaching a stationary object...But if I had not been aware of the limitations that could have been really nasty”
Most new vehicles have digital maps that specify the speed limit on a given section of road. Some partially automated vehicles also draw data from traffic sign recognition (TSR) features, which use cameras to read the physical speed signs as the vehicle drives past. Given Victorian motorways often use Electronic Speed Limit Signs (ESLS) with varying speed limits, this extra source of data is important as a road’s speed may not be correctly reflected in the digital map.

Some of the trial vehicles had TSR which drivers used as guidance in manually setting or adjusting the vehicle speed. In many cases it was not possible to determine from the instrument panel, whether the vehicle used a digital map or TSR to determine the speed limit.

In our TSR analysis we noted vehicle responses when a vehicle passed a speed sign requiring a change in speed (for example, going from 60km to 80km). We excluded instances where a vehicle passed a sign showing the same speed displayed on the vehicle’s instrument panel from our analysis because we could not tell if the vehicle had read the most recent sign.

As vehicle automation increases and vehicles begin adjusting their speed automatically, it is critical that vehicles can identify the correct speed.

**Most static signs are easily read**

- Static signs were read well, but sometimes vehicles read static ramp signs while travelling on main motorway

As electronic signs are increasingly used to manage urban motorways in Victoria, static signs are becoming less common; although these still appear on exit ramps, and sections of road beyond managed motorway networks.

Static signs on, or near the motorway network were generally identified and read correctly and, in most cases, assisted the driver. However, there were some examples where vehicles driving on the motorway identified and read static signs on adjacent entry and exit ramps. In these cases the static signs applied to the ramp, not the motorway, resulting in a misinterpretation of the speed limit.

The placement, reflectivity and luminosity of static signs are guided by national standards, however guidelines may need to be revised to ensure the position of a sign does not create confusion for TSR systems.

**Recommendation**

- Where possible, reposition signs to be visible on ramp but less visible from main motorway
Electronic signs are challenging

- Electronic speed signs were more challenging for some vehicles
- Signs on tunnel walls were rarely read correctly
- Flashing signs were read correctly, more reliably than constantly illuminating signs
- Some specific sign types, locations and positions were more challenging to read than others

Not all of the trial vehicles had TSR activated for use in Australia. Vehicles with TSR varied in ability to identify and correctly read the speed limit for most sign types across different vehicle manufacturers.

Sign positioning impacted a vehicle’s ability to correctly identify and read speed signs. For example, road-side fixed signs were generally read better than overhead (gantry-mounted) or portable signs beside the road (refer to Figure 4).

In CityLink’s tunnels, ESLs are mounted on the tunnel walls rather than overhead to provide more clearance for higher vehicles. These signs are smaller than other ESLs and were especially challenging for vehicles to identify, regardless of the lane the vehicle was travelling in. Further analysis is now under way to determine whether size, positioning, LED refresh rate, pixel scanning, height and luminosity may be contributing factors.

Where signs were identified, there were several instances where they were incorrectly read. For example, 80 km/h was misread as 60 km/h, but also sometimes as 30, 40 or 100 km/h. While it is unclear why this happened, we are providing feedback to the vehicle manufacturers to allow them to refine their TSR algorithms.

The two concentric circles around the edge of an electronic sign, flash to draw attention to a speed limit differing from the normal limit in that location. On average, flashing speed signs were correctly read more often than solid or continuous signs. This was unexpected, as anecdotal industry feedback suggested that flashing signs were problematic (refer to Figure 5).
Also, some specific sign locations seemed more problematic than others, but we had too few observations of each such location by the different vehicles to be sure, or to work out why this might have been the case.

- Motorway-to-motorway interchange—the electronic signs on a gantry over a downhill motorway-to-motorway interchange ramp were read less accurately than other gantry-mounted signs. We are currently analysing if there is anything unusual about this location, such as ramp gradient or sign height, and whether these could be factors.
- Unusual gantry design next to billboard—another location where electronic signs were read less reliably was at a gantry with an unusual design, with a large billboard to the left of the gantry. It seemed as though vehicles had difficulty with TSR from the left lanes of the motorway, despite accurately reading the signs from the right lanes. We are currently analysing whether factors such as the structure of that gantry or location of the billboard have any impact on TSR performance.

### Recommendation

- Share data with vehicle manufacturers to refine traffic sign recognition algorithms
- Use different signs and change their position in future tunnels
- Review sign height and positioning at problem locations, and design of new road furniture
- Review and update electronic sign standards, if deemed necessary

![Overhead (gantry-mounted) ESLS](image)
Urban design vs vehicle science

Sound Tube

- The CityLink Sound Tube art installation disrupted autonomous driving mode and disengaged lane keeping technology
- Inside the tube some vehicles did not detect the correct speed limit, reading 80 km/h as 110 km/h or derestricted. The same vehicles read signs correctly before and after the tube
- In one instance, a ‘ghost’ vehicle was detected where there was no lane

Sound Tube, a unique and iconic piece of motorway architecture, encases CityLink between Racecourse and Brunswick Roads.

The Sound Tube environment appeared to trigger a mix of behaviours across different vehicles, interfering with their ability to stay in their lane, detect other vehicles and determine the correct speed limit.

For instance, at certain points within the Sound Tube some vehicles identified the speed limit as 110 km/h or ‘derestricted’ despite having identified the correct limit beforehand and continuing to do so afterwards. This was an issue in particular in the left lane, southbound.

In another instance, a vehicle using ACC through the Sound Tube detected and braked in response to a ‘ghost’ vehicle that was not actually there. Various theories suggest the environment may be influenced by factors such as reflections from communication signals, electro-magnetic interference and unusual light and shadow patterns, but the cause is unclear.

We’ll continue working with vehicle manufacturers and engineers to understand how the Sound Tube interacts with CAV technology.

Recommendation

- Highlight to vehicle manufacturers and map providers to help identify cause
- Once causes are understood, factor into future urban design wherever possible
While we take care in ensuring our motorways are clear at all times, there are instances where other objects may be on the road. These may be planned for and controlled as is the case with roadworks, or unplanned and dangerous such as if material falls from a vehicle.

At this stage, vehicle manufacturers acknowledge that debris, people, and plastic bollards may not necessarily be identified by the current generation of partially automated vehicles.

Similarly, merging vehicles would not necessarily be identified by the current generation of these vehicles, which means that there would be no ‘merging politeness’ (speeding up or slowing down to allow the merging vehicle to enter the lane) displayed by the CAV vehicle on the motorway.

**Other vehicles on the road**

- Vehicles travelling to the side of trial vehicles (for example, merging from entry ramps) may not be detected. Trial vehicles did not create gaps to allow merging vehicles into traffic

**Recommendation**

- Explore further with vehicle manufacturers
- Where available, suggest drivers choose middle lane(s) when using automated driving features, if their vehicle is susceptible to these issues

**Other objects on the road**

- Objects on roads may not be detected by CAV vehicles, including debris, stopped vehicles, people getting out of their vehicle (such as during an incident or breakdown), and roadworks equipment including traffic cones, plastic bollards, temporary and portable signs, and truck-mounted attenuators

**Recommendation**

- Educate drivers about the limitations of driver-assistance features to ensure they do not overestimate the capabilities of their vehicle
Community understanding of CAV technology is an important factor in its safe transition onto our roads.

Our community research program focused on community attitudes and perceptions towards partial automation, as well as the reasons why people may not accept, or be wary of increased automation on motorways.

The research activities took place in Victoria, New South Wales and Queensland with participants ranging from non-CAV drivers through to experts.

Research finding

Research participants found that driver assist features work best on motorways or clearly marked roads, with good double lane (minimum) roads and a speed limit of 80km and over.
Attitudes to partial automation

A qualitative study involving 205 drivers, some already using automation and others not, contributed to a two-week online forum.

Our research showed that many people within the community have heard about autonomous vehicles, but there is still some confusion about how and when these features will reach them. They view the technology as having the potential to make roads safer, not just a way to make driving easier.

Despite being broadly aware of the inevitable change from human to autonomous driving, the community’s understanding of partial automation features is low and there wasn’t consistent language used when describing the technology.

As people try out driver-assistance features—typically in their own car—they generally feel more positively towards the technology and advocate its benefits to friends and family. So far this group has been quite small, comprising owners of new or luxury vehicles, but this may change as vehicles across all price points begin to offer these features in line with customer expectation and safety rating agency guidelines. Uptake of this technology has the opportunity to make our roads safer, but only if drivers are aware of the limitations such as those identified as part of our trial.

“I especially love the adaptive cruise control—it makes me feel a lot safer and keeps me a safe distance from the car in front. I think all cars should have this then we wouldn’t have people tailgating. Fewer accidents if we had to have it and we couldn’t switch it off.”

Male, 46-50, QLD, CAV advocate

“Anything to make it safer and easier to drive is a bonus and I would certainly use any new technology available.”

Male, 51-55, VIC, CAV advocate

“I love all these gadgets and I reckon they have saved me from a bump or two over the last few years. I must admit though, they are only a help and are by no means infallible. The driver must read their car manual very carefully and be aware of what each system can do and, most importantly, what it can’t do.”

Male, 46-50, QLD, CAV advocate
Barriers to adoption and acceptance

Eighty-four per cent of respondents were eager to have automated features in their next car. Nine per cent said they would be very hesitant and seven per cent were neutral. Across these groups, there was no significant difference between gender or age. Among the group who identified as ‘very hesitant’, five key barriers to adoption emerged.

Transurban customers responded to a survey that asked them about how they felt toward having automation features in their next vehicle.

Nine per cent of respondents profiled as ‘very hesitant to automation features’.

From that subset, 40 participated in an online forum.

Figure 8. Five key barriers to adoption

- **Fear of new technology**: Many do not trust a computer to be better than a human
  - “I’m not too sure about the park assist, adaptive cruise control & automatic braking as I’m probably too much of a control freak and not sure I would trust that the computer components would not malfunction.” Female, 51-55, QLD, CAV rejector

- **Potential impact on driving skills and behaviours**: Fear of social change, decrease or loss in driving skills
  - “I find the other mentioned features are creating lazy drivers. People no longer check their blind spots, or look in their mirrors and I often see people drift between lanes. It’s dangerous and scary to think a new generation of drivers will know these features as standard.” Female, 25-27, NSW, CAV rejector

- **Overconfidence in one’s ability**: Feel there is no current need to use driver-assistance and to trust in own ability
  - “I am a skilled driver and do not need these features to ‘help’.” Female, 25-27, NSW, CAV rejector

- **The enjoyment of driving**: Driving is more than just getting from ‘A’ to ‘B’
  - “I like DRIVING. I’m not sitting in the car, letting “something” else do the driving for me.” Female, 46-50, NSW, CAV rejector

- **Price/value**: Want to buy most affordable car available, not interested in frills or special features
  - “Great make them standard and raise the price of cars higher than ever. All these gadgets cost and cars are over priced already. I think I’ll buy a horse.” Male, 51-55, QLD, CAV rejector
Conclusion

The trial has delivered a mixed set of findings, in some cases these findings led to clear recommendations, however others are inconclusive and require further investigation.

Throughout our trial we provided specific feedback to vehicle manufacturers, highlighting how automated driving technologies were challenged by specific motorway features for use in their on-going product development.

We thank the vehicle manufacturers for their ongoing co-operation and also acknowledge the technical support provided by ARUP.

It doesn't make sense to make all the recommended changes now. The development of vehicle technology is likely to outpace road infrastructure owners and operators' ability to make physical modifications to infrastructure. Some of the challenges identified in our trial could potentially be addressed in the longer term through more advanced connected vehicle communications (e.g. I2V/V2V communications) or high-precision maps. We are, however, making two practical changes now:

- line markings—paint lines under toll gantries
- tunnel wall speed signs—ensure a different sign type for future tunnels such as West Gate Tunnel.

We will also incorporate what we’ve learned in the design of new roads and how we operate them.

Some of our recommendations suggest changes to the standards and guidelines that are being used today. We will work with industry to ensure these feed into an ongoing review process, to improve national consistency and harmonisation.

Next steps

As vehicle technology continues to evolve, further trials will be important to measure how these developments address the road infrastructure challenges we identified. Our future trial program will include trialling:

- the same vehicles with newer automation systems to learn about improvements in these systems. Also, redoing trials after we have made changes to our infrastructure will allow us to assess the impact of those changes
- different vehicles to help us understand further issues and interactions not already identified from the trials to date
- additional roads more broadly across the network within Victoria and other jurisdictions, to help identify further findings specific to those road environments.

In the next phases of the trial program, we will build on the learnings from this first phase by introducing more highly automated vehicles and connected vehicle communications.

We look forward to sharing further details of these trials as they become available, and welcome further industry collaboration to accelerate the introduction of these important new technologies.
Glossary

AARC
Australian Automotive Research Centre

ACC
Adaptive Cruise Control—builds on standard cruise control functions and maintains a set speed and following distance to the car in front

ANCAP
Australasian New Car Assessment Program—it provides Australian and New Zealand consumers with independent vehicle safety information

CAV
Connected and automated vehicle

Driver-assistance features
Vehicle safety systems that assist drivers in some elements of driving, such as warnings and the emergency breaking

GPS
Global positioning system—high precision maps 3D maps which vehicles can compare against what their sensors ‘see’, to help pinpoint their exact location

I2V
Infrastructure-to-vehicle

Identify a traffic sign
Where a vehicle detects a traffic sign exists

LIDAR
Measurement of distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor

Line marking
Lines used on a road surface to provide guidance and information to drivers and pedestrians—commonly to delineate lanes

LKA
Lane-keep assist—reads lane lines and proactively intervenes with the steering of the vehicle to ensure that it does not unintentionally leave the lane

Map providers
 Providers of digital maps to the vehicle manufacturers e.g. HERE Maps, TomTom, etc.

MRC
Minimal Risk Condition—this refers to the way the vehicle reacts if, after multiple warnings, the driver does not take back control of the vehicle

NTC
National Transport Commission

Radar
A system for detecting the presence, direction, distance, and speed of objects, by sending out pulses of radio waves which are reflected off the object back to the source

Read a traffic sign
Where a vehicle identifies and correctly reads the speed sign and illustrates the speed on the instrument panel

Sound Tube
Encasing CityLink between Racecourse and Brunswick Roads the Sound Tube is a unique and iconic piece of motorway architecture

Toll point/gantry
Elevated structure above the road which monitors vehicles underneath for billing purposes

TSR
Traffic Sign Recognition—camera technology that detects and reads traffic signs and displays them in the vehicle

V2V
Vehicle-to-vehicle
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