



AUTOMATED AND
ZERO EMISSIONS
VEHICLES ADVICE

CONSULTATION SUMMARY

May 2018

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INTRODUCTION

In October 2017, the Victorian Special Minister of State asked Infrastructure Victoria to provide advice on what infrastructure might be required for highly automated and zero emissions vehicles. You can read the full request on our website at infrastructurevictoria.com.au/AVadvice.

Our advice will consider how, and when, automated and zero emissions vehicles may emerge in Victoria, and how their ownership and market models could shape the future. We will also comment on the potential sequencing, timing and scope of infrastructure development to support these changes.

The first phase of the project focused on the development of potential future scenarios for automated and zero emissions vehicles, which is now complete. Consistent with our values and the request for advice, we undertook extensive stakeholder engagement in this phase to develop and test target outcomes of these future vehicles for Victoria, and to confirm the relevant issues and areas of focus for further analysis.

Through this engagement we met with and heard from more than 130 organisations and individuals who provided valuable input and helped us to refine the scope of our research and analysis. Much of that detailed work is now underway. This report summarises what we did in this first phase of consultation and shows how what we heard has influenced the preparation of our evidence base for this advice.

Next, we will release this evidence base in August 2018 and open again for consultation.



What we did

In late 2017, Infrastructure Victoria commenced an initial phase of informal consultation with key organisations to begin to identify the issues and areas of concern for stakeholders.

These early discussions helped us shape the program of work to inform the advice, including the technical analysis and research that has already commenced, and identified the areas of focus that will require careful examination.

We then began a process of formal stakeholder consultation in early February 2018, which consisted of:

- online feedback collection via Infrastructure Victoria's consultation website from 7 February to 7 March
- three stakeholder workshops, two of which were held in Melbourne and one in Castlemaine.

This phase of formal consultation examined the target outcomes that automated and zero emissions vehicles could achieve for the state, as well as the areas of focus for the advice we identified through early meetings with stakeholders.

Early consultation

From November 2017 to March 2018, Infrastructure Victoria identified and met with a range of companies, industry groups, academic institutions and other relevant stakeholders to build the basis of the scenarios and the advice.

Meetings were held with:

- ABB
- AGL
- The Australia and New Zealand Driverless Vehicle Initiative
- Australian Association for Hydrogen Energy
- Australian Energy Market Operator
- Australian Road Research Board
- Clean Energy Finance Corporation
- Committee for Melbourne
- ConnectEast
- Deakin University
- Electric Vehicle Council
- Energy Networks Association
- Engie
- Environment Protection Authority
- Federal Chamber of Automotive Industries
- Hyundai
- ITS Australia
- Latrobe University
- Lumen
- Monash University
- Moreland City Council
- National Transport Commission
- RACV
- RMIT University
- Roads Australia
- Swinburne University
- Telstra
- Tesla
- Toyota Australia
- Transoptim
- Transurban
- University of Melbourne
- Victoria Police
- VicRoads
- Victoria University
- Vodafone
- Waymo
- Zoox

Meetings focused on identifying, testing and refining the target objectives that the state should aim to achieve through the adoption of automated and zero emissions vehicles, and the key areas of focus for the advice.

We also met with a range of Victorian Government departments and agencies, including the Department of Premier and Cabinet, Department of Treasury and Finance, Department of Economic Development, Jobs, Transport and Resources, Transport for Victoria, Department of Environment, Land, Water and Planning and VicRoads. An advisory group of government representatives also confirmed that the scenarios are appropriate to test the key issues for this work.

Submissions

The online feedback form was open on Infrastructure Victoria's consultation website from 7 February to 7 March 2018. A total of 25 submissions were received from a broad range of stakeholders representing local government, universities, professional associations, the automotive sectors, energy, engineering, transport, telecommunications, planning, environment and people living with a disability.

Submissions were published on the Infrastructure Victoria consultation website: yoursay.infrastructurevictoria.com.au/vehicles-advice

Workshops

To complement the online submission process, we also ran three stakeholder workshops to ensure that we heard a wide range of views, to encourage stakeholders from different industries to exchange views, and to allow as many people as possible to provide input to the advice. Ernst & Young (EY) was engaged to facilitate these workshops, where attendees were asked to consider key uncertainties to be considered in the advice, and key decisions that Victoria will need to make about the future of automated and zero emissions vehicles. They were also asked to identify triggers for these decisions where possible.

Two workshops were held in Melbourne, one with members of the Committee for Melbourne and the other with a group of targeted stakeholders who were highly active or interested in automated and/or zero emissions vehicles.

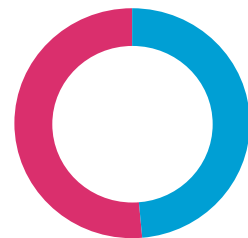
The third workshop was coordinated with the Municipal Association of Victoria and hosted by the Mount Alexander Shire Council in Castlemaine in regional Victoria. At this workshop, we posed the same questions to local government representatives, local environment groups, regional businesses and residents.

The workshops included a gallery of previously identified uncertainties and decisions, which were showcased to participants to encourage thinking around the infrastructure requirements of automated and zero emissions vehicles. This was followed by roundtable discussions, each of which was facilitated by an EY or Infrastructure Victoria subject matter expert.

Feedback on the workshops was collected via an online survey, with 39 out of 77 workshop attendees providing a response. The overall feedback received was overwhelmingly positive, with all surveyed attendees very satisfied or satisfied with the workshops.

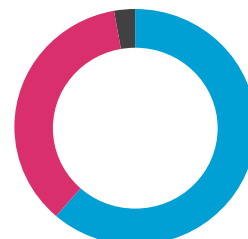
Stakeholder workshop survey results:

How satisfied are you with today's workshop overall?



- Very satisfied
- Satisfied
- Somewhat satisfied
- Not satisfied

How satisfied are you that you've had a chance to have your say at today's workshop?



- Very satisfied
- Satisfied
- Somewhat satisfied
- Not satisfied

WHAT WE HEARD

Target outcomes

Our approach to this advice is based on ensuring that the infrastructure to support automated and zero emissions vehicles is planned and delivered in a way that benefits all Victorians. In keeping with this approach, we identified ‘target outcomes’ for automated and zero emissions vehicles that highlight the specific ways in which these technologies could benefit Victorians and help achieve the objectives in Infrastructure Victoria’s 30-year infrastructure strategy (for more details see infrastructurevictoria.com.au/30-year-strategy).

Those target outcomes are as follows:

Improve safety and public health	Decrease carbon emissions
Improve transport system performance and accessibility	Decrease air and noise pollution
Improve mobility options	Improve reliability and sustainability of energy systems
Improve access to jobs and services	Support the productivity and growth of the Victorian economy
Enable optimal land use	

We asked stakeholders to comment on whether there were any additional outcomes that automated and zero emissions vehicles could contribute to achieving in Victoria, and whether any of these outcomes were more important than others. We received broad support from stakeholders on these through both our informal and formal consultation phases. The vast majority of people we spoke to and heard from were pleased to see that target outcomes had formed part of Infrastructure Victoria’s approach to the advice. Some stakeholders provided feedback about the prioritisation of the target outcomes, with different people highlighting different outcomes as the highest preferred priority.

New feedback is detailed in the table of additional factors on page 20.

Key areas of focus

Our key areas of focus for consultation were:

Changes to travel and land use patterns	Interface with physical infrastructure
Digital infrastructure	Levels of sharing and ownership
Economic impacts	Public acceptance and government policy
Energy supply and charging capacity	Social consequences and opportunities
Environmental and human health impacts	Technology development

Almost all submissions and comments we received from stakeholders related to the areas of focus, which we identified through our early engagement and published online as part of the formal consultation phase. Within each area of focus, many of the common themes that emerged through consultation had previously been identified and incorporated into our work through a literature review or through early discussions with stakeholders. A summary of what we heard on each of those areas of focus is detailed in this section.

In addition, we received some new information and issues to consider through the consultation. That new information, as well as our response, is detailed on page 20, including where some issues are considered to be outside the scope of this advice.

Key areas of focus



About changes to travel and land use patterns we heard:

- Automated vehicles may impact travel patterns by increasing congestion, causing more development in fringe areas, or reducing active transport (like walking and cycling). These changes may occur if people perceive the time they spend commuting differently in an automated vehicle as they can undertake tasks other than driving, which could mean they are prepared to travel for longer.
- Car parking regulations and planning controls may need to change, particularly if there is a shift towards shared mobility. This could accelerate the downward trend in the need for car parking in the City of Melbourne and other areas. Currently, 17 per cent of shopping trips in the CBD are taken by car, and approximately 40 per cent of private car spaces in the Melbourne CBD, Docklands and Southbank are unoccupied overnight.
- Current car parking spaces may be repurposed for other uses, like increasing housing density. Space for things like pick up and drop off areas would need to be allocated for automated vehicles, and these spaces would need to be accessible to people with mobility impairments.
- Shared mobility could shift the space required for car parking from public land to private depots where vehicles could also be cleaned and refuelled, or charged.



About digital infrastructure we heard:

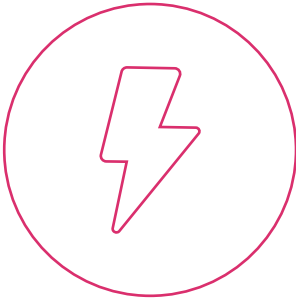
- Uncertainties around data usage and collection were raised, including whether data would be used for real time transport network management, for network planning or for law enforcement. Further, stakeholders expressed uncertainty over whether data could or should be collected and used for management of the electricity grid.
- The tension between the opportunities for innovation and integration of transport services enabled by open data and interoperability, and the challenges of data privacy must be balanced. Stakeholders suggested government has a role to ensure that privacy laws are adhered to.
- Data use is expected to increase, with a need to ensure that data capture and storage is done safely and securely, particularly for protection against cybersecurity threats. One suggested solution was to introduce a security credential management system to authenticate the various actors within the transport network, combined with secure mobile systems.
- Uncertainty exists over which vehicle communication technology will be appropriate to support automated and connected vehicles: dedicated short-range communications (DSRC), or cellular mobile systems (e.g. 5G). Stakeholders told us that for direct communication, between vehicles or to infrastructure, either technology will be sufficient, but cellular technology is more suitable for network communication. Communications systems that allow vehicle-to-anything (V2X) communication are already installed in some new vehicles and standards are currently being amended to allow this technology to operate via mobile networks. However, mobile coverage in regional areas is limited, which caused stakeholders to raise concerns about a network failure or outage.
- Global Navigation Satellite Systems (GNSS), such as Global Positioning Systems (GPS), are not perceived by some stakeholders to be at the standard where automated vehicles can rely on these technologies alone. Many automated features in current vehicles are also supported by their in-vehicle systems, which could be further supported by vehicle-to-infrastructure systems. Other stakeholders expressed the view that in-vehicle systems could operate without the need for GPS at all. Infrastructure-to-infrastructure and vehicle-to-person systems that allow communication between vehicles and pedestrians and cyclists were also highlighted by stakeholders as ways to increase road safety.
- It was suggested that government should provide some information for the mapping needs of automated vehicles, like speed limits. The spatial data required to support navigation of automated vehicles was also raised, including whether changes to Vicmap are needed to make the data sets appropriate for use.

Key areas of focus



About economic impacts we heard:

- The source of funding for new infrastructure associated with automated or zero emissions vehicles, as well as existing road infrastructure, was a big concern for stakeholders, particularly given the likely drop in funding from the fuel excise if there are fewer petrol or diesel cars on the road. Several local governments, particularly the City of Melbourne, also collect significant revenue from parking fees and fines, which may be impacted by automation or shifts in market models. Regional councils expressed concern on the impacts to their budgets if significant changes are required to the roads that they maintain. Stakeholders identified that there is a need for new transport funding models which take an integrated view of transport funding and subsidies.
- Automated and zero emissions vehicles may provide savings through decreases in property damage, insurance, legal costs, emergency services, congestion and pollution. The potential increased mobility for elderly, youth and people with a disability may also provide economic benefits.
- The cost, particularly the price parity to conventional vehicles, of automated and zero emissions vehicles is expected to be a major trigger for change. Therefore, the level and outcomes of international vehicle production are likely to impact vehicle uptake in Australia.
- Telecommunication companies in rural Victoria work within low profit margins, which stakeholders felt may impact their capacity to build and maintain new infrastructure to support automated and zero emissions vehicles.
- Automated and zero emissions vehicles are expected to impact many businesses, including the automotive, personal transport, freight, construction, insurance and legal industries. New industries could emerge in both urban and rural areas. Automation could impact the freight industry by removing the need for drivers, but more highly-paid technical roles may also be created.
- The introduction of automated and zero emissions vehicles may reduce vulnerability to increases in fuel prices, particularly for those who are highly reliant on petrol vehicles in regional and rural areas. The introduction of automated and zero emissions vehicles could also see more one-car or no-car households, particularly if car and ride sharing increases. Electric vehicles, excluding plug-in hybrid electric vehicles, have lower ongoing maintenance costs, further reducing the financial burden of vehicle ownership.



About energy supply and charging capacity we heard:

- Many stakeholders felt government should play a role in the ownership of energy infrastructure, including where chargers are located and charging standardisation, though the balance between local, state and federal involvement in this was not clear. There is uncertainty regarding the level of involvement government will have with charging locations, standards, market regulation and freight and regional needs.
- 'Range anxiety' for electric vehicles remains a key concern for regional and rural car owners, with some stakeholders calling for more public chargers across Victoria. Suggestions were made that government could accelerate demand and supply of charging infrastructure by procuring zero emissions vehicles for government fleets, and by requiring electric vehicle charging capabilities in new developments. Stakeholders also felt that government should play a role in coordinating non-government charging programs, and opportunities for the private sector to be involved in the provision of charging infrastructure should be investigated.
- Stakeholders raised the potential of wireless charging technologies to bring added benefits, but emphasised that government should consider the appropriate point at which to invest in emerging technologies.
- Consideration should be given to international examples of zero emissions vehicle charging infrastructure implementation.
- The capability of the energy network to meet increased demand was raised, with many stakeholders stating their concerns about the impact of zero emissions vehicles on peak and off peak capacity and pricing. Changes to peak times or peak demand for energy could emerge through vehicle charging patterns, and new pricing structures may be necessary to encourage/discourage charging at specific times to manage energy demand.
- Stakeholders suggested that electric vehicle batteries could potentially be used to help stabilise the grid by connecting vehicles and infrastructure, providing flexibility and efficiency benefits. Zero emissions vehicles may therefore improve network utilisation, which could lower electricity prices. Changes may need to be made to the energy regulatory and market frameworks to ensure these benefits can be realised.
- Renewable sources of energy are essential for vehicles to be truly 'zero emissions'. Distributed renewable energy production could be installed at charging sites, particularly in rural areas. We heard that, at a minimum, renewable energy production must rise at the same rate as the increase in energy demand from zero emissions vehicles.
- Fast chargers can cause issues for batteries and are expensive to build and run, particularly if the charging infrastructure is networked. We heard that type two chargers are more appropriate for trips of 100 km or less, but have high costs for private use when installation, maintenance and insurance are taken into account. Refuelling or charging at home is the preferred option for visually impaired people, as public fuelling stations present numerous personal safety risks. While wireless inductive charging is a potential future technology, installation of in-road charging may be expensive.
- Electric batteries may not be suitable for heavy vehicles, and energy demand for some vehicles will be determined by seasonal harvesting patterns.
- Stakeholders told us that safety considerations for the storage and transportation of hydrogen for fuel cell vehicles should be investigated.

Key areas of focus



About environmental and human health impacts we heard:

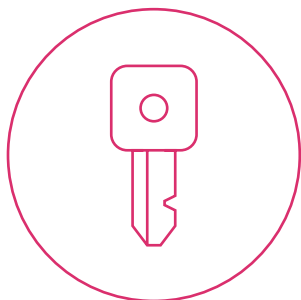
- Safety was a key concern for stakeholders, particularly with regard to vehicles that are not fully automated, and the safety of interactions between automated vehicles and human drivers. Although our study focuses on fully automated vehicles, this is an important element of transition.
- Active transport users, such as people who currently walk or cycle to their destinations, could shift to automated vehicles if they are cheap and widespread. We heard that a network planning approach with a sustainable transport hierarchy should be considered, so active transport modes are not disadvantaged.
- Automated and zero emissions vehicles can offer environmental benefits, particularly if shared mobility is achieved. Zero emissions vehicles can increase air quality and help to decarbonise the energy grid. Reduced energy use per person per kilometre was suggested as an environmental goal. Decreasing carbon emissions is recommended by stakeholders as a top priority, as the negative impacts of climate change will have consequences for all other issues. Connected and integrated technologies could further reduce emissions through increases in vehicle and road efficiency.
- Stakeholders raised concerns that new vehicle technologies, particularly automated technologies, may pose safety risks, and raised potential issues about disaster-response requirements. Concerns were also raised about difficulties for other road users in detecting electric vehicles, as they are much quieter than petrol cars. Eventually, safety benefits for vulnerable road users like pedestrians and cyclists are expected to be realised.
- Uncertainties were also identified over the environmental impacts of batteries and components, the possibility of dumping of traditional vehicles, and minerals extraction for new vehicle components. Adopting an approach like the European Union, where battery makers are required to recycle used batteries, was suggested as one potential solution.
- The use of automated vehicles may reduce driver stress and increase access to essential services, such as health care, for many people.



About the interface with physical infrastructure we heard:

- The timelines for infrastructure planning and when the impacts of automated and zero emissions vehicles should be considered was raised as an issue. There is uncertainty around who is responsible for meeting the infrastructure needs of future vehicles, given responsibility for roads is shared between local and state governments. The question of who will initiate and lead automated and zero emissions vehicle infrastructure was also raised.
- It was noted that on-demand transport systems are most effective and efficient when they operate alongside high capacity public transport. Future automated shuttles could travel in high occupancy lanes, which could be introduced for buses now. Zero emissions vehicles could also be permitted to use high occupancy lanes to encourage uptake.
- The interactions between automated vehicles and road infrastructure was highlighted as a concern, including lane sizes, line markings and lights, congestion, loading and unloading, road space allocation, public transport and new infrastructure. Some stakeholders expressed the view that bridges are currently under-maintained and may struggle to cope with increased loading from heavy vehicle platooning.
- Stakeholders were in general agreement that physical infrastructure should be consistent across Australia to enable the operation of automated vehicles. There was uncertainty about whether infrastructure should be aligned with other countries, but some stakeholders believed that could be an enabler for automated vehicles here.
- It was noted that the City of Melbourne transport policy prioritises space-efficient transport within the inner city, including giving more space to infrastructure for pedestrians and bikes, as well as urban greening. There is uncertainty over how automated vehicles may impact on active transport users and these priorities.
- Some stakeholders told us that streets should be differentiated between high speed, efficiency-focused locations, and low speed, local spaces, and planning for automated vehicles should be differentiated on this basis.
- People said that pick up and drop off infrastructure should be designed for those who are physically impaired. Concerns were expressed over whether users with a disability would trust an automated vehicle, and if design would inhibit operation and interaction, particularly in the event of a crash. Separate lanes could be introduced initially to allow people to build trust in automated vehicles.

Key areas of focus



About levels of sharing and ownership we heard:

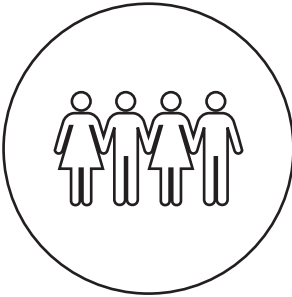
- There is considerable uncertainty regarding the viability of shared mobility models in rural Victoria. Stakeholders told us there are cultural barriers to vehicle sharing and there is the potential for different options in different areas. Increased trip time, waiting time and safety concerns in driverless, multi-passenger vehicles were concerns for shared mobility.
- Some stakeholders suggested that the government should promote sharing and/or Mobility as a Service (MaaS), to offset possible increases in congestion and emissions resulting from automation. Car parking spaces could be reduced and a target could be implemented to support shared mobility. Shared mobility, combined with zero emissions vehicle technology, could substantially reduce emissions. It could also increase public transport use, further reducing emissions and increasing accessibility.
- New platforms are likely to be developed for MaaS, with viability expected to increase as more offerings become available. Stakeholders felt that the government should allow companies to interact with the public transport ticketing system to create new, integrated services. A centralised system with real-time information, where services are transparent on travel time, cost and emissions, is necessary.
- We heard that shared mobility is not likely to be a valid replacement for high capacity public transport, and does not shift commuters to active transport.



About public acceptance and government policy we heard:

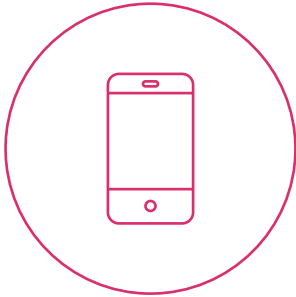
- The role of government in enabling automated vehicles in Victoria was a common theme raised. There are many questions to be addressed, including certification, liability, preferred market models, the safety of human drivers in the future, data ownership and use, appropriate level of regulation and infrastructure provision. Stakeholders asked whether government would promote, facilitate or regulate these new vehicles, and whether it would take an active approach to funding, planning and delivering infrastructure.
- The appropriate level of government involvement in enabling zero emissions vehicles was raised. Questions including energy ownership, incentives and subsidies, targets, shift of government and public fleets to zero emissions vehicles, emissions targets for government fleets, types of mechanisms for emissions reductions and future funding mechanisms were all posed. Some stakeholders support incentives for zero emissions vehicles, while others contend that this is not a sustainable long-term solution.
- Some stakeholders suggested that if the government does not take a proactive role then congestion will worsen, Mobility as a Service (MaaS) platforms will be owned overseas, and the vehicle transition period will be prolonged. Potential solutions included road/congestion pricing, MaaS platform ownership by government with operation by the private sector, integrating public transport, ensuring roads are a suitable standard for automated vehicles, and reviewing land use policies for integration with automated vehicles. Other stakeholders suggested the government should wait for change and then assess the necessary response to the effects. They felt that potential taxes, incentives and regulations should be implemented transparently and should account for integrated urban systems.
- There was general alignment between stakeholders that decisions made by other countries, levels of government, states and the private sector are expected to have implications for decisions and outcomes in Victoria. Coordination and responsibility is spread across jurisdictions, with a need for national and global alignment on regulation and policy. Victoria may face pressure from overseas to adopt automated vehicles quickly. Public opinion will also have implications for decision making.
- Some stakeholders felt that change should be led by the community, not the technology. Local areas have unique needs and localised, original solutions can address these issues. One-size-fits-all policies that are inappropriate for some areas may affect public acceptance of automated and zero emissions vehicles.
- The public is currently uncomfortable with the idea of riding in automated vehicles, but public acceptance is expected to rise as people see and experience the technology and trust builds over time. Trials may increase public engagement and awareness of the technology, and marketing and education may be needed to affect behaviour change. The number of accidents is likely to affect public acceptance, as the public must be confident that the government has implemented appropriate safety regulations.

Key areas of focus



About social consequences and opportunities we heard:

- Automated vehicles could extend access to the services and amenity of middle and inner Melbourne. This may increase independence, reduce isolation and improve access to essential services, including for people with a disability and elderly people. This increased accessibility may be dependent on market models and vehicle costs. Some stakeholders said government should decide whether it will intervene to ensure equity of access if the market does not deliver this.
- Concerns over equity of access to automated and zero emissions vehicles, across age, income and location, was mentioned. If zero emissions vehicles are cheaper to maintain and run but have a high upfront cost, stakeholders expressed concern about creating inequality of access to these benefits.
- We heard that infrastructure at transport arrival and departure points (e.g. pick-up and drop-off locations) should be accessible to allow elderly and people with a disability to access automated vehicles.
- Restrictions and regulations like minimum or maximum ages or capabilities are further uncertainties, and safety and inclusivity, will need to be balanced.



About technology development we heard:

- Stakeholders felt that there is a risk that rapid technology development could render infrastructure assets obsolete.
- Stakeholders were uncertain as to whether automated and zero emissions vehicles should be considered together or separately. Also, it was suggested that vehicle and infrastructure connectivity is likely to be the key factor for realising benefits, rather than autonomy.
- The range, coverage, interoperability, and reliability of automated and zero emissions vehicles, as well as the potential ability to convert traditional vehicles to new technologies, are uncertain. Some stakeholders suggested that level four automated vehicles may be available in Victoria by 2025 and level five by 2035, although this could be sooner if regulatory barriers can be removed more quickly. Other stakeholders suggested full autonomy could be reached by 2025, while others argued it was not reasonable to expect that full autonomy would ever be achieved. The underlying technologies behind automated vehicles have been developing quickly, however artificial intelligence and deep learning may need significant development time to deal with complex situations.
- The megatrends of multi-modal connected transport and ride sharing are expected to continue and have implications for automated vehicles.
- Regulation is expected to support a phased introduction of levels of automation, with conditional automation prior to 2020, and high to full following 2020. It was highlighted that a verification and/or certification process may be needed for the testing and deployment process.
- A stage when automated and traditional vehicles will coexist on the road infrastructure is anticipated, and it was noted that this stage will require significant public and private cooperation to ensure safety.

ADDITIONAL FACTORS IDENTIFIED THROUGH CONSULTATION

Much of what we heard from stakeholders supported and reinforced what we discovered through our literature review process, but we also received some new information that has shaped the planning of our research. The new information we heard from stakeholders was categorised by the following general themes:

- **Equity** – including the needs of rural, people with a disability and elderly Victorians
- **Communications** – views on changes to digital needs and communications infrastructure
- **Physical infrastructure** – the suggested requirements of, and impacts on, energy, road, pedestrian and recycling infrastructure
- **Objectives** – what stakeholders felt we should focus on in our research program and target outcomes for the state
- **Role of government** – perspectives on the level of involvement and role for governments.

More detail on the new information we heard is in detailed in this section. In addition to what we heard about these themes, we received some new feedback on matters that are not within the scope of this advice. This feedback is still important, and in some cases worthy of further work by other organisations within and outside of government. That information is also listed here.

Equity

ADDITIONAL FACTOR	INFRASTRUCTURE VICTORIA'S RESPONSE
Infrastructure (e.g. pick up/drop off zones) should be appropriate for those with disabilities.	The implications of automated and zero emissions vehicles for accessibility and inclusivity will be considered across our socio-economic and transport engineering workstreams. Specific infrastructure changes and needs will be addressed within our transport engineering workstream.
People with disabilities or mobility impairments may prefer to charge electric vehicles at home and avoid petrol stations.	Our advice will consider the potential impacts of people who are currently unable to drive entering the vehicle market. The implications of different electric vehicle charging patterns, including home charging, will be considered in our energy workstream.
New technology is typically applied to high-end vehicles first, contradicting the potential for autonomy to be quickly dominant in many low-cost vehicles.	We will consider the issues of vehicle pricing, market models and any equity implications across our socio-economic and finance workstreams.
Different infrastructure may be needed in different urban environments, as speeds and journey types may be different.	Across all of our workstreams we will consider the unique characteristics of different types of urban, peri-urban, and regional and rural urban environments.

Communications

ADDITIONAL FACTOR	INFRASTRUCTURE VICTORIA'S RESPONSE
Dedicated short-range communications (DSRC) and mobile networks are both appropriate for direct communication, but mobile networks are preferable for network communication.	Though we are unlikely to recommend a specific technology at this stage, we will investigate the benefits and risks of both DSRC and mobile network technologies in our ICT workstream.
Mobile networks and data owners could support law enforcement to retrieve real-time information on vehicles.	We will address some issues of privacy and use of information, including by government, in our ICT workstream.
A security credentials management system is required to authenticate the various actors communicating with each other across digital transport systems.	Issues of cybersecurity and communications infrastructure will be addressed within our ICT workstream, although we do not expect to make recommendations on specific security systems.
Communications from external data sources to the vehicle will not alone be sufficient in safety critical incidents; the on-board sensor suite should remain the primary input.	While on-board sensors will have an impact on the infrastructure required to enable automated vehicles, manufacturing decisions and specifications are considered out of scope.
Uncertainty over whether the use of the Digital Cadastral Mabase dataset (Vicmap) is planned, accurate and fit for purpose for automated vehicle operation.	We will identify the current and possible future role of mapping technologies as part of our investigation in the ICT workstream.
Need to investigate the differences in implications between connected automated vehicles and non-connected automated vehicles.	In general, we are assuming that highly automated vehicles are likely to be connected in most but not all circumstances. We will examine potential future technologies using assumptions about current technologies and trends through our ICT workstream. This work will be supported by our international market analysis workstream which will examine activities and directions outside of Australia.

Physical infrastructure

ADDITIONAL FACTOR	INFRASTRUCTURE VICTORIA'S RESPONSE
<p>Separate bus lanes should be designated now, and in the future could be used for automated shuttles.</p>	<p>The benefits and risks of designated lanes will be investigated through our transport engineering workstream.</p>
<p>Sensors on bridges to detect loads could be used for traffic management.</p>	<p>The benefits and risks of traffic management will be examined through our transport engineering and ICT workstreams.</p>
<p>An analysis of the regulatory framework should be done to ensure that our energy grid does not present a barrier to the uptake and effective utilisation of electric vehicles.</p>	<p>We will consider implications of automated and zero emissions vehicles for the energy grid in our energy workstream.</p>
<p>Alternative forms of congestion charging may be beneficial.</p>	<p>The implications of road user pricing under different scenarios may be considered within our transport modelling workstream. Separately to this advice, Infrastructure Victoria is investigating the complexities of managing transport demand, including transport network pricing.</p>
<p>There are peak seasonal times of energy demand for regional areas (during harvest).</p>	<p>We will consider implications for the energy grid, including the potential role for hydrogen, within our energy workstream. This work will be reported based on the zone substation level. This will enable a localised view of energy grid implications, including for regional areas.</p>
<p>City of Melbourne presently has a large car park sensor network, and the Australian Integrated Multimodal Ecosystem will contain 1,000 sensors, which could be further leveraged through the introduction of automated vehicles.</p>	<p>We will consider the needs and opportunities for interaction between automated vehicles and current and future technologies within our transport engineering and ICT workstreams.</p>
<p>Bridge safety estimations may require adjustments to take into account the impacts of automated vehicles, including platooning. A concern was also raised that there is currently under-maintenance of bridges.</p>	<p>We will consider the impacts of automated vehicles on physical infrastructure within our transport engineering workstream.</p>
<p>Pedestrian overcrowding in the City of Melbourne is a significant issue and automated vehicles may positively or negatively impact this issue.</p>	<p>We will consider the implications of automated vehicles for other transport users, including pedestrians, within our transport engineering workstream.</p>
<p>Infrastructure to recycle and reuse materials from electric vehicles is necessary, to avoid over-reliance on overseas arrangements.</p>	<p>We will consider the infrastructure requirements of electric vehicles throughout their lifecycle within our environment workstream.</p>
<p>A verification process that takes into account the current diverse range of road infrastructure is required in the early stages of highly automated driving.</p>	<p>We will consider urban, regional and rural road infrastructure and quality across our workstreams. This work will inform our final recommendations.</p>
<p>Alternative short-term funding methods for electric vehicle charging should be explored.</p>	<p>We will investigate the requirements and implications of charging infrastructure through our energy, finance and transport engineering workstreams.</p>

Objectives

ADDITIONAL FACTOR	INFRASTRUCTURE VICTORIA'S RESPONSE
Infrastructure Victoria should align its advice with the goals of 'Plan Melbourne'.	Many of the assumptions, target outcomes and timeframes within our workstreams are aligned with Plan Melbourne.
Reducing traffic congestion should be a target outcome.	We have identified improving transport system performance and accessibility as a target outcome that could be achieved through the introduction of automated and zero emissions vehicles. This target does not focus solely on congestion, but aims to comprehensively improve the transport system.
Safety improvements should be the primary target outcome.	'Improve safety and public health' is one of our nine target outcomes, and will be important in assessing our advice.
'Improving transport system performance' should focus on the movement of people, not movement of vehicles.	We agree that movement of people (and goods) rather than vehicles is the focus of this target outcome, and intend to progress our research with this understanding.
'Enable optimal land use' should be clarified, to highlight whether it is consistent with 'Plan Melbourne' and the implications for regional areas.	We have aligned our assumptions and understanding of land use planning with Plan Melbourne and the views expressed in our 30-year Infrastructure Strategy.
Areas/populations for accelerated automated vehicle introduction should be identified.	We will consider if a potential recommendation should be made on this issue once our research is complete.
Understanding the relationship between physical and digital connectivity should be important to this work.	We agree that this is an important part of the advice, and intend to progress the research with this focus.
Land use amenity should be an objective.	Enabling optimal land use is a target outcome of this project, and impacts on land use amenity will be studied within our land use workstream.
Reducing energy per person-km should be an objective through requiring future vehicles to be electric.	Decreasing carbon emissions is one of our nine target outcomes, and any potential recommendations will be assessed for their ability to meet this goal.
Decreasing carbon emissions should be the primary objective.	Decreasing carbon emissions is one of our nine target outcomes, and will be a major consideration in both our energy and environment workstreams.

Role of government

ADDITIONAL FACTOR	INFRASTRUCTURE VICTORIA'S RESPONSE
The Victorian Government should support trials to gain public acceptance of automated vehicles.	There are currently several trials underway in Victoria. In our 30-year Infrastructure Strategy, which was released in 2016, we recommended introducing regulatory changes to enable the testing and deployment of automated vehicles. Recent legislative changes have also been made to enable trials. We support trials as an important stage in the introduction of automated vehicles, and are interested in using the outcomes of these trials to inform our knowledge on future infrastructure needs.
Electric vehicle infrastructure could be funded through a levy on high polluting vehicles.	We will consider infrastructure funding needs and opportunities through our finance workstream.
Technology decisions require a fine balance of regulation.	We will consider the implications of technology regulation and governance within our ICT workstream.
The impacts of low profit margins for rural telecommunication companies on reliability and maintenance should be considered.	We are examining minimal and optimal requirements for communications infrastructure within our ICT workstream which may provide guidance to communication companies.
Local government can provide leadership on infrastructure and vehicle technology promotion.	We will consider the infrastructure needs of all areas of Victoria in our recommendations, including the roles for different levels of government.

Out of scope

ADDITIONAL FACTOR	INFRASTRUCTURE VICTORIA'S RESPONSE
Hydrogen internal combustion engine vehicles, as well as hydrogen fuel cell vehicles, should be considered.	This scope for this advice is zero emissions vehicles in Victoria. Hydrogen internal combustion engines are not a zero emissions technology and therefore these vehicles are considered out of scope.
Potential for zero emissions vehicles to lower energy prices through improving the utilisation of existing networks should be considered.	We will consider implications for the energy grid of automated and zero emissions vehicles in our energy workstream. However, this work will not specifically model impacts on energy prices.
If government introduces vehicle-to-infrastructure technology it will be responsible for any breaches.	We will examine the benefits and risks of vehicle-to-infrastructure technology within our ICT workstream. However, questions of liability are considered outside the scope of this project.
A national body should be established to support diverse mobility modes.	The scope of this advice is infrastructure to enable the introduction of automated and zero emissions vehicles in Victoria.
The impact of automated vehicles on the viability of a very fast train across the eastern seaboard should be considered.	The focus of this advice is infrastructure that is required to enable automated and zero emissions vehicles within Victoria.
The road governance structure in Victoria could create conflict over maintenance/liability.	We will examine matters of governance within our analysis, however questions of liability are outside the scope of this project.
Townships can create localised responses, such as automated grocery delivery within a specific area.	We see the opportunity for local responses to automated vehicles to be a potential benefit to Victoria. However, the creation of new industries is not a focus of this advice.
Establish an ethics committee to oversee automated vehicles.	As this advice covers the infrastructure required to enable the introduction of automated and zero emissions vehicles in Victoria, ethics is considered out of scope. However, this is clearly an important area where work from other relevant organisations will be required.
The potential of non-road automated vehicles, including PodCars, to achieve objectives should be examined.	The focus of the request for advice is on automated and zero emissions road vehicles. As such, a number of related emerging transport technologies are considered out of scope for this advice.

ADDITIONAL FACTOR**INFRASTRUCTURE VICTORIA'S RESPONSE**

The potential negative effects of road user pricing on electric vehicle uptake should be considered.

The implications of transport network pricing within different scenarios may be considered within our transport modelling workstream. The terms of reference for our advice focus on enabling automated and zero emissions vehicles as a high proportion of the Victorian fleet, so we are not undertaking a detailed examination of policy interventions to support uptake of any one technology.

Australia has significant raw lithium reserves which could be used to support battery production.

While new industries could be a potential benefit of zero emissions vehicles, issues related to these industries or industry support are outside the scope of this advice.

The automation levels of emergency vehicles and the resulting implications are an important consideration.

Automated or zero emissions emergency vehicles are not expected to have onerous unique infrastructure needs, so we expect many of our recommendations to be relevant to all road vehicles. The specific needs of emergency vehicles will likely warrant further investigation by other relevant organisations to ensure their safe and reliable operation.

Agriculture/farming equipment will require zero emissions vehicle charging infrastructure.

As this advice is focusing on the infrastructure to enable the introduction of automated and zero emissions vehicles on public road infrastructure in Victoria, a number of related emerging transport technologies are considered out of scope, including vehicles operating primarily on private land. The impacts on agriculture and farming equipment of automation and any regulation or policy on zero emissions should be examined by other relevant agencies to ensure Victorian farmers can access the benefits of these new technologies.

People with disabilities may have unique needs in the event of a crash.

Crash and vehicle management is not directly related to infrastructure, and therefore is not a focus of this work. However, given the importance of this issue, we recommend that this and other safety issues are considered by safety and standards organisations in their work on automated vehicles.

HOW WE'VE USED WHAT WE HEARD

Our engagement approach has been iterative. We used what we heard in our early discussions with stakeholders to shape the draft target outcomes and areas of focus we published as part of our formal consultation. We then held workshops to delve into more detail on the uncertainties, decisions and triggers we need to consider as part of our advice.

The areas where we needed to focus our research for our advice emerged quickly in our early conversations with stakeholders. The key uncertainties for some areas were quite obvious, while other areas like energy supply and digital infrastructure needed more consideration to plan what further work was required.

Many stakeholders pointed us to major academic pieces of research or publications from well-respected organisations, which formed part of our literature review, which will be published in August 2018 as part of our evidence base. The literature review also included a comprehensive consideration of local and international reports on our areas of focus, which will be complemented by further international engagement and research as the advice progresses.

Given the inherent difficulty in predicting the future, those we spoke to were in general agreement on the key uncertainties and questions that need to be answered. We did hear different views from urban Melbourne and regional and rural Victorian stakeholders, and it was clear that the needs of country Victoria are different to Melbourne. Regional and rural stakeholders were particularly concerned about how they could access the benefits of automated and zero emissions vehicles when it may be expensive or impractical to roll out driverless or shared services, or new physical and digital infrastructure.

What we heard through consultation, including the additional factors detailed previously and feedback on the key areas of focus, will be examined in further research to inform our final advice. The following areas of work will be undertaken to inform our analysis:

- **Transport modelling** – to understand the changes in travel behaviour and implications for Victoria's transport network resulting from the emergence of automated and zero emissions vehicles.
- **Land use** – how changes in people's travel behaviour affects where people choose to live and work.
- **Energy** – the implications of automated and zero emissions vehicles on energy demand and the future energy network, including risks and opportunities presented by zero emissions vehicles.
- **ICT** – understanding the ICT infrastructure requirements to enable automated and zero emissions vehicles to operate.

- **Transport engineering** – how the way in which automated and zero emissions vehicles operate might affect our roads, and what needs to be done to accommodate them.
- **Finance** – understanding the likely financial impacts of the emergence of automated and zero emissions vehicles on Victorian consumers, businesses and state and local governments.
- **Socio-economic** – how the emergence of automated and zero emissions vehicles will affect key equity outcomes for Victorians such as mobility, accessibility to services and employment.
- **International markets** – understanding how technologies and market models are evolving overseas and what this is likely to mean for the types of automated and zero emissions vehicles we receive in Victoria, and what infrastructure will be needed to accommodate them.
- **Environment and population health** – the impact of automated and zero emissions vehicles on Victoria's environment, and the likely population health impacts of reduced vehicle emissions, improvements in vehicle safety, or changes to travel behaviour.
- **Urban design** - how the visual landscape of different locations across Victoria may change with automated and zero emissions vehicles.

We are undertaking a broad examination of the infrastructure issues that government needs to understand and respond to in order to enable automated and zero emissions vehicles. However, we will not be covering every issue in detail, particularly where issues are highly technical or not directly relevant to infrastructure.

The ultimate aim is to identify which infrastructure interventions make sense in spite of all the uncertainty, which investments should only be made once particular triggers are met, and which decisions and trade-offs need to be made to achieve the best outcomes.

Therefore, some concerns and issues raised by stakeholders may not be covered by our final advice, but should be noted for future consideration as vehicle technologies emerge and adapt to the Victorian context.

Another chance to have your say

This report summarises what we did and heard in our first phase of consultation. We started this phase of consultation very early in the development of our advice, as we wanted to hear from stakeholders and experts about where we should focus our efforts as we planned our research.

We have also now released a *Future Scenarios* report, which outlines seven possible futures for automated and zero emissions vehicles, which together allow us to test the critical variables of the evolution of these new technologies, and to help develop our recommendations to government.

The next step will be the release of our evidence base in August 2018. We will publish the technical studies we have commissioned as part of this advice on our website, as well as a report that explains our overall findings and interpretation of the results.

At that stage, we will commence a second phase of consultation and ask stakeholders to consider the technical studies and give us feedback on the evidence we have gathered to help us prepare our advice. We will also be consulting on whether there is anything else we should be considering before we form our final recommendations.

You can find out more by checking our consultation website yoursay.infrastructurevictoria.com.au, or register for updates by emailing enquiries@infrastructurevictoria.com.au

ABOUT US

Infrastructure Victoria is an independent advisory body operating under the *Infrastructure Victoria Act 2015*.

It has three main functions:

- preparing a 30-year infrastructure strategy for Victoria, to be refreshed every three to five years
- providing written advice to government on specific infrastructure matters
- publishing original research on infrastructure-related issues.

Infrastructure Victoria also supports the development of sectoral infrastructure plans by government departments and agencies.

The aim of Infrastructure Victoria is to take a long-term, evidence-based view of infrastructure planning and raise the level of community debate about infrastructure provision.

Infrastructure Victoria does not directly oversee or fund infrastructure projects.



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Printed by Infrastructure Victoria

May 2018

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