Campbell Sims

BSc(Hons), MSc, CEng FIMechE, MIEAust CPEng NER

Regulatory Approach to Safety Systems using Artificial Intelligence in Automated Vehicles

Acmena

Background

Mechanical Engineer

10 years experience in Design Engineering
- Shipbuilding – Warship Design and Build
- Subsea Pipelay
- Pipework In-Service Inspection
- Oil & Gas Subsea Intervention Design

12 years experience in Technical Safety:
- Oil & Gas Functional Safety in Global Leadership role
- Oil & Gas Product Safety & Regulatory Compliance in Global Leadership role
- Rail Safety Assurance – Brisbane Cross River Rail, Queensland Rail

MSc in Safety & Risk Management

Project thesis:

Is the approach to safety regulation, in the development of Automated Vehicles, sufficient?

BAE SYSTEMS
aquatic
DOOSAN
TechnipFMC
Baker Hughes
CROSSRIVERRAIL
QueenslandRail
University of Strathclyde Glasgow
Acmena

Regulatory approach to safety systems using artificial intelligence in automated vehicles

- Motor Vehicle Control and Regulation……a story from the past to the future
- why the public are concerned about AI being used in AV safety systems
- specific AI elements of AV safety systems
- current and potential future state of regulation, both in Australia and internationally

Acmena

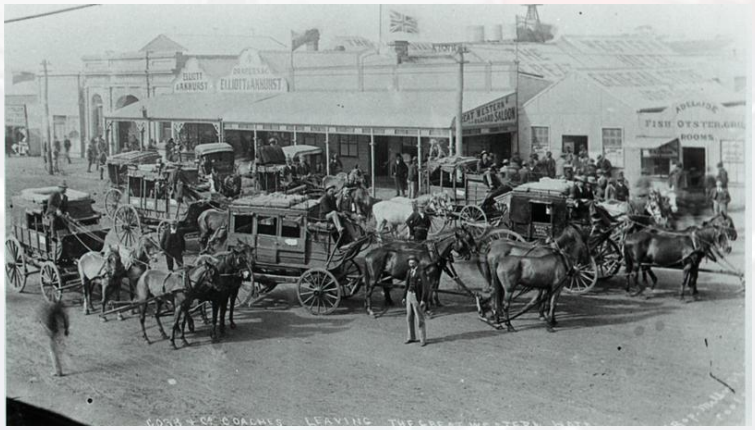
The first Paradigm Shift

To understand the issues of automated Vehicles and Regulation, we need to rewind a bit……..

Acmena

Road Vehicle Evolution

From horse and carriage



In the 1860's, the last disruptive road technology came about. Industrial steam engines used for farming and rail found their way onto the road…….replacing horses and horse drawn vehicles.

Road Vehicle Evolution

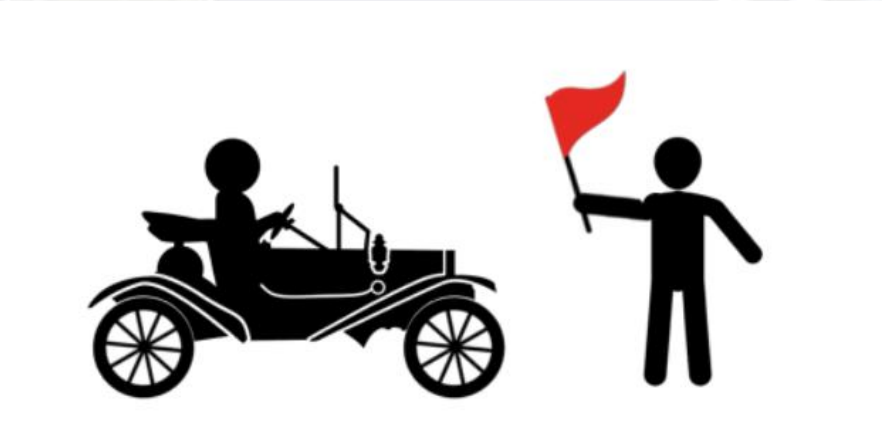
It can be deduced that there was some concern by the public, moving from horse to machine

"We should not overlook the fact that the driving of a horseless carriage calls for a larger amount of attention, for [the driver] has not the advantage of the intelligence of the horse in shaping his path, and it is consequently incumbent upon him to be ever watchful of the course his vehicle is taking,"

Alfred Sennett, 1896, British Association for the Advancement of Science

Road Vehicle – Early Regulation

UK Locomotive Act 1865 (also known as Red Flag Act) introduced, limiting speed to 4mph, with 3 people in control of vehicle, including one walking in front waving a red flag. Drivers had to stop and give way to horse drawn vehicles.



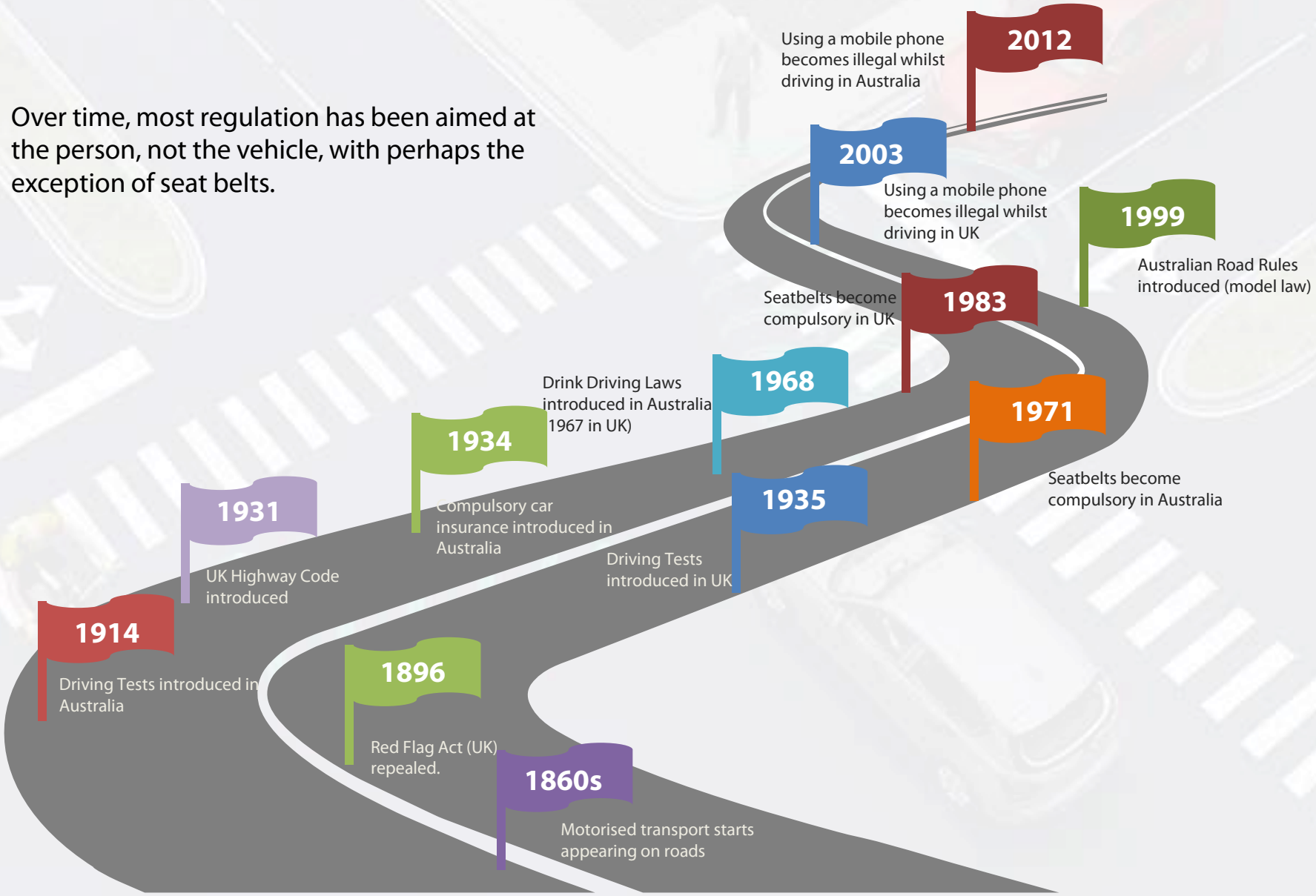
Red Flag Act essentially assured safety but was restrictive to market development.

Red Flag Act was repealed in 1896, in time with the development of the internal combustion engine.

If it hadn't been repealed would the motor vehicle have developed commercially, given the regulatory restrictions?

Road Vehicle – Regulation Through the Years

Over time, most regulation has been aimed at the person, not the vehicle, with perhaps the exception of seat belts.



Acmena

Road Vehicle – Safety

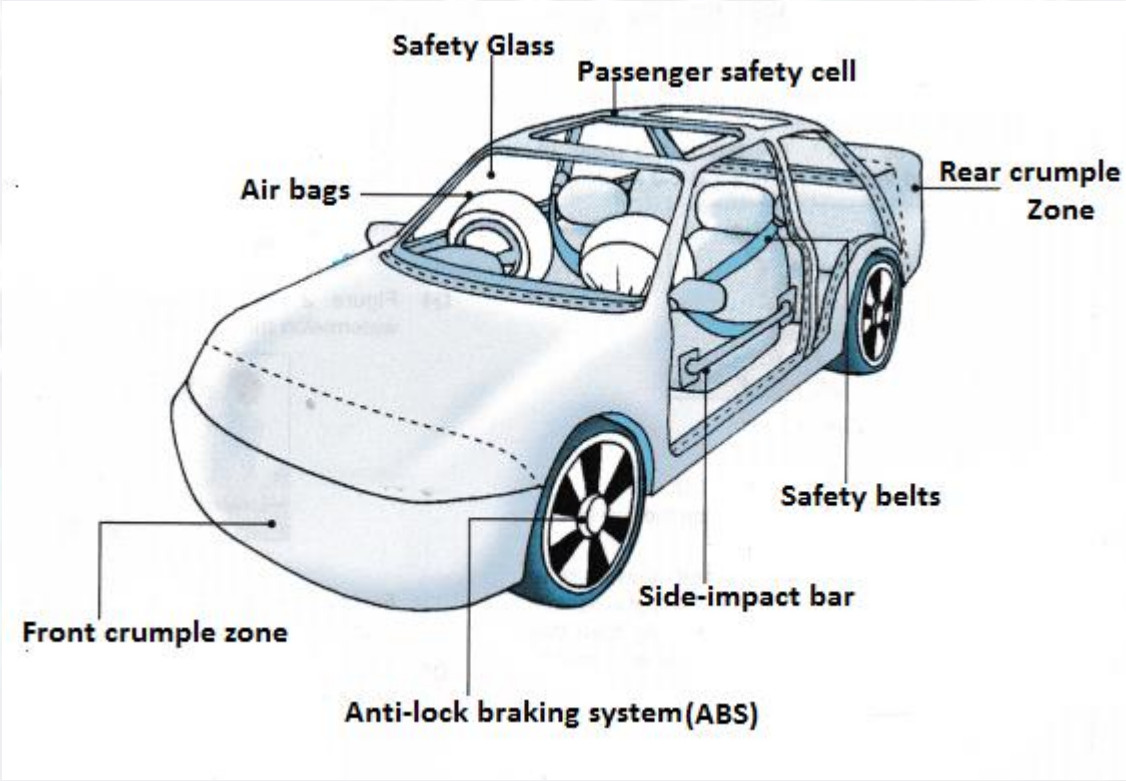
For the past 100 years, not a huge amount has changed. The fundamentals of driving have remained consistent, with regulations based around safety.

In General Terms::

- ✓ **Road rules (Australian Road Rules, UK Highway Code, etc)** are well defined and are generally consistent worldwide, based on similar principles (with some exceptions and differences)
- ✓ **Responsibility for operating a motor vehicle**, in terms of following the rules, vehicle road worthiness, mandatory testing and insurance are well understood
- ✓ **Liability for accidents** is generally consistent, legal frameworks exist for types of licensing, permissions and punishment for offences
- ✓ **Specific laws exist to prohibit dangerous activity** for drink driving, mobile phone use while driving, speed limits and not wearing seatbelts.
- ✓ **Road rules are policed and enforced** using technology such as speed cameras, breathalysers and AI cameras / devices to capture mobile phone use

Road Vehicle – Safety

With such established rules and regulation, road travel should be a safe mode of transportation……we've had over 100 years to get it right.



Road Vehicle - Statistics

Yet, WHO statistics show that 1.35 million people are killed in road traffic accidents annually.

1200 across Australia.

It is the #1 cause of death globally in people aged between 5 and 29.

That equates to approximately: 7, fully loaded A380s crashing EVERY DAY of the year, with no survivors.

Would this be acceptable to society? If it was aircraft crashing, would people fly at all?

Road Vehicle - Statistics

Of those 1.35 million deaths each year, over 90% in 2022 are due to humans making mistakes or violating the law.

This figure has remained constant since the first published study in 1977.

Yet if we look at modern aircraft cockpits, it's more about systems management than flying.

The aircraft industry paradigm has been to take the pilot out of the decision-making process, which has reduced incidents due to "*pilot error*".

Acmena

Surely new technology development which has the potential to reduce fatalities and injuries on the road and improve safety is a good thing?

Not everyone thinks so!

To many people, taking the human away from control of a vehicle is a major worry…..despite statistics and evidence from other transportation sectors telling us otherwise.

Is it losing the human, or using the machine which is a concern?

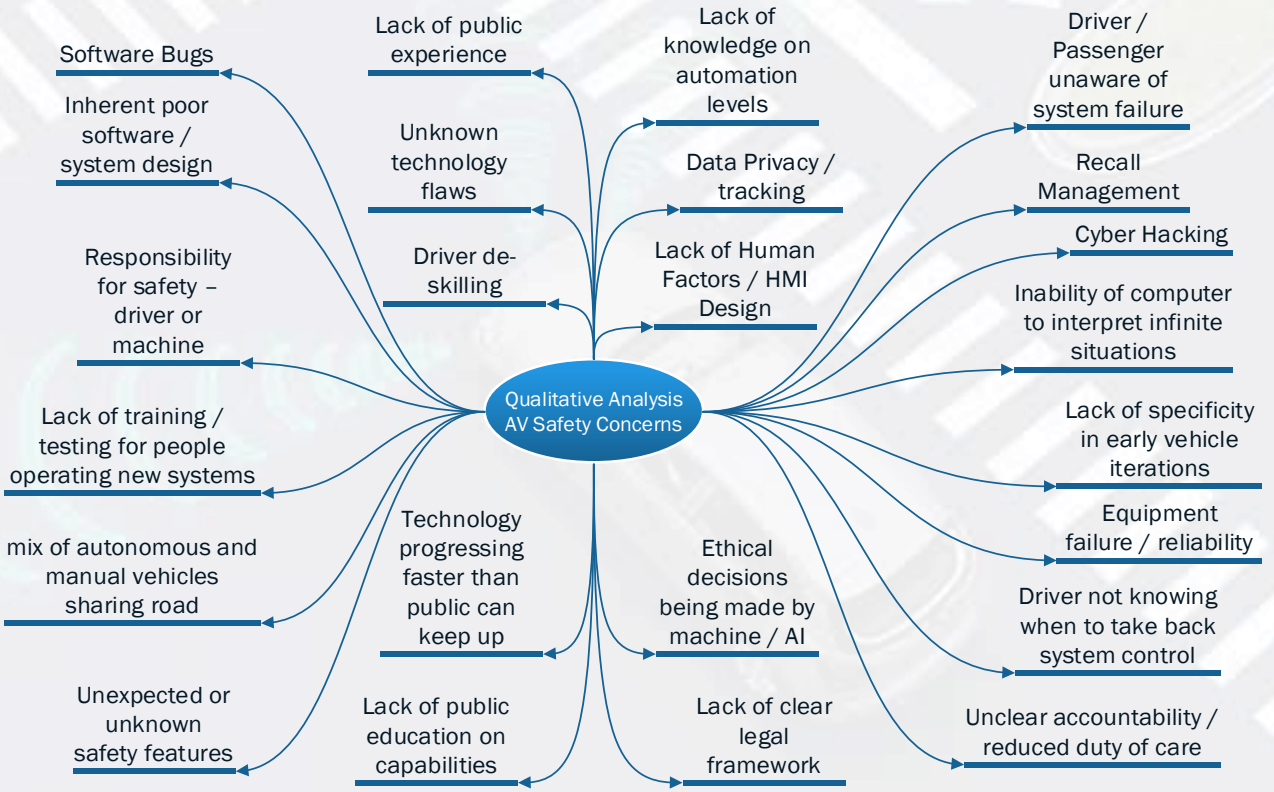
Research Analysis

Qualitative Analysis

Each study had a slightly different research objective, questioning public perception and opinion on the technology of AVs from different viewpoints.

These viewpoints include perceptions of other road users to AVs, views of the technology benefits, emotive or cognitive responses to safety, experience from riding in AVs and integration into existing systems.

	Author(s)	Date	Sample Size 'n'	Location	Exposure to AVs during research
1	Buckley, Kaye & Pradhan	2018	68	Australia	Yes (Simulator)
2	Hulse, Xie & Galea	2018	925	UK	No
3	Pettigrew, et al	2019	1624	Australia	No
4	Hilgarter & Granig	2020	19	Europe	Yes (closed road)



Acmena

Consolidation of Issues for Quantitative Analysis

Issues identified in Qualitative Analysis were consolidated to make Quantitative Analysis easier.

Software / System Design	• Software bugs. • Bad system design, including Human Machine Interface. • Capability of computer to interpret situations under different conditions. • Unknown technology flaws. • Equipment failure / reliability. • Poor iteration management.
Liability / Responsibility	• Who is responsible – driver or manufacturer? • Unclear accountability. • Lack of clear legal framework. • Recall management. • Road sharing between AV and other road users.
Human Factors	• Lack of training or testing • Unexpected or unknown safety features • Lack of experience • Lack of knowledge • Driver de-skilling • Driver unaware of system failure or what to do • Driver not knowing when to take back control of vehicle • Lack of education amongst general public
Technology, AI & Ethics	• Technology developing too quick and regulation / public awareness having to play catch-up • Ethical decisions being made by machines – trolley problem • Artificial intelligence incorrectly making decisions
Security	• Data privacy / ability to track people or know where they've been • Cyber security / hacking

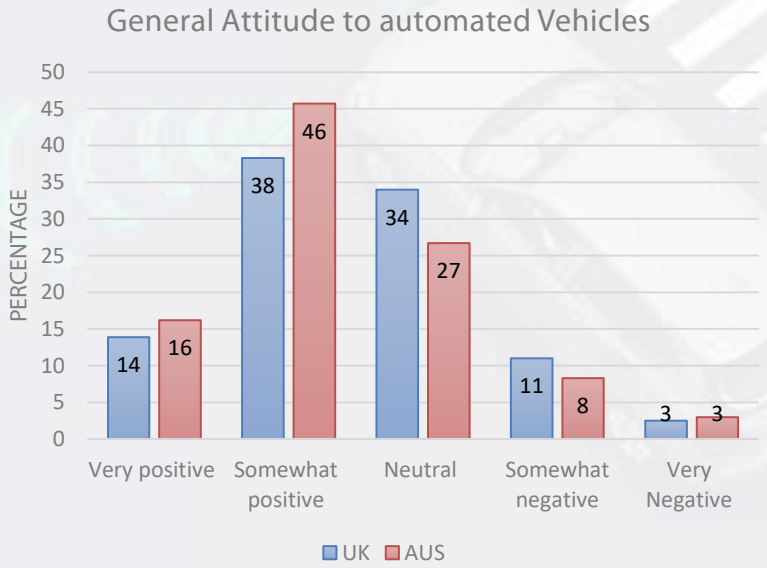
Research Analysis

Quantitative Analysis

	Author(s) / Organisation	Date	Sample Size 'n'	Location
1	Schoettle & Sivak	2014	1533	UK / Australia / US
2	Eurobarometer	2015	27801	UK & EU
3	Krueger et al	2016	435	Australia
4	Ruggeri et al	2018	2850	UK
5	Hulse et al	2018	916	UK
6	Tennant, Stares & Howard	2019	11827	UK, Australia and others
7	Cunningham et al	2019	5089	Australia

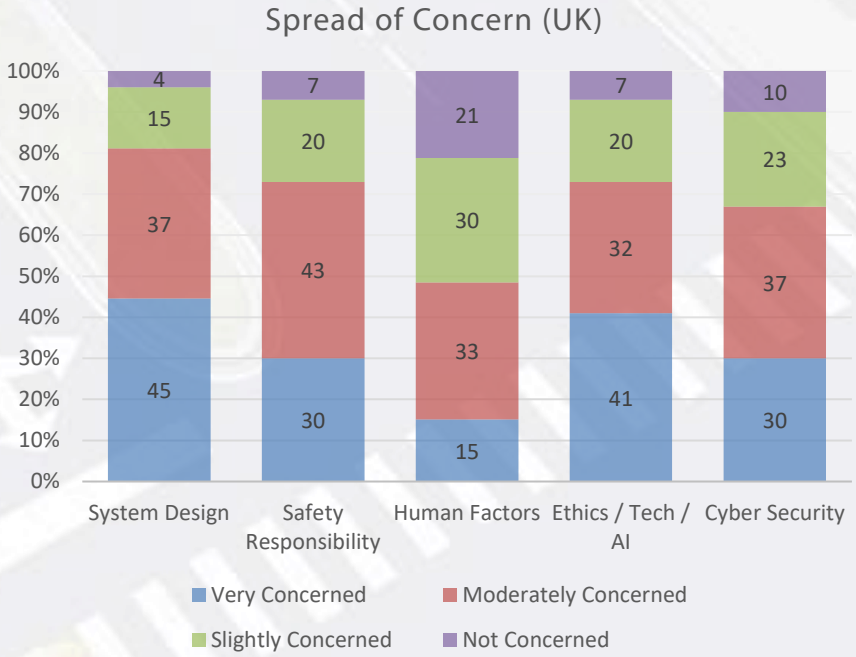
Quantitative analysis also considered a variety of academic surveys, each addressing the issue from a slightly different perspective, with ability to establish Australian and UK concerns in order.

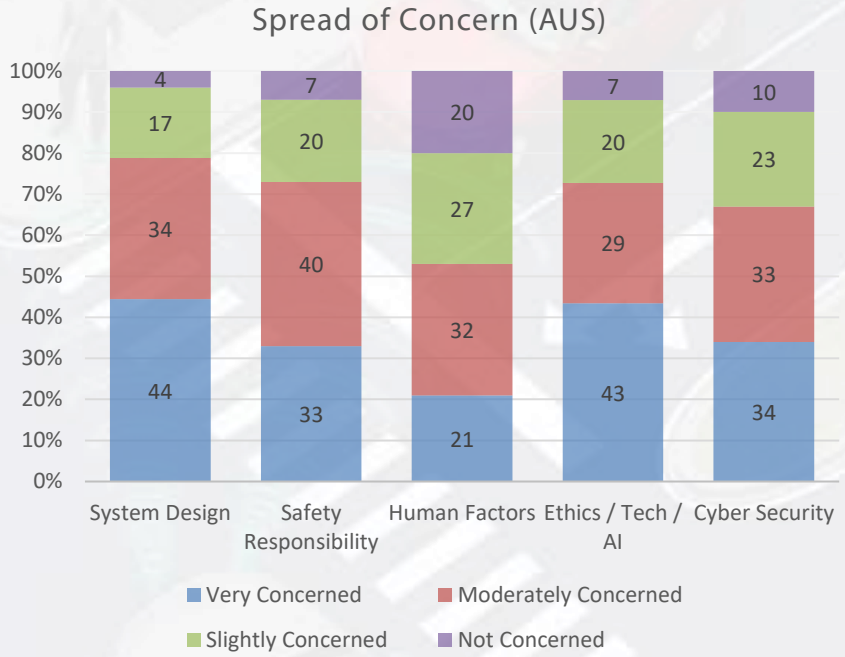
Analysis of attitudes showed most people are positive about the technology. However, significant concerns remain….



Acmena

Analysis Results – A Matter of Trust





Ranked concern

1.	System Design	people don't trust engineers
2.	Ethics / Technology / AI	people don't trust tech companies
3.	Cyber Security	people don't trust state actors / criminals
4.	Liability / Responsibility	people don't trust law makers / enforcers / insurance / other drivers
5.	Human Factors	people don't trust themselves….well actually they do, which is a problem

Acmena

Analysis Results – A Matter of Trust

So, in the space of 150 years:

People didn't trust humans to operate vehicles as it was thought they wouldn't be as safe as the natural collision avoidance ability of horses.

And they were probably right, however…..

For the last 100 years or so, people DO generally accept the risk of fellow humans operating vehicles, despite them causing over 1 million deaths per year.

But people have difficulty trusting AI and machines in mainstream road vehicle applications, even though computers can't succumb to the things that cause 90% of all accidents…….fatigue, distraction, emotion, aggression, substance impairment, lack of experience, lack of competence, violation of road rules.

Is it all about awareness and education or regulation, or a bit of both?

AI in AV Safety Systems

Acmena

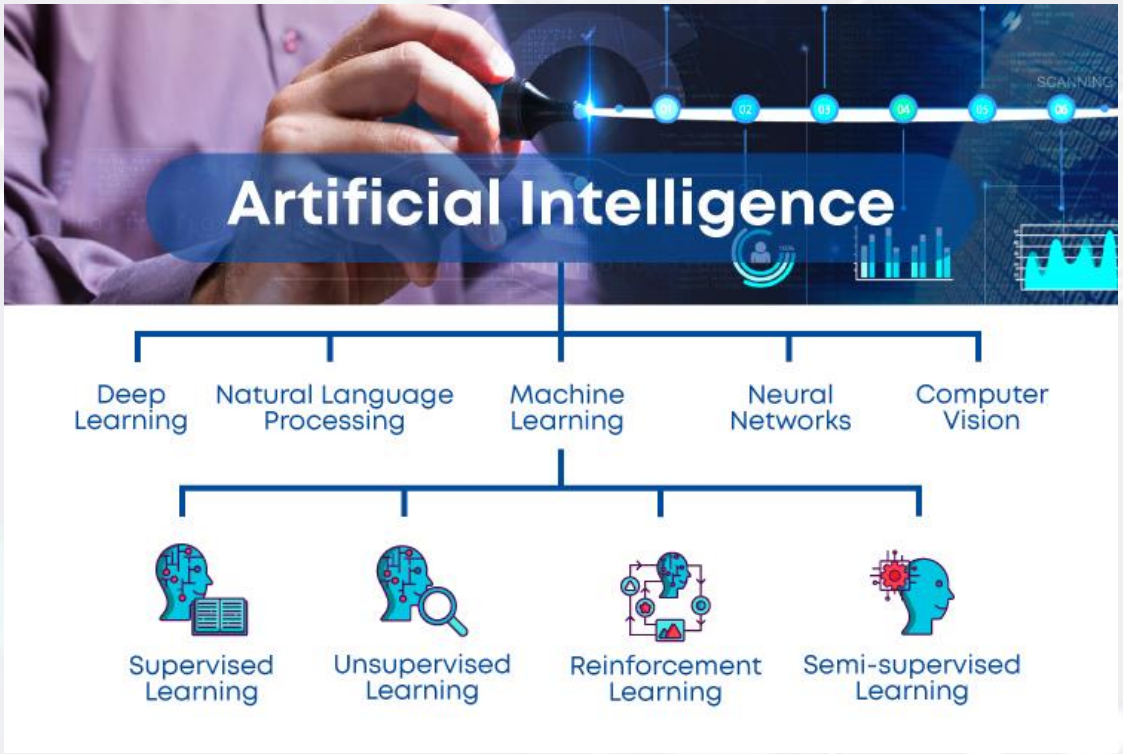
Automated Vehicles – Artificial Intelligence

What is AI?

In automated Vehicle terms:

The theory and development of computer systems able to perform dynamic driving tasks normally requiring human intelligence, such as visual perception and decision-making.

There are, however, many different ways in which systems can do this ::

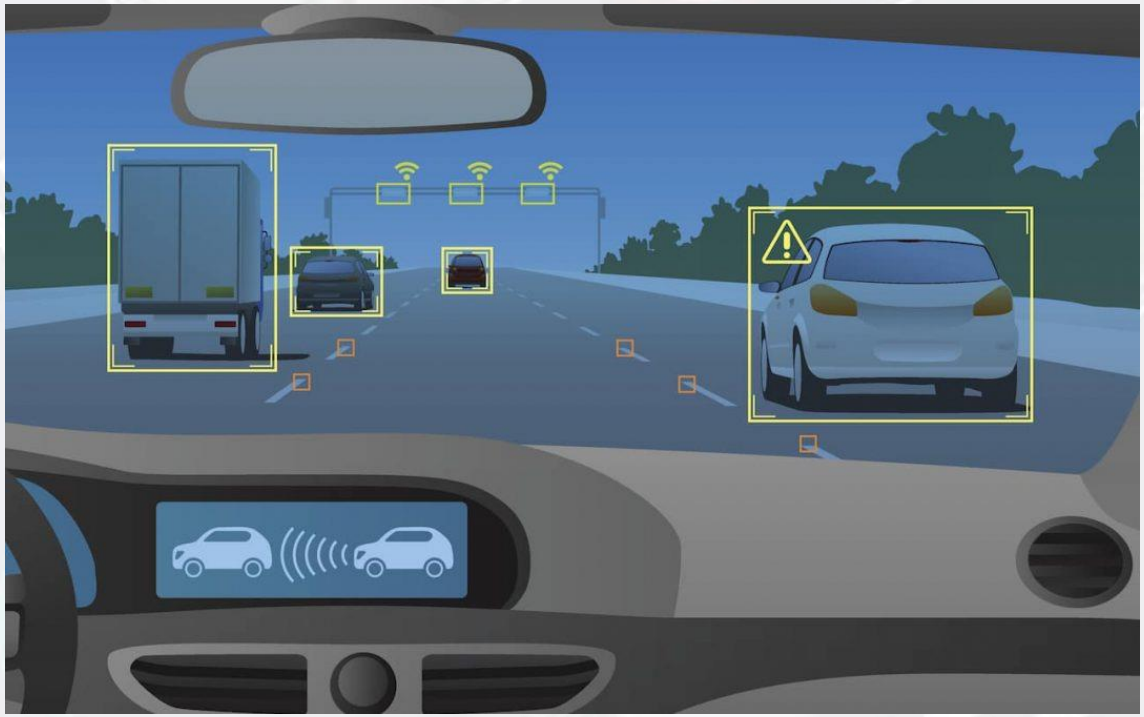


Automated Vehicles – Artificial Intelligence

What is an AV?

According to the National Transport Commission:

That is, an AV is a vehicle which contains an 'automated driving system' that performs all dynamic driving tasks whilst observing the external environment, with some to no human driver input

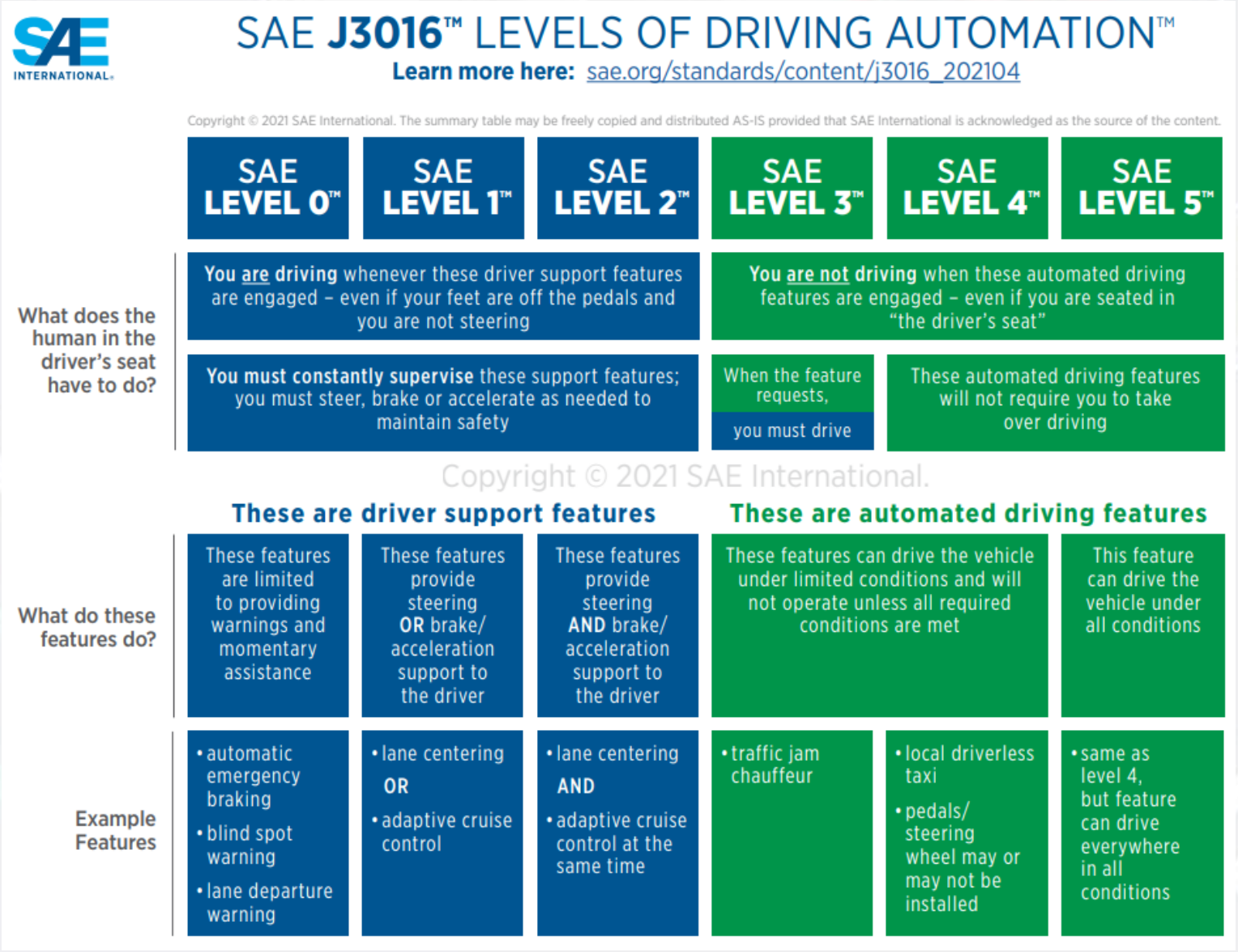


Acmena

Automated Vehicles – Levels of Automation

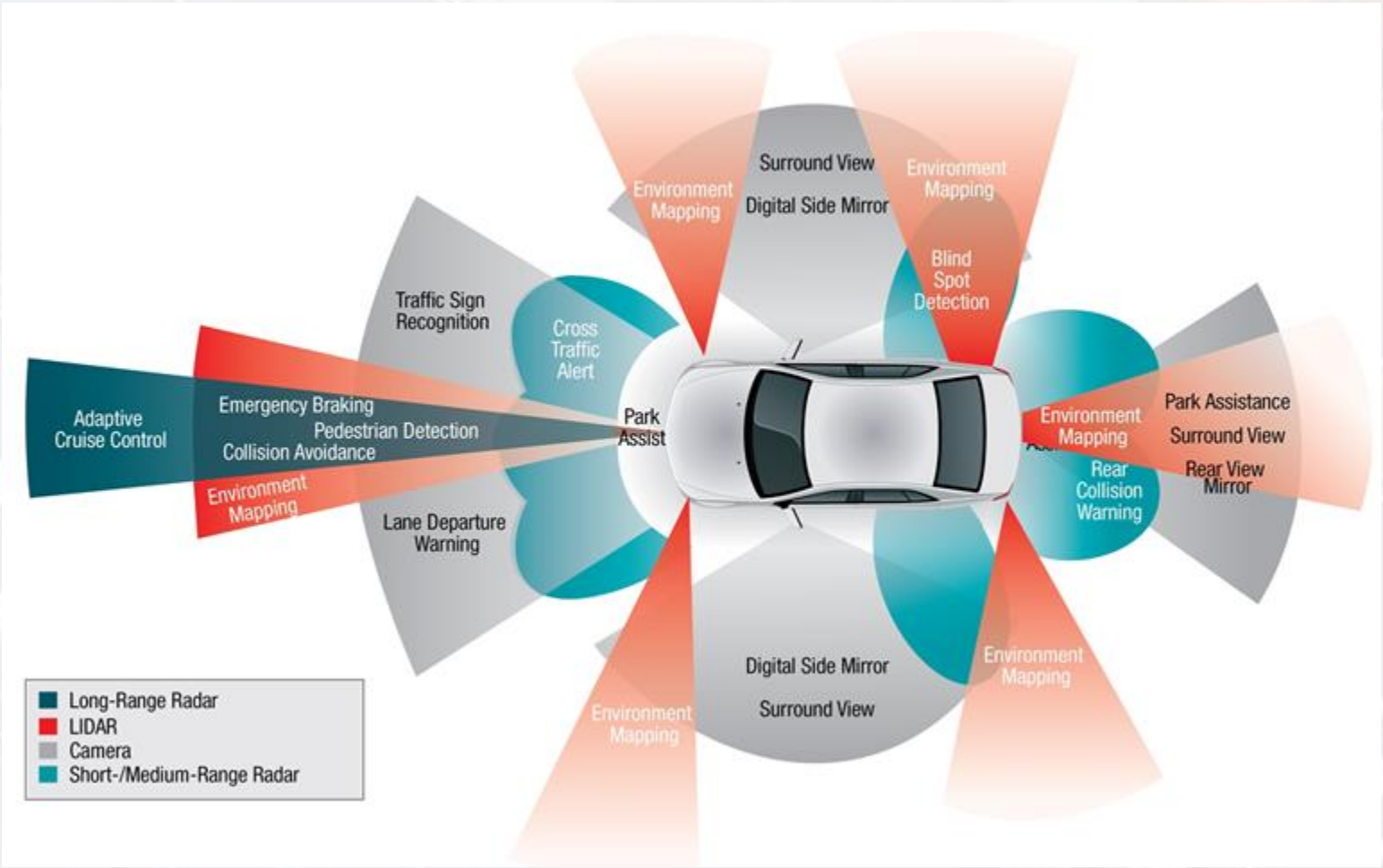
Most vehicles today are up to Level 2.

Driver is still responsible and liable.



Acmena

Automated Vehicles – AI Safety Features



Automated vehicles are fitted with cameras, sensors and communication systems to enable the vehicle to generate massive amounts of data which, when applied with AI, enables the Automated Driving System to see, hear, think and make decisions just like human drivers do.

Acmena

Automated Vehicles – AI Safety Features Sensors

Multitude of Systems

- **Lidar** (light detection and ranging), also known as 3D laser scanning, is a tool that self-driving cars use to scan their environments with lasers. Lidar systems measure the amount of time it takes to emit a laser signal and sense the same light beam reflected from a physical surface onto its photodetectors.
- **Radar** (radio detection and ranging) emits radio waves in known directions with radar transmitters. Reflected waves that return to a car's radar receiver help the car derive information about environmental objects like object range, direction of travel and velocity
- **Cameras** can visualize the environments with high-resolution digital images. Self-driving cars can use camera images to "see" and interpret environmental details, such as road signs, traffic lights, animals, pedestrians) in ways that approximate human vision
- **Microphones** are used to listen for sirens of emergency vehicles
- **Internal inertia devices** such as accelerometers can help self-driving cars stabilize themselves and help determine whether they should take any kind of protective safety actions, such as deploy airbags or pre-tension seatbelts

AI element of all these systems determines vehicle response ::

•Artificial intelligence programming in the vehicle is associated with every one of the sensors. The AI recreates human perceptual and dynamic responses.

•This manifests itself in controlling the vehicle as a human would do.

•However, the system is only as safe as the programming of the computer response.

•Human error is passed upstream from the operation of the vehicle to the engineering of the system.

Should AI be regulated?

Returning to the research and distrust of AI, should that be the target for regulation? If we regulate the person at present, shouldn't we regulate the new "human"?

If the machine can make decisions much quicker than people, and different types of AI being utilised, should the way in which the AI has been developed be scrutinised?

Ethics and bias become a factor on how decisions are made for a specific outcome in a specific situation.

Should AI be regulated?

Some consideration being given to AI regulation, but at present in Australia, AI is on a basis of self-regulation by principle:

Australian Government
Department of Industry, Science, Energy and Resources

Australia's Artificial Intelligence Ethics Framework

Principles at a glance

1. **Human, societal and environmental wellbeing:** AI systems should benefit individuals, society and the environment.
2. **Human-centred values:** AI systems should respect human rights, diversity, and the autonomy of individuals.
3. **Fairness:** AI systems should be inclusive and accessible, and should not involve or result in unfair discrimination against individuals, communities or groups.
4. **Privacy protection and security:** AI systems should respect and uphold privacy rights and data protection, and ensure the security of data.
5. **Reliability and safety:** AI systems should reliably operate in accordance with their intended purpose.
6. **Transparency and explainability:** There should be transparency and responsible disclosure so people can understand when they are being significantly impacted by AI, and can find out when an AI system is engaging with them.
7. **Contestability:** When an AI system significantly impacts a person, community, group or environment, there should be a timely process to allow people to challenge the use or outcomes of the AI system.
8. **Accountability:** People responsible for the different phases of the AI system lifecycle should be identifiable and accountable for the outcomes of the AI systems, and human oversight of AI systems should be enabled.

Australian AV Regulation

Acmena

Automated Vehicles – Australian Regulatory Approach

Regulation of AVs needs to address the 5 areas detailed previously ::

1. System Design…….Ensuring designs are safe SFAIRP, including through life support
2. Ethics / Technology / AI…….Prevent upstream errors or suspect intentions with clear operating domain
3. Cyber Security…….General regulation already exists, does it need to be specific to AVs
4. Liability / Responsibility……Complete change to the way the law currently applies
5. Human Factors……..How will regulation ensure people are competent to operate AVs

Vehicles are currently required to comply with the **Road Vehicle Standards Act 2018**, applied through the **Australian Design Rules** Standard (harmonized with UNECE rules)

Operating (driving) rules are mandated by the **Australian Road Rules**, which are set in legislation for each state and territory.

The applicability of the Australian Road Rules to AVs is contingent upon ensuring that AI systems can appropriately model these rules.

Acmena

Automated Vehicles – Current Australian Position

No present regulation in Australia without the human being in control

Even cars fitted with Level 3 automation, the driver is still in control of the vehicle and liable for any incidents, including if the vehicle is in an automated mode.

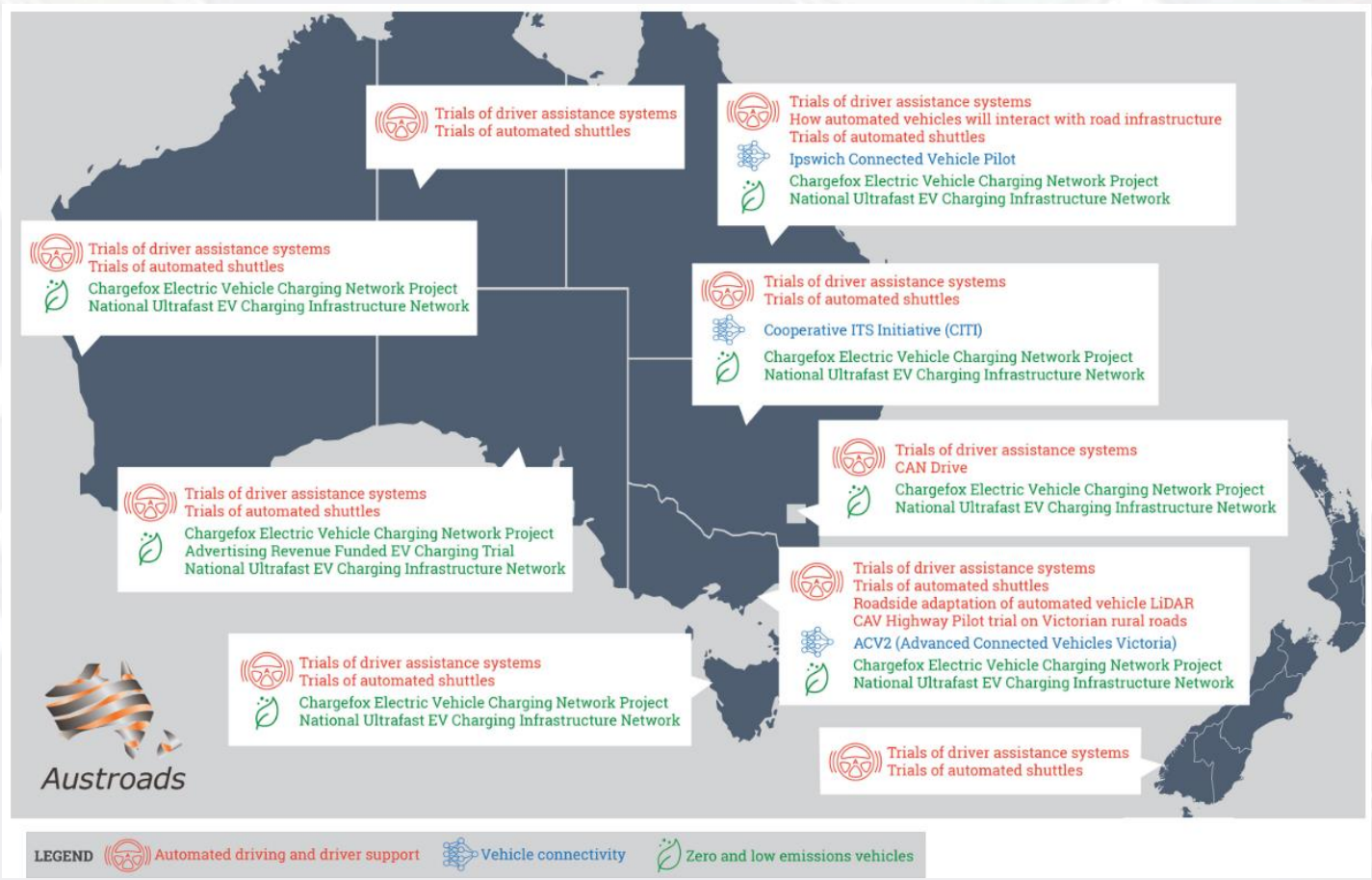
Level of automation			Examples of behaviours that indicate *proper control*			
Level of automation	**Who is undertaking the driving task?**	**Responsibility for compliance with road traffic laws (who is in control?)**	At least one hand on the steering wheel	Seated in the driver's seat	Alert enough to resume the entire driving task if requested or if there is an evident vehicle system failure (e.g. eyes open, checking the external environment)	Not reading or viewing a device or thing unrelated to navigation or driving (existing restrictions on mobile phones and visual display units continue to apply)
When there is no driving automation system engaged at a point in time	**Human driven** The human driver performs the entire driving task.	**Human in control and responsible for compliance with road traffic laws** The human driver performs the entire driving task although there may be active safety systems (that warn or intervene during a high-risk event or maneuver).	**Yes**	**Yes**	**N/A** The driver is always responsible for the entire driving task.	**Yes** The driver must not engage in any activity other than driving.
Level 1 – driver assistance (steering *or* braking and acceleration control)	**Human driven** The human driver performs the majority of the driving task.	**Human in control and responsible for compliance with road traffic laws** The human driver is required to perform all or part of the driving task.	**Yes**	**Yes**	**Yes**	**Yes** The driver must not engage in any activity other than driving.
Level 2 – partial automation (steering, acceleration and braking control)	**Human driven** The driving automation system cannot perform the entire driving task for a sustained period without a human in the loop to monitor the system.	**Human in control and responsible for compliance with road traffic laws** The human driver is required to perform all or part of the driving task.	**Yes**	**Yes**	**Yes**	**Yes** The driver must not engage in any activity other than driving.
Level 2 – partial automation (parking assistance – driver remains in driver's seat)	**Driving task shared between the system and the human driver** The driving automation system performs the parking task and the driver is responsible for object detection and intervenes if an obstacle enters the vehicle's path.	**Human in control and responsible for compliance with road traffic laws** The human driver is required to perform all or part of the driving task.	**No**	**Yes**	**Yes**	**Yes** The driver must not engage in any activity other than supervising the system.
Level 3 – conditional automation	**System capable of operating the vehicle** The ADS can perform the entire driving task for a sustained period without a human monitoring the system, but the human is expected to intervene with the driving task if requested or if there is an evident vehicle system failure.	**Human in control and responsible for compliance with road traffic laws** The ADS entity is not currently recognised in legislation and therefore cannot be in control. The human driver is not required to perform any of the driving task while the ADS is engaged but has a fallback role.	**No**	**Yes**	**Yes**	**Yes** While not driving, the human driver must not engage in activities that prevent him or her from responding to takeover demands, are not in line with the intended use of the automated driving function or are prohibited by law.

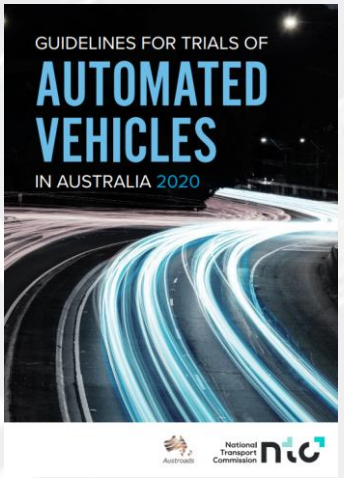
Acmena

Automated Vehicles – Australian Regulatory Approach

Automated Vehicle Trials in Australia::

Legislation does exist for AV trials, at a state & territories level:





Acmena

Important Concepts for Australian Regulation ::

Automated driving system (ADS): the hardware and software collectively capable of performing the entire dynamic driving task on a sustained basis without human input.

This is effectively what replaces the human as per conventional vehicles.

Automated driving system entity (ADSE): the party that will self-certify the safety of the ADS and take responsibility for it over its life. The ADSE will self-nominate at first supply when applying for type approval or when applying to take responsibility for an ADS in service.

This is who is responsible for the safe operation of the ADS, who will apply for Type-Approval, probably vehicle manufacturer.

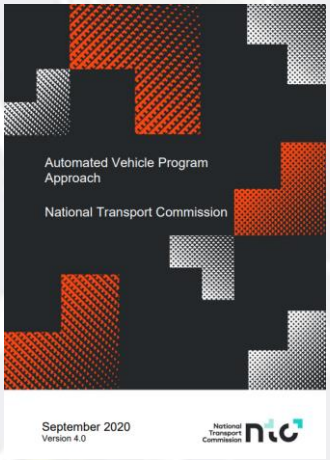
Operational design domain (ODD): the specific conditions under which an ADS or feature is designed to function (for example, location, weather conditions, driving modes).

Where and under what circumstances the ADS can operate.

National Position on Automated Vehicles

Is the Australian government addressing people's concerns?

Australian NTC published their Regulatory Framework paper in February 2022, which follows their published approach and consultation process over the previous few years.



3 Regulators:
1. First-supply
2. In Service
3. States & Territories

Key Themes:

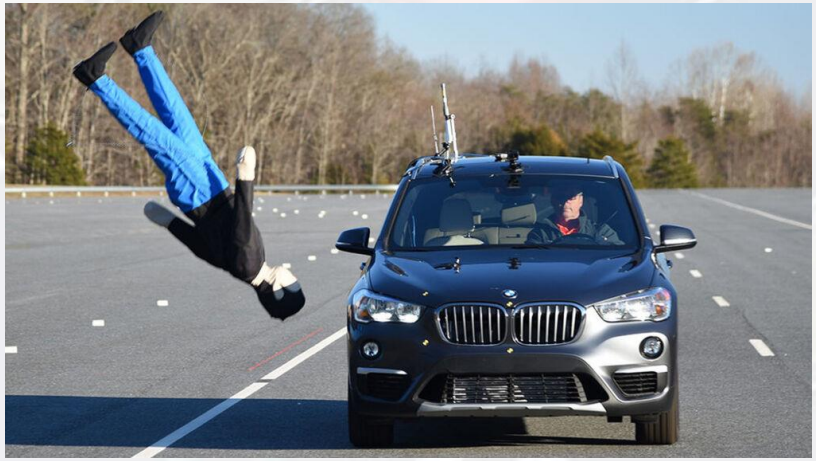
- **Implementation in states & territories over next 5 years**
- First supply vehicle framework will involve type-approval, following 11 point safety based criteria from Australian Design Rules
- Type Approval to be administered by Commonwealth Department of Infrastructure, Transport and Regional Development (DITRDC)
- Type Approval applications will involve self-certification showing how the vehicle meets the 11 point safety requirements.
- Liability with ADSE Executive Officers

NO MENTION OF AI

Acmena

National Position on Automated Vehicles

First Supply Regulator:



11-Point Outcomes Based Safety Criteria ::

1 Safe system design and validation process

2 Operational Design Domain

3 Human-machine interface

4 Compliance with relevant road traffic laws

5 Interaction with emergency services vehicles

6 Minimal risk condition

7 On-road behavioural competency

8 Installation of system upgrades

9 Verifying for the Australian road environment

10 Cybersecurity

11 Education and training

National Position on Automated Vehicles

In-Service Regulator:

Onus on ADSE to maintain safety – Main Themes

- ADSE maintains general safety duty to ensure safe operation SFAIRP through life of ADS
- ADSE is responsible for identifying and mitigating risks that may emerge
- Ensure system upgrades to ADS are undertaken and do not result in unsafe operation
- Provide education and training to relevant parties, including users
- Make efforts to prevent interference of ADS by 3rd parties
- Record and store data relevant to compliance and maintain records of safety incidents, reporting systematic issues to regulator
- Ensure accountability to demonstrate compliance

In-Service regulator shall have a crash investigation function

Acmena

National Position on Automated Vehicles

States & Territories Regulator:

Onus on ADSE to maintain safety – Main Themes

- Registration of owners / operators
- In-service safety obligation for registration and roadworthiness of vehicles
- Technical standards for roadworthiness based on Australian Design Rules
- Maintaining road infrastructure

For other road users, including pedestrians, cyclists, motorcyclists and passengers:

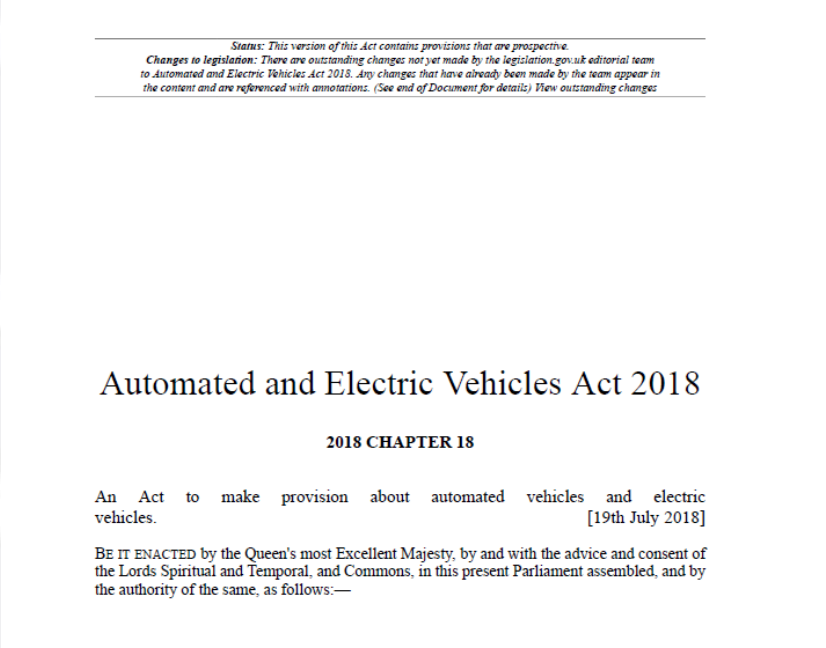
These other road users are not expected to change their behaviour around automated vehicles. Automated vehicles will need to be able to operate safely around these road users.

Acmena

Overseas Position on Automated Vehicles - UK

Are overseas governments such as the UK addressing people's concerns?

UK already has the Automated and Electric Vehicles Act 2018.



Status: This version of this Act contains provisions that are prospective.
Changes to legislation: There are outstanding changes not yet made by the legislation.gov.uk editorial team to Automated and Electric Vehicles Act 2018. Any changes that have already been made by the team appear in the content and are referenced with annotations. (See end of Document for details) View outstanding changes

Automated and Electric Vehicles Act 2018

2018 CHAPTER 18

An Act to make provision about automated vehicles and electric vehicles. [19th July 2018]

BE IT ENACTED by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

Light on content, it basically states that if operating a vehicle in automated mode, the driver must be insured to operate the vehicle in this manner.

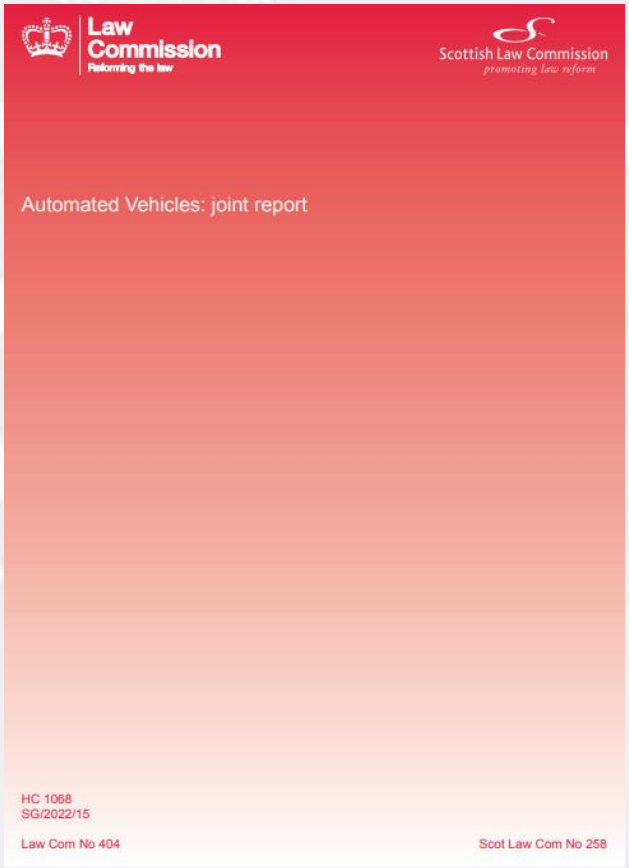
This applies to vehicles not required to be controlled or monitored by a human.

Acmena

Overseas Position on Automated Vehicles - UK

Since 2018, the UK Law commission has been developing a report with recommendations, which was published in January 2022.

UK will set up a Vehicle Certification Agency to certify as an Approval Authority



Somewhat similar to Australia, transport matters are devolved in the UK to the individual nations.

UK approach aims to keep safety and innovation at the forefront, while also retaining the flexibility required to regulate for uncertain future development.

Clear demarcation between cars being driven by driver and cars which drive themselves. They may appear similar due to the continuum of levels but legally they are very different.

Onus on ADSE to prove ADS is safe

NO MENTION OF AI in ADS operation

Acmena

Overseas Position on Automated Vehicles - UK

The UK Law Commission report does consider AI in context of:

- Consideration of the appropriate legal test for the standard of care.
- The application of rules of causation.
- The appropriateness of a fault-based model of liability.
- Options for regulation including licensing.

……but as a separate piece of work and not as part of this document scope

Overseas Position on Automated Vehicles - UK

UK approach will require the ADS to be capable of doing more than just the Dynamic Driving Task, of steering, braking and, signalling, if operating in self-driving mode.

It also involves monitoring the driving environment and responding to objects and events.

- ADS monitoring, the way the car is driving itself.
- Environment monitoring, what is happening around it and other external factors.
- Vehicle performance monitoring, is the vehicle suffering failures, e.g., flat tyre.

automated Vehicles – are we really improving safety?

UNECE

Inland Transport Committee

World Forum for Harmonization of Vehicle Regulations

The level of safety to be ensured by automated/automated vehicles implies that "an automated vehicle shall not cause any non-tolerable risk", meaning that automated/automated vehicle systems, under their automated mode, shall not cause any traffic accidents resulting in injury or death that are reasonably foreseeable and preventable

Acmena

World Health Organization

The countries who may benefit the most from AVs are those with the worst safety records.

These are primarily in Africa, Central & SE Asia and South America. How would an AV manage in these circumstances:

Are AVs really being developed to improve safety, or for commercial gain?

Q&A