ADVI
AUSTRALIAN
DRIVERLESS VEHICLE INITIATIVE

ADVI FACT SHEET

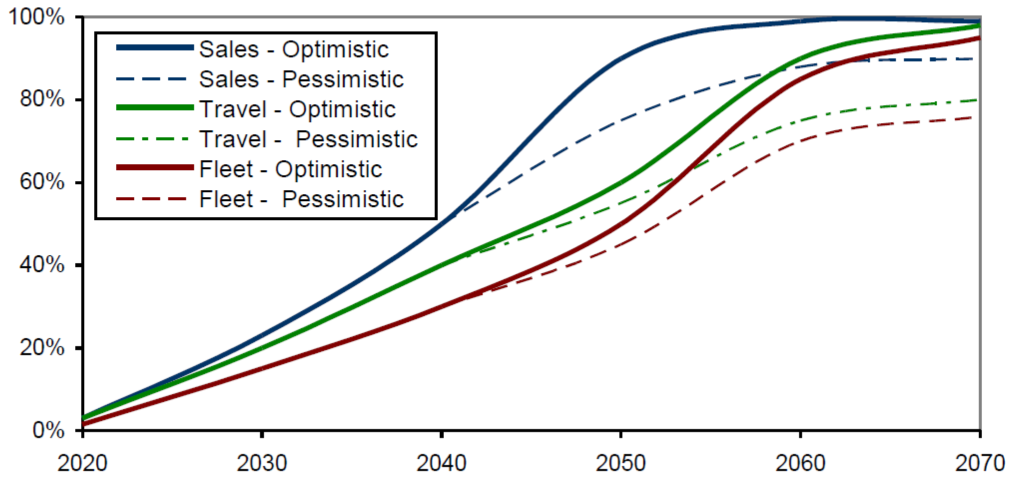
Self-Driving Vehicle Facts - Summary Fact Sheet

Background

1. Percentage of Fleet that will be driverless

Figure 1 is assumed to be general worldwide based on references to rate of purchase of other technologies globally. It would be assumed to be in a general economy of the scale of U.S, Canada, Europe or Australia as opposed to third world economies.

Figure 1 **Autonomous Vehicle Sales, Fleet and Travel Projections** (Based on Table 6)



Source: (Litman, Autonomous Vehicle Implementation Predictions: Implications for Transport Planning, 2015)

Figure 1 is based on the market response of previous new technologies and the number of decades they have taken to be accepted and come to dominate the market (Litman, Autonomous Vehicle Implementation Predictions: Implications for Transport Planning, 2015)

"Under the right circumstances, we could reach a 50 to 75% autonomous fleet mix between 2035 and 2045." (Bierstedt, et al., 2014, p. 10)

2. Predicted Implementation Timeline

A presentation by David Singleton at the Smart Mobility Forum suggested that limited autonomy (where a driver intervenes in critical situations) will be common on roads by 2020, semi-autonomy (where a driver's attention is required with manual override) by 2025 and full autonomy (no driver backup) by 2030 (Singleton, 2015).

3. Current Legislation in the U.S.

Some U.S. states have proceeded with AV-enabling legislation including California, Florida, Nevada, Michigan and Washington D.C. These states have enacted bills to regulate AV licensing and operation.

Predicted benefits of autonomous vehicles

1. Road Capacity Improvement

Projections suggest that "aggressive programming could reduce vehicle delays by about 45% once half the fleet is operating autonomously" while "intermediate parameter settings require 75% autonomous fleet mix to achieve moderately high capacity (25-30%)" (Bierstedt, et al., 2014, p. 26).

Based on previous research by Varaiya (1993), it is estimated that the vehicle density (capacity) increases by a factor of 5 for a platoon of 20 vehicles versus free vehicles, both travelling at 72 km/hr. At 36 km/hr the road capacity increases by a factor of 3 for platoons of 20 vehicles. For smaller platoons of 5 vehicles, the road capacity increase is 1.8 for 36km/hr and 2.8 for 72 km/hr (Fernandes & Nunes, 2012).

Cooperative adaptive cruise control (CACC) with market penetrations of 10%, 50% and 90% increase lane capacity by approximately 1%, 15% and 90%, respectively." (Schladover, Su, & Lu, 2012, p. 66)

"At a 20% market penetration, [the Vehicle Awareness Devices (VAD)] addition increases capacity by 7%, at 30% market penetration it increases by more than 10%, and in the 50% to 60% market penetration range the increase is in the range of 15% compared with the cases without VADs". (Schladover, Su, & Lu, 2012, p. 67)

"Considering a normal situation with 2 trucks driving 80 km/h with a 2 seconds gap. With a truck length of 18.75 metres this results in a claim of 82 metre road, excluding the gaps in front of the first truck and behind the following truck. Using platooning, a 0.3 second gap would decrease the length of those two trucks with 46% to 44 metres" (Janssen, Zwijnenberg, Blankers, & de Kruijff, 2015, p. 24).

"If all of the vehicles use sensors alone, the increase in [US] highway capacity is about 43%. While if all of the vehicles use both sensors and vehicle-to-vehicle communication, the increase is about 273%." (Tientrakool, Ya-Chi Ho, & Maxemchuk, 2011, p. 1)

A study by the Eno Center for Transportation suggests that, annually, travel time can be reduced by 756 million hours, 1680 million hours and 2772 million hours for autonomous vehicle penetrations of the US market of 10%, 50% and 90%, respectively (Fagnant & Kochelman, Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations, 2015, p. 175)

2. Planning for Driverless Vehicles

Of 68 of the most populous US cities surveyed, only 6% of the cities consider the potential effects of driverless technology in their transportation plans (National League of Cities, 2015, pp. 2,4).

3. Reduction in the size of the fleet / shared-use

Spieser et al. report that"...a shared mobility solution can meet the personal mobility needs of the entire population [of Singapore] with a fleet whose size is approximately one third of the total number of vehicles currently in use." (Spieser, et al., 2015, pp. 1,15)

OECD state that in a self-driving ride-sharing scenario "nearly the same mobility can be achieved with 10% of the cars" (International Transport Forum, 2015, p. 5).

It is suggested that each shared autonomous vehicle would serve "approximately 31 to 41 travellers per day, with an average waiting time of less than 20 seconds" (Fagnant & Kockelman, The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios, 2014, p. 13)

A comprehensive study for the US federal government has indicated that, at market penetrations of 10%, 50% and 90%, there will be a reduction in the number of vehicles on US roads of 4.7%, 23.7% and 42.6%, respectively (Fagnant & Kochelman, Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations, 2015, p. 175).

It is estimated that, by having household cars service multiple individuals, vehicle ownership could be reduced by up to 43% (Sivak & Schoettle, 2015, pp. 8,9). Conversely, it is stated that the distance travelled would increase by 75%.

Researchers at the Paris-based Organization for Economic Cooperation and Development estimate "that a fully automated fleet of self-driving vehicles will reduce cars on the road by 90 percent" (Ferenstein, 2015).

The International Transport Forum established a model of a mid-sized European city to examine the effects of shared driverless vehicle use. The "results suggest that each SAV would serve 31 to 41 persons per day, with an average waiting time below 20 seconds. Each SAV would replace nearly 12 conventional vehicles, and would lead to the elimination of 11 parking spaces per SAV in operation" (International Transport Forum, 2015, p. 9).

"TaxiBots [shared driverless vehicles] combined with high-capacity public transport could remove 9 out of every 10 cars in a mid-sized European city" (International Transport Forum, 2015, p. 5).

"Based on the most recent research, this replacement ratio of AVs to privately owned cars could be anywhere between 1:2 and 1:13—where any ratio of 1:1.2 or greater could itself be transformative in reducing congestion" (Godsmark, Kirk, Gill, & Flemming, 2015, p. 16).

4. Vehicle kilometres travelled

The ITF predicts that the vehicle kilometres travelled could almost double under more extreme shared self-driving vehicle scenarios. Furthermore, "if only 50% of car travel is carried out by shared self-driving vehicles and the remainder by traditional cars, total vehicle kilometre travel will increase between 30% and 90%" (International Transport Forum, 2015, p. 5).

A study has found that the distance travelled per shared vehicle will increase due to a single car fulfilling the role of several individuals' vehicles. The increase could be as little as 6% or as high as 89% depending on the type of shared use system employed. (International Transport Forum, 2015).

5. Impacts on parking requirements

ITF states "up to 80% of off-street parking could be removed [with self-driving fleets] generating new opportunities for alternative uses for this space" (International Transport Forum, 2015, p. 5).

Fagnant and Kockelman suggest that each shared autonomous vehicle "has the ability to replace nearly 12 privately owned vehicles" and that the findings indicate that "almost eleven parking spaces can be eliminated for every shared autonomous vehicle". (Fagnant & Kockelman, The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios, 2014, p. 14)

Based on estimates provided by Litman (2012), it is estimated that moving parking areas out of the central US CBDs to suburban areas can save US$3000 (Fagnant & Kochelman, Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations, 2015).

"In all cases examined, self-driving fleets completely remove the need for on-street parking. This is a significant amount of space, equivalent to 210 football fields or nearly 20% of the kerb-to-kerb street space in our model city (Lisbon, Portugal)." (International Transport Forum, 2015, p. 5).

6. Impacts on public transport

ITF state that, for "small and medium-sized cities, it is conceivable that a shared fleet of self-driving vehicles could completely obviate the need for traditional public transport" (International Transport Forum, 2015, p. 33).

7. Cost of travel

Burns et al. state that a shared and self-driving service using conventional cars could reduce the cost of car travel by 75%. (Burns, Jordan, & Scarborough, 2013, p. 6)

An estimate by the Victoria Transport Policy Institute in Canada suggests that the use of shared autonomous vehicles can reduce current taxi costs by 67-70% (Litman, Autonomous Vehicle Implementation Predictions: Implications for Transport Planning, 2015, p. 6)

8. Crash Reduction

"By removing the driver from behind the wheel, AVs are expected to eliminate most of the 93 per cent of collisions that currently involve human error (National Highway Traffic Safety Administraion, 2008)" (Godsmark, Kirk, Gill, & Flemming, 2015, p. 16)

The US-based Department of Transport reports that a combined vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication system could potentially prevent "81 percent of all-vehicle" crashes annually. (Harding, et al., 2014, p. 19) .

"Among the critical reasons attributed to drivers, about 41 percent were recognition errors, about 34 percent were decision errors, about 10 percent were performance errors, and about 7 percent were non-performance errors. About 18 percent of the drivers were involved in at least one non-driving activity, with the majority (about 12%) engaged in conversing either with other passengers or on a cell phone." (National Highway Traffic Safety Administraion, 2008, p. 31).

Many previous studies have stated that "driver error contributes to as much as 75% of all roadway crashes" (Hankey, et al., 1999) cited in (Salmon, Regan, & Johnston, 2005, p. 87). It can be argued that by implementing driverless cars (aka removing the human error) the number of crashes can theoretically be reduced by 75%.

According to a report on behalf of the Eno Center for Transportation, it is estimated that 1,100, 9,600 and 21,700 US lives could be saved per year with an autonomous vehicle market penetration of 10%, 50% and 90%, respectively (Fagnant & Kochelman, Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations, 2015, p. 175). The study also states that 211,000, 1,880,000 and 4,220,000 fewer crashes will occur at the respective market penetrations.

It is argued that, as human error contributes up to 90% of traffic accidents, the introduction of driverless vehicles will eliminate 90% of all accidents (KPMG, 2012)

According to the World Health Organisation "about 1.25 million people die each year as a result of road traffic crashes" and "20 to 50 million more people suffer non-fatal injuries" (WHO, 2015) due to human error. Driverless vehicles have the potential to remove the human factor from driving.

"Over 90% of all traffic accidents are caused by human error" (Janssen, Zwijnenberg, Blankers, & de Kruijff, 2015, p. 24) (Economist.com, 2012).

9. Cost of Crashes

"The annual economic cost of road crashes in Australia is enormous—estimated at $27 billion per annum" (Infrastructure.gov.au, 2015) (Department of Infrastructure, 2015). Based on a 75% reduction, which is possible based on the percentage of accidents due to human error (Hankey, et al., 1999)cited by (Salmon, Regan, & Johnston, 2005), this would decrease the annual economic cost of crashes by $20.25 billion to $6.75 billion per annum.

MUARC (Budd & Newstead, 2014, pp. x,xi,56,68) quantified the Australian economic benefits of new automated vehicle technologies as shown below:

Technology	Lives saved/year	$ M/year
Autonomous Emergency Braking System	67	62 - 187
Lane Departure Warning System	16	45
Electronic Stability Control	11	31
Fatigue Warning System	10	28
Total	104	171 - 291

10. Cost of Congestion

"…base case projections have these social costs of congestion rising strongly, to an estimated $20.4 billion by 2020" (Department of Transport and Regional Services, 2007, p. xv). Assuming a 30% improvement by introducing driverless vehicles as suggested by Bierstedt et al., 2014, p. 26, the cost of congestion would decrease by an amount of $6.12 billion to $14.28 billion. It should be noted that the suggested 30% improvement is based on a fleet penetration of 75% and the technology is likely to be limited to 10% by 2020. However, the results are still clearly visible.

According to the Bureau of Infrastructure, Transport and Regional Economics (BITRE), the avoidable cost of congestion for Australia's capital cities is estimated to be approximately $16.5 billion for the 2015 financial year, growing from $12.8 billion in the 2010 financial year. The 2015 total avoidable cost of metropolitan congestion of $16.5 billion is comprised of approximately $6 billion in private time costs, $8 billion in business time costs, $1.5 billion in extra vehicle operating costs and $1 billion in extra air pollution costs. (Department of Infrastructure and Regional Development, 2015)

Base case projections have estimated the avoidable cost of metropolitan congestion to rise to around $30 billion by 2030 with various results suggesting as high as $37.3 billion. (Department of Infrastructure and Regional Development, 2015)

11. Reduction in Cost of Moving Freight

"Fuel costs have consistently been the biggest MC influence across all of the years ATRI has conducted this study, and generally account for approximately 30 – 40 percent of a motor carrier's CPM (Murray & Torrey, An Analysis of the Operational Costs of Trucking, 2013)" (Murray & Torrey, 2014, p. 10)

Based on figures in Table 9 of the Operational Costs of Trucking 2014 report (Murray & Torrey, An Analysis of the Operational Costs of Trucking: 2014 Update, 2014, p. 13), fuel costs account for 38% of the total cost, while the driver-based costs amount to 34%. Assuming that with the introduction of driverless vehicles the human factor can be removed completely, then this results in a reduction of 34% in costs. If the approximate 7% reduction of fuel cost due to platooning (Alam, Gattami, & Johansson, 2010, p. 306) is also incorporated, then the total cost is decreased by 36.6%.

According to TNO, "Platooning yields average fuel consumption reductions of 10%, with both the Leading Vehicle and Following Vehicle enjoying savings" (Janssen, Zwijnenberg, Blankers, & de Kruijff, 2015, p. 23).

According to the SARTRE project, fuel costs for the following vehicle in a platoon are decreased 8-13% due to reduced drag while the leading vehicle uses 2-8% less fuel (SARTRE, 2014).

"The North American Council on Freight Efficiency and a major fleet verified that Peloton's platooning technology saves more than 7% at 65mph – 10% for the rear truck and 4.5% for the lead truck" (Peloton Technology, 2015) This will provide the opportunity to "save more than US$6 Billion of diesel fuel annually".

A study into vehicle platooning and fuel use reduction has shown that at a set speed of 70 km/h two identical trucks can achieve a "maximum fuel reduction of 4.7-7.7%" (Alam, Gattami, & Johansson, 2010, p. 306).

12. Emissions Reduction

Despite increased kilometres travelled a shared fleet for a medium sized European town produces "5.6% less greenhouse gas emissions, 34% less carbon monoxide emitted, as well as a 49% reduction in volatile organic compound emissions, among others, compared to the traditional US light duty fleet." (International Transport Forum, 2015, p. 10)

The European SARTRE project suggests that a 20% reduction in vehicle emissions will occur due to platooning (SARTRE, 2014)

A business case for truck platooning states that "platooning is better for the environment than driving without platooning. With an average CO2 emission of 2.6 kg per litre of diesel, a 10% fuel reduction can lead to substantial environmental benefits" (Janssen, Zwijnenberg, Blankers, & de Kruijff, 2015, p. 23).

Research at Berkeley Laboratory reported that "if five percent of 2030 vehicle sales (about 800,000 vehicles) were shifted to autonomous taxis, it would save about 7 million barrels of oil per year and reduce annual greenhouse gas emissions by between 2.1 and 2.4 million metric tons of CO2 per year, equal to the emissions savings from more than 1,000 two-megawatt wind turbines" (Chao, 2015).

13. Economic Benefits

"The potential benefit of this technology could be a reduction in the order of 600 fewer fatalities and 10,000 fewer injuries per year, with suitable design for future climate conditions. The safety figures translate as savings in excess of $5-10 billion/ year due to the reduction of vehicle related fatalities and injuries." (Erskine, 2014, p. 68). This is for Australian benefits and therefore figures are in AUD.

Research by PATH suggested that the fuel use created by platooning could decrease as much as 10% in urban environments and 30% in highway operation (Zabat, Stabile, Frascoaroli, & Browand, 1995, p. 31). This does not include smart accelerations and decelerations to obtain the optimal fuel efficiency. Based on statistics by the Australian government (Australian Bureau of Statistics, 2015), the average fuel consumption is 12L/100kms. Taking a 10% reduction, then the fuel consumption per 100km could decrease by 1.2L.

It is estimated that "close to 4% of the total household budget, or over 5% of the total household consumption" could be saved by the introduction of driverless vehicles. This "does not include potential savings in freight costs, some of which would be expected to flow through to households in the form of lower prices for consumer goods" (Godsmark, Kirk, Gill, & Flemming, 2015, p. 53).

In a detailed study undertaken for the US federal government, it was stated that a 10% penetration of the US car market by autonomous vehicles would result in economic savings of US$5.5 billion. A market penetration of 50% would result in an estimated saving of US$48.8 billion and a 90% penetration would result in an estimated US$109.7 billion in savings per year (Fagnant & Kochelman, Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations, 2015, p. 175).

A report prepared for the Canadian Government estimates that "the total economic benefit may be over (Canadian) $65 billion per year, including collision avoidance, fuel cost savings, and congestion avoidance" (Godsmark, Kirk, Gill, & Flemming, 2015, p. ii).

Based on a Canadian paper, statistics indicate that "productivity gains from regained driver time will be $507 billion (Canadian) —based on average commute times of 25.5 minutes (U.S. Census Bureau, 2011) for the U.S., which is similar to the Canadian average of 25.4 minutes (Statistics Canada, 2015)" (Godsmark, Kirk, Gill, & Flemming, 2015, p. 21).

Estimates from the Eno Center for Transportation in the US predict that, per annum across the country, 102 million gallons, 224 million gallons and 724 million gallons of fuel can be saved for market penetrations of 10%, 50% and 90%, respectively (Fagnant & Kochelman, Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations, 2015, p. 175).

14. Public Perception

A study by the Transport Systems Catapult (TSC) implies that the younger generation is more likely to embrace autonomous vehicles. Of the 10,000 questionnaire respondents, 39% said they would consider using self-driving vehicles with the value rising to 62% for younger individuals. (Wockatz & Schartau, 2105, p. 9)

15. Reduced insurance premiums

With the prediction of less vehicles being on the road due to car-sharing AV networks and reduced risk of accidents, it is expected that insurance premiums for AVs will reduce compared to their driver-operated counterparts (KPMG, Connected and Autonomous Vehicles – The UK Economic Opportunity, 2015).

A public opinion survey conducted by the University of Michigan in Australia, the UK and US found that the majority of people believed that driverless vehicles would reduce crashes and their severity, lower insurance rates, provide better fuel economy and decrease fuel emissions. However, they also believe that shorter travel times and less congestion are unlikely to occur (Schoettle & Sivak, A survey of Public Opinion about Autonomous and Self-Driving Vehicles in the U.S., the U.K, and Australia, 2014).

16. Driverless Crashes

A study by the University of Michigan has compared crash records of self-driving vehicles to those for normal road users. The study reported that the "self-driving vehicles were not at fault in any crashes they were involved in" and that "overall severity of crash-related injuries involving self-driving vehicles has been lower than for conventional vehicles" (Schoettle & Sivak, A Preliminary Analysis of Real-World Crashes Involving Self-Driving Vehicles, 2015, pp. i,18).

"About 70 per cent of all self-driving car crashes occurred while the cars were stopped or going less than 5 mph. No human has been seriously hurt; and self-driving cars have never been at fault in any reported incident." (Walker, 2015)

In an interview with Google's Chris Urmson regarding a crash that a driverless car was involved in it was reported that "our braking was normal and natural, and the vehicle behind us had plenty of stopping distance — but it never decelerated. This certainly seems like the driver was distracted and not watching the road ahead" (Knibbs, 2015).

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